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LIVESTOCK SYSTEMS RESEARCH IN NIGERIA'S SUBHUMID ZONE

**PROCEEDINGS OF THE SECOND ILCA/NAPRI SYMPOSIUM
HELD IN KADUNA, NIGERIA
29 OCTOBER-2 NOVEMBER 1984**



MARCH 1986

**INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
P.O. BOX 5689, ADDIS ABABA, ETHIOPIA**

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EXTENSION ACTIVITIES/

ABSTRACT

This collection of symposium papers presents the results of livestock systems research in Nigeria's subhumid zone. Basic information about the zone's population, land use, ecology, vegetation, animal health and traditional crop and livestock production systems is given. The interactions between crop and livestock production and the need to improve animal feed resources are discussed. The supplementary feeding of cottonseed cake, and the establishment of fodder banks, their utilization and the reactions of Fulani agropastoralists participating in the research are described. The role of national institutes and extension services in present and future work is discussed.

MOTS-CLES

RAPPORT DE REUNION/ NIGERIA/ ZONE SUBHUMIDE/ SYSTEME D'ELEVAGE/ RECHERCHE/
ALIMENTATION SUPPLEMENTAIRE/ LEGUMINEUSE FOURRAGERE/ BANQUE FOURRAGERE/
CULTURE MIXTE/ RESIDU DE RECOLTE/ ENGRAIS ORGANIQUE/ REGIME FONCIER/
UTILISATION DES TERRES/ SANTE ANIMALE/ VULGARISATION AGRICOLE

RESUME

Cette collection de communications présente les résultats de recherches sur les systèmes d'élevage de la zone subhumide du Nigéria. Des informations de base sont fournies sur les populations de la zone, l'utilisation des terres, l'écologie, la végétation, la santé animale et les systèmes traditionnels de productions culturale et animale. Des études sont consacrées aux interactions entre l'agriculture et l'élevage et à la nécessité d'améliorer les ressources disponibles pour l'alimentation du bétail. La complémentation de la ration de base par des tourteaux de graines de coton ainsi que la mise en place de banques fourragères, leur exploitation et les réactions des pasteurs peuls participant aux essais font l'objet de descriptions. Le rôle des organismes nationaux et des services de vulgarisation dans le cadre des activités en cours et projetées est examiné.

Acknowledgments

These papers report the results of a livestock systems research effort. The successful holding of the symposium and publication of the proceedings were not, however, the result of carefully identifying constraints and planning how to overcome them: the list of constraints would have been too daunting. Instead, I depended completely on unstinted team spirit and good humoured improvisation from all concerned. They came forth in full measure from all parties - the staff of ILCA's Subhumid Zone Programme, NAPRI colleagues and ILCA Publications Section - and I humbly acknowledge my gratitude.

Ralph von Kaufmann
Team Leader
ILCA Subhumid Programme
Kaduna

P R E F A C E

The International Livestock Centre for Africa (ILCA) was founded in 1974 as one of the research centres of the Consultative Group on International Agricultural Research (CGIAR). Its mandate is, through research, documentation and training activities, to assist national efforts to improve livestock production in sub-Saharan Africa. In addition to its headquarters research, ILCA conducts field research in the continent's five major ecological zones: the arid, semi-arid, subhumid, humid and highland zones.

ILCA began its research programme in the subhumid zone of Nigeria in 1978. In the following year the first ILCA/NAPRI Symposium on Livestock Production in the Subhumid Zone was held at Kaduna. This symposium reviewed the state of livestock production in the zone and laid down important guidelines for ILCA's future research, including the need to increase the zone's fodder production.^{1/}

Since then ILCA's Subhumid Zone Programme has continued to work closely with national institutes in Nigeria on research to improve the crop and livestock production systems of the zone's pastoralists and farmers. This volume of symposium proceedings presents the results of that research to date. The papers it contains were presented at the second ILCA/NAPRI Symposium, held at Kaduna 29 October to 2 November 1984, and attended by over 120 participants.

^{1/} The results of the symposium provided the basis for Livestock production in the subhumid zone of West Africa: A regional review, ed. Westley, S.B. ILCA Systems Study No. 2. Addis Ababa, 1979.

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Welcome address

R. von Kaufmann
Team Leader
ILCA Subhumid Programme, Kaduna

On behalf of Dr Peter Brumby, Director General of the International Livestock Centre for Africa (ILCA), and Professor Saka Nuru, Director of the National Animal Production Research Institute (NAPRI), I welcome you all to the Second ILCA/NAPRI Symposium on Livestock Production in the Subhumid Zone.

Many of you will recall that 5 years ago, at the start of ILCA's research at Kaduna, NAPRI and ILCA hosted a similar symposium. The Subhumid Zone Programme has now reached a stage at which it is appropriate to reassess the state of knowledge and the direction of future research. NAPRI and ILCA are, therefore, holding this symposium so that ILCA staff and their colleagues from other institutions can present their results and views on the future of livestock systems research (LSR) in the zone.

It is our hope that the papers and discussions will provide a basis and an opportunity for you to give us the benefit of your advice on the future direction and content of ILCA and national LSR efforts.

Obviously a symposium on the work of a small, new field team is not going to provide dramatic new discoveries comparable to those revealed at other national and international conferences you may have attended. Whilst we nevertheless hope each one of you will find something new, our main objective is to refresh your interest in the concept, objectives and methods of LSR as a whole. We hope that this symposium will encourage other LSR efforts in Nigeria and other countries.

During the course of the symposium we hope that the role of ourselves and our organizations in the future of LSR will become more sharply defined. Unlike scientists working on single specialized topics, the livestock systems scientist needs the active cooperation of everyone involved:

- | | |
|----------------------------------|---|
| Policy makers | - to set the goals |
| Specialized scientists | - to resolve specific problems and develop new techniques |
| Development and extension staff | - to help extend new interventions |
| Businessmen and commercial firms | - to produce and supply farmers' requirements for inputs |
| Farmers and livestock producers | - to help develop and adopt new interventions. |

Judging by the above, LSR appears somewhat parasitic and, indeed, in its early years, it most definitely is so. In fact it seeks to be cost effective by exploiting existing knowledge and expertise. ILCA acknowledges with deep gratitude the very great assistance the subhumid zone team has had from NAPRI, FLD, NLFU, the Kaduna State Ministry of Agriculture, the Kachia Local Government, the livestock producers and farmers, and many others. This spirit of cooperation has been recognized here and abroad, and has been a source of considerable credit to all involved.

Despite the relatively early stage in the life of a research programme dealing with complex and long-term issues, we hope that by the end of this symposium you will be able to appreciate the pay-off from our research in terms of:

- Providing 'farm-ready' technology for use by development and extension agencies.
- Providing data useful to policy makers.

- Indicating areas where specialized researchers can more effectively support livestock development.

- Identifying those gaps in the knowledge that escape detection in the course of conventional on-station trials.

ILCA's subhumid zone research team is grateful that the heads of the three premier Nigerian livestock policy, research and development agencies intended to honour the symposium with their presence on this first day. That they are represented among us is a reminder of ILCA's role: to adopt goals from national policy makers, and to use all available knowledge to contribute, through LSR, to the efforts of national development agencies.

But for the harmattan, Dr. K. B. David-West, Director, Federal Livestock Department, and member of the board of ILCA, would, as our guest speaker, have provided the policy setting; Professor Saka Nuru, Provost, Faculty of Agriculture and Veterinary Medicine, Ahmadu Bello University, Director, National Animal Production Research Institute, and Chairman of the Technical Advisory Committee to ILCA's Subhumid Zone Programme, will, in his keynote address, expose the wealth of Nigerian research experience on which the team has been able to draw; while Dr. J Binchan, Executive Director, National Livestock Project Unit, is the most fitting person to chair the first session, since without the quiet but firm support and interest of the NLPU, the ILCA team's work would hardly have been possible or worthwhile.

The subhumid zone team is also indebted to Dr. J. Lambourne, Director of Research at ILCA, for agreeing to explain the role of the Subhumid Zone Programme in ILCA's overall mandate. This is essential because, as part of an international organization, ILCA's field teams must always serve two masters. The interest of the host nations must be harmonized with the international goal of serving all of tropical Africa. With extremely limited resources that is no easy task. By way of illustration ILCA has less than half the number of scientists employed by the Institute of Agricultural Research (IAR) at Ahmadu Bello University. A close understanding of the comparative strengths and limitations of Nigerian

institutions and ILCA will help formulate the best mix of activities for both Nigeria and ILCA.

We are of course equally indebted to our other chairmen: Pieter de Leeuw, formerly of NAPRI and now of ILCA's East African Rangelands Programme in Nairobi; Professor A. A. Ademosun, Department of Animal Science, University of Ile Ife; Professor G.I.O. Abalu, Programme Leader, Farming Systems Research, Institute of Agricultural Research, Ahmadu Bello University; Professor H.R. Chheda, Department of Agronomy, University of Ibadan; and, second to none, Alhaji Aliyu Barau, Chief Animal Husbandry Officer, Kaduna Ministry of Agriculture.

It is particularly fitting that Alhaji Aliyu Barau should chair the last session, because in the final analysis the extension of interventions to livestock producers is in the hands of state extension staff. ILCA is aware of its debt to many staff of the Kaduna State Ministry of Agriculture, both in Kaduna town itself and in the field.

With the impetus that will be given by the contributions of these leaders of livestock research and development, I trust that we can expect an interesting and enjoyable 4 days. ILCA's subhumid zone team thanks you all for attending and assures you that it is very much looking forward to your contributions as chairmen, as speakers, as participants from the floor and, equally importantly, in the corridors, both now and in the future.

Kaduna, 30 October 1984

Paper 1

Livestock research in Nigeria

Keynote address

Professor Saka Nuru

Director

National Animal Production Research Institute

Ahmadu Bello University, Zaria

ABSTRACT

Livestock account for one third of Nigeria's agricultural GDP, providing income, employment, food, farm energy, manure, fuel and transport. They are also a major source of government revenue. Traditional livestock production in Nigeria is varied and complex. Livestock, especially ruminants, are the most efficient users of uncultivated land and can contribute substantially to crop production.

National livestock research started in the 1920s, with the main emphasis on disease control. The Shika Research Station was established in 1928, becoming an autonomous unit (NAPRI) in 1976. The universities have played an important role in livestock research from 1950 onwards. Ibadan, Ife and Ahmadu Bello Universities were the pioneers in this field. NAPRI's research on livestock production has concentrated on ruminant and poultry species, and on animal feed resources for profitable, commercial livestock enterprises.

NAPRI has supported ILCA's livestock systems research (LSR) since 1979. LSR can be very productive if it uses all available research results, and by the same token can provide useful feedback to specialized research bodies. ILCA's Subhumid Zone Programme has made some notable progress and NAPRI has emulated it by setting up its own LSR team to work in the northern savanna zone of Nigeria, often referred to as the Cattle Belt.

ADDRESS

First let me take this opportunity to welcome you all to this Symposium on Livestock Production in the Subhumid Zone of Nigeria, which is a follow-up of the one held in 1979, the formative year when the concept of livestock systems research (LSR) was about to be put into practice in Nigeria. In that year, ILCA and NAPRI cosponsored a symposium on Livestock Production in the Subhumid Zone of West Africa, the purpose of which was to review the state of knowledge on livestock production and potential at that time.

Before I discuss the achievements and lessons learnt from applied and systems research in Nigeria, let me re-emphasize the role of livestock in the national economy and the place of basic and applied research in the development of the livestock industry in Nigeria. As in many other countries of sub-Saharan Africa, livestock account for as much as one third of Nigeria's agricultural gross domestic product (GDP), providing income, employment, food, farm energy and manure, fuel and transport. Livestock fulfil many roles for a substantial number of people in the country. The livestock industry is a major source of government revenue, for example through taxation and export earnings from hides and skins. Yet planners and economists often underestimate the contribution of livestock to GDP. Their role as a source of farm power in the northern savanna zone and as a source of organic manure to boost crop production, as well as their efficient utilization of otherwise unuseable plants to produce meat, milk and other products, are often not considered. For example, manure outputs of 1368 kg DM/head/year and 248 kg DM/head/year have been estimated for cattle and sheep respectively (Hendy, 1977). These outputs are a major contribution to soil fertility.

The majority of households in both the savanna and the subhumid zones of Africa own some livestock, be it cattle, sheep and/or goats, in addition to poultry. These animals contribute substantially to the quality of the human diet as well as to the household economy.

Traditional livestock production is varied and complex in nature. It has evolved over centuries of adaptation under prevailing conditions of harsh climate and severe disease challenge, and now represents an excellent adaptation to uncertain environmental conditions. It promotes the most efficient possible use of non-arable land, and can also contribute substantially to crop production. Our role as livestock scientists is not to drastically change these systems, but to modify and improve them by introducing new production technology which can increase rural incomes. We must, however, remind ourselves that technical innovations alone are not enough to bring about increased production, since other constraints, socio-economic, cultural and political, are also factors of great significance. This is why a multi-disciplinary approach to both basic and applied research by NAPRI and ILCA becomes relevant. Together with ILCA, a new age of technical innovation in livestock development has dawned in Nigeria. Hopefully, the knowledge it brings can also be used in other countries within the West African region.

For carrying research findings into the field, the systems approach initiated by ILCA and supported by NAPRI scientists and the Federal Livestock Department (FLD) seems to be a most useful tool. Since the 1979 symposium, the ILCA subhumid team has been conducting LSR jointly with NAPRI scientists and technicians. I will say more about this approach to livestock research and development later.

At this juncture, I shall briefly mention past national research and development efforts in livestock production. Initial efforts in this field were launched mostly at the livestock centres or agricultural research stations under the regional Ministries of Agriculture in the early 1930s. The Veterinary Research Centre at Vom (which originated earlier in

Zaria) was established in 1924 to carry out research on animal diseases and the production of vaccines to control or eradicate them. Epidemic diseases at that time were rampant. The regional Ministry of Agriculture outstations were concerned with the breeding and selection of local and exotic cattle, sheep and goats, and with improvements in husbandry practices. However, their efforts were frustrated because of the greater importance attached to epidemic diseases, and finally - at least in the northern region - animal production was transferred to the new Ministry of Animal and Forest Resources. Such centres as Tumu and Darazo in Bauchi Province, Kofare in Adamawa Province and Ilorin in Ilorin Province were transferred from the Ministry of Agriculture to the Ministry of Animal and Forest Resources between 1961 and 1963. The Shika Research Station, established in 1928, changed hands from the Northern Regional Ministry of Agriculture to Ahmadu Bello University in 1962. Not until 1976 did it become an autonomous unit, set up by Decree No. 35 as a specialist national research institute for animal production: NAPRI, the National Animal Production Research Institute.

The role of Nigeria's universities in livestock research from the 1950s onwards was a very important one. The University of Ibadan, the University of Ife and Ahmadu Bello University were the pioneers of agricultural and livestock research in this country. Through their individual and collective efforts, these institutions began research into nutrition, breeding, management and the economics of production. Newer universities, with Departments of Animal Science or Agriculture, are following suit in pursuing basic and applied research in livestock production. The various Faculties of Veterinary Medicine have contributed in no small measure to our knowledge of epidemiology, the biology of various parasites, and the means of controlling or eradicating debilitating or devastating livestock diseases. Areas of their research include trypanosomiasis, tick-borne diseases, helminth parasites, and a number of bacterial and viral diseases.

Other national institutes also contributed, in areas covered by their mandates. The National Root Crop Research Institute did useful work on cassava utilization for poultry nutrition. The Nigerian Institute for

Oceanography and Marine Research (NIOMAR) worked on otherwise unuseable fish parts to make fish meal. The Lake Chad and Kainji Lake Research Institutes have also done work relevant to livestock production.

NAPRI's research has concentrated on ruminant and poultry species, with special emphasis on nutrition and improved husbandry. Nutrition was and still is one of the biggest constraints to livestock production in these species. The choice of ruminants and poultry was not accidental. Nigeria has about 40 million hectares of available grazing land yet to be fully exploited. Cattle, sheep and goats provide over 70% of the national meat supply and all the locally produced milk in Nigeria, while the poultry sector, still small at that time, provided opportunities for rapid growth.

I cannot resist highlighting some of NAPRI's major achievements at this point. In the area of beef production, NAPRI scientists have shown that some of our indigenous cattle can gain an average of 0.9 to 1.2 kg per day on silage and concentrate rations. The potential of this finding can be assessed when it is realized that at present over 1 million head of cattle are slaughtered annually in Nigeria, but that 75% of them are fit for further fattening and could yield an extra 25 000 to 45 000 tonnes of meat per year if this technology were employed (Nuru, 1978; 1983).

NAPRI's research on dairy cattle has shown that a linear increase in milk yield from crossbred cows takes place as the exotic gene is increased up to the 7/8 level. The F_1 Friesian x Bunaji cow (50%) gives 1684 kg, the 3/4 (75%) gives 1850 kg and the 7/8 gives 2051 kg of milk in a lactation of about 260 days. However, the economic return does not justify increasing the exotic gene pool beyond 50% (Nuru and Buvanendran, 1984).

In the area of poultry production, work concentrated on achieving optimum energy and protein levels in the rations of laying chickens, and on broiler production. The protein and energy sources are quantitatively the most important and expensive aspect of economic ration formulation (Olamu, personal communication). Import substitution for fish meal, an expensive imported feed ingredient, has received special attention over the last few

years. Investigations into local fish sources and the use of blood meal have been conducted by NICMAR and NAPRI respectively. Today, many local feed ingredients and agricultural byproducts have been analysed with a view to compounding least-cost rations for poultry, depending on whatever feed ingredients are plentiful and cheap on the market throughout the year.

Finally, as regards animal feed resources, NAPRI led the way in screening and evaluating suitable grasses for native pasture improvement.

We can now ask ourselves what the role of ILCA/NAPRI is in LSR, and why efforts are increasingly channelled through this new approach to ruminant production? A major criticism of traditional research, basic or applied, is the problem of transfer of research results to users within a reasonable time and in a language they can understand, for adoption on a large scale.

The agricultural extension services at the Federal and State level are inadequate, and often too thin on the ground for effective communication of research findings to users. Scientists need to receive feedback on field problems that require further research. In addition, there are the socio-cultural and socio-economic constraints of the livestock owners themselves. Aware of these problems, NAPRI has worked very closely with the Agricultural Extension and Research Liaison Service (AERLS) of Ahmadu Bello University over the years to ensure the maximum impact of research on the livestock industry, including poultry production. In addition, within the last 2 years, NAPRI has been actively engaged in field work on artificial insemination (AI) and in pasture establishment programmes for prominent livestock owners in various states. This work was undertaken to bring about a positive effect on livestock production through field demonstration.

But LSR is more than this. LSR is by its nature 'integrative and team-orientated'. In reality it is 'a systems approach to livestock development'. Many disciplines are involved since, to be effective, a detailed knowledge of all aspects of a production system is required, including the perceptions of potential beneficiaries. LSR is field-

oriented and involves the active participation of beneficiaries. In its diagnostic phase, baseline data on production systems, together with information about the socio-cultural and socio-economic status of producers, are obtained and production constraints identified. Suitable interventions to resolve the constraints are then devised and tried out in the field, with the active participation of farmers and pastoralists. Success is judged in terms of the adoption rate after the researchers have withdrawn from the scene but closely watched how producers implement their recommendations without supervision.

LSR is only one approach to the development of the livestock industry, yet it professes to be 'cost-effective', and if it is done well I believe it can be very productive. However, to be cost-effective and productive it must take maximum advantage of all existing knowledge and not wastefully repeat research already carried out elsewhere. Nor must it attempt to do research that can be done more effectively by more specialized bodies or at national research centres.

By the same token, the work of more specialized bodies can be made much more relevant to the real needs of the livestock industry if these bodies receive feedback from the LSR teams, which should have much better contact at grass roots.

From 1979 onwards, NAPRI and ILCA have worked very closely in the subhumid zone of Kaduna State at two locations - Kurmin Biri and Abet. During the workshop the results of this work will be presented for critical review by the participants. Kurmin Biri is a large grazing reserve of about 2500 km², while Abet is a typical arable cropping area of about 2475 km², with Kaje and Kamantan farmers being the dominant inhabitants. By working directly with the pastoralist on a daily basis, the confidence of the Fulani in these areas has been won.

Prominent among the technical achievements are the appreciation and utilization of supplementary feed in the form of molasses and cottonseed cake by the pastoralists during the dry season, the development of forage

crops within the cropping system and, more importantly, the establishment of fodder banks for pastoralists, some of whom are embarking on this new technique by themselves with very little, if any, supervision. On the health side, a great deal has been achieved on the maintenance of a systematic disease monitoring, prevention and control schedule on the farms under study, while a few crossbred cows have been introduced as a test case to monitor their survival and productivity under prevailing disease conditions in the traditional pastoral system. You will hear more about these achievements during this week, the details of which are contained in the papers to be presented in the next few days.

In order to ensure that IILCA's LSR work will be relevant, and its results acceptable to livestock producers, the Federal Livestock Department requested the formation of a Technical Advisory Committee (TAC) consisting of sociologists, livestock extension experts, ruminant nutritionists, veterinary and range management experts under the chairmanship of myself, the Director of NAPRI. The task of the committee is to monitor events in the field and report on progress to the Director of the Federal Department.

Encouraged by the achievements of LSR to date, NAPRI is now about to embark on a similar LSR field programme in the savannah zone at Giwa, about 20 km from NAPRI headquarters. The team will be led by the Head of the Department of Pasture Agronomy, who will brief you on activities so far during this workshop (Paper 20).

NAPRI's objectives in LSR are:

1. To establish national expertise in this area, which is now gaining momentum in many countries.
2. To create awareness among pastoralists of what technical improvements are feasible, and what constitutes profitable management of cattle.

3. To create practical models for other livestock pastoralists and entrepreneurs outside the Giwa project area to emulate.

We firmly believe LSR to be a revolutionary approach to livestock development through applied field research. Working hand in hand with the livestock owners, we hope to implement this new approach under the Second Livestock Development Project of the Federal Ministry of Agriculture.

It is our prayer that the participants at this symposium will freely contribute their advice and suggestions on the papers presented, thereby sharing with others their own research and/or development experience. In 1979 we received very useful comments and criticisms which were reflected in the final report on the proposed ILCA research; we now look forward to similar critical review and comments on the achievements so far, and guidance on future research, both for ILCA and NAFRI. Let us remember the need for concerted team work in LSR, so that we avoid the dangers of isolation and limited perspectives. It is commendable that the ILCA team has seen these dangers and has sought to avoid them by exposing its work to detailed examination by this audience of eminent scientists from various disciplines, livestock policy makers and national institute directors. You are our mirror: we cannot see ourselves, but we strongly believe you are the best judge of our efforts to improve and increase productivity throughout the subhumid zone of Nigeria.

I wish you memorable and fruitful deliberations.

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Paper 2

An introduction to the subhumid zone of West Africa and the ILCA Subhumid Zone Programme

R. von Kaufmann
Team Leader
ILCA Subhumid Zone Programme

ABSTRACT

Of all the ecological zones of Africa the subhumid zone has the greatest potential for increased livestock production. It has therefore been a major focus of attention for the International Livestock Centre for Africa (ILCA). The zone has the capacity to support increased livestock numbers as well as higher productivity per animal. This potential is particularly apparent in Nigeria, where the relatively underutilized subhumid zone occupies about 50% of the country (455 000 km²). The zone's high arable potential will be exploited primarily for food crop production. Researchers have traditionally considered cropping to be incompatible with livestock production. This is not true in practice, and future research must take the links between the two into account, particularly since pastoralists themselves are tending towards more settled agropastoralism.

There is considerable scope for increased cattle productivity through improved animal nutrition. Suitable interventions for small ruminants are more difficult to identify.

The objective of ILCA's research is to produce 'farmer-ready' techniques to pass on to national livestock development and extension agencies.

The research is conducted within a livestock systems research approach with diagnostic, design, testing and application/extension phases.

INTRODUCTION

In March 1979 the National Animal Production Research Institute (NAPRI) of Nigeria and the International Livestock Centre for Africa (ILCA) cosponsored a symposium on Livestock Production in the Subhumid Zone of West Africa. The symposium provided both a summary of the state of knowledge and guidance on the direction of future research to be undertaken by the ILCA Subhumid Zone Programme. It is now appropriate that the information gathered since 1979 be presented so that the state of knowledge and direction of further research can be re-assessed.

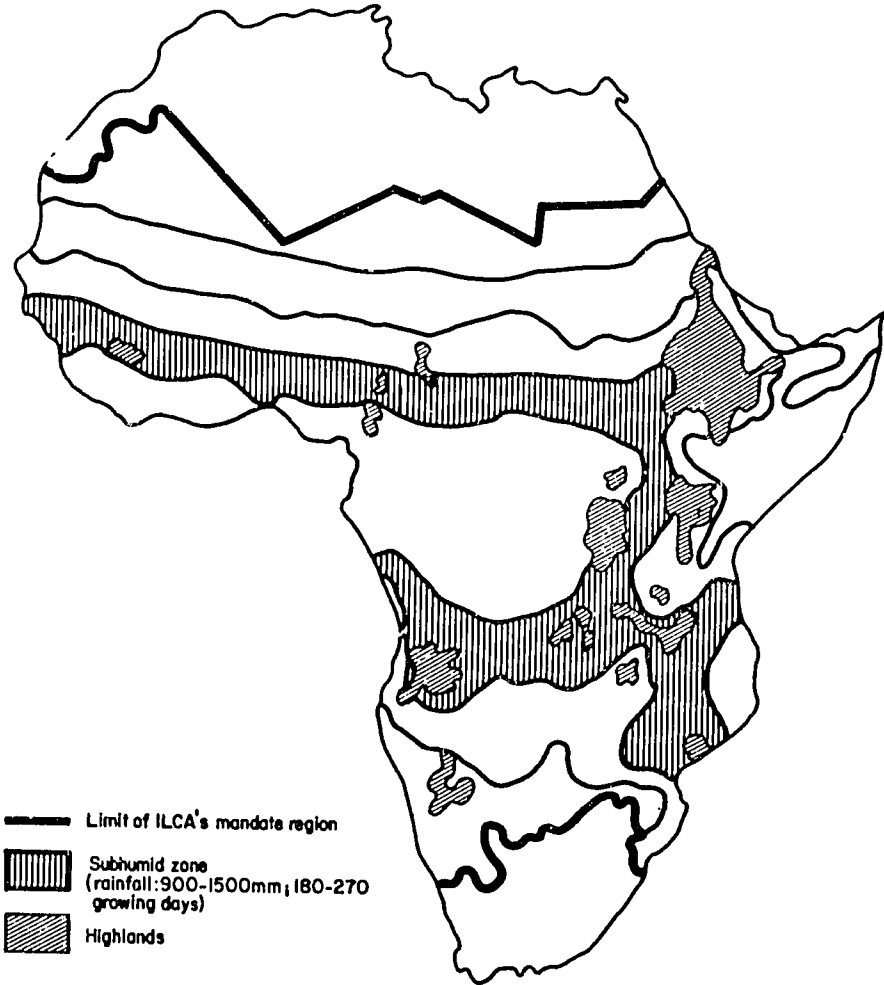
This paper provides an overview of the zone, and a background to the more detailed papers that follow. It is in two parts: an introduction to the subhumid zone and an introduction to the ILCA Subhumid Zone Research Programme. It indicates why ILCA is concerned with research in the zone as a whole and in Nigeria in particular. It also explains the research and development policies and institutions involved in the country's livestock sector.

GENERAL CHARACTERISTICS OF THE SUBHUMID ZONE

The subhumid zone occupies some 5 million km² or 23% of Africa (Figure 1), with a rainfall of between 900 and 1500 mm per annum and a crop-growing period of between 180 and 270 days. It is inhabited by 25% of the people and supports 22% of the cattle, 13% of the sheep and 16% of the goats of Africa. In contrast, the semi-arid zone, with only 18% of the land area, supports 28% of the people and 30% of the cattle (Table 1). The heavy concentrations of people and stock on both its northern and southern borders suggest that the low populations in the subhumid zone cannot be accidental. As the constraints to occupation are lifted (Paper 5) and/or

outside pressures mount further, there is accelerating immigration into the zone. In a continent short of food, it is somewhat anomalous that the agricultural research community has done so little to improve livestock production in the subhumid zone.

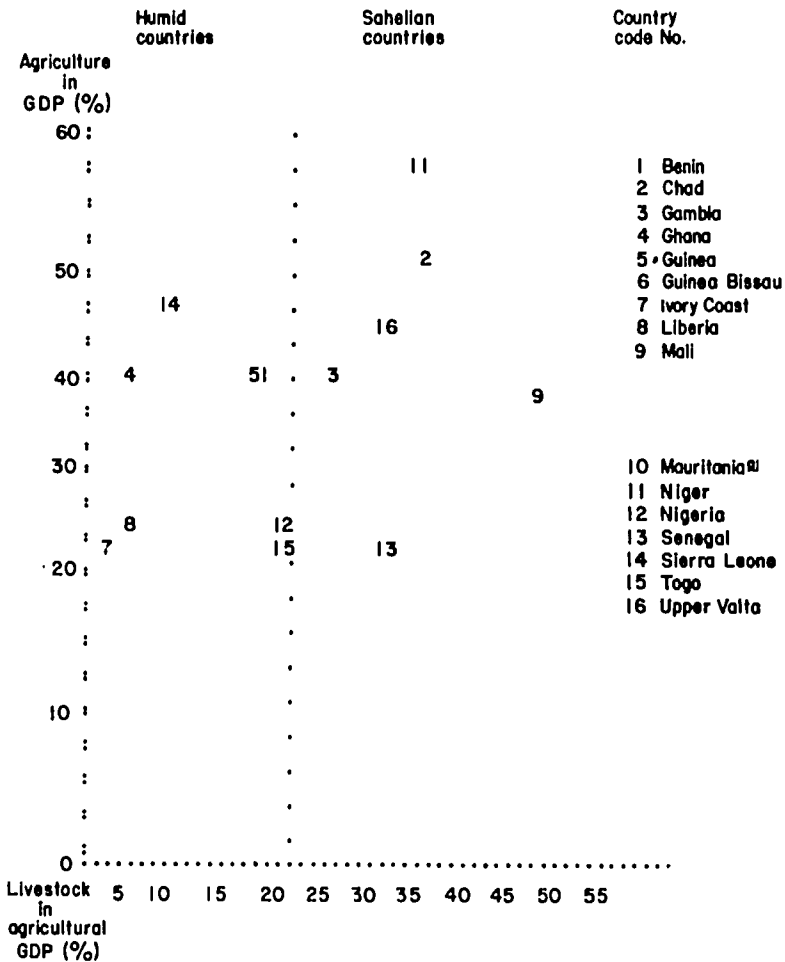
Figure 1. The ecological zones of sub-Saharan Africa.



Although the livestock subsector contributes a significant US\$ 2 billion to the gross domestic product of West African countries, the region's 35 million ruminant livestock units cannot satisfy the needs of its 144 million people (Jahnke, 1982). By extrapolation from ILCA's herd productivity data the regional output is estimated to be 42 kg of milk and 15 kg of beef per head of livestock per annum. That is equivalent to about 0.2 g of protein/caput/day. On the same basis, the estimated 9.3 million cattle in Nigeria produce about 28 million kg of protein. Assuming a national population of 90 million people (Federal Ministry of Agriculture, 1981), that would allow 0.9 g of protein/caput/day, or in other words one tenth of the 8 g/caput/day required from livestock in a target of 34 g/caput/day from all food sources (Federal Ministry of Agriculture, 1981).

Livestock production in the region tends to be limited north of the subhumid zone by aridity and south of the zone by tsetse-borne trypanosomiasis. About half the land area of West Africa is arid, and the other half tsetse-infested (Jahnke, 1982). This statement is something of an oversimplification, since quite extensive areas have been cleared of tsetse infestation. Some countries are more fortunate than others in their non-agricultural resources (such as oil in the case of Nigeria, for example) and in their stage of development. This is reflected in a reduced share of GDP produced by agriculture (Figure 2). It is noticeable, however, that all the Sahelian countries - Senegal, Gambia, Mauritania, Mali, Burkina Faso, Niger and Chad - feature on the right of Figure 2. Livestock are less important in other, more humid coastal states.

Figure 2. Proportion of agriculture in GDP and proportion of livestock in agricultural GDP in West African countries.



Source: Jahnke (1982).

[¶]Mauritania is off the scale at 35% agriculture, of which 85% is from livestock.

Table 1. Human and animal populations of ecological zones of sub-Saharan Africa.

Zone	Land area (million km ²)	Humans	Cattle	Sheep	Goats
		(millions)			
Arid	8	25	32	37	48
Semi-arid	4	66	45	25	33
Subhumid	5	60	33	14	20
Humid	4	50	9	8	12
Highlands	1	38	29	24	12
Total	22	239	148	108	125

The countries of West Africa can be classified as primarily either producers or consumers of ruminant, particularly cattle, products. The drier countries have large cattle populations relative to their human populations; these include Mauritania, Mali, Burkina Faso, Niger and Chad. The converse situation of large human populations and relatively limited numbers of cattle exists in the humid coastal countries such as Ivory Coast, Ghana, Togo and Benin. An examination of the cattle statistics for the various states within Nigeria by Milligan et al (1978) found that Nigeria's situation was in line with the regional trend, showing greater numbers in the drier states.

These varying numbers of livestock must inevitably lead to different approaches to development. The coastal states might, for instance, be expected to opt for 'modern' commercial production with an emphasis on intensive finishing operations such as the Ferkessedougou and other feedlots in Ivory Coast (Delgado and Staatz, 1980). The traditional cattle-producing countries will, on the other hand, be more interested in raising the productivity of traditional pastoralism. Most countries will,

however, have some desire to stratify production according to the peculiar merits of each ecological and economic zone (Ariza-Nino et al, 1980).

Nigeria is a good regional case study because in many ways it is demonstrating the paths other countries in the zone are likely to follow (FAO, 1984). Though it has a large national herd of some 9.3 million head, the demand for milk and beef still greatly exceeds supply. About 60% of cattle movements across national boundaries in West Africa involve cattle destined for Nigerian markets. Nigeria has also tried most of the familiar development strategies, such as grazing reserves, ranches, dairy farms and feedlots.

Most significantly, however, the pastoralists and the government are becoming increasingly interested in the possibility of increased production through the occupation and development of the country's subhumid zone. By 1976 tsetse eradication programmes had covered over 210 000 km² of Nigeria, thus effectively doubling the area of land free of tsetse fly. These programmes, involving various means of spraying and biological control, are increasingly moving into the subhumid zone (Federal Ministry of Agriculture, 1981). This movement is consistent with the government's policy for relocating in the subhumid zone a major portion of the national herd from the overstocked arid zones (David-West, 1980).

Meanwhile the pastoralists themselves have been gradually changing their traditional ways. Instead of using the subhumid zone only in the dry season and moving out as tsetse populations spread north during the wet season, they are increasingly using the zone as their permanent home. Van Raay (1974) estimated that about half the Fulani in Nigeria are at least semi-settled, and the trend towards settlement is continuing. The density of cattle in four typical areas of the Nigerian subhumid zone indicates extensive permanent settlement there (Table 2).

Table 2. Cattle densities in four case study areas in the Nigerian subhumid zone.

	Area (km ²)	Density (head/km ²)	
		Dry season	Wet season
Kurmin Biri	2500	17.3	4.2
Abet	2475	37.4	22.7
Mariga	2750	6.6	23.5
Lafia	3500	12.7	37.7

Source: Milligan (1983).

The latest estimate of 4.5 million cattle in the zone (Bourn and Milligan, 1983) is very much higher than the previously accepted figure of 2.28 million (Jahnke, 1982). This new figure suggests that there has been a significant increase in cattle numbers in the zone in Nigeria, and it is most likely that the trend is the same throughout the whole zone in West Africa (Oxby, 1982). Whilst the international community has been focussing its attention on the plight of the Sahelian countries, a major restructuring of the regional livestock industry is occurring largely unappreciated, unaided and very much under-researched. The growing demand for livestock products and the restrictions imposed by tsetse and aridity in other areas emphasize the importance of livestock research for development in the subhumid zone.

The pastoral communities have not been moving in alone. Arable farming communities have been spreading in from the north and south, as well as expanding within the zone (Bourn and Milligan, 1983).

Oxby (1982) and others have pointed out that the settlements of arable farmers and pastoralists are physically, economically and socially related. This close proximity of farming and pastoral communities implies some degree of integration between crop and livestock production. Van Raay (1974) cited deferred grazing of the pastoralists' own crop residues and the corralling of cattle on their fields as instances of deliberate integration of the two production systems. He also analysed the relative

advantages of settlement, and concluded that settled pastoralists with good access to crop residues had better chances of meeting their herds' nutritional requirements than did nomadic pastoralists.

Cereal farming communities normally appreciate cattle food products and the manure and draught benefits obtainable from cattle. The pastoralists appreciate the benefits of crop residue grazing, and subsistence cropping is increasingly important to their well-being. They thus have the same ecological and market needs as the arable farmers and will tend to congregate within or on the periphery of farming communities (Okali and Milligan, 1981).

With rapidly growing human populations and critical shortages of foreign exchange, domestic food crop production is the highest national priority. The logical outcome of this priority is that all potentially arable land will eventually be utilized for crop production. As a result of this argument there is a tendency in some quarters to lower the priority or even deny the need for livestock development. That is a false and retrogressive conclusion on two counts (von Kaufmann, 1983a). Firstly, ruminants can convert feedstuffs that human beings cannot eat into high-value human food. They can not only utilize the vegetation from non-arable and fallow land but also the dry matter (DM) produced by crops but not harvestable as grains or other human food. Bywater and Baldwin (1980) demonstrated that, even if some grain is required to top up cattle rations, human food to human food conversion efficiencies of over 100% are obtained. Secondly, cattle densities in the subhumid zone have been found to increase with increasing cultivation until 50% or more of the land is cultivated (Figure 3) (Bourn and Milligan, 1983). Since at the present time cultivation rarely averages more than 25% of the available land, there is room for considerable expansion of cattle numbers in the subhumid zone (Figure 4).

Figure 3. Variation in cattle density, herd density and herd size with land-use intensity in the Nigerian subhumid zone

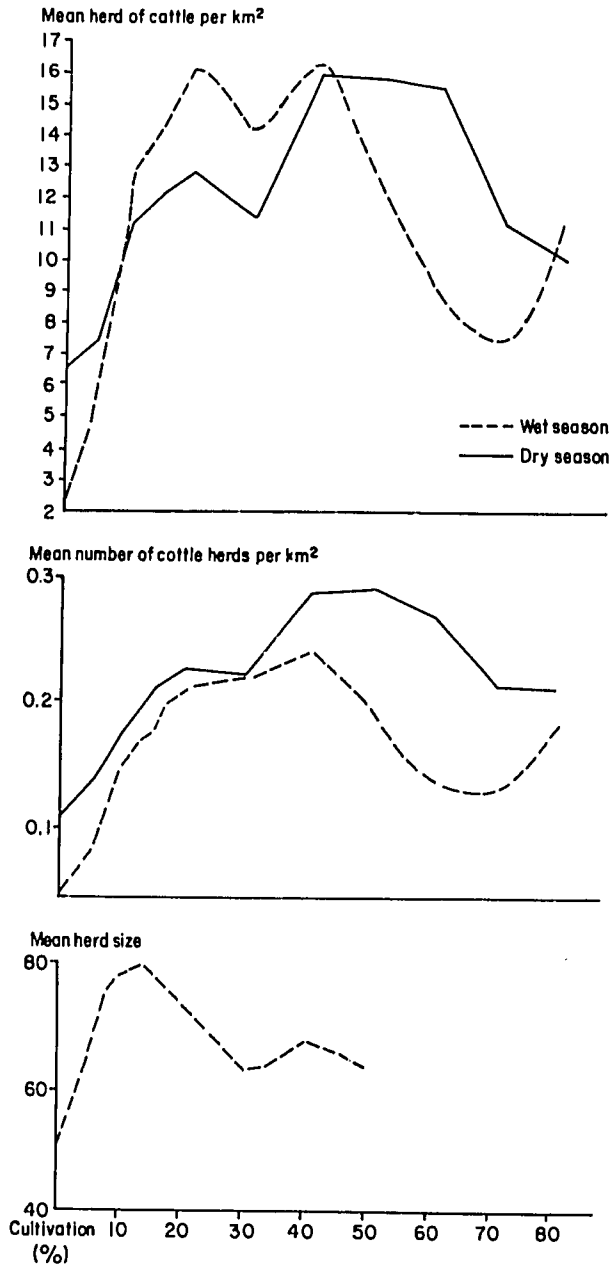


Figure 4 . Geographical components of land-use intensity gradients in the Nigerian subhumid zone .

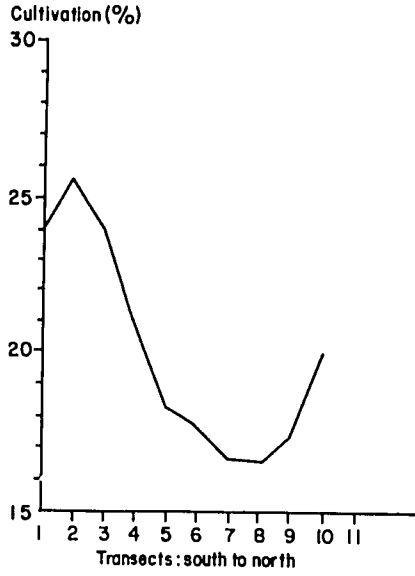


Table 3 shows the extent of various intensities of land cultivation in the subhumid zone and the cattle populations they are supporting. The table also shows projections of the number of cattle the zone could support if any particular intensity of cultivation becomes typical for the whole zone in the future. These projections peak at an overall average of 50% of the land under cultivation, but even at 70%, which may be the highest attainable level, the zone could still support the present cattle population (Bourn and Milligan, 1983). These figures are based on current land management practices.

Table 3. Present and projected cattle numbers at varying levels of land cultivation, Nigerian subhumid zone.

Land cultivated (%)	Land area ('000 km ²)	Present cattle Nos. ('000)	Projected cattle Nos. ('000)			
			(%)	Dry season	Wet season	Dry season
0 - 9	136	38	955	546	2258	1426
10 - 19	76	21	857	955	3993	4456
20 - 29	38	11	478	611	4456	5704
30 - 39	26	7	290	360	4028	4991
40 - 49	26	7	406	411	5633	5704
50 - 59	20	6	311	238	5597	4278
60 - 69	17	5	265	154	5526	3209
70 - 79	17	5	180	158	3743	3298
Totals	356 ^{a/}	100	3742	3433	-	-

^{a/} Total land area surveyed.

Source: Bourn and Milligan (1983).

Table 4 gives a comparison of the changes in quantity and value of production that might be expected from increased numbers and/or productivity. The table suggests that even on the basis of small improvements in parameters such as fertility (raised to only 55%), production could be raised by 20%, which is equivalent to adding 680 000 head to the existing 3.5 million head of cattle in the areas surveyed by ILCA.

The orders of magnitude of potential returns suggest that there is scope for investment in research for increased productivity. At the same time the low output suggests that past research and development efforts have as yet had little impact at the producer level.

Table 4. Production matrix for different assumptions of cattle productivity in the subhumid zone of Nigeria.

No. of cattle	Protein (kg) ^{a/}			Value(₦) ^{a/}		
	Present	Projected	Increase	Present	Projected	Increase
	3.5 ^{b/}	4.18	0.68	3.5	4.18	0.68
Present productivity	10.69	12.77	2.08	385.4	456.72	74.32
Improved productivity	12.80	15.29	2.49	456.09	544.70	88.61
Quantitative increase	2.11	2.52		73.69	88.08	
Percentage increase	20	20		20	20	

^{a/} All amounts in millions. One Naira = US\$ 1.12.

^{b/} 3.5 million cattle in surveyed area; 4.5 million cattle projected for whole zone = (1.3 x 3.5).

There are many interacting factors persuading pastoralists to settle and take up crop farming along with their traditional livestock husbandry (FAO, 1984). Whatever their reason for doing so, it would appear that the rate of settlement is increasing, yet the research results on which to base development programmes are wholly inadequate (von Kaufmann, 1983b).

Though settled pastoralists may be disdainful of the nomadic Fulani, their way of life and animal husbandry practices are still much the same. Tradition is still a very strong force amongst settled Fulani and will certainly affect matters such as grazing management, and the quantity of labour and supervision they devote to livestock production. It will also influence their perceptions of the usefulness of any new intervention.

There is ample evidence (ILCA, 1979) that pastoral cattle breeds are capable of very much higher performance levels, if their nutrition is improved. Given the seasonally poor quality of the natural rangeland grasses (ILCA, 1979), cattle cannot be expected to perform at high levels of productivity without supplementation. Johnson et al (1977) determined that of all the possible changes improved nutrition would be the most effective in raising performance. Whether it be for beef or milk production, in a situation of scarce high-quality feeds the best returns are likely to come from feeding the breeding females (von Kaufmann and Otchere, 1982). Given the shortages of agro-industrial byproducts and other feeds, improved crop residue utilization and forage production on fallow lands (Tiver, 1979) will be essential to increased livestock production. Both of these imply integrated crop/livestock farming systems.

Pastoralists now settling in the subhumid zone can usually find land because traditionally most communities in West Africa acknowledge the right of all men to land for subsistence cropping. Finding land will, however, become increasingly difficult as the zone's population increases in the future. In these circumstances livestock production will grow only to the extent that farmers adopt mixed crop - livestock production and/or pastoralists integrate their own production system with the arable farming system. Before 1979 there was little understanding of how the existing systems were integrated, and even less idea of how this integration might be improved. The reactions of pastoralists to interventions must be fed back into research design. The settled pastoralists are part of the market economy and are subject to other outside influences, but the effect of government extension efforts to date has not been very great (except for veterinary services). Inevitably the success of any intervention will be as much determined by its appropriateness to development policies and extension capabilities, as by its inherent technical merit. Research programmes must, therefore, take full cognizance of the extension factor.

OBJECTIVES OF THE ILCA SUBHUMID ZONE PROGRAMME

Since techniques for controlling the major pandemic diseases had already been developed, the 1979 state of knowledge review (ILCA, 1979) indicated that improving cattle nutrition should be given the highest priority in ILCA's Subhumid Zone Programme. It was clear from the outset that purchasing feed was not a viable long-term solution. There was not enough for current demand and its price would rise faster than the prices of animal products (Paper 21). Natural range grasses were of poor quality and the range was communally owned, often by non-cattle owning cultivators. Livestock owners must therefore learn to grow forage for themselves, but encouraging them to do so would depend on the availability of appropriate forage production techniques. There were no suitable forage production interventions available to the livestock extension services concerned with the subhumid zone in 1979. The overall objective of ILCA's Subhumid Zone Programme has therefore been to produce 'farmer-ready' forage production techniques to pass on to national livestock development and extension agencies.

Approach to research

To achieve the above objective it is necessary:

1. To develop and test interventions that will enable ruminant livestock owners to produce (or obtain) and utilize efficiently more and better quality forage.
2. To ensure that forage research is backed by sufficient understanding of the environment in which interventions will be adopted. This, inter alia, requires an understanding of livestock productivity, animal health, the socio-economic circumstances of the intended beneficiaries and their perceptions of the interventions.

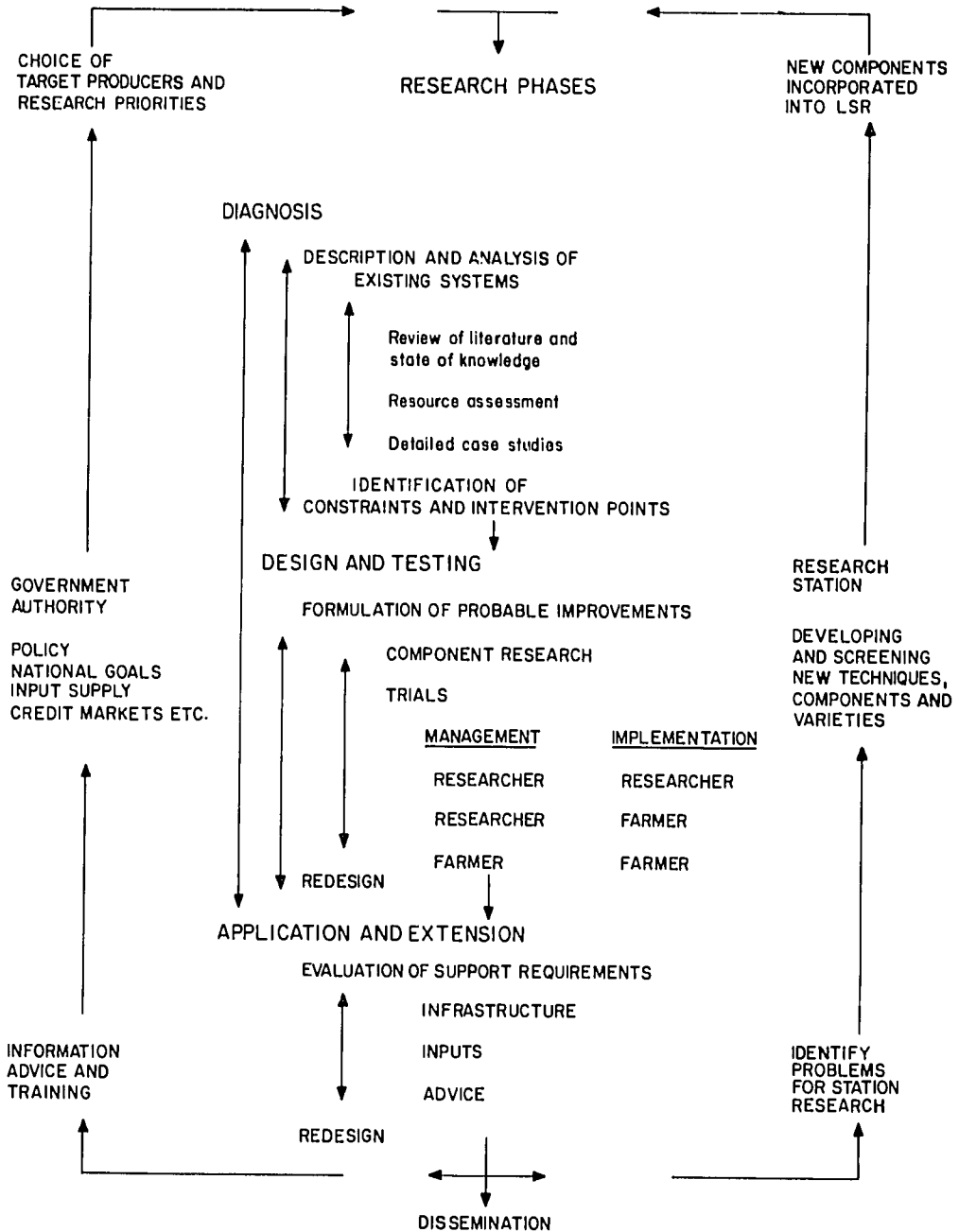
3. To maintain an agronomic research programme to resolve technical problems identified through intervention testing, and develop back-up and/or alternative techniques.
4. To transfer the LSR research approach to national research institutions so as to maximize the impact of ILCA's work over the long term.

The programme's work is carried out using a livestock systems research approach. The agronomic research is conducted along accepted on-station lines. The methods will be explained in more detail later in the symposium (Papers 14 and 15).

Livestock systems research

From the outset, the ILCA Subhumid Zone Programme has followed a livestock systems research (LSR) approach (Figure 5), developed from established farming systems research (FSR) techniques, but modified to suit the nature of livestock production and the particular research environment (von Kaufmann, 1983c). Dillon's (1973) summary of FSR applies well: "that man, not cations, or nodules, or rumen flora, or crop varieties, or livestock species, or dollars, consummates the system, must be a basic text." Dillon continues by stressing the need "to take a teleological view that effects may be due to the purposes they serve and only a holistic approach, with openness and teamness through interdisciplinary endeavour, can lead to the capturing of adequate understanding of a system for the purpose of improving performance."

Figure 5.1 LCA Subhumid Zone Programme:
Livestock systems research (LSR).



The settled agropastoralist is the primary user of the technology developed by the Subhumid Zone Programme, but given the close linkages between Fulani and arable farmer, both communities became part of the research effort. Lately, mixed crop - livestock farmers, who may be able to adopt some techniques more readily, have been included in the programme.

ISR as practised by the Subhumid Zone Programme involves concurrent phases of diagnosis, design, testing and application. Each phase interacts with the others in the continuing process of knowledge generation, intervention design, testing and re-assessment. Data are collected in increasing order of detail: i.e., zone as a whole; zone of Nigeria; case study areas in Nigeria; pastoral and arable households, herds, flocks, fields; and experimental herds and fields. Whenever possible, a single data pool is used to economize resources and to strengthen interdisciplinary research.

Diagnostic phase

The diagnostic phase involves the description and analysis of the existing system. This includes animal production and health monitoring, household socio-economic surveys, crop - livestock interaction studies, ecology and grazing resource evaluation, and studies of decision-making and resource allocation within households. These activities are sometimes continuous, as with livestock production monitoring, and sometimes of limited duration, when time series data are not required. Diagnostic studies have been undertaken to provide information on the socio-economic and technical constraints in the system, to establish baseline data against which any innovation can be tested, and to provide data on specific aspects of the system which are expected to be affected by intensified livestock production.

After a ground survey and selection of case study areas, there was a need for global information about these areas. Systematic low-level aerial surveys were used to obtain a resource inventory. The surveys provided baseline information about the ecology, agriculture and inhabitants. Aerial survey techniques (Norton-Griffiths, 1978), further developed in

Nigeria by the late Dr. Kevin Milligan and his colleagues (Milligan and de Leeuw, 1983), are now capable of yielding far more information, especially in regard to mixed farming, than was considered possible in 1979.

Design phase

The design phase involves the formulation of probable improvements based on identified constraints. Through close association with NAPRI, which has conducted livestock research in Nigeria for over 30 years, the Subhumid Zone Programme can capitalise on existing information and results in the design of innovations. Component research has included work on forage improvements through agronomic plot trials, on indigenous livestock production potential using the ILCA-controlled cattle herd and sheep flock, and on improved livestock production using ILCA-owned crossbred cattle maintained by pastoralists. This experimentation supports the formulation of improvement packages and the testing of potentially high-risk interventions.

Testing phase

The testing phase in the LSR sequence is linked with design and redesign. On-station and on-farm trials have been conducted on rationing of agro-industrial byproducts, undersowing and intersowing and inter-row sowing of legumes, establishing fodder banks, treating helminthiasis in calves, and increasing grain crop and dry matter yields in association with forage legumes. As far as possible, the Subhumid Zone Programme follows the FSR cycle, which includes:

1. Researcher-managed/researcher-implemented trials
2. Researcher-managed/farmer-implemented trials
3. Farmer-managed/farmer-implemented trials.

The final stage of farmer-managed/farmer-implemented trials has been achieved with dry-season supplementation using agro-industrial byproducts and fodder banks, and with various crop agronomy improvements. An important aspect during the farmer-managed/farmer-implemented trials has been the evaluation of pastoralists' and farmers' reactions to the innovations, which are fed back into the research design as part of the effort to produce interventions that have a high potential for adoption.

Application and extension phase

The application and extension phase of LSR is perhaps the most critical, since it is at this point that the interventions move beyond the relatively small number of cooperating producers that ILCA can afford to work with. The Subhumid Zone Programme enjoys a close working relationship with the Federal Livestock Department (FLD) and the National Livestock Project Unit (NLFU), as well as with the Kaduna State Ministry of Animal and Forest Resources. These links with development and extension agencies have provided ideal circumstances for involving extension personnel in the research process and in the implementation of improvement packages. One concern is that innovations may be taken up by extension for dissemination before they have been fully tested. On the other hand, without the involvement of development and extension agencies it would not be possible to achieve enough replicates for analysis or to incorporate the objectives and requirements of extension. A delicate balance has to be found, which is only possible with good understanding and cooperation between development and research agencies.

The NLFU is currently extending two of ILCA's innovations: the rationing of agro-industrial byproducts to cows, and, on a limited scale, fodder banks, which are small pastures of improved legumes. ILCA is closely monitoring the rate of adoption of these two improvement packages as well as their implementation, since an important assessment of an innovation's appropriateness is whether, and to what degree, it can be extended by national agencies.

Justification and expected benefits

Sandford (1983) has stressed the efficiency of many traditional systems and the lack of demonstrable improvements under modernized or commercialized management. Although the production parameters determined for the settled Fulani herds monitored by the ILCA Subhumid Zone Programme are below the breed's proven potential, difficulties can be expected in achieving significant improvements in productivity.

The Subhumid Zone Programme is not, however, seeking to change whole systems. The interventions on which the programme is working are designed to meet a felt need of livestock owners and to be implemented with minimal changes. The programme is seeking to make changes with marginal costs relative to the total capital invested in livestock but which, if successful, will yield significant increases in productivity. The programme is also constantly revising its recommendations on the basis of controlled experimentation on components identified as problems through observation and feedback from producers and extension workers. The ultimate packages will thus have been jointly developed and tested by the scientists, extension staff and producers.

The programme's expected benefits are:

Producer level:

1. Improved cow productivity: milk yield, calving rate, calf survival, etc.
2. Better maintenance of soil capability for higher crop yields.
3. Improved feed resources and management to support more productive cattle, e.g. exotic crosses.

National level:

1. Increased producer awareness and extension contact.
2. Better information for development planning and execution.
3. Improved extension officer orientation and motivation.
4. More relevant research by national institutions.

Because grazing animals represent two-stage production systems with delayed responses on account of long generation intervals, the financial implications of changes in input - output relationships can best be tested by simple simulation models. Annual budgets are normally not adequate, because they usually only reflect 'before' and 'after' situations, and do not account for variations in cash flows. Moreover, they cannot always be readily applied to assess the sensitivity of various cost - benefit criteria to changes in technical relationships.

The models need not and, indeed, should not be complex. The objective of ISR is to serve the livestock producers; and the producers, particularly if they are poor, are averse to risk. They will only be interested in interventions that offer major contributions to the achievement of their goals. ISR is also intended to be cost-effective, and this cannot be achieved by the relentless pursuit of minutiae.

Some models will be discussed in a later paper (Paper 21) following explanations of production systems and the technical features of the interventions. At this stage, it is important to be aware of the need to synchronize all steps from data collection through technical interpretation to economic analysis. That is, interventions must promise to be technically feasible, socially acceptable, financially viable and economically defensible. All these criteria must be periodically checked so that unpromising lines of research can be dropped and more fruitful areas pursued more vigorously. It is not adequate merely to provide 'before' and 'after' evaluations.

More details on the implementation of an LSR programme are given in von Kaufmann (1983c). The implementation of such a programme in the subhumid zone of Nigeria was, and remains, dependent on the conviction that the zone offers opportunities for finding technically feasible interventions that will promote producer welfare. The evidence at the moment is that the subhumid zone does offer the potential, but it will only be successfully tapped by a holistic, multidisciplinary and sustained research effort.

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Population and land use in the subhumid zone of Nigeria

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ABSTRACT

The subhumid zone of Nigeria is sparsely populated relative to the humid coast and the semi-arid north. Immigration into the zone from these areas as a result of population growth and expansion of cultivation is changing the physical environment of the zone, in particular reducing the habitat for tsetse flies.

The indigenous population of the zone consists of numerous fragmented ethnic groups who lived in nucleated and often fortified settlements. Pacification permitted greater freedom of movement, resulting in a dispersed settlement pattern.

As a consequence of the jihad in the nineteenth century and the expansion of cultivation in the north in the present century, cattle-keeping Fulani have penetrated the subhumid zone and now comprise roughly 5% of the rural population there. Herds from the north traditionally grazed in the Middle Belt during the dry season, when relatively abundant forage and water were available and the tsetse fly was more restricted than during the rains. The major southward shift of cattle into the zone for year-round grazing has taken place since about the 1950s.

Cattle keepers in the subhumid zone can be classified according to enterprise system and degree of mobility as follows:

1. Pure pastoralists: full-time cattle keepers ranging from those with no consistent association with a particular area (nomads) to those based at one site.
2. Agropastoralists: cattle keepers who practise some cropping, but such that it is subsidiary to cattle husbandry.
3. Cattle-keeping farmers: crop farmers who keep some cattle, but such that cattle husbandry is subsidiary to cropping.

The majority of Fulani in Nigeria today belong to the second group, often living in the midst of indigenous farming communities.

The ILCA Subhumid Zone Programme is conducting livestock systems research in three case study areas. Kurmin Biri is a site of government-assisted settlement of pastoralists on a grazing reserve with low cultivation and cattle densities. Abet is an area of spontaneous settlement of Fulani pastoralists in the midst of crop farmers, with cultivation and cattle densities slightly above average for the subhumid zone as a whole. Ganawuri is an area of high cultivation density where the indigenous farmers have diversified into cattle husbandry.

INTRODUCTION

The subhumid zone of Nigeria, as of West Africa as a whole, is sparsely populated in comparison with the humid coastal region and the semi-arid zone to the north. The subhumid zone corresponds roughly with the area known as the Middle Belt, between latitudes $8^{\circ} 30'N$ and $10^{\circ} 30'N$, covering 40% of Nigeria's total area but containing only about a quarter of its population.

The low population density has been attributed in part to generally low soil fertility, the incidence of various human and animal diseases (above all, sleeping sickness and trypanosomiasis carried by the tsetse fly) and the history of inter-tribal warfare plus slave-raiding by the northern Hausa-Fulani empires and southern kingdoms prior to this century.

Nigeria has the largest human population of any country in Africa, and is ethnically one of the most diverse. Demographic statistics are unreliable. The present population may be in the order of 90-100 million, and the growth rate is generally assumed to be about 2.5% per annum. Resulting expansion of cultivation has led to immigration into the subhumid zone from the more densely cultivated areas in the north and south. The rate of population increase in the subhumid zone is, therefore, higher than the average for the country as a whole. One study in the Lafia area suggested an increase of about 5% per annum in the period from the early 1960s to the early 1970s (Putt et al, 1980). This expansion of population and cultivation has changed the physical environment of the zone, above all by reducing the habitat for tsetse, as explained in more detail in the section on trypanosomiasis. Population distribution in the zone is currently uneven. Most densely populated are the southern peripheral areas, with well over 200 persons/km², while vast areas are extremely sparsely inhabited, e.g. Borgu, Kontagora, and parts of the Benue Valley.

The indigenous population of the subhumid zone consists of a variety of small, fragmented ethnic groups, in contrast to the large clusters of state-building peoples to the north and south; this suggests that the zone served as a refuge for weaker population groups. Nucleated and often fortified settlements were the rule before pacification was enforced by the British at the beginning of this century. Each ethnic group usually lived in a defined contiguous territory, and expanded or contracted according to its relative martial strength. Since pacification, there has been greater freedom of movement within the zone. Territorial patterns have become more diffuse, with enclaves of some ethnic groups within the territories of others. Certain groups, e.g. the Tiv, tend to be more expansionist than others in their search for new farm land. This process is continuing, and

changes in territorial claims and concomitant boundary disputes can also be expected in the future.

The settlement form within ethnic areas has also become more diffuse. Many hill settlements with terraced gardens have been abandoned for more accessible and productive sites on the plains, where hamlets have sprung up with only a few compounds as a nucleus to which several isolated compounds, each surrounded by farm land, regard themselves as linked.

In addition to intra-zonal movements, members of various other ethnic groups have penetrated the zone, particularly Hausa and Fulani from the north and Yoruba and Igbo from the south, mainly traders and farmers. Some areas, above all around the larger towns established in the present century as administrative, communication and commercial centres, e.g. Kaduna, now contain a multiplicity of ethnic communities, including expatriate groups.

The indigenous people of the subhumid zone traditionally held animistic beliefs. The majority have now become Christian, like most of the immigrants from the south. The Hausa and Fulani immigrants from the north are almost exclusively followers of Islam. In the northern part of the zone, Hausa is now the lingua franca; English is more widespread further south, and Fulfulde in the east. However, each of the hundreds of ethnic groups in the subhumid zone of Nigeria has still retained its own language.

Largely as a result of the empire-building activities of Fulani forces in the nineteenth century and the retreat of pastoralists faced with expansion of permanent cultivation in northern Nigeria in the twentieth century, cattle-keeping Fulani are now widespread throughout the subhumid zone, although they comprise only a small part (roughly 5%) of the zone's total rural population. Traditionally, the Fulani were thought to have led a nomadic existence, inhabiting the north of Nigeria in the wet season and moving southwards in the dry season, when relatively abundant forage and water resources were available in the Middle Belt and tsetse fly distribution was more restricted than during the rains. This was probably the general pattern until a few decades ago, although some cattle-keeping

Fulani groups have been using the subhumid zone year-round for almost two centuries. These groups possibly found pockets of lower trypanosomiasis pressure and/or built up herds of zebu cattle with some degree of resistance to the disease. Since about the 1950s, there has been a marked southward drift in the distribution of Nigeria's cattle population (Fricke, 1979; Putt et al, 1980). Those Fulani who are now operating entirely within the subhumid zone appear to have gradually shortened their pattern of seasonal herd movements, established more permanent settlements and increased their cropping activities.

The various Fulani groups which inhabit the subhumid zone either seasonally or year-round vary greatly in their life-style and mode of livestock husbandry. The Fulani are generally classified according to their mobility, e.g. nomadic, semi-nomadic, semi-settled, settled (e.g. van Raay, 1975). For the planning and implementation of cattle development, it is perhaps more useful to classify them according to enterprise system (cf. Fricke, 1979) into two major groups:

1. Full-time cattle keepers ranging from those with no consistent association with a particular area (nomads) to those based at one site; this group can be referred to as 'pure pastoralists';
2. Cattle keepers who practise some cropping, but such that cropping is subsidiary to cattle husbandry; these 'agropastoralists' can be divided into those who crop at one site but seasonally move all or some of their cattle to other grazing areas, i.e. transhumant agropastoralists; and those who keep cattle year-round close to the site of their cropping activities, i.e. sedentary agropastoralists.

By far the majority of Fulani in Nigeria today belong to the latter group. In various areas of the subhumid zone, these livestock keepers are operating in the midst of indigenous farming communities. Some Fulani groups have adopted local customs and language and inter-married with the indigenous people to such an extent that they can be considered absorbed,

e.g. in Nupe land (Udo, 1979). In other areas, they have retained their identity as Fulani even though cattle keeping may have become subsidiary to their farming activities. In any case, only a small proportion of the estimated 2.5 million cattle-keeping Fulani in Nigeria today (van Raay, 1975) are nomads without a fixed home base.

Moreover, the dominance of the Fulani in cattle keeping has been declining. In the past few decades, indigenous farmers have managed to acquire cattle, either as wages for herding for the Fulani or through purchase using earnings from crop sales. Thus, a gradual disintegration of the ethnic division between herding and cropping is taking place. Some of the zone's indigenous people, as well as some Fulani, can be included in a third group of cattle keepers classified according to enterprise system:

3. Crop farmers who keep some cattle, but such that cattle husbandry is subsidiary to cropping; these will be referred to hereafter as 'cattle-keeping farmers'.

There are even individuals in the indigenous ethnic groups in the subhumid zone who could now be classified as agropastoralists. An overview of the classification of cattle keepers according to enterprise system is presented in Table 1.

Table 1. Classification of cattle keepers in the subhumid zone of Nigeria.

Enterprise system	Mobility:	No home base	Home base	Home base
		Cattle movements throughout year	Seasonal cattle movements	No major cattle movements
Full-time cattle husbandry		Nomadic pastoralists	Transhumant pastoralists	Sedentary pastoralists
Cattle husbandry with subsidiary cropping		-	Transhumant agro-pastoralists	Sedentary agro-pastoralists
Cropping with subsidiary cattle husbandry		-	-	Cattle-keeping farmers

THE ILCA CASE STUDY AREAS

Three case study areas were selected by the ILCA Subhumid Zone Programme for detailed studies of livestock production systems, component research and intervention testing (Figure 1). They represent areas of low, slightly above average, and high cultivation densities (Table 2) relative to the zone as a whole.

Table 2. Human and cattle population and cultivation densities in ILCA case study areas in the Nigerian subhumid zone.

	Case study area (CSA)					
	Kurmin Biri (7°55'E/10°10'N) ^a		Abet (8°10'E/9°40'N)		Ganawuri ^d (8°35'E/9°N)	
	Aerial ^b survey area	Intensive ^c CSA	Aerial ^b survey area	Intensive ^c CSA	Aerial ^b survey area	Intensive ^c CSA
People/km ²	12	4	70	70	n.k. ^e	85
Cattle/km ² :						
Wet season	4	5	23	25	n.k.	n.k.
Dry season	18	10	37	40	24	21
Cultivation density (%)	15	5	24	25	33	41

^aCoordinates indicate centre point of case study area.

^bSource: Milligan et al (1979).

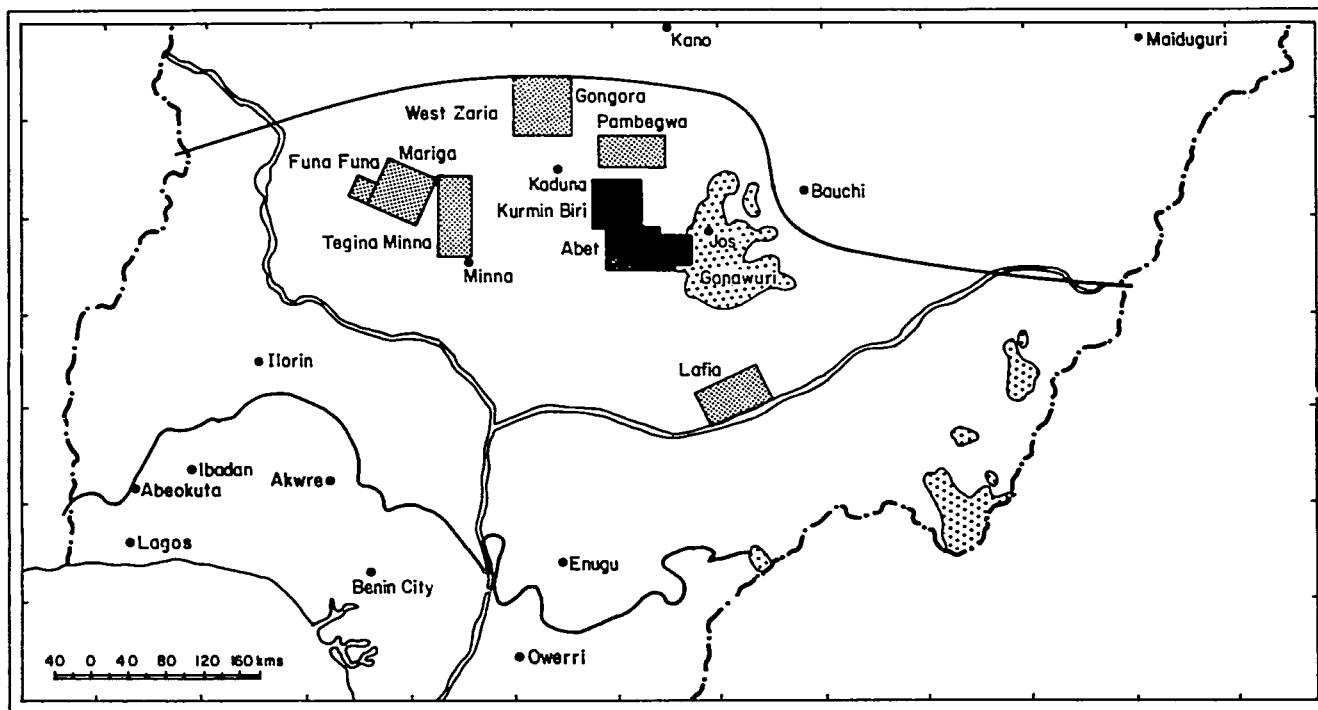
^cEstimates based on ground observations.




^dSource: Milligan et al (1984).

^eNot known.

The Kurmin Biri and Abet case study areas (both roughly 2500 km²) were surveyed by air in 1979, with repeat surveys in 1984. Ground work in Kurmin Biri began in 1979 in the Kachia Grazing Reserve (310 km²), established by the Nigerian Government for the settlement of Fulani pastoralists, and was expanded at the intervention testing stages of the research to the non-reserve Fulani settlement area around the town of Kachia. Ground work in Abet began in 1979 on the Abet Plains (ca 60 km²),

Figure 1. ILCA study areas in the subhumid zone of Nigeria.



-  = Aerial survey area only
-  = Aerial survey or field work
-  = Plateau (over 1000 m a.s.l.) and new area of field work.

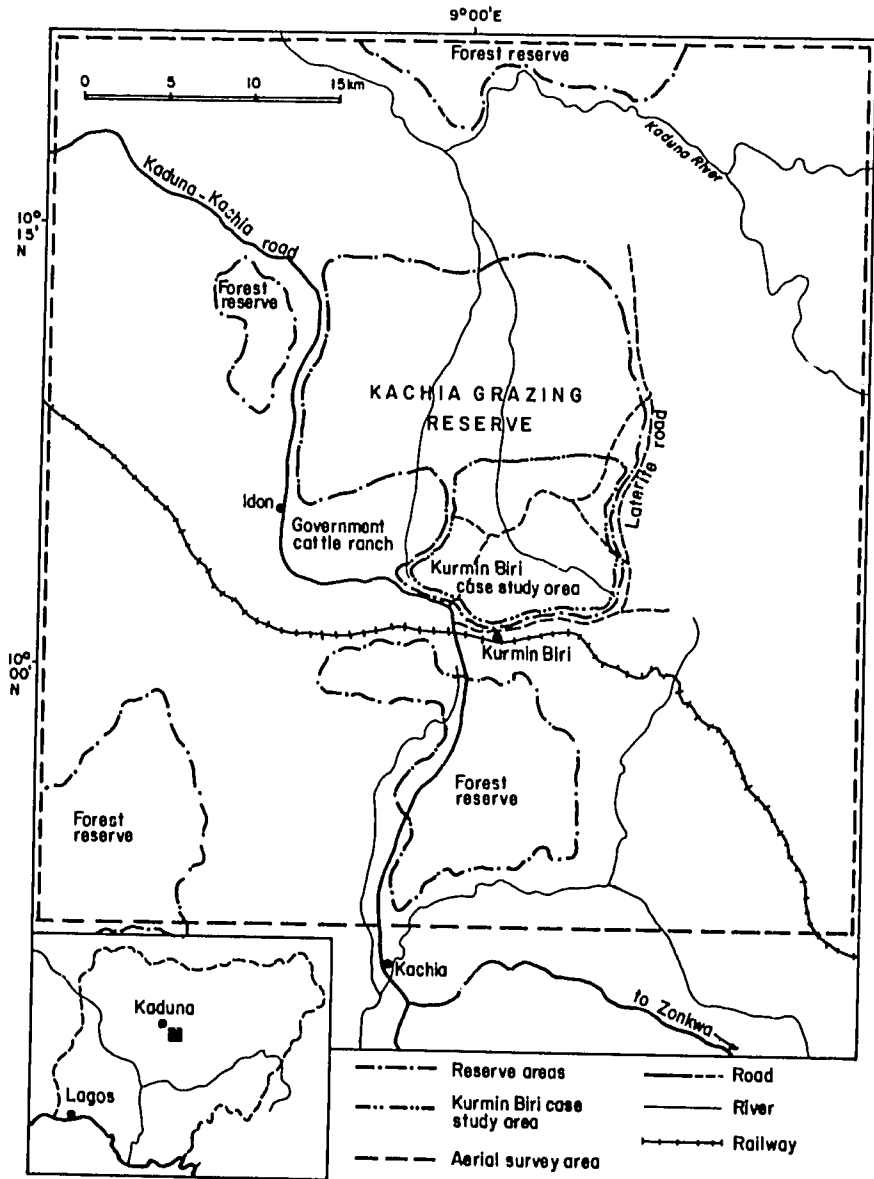
where Fulani pastoralists had settled spontaneously in the midst of crop farmers, and was expanded in 1981 to include Fulani settled close to the town of Zonkwa, mainly in the Madauchi village area. Until early 1984 the programme had concentrated on Fulani cattle keepers but, in view of the diversification of indigenous crop farmers into cattle husbandry and the possibility that some of the interventions being developed by ILCA would well suit this situation, an additional case study area - Ganawuri - was then included in the programme. An aerial survey of Ganawuri and environs (ca 800 km²) was conducted and ground work in the Kaduna River valley of Ganawuri (ca 40 km²) began in 1984.

An overview of population and land-use characteristics in these case study areas is presented here. A more detailed account of settlement and land use by Fulani agropastoralists in Abet and Kurmin Biri, the areas of spontaneous and government-assisted settlement respectively, is given in Paper 11.

Kurmin Biri case study area

Annual rainfall in the Kurmin Biri case study area is roughly 1200 mm, of which 95% falls between April and October. About 50% of the natural vegetation consists of tree savanna; the rest is mainly woodland and scrubland, except for cultivated areas in the northwest and southeast and along the Kaduna - Kachia road (Figure 2). Human and cattle population and cultivation densities in the aerial survey area of 2500 km² and the intensive case study area of 100 km² are given in Table 2. Fallow land accounts for about 15% of total area in the aerial survey region. The proportion of land under fallow is greatest in the west, while there appears to have been a recent increase in use of the southeastern region for cultivation. Distribution of cultivation and pastoral activities is influenced by the fact that the south-central part of the aerial survey region is used for military purposes.

Figure 2. Kurmin Biri aerial survey area, indicating case study area.



Within the Kurmin Biri aerial survey area lies the Kachia Grazing Reserve of 31 000 ha, the initial site of ILCA's research. Established in 1970 by the Kaduna State Ministry of Animal and Forest Resources, this grazing reserve was one of numerous areas demarcated by the ten northern states to safeguard land for grazing by traditional livestock producers.

The concept of preserving rangeland for the exclusive use of livestock dates back to pre-colonial times. Following the Fulani conquest in the north, the traditional hurmi (grazing grounds) were allocated to pastoralists around towns and villages and in many cases served as the sole source of fodder during the cultivation season. However, with increasing population and no legal statute to prevent encroachment by farming, most hurmi and their connecting burtali (cattle paths) disappeared under cultivation (Nigeria, 1978). The alienation of grazing lands was increasing throughout the north due to rising population and cultivation pressures as well as to an increasing ruminant population resulting from improved veterinary services and the tsetse campaign. Thus, during the 1960s, certain forest reserves in the areas cleared of tsetse were designated for use as grazing reserves by pastoral nomads.

The idea of preserving grazing land through the establishment of reserves was then put before the legislature in 1965 as the Grazing Reserve Law for Northern Nigeria. This law still prevails today. During the period of the Third National Plan, a target figure was set of 22 million ha to be acquired by the 10 northern states as grazing reserves (Ministry of Agriculture, 1981), but in fact only 2.3 million ha had been acquired by 1980 (Oxby, 1982): "...the expected reservation of about one third of the northern states for their livestock has only fractionally been realized during the last 12 years" (Nigeria, 1978). Selection and acquisition of grazing lands as well as compensation for the land have been solely up to the individual states. Thus, given the Federal Land Use Act of 1978 with its recommended high levels for land compensation, few reserves have been actually gazetted and many states have delayed or terminated their reservation plans (Nigeria, 1978). Because of the absence of formal gazetting, any investment in development is insecure and the central objectives of

legalizing grazing rights, securing title to land and inducing pastoralists to settle have not occurred as envisioned.

The Kachia Grazing Reserve consists mainly of relatively flat land covered with tree savanna and shrub. It has few low-lying (fadama) areas suitable for dry-season grazing. Cultivation density within the reserve is estimated at 5% or less. In 1979, only four Fulani households were known to be settled in the reserve (Phillipson, 1979). In 1984, 34 Fulani households were recorded as settled in the reserve, keeping herds ranging in size from 4 to 125 head of cattle. The Fulani are concentrated in a relatively small area close to the administrative camp in the southeast corner of the reserve. This area of about 100 km² has been the site of an intensive case study by ILCA. A major road (Kaduna - Kachia) runs along the western edge of the reserve. All-season laterite roads serve the developed southeast corner of the reserve; the remaining area is inaccessible by vehicle.

The grazing reserve was sprayed in 1967 and declared tsetse-free. Past development efforts have focussed on encouraging Fulani to settle and establishing an infrastructure, including administrative headquarters, roads, fire-breaks, dams and cattle dips. More recently, with the involvement of the Federal Livestock Department, the National Livestock Project Unit (NLPU) and ILCA in the development of the reserve, efforts include a farmer service centre, credit scheme, veterinary service, bore wells, and experimentation with various methods of pasture improvement. Previously under the Kaduna State Ministry of Animal and Forest Resources, the development programme of the reserve is now largely funded by the World Bank through the NLPU, and includes a field staff of about 24.

The grazing reserve lies to the north and west of major migration routes followed by transhumant Fulani based in the Kano and Bauchi areas, who trek to and from their dry-season grazing grounds in the Abet aerial survey area and around Abuja (Federal Capital Territory). However, some transhumant Fulani branch off the migration routes to use the Kachia reserve for dry-season grazing. As a result of this influx, dry-season cattle density in

the reserve is estimated at 10 head per km², compared with 5 during the wet season. In the aerial survey area as a whole, dry-season cattle density (18 head/km²) is over four times higher than wet-season density.

The Ikulu people are the indigenous population of the Kurmin Biri area. Their main occupation is cropping, but they also keep some livestock - mainly poultry, goats and pigs, and occasionally one or two cattle for fattening. Three Ikulu village enclaves are inside the grazing reserve, and several more villages are located along the western and southeastern edges of the reserve.

While an objective of the Grazing Reserve Law has been to encourage the settlement of nomads, none of the current settlers on the reserve were previously nomadic. All are Kachichere Fulani whose families have been resident in southern Kaduna State (formerly Southern Zaria Emirate) for generations. Several households had been living in the Kurmin Biri area, although they might have relocated every few years within a limited radius. They consider themselves indigenous to the Kurmin Biri area. The other households which have settled in the reserve within the past 6 years have come from within 100 km of Kurmin Biri.

Abet case study area

The Abet case study area has an average rainfall of 1270 mm per annum, of which 95% falls between April and November. The vegetation consists of woodland and tree savanna in the upland areas, and scrubland in the lowland areas. Human and cattle population and cultivation densities in the aerial survey area of 2500 km², and the intensive case study area of ca 60 km², are presented in Table 2.

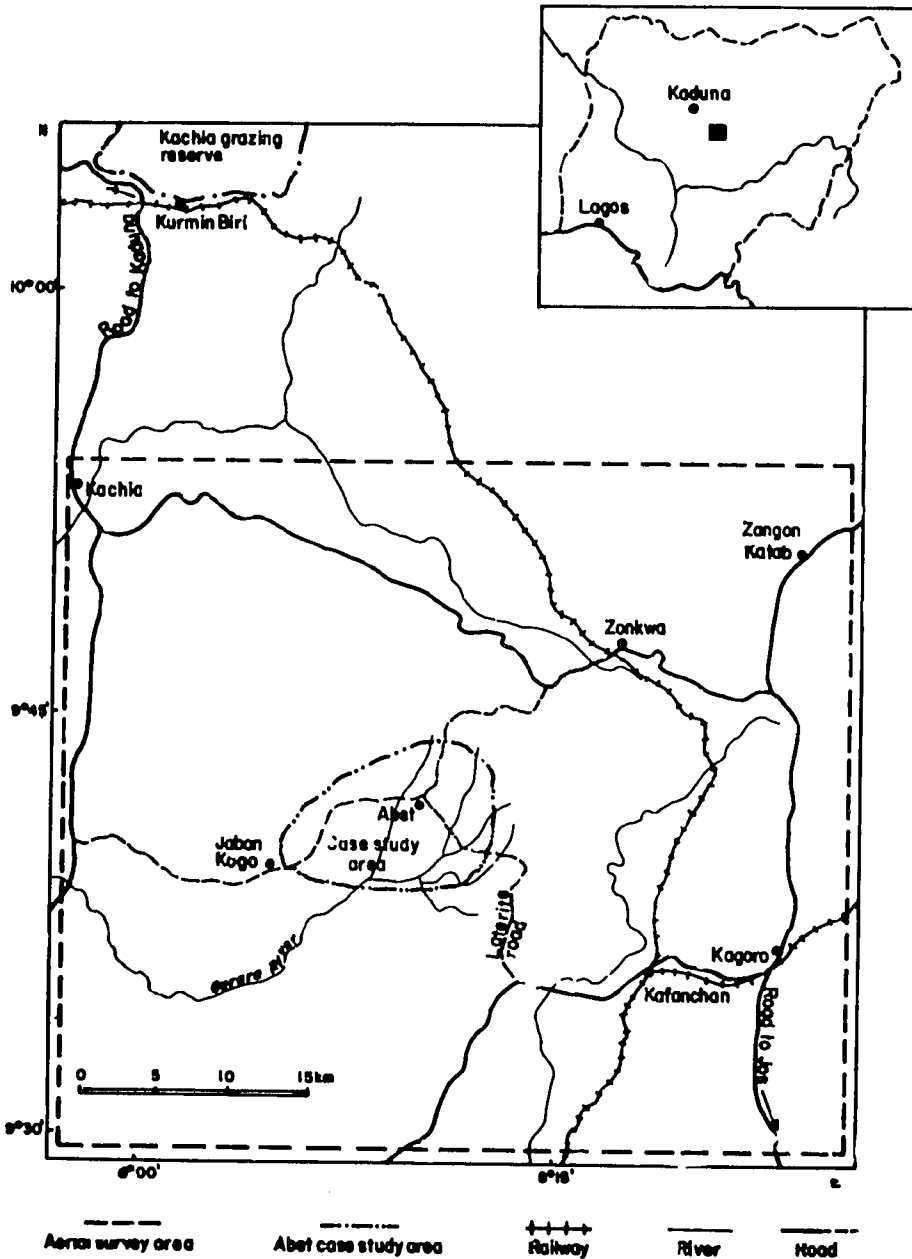
Cultivation is spread fairly evenly over the entire region, and tends to be close to low-lying areas and water courses. Fallow land accounts for roughly one third of the aerial survey area.

A second aerial survey carried out in 1984 (dry season) indicated a slight but non-significant decrease in cattle density from 37 to 32 head per km², suggesting somewhat less movement of non-resident herds into the region. This may be attributable to the outbreak of rinderpest in 1983, which continued into 1984, restricting herd movements in some areas of Nigeria and causing deviation from customary transhumance patterns in other areas. Distribution of cattle has not changed substantially over the past 5 years, with the greatest concentration still in the southwest quadrant of the survey area, and relatively few cattle in the southeast.

In 1984 the mean level of cultivation was 20%, slightly but not significantly lower than in 1979. The slight decrease probably reflects the lateness of the rains in the 1983 wet season, which prevented farmers from cultivating as large an area as in a more normal season.

The intensive case study area referred to here as the Abet Plains consists of flat to undulating land (ca 900 m a.s.l.) lying to the north of the Gurara River and bordered by groups of granite inselbergs to the north and east and by the sole inselberg of Jaban Kogo to the west (see Figure 3). The plains are transected by seasonally flowing streams which retain surface water throughout the dry season. Abet is linked to the towns of Zonkwa in the northeast and Kafanchan in the southeast by two laterite roads which are motorable year-round, although with difficulty in the wet season.

Figure 3. Abet aerial survey area, indicating case study area.



The indigenous population of the Abet Plains belongs to the Kaje and Kamantan ethnic groups. Several generations ago, the Kaje migrated westwards from the edge of the Jos Plateau to Kurmin Bi, near the present town of Zonkwa. Two large clan groupings moved further south to the hills on the eastern edge of the Abet Plains, seeking refuge from inter-tribal warfare and slave-raiding. They planted small plots of arable land close to their village and ventured onto the plains only for hunting and in order to cultivate some land immediately at the foot of the hills. It was not until pacification at the turn of the present century that they moved down to settle on the plains. Before pacification, the Kamantan were living mainly in the hills to the north of the plains, although some families had established small settlements in the shelter of thickets (*kurmi*) lining the streams on the plains. Segments of the expanding Kaje clans gradually spread into areas in which the Kamantan had been or were still living and farming. The Abet Plains are now a mosaic of Kaje and Kamantan settlements, the former predominating, and disputes occasionally arise over the tribal and family ownership of specific plots of land.

The settlement form on the plains is dispersed in contrast to the confined hill settlements. A farming compound typically comprises two or three closely related households, such as father with married sons or married brothers. Each household within a compound is an independent economic unit which farms separately and has its own cluster of houses, kitchen areas, grain-drying platform, granaries and livestock enclosures. Most structures are of mud-brick with thatched roof. The aerial survey of 1979 noted a ratio of eight grass roofs to one 'tin' roof (galvanized corrugated metal sheets). The main occupation of the Kaje and Kamantan is crop farming, but they also collect sylvan produce (e.g. locust beans, wild honey) and keep some pigs, goats, sheep and poultry.

The Kaje and Kamantan have customary rights of land occupancy. Land is inherited patrilineally, being divided more or less equally among the sons, though reportedly the senior son has first choice of location. Since land scarcity is not a problem in this area, land can be obtained easily on loan if the inherited portion is insufficient. Ownership of former and present

farm land is considered by the Kaje and Kamantan to be vested in the family; other land within the generally recognized ethnic territories is in the control of the chiefs. Farm land sales have not been recorded as yet, although one was under negotiation in 1984 and land has been sold previously for house construction.

School attendance and rural-urban drift are depriving the Kaje and Kamantan households of their youthful labourers. Land must be left fallow on account of labour shortage, and the traditional rotation of plots is becoming less common. Cultivation density is highest within and around the village clusters; fallow fields are more obvious on the periphery. Many families left the lee of the hills bordering the plains to move to the village centres of Gidan Maga, Abet and Farman when schools were opened in the 1940s, but they still retain ownership of their former farms, which are now largely fallow.

Settled Fulani comprise almost one tenth of the population on the Abet Plains. As Muslims, the Fulani are not only an ethnic but also a religious minority in a largely Christianized area. In the first decade of the nineteenth century, Fulani - Hausa jihad forces penetrated into what is now southern Kaduna State with a following of cattle-keeping Fulani. Kachichere, an upland area some 30 km east of Abet, became a centre of Fulani settlement. However, even before this time Fulani herders had been passing through or camping for several months on the Abet Plains during the dry season. Parts of the Abet aerial survey area inhabited by other ethnic groups (e.g. Jaba, Koro, Kagoma) were sites of Fulani settlement already in the nineteenth century. However, the history of Fulani - Kaje relations during the jihad was not as peaceful as in these other areas, and Fulani settlement on the Abet Plains appears to have been rare before pacification at the turn of the century.

Because the Abet area was not completely subjugated during Fulani rule in northern Nigeria, local administrative posts are held by members of the indigenous population. The present-day Fulani inhabitants thus cannot take advantage of association with a local ruling elite, as in some other parts of the subhumid zone.

The settled Fulani in Abet are mainly of the Kachichere group; only about 5% are non-Kachichere who have given up a migratory existence within the last few years. A small number of Kachichere Fulani families have been living in the Abet area for up to four generations, but the majority settled there - i.e. began to live at one site year-round - within the last three decades.

Ganawuri case study area

Annual rainfall in the Ganawuri case study area is about 1500 mm, the upper limit for the subhumid zone. The northern and eastern segments of Ganawuri District form part of the Jos Plateau; ILCA's intensive case study area is in the west and south, in the wide valley of the Kaduna River (ca 1000 m a.s.l.). Here, population density is estimated at 85 persons/km² and cultivation density ranges between 40 and 60%. The predominant ethnic group is the Aten or Ganawuri (referred to hereafter as the Ganawuri); minor groups also inhabiting the area are Ataka, Fulani and Hausa, each making up less than 5% of the total population. Transhumant Fulani pastoralists pass seasonally through the upper part of the Ganawuri District, but skirt the main population and farming area on the Kaduna Plains.

The Ganawuri are primarily crop farmers. Their staple food is acca (Digitaria exilis). Other crops include millet, sorghum, maize, rice, groundnuts, sesame or beniseed, rizga, yams, cocoyams, some cassava, and various garden vegetables. Land is under the control of the ruler of Ganawuri, but areas farmed by particular families are inherited and regarded as their own. Upon application to him, the Ganawuri chief grants immigrants use of land not being farmed, even if it had been farmed by

Ganawuri people some years previously. According to the chief, no individual or family in Ganawuri District possesses an official certificate of occupancy.

Cattle-keeping Fulani of the Kachichere group began to settle around 1910 in Ganawuri on the Kaduna River plains, which even by then were said to be tsetse-free. Ganawuri boys were hired by the Fulani as herders. This practice has continued to the present day, when Kachichere Fulani, including some from the Abet and Kurmin Biri case study areas, still come to Ganawuri to seek herders. The boys earn a bull per year or a heifer every 2 years, in addition to being given board, lodging and clothing. In this way, the Ganawuri people acquire both cattle and cattle-keeping skills. They also purchase cattle from the Fulani. Ganawuri-owned cattle were formerly left in the care of settled Fulani, but in the 1940s (Berthoud, personal communication) some Ganawuri began to herd their own cattle.

The animals are kept primarily as a form of investment, eventually to be sold or consumed at ceremonies. Manure is valued for sorghum and millet fields, but not for acca because of weeding problems. The cows are milked by the herders irregularly, and not at all in the latter half of the dry season. Milk is used to a very limited extent for household consumption and occasionally sold at the 'farm gate' to settled Fulani women, who resell it at a profit.

The Ganawuri traditionally keep goats, small horses and a few sheep. Pig keeping is rare; poultry keeping is widespread. The horses were used formerly for warfare, now for hunting and ceremonial occasions. They are kept in individual mud-walled, thatched huts within the farm compound and are fed mainly on grasses cut in low-lying areas and carried to the huts. Horses are allowed to graze to a limited extent, but are usually tethered or hobbled. Goats were traditionally slaughtered and consumed at ceremonies. Horses and goats constituted the major part of the bride-price. However, by the end of the 1960s (Berthoud, personal communication)

cattle were being slaughtered on ceremonial occasions and frequently formed a component of the bride-price.

Among the 12 farmers collaborating with IILCA in on-farm trials with forage plants, average cattle holding is 40 head. According to the chief, Ganawuri cattle holdings are gradually increasing, while those of the settled Fulani in the area are gradually decreasing. Both cattle-keeping farmers and Fulani say that wet-season grazing is a constraint to production because such a high proportion of the Ganawuri area is cultivated. Cattle must often retreat to the hills in the growing season. Grazing is not permitted in the Ganawuri Forest Reserve (about 60 ha of eucalyptus trees); the grass there is reserved for thatching roofs. Crop residues are freely grazed in the dry season; the cattle appear to prefer millet and sorghum, although acca residues are also grazed.

Ganawuri was chosen as a case study area in which crop farmers with traditional land rights keep cattle, and where livestock keeping by farmers appears to be on the increase. Furthermore, it is an area of high cultivation and human population density, giving an example of a future situation to be expected in other parts of the subhumid zone. The Ganawuri farmers seem to be aware of the value of Stylosanthes spp. as soil conditioners and fodder from their previous contact with a Nigerian Federal Government Soils Reclamation Programme in that area. It is therefore expected that incorporation of a forage legume into the existing production system, using techniques developed by IILCA in the Abet and Kurmin Biri case study areas, will find acceptance among the cattle-keeping farmers of Ganawuri.

CONCLUSIONS

The three case study areas chosen by the IILCA Subhumid Zone Programme represent some of the most widespread land ownership/use and livestock husbandry systems in the subhumid zone of West Africa. Their physical proximity makes it practical to test the applicability of interventions to different livestock production systems with the minimum of extraneous factors.

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The ecology, vegetation and land use
of subhumid Nigeria

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ABSTRACT

The subhumid zone of Nigeria covers 455 000 km² or approximately half of Nigeria and a third of the zone in West Africa.

Typically low in carbon and nitrogen, the soils have a tendency to form hard crusts. They have a poor capacity for retaining nutrients, poor water penetration and shallow water tables, all of which adversely affect cropping potential.

Rainfall in the zone ranges from 1000 to 1500 mm, with growing season from 180 to 300 days per year. The zone offers a wide variety of cropping options, but the growing season is invariably punctuated by dry spells. There is high runoff. During the growing season the humidity is conducive to pathogen survival and transmission. In the dry season the vegetation is subject to burning.

The zone has five vegetation subzones, but the Guinea and derived savanna subzones account for some 90% of the zone. There is good vegetation cover, although it is dominated by varieties suited to impoverished soil conditions. The feed quality of the grasses rises after the onset of the rains, but declines rapidly after they stop and is low for most of the year. The pattern of vegetation and land use form a mosaic of medium to high

levels of cultivation, grassland and woodland. Twenty percent of the zone is cultivated, and cultivation is expanding at 4.8% per annum. It is estimated that by the turn of the century 33% will be cultivated. This estimate is well below the former one of 70%.

Crop yields cannot be sustained on cleared land for more than 3 years without fertilizer or manure. There are opportunities for introducing forage legumes, but such interventions must be in accord with intricate and well established mixed cropping systems. The bigger the contribution of forage legumes to soil fertility and hence to food crop yields, the better the chances of their adoption.

INTRODUCTION

The Nigerian subhumid zone, as defined by ILCA (1979), is bounded to the north by the limit of the 180-day crop growing season and to the south by the interface between the derived savanna and forest vegetation zones (Nord, 1982). It occupies some 455 000 km², amounting to approximately one half of Nigeria's total land area and one third of the zone in West Africa (Jahnke, 1982).

GEOLOGY

More than half of the Nigerian subhumid zone is covered by Pre- to Upper Cambrian basement complex. It includes the oldest rocks known in Nigeria, principally composed of metamorphic and igneous material. Over most of the area underlain by basement complex there is a discontinuous mantle of weathered gneiss and granite, but this is generally thin, with a high clay content, and does not serve as an efficient aquifer. The water tables are shallow and adversely affect crops and cropping potentials at the height of the wet season. The soil tends to form a hard crust after the first rains, effectively preventing penetration of water and seedling emergence. It therefore needs tillage for cropping. Areas with excessively coarse materials, a poor capacity for retaining nutrients due to low cation exchange capacity, and topography exceeding 2-3% slope are normally avoided

by farmers. Under the traditional production system long fallow periods are necessary for maintaining soil fertility.

RELIEF

For an area covering half a million square kilometres, the variation in relief within the subhumid zone is limited. Four major relief types can be identified:

The Niger-Benue trough is a Y-shaped lowland area which divides the subhumid zone into three parts. It has been deeply dissected by erosion into tabular hills separated by river valleys. The Niger section is especially rugged.

The upland areas north of the Niger-Benue trough, and west of the Niger river, are generally undulating and strongly marked by inselbergs. The north-central plateau is made up of two different platforms - the high plains of Hausaland, which at an average height of 600 m a.s.l form the first step, and the Jos Plateau at an elevation of between 1000 and 1800 m forming the second step. The latter falls outside the subhumid zone.

The area south of the Benue and east of the Niger, extending eastwards as far as $9^{\circ}30'E$, consists of the lowland Cross River plains, east of Enugu, which show outcrops of limestone and shales whereas the relief in general is gentle; and the scarplands west of Enugu, which are made up of the Udi and Awka-Orlu plateaux.

SUNSHINE AND RADIATION

The maximum seasonal variation in day length in Nigeria is 1 hour and 45 minutes. This variation is sufficient to cause differences in the performance of crops sensitive to photoperiodism. The mean annual number of hours of sunshine increases progressively to the northeast. The daily mean duration of sunshine in July, at the height of the rainy season, is greater in the north than in the south, where the cloud cover is more

constant. The same pattern is observed in January, when there is a general lack of cloud cover in the north, but due to humid air from the Gulf of Guinea cloudiness may be expected in the south. This results in a marked zonal pattern when the whole of Nigeria is considered. The northern part of the subhumid zone stands out as having the highest national values of net radiation. Further to the north, outside the zone, surface albedo is higher, reducing net received radiation.

RAINFALL

Most of the Nigerian subhumid zone lies between the 1000 mm and 1500 mm isohyets, offering a wide choice of crop options. Rainfall is governed by the annual passage of the Inter-Tropical Convergence Zone (ITCZ), the meeting point of a dry northeastern low-pressure air mass and a moist southwestern high-pressure air mass. The northeastern movement of the ITCZ and the rain-bearing winds that accompany it mark the onset of the rainy season. Its southwestward movement and the accompanying harmattan winds mark the beginning of the dry season. Annual rainfall and its reliability decrease from the south northwards.

The northern part of the zone has unimodal rainfall distribution in which rains increase in frequency and amount, beginning in May and peaking in August. In the southern part the rainfall pattern is bimodal, the first peak occurring in June-July, and the second in September, with August relatively dry. Variations in annual rainfall make it difficult to draw a strict geographical boundary between these two distribution patterns. Much of the subhumid zone is transitional between unimodal and bimodal rainfall distribution.

The rains are expected to reach the southern boundary of the subhumid zone at the beginning of March, and the northern boundary 2 months later (Walter, 1968). At the northern boundary the rainy season normally ends in early October, and at the southern boundary 6 weeks later. The expected duration of the wet season in the subhumid zone thus ranges from 5 months in the north to more than 8 months in the south. Nevertheless the season

(April to October) is invariably punctuated by dry spells, the length of which varies from a few days to a few weeks.

Evapotranspiration exceeds rainfall north of latitude $7^{\circ}30'N$ (Kowal and Knabe, 1972), although almost everywhere in the zone there appears to be a period of water surplus in the year when rainfall exceeds evapotranspiration. Rainfall is usually torrential, 25 to 50 mm or more often falling within 1 hour. Measurement of infiltration or rainfall acceptance on a ferruginous soil type using catchment gauges gave an average ultimate infiltration of 24 mm/hour. Rainfall exceeding this rate can cause serious erosion and runoff. High humidity and concentrated rainfall during the growing season are conducive to pathogen survival and transmission. The dry season, on the other hand, is severe and the vegetation becomes parched and easily combustible.

MAJOR SOIL TYPES

Ferruginous tropical soils cover approximately half the Nigerian subhumid zone. These soils are generally characterized by a sandy surface horizon overlying a weakly structured clay accumulation. Their base-exchange capacity is low, but their base saturation and pH values are relatively high. They have high natural fertility, and FAO (1966) rates them as having good potential. However, under traditional management practices ferruginous tropical soils are of low productivity, are sensitive to erosion and have low water-holding capacity.

The alluvial soils found along the Niger and Benue rivers show light accumulations of organic matter but are often, under traditional management practices, too wet during the rainy season for crops other than rice. Under improved management practices, including irrigation and drainage, these soils have been classified by FAO (1966) as having strong to good potential, depending on their local texture and salt content.

The ferralsols that occupy much of the other half of Nigeria's subhumid zone are deep, strongly weathered soils of friable consistency. They have a low base-exchange capacity, low pH values and generally low nutrient contents. However, their resistance to erosion and good physical properties make these soils suitable for a wide range of crops. The

ferralsols within the subhumid zone are categorized by FAO as soils of low present productivity, but as having medium potential if their management can be improved.

The lithosols found in the north-central part of the zone are of local significance only, and have been classified by FAO as being of variable productivity and potential. Under traditional management they are dry for 6 to 8 months of the year. In addition they are shallow, moderately leached with little organic matter, and have a low base-exchange capacity.

The vertisols found in a small area west of Yola are difficult to work under traditional management practices. They crack deeply when dry, and have a heavy dark texture when moist. They are therefore of only medium productivity, in spite of being generally high in nutrients. Under improved management practices, FAO classifies these soils as having good potential.

The soil properties in ILCA's case study areas are shown in Table 1.

Table 1. General soil properties in two ILCA case study areas.

Location	pH	Organic C (%)	Total N (%)	Avail- able P (ppm)	Ca	Mg (Meq/100 g)	Mn	K	Total acid- ity
Kurmin Biri	5.2	0.58	0.071	3.9	1.12	0.37	0.02	0.13	0.78
Abet	5.3	0.36	0.086	1.8	1.04	0.49	0.11	0.13	0.46

VEGETATION AND LAND USE

The subhumid zone includes five vegetation subzones, excluding those found at high altitude. The Guinea and derived savanna subzones occupy some 90% of the area. The areas of Nigeria where man's influence on the vegetation is greatest lie to the north and south of the subhumid zone, exemplified by conditions in the Sahel and by the diminishing rain forest. Blair-Rains (1968) stated that the existing vegetation in Nigeria in general may bear little resemblance to the original zonal categories, because of the combined effects of human activity: burning, cultivation, tree felling and cattle grazing.

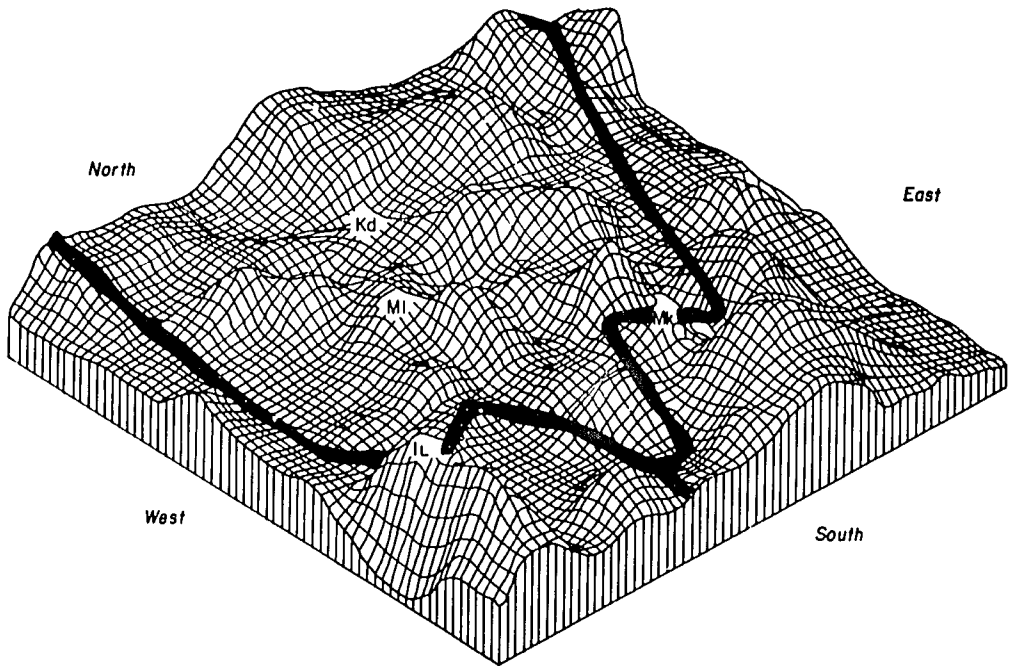
Extensive areas of medium to high levels of land-use intensity are found on the northern border of the subhumid zone extending northwards, with the highest cultivation density being associated with major towns. The same pattern is found on the southern border, around Enugu, and southwards, where the proportion of land cultivated reaches its highest, at 25%. The land in between these two areas falls within the subhumid zone, where cultivation declines to some 17%. Here the pattern of vegetation and land use can best be described as a mosaic of varying levels of cultivation, grassland and woodland. An interconnecting patchwork of more intense cultivation links the northern and southern cultivated regions of Nigeria, through a broad belt north of Lokoja including Bida, Minna, Abuja, Iafia, Shendam, Kafanchan, the Jos Plateau, Kaduna and Saminaka. In this belt, cultivation reaches a peak of 35%. To the west and east of it, cultivated areas are generally more scattered (10%) with woodland tending to predominate.

DISTRIBUTION OF CULTIVATION

Bourn and Milligan (1983) estimated 20% of the Nigerian subhumid zone to be under cultivation. The overall distribution of this farmland, and hence the intensity of land use, are represented by the three-dimensional surface shown in Figure 1, in which the proportion of land under cultivation is indicated by apparent height. As already suggested by the side-looking airborne radar (SLAR) vegetation and land-use map, cultivation was found to be unevenly distributed within the subhumid zone, being concentrated in a series of semi-isolated peaks of high-intensity land use, surrounded by

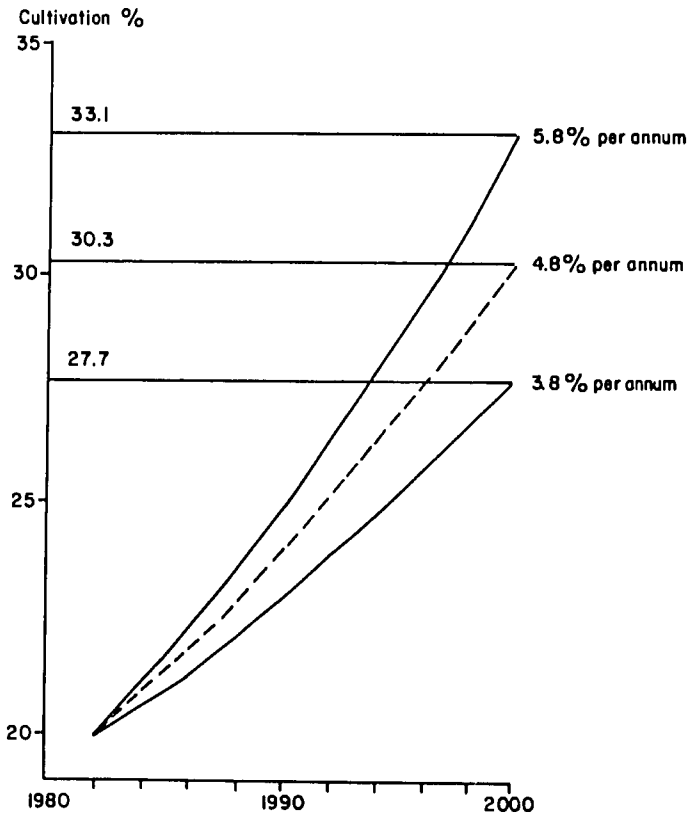
areas of relatively low cultivation. However, an important feature indicated in Figure 1 but not evident on the SLAR map is that cultivation is taking place throughout the surveyed area, albeit at very low levels in the more western areas and to the southeast.

Figure 1 . Distribution of cultivation in the Nigerian subhumid zone.



Putt et al (1980) have demonstrated a rapid rate of agricultural expansion, associated with human population increase, both within and outside the subhumid zone. In the Lafia region, for example, comparative airphoto-interpretation indicated that cultivation was expanding at an annual rate of 4.8%. Assuming continued expansion at that rate (plus or minus 1%) and an estimated 20% of the zone to be cultivated at present, Figure 2 projects the increasing proportion likely to be under cultivation to the turn of the century. Even the higher estimate of 33.1% under cultivation is very much below the previous estimate of 70% for the zone as a whole (ILCA, 1979). Since approximately one third of the West African subhumid zone is in Nigeria, the figure of 70% would appear to be an overestimate.

Figure 2. Projected land area under cultivation within the Nigerian subhumid zone until the turn of the century.



FORAGE RESOURCES

The herbaceous cover of the subhumid zone consists mainly of annual grasses, with a very low percentage of native legumes. Seasonal changes in herbage quality are primarily due more to changes in plant development than to climatic conditions per se. The C₄ photosynthetic pathways in grasses promote a rapid accumulation of structural components, resulting in dilution of nutrients such as N and P in the tissue. Legumes, on the other hand, exhibit a less efficient C₃ photosynthetic pathway and are independent of soil N, which is secured through biological fixation in the root nodules. Legumes are therefore usually higher in protein and minerals and have higher dry matter (DM) digestibility and voluntary intake by animals than do grasses at similar stages of growth. Growing forage legumes should thus provide a means of overcoming the protein deficiency of the grasses which dominate natural feed supplies.

FORAGE PRODUCTIVITY

Measurement

Land-use patterns affect the productivity of natural forage. Because of its favourable rainfall the subhumid zone is also likely to be increasingly utilized for cropping wherever edaphic and other conditions are favourable. Forage productivity measurements were carried out in two environments where pastoralists are settling:

1. An intensive arable farming area (Abet).
2. An area reserved by the state for grazing (Kurmin Biri - Kachia).

An inventory, and the frequency, of existing flora in the herbaceous cover were compiled by using line transects. A number of transects were read in three distinct ecological niches in each study area.

Potential yield of the herbaceous strata of the three ecological subdivisions was estimated from five samples of 1 m² each, clipped to ground level at the beginning and end of the rains, within a 5 x 5 m enclosed area protected from livestock throughout the growing season. Monthly forage production and botanical composition were also estimated from 1 m² samples, clipped to the ground within similar enclosures as above, but moved randomly after each monthly clipping. Weight difference or DM disappearance between clipped samples from within and outside the enclosures was assumed to have been grazed by livestock during that month. Cut samples, hand-separated into grass and non-grass (forb), were taken, dried and analysed for crude protein (CP) and DM digestibility. Data collected from the three ecological subdivisions were pooled to construct a generalized pattern of forage production in the subhumid zone (Figures 3 and 4).

Figure 3. Generalized productivity and utilization pattern of natural herbage at Kachia Grazing Reserve.

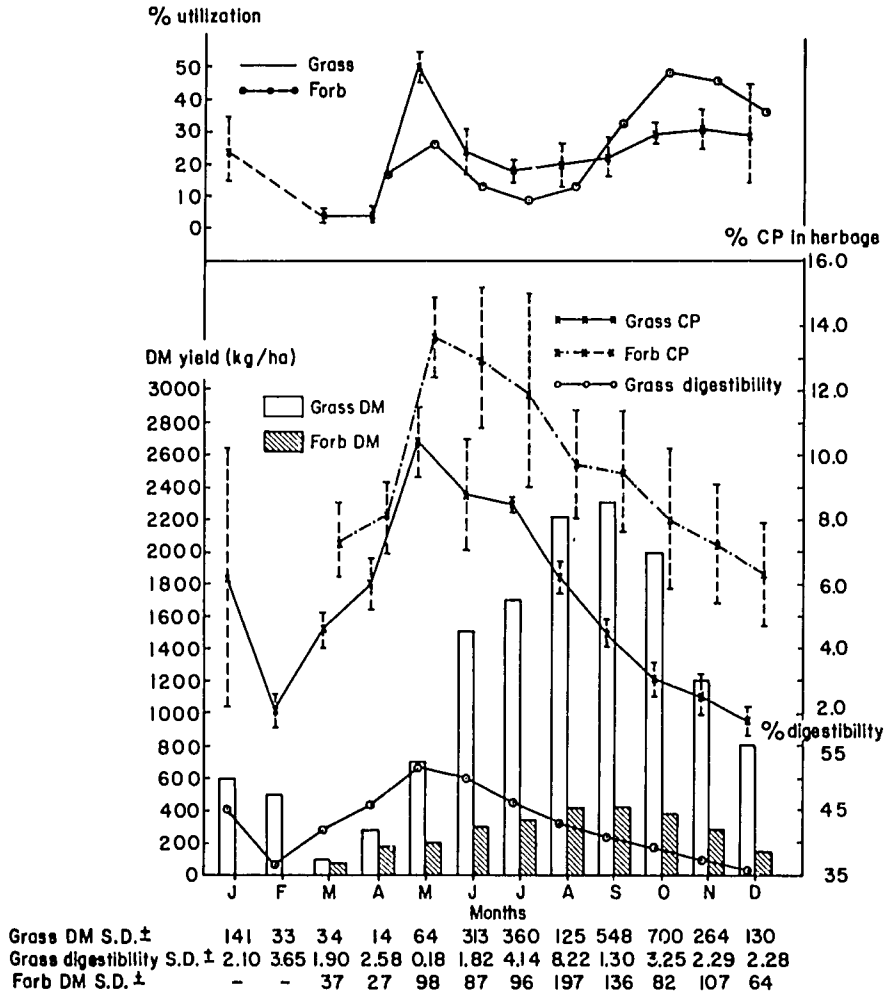
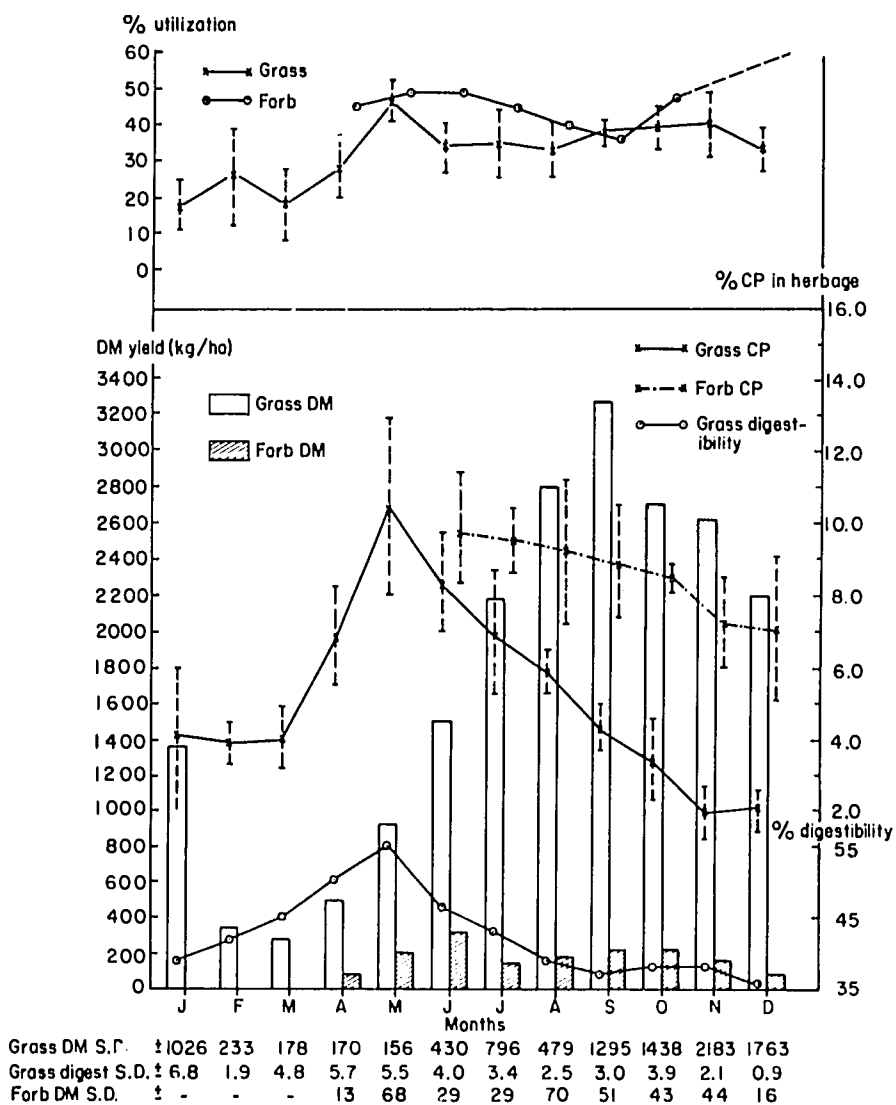


Figure 4. Generalized production and utilization pattern of natural herbage at Abet.



DM productivity

One season of uninterrupted growth of the herbaceous stratum in a burnt area in the subhumid zone produced a DM yield of 2250 kg on shallow, ferruginous soils. Fadama (lowland) soils, with deep hydromorphology, tend to support higher DM productivity .. up to 5 tonnes in one growing season (Table 2). On this soil type forage growth is prolonged by residual moisture long after the rains have ceased (Figure 5).

Figure 5. Dry matter production pattern of herbaceous cover in a fadama area at Abet.

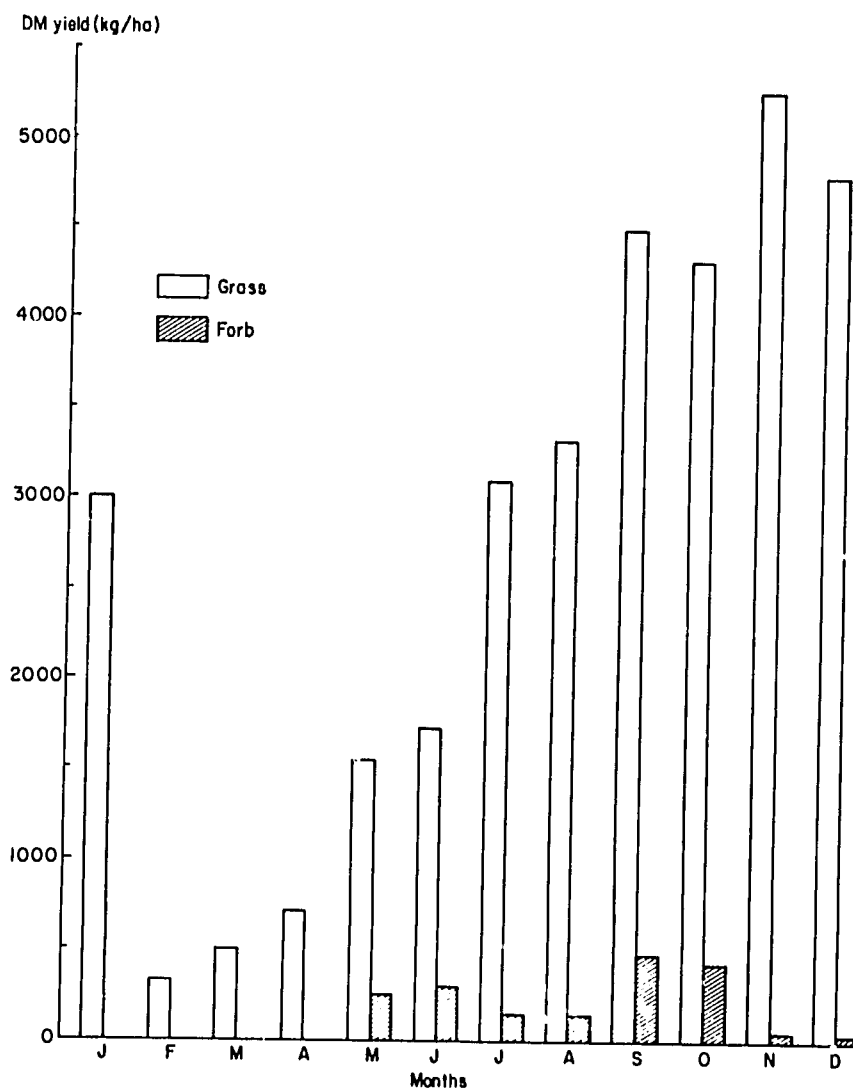


Table 2. One season's DM production (kg/ha)^{a/} of the herbaceous layer in different eco-subsystems in two study areas of the subhumid zone of Nigeria.

	Fadama	Woodland	Scrubland	Riverine
Kurmin Biri	3754	1758	2251	2156
Abet	4922	-	2185	1940

^{a/}Uninterrupted growth.

Herbage growth and production varies seasonally, and the maximum herbaceous biomass on offer is attained between August-September (Figures 3 and 4). Seasonality of production also affects non-graminoid components, and their proportion in the total biomass is higher at the beginning of the rainy season (Table 3). Non-graminaceous types are insignificant in the herbaceous layer, especially in burnt areas.

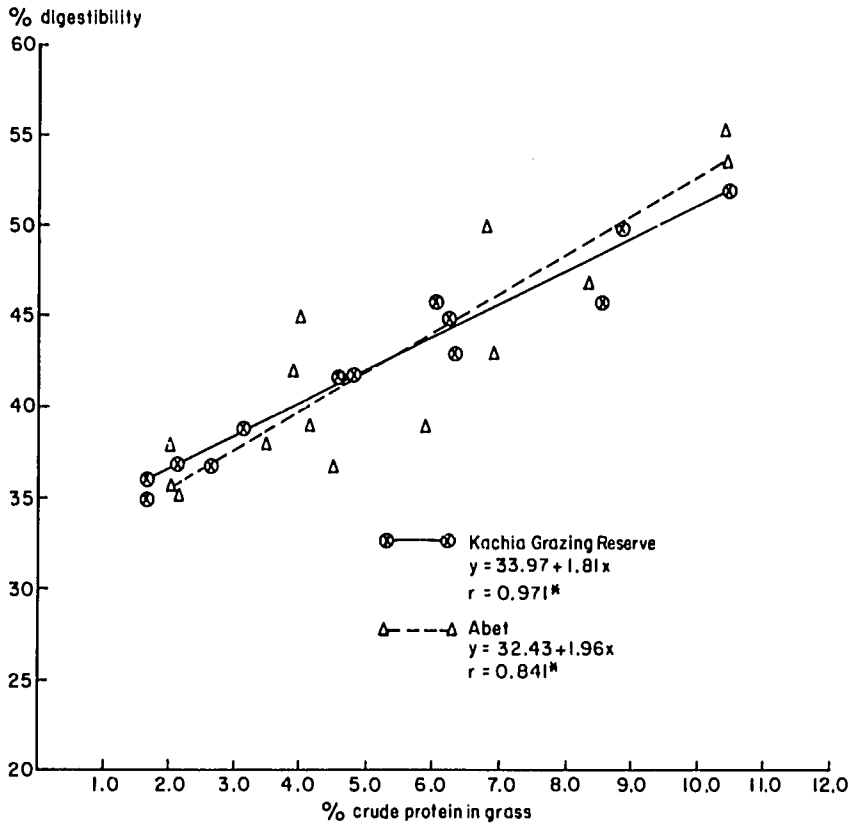
Productivity of the herbaceous cover also varies between years. Herbage produced in the fadama at Abet was about 1 tonne higher in 1981 when the area received 167 mm more rain than the previous year. Both seasonal and species differences contribute to changes in forage quality. During their early development grasses increase in protein content. Where conditions are favourable, the release of soil nitrogen early in the growing season may increase their CP to 9%. But once the rains are over CP content declines rapidly, and since the main bulk of forage on offer is grass, the overall nutritive value of the herbaceous cover in terms of protein is low for most of the year.

Table 3. Botanical composition of the herbaceous layer of two ILCA case study areas in the subhumid zone of Nigeria (kg/ha).

Study area/ Months	Grass	Forb	Total	% Forb
Kurmin Biri				
January	612	-	612	-
February	504	-	504	-
March	144	76	220	34
April	288	172	460	37
May	714	206	920	22
June	1573	301	1874	16
July	1799	368	2162	17
August	2298	431	2729	16
September	2380	437	2817	18
October	1980	386	2366	16
November	1200	285	1485	19
December	826	165	991	20
Abet				
January	1382	-	1382	-
February	322	-	322	-
March	290	-	290	-
April	518	93	611	15
May	910	203	1113	18
June	1502	328	1830	18
July	2193	166	2359	7
August	2811	189	3000	6
September	3094	226	3320	7
October	2729	218	2947	7
November	2688	153	2851	6
December	2212	94	2306	4

The digestibility of grass is low throughout the year (Figures 3 and 4). It exceeds 40% for only 4 months during the growing season, when the tissues are tender. Digestibility changes closely follow the level of protein in the tissue (Figure 6). This correlation highlights the importance of increasing protein levels in the forage.

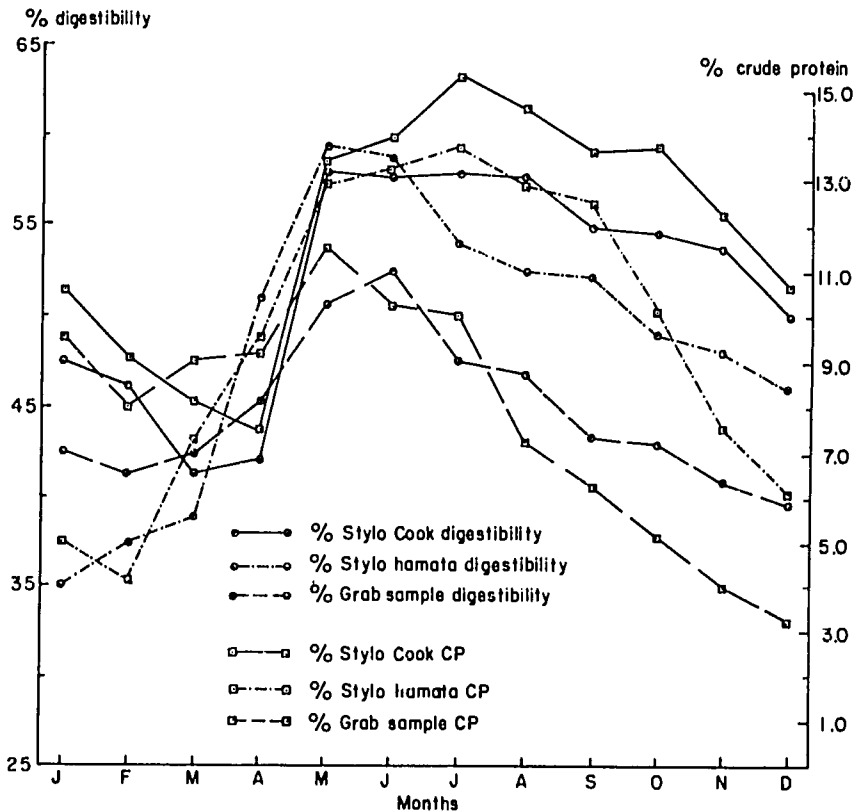
Figure 6. Relationship between herbage crude protein and digestibility of graminoid forms in the herbaceous cover of the Nigerian subhumid zone.



* Significant at $P < 0.01$

Livestock, through selective grazing, tend to consume a better quality diet than average protein and digestibility levels would suggest. Analyses of grab samples collected by following animals showed higher protein content and digestibility throughout the year (Figure 7). The overall quality of forage from a burnt area was also higher. Burning as early as October-November increased the quality of regrown forage, but the bulk left at the end of the growing season was very low in quality and therefore less utilized by livestock, which prefer the new flush of shoots induced by burning (Figures 3 and 4).

Figure 7. Digestibility and crude protein (%) of forage legumes and grab samples at Kurmin Biri.



Indications are that forage utilization in more intensively farmed areas is higher than in other areas, possibly because of the tendency of pastoralists to settle near arable farmers.

FORAGE COMPOSITION AND AVAILABILITY

The subhumid zone has good ground vegetative cover. Empty spaces in any area account for 8 to 17%, depending on the type of soil, available moisture and the level of land use. Grasses make up about 62 to 82% of the total herbaceous forage. Leguminous species are very low. Other short-growing dicots, associated with grass, make up about 10 to 20% of herbaceous cover (Table 4).

Table 4. Composition of the herbaceous cover of three eco-subsystems of the subhumid zone (%).

Plant cover	Eco-subsystem		
	<u>Fadama</u>	Scrubland	Riverine
Total plant cover	92.1	83.7	83.2
Grass	82.0	64.2	62.3
Legumes	0.7	4.4	1.4
Others	9.4	15.1	19.5

On the basis of percentage frequency, Rattray (1960) used a given grass genus that emerged as the dominating type to designate a particular climatic zone. Accordingly, the subhumid zone of West Africa could be divided into three belts that cross the south-north axis: the Pennisetum, Hyparrhenia and Andropogon belts. These dominant species have given way to others over the years, doubtless as a result of human influence. The graminoid types in both the ILCA study areas are dominated by Loudetia simplex, which is a tufted perennial, suggesting impoverished soil conditions (Table 5).

Table 5. Frequency distribution of the major grasses in the herbaceous cover of the Kachia Grazing Reserve.

Grasses	Occurrence (%)
<u>Andropogon</u> spp.	6.2
<u>Brachiaria</u> spp.	8.3
<u>Digitaria</u> spp.	0.8
<u>Hyparrhenia</u> spp.	11.4
<u>Loudetia</u> spp.	40.7
<u>Panicum</u> spp.	0.8
<u>Paspalum</u> spp.	1.4
<u>Setaria</u> spp.	0.6

FORAGE CONSTRAINTS AND INTERVENTIONS

Cropland

Land cleared and prepared for cropping has an unprotected surface and therefore deteriorates rapidly under the impact of the torrential rains typical of the subhumid zone. Clearing increases surface runoff and leaching of nutrients. Moreover, the temperature of an unprotected soil surface tends to be higher, which encourages more rapid decomposition of organic matter than in a soil with a natural vegetative cover. Soil undergoing degradation at such a rate cannot support continuous cropping unless its lost properties are restored in some way. When such a soil is cropped repeatedly, crop yields decline and the capacity of the land to support human life diminishes with time (Table 6). Experienced farmers are able to predict the time limit for profitable cropping once an area is cleared, which generally ranges from 1 to 3 years unless manure or fertilizer is applied.

Table 6. Productivity of sorghum (kg/ha) when cropped for 3 years continuously with or without manure additions (Kurmin Biri, 1981-1983)^{a/}.

	Year		
	1981	1982	1983 ^{b/}
Without animal manure			
Grain yield	858	690	267
Crop residue	4330	3740	2133
With animal manure			
Grain yield	-	1352	933
Crop residue	-	5710	4000

^{a/} Each replicate in the trial was divided into two, and 20 to 30 animals were confined for 5 days on one half, prior to land preparation in 1982 and 1983.

^{b/} In 1983 there was a very short wet season compared with previous years.

Soil fertility is traditionally restored by fallowing. The length of time the soil is rested after cropping is generally a function of population pressure. Where population is low, rest periods between cultivated phases may be prolonged, resulting in a low cropping index. In this system a farmer has to clear a new area for cultivation each time he abandons the old one. Soil restoration is left to take a natural but prolonged course with no inputs from the farmer. Areas with a low cropping index can provide reasonably well regenerated land whenever this is required by farmers.

Higher population levels make prolonged fallow periods less feasible. Farmers are obliged to return to a previously cropped area much sooner. Incomplete recovery then has to be compensated by additional inputs to make the soil productive. The return of ash, household sweepings, night soil and, of course, fertilizers to the land are some of the measures used.

For the farmers in parts of Nigeria's subhumid zone, access to manure plays a very significant role in the maintenance of soil fertility with or without short rest periods. Manure allows intensive cropping and hence

higher human support capacity per unit area of land. Crop and livestock production are commonly carried out by ethnically separate communities, although mixed farming is increasing in Nigeria. Fulani pastoralists prefer to settle in the vicinity of cereal farmers, who thus have access to manure even if they do not own livestock themselves. Animals can also be used for traction and transport, besides being a source of much needed protein.

For all the contributions of livestock, the crop sector at the moment tends to offer only crop residues and unimproved fallows in return. Although valuable to livestock early in the dry season (Paper 14), crop residues alone are inadequate to meet the nutritional demands of animals.

Growing cereal crops and forage legumes in a mixture is a recent concept in African agriculture. Both components in the mixture require a different production emphasis (grain from cereals and hence emphasis on the reproductive phase, but herbage from legumes, and hence emphasis on the vegetative stage). The agronomic requirements of a cereal/forage crop mixture differ from those of other conventional crop mixtures.

Research carried out by ILCA in the past 3 years indicates that forage legumes can be incorporated into existing cropping systems by simple adjustments of sowing time, plant densities or planting sequences. These adjustments improve the nutritive value of crop residues and hence the economic returns per unit area of land.

Mixed cropping is the basic farming practice in the subhumid zone of Nigeria. Sorghum is the principal crop and predominates in the different crop mixtures. Most commonly, it is intercropped with soybean and/or maize, but various other crops, such as groundnut, cowpea, millet, and okra, also feature.

Farmers' reasons for growing a mixture of crops are to minimize risk, spread labour inputs, and reduce disease problems (Evans, 1960; Norman, 1974). These advantages outweigh the benefits of sole cropping, and mixed

cropping will doubtlessly remain the standard practice in the subhumid zone for the foreseeable future. Yield advantages in mixed as compared to sole cropping are also common when the component crops complement each other. This happens when their growth patterns differ in time, so that each crop makes its major demands on resources at different times (Wiley, 1979). It will be possible to incorporate forage legumes into crop mixtures only if appropriate adjustments can be made to cropping patterns. These adjustments should not be too far removed from the existing practices if they are to be adopted easily by the farmers.

Rangeland

Natural forage provides the cheapest source of nutrients for ruminants, but the land on which it grows does not often have a high capacity for biomass production. The deflected or disclimax vegetations typical of such land are also likely to increase with the spread of human activity into areas which are as yet underutilized. These areas will not revert back to climax floral associations whilst under continued pressure from man and stock.

Livestock grazing natural rangeland derive most of their feed from grasses, with browse becoming increasingly important (but never dominant) as the dry season progresses.

High costs and the communal ownership of rangeland preclude large-scale pasture development in Nigeria's subhumid zone. Unrestricted access and widespread burning have so far frustrated conventional range management strategies. Small units of sown forage might nevertheless be respected on private property, just as cereal crops are. The Fulani in the ILCA case study areas have traditionally sown fonio (*Digitaria exilis*) on areas grazed and trodden by cattle. This technique can be adapted to provide the labour required for legume establishment. Small units are probably a safer investment than large ones, owing to the risk of fire.

CONCLUSIONS

The land and ecology of subhumid Nigeria are not as hospitable to change as may at first appear. The soil presents difficulties because of its structure, high water table, poor drainage, low fertility, high surface temperatures and fragility. The rainfall is adequate in total quantity but likely to be erratic in the critical early growing season and overabundant at other times, leading to soil erosion and plant disease.

The zone is not highly cultivated but the distribution of cultivation is uneven, tending to be high in the north and south. Mixed crop-livestock systems are expanding.

There are opportunities for introducing forage legumes, but these must be considered in conjunction with existing cropping systems.

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Paper 5

Tsetse, trypanosomiasis and cattle in a changing environment

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ABSTRACT

The Nigerian environment is undergoing profound and widespread changes induced by human population growth and agricultural expansion. As land suitable for cultivation becomes increasingly scarce in the more highly populated areas, particularly to the north and south of the country, the relatively underutilized regions of the Nigerian subhumid zone are becoming more extensively exploited.

As a result of these artificial changes in the environment, natural vegetation is being transformed into farmland, and wildlife populations are being hunted out. Consequently, the natural habitats and hosts of tsetse (*Glossina* spp.), the vectors of animal and human trypanosomiasis, are tending to disappear.

Coincident with the expansion of human settlement and cultivation, and the declining importance of trypanosomiasis, there has been a southward spread in the distribution of cattle. Recent population estimates, based on low intensity, low-level systematic aerial surveys, indicate that the subhumid zone supports some 4.5 million head of cattle, and that the overall population size does not change significantly with season. A seasonal redistribution appears to take place within the zone, but in general terms cattle distribution remains closely associated with cultivation and human settlement.

INTRODUCTION

Nigeria possesses the largest and most diverse human population of any country in Africa. The population has been, and still is, growing rapidly. As a result, there has been a progressive expansion of agricultural land which has inevitably affected the natural environment. Many of these effects are being felt in the subhumid zone, as defined by ILCA (1979). It is the purpose of this paper to identify the interrelationships between some of the major changes that have taken place and the distribution of the national cattle population, particularly in relation to the incidence of tsetse and trypanosomiasis.

TSETSE AND TRYPANOSOMIASIS

Tsetse (*Glossina* spp.) are the primary vectors of animal and human trypanosomiasis, and as such have been the subject of many years of intensive scientific study. Although Nigeria has had a long history of tsetse control and eradication through the application of insecticide, operations within the subhumid zone have been relatively limited (Putt et al, 1980). Much of the eradication programme has taken place outside the zone (Davies, 1964; 1971), and the effects within have been confined to adjoining regions to the north and northeast. Various localized tsetse control operations have been mounted within the subhumid zone, largely as protective measures around ranches and areas of residual human sleeping sickness.

Recently, alternative control methods have also been used. The Federal Department of Pest Control Services (FDPCS), in conjunction with the International Atomic Energy Agency and the Food and Agriculture Organization of the United Nations, has initiated a Project for the Biological Control of Tsetse in the Lafia area, which employs a novel form of control, utilizing the sterile male release technique in place of conventional insecticide application.

Of the eleven recorded species of Nigerian tsetse (Davies, 1977), six have been found within the boundaries of the subhumid zone. Each of the main species-groups is represented: G. morsitans and G. longipalpis of the 'savanna' dwelling group; G. palpalis and G. tachinoides of the 'riverine forest' group; and G. fusca and G. haningtoni of the 'forest' dwelling group. The latter two species are exceptional for the subhumid zone in that they are basically rain forest species and records have been confined to atypical forest outliers. Essentially, therefore, four species predominate within the zone.

Nigerian tsetse distribution maps (FDPCS, 1980; and map 16.13 in Nord, 1982) show G. morsitans occurring in a series of discontinuous belts scattered across the northern two thirds of the subhumid zone. The other savanna species, G. longipalpis, has been recorded over a wide area of central and southwestern portions of the zone. The two riverine species occur throughout the zone, G. palpalis being absent from the extreme northeast, and G. tachinoides absent only from limited areas on the southern boundary.

As with any genus, a variety of complex interacting factors and species-specific requirements determine tsetse distribution and abundance. The availability of suitable habitats and hosts are two determinants of primary importance, both of which, in the course of time, have been greatly influenced by human activity.

Human population is increasing throughout Nigeria, particularly in the north and south. Both central and northern Nigeria have also absorbed significant numbers of both pastoralists and agropastoralists who have moved southwards, away from the drought-affected semi-arid and arid zones further north. The consequent pressure on land resources has led to an accelerated agricultural expansion within the relatively underpopulated subhumid zone. Such expansion has been facilitated, and its direction channelled, by Nigeria's rapidly developing road network. As a result, a wide variety of natural tsetse habitats have been transformed by the combined processes of land clearance and wet-season cultivation of upland savanna; removal of riverine forests for dry-season cultivation; firewood collection; and extraction of valuable timber. In addition the demand for

bushmeat and associated heavy hunting pressure has greatly reduced, and in many areas eliminated, the natural hosts of tsetse. The net result of these artificial environmental changes has been to reduce the availability of both the habitats and hosts favoured by Glossina spp., which in turn has caused an overall decline in the distribution and abundance of tsetse populations (Bourn, 1983).

The savanna tsetse species are most susceptible to the impact of agricultural expansion. As wildlife hosts are hunted out and natural woodland vegetation is turned into farmland, the distribution and abundance of G. morsitans and G. longipalpis are bound to decline. The fragmentary nature of G. morsitans belts, in an environment which would otherwise be suitable, is itself evidence of the impact of long-term human activity on the availability of suitable hosts and habitats. Various advances and recessions of G. morsitans have been documented in the past (MacLennan, 1958; Wilson, 1958; and Ford 1971), but on balance the overall trend has been one of general contraction and, eventually, local extinction (Putt et al, 1980; and also compare published and revised tsetse distribution maps 6.13 and 6.14 in Nord, 1982).

However, the more dense riverine forest/thicket vegetation is more difficult to transform into farmland than is woodland. It is also a naturally very patchy habitat. As a result, the primary habitat of riverine tsetse species is, initially at least, more likely to remain intact. Thus G. palpalis and G. tachinoides tend to persist even in very confined habitats surrounded by extensive areas of cultivation. Under these circumstances, however, in the virtual absence of wildlife, cattle and people are likely to become the major hosts, with tsetse populations concentrated at regularly used forest crossings or at cattle and village watering points.

As land-use intensity continues to increase, even the remaining riverine forest will be encroached upon by cultivation, logging, palm wine collection and fire. Suitable habitats for riverine species of tsetse are therefore also likely to dwindle and ultimately, in extreme cases, to disappear.

Thus, under the generally prevailing conditions of declining tsetse populations, disappearing wildlife reservoirs of trypanosomes, and the increasingly sedentary nature of livestock husbandry in more southerly locations, both Putt et al (1980) and Bourn (1983) concluded that there must have been a fundamental shift in vector-host-parasite relationships, and that the very nature and importance of the disease had changed. In part at least, this is reflected in the rise and fall of various government-sponsored disease control measures shown in Figure 1.

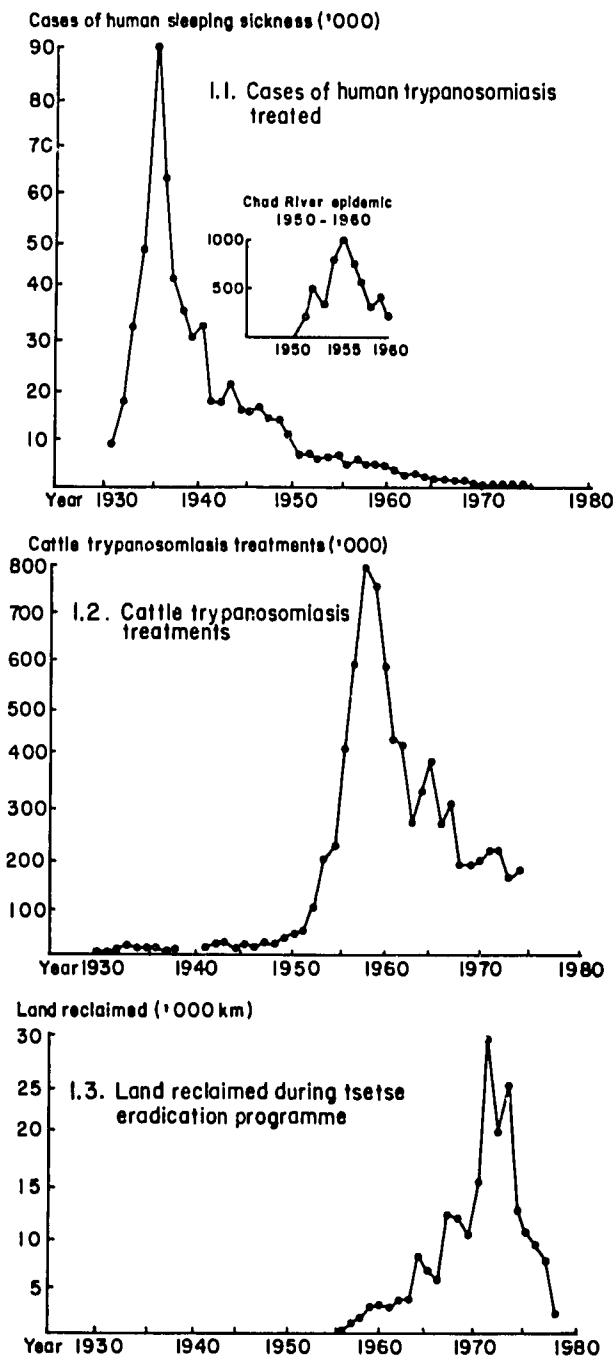
CATTLE

How many, and where are they?

The size and distribution of Nigeria's cattle population has long been a subject of debate and partially informed guesswork. Various indirect population estimates have been derived on the basis of cattle tax (jangali) returns, offtake rates, hide and skin exports, the numbers of trade cattle passing from the north to southern markets, and vaccination returns. The accuracy of the estimates obtained of course depends on the validity of the underlying assumptions: the degree of tax evasion, the measure of herd productivity, the proportion of animals imported into the country, and the efficiency of the vaccination programmes. Nevertheless, despite the inherent uncertainty, it is generally believed that the size of Nigeria's present cattle population is in the range of 10 to 15 million, the majority of which are humped zebu owned by the Fulani people.

In addition to zebu cattle, there are an estimated 300 000 head of the more trypanotolerant cattle (ILCA/FAO, 1980). Their distribution is largely restricted to the derived savanna and forest regions south of the Benue and Niger rivers. Three major breeds are recognized: 150 000-180 000 Keteku (Muturu x White Fulani Zebu); 100 000-120 000 Muturu (Dwarf West African Shorthorn); and some 15 000 N'Dama. No clear boundary can be defined between the distribution of zebu and trypanotolerant breeds, but as mentioned earlier, with the southward drift of zebu cattle into southern Guinea and derived savanna vegetation zones, there is likely to be a significant, and increasing, degree of overlap.

Figure 1. Trypanosomiasis treatments and land reclamation.



Traditionally, the Fulani pastoralists were regarded as living a primarily nomadic existence. The bulk of the cattle population was considered to inhabit the northern part of the country in the wet season, and to move southwards into the 'Middle Belt', or subhumid zone, during the dry season. This nomadic, or extensively transhumant, life-style was believed to reduce the risks of contracting trypanosomiasis in more southerly tsetse-infested regions during the wet season. In the dry season the distribution and abundance of tsetse were greatly restricted by adverse climatic conditions, and cattle owners took advantage of the lower tsetse and trypanosome challenge in order to utilize the relatively abundant forage and water resources.

However, it would appear that this traditional view is no longer generally valid. Fricke (1979) and Putt et al (1980), in independent analyses of jangali tax returns, have both demonstrated that since the 1950s the overall numbers of tax returns have declined in the north, but risen in the south. Thus there appears to have been a marked southward drift in the distribution of Nigeria's cattle population. A substantial body of circumstantial and anecdotal evidence supports this conclusion, and it seems likely that this trend has been further encouraged by the Sahel drought of the late 1960s and early 1970s.

Such a phenomenon is clearly of great importance to Nigeria, which has a combined policy of relocating the national herd in more southerly latitudes, and settling pastoral communities (David-West, 1980). It is therefore desirable to establish by more direct methods whether there is indeed a substantial and comparatively static population of cattle in the subhumid zone. Until recently, such estimates of cattle numbers and distributions have not been available. Answers to the fundamental questions: How many cattle are there? and where are they to be found? have remained largely a matter of conjecture and speculation.

Low-level aerial survey

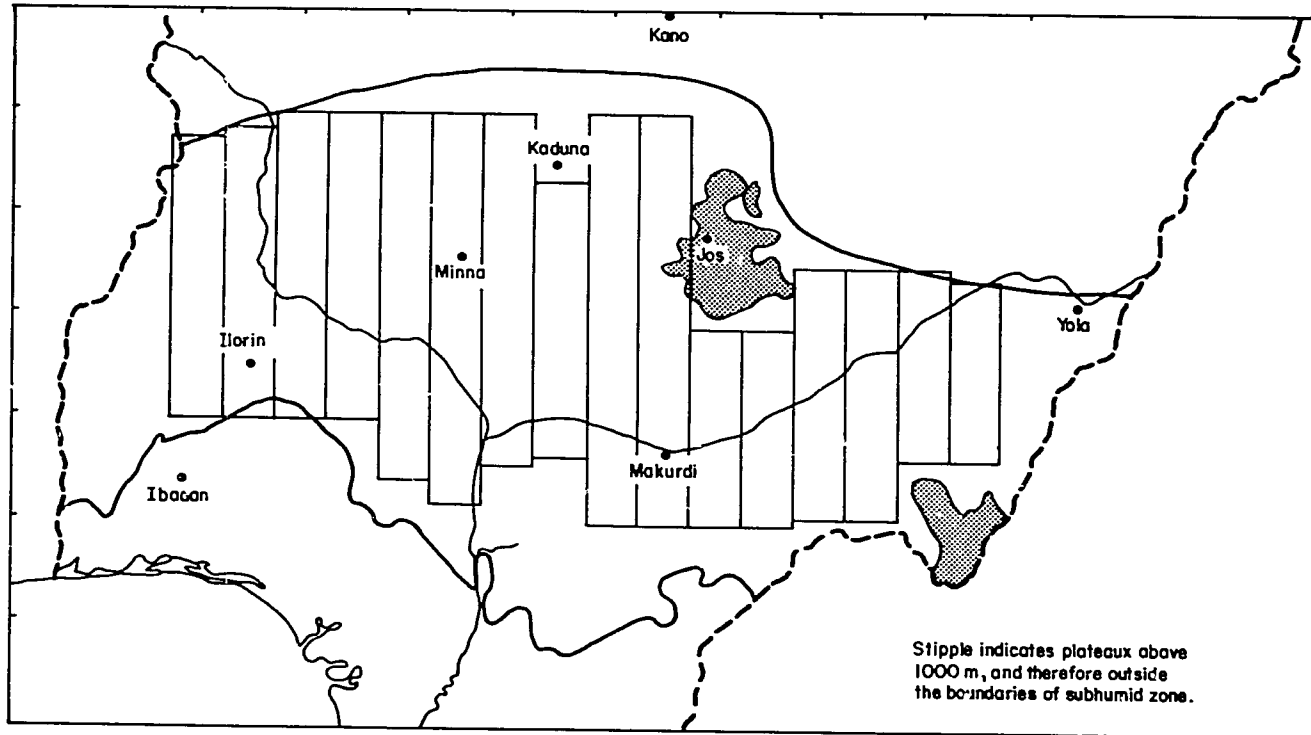
In order to obtain more objective measures of cattle distribution and abundance in the Nigerian subhumid zone than had previously been undertaken, IICA adapted and extended an existing technique of wildlife population assessment, based on low-level aerial survey, or systematic

reconnaissance flights (Norton-Griffiths, 1978; Milligan et al, 1979; Milligan and de Leeuw, 1983).

Time, manpower and financial constraints limited high sampling intensity aerial surveys to specific case study areas, but nevertheless low-intensity surveys over some 356 510 km² of the subhumid zone were carried out during March and July 1983 (dry and wet seasons, respectively). The primary objectives were to put the ILCA case study areas into zonal perspective; to assess overall cattle distribution gradients; and to determine seasonal changes in cattle density and herd size. With the necessarily low sample intensity, estimation of total cattle numbers was considered to be of secondary importance, and the figures obtained should be treated as a first approximation, and as a basis for further study. Nevertheless, the results were of considerable general interest, as they provided the first objective measure of the size of the Nigerian subhumid zone's cattle population. They have therefore been used in this paper to examine the zonal cattle populations in the light of the changes described in the preceding pages.

Essentially the ILCA aircraft, a high-winged, twin-engined Partenavia P68B, flew a series of 16 north-south parallel flight lines of varying length, across the subhumid zone, at intervals of half a degree of longitude (56 km), as indicated in Figure 2. At the selected flying altitude of 1000 feet above ground level, back-seat observers, to the left and right of the aircraft, monitored two strips of ground, each 400 m wide, giving a sampling intensity of 1.4%. The size of all cattle herds seen within these strips was estimated by eye, and wherever possible a 35-mm photograph was also taken, using cameras fitted with zoom lenses. Subsequently, herd size was accurately counted from these photographs; observer biases were determined; and corrections were made to observer estimates. These corrected figures were then used to calculate cattle density and estimate population size by the ratio method (Jolly, 1969).

Figure 2. Longitudinal blocks sampled during low-altitude, low-intensity aerial survey of the Nigerian subhumid zone.



Estimates of cattle and herd numbers

There was no significant difference between overall seasonal cattle population estimates (Table 1). For the area surveyed they ranged from 3.4 million head in the wet season to 3.7 million head in the dry season, equivalent to a total of between 4.3 and 4.7 million head for the Nigerian subhumid zone as a whole. The dry-season estimate of 10.3 animals per km² was only 8% higher than the wet-season value of 9.4 animals per km². Thus, no major dry-season net influx of cattle was detected. This would indicate that either seasonal immigration was more or less equal to emigration; or, as seems more likely in view of the probable increase in sedentarization of the Fulani, most seasonal cattle movements occurred only on a relatively modest scale and took place largely within the subhumid zone.

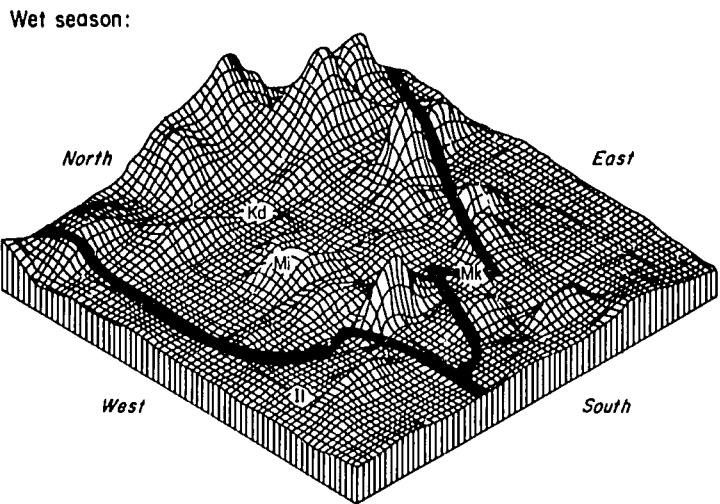
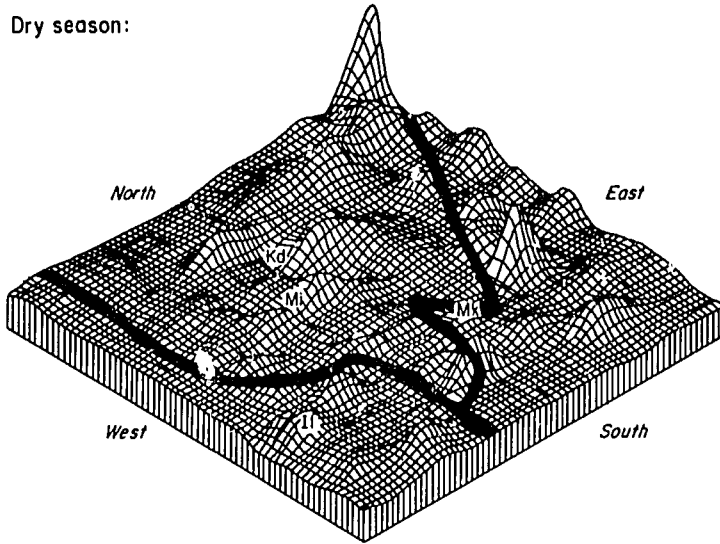
Although only minor seasonal differences were found in the estimated size and density of the subhumid zone's cattle population, a substantial 25% difference in mean herd size was detected (Table 1)^{1/}. Mean herd size in the dry season was 55, whilst in the wet season it increased to 68 animals per herd. This resulted in a marked fall in the estimated number of herds in the surveyed area from 66 000 in the dry season to 49 000 in the wet season, or 85 000 and 63 000 respectively for the subhumid zone as a whole. In terms of overall herd density this amounted to a decline from 18 to 14 herds per 100 km². Such seasonal changes in mean herd size have been detected in other aerial surveys within the subhumid zone (Milligan et al, 1979) and are largely due to the Fulani management practice of herd splitting during the dry season (Okali and Milligan, 1980).

Distribution of cattle

The contrasting patterns of wet- and dry-season cattle distribution over the subhumid zone are represented by the three-dimensional surfaces shown in Figure 3, in which cattle density is indicated by apparent height.

^{1/} Throughout this paper the term 'herd' is used to mean 'grazing unit', i.e. the groupings of cattle that are observed from the air.

Figure 3. Wet- and dry-season cattle distribution in the Nigerian subhumid zone.



Caution is required in the interpretation of these surfaces, as the coordinates of the subhumid zone have been transformed in order to make the information amenable to three-dimensional computer analysis. Effectively the east-west dimension has been foreshortened, and the north-south dimension has been equilibrated, so that the whole of the Nigerian subhumid zone is represented by a square. However, as an aid to orientation and better understanding, the course of the Benue and Niger rivers, and the location of major towns have been indicated.

Comparison of the two surfaces illustrates clear changes in seasonal cattle distributions. Although cattle were found throughout the zone in both seasons, their overall distribution was far from uniform and shows a generally clumped pattern which was most pronounced during the wet season. In the dry season the cattle were more evenly distributed, with higher densities occurring to the east and northeast, and lower densities to the southeast and along the southern, western and most of the northern boundaries.

In contrast, wet-season cattle distribution appeared to be generally more restricted and concentrated within a broad central region to the north of the Niger and Benue rivers. The highest densities occurred on the northern boundary of the subhumid zone, with a progressive decrease in density further south, particularly to the southwest and the southeast. In more southerly latitudes dry-season cattle density exceeded that found in the wet season, whilst in more northerly parts of the zone the reverse was the case. Only in the extreme east and north of the region was there any indication of substantial cattle movements between seasons, and there were significant numbers of livestock in the southern half of the study area during both surveys.

Table 1. Cattle and herd estimates for the Nigerian subhumid zone, derived from low-intensity, low-level aerial surveys.

	Dry season	Wet season
Area of subhumid zone (km ²)	455,500	455 500
Area surveyed (km ²)	356 510	356 510
Area sampled (km ²)	4 959	4 536
Sample intensity (%)	1.4	1.3
Date of survey	March 1982	July 1982
Mean cattle density/km ²	10.25	9.44
Mean cattle stocking rate/ha	9.8	10.6
<u>Estimated number of cattle</u>		
In area surveyed	3 654 200	3 365 500
In subhumid zone	4 668 900	4 299 900
Mean herd density/100 km ²	18	14
Mean herd size	55	68
<u>Estimated number of herds</u>		
In area surveyed	66 440	49 490
In subhumid zone	84 890	63 230

Cattle density and vegetation type

Table 2 gives the seasonal mean cattle densities and mean herd sizes in each of the predominant vegetation types within the surveyed area of the subhumid zone, based on Side Looking Airborne Radar Vegetation and Land Use Maps (FDF, 1978). The estimated area of the major vegetation and land use types is also shown, as is the proportion estimated to be under cultivation within each.

The highest cattle densities were found during the dry season in regions where aquatic grassland and riparian vegetation predominated. Mean densities of more than 30 head per km² were encountered and reflected a concentration of cattle in riverine floodplains and in proximity to perennial water sources, as represented by riparian forest. However, because these vegetation types amounted to only 3% of the surveyed area,

the proportion of the total cattle population they contained was relatively small - around 10% in the dry season and 3% in the wet season.

Little seasonal change was evident in the cattle density within transitional woodland. This was much the largest vegetation and land-use category, amounting to some 40% of the surveyed area, but at 6-7 head per km², was one of the least well stocked. As a consequence, this category contained only 24% of the estimated overall cattle population in the dry season, and 30% in the wet season.

Cattle density in woodland vegetation was somewhat higher than in transitional woodland, but showed little seasonal change and remained constant at about 10 animals per km². However, as this vegetation type only occupied some 7% of the surveyed area it contained a relatively small proportion of the overall cattle population.

The four remaining vegetation and land-use types, occupying some 46% of the surveyed area, contained approximately 60% of the estimated overall cattle population in both the wet and dry seasons. A feature common to each of these vegetation and land-use categories was that more than 20% of their land area was under cultivation. In the two farmland categories cattle density increased from around 11-12 animals per km² during the dry season to 16-17 per km² during the wet season. The other two categories, wooded-shrub-grassland and farmland/woodland mosaic, showed the opposite trend in cattle density, with a decline from about 13 animals per km² in the dry season, to between 8 and 11 in the wet season.

Cattle density and land-use intensity

The distribution of cattle in relation to cultivation levels was also examined in more detail than was possible from the SIAR maps, using estimates of cultivation made from the air. These do not include fallow land. Figure 4 shows the variations in mean cattle density, mean herd density and mean herd size that were found at different levels of land-use intensity. Very few cattle were found in areas where cultivation was absent, particularly in the wet season. In both seasons mean cattle density rose progressively to reach a peak of approximately 16 animals per

km² at between 20 and 40% cultivation. At higher cultivation levels, cattle density decreased in both seasons, but more so in the wet season.

Table 2. Seasonal cattle density and mean herd size in the predominant vegetation and land-use types of the Nigerian subhumid zone.

Vegetation and land-use types	% Area	% Cultivation ^{a/}	Cattle density ^{b/}		% Total cattle		Mean herd size	
			Dry	Wet	Dry	Wet	Dry	Wet
Woodland	7	10	9.77 (31%)	9.97 (86%)	7	7	65	111
Transition ^{c/}	40	12	5.94 (18%)	7.20 (25%)	30	23	50	63
Wooded-shrub-grassland	6	21	13.44 (30%)	8.37 (18%)	5	8	46	52
Mosaic ^{d/}	24	30	12.95 (16%)	10.76 (19%)	27	31	62	77
Farmland 30 - 60%	8	26	11.89 (15%)	17.23 (25%)	14	10	50	64
Farmland > 60%	8	50	11.17 (46%)	15.98 (26%)	14	9	49	61
Aquatic grassland	2	7	31.22 (21%)	4.08 (64%)	1	6	78	51
Riparian	1	12	30.02 (39%)	12.92 (89%)	2	4	83	92
Minor Types	4	8	-	-	-	2	-	-
Total/Mean	100	20	10.25 (11%)	9.44 (16%)	100	100	55	68

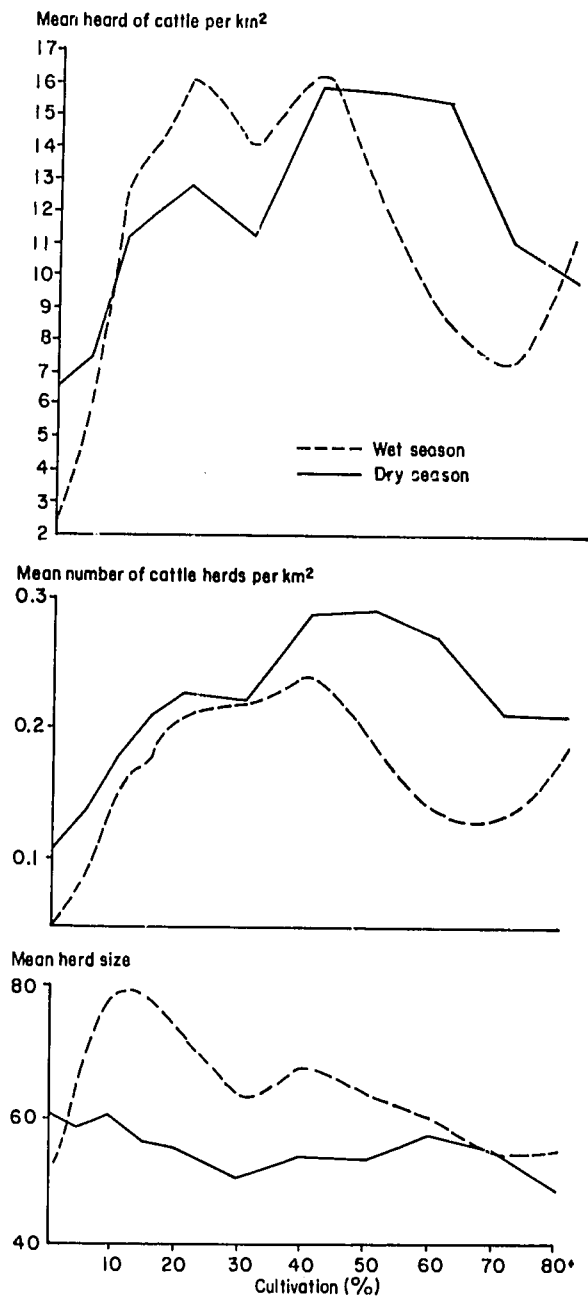
^{a/} Figures in parenthesis are percentage standard errors.

^{b/} Visually estimated during aerial survey.

^{c/} Transitional between woodland and wooded-shrub-grassland.

^{d/} Mosaic of wooded-shrub-grassland and farmland, with 30 - 60% cultivation.

Figure 4. Variation in cattle density, herd density and herd size with land-use intensity in the Nigerian subhumid zone



Mean herd density followed a similar pattern to that of cattle density, but it was evident that dry-season herd densities were consistently higher than in the wet season.

A maximum mean herd size of some 80 animals was found during the wet season at land-use intensities of between 10 and 20%. At higher levels of cultivation mean herd size progressively declined. In contrast, during the dry season mean herd size appeared to be relatively stable, fluctuating between 50 and 60 animals per herd, over a wide range of land-use intensity.

DISCUSSION AND CONCLUSIONS

Referring to the typical seasonal movement of cattle in Nigeria, Glover (1960) commented that: "The annual migration of Fulani takes two forms in the dry season. In one the movement is local; the herds only go short distances into neighbouring river valleys which are often infested by tsetse flies where grass and water can be found. This form of local migration also includes the movement of cattle from high ground, like the Jos Plateau, into the surrounding foothills. The other form, which applies to most of the Fulani cattle, consists of a journey southwards, covering hundreds of miles in search of food and water. The herds often traverse large fly belts on the way and may well spend the whole dry season in tsetse-infested country."

Nearly a quarter of century has elapsed since that description was written, and during that time the Nigerian environment has been modified substantially; the pattern and extent of seasonal cattle movement has altered significantly; and the proportion of nomadic cattle owners has declined (Oxby, 1982). Van Raay (1975) considered that only 12% of Nigerian Fulani were fully nomadic, while he regarded 38% to be semi-settled, and the remaining 50% to be fully settled.

For many years the primary cause of the profound and widespread changes in the Nigerian environment has been the rapid increase in human population, which has led to an ever increasing demand for food and land. This demand has been further exacerbated by the immigration of pastoralists from the Sahel in response to the frequent droughts. As a result there has been

greater competition for land in areas of high human population density, and consequently a progressive expansion of agriculture into areas of lower human population density. The latter process has been both encouraged and channelled by the expansion of Nigeria's major road network, particularly into the moderately high rainfall areas of the subhumid zone.

In the past both the northern and southern regions of Nigeria were recognized as areas of high human population density, with the central 'Middle Belt' being characterized by relatively low human population levels and little cultivation (Buchanan and Pugh, 1955). However, as reflected in the SIAR vegetation and land-use maps, circumstances have changed and these characteristics can no longer be considered valid for the zone as a whole. Not only are local populations increasing in size, but also, because of increased land pressure, both to the north and to the south, people are leaving their traditional areas and are moving into and settling within the subhumid zone.

It is apparent that the main thrust of this agricultural expansion within the subhumid zone has been experienced in a central bridging band, from Kano State in the north, southwards to the west of and including the Jos Plateau, through Abuja, across the Niger and Benue fork, towards Benin city and Enugu. There has been a consequent expansion of markets and trade routes into areas of previously high tsetse and trypanosomiasis challenge.

The increasing extent and intensity of both farming and hunting within this central bridging belt has greatly changed the pattern of vegetation and land use, and inevitably led to an overall reduction in wildlife species, and in many places brought about their local extinction. Thus both natural habitats and hosts of tsetse, the vectors of trypanosomiasis, have declined, which in turn has brought about a widespread reduction in the flies' distribution. The two savanna species, G. morsitans and G. longipalpis, which typically have high trypanosome infection rates, have been most severely affected by the changes taking place within the subhumid zone, and their overall distribution has contracted. This, together with the general decline in the wildlife reservoir of trypanosomiasis has resulted in a marked reduction in the silvatic cycle of disease transmission.

In contrast, the riverine species of tsetse G. palpalis and G. tachinoides, which have comparatively low infection rates, have tended to persist despite widespread environmental changes brought about by agricultural expansion. In part their continued survival has depended on their close association with riverine forest and thicket vegetation, and the greater human effort required to convert this type of vegetation into farmland. The continued survival of riverine species of tsetse has also depended on their more catholic feeding habits; in particular, their ability to adapt to the alternative hosts provided by the frequent, regular passage of cattle and people at forest crossing and watering points.

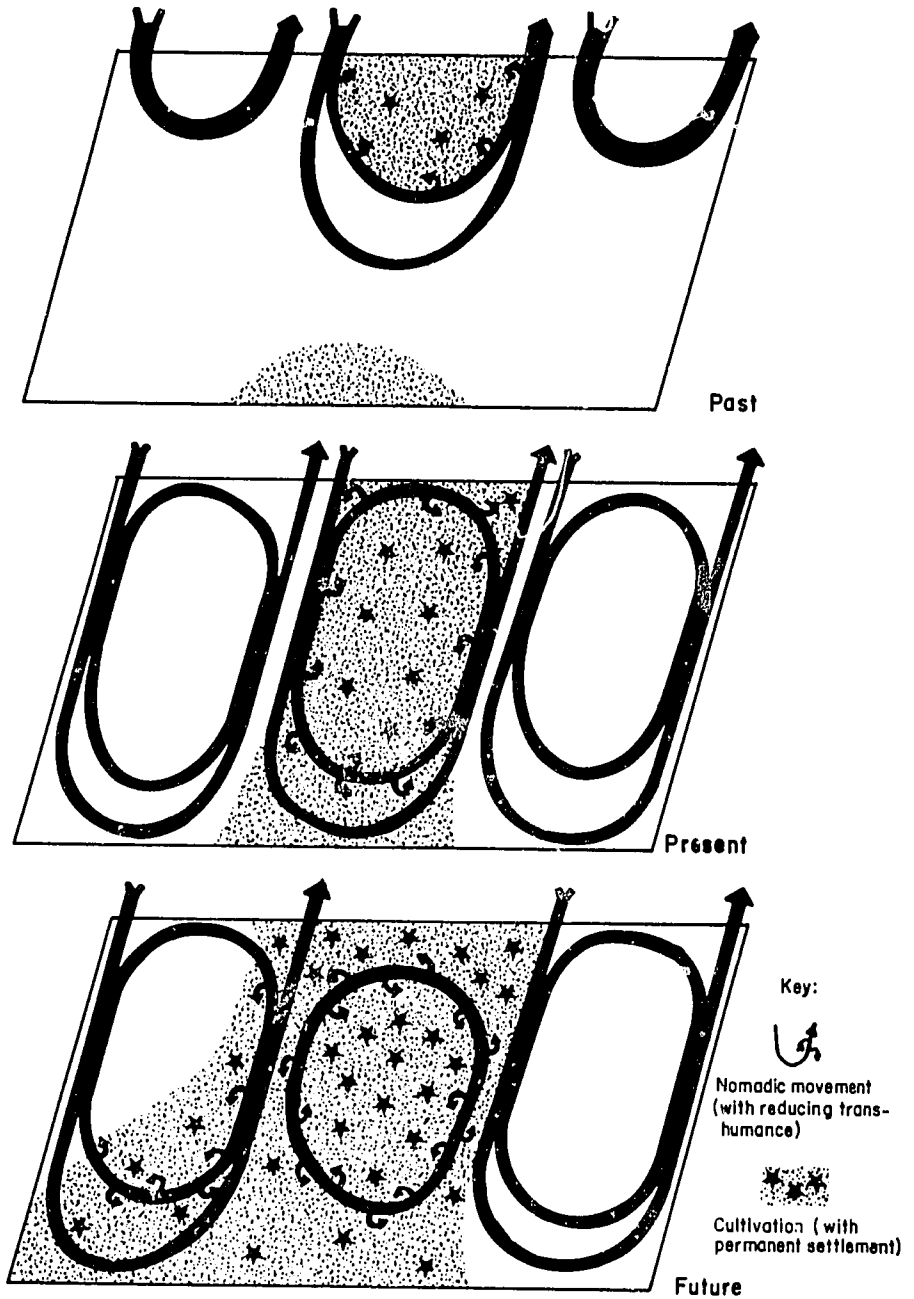
Nevertheless, because of the very restricted distribution of riverine tsetse, their relatively limited abundance, and their low infection rates, typically with trypanosomes of non-silvatic origin, the trypanosomiasis challenge they represent is likely to be relatively low.

The distribution of cattle within the subhumid zone and the seasonal changes described in this paper are considered to represent a transitional stage in a continuing southward spread of Fulani cattle owners and their zebu stock. This southward drift is inextricably bound up with three interrelated factors. A long-term process of agricultural expansion, resulting from human population increase and greater competition for land resources, is generally opening up and changing the environment of the subhumid zone, and at the same time leading to a proliferation of local markets for the sale of dairy and meat products. This has led to a decline in the incidence of trypanosomiasis during the wet season, and a rise in levels of cultivation. Both these processes have encouraged an influx of pastoralists and their cattle. Many of these settle permanently, either because they were sedentary before they migrated, or because they were nomads but have abandoned their traditional way of life in response to the falling value of milk products relative to grain (RIM, 1984).

A SCHEMATIC MODEL OF CATTLE DISTRIBUTION DYNAMICS

A conceptual view of the possible overall dynamics of cattle distribution within the Nigerian subhumid zone is illustrated in the form of a three-phase model shown in Figure 5, in which past, present and future conditions within the zone are represented.

Figure 5. Schematic model of the dynamics of cattle distribution in the Nigerian subhumid zone.



In the past, zebu distribution was transient and limited largely to a dry-season influx of nomadic cattle from the north, indicated by the broad pathways entering and exiting the zone. Cultivation, represented by stipple, is shown encroaching the zone centrally from both the north and the south.

Associated with the expansion of agriculture into the subhumid zone, there has been an increasing degree of sedenterization amongst Fulani cattle owners. This has involved both a reduction in the range of their seasonal transhumance, represented in Figure 5 by the 'eddies' spiralling off the schematic pathways of cattle movement; and an increased proportion of permanent settlement, symbolized by stars.

As time passed and population increased, agricultural expansion was focussed on the central bridging band across the subhumid zone, but because of generally increased competition for limited land resources to the north, seasonal cattle movements extended progressively further south into the subhumid zone. This southward dispersal of cattle, which has occurred across the entire zone, has been encouraged by a trend of increasing aridity further north, and by a general decline in the distribution and abundance of tsetse and a consequent reduction in the significance of trypanosomiasis.

This situation is illustrated in the central model of Figure 5, representing conditions at present, in which substantially reduced seasonal transhumance and increased settlement of Fulani and their cattle is indicated within the central bridging band of cultivation stretching across the subhumid zone. To the east and the west a southward dispersal of cattle has also taken place, to such an extent that much of the seasonal movement of cattle, even of long-distance transhumance (represented by the large oval pathways), is now believed to take place within the subhumid zone itself. The proportion of nomadic immigrants from further north is now considered to be low in comparison with permanent residents of the subhumid zone.

In the future, as land pressure in the central bridging zone, as well as to the north and south, continues to increase, as it must while the rural human population increases, it seems inevitable that agricultural expansion will increasingly be directed outwards to the west and east.

However, because of the siting of the new Federal Capital at Abuja and the major commercial/communication axis linking Lagos, Ibadan, Abuja, Kaduna and Kano, preferential agricultural expansion and land development are likely to take place to the south and west. Thus, as indicated in the future model of the subhumid zone, southwestward spread of arable agriculture and rural populations can be anticipated, along with a closely associated dispersal of cattle and Fulani who can be expected to settle and gradually establish a system of mixed farming.

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Traditional cattle production
in the subhumid zone of Nigeria

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ABSTRACT

The sizes, structures, general management and productivity of herds under pastoral conditions in the Kaduna Plains of Nigeria are briefly described. Herd sizes averaged 45.9 head, 64.4% of which were females. Calvings and conceptions were bimodally distributed. Age at first calving, calving percentage and calving intervals averaged 60 months, 48% and 25 months respectively. Calf liveweight and mortality to 1 year of age averaged 103 kg and 22.4% respectively. After adjusting for length of calving intervals, milk for humans and calves averaged 112 and 169 litres/cow/year respectively. The productivity of Bunaji cattle under sedentary pastoral management is thus well below genetic potential.

INTRODUCTION

The Bunaji breed constitutes about 51% of the estimated 9.3 million cattle in Nigeria (Lamorde and Franti, 1975). Studies were initiated by IILCA's Subhumid Zone Programme to determine the constraints on improving the productivity of this breed.

Bunaji herds in the case study areas are routinely penned at night, released after milking each morning and herded to the grazing ground. Unweaned calves are tied in order from youngest to oldest to a rope called

the dangwali, situated near the enclosure for the adults. Throughout the growing season animals are penned to prevent them from damaging crops, and to ensure that they are not stolen. The enclosure is often a single strand of barbed wire. During the dry season, once crops have been harvested, adult animals are often tied in open fields in pairs, according to age.

Breeding is not controlled, allowing cows to become pregnant throughout the year and spreading the income from milk sales. Calves usually wean themselves when the dam ceases milking but pastoralists resort to artificial weaning when the dam is in an advanced stage of pregnancy and the previous calf is still suckling. This is done by smearing the dung of young calves on the dam's teats every day until the calf stops sucking. Bulls not wanted for breeding are not castrated unless they are troublesome, and in any case not until they are 2 or more years of age. Castration is performed in crude surgical operations, or by stretching the scrotum between two light poles and crushing the spermatic cords with an iron bar.

The daily morning milking is begun by allowing the calf to suckle for about a minute to initiate the flow of milk. The calf is then tethered to the near side foreleg of its dam while the hind legs of the dam are held to prevent the cow from kicking whoever milks her. Milking is usually done by men or boys. The quantity of milk extracted from each cow depends on the milker's experience, discretion and the cow's stage of lactation. After milking, the cow and calf are released and the calf suckles the remainder of the milk. Since cows will not let down in the absence of their calves, milking stops when a calf is lost.

After the milking the pastoralists put out karwa, a local mineral supplement that is high in calcium (23.7%) and also contains a little phosphorous (0.6%). Karwa is a traditional trade item brought from northeastern Nigeria and often erroneously called potash.

MATERIALS AND METHODS

Data were collected over a 4-year period for some 30 herds in the Abet, Kurmin Biri, Kaduna and Madauchi areas of central Nigeria. The Kaduna and

Madauchi herds are located in peri-urban locations near Kaduna city and Zonkwa town, and were included in the study to provide a contrast with the rural sites of Abet and Kurmin Biri.

Initial records of age and number of calves dropped by breeding females in each herd were obtained by questioning the owners. Age was verified or modified after the animals' teeth were examined. As calves were born into the herd, date of birth, birthweight and dam number were recorded. The initial herd calving percentage was estimated as follows:

$$\text{Calving percentage} = \frac{\text{Total number of calves dropped}}{\text{Total number of cow years}} \times 100$$

Cow years were augmented by adding one third of the total for weaned heifers. This was done because an earlier survey had shown that one third of weaned heifers were capable of calving. Calving percentage was updated monthly by the same formula, in which cow months were divided by 12 to give cow years.

Calves were weighed at weekly intervals until weaned. Calves weighing more than 100 kg were measured around the heart girth and the scapulo-ischial length to estimate weight by the Ross (1958) formula. Adult animals in the ILCA research herd were weighed periodically using a weighbridge. The amount of milk extracted for human consumption was recorded daily. The milk equivalent for calf growth to 180 days postpartum was estimated by the following formula (Drewry et al, 1959; and Montsma, 1960; 1962):

$$\text{Milk equivalent} = (120\text{d wt} - \text{birth wt}) \times 11.65 + (180 \text{ wt} - 120\text{d wt}) \times 8.55$$

A milk production index was then calculated:

$$\text{Milk production index} = \frac{\text{Annual extracted milk} + \text{milk equivalent}}{\text{Calving interval}} \times 365$$

Owners were interviewed from mid-February 1984 to mid-April 1984 to determine which cows were pregnant and the approximate stage of each pregnancy. Ninety-five calving intervals were estimated in this way and added to the intervals already recorded over the previous 3 years.

Based on rainfall data recorded by ILCA since 1980 in the study area, the months of the year were grouped into four subseasons:

<u>Subseasons</u>	<u>Months</u>
Dry	December-February
Early wet	March-May
Peak wet	June-August
Late wet	September-November

Data on birth weights, growth rate, milk offtake, calf survival and calving intervals were analysed by Harvey's least squares fixed model procedures (Harvey, 1972). The model included effects of season, year, sex of calf, location, and owner. Interactions between year and season were incorporated in the model. Parity of the calf at birth was not known and was therefore not considered in the analysis. Unequal and disproportionate subclass numbers gave unbalanced factorial designs for which conventional analysis of variance techniques were not applicable. The factors used in the model are evident when the results are presented for each character analysed. The residual mean square was used as the error term to test the significance of all differences evaluated. Linear contrasts of least squares means were computed to determine differences between groups.

RESULTS AND DISCUSSION

Herd size and structure

Herd size data were obtained from three study locations and are shown in Table 1.

Table 1. Herd sizes at different locations, 1979.

Location	N	Herd size		Mean	SD±
		Maximum	Minimum		
Abet	11	61	13	38	16.2
Kurmin Biri	12	96	16	48.6	27.0
Madauchi	11	135	25	50.8	29.8
All herds mean	34	-	-	45.9	24.9

The results of a survey involving 1560 head of cattle grouped into age and sex classes in 34 herds at Kurmin Biri (583), Abet (418) and Madauchi (559), are summarized in Figures 1, 2, 3 and 4. Females averaged 64% of the herds in the three different locations.

Herds in Abet contained a low number of males, and no males older than 8 years were observed. In Kurmin Biri there were a few males older than 8 but under 10 years. These were steers. At Madauchi, there were more older males, again mostly steers. The percentage of steers in the herds were 3.9, 3.1 and 7.5% in Kurmin Biri, Abet and Madauchi respectively.

Reproductive performance

Age at first calving, length of calving interval and length of productive life of the cow are the most important factors in the productivity of breeding herds.

Data summarized in Table 2 suggest that the average age at first calving is about 60 months. This agrees with data obtained from Bunaji herds on the Jos Plateau (Pullan, 1979; Synge, 1980). Average age at first calving of Bunaji females on government farms at Kabomo and Birnin Kudu in northern Nigeria was about 42 months (Wheat and Broadhurst, 1968; Wheat et al, 1972). At the National Veterinary Research Institute at Vom, age at first calving in Bunaji averaged 37 months (Ologun, 1980).

Figure 1 . Composition of pastoralists' herds in Kurmin Biri.

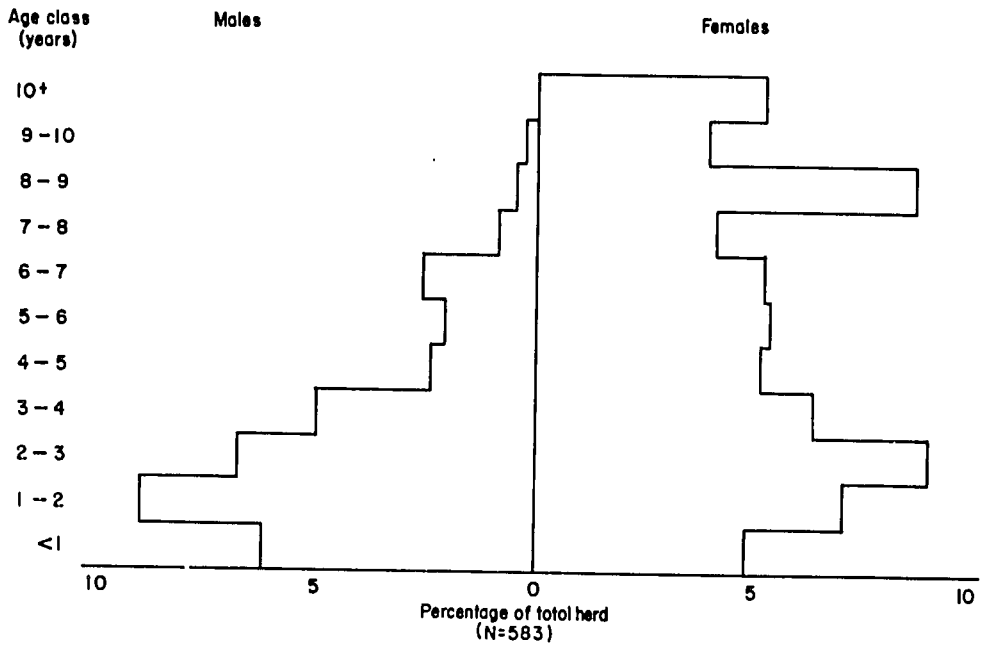


Figure 2 . Composition of pastoralists' herds in Abet.

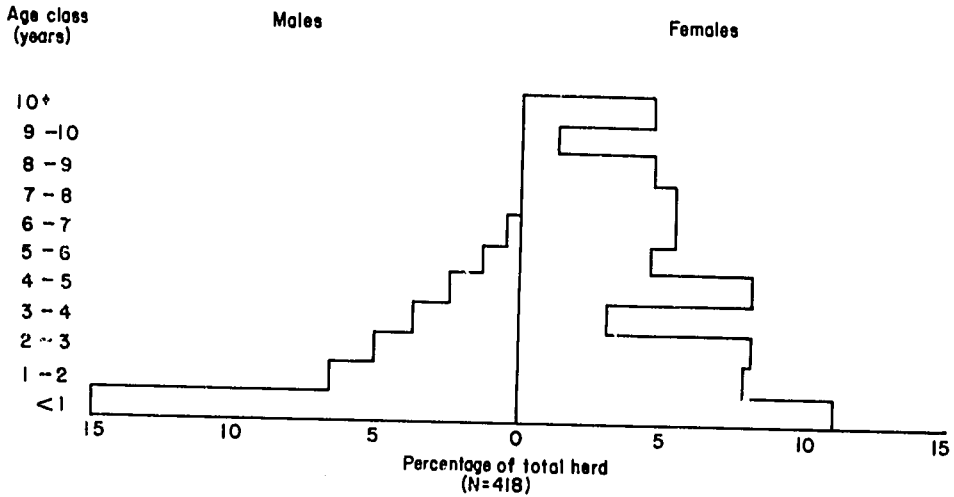


Figure 3. Composition of pastoralists' herds in Madauchi.

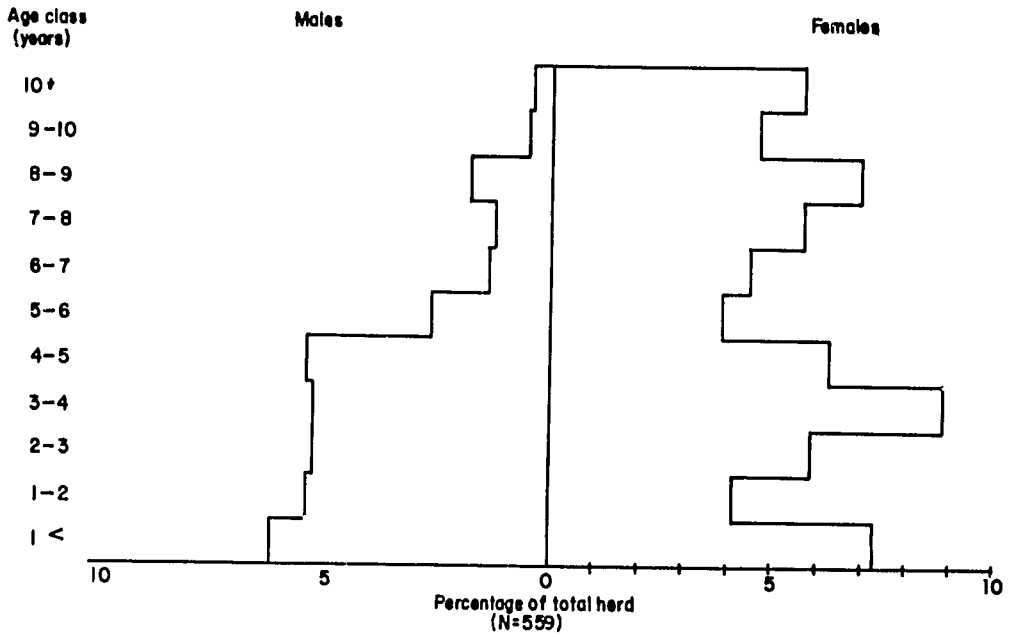
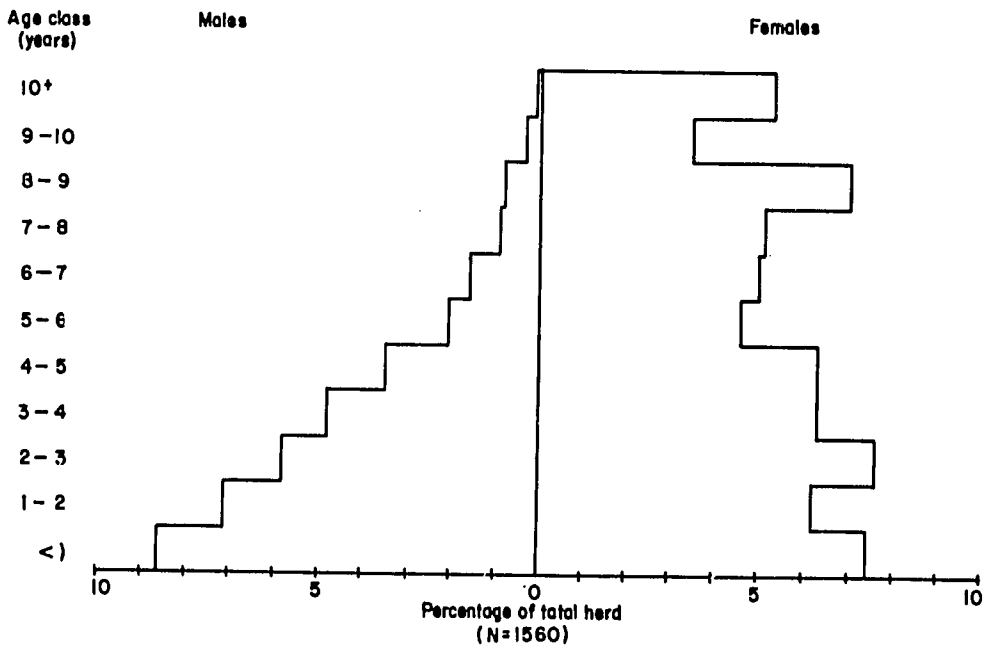


Figure 4. Composition of pastoralists' herds in Kurmin Biri, Abet and Madauchi.



Only a few of the females in this survey had produced more than four calves (Table 2). With an estimated age at first calving of about 5 years and a calving interval of about 25 months, cows with four calves would be about 11 years old.

Since breeding is uncontrolled it was expected that heifers were breeding too young. Only eight heifers born since ILCA started recording births in 1979 had calved for the first time when this analysis was made. This subgroup averaged 43 months at calving. That uncontrolled breeding does not necessarily lead to premature breeding is also borne out by the results of Wilson and Clarke (1975).

Table 2. Number of cows reported by producers to have given birth to different numbers of calves in three study locations.

Number of permanent incisors (age of cow)	Number of cows ^{a/} giving birth to number of calves						
	0	1	2	3	4	5	6+
1 pair (over 24 months) ^{b/}	28						
2 pairs (over 30 months)	73						
3 pairs (over 39 months)	53	8					
4 pairs (over 48 months)	38	74	85	90	76	19	19
Total	192	82	85	90	76	19	19
% of overall total	35.5	14.3	14.8	15.7	13.3	3.3	3.3

^{a/}Total number of cows = 563 from 32 herds.

^{b/}According to Wilson and Clarke (1975).

Calving intervals

The mean calving interval for 236 records from 1979 to 1981 was 757.3 days. None of the environmental effects included in the model had a significant effect on calving interval.

Least squares means of calving intervals are shown in Table 3. The mean for calvings which occurred in 1979 was below the overall mean, while that of 1980 was 28.9 days longer. The interval for calvings that occurred in

the dry season was 110 days longer. Although the intervals of these calvings was not significant at the 5% level, with more data they may prove to be the result of poor nutrition.

Calving intervals for herds in Abet and Madauchi were below the overall mean, while those in Kurmin Biri were about 31 days longer.

Table 3. Estimated least squares means for calving interval (days) in Bunaji herds.

Variable	No. of records	Mean
Overall	236	757.3 (25.2) ^{a/}
<u>Year of calving</u>		
1979	49	730.0 (24.3)
1980	76	786.2 (26.2)
1981	111	755.7 (25.2)
<u>Season of calving</u>		
Dry	28	867.3 (28.9)
Early wet	93	767.2 (25.6)
Peak wet	36	68.2 (22.7)
Late wet	79	712.5 (23.8)
<u>Sex of calf</u>		
Male	119	765.5 (25.5)
Female	117	749.1 (25.0)
<u>Location of herd</u>		
Kurmin Biri	114	789.6 (26.3)
Abet	96	734.5 (24.5)
Madauchi	26	748.8 (25.0)

^{a/} Figures in parenthesis are calving intervals in months.

Pullan (1979) estimated a calving interval of about 27 months in Bunaji cows in pastoralists' herds on the Jos Plateau. Bunaji cows in government herds have averaged about 14 months (Wheat and Broadhurst, 1968; Wheat et al, 1972). The long calving intervals recorded by IICA are probably associated with lactation stress, since milking and calf suckling are continued as long as possible. Cows suckle their calves and are milked by hand as long as even a very small amount of milk is produced. Offtakes as low as 250 ml/cow/day are not uncommon.

Calving percentage

From the calving intervals reported above, calving percentage was estimated to average about 48.2%. This figure is close to the mean of 47% obtained by dividing the total number of calves by the total number of cow years. The mean calving percentage observed in this study was higher than that observed in traditional herds on the Jos Plateau (Pullan, 1979; Synge, 1980).

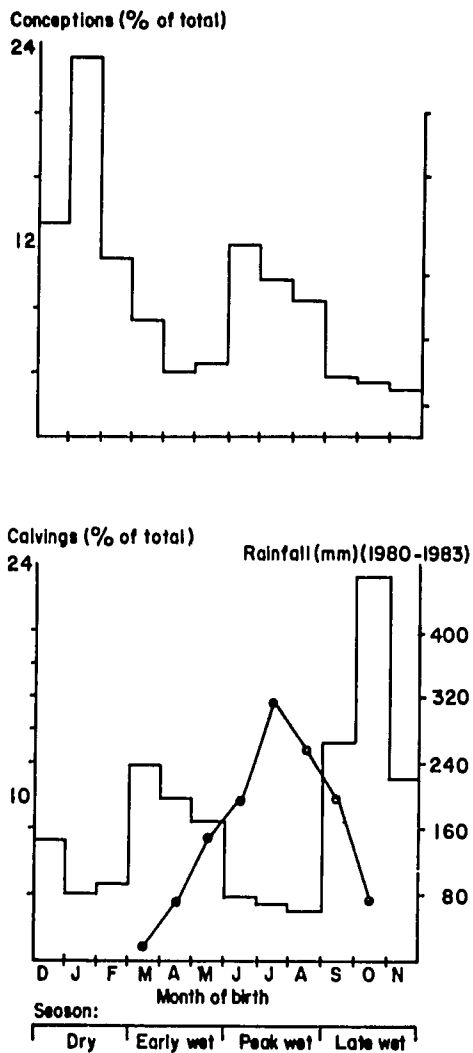
Seasonal effects

Whereas high correlations ($r = 0.82$) between annual rainfall and calving have been found elsewhere (Butterworth, 1983), in the present study very low correlations were found between annual rainfall and calving or conception.

Several research workers have demonstrated that uncontrolled breeding leads to seasonally uniform calving (Menendez et al, 1978; Pena and Plasse, 1971; Butterworth, 1983). The present study revealed two calving peaks (Figure 5), an early wet-season peak between March and May and a late wet-season peak between September and November. Similar observations have been made on the Jos Plateau (Lamorde and Franti, 1975; Pullan, 1979; Synge, 1980). Zakari et al (1981) reported fewer oestrous cycles in Bunaji cows during the dry and pre-rainy seasons, when behavioural signs of oestrus were poorly manifested and lasted for only a short period. During the rainy and pre-dry seasons, however, the duration of oestrus and behavioural signs of heat were much more pronounced.

These findings are related to the nutrition of the animals, since the periods when forage quality is low coincide with the periods of suppressed oestrus and mating behaviour.

Figure 5 . Monthly distribution of rainfall, births and conceptions .



The present study found that about 74% of conceptions occurred during the dry months from November to February; the remainder occurred during the early and peak wet-season months from March to August.

The wet-season peak is caused by improved nutrition and the rising liveweights of the heifers and cows. The reason for the dry-season conception peak is less obvious, but it is probably related to crop residue grazing. Cattle spent about 200 minutes each day on crop residues in December, and about 60 minutes in January and February. The chemical composition of the major crop residues (sorghum and millet) and the time spent grazing them indicate that residues are a major source of nutrients during this period (Paper 14).

From February to April, cattle spent over 60 minutes a day (about 12% of their total grazing time) browsing, and this must be an important part of their diet (Le Houérou, 1980; Dicko-Touré, 1980; Toutain, 1980). Leguminous browse plants are rich in phosphorus (Kapu, 1975; Agishi, 1984). As noted above, karwa, a local mineral supplement, is fed to animals during the dry season. Although it has been analysed (Table 4), its effect on oestrous activity in the dry season is unclear. Its phosphorus content is higher than that of local native pasture, but its high calcium to phosphorus ratio could cause a nutritional imbalance. It is possible that the cumulative effects of crop residue grazing, browsing and the mineral supplement could cause the higher conception rate during this period.

Table 4. Principal elements in karwa cattle salt.

Na (%)	K (%)	Ca (%)	P (%)	Mg (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Co (ppm)	Zn (ppm)
1.5	4.7	23.7	0.6	848.7	774.7	407.2	44.2	23.6	176.0

Calf growth

The data set used to assess calf growth contained 322 records and covered the period 1979-1982. Weaning weights were included. The results are presented in Table 5.

Table 5. Least squares means of calf liveweight (kg) from birth to 1 year.

Variable	No. of records	Age (days) ^{a/}				
		Birth	30	90	180	365
Overall mean	322	19.4	28.4	43.6	60.2	103.6
<u>Year of calving</u>						
1979	58	19.3	27.7ab	41.9ab	56.9a	104.4b
1980	87	19.2	27.1a	40.1a	52.0a	94.2a
1981	102	19.0	28.6ab	44.0b	63.4b	106.4b
1982	75	19.8	30.2b	48.6c	68.4c	109.4b
<u>Season of calving</u>						
Dry	52	19.1	27.0	39.8a	61.0ab	101.1ab
Early wet	110	19.4	28.7	44.8a	63.7b	97.1a
Peak wet	31	19.2	29.2	47.0b	58.6ab	104.4a
Late wet	129	19.7	28.8	42.9ab	57.4a	111.8b
<u>Sex of calf</u>						
Male	166	19.9a	29.0	44.8a	60.7	105.5
Female	156	18.8b	27.9	42.4b	59.6	101.7
<u>Milk offtake</u>						
Dam not milked	45	19.2	27.5a	44.1	61.3	107.3a
Dam milked	277	19.5	29.3b	43.1	50.0	99.9b

^{a/}Main effects with different superscripts within a column are significantly different ($P < 0.05$).

Overall mean birth weight was 19.4 kg. It was lower than that reported for Bunaji calves under improved management in northern Nigeria (Wheat and Broadhurst, 1968; Wheat et al, 1972; Ologun, 1980; Alaku, 1982). Season of birth had no effect on birth weight, which is at variance with reports by Wheat and Broadhurst (1968), Wheat et al (1972), Alaku (1982), but which agrees with Ologun (1980).

Male calves were 5.9% heavier ($P < 0.01$) than females. The observation confirms earlier reports on Bunaji calves in Nigeria (Wheat and Broadhurst, 1968; Wheat et al, 1972; Ologun, 1980). However, Alaku (1982) observed no difference in the birth weights of male and female calves in northern Nigeria.

Year effects on the liveweight of calves up to 180 and 365 days were highly significant ($P < 0.001$). Calves born in 1980, the year with the most irregular rainfall pattern of the 4 years studied, were 31.5 and 15.2% lighter ($P < 0.001$) by 180 and 365 days than were calves born in 1982, the best year. Calves born in 1981 were also significantly heavier ($P < 0.001$) than the 1980 calves.

By 180 days of age, calves born in the early wet season were significantly heavier ($P < 0.01$) than calves born in the late wet season, but differences in the weight of calves born in the other seasons were not significant. By 365 days of age, calves born in the late wet season were 15.1% heavier than those born early in the wet season ($P < 0.001$). Calves born late in the wet season were 10.6% heavier than those born in the dry season ($P < 0.01$).

Male calves were 5.4% heavier than females ($P < 0.05$) by 90 days of age. However, by 180 and 365 days of age, male calves were only 1.8 and 3.7% heavier respectively than females. That the differences in weight between the two sexes reduced with age indicates that there was no preferential milking of the dams of male or female calves. The similarity in early growth rates is at variance with reports in the literature (Montsma 1960; Wheat and Broadhurst, 1968; Wheat et al, 1972; Gregory et al, 1979; Ologun, 1980).

The overall weaning weight averaged 112.1 kg at an age of 411.2 days (13.7 months). Differences between years were highly significant ($P < 0.01$) but seasonal effects were not significant ($P > 0.05$). Weaned males were heavier by 7.7 kg (7.7%) than females ($P < 0.05$). The effect of nutrition is again demonstrated by the acceleration and deceleration in the rates of weight gain during the wet and dry seasons.

Table 6 shows the least squares means of weight for age of calves at the different locations. Linear contrasts showed that birth weights of calves

born in Abet were significantly higher ($P<0.05$) than those of Kurmin Biri. Although Abet calves were consistently heavier at all ages, the difference after birth was not significant ($P>0.05$).

Table 6. Effect of herd location on calf growth.

Location	No. of records	Age (days) ^{a/}				
		Birth	30	90	180	365
Kurmin Biri	157	19.7b	28.5b	45.3b	65.7b	103.9b
Abet	114	20.9c	29.1b	47.4bc	67.9b	108.0b
Madauchi	37	17.4a	20.2a	29.1a	43.2a	84.2a
Kaduna	14	19.4ab	35.8c	52.7c	63.8b	118.3b
Overall mean	322	19.4	28.4	43.6	60.2	103.6

^{a/} Means with different superscripts within the same column are significantly different ($P<0.05$).

Calves born in Kurmin Biri and Abet were highly significantly heavier ($P<0.01$) than those born in Madauchi at all ages. Differences in birth weights of calves at Madauchi and Kaduna were not significant ($P<0.05$), but after that Madauchi calves were highly significantly lighter ($P<0.01$) than Kaduna calves up to 1 year of age. The poor performance of Madauchi calves may be partly attributed to low milk consumption (see Table 12) and partly to disease.

Pastoralists sometimes do not milk certain cows that are poor milk producers. Calves from dams that were not milked were 7.4% heavier ($P<0.05$) at 1 year than those from dams that were. Dams that were not milked constituted about 16.2% of the population of all dams.

Calf viability

Data on 723 calves born between 1979 and 1982 were used to determine calf viability. The mean mortality rate to 1 year of age was 22.4%; 8.2% died before 90 days, and a further 9% before they were 180 days old. These rates were consistent with Umoh and Jagun (1981) and Umoh (1982), who

reported an average Bunaji calf mortality of 6.0% up to 90 days under NAPRI conditions at Shika, while average mortality from 6 to 12 months was 5.2%. In the present study, over 50% of the deaths occurred by 120 days. Jagun (1980) noted that about 50% of the deaths occurred during the first 30 days of life. He attributed these deaths to calf scours, calf pneumonia, navel ill and physiological starvation. The causes of deaths in the present study were not determined because of the difficulty of obtaining carcasses for postmortem examination.

Effect of year of calving was significant ($P < 0.05$) only at 120 days. Mortality in calves born in 1980 was consistently higher (about 30%) up to 1 year. Calves born in 1981 had the highest survival rate, followed by those born in 1982 and 1979. The causes of these annual differences were not determined.

Table 7. Least squares means of calf viability (%) to 365 days, by location of herd.

Location	No. of records	Age (days) ^{a/}			Average mortality
		90	180	360	
Kurmin Biri	298	96.9	90.8	88.5b	11.5
Abet	264	94.6	86.1	80.6b	19.4
Madauchi	129	94.9	79.5	70.0a	30.0
Kaduna	32	80.7	74.8	71.5ac	28.5

^{a/} Means with different superscripts within a column are significantly different ($P < 0.05$).

Calves born in the dry season had better (but non-significant: $P > 0.05$) survival rates than those born in the other seasons. By 1 year calf mortality averaged about 14% in animals born during the dry season compared with those born in the early and peak wet seasons (24%) and in the late wet season (28%). Calves born in the dry season averaged 12.5% mortality up to 6 months, and only 1.4% between 6 and 12 months. Mortality rates for animals born in other seasons were higher at all stages up to 1 year of age.

The survival rate observed in this study agrees generally with data collected under similar management conditions, but the seasonal pattern of mortality is quite different (Pullan, 1979; Wilson and Clarke, 1975). In other studies mortality was usually higher in the dry season when the nutrition of calves and dams was poor, whereas in the ILCA study survival was better in calves born in the dry season.

The sex of the calf had no effect ($P > 0.05$) on survival rates. This finding agrees with Jagun (1980), who reported a mortality rate of 16.1% in calves up to 1 year old at NAPRI, Shika, with sex having no effect on the pattern of mortality.

The importance of environmental effects on pre-weaning viability is shown in Table 8. Calf mortality up to 1 year was lowest (11.5%) in Kurmin Biri, followed by Abet (19.4%). It was highest (30%) in Madauchi, followed by Kaduna (28.5%). Mortality to 6 months followed the same pattern, except that the figure for Kaduna was higher than that for Madauchi. However, Table 8 shows that from 7 months to 1 year mortality was lowest in Kurmin Biri (2.3%), followed by Kaduna (3.3%); it was highest in Madauchi (9.5%), followed by Abet (5.5%) (Table 8).

Milk yield

The Bunaji has been recognized in Nigeria and other parts of West Africa as a good dual-purpose animal. Hartley and Baker (1935) quote yields of 1082 kg of milk with over 7.5% butterfat in 305 days. Hill (1956) reported milk yields of 2475 kg over the same period from Bunaji cows at the University of Ibadan farm. ILCA (1978) showed the Bunaji to be above average in major production parameters like calving interval, milk production and growth. These data were, however, obtained under research station rather than pastoral conditions.

Table 9 shows least squares means of milk taken off for human consumption, based on 585 cow records. Overall mean offtake was 108.3 litres over the 180-day period.

Table 8. Least squares means of calf viability (%) to 365 days.

Source	No. of records	Age (days) ^{a/}						Mean Mortality
		30	90	120	180	300	365	
Overall mean	723	97.0	91.8	87.5	82.8	80.5	77.6	22.4
<u>Year of calving</u>								
1979	108	100.0	98.1	92.3	83.7	80.9	77.6	22.4
1980	152	93.4	86.4	79.5	76.1	72.9	70.0	30.0
1981	174	97.8	90.0	89.1	85.1	84.1	82.5	17.5
1982	289	95.6	92.5	89.1	86.4	83.8	80.3	19.7
<u>Season of calving</u>								
Dry	152	99.8	95.2	92.9	87.5	86.8	86.1	13.9
Early wet	264	98.0	92.8	87.7	83.1	80.3	76.1	23.9
Peak wet	61	94.7	89.2	85.1	81.4	79.9	76.3	23.7
Late wet	246	95.0	89.8	84.4	79.2	74.8	71.9	28.1
<u>Sex of calf</u>								
Male	383	96.9	91.3	87.9	81.5	79.1	76.2	23.8
Female	340	96.8	92.2	87.2	84.2	81.8	79.0	21.0

^{a/}Main effects with different superscripts within a column are significantly different (P<0.05).

Mean offtake during 1981 was significantly higher (P<0.01) than for the other 3 years. Offtakes for 1979, 1980 and 1982 were below the overall mean. Offtake for lactations starting in the late wet season was significantly lower than for those that started in the other seasons (P<0.01).

Similarly, offtake from lactations which started in the dry season was significantly lower than offtake from lactations that started in the early or peak wet seasons (P<0.05). There were no differences in the offtake for lactations that started in the early or peak wet seasons (P<0.05). Interactions between year and season had very significant effects on milk offtake from calving up to 120 days postpartum (P<0.01). Differences in the amount of milk taken for human consumption varied significantly (P<0.05) for the different locations at 30 and 120 days after calving (Table 10). However, total offtake was not significantly different. As suspected from the growth and viability data, the sex of a calf did not significantly influence the amount of milk extracted (P<0.05).

Table 9. Milk offtake (litres) for human consumption from Bunaji cows.

Variable	No. of records	Days postpartum ^{a/}			
		30	90	180	Total
Overall mean	585	15.6	20.6	17.2	108.3
<u>Year of calving</u>					
1979	82	12.0a	20.4a	16.0ab	101.1a
1980	119	14.3a	17.3a	16.7a	97.0a
1981	139	20.1b	25.0b	21.1b	131.8b
1982	245	16.0a	19.9a	14.9a	103.4a
<u>Season of calving</u>					
Dry	125	13.2a	16.2a	21.3c	104.0b
Early wet	210	12.8a	25.3b	20.3bc	124.3c
Peak wet	66	24.3b	25.9b	15.1ab	129.0c
Late wet	183	12.1a	15.2a	12.0a	76.3a
<u>Sex of calf</u>					
Male	315	16.2	20.7	16.5	108.5
Female	270	14.9	20.6	17.8	108.1

^{a/}Main effects with different superscripts within a column are significantly different ($P < 0.05$).

Table 10. Milk offtake (litres) for human consumption at three different locations.

Location	No. of records	Days postpartum ^{a/}			
		30	90	180	Total
Kurmin Biri	250	15.7b	19.6	14.0	103.2
Abet	209	9.2a	21.5	17.4	107.8
Madauchi	100	20.0c	19.9	16.0	108.3
Kaduna	26	17.5bc	21.5	21.2	113.9
Overall mean	585	15.6	20.6	17.2	108.3

^{a/}Main effects with different superscripts within a column are significantly different ($P < 0.05$).

Estimated milk consumed by calves

Table 11 shows least squares means of estimated milk consumed by Bunaji calves up to 180 days postpartum. The overall mean averaged 442.3 litres

or 2.5 litres per calf per day. Analysis of variance showed that the year during which the lactation started had significant effects ($P < 0.05$) on milk consumed by the calf, except at 90 and 180 days after calving. Total milk consumed by calves in 1981 and 1982 was significantly greater ($P < 0.05$) than in 1979 and 1980.

Table 11. Least squares means of estimated milk consumed (milk equivalent) by Bunaji calves (litres).

Variable	No. of records	Days after calving ^{a/}		
		90	180	Total
Overall mean	585	75.9	53.0	442.3
<u>Year of calving</u>				
1979	82	67.8	51.3	427.5a
1980	119	71.7	49.4	379.8b
1981	139	85.1	59.8	477.0b
1982	245	79.2	51.6	485.0b
<u>Season of calving</u>				
Dry	126	72.2c	72.2c	446.3b
Early wet	210	92.1b	57.6b	480.4b
Peak wet	66	68.6a	29.0a	421.0a
Late wet	183	70.9a	53.3b	421.8a
<u>Sex of calf</u>				
Male	315	75.5	49.9	442.6
Female	270	76.4	56.2	439.3

^{a/}Main effects with different superscripts within a column are significantly different ($P < 0.05$).

Season of calving had a significant effect ($P < 0.05$) on milk consumed by calves at 90, 120 and 180 days postpartum. Early wet-season calves consumed significantly more milk ($P < 0.05$) than those born in other seasons. The reason for the low amount of milk consumed by calves born in the peak wet season is not apparent but may be related to the nutrition of their dams.

Bayer and Otchere (1982) pointed out that grazing time of animals in pastoral herds was shorter during the cropping season, and that this may well affect their productivity.

Table 12 shows the quantity of milk consumed by Bunaji calves according to the location of the herd. Analysis of variance showed that location had significant effects on the amount of milk calves consumed ($P < 0.05$) from birth to 150 days of age. Madauchi calves consumed significantly less milk ($P < 0.05$) than those in all other locations, while Kaduna calves consumed significantly more ($P < 0.05$).

Table 12. Least squares means of milk consumed by Bunaji calves (litres) up to 180 days of age in different locations.

Location	No. of records	Days after calving ^{a/}				Total
		30	90	120	180	
Kurmin Biri	250	117.6b	76.3b	59.4b	54.4	462.3
Abet	209	116.6b	95.0b	59.2b	56.9	486.7
Madauchi	100	67.1a	42.8a	40.1a	48.1	293.1
Kaduna	26	183.3c	89.7b	40.0a	52.7	527.4
Overall mean	585	121.1	75.9	49.7	53.0	442.3

^{a/} Column means with different superscripts are significantly different ($P < 0.05$).

By 90 days postpartum, cows that had calved in the early wet and late wet seasons were under nutritional stress and milk production was falling. Thus calves born in the peak or late wet season had 4.8 and 4.3% less milk respectively than the overall mean. They also suffered from the lower feed intake of their dams due to the shorter grazing day (Bayer and Otchere, 1982).

Estimated total milk produced

Table 13 shows estimated least squares means of total milk produced, without allowing for calving intervals. The overall mean was 550.3 litres up to 180 days after calving. Total milk produced in 1979 was marginally below the mean, while milk produced in 1980 was 13.3% below. The totals produced in 1981 and 1982 were respectively 10.6 and 6.9% higher than the overall mean.

Table 13. Least squares means of total milk (litres) produced by Bunaji cows in pastoral herds.

Variable	No. of records	Days postpartum ^{a/}				Total
		30	90	120	180	
Overall mean	585	136.7	96.6	67.9	70.2	550.7
<u>Year of calving</u>						
1979	82	119.6a	88.2	61.8ab	67.2	528.6
1980	119	125.3a	89.0	51.9a	66.1	477.1
1981	139	155.8b	110.0	77.0bc	81.0	608.8
1982	245	146.2b	99.1	80.9b	66.6	588.5
<u>Season of calving</u>						
Dry	126	123.1	88.4a	71.7b	93.5d	550.3
Early wet	210	134.0	117.4b	82.9b	77.9c	604.6
Peak wet	66	156.2	94.5ab	68.2b	44.1a	550.0
Late wet	183	133.7	86.0a	48.7a	65.2b	497.8
<u>Sex of calf</u>						
Male	315	140.1	96.1	64.2a	66.4a	551.0
Female	270	133.3	97.0	71.6b	74.0b	550.3

^{a/}Main effects with different superscripts within a column are significantly different ($P < 0.05$).

Season of calving had no effect on milk produced during the first month, but differences in subsequent months were significant ($P < 0.05$). Total milk produced for lactations that started in the dry and peak wet seasons were the same as the overall mean. Total milk produced in lactations which began in the late wet season was 9.5% lower than average, whereas lactations beginning in the early wet season produced a total amount of milk 9.9% higher than the overall average. Again, the above pattern may be a reflection of the shorter grazing pattern (Bayer and Otchere, 1982).

Milk production index

A total of 236 cow records including calving intervals, milk offtake and calf viability data to 180 days postpartum were used to estimate milk production indices. Least squares analysis of variance for this data subset are shown in Tables 14 and 15.

Table 14. Least squares means of estimated milk production index for Buraji cows in pastoral herds.^{a/}

Variable	No. of records	Milk for humans	Milk for calves	Milk production index
Overall mean	236	111.5	169.2	280.7
<u>Year of calving</u>				
1979	49	110.9	174.6	285.5
1980	76	107.6	140.8	248.4
1981	111	115.9	192.3	308.2
<u>Season of calving</u>				
Dry	28	111.7	152.5	264.2
Early wet	93	114.7	184.3	299.0
Peak wet	36	123.0	170.7	293.7
Late wet	79	96.5	169.4	266.0
<u>Sex of calf</u>				
Male	119	115.3	157.0	272.3
Female	117	107.6	181.5	289.1

^{a/} None of the main effects within a column in the table were significantly different ($P > 0.05$).

Table 15. Least squares means of milk production indices for Kurmin Biri, Abet and Madauchi (litres).

Location	No. of records	Milk for humans	Milk for calves ^{a/}	Total milk ^{a/}
Kurmin Biri	114	131.4	228.5a	359.8a
Abet	96	101.8	217.5a	319.3a
Madauchi	26	102.2	61.7b	163.0b

^{a/} Means with different superscripts within a column are significantly different ($P < 0.05$).

Lactation length averaged 411.2 days or 13.7 months while calving interval averaged 757.3 days or 25.2 months. Consequently, in this study the milk production index was calculated on a 365-day basis.

The overall means for human milk offtake and milk consumed by the calf were 111.5 and 169.2 litres/cow/365 days respectively. Thus the estimated total amount of milk produced by the average Bunaji cow was 280.7 litres per year. Neither year nor season of calving had any effects ($P>0.05$) on the indices. Allowing for calving intervals, the total amount of milk produced in 1981 was thus 9.8% higher and that of 1979 was marginally above the overall mean. Lactations that started in the dry or late wet seasons were below the overall mean, whereas those that began in the early and peak wet seasons were 6.5 and 4.6% above. No significant differences were detected between Kurmin Biri and Abet in all of the three indices, but Kurmin Biri was consistently higher in all cases. Kurmin Biri and Abet were significantly superior ($P<0.05$) to Madauchi in all the indices. Owners in Kurmin Biri differed significantly ($P<0.001$; $P<0.05$; and $P<0.01$) in the amount of milk taken for human consumption as well as in total milk production. There were no differences between owners at Abet or Madauchi ($P>0.05$).

Cow viability

The data set from which cow viability results were obtained had 582 records and covered the period 1979 to 1982 (Table 16). The year of calving had a significant effect ($P<0.05$) on the viability of cows. Cow viability was significantly lower ($P<0.01$) in 1980 than in the other 3 years. Differences between 1979, 1981 and 1982 were not significant. Herd location had no effect on cow mortality ($P>0.05$). However, differences between owners in Kurmin Biri were very highly significant ($P<0.001$), whereas differences between owners in Abet were significant ($P<0.05$). There were no differences between owners in Madauchi and Kaduna ($P>0.05$).

The season of calving had no significant effect ($P>0.05$) on cow viability. The interaction of year and season was also not significant ($P>0.05$). Overall cow mortality averaged 6.2%.

Table 16. Least squares means of cow viability in pastoral herds.

Variable	No. of records	% Mean ^{a/}	Mean mortality ^{a/}
Overall	582	93.8	6.2
<u>Year of calving</u>			
1979	74	95.6b	4.1
1980	103	85.1a	14.9
1981	135	97.0b	3.0
1982	270	97.1b	2.9
<u>Season of calving</u>			
Dry	129	93.9	6.3
Early wet	233	93.4	6.6
Peak wet	46	95.0	5.0
Late wet	184	92.8	7.2
<u>Sex of the calf</u>			
Male	311	92.6	7.4
Female	271	95.0	5.0
<u>Owners within location</u>			
Kurmin Biri	235	91.7	8.3a
Abet	197	94.4	5.6b
Madauchi	118	94.1	5.9
Kaduna	32	95.0	5.0

^{a/} Means of a main effect with different superscripts within a column are significantly different ($P < 0.05$).

Cattle offtake

Certain constraints make it difficult to estimate cattle offtake accurately. Muslims are forbidden to eat animals not slaughtered according to Islamic rites. Provided the disease is not thought to be enzootic, animals are therefore slaughtered and consumed on the prognosis of death, making postmortems impossible.

Overall offtake of all adult animals averaged 12.2% over the period July 1980 - June 1982. Cow sales averaged 10.6% of all cows, or 4.5% of all adult cattle. The sale of adult males averaged 14.4% of all adult males or 7.7% of all adult cattle. These figures are higher than those reported from other locations in Nigeria and elsewhere in Africa. Okaiyeto (1980) reported a

rate of 7.1% in a questionnaire survey in three villages around Zaria. Fricke (1978), using registered slaughter data, estimated offtake in Nigeria at about 6.8% from 1969 to 1974. When he made allowances of 25% and 50% for non-registered slaughters, mean offtakes of 8.2 and 9.5% respectively were obtained. Reasons given by owners in the present study for the sale of their animals included the following: the animal was terminally sick; money was needed for going on pilgrimage, for food, clothing and marriage expenses. Cows were sold mainly because of old age and breeding problems.

Although it was very difficult to get pastoralists to weigh their animals, the mean weight of 395 cows averaged 268 kg. Wheat et al (1972) reported that mature Bunaji females at Shika weighed 350 kg, whereas the mature females in this study were about 85 kg lighter.

In this study it was observed that during the 1980/81 dry season (November to April), cows lost about 16% of their liveweight. During the 1982/83 dry season animals having no access to a Stylosanthes fodder bank lost 18.9 and 23.6% of their liveweights respectively.

CONCLUSIONS

ILCA's study of the productivity of traditionally managed Bunaji cattle has revealed the following average production parameters:

1. Herd size: 45.9 head
Females: 64.4% of herd
Breeding females: 42.8% of herd

2. Reproductive performance:
Age at first calving: 60 months
Calving interval: 757.3 days (25.2 months)
Calving %: 48.2%
Birth weight: 19.4 kg
180-day weight: 60.2 kg
365-day weight: 103.6 kg
Weaning weight: 112.1 kg
Adult cow weight: 268 kg

3. Mortality:

Calf mortality, 90 days:	8.2%
Calf mortality, 365 days:	22.4%
Adult mortality:	6.2%

4. Offtake:

Cow offtake rate:	10.6%
Bull offtake rate:	14.4%

5. Milk production to 180 days postpartum:

Human offtake:	108	litres
Consumed by calf:	442.3	litres
Total:	550.3	litres

Average (whole herd basis):		
Human offtake:	111.5	litres/cow/365 days
Consumed by calf:	169.2	litres/cow/365 days
Total:	280.7	litres/cow/365 days

The generally low performance of traditionally managed Bunaji cattle compared to the breed's demonstrated productivity on government farms and research stations can be ascribed to poor nutrition during the late dry season. This confirms the conclusion of the 1979 ILCA/NAPRI symposium. The study provides important baseline data on herd performance, against which the effects of any interventions can be measured. It has also revealed seasonal and locational differences in performance that should be the subject of further research.

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Traditional small ruminant production
in the subhumid zone of Nigeria

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ABSTRACT

In Nigeria small ruminants contribute an estimated 35% to the total meat supply; they are more important in the north than in the south, and more important in rural than in urban areas. Population estimates suggest there are roughly 1 million head of sheep and 7 million goats in the subhumid zone of Nigeria. In livestock units, this represents 3% and 16% respectively of total ruminants in the zone. The major breed of sheep is the Yankasa; the West African Dwarf is the major goat breed.

Sheep are kept predominantly by Fulani pastoralists, who manage them fairly extensively. Goats are kept mainly by crop farmers, whose management practices include housing overnight and tethering by day during the wet season, some cut-and-carry feeding shortly before harvesting their food grain crops, and allowing them to roam freely in the dry season.

In sheep flocks kept by Fulani, fertility of ewes is approximately 120%, twinning rate is 12%, and lamb mortality up to 3 months is 25%. Based on limited weight data, a productivity index has been calculated of 0.327 kg lamb/kg ewe per year, assuming a weaning age of 90 days, and 0.490 kg for an assumed 180-day weaning age. The major problems in sheep keeping are a high rate of adult mortality, liver fluke infections, and lameness during the wet season.

In goat flocks kept by farmers, twins and triplets account for almost 40% of total births, but overall fertility is low (below 100%). Most of the kids are born in the period June-September; this means that conception takes place before tethering begins, and suggests negative effects of tethering on fertility. Mortality rates are low: 22% for kids and 14.4% for adults. Calculations of productivity indices for 90 and 180 days weaning age are 0.259 kg and 0.437 kg kid/kg doe respectively. Low fertility and weight losses during the second half of the wet season are the major problems in goat keeping.

The reasons given by farmers for sales reveal that goats perform an important function by providing money for household needs as well as for farm inputs, such as fertilizer. Partial payment for communal farming is also a significant reason for goat slaughter.

It is recommended that browse gardens for goats and a veterinary package for sheep and goats be tested as interventions.

INTRODUCTION

The importance of small ruminants for meat production in the tropics is well recognized (e.g. Williamson and Payne, 1978; de Haas and Horst, 1979). Adu and Ngere (1979) found that 11% of the meat supplied from slaughterhouses in Nigeria comes from sheep, and they state that the importance of sheep is greater if rural unregistered slaughters are taken into account. Brinkmann and Adu (1977) estimate that goats contribute about 20% of Nigerian meat supply. This means that about 35% of total meat supply comes from small ruminants. Nevertheless, large differences exist between regions as well as between the countryside and city. According to Sarniguet et al (quoted in Grell, 1976), in rural areas of northern Nigeria the contribution of small ruminant meat to total meat consumed is three times that of beef; but in the cities small ruminants contribute only a quarter as much as cattle to total meat consumption. In the rural areas of southern Nigeria, beef and small ruminant meat are equally important, whereas in urban areas beef consumption is more than eight times as great as the consumption of small ruminant meat.

GENERAL INDICATORS OF SMALL RUMINANT PRODUCTION IN THE ZONE

Sheep and goat numbers

Census figures for sheep and goats are as approximate and unreliable as those for cattle. Adu and Ngere (1979) estimate a population of 7.2 to 8.2 million sheep in Nigeria. ILCA (1979a) gives a figure of 7.6 million sheep and 22 million goats. Brinkmann and Adu (1977) estimate about 29 million goats and that the number of sheep, i.e. approximately 9 million, equals the number of cattle. The numerical ratio between sheep and goats in Nigeria would thus be 1 to 3. This ratio contrasts with neighbouring countries such as Ghana, Togo and Ivory Coast, where sheep slightly outnumber goats (ILCA, 1979a).

Within Nigeria, livestock density in the subhumid zone is lower than in the semi-arid and humid zones. Bourn and Milligan (1983) estimate that there are approximately 4.2 million head of cattle in the subhumid zone of the country. Milligan (personal communication) concluded from aerial surveys that cattle outnumber sheep by 5 to 1 in Fulani herds; this figure would suggest 0.8 million sheep. A recent survey of 100 Fulani households near Kachia revealed a ratio of 4 to 1 between cattle and sheep (Nweke, personal communication). Although arable farmers in the subhumid zone also keep sheep, they have considerably fewer than the Fulani. Allowing for these, it is estimated that there are approximately 1.1 million head of sheep in Nigeria's subhumid zone.

In the absence of more precise data, the present goat population in the subhumid zone of Nigeria can only be estimated roughly. If Fulani pastoralists represent 5 to 7% of the total population active in agriculture, and average herd size is 50 cattle, then the 4.2 million cattle in the zone must be kept by 84 000 pastoral households, and there must be about 1.6 million crop farming households in the zone. If 90% of the farmers keep goats and average flock size is 5, as revealed by ground surveys in the ILCA case study areas, then the zone's goat population must be about 7 million head.

If the above-mentioned small ruminant and cattle populations are converted into livestock units (LU), then sheep would represent about 3% of the total, goats 16% and cattle 80% (1 head of cattle = 1 LU; 1 sheep or goat = 0.1 LU; Williamson and Payne, 1978). For Nigeria as a whole, 75% of the ruminant livestock units are cattle, 18% goats and 7% sheep. These calculations must, of course, be treated with great caution, since the data base is far from firm. However, it appears realistic to state that small ruminants, particularly sheep, are less important relative to cattle in the subhumid zone of the country than they are in Nigeria as a whole.

A survey of agriculture in the central part of the zone (Blair Rains, 1978) provides more information about the distribution of sheep and goats. Whereas goats were kept in 99 of the 100 villages in the sample, village sheep keeping is not quite so widespread: it is absent or rare around the Jos Plateau and in the southern part of the zone (Figure 1).

Breeds

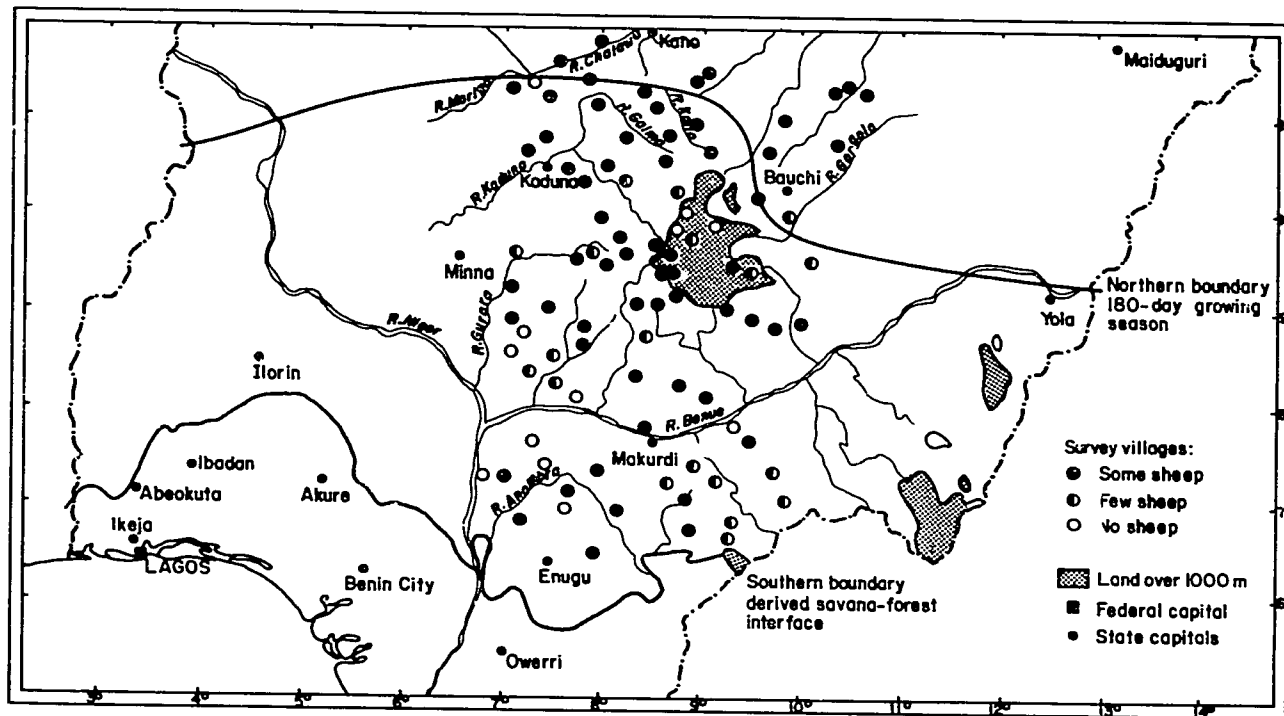
According to the classification by Adu and Ngere (1979), the predominant type of sheep in the subhumid zone is the Yankasa, which, according to ILCA's classification, corresponds with the Djallonke savanna type (ILCA, 1979b). In cities and towns, as well as in the transhumant flocks of the countryside, the Sahelian breeds of sheep (Uda and Balami) occur most frequently. The Uda are predominant near Kontagora, where large flocks can be seen in the dry season. Where the Sahelian and Yankasa types occur together, crossbreeding is common.

The predominant goat breed in the subhumid zone is the West African Dwarf. However, the Red Sokoto goat can be observed frequently in urban areas as far south as Ilorin. Again, crossbreeding is common, particularly in the northern part of the zone, where Red Sokoto goats are found not only in cities but also in rural areas.

Nutritional status

The fact that sheep under station conditions grow faster and attain heavier weights than those in villages indicates the presence of nutritional constraints under village conditions. However, as Brinkmann and Adu

Figure 1. Sheep keeping in land resource survey villages in central Nigeria.



Source : Gosden (1978).

(1977) point out, sheep tend to lose weight much less than cattle during the dry season in the subhumid zone, and goats are even less susceptible to weight losses than sheep. One reason for these differences may be that small ruminants select a diet of better quality from natural fodder resources than cattle do (ILCA, 1979a).

Some researchers state that goats are superior to sheep in their ability to select a good diet (ILCA, 1979a; Wilson et al, 1975). However, Squires (1980) found in subtropical Australia that in those cases where there were evident differences between the ability of the two species to select diet, sheep were superior to goats.

Sheep are basically grazers, whereas goats eat a substantial amount of browse (ILCA, 1979a). Variations in the nutritional quality of browse plants from region to region may lead to the conflicting observations. The higher resolution of selectivity in smaller animals compared with larger ones is attributed by Arnold and Dudzinski (1978) to relative jaw size and to differences in the geometry of lip and tongue movement. ILCA (1979a) suggests that goats may be able to digest low-quality forage better than either cattle or sheep. However, the evidence is conflicting: many reports, the majority of them based on pen trials, do not take into account the possibility that goats are more selective and make no statements about the nutritional quality of plants or plant parts that were not selected (Butterworth, personal communication). Greater selectivity rather than digestive efficiency as such may be a major reason for differences between goats and sheep in their ability to digest fodder. Nevertheless, the superiority of goats and sheep over cattle in diet selection capacities is undisputed. The scope for increasing productivity by improving nutrition is thus likely to be much less in small ruminants, particularly in goats, than in cattle.

Fertility

Generally, sheep and goats mature early. Adu and Ngere (1979) state that the age of sheep at first oestrus is 5 to 8 months for the West African Dwarf breed, 7 to 9 months for Yankasa and about 9.5 months for Uda. Age at first parturition varies considerably. In West African Dwarf sheep it occurs between 11 and 37 months (Adu and Ngere, 1979), in Mali 50% of the

ewes had lambed by 15 months and the mean lambing interval of sheep was found to be 253 days, resulting in 1.4 births per ewe per year (Wilson et al, 1983). Adu and Ngere (1979) give a lambing rate of 110 to 112% for Yankasa and 120% for West African Dwarf sheep. Matthewman (1980) found a lambing rate of 115% in his village survey near Ibadan. Since multiple births are common among small ruminants, the number of lambs born per ewe per year (or kids born per doe) is higher than the lambing or kidding percentages reflect. ILCA (1979a) differentiates between fertility (parturitions per dam per year), prolificacy (average litter size) and fecundity (number of offspring born per dam per year). In Ivory Coast, Ginistry (quoted in ILCA, 1979a) found that fertility was 160% and fecundity 170%.

Kidding intervals are generally found to be similar to lambing intervals; age at first kidding also differs little from age at first lambing. Vohradsky and Sada (quoted in ILCA, 1979a) observed a kidding interval of 285 days on Nungua Research Station in Ghana. In Mali, a mean kidding interval of 265 days was found in village flocks, whereas Otchere and Nimo (1976) calculated 254 days in Ghana under research station conditions. Matthewman (1980) and Putt et al (1980) consider three parturitions in 2 years as the maximum in both sheep and goats in Nigeria.

The average litter size is usually greater in goats than in sheep. For example, Wilson (1980) found 1.5 and 1.4 lambs born per ewe in Sudan and Mali respectively. The corresponding figures for goats were 2.4 and 1.6 kids per doe (Wilson, 1982). Vohradsky and Sada (quoted in ILCA, 1979a) report that in goats 32.9% of the births were single, 52.9% twins, 13.7% triplets, and 0.3% quadruplets, resulting in 260% fecundity. Otchere and Nimo (1976) found a fecundity of 267% amongst West African Dwarf goats in Ghana. According to these sources, both species are highly fertile, but the fecundity of goats is normally superior to that of sheep, largely as a result of greater litter size.

Mortality and offtake

The survival rate of sheep up to 6 months of age was 70% in Mali and 75% in Kenya (Wilson, 1980). The corresponding figures for goats are 65% in Mali and 73% in Sudan (Wilson, 1982), indicating comparable mortality levels for kids and lambs.

In the humid zone of Nigeria, Matthewman (1980) found a preweaning mortality of approximately 15%, but states that this is possibly an underestimate. Major factors influencing preweaning mortality within a breed are birth weight, litter size and parturition number (Wilson, 1980). Trail and Sacker (1966), working with indigenous black-headed sheep in East Africa, discovered that the lambs which died were considerably lighter at birth than the surviving ones. Parturition number and litter size also influenced preweaning mortality rates, since lambs born to gimmers were normally lighter than those born to ewes. The preweaning mortality of lambs born singly to ewes was 16%, that of single lambs born to gimmers was 20%, and that of twins born to ewes was 28%.

Osuagwuh and Akpokodje (1981), working with West African Dwarf goats at the University of Ibadan in Nigeria, found mortality of 38.6% in kids up to 3 months. A review by ILCA (1979a) and an evaluation of data collected in Mali (Wilson et al, 1983) indicate that parturition interval can also influence preweaning mortality in goats and sheep. Rombout and van Vlaenderen (quoted in ILCA, 1979a) found that parturition intervals of less than 7 months greatly increased lamb mortality. The Mali study found that parturition intervals of 183 days or less resulted in a lamb and kid mortality of more than 50%, whereas mortality declined to 25% when the interval was 245 days or more.

Age of dam at first service also influences mortality of young animals. Ngere (quoted in ILCA, 1979a) found that only 42% of gimmers serviced at 8 months conceived, but only 17% produced live births, whereas all animals serviced at 11 months became pregnant and produced 100% live births. However, Wilson and Durkin (1983) argue that systems with controlled breeding (as practised on stations) may lead to an increase of 100 days or more in age at first lambing or kidding. This increased age may reduce the advantage of a lower mortality; total herd productivity may, in fact, be greater in a system permitting early breeding.

Matthewman (1980) found 15% adult annual mortality for sheep and goats in southern Nigeria, but he points out that this may be an underestimate. Wilson (1976) observed an overall mortality of approximately 30% for sheep and goats in the semi-arid region of Sudan.

Despite a rather high mortality rate, offtake from small ruminant flocks is considerable. In Sudan, Wilson (1976) reported an offtake of 28% for both sheep and goats. The simultaneous increase in goat numbers could be interpreted as underutilization, whereas the declining numbers of sheep would indicate some overutilization. Matthewman (1980) found that more than 90% of male offspring of both sheep and goats were sold immediately after weaning; the total offtake from all lambs and kids in the flocks was about 67%, and offtake from adult animals in the flocks was about 20%.

In ILCA's Mali study, sales and slaughters amounted to about 18% in sheep and 15% in goat flocks (Wilson et al, 1983). However, as in other studies, it was difficult to distinguish between deaths and slaughters in extremis. Therefore, the mortality figures which include such slaughters probably underestimate the percentage of animals used for human consumption. In non-Muslim societies, animals that have died, as opposed to those that have been slaughtered, may also be consumed; this practice is common amongst arable farmers keeping goats in ILCA's case study areas in the subhumid zone.

Weight development

According to ILCA (1979a), the birth weight of sheep is generally 7 to 8% of adult weight. Ngere (quoted in ILCA, 1979a) found an adult weight of 21 kg and an average birth weight of 1.66 kg for the West African Dwarf. In ILCA's village survey in southeastern Nigeria, an average birth weight of 1.8 kg was recorded (ILCA, 1979a). Dettmers et al (quoted in ILCA, 1979a) found an average birth weight of 1.9 kg for single lambs, 1.6 kg for twins, and 1.5 kg for triplets.

Fall et al (1982) state that year of birth, month of birth, parturition number, litter size and sex all influenced birth weight significantly. Lambs born in the late dry season tended to be lighter than animals born at other times of the year, lambs at first parturition were lighter than lambs from subsequent parturitions, twin lambs were lighter than singles, and females lighter than males.

For sheep and goats in Mali, the season of birth had no significant effect on birth weight; instead, litter size and sex were the significant factors (Wilson et al, 1983).

Goats generally have lower adult weights than sheep in the same ecological zone (Wilson 1976; 1980; 1982; ILCA, 1979a). Partly for this reason, birth weights can be expected to be lower in goats than in sheep. The larger litter size of goats also accounts for lower birth weights. The ILCA village survey in southeastern Nigeria revealed an average birth weight in goats of 1.2 kg; in Ghana an average birth weight of 1.4 kg was recorded with a range from 0.5 - 2.5 kg (ILCA, 1979a).

Osuagwu and Alpokodje (1981) found that surviving kids had an average birth weight of 1.24 kg; kids that were born alive but died within 3 months had an average birth weight of 1.04 kg.

For Yankasa sheep, Adu and Ngere (1979) give 35 kg as the mature weight of females and 21 kg as the weight at first oestrus at 8 months. Preliminary results from ILCA's work in the subhumid zone indicate slightly lower weights: about 20 kg at 12 months of age and 30 kg as mature weight attained after 4 years. Orji and Steinbach (1981) found that mature weight of West African Dwarf sheep is 32 kg under station conditions; this weight is reached by ewes at approximately 3 years of age.

ILCA (1979a) found that the mature weight of dwarf goats was approximately 25 kg. These animals matured late; their weight and size were still increasing when they were 3 years old (after three kiddings, on average).

Weaning is assumed to occur among both sheep and goats at 150 days (Wilson et al, 1983), although Matthewman (1977) found that lambs and kids were sucking their dams for only about 100 days after birth.

Productivity

By far the most important product of small ruminants kept in the subhumid zone is meat. Neither sheep nor goats seem to be milked in this region. Hides, particularly those of goats (preferably Red Sokoto), are valued but in many parts of the zone skins are eaten.

Because only one product must be considered, the productivity of the small ruminants in the zone is relatively simple to assess, in comparison with the productivity of multi-purpose cattle. Various formulae for calculating productivity indices are currently used. Wilson (1976) expresses productivity as follows:

$$p = \frac{b \times s \times l \times d}{L}$$

where:

- p = meat production
- b = lambing/kidding percentage
- s = survival rate up to 6 months
- l = liveweight of kids/lambs at 6 months
- d = dressing percentage
- L = liveweight of ewe/doe postpartum.

This formula considers only the production of breeding females and not growth after weaning. However, it is generally agreed that the productivity of breeding females is a good indicator of overall productivity. The use of dressing percentage as a criterion for meat production is problematic, since large amounts of offal not included as 'meat' may in fact be consumed. Therefore, new formulae emphasize liveweight of lambs/kids^{1/}, for example, that of Fall et al (1982).

$$\text{Index 1} : \frac{\text{weight of weaned lambs per ewe} \times 365}{\text{lambing interval}}$$

There are large weight differences between breeds; for interbreed comparisons, an adjustment must therefore be made for weight of ewe. This yields the following index:

$$\text{Index 2} : \frac{\text{Index 1}}{\text{ewe weight}}$$

^{1/}For productivity indices for goats, read 'kids' for 'lambs' and 'does' for 'ewes'.

Since small animals eat relatively more feed per kg body weight than large ones, metabolic weight may be more meaningful to use, giving the index:

$$\text{Index 3} : \frac{\text{Index 1}}{\text{ewe weight}^{0.73}}$$

In the literature, slightly differing exponents for metabolic weights appear; e.g. 0.734, (Wilson, 1980) or 0.75 (ARC, 1980). Since the exponent represents convention rather than strictly biological function, agreement on the use of only one exponent would facilitate productivity comparisons. The present author suggests 0.75.

In the early stage of productivity studies, when figures for lambing intervals are not plentiful, some changes must be made in the formulae to permit preliminary calculations of productivity. The following index results:

$$\text{Index 4} : p = b \times l \times s \times l$$

in which:

- b = number of births per ewe per year
- l = litter size
- s = survival up to n months
- l = liveweight of lambs at weaning.

The value 'b' can be obtained by dividing the number of births per month by the number of breeding females per month and adding the values of all 12 months of the year. This procedure is necessary because the number of breeding females varies from month to month. Weaning is rarely practised in village flocks. Therefore, a certain age of possible weaning is chosen (e.g. 90 days, 180 days) and weights at this age are taken as weaning weights. As a basis for comparing the productivity levels found in surveyed flocks in the subhumid zone of Nigeria with those of flocks in other countries, the values obtained in productivity studies are presented in Table 1.

Table 1. Productivity levels of sheep and goats in various parts of Africa, calculated according to Index 2 (Fall et al, 1982) (g of lamb raised per 1000 g ewe).

Species	Country	Age of weaning (days)			Source
		90	150	180	
Sheep:	Sudan			600	Wilson, 1980
	Ethiopia			510	Wilson, 1980
	Mali			560	Wilson, 1980
	Kenya			510	Wilson, 1980
	Nigeria	454			Mack, 1982
	Senegal			465	Fall et al, 1982
Goat:	Sudan		1030		Wilson, 1982
	Kenya		440		Wilson, 1982
	Mali		620		Wilson, 1982
	Nigeria	359			Mack, 1982

INVESTIGATIONS OF SMALL RUMINANT PRODUCTION IN CASE STUDY AREAS

Sheep management

Sheep management by settled Fulani pastoralists in the study areas is of fairly low intensity. Many households do not herd the animals during the day, do not restrain them overnight, and some even let their sheep roam without supervision at a considerable distance from the homestead. This is particularly true during the dry season. Fulani living close to hills tend to leave their sheep unattended in the hills during the wet season as well. Sheep tend to be treated as scavengers requiring minimal investment of capital and labour. Supplementary feeding is normally restricted to providing some *kanwa* (local salt) at irregular intervals. Fulani living close to crop farmers are obliged to pay somewhat more attention to their sheep in order to avoid crop damage. The few crop farmers who keep sheep manage them just as they do goats. Little breeding management is practised. Some small flocks may be without a fertile male for several months; in others, males between 6 and 12 months may serve the ewes. A few larger flocks, however, keep breeding rams, normally selected from within the flock.

Sheep flock structure

An analysis of flock structure (Table 2) reveals a high percentage of breeding females (50%). This finding agrees well with others on sheep production in African villages (e.g. Wilson, 1980; Mack, 1982). Since there is no reason to believe that males have higher mortality than females, it indicates that males are taken off at a fairly young age. That in turn suggests a strong demand for mutton and/or an urgent need for cash because the preferred animals, especially for Muslim festivals, are male sheep with at least one set of permanent incisors. In the study flocks, only 2.8% of the sheep were males older than 12 months, and only 1.4% had more than one pair of permanent incisors. Female animals over 15 months (which was assumed to be the minimum age for breeding) accounted for somewhat less than 50% of the flock. The ratio of males over 12 months to breeding females is 1 to 16; the ratio of males over 6 months (which could be regarded as capable of serving ewes but not yet sexually mature) is 1 to 4.5. This agrees well with ratios found in sheep flocks near Ibadan in southern Nigeria (Mack, 1982).

Table 2. Structure of sheep flocks kept by settled Fulani (November 1983), southern Kaduna state, Nigeria.

Class of stock	No. of sheep		% of flock	
	Males	Females	Males	Females
Lambs up to 3 months	17	9	8.9	4.9
Lambs 3-6 months	15	14	7.9	7.3
Lambs 6-12 months	15	20	7.9	10.5
Lambs 12-15 months	2	-	1.0	-
Ewes over 15 months	-	95	-	49.8
Rams over 15 months	4	-	2.0	-
Castrates	-	-	-	-
Total flock	53	138	27.7	72.3
Males over 12 months ^{a/}			3.1	
Males over 6 months ^{b/}			11	

^{a/} Ratio males over 12 months : females over 12 months = 1:15.8.

^{b/} Ratio males over 6 months : females over 12 months = 1: 4.5.

Sheep fertility

In the first year after establishment, ILCA's experimental flock had 1.2 births per ewe, and one pastoralists' flock that was followed continuously showed a fertility rate slightly above 100%. This rate is consistent with 1.12 births per ewe per year found in a wider-based single-round survey. Out of 50 births recorded in the experimental flock, only 2 were twins. The evaluation of animal life histories given by pastoral flock owners suggests a twinning rate of about 20%. The single-round survey suggests a twinning rate of 12% (1.4 lambs/ewe/year). The available data do not permit examination of the seasonality of births.

Lamb mortality

The survey of life histories suggests that 25% of the lambs die within 90 days of birth. This figure is likely to be an underestimate because not all lambs included in the survey had reached 3 months, and because animals are rarely weaned by this age. True viability at 6 months is therefore likely to be 65 - 70%. Thus, the number of lambs raised up to 3 months per ewe per year would be about 1, and that of lambs raised to 6 months would be 0.95.

Adult mortality in sheep

One of the main problems in sheep keeping is the high rate of adult mortality. For example, in the experimental flock, four animals died within a week in March 1983 from liver fluke infection. Similar cases were reported amongst pastoralists' flocks: 5 out of 10 ewes died in one flock in May 1983, and 7 out of a flock of 35 died in October 1983. Another major health problem is lameness caused by foot-rot and tick bites during the wet season.

Weight changes in sheep

Average ewe weight was 26.3 kg. Ewes between 1 and 2 years of age weighed 23.1 kg on average, 2 to 3 year-olds weighed 25.4 kg, 3 to 4 year-olds weighed 27.1 kg, and females of 4 years or more weighed 29.9 kg.

Table 3. Weight for age in sheep kept by settled Fulani (1982/83) in southern Kaduna state, Nigeria.

Weight	Pastoralists' flocks		ILCA experimental flock	
	(kg)	(No.)	(kg)	(No.)
Birth weight	1.6	19	1.9	9
30-day weight	4.0	9	5.2	7
90-day weight	11.0	9	8.7	8
180-day weight	17.6	18	14.5	9
360-day weight	22.0	15	21.1	5

Sheep productivity indices

Three formulae were used in two variations to calculate annual production indices.

- Index 1: weight (kg) of offspring at 3 (and 6) months per ewe.
 Index 2: weight (kg) of offspring at 3 (and 6) months per kg of ewe.
 Index 3: as for index 2 but using metabolic weight of ewe.

Data: at 3 months : 1 lamb/ewe/year
 at 6 months : 0.9 lamb/ewe/year
 average ewe weight : 26.6 kg
 weight data for offspring derived from experimental flocks.

Productivity according to:

	<u>3 months' survival</u>	<u>6 months' survival</u>
Index 1:	8.7 kg/ewe/year	13.05 kg/ewe/year
Index 2:	0.327 kg/kg ewe/year	0.490 kg/kg ewe/year
Index 3:	0.746 kg/kg ^{0.75} ewe/year	1.120 kg/kg ^{0.75} ewe/year

The results agree with other studies in African rural environments (Table 1).

Goat management

An estimated 95% of the goats in the study areas are kept by crop farmers; nearly every farmer keeps some. A total of 33 out of the 35 farmers interviewed were goat keepers, and their average flock size was five. Some farmers buy does for breeding, but farmers commonly acquire stock by looking after other people's goats and sharing the offspring.

Only 4% of Fulani pastoralists in the Kachia area keep goats (Nweke, personal communication). As a rule, these Fulani have lived at one site for several years and have adopted local farmers' goat management practices. In many other respects, such as housing, they have also assumed the local farming community's way of life. Some Fulani, particularly women, may own goats but leave them in the care of farmers, who are often also women (Paper 2). The farmers regard goat keeping as a subsidiary business that must fit into the pattern of cropping activities, which are more important. During the growing season goats are tethered for grazing by day and kept in huts overnight. Animals are sometimes not tethered until 11.00 a.m. Labour requirements may not only restrict grazing time but may also place an upper limit on the number of goats that a household can keep. During the wet season (until July/August) the goat manure which accumulated in the goat huts is mixed with wood-ash and applied to millet nurseries as fertilizer. After the grain is harvested the goats are allowed to roam freely and often do not even return to the compound at night. Some feeding is done: grasses and immature grain heads are cut and carried to the animals shortly before harvest, when goats are still being tethered but the quality of natural grasses has deteriorated. Brewers' grain and kanwa are occasionally fed to them as well.

Goat flock structure

The flock structures in the case study area correspond with those in other African settings where goats are kept primarily for meat. At the beginning of the study in June 1982, does of 12 months and above made up more than 50% of the flocks, but as shown in Table 4 their relative importance has decreased since then. The ratio of males to females above 12 months was 1 to 17 in November 1983, although it was initially much lower: 1 to 45 in June 1982. Such low levels may impair flock fertility.

Table 4. Summary of goat flock structures in the Abet case study area(1982/83).

Class of stock	No. of goats		% of flock	
	Males	Females	Males	Females
Kids up to 3 months	20	17	10.1	8.6
Kids 3 - 6 months	15	21	7.6	10.6
Kids 6 - 12 months	9	9	4.6	4.6
Kids 12 - 15 months	4	14	2.0	7.0
Does over 12 months		86	-	43.4
Bucks over 12 months	2	-	1.0	-
Castrates	1	-	0.5	-
Total herd	51	147	25.8	74.2
Intact males over 12 months ^{a/}			3	
Intact males over 6 months ^{b/}			7.6	

^{a/} Ratio intact males over 12 months: females over 12 months = 1:16.7.
^{b/} Ratio intact males over 6 months: females over 12 months = 1:6.7.

Goat fertility

The fertility rate of 98.6% in the surveyed flocks is fairly low for goats (Table 5). During 1983 the rate was only 85.3%, but 65% of the births occurred from June to September. In 1982 when the study started in mid-year, 73.8% of the number of recorded births occurred between July and September. This seasonality may be caused partly by the maturing of young bucks that had been spared from previous sales and now had free access to does, but it may also be influenced by nutrition, since from February to April the growth of shrubs before the wet season provides highly nutritious fodder.

Table 5. Fertility of goats kept in the Abet case study area (1982/83).

	1982						1983					
	JL	A	S	O	N	D	J	F	M	A	M	Jn
No. of breeding females	90	88	99	99	90	90	92	96	94	97	98	104
No. of births	22	10	9	8	1	6	3	5	9	2	7	11
Fertility %	24.4	11.4	9.1	8.1	1.1	6.7	3.3	5.2	9.6	2.1	7.1	19.6
Total fertility:	98.6%											

The distribution of birth events according to litter size during the period July 1982 to June 1983 is shown in Table 6.

Table 6. Distribution of kid births according to litter size in the Abet case study area (1982/83).

Type of birth	No.	Percentage of birth events
Single	57	61.3
Twin	32	34.4
Triplet	3	3.2
Quadruplet	1	1.1
Total No. of births	93	100

This yields an average litter size of 1.44, which is similar to findings in Ibadan. Sex distribution among kids born was 49.3% males and 50.7% females.

Goat mortality

Kid mortality up to 3 months of age was 22.4% over the first year of recording, while overall flock mortality was 14.4%. These apparently low figures may be due to gaps in the recording and should be treated with caution. The relatively small sample size did not permit analysis of kid mortality according to litter size.

Goat weight changes

The weight changes from birth are shown on a yearly basis because there were large differences between the 2 years (Table 7). The favourable nature of 1983 is indicated by low mortality figures and increases in animal numbers, as well as by generally higher weights.

Table 7. Weight changes in goats (kg) in the Abet case study area (1982/83).

Year of birth	1982			1983		
	No.	Mean	(SD±)	No.	Mean	(SD±)
Birth weight	17	1.42	(0.34)	50	1.75	(0.29)
30-day weight	17	2.31	(0.67)	62	3.42	(1.07)
90-day weight	16	3.86	(1.21)	58	5.37	(1.16)
180-day weight	16	6.08	(1.64)	7	10.80	(2.29)

The average postpartum weight of dams was 19.3 kg. When weights are classified according to age (Table 8), increased weight is evident in animals more than 4 years old. This increase clearly indicates the high reproductive capacity of goats, which are already reproducing long before mature weight has been reached.

Table 8. Postpartum weight of dams (kg) according to parity and age (kg) in the Abet case study area (1982/83).

	Weight (kg)		
	No.	Mean	(SD±)
Parity:			
First	24	15.5	(3.55)
Second	12	19.2	(3.54)
Third	14	20.0	(2.72)
Fourth or more	28	22.3	(3.40)
Age of dam:			
Below 2 years	16	14.3	(2.53)
2 - 2.5 years	15	18.4	(3.42)
2.5 - 3 years	17	19.8	(3.47)
3 - 4 years	13	21.9	(2.48)
Above 4 years	15	22.6	(6.37)

Goat productivity indices

For calculations of goat productivity, the following data were used:

Average weight of dam	19.3 kg
Fertility rate	0.98
Average litter size	1.44
No. kids born/doe	1.4
No. kids to 3 months raised/doe/year	1.09
No. kids to 6 months raised/doe/year	1.0
Weight of kid at 3 months	4.6 kg
Weight of kid at 6 months	8.44 kg

Calculation of goat productivity according to the different indices yields the following results in terms of kg kid production:

	Assumed weaning age	
	<u>3 months</u>	<u>6 months</u>
Index 1: Liveweight of kids raised/doe	5.01 kg	8.44 kg
Index 2: Weight of kids raised/kg doe	0.259 kg	0.437 kg
Index 3: Weight of kids raised/kg ^{0.75} doe	0.544 kg	0.917 kg

These data indicate that sheep are more productive than goats in the study area. One reason for this may be that goats are kept by people whose main enterprise is cropping, so the animals are severely restricted during the wet season, whereas sheep kept by pastoralists are less restricted.

Goat offtake

As shown in Table 9, actual offtake over the year was 23.4%. Together with an increase in numbers of 15.2%, the potential offtake was 38.6%. Goats were sold in order to pay for fertilizer; in addition, a poor harvest forced some farmers to buy grain, and inflation has increased in Nigeria since June 1983.

Table 9. Offtake from farmers' goat flocks in the Abet case study area (July 1982 - June 1983).

Offtake classification	No. of animals
Net transfers out	4
Sales	32
Slaughters	8
Total offtake	44
Percentage offtake	23.4%

^{a/} Average flock size, 5.37; total animals surveyed, 188.

Offtake was analysed in more detail for June 1982 to October 1983. Of 50 goat sales recorded between June 1982 and October 1983, 25 (50%) occurred during June and July 1983. This peak in offtake may partly be a reaction to the increase in the size of flocks over the previous year, but also to the high price of mineral fertilizer, which was available only on the unofficial market at up to four times the official government prices. In 16 out of the 50 sales, it was explicitly stated that animals were sold because money was needed to buy fertilizer; 13 of these 16 sales were recorded in June and July 1983. Other reasons for sales included the ill-health of an animal (5 cases or 10%), general lack of money without an indication of how the money would be used (28 cases or 56%) and raising money to equip a son going to college (1 case). Ill-health was the most frequent reason for slaughter (6 of 14 cases), followed by slaughtering to provide meat for participants in communal farming (4 cases), and for various ceremonies or other occasions (4 cases).

In total, data on sales and slaughters indicate that a relatively small part (17%) can be attributed to ill-health. The most important reason for sales is the need for cash for purposes unrelated to goat production. In other words, the small ruminant is used as a 'savings account' from which money can be readily withdrawn. The extent of goat slaughters for communal farming is underestimated by these figures, for it is known that some farmers buy goats on the market for this purpose even though they may have goats of their own. Since the purchase and slaughter of goats as payment for communal farming often take place on the same day or within only a few days, these goats do not appear in the survey data on farmers' flocks.

POTENTIAL INTERVENTION POINTS IN SMALL RUMINANT PRODUCTION

The major problem in sheep production is adult mortality from respiratory diseases and liver fluke infections. Furthermore, animals lose condition in the wet season because of ectoparasites. A veterinary package should therefore be the first priority in research and development.

During the establishment phase of the ILCA experimental flock, lamb mortality was about 60% for the first 6 months. Birth weights of lambs that died averaged only 1.3 kg compared with a 1.9 kg average birth weight in surviving lambs. Improved nutrition led to an increase in birth weight and lamb survival, although the lamb mortality rate in 1983 was still high at 35%. In 1983 there was no difference in birth weight between surviving lambs and those that died.

With regard to goat production, the data must be treated with some caution because 1983 appears to have been a very favourable year. A late and short wet season reduced the time of stress (due to confinement) and high disease susceptibility. In addition, greater quantities of immature millet were a source of good-quality feed around harvest-time. The difference in weight development of growing animals between the 2 years and the fact that 34% of kids born between June and December 1982 had died by December 1982, indicate that there might be more problems in other years.

The inclusion of more males of breeding age in the flocks seems an obvious intervention for raising fertility, but what is preventing the farmers from doing this must be established first. An exceptional case of quadruplet (all female) birth led to the observation that there is some scope for improvement of goat nutrition. Birth weights of the quadruplets ranged between 1.0 and 1.1 kg; upon the author's advice, the goat owner started to feed the dam. Not only did all four kids survive, they also grew at an above-average rate and within 1 year of their birth two of the kids had already given birth themselves. With regard to weight development, there is some evidence of a period of weight loss in the late wet season. Since grazing or cutting of *Stylosanthes* spp. at that time of year would endanger the persistence of the plants, utilization of browse plants might be a more suitable intervention for improving goat nutrition.

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Animal health
in subhumid Nigeria

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ABSTRACT

Infectious diseases continue to be the most common cattle health hazard in the subhumid zone of Nigeria. The principal ones are rinderpest, foot-and-mouth disease, and contagious bovine pleuropneumonia. Although there have been outbreaks of these in locations adjacent to the ILCA study areas, ILCA herds were not affected. A small number of cases of dermatophilosis, lumpy skin disease, papillomatosis and keratoconjunctivitis were also observed. No cases of anaplasmosis, babesiosis or heartwater were observed in indigenous cattle.

A study of helminthiasis in traditionally managed Bunaji calves was followed by research on the effect of treatment on weight gains of calves. Helminthiasis was prevalent in over 50% of calves from April to December.

Fenbendazole produced a 96% reduction in epg in seven experiments, but no significant difference in weight gains was observed between treated and control groups.

The seasonal pattern of tick load on Bunaji cattle under traditional management was investigated in order to assess the possibility of strategic use of acaricide. Twice to thrice weekly, ticks were removed by hand from 16 animals, and the species and genera determined. Tick load was low in

the dry season, increased after the onset of the first scattered rains, reached a peak 1 month after the beginning of heavy rains, and declined thereafter. The dominant tick species was Amblyomma variegatum; others found were Boophilus decoloratus, Rhipicephalus (simus) senegalensis, R. tricuspis and Hyalomma spp.

INTRODUCTION

The first joint ILCA/NAPRI symposium of 1979 highlighted rinderpest, contagious bovine pleuropneumonia, trypanosomiasis and dermatophilosis as the major health constraints to livestock development in the subhumid zone of Africa.

The main objective of the ILCA Subhumid Zone Programme is to improve livestock output through improved forage production and utilization. Inevitably, the herds that adopt the interventions will increasingly stay and graze in the same area. This trend could introduce new health problems that the traditional systems tend to avoid. The build-up of internal parasites is one such potential problem. The control measures applicable to Fulani herds, particularly for gastro-intestinal parasitic infestation in young cattle, were therefore investigated.

The veterinary research work so far carried out by the ILCA team has been mainly concerned with the monitoring and surveillance of animal health problems in traditionally managed cattle. In-depth studies were conducted on:

1. Helminthiasis in traditionally managed Bunaji calves, including the effect of treatment on weight gains.
2. The seasonal pattern of tick burden on cattle.

The health of F₁ Bunaji x Friesian crossbred cattle, introduced into pastoralists' herds in the case study areas, was also monitored.

MATERIALS AND METHODS

Cooperating pastoralists were visited at least once every fortnight. During these visits all animals reported sick were examined to establish disease incidence, and necessary samples were taken for laboratory analysis. If deaths occurred between visits, the owner was questioned in order to establish their cause. Adult animals were seldom available for postmortem because they were sold and slaughtered in extremis.

Internal parasites

In 1982 a study was conducted to investigate the effect on weight gains of treatment against naturally acquired helminthiasis in traditionally managed Bunaji calves. A total of 92 Bunaji calves, unweaned and under 6 months, were included in the survey.

The drug used was fenbendazole (methyl (5-phenylthio) benzimidazole-2-carbonate), which is reported to have a broad anthelmintic spectrum against gastro-intestinal nematodes (Fabiya et al, 1980).

Faecal samples were collected monthly and analysed. Fenbendazole in ready-to-use aqueous suspension was administered orally at a dosage of 5 mg per kg of body weight. Control groups were treated with weak milk solution. A week after each treatment a post-treatment faecal sample was taken to check the efficacy of the drug. The calves were divided into three groups:

Group A:

Treatment regime: five times - end of dry season (April), beginning of rains (June), middle rains (August), end of rains (October), and early dry season (January).

Group B:

Treatment regime: three times - June, August, October.

Group C:

Treatment regime: nil.

All calves were weighed and recorded weekly. The experiment took 349 days.

External parasites

The seasonal pattern of tick burden on Bunaji cattle was also examined. Sixteen Bunaji cows were used in the study. The ticks removed by hand by the Fulani herdsmen from each cow's entire body were stored in bottles. Hand deticking of all cattle was done twice weekly during the dry season (November to March) and thrice weekly during the wet season (April to October) in accordance with the normal management routine of Fulani pastoralists. Each week, the species or genera in each sampling bottle were determined and counted.

DISEASE INCIDENCE

Rinderpest

Felton and Ellis (1978) have deduced, from somewhat nebulous historical evidence, that the cattle population in 1886 was about 9.1 million, which is approximately what it was estimated to be in 1981 (Federal Ministry of Agriculture, 1981). The first devastating epidemic of rinderpest occurred in 1886, and resulted in an estimated mortality of between 80 and 90%. Subsequently cattle numbers recovered to some extent before a further epidemic, following a widespread drought in 1913/14, and another in 1919/20, which caused mortalities estimated at 60%. Even in the 1920s and 1930s, when veterinary control campaigns against a range of diseases had been introduced and rinderpest was having less severe effects, the sales of cattle were such that the overall population scarcely increased (Ford, 1971).

Rinderpest can cause very high mortality (up to 90%) in newly infected areas. The introduction of tissue culture rinderpest vaccine (TCRV) in the early 1960s made its control and eradication technically feasible. A Joint Regional Campaign (JP 15) to eradicate the disease was initiated in 1962. This campaign achieved considerable success, such that by 1972 the disease was thought to have been eradicated in Nigeria. Since then vaccination has been restricted to the annual calf crop.

However, between 1976 and 1979 rinderpest was reported in Mali, Mauritania and Senegal, whence it spread to other neighbouring West African countries. In Nigeria, seven outbreaks were reported in 1980 and five in 1981. The first suspected outbreak in the Kachia LGA was in February 1980. No outbreak to date has been reported in any of the ILCA cooperating pastoralists' herds.

Contagious bovine pleuropneumonia

Contagious bovine pleuropneumonia (CBPP) has continued to be major disease problem in spite of the availability of an effective vaccine. If properly used the vaccine, based on strain T₁ 44, appears to confer immunity lasting more than 12 months (Lindley, 1973). No outbreak of contagious bovine pleuropneumonia occurred in any of the ILCA cooperating pastoralists' herds. Three outbreaks were reported in 1980 and one in 1982 in the Kachia LGA.

Foot-and-mouth disease

A suspected outbreak of foot-and-mouth disease occurred in four herds in Kurmin Biri in October 1981, involving a total population of 242 animals. The disease took a mild course: no deaths or abortions occurred. The main clinical signs were fever, lameness due to interdigital lesions, and a sharp fall in milk offtake. The source of infection was traced to a new bull that had been introduced into one of the neighbouring herds.

Dermatophilosis (streptothricosis)

The dermatophilosis infection rate in Nigeria was reported to be 5.81% in the wet season and 3.12% in the dry season (Oduye and Lloyd, 1971). Bida (1973) recorded 11.6% and 4.1% for the wet and dry seasons respectively. Oppong (1973) observed rates of 12.8% and 4.8% in the wet and dry seasons respectively on the Accra Plains. ILCA's observations in two case study areas (Table 1) revealed rates far below the above figures.

Table 1. Dermatophilosis infection rates in cattle in the subhumid zone of Nigeria.

Location	1981		1982		1983	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Abet	0.35%	2.91%	-	1.18%	1.26%	2.77%
No. of cattle examined	285	172	-	255	237	252
K'Biri	1.99%	2.24%	0.95%	1.26%	-	0.88%
No. of cattle examined	302	312	315	317	-	340
Experimental herd (Kurmin Biri)	-	25%	5.26%	23.5%	4.6%	19%
No. of cattle examined	-	-	38	34	65	62

The high infection rates in the experimental herd probably occurred for two reasons. The herdsmen hired by ILCA were not as dedicated, particularly at deticking, as other pastoralists. Secondly, the herd was made up of culled animals purchased from different cattle markets.

Other skin diseases

Lumpy skin disease (LSD) was first identified in Nigeria in 1974 (Woods, 1974). Synge (1981) reported the disease on the Jos Plateau. Other cases of suspected LSD have also occurred in various places.

In herds studied by ILCA, three suspected cases of LSD were observed in 1981 in two herds. Six cases of suspected LSD were also observed in October 1983 in one herd. The clinical signs observed were high temperature (40.5°C to 41°C), lacrimation, watery nasal and oral discharge, followed by the appearance of subcutaneous nodules of different sizes.

Cases of sucking lice (*Haemotopius* spp.), mostly in young unthrifty calves, were observed. There were also cases of dermatitis in young, emaciated calves, particularly in the dry season.

Reproductive disorders

Bovine brucellosis appears to be the only reproductive disease in the subhumid zone of Nigeria that has been well documented (Nuru, 1975; Esuruoso, 1974). Different prevalence rates of bovine brucellosis have been reported for Kaduna State. Esuruoso (1974) reported 17.6%, while Nuru and Dennis (1975) reported a far lower rate of 0.7%. During the period of observation, 17 cases of abortions were reported in the ILCA cooperating pastoralists' herds. Six of these were in one herd. Milk ring test for brucellosis from this herd was positive. Two cows in this herd that have a history of abortions also have hygromas.

Bovine infectious keratoconjunctivitis (pinkeye)

Pinkeye occurred in four herds in 1982 and in five herds in 1983. About 25% of both adult and young animals in these herds were infected. Cases of pinkeye appeared mainly during the months of August and September. The clinical signs were watery lacrimation, photophobia and, later, a small opacity which varied from white to yellow. Only three cases had residual opacity; all others healed completely.

Thelaziasis

Two cases of thelaziasis were observed in 1983 in one herd. These worms were observed in the conjunctival sacs of two cows; however, no conjunctivitis was observed. In both cases, the worms were physically removed by herdsmen.

Fractures and other injuries

Fractures in young growing animals (five cases) were observed. All cases of fractures were aligned and immobilized by pastoralists, generally with success. Traumatic horn-inflicted injuries are common in most herds.

RESULTS AND DISCUSSION

Helminthiasis

Helminthiasis was prevalent in over 50% of calves in the control group from April to December (Figure 1). Similar seasonal patterns were observed in the two treatment groups, but prevalence rates were lower than for controls. Two eggs per gram of faeces (epg) peaks were also observed in the month of June and a minor one in September in the control group (Figure 2). The abnormally high epg observed in group A in April was caused by 4 calves (out of 35) shedding mainly *S. papillosus* ova. For most of the year (8 months out of 12) mean epg was below 400, even for the control group. The mean weight gains of Bunaji calves subjected to varying anthelmintic treatments are shown in Table 2.

Table 2. Mean weight gains in Bunaji calves subjected to varying anthelmintic treatments^{a/}.

		Mean total weight gain (kg)	Mean daily weight gain (kg)
Group A	35	63.31	0.181
Group B	33	64.81	0.182
Group C	22	59.4	0.169

^{a/}Group A: treated five times; group B: treated three times; group C: no treatment (control).

Figure 1. Prevalence of helminth ova.

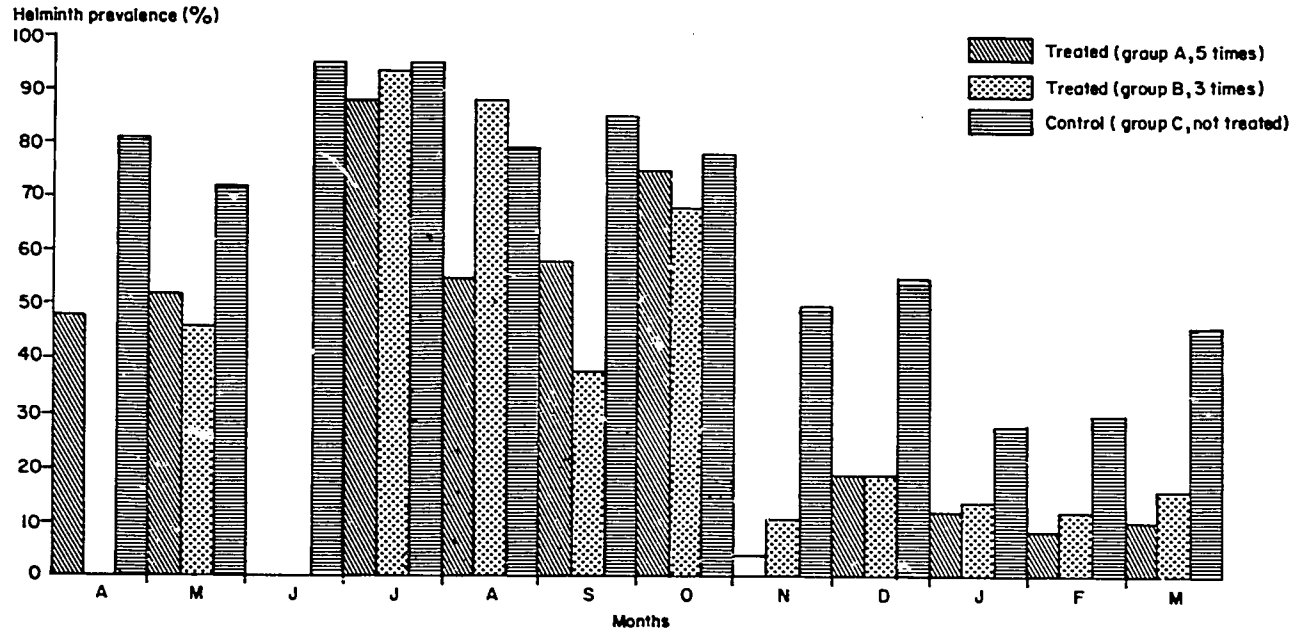
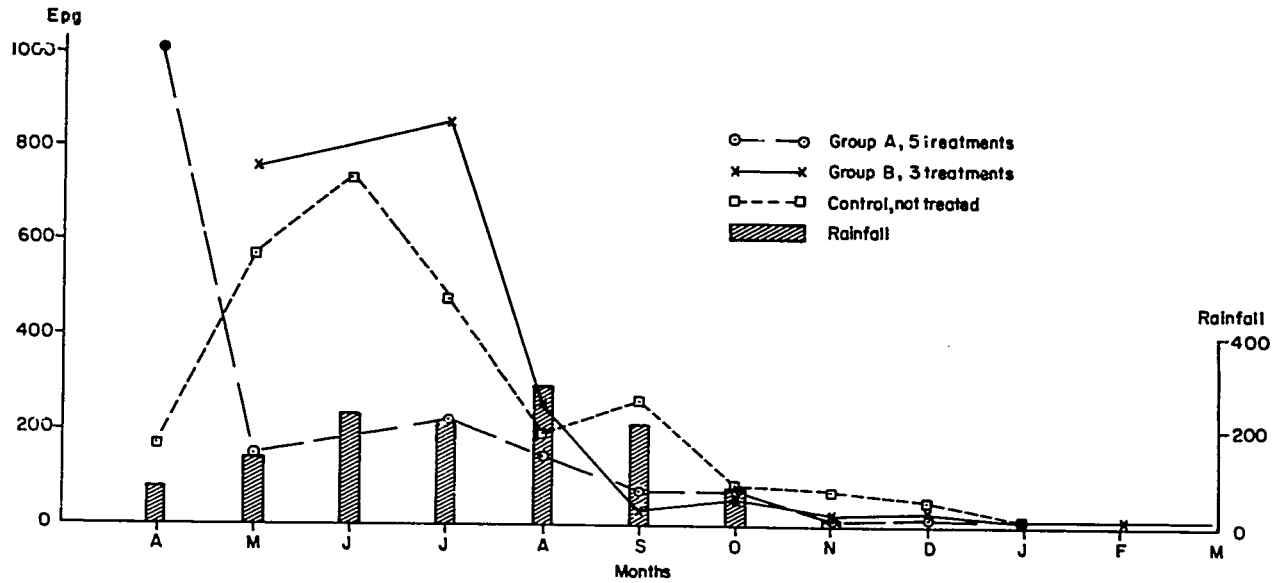


Figure 2. Epg of faeces from Bunaji calves.



The control group (C) had gained 59.4 kg by the end of experiment as against 63.31 kg for group A ($t = 0.88$) and 64.81 kg for group B ($t = 1.33$). The differences were, however, not statistically significant. Similar observations were made by Pullan and Sewell (1980) on the Jos Plateau. Waldhelm and Richard (1977) observed no significant weight gain differences between groups of feedlot cattle treated with different anthelmintics and a control group. They observed that the mode of action of antimicrobial and antiparasitic drugs was not to stimulate host growth but rather to prevent its depression.

Ross and Armour (1960) considered an epg of 600 for haemonchus as pathogenic. ILCA's observation was that in untreated calves the mean epg was below 400.

Fenbendazole was found to be effective in reducing epg in calves. It produced an average of 96.6% reduction in epg in seven experiments. The percentage reduction ranged from 78.9 to 100%. However, percentage reduction in epg of 57.6 to 66.2% was also observed in three out of four observations in control groups (Table 3).

Table 3. Percentage reduction^{a/} in epg counts for Bunaji calves subjected to varying anthelmintic treatments.^{b/}

Month	Group A	Group B	Group C
April	99.86	-	66.23
May	78.94	98.89	57.60
August	100	98.54	11.42
October	100	100	60

^{a/}Calculated as:

$$\frac{\text{Total epg count before treatment} - \text{epg count after treatment}}{\text{Total epg count before treatment}} \times 100$$

^{b/}For treatments, see footnote to Table 2.

The efficacy of fenbendazole in these results is in close agreement with the findings of other workers. Fabiyi et al (1980) reported that fenbendazole achieved 100% efficacy in naturally acquired infection of gastro-intestinal nematodes in zebu cattle in Vom, Nigeria.

Rainfall is necessary for the development and distribution of trichostrongyles larvae in herbage. Lee et al (1960) observed at Shika (NAPRI) that a significant burden of trichostrongyles larvae was only acquired when rainfall exceeded 150 mm per month and the monthly mean maximum temperatures were up to about 32°C. In the ILCA case study areas this occurs from May to September. The two peaks in both prevalence rates and epg follow the two peak precipitations observed in June and August. The fall in epg between June and September in the treated groups (A and B) can thus be attributed to the treatment regimes. By the month of January, which is early dry season, the epg dropped to its minimum in all the three groups, doubtless due to dry-season effect on larvae. Other workers (Lee et al, 1960) have observed a similar decrease in epg during the dry season in Nigeria.

In the control group, a sharp fall in epg was also observed from June to August and from September to October. Similar observations were made by Lee et al (1960) and Synge (1981). Both authors attributed such sharp decline in epg to immune expulsion (self-cure). Stewart (1953) showed that by feeding large numbers of infective larvae a sharp drop in epg can be induced. It is postulated that the increased rainfall provides moisture which enables large numbers of infective larvae to concentrate on the herbage. Once consumed by cattle, they induce 'self-cure'. However, recent investigations suggest that there may be another, non-immunological basis for the phenomenon. Allonby and Urquhart (1973) observed lambs expelling worms after rain. Similarly, von Geldorn and Veen (1976) observed drops in epg in sheep during the early rains in Nigeria. These drops were attributed to pharmacological factors in newly growing herbage.

Some herdsmen in the case study areas have been observed treating calves with selected herbs as well as purchased proprietary drugs. Some of the herioal extracts have since been shown to be effective against Nippostrongylus braziliensis in rats (Ibrahim et al, 1983; and Paper 9).

Ticks

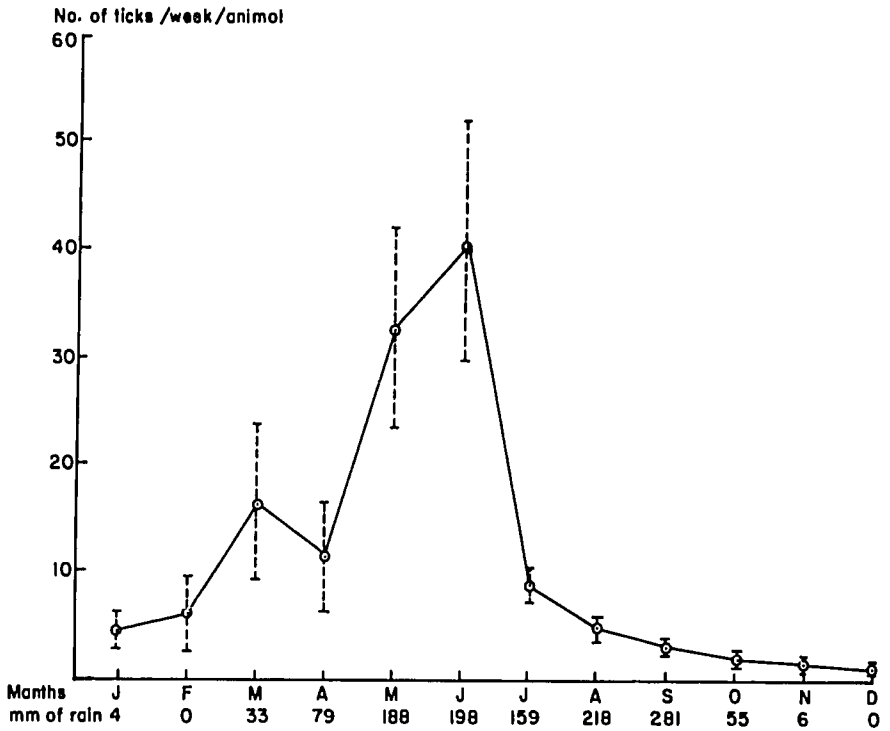
Ticks were the main ectoparasites of cattle in the zone. Pastoralists manually detick as a routine management practice three times a week during the wet season (April to October) and twice weekly during the dry season (November to March). The seasonal pattern of ticks on Bunaji cattle was investigated.

As shown in Figure 3, the tick load is low during the dry season, rises to a pronounced peak at the beginning of the wet season, and declines thereafter. The most common tick found was Amblyomma variegatum. Other ticks, in order of frequency of occurrence, were Brophilus decoloratus Rhipicephalus spp. and Hyaloma spp. (Bayer and Mainz, 1984).

The overall tick load was not high, particularly if the variety of tick species is considered. Sutherst et al (1983) reported that the current threshold for economic dipping in Australia is when cattle are dropping more than 150 engorged females per day. In several Australian studies it has been noted that European cattle breeds carry a higher tick load than zebu cattle or crossbreds (Wharton et al, 1969; Seifert, 1971; Rudder et al, 1976).

The predominant tick species found was A. variegatum, a large tick. Hand deticking involves a bias towards removal of large ticks, but still does not achieve 100% removal. This bias could be reinforced by the common Fulani practice of concentrating on the removal of the 'dangerous ticks', the kotti, in Fulfulde, which are Amblyomma. Fulani pastoralists state that the other ticks, the miri, are less harmful to cattle (Bayer and Maina, 1984).

Figure 3. Average number of ticks /week / animal on Bunaji cattle in the subhumid zone of Nigeria.



The results of the tick load study indicate that it would be feasible to use strategic chemical treatment during the early wet season to break the peak in tick load.

For cattle under traditional management, hand spraying of acaricide would appear to be a more appropriate way of application than the construction of stationary cattle dips or spray races. However, labour saving would be minimal if intensive hand spraying were to replace hand deticking as a routine. Observations on stall-fed crossbred animals in the study areas revealed that the spraying of one adult animal requires about 6 minutes, and of young stock about 4 minutes per head (Bayer and Maina, 1984). The average herd size in the study area is 40 to 50 head of cattle, about 60% of which are adult. Each spraying of the entire herd would thus require 3.5 to 4 hours, not including time for preparation of the spray solution and restraining the animals. Since the animals would have to be sprayed twice per week during the peak of tick occurrence, the labour requirements for tick control would average 1.5 to 2 hours per day over the critical period of about 2 months.

In contrast, the time spent by pastoralists in hand deticking is generally less than 1 hour per day in an average-sized herd, even at the beginning of the wet season (Bayer and Maina, 1984). Because no special preparation is required, hand deticking can be carried out at any time, and in conjunction with other husbandry activities such as milking, and is thus more flexible than chemical treatment. However, it is clear that only ticks that are easily visible will be removed in such a short time; those high on the groin or the axillae, which are the favoured sites, could easily be missed. Tick control by spraying is thus likely to be more thorough than hand deticking. Spraying may also help to minimize dermatophilosis and consequent loss of udder quarters.

A less intensive regime of minimal hand spraying of axillae, groin, udder and perineum at fortnightly intervals successfully controlled the related A. lepidum on zebu (Kenana) cattle in Sudan (Tatchell, personal communication). Untreated cattle carried 50 to 60 male and female A. lepidum but suffered no ill effects with respect to weight gain.

Besides labour requirements, other difficulties associated with the introduction of hand spraying would be the cost and availability of chemicals and equipment, water availability, the repair needs of equipment, and dangers resulting from improper use of acaricide.

Although the tick burden study was visualized primarily as an aid in planning cost-effective tick control in indigenous cattle, the results are also useful in planning the introduction of exotic breeds. Whereas the significance of tick-borne diseases in indigenous cattle is ambiguous, exotic cattle have proved to be highly susceptible and may die of diseases such as heartwater, anaplasmosis and also babesiosis (Ajayi et al, 1982). Their susceptibility may be due to non-exposure to an early immunizing attack. The build-up of immunity in exotic cattle can be accelerated by means of prophylaxis. The crossbred cattle introduced into two case study areas by ILCA are treated with 2.5 mg per kg body weight of imizol (imidocard dipropionate) immediately before introduction. The treatment is repeated 2 weeks later and at 6-month intervals thereafter. The animals are subsequently sprayed to maintain a low tick challenge. This approach has been used successfully to introduce Friesian x Bunaji crossbred cows into the study area (Bayer and Maina, 1984). Before adoption of the prophylaxis approach, 25% of the introduced animals died as a result of babesiosis and anaplasmosis. Since then, only one more crossbred has died from heartwater.

The seasonal pattern of tick load found in this study suggests that exotic cattle should be introduced into enzootic areas in the dry season, when they will be exposed to relatively low tick burdens, so that they will be able to develop sufficiently strong resistance before the tick-borne disease challenge peaks after the onset of the rains. However, this would mean that the animals would be introduced during a period of nutritional stress, and the need of supplementary feeding would increase.

CONCLUSIONS

Infectious diseases have continued to be the major health hazard in the Nigerian subhumid zone, but vaccination campaigns by federal and state government agencies appear to have effectively controlled them, at least until 1982, when rinderpest resurfaced.

Faecal egg counts are affected by numerous factors and must therefore be interpreted with caution. However, the number of eggs in faeces may still be considered as a rough index of the number of worms in the intestinal tract. ILCA's observation of an egg count of 400 may have been influenced by the use of proprietary drugs and traditional herbs used by pastoralists. However, the adoption of forage interventions by pastoralists will increasingly cause them to stay and graze in the same area. This will increase the build-up of internal parasites, so that the helminth infestation will become a major constraint. Increased productivity due to improved nutrition may also bring about metabolic diseases.

Seasonal patterns of tick burden on cattle found in this study are such that the strategic use of acaricides in the early wet season may be a cost-effective method of breaking the peak in tick challenge. However, at least in the case of indigenous cattle, strategic hand spraying is unlikely to be a suitable alternative to the present practice of hand deticking, largely because of labour and material input requirements of hand spraying relative to hand deticking.

The dry season, as the time of low tick challenge, would be the most appropriate period for introducing exotic cattle. Animals introduced into the zone should be supported by appropriate prophylactic treatment. Imizol (imidocard dipropionate) appears to confer effective immunity against anaplasmosis and babesiosis. For heartwater, tetracycline treatment would be more appropriate. Calves born to immune crossbreds appeared to be immune to tick-borne diseases. A less intensive regime of minimal hand spraying of axillae, groin, udder and perineum at weekly intervals during the months of February to August and at fortnightly intervals thereafter will minimize dermatophilosis and the consequent loss of udder quarters in crossbred cattle.

FUTURE RESEARCH

The programme's future veterinary research should focus on the following:

1. In Nigeria, rapid agricultural expansion and heavy hunting pressure have transformed the habitat and removed the wildlife hosts of tsetse. Bourn (1983) concluded that as a result there has been a fundamental shift in the vector-host-parasite relationship and that the very nature of the disease has changed. Future research should investigate the prevalence of trypanosomiasis and its effect on productivity.
2. Ogunrinade and Ogunrinade (1980) estimated a 2.5% annual incidence of fascioliasis with an annual mortality of 1% in Nigeria. On the Jos Plateau Synge (1981) found that 31.6% of all adult animals sampled were positive for Fasciola gigantica ova. In ILCA's experimental sheep flock fascioliasis has been the main cause of mortality. There is therefore a need to assess the economic importance of fascioliasis in cattle and sheep in Nigeria's subhumid zone.
3. A study on reproductive disorders needs to be conducted to establish the causes of the low productivity of local herds.
4. Observations on the health of crossbred cattle need to be continued with a particular focus on dermatophilosis. The effect of intensive hand spraying on dermatophilosis needs to be monitored.
5. The general health status of small ruminants needs to be investigated. Preliminary analysis of goat and sheep sera samples has shown positive reactions to the following diseases: infectious bovine rhinotracheitis (46%), peste des petits ruminants (7.5%), bluetongue (78%), and contagious ecthyma (orf) (57%).

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Veterinary traditional practice
in Nigeria

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ABSTRACT

Current veterinary therapy in Nigeria is suffering from both the scarcity and the high cost of drugs. Reduced funding for animal disease control programmes is likely to influence the incidence of some important animal diseases to the detriment of the nation's livestock sector. The danger exists that the cost of veterinary care may grow beyond the reach of the Nigerian livestock owner.

The easiest and most rational solution to the problem is to develop acceptably effective drugs from reasonably inexpensive sources for use as supplements to commercial drugs. Veterinary traditional medicine provides a shortcut to this end, and is more readily accessible for scientific investigation than its counterpart, traditional human medicine.

The importance of collecting baseline data about traditional practices is discussed, and examples are given of the traditional definitions of some important diseases of food animals, including streptothricosis, trypanosomiasis, helminthiasis, brucellosis and certain neuropathies, as well as the traditional treatments for these and other diseases. A method of standardizing the collection and analysis of ethno-veterinary medical information is proposed.

INTRODUCTION

Pharmacotherapy is one of the most important means of controlling animal diseases. In veterinary practice, the cost of treatment is important in determining the usefulness of a drug. Owing to current economic trends, the cost of veterinary care in Nigeria is becoming prohibitively high, while some drugs are not obtainable at all.

For example, the land area reclaimed from tsetse in Nigeria has declined from 7024 to 5404 and to 0.0 km² in 1982, 1983 and 1984 respectively due to reduced funding and increasing costs of insecticides and other vector control inputs (Jawonisi, 1984).

A practical solution to this problem is to develop acceptably effective drugs from reasonably inexpensive and locally available raw materials. The easiest and most traditional way of achieving this goal is through study of Nigeria's traditional veterinary and human medical practices, selecting from them those preparations that show promising results for development into drugs.

Successful use of herbal remedies in modern health care systems is being achieved in China, India and the Soviet Union (Obianwu, 1984). Serious efforts are being made in some African countries, including Nigeria, Ghana and Tanzania. However, very little is being done to exploit traditional medicine as it applies to veterinary practices, even though the integration of traditional remedies may be much easier in the veterinary than in the human medical field (Nwude and Ibrahim, 1980).

The branch of traditional medicine most amenable to scientific investigation is herbal medicine. Indications that studies of herbal remedies can yield fruitful results abound in the literature. A decoction of the plants Combretum mucronatum and Mitragyna stipulosa, used traditionally as a cure for guinea worm infestation in Ghana, is now considered the treatment of choice against the disease (Ampofo, 1977; Sofowora, 1982; Obianwu, 1984). Artemisinin, isolated from a herb used as an anti-malarial in Chinese human traditional medicine, is the drug of choice against cerebral malaria (Ekanem, 1983). Syrup xylopica is a

pharmaceutically acceptable broad-spectrum antimicrobial preparation for use against infections of the bronchial system, and was developed from Xylopia aethiopica (Flagbe, 1983).

Many international organizations, such as the World Health Organization, the United Nations Educational, Scientific and Cultural Organization, the Organization of African Unity, and the United Nations Industrial Development Organization, participate actively in the field of human traditional medicine (Sofowora, 1982). This is not true for veterinary traditional medicine, probably due to a lack of awareness of its existence and potential amongst the elite public and scientists. Moreover, professional traditional healers have contributed immensely through their associations and unions in kindling public interest to the level at which it leads to institutional participation. The absence of organized professional traditional veterinarians in Nigeria (Nwude and Ibrahim, 1980) is therefore an additional reason why traditional veterinary practices have not attracted as much attention.

Interest in veterinary traditional practices in Nigeria is now being generated by virtue of necessity. Both at the First National Conference on Tsetse and Trypanosomiasis Research in Nigeria (Kaduna, August 10-12, 1981), and at the Fifth International Symposium on Medicinal Plants (Ife, July 13-15, 1983), calls were made for studies on traditional antitrypanosomal herbs due to the dearth of new drugs against the disease and the resistance of trypanosomes against available antitrypanosomal agents. Recently ILCA supported a research programme on some aspects of veterinary traditional practices of the Fulani in Kaduna State, Nigeria. This paper reports on some of the findings, identifies some of the problems encountered and suggests aspects for further study and development.

A COMPARISON OF VETERINARY AND HUMAN TRADITIONAL MEDICAL PRACTICES

The veterinary and human aspects of traditional medicine are quite distinct from each other in terms of their practitioners, concepts, materials and the methods employed in Nigeria. Human traditional medicine is practised mainly by professional traditional doctors or healers, who often rely on their practice exclusively for their livelihood. As a result, their

knowledge is guarded jealously and is divulged usually only to close relatives, and their methods are shrouded in secrecy (Sofowora, 1982). By contrast, there are no such professional veterinary traditional healers. Instead, practices relating to particular animal species are tied closely to group occupations. Thus canine diseases and their like are known chiefly by hunters, while horse medicine is the domain of those in the service of the ruling families or owners of race horses; traditional food animals practices are the speciality of traditional herders like the Fulani, the Shuwa and the Koyam (cattle), or women (poultry) and men (small ruminants) among the settled farmers (Ibrahim et al, 1983; Ibrahim, 1984).

Within each of these various categories, information on the diseases and remedies of the respective animal species is allowed to diffuse freely. As a result, there is more uniformity in practices within a given community and far less secrecy and attendant mysticism. The collection of information by scientists should be much easier and the information collected more reliable than in the case of human traditional medicine.

Diseases of man are ascribed to five causes, namely physical, psychological, astral, spiritual and esoteric (Sofowora, 1982), of which only the first two are recognized by modern medicine. In veterinary traditional practice, on the other hand, the only animal diseases attributed to non-physical causes are those manifested by neurological signs, which are generically called daji by Fulani herders. These, in further contrast to human traditional medicine, are treated with drugs rather than with incantations and/or exorcism.

Human traditional medical practitioners rely almost exclusively on symptoms of diseases and sorcery as diagnostic tools. Fulani herdsmen, on the other hand, pursue sick animals to the butchers and thus have some knowledge of the gross pathology of some animal diseases. Indeed, a number of animal diseases are traditionally recognized and named after the principal organs observed to be affected after slaughter. Thus anthrax, contagious bovine pleuropneumonia (CBPP) and fascioliasis are called in Hausa saifa (spleen), ciwon huhu (disease of the lungs) and hanta (liver) respectively. Also, certain internal animal diseases are named after the causative agents which are observed grossly after slaughter. Some of the

helminthic infections described below belong to this category. This additional advantage has contributed to a better understanding of animal diseases compared to human ailments.

VERNACULAR NOMENCLATURE OF ANIMAL DISEASES

The lack of a standard glossary or dictionary has made the scientific interpretation of disease terms in the vernacular difficult and unreliable (Ibrahim et al, 1983; Ibrahim, 1984). Presently, ethno-veterinary information is collected and interpreted freely by investigators without conformity to any previously established standards. This situation is further confounded by the fact that the vernacular names of diseases and of plants vary widely amongst different settlements even in the same geographical area, as well as among different dialects or ethnic groups. As a result it is difficult to correlate information collected by different workers, or even by the same worker from different sources or areas. In addition, the results of scientific investigations into the efficacy of veterinary traditional medicines may not be correlated with their traditional uses or indications. This has the effect of reducing the value of using ethno-veterinary botanical information as a starting point in the study of medicinal plants.

Until an acceptable glossary is available investigators should state fully the traditional descriptions of the diseases whose traditional treatments they are reporting on. Such a glossary can meanwhile be prepared by a multidisciplinary team of investigators including clinicians, pathologists, pharmacologists, parasitologists, botanists, linguists and anthropologists.

The sample definitions given below were compiled principally from Fulani herdsmen living around the Zonkwa and Samaru areas of Kaduna State, and the terms reported are exhaustive neither for the geographical areas nor for the diseases covered.

Helminthic infections

Bu'd'di is a general Fulfulde term for gastro-intestinal helminthiasis. Based on their observations of the clinical signs and of slaughtered animals, the Fulani appear to have correctly identified all the common and important types of helminthic infections, and classified the condition according to aetiology and/or signs as follows:

1. Bu'd'di pammare is caused by round white worms, which inhabit the intestines and are often passed in the faeces of affected animals. Informants identified specimens of Heterakis spumosa from rats and Toxacara vitulorum from calves as pammare. This term can thus be interpreted to mean ascariasis.
2. Bu'd'di gyaju'di is caused by flat white worms which are also seen in the faeces and in the intestines of affected animals. Samples of tapeworms from rodents (Inermicapsifer congolensis and Hymenolepis spp.) were identified as gyaju'di by herdsmen. This term obviously refers to cestodiasis.
3. Bu'd'di bu'deji is described as being caused by small reddish worms usually found attached inside the stomach of affected animals, and not seen in the faeces. The disease is associated with lokoje (oedematous swelling under the jaw) and is said by herdsmen to be the most difficult to treat. Samples of hookworms (Heligomina thannomysi) from rats were recognized by informants as bu'deji. The term bu'd'di bu'deji may thus be translated as haemonchosis or trichostrongylosis.
4. Balku is a more appropriate term for liver fluke infestation or fascioliasis than the Hausa haji'a. Fulani informers described the disease as affecting ruminants and characterized by 'poor doing'. The disease has been associated with streams and lakes but not with snails. The aetiological agents are said to be motile and flat, and are seen in the livers of affected animals.

5. Hanta, on the other hand, is described as characterized by hyperaemia and discharges affecting the eyes in live animals, and a swollen liver in slaughtered animals. Some herdsmen distinguished between a 'black' and a 'white' form of the condition, based on the colour of the liver of affected cattle. This distinction suggests haemorrhages or congestion for the former, and anaemia or necrotic changes for the latter. The cause of hanta was not known. The term hanta hitherto widely interpreted to mean fascioliasis, does not seem appropriate for that disease. Further studies are required to establish the meaning of hanta.

6. Goli is described as a disease of the young calf characterized by bloody diarrhoea. Worms were implicated as the cause of the disease by some informants. The term is usually freely translated to mean helminthiasis. Coccidiosis and bacterial enteritis should also be considered as possible translations.

7. Madara (the Hausa work for milk) is described by herdsmen as a disease of very young calves characterized by diarrhoea or constipation and transmitted to the calf through the milk of the dam. The description is suggestive of toxocariasis or bacterial enteritis.

Diseases with neurological signs

It appeared from interviews with herdsmen that most diseases with unknown (microscopic) causes and manifested by the neurological signs are referred to by the generic name daji. The causes are described by herdsmen as related to iskoki, meaning 'the unseen' or 'spirits' (Abraham, 1958). All forms of daji are however treated without the aid of incantations or magical rites, suggesting the imputation of unknown physical causes.

The Fulani herdsmen recognize three forms of daji:

1. Mi'du is characterized by 'earth-eating' and 'poor doing'. Earth from abandoned ant-hills is included in prescriptions

used in treatment. This term may refer to any disease manifested by pica, for example mineral deficiencies.

2. Nauru is described as characterized by depression or stupor. One ear appears floppy, while the other remains erect. The affected animal seeks shade. It is said to be a killer disease. The term may have been derived from the Arabic word for 'light'. The condition called nauru by the herdsmen may refer to photosensitization, although skin reactions were not mentioned by the informants.
3. Waire affects cattle and has a sudden onset. It is characterized by convulsions and recumbency. The herdsmen stated that the affected animal may recover without treatment. The description given was vague and could fit any of a number of diseases like cowdriosis, certain toxic reactions, etc.

Streptothricosis

Kirci, a Hausa word, is widely translated as streptothricosis. The Fulani describe kirci as a disease affecting the skin of cattle, and have associated it with ticks. They recognize three forms of kirci as follows:

1. Kirci mai she'ka: the lesions start as boils or papules, mostly on the tail and udder, and are difficult to treat.
2. Kirci mai dusa: this is manifested by crusty lesions, usually observed on the back. This is the form usually referred to simply as kirci, and is said to be easier to treat.
3. Bajale: this is said to be a form of kirci in which the lesions consist of long cutaneous outgrowths, which do not coalesce and which appear mostly on the face. This form is said to be difficult to treat.

These descriptions given by herdsmen are strongly reminiscent of the descriptions given for three of the four forms of streptothricosis by Mornet and Theiry (1955) as the nodular, the ickthyotic and the tumorous forms respectively.

Brucellosis

The term bakkale is used to denote a disease of cattle manifested by lameness and hygromas, and abortions in pregnant cows. It can be translated as brucellosis.

Trypanosomiasis

Sammore has been so extensively used to mean trypanosomiasis of cattle that it has come to be accepted as such. It has been described by some Fulani as a disease of cattle characterized by weakness, emaciation and inappetence, and caused by tsetse fly bites (Ibrahim et al, 1983). However, descriptions given by some herdsmen are vague, do not include the vector, and seem to fit most debilitating diseases. In some instances the following definition was given: A disease of cattle manifested by loss of weight and disturbed hair coat (this was said to show only in the afternoons), without any association with tsetse. It seems that the term means different things to different groups of herdsmen even in the same locality. Trypanosomiasis is therefore not the only translation.

TRADITIONAL CONTROL OF ANIMAL DISEASE

The scientific investigation of veterinary traditional practices is still embryonic, but it is already revealing some interesting facts. Fulani herders in Kaduna State often wash their hands in an infusion made from the leaves of Nelsonia campestris and Guiera senegalensis before collecting or handling drugs intended for treatment: the latter is now known to possess anti-microbial properties (Sokomba et al, 1983), a fact which would appear to justify its use.

Chemotherapy, chemoprophylaxis and preventive medicine are developed to an appreciable extent in veterinary traditional disease control systems in Nigeria. For example, the Fulani herders employ three types of drugs in

the control of helminthic infections: those which kill worms (vermicides), those which only expel worms (vermifuges), and those which protect against infection (prophylactics). Four out of nine plants used as veterinary traditional anthelmintics for cattle by herdsmen in Kaduna State were found to be effective against experimental trichostrongyle infections. There were Aloe barteri, Terminalia avicennioides, Butyrospermum paradoxum, and Acacia albida (Ibrahim, 1984). The first two have recently been tested against natural helminthic infections of sheep, for which they also appear effective (Ibrahim, unpublished data).

For most infectious diseases, the herders distinguish between therapeutic and prophylactic agents. For example, sammore is treated with a combination of the root of Cochlospermum tinctorum and the seed of Anogeissus leiocarpus, or Cassythia filiformis, or a combination of bark from Khaya senegalensis and Pterocarpus erinaceus, while the latter is used alone for prevention.

Furthermore, the role of insects in the spread of diseases is fully appreciated by herdsmen. Hydrotherapy is sometimes employed to prevent insect bites. For example, cattle are bathed with an infusion of Sesbania aculeata before traversing a tsetse belt (Dalziel, 1937). Animal houses are also fumigated with herbs like Adansonia digitata, Guiera senegalensis (Dalziel, 1937), Citrus aurantifolia (Nwude and Ibrahim, 1980) or else the ash and/or pomade from certain plants may be applied externally, as with the tobacco plant (Dalziel, 1937; Nwude and Ibrahim, 1980).

Certain diseases are recognized by herdsmen as very difficult to treat. Kirci (streptothricosis) is one example. Indeed, most of the treatments for kirci consist of topical applications with oils from plants such as Butyrospermum paradoxum, Parkia clappertoniana (Nwude and Ibrahim, 1980), or with infusions like that of Fadogia agrestis. There are also some diseases for which herdsmen state that they know of no effective treatment. Rinderpest belongs to this category.

Magical uses of plants are sometimes encountered in veterinary traditional medicine. For example, abundant clustered fruits may suggest fertility, as with Ficus capensis. Also, many plants with thick leaves or milky juices are used as galactogogues because of their resemblance to the udder or milk. Perularia tomentosa, some species of Euphorbia, Lactuca taraxaciflora and Picrus humilis probably belong to this category. Striga senegalensis is used in cases of poisoning resulting from excessive consumption of corn by virtue of its parasitic effect on corn. Heliotropium indicum is used to treat scorpion stings because the inflorescence resembles the scorpion sting.

On the other hand, certain diseases which are poorly understood by herdsmen are treated exclusively with herbal drugs. For instance, the neurological condition waire is treated with a combination of the leaf of Abrus precatorius and the root of Tamarindus indica, while ma'du is treated with Tapinanthus belvisii and earth from ant-hills.

COLLECTION OF INFORMATION ON VETERINARY TRADITIONAL PRACTICE

Various methods of collecting information on medicinal plants used in human traditional medicine have been suggested (Sofowora, 1982). Owing to the differences between the two fields mentioned earlier, most of them are not appropriate and the rest need some modification before they can be applied to veterinary traditional practice.

To begin with, the source of the information to be consulted should be selected in accordance with the animal species the investigator desires information about, otherwise the information collected is at best incomplete.

Secondly, due account should be given to the description of the disease as well as to those diseases which informants think are similar, i.e. the traditional alternative diagnoses.

Thirdly, the information given depends entirely on the format of the enquiry. For example, if an investigator enquires about treatments for bu'd'di per se, it will not later be possible to know whether the treatment is meant for cestodiasis, trichostrongylosis or ascariasis. Ignorance will result in falsely negative results if the medicament is tested against the wrong helminth model.

Information should also be collected on the biography of the informant. Biography is important, especially when consulting Fulani herdsmen, as their vernacular names for diseases and the plants used in treatments may depend on their contact with people far away from their present area of habitation. For instance, of 30 plants on which information was collected from herdsmen living in Kaduna State, only 11 could be collected for identification because the herdsmen said the plants were available only in former settlements (Ibrahim, 1984), which sometimes included other countries.

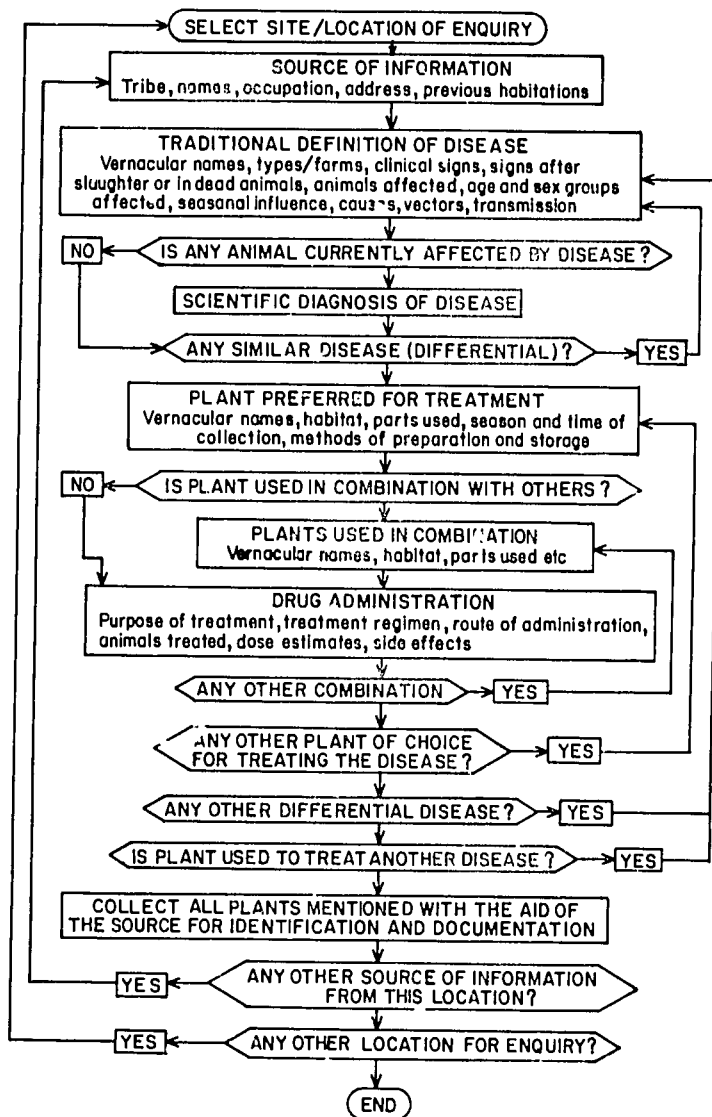
The flow chart shown as Figure 1 can be used as a guideline for collecting and analysing information on veterinary traditional practice.

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Figure 1. Veterinary traditional practices: Information collection and analysis.



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The effects of supplementary feeding
of traditionally managed Bunaji cows

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ABSTRACT

The response of Bunaji cattle to supplementary feeding under pastoral conditions is described. Supplementary feeding of cows significantly improved the weights of their calves at birth and at 1 year of age compared with controls (20.1, and 107.9 kg versus 18.6 and 99.3 kg, respectively). At 365 days of age, viability of calves from supplemented dams averaged 88% versus 67% in calves from non-supplemented dams ($P < 0.001$). Milk for calves and humans averaged 128 and 179 litres/cow/year ($P < 0.05$). Differences between type of supplement fed were not significant ($P > 0.05$). Supplementary feeding did not improve calving intervals, thus calling for a closer examination of the feeding regime.

INTRODUCTION

This paper discusses the effects of supplementary feeding of Bunaji cows on the birth weight and growth of their calves to 365 days of age. Pullan (1980) and Synge (1981) had clearly demonstrated the positive effects of such feeding under pastoral management on the Jos Plateau at sites close to ILCA's present case study areas. Synge (1981) concluded that "the increased milk production alone was not economic while the economics in terms of increased numbers of calves was staggering. Although feeding the total herd was economic at the time of study, if the price of feedstuffs were to increase markedly with respect to cattle prices the exercise may no

longer be economic. However, feeding only the breeding cows leaves a very wide profit margin, the income being seven times the outlay."

A theoretical analysis by Milligan and von Kaufmann (1979) demonstrated the inadequacy of natural forage in terms of an average Buraji milking cow's requirements. ILCA concluded that the work of Pullan and Synge should be repeated in the subhumid zone but, in expectation of increasing shortages and rising prices of feedstuffs, the feeding of agro-industrial byproducts should be introduced only as a precursor to rationing of improved forages (Papers 15 and 16), and should be directed towards the pregnant and lactating cows. The major objectives were to determine whether the pastoralist would accept the principle of rationing certain amounts to certain animals and, if he did, how the animals would respond in terms of increased productivity. The methods used were to follow the phases of livestock systems research (Paper 2) in order to ascertain the livestock owner's willingness to pay for supplementary feedstuffs, and the extension and input requirements necessary to support a supplementary feeding scheme (Paper 19).

MATERIALS AND METHODS

Effects of feeding of cottonseed cake at the rate of 1 kg/cow/day or grazing of Stylosanthes fodder bank for 2.5 hours/day on the productivity of cows were studied. During the researcher-managed phase, supplementation started in November and ended in April. During the producer-managed phase, supplementation usually started in January. A 1-litre molasses-urea supplement (80 g of urea) diluted to 40 litres with water and containing 30% crude protein equivalent (as in cottonseed cake) was tried in the 1980/81 dry season only. The data analysis procedures were the same as reported in Paper 6.

The feeding trials followed the phases of livestock systems research outlined in Paper 2. In the early phases, under researcher management, there is much more control. In the later phases, under producer management, many complicating factors, such as farmers' whims and problems in extension supervision, affected the outcome (Paper 19).

RESULTS AND DISCUSSION

This section reports on the analysis of the aggregate data from both researcher-managed and producer-managed trials.

Prewaning calf growth

Table 1 shows the effect of supplementary feeding of Bunaji cows on the birth weight and growth of their calves to 365 days of age.

Table. Least squares means of calf body weight (kg) from birth to 365 days, ILCA case study areas, southern Kaduna State, 1979-1982^{a/}

Variable	Age (days)				No. of records
	Birth	90	180	365	
Overall mean	19.4	43.6	60.2	103.6	322
Supplementation:					
No	18.6 a	42.4	56.8 a	99.3 a	218
Yes	20.1 b	44.8	63.5 b	107.9 b	104

^{a/}Means within a column with differing superscripts are significantly different ($P < 0.05$).

The birth weight of calves whose dams received supplements of any sort were significantly heavier than those from controls ($P < 0.05$). When the supplements were partitioned, the birth weight of calves whose dams had received molasses-urea or grazed Stylosanthes fodder bank appeared significantly heavier ($P < 0.05$) than that of calves from dams which had received cottonseed cake. These results differ markedly from those of Pleasants and Ginindza (1981), Hight (1966) and Ward (1968), who reported no improvement in the birth weight of calves from dams which were fed supplements. ILCA's results indicate the greater severity of undernutrition of cows in the present study.

At 1 year of age the difference in weights (8.6 kg) of calves from supplemented and non-supplemented dams was still significant ($P < 0.05$). As Table 2 shows, calves from dams fed molasses-urea had an advantage over

those from dams fed other supplements, but this was not significant ($P<0.05$). The sample was small (14 cows) because pastoralists objected to the feeding of molasses when their animals became coated with it.

Table 2. Effect of type of supplement fed to dam on body weight (kg) of Bunaji calves.^{a/}

Supplement type	Age (days)				No. of records
	Birth	90	180	365	
Cottonseed cake	18.1 a	44.7	64.2	104.0	66
Molasses-urea	21.9 b	44.3	64.9	112.2	14
Fodder bank	20.2 b	44.5	61.5	107.4	24

^{a/}Means within a column with differing superscripts are significantly different ($P<0.05$).

The viability of calves (Table 3) from supplemented dams was significantly superior ($P<0.05$) to that of calves from non-supplemented dams at all ages up to 365 days. At 365 days of age the viability of calves from supplemented dams averaged 88%, versus 67.2% in calves from non-supplemented dams ($P<0.001$). This dramatic reduction in calf mortality was readily acknowledged by cooperating pastoralists.

Table 3. Estimated least squares means of viability of calves from Bunaji cows fed supplements.^{a/}

Variable	Age (days)					No. of records
	30	90	180	360	Mortality	
Overall mean	97.0	91.8	82.8	77.6	22.4	723
Supplementation:						
No	93.4 a	84.5 a	72.6 a	67.2 a	32.8	557
Yes	100.0 b	99.0 b	93.1 b	88.0 b	12.0	166

^{a/}Means within a column with differing superscripts are significantly different ($P<0.05$).

Milk yield

Table 4 shows least squares means of human milk offtake from supplemented and non-supplemented Bunaji cows. There were no significant differences ($P>0.05$) at any stage of the lactation up to 180 days. However, the total amount taken off supplemented dams was 9.3% higher than from the control animals. The interaction between the dry or early wet season and supplementation was significant only at 30 days after calving ($P<0.05$).

Table 4. Least squares means of human milk offtake (litres) to 180 days.

Variable	Days postpartum		No. of records
	90	180	
Overall mean	56.3	108.3	585
Supplementation:			
No	54.6	103.6	430
Yes	58.1	113.2	155

Table 5 shows least squares means of milk estimated to have been consumed by Bunaji calves in pastoralists' herds. The total for calves from non-supplemented dams averaged 430.3 litres or 2.4 litres per day over the 180-day period, whilst calves of supplemented dams obtained 5.6% more at 454.6 litres or 2.53 litres per day. The mean amount of milk consumed by calves from supplemented dams was significantly higher ($P<0.05$) only during the fourth month after birth.

Table 5. Least squares means of estimated milk (litres) consumed by Bunaji calves.

Variable	Days postpartum		No. of records
	90	180	
Overall mean	298.1	442.3	585
Supplementation:			
No	298.0	430.3	430
Yes	298.4	454.6	155

Table 6 shows least squares means of the estimated total amount of milk produced by Bunaji cows up to 180 days after calving. That produced by cows which received supplements was 567.7 litres, only 6.4% higher than that produced by cows with no supplements.

Table 6. Least squares means of total milk (litres) produced by Bunaji cows.

Variable	Days postpartum		No. of records
	90	180	
Overall mean	354.5	550.7	585
Supplementation:			
No	352.5	533.7	430
Yes	356.5	567.7	155

Results under researcher management

The results of the two feeding trials under researcher management are summarized in Tables 7 and 8.

Table 7. Response of Bunaji cows to supplementary feeding (1979/1980).

Production trait	Control ^{a/}	Supplemented ^{a/}	Significance level
Milk offtake (ml/day \pm SE) Nov 1979 - Apr 1980	424+77 (22)	750+85 (22)	P<0.01
Milk offtake during first 90 days (ml/day \pm SE)	620+110 (17)	1519+150 (11)	P<0.01
Calf birth weight (kg \pm SE)	18.29+1.26 (17)	22.09+0.71 (11)	n.s. ^{c/}
Calf weight gain during first 90 days (kg/day \pm SE) ^{b/}	0.19+0.02 (17)	0.23+0.03 (11)	n.s. ^{c/}
Total milk yield during first 90 days (ml/day \pm SE)	2830+310 (17)	3880+470 (11)	n.s. (c/)

^{a/} Figures in parenthesis represent number of observations.

^{b/} Total milk yield = human offtake plus milk to calf. Milk to calf was calculated from calf weight gain using a liveweight gain ratio of 11.65:1 (Drewry et al, 1959).

^{c/} n.s. = not significant.

Table 8. Response of Bunaji cows to supplementary feeding (1980/81).^{a/}

Production trait	Control ^{a/}	Supplemented ^{a/}	Significance level
Milk offtake (ml/day \pm SE) Nov 1980 - Apr 1981	341+54 (14)	636+54 (18)	P<0.01
Milk offtake during first 90 days (ml/day \pm SE)	418+66 (12)	864+102 (16)	P<0.01
Calf birth weight (kg \pm SE)	19.25 (12)	18.75 (16)	n.s. ^{c/}
Calf weight gain during first 90 days (kg/day \pm SE)	0.23+0.03 (12)	0.33+0.02 (16)	P<0.01
Milk consumed by calf during first 90 days (ml/day \pm SE)	2679+318 (12)	3843+276 (16)	P<0.01
Total milk yield during first 90 days (ml/day \pm SE) ^{b/}	3096+302 (12)	4707+285 (16)	P<0.01

^{a/} Figures in parenthesis represent number of observations.

^{b/} Total milk yield = human milk offtake plus milk to calf. Milk to calf was calculated from calf weight gain using a liveweight gain ratio of 11.65:1 (Drewry et al, 1959).

^{c/} n.s. = not significant.

The results of both trials indicate that significantly (P<0.01) more milk (about 77% in 1979/80 and 87% in 1980/81) was taken off from supplemented cows than from controls. Also, for cows to the first 90 days after calving, significantly (P<0.01) more milk (about 90% for 1979/80 and over 100% for 1980/81) was extracted from those which received cottonseed cake than from the controls. In the 1979/80 trials, there were no differences in the amount of milk consumed by the calf, nor in total milk yield during the first 90 days after calving. Whilst supplemented cows produced 37% more milk than controls the differences were not significant (P>0.05). In the 1980/81 trials, however, the differences in milk consumed by the calf and in the total milk produced were very highly significant (P<0.01). Milk consumed by the calf and total milk produced averaged 43.4 and 52.0% higher

respectively in the treatment group than in the control animals. The birth weights of calves from dams which had supplements for only 1 month before calving were not significantly different ($P>0.05$) from controls in either year of the experiment.

Average daily weight gains during the first 90 days postpartum of calves from supplemented dams versus control calves for 1979/80 and 1980/81 were 0.23, 0.19, 0.33 and 0.23 kg respectively. The differences in growth rate in 1979/80 were not statistically significant ($P>0.05$). In the 1980/81 trial however, the differences were significant ($P<0.01$). Up to 90 days of age, the calves from supplemented cows grew faster by about 21% for 1979/80, but by about 43% for 1980/81 than those of control cows.

Results under producer management

Owing to the greater difficulties encountered in monitoring the producer-managed trials, and because they started more recently, it is as yet too early to report the results with any confidence. Initial indications are that under producer management the results are similar but less marked: supplementation has little effect on calving intervals, or may even lengthen them. This 'result' may be due to producers sharing the feed with animals in the herd other than those selected for supplementation, and milking their supplemented cows over longer periods than their control animals. Increased calf survival may also be keeping more cows longer in lactational anoestrus, an effect that can be countered by early weaning and calf supplementation.

CONCLUSIONS

The main effects of supplementation are enhanced calf viability and faster calf growth. This statistically significant effect must be due to increased milk consumption, but the estimated milk consumption was not significantly different. The method for estimating milk consumed by calves therefore needs to be re-evaluated for subhumid zone conditions.

The recommended feeding regime must be amended to permit the feeding of all cows in order to break the anoestrus of non-lactating animals. It is clear from producers' responses that the extent of severe nutritional stress in individual animals had not been appreciated in the past and must be catered for. The improvement in calf viability suggests that calves should be supplemented directly, thus facilitating early weaning and possibly encouraging owners to extract more milk from their dams.

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Paper 11

Settlement and land use by Fulani pastoralists in case study areas

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ABSTRACT

Abet was selected for studies of settlement and land use because the area represents a widespread situation in the subhumid zone: Fulani cattle keepers settled amidst crop farmers and practising cropping.

The Fulani settled because herd movements were no longer considered necessary and settled life was viewed as more comfortable. They settled close to farming communities, which they regard as customers for meat, milk and manure. In addition, they value the presence of public services such as schools and a dispensary.

The settled Fulani live year-round at one site, but shift every few years to another site a few kilometres away, in contrast to the transhumant Fulani who come into Abet from the north each dry season. The influx of transhumant herds creates competition for grazing resources. The settled Fulani do not have specific grazing areas for herds belonging to individual families or groups.

Settled Fulani homesteads are generally located on marginal land bordering hamlet areas and on fields which farmers have left fallow for several years. The Fulani do not own land in Abet, nor do they hold certificates of occupancy. However, in adjacent areas like Zonkwa and Kachia, some Fulani have gained land rights through purchase or after lengthy occupation of unclaimed land. The Kaje and Kamantan farmers in Abet generally regard the Fulani as only temporary occupants of their land. Of all civil

complaints in the courts involving Fulani, very few were land disputes per se. The main reason for suing Fulani was crop damage by cattle.

The prime motive of the few Abet Fulani who have moved to the Kachia Grazing Reserve in the last 5 years has been to gain access to adequate land for cropping and grazing without problems with farmers. However, because the farmers in and around the grazing reserve have not been compensated by the government for their land, these Fulani are realizing that relations with farmers may not be any better than in Abet, while grazing is definitely worse. Rather than living in false expectation of security, the Fulani in Abet are aware of the need to come to terms with the farmers with whom they co-exist, and make conscious efforts to do so.

INTRODUCTION

As an area which represents a widespread situation in the Nigerian subhumid zone - Fulani cattle keepers settling amidst crop farmers and becoming agropastoralists - Abet was selected for detailed studies of settlement and land use by Fulani and of farmer-Fulani relations. Some comparative studies were made in the Kachia Grazing Reserve, an area of government-assisted pastoral settlement.

ABET STUDY AREA

Settled Fulani comprise almost one tenth of the population on the Abet Plains. As Muslims, the Fulani are not only an ethnic but also a religious minority in a largely Christianized area. In the first decade of the nineteenth century, Fulani - Hausa jihad forces penetrated into what is now southern Kaduna State with a following of cattle-keeping Fulani. Kachichere, an upland area some 30 km east of Abet, became a centre of Fulani settlement. However, for some time already Fulani herders had been passing through or camping for several months on the Abet Plains in the dry season. Because the Abet area was not completely subjugated during Fulani rule in northern Nigeria, local administrative posts are held by members of the indigenous population. The present-day Fulani inhabitants thus cannot take advantage of association with a local ruling elite.

The settled Fulani in Abet are mainly of the Kachichere group; only about 5% are non-Kachichere who have given up a migratory existence within the last few years. A small number of Kachichere Fulani families have been living in the Abet area for up to four generations, but the majority settled there - i.e. began to live at one site year-round - within the last three decades.

The Fulani homestead, bukkaaru or ruga (Hausa word for 'cattle encampment'), includes one to several households: cooked pots of food may be shared, but the herds of the individual households are usually managed separately and household heads generally farm individually and control separate stores of grain. The homesteads in Abet comprise mainly domed grass huts which must be renewed every 3 or 4 years, but some homesteads contain one or several more durable buildings with mud-brick walls, thatched or metal roofs, and wooden or metal doors. As a rule, the first such structure is built for the household head, either in the traditional circular style or in the form of a long rectangle with two or more rooms like the modern dwellings of the local farmers. Other structures may include grain-drying platforms, thatched mud-walled granaries similar to those in local farm compounds, and shelters for poultry, calves, sheep or - more rarely - goats. A recent innovation is a thatched kitchen hut for each wife.

Fulani settlement sites

Most present-day household heads did not themselves make the decision to settle; rather this was made by an earlier generation. The most common reason for initial settlement by forefathers is that the family was 'tired of moving', that migration caused 'too much suffering'. These Fulani obviously view a settled existence as a more comfortable life-style. Family histories reveal that the time of initial settlement usually coincided with the time when the family first started grain farming, although the need to farm was seldom explicitly stated as a reason for settling. Cropping and year-round settlement do not necessarily coincide: many of the transhumant Fulani who spend the dry season in Abet now

cultivate at their wet-season bases further north, and there are settled Fulani in Abet with large herds or off-farm sources of income who do little or no cropping.

With regard to choice of Abet rather than elsewhere for settlement, good-quality farmland is mentioned by the Fulani as a favourable feature of the area. However, the prime reasons stated are the availability of sufficient forage and water for the herds throughout the year and a healthy environment for livestock. Further advantages for animal production in a farming area like Abet are, according to the Fulani:

1. Herding is easier and safer on cleared land.
2. Vegetation on recent fallow is of better quality and more easily accessible for grazing than in uncleared woodland.
3. Early grass growth on last year's cropped land is particularly valuable for grazing.
4. Crop residues provide good early dry-season grazing, leading to higher milk production and conception rates, and a build-up of reserves for later in the season.

Abet also has many low-lying fadama areas which are valued by the Fulani for dry-season grazing of their herds.

Markets for sale of milk products are mentioned by the Fulani women as a criterion for choice of settlement site, but the male household heads do not usually give this the same importance. The men have close links with the local butchers and traders, who purchase livestock from them. The farmers also buy stock directly from the Fulani, either for family or religious celebrations or as an investment of earnings from crops. In addition, the farmers pay the Fulani for manuring cropland with their cattle herds. The Fulani regard the farmers not only as a market for milk, butter, meat and manure, but also as a convenient source of crop products for purchase. The Fulani are attracted by the opportunities in an established farming area like Abet to hire skilled farm labour for ridging

and weeding. The farmers are also a source of crop management knowledge appropriate to the location; the Fulani, who say they have learned through observation, have adopted local farming techniques. A further attraction of a relatively densely populated area like Abet is that there are already established public services, e.g. schools and a dispensary, of which the Fulani are eager to take advantage.

The settled Fulani live year-round at one site but shift to other sites a few kilometres away every few years. Reasons for shifting include: a request by a farmer for the return of loaned land, the desire of Fulani to join friends or relatives who have moved, departure from a site where cattle have fallen ill or died, gaining better access to motorable roads and taxi routes, and avoiding the risk of crop damage in fields which farmers began to cultivate close to the Fulani homestead after it had been established. In many cases, the deserted homestead area is then cultivated by Kaje or Kamantan farmers wishing to take advantage of the soil fertility from accumulated animal manure.

Access to land

Settled Fulani homesteads are generally located on marginal land bordering farming hamlet areas, and on fields which farmers have left fallow for several years. None of the Fulani in Abet owns land there, nor have any obtained official certificates of land occupancy. Only two have agreements for permanent land use, in both cases grants of land made by village heads in the presence of witnesses. However, in adjacent areas still within the Abet aerial survey area, some Fulani have gained land rights through purchase or after lengthy occupation of unclaimed land. For example, in Madauchi close to the Kaje centre of Kurmin Bi/Zonkwa, one clan of Kachichere Fulani holds customary rights of land occupancy, having settled three generations ago on previously uncultivated land. The leading family in the clan later shifted their homestead further south but returned to Madauchi after 24 years; their claim to the land was recognized by the local Kaje community.

On the Abet Plains, however, the Fulani are generally regarded as only temporary occupants of any particular piece of land. Each time the Fulani shift their homesteads, they make new arrangements with farmers or village

leaders for rights to use specific areas for dwelling and cropping. In most cases no time limit is set, but rights to crop fields not contiguous with the homestead site must be renewed annually. The farmers do not demand payment, but a Fulani wishing to retain permission for land use customarily provides cattle manure free of charge for the farmer's fields and makes the occasional gift of meat or even a calf to the farm family. Until recently, it was generally understood by Fulani and farmers in Abet that livestock are free to graze any uncropped or harvested area, with the exception of certain village reserves, e.g. for thatching grass.

The farming community is willing to loan land to the Fulani mainly so as to have access to animal manure, which is particularly valued for the farmers' ginger fields, but also for grain crops. Ginger is one of the main cash crops in the area, and requires organic matter for proper rhizome development. Farmers are prepared to pay the Fulani for keeping cattle overnight on fields before planting, and those farmers who loan land to the Fulani can expect to receive manure at reduced rates or free of charge. Another advantage of allowing Fulani to occupy farm land which is temporarily not being cultivated by the farmers, often because of labour shortage, is that less bush encroachment occurs, so that less labour is required for clearing when the farmers decide to use the land again.

Land-use conflicts

Because land-based innovations in livestock production require that pastoralists have access to land, and because it was thought that land conflicts might be serious in this area of relatively high cultivation density and significant Fulani population, a study was made of land issues as reflected in court cases over the period 1960-1979 (van der Valk, 1981). It was found that, contrary to general belief, land disputes in the local court (Zonkwa) constituted only a small proportion of all civil complaints involving Fulani. The main reason for suing Fulani was crop damage by cattle. There was no significant increase in the occurrence of such crop damage cases with increasing human and livestock pressure on the land. Rather, the incidence rate fluctuated over the years and was seemingly influenced by chance events such as drought or the wide distribution of fertilizer during the Operation Feed the Nation campaign. Even in those

cases settled eventually out of court (generally arbitrated by the village head), it was found that crop damage by farmers' animals (pigs, goats) was more frequent than damage by Fulani cattle and sheep. Out of all 204 cases of crop damage by animals, 65% involved Fulani; thus, the problem is not exclusively that of the Fulani. However, the Fulani were more often ordered to pay compensation. Not reflected in this study are the cases settled between individuals before reaching the traditional ruler or the court, reported in interviews with farmers and Fulani to be the majority of crop damage incidents involving Fulani-owned livestock. Settlement of the incident normally consists of a payment by the Fulani to the farmer, usually in cash but sometimes also by way of providing manure for cropping.

Since the study of court cases was completed, there have been isolated incidents of conflict between Fulani and Kaje individuals. As a result, customary Fulani grazing rights in Abet have been somewhat restricted. Whereas the Fulani could previously graze their herds freely on crop residues in farmers' fields, the owner of the first herd entering a harvested field must now ask permission of the field owner. Not all Fulani are adhering to this new unwritten rule which the farmers have been trying to implement over the last 2 years (the 1982/83 and 1983/84 dry seasons). In addition, Kaje farmers are now objecting to herds grazing cropland after the first rains of the wet season, because the cattle's hooves compact the soil, making it more difficult to cultivate. Monitoring of farmer - Fulani relations in Abet should continue in order to see whether a trend is developing or whether the situation will return to normal. In any case, a waning of the mutual dependence between farmers and Fulani is clearly occurring: the increased availability of mineral fertilizers has reduced farmers' dependence on Fulani herds for soil fertility maintenance, and increased cropping activity by the Fulani has reduced their dependence on farmers' grains and crop residues. Whether these developments will have a negative effect on farmer - Fulani relations remains to be seen.

The Fulani have one main complaint about the farmers: that they burn too extensively. Each dry season, the farmers burn cropland, grassland and bush, primarily to flush out game but also to clear fields of debris and to protect homes from uncontrolled fires. Herders bring cattle to burnt areas to graze the relatively nutritious regrowth, but complain that the animals are more in need of the bulk of vegetation which was lost to fire.

The settled Fulani also blame the transhumant Fulani for depletion of dry-season grazing resources. Two major cattle migration routes cut directly across the Abet Plains. Herders from the Bauchi Plateau pass through Abet before and during the grain harvest in November/December, en route to the Abuja area above the confluence of the Niger and Benue rivers, and return through Abet in April/May. In January/February, Fulani based in Kano State, after having harvested their crops and grazed their herds on crop residues there, move into the Abet area and southwest into Jabaland to spend the dry-season, returning to the north in May/June when Abet farmers have begun to plant. Dry-season cattle numbers increase by about two thirds over wet-season numbers in the Abet aerial survey area (Milligan et al, 1979). The dry-season camps of the transhumant Fulani are interspersed between settled Fulani homesteads and farmers' compounds, often on harvested or fallow fields.

The influx of transhumant herds in the dry season creates competition for grazing resources in Abet. Moreover, a few herds from the Zonkwa and Kachia areas (15 - 60 km from Abet) also graze the area in the dry season. Rough calculations reveal that, in the Abet case study area of ca 60 km², non-resident herds account for more than one third of total cattle grazing days during the 6-month dry season. The settled Fulani have not been able to reserve specific grazing areas for herds belonging to individual households or groups of families such as members of a clan. Except for a few weeks spent following the first rains of the wet season and irregular cases of wet- or dry-season movement of all or part of a herd, the Fulani settled in Abet normally graze their herds within about 5 km of the homestead. However, any other settled or transhumant herd is free to graze the same area. Many Abet Fulani have expressed the desire for the assistance of some government agency to exclude transhumant herds from areas customarily grazed by settled herds; they do not see how they could implement such grazing controls themselves.

Livestock watering points in the Abet area are, like grazing areas, not reserved for exclusive use by certain individuals or groups of livestock keepers. Several flowing streams provide ample water in the wet season, and there is still enough surface water in stream beds for the needs of both settled and transhumant herds throughout the dry season. No wells or water

holes need to be dug for watering livestock. The Fulani take their animals to water two or three times a day in the dry season. They regard Abet as an area well favoured with water.

Socio-political organization of the Fulani

An investigation by ILCA into forms of Fulani socio-political organization above the level of individual households revealed that they presently have limited influence in defining land-use patterns (Okali and Sule, 1980). The traditional political leader of an agnatic lineage group of Fulani pastoralists is the ardo, who either inherits title and position from his father or gains recognition on the merits of his personal abilities and prosperity. To encourage the settling of pastoralists and supervision of herds, these traditional leaders were incorporated into the colonial administrative structure and given responsibilities, primarily in collecting the cattle tax (jangali) and in campaigns against animal disease. The ardos were encouraged to establish permanent villages in the wet-season grazing areas of their followers; each is now responsible for a specific area rather than a specific group of people.

Since the abolition of jangali in 1976, the official role of the ardo has been vague. Present activities of an ardo include organizing Fulani access to veterinary and agricultural services, identifying diseased cattle and restricting their movement, settling disputes between Fulani over property inheritance, and - in conjunction with the village head as representative of the farmers - settling disputes between Fulani and farmers over land use or crop damage by livestock.

In Abet, one ardo is officially responsible for the Fulani living in Kaje areas and another for those living in Kamantan areas. Each ardo has three or four assistants who are responsible for Fulani living in subsections of these areas. The ardo for Kajeland appears to have little contact with the Fulani settled on the Abet Plains on the edge of his territory; the ardo for Kamantanland (a smaller territory) serves as the Abet Fulani's link to veterinary, agricultural and administrative services and is their representative in negotiations and disputes with local farmers.

A recent development in the socio-political organization of the Fulani is the Miyetti Allah Association, established in 1972 to promote the welfare of Fulani pastoralists and to represent their interests before government bodies. While a written constitution exists, many club branches are unaware of it and have formulated their own diverse goals, emphasizing literacy, Islamic education, and improved animal husbandry. There are at least 12 branches of the association in Kaduna State, but there are no regular meetings, no full-time officials, minimal record keeping, and sporadic attendance at meetings. Achievements such as the building of classrooms are due more to individual initiative and sponsorship than to the organization of members per se. The Miyetti Allah is a movement aimed at encouraging Fulani to claim their rights through education and settlement, but it has no authority in the domains of most concern to pastoralists, namely disease control and land rights. Consequently, it must content itself in assisting in court cases and in publicizing the land rights issue. As with the ardos, who are at least recognized as having authority, the Miyetti Allah has difficulties in organizing widespread involvement and continuing commitment of individual pastoralists, who have a tradition of relative independence in their production activities.

KACHIA GRAZING RESERVE

In view of the inability of most Fulani cattle keepers, either as individuals or through their socio-political organization, to gain secure rights to land, they have shown increasing interest in the government grazing reserves. While an objective of the Grazing Reserve Law has been to encourage the settlement of nomads, none of the current settlers on the Kachia reserve were previously nomadic pastoralists. All are Kachichere Fulani who have been resident in southern Kaduna State (formerly Southern Zaria Emirate) for generations. Several households had been living in the Kurmin Biri area, although they might have relocated every few years within a limited radius. The other households which have settled in the reserve within the past 6 years have mainly come from the Abet, Zangon Katab, Kachia, Zonkwa, Ungwar Rimi and Kagoro areas, all within 100 km of Kurmin Biri.

The prime motive of the Fulani for resettling within the reserve has been to obtain secure usufructuary rights to land where they can settle permanently without being disturbed by farmers. The grazing reserve is seen as offering this opportunity, as land which "belongs to the Fulani". All the Fulani had encountered problems with farmers at their previous sites in terms of crop damage charges and difficulties in obtaining sufficient cropland. In addition to this desire for undisturbed use of land, Fulani who settle in the reserve expect that the government will provide facilities and services such as water, veterinary care, insect control and tractor hire for land clearing.

In the grazing reserve, settlement sites are chosen mainly on the basis of suitability of land for cropping, since the cattle can be herded more widely for grazing. Thus, some Fulani are settling near indigenous farmers, since it is assumed that farmers have already selected the good farm land. Such locations near farmers also have the advantage of being relatively clear, flat and possibly even previously cropped, so cultivation is relatively easy, and there is road access and a taxi service. In contrast, a few Fulani have purposefully not settled close to farmers, preferring more isolated sites but still seeking good farm land. Much of the reserve is considered stony and unsuitable for cropping.

While the stated primary determinant of settlement site in nearly all cases is suitability of land for cropping, other factors are considered simultaneously, namely closeness to water and closeness to the main road, or access by road to markets and schools. Fulani children were attending schools before moving to the reserve, and continuation of their education is considered vital by the settled Fulani.

Despite Fulani expectations of security of tenure once they move to the grazing reserve, the reserve has not been gazetted and the indigenous Ikulu farmers are demanding payment for their land. Farmers clearly expect the government to pay for their land; this may make the land situation in the reserve more volatile than in non-reserve settlement areas. Certain tensions and hostilities exist: farmers refusing to grant Fulani and grazing reserve staff alike access to certain areas, farmers demanding unreasonable crop damage charges, and farmers purposefully opening up

bushland for cultivation in order to restrict grazing areas. Numerous threats have been reported, but there has been no major conflict to date. The Fulani express disappointment about the government's delay in resolving the land compensation issue and about recurring Fulani - farmer antagonism. However, there is a general feeling among the pastoralists who have moved to the reserve that the government will eventually pay and/or handle any problems.

While there has been an eightfold increase in Fulani settlement within the reserve over the past 6 years, there are still only some 34 households on a reserve which started operations in the early 1970s. While the development and promotion of a grazing reserve is a long-term process, there are certain factors apparently impeding Fulani settlement and/or permanence on the reserve. These are largely the same issues which, in reverse, lead to the spontaneous settlement by Fulani in areas of higher population and cultivation densities. Impediments to settlement on the reserve are:

1. The relative absence of socio-economic amenities, including markets, schools, health services and neighbours, considered necessary for a settled existence.
2. A shrubland ecology which makes herding difficult, harbours wild animals, holds the risk of uncontrollable bush fires that deplete dry-season forage bulk, and results in an isolated existence where children cannot play safely.
3. The minimal presence of fallowland, crop residue and fadama grazing resources, which are valued feedstuffs; consequently, in the dry season, many Fulani extend their grazing orbits outside the reserve boundaries or transfer their herds to other areas, both of which strategies make demands on labour; 30% of the herd managers in 1984 transferred part or all of their respective herds off the grazing reserve in the dry season.
4. The lack of labour available to hire on account of the small farming population; consequently, while there is land on the reserve available for farming and pasture development, the labour constraint prevents it from being fully exploited.

5. The influx of transhumant Fulani in the dry season who compete for the limited grazing resources and whose herds are thought to spread disease; since this is a government grazing reserve for settled Fulani, the settlers expect the government to ban the movement of transhumant Fulani into the reserve, but this has not been done.

6. Above all, as discussed previously, the growing friction with the indigenous farmers over land use. Because most of the Fulani moved to the reserve from higher population areas, they have, in effect, given up advantages such as more socio-economic amenities, fallowland and crop residue grazing, and the availability of labour for hire, in order to secure land rights without disturbance from farmers. Yet problems with farmers still occur on the grazing reserve and, at the same time, grazing possibilities are more limited and living conditions more severe than in many non-reserve areas where Fulani are settling. However, the Fulani in the reserve have the distinct advantage of not being confined by the amount of land available to them for cropping, and they do expect the government eventually to resolve land-use competition with indigenous farmers and transhumant Fulani.

Not all Fulani are so optimistic. On the Abet Plains, for example, Fulani who had contemplated moving to the Kachia Grazing Reserve or had even begun to build huts there, have now decided to remain in Abet at least until the land situation in the reserve is resolved. In Abet, the position of the Fulani is fairly clear: as long as they recognize the claims of the indigenous farmers to ownership of the land, they can obtain rights to use the land at least temporarily without having to expend capital to purchase it or labour to clear it, and they retain the flexibility to move herd and homestead whenever the need or desire arises. The benefits which the farmers and Fulani are gaining from each other in the way of crop - livestock and socio-economic interactions ensure that each group makes an effort to come to terms with the other. The Fulani may not have the long-term security of tenure on free land (as promised but not always realized

by the Grazing Reserve Law), but they and the landowners have at least evolved a system of relatively conflict-free and mutually beneficial co-existence.

CONCLUSIONS

The above observations are important because they highlight some of the factors involved in assisting settlement or resettlement of agropastoralists. They also demonstrate that agropastoralists can, in the right circumstances, settle peacefully amongst arable farming communities. This peaceful settlement is encouraging because it is unrealistic to expect more than a minority of agropastoralists to settle on reserves, since there is neither enough free land nor adequate funds with which to compensate resident farmers.

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Socio-economic aspects of Abet farming households

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ABSTRACT

ILCA's interventions, whether designed for pastoral or arable farmers, are more likely to succeed if the interactions of the two groups are borne in mind. This paper presents socio-economic information on 21 Abet farming households, based on a survey carried out during the crop year of 1981/82. The survey was based on the methodology and software developed for agricultural project monitoring.

The people of the area include the Kaje and Kamantan arable farmers and the Fulani agropastoralists. The main crops are sorghum, millet, maize, cocoyam and yam. Animals raised include cattle and sheep, mainly kept by the Fulani, goats and pigs kept by the arable farmers, and poultry.

Average household size is 9 persons, who contribute virtually all the labour. Peak labour demands occur in May-August (cultivation) and November (harvest). There are some age- and sex-related differences in seasonal labour.

Livestock accounted for 56% of cash income, independent of time of year. Over 38% of reported purchases of inputs and equipment were fertilizers of various types. Expenditure on food indicated little purchase of milk from neighbouring Fulani. The apparent excess of expenditure over income can only be attributed to off-farm earnings and remittances, which the survey did not record.

INTRODUCTION

ILCA's efforts to help improve the productivity of livestock and hence the incomes and welfare of producers in the subhumid zone depend on understanding the socio-economic circumstances of pastoral as well as farming households. The distinction between pastoral and farming households, although strong at the moment, can be expected to weaken in the future as the trend towards settlement and farming by herders continues. Likewise, the increasing tendency of farmers to acquire livestock further emphasizes the ambiguity of the terminology.

The important point, however, is that interventions designed for either group are more likely to succeed if the other is also kept in mind, due to the strong interactions between the two.

This paper presents the results of a farming household survey carried out by ILCA during the 1981/82 cropping year. It reports on the allocation of household and non-household labour during the year as well as its distribution between the various crops grown in the area. It also discusses the sources and amounts of income accruing to the sample households and examines their expenditure patterns.

MATERIALS AND METHODS

The household survey was carried out in Abet village, one of ILCA's study areas, from July 1981 to July 1982.

The survey forms used were identical to those used by the Agricultural Projects Monitoring Evaluation and Planning Unit (APMEPU) in their clearline farming household economic surveys all over Nigeria. The use of such forms enabled ILCA to be in the field much earlier than would have been possible if the Centre had had to design its own questionnaires. A further advantage was that the experience gained by APMEPU could be made available to ILCA, as well as APMEPU's trained personnel in the field of data collection and analysis.

However, such advantages were to some extent offset by problems familiar to any field researcher who has tried to use survey forms designed for a given purpose in a different setting and for a different purpose. Variables considered vital to ILCA were either completely left out of the questionnaire or were given cursory attention. In addition, information was collected on other variables of little interest to ILCA.

Abet (9° 40'N, 8° 10'E), the study village, is located about 14 km south of Zonkwa and inhabited mainly by the Kaje ethnic group. Other ethnic groups in and around the village are the Kamantan and the Fulani. The Kaje and the Kamantan are predominantly arable farmers, while the Fulani, although they grow some crops, raise livestock as their main source of income.

The major food crops in the area are sorghum, millet, maize, cocoyam and yam. Other crops include ginger, groundnuts, beans, rice, acha (fonio) and sweet potatoes. Animals raised include cattle (mainly by pastoral households), goats, sheep, pigs and poultry.

Average household size in the village was estimated at 9 persons, varying from 2 to 25 persons. The average household consisted of 1.6 children between the age of 0 and 7, 2.8 children between 7 and 14, 4.6 adults between 15 and 65, and 0.1 elderly persons over 65.

In terms of cropping practices, slightly over half the cultivated area was devoted to mixed cropping (54.5%), while the rest (45.5%) was devoted to sole crops. The cultivated areas per adult male farmer ranged from 1.5 to 3.5 ha (Powell and Waters-Bayer, 1984). In the non-pastoral households, 34 out of 35 households surveyed kept goats, 31 kept pigs, 33 had chickens, and 4 had ducks.

Methods used for data collection

Village chiefs and their subheads were visited and their permission sought before selecting the sample of farmers. The number of farming households under each subhead was obtained, and these formed the sample frame from which a random sample of 40 households was selected.

The sample size of 40 was chosen to make the best use of enumerator time and the supervisory capacity available. The survey lasted 1 year and each household was to be interviewed twice a week.

Of the original sample size of 40, only 28 household records proved useable by the time the data had been entered on the computer. The raw data were coded and stored on an Apple microcomputer before transfer to AFMEFU's computer for analysis. During transfer the useable number of household data records again fell, from 28 to 21, mainly due to problems in the transfer process. All the preliminary analyses being reported here concern the 21 households that were successfully transferred to AFMEFU's computer.

HOUSEHOLD LABOUR UTILIZATION

Family and hired labour

The peak nature of demand for labour is revealed when the distribution of labour for cropping according to months as well as according to the sex and age of the people doing the work is examined (Table 1). The table indicates that for male adults the heaviest months in terms of labour input are May, June, July, August and November. May and June are when first weeding takes place, while July and August are for subsequent weedings. These peaks are followed by a slight rest period during September and October. November is the harvest period for Guinea corn, and hence considerable male adult labour is required.

Labour input by female adults and children has a comparable distribution over the course of a year. However, during December children contributed more labour than adults. They became heavily involved in harvesting crops and transporting them from the farm to the house, as well as in taking care of crop residues.

Table 1 also gives the relative contribution of the three groups to total labour used. Female adult contributions ranged from 8 to 32% depending on the month. November is the month with the highest input from females, corresponding to the harvest time for late crops such as Guinea corn. Children's contributions ranged from 1 to 40%, with the highest input occurring during December.

Table 1. Total family labour used on Abet farms, 1981/82 (hours).

Month	Male adult	Female adult	Child	Total	Female (%)	Child (%)
July	3650	2187	2099	7936	28	26
August	3691	1508	1059	6258	24	17
September	2000	671	840	3511	19	24
October	1179	781	774	2734	29	28
November	3835	3310	3129	10274	32	30
December	1155	763	1275	3193	24	40
January	1872	235	966	3073	8	31
February	722	144	433	1299	11	33
March	284	69	5	358	19	1
April	3837	579	874	5290	11	17
May	6630	2263	1452	10345	22	14
June	7557	2363	1722	11642	20	15
Total	36412	14873	14628	65913	23	22

There are substantial differences in the distribution of labour between households that are not captured by the aggregates reported in the table. Table 2 indicates such differences for five households in the survey.

The differences in labour allocation between households imply either the cultivation of different crops and/or variable crop management practices. Nonetheless, the pattern of peak activity during July and August still emerges clearly. The dry season, when little farming activity takes place, is reflected in the figures for January to March, when in some households no labour use was recorded on the farm.

Table 2. Labour input distribution for selected households (% of year's labour input).

Household No.	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun
1	60.8	19.6	2.0	17.6
2	32.5	10.0	10.0	47.5
3	45.2	31.0	0.0	23.8
4	80.8	7.7	0.0	11.5
5	45.2	0.0	6.5	48.4

Table 3 confirms the low level of utilization of hired labour in the area. In Abet, as in most traditional agricultural settings, labour and land form the most important farm inputs. Most of the labour comes from within the farm household, and its importance is emphasized by the high correlation between available family labour and cultivated farm area. This suggests that while the family continues to provide the main source of labour in farm production, there is an upper limit to the amount of land that can be cultivated.

Analysis of the labour input data indicated that 97.7% of the total labour used by the average household came from the farming family. Of the 1318 hours hired during the year, 1066 were on a contract basis while 252 were on other terms. The amount reported in this category probably includes exchange labour, which was not recorded. The period for which non-household labour was hired coincided with the weeding months of June, July and August, indicating the pressure on household labour during this period.

Table 3. Hired labour in 21 Abet farming households, 1981/82 (hours).

Month	Contract	Other	Total
July	77	110	187
August	430	0	430
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0
January	0	0	0
February	0	5	5
March	0	0	0
April	0	0	0
May	3	0	3
June	556	137	693
Total	1066	252	1318

The allocation of labour by crop indicates that maize, Guinea corn, beans, yam, cocoyam, late millet and okra are the leading crops in the area (Table 4).

Table 4. Labour allocation by crop in 21 Abet farming households, 1981/82 (hours).

Crop	Male adult	Female adult	Child
Acha (fonio)	43	9	0
Guinea corn	8731	3344	4037
Maize	10745	4027	2698
Millet	4873	3247	3132
Rice	317	214	113
Beans ^{a/}	1524	707	963
Pigeon peas	171	63	84
Groundnuts	460	121	107
Cassava	638	7	0
Cocoyam	4745	415	1594
Sweet potato	113	47	236
Yam	1185	327	319
Garden egg	6	18	6
Okra	1082	140	639
Peppers	134	513	31
Ginger	618	442	772
Cashew nut	6	0	0
Others	3765	1257	834
Total	37650	14898	15565

^{a/} Includes soybeans, cow peas and other species.

Contribution of arrivals in the household to labour supply

An analysis of people entering the household was carried out to determine the reasons why they were joining the household as well as what proportion of them were available for farm work during their stay. Sixty-five percent of those joining the households were male. Reasons for coming included visiting, returning from school, ceremonies, work, return from hospital, and birth, as shown in Table 5.

Table 5. Reasons given by people entering 21 Abet farming households, 1981/82 (% of arrivals).

Reason	Percent
Visiting	30.8
Return from school	20.0
Ceremonies	6.0
Relative for work	5.6
Return from hospital	1.5
Birth	1.1
Other	35.0

Whether or not they gave work as a reason, the majority of those joining households (74%) were available for farm work. Some came specifically for that reason. A higher percentage of female than male arrivals were available for work (78 and 66% respectively).

Table 6. Availability for farm work of arrivals in 21 Abet farming households, 1981/82 (% of arrivals).

Sex	Percent
Males	66
Females	78.2
Total	73.6

SOURCES OF INCOME

This section examines the income patterns of the households surveyed. The sources of income examined were limited to income accruing from the sale of crops and livestock. Cash sales as well as sales in kind were considered. Table 7 indicates the frequency of items sold for cash.

Of the items sold for cash, those derived from livestock accounted for almost 56% in value terms, although they account for only 20% of the number of items in the list. This indicates the higher cash value of livestock products compared to crops.

Table 7. Major items sold by 21 farmers in Abet, 1981/82.

Item	Percent of all items sold	Cash received (₦) ^{a/}
Guinea corn	15.2	805.50
Maize	3.7	544.28
Millet	4.8	168.20
Rice	3.4	656.85
Pigeon peas	1.6	26.60
Groundnuts	1.2	92.50
Cassava	2.3	184.20
Cocoyam	5.5	89.90
Sweet potato	1.1	284.20
Yam	3.2	160.40
Garden eggs	n.a. ^{b/}	43.20
Okra	1.2	26.20
Vegetables	n.a.	14.80
Spices ^{c/}	12.9	1050.40
Citrus	1.8	196.60
Guava	n.a.	6.00
Locust bean	9.9	820.00
Mango	1.6	17.20
Goats	4.2	550.30
Sheep	n.a.	80.00
Pigs	6.7	4483.82
Chickens	10.4	409.60
Guinea fowls	n.a.	10.00
Ducks	n.a.	5.00
Fish	n.a.	13.90
Eggs	1.4	11.20
Turkeys	n.a.	821.00
Cattle	n.a.	284.00
Skin	n.a.	0.20
Others	7.9	n.a.
Total	100	11856.05
Livestock income		6655.52
% of total income		56.14
Pigs % of livestock income		67.37

^{a/}* 1.00 = approximately US\$ 1.33 in 1984.

^{b/} n.a. = sale below 1% of total items sold.

^{c/} The principal component of this category is ginger, but other spices are also included.

Since some expenditure is time-dependent, for example payment for farm inputs, the timing of cash income is very important. The income of farmers comes mainly from the sale of crops, and is thus governed by biological processes that are also time-dependent. In general, sales of crops are heaviest during the immediate post-harvest period. This peak reflects the inadequacy of storage structures as well as the pressing needs of farmers for cash. Livestock sales are more independent of the time of year. Table 7 gives a breakdown of the timing of the receipt of income from major crop and livestock sales. The largest receipts came during the harvest months of November and December, and the 2 months following these, as indicated in Table 8.

Table 8. Timing of sales of crops and livestock in Abet farming households (N, month).

Month	Amount
July	683.90
August	679.10
September	497.90
October	240.50
November	1243.30
December	1102.00
January	1008.00
February	1526.20
March	2836.50
April	1470.70
May	504.30
June	1180.70
Total	12973.10

EXPENDITURE

On farm inputs

The income received by farmers from the sale of crops and livestock, as well as from other sources, is either spent on farm inputs, food and household items, or is given away in the form of gifts, or is saved.

Table 9 gives a percentage breakdown of the types of inputs and equipment on which farmers spent their income, whereas Table 10 shows the sources of these. The inputs purchased are mainly fertilizer, simple farm implements (hoes) and planting materials. Over 38% of reported purchases of inputs and equipment were fertilizers of various types.

Table 9. Purchased inputs and equipment for 21 Abet households, 1981/82.

Item or equipment	Percentage of reported purchases
Hoe	22.6
Compound fertilizer	24.1
C.A.N. fertilizer	9.2
Cutlass/Axe/Knife	8.2
SUPA fertilizer	5.6
Cocoyam (planting material)	4.6
Pigeon peas (planting material)	2.1
Rice (planting material)	1.5
Others	17.5

Table 10 indicates that the market place is the most important source for farm inputs and equipment, followed closely by farmer cooperative societies and councils. The cooperative institutions seem to have a strong base in the area. The relatively poor performance of Farm Service Centres (FSCs) was probably due to their relative scarcity in the area at the time, since the FSCs are known to have performed very well and captured a much bigger share of the farm input market in other parts of the state.

Table 10. Major sources of purchased inputs and equipment in 21 Abet farming households, 1981/82.

Source	Percentage share
Trader/Market	33.8
Cooperative	28.2
Farmer council	10.8
Farm service centre (FSC)	10.3
Relative/Friend	4.1
Other government source	2.6
Own <u>unguwa</u> /Village head	2.1
Own farm	1.5
Other sources	6.7

On food and household goods

The types of food purchased by farmers complement what they already grow and consume. Hence there are no leading cereal crops in the list of food and household goods given in Table 11. Home-made beer (burkutu), a popular drink in the area, topped all other items in terms of the amount of money spent. Other leading items included soap, palm oil, clothing, meats and tinned milk. The purchases of fresh and sour milk, which are offered for sale by pastoral households, were very low, suggesting that the Abet Fulani probably take their milk further afield for sale in other villages and towns. If these survey figures are a true reflection of the activities of the total population in the area, it means that by settling down the Fulani have 'agreed' to incur the 'cost' of having to travel out of the immediate area in order to have access to more favourable markets for their milk.

Table 11. Important food and household item purchases in Abet farming households, 1981/82.

Item	Amount spent N ^{a/}
Rice	77.20
Beans	123.90
Cocoyam	40.10
Spices	246.54
Pork	39.90
Beef	90.10
Other meats	353.80
Fish	80.30
Bread	56.12
Palm oil	1389.73
Tinned milk	122.16
Fresh cow milk	8.90
Sour milk	8.60
Locust bean cake	60.00
Sugar	48.80
Salt	220.45
Bottled beer	110.80
Home-made beer	1678.79
Palm wine	97.10
Shoes	153.60
Clothing	515.75
Kerosine	142.46
Soap	941.16
Other toiletries	56.16
Transport	104.13
All others	8087.14
Total	14853.69

a/ * 1.00 = approximately US\$ 1.33 in 1984.

Comparison

Finally, it is of interest to compare the expenditure on food and other household items with that on farm inputs. Since available cash is always limited, farmers might be expected to have developed decision-making mechanisms to allocate income optimally to the two expenditure categories at any given time of year. For example, a decline in food expenditure might be expected during the period of heaviest fertilizer purchases, unless borrowing is involved. The figures presented in Table 12 do not support this hypothesis. This is probably due to the existence of other types of expenditure as well as to the contrasting behaviour of individual

farmers in relation to the two categories of expenditure: clearly more complex decision-making mechanisms are involved.

Table 12 shows the timing of input purchases, most of which occur early in the growing season. July turned out to be the month of highest input purchases. This is a little late in the season, since generally the rains come in May. The high figures for July may indicate the late delivery of fertilizers (a major input) in the area in that year of the survey.

Table 12. Expenditure on farm inputs, food and other household items in Abet farming households, 1981/82 (₦).

Month	Inputs	Food or other items	Total	Inputs as % of total
July	2352.7	932.80	3285.50	72
August	588.5	4893.40	5481.90	11
September	1642	4152.50	5794.50	28
October	51.2	3608.80	3660.00	1
November	19.2	938.30	957.50	2
December	0	1714.70	1714.70	0
January	15.5	2090.50	2106.00	1
February	39.2	1932.50	1971.70	2
March	106.6	1076.70	1183.30	9
April	264.3	4142.40	4406.70	6
May	146.6	842.80	989.00	15
June	46.5	1348.50	1395.00	3
Total	5272.3	27673.90	32946.20	16

Looking at income and expenditure simultaneously shows that farmers were in deficit for 10 out of the 12 months of the survey year. However, the only income sources recorded were crops and livestock. Income from other sources, such as remittances, payment for custom work, tailoring, salaries etc, were not taken into account. Such data are currently being analysed. The figures nevertheless indicate that the income from crops and livestock was inadequate given the level of expenditures for inputs, food and household goods (Table 13). In other words, the 2 months with a surplus of income over expenditure were November and March. November is the harvest period for most late-season crops, while the surplus in March might indicate increased sales of stored farm products, livestock and/or a

reduction in expenditure in anticipation of the need to buy farm inputs for the new cropping season.

Table 13. Income and expenditure patterns of Abet farming households, 1981/82 (K).

Month	Income from crops and livestock	Expenditure on inputs and equipment	Expenditure on food, etc	Net income
Jan	1000.80	15.50	2090.50	-1098.00
Feb	1526.20	39.20	1932.50	- 445.00
Mar	2836.50	106.60	1076.60	1653.20
Apr	1470.70	264.30	4142.40	-1834.70
May	504.30	146.60	842.80	- 485.10
Jun	1180.70	46.50	1348.50	- 214.30
Jul	683.90	2352.70	952.80	- 488.10
Aug	679.10	588.50	4893.40	-1234.50
Sep	497.90	1642.00	4152.50	-3635.60
Oct	240.50	51.20	3608.80	-1887.20
Nov	1243.30	19.20	938.30	285.80
Dec	1102.00	0.00	1714.70	- 612.70

CONCLUSIONS

In conclusion, the paper has examined two major aspects of the Abet farming household economy: labour utilization and the sources and disposal of income from farming activities. Household economics need to be considered in the design, execution and evaluation of improved technology packages.

The paper has also brought out the interactions between crop and livestock production. In particular, it has revealed the very important role of livestock and livestock products in the generation of income for farming households. This topic warrants further study, especially given the often problematic state of the data from which these results were obtained. The distribution of labour shows that the contribution of women and children is significant and should be considered in the design of interventions.

The labour distribution over time indicated the possibility of a 'rest period', with little farm work, sometime in September and October. Further study on this could generate a point of ILCA intervention to fit the period, and thus the circumstances of farmers. The peak labour demand periods indicated the involvement of all family members in farm work. There was also hiring of labour to some extent. Ways to reduce the peaks should be investigated. A linear programming model of farm households might be useful in this regard. The overall impacts of labour use, income, and expenditure on the household economy could then be examined in a holistic manner.

Given that the farmers live interdependently with pastoralists, it is important that similar information relating to the pastoralists be examined. This is being done and results are expected shortly. Comparison of the two economies is expected to improve on the knowledge of crop-livestock interactions.

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Cropping systems in the subhumid zone
of Nigeria

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ABSTRACT

Given the projected rise in population and subsequent increase in cropping across the subhumid zone of Nigeria, innovations are needed that mutually benefit both crop and livestock sectors. An understanding of representative cropping systems is necessary in order to identify constraints and develop appropriate techniques for increasing the quantity, quality and availability of feed resources while assuring that subsistence needs are still met. To this end baseline studies have been conducted with traditional crop farmers and Fulani agropastoralists to define current cropping patterns, management and yields, and the constraints to increased grain and forage production.

The prime aim of both farming and pastoral ethnic groups in cropping is to meet household consumption needs. For the Fulani this is to reduce the need to sell animals for purchasing grain. Sorghum, maize and millet are the principal grain crops for both farmers and Fulani, although farmers also grow soyabeans, ginger and groundnuts for sale. Cropping patterns are typical of these throughout the zone; intercropping is prominent and a variety of cereals, pulses and tubers are grown. Soyabean and maize appear to be increasing in importance in the cropping pattern of farmers. Millet is apparently becoming less important.

The farmers in Abet still practise fallowing, although the availability of chemical fertilizer and the added labour involved in opening up fallow lands have resulted in more permanent cultivation of fields. Competition

for labour between cropping and livestock husbandry seems to exist in the Fulani agropastoral system in Kurmin Biri.

Grain yields of farmers are comparable to those in other subhumid locations in Nigeria. The Fulani, who rely principally on cattle manure and experience competition for labour with cattle management, still attain comparable yields to the specialized farmers, who almost exclusively use chemical fertilizer.

INTRODUCTION

Crop production can be increased by improving yields or by expanding the area under cultivation. In Nigeria's subhumid zone, where population is rising rapidly and supplies of inputs are limited, the most common response is to cultivate more land. As the area under cultivation increases, prime grazing areas will diminish, with ruminant livestock becoming more and more dependent on fodder obtained from cropland. With the reduction in fallowing, or in some cases its complete disappearance, the role of livestock in maintaining soil fertility through manure could become an important factor in sustaining productivity in many parts of the zone. Likewise, the use of animals as a source of power and transport can greatly increase the returns to labour in cropping. This paper presents a general discussion of cropping systems across the zone and the results of in-depth studies carried out on the cultivation practices of indigenous crop farmers and Fulani agropastoralists in the IICA case study areas of Abet and Kurmin Biri.

GENERAL DESCRIPTION OF CROPPING SYSTEMS

Cropping systems across the zone are characterized by tremendous diversity. The predominant form of crop husbandry in the case study areas is the rainfed cultivation of annual cereal crops. Areas under cultivation are generally small (2 to 4 ha), the primary objective of farmers being to meet subsistence needs. Surplus crops, however, are sold and some cash crops may be grown.

Because cropping operations are almost exclusively done manually, labour is the major input. The amount of land cultivated annually per household is

therefore a function of family and/or hired labour availability during periods of peak demand, namely during land preparation and weeding. Although this labour constraint is the critical factor in many parts of the subhumid zone where population densities are low, in areas of high population concentration land is the limiting factor. Norman (1978), working in three villages in the northern part of the Nigerian subhumid zone, found that farm size is inversely related to population density. Similar relationships in the subhumid zone of Benin and Togo have also been found (Steiner, 1982). In areas of high population density, the return per unit area, rather than the return per unit labour, becomes the critical production factor (Burnham, 1980).

As in much of sub-Saharan Africa, intercropping, or the simultaneous cultivation of two or more crops on the same piece of land, is common throughout the zone. Norman (1974) reviews the numerous physical and technical advantages of intercropping over sole cropping. The main advantages mentioned by farmers relate to maximizing returns from limited resources and stabilizing income over time (Abalu, 1976). The range of local climatic and soil conditions, resource availability, and markets or farmers' tastes and preferences allows a wide variety of cereal, pulse and tuber crops to be grown. The zone's long growing period of 180 to 270 days accommodates the predominant crops of the north, including sorghum, millet, groundnuts and cowpea, as well as yams, cocoyams, cassava, rice and maize in the more humid south. A variety of subsidiary crops and vegetables are also grown.

By combining crops of different growing periods, farmers develop highly diversified cropping patterns involving as many as 5 to 6 but more commonly 2 to 3 crops in a mixture (Okiybo and Greenland, 1976; Steiner, 1982). The most complex mixtures and highest yielding plots are small areas close to the household where soil fertility is maintained at high levels through concentrated additions of animal manure, night soil, household sweepings, ash, etc. The complexity of crop mixtures, as well as crop yield, generally decline in fields more distant from the household. In these fields, yields are generally proportionate to the additions of organic manure and chemical fertilizer and the levels at which crop rotations and fallowing are practised.

The zone's relatively high rainfall subjects soils to leaching and erosion, with a consequent loss in productivity if cultivated continuously. Fallowing is commonly practised as a means of maintaining land at a steady productive level without its undergoing severe or progressive degradation. When the fallow period is long enough in relation to the cropping period on the given soil type, natural vegetation restores soil organic matter, nutrient status and structure, and suppresses weeds, pests, and/or diseases that may have been a problem during cropping years.

Ruthenberg (1980) describes agricultural systems in the subhumid zone as being in transition between shifting and permanent cultivation: the frequency of cropping is increasing and fallowing is decreasing. In these systems the cultivation factor $R^{1/}$ is 30 to 40, with loss of soil fertility being a particular problem. In areas of high population density where land is the limiting factor, the length of fallow periods is greatly reduced or the practice abandoned altogether. The opportunity cost of leaving land idle is high and farmers are encouraged to surrender their usufructuary rights to fallow land (Norman, 1978). In low population areas, the limited labour supply is concentrated on cultivating the most productive lands, leaving less productive land to regenerate. Shifting cultivation, typified by slash-and-burn, and involving the movements of whole communities from one site to another every few years, is today found only in isolated areas within the subhumid zone of Nigeria.

Young and Wright (1980) have determined fallow period requirements for the major soil types of the savanna zone (i.e. 180 to 270 growing days) at different levels of inputs (Table 1). Even at high input levels, all soils would require some fallow period to maintain productivity. The uncertain availability and expense of the necessary inputs to maintain soils at high or even medium fertility levels limit the use of such inputs by most farmers. Soils in the zone therefore require fallowing. The optimum length of the fallow period can be reduced by the application of organic manure, if this is available in sufficient quantities.

$$R = \frac{\frac{1}{\text{crop years}} \times 100}{(\text{crop years} + \text{fallow years})}$$

Table 1. Cultivation factors (R values) of soils in the savanna zone of tropical Africa.^{a/}

Soil type	Input levels ^{b/}		
	Low	Intermediate	High
Regosols, Arenosols, Acrisols	15	35	65
Ferralsols	15	35	70
Luisols	30	50	75
Nitisols	30-55	80	90
Cambisols	50	60	85
Vertisols	55	75	90
Fluvisols, Gleysols	70	80	90

^{a/}R = number of crop years x (100)/(crop plus fallow years). The savanna zone corresponds to the area where the growing period is 180 to 270 days.

^{b/}Low = traditional methods of farming with no use of chemical fertilizers or transported organic manure.

Intermediate = use of improved agricultural techniques but limited technical knowledge and/or capital resources. Fertilizers at levels of 50-100 kg/ha of nutrients and/or practicable amounts of organic manure.

High = modern methods with advanced technology and high capital resources. Fertilizers at levels of maximum economic return, chemical weed control, adequate soil conservation methods.

Source: Adapted from Young and Wright (1980).

CROPPING BY FARMERS IN ABET

The baseline information on cropping practices by indigenous farmers in Abet has been derived from 35 farming units representing a 15% sample in a 32 km² area. The farming unit consists of one nuclear family and its land holding. Land used by these farm units can be divided into three general categories: small gardens adjacent to the compound, cultivated fields at various distances from the compound, and fallow lands that are generally furthest from the compound.

Cultivated areas

There is a large range in the number of cultivated fields per farmer and hence in the area devoted to crops among the 35 farmers, as shown in Table 2. On average, farmers cultivate between 1.5 and 3.5 ha, although some cultivate considerably more. When the area cultivated by the 35 farmers is extrapolated to the total farming population in the 32 km² area, it is estimated that 23% of the total land area is under cultivation. This corresponds closely to the 25% found by aerial survey (Milligan et al, 1979).

Table 2. Cultivated areas of crop farmers in Abet (1981).

Farmers (No.)	Fields/ farmer	Field total	Estimated area ^{a/}	
			Farmer (ha)	Total (ha)
4	2	8	1.42	5.68
6	3	18	2.13	12.78
12	4	48	2.84	34.08
6	5	30	3.55	21.30
2	6	12	4.26	8.52
2	8	16	5.68	11.36
2	9	18	6.39	12.78
1	10	10	7.10	7.10
Total	35	160		113.60

^{a/} Estimated areas based on average field size derived from 41 fields or total cultivated areas of 16 farms where mean = 0.71, SD_t = 0.49, range = 0.26 - 1.29.

A total of 23 crops combined in 64 cropping enterprises were identified in farmers' fields. Sorghum, millet, maize and soybeans are the most important crops (Table 3) and intercropping is the predominant practice although millet is almost exclusively sole cropped. Of the total enterprises, two crops in combination is the most common (38%), followed by three crops (26%), sole crops (25%), four crops (6%), and five crops (5%).

The long-season sorghum variety of the Guinea race (Sorghum bicolor) cultivated in Abet is the dominant type of sorghum in the savanna belt of West Africa (Harlan and de Wet, 1974), while a late variety of millet (Pennisetum typhoides) transplanted from nurseries is restricted to more humid areas (Nwasike et.al, 1982). Maize (Zea mays) consists mainly of improved varieties that are widely cultivated in Nigeria (IITA, 1981). The soybeans (Glycine max) grown are a long-season variety with an indeterminate growth habit, while groundnuts (Arachis hypogaea) are short-season, small-kerneled Spanish types. Significant soybean production is confined to only two areas in central Nigeria (Knipscheer and Ay, 1982), one of which includes Abet.

As with most crop farmers across the zone, the first priority of Abet farmers is food crops to meet household needs. However, surpluses are sold and some crops, notably soybean, groundnuts and ginger, are grown primarily for sale. Farmers' decisions on cropping patterns take into consideration the onset and probable duration of the wet season, input availability (especially fertilizers) and, to some extent, prices (Balcet, 1982). A generalized planting and harvesting pattern for sorghum, millet, maize, soybean and groundnuts in relation to rainfall distribution in Abet is given in Figure 1. Although the early rains can be very erratic, the wet season in Abet is long enough to allow some flexibility in planting the major crops as well as the cultivation of a wide range of subsidiary crops.

Figure 1. Crop planting and harvesting patterns in relation to rainfall distribution and soil moisture in Abet.

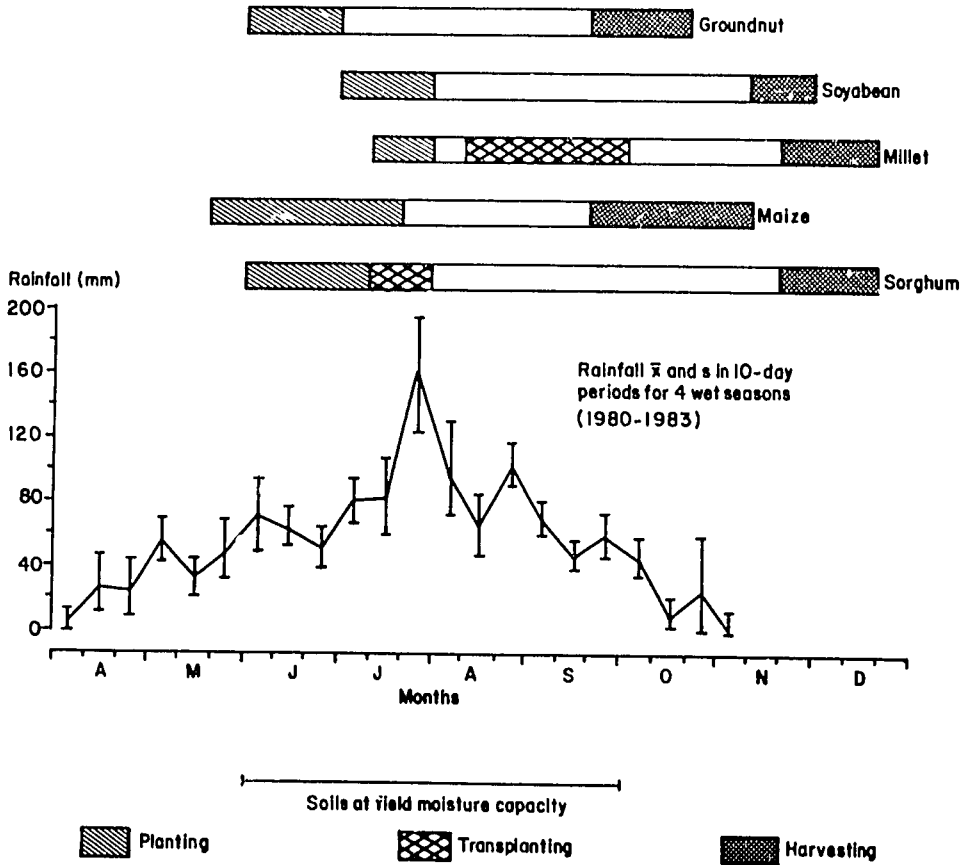


Table 3. Cropping patterns for crop farmers in Abet (1981).

Crop enterprise	Plots (No.)	Plot sizes		Cultivated area (ha)	% of total cultivated area
		(No.)	Mean (ha)		
Millet	86	18	0.53	45.58	40
Sorghum/maize	32	4	0.55	17.60	15
Sorghum/soybean	38	9	0.30	11.40	10
Sorghum	30	11	0.34	10.20	9
Sorghum/maize/soybean	23	6	0.29	6.67	6
Others ^{a/}	121			22.15	20
Total	330	48		113.60	100

^{a/}Others: 59 other cropping enterprises involving the above-mentioned and the following 19 crops: groundnuts, African rice (*Oryza glaberrima*), ginger (*Zingiber officinale*), lima bean (*Phaseolus lunatus*), yams (*Dioscorea* spp.), okra (*Hibiscus esculentus*), cocoyam (*Colocasia esculentus*), sweet potato (*Ipomoea batatas*), finger millet (*Eleusine coracana*), fonio (*Digitaria exilis*), cowpeas (*Vigna unguiculata*), cassava (*Manihot esculenta*), pepper (*Capsicum annum*), garden egg (*Solanum incanum*), spinach (*Amaranthus* spp.), sesame or beneseed (*Sesamum indicum*), roselle (*Hibiscus sabdariffa*), bitterleaf (*Vernonia* spp.), and kenaf (*Hibiscus cannabinus*).

During the early wet season, priority is given to sorghum and maize over cash crops and food crops of lesser importance. When a farmer sees that self-sufficiency in these crops has a high probability of success, then he will consider income generation. Maize is the first crop to be planted. Sorghum is interplanted 2 to 3 weeks later, during which time groundnut fields are also prepared and planted. Soybeans are interplanted into sorghum/maize and sorghum fields in mid-July, concurrently with weeding operations and the establishment of millet nurseries. The harvest starts with maize and groundnuts in mid-September. Sorghum, millet and soybeans are harvested, approximately a month after the rains have ended, from mid-November to mid-December. Maize serves an important purpose in filling the 'hungry gap' between the sorghum and millet harvests. A retrospective survey on the change in cropping patterns in Abet shows that both maize and soybean are gaining in importance while millet may be declining (Table 4).

Table 4. Frequency of crops in crop mixtures of farmers in Abet (N = 54 plots).

Crop	Crop plantings ^{a/}			
	1978	1979	1980	1981
Sorghum	15	24	19	23
Maize	1	3	8	10
Millet	41	26	34	19
Soybean	7	7	8	12

^{a/} Number of times crop was planted alone and/or in a mixture.

Due to the various climate, input availability and price factors that can influence crop selection, cropping patterns are highly flexible. If early rains are unusually erratic and/or late, resources may have to be shifted to millet. When early rains are normal and mineral fertilizers readily available, more maize is planted. Changes in market prices particularly affect the amount of resources devoted to the cash crops, soybean, groundnuts and ginger.

Fallowing

Fallowing still figures in the Abet cropping cycle although, due to the availability of fertilizers and the added labour involved in recultivating fallow land, more and more land is being permanently cultivated. Of the 35 farmers, 5 cultivated all their land without fallowing. The remaining farmers have an average of 1 to 3 fields in fallow. Observations indicate that more recently fallowed fields are of comparable size to currently cultivated fields (0.71 ha), while fields fallowed for a longer period tend to be larger and further from the compound. These observations confirm those made during the aerial survey of Abet, which also estimated that 33% of the total land area was in fallow (Milligan et al, 1979).

Fallow periods vary from 1 to over 20 years, and occur for six reasons (Table 5). Sixty percent of the 89 fallow fields had fallow periods of 5 years or less. Fifty-eight per cent of those were due to lack of labour to recultivate the land. Soil fertility regeneration, suppressing the build-up of pests, and farmers' poor health together accounted for only 20% of

fallow land. Three of the 35 farmers had allowed Fulani to settle on their fallow fields.

Table 5. Reasons for fallow and length of fallow periods in Abet.

Reasons for fallow	Fallow period (years)						Total
	1	2	3	4	5	>6	
Labour shortage	3	4	2	7	4	32	52
Sufficient fields	6	3		3	1	3	16
Low soil fertility	2		4	3	2	1	12
Poor health		2		2			4
Fulani settlement			1	1	1		3
Pests	2						2
Totals	13	9	7	16	8	36	89

History of the cropping patterns for 54 plots belonging to 29 farmers revealed that 41 or 76% of the plots had been cultivated for as long as the farmer could remember, suggesting that a high proportion of cropland in Abet is permanently cultivated. When practised, fallow periods are generally less than 5 years, and may well be getting even shorter. Land with fallow periods greater than 5 years, therefore, can be considered as permanent fallow. Labour, not land, limits crop production in Abet. Schooling and employment opportunities outside the area have reduced available farm labour. As a result, there is a high incidence of permanent cultivation and permanent fallow.

Inputs

Labour is the major input in the Abet cropping system, since all work is done manually. The amount of land a farmer cultivates each year is thus a function of family and/or hired labour availability.

Total and operational labour inputs for six plots each of sorghum, sorghum/maize, and millet were recorded during the 1982 wet season. Recordings were made at various times of the day and lasted for approximately 1 hour per observation, so that rest periods could be taken into account. Although there was great diversity in working abilities within and between age groups, the mean time spent by each household member per operation was used to calculate total labour expended per crop operation.

Sorghum/maize intercropping required a total of 766 hours/ha or 29% and 69% more labour than sorghum and millet sole cropping respectively. The total labour input for sorghum sole cropping (594 hours/ha) was 31% greater than for millet (453 hours/ha). Labour differences between intercropping and sole cropping sorghum were principally associated with the added labour of harvesting maize (202 hours/ha).

In Abet, contour ridging is the normal practice. Ridging at approximately 85-cm intervals to a height of 30 cm was exclusively done by males, and planting/transplanting principally done by females. The two operations are performed concurrently, such that the time of ridging/planting/transplanting was that of peak labour demand for each crop enterprise. Although ridging requires a major labour input, only half of the land area covered is actually cultivated. Benefits associated with ridging include the concentration of organic and inorganic fertilizers, water conservation during dry periods, and prevention of rapid rainfall runoff or waterlogging during wet periods. Ridging and transplanting millet accounted for over half the total time spent on millet sole cropping. Although ridging in mid-August demands less time (142 hours/ha) than ridging in the early dry season (181 hours/ha), the transplanting operation requires 72 hours/ha or 22% of the total labour devoted to millet. However, the principal advantage of transplanting over a 6- to 8-week period is the spread of labour demands between cropping enterprises (e.g. weeding sorghum and maize fields, harvesting early maize and groundnuts).

Weeding is normally performed in three operations: thinning of an oversown area and/or hand-roguing of weeds; hoeing or the partial breakdown of ridges to remove weeds on the ridge and bury them in the furrows; and ridging-up, when ridges are reconstructed with the soil and organic matter removed during hoeing. Thinning may be excluded if an area is not sown heavily and/or weeds are not severe. Sorghum is almost always oversown to ensure good establishment, with later thinning to obtain transplants and/or to intercrop soybeans. Thinning sorghum is almost always necessary, adding a labour input that is not associated with maize or millet. The prevalent practice of interplanting soybeans in sorghum and sorghum/maize fields to fill in gaps along the ridge coincides with either thinning or hoeing operations and requires no additional labour in future weeding operations. Any additional labour involved is associated only with the time required to plant and harvest soybeans. Harvesting soybeans, however, competes with labour for sorghum and millet because all three crops are harvested during the same period.

Fertilizer is a diversely managed input by farmers in terms of types and quantities used as well as the methods and timeliness of application. All the surveyed farmers use fertilizer, which is currently subsidized by the government. Although farmers are well aware of the benefits of fertilizers, little distinction is made between types and the amounts to apply to the various crops. Fertilizer management depends on when and in what amounts the different kinds of fertilizer become available to the farmer. If available before the onset of the wet season, some fertilizer is incorporated into the ridges. Otherwise, the most prevalent practice is to apply small amounts at the base of plants, usually at the same time as weeding.

Grain yields

Sorghum, maize and millet yields under traditional farmer management recorded at various locations in central Nigeria from 1980 to 1982 averaged 840 kg/ha for each crop (Nigerian Federal Ministry of Agriculture, 1983). In areas of similar rainfall to Abet, sorghum and millet sole crops yielded 1040 kg/ha and 650 kg/ha respectively, while sorghum and maize as single intercrops yielded 920 kg/ha and 860 kg/ha respectively. Yields of sorghum, maize and millet recorded from farmers' fields in Abet from 1981

to 1983 (Table 6) appeared comparable to yields in other locations in Nigeria. (APMEPU, 1980).

Table 6. Grain yields of major cropping enterprises over a 3-year period in Abet.

Cropping enterprise	Average grain yields (kg/ha)			Mean
	1981 (n=42) ^{a/}	1982 (n=22)	1983 (n=32)	
Sorghum	1000	n.r.	n.r.	1000
Sorghum/maize	970/n.r.	970/1500	770/640	900/1070
Sorghum/soybean	890/150	900/380	900/340	900/290
Millet	740	770	390	640

^{a/} Number of 100 m² for all cropping enterprises from which yields/ha were calculated.

n.r. = not recorded.

The marked reduction in 1983 sorghum/maize intercrop and millet yields can be attributed to uneven rainfall distribution, which resulted in late planting. The 1983 wet season in Abet was unusual in that early rains were erratic: there was a wet period in late July, and the rains ended abruptly 4 weeks before normal cessation. Although total 1983 wet-season rainfall in Abet was normal (1310 mm), its uneven distribution adversely affected yields. Sorghum and maize intercrop yields were reduced by 21% and 52%, respectively, and millet sole crop yields by 49% compared with 2 previous normal wet seasons. Sorghum yields, when intercropped with soybeans, were the same during the 3 years because soybeans are interplanted in fields where sorghum has been planted early.

CROPPING BY FULANI IN ABET AND KURMIN BIRI

Given the relationship between cattle and cropping within the Fulani agropastoral system, there may be a potential for increasing feed resources from the Fulani cropping system. A study was undertaken with Fulani cooperating with IICA to investigate the extent and methods of crop production in the agropastoral system (Powell and Taylor-Powell, 1984).

The majority of the 25 sampled Fulani had been farming for most of their lives, if only on a limited basis. All said, however, that their cropping had expanded over the years to offset the rising price of grain. Cropping played an important role in the production system, preventing cattle from having to be sold to buy grain. The aim was to contribute to or satisfy household consumption needs rather than to produce for market. Surplus supplies are sold, however, and a few Fulani were experimenting with soybean as a cash crop. The similarity in practices between Fulani and local crop farmers as well as the Fulani's own comments indicate that the Fulani have learned their farming techniques from the neighbouring crop farmers.

Cultivated area

The area cultivated by the 25 Fulani households ranged from 0.23 to 2.19 ha, with an average of 0.87 ha/household. This was about one third of the crop area cultivated by Kaje farmers in the area. Delgado (1979) found that in central Upper Volta Fulani were cultivating an average of 2.46 ha per household, about two thirds of the crop area of neighbouring farmers.

Farm size, household size and herd size for Abet and Kurmin Biri are given in Table 7. Positive correlations were found between farm size and household size in both Abet ($r = 0.552$; $P < 0.05$) and Kurmin Biri ($r = 0.695$; $P < 0.01$), indicating that farm size increased with respect to household consumption needs. The expected relationship between farm size and household labour supply was found in Kurmin Biri, where a positive correlation existed between farm size and number of active males in the household ($r = 0.683$; $P < 0.01$). However, this did not hold for the sample in Abet, perhaps due to the availability of some labour for hire and/or

greater opportunities for off-farm employment. Although the sample was small, the negative but non-significant correlation between farm size and herd size found in Kurmin Biri ($r = -0.423$) may indicate labour competition when cropping and cattle husbandry are combined.

Table 7. Fulani farm, household and herd sizes, in Abet (1982) and Kurmin Biri (1983).

Location	No. of household	Household size		Farm size (ha/household)	Herd size ^{a/} (cattle/household) ^{b/}
		Persons	Active males (8 years and older)		
Abet	13	Mean 9 (SD± 5) (range 2-19)	3 (2) (1-6)	0.67 (0.33) (0.23-1.19)	49 (43) (10-182)
Kurmin Biri	12	Mean 12 (SD± 6) (range 3-22)	4 (2) (1-7)	1.10 (0.53) (0.40-2.19)	53 (24) (4-86)

^{a/} Fulani herds also include sheep at a ratio of about 1 sheep to 4 cattle.

^{b/} Calculated for nine herds because six households combined herds into three management units; three herds in Abet are also jointly managed, but cattle associated with each household are known.

While farm size increased with household size for both sites, average cultivated area per household in Kurmin Biri was nearly twice that of Abet. Household size was somewhat larger in Kurmin Biri than Abet, but the difference in average farm sizes is largely explained by the greater availability of land in Kurmin Biri. In Kurmin Biri, Fulani ostensibly have secure land rights within the government grazing reserve. The reserve has not yet been officially gazetted and farmers are demanding compensation for their land (see paper 11). As a result there is some tension between farmers and Fulani. Nevertheless, the low cultivation density in the reserve means that there are large areas of potential arable land. Once the initial high labour investment is made to clear land, however, the Fulani in Kurmin Biri expect to have secure and permanent rights to the land, whereas in Abet the clearing of land is not associated with secure land rights and Fulani have to negotiate with farmers for land to cultivate.

Crop enterprises

Sorghum and maize, either sole cropped or in combination, accounted for about 70% of the area cultivated by the 25 Fulani. Millet ranked third at 13% of the total area. The concentration of these cereal crops, staples in their diet, is in keeping with the Fulani's aim to meet household consumption needs. Rice and yams are also important in the Fulani diet but are considered special foods; they were purchased mainly because of the limited availability of low-lying land suited to rice cultivation and the labour required in preparing yam ridges. Although there are low-lying sites in Abet for rice cultivation, these are valuable areas and tend to be reclaimed annually by farmers.

Iburu (Digitaria iburua), the other cereal crop grown by the Abet Fulani, was sown by broadcasting seed in scattered small plots where cattle had been kept overnight. It involved no cultivation or subsequent management. Iburu was not grown by the Fulani in Kurmin Biri because it was a low priority crop and, since land was available, resources such as manure were better used for sorghum, maize and millet. Sweet potato was the predominant tuber, followed by yams and cocoyams. Again, the lower incidence of cocoyam in Kurmin Biri compared to Abet was due to the relative scarcity of suitable low-lying sites.

Sole cropping and two crops in combination accounted for 98% of the total area under cultivation in Abet and 97% in Kurmin Biri. Millet (a late variety transplanted from nurseries) and rice were always sole cropped. In Kurmin Biri the Fulani devoted 46% of the area to sole cropping and 51% to two crop mixtures versus 57% and 41% respectively in Abet. The greater reliance on sole cropping in the Fulani system and the absence of the diverse mixtures commonly sown by crop farmers in the region is attributed to the higher yields for less labour obtained in sole cropping - an expressed Fulani aim - and a greater dependence on the three staple grains. Delgado (1979) likewise found Fulani practising a less labour-intensive mode of cultivation than farming groups, principally because of conflicts in labour requirements between cropping and herding. In northern Nigeria, it was found that mixed cropping required a 62% higher annual labour input/ha than sole cropping, although the difference reduced to 29% during the peak labour period (Norman et al, 1982).

Striga (Striga hermontheica), a parasitic weed associated with low fertility conditions, was a major problem in sorghum and maize fields in Abet but not in Kurmin Biri, where land has been more recently cultivated. Rotating sorghum and/or maize with millet to suppress striga, as done by crop farmers, was practised widely by the Fulani. Head smut (Sphaecelotheca reiliana) on sorghum and downy mildew (Sclerospora graminicola) on millet were also more prevalent in Abet than Kurmin Biri. Many of the Fulani used seed dressing, but the prevalence of these diseases suggests incorrect usage.

Cropping inputs

In general, the Fulani have become skilled cultivators. Only 3 of the 25 expressed disdain for cultivation and had hired out all farm work apart from planting and harvesting, the latter being a time of hired labour shortage. Twelve of the 25 Fulani hired no labour because it was either not available or it was unnecessary given their small farm sizes and sufficient household labour, or they had no money to spend on it. Only a few Fulani, however, farmed both morning and evening or throughout the day; most confined farm work to the morning hours. The Fulani employed any or a combination of four systems of labour use in cropping:

1. Self: All work is done by the individual farmer, with perhaps help from children and/or wife (wives).
2. Adashe: An arrangement among a group of relatives or friends who cooperate in cultivating each individual's farm in turn; such arrangements usually cover only the strenuous cultivation tasks such as ridging and weeding.
3. Gaya: Group work for a specific task with food and drink given in return; the group is not necessarily made up of Fulani alone.
4. Contract: Labour is hired, generally by the job; this may include tractor hire.

Three labour peaks were identified by the Fulani: May to early June, when land is being prepared for sorghum and maize planting; end July to September, when sorghum and maize are being weeded and millet is being cultivated; November and December (harvest time), when herding has to be the most closely supervised. Because grazing areas are reduced during the cropping season, careful herding is necessary to prevent crop damage. Most of the interviewed Fulani had sons or hired herder boys skilled enough to manage the herds alone for the rest of the year, but during harvest most household heads plus all possible labour must help with herding - often three to four men and boys with each herd - in order to keep the cattle out of unharvested fields.

None of the interviewed Fulani had ever used draught animal power. Animal traction had been introduced in Abet and was being used as late as 1980 by one crop farmer, but only four other farmers had ever used it. The principal deterrents to continued use were cited as the labour required to graze the animals and the inadequate extension support in providing training and replacement stock. Fulani did not express any interest in using cattle for farming. Their reasons included the perceptions that soils are heavy and studded with bush, equipment is expensive, cattle would suffer. Tractor hire was preferred, despite its limited availability.

The Fulani rely almost exclusively on cattle manure to fertilize their fields. Methods of manure application on cropland and their associated advantages and disadvantages are explained in detail in Paper 14. Almost all the Fulani surveyed (21 of 25) used some chemical fertilizer, although applications were generally confined to small areas and little was known about application rates or timing. Most of the Fulani stated a preference for chemical fertilizer because it gave higher grain yields than cattle manure. A disadvantage was that fertilizer had to be applied annually, whereas manure had a residual effect lasting 2 to 3 years. Also, the uncertain availability and timing of fertilizer distribution in the cropping cycle meant that most of the Fulani continued to rely mainly on cattle manure. Sorghum and maize received the majority of the available fertilizer, confirming their place as the most important crops.

Grain yields

Grain yields from Fulani fields in Abet and Kurmin Biri for 1983 are given in Table 8.

Table 8. Grain yields from Fulani fields in Abet and Kurmin Biri, 1983.

Location	Cropping enterprise	No. of plots ^{a/}	Mean grain yield ^{b/} (kg/ha)		
			Sorghum	Maize	Millet
Abet	Sorghum/maize	6	800 (170)	490 (170)	-
	Millet	4 ^{c/}	-	-	370(40)
Kurmin Biri	Sorghum/maize	8	630 (120)	510 (230)	-
	Millet	6 ^{c/}	-	-	530 (160)
	Sorghum	5	740 (90)	-	-

^{a/} Number of 100 m² areas.

^{b/} Standard deviations are given in parenthesis.

^{c/} Excludes two plots grazed by cattle in each location.

Combined sorghum and maize yields of 1290 kg/ha and millet yields of 370 kg/ha obtained by the Fulani in Abet were only slightly lower than those obtained by farmers in Abet for the 1983 harvest. In Kurmin Biri, lower rainfall was blamed for the reduced sorghum and maize yields of 1140 kg/ha. However, millet yields of 530 kg/ha were 40% greater than those obtained by the Fulani or by indigenous farmers in Abet. The higher millet yields obtained in Kurmin Biri were attributed to the timely transplanting of millet in response to the 1983 rainfall pattern. These data indicate that the Fulani who relied principally on cattle manure and experienced competition for labour with cattle management were attaining comparable yields to those of neighbouring crop farmers who almost exclusively used chemical fertilizer and were specialized farmers. Two millet fields in each site were accidentally grazed by their owners' herds just before harvest, reflecting one disadvantage of trying to crop and raise livestock in close proximity.

The average energy contribution of sorghum, maize and millet to annual household requirements was estimated to be higher in Kurmin Biri than in Abet, although there was considerable variability in both locations (Table 9). The larger cultivated areas and consequent greater overall grain output in Kurmin Biri account for the difference. Five household heads in both locations said that their yields of sorghum, maize and millet were sufficient, and that they would not need to buy these grains. Another seven Fulani said that they had met household requirements either in sorghum and maize or in millet production. Of the five households that were reportedly self-sufficient in the three grains, one produced enough annually for sale. The percentage contribution of the cereals to energy needs in the four other households that said they would not need to buy any of the three grains was 25, 41, 44 and 75%, perhaps reflecting a range in preferences for other foods. It has been estimated that milk provides approximately 10% of the annual energy requirements of settled Fulani households in the area (Waters-Bayer, 1984). Although some energy is supplied by meat and by the produce from the small cultivated areas that the Fulani devote to other crops, the bulk of the deficit must be met through purchase.

Table 9. Sorghum, millet and maize grain contributions to household annual energy requirements in Abet and Kurmin Biri, 1983.

Location	No. of households	Contribution to annual energy requirements ^{a/} (%)		
		Mean	SD± (%)	Range
Abet	13	33	24	9 - 90
Kurmin Biri	12	42	21	18 - 93

^{a/} Assumes 20% grain loss in storage, 18.8 MJ energy/kg of grain dry weight, and an annual energy requirement of 3504 MJ/adult equivalent.

The Fulani cannot be viewed solely as cattle keepers. Cropping is becoming increasingly important in their production system to avoid the need to buy grain. For the settled Fulani in southern Kaduna State, however, self-sufficiency in grain production may weaken their relationships with the

indigenous farming groups. These relationships are undergoing change as the Fulani become less dependent on farmers for grain purchases while the farmers rely increasingly on chemical fertilizers (although the decrease in subsidy may modify farmer reliance on chemical fertilizer - previously subsidized to 75%, fertilizer is being subsidized at only 25% in 1984).

The land tenure pattern in this region makes it difficult to envisage any significant expansion of Fulani cultivation. Where Fulani can secure land, as on the government grazing reserve or through guaranteed occupancy rights, competition for labour between herding and cropping may become the major limitation if hired labour is unavailable during seasonal shortages. When land, hired labour and fertilizer are available, however, Fulani appear willing to expend livestock earnings to increase crop production. Around Zaria, Norman et al (1982) found Fulani cattle owners cultivating larger farms than non-cattle owning farmers (3.7 ha versus 2.2 ha), apparently because their livestock revenues made it possible for them to purchase usufructuary rights and to hire more labour.

If meeting subsistence grain needs is the goal, Fulani are not likely to jeopardize food production in order to increase forage production, particularly if there are alternative dry-season feed resources in the region, albeit of low quality. Because of the relatively small areas under cultivation by Fulani agropastoralists in the study area, any increase in forage production is likely to be minimal. Herd size relative to cultivated area becomes an important consideration in trying to improve cattle nutrition through integrating crop and forage production. But just as herders are taking up farming, so are farmers investing in cattle (cf Toulmin, 1983; McCown et al, 1979; Diarra, 1975). It appears that innovations to increase feed resources from cultivated land would best be directed towards agropastoralists or mixed farmers who cultivate sufficient land to allow forage production to have a sizeable impact on animal nutrition.

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Crop-livestock interactions in the
subhumid zone of Nigeria

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ABSTRACT

Crop-livestock systems in the subhumid zone of Nigeria are diverse. The two enterprises can be ethnically and operationally separate but are more commonly integrated in the agropastoral and/or mixed farming production systems. The successive use of land for grazing and cultivation can increase the production potential of both livestock and cropping enterprises. Cattle provide manure for cropping; crop residues provide an important dry-season feed reserve.

In this paper interactions between cropping and livestock husbandry in an area of Fulani settlement amid farming groups are described, as well as interactions between the two enterprises in the Fulani agropastoral systems. Fallow lands appear to provide twice as much biomass for grazing as natural range during the first 3 months of the wet season. Grain yields can be used to predict crop residue dry matter (DM) yields. Fractionating total crop residue DM into plant parts is desirable given the wide variation in the nutritive value of the various crop residue components, and the selective grazing behaviour of cattle.

Sorghum, millet, rice and soyabean residues are grazed during the dry season, accounting for 50% of the dry-season and 20% of the total annual grazing time of cattle. During the first month of crop residue grazing cattle selected the panicles and upper leaves of sorghum and millet residues, followed by lower leaves and weeds. Animal production gains, such as the increase in fertility that coincides with early crop residue grazing, may be attributed to the crude protein and phosphorus contents of

the crop residue diet, which are two to three times higher than those found in the natural range during the same period of the year.

Farmers in Abet hire Fulani to camp their animals overnight on fields during the dry season. The Fulani themselves manure each of their fields every other year. It was found that the nitrogen and phosphorus contents of manure varied seasonally. Maize grain yields were about 1 tonne higher and weed growth 90% greater in manured than in non-manured areas. Reducing the competition between crops and weeds is needed if grain crops are to obtain the full benefit of manure application.

INTRODUCTION: GENERAL DESCRIPTION OF CROP-LIVESTOCK SYSTEMS IN THE ZONE

Many parts of the Nigerian subhumid zone have been freed of tsetse flies by wildlife hunting, an expanding human population and concomitant bush clearing for farming, and chemical control (Bourn, 1983; Paper 5). With its favourable climatic conditions, the relatively sparsely populated zone is attracting crop farmers from more densely populated areas in the north and south. At the same time, increasing cultivation densities and periodic droughts in the northerly, semi-arid region have resulted in a gradual southward drift of pastoral activities (Fricke, 1979; Putt et al, 1980).

In situations where livestock husbandry and cropping are managed separately, herders and farmers develop linkages such as the exchange of meat and milk for manure and grain (McCown et al, 1979). These interactions traditionally develop in areas of low population and cultivation densities (Norman et al, 1982). However, as population and cultivation increase, livestock and cropping compete for diminishing land areas and crop damage by animals becomes more of a hazard. Some farmers have invested cropping income into livestock, and livestock subsequently become an integral part of their production system. The traditional practice of transhumant herding declines in areas where rising human population demands more land for cropping. In the Nigerian subhumid zone it has been estimated that 36% of the cattle-keeping Fulani are settled (de Leeuw, personal communication). The Fulani have taken up cropping to reduce the need to sell cattle for purchasing grain (Powell and Taylor-Powell, 1984).

In mixed farming systems, cattle are used for draught; they also provide manure to cropland and meat and milk for the household. Such an integration occurs in situations where household labour supply is adequate to cope with the management of both crops and livestock (Toulmin, 1983), particularly during periods in the wet season when labour demands for cropping are high (e.g. weeding and harvesting). Where labour is in short supply some farmers hire Fulani to herd and manage their cattle (cf Delgado, 1979). The successive use of land for grazing and cultivation increases the production potential of both livestock and crop enterprises. The grazing of harvested cropland provides an important feed resource for ruminant livestock during the dry season, when natural forages are at their lowest feeding value (van Raay and de Leeuw, 1971; 1974; Dicko, 1980; Bayer and Otchere, 1984). According to Putt et al (1980), cultivated areas can support more cattle during the dry season than non-cultivated areas, and van Raay (1975) found that in semi-arid areas of northern Nigeria cattle resident in farming areas are better able to meet their protein requirements than transhumant cattle.

There is no doubt that the importance of animal manure in cropping systems will increase as more land is brought under cultivation and the practice of fallowing diminishes. The effectiveness of cattle manure in maintaining soil fertility has been under continuous investigation in Nigeria since 1940. Preliminary conclusions drawn from the trials were that annual manure applications of 3 t/ha were sufficient to maintain sorghum and millet yields and to replace a 3-year fallow period (Dennison, 1961; Watson and Goldsworthy, 1964). Later findings showed that continuous manure applications increased available mineral N in the soil when crops were planted and resulted in an overall build-up of total soil N (Wild, 1972). No additional grain response to inorganic N was obtained over an 11-year period when the annual manure application rate was 7.5 t/ha (Abdullahi and Lombin, 1978). The P content of manure, together with its ability to raise soil pH and improve soil physical properties, were additional reasons given for the maintenance of yields (ibid.).

As land becomes limited, there is evidence of "...increasing conflict over whether land should be devoted to crop or animal production which inhibits the increasing benefits that livestock can have in slowing the decline in soil fertility" (Norman et al, 1982). Cattle ownership and thus control of

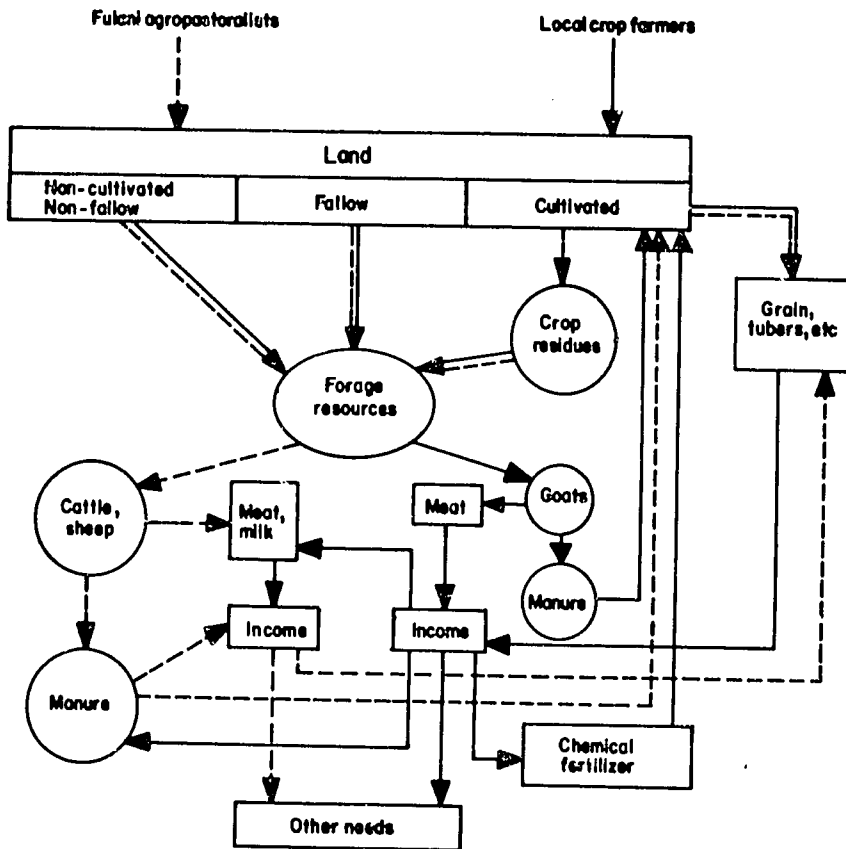
manure is mainly in the hands of the Fulani in northern and central Nigeria (van Raay, 1975). As more Fulani engage in cropping, they require greater amounts of manure for their own fields. But, just as the Fulani are taking up cropping, so are farmers becoming cattle keepers (Toulmin, 1983; McCown et al, 1979; Diarra, 1975; Norman et al, 1982). In addition to the increased use of cattle for draught, manure becomes a vital input in cropping systems, especially in areas of high cultivation. Case studies in northern Nigeria showed that in an area of high cultivation density (i.e. 38%) farmers kept an average of three cattle and were applying 4 t/ha of manure to cropland, whereas in an area of low cultivation density (i.e. 19%) farmers kept an average of 10 cattle and applied 1.9 t/ha to cropland (Norman et al, 1982). In the former area, non-cattle owners were applying amounts of manure to cropland comparable to those applied by cattle owners, reflecting the importance of manure in maintaining soil fertility.

CROP-LIVESTOCK INTERACTIONS IN ABET AND KURMIN BIRI CASE STUDY AREAS

Investigations by ILCA into the interactions between cropping and livestock husbandry have concentrated on the Abet area, where Fulani settlement in a farming area provides an ideal research setting. Crop-livestock integration in the Fulani agropastoral system at Kurmin Biri has recently been included in the research to serve as a comparison to the system in Abet.

The Fulani settled in Abet make arrangements with farmers or village leaders for rights to use land for dwelling and cropping (Paper 3). No payment is required and, as a rule, no time limit is set, except for fields not contiguous with the homestead. The farmers generally regard the Fulani as temporary residents on their land, and the Fulani commonly shift their homesteads a few kilometers at intervals ranging from 2 to over 20 years. Reasons for the pastoralists' attraction to Abet and for farmers' willingness to share their land temporarily with the Fulani lie in the mutual benefits enjoyed by livestock husbandry and cropping enterprises operating in close proximity (Figure 1).

Figure 1. Interactions between cropping and livestock husbandry in Abet, central Nigeria.



Fulani perceptions of the advantages of an established farming area for animal production are that herding is easier and safer on cleared land and crop residues provide good early dry-season grazing, leading to increased animal productivity and a build-up of body reserves for later in the dry season. Early vegetative growth on the previous year's cropped land is particularly valuable for grazing. Measurements on cropland in Abet indicated that approximately 5400 kg/ha of vegetative dry matter, mostly grass species, became available for grazing during the first rains in early April to late June, when land was cultivated for sorghum. The plant growth on cropland was more than double that on natural range during the same period. However, because soil compaction by cattle makes manual cultivation more difficult, some Abet farmers have attempted, thus far with limited success, to persuade Fulani to avoid grazing cropland immediately prior to land preparation.

CROP RESIDUES

Quantity of crop residues produced

Grain yields, crop residue dry matter (DM) and harvest indices (HIs), or the ratio of grain to total above-ground DM, for the varieties of sorghum, millet, maize and groundnuts grown by farmers in Abet are presented in Table 1.

Table 1. Grain and vegetative DM yields of predominant crops in Abet.

Crop	Plots harvested (n) ^{a/}	Grain (15% moisture) (kg/ha)	Vegetative DM (kg/ha)			HI (%)	
			Total	Leaf	Stalk		
Sorghum	18	Mean	1420	5280	1190	4090	23
		SD±	800	2335	450	1915	3
Millet	23	Mean	700	3180	720	2460	20
		SD±	260	1420	320	1190	6
Maize	9	Mean	1800	3880	1000	2920	33
		SD±	1260	1240	340	860	2
Groundnuts	17	Mean	885	1040			47
		SD±	360	315			3

^{a/} Number of 50 m² plots from which all residues were harvested; 11 sorghum and 13 millet plots were 100 m² areas in farmers' fields.

Since yields were measured from both on-farm and on-station plots at various treatment levels, there was a wide variation among grain and component DM yields for each crop. Sorghum grain yields varied from 600 to 3040 kg/ha, millet from 310 to 1370, maize from 420 to 3300, and groundnut from 300 to 1230 kg/ha. However, when grain yield and total, leaf and stalk DM from all plots were correlated for each crop, highly significant positive correlations ($P < 0.01$) were found between grain and DM, as shown in Table 2.

Table 2. Relationship between grain yield and vegetative DM of predominant crops in Abet.

Crop	Plots (n)	DM component	Regression relationship (y=DM, x=grain in kg/ha)	
			$y =$	r^2
Sorghum	18	Leaf	$y = 453 + 0.516 x$	0.88
		Stalk	$y = 1041 + 2.15 x$	0.81
Millet	23	Leaf	$y = 78 + 0.918 x$	0.58
		Stalk	$y = 178 + 3.25 x$	0.51
Maize	9	Leaf	$y = 431 + 0.283 x$	0.98
		Stalk	$y = 699 + 0.697 x$	0.94
Groundnuts	17	Total	$y = 300 + 0.834 x$	0.91

Given the high r^2 values between the grain and component DM yields of sorghum, maize and groundnuts, nearly all the variation in grain yields for each crop can be associated with DM production. Factors that account for the lower r^2 values for millet are longer planting period, tillering, and the observed prevalence of downy mildew (*Sclerospora graminicola*), which can greatly reduce the number of panicles producing grain.

Delayed planting of photosensitive sorghum and millet, however, can greatly reduce grain and DM yields and alter the HI (Kassam and Andrews, 1975). This is due to the shorter vegetative phase and consequent adverse effects on sink size of grain heads and length of grain filling period. Also, although sorghum and millet are adapted to relatively low rainfall conditions, maize grain yields can be greatly reduced if rainfall is inadequate and temperatures are too high during the 30 days before pollination. Due to these various factors that can affect yields, it is necessary to be cautious when using DM predictive equations derived from years of normal rainfall distribution.

Crop residue quality

Although the feeding value of groundnut hay is considered high, the nutrient content of cereal stover has been characteristically reported on a total stover basis and is generally regarded as low, so that supplementation is required if animals are to maintain body condition (Miller et al, 1964; GRET, 1978; 1979; O'Donovan, 1983). However, stover consists of various plant parts which have different digestibilities (Hacker and Minson, 1981) and nutrient contents, and grazing ruminants initially select the most palatable fractions of the total stover (Perry, 1974; Powell, 1984a).

The relative proportion of the various plant parts in sorghum, millet, maize and groundnut residues is given in Table 3. Leaf sheaths, calculated as the percentage of total stalk DM, were found to be 21% for sorghum, 19% for millet and 40% for maize. Much of the maize stalk DM was thus actually leaf sheath material. For total groundnut residues it was necessary to include the root fraction, since this is a component of hay. On a weight basis, 10% of total groundnut residue weight was determined to be soil on roots.

Table 3. Percentage composition of sorghum, millet, maize and groundnut residue.

Component	% of total stover ^{a/}							
	Sorghum (n=8) ^{b/}		Millet (n=10)		Maize (n=9)		Groundnuts (n=9)	
	Mean	SD _t	Mean	SD _t	Mean	SD _t	Mean	SD _t
Immature panicles	1	0.5	2	0.5	3	1	-	-
Upper (green) leaves	9	3	9	3	14	2	-	-
Lower (brown) leaves	13	1	12	3	20	3	-	-
Upper stalk	24	5	29	3	15	2	-	-
Lower stalk	53	7	48	3	48	3	-	-
All leaves	-	-	-	-	-	-	38	3
Entire stem	-	-	-	-	-	-	35	5
Roots	-	-	-	-	-	-	27	4

^{a/} On dry weight basis.

^{b/} n = number of 50 m² plots from which entire residue was fractionated into morphological components. For groundnuts, 10 plants were randomly selected from each plot and fractionated.

There were significant differences between the nutritive value of plant parts for each crop. The digestibility of cereal stover plant parts showed a similar pattern for sorghum and millet but a different pattern for maize (Table 4). Differences between the digestibilities of sorghum, millet and maize plant parts can be partially explained by their varying fibre contents. Maize stalks had lower NDF (neutral detergent fibre), ADF (acid detergent fibre) and lignin contents than either of the sorghum or millet stalk fractions. Conversely, maize upper and lower leaves contained higher amounts of the same fibres than either the upper or lower leaf fractions of sorghum and millet stovers. Maize upper and lower stalks also had a higher silica content than sorghum or millet stalks. Silica appears to promote the accumulation of sucrose while lowering lignin (and nitrogen) content in plant tissue (van Soest, 1982). Maize stalks reportedly contain 8% sugar before grain is formed, and as much as 10.5% sugar when pollination fails or is prevented (Sayre, cited in Martin et al, 1976).

Table 4. Fibre, silica content and apparent digestibility of crop residue plant parts (% total DM).^{a/}

Crop	Plant part	NDF	ADF	Lignin	Silica	ADDM ^{b/}
Sorghum	Immature panicles	50.5	22.5	3.9	0.7	59.8 a
	Upper leaves	63.3	34.4	3.9	3.1	59.3 a
	Lower leaves	73.5	47.3	6.1	2.0	53.7 b
	Leaf sheaths	79.9	53.2	6.1	3.0	53.5 b
	Upper stalk	82.9	54.4	8.1	0.5	48.8 c
	Lower stalk	84.5	61.4	10.2	0.3	44.9 c
Millet	Immature panicles	63.1	27.3	2.7	1.1	64.7 a
	Leaf sheaths	74.9	47.8	4.1	1.9	64.2 a
	Upper leaves	56.5	28.2	3.2	4.3	59.9 b
	Lower leaves	62.7	34.2	4.0	3.0	59.3 b
	Upper stalk	79.6	53.9	8.7	n.d. ^{c/}	48.5 c
	Lower stalk	79.2	55.4	9.7	n.d.	46.3 c
Maize	Upper stalk	71.6	42.7	4.5	1.2	60.9 a
	Lower stalk	64.0	41.2	5.6	0.7	58.6 a
	Leaf sheaths	83.9	47.4	4.8	2.2	57.1 a
	Upper leaves	73.1	37.7	5.2	3.5	52.0 b
	Lower leaves	76.5	46.1	5.3	4.8	52.0 b
	Tassels	82.3	46.2	7.9	5.1	38.8 c
Groundnuts	Leaves	33.4	26.6	5.5	1.6	64.8 a
	Roots	44.8	40.4	8.8	4.3	53.8 b
	Stems	41.5	42.5	10.3	5.9	52.2 b

^{a/} Means with common letters within each crop are not significantly different at 0.05, using Duncan's Multiple Range Test.

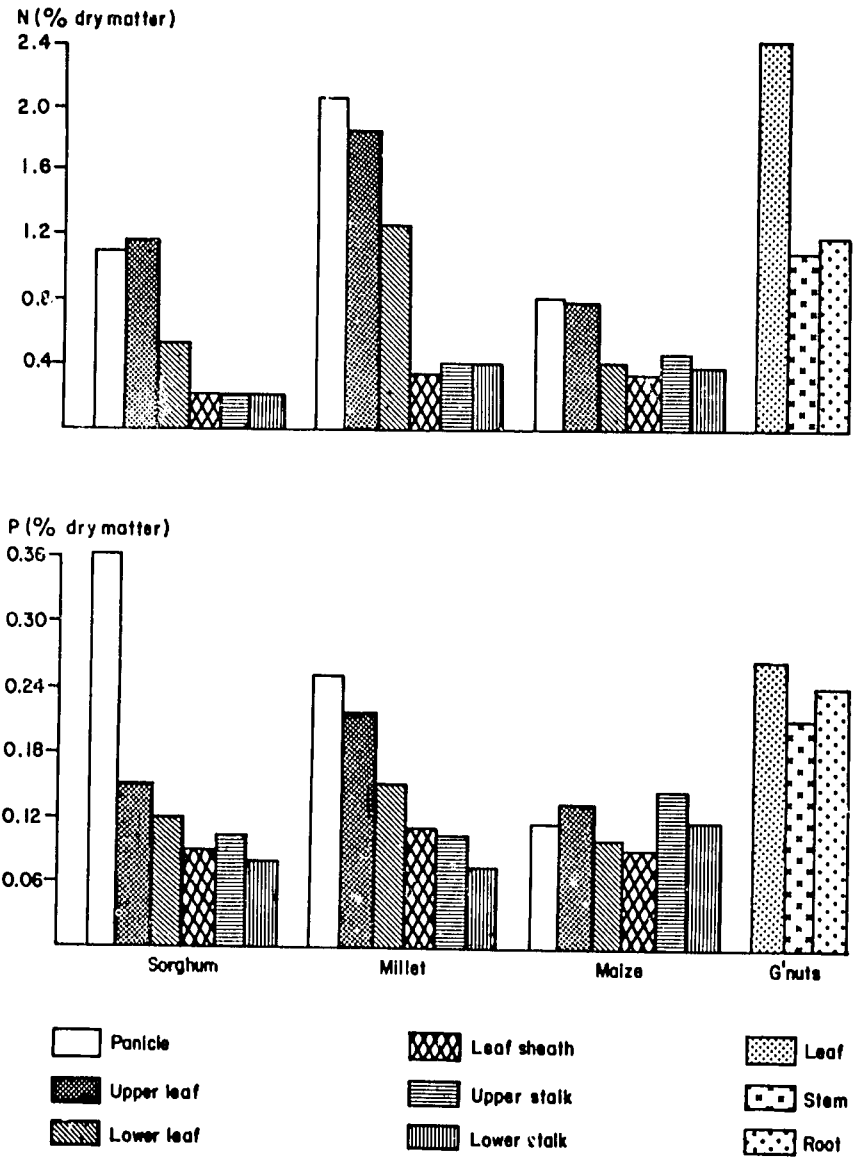
^{b/} ADDM = apparent digestible DM.

^{c/} n.d. = not detectable.

Some typical differences between grass and legume fibre contents can be noted from the analyses: groundnut plant parts in relation to cereal stover plant parts of similar digestibilities contain lower plant cell wall (NDF), and lignin values are generally higher.

The nitrogen (N) and phosphorus (P) distribution in cereal stover and groundnut haulm plant parts are illustrated in Figure 2. For sorghum and millet, the content of both nutrients in plant tissue generally decreases from panicles, through upper leaves to lower leaves, with leaf sheaths and stalk fractions having similar or lower N and P than the upper plant parts.

Figure 2 . Nitrogen and phosphorus content in crop residue plant parts, Abet, central Nigeria, 1984.



The relatively high concentration of these nutrients in the upper plant parts can be explained by nutrient upward translocation during grain development. Also, N and P are principal nutrients in photosynthesis, and the upper leaves of sorghum and millet are still photosynthetically active at grain harvest.

For maize, P concentration in both stalk fractions was similar to P levels in tassels and upper leaves and significantly higher than P in leaf sheaths and lower leaves. Again, the movement of nutrients to the photosynthetically active upper leaves explains the higher N and P concentrations in this stover fraction. The similar P levels in upper leaves and both stalk fractions may be attributed to the two locations of maize grain formation; one cob located on the defined lower stalk and one on the upper stalk.

Groundnut leaves contained more than twice the N content of either the stem or root fractions. Root N was similar to stem N, probably due to intact nitrogen fixing nodules on roots at the time of sample preparation. Groundnut leaves, stems and roots all had similar P values. Using the % plant part values and the respective DM, digestibility, N and P contents of each plant part, it is possible to assess the quality of each crop's total residue DM as shown in Table 5.

Table 5. Quality of total crop residue DM (%).

Crop residue	ADDM	N	P
Sorghum	48.4	0.35	0.11
Millet	50.2	0.65	0.11
Maize	56.1	0.45	0.11
Groundnuts	57.4	1.61	0.24

The difference between millet and sorghum N can be explained by the different growing periods of each crop. Sorghum is planted during the first month of the wet season and has a 150- to 180-day growing period. Millet, in contrast, is planted midway through the wet season and has a 100- to 120-day growing period. Millet therefore produces less vegetative growth than sorghum, thereby concentrating nutrients. Also, millet

continues to produce more tillers and heads after grain harvest, if adequate soil moisture is available. Unlike sorghum and millet, maize is physiologically mature at grain harvest, with little or no additional vegetative growth thereafter.

In summary, because of notable differences in the feeding value between the different plant parts of crop residues, DM should be fractionated when assessing feed quality. Non-representative sampling can lead to large errors in determining both the quantity and quality of residues available for feeding.

Crop residue grazing in Abet

Crop residue grazing in Abet starts in late November, when the sorghum, millet and soyabean harvests begin. The rice harvest begins in mid-December. Sorghum is harvested by felling plants between ridges before removing the heads, whereas millet plants are left standing and the heads are pinched off at the upper node. As in sorghum and millet, only the panicles of rice are harvested, and the vegetative growth remains in the fields. Soyabean plants, however, are rogued, gathered and dried before threshing.

Even though the ownership of cattle and cropland is divided between different ethnic groups, no payment or pre-arrangement was normally made for crop residue utilization. However, arrangements were made in cases where the farmer negotiated with the Fulani for manure and then gave him first access to crop residues, or where the farmer was still harvesting part of the field. Once a harvested field had been initially grazed, it became a communal resource open to all livestock. This custom contrasts with other reports from northern Nigeria, where Perrier (1983) found that agropastoralists in the Zaria area helped farmers in harvesting crops in order to gain access to the residues. In the Katsina area, van Raay and de Leeuw (1971) found that the situation was rapidly changing from one of free access to crop residues to one in which farmers were demanding that pastoralists first seek permission for grazing harvested fields. At the onset of crop residue grazing in Abet in the 1982 and 1983 dry seasons, some farmers tried to demand payment from pastoralists for crop residue grazing rights. After a somewhat hesitant start, crop residues were ultimately

utilized as a free communal resource. These incipient conflicts may indicate imminent change such as has already occurred further north. As a result of increasing stocking and cultivation pressure in some northern areas, crop residues have become a commodity for which payment must be made.

Crop residue grazing contributed about 50% to the total grazing time during the 21 weeks of this study and roughly 20% to total annual grazing time (Figure 3). Although this is lower than in semi-arid areas (van Raay and de Leeuw, 1971; Dicko, 1980), crop residues are still a major contributor to dry-season grazing by cattle in the subhumid zone, at least in farming areas. During the first 7 weeks, sorghum and millet fields were the only type of cropland grazed. From mid-January, rice and soybeans became more important, contributing more than 90% of crop residue grazing by mid-March. Towards the end of the dry season, the animals returned to the sorghum and millet fields, probably because soybean and, to a lesser extent, rice residues had been exhausted.

In terms of grazing time, rice residues had about the same importance as millet; these were followed in importance by sorghum and soybean residues (Table 6). These results to some extent contradicted the identified cropping pattern, in which rice occupied only 6% of the plots. Rice growing may have been underestimated, because the cropping survey was conducted among male farmers of the major ethnic group, the Kaje. The other predominantly crop farming group, the Kamantan, also cultivate rice, and rice is an important women's crop. In addition, rice fields are situated in low-lying areas where residual soil moisture permits green regrowth throughout most of the dry season. They can thus be more heavily utilized by grazing ruminants than the upland sorghum and millet fields, where little plant growth occurs after the rains cease.

Maize, found in approximately 21% of the cultivated area (Paper 13), contributed to less than 1% of crop residue grazing time. Maize was intercropped with sorghum and harvested in September; that is, 2 to 3 months before the sorghum harvest, when the cattle first gained access to crop residues. By that time, maize stover had already deteriorated and lost much of its palatability.

Figure 3. Total and specific crop residue grazing times in Abet (mean daily min/month).

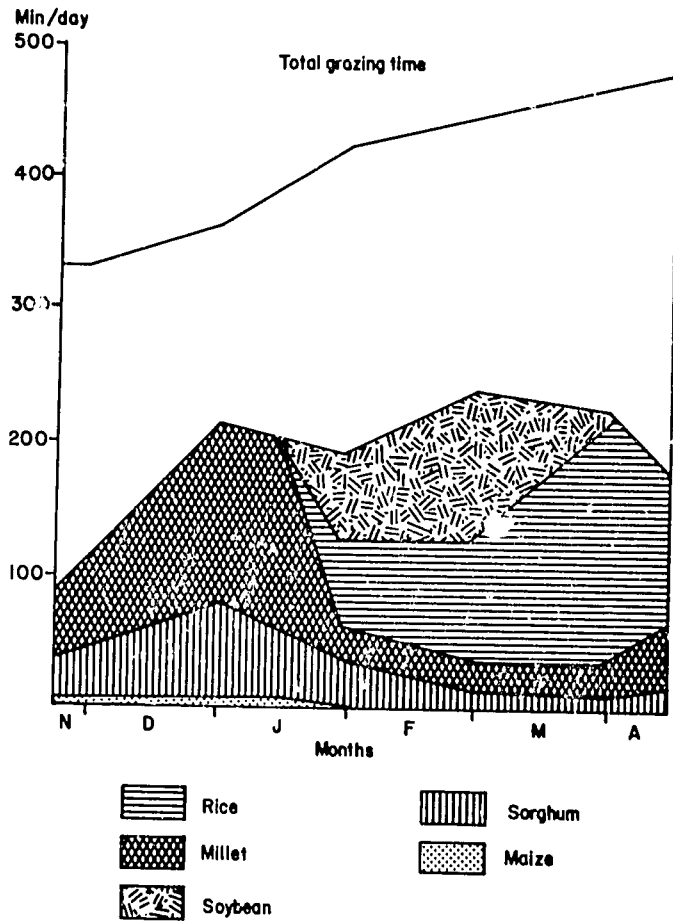


Table 6. Percentage of time spent grazing different crop residues in Abet 1982/83.

Crop residue	Grazing periods (% of grazing time)	
	Dry season	Annual
Rice: Regrowth and stubble	14	6
Threshing areas	3	1
Millet	16	6
Sorghum	9	4
Soybean	8	3
Totals	50	20

In summary, crop residue grazing in the Abet area appeared to provide an important source of dry-season feed for cattle, although it did not approach the levels found in semi-arid areas. Since the availability of crop residues is linked to a spatial integration of cropping and livestock keeping, any attempt to separate these enterprises on a year-round basis (e.g. by confining pastoral herds to grazing reserves) would limit utilization of crop residues by cattle and would probably aggravate the nutritional constraints to increased production.

Crop residue contribution to cattle diet

Since inadequate animal nutrition during the dry season has been identified as the major constraint to increased cattle productivity in central Nigeria (ILCA, 1979), the current contribution of sorghum and millet residue grazing to the diet was assessed in order to better define supplementation needs. Otchere et al (1982) and Zakari (1981) found that cattle conception coincided with the onset of crop residue grazing. An additional objective of the study was, therefore, to determine if these two events could be linked.

At grain harvest, the total DM on offer in fields consisted of various proportions of stover plant parts (with differing feeding values), weeds, and, in sorghum fields where soybean was intercropped, soybean leaves (Table 7). In sorghum fields, total DM was some 160% greater than in

millet fields. This large difference was partially due to the greater weed DM, which accounted for 34% of the total DM in sorghum fields versus only 20% in millet fields. The difference in weed DM between sorghum and millet fields can be attributed to different crop management. The last weeding operation on sorghum is generally done in early August, whereas for millet it is performed in early October.

Table 7. Total DM & composition in sorghum and millet fields at grain harvest, Abet^{a/} 1982/83.

DM component	Sorghum fields				Millet fields			
	DM	ADDM ^{b/}	CP	P	DM	ADDM	CP	P
Stover plant parts								
Immature panicles	2.0	59.8	7.8	0.37	3.4	64.7	12.6	0.26
Upper green leaves	18.1	59.3	7.3	0.15	15.2	59.9	11.4	0.21
Lower brown leaves	26.3	53.7	3.3	0.12	20.2	59.3	7.6	0.15
Upper stalk	48.5	48.8	1.4	0.10	48.9	48.5	2.4	0.10
Lower stalk	107.1	44.9	1.3	0.09	80.9	46.3	2.5	0.08
Other								
Weeds	112.4	55.0 ^{c/}	7.0	0.15	44.0	55.0 ^{b/}	7.0	0.15
Soybean leaves	2.2	62.5 ^{c/}	21.5	0.21	-	-	-	-
	316.6				212.6			

^{a/}n = 101 ha; 52 ha sorghum and 49 ha millet.

^{b/} Apparent digestible DM.

^{c/} Estimated values.

During the first 2 weeks of grazing, sorghum and millet panicles and upper leaves were the most preferred parts, accounting for 50% of the recorded bite counts (Figure 4). As upper leaves disappeared from the forage on offer, more weeds were selected. Lower leaves were grazed throughout the dry season, although it is likely that many of the observations of lower leaf selection actually referred to leaf sheaths, which animals can more easily remove from stalks when dried. Throughout the dry season, selection of upper stalks continued in both sorghum and millet fields.

The observed rate of leaf, stalk and weed DM disappearance during the dry season was similar in sorghum and millet fields (Figure 5). By the end of the dry season in April, approximately 87, 36 and 83% of the original leaf,

Figure 4. Grazing times and component selection of sorghum and millet residues in Abet, 1982/83.

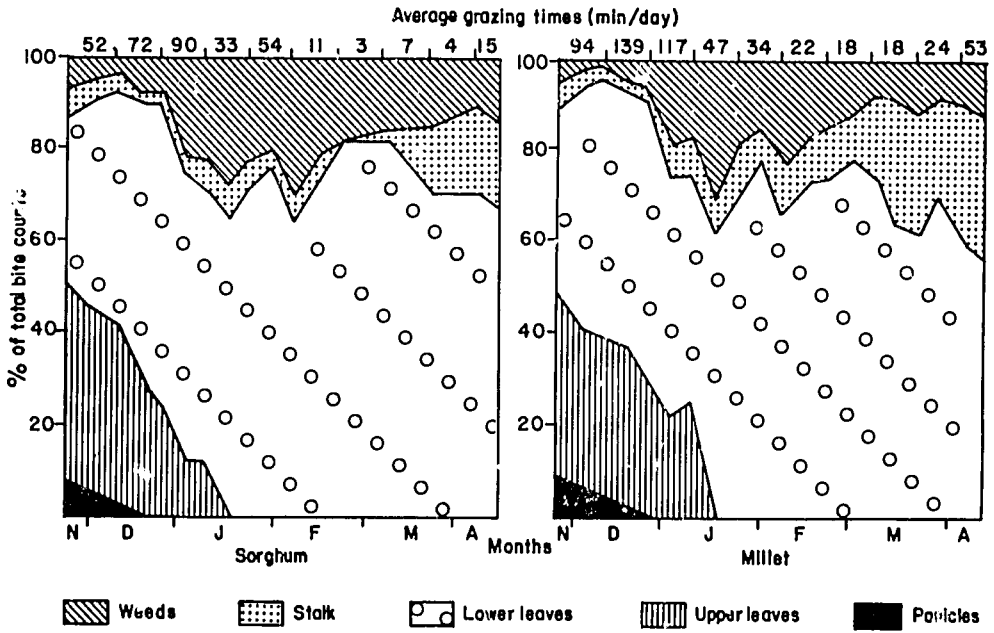
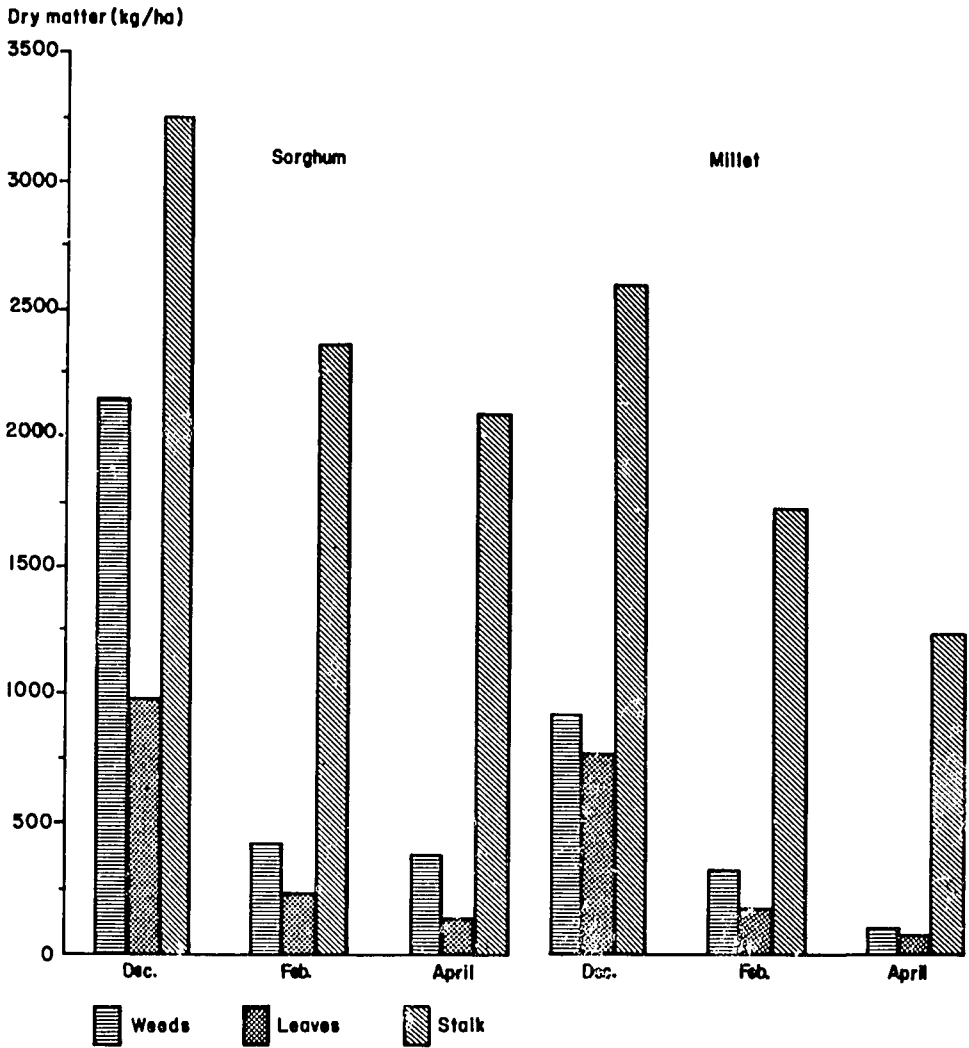


Figure 5. Observed dry matter disappearance in sorghum and millet fields in Abet during crop residue grazing, 1982 / 83.



stalk and weed DM had disappeared from sorghum fields and 93, 53 and 92% of each component respectively from millet fields. However, of the eventual total DM disappearance, 86% had occurred in sorghum fields by mid-February and 72% in millet fields. At this point in time herds had spent 88% of their eventual total sorghum grazing time and 72% of the total millet grazing time. The estimate of total DM disappearance and diet quality is therefore restricted to the first 3 months of crop residue grazing.

Table 8. Total DM disappearance and quality during the first 3 months of sorghum and millet residue grazing in Abet, 1982/83.

2-week periods from onset of grazing	DM disappearance (t/101 ha)	ADDM ^{a/} (%)	CP (%)	P (%)
1	39.1	55.4	6.5	0.16
2	31.7	55.7	6.8	0.15
3	44.2	54.0	5.9	0.14
4	51.3	53.2	5.2	0.13
5	52.4	53.3	5.1	0.13
6	58.1	53.2	5.0	0.13

^{a/} Apparent digestible DM.

The amount of DM disappearance during the first 2 weeks was higher and CP content slightly lower than during the second fortnight (Table 8). Grazing at the beginning of grain harvest is somewhat restricted by the number of newly harvested fields available. The rate of DM disappearance increased and CP content decreased from the second fortnight onwards. DM digestibility, however, remained about constant throughout the 3-month period. One of the reasons why CP and P contents did not decline more rapidly and the DM digestibility was maintained may be the uniform nutritional values of weed over time. However, as was observed with stover grazing, animals initially selected weeds of higher quality and later selected weeds of lower quality than indicated in the reported average CP, P and digestibility values. The major weeds identified in sorghum and millet fields at grain harvest showed that the botanical composition and consequently the nutritional value of weed DM varied considerably (Table 9).

Table 9. Weeds in sorghum and millet fields at grain harvest in Abet (December, 1982).

Weed types	Times identified (n)	% identification
Grasses ^{a/}	73	44
Broad leaves ^{b/}	72	44
Sedges ^{c/}	17	12
Totals	162 ^{d/}	100

a/ Cynodon dactylon, Hyparrhenia violascens, Pennisetum polystachion.

b/ Acanthospermum hispidum, Mitracarpus scaber, Nelsonia canescens.

c/ Cyperus spp.

d/ The 3 most predominant weeds were identified in each of 3250 cm² quadrants in 9 sorghum and 9 millet fields.

During the first 2 weeks of the study almost all sorghum and millet fields (97%) were grazed for the first time. The grazing pressure during this period, estimated from the area covered by herds and the pressure exerted by farmers' goats, was determined to be about 2300 TLU days on the 101-ha survey area. An aerial survey of the Abet area in February 1979 estimated a dry-season cattle density of 37.4 head/km² (i.e. 28.4 TLU) (Milligan et al, 1979). Since all cattle in the area spent the first part of their grazing day on sorghum and millet fields (about 20% of the total land area), the 28.4 TLU/km² would have exerted a fortnightly grazing pressure of 1989 TLU days on the study area. By adding the pressure exerted by farmers' goats, the aerial survey figure can be increased to 2234 TLU days, which corresponds well with 2300 TLU days estimated by this study.

The daily amounts of DM, digestible crude protein (DCP) and P disappearance per resident TLU were found to be very high - in excess of what animals would have been able to consume (Table 10). However, relating disappearance to actual consumption is difficult because of numerous factors other than grazing by resident cattle, sheep and goats that account for DM reduction.

Table 10. DM, DCP and P disappearance during 3 months of crop residue grazing in Abet, 1982/83.

2-week periods from onset of grazing	DM disappearance ^{a/} (kg/TLU/day)	DCP ^{b/} (g/TLU/day)	P
1	17.0	425	27
2	13.8	386	21
3	19.2	365	27
4	22.3	268	29
5	22.8	251	30
6	25.3	253	33

^{a/}Grazing pressure/fortnight = 2300 TLU days.

^{b/}DCP derived from equation: % DCP = % CP - 4
(Bogdan, 1977).

Consumption of herbage by termites and losses due to trampling accounted for some of the DM disappearance. Also, transhumant herds of cattle and sheep pass through the Abet area in December, staying 2 to 3 days before moving further south; other herds arrive in January and February to spend the remainder of the dry season (Waters-Bayer, 1983). Herds of other settled Fulani from nearby areas may move into Abet for crop residue grazing and stay the remainder of the dry season to graze the lowlands. Although the grazing pressure estimated by the aerial survey would account for the presence of other herds in the middle of the dry season, it would not have detected herds passing through during the first 6 weeks of crop residue grazing.

CONCLUSIONS: CROP RESIDUE GRAZING

The results of this study show that a relatively high-quality diet was available to livestock during the first 6 to 8 weeks of crop residue grazing. The CP content of the crop residue diet appeared to be two to three times greater than the average 2% CP of natural range in Abet during the same time of year (Paper 4). The P content of 0.16 to 0.13% in the diet was higher than the level of 0.12% found sufficient for growing stock in tropical Australia (Little, 1980) and much higher than the 0.04% found in natural grasses at the same time of year in Abet (Mohamed-Saleem, personal communication). Since adequate P in the diet is a prerequisite for cow conception, the local practice of applying phosphate fertilizer to cropland

and the consequent incorporation of P into the crop residue DM may be considered an important benefit to animal production among the many linkages between cropping and livestock husbandry. These results indicate that the integration of pastoral systems with cropping systems can reduce the need for external inputs of diet supplements in seasonally dry tropical climates.

MANURE USE FOR CROPPING IN ABET

Management practices

The availability of manure for cropping is another benefit associated with the integration of livestock husbandry and cropping. Manure is returned to cropland during crop residue grazing, by keeping herds overnight on fields, and also by spreading manure collected from corrals.

During the 6 months of crop residue grazing the quantity of cattle manure deposited in 20 fields was estimated to range from 27 to 161 kg/ha of DM (mean = 111 kg/ha). These amounts are lower than the 70 to 400 kg/ha range estimated in northern Nigeria, where cattle spent more time grazing crop residues (van Raay, 1975). Given its small quantity, wide dispersion and the long time before it is incorporated into the soil, the manure return during crop residue grazing can have little immediate effect on soil fertility.

The major contribution of cattle to farmers' crops is by way of overnight manuring of fields during the dry season. Manured areas are used primarily for ginger cultivation, the major cash crop in the area. Half of 22 surveyed farmers in Abet hired Fulani to camp their animals on fields. Payments were pre-arranged according to herd size and manuring period, and were made in cash or kind including grain, thatching grass and Fulani settlement rights. Ginger sales from small manured areas bring a high return to farmers, as shown in Table 11.

Table 11. Manured areas, payments made and cash derived from manuring in Abet^{a/}.

Observation	Unit	Mean	Standard deviation	Range
Plot sizes	ha	0.08	0.04	0.04-0.16
Value of payment	Naira ^{b/}	34	34	18-170
Ginger sales	Naira	920	610	540-2,400

^{a/}n = 8 farmers.

^{b/}One Naira = US\$ 1.33 (1984).

In the dry season cattle are tied in pairs and crowded around fires in farmers' fields overnight. In this way, the average herd of 50 cattle manures about 0.04 ha during five consecutive nights before being shifted to a contiguous area. Once the rains are established in April/May, the nitrogen content of the manure increases (Table 12). The Fulani then use their herds to manure their own fields. During the early wet season, the animals are shifted every third night (depending on the rainfall) to avoid soil compaction. In Kurmin Biri, because of the low farming population on the grazing reserve and the resulting low demand for manure, the Fulani manure their own fields throughout the dry season.

The Fulani manure each of their fields every other year. The area covered is a function of herd size and time available before planting begins. Since an average herd of 50 cattle covers an area of 0.04 ha per shift (i.e. 0.0008 ha/animal), in Abet, where the average cultivated area per Fulani household is 0.87 ha, 22 nights would be required to cover half of it. For the Fulani in Kurmin Biri, half of the average cultivated area of 1.1 ha would require 69 nights of dry-season manuring or 28 nights of early wet season manuring by 50 animals.

Seasonal quantity and quality of manure

It has been estimated that in the derived savanna of Nigeria cattle grazing improved pasture void an average of 1.1 and 2.2 kg of manure DM per head per grazing day in the dry and wet seasons respectively (Onaliko, 1981). Cattle of larger size grazing natural pasture during the dry season in the savanna of northern Australia void 2.3 kg of manure DM per head per 24-hour

period (Siebert et al, 1978). In Abet and Kurmin Biri, the herds are kept on cropland approximately 14 hours per day during both the dry and early wet seasons. It is reasonable to assume that the quantity of manure voided per animal from evening to morning approximately equals the amount voided during the grazing day. The average herd of 50 animals would thus deposit about 275 kg of manure DM on 0.04 ha during a 5-night period in the dry season (i.e. 6875 kg/ha). Although manuring in the early wet season is only about 2 nights per shift, a herd would deposit an equivalent of about 5500 kg/ha of manure DM given the double amount of DM voided at this time of year.

Using the estimated amounts of manure DM deposited in fields, and its N and P values (Table 12), approximately 41 kg/ha of N and 10 kg/ha of P were applied by dry-season manuring, versus 104 kg/ha of N and 15 kg/ha of P during the early wet season.

Table 12. Seasonal N and P content in cattle manure.

Season	Manure contents (%DM)	
	N	P
Crop residue grazing		
(December)	1.55	0.26
Mid-dry (March)	0.60	0.15
Early-wet (June)	1.89	0.27

The N and P content in manure can be related to animal diet, and the analytical results indicate that animals maintain a relatively high level of nutrition during the early wet and crop residue grazing periods. Manure N values exceed the average N content of forages available during these periods, indicating that the diet is enhanced by selective grazing. These results imply that animal fertility would indeed be highest during the early wet and crop residue grazing periods, as found by Otchere et al (1982) and Zakari (1981), and agree with the Fulani perception that production gains correspond to these two times of the year.

Yields in manured and non-manured areas

Total intercrop yields in manured areas (n=8) of farmers were from 25 to 115% greater than those of adjacent non-manured areas during the 1982 growing season. The Fulani in both Abet and Kurmin Biri, who rely on manure to fertilize their fields, obtain comparable grain yields to neighbouring farmers who almost exclusively apply chemical fertilizers (Powell and Taylor-Powell, 1984). More detailed studies were conducted in Abet to estimate the N contribution of manure to grain crops (Powell, 1984b).

Maize grain yield was about 1 t/ha higher in manured areas than in non-manured areas across all N treatment levels. However, in both the manured and non-manured areas maize did not respond to N as expected (Figure 6). Various factors prevented it from attaining its yield potential. The intended plant population for the trials was 48 000 plants/ha; the average population at harvest in manured areas was only 22 800 (SD±=2500), and in non-manured areas 21 600 (SD±=3200), mainly due to predators (birds and goats). In addition, striga (*Striga hermontheca*) the parasitic weed that particularly affects maize (and sorghum), was prevalent in some fields. It was also difficult to synchronize the management operations (e.g. weeding and last N application), and this increased trial variability. The results should therefore be viewed as average maize yields obtained under farmer management conditions.

Weed growth in manured areas

One of the problems associated with manuring is weed infestation, especially in areas of dry-season manuring. In Abet, ginger fields are heavily mulched at planting, controlling weeds while conserving soil moisture. However, as shown in Table 13, the weed growth in manured maize areas was some 90% greater and weed N content was much higher than in adjacent non-manured areas. In addition to competition for nutrients, weeds in manured areas competed for soil moisture. The moisture content of weeds in manured areas was 54% (SD±=3%) versus 44% (SD±=6%) in non-manured areas.

Figure 6. Maize grain yields in manured and non-manured areas at various nitrogen levels (n = 8 farmers' fields)

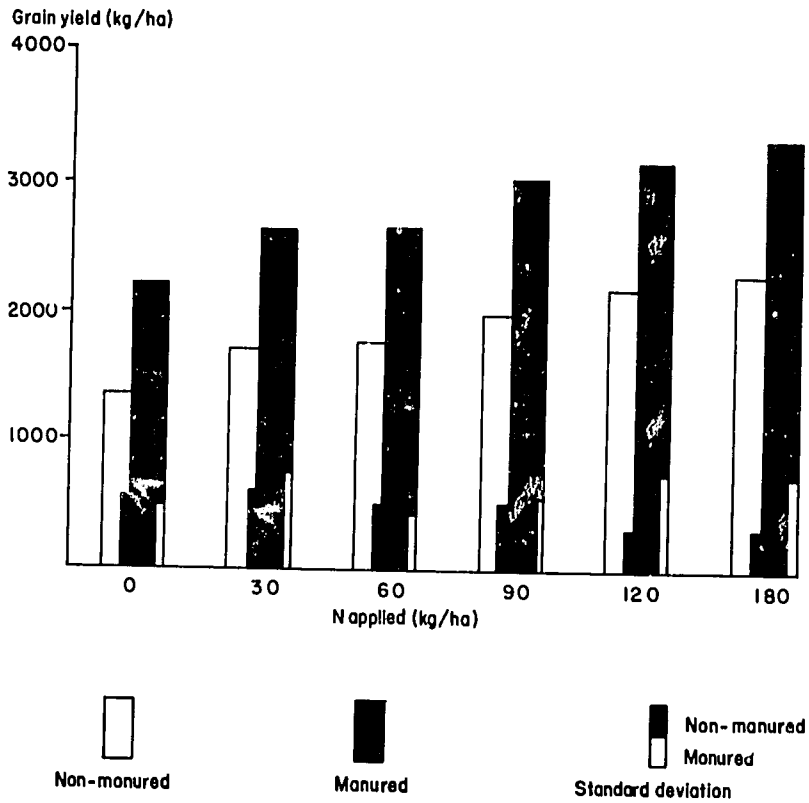


Table 13. Yields and N and P contents of weeds in manured and non-manured maize plots at grain harvest.^{a/}

DM component	Non-manured areas (n = 8)	Manured areas (n = 8)
Yield (g/m ²)	280 (131) ^{b/}	528 (209)
N (%)	167 (0.22)	2.26 (0.45)
P (%)	0.38 (0.10)	0.36 (0.08)

^{a/} Common treatment of 90 kg/ha of N and 44 kg/ha of P applied to each area.

^{b/} Figures in parenthesis are standard deviations.

Nitrogen and phosphorus uptake in manured and non-manured areas

The competition between weeds and maize for nutrients in manured and non-manured areas can be estimated from the relative amounts of N and P in the various above-ground DM components (Table 14). Stover yields for maize were estimated from grain yields for the treatment with 90 kg/ha of N, and a 33% harvest index determined for the cultivar used in the trial (Powell, 1984b). The average N and P content in maize stover were estimated to be 0.45% and 0.11% respectively over a range of fertilizer levels (Powell and Butterworth, 1984). The N and P uptake by maize grain and stover in both manured and non-manured areas agrees with a compilation of findings in other tropical areas (Sanchez, 1976).

Table 14. N and P uptake in manured and non-manured maize plots (kg/ha).

DM component	Non-manured plots		Manured plots	
	N	P	N	P
Grain ^{a/}	24	6	35	9
Stover	16	3	20	4
Weeds	47	11	119	19
Total	87	20	173	32
Applied nutrients ^{b/}	(-45)	(-44)	(-45)	(-44)
Nutrient balance	42	(-24)	128	(-12)

^{a/} N and P contents of maize grain equal 1.60% and 0.43% respectively (Martin et al, 1976).

^{b/} Assumes 50% recovery of applied N.

Weeds apparently benefited more than maize from manuring. In manured areas weeds accounted for about 68% of total N uptake versus 28% in non-manured areas. P uptake in both areas was similar (28% and 30%). After subtracting the amounts of N and P applied, the N balance in manured areas (128 kg/ha) is about three times the N balance in non-manured areas (42 kg/ha). The negative P balance in both areas can be attributed to soil P fixation. However, more P became available to plants in manured areas. The difference of 12 kg of P between manured and non-manured areas relates well to the estimated 10 kg deposited in dry-season manure and suggests that all of the P in manure became available during the first cropping season.

From these results, 84 kg/ha of N can be attributed to manuring, although the total N in dry-season manure was estimated to be only 41 kg/ha. The difference may be partially attributed to the N in urine. Vallis et al (1983) found that during the dry season in northern Australia at least half of the urine N returned by cattle grazing pasture may be lost from the soil-plant system within a few months. The N contribution from urine to a succeeding sorghum crop in the ley cropping system appeared to be negligible. However, under the prevailing overnight manuring practices in the ILCA case study areas much larger amounts of urine are returned to the soil than in a pasture system. In the sandy loam soils common in Abet and Kurmin Biri more urine is likely to penetrate the soil to a sufficient depth, inhibiting gaseous N losses. Also, the increased cation exchange capacity in manured areas may have caused a more efficient use of applied N.

Effect of manuring on soil properties

Soil samples taken from a depth of 0 to 15 cm from manured and non-manured ridges 3 weeks after maize planting showed that manuring increased soil pH, organic carbon, total N, exchangeable P and the cation exchange capacity of soils in Abet (Table 15). The C to N ratio in manured areas was the same as in non-manured areas (11 to 1), indicating that the manure was well mineralized. Between the time when manure is deposited in the dry season and incorporated into the soil in the wet season, it is already degraded by

macro-arthropods, especially Isoptera and Coleoptera spp. (Omali, 1981). The decomposition of exposed manure should be considered beneficial as it reduces the manure's carbon content, thereby hastening mineralization once incorporated into the soil. Termites and beetles also transport some of the manure to lower soil depths and mix it with the topsoil. However, leaving manure exposed can reduce its N content.

Table 15. Effect of overnight manuring on selected soil properties.^{a/}

Soil analysis	Non-manured areas (n=8)	Manured areas (n=8)
pH (%)	5.1 (0.4) ^{b/}	5.8 (0.3)
Organic carbon (%)	1.50 (0.48)	1.91 (0.66)
Total N (%)	0.131 (0.037)	0.164 (0.059)
Available P (ppm) (Bray-1)	4.6 (1.8)	9.6 (2.5)
Cation exchange capacity (meq/100 g)	4.34 (1.77)	6.15 (1.88)

^{a/} Common treatment of 44 kg/ha of P applied to each area.

^{b/} Figures in parenthesis are standard deviations.

The carbon (C) and N values in non-manured ridges were higher than the average 0.78% C and 0.07% N given for the surface horizon of ferralic cambisols, the predominant soil types in Abet (Bennett et al, 1977). The difference may be attributed to the concentration of organic matter during ridging. In Abet, a new ridge is made each year by overturning half of the vegetative growth and topsoil of two adjacent ridges into the previous year's furrow. This practice results in a two- to threefold concentration of both topsoil and organic matter. Since soil samples were taken from the ridges, the analytical results represent the concentration of organic matter within the ridge.

Cutting from 3 m² quadrants in each of eight fields in late June showed that an average of 3300 kg/ha of vegetative DM (SD±=640 kg) was incorporated into ridges. The average N content of this DM (n=10 samples) was estimated to be 1.65% (SD±=0.3%), equalling approximately 54 kg/ha of N. Therefore, much of the 42 kg/ha of N in non-manured areas (Table 14) probably came from the mineralization of vegetation incorporated into ridges prior to planting.

Manure increases soil organic C, resulting in a greater moisture-holding capacity. An increase in the water-holding capacities of the sandy loam soils common in the savanna zone of West Africa could, in itself, lead to increased grain yields by extending the period of water availability during drought periods.

One of the merits of overnight manuring is that it requires no labour for manure handling, storage, transport and/or spreading. However wet-season manuring can lead to soil compaction, requiring more labour for cultivation. The main advantages of manuring during this time of the year are the threefold increase in manure N and the twofold increase in manure output. However, since the period of early wet-season manuring corresponds with the beginning of cultivation, the amount of land a herd can manure before planting is limited.

CONCLUSIONS: MANURING

In the system under study, the practices of depositing 5.5 t/ha of manure in fields during the early wet season and of manuring each field every 2 years seem to be rational ones. Although it is difficult to estimate the proportion of applied manure N (i.e. 104 kg/ha) that will mineralize and subsequently become available to the crop during the first year, farmers and Fulani agree that manured areas have sufficient reserves left the following year to maintain yields. Further research is needed to evaluate this residual effect as well as to compare the effectiveness of dry-season versus early wet-season manuring.

The estimated 6.9 t/ha of manure deposited during the dry season is probably required to obtain proper rhizome development in ginger, and hence good ginger yields. However, such high application levels are probably not required to maintain grain yields. An increase in weed growth in dry-season manured areas and consequent competition with the crop for nutrients and water were evident. Labour saving methods to control weeds (e.g. use of herbicides) need to be considered if grain crops are to obtain the full benefit of manure in the future.

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Integration of forage legumes into the cropping
systems of Nigeria's subhumid zone

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ABSTRACT

The subhumid zone of Nigeria is increasingly being occupied by arable farmers and pastoralists. As a result the traditional grazing land is declining, but the total potential fodder from crop residues could compensate for this loss, at least in terms of bulk. The nutritive value of crop residues can further be enhanced by inclusion of a forage legume in the mixed cropping system. However, in order to optimize the returns of both grain and fodder, the spatial and temporal requirements of the various components in the mixture need to be manipulated. Undersowing sorghum with stylo 6 weeks after planting the grain crop or sowing the two in alternate rows (inter-row sowing) seems to achieve both the desired benefits, from grain for human consumption and from fodder for livestock consumption. But because land tenure is controlled by the arable farmers, who do not generally own livestock, there is no incentive to improve crop residues just for the benefit of pastoralists. It may be easier to persuade farmers to lease land to pastoralists if forage improvement using legumes is equally beneficial to subsequent crop production.

Grain yields of 2 tonnes more on a soil after 2 or 3 years under stylo than on continuously cropped soil suggest that the soil benefits from the planted legume are higher than benefits from natural fallow during a similar period. Hence, legume-based cropping has important implications for soil management, especially in areas where prolonged fallows are not practical due to population growth. Various crop combinations and cropping techniques are discussed.

INTRODUCTION

In the subhumid zone of Nigeria the majority of the cattle owners are pastoralists, who are now settling and will continue to settle in the midst of arable farming communities. To a settled pastoralist, raising crops becomes as important as cattle keeping. There are also many mixed farmers in the subhumid zone, both within and outside Nigeria. Subhumid conditions are favourable for both cropping and livestock enterprises. However, arable farming is spreading at the expense of traditional grazing land. But increase of arable farming does not seem to discourage movement of livestock or their permanent residence within the zone. This imposes a strain on the dwindling grazing resources. Under present farming systems cropped land deteriorates rapidly. Under these circumstances development of integrated pasture-livestock-crop systems offers a method of accommodating and improving both crop and livestock production.

UNDERSOWING OF CEREALS WITH FORAGE LEGUMES

Under the smallholder subsistence farming practised in the subhumid zone a single household does not cultivate more than 2 to 3 ha at a time even if land is readily available. The small size of farms is primarily due to the labour required for various cultural operations.

Undersowing cereal crops with a forage legume appears to offer a simple method of enhancing the quality of grazing after grain harvest. It imposes minimum inconvenience to or change in the traditional cultural practices.

Experiments were carried out for 2 years (1980 and 1981) to determine the optimum time of undersowing various stylo cultivars into sorghum. Stylosanthes guianensis cv Cook and S. hamata cv Verano were chosen because they grow well under subhumid conditions. The experiments involved the following treatments:

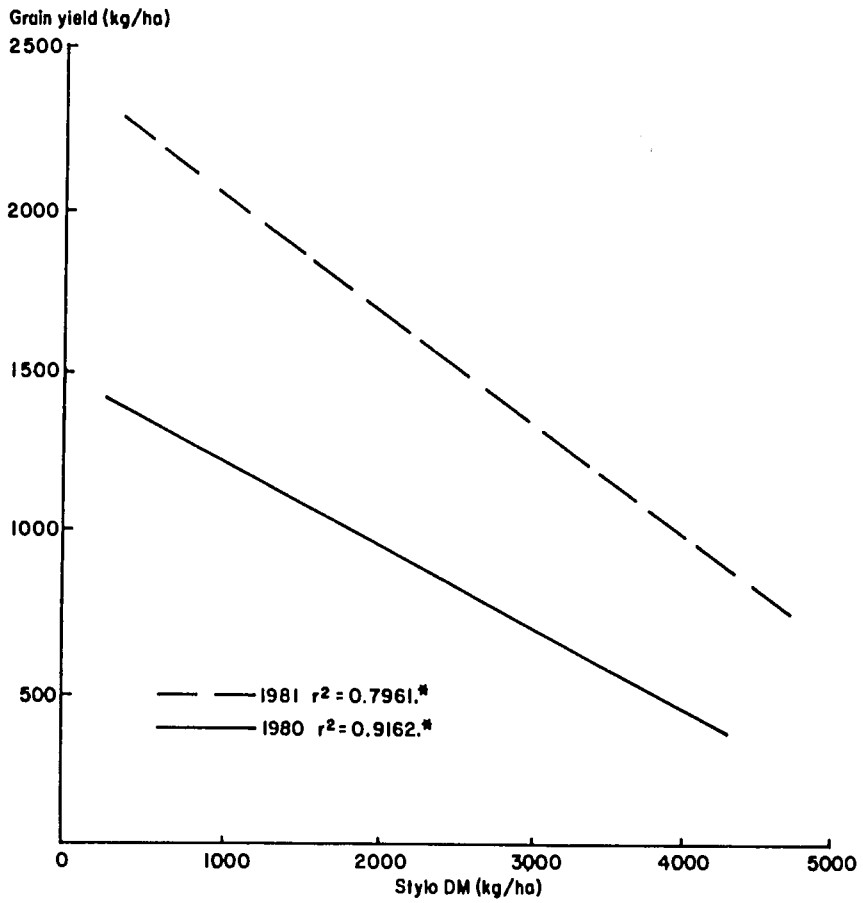
1. Control, i.e. sole crop of sorghum (C₀).
2. Sorghum plus stylo planted on the same day (C₁).
3. Sorghum plus stylo planted after 3 weeks (C₂).
4. Sorghum plus stylo planted after 6 weeks (C₃).
5. Sorghum plus stylo planted after 9 weeks (C₄).

In 1980 a local sorghum variety and S. hamata were used. Since phenotypic and genotypic variations were found in the local variety, the experiment was repeated in 1981 with sorghum (variety 5912) recommended by the Institute of Agricultural Research, Samaru, and S. guianensis cv Cook.

The time of undersowing was found to be critical and specific to the legume type. Planting S. hamata cv Verano after 3 weeks and S. guianensis cv Cook after 6 weeks caused minimum grain yield reductions and increased the quality of available fodder (Table 1). The crude protein (CP) content of the total fodder from underrown plots was greater than that of the crop residue alone. Grain yield reductions were a function of the productivity of the introduced stylo (Figure 1).

Despite its simplicity and low cost, this technique will apply only to farmers with small numbers of stock because of the small areas that are cultivated. Thus farmers with a few small ruminants or two draught oxen should find it useful. Pastoralists with large herds will not appreciate its value for feeding purposes, but they may use it as a source of seed and for spreading the legume in fallow land following the last crop.

Figure 1. Relationship between grain and stylo yields.



* Significant at $P < 0.01$.

Where farmers cultivate larger areas with the aid of animal power, undersowing cereals could substantially raise the output of good-quality fodder. For example, in the subhumid zone of southern Mali, where an average farmer claims he is able to cultivate between 7 and 10 ha/year, it may be possible, given yields similar to those obtained in Kaduna (Table 1), to raise the total protein output of fodder from 1785 - 2550 to 2905 - 4150 kg/7-10 ha unit/farmer, simply by undersowing sorghum with S. guianensis cv Cook 6 weeks after sowing the grain crop.

In the following year, self-seeded regrowth will have to be controlled for at least 3 to 6 weeks from the time of planting the sorghum, because of the latter's otherwise slow initial establishment. During early growth sorghum does not withstand competition from Stylosanthes and can easily be smothered (Table 1).

SIMULTANEOUS SOWING

The results of another experiment, carried out in 1983, suggest that sorghum (variety 5912) can compete effectively with Centrosema pascuorum, Alysicarpus vaginalis and Macroptilium lathyroides without staggered planting dates. These legumes caused no significant differences between the yields of sorghum when undersown and when sown as a sole crop (Table 2). In this case sowing the forage legumes on the same day with the grain crop has the advantage of eliminating the need for extra labour for undersowing later on.

Table 1. Effect of undersowing stylo on grain yield of sorghum and total available fodder after harvest, Kurmin Biri, 1980-1981.^{a/}

Time of sowing stylo	Grain yield (kg/ha)	Grain yield deviation from C ₀ (%)	Fodder yield			
			Crop residue (kg/ha)	Stylo DM (kg/ha)	% CP in total fodder (%)	Available CP (kg/ha)
<u>1980</u>						
Sole crop (C ₀)	1226 a		7503 a (2.4)		-1.09	180
With grain crop (C ₁)	357 b	-70	1303 c	4010 a	5.02	490
After 3 weeks (C ₂)	1224 a	+ 0	3719 b	1729 b	1.78	281
After 6 weeks (C ₃)	1287 a	+ 5	4260 b	702 c	-0.19	178
After 9 weeks (C ₄)	1240 a	+ 1	3919 b	408 c	-1.28	142
<u>1981</u>						
Sole crop (C ₀)	2192 a		8796 a		-0.64	255
With grain crop (C ₁)	480 c	-78	2367 c	4334 a	4.66	592
After 3 weeks (C ₂)	1550 ab	-29	3524 c	3215 b	3.34	493
After 6 weeks (C ₃)	1918 ab	-13	5385 b	2464 b	1.42	415
After 9 weeks (C ₄)	1980 a	-10	7463 a	456 c	0.01	283

^{a/} Values in a column in each year followed by common letters do not differ significantly at the 5% level.

Table 2. Grain yield (kg/ha) of sorghum when planted together with forage legumes on land prepared by two different methods at Kachia Grazing Reserve, 1981.^{a/}

Type of crop/ legume mixture	Grain yield (kg/ha)		Difference in grain yields between ridged and flat land (%)
	Land preparation		
	Ridge	Flat	
Sole sorghum	1295 a	870 b	-33
Sorghum plus <i>S. hamata</i> cv Verano	313 def	141 f	-55
Sorghum plus <i>S. guianensis</i> cv Cook	388 def	246 ef	-37
Sorghum plus <i>M. atropurpureum</i>	356 def	444 cdef	+25
Sorghum plus <i>C. pascuorum</i>	1019 ab	595 cde	-42
Sorghum plus <i>A. vaginalis</i>	1092 ab	722 bcd	-34
Sorghum plus <i>M. lathyroides</i>	1297 a	333 bc	-36

^{a/} Figures between and among the columns followed by one or more common letters do not differ at the 5% level of significance.

Although the total amount of fodder per unit area from each of the crop-legume mixtures did not vary significantly from that obtained from sorghum as a sole crop, the increase in legume content raised the quality of the fodder (Table 3).

Table 3. Fodder yield (kg/ha) of sorghum when planted together with forage legumes on land prepared by two different methods at Kachia Grazing Reserve, 1983.^{a/}

Type of crop-legume mixture	Yield (kg/ha) ^{b/}						Difference in fodder yields between ridged and flat land (%)
	Land preparation						
	Ridge			Flat			
	Crop residue	Legume DM	Total fodder	Crop residue	Legume DM	Total fodder	
Sole sorghum	4667 a		4667 a	2722 bc		2722 bc	-42
Sorghum plus <u>S. hamata</u> cv Verano	1685 c	2778 a	4463 a	1944 bc	1796 bc	3740 ab	-17
Sorghum plus <u>S. guianensis</u> cv Cook	1555 c	2063 b	3618 ab	2037 bc	1167 de	3204 ab	-11
Sorghum plus <u>M. atro-purpureum</u>	2111 bc	1296 de	3407 ab	2430 bc	1019 e	3449 ab	+1
Sorghum plus <u>C. pascuorum</u>	2981 b	1204 de	4185 a	2426 bc	1315 de	3741 ab	-11
Sorghum plus <u>A. vaginalis</u>	2519 bc	926 e	3445 ab	2074 bc	481 f	2555 b	-26
Sorghum plus <u>M. lathyroides</u>	2741 bc	1481 cd	4222 a	2667 bc	1000 e	3667 ab	-13

^{a/} Figures between and among corresponding columns followed by one or more common letters do not differ at the 5% level of significance.

^{b/} Due to the early start of the dry season the yields of grain and fodder were generally below expectation for the sorghum cultivar used.

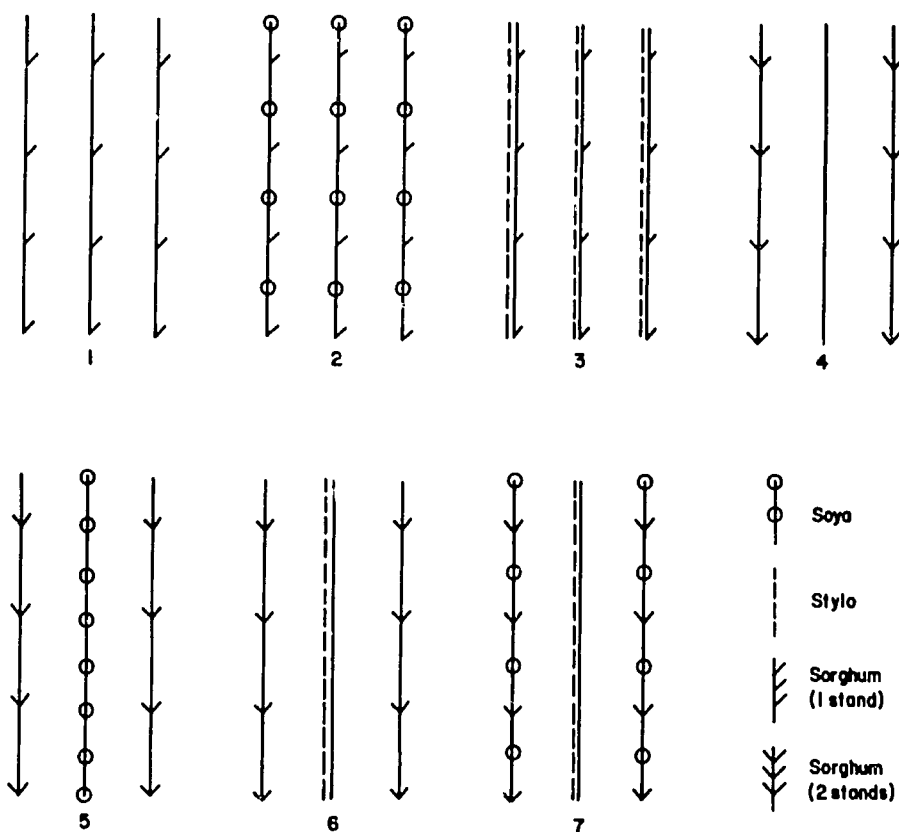
The seeds of the six legume types were broadcast and slightly worked into the soil of all three replications. Sorghum was planted either on flat seedbeds or on ridges. Ridge making involved more work but resulted in higher grain yields (Table 2). Crop residue yields did not differ significantly between planting on the ridge and on the flat. When sorghum was planted alone on the flat the residue from it was 42% lower than when

planted on ridges, but there was no significant difference in legume production between ridges and flatbeds (Table 3).

ALTERNATIVE CROP GEOMETRY TO ACCOMMODATE FORAGE LEGUMES

The possibilities for incorporating forage legumes through simple adjustments in plant geometry and fertilizer application were also investigated with *S. guianensis* cv Cook. A mixture of sorghum and soybean, as traditionally planted on ridges according to local practice, was taken as a reference model (Figure 2, pattern 2) for comparison with different crop-forage combinations (Figure 2, patterns 3-7).

Figure 2 . Crop-crop-forage planting patterns .



On one ridge, two sorghum stands were planted 0.3 m apart, with soybean in between, while *S. guianensis* cv Cook was planted alone on the other ridge (inter-row planting or alternate row planting - Figure 2, pattern 7). This variation offered a good compromise for growing a two-crop and one-forage mixture without having adverse effects on grain yields compared with sole cropping (Table 4). Undersowing sorghum with soybean did not cause as severe a grain reduction as undersowing with stylo.

Table 4. Grain and fodder yield (kg/ha) when soybean and stylo were undersown (US) or sown on alternate ridges (AR) with sorghum, 1982.^{a/}

Sorghum spacing (m)	Legume sowing method		Grain yield ^{b/} (kg/ha) at:			Fodder yield ^{b/} (kg/ha) at:			Mean grain yield (kg/ha)	Mean crop residue yield (kg/ha)
			0	40	80	0	40	80		
			(kg N/ha)			(kg N/ha)				
1 x 0.30	-	-	952	1481	2040	3921	7092	7571	1491 ab	6159 ab
1 x 0.30	US	-	740	1217	1645	2652	6238	6619	1201 bc	5170 c
			(47)*	(90)	(137)				(91)	
1 x 0.30	-	US	617	1206	1365	1904	3381	4968	1063 c	3418 d
						(1159)	(1460)	(1381)		(1333)
2 x 0.30	-	-	857	1730	2142	3603	7625	8095	1576 a	6441 a
2 x 0.30	AR	-	834	1666	2174	2998	6619	7031	1558 ab	5549 bc
			(162)	(170)	(185)				(172)	
2 x 0.30	-	AR	778	1429	1963	3540	5238	7008	1390 abc	5262 c
						(1556)	(1857)	(2016)		(1803)
2 x 0.30	US	AR	779	1335	1878	2746	5032	6662	1331 abc	4813 c
			(29)	(69)	(108)	(1127)	(1286)	(1667)	(68)	(1360)

^{a/} Mean grain and crop residue values followed by common letters do not differ significantly at the 5% level of significance.

^{b/} Values in parenthesis correspond to grain yield of soybean and fodder yield of stylo respectively.

Both sorghum and soya grain yields responded to the application of nitrogen. With N application to the sorghum row, they produced comparable yields when planted either separately on different ridges or together on the same ridge and alternated with stylo rows. When fertilized with 80 kg

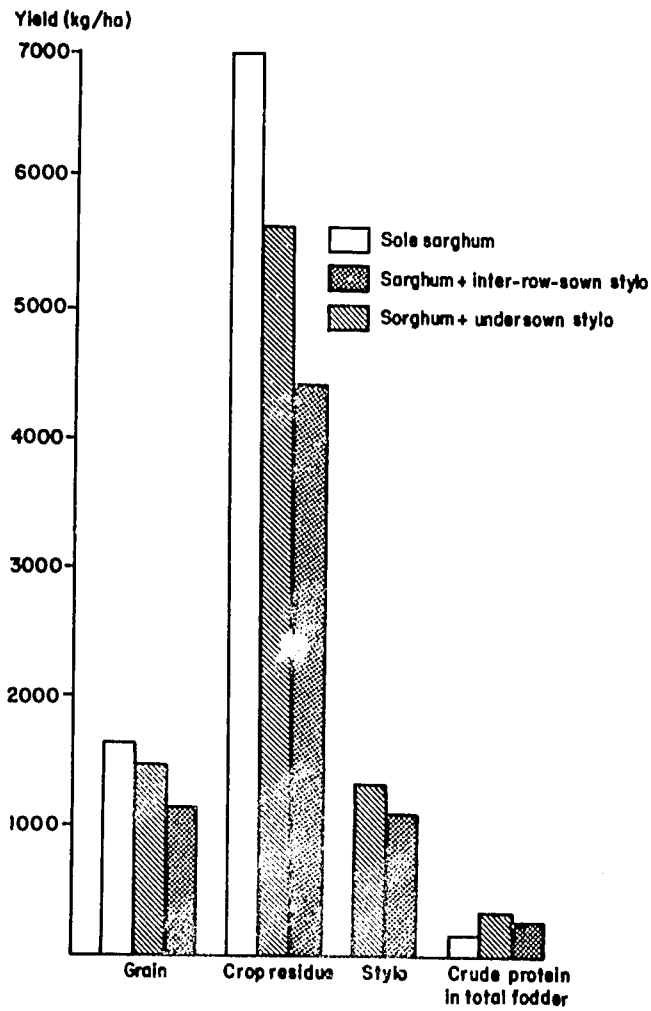
of N/ha the inter-row sowing of stylo, with sorghum and soya on alternate ridges, produced 8.2 tonnes of fodder per ha. Out of this, 1.6 tonnes were made up of stylo (CP = 13.1%), increasing the CP yield over sole-crop sorghum from 216 kg to 391 kg/ha.

Undersowing and inter-row sowing were also tested in researcher-managed, farmer-implemented trials. Thirteen farmers who had previously planted sole-crop sorghum were recruited at Abet in 1981 and persuaded to undersow or inter-row sow their crop with Stylosanthes. When inter-row sown the total sorghum plant population was maintained by planting two stands per position instead of one. Inter-row sowing resulted in a reduction of about 10% in grain yields compared with the sole-crop control. Undersowing resulted in a grain loss of about 30% (Figure 3).

The value of the grain loss from inter-row sowing was less than that of the extra fodder gain, based on the comparative cost of obtaining the same amount of protein from cottonseed cake.

Stylosanthes was also more productive on ridges (Table 4) but farmers will not expend labour on ridge making and then plant only half their ridges with cereal unless they either own livestock or have access to a market for the fodder.

Figure 3. Average grain and fodder yields of sorghum with under- or inter-row-sown stylo in researcher-managed farmer-executed trials, Abet, 1981.



CONTRIBUTION OF FORAGE LEGUMES TO FOOD CROP PRODUCTION

Land under S. hamata cv Verano and S. guianensis cv Cook for various lengths of time supported higher maize yields compared with those from uncropped or previously cropped areas. This became evident from trials using maize rows (four replications) to assess the effect of different rates of N (0, 20, 40, 60, 80, 100, 133, 166, 199 kg/ha) on grain and fodder productivity of land that had had the following histories:

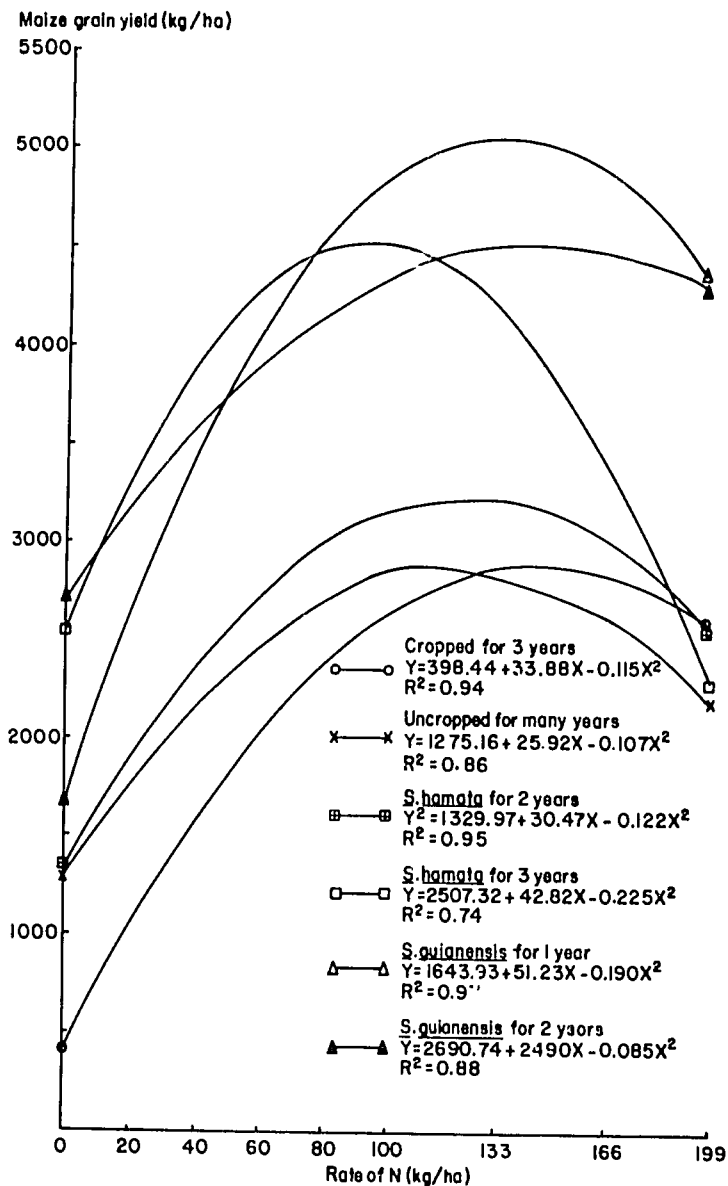
1. Uncropped for a number of years.
2. Cropped for 3 years.
3. Under S. hamata cv Verano for 2 years.
4. Under S. hamata cv Verano for 3 years.
5. Under S. guianensis cv Cook for 1 year.
6. Under S. guianensis cv Cook for 2 years.

The results of this experiment are summarized in Figure 4, from which the amounts of N required to be applied to a soil cropped for 3 years to achieve crop yields equivalent to the various legume fallow treatments can be derived. The amounts are given in Table 5.

Table 5. Estimated level of N utilization (kg/ha) from soil with different histories at Kurmin Biri, 1983.

Soil type	Grain yield at 0 kg/ha of N	Amount of applied N (kg/ha) required by cropped soil for equivalent yields of other soil types at zero N
Cropped for 3 years	461	
Uncropped for many years	1275	30
<u>S. hamata</u> for 2 years	1329	32
<u>S. hamata</u> for 3 years	2507	90
<u>S. guianensis</u> for 1 year	1643	44
<u>S. guianensis</u> for 2 years	2696	110

Figure 4. Effect of N application on grain yield of maize grown on land with different cropping histories, Kurmin Biri, 1983.



The main crop benefitted from N amounts equivalent to 90 and 110 kg/ha from soil that had been under S. hamata cv Verano and S. guianensis cv Cook for 3 and 2 years respectively. It produced much higher yields, approximately 1.2 to 2.2 tonnes/ha over and above those from previously cropped or uncropped soils.

The more rapid improvement of soil under stylo than under natural fallow has favourable implications for forage cropping in the subhumid zone. However, for how long such an improved soil could support cereal production has not yet been determined. Studies in Kenya (Maher, 1951; Webster, 1954) showed that the beneficial effects of a grass pasture were lost after 1 or 2 years of grain cropping.

There may be other legumes resistant to anthracnose that could impart greater benefits to soil than S. guianensis cv Cook and S. hamata cv Verano in the subhumid zone. In a screenhouse study where maize was grown for 6 weeks in pots using soil collected from legume introduction plots after two growing seasons, several lines showed higher beneficial effects (Table 6). The different lines were acquired from CIAT (Columbia) and were not inoculated at the time of planting.

Table 6. Total dry matter (DM) yield of maize in pots using soil collected from plots of respective legumes after two growing seasons, 1984.

Accession	Species	Yield ^{a/} (g/plot of 10 seedlings)
350	<u>D. ovalifolium</u>	7.16 a
1019	<u>S. capitata</u>	6.97 ab
3001	<u>D. gyroides</u>	6.80 abc
5233	<u>C. aurinarium</u>	6.78 abcd
2039	<u>S. macrocephala</u>	6.74 abcd
1582	<u>S. macrocephala</u>	6.68 abcd
5062	<u>C. macrocarpum</u>	6.66 abcd
728	<u>Z. latifolia</u>	6.64 abcd
5234	<u>C. brazilianum</u>	6.56 abcd
7485	<u>Z. brazilianum</u>	6.53 abcd
1342	<u>S. capitata</u>	6.38 abcd
1523	<u>S. quianensis-tardio</u>	6.36 abode
1045	<u>S. capitata</u>	6.30 bode
1693	<u>S. capitata</u>	6.30 bode
5274	<u>C. macrocarpum</u>	6.24 bode
2133	<u>S. macrocephala</u>	6.14 bodrf
1318	<u>S. capitata</u>	6.14 bodef
2044	<u>S. capitata</u>	6.12 bodef
1280	<u>S. quianensis-tardio</u>	6.08 odef
1097	<u>S. capitata</u>	6.02 cdefg
1728	<u>S. capitata</u>	5.94 cdefg
1315	<u>S. capitata</u>	5.92 defg
1441	<u>S. capitata</u>	5.50 efg
5234 x 5224	<u>C. brazilianum</u>	5.36 fgh
1643	<u>S. macrocephala</u>	5.20 gh
1283	<u>S. quianensis-tardio</u>	4.66 hi
Control	No legume	3.50 i

^{a/} Means of four replications. Values in the column followed by one or more common letters do not differ at the 5% level of significance.

LEGUME-BASED CROPPING TECHNIQUES

Rate of soil regeneration under a legume is a function of the legume's concentration and productivity. A concentrated legume stand cannot be maintained indefinitely. After 2 or 3 years fodder banks tend to be invaded by nitrophilous grasses in response to the build-up of N in the soil. A cereal crop can be planted to use the surplus nitrogen instead, thus benefitting not only itself but also the legume, the subsequent concentration of which will be improved.

Land preparation after a natural fallow is geared towards producing a clean seedbed. Methods may include burning, stumping large trees and shrubs, ridging, etc. But when clearing an area that has been under a legume, farmers should not aim at its total removal. The crop and legume phases should each be short because, as noted above, gains in soil fertility are not long lasting. Hence, there is a need to maintain adequate legume seed reserves for re-emergence.

Again, the presence of legumes amongst the grain crop residue is of value to livestock, but as noted above the regrowth of the legume must be controlled for the first 3 to 6 weeks in order to avoid competition after sowing of the grain crop at the start of the following growing season.

In the light of these considerations, research has been carried out on two techniques: superimposed cropping and intersod transplanting.

Superimposed cropping

Superimposed cropping means growing a cereal every year in areas also sown with forage legumes. The essential feature is that the cereal grows while the legume is kept under control by manual weeding or by herbicide application. Once the grain crop is fully established and able to withstand competition, the legume is allowed to regenerate from seed and contribute to the total post-harvest fodder. This system requires large legume seed reserves in the soil, and thus a good seed return after each growing season. The presence of adequate seeds with different sensitivities will ensure regeneration of the legume after land preparation and weed control have eliminated early legume flush.

In an experiment at Kurmin Biri where sorghum was planted in an area under Stylosanthes hamata cv Verano, application of a herbicide - Round-up (glyphosphate) at 3 litres/ha before planting the grain crop - did not reduce early re-emergence of the legume, although the initial flush was totally killed. The growth rate of sorghum planted on the flat was low compared to that planted on ridges (Table 7). Sorghum planted on the flat was smothered completely by the legume in spite of herbicide application.

Table 7. Growth of sorghum at 7 weeks when planted in an area under S. hamata after different land preparations, Kurmin Biri, 1983.

Land preparation	Plant height (cm)	Root length (cm)	Number of leaves	Leaf area index
<u>No-legume area</u>				
Ridge	124	42	9	0.32
Flat	50	25	6	0.18
<u>S. hamata area</u>				
Ridge	119	44	9	0.32
Flat	43	23	5	0.09

When the soil was ridged and the grain crop sown early in the season, legume emergence was low and was confined to the valleys, while grain crop growth was faster (Table 8). This low emergence was probably due to burial of most of the legume seeds under the ridges. Application of herbicide after making the ridges but before planting the grain crop did improve grain yields from both legume and non-legume areas but, in the former, legume content of the final fodder was reduced as compared with that from unsprayed ridges. Although grain and fodder yields of sorghum were low (probably due to moisture stress imposed by the early start of the dry season in 1983), there appears to be a clear yield advantage from ridging, especially when grain crops are superimposed on a legume area (Table 8). This result suggests that a planted legume fallow or a fodder bank should be cultivated using ridges in the traditional manner.

Table 8. Effect of land preparation and herbicide application on the grain and fodder yields when sorghum was superimposed on an area under S. hamata, 1983.

	Herbicide			No herbicide		
	Grain (kg/ha)	Crop residue (kg/ha)	Stylo (kg/ha)	Grain (kg/ha)	Crop residue (kg/ha)	Stylo (kg/ha)
<u>No-legume area</u>						
Ridge	749	4124	-	542	2562	-
Flat	457	1662	-	329	1500	-
<u>S. hamata area</u>						
Ridge	1213	4687	1088	750	3581	1882
Flat	340	1725	3980	125	1440	5850

The presence of a forage legume may provide better protection against soil erosion than a sole crop. However, an important consideration for a farmer is the relative labour requirements for ridging a soil that has been under a legume compared with that which has not. This still needs to be tested.

Intersod transplanting

Intersod transplanting means transplanting cereals into established legume swards. Ridge making is a labour-intensive operation. The extent of land that can be prepared for cropping largely depends on the labour availability at the appropriate time. Techniques that reduce labour requirements and/or spread labour demands into slack periods would thus benefit the farmer. Farmers in the ILCA study areas habitually transplant millet and, to a lesser extent, sorghum. Sorghum is transplanted when it has to be re-established during the growing season or when opening rains are late in the year. Seedlings raised in nurseries are easier to irrigate than when they are on larger plots.

Building on this traditional practice, preliminary attempts were made to transplant sorghum and millet into 1-year-old plots of S. hamata cv Verano. Nurseries of sorghum and millet were established in June and July, and seedlings were transplanted in July and August into separate plots of S. hamata at 30- and 25-cm spacings respectively along the rows. The rows,

each 30 cm in width and 1 m apart, were cut or strip-hoed within an established plot of *S. hamata*. In some plots the herbage between the rows was also cut and removed from the plots at the time of transplanting.

Transplanting into stylo reduced grain yield of the two cereals by 20 to 38% compared with the yield anticipated on traditional ridges without stylo (Table 9). Removing stylo from between as well as within rows at the time of planting improved grain yields of transplanted millet.

Table 9. Grain and fodder yields (kg/ha) of sorghum and millet under different land preparations and planting methods, Kurmin Biri, 1981.

Land preparation/ planting	Grain yield	Deviation in grain in relation to L_1 (%)	Crop residue ^{a/}	Stylo DM ^{a/}	Total fodder CP
Sorghum					
Ridge - no stylo (L_1)	1833	-	4916 (24)	-	118
Intersod transplanting within stylo (L_2)	1366	-20	3800 (2.4)	2432 (12.9)	409
Millet					
Ridge - no stylo (L_1)	860		1748 (3.18)		
Intersod transplanting (stylo between rows uncut at planting) (L_2)	530	-38	648 (2.89)	2820 (12.3)	366
Intersod transplanting (stylo between rows cut at planting) (L_3)	670	-22	894 (3.10)	2238 (12.1)	298

^{a/}Values in parenthesis indicate % CP.

In another experiment in 1983 intersod transplanting of sorghum was compared with transplanting onto ridges. The grain yield of sorghum transplanted onto ridges made within plots of *S. guianensis* cv Cook was twice as high as that from ridged areas without stylo (Table 10). Sorghum established in the stylo from seeds suffered greater loss of grain yields,

especially when planted late to coincide with transplanting in a year with a short wet season. Application of weed killer reduced the productivity of stylo. The effects of stylo soil and ridging on crop yield were again very evident.

Table 10. Effect of land preparation and method of crop establishment within stylo fields on grain and fodder yields (kg/ha) of sorghum, Kurmin Biri, 1983.

Land preparation method	Planting method	Yields ^{a/}		
		Grain (kg/ha)	Crop residue (kg/ha)	DM stylo (kg/ha)
Sorghum without stylo ^{b/}				
Ridge	Seed	292 d	2750 de	
	Transplant	795 bc	4833 ab	
Strip-hoe	Seed	84 d	1646 fg	
	Transplant	583 c	3667 cd	
Sorghum with <i>S. guianensis</i> cv Cook				
Ridge and no herbicide	Seed	342 d	2617 def	1440
	Transplant	1093 b	4315 bc	1512
Strip-hoe and no herbicide	Seed	94 d	1313 g	2205
	Transplant	240 d	2050 efg	2058
Ridge and herbicide	Seed	531 c	3375 d	748
	Transplant	1563 a	5716 a	760
Strip-hoe and herbicide	Seed	250 d	2207 ef	1030
	Transplant	563 c	3750 c	942

^{a/} Values of grain and crop residue followed by one or more common letters do not differ at the 5% level of significance.

^{b/} Grain and crop residue yields of sorghum on stylo-free area did not differ significantly between herbicide and non-herbicide treatments.

Transplants compete with stylo better than do seedlings. Raising seedlings first in a nursery helps to select strong, healthy plants. Transplanting into stylo without having to make ridges offers another way of growing crops and forages together without increasing labour

requirements. The amount of labour spent on strip-hoeing is approximately one third of that required for ridge making. It would thus be possible to compensate for the loss of grain by cultivating larger areas with the available labour. This innovation could be very advantageous wherever labour rather than land is the limiting factor, as in many parts of Nigeria's subhumid zone.

CONCLUSIONS

Superimposed cropping and incorporating forage legumes into crop mixtures appear to offer the most promising methods of improving fodder supplies and maintaining soil fertility without prejudicing grain crop yields, but more research with farmer participation needs to be done on all the various cropping techniques and combinations to evaluate their relevance in agropastoral production systems.

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The establishment and management of fodder banks

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ABSTRACT

The herbaceous cover of Nigeria's subhumid zone consists mainly of annual grasses, and its fluctuating quality does not meet livestock feed requirements, particularly in the dry season. Supplementation with agro-industrial byproducts is ruled out because of their scarcity and increasing cost.

The fodder bank (FB) concept, whereby a forage legume is established and properly managed in a concentrated unit, can provide useful dry-season supplementation for the most responsive animals in an average herd. Since factors such as climate, soil, legume species and the access of pastoralists to resources - land, labour and capital - are not uniform throughout the zone, fodder bank development should be modified to suit a given situation. The general guidelines for establishing and managing fodder banks with minimum inputs can nevertheless be summarized as follows:

1. Fence a block of about 4 ha.
2. Prepare the seedbed by confining the herd overnight in the area or by simply grazing down for 1 or 2 weeks following seed broadcast.
3. Broadcast scarified seeds.
4. Control fast-growing grasses through early-season grazing.

5. Allow forage to bulk up by deferring grazing until the dry season.
6. Graze the pregnant and lactating animals in the herd (up to a maximum of 5/ha) for 2.5 hours per day during the dry season.
7. Ensure sufficient seed drop and stubble for regeneration in the following season.

The profitability of fodder banks depends on the maintenance of high concentrations of legumes over several years. However, because of the nitrogen build-up in the soil they tend to be invaded by nitrophilous grasses. This nitrogen could instead be exploited by cereal crops, which in turn may provide farmers with an incentive to respond favourably to pastoralists' requests to use their land for fodder banks.

Research on fodder banks has so far been restricted to the three stylo cultivars: Stylosanthes guianensis cv Schofield, S. guianensis cv Cook and S. hamata cv Verano. The guianensis types are prone to anthracnose; there is therefore an urgent need to identify and multiply suitable resistant species.

INTRODUCTION

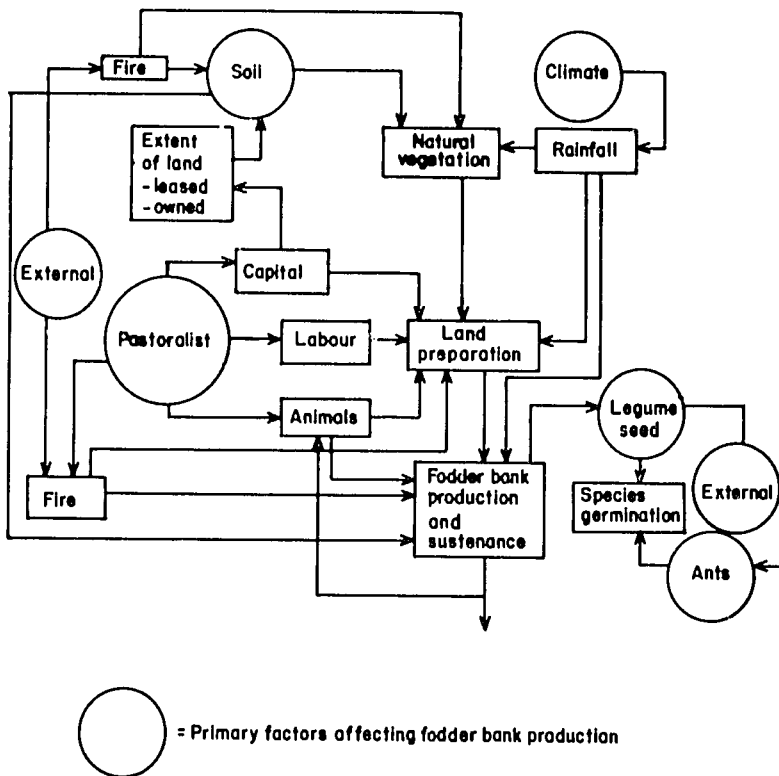
The herbaceous cover of Nigeria's subhumid zone consists mainly of annual grasses with a very low percentage of native legumes (Paper 4). Seasonal changes in herbage quality are caused primarily by changes in plant development rather than by climatic conditions per se. The C₄ photosynthetic pathways in grasses allow a rapid accumulation of structural component, with the resultant dilution of nutrients, such as N and P in the tissue. Unlike grasses, legumes exhibit a less efficient C₃ photosynthetic pathway and are independent of soil N, which is secured through biological fixation in the root nodules. As a result, legumes are usually higher in protein and minerals. They have higher DM digestibility and voluntary intake by animals than associated grasses at similar stages of growth. Growing forage legumes is therefore one way of overcoming the protein deficiency of grasses. This is the objective of fodder banks, in

which forage legumes are established and managed in concentrated units that can provide dry-season supplementation for ruminant livestock. The techniques for establishing and maintaining fodder banks have been adapted to the socio-economic environment and technical capability of the settled pastoralist.

LIMITATIONS TO FODDER BANK DEVELOPMENT

The factors involved in fodder bank production in the subhumid zone of Nigeria have been identified and are shown in Figure 1.

Figure 1. Schematic representation of major factors affecting fodder bank production in the subhumid zone of Nigeria.



The principal factors that together influence the productivity of fodder banks are: land, labour, capital, soil, climate, seed (variety and quality), fire and ants. These and other factors are discussed below. Understanding how these factors operate under the varying conditions of different parts of the subhumid zone will help identify the problems and prospects of fodder bank development.

Soil

The poor soil structure and fertility typical of the subhumid zone, and the need for fallowing, have been discussed in Paper 4. These conditions provide a point of entry for fodder banks to improve soils for cropping.

Land, labour and capital

The availability of land for fodder banks depends on where a pastoralist chooses to settle; the most common choice is in the vicinity of crop farmers (Paper 4). Fallow land is attractive because it has less tree and shrub cover and requires less clearing, but there may be difficulties in obtaining it because of rising demand for cropland. Wherever there are arable farming communities in the subhumid zone they control land ownership and use. These communities will therefore play a significant, even if indirect, role in providing land for fodder banks to those pastoralists settled in their neighbourhood and must eventually benefit from fodder banks or else the intervention will have limited applicability.

Pastoralists settled on grazing reserves or in less heavily populated areas may have easier access to land, but the generally poorer soil and higher ligneous cover of these sites may require a different approach to fodder bank establishment and management.

Pastoralists' decisions on how much labour and capital (cash and livestock) to allocate to fodder banks will determine the area of land that can be used, the method of land preparation and other inputs affecting the productivity and continued existence of the banks. Many of the beneficiaries' responses cannot be predicted and are only observable once the pastoralists control their own fodder banks.

Climate

The climate of the subhumid zone has also been described in Paper 4. Forage legumes could help minimize moisture runoff and soil erosion and improve infiltration and water retention.

Seed (varieties and quality)

Although various forage legumes have been tested in Nigeria, little or no effort has gone into screening types suitable for the subhumid zone. The National Animal Production Research Institute (NAPRI) has released three stylo cultivars for general adoption: Stylosanthes guianensis cv Schofield, S. guianensis cv Cook and S. hamata cv Verano. Of these S. guianensis cv Schofield is highly susceptible to anthracnose, caused by the fungus Collectotrichum gleosporoides. When conditions are more humid S. guianensis cv Cook is also prone to anthracnose attack.

Pasture seed production is in its infancy in Nigeria. The few commercial producers do not adhere to proper quality standards, and there are no appropriate production, curative and storage facilities. Stylosanthes cultivars - Verano, Cook and Schofield - are the only varieties with seed available in commercial quantities, and they are marketed at prohibitive cost: the price of a kilogramme of stylo seed ranges between 10.00 and 14.00 Naira (US\$ 13 to 18). Table 1 shows the quality of a typical sample of commercial seed. Low seed quality increases the seed requirements, and hence the cost of establishing a unit area of fodder bank.

Table 1. Quality of commercially supplied stylo seed for fodder bank establishment.

Year	Stylo type	Composition by weight (%)				Germinability (%)
		Stylo	Sand	Weed	Trash	
1982	<u>S. hamata</u> cv Verano	36	42	18	4	60
	<u>S. guianensis</u> cv Cook	41	37	21	1	69
1984	<u>S. hamata</u> cv Verano	50	30	16	4	30
	<u>S. hamata</u> cv Verano	30	60	8	2	16
	<u>S. guianensis</u> cv Cook	60	20	12	8	80

Seed shortages and the absence of more appropriate legume varieties are the two most important impediments to fodder bank development. But until other species are identified and multiplied, work with S. guianensis cv Cook and S. hamata cv Verano will continue.

Fire

Fodder banks can only be useful for feed supplementation if forage is available throughout the dry season. Their regeneration depends on the amount of stubble (in the case of a perennial such as S. guianensis cv Cook) and of seeds in the soil. The annual burning of both crop- and rangeland by farmers and pastoralists is a serious problem for fodder bank management, since it not only destroys the herbage but may also affect legume regeneration.

Ants

Legume establishment in both the first and subsequent years is largely determined by the number of seeds germinating per unit area. About 1 kg/ha of seed out of 8 kg sown was recovered near ant holes when a broadcast of Stylosanthes guianensis cv Cook was followed by 2 weeks of drought. Although collection by harvester-ants has been found useful in concentrating good-quality seed so that it can be easily gathered, it can

lead to a very serious loss of viable seed needed for establishment and regeneration.

HERBAGE PRODUCTION

Since grasses deteriorate rapidly in quality during the dry season, the quality of a fodder bank is a function of the proportion of legumes in the sward. Management practices on the fodder bank should aim at optimizing legume growth with respect to grass growth. To achieve this objective in the subhumid zone of Nigeria, the following factors must be considered.

Choice of site

A fodder bank should be situated near the dwelling of a settled pastoralist. The pastoralist must keep a close watch on the fodder bank to prevent its misuse by animals during the growing season, and to control animal grazing time and confinement during seedbed preparation.

The area of land required for a fodder bank depends on the number of animals that need to be fed. In ILCA's case study areas an average herd consists of about 50 animals, with 15 to 20 pregnant or lactating cows (Paper 6) that are likely to respond most profitably to supplementary feeding. Given the productive potential of a well managed fodder bank, 4 ha should be a reasonable size. Since a single piece of land suitable for a fodder bank may not be available in one block, particularly in areas of intensive cropping, more fodder banks may be required, but this increases the cost of fencing per unit area and raises other management problems.

Land preparation

Land preparation, from the time of site selection until sowing, must provide optimum conditions for germination, emergence and establishment.

Despite its high cost, fencing is indispensable. Pastoralists do not yet regard forage crops as private property in the way that they do food crops. Attempts to oversow or strip-sow stylo in natural pastures failed because of inadequate establishment under communal grazing. Fencing is thus

obligatory, although the kind used (bush poles and barbed wire, or metal fences) remains at the discretion of the pastoralist.

Burning, grazing and trampling are cheap methods of reducing herbaceous cover. However, the timing of these operations is critical, and the choice of any one or a combination of them is site-specific, depending on vegetation, topography, etc. For instance, burning steep slopes leads to excessive soil erosion and wash-off of seeds.

Two methods of seedbed preparation, namely mechanical ploughing and dry-season confinement of animals on the site, were tested by ILCA. Both methods produced a satisfactory legume cover, but mechanical ploughing was considered irrelevant because of its high cost and the difficulty of securing such services in remote areas. It could upset the delicate patterns of land use, since the extent of cultivation is currently determined by labour availability (Paper 4). Dry-season confinement of animals was also unacceptable to pastoralists because of the need to deposit manure on crop fields. Even early in the dry season, confining animals to control grasses and weeds was unacceptable because of the fear of worm infection from recently manured areas.

However, confining animals during the wet season proved to be effective, and the time required for trampling was short. Between 500 and 800 m² of land could be satisfactorily prepared in 1 night. At this rate it would take 2 months to prepare 4 ha, so a combination of techniques and/or assistance from other herds may be necessary to prepare the seedbed in time. However, it has proven possible to establish a satisfactory fodder bank of *S. guianensis* cv Cook in an area having ferruginous soil by selectively cutting the shrubs, trampling the soil, and sowing the small, freshly trampled areas almost daily quite late into the wet season. The seed set in the first year should increase the cover in the second year.

Using land clearing machines to remove trees may not be wise. Land graded for fodder bank development in Kachia Grazing Reserve had the lower hard pan exposed, leading to erosion and extremely poor establishment of the legume. Machine clearing also led to impeded water infiltration and aeration. Such areas may have to be renovated using chisel or shatter ploughs to break the hard pans.

ESTABLISHMENT

Germination

Seeding rate depends on seed quality, and because the latter is generally poor 8 to 10 kg/ha was found necessary for satisfactory establishment. Commercially available seed has only 60% purity and 50% viability, whereas effective establishment requires at least 30 to 40 plants per m². The presence of other legume species in the seed may not be a disadvantage, but that of weeds is.

Stylo seeds have two dormancy mechanisms: embryo dormancy and seed coat impermeability (hardness of seed). These mechanisms gradually decrease when seeds are on the ground or are treated artificially by heat treatment or scarification. Such treatment allows a high germination per unit area within a short period early in the growing season. The pastoralists found scarification by brief immersion in boiling water easier than other methods. The length of time seed is in contact with boiling water is critical. Softening of seeds is achieved by taking 2 or 3 kg of seeds at a time in a cloth bag and immersing for 1 minute in boiling water. However, for testing germination with only small handfuls of seed, 20 to 30 seconds of hot water treatment will be adequate. Scarified seeds need to be sown immediately because in storage they lose their viability. They germinate uniformly, leaving little reserve if the first flush of seedlings does not survive. At least one third of the seed should, therefore, be unscarified as an insurance against false starts. *S. guianensis* cv Cook and *S. hamata* cv Verano do not require seed inoculation because these two species nodulate freely with cowpea rhizobium, which is ubiquitous in Nigerian soils.

Stylo seeds can germinate under a wide range of soil surface conditions, but cultivated, trampled, grazed or burnt surfaces tend to have different temperatures and water potentials, which affect seed germination and seedling survival.

A cultivated surface, where the soil is loosened by ploughing, harrowing, etc, allows seeds to be covered with soil. Water imbibition by seed can therefore take place from all sides. Under these conditions, radicle

emergence and root anchorage are easy. However, when seeds are broadcast on an uncultivated surface, water imbibition will take place only through the area of the seed in contact with the soil. Moreover, most of the water absorbed will be lost by evaporation through the part that is not in contact with the soil. This loss occurs especially in seed sown on burnt areas, or areas where weeds are trodden down by corralled animals or bared by intensive grazing. Maintaining low water tension and high humidity in the micro-environment is thus important when seeds are sown on uncultivated land. The consequence of high water tension and low humidity in dry spells varies according to the stage of germination. Seeds dehydrated before metabolic change begins may be reactivated when rehydrated. But dehydration after the initiation of the radicle may cause irreversible damage to the seed and hamper the emergence of seedlings.

The time taken to complete germination varies from species to species, depending on the nature of their seed coats. The length of time the soil is moist appears to be critical for both germination and establishment. In an experiment testing the effect of the frequency of wetting to the field capacity of a ferruginous soil on germination of *S. hamata* cv Verano, it was found that a break of 2 days in the watering regime was sufficient to reduce seed germination by 52% (Figure 2).

Once the radicle emerges, further survival depends on how successfully it is anchored in the soil. Survival is strongly determined by the type of land preparation. An experiment to determine the effect of different land preparation and sowing techniques on the establishment of *S. guianensis* cv Cook in fodder banks revealed that broadcasting seeds in mid-June, after the rains had properly set in, followed by 2 weeks of intensive grazing of the grass cover, gave a high seedling density at 6 weeks (Table 2). Dry spells following sowing encourage harvester-ants to work. A substantial amount of seeds were seen around ant-hills on pastoralists' fodder banks 1 week after broadcasting.

Figure 2. Effect of different moisture regimes on germination of Stylosanthes hamata cv Verano at Kurmin Biri, 1984.

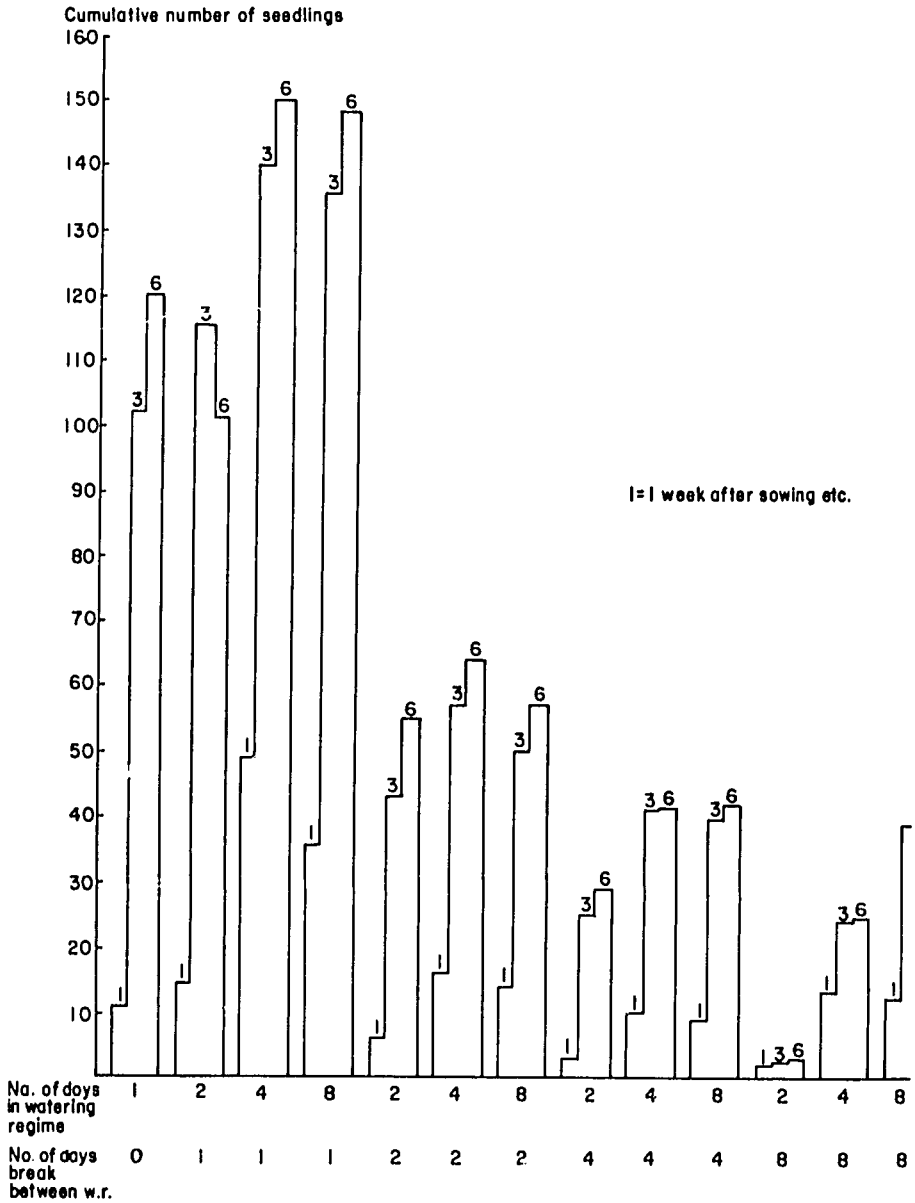


Table 2. Effect of different land preparation methods and seed treatment techniques on stand count/m² of S. guianensis cv. Cook 6 weeks after planting.

Land preparation method	Seed treatment techniques			Mean
	Mixed with sand	Mixed with dung slurry	Insecticide dressing	
1 week intensive kraaling	150	76	167	137
2 weeks grazing before sowing	69	99	67	78
2 weeks grazing after sowing	205	176	212	197
Burning in the dry season	45	195	133	108
Mean	117	157	133	-

The whole experimental area had been burnt during the previous dry season, so that its grass cover at the beginning of the growing season was all regrowth. Seeds mixed with a slurry of dung or insecticide generally gave improved establishment, compared to broadcasting seeds accompanied with sand.

Seedling establishment and early management

The appearance of the first trifoliate leaf marks the independence of seedlings from seed nutrients. It occurs about 12 days after sowing in S. guianensis cv Cook and S. hamata cv Verano. Seedlings with fast-growing root systems have a better chance of surviving the moisture stresses common in the subhumid zone at the beginning of the rainy season. However, even after that there are more hazards which will determine the quantity of the fodder finally available.

For instance, seeds of S. guianensis cv Cook with a viability of 80% and sown after scarification at the rate of 10 kg/ha (1 kg = 250 000 seeds) could potentially result in a population density of 200 plants/m². In practice, competition for space, moisture, light and nutrients, and the relative abilities of the various species in the micro-niche to utilize these are what determine legume survival, and the ultimate plant density is

almost always lower than the potential number of 200. A legume such as S. hamata, which has faster root elongation, is more competitive than S. guianensis cv Cook.

Tropical grasses are generally endowed with a C₄ photosynthetic mechanism, making them physiologically and biochemically more efficient in high light intensities. When moisture is unlimited these grass species grow fast, rapidly occupying the available space and shading the legume growing underneath. Grasses at the early stages of growth are high in nutritive value and are selectively grazed by cattle either by choice or because they are so predominant. In tropical Australia this selectivity facilitates legume growth in grass-legume mixtures when the mixed pasture is grazed early in the season. However, grazing behaviour studies on experimental fodder banks at the Kachia Grazing Reserve revealed that animals did not differentiate legumes from grass until 4 weeks after the start of the rainy season. This result suggests that the period for using grazing to control grass is quite critical. This practice is discussed in Paper 7.

The soils of the subhumid zone are generally low in organic matter, phosphorus and nitrogen. Legumes have higher P requirements than grasses. Under increasing levels of P, Stylosanthes spp. had better nodulation, increased N uptake and higher DM productivity (Figures 3 and 4). Soils in the subhumid zone may also be deficient in micro-nutrients, as evidenced by the performance of S. hamata cv Verano in an experiment that systematically omitted a particular element from the nutrients supplied to a plot. Elimination of Cu and S produced only 35% and 59% respectively of the potential DM, although the stylo was supplied with all other necessary nutrients (Figures 5 and 6).

In the subhumid zone of Nigeria a dressing of 150 to 200 kg of single superphosphate should generally be provided at the time of sowing stylo. Depending on soil conditions, this rate may have to be varied and other nutrients added as more fodder banks extend to other parts within the zone.

Figure 3. Effect of phosphorus application on dry matter and crude protein productivity of stylo cultivars.

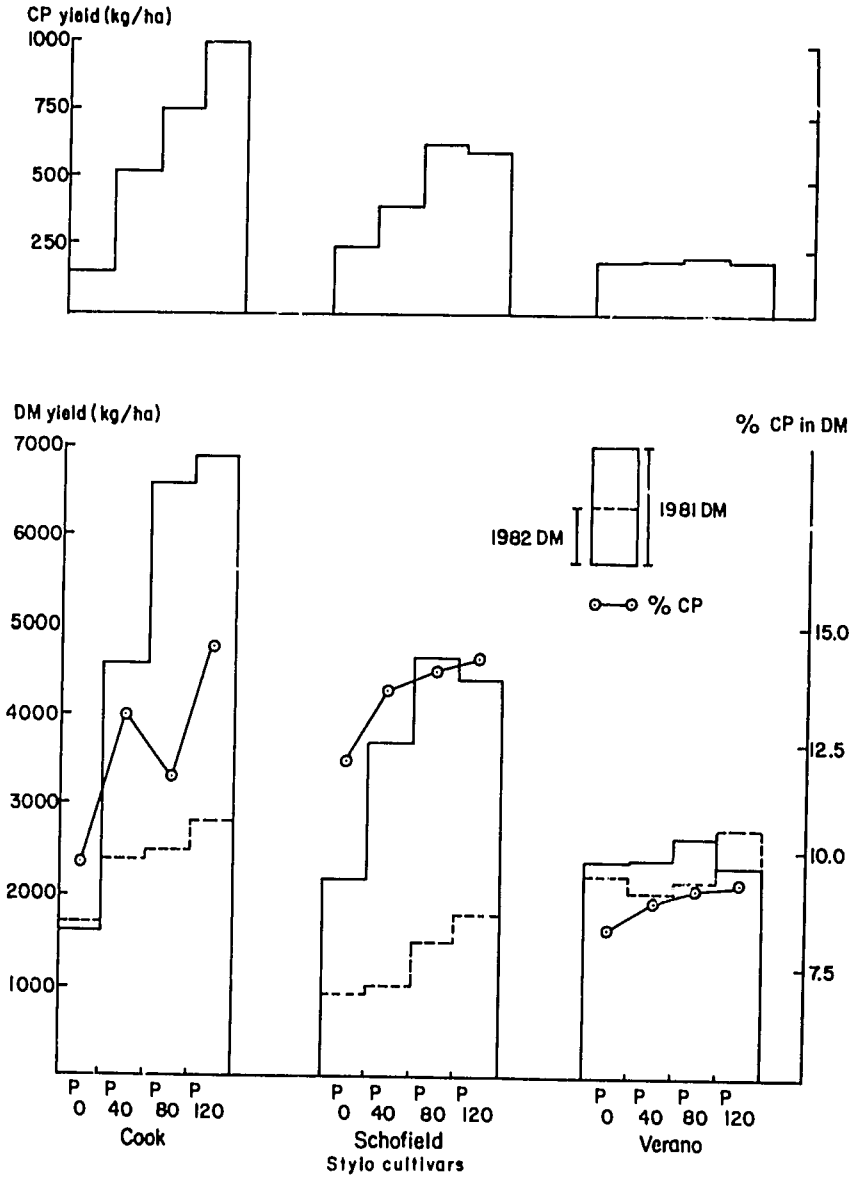


Figure 4. Effect of P application on nodulation of stylo cultivars.

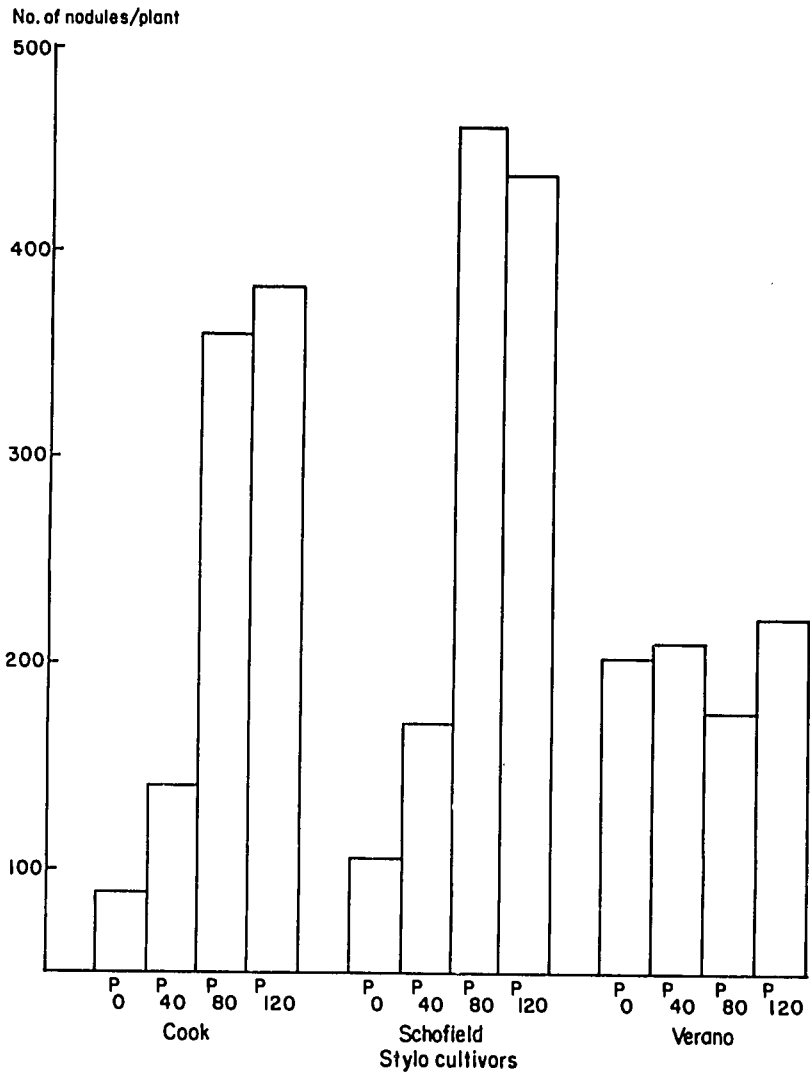


Figure 5. Dry matter productivity (kg/ha) of *Stylosanthes hamata* cv Verano on a soil with or without nutrients, Kurmin Biri, 1983.

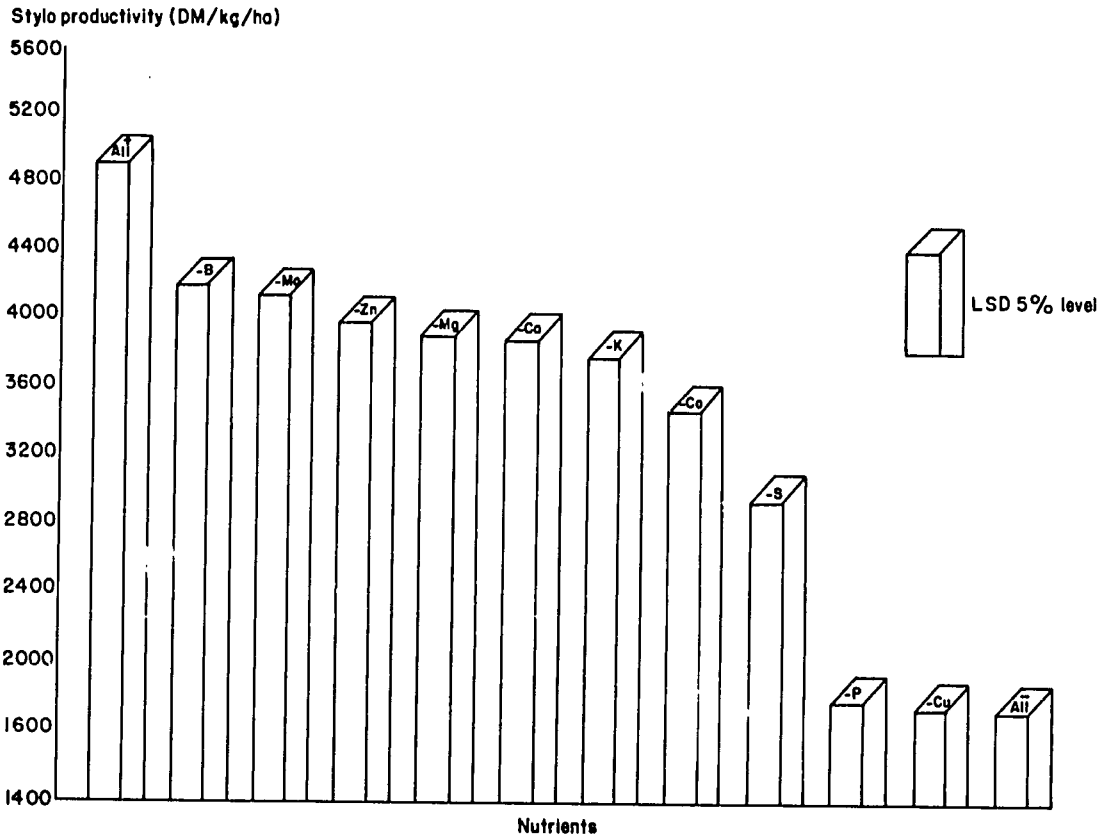
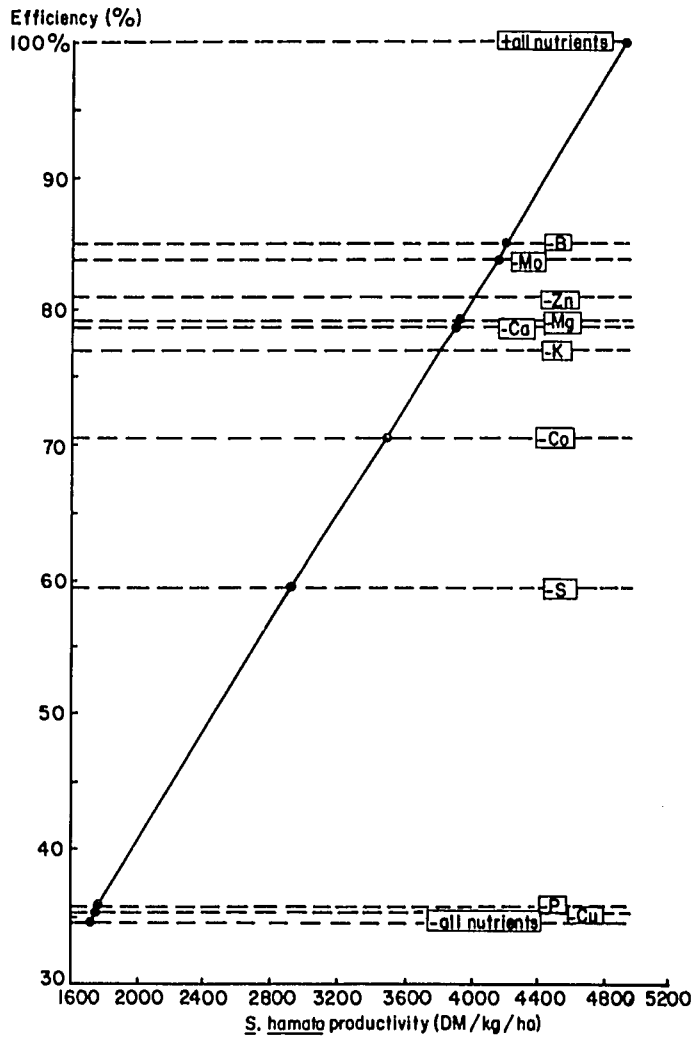


Figure 6. Efficiency of DM production of *Stylosanthes hamata* cv Verano in a soil with or without nutrients, Kurmin Biri, 1983.



PRODUCTIVITY

At the end of a normal growing season the two stylo cultivars used on fodder banks at the Kachia Grazing Reserve had an average of 12% CP. It was assumed that a daily ration of 2.5 kg of stylo DM would provide a protein supplement equivalent to 1 kg of cottonseed cake with 30% CP. A supplemented period of 6 months would therefore require 9000 kg of stylo for 20 animals. With utilization assumed at 50% of the available herbage, a fodder bank capable of producing about 20 000 kg of stylo DM would be required. Given an anticipated yield of 5000 kg of DM per ha, a fodder bank of 4 ha should suffice. In practice fodder bank size depends on land availability, size of herd, producer commitment and other factors. Even the recommended size of 4 ha may be changed as more information becomes available on botanical composition, seasonal changes in legume quality, grazing behaviour, and producer preferences with regard to the numbers and classes of stock to be grazed.

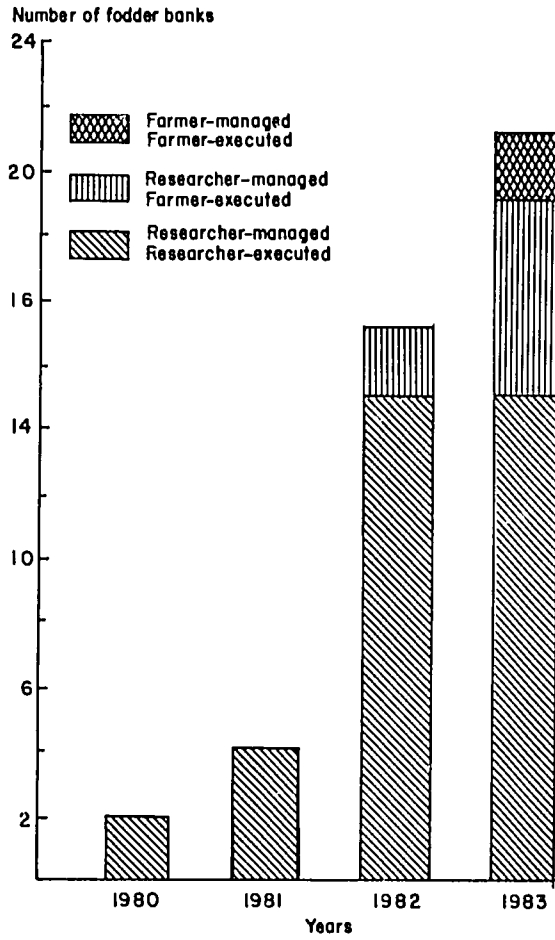
The number of fodder banks at different stages of evaluation in 1983 in the various phases of systems research are shown in Figure 7. The first-year productivity of researcher-managed trials is given in Table 3.

Table 3. Stylo productivity and quality in researcher-managed and implemented fodder banks during 1981/82 dry season.

Location	Observations	Month			
		Oct 1981	Dec 1981	Feb 1982	Apr 1982
K'Biri	Total DM (kg/ha)	6824			
	Weight of stylo (%)	56.0			
	Weight of stylo (kg/ha)	3821			
	Stylo CP (%)	13.8	10.6	9.2	5.8
	Stylo CP (kg/ha)	527			78
K'Biri ^{a/}	Total DM (kg/ha)	4191			
	Weight of stylo (%)	68.0			
	Weight of stylo (kg/ha)	2850			
	Stylo CP (%)	13.0	10.4	9.8	7.9
	Stylo CP (kg/ha)	370			90
Abet ^{a/}	Total DM (kg/ha)	4900			
	Weight of stylo (%)	63.0			
	Weight of stylo (kg/ha)	3087			
	Stylo CP (%)	12.6	11.3	8.9	7.2
	Stylo CP (kg/ha)	389			88

^{a/} Experiments on pastoralists' sites but under strict management of the researcher.

Figure 7. Number of fodder banks at various levels of evaluation by ILCA, 1983.



The CP of the stylo in the fodder bank declined markedly during the dry season. Higher amounts of stylo will clearly be required to derive the same amount of protein supplementation as the season progresses, even if the animal rate of intake is assumed to remain unchanged.

Productivity and composition of stylo in the herbage were found to vary among fodder banks in the same soil top sequence, even in the first year. Herbage yield per unit area also varied within the same fodder banks as a function of the time of sowing stylo (Table 4). Such differences in herbage productivity with fodder banks may be more pronounced in years of unusual distribution of rainfall, such as 1983.

Table 4. Productivity and botanical composition at the end of the growing season within a farmer-managed and -implemented fodder bank with areas planted at different times of the year.

Time of planting ^{a/}	Total weight of fodder (kg/ha)	Weight of stylo in fodder (kg/ha)	Weight of stylo in fodder (%)	Weight of grass in fodder (kg/ha)
June 1983	9111	6210	68	2910
July 1983	8310	4290	52	4020
Aug 1983	4380	2220	51	2160
Sept 1983	2460	1320	54	1140

^{a/} Before each sowing the entire herd of cattle was confined in the area for 1 to 3 nights.

DM yields are normally measured by cutting, drying and weighing samples. Doing this for several 4-ha fodder banks, with their inter- and intra-variability, is very cumbersome. If measurements are to be taken repeatedly, a much faster and non-destructive technique is needed. The DM ranking method described by Haydock and Shaw (1975) was very useful in determining the yield and botanical composition of fodder banks. In this method a set of five fixed quadrats is first chosen to represent a yield scale, followed by rating on this scale. Other quadrats are laid out in a grid to cover the entire fodder bank. Laying quadrats on a grid helps monitor the productivity and condition of a fodder bank in successive years. The method is based on the belief that it is easier to estimate the yield of a sample that is at some point on a visual scale, than it is to

estimate the actual weight. The estimates of six people involved in yield measurements using DM rating, correlated against the actual weights, are given in Table 5. Estimates of botanical composition can also be made, giving the species likely to take first, second and third places in the DM within a quadrat; these estimates are multiplied by weighing factors to produce dry weight percentages.

Table 5. Regression equations and coefficients of correlation between visual DM score (X) and DM yield (Y) for various enumerators.

Enumerator No.	Regression equation	r
1983		
1	$Y = -19.1 + 34.9X$	0.81
2	$Y = 5.2 + 43.0X$	0.88
3	$Y = -4.5 + 40.6X$	0.94
4	$Y = -18.5 + 37.9X$	0.84
1984		
2	$Y = 10.6 + 31.9X$	0.92
3	$Y = 21.5 + 31.4X$	0.88
5	$Y = 19.7 + 37.1X$	0.93
4	$Y = 27.7 + 26.3X$	0.92
6	$Y = 8.3 + 30.6X$	0.86
7	$Y = 19.5 + 40.7X$	0.83

Differences among fodder banks in herbage productivity within and between years must be anticipated because of differences in topography, patterns of land preparation, sowing time and technique, weed control methods and rainfall patterns. An effective fodder bank development programme thus requires a well researched set of alternative policies to fit different situations.

REGENERATION

In order to be financially viable, fodder banks will have to remain productive for 5 years or more, and should be managed so that they will regenerate themselves.

In the case of perennial legumes, such as S. guianensis cv Cook regeneration can stem either from living shoots left after dry-season grazing or else from seed. Theoretically, S. guianensis cv Cook, repeatedly grazed to a height of about 10 to 15 cm, should regenerate for many years, but experience at the experimental fodder bank at Kurmin Biri has been somewhat different. Only about 0.7% of the established stylo went into the third year, while only 28.2% regenerated in the second. This loss occurred because termites attacked the old stylo stems. When fodder banks were managed by pastoralists, there were difficulties in controlling the stocking rate. On almost all such fodder banks, shoots of S. guianensis cv Cook did not last more than one season due to overgrazing. Furthermore, the accidental burning of fodder banks in bush fires kills all living stylo shoots from the previous season. Hence, the size of the seed reserve in the soil, even for this perennial legume, is very important.

The seed reserve depends on many factors. Under subhumid conditions, S. guianensis cv Cook flowers in October/November and seed set takes place in January. Since the dry season normally begins in October/November, grazing an S. guianensis cv Cook fodder bank very early in the dry season reduces the seed returned to the soil.

S. hamata cv Verano flowers earlier, in July/ August and seed set generally takes place before the dry season begins. The quantity of seed set at the end of the growing season is very high (Table 6). In the subhumid zone S. hamata behaves like an annual and regenerates almost entirely from seed.

Table 6. Seed reserves of some fodder banks in ILCA case study areas (February 1983).

Fodder bank	Year of establishment	Stylo type	No. of seeds ₂ per m ²	Germination (%)	
				Unscarified	Scarified
Kurmin Biri ^{a/}	1981	Cook	860	25.7	62.6
Mairiga	1981	Cook	407	20.1	71.4
Mairiga	1981	Verano	1482	57.4	70.7
Yamusa	1982	Cook	204	14.5	68.6
Bairage	1982	Cook	82	17.5	66.8
Yakubu	1982	Cook	260	15.3	69.2
Damina	1980	Verano	2626	50.0	60.0

^{a/} Experimental plot.

Burning of fodder banks changes the pattern of germination, probably because more seeds are softened. Higher germination has been recorded on burnt areas at the beginning of the rainy season (Table 7). This might be a disadvantage, especially in a year of erratic rainfall. However, regeneration, in particular of *S. hamata* cv Verano, was unaffected after the fodder bank had been burnt in the previous dry season.

Table 7. Effect of burning on the regeneration of stylo.

Area	Monthly new seedling counts/m ²				No. of plants at end of season
	June	July	Aug	Sept	
<i>S. guianensis</i> cv Cook					
Burnt	45	12	6	2	36
Unburnt	26	34	22	8	48
<i>S. hamata</i> cv Verano					
Burnt	280	196	72	16	259
Unburnt	264	74	126	81	268

Estimates of the seed reserve in the soil at the beginning and end of the dry season suggest a large discrepancy. Roughly 22% of the seed might have been gathered by harvester-ants from the area during that time. Grazing behaviour studies on heavily stocked fodder banks have recorded animals licking the ground, probably to pick up seeds. Seed losses of this kind could result in poor regeneration in subsequent years.

INTEGRATED CROP AND LIVESTOCK PRODUCTION WITH FODDER BANKS

When allowed to grow for 2 or more years, a forage legume such as Stylosanthes increases soil N content. The amount of N returned to the soil by the legume depends on the same factors, varying from species to species, that favour legume growth (Table 8).

Table 8. Effect of phosphorus application on soil properties at the end of one season of growing different stylo cultivars.

Stylo cultivars	Treatments (P kg/ha)	Soil properties		
		pH	Organic C (%)	Total H (%)
Cook	0	5.1	0.87	0.061
	40	4.8	0.92	0.087
	80	5.2	0.93	0.100
	120	5.1	1.13	0.113
Schofield	0	5.1	0.76	0.069
	40	5.2	1.01	0.072
	80	5.2	1.11	0.075
	120	5.2	1.18	0.121
Verano	0	5.4	0.93	0.58
	40	5.2	0.90	0.48
	80	5.1	1.03	0.84
	120	5.2	1.18	0.122

Legumes also improve the physical properties of soil (Table 9) and hence resistance to erosion. With the increase in soil N, nitrophilous grasses tend to assert themselves. In one 4-year-old Verano fodder bank, although the proportion of legume in the total bulk declined the number and weight of stylo per unit area increased.

Table 9. Influence of vegetation on some soil physical properties (preliminary results).

Type of vegetation	Ultimate infiltration rate (mm/hour)	Mean soil bulk density (g. cm ⁻³)
Hamata (After 3 years)	49	1.32
Uncropped areas with sub-climax vegetation	20	1.77
3-year cropped area	15	not determined

The possibility of soil improvement through the use of forage legumes adds another dimension to the fodder bank concept in the subhumid zone. Crops such as maize, grown after 2 to 3 years of stylo, have indicated highly significant yield increases (Paper 17). Cereal cropping within a fodder bank in short rotations may prove a viable way of integrating crop and livestock production systems.

FUTURE COMPONENT RESEARCH

The initial success of the researcher-managed trials suggests that fodder banks could play an important role in improving livestock productivity. However, numerous problems were encountered when fodder banks were developed without the close supervision of the researcher. Pastoralists failed to understand and/or carry out recommended procedures at any point from the preparation of the land onwards. More research is needed to simplify, explain and increase the repeatability of the various technical aspects of fodder bank production. One of the main concerns is the need to look for other legume species that are more suited for establishment based on surface sowing and sod sowing.

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Utilization of fodder banks

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ABSTRACT

Fodder banks are designed not to supply forage year-round for an entire herd but rather to be used strategically for limited periods with selected animals. A number of management variables exist.

Animals generally select against Stylosanthes in their diet in the early wet season, but for Stylosanthes in the late wet and in the dry season. This pattern of diet selection has been used to suppress grass growth in the early wet season and thus encourage legume growth.

In the existing pastoral system of the settled Fulani in the study areas, the late dry season is the most stressful period for animals in terms of nutrition. In grazing trials it was found in the 1983/84 dry season that fodder bank grazing for 2 or 4 hours per day led to a highly significant reduction in liveweight losses despite an overstocking of the fodder banks.

Diet selection studies showed that Stylosanthes hamata was well utilized, accounting for up to 80% of bites recorded per grazing period. Leaf drop did not inhibit utilization. Observations on an S. guianensis-based fodder bank showed a maximum of only 20% of bites recorded during any one grazing period consisted of stylo. This pattern differs, however, from that observed in previous years (1981/82 and 1982/83) when S. guianensis was preferred over S. hamata.

Trials indicate that animals may reduce their effective grazing time on free range if they have access to a fodder bank for part of the day. In the 1984 experiment, grazing on fodder bank replaced grazing on free range instead of being additional to it. Night-grazing may offer a solution to this problem.

INTRODUCTION

Improved legume pastures in the tropics have been extensively researched during the last 25 years, particularly in Australia. For the subhumid tropics, work has concentrated on Stylosanthes species. Major findings with respect to animal production and the pasture - animal interface are as follows:

1. Stylosanthes spp. grow on relatively infertile soils given little or no fertilizer, but pastures as well as grazing animals respond well to fertilizer application (Gillard and Fisher, 1978).
2. Liveweight gains per head on Stylosanthes pastures are in the order of 100 to 150 kg per year without and up to 200 kg per year with mineral supplementation of the animals, compared with 50 to 100 kg per year on native pastures (Winks, 1984; Winter, personal communication). The higher stocking rates possible on Stylosanthes pastures lead to four- to sixfold increases in animal production per hectare over that from native pasture ('t Marnetje, 1978). In some cases, the increases are considerably higher (Gillard and Edye, 1984).
3. Major differences in animal weight gain occur in the late wet season, when weight gains are greater on improved than on native pastures, and during the dry season, when weight losses are reduced on improved pastures (Norman, 1970; Gillard, 1982).

4. Some Stylosanthes spp. stands improve with an increase in stocking rates, leading to a situation in which - in some trials - liveweight gain per head increases with increasing stocking rate (Norman and Beggs, 1973). In ungrazed swards, Stylosanthes spp. often do not persist (Gillard and Fisher, 1978).
5. Selection of Stylosanthes spp. by cattle is highly seasonal, with selection 'against' occurring in the early wet season, and selection 'for' occurring during the late wet and the dry season (Gardener, 1980; Bayer, 1983).

Despite their clearly demonstrated benefits, improved pastures in the tropics still play only a minor role in production systems (Mott et al, 1981). If ranches establish improved pastures, these are normally only small areas used for special purposes such as finishing beef cattle, feeding weaners or heifers or first-calving cows or, in extreme cases, survival feeding of breeding stock during the dry season.

In the subhumid zone of Nigeria the opportunities for pasture development are even more limited than, for example, in ranching areas of Australia, on account of the zone's higher population and cultivation densities and the limited availability of necessary inputs. ILCA's current research, focussing on the development of 4-ha units of pasture (fodder banks) for an average pastoralist's herd of 40 to 50 head of cattle, implies restricting pasture use to certain times of the year and/or to selected animals from the herd. In such a situation, the major management variables are:

1. Season of fodder bank grazing.
2. Length of fodder bank grazing period (e.g. late wet season, late dry season, entire dry season).
3. Time of day when fodder bank is grazed (e.g. morning, afternoon, night).
4. Hours of fodder bank grazing per day.
5. Classes and number of stock permitted to graze the fodder banks (e.g. whole herd, lactating cows only, weak animals).

Monitoring of fodder bank use in on-farm trials involving pastoralists' herds is very labour-intensive, and the results are difficult to interpret. A herd of cattle under ILCA management was therefore used to test some management options for fodder banks in controlled experiments.

MATERIALS AND METHODS

In most pasture experiments the animals are kept on the pasture for 24 hours per day during both wet and dry seasons. In the tropics, experiments with pasture utilization restricted to the dry season only are rare, although some results of this kind are presented by Norman (1970).

According to present ILCA perceptions of the Fulani system, the most economical way of using fodder banks appears to be by restricting grazing to the second half of the dry season, using them as an additional resource available for only part of the day. 'Supplementation' trials of this type appear to have been extremely rare: as far as the present author is aware, no publications have appeared about experiments in the use of improved tropical pastures for only part of the day during part of the year.

Initial trials by ILCA have been conducted with only one management variable: hours of fodder bank grazing per day. Morning and afternoon grazing of improved pasture may differ in terms of effect on animal behaviour and animal performance, but only afternoon grazing has been examined thus far. The trials were carried out in the Kachia Grazing Reserve in the Kurmin Biri area. During the 1981/82 and the 1982/83 dry seasons, comparisons were made between 2 hours of fodder bank grazing in addition to grazing of natural range for 8 hours, and the grazing of natural range only for 10 hours. In the 1983/84 dry season, a further treatment consisting of 4 hours of fodder bank grazing in addition to grazing natural range for 6 hours was included in the trial.

The experimental herd is of mixed composition (bulls, heifers, cows and calves) and was subdivided for the trial as follows:

4-hour group	-	13 cows and heifers, no calves
2-hour group	-	18 cows and heifers, 9 calves
control group	-	12 cows and heifers.

The bulls were grazed together with the control group. Herd management of the cattle followed Fulani practices, including the use of crop residues on farmers' fields and the provision of browse through lopping in the late dry season. Grazing time (8:00 - 18:00 hours) and watering times (at 10:00, 13:00 and 15:30 hours) were standardized.

The inclusion of more animals in the grazing trial in 1983/84 necessitated expansion of the trial area beyond that used in previous years. An area of 6 ha adjacent to the original experimental fodder bank was included. It had been previously cropped and undersown with S. hamata cv Verano and S. guianensis cv Cook. All improved pasture areas had received a basic dressing of 100 kg of single superphosphate (10% P) per year. To avoid possible confounding factors consisting of nutritional differences between pastures, the two fodder bank grazing groups were alternated daily between the two pastures.

RESULTS AND DISCUSSION

In 1981/82, the experimental herd was still in its establishment phase. Grazing of pastures based on Stylosanthes guianensis cv Cook from November 1981 to April 1982 produced little difference between the two treatment groups. Whereas the cattle in the control group lost 18 kg per head over the trial period, the losses in the cattle grazing fodder bank for 2 hours in addition to natural range were 12 kg per head. These differences were not statistically significant.

In 1982/83 fodder bank grazing started in December, but no differences in weight losses were evident until after the first rains in April. By May, when fodder bank grazing stopped, the two groups differed by 20 kg per head; these differences were significant at the 5% level. By October 1983, however, differences between the two groups were reduced to only 5 kg per head and were not significant.

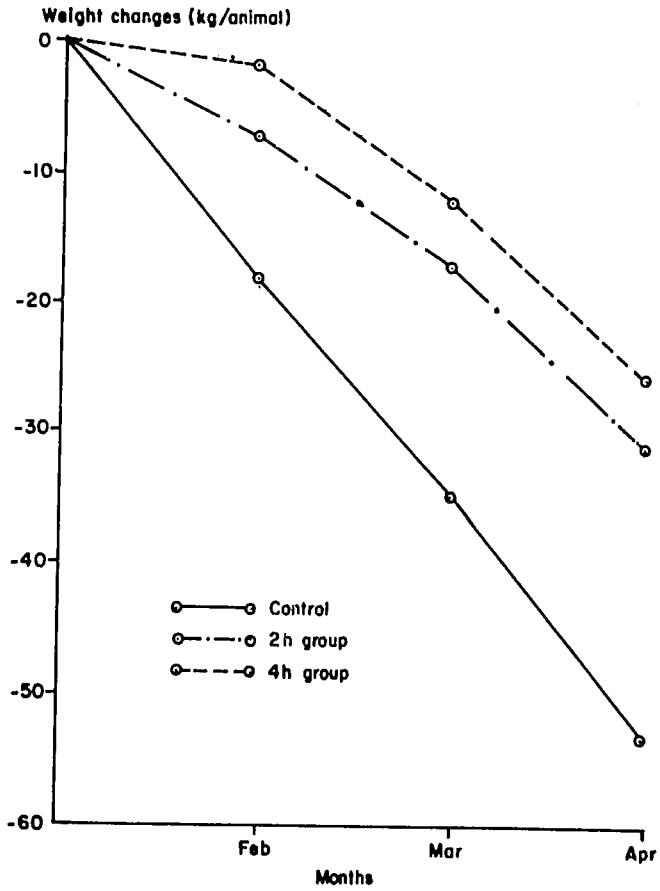
In the 1983/84 dry season, fodder bank grazing did not begin until January, after the initial period of nutritious crop residue grazing in the traditional pastoral system. A 4-hour fodder bank grazing group was formed by dividing the control group of the previous years. Thus, only the 2-hour group consisted of animals with previous fodder bank grazing experience. An examination of pre-trial weights revealed only small, statistically non-significant differences in average weights between the 4-hour, 2-hour and control groups.

During the first 2 months of fodder bank grazing in the 1983/84 dry season, the two treatment groups lost less weight than the control group (Figure 1). The differences in weight losses between the groups with access to improved pasture and the control group were statistically highly significant ($P < 0.01$) during the first 2 months as well as over the entire trial period. However, the differences between the 2-hour and 4-hour fodder bank grazing groups were not significant. The loss of more than 50 kg per head in 88 days in the control group reflects the severity of the dry season in 1983/84.

The small difference between the 2-hour and 4-hour groups in terms of weight change contradicts findings by Norman (1970) that liveweight gains of cattle were proportional to time spent on *S. humilis* pasture. However, Norman's trial was conducted in the first rather than the second half of the dry season, and stopped when the animals began to lose weight.

The treatment groups were too small to permit statistical analysis of differences in fertility and mortality rates. It is nevertheless of interest to note that, in the control group, four cows and two calves died, and two cows had to be culled on account of poor condition during or shortly after the trial period, whereas no losses occurred in the two groups of animals with access to fodder banks. Furthermore, 14 of the 18 cows and heifers in the 2-hour group were served, in comparison with only 1 animal in the control group. This apparent increase in fertility must be attributed to fodder bank grazing in previous years, since no services were reported in the 4-hour group, which did not have access to fodder banks until 1983/84.

Figure 1. Weight changes of cattle in 1983/84 dry season grazing trial in Kurmin Biri.



Although the attempt was made to tailor management of the experimental herd along the lines of that in the traditional pastoral system, certain elements of the latter could not be included, the most important being the movement of herds during the time of initial scattered rains in March and April, when the Fulani deliberately 'follow' rains with their herds. The new grass growth provides high-quality nutrition and also some bulk, in contrast to areas where rain has not yet fallen and the ground is almost bare (as was particularly the case on the grazing reserve in the 1983/84 dry season). Thus, because the animals in the trial were kept exclusively on the grazing reserve, the nutritional constraints in the late dry season were more severe than for the more mobile pastoral herds, in which mortality would not have been so high as in the control group.

In experiments with grazing cattle in South America, animal response to concentrates was below expectations and it was found that the supplemented cattle had reduced their intake from pasture (Combellas et al, 1979). Intake measurements on pasture are complex (e.g. Corbett, 1978) and not possible at present within the agropastoral system under study by the Subhumid Zone Programme. However, differences in grazing time on range when improved pasture is used as a supplement may give a first indication of reduced feed intake from range. The following trial was carried out.

In each of the three experimental groups, two animals of similar weight and condition were fitted with vibro-recorders and their grazing times were recorded daily from late February to mid-March. The results must be regarded as preliminary because of the small number of animals involved, but are striking enough to justify presentation here. Total daily grazing time was longest in the control group, intermediate in the 2-hour fodder bank grazing group and shortest in the 4-hour group. The reductions in grazing time occurred entirely during the period of grazing natural range. Longer grazing times than in the other two groups were found in the 2-hour group between 16:00 and 18:00 hours, their period of fodder bank grazing. This suggests an intensification of grazing activity at times when better quality pasture is made available.

The average reduction in total daily grazing time per hour of fodder bank grazing (11 minutes in the 2-hour group; 11.6 minutes in the 4-hour group) corresponds closely with findings by Combellas et al (1979) that

supplemented dairy cattle grazing Cenchrus ciliaris pasture in Venezuela reduced their grazing time by 11 minutes for each kg of concentrates fed.

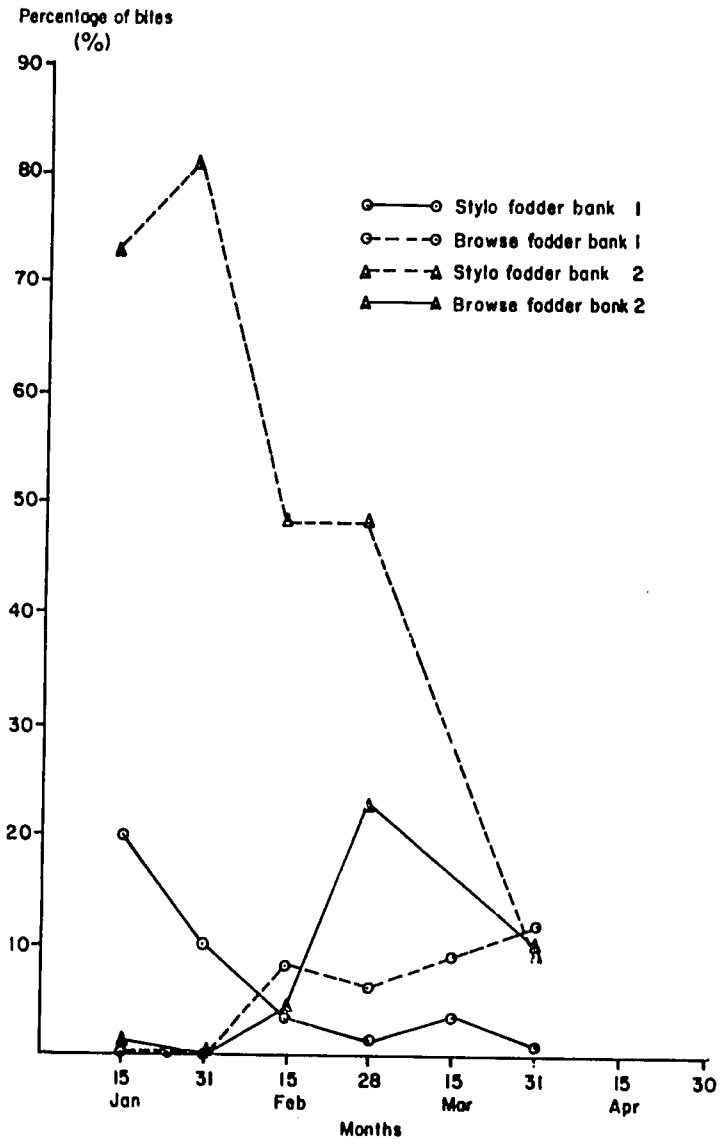
If these differences in grazing activity by cattle with access to improved pasture are confirmed in further trials, they will influence assessment of the potential role of fodder banks. It may be that animals substitute fodder bank for natural range to a greater extent than indicated by the relative times they are allowed to graze each. Some pastoralists have been observed practising night grazing. This practice may offer a way of overcoming reductions in grazing time, and its effects should be studied in the course of further experimentation. If night grazing of fodder banks is to be incorporated into the production system, then the fenced fodder banks will have to be sited near Fulani homesteads.

The smaller reduction in grazing time on natural range and the greater intensity of fodder bank grazing by the 2-hour group compared with the 4-hour group may partially explain the small differences in weight changes between the two groups.

Evidence of seasonal changes in diet quality from a fodder bank emerged from observations of diet selection (Figure 2). In this study, bites during grazing were counted and classified into: S. guianensis, S. hamata, herbs, shrubs and grasses. It was found that S. hamata was well utilized, accounting for up to 80% of bites recorded per grazing period. Leaf drop did not inhibit utilization; in fact, the majority of S. hamata bites took the form of licking leaves and inflorescences from the ground. This observation contrasted with those made on the S. guianensis-based fodder bank where a maximum of only 20% of bites recorded during any one grazing period consisted of stylo. On both banks it was observed that, over time, the proportion of Stylosanthes in the animals' diet decreased, suggesting that the preferred fractions had already been eaten. For example, a switch occurred from licking S. hamata leaves and inflorescences to biting the legume stems, resulting in a decline in diet quality. Noteworthy also was the contribution of browse plants to total diet on both fodder banks.

The licking of leaves from the ground and the poor acceptance of S. guianensis appeared to be specific to the 1983/84 dry season. In previous years, it had been observed that on fodder banks with mixed stands of S.

Figure 2. Diet selection of cattle on two fodder banks in Kurmin Biri in 1983/84 dry season (fodder bank 1 based on Stylosanthes guianensis cv Cook, fodder bank 2 based on S. hamata cv Verano).



hamata and S. guianensis the cattle first grazed the S. guianensis plants and only later switched to S. hamata. These differences in diet selection between years can be explained by differences in rainfall pattern. The 1983 wet season was about 1 month shorter than the 1981 and 1982 wet seasons. The occurrence of dew therefore ceased earlier. Heavy dew after leaf drop and out-of-season rains, which occurred in the 1981/82 dry season, render the S. hamata litter mouldy and unpalatable to cattle (McCown and Wall, 1981). Furthermore, in S. guianensis some pre-wet-season growth can be observed, and young Stylosanthes shoots have a low palatability for cattle; this may explain the non-utilization of green forage at the very end of the dry season on S. guianensis pasture.

Diet selection observation can also aid in 'pasture maintenance grazing'. Because Stylosanthes spp. grow more slowly than grasses and are relatively unpalatable to cattle in the early wet season, grazing of the fodder bank in the early wet season was used to reduce grass competition, thus increasing legume growth and improving establishment. Such grazing brings no apparent extra benefits to the animals themselves, except in cases of lack of forage bulk on the natural range at that time of year. Perennial grasses tend to grow more vigorously in improved pastures. The early wet-season differences between the 2-hour fodder bank grazing group and the control in the 1982/83 trial can probably be explained by the greater prominence of such perennial grasses and thus the higher dry matter availability in the fodder bank as compared with the range. However, to allow the stylo to bulk up, pasture maintenance grazing should be stopped when the animals start to graze stylo instead of grass. It was observed in the experimental herd that, 3 to 4 months after the first heavy rains, animals began to graze stylo (up to 50% of the bites) in those areas of the pasture where the grasses had been grazed down to the same height as the stylo plants. However, if the animals were shifted to a site in the same pasture where grasses were higher than stylo plants, the diet consisted entirely of grass, even though there was no obvious difference in stylo and grass plant population between the two sites. Thus, apart from direct observations of cattle diet selected, observations of the relative height of grass and legume plants may be used as an aid in deciding when to stop pasture maintenance grazing.

CONCLUSIONS

The tenure and rights of use of land in the subhumid zone and the economics of livestock production predicate the development of only small units (fodder banks) of improved forage. This in turn necessitates careful balance between season, length of grazing period, time of day and hours when restricted numbers of cattle are given access to the fodder banks. The studies have demonstrated that animals do respond positively to an improved diet and that this may be a key to more effective use of grazing resources. However, they also show that a greater understanding of animal and plant behaviour could lead to the formulation of better fodder bank utilization practices.

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Beneficiary reactions to the fodder bank trials

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ABSTRACT

The fodder bank was designed by ILCA to ease the livestock feed shortage during the dry season that occurs in the subhumid zone. A land area of about 4 ha is cleared, fenced, prepared and sown with a legume which is then grazed by selected animals in the herd during the dry season. The initial on-farm trials produced a variety of reactions from the cooperating Fulani. Closer documentation of Fulani behaviour was undertaken to appreciate these responses, which are summarized in this paper.

Not surprisingly, Fulani perceptions of expected costs and benefits were principal considerations in their decisions to test a fodder bank. Costs include the necessary inputs, land and labour, while the primary benefit is a protected dry-season grazing resource. The prerequisite is available, secure land.

Once the Fulani decide to test a fodder bank, then, a variety of factors influence the extent to which they follow the research recommendations. These factors include individual production objectives and management strategies, herd ownership patterns, household resources and competing demands on those resources, seasonal labour priorities, and dry-season grazing conditions. The multiple purposes cattle serve in the Fulani system and the multiple ownership of herds add complexity to the intended utilization of fodder banks in the dry season.

Over the 5-year experience with fodder banks, feedback from pastoralists has led to component research and modifications in the research recommendations. Initially ILCA-funded and managed, fodder banks are now Fulani-funded and managed.

INTRODUCTION

Recognizing that the producer's subjective assessment of a technology is the critical determinant of adoption, ILCA has sought Fulani feedback to its fodder bank trials. The interaction between fodder bank and pastoralist is dynamic; assessments vary from one period to another and from one pastoralist to another.

This paper outlines some of the social and economic issues involved in fodder bank adoption, based on information gained from pastoralists in the ILCA case study areas. ILCA has been testing the fodder bank with Fulani since 1980. Ensuring producer feedback provides the research team with the basis for improving the design of the technology.

THE SAMPLE OF FODDER BANKS

By the end of 1983, the number of established fodder banks had risen to 20 in the three areas of Kurmin Biri, Abet and Kachia. Kurmin Biri and Abet had high ILCA and/or government involvement, and the Fulani had expectations based on previous incentives and exposure. In contrast to Abet and Kurmin Biri, Kachia represents a site of spontaneous uptake. Over the 5 years of fodder bank research, responsibility for investment costs has gradually been transferred to the owners. At the outset ILCA met all the establishment costs (except land), but now the pastoralists incur all costs. Credit is extended by NLFU. Management advice is given by NLFU and ILCA.

It is too early yet to determine the rate of adoption or identify the likely group of adopters. Notwithstanding, some relevant socio-economic indicators for the research sample of 20 fodder bank participants are presented in Table 1.

Table 1. Socio-economic indicators of participants in ILCA's fodder bank programme.^{a/}

Indicator	Average	Range	Responses
Hard/flock size ^{b/}			
No. cattle/household	60	30-124	
No. sheep/household	9	0-31	
Farm size (ha/household) ^{c/}	1.1	0.23-2.19	
Household size ^{b/}	14	8-22	
Active males/household ^{b/ d/}	5	2-8	
Age of household head	48	28-75	
Off-farm income			
Yes			9
No			9
Literacy (household head)			
Arabic			4
Hausa + Arabic			4
Hausa + English			1
Hausa + Arabic + English			1
None			8

^{a/} n = 18 Fulani households.

^{b/} n = 17 households; excludes 1 household with 700 head of cattle and 30 sheep in the household because atypical of sample.

^{c/} n = 10 farms measured; all these Fulani are farmers except 1; 2 others practise farming very minimally.

^{d/} Active males above 6 years old indicates potential labour for herding, farming and cattle management, although actually they may be involved in schooling or off-farm employment.

All of the current fodder bank participants in the three locations are Kachichere Fulani. They have been resident in the general area of their current settlement site for a considerable period, and may be considered settled Fulani, but this is a relative term since they may periodically move their rugas (homesteads) over a limited distance or, more often, transfer part of their herd at various times of the year to exploit seasonal grazing possibilities. The length of continuous settlement at the current site ranges from 1 to 12 years. Three of the fodder bank participants, all in the Kachia area, have purchased usufructory rights to

their land. They are all pastoralists, but their sources and levels of income, standards of living and direct involvement in cattle management vary considerably. In general, their production objective is to increase or at least maintain their herd size, and their cattle serve multiple functions in the social and economic order.

INITIAL DECISIONS TO TEST A FODDER BANK

Multiple interviews with the fodder bank participants (n=20), as well as with 35 other pastoralists who have seen fodder banks but have not yet expressed an interest in testing one, revealed four central and interrelated factors influencing decisions. These factors are land availability, perceived costs, perceived benefits, and personal motivation.

Land

The availability of land is a prerequisite for interest and willingness to invest in a fodder bank. Land availability depends on locational factors such as the land tenure system, fragmentation of holdings, opportunity cost of land, and individual farmer - Fulani relations. The Fulani's reasons for settling and the interded nature of the settlement - permanent or temporary - affect their attitude towards investment in land development.

The three areas where fodder banks have been established represent differing land situation and settlement rationales. In Kurmin Biri, Fulani have purposefully settled on the grazing reserve in the expectation of secure and permanent land rights for cropping and grazing. In Kachia, there is unexploited land available for sale. Three of the four fodder bank participants in Kachia have purchased land through the District Head. Reportedly, other Fulani are now in the same process. The Fulani consider such land purchases necessary in order to guarantee occupancy and to provide the legal basis for security against troublesome farmers.

Abet, in contrast, is an area of relatively high population and cultivation density where the indigenous Waje and Kamantan farming groups claim competing rights for settlement and cropping. In 1983 and 1984, farmer-Fulani conflicts made it impossible for interested fodder bank participants

to acquire the necessary land. Only two Fulani in the Abet area, both fodder bank testers, have more secure land agreements. In one case, the Fulani was granted a gift (*kyauta*) of unused land which implied inheritance rights; in the other, the Fulani has a witness paper signed by the village head signifying occupancy for as long as the Fulani wishes. In 1984, for the first time, farmland was purchased; the buyer was a Fulani.

Only 3 of the 20 participants do not have some form of relatively secure right to land and intended permanence of settlement, through either living on the grazing reserve, purchased usufructory rights or locally negotiated transactions. Two of the three were ILCA-enlisted participants. The other Fulani was self-enlisted but had left his site and the fodder bank after 1 year. Secure land rights and permanent settlement appear to be essential prerequisites to adoption. In general, the Fulani response is that unless they 'own' land or use unexploited land which is unlikely to be reclaimed by farmers, they cannot have a fodder bank. Besides security in title, the land area must be large enough to support a fodder bank. The exact size of the fodder bank depends upon land available and the opportunity cost of the land.

The fodder bank might be viewed by Fulani as a means of gaining land rights. This does not appear to be the case. Use of marginal land for fodder bank development without securing rights first is inhibited by two factors. Encroachment by farmers has made many pastoralists unwilling to invest in marginal land. Also, the use of such land depends upon its suitability as a site for family compound, cattle corral, and for subsistence cropping: people, cattle and crops go together.

Costs

Fencing is essential to control grazing, but it is a major expense and acts as a key deterrent to fodder bank establishment, not only in terms of capital outlay but also because it formalizes the use of a given land area. Fulani prefer metal posts, but these add to the cost. A few Fulani have used local materials, such as termite-resistant wooden posts or cuttings from indigenous trees that root when buried to become live fence posts. Such indigenous fencing materials provide lower cost alternatives.

Other costs to be considered include the initial labour requirements for land clearing if necessary, fence erection, fencing materials (when locally made) and firebreak creation, recurring costs of reseeding and maintenance and any opportunity costs such as land, family labour and use of animals in seedbed preparation versus manuring cropland. It is not clear yet how such costs will affect adoption.

Benefits

The expected value of the return from the fodder bank depends upon a variety of interrelated factors. These include perceptions about the severity of the dry-season grazing problem, size of the fodder bank in relation to herd size, and the degree of uncertainty about the expected benefits. A major benefit is the fencing, which protects the area from communal grazing.

Kurmin Biri is thought by the Fulani to have a more severe dry season than other locations: the dry season is longer; there are fewer crop residues to graze; riverine grazing is inaccessible due to dry-season farming; natural grasses are said to be of lower quality than in more densely cultivated areas; the fact that the bush is a vast open area results in uncontrolled burning depleting valuable bulk. One would expect the Fulani in such areas to be predisposed towards the establishment of fodder banks.

Dry-season grazing resources are more plentiful in Abet, consisting of crop residues and low-lying (fadama) grazing sites. Although the nomadic Bororo bring their herds into Abet during the dry season, which means competition for these resources, the Fulani generally do not consider the dry season to be as severe in Abet as it is elsewhere. Thus there is less motive to incur the cost of a fodder bank, since an additional grazing resource is less necessary.

Depending upon the individual Fulani's herd size and management strategy, the fodder bank's size becomes a factor influencing adoption. For Fulani with small herds, who split their herds in the dry season or who expect the fodder bank to feed only a limited number of animals, size is not a problem. Many Fulani, however, view the costs of establishment as too high for a limited grazing area that cannot adequately feed their whole herd.

In the short term the Fulani expect to see an immediate and visible gain from the fodder bank in terms of improved animal condition. In a few cases this benefit has been observed, but in most it has not - either by participants or by onlookers. The uncertainty of any benefit and the time lag before the fodder bank results in visible cattle improvement are negatively influencing Fulani interest at this intervention testing stage of the ISR cycle.

Motivation

Various ulterior motives influenced decisions to establish fodder banks. They include:

- . The expectation that the research programme will allow them access to veterinary services, future government loans or anything else that the Fulani need, including fertilizer and supplementary feeds.
- . The belief that government assistance with free inputs would not continue or land would become unavailable.
- . The desire to be seen by other Fulani as a government collaborator and an innovator.

Until a profitable return is proved, it is likely that such motives will outweigh genuine interest in fodder banks.

Depending on motivation, the commitment to fodder bank investments obviously varies. When their interest was not self-initiated and/or the motive was not genuine interest, the Fulani have been largely unwilling to shoulder the establishment and maintenance costs and tasks. This unwillingness was particularly evident for participants in Kurmin Biri. They have settled on the grazing reserve largely expecting the government to provide services; administrators, in turn, have made various promises. Together, these factors have resulted in a generally low level of personal commitment.

FULANI FEEDBACK ON FODDER BANK ESTABLISHMENT

From the sample of 20 fodder bank testers, data were collected to determine to what degree Fulani followed the recommendations; what were the deviations and why.

Land clearing and fencing

Land clearing is considered strenuous work and is often hired out. The labour costs of land clearing depend on the amount of bush and tree cover. The objective is therefore to use land that is already fairly clear, but this depends on what is available. In areas where Fulani do not have secure land rights, the use of fallow land for long-term investment is considered untenable by the Fulani since farmers are certain to reclaim the land. Unexploited land is viewed as the only choice for fodder bank establishment; but such land is likely to be heavily covered with trees, bushes and grasses, and hence more costly to clear.

Likewise, erecting a fence round a 4-ha area involves considerable labour. There is no previous experience with setting fence posts and stringing barbed wire into a tight, secure fence.

Consequently, ILCA or NLFU have largely done both the clearing and the fencing to date. It is difficult to ascertain how much of a constraint the costs or labour involved in these tasks will be, and their effect on adoption rates across economic classes remains as yet unknown.

Seedbed preparation

Trampling by cattle during overnight corralling to prepare a seedbed has proved ineffective and unacceptable in many cases. These Fulani have long experience with confining cattle overnight to prepare cropland and deposit manure. Consequently, they have considerable ethno-science relating to the practices and benefits of using cattle to prepare cropland. Fulani use their herds to manure cropland in the early rainy season, so there is competition between preparing the fodder bank and plots for subsistence crops. In the dry season in areas like Abet, Fulani are paid by farmers to corral their cattle overnight on farmers' land. Also, the Fulani

traditionally prepare iburu (Digitaria iburea) and rice seedbeds by confining cattle overnight on the site.

The technique is effective because the Fulani distinguish carefully between land types, soil quality (primarily in terms of water retention and compaction) type and quantity of the vegetative cover, size of the herd to be used, timing in the rainy season when confinement is done and the subsequent effect on grain and natural vegetative yields. Efficiency of trampling is a function of herd size and the length of the trampling period. The area that can be trampled in any 1 year is generally considered too limited. Using animals during the dry season to graze down the area and deposit manure merely increased grass competition. In response to these problems, ILCA has carried out component research on seedbed preparation methods. Initial results suggest that a brief trampling period after seeding will be acceptable to producers (Paper 16).

Grazing of weeds

The Fulani rightly consider weed competition a major inhibitor of stylo germination and growth. However, they have been unwilling to use their herds to graze down competing grass growth. They fear the disease threat inherent in recently manured areas, and claim that animals refuse to graze where the smell of manure is strong.

The Fulani also observe that their animals are not selective, eating the stylo together with the grasses and thus depleting the valuable stylo. In addition they believe that trampling, which occurs during grazing, damages stylo seedlings. In 1984 two Fulani adopted their own wet-season grazing strategy to control grasses. The whole herd was put in for grazing at the start of the early rains in March to control grass competition. When the grasses were considered to be adequately controlled, grazing was stopped (by mid-May). They stated they would not graze further until the dry season. The outcome of this approach will be reviewed at the end of the 1984/85 dry season and compared with existing methods.

Firebreaks

Fulani consider fire a major threat to fodder bank and pasture development. As a result they have been willing to expend labour to create firebreaks, mainly through controlled burning.

UTILIZATION OF FULANI-MANAGED FODDER BANKS

ILCA recommended dry-season utilization of the fodder bank by lactating and heavily pregnant cows for 2 to 3 hours per day. This recommendation was intended to provide supplementary protein at the time of greatest need to the classes of stock most able to respond profitably. The response was expected to be increased milk production (for human offtake and calf consumption), and improved calf survival and growth rate. This management strategy was thought to be consistent with the objectives of the Fulani as regards herd size, milk offtake and animal sales. It was also thought to be consistent with national objectives of increased milk and beef production (von Kaufmann and Otchere, 1982).

In January 1984 ILCA recommended a stocking rate of about 15 animals for each of the 11 fodder banks that had established well enough to implement a grazing regime. Pastoralists participated in the animal selection process. Despite this recommendation, in most cases whole herds were given access to fodder banks—either the total herd ranging from 30 to 120 animals, or that part of the herd that remained at the ruga (encampment) when other animals were transferred elsewhere, ranging from 16 to 61 animals.

The feeding strategy observed among fodder bank participants indicates that their objective is to ensure the well-being of all animals within the herd during the dry season. If a given feed resource is limited in availability and/or costly to obtain, such as cottonseed cake, then selective feeding may occur, but out of necessity rather than choice. The behaviour of participants is related to two central factors: the multiple objectives of Fulani cattle husbandry, and multiple herd ownership.

Multiple objective system

For the Kachichere Fulani female animals are the most valued asset because of the calves and milk they produce. But all animals in the herd are productive and have a purpose; otherwise, they are sold or exchanged. Feeding only a few is viewed as irrational because all animals are needed for family subsistence, whether they provide milk for the calf, for the family, or for the wives to sell; or capital to purchase grain and consumer goods or to pay school fees; or a means of meeting social and cultural obligations (van Raay, 1975).

Cattle are both a means to an end and an end in themselves (van Raay, 1975). They provide the basis for family subsistence as well as being a way of life. Animals that can be accumulated beyond the perceived needs of the household serve as an investment and an insurance against times of adversity, as well as bringing prestige and a means of helping others.

Multiple ownership

Individual animals may be owned by wives, children and relatives, or entrusted to them by non-kin owners. Major management decisions are not made in isolation, nor by one individual. Weak or sick animals receive special treatment regardless of ownership, but for the rest multiple ownership implies multiple decision makers. Multiple decision-making adds complexity as well as encouraging the tendency to treat all animals equally.

The result of these two factors is that Fulani generally employ a maintenance or survival feeding strategy in which animal condition determines feeding practices. As the quantity and quality of natural resources decline over the dry season, even a limited feed resource, such as the fodder bank, is made available to all animals.

Interviews with a random sample of 38 Fulani indicate that on average three to five animals per herd either die or must be sold/culled in extremis due to the dry-season grazing constraint (Table 2). Fulani distinguished between diseased animals and animal losses from weakness due to dry-season

conditions. Maintenance or survival feeding means being able to sell an animal when desired--i.e. when in good condition, when sale prices are high, or when the owner needs cash--rather than when forced to do so by external events--such as in the case of emergency sales in the late dry season, when the animal is emaciated and market prices are low. The advantage of fodder banks from the Fulani point of view lies in their ability to maintain animal condition and/or herd viability. Future component research by IICA on the effects of fodder bank grazing on herd productivity will therefore include the feeding of weak animals. IICA and extension staff will also ensure that all such animals are selected for intervention testing.

Table 2. Animal losses in the dry season, Kurmin Biri and Abet, 1982/83 and 1983/84.

Variable	1982/83		1983/84	
	Kurmin Biri ^{a/}	Abet ^{b/}	Kurmin Biri ^{a/}	Abet ^{b/}
No. of herds which lost animals	6	18	8	16
% of herds which lost animals	46	72	62	64
Total number of animals lost	24	63	40	45
Average loss per herd (head)	4	3.5	5	2.8

^{a/}n = 13.

^{b/}n = 25.

Given the longer dry season, more losses were expected for 1983/84 than for 1982/83. This was the case for Kurmin Biri but not for Abet, where the rains started in early March in 1984. Early rains bring new green grass growth and a last chance to avoid animal losses.

OTHER FACTORS INFLUENCING FODDER BANK UTILIZATION

Labour

Separating animals and managing two groups of cattle, one in the fodder bank and the other not, require additional labour inputs. While young children may be responsible for the non-fodder bank group, it takes a fairly skilled, older person to separate out the selected animals and move them onto the fodder bank. If either the skilled herder or the children were lacking, then the fodder bank group could not be handled separately.

Fencing

In three cases fencing around the fodder banks was insecure, so that controlled grazing was impossible even if it had been intended.

Animal selection

The Fulani had their own ideas about which animals should be included in fodder bank grazing well before ILCA came to solicit their participation. They claim that they did not participate adequately in the animal selection process. Rather, they suggest that ILCA selected certain lactating and pregnant cows; they privately agreed or disagreed and followed the recommendations or not accordingly.

Forage quantity and quality within the fodder bank

Using their knowledge of the effects of different legumes and grasses on animal condition, the Fulani evaluated the quantity and quality of fodder on the bank and decided how to use it. Their decisions often changed as the dry season progressed.

The Fulani recognize stylo as a quality forage which can benefit weak animals, increase milk production and/or raise herd fertility. In some cases, Fulani felt that their fodder banks had sufficient forage to support more animals than selected by ILCA. On the other hand, when the proportion of stylo in the fodder bank was too low or had been used up, the Fulani

viewed the bank as merely a bulk reserve. They did not feel that it was worth the effort to prevent some animals from grazing.

Grazing time

All of the Fulani chose to use their fodder banks in the morning rather than the evening. It is easier to separate animals at the time of milking, done exclusively in the morning, than in the evening when cattle are returning from grazing. Also, grazing the fodder bank in the morning fitted into the traditional grazing routine practised in the dry season. Because feed resources are so limited, grazing begins very early in the morning, such that the grazing day is divided between two graziers, the first of which is responsible for a 3-hour early morning period before the second takes the herd further afield for the rest of the day. In response, ILCA has agreed to monitor animal productivity under a morning grazing regime.

Daily management

The Fulani developed an alternative form of rationing by restricting the frequency of fodder bank grazing. Depending on their estimates of the quantity of forage available on the fodder bank, most did not use the bank daily. One Fulani deferred grazing of his fodder bank in mid-February for 2 weeks in order to hold the forage for later grazing. Also, fodder bank grazing did not occur on days when the traditional mineral supplement kanwa was fed, because kanwa feeding took place during the hours usually spent in morning grazing.

Management response to differing dry-season conditions

The difference between Abet/Kachia and Kurmin Biri in terms of the length and severity of the dry season resulted in different decisions concerning the use of fodder banks. Both Abet and Kachia had rains early in March 1984, so that a nutritious alternative in the form of new green grass was available, allowing fodder bank grazing to end. The first rains in Kurmin Biri, in contrast, did not come until the end of April (6 weeks later), such that cattle there spent about 2 months with very minimal feed. By the end of the dry season whole herds were still using the fodder banks, licking

debris from the ground throughout April. Also, in Kurmin Biri two Fulani began night grazing of their fodder banks. This was an important development, since these Fulani do not normally practise night grazing.

Period of use

The overall consensus among the Fulani was that fodder banks are best reserved for later dry-season grazing. This may have been a reaction to the severity of the 1984 dry season, but two main reasons were given: (a) because of the fence, the fodder bank can be reserved until late in the dry season when little other forage is available and animals are under the most stress; (b) animals that graze the fodder bank during the early dry season will still lose condition once the stylo is depleted. The advantage of a quality diet in the early dry season, such as obtained through crop residue grazing, is considered by the Fulani only to be realized if the animals continue to obtain a reasonable diet throughout the dry season. Therefore, the strategy would be to pursue natural grazing until it is depleted and then move to the fodder banks in order to have a steady intake.

Herd splitting during the dry season

While the Kachichere Fulani are 'settled', they maintain many of the same flexible grazing strategies as the more mobile groups. The major difference is that they confine their grazing to within a 30- to 50-km radius of the ruga. Cattle transfers during the dry season thus determine which animals are available, and/or the timing of fodder bank grazing. Apart from the desire to exploit grass growth caused by early rains in adjacent districts, there are three other types of animal transfer that may affect utilization:

1. Dry-season transfers. Usually the herd is split and part of it moved to another area for the entire dry season in order to distribute stocking pressure or to take advantage of better feed resources elsewhere.

2. Crop residue transfers. Whole herds may be temporarily moved away from the ruga in order to exploit crop residue resources in nearby farming areas.
3. Transfers for manuring contracts. Where Fulani gain cash or other assets in exchange for manuring farmers' fields during the dry season, whole herds may be moved some distance away from the ruga to spend nights on farmers' fields.

CONCLUSIONS

Although most of the Fulani expressed dissatisfaction with their fodder banks in terms of not having enough stylo or not being large enough, all were very interested in them. The expected return is sufficient to maintain interest. The Fulani say that fodder bank grazing maintains strength so that animals do not become so weak that they cannot stand without support and have to be culled from the herd. They also recognize that fodder banks make concentrate purchases less necessary and can feed more animals than concentrates, the supply of which is too scarce, costly and unreliable.

Fulani consider dry-season nutritional constraints a major problem in cattle production. Any effort to alleviate this problem is regarded with interest, especially in locations with particularly poor dry-season grazing, such as Kurmin Biri.

SUGGESTIONS FOR FURTHER RESEARCH

Maintaining animal condition is the most critical concern of the Fulani, not increased productivity per se. The value attached to a live animal in the herd is very high and, if there has to be a choice, it is more reasonable to save as many animals as possible during the dry season rather than aim for increased productivity in a few. Productivity changes that are unrelated to herd maintenance are unlikely to command attention under current management practices.

Given the variation in management strategies even within a particular production system, a range of utilization options (stocking rate, length of grazing period, etc) is probably needed. The range should be based on:

1. Producer objectives
2. Labour availability
3. Expected length and severity of the dry season
4. Availability of alternative dry-season grazing resources
5. Stylo and grass composition on the individual fodder bank
6. Size of herd resident at ruga during the dry season.

The expected benefits for the various options could be projected. Considerable research is required to determine the effect of alternate options on herd productivity.

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Extension implementation of ILCA
interventions: Dry-season cow
supplementation and fodder banks

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ABSTRACT

ILCA scientists have tested the rationing of agro-industrial byproducts and legumes grown in fodder banks as interventions amongst Fulani pastoralists in the two case study areas of Kurmin Biri and Abet over the past 5 years, using the three stages of on-farm experimentation in livestock systems research (LSR); namely:

- Researcher-managed and -implemented trials
- Researcher-managed and farmer-implemented trials
- Farmer-managed and -implemented trials.

The next phase in the cycle is the multi-locational testing of these interventions so that their adaptability and acceptability to producers can be established under different ecological and socio-cultural conditions. This phase is best accomplished in cooperation with extension and development agencies, which are essential to LSR as vehicles for testing the proposed interventions and procedures. Without close links with national extension services LSR at this stage cannot be effective.

Two of ILCA's innovations are currently being extended by the National Livestock Project Unit (NLFU): dry-season cow supplementation, under the government scheme of that name, and fodder banks. A fixed loan was extended by the NLFU for the purchase of inputs for each of the two packages.

These extension efforts gave ILCA's team members the opportunity to stand back and observe whether the innovation they had designed would survive without them. The team needed to know whether the extension services would be able to implement the interventions; how closely extension and producers would adhere to the original design; what modifications they would introduce; how successful the intervention would be in terms of the goals it was designed to achieve; how persistent it would be and what side-effects it might have.

The problems that emerged during implementation were identified as the unreliable supply and high cost of inputs, an inadequate and inexperienced extension system and a regulatory credit system. Extension and producer deviations during implementation from the ILCA recommendations were recorded. The move from researcher- to farmer-managed and -implemented experiments led to unclear animal productivity results. The need for more emphasis on fodder bank research was clearly demonstrated. The rate of adoption could not be predicted due to the small sample size and inadvertent researcher effect, emphasizing the need for more replicates in different ecological and socio-economic situations.

INTRODUCTION

ILCA faces not just the technical problem of improving livestock nutrition but also that of converting the technical research results into innovations that will be accepted by livestock producers and which can be implemented by the national extension systems. The many instances of results from research agencies that have not been adopted by local producers indicate the need for ILCA to continually assess the appropriateness of its interventions. Extension services must be equipped with the necessary resources, so that a willing producer can obtain the inputs needed to implement the innovation.

Two of ILCA's innovations are currently being extended by the National Livestock Project Unit (NLFU). They are the rationing of agro-industrial byproducts to cows, under the government's Dry-season Cow Supplementation Scheme, and, on a limited scale, fodder banks. To various degrees, NLFU had been involved in the trials since 1980.

Structured and unstructured interviews with pastoralists and extension staff testing the ILCA interventions were conducted. Observations of actual behaviour - recording deviations from ILCA recommendations and finding out why they occurred - were also made. Input and extension requirements to implement the interventions were analysed.

DRY-SEASON COW SUPPLEMENTATION

In 1984, the NLFU became solely responsible for the implementation of the Dry-Season Cow Supplementation Scheme. The scheme was supervised by the staff of the Kachia Grazing Reserve under the direction of the Range Management Officer. One Grazing Control Assistant was detailed to extension and supervision for each of the three sites in Kurmin Biri, Abet and Zonkwa. They were expected to provide technical assistance and supervision at frequent intervals.

A fixed loan of up to ₦ 250 (US\$ 335) with a 6-month repayment period was offered for the purchase of inputs such as cottonseed cake, wheat bran, molasses, drugs, mineral salt licks, feeding troughs and fencing materials to erect a feeding enclosure. The scheme's main input was the provision of cottonseed cake - enough to feed an enterprise of 5 cows for 100 days over the dry season. Participants were to select and feed these animals with the objective of increasing milk yields.

Participant behaviour

Fourteen Fulani registered in the scheme, only 23% of the projected enrollment. The principal reasons for lack of interest were the costs of cottonseed cake (the 1984 price was double that of 1983, rising from 8.75 Naira to 15.00 Naira for a 50-kg bag) and the terms of the loan. In previous years, Fulani had been able to purchase cottonseed cake when they needed it and feed it to the animals that they wished. The new loan requirements were seen as rigid and unacceptable.

Of the 14 pastoralists registered in the scheme, 5 initially followed the feeding recommendation of selective rationing; 2 of the 5 left the scheme in mid-season because they felt that they were incurring too much debt without enough gain; the other 3 had by March increased the numbers of cattle being fed or even included their whole herds. The remaining 9 pastoralists did not follow the feeding recommendation exactly, but practised some form of rationing. However, the number of animals involved ranged from 6 to 20. They were mostly lactating cows in poor condition. In 5 cases they constituted the part of the herd which was left at the ruga when other animals were transferred elsewhere for the dry season. One pastoralist instituted his own experiment and fed 4 lactating cows, 5 heifers, 4 calves, and 2 bulls to see the effect of feeding cottonseed cake to each. In only one case was there no consistency at all in the pattern of feeding.

Half the Fulani had additional feedstuffs to those purchased under the scheme. This may have been a reason for the increased numbers of animals fed. Maintenance feeding and, in some cases, survival feeding were the general aims of participants - as they were also among the fodder bank participants (Paper 18). Those Fulani who were willing and able to register in the scheme in 1984 did so in order to gain access to a cottonseed cake supply which, by and large, they fed to all lactating cows in poor condition with insufficient milk for their calves.

Extension implementation

For a variety of reasons, the scheme was not actually implemented as planned. Ear-tagging to identify the selected animals was delayed or not done at all; the veterinary component of the loan was not extended; extension support was minimal; there was virtually no supervision of pastoralist compliance with the scheme; pastoralists were meant to transport their own supplies but, in the event, NLFU did it for them.

1. Planning. The divergence between plans and implementation as experienced in 1984 was to some extent brought about by the 'push' to get the scheme under way in January, with too little time allowed for efficient organization. Plans were formulated and the terms of the loan drawn up in

a matter of a few weeks before and during the scheme's start-up. Some of the supplies needed were not available at the Service Centre at Kurmin Biri. No time was allowed for the orientation of minimally trained extension staff. Motorcycles intended for the Grazing Control Assistants were in disrepair. Delay and confusion reigned from the outset, and certain components of the scheme were never implemented.

2. Supplies. As it turned out, it was lucky that only 14 Fulani registered for the scheme, because higher numbers could not have been serviced with the existing supply of cottonseed cake at Kurmin Biri. Given the high cost and limited availability of cottonseed cake in 1984, NLFU would have had great difficulty procuring an additional supply; various negotiations to acquire more cottonseed cake never came to fruition and, due to the costs, NLFU recognized that dry-season supplementation could not be continued with a cottonseed cake ration.

As was expected, extension supervision was clearly more adequate in Kurmin Biri than in Abet or Zonkwa, principally due to proximity to resources and on-site staff. The Grazing Control Assistant responsible for the scheme in Kurmin Biri managed to visit various rugas sporadically. In Zonkwa and Abet, however, visits were very irregular and taken up with distributing the feedstuffs rather than with extension or supervision. The lack of transport made it difficult for the extension staff to establish a programme of work, even if they intended to do so.

3. Communications. As with any new programme, there were likely to be delays in start-up. But delays were aggravated by a change-over in supervisory staff at Kurmin Biri. Consequently there were misunderstandings, both between the different NLFU staff levels and between NLFU and the Fulani. These occurred in the early stages and were cleared up over time.

None of the Kurmin Biri field staff who were to supervise the scheme had any previous exposure to it before the programme start-up. Thus they were learning about the scheme at the same time as implementing it. In discussion several weeks later, these Grazing Control Assistants showed confusion over the terms of the loan and specific implementation questions. Not surprisingly, interviews with the Fulani also revealed confusion and

misinterpretations of the loan. Most of this confusion was cleared up as the programme progressed, and by March the assistants appeared to have an adequate grasp of the scheme. However, none of the assistants are Fulani. There is a certain margin for misinterpretation when instructions are originally given and printed in English, verbally translated into Hausa and finally transmitted to Fulfulde speakers with four ranks of the extension service in between. The assistants were also in the difficult position of requesting Fulani to repay past loans at the same time as trying to persuade them of the benefits of cottonseed cake feeding.

4. Incentives. If the Grazing Control Assistants were to supervise and monitor selective rationing, they had to visit Fulani herds at the time of feeding, i.e. 6.30 - 7.00 hours and/or 17.30 - 18.00 hours. The established working day for all government employees is 7.30 - 15.30. No payment was made for overtime, so there was apparently little incentive to visit rugas at the time of feeding. The assistants were also embarrassed by changing policies, their own lack of understanding of the scheme's objectives and their role as debt collectors.

The cost of cottonseed cake and the loan requirements appeared to be the central factors affecting uptake of the supplementation scheme, although implementation was confounded by numerous inadequacies in the extension effort. It appears that unless a cheaper feed supply is identified - a task NLFU is trying to tackle - only the more wealthy producers are likely to register for the loan and procure the feedstuffs, a tendency which will only intensify existing inequalities.

NLFU is a loan agency and any dry-season supplementation scheme would be included under a loan. If a comparable scheme is to continue, the terms of the loan need to be more flexible (i.e., in terms of quantity of supplement to be disbursed, the animals to be fed, the feeding period in the dry season), based on beneficiaries' objectives and their perceptions of the expected return. Likewise, it needs to be planned well in advance, detailing the operational steps and budgetary needs to execute implementation.

FODDER BANKS

It was principally due to the rising cost of agro-industrial byproducts that ILCA formulated the fodder bank package. Cottonseed cake feeding was intended to acquaint pastoralists with the principles of rationing as a lead into the fodder bank scheme. Experience has shown that rationing is practised, to the extent of not allowing indiscriminate use of all available feedstuffs. It seems possible that Fulani would be willing to follow the recommended feeding scheme if other feedstuffs were available to feed other animals considered in need. Some pastoralists will be unwilling or unable to invest in fodder banks, but could utilize purchased feedstuffs if they were available on a flexible basis. Even pastoralists with fodder banks, whilst acknowledging that a fodder bank makes feed purchases less necessary, have expressed a desire to be able to purchase additional dry-season supplements. Six Fulani with fodder banks registered in the cow supplementation scheme in order to be able to purchase cottonseed cake.

By the end of 1983, the number of established fodder banks had risen to 20 in the three areas of Kurmin Biri, Kachia and Abet. This number will rise to 46 at the end of 1984 in Kaduna and four other states in Nigeria (Table 1). In contrast to Abet and Kurmin Biri, Kachia represents a site of spontaneous uptake since 1982. Those in other states are a result of NLFU's efforts to extend the package throughout subhumid Nigeria.

Table 1. Fodder banks establishment at various sites in subhumid Nigeria.

Location	Year					Total
	1980 ^{a/}	1981 ^{a/}	1982 ^{b/}	1983 ^{c/}	1984	
Kurmin Biri	1	1	6	4	2	14
Abet	1	1	2	-	-	4
Kachia ^{d/}	-	-	2	2	3	7
Kaduna ^{e/}	-	-	3	-	2	5
Ganawuri ^{f/}	-	-	-	-	5	5
Plateau ^{g/}	-	-	-	-	3	3
Niger ^{d/}	-	-	-	-	3	3
Benue ^{g/}	-	-	-	-	4	4
Gongola ^{g/}	-	-	-	-	1	1
Total	2	2	13	6	23	46

^{a/}Fully funded and managed by ILCA.

^{b/}Funded and managed by ILCA/pastoralists.

^{c/}Fully funded and managed by pastoralists.

^{d/}Spontaneous uptake.

^{e/}Semi-commercial farms.

^{f/}New ILCA case study areas.

^{g/}Extended by NLFU.

Over the 5-year life span of the fodder bank research, responsibility for investment costs has gradually been transferred. At the outset ILCA incurred all the establishment costs (except land), but now the pastoralists are to incur all costs (Paper 21). Credit is extended by the NLFU to pay for the fencing materials, seeds and fertilizer. Management inputs by the participating pastoralists include fencing, land clearing, trampling by cattle to prepare the seedbed, seeding, early grazing to control weeds, firebreak establishment, maintenance and rationing to selected animals during the dry season. Establishment costs are detailed in Table 2.

Table 2. Fodder bank initial investment costs (4 ha).

Item	Cost (Naira) ^{a/}
Fencing 800 m @ 3 ₦/m	2400
Seed 4 ha @ 7 kg/ha @ 12 ₦/kg	336
Fertilizer 4 ha @ 150 kg/ha @ 0.10 ₦/kg	60
Labour 30 worker-day @ 4 ₦/worker-day	120
Total	2916

^{a/} One ₦ = US\$ 1.123.

In 1983, NLFU took over the establishment of fodder banks in the ILCA case study areas. A total of six new fodder banks were started. Pastoralists were to obtain the necessary inputs through the credit package from the Livestock Service Centre at Kurmin Biri and erect their own fodder banks. Management advice would come from the NLFU personnel at Kurmin Biri, with close liaison and supervision by the ILCA research team. As might be expected, given the testing stage of the technology and the lack of experience of NLFU field staff with the fodder bank, numerous deviations occurred from what ILCA had intended: administrative delays meant that fodder bank promotion was late in start-up; heavy earth-moving equipment was used to clear fodder banks; extension advice and supervision was inadequate; extension staff did management tasks rather than encourage active participation by the Fulani.

As a result of these difficulties, an ILCA/NLFU workshop was held in December 1983 to better prepare extension staff. It was attended by NLFU staff from eight states. The purpose of the workshop was to provide general guidelines for the extension of fodder banks in other states during 1984. Subsequently, the NLFU has extended fodder banks in four other states of Nigeria during 1984-85. This extension provide the necessary multi-locational testing of the fodder bank intervention. ILCA is monitoring extension implementation and pastoralist behaviour in these new sites.

CONCLUSIONS

For a research institute such as ILCA, it is at this implementation stage of research that the real problems and potentials of a new technology come to light. While the NLFU is not an extension agency per se, the problems experienced in implementing the cow supplementation scheme and the fodder bank technologies are not new nor atypical of lessons documented elsewhere in the developing world:

- Lack of policy commitment and budgetary provisions for long-term development.
- Limiting or irregular supply of essential inputs.
- Hierarchical organization and structural rigidities.
- Ad hoc planning with inadequate implementation procedures.
- Inexperienced and untrained field staff.
- Ineffective field-level supervision and support.
- Lack of incentives and personal motivation.
- Credit arrangements with too many regulations.

ILCA was aware of many of the problems of extension in Nigeria and thought it possible to minimize their effects by seeking interventions that the producers could largely implement themselves. The predicted rise in the cost of feed concentrates has occurred sooner and more severely than anticipated. The supplementary feeding of concentrates for increased productivity is for the time being no longer a viable proposition. This places even greater urgency on ILCA's fodder bank research.

The future of livestock systems research
in Nigeria

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ABSTRACT

Much livestock-related research has been done in Nigeria, but there has been little transfer from research station to producer. Crop research has been more successfully taken up by farmers. This may in part be due to the pioneering work and continued interest in farming systems research at the Institute of Agricultural Research, Zaria. Until recently there has been no national body committed to livestock systems research (LSR). However, the National Animal Production Research Institute (NAPRI) has now established an LSR team and work has begun in a case study area close to its headquarters.

INTRODUCTION

The relevance of research topics at our research centres and universities for the improvement of livestock production is being questioned by many interested in the development of Nigeria's livestock industry. Some observers hold the view that the so-called new technology developed by institutionalized research - which development programmes mostly draw on - has sometimes hindered rather than benefitted the producer. Many believe that lack of active involvement of the producer in the processes of

research and development is one reason why the technologies developed are inappropriate, and why producers themselves are less likely to know about and be interested in research results.

Livestock systems research (LSR) is one approach to getting the producer involved. This paper speculates on the future of LSR in Nigeria. To do this, we first briefly consider the background of the producer and the researcher, and their activities in the maintenance and improvement of the nation's livestock industry.

BACKGROUND TO LIVESTOCK SYSTEMS RESEARCH

Livestock production is an industry that depends on local raw materials to yield its primary products - milk, meat, etc. It is known to all that ruminant livestock production in this country is almost entirely in the hands of herdsman who are either pastoralists or agropastoralists. The animals are pure or crossbreds of indigenous breeds. Livestock depend almost entirely on natural range vegetation for their nutritional requirements. They graze upland ranges and fallow lands during the wet season; in the dry season the available residual forage of the upland ranges is complemented by utilization of crop residues, browse and fadama grassland.

The typical Nigerian livestock producer is a rural person who is well aware of his animals and the environment in which they thrive. He knows good animals and good pasture when he sees them. He is a sceptic, and a curious observer. He is cautious, but within the limits of his resources he is quick to adopt innovations that enhance the productivity of his enterprise. However, his production constraints are many:

1. Inadequate quantity of feed and low quality of feed available.
2. Inadequate water supply and uneven water distribution.
3. Prevalence of diseases and parasites.

4. Unstable supply of external inputs including veterinary supplies, concentrates, fertilizers, etc.
5. Low genetic potential of native livestock with regards to feed conversion and reproduction.
6. Lack of concrete national policies that would give focus and direction to livestock production and research.

In spite of the fact that he has to contend with such odds the traditional herdsman is still the main producer of milk and live animals for Nigeria's teeming population.

Comparatively, the typical livestock researcher in this country is urban or urbanized. He is highly trained and specialized in one or the other disciplines of livestock production. He is affiliated to an institute, university or other conventional research centre. Like his colleagues in other parts of the world his ideas about research stem from his past or prevailing experiences, or occasionally from projected future circumstances. His achievements in the various disciplines of livestock production since the beginning of formal research in the late 1920s have been substantial. Thus:

1. Most of the epidemic diseases and pests have been identified; control and preventive measures have been defined.
2. Significant improvement in the indigenous gene pool by introduction of exotic breeds has been achieved.
3. Nutrition of indigenous and exotic crossbreeds has been assessed and various rations have been tested.
4. Rangeland productivity has been evaluated, management of indigenous and introduced fodders has been defined and a number of promising species have been released for large-scale pasture production.

In spite of such achievements, which were all aimed at improving the nation's livestock industry, one is left wondering why there is not much visible impact of the new technologies on the traditional livestock production system.

Until recently research institutions in Nigeria have directed their energies towards producing new technologies at the research stations and then passing these new technologies via extension agents on to the livestock producer. This procedure has had limited benefits for the traditional livestock producer. Many recommended practices have either simply not been suitable to the existing conditions under which the traditional system operates, or the institutions and social structures which were expected to support the recommended practices have instead limited their applicability. In many instances, the new technologies have themselves been inappropriate, given the resource position and actual needs of the livestockman. Thus, to make research more purposeful, there is a need to bridge the gap between research and production. Livestock extension delivery, the machinery through which research findings are transmitted to the producer, should be strengthened in both directions: that of passing new technology on to the producer, and that of passing the producers' reactions back to the researcher. Thus there is a strong case for a systems approach to the problem.

INTRODUCTION OF LIVESTOCK SYSTEMS RESEARCH

For over a decade systems research has been going on at the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria, resulting in an excellent document that can be considered a classic in the literature (Norman et al, 1982). However, in farming systems research (FSR) livestock systems were not adequately treated. The focus of FSR has been largely on crop research, tailoring component research findings to crop farmers' situations. Nevertheless, the livestock subsector may very well borrow a leaf from FSR experiences, judging from the successes so far achieved in the use of improved seed varieties, fertilizers, etc.

To this end, the National Animal Production Research Institute formally embarked on livestock systems research (LSR) in late 1983. A multidisciplinary team was charged with the responsibility of conducting

livestock research on indigenous livestock production systems as the main focus in all its subprogrammes. NAPRI's objectives in this approach are:

1. To establish national expertise in livestock systems research, which is now gaining momentum in many countries.
2. To bring into focus the critical components of production and to create awareness among livestock producers of what technical interventions are feasible, and what constitutes profitable management of livestock in time and space.
3. To create practical models of existing systems of production and explore possible pathways for introducing interventions.

The research has four complementary subprogrammes:

1. Fodder and arable crop/livestock interactions
2. Animal management
3. Animal health/artificial insemination
4. Socio-economics

The general objective of the research is to improve understanding of existing traditional systems of livestock production and help improve their productivity through technical interventions. In the process team work will be strengthened between specialists who have contributions to make in the development of livestock in Nigeria but who have tended to work in isolation in the past.

The team's research process follows the classical four-stage sequence of activities often described for systems research: descriptive/diagnostic, design, testing and extension.

NAPRI's systems research is comparatively young, but it has the advantage of having at its disposal a vast store of on-station data that can be used for on-farm testing. Similarly, with IAR's experience to tap and having a close association with the Subhumid Zone Programme of ILCA, the NAPRI team may be able to by-pass certain processes in some of the stages outlined.

NAPRI's livestock systems research is now at the diagnostic phase. The aim at this stage is to come up with practical models of livestock production systems in the various ecological zones of Nigeria. A circular case study area having a 50-km radius with Giwa as its centre has been selected for the team's activities. The Giwa case study area is an ecotone between the typical Sudan and Guinea savannas. It has been selected for its diverse agricultural activities - pastoralists (settled and transhumant), agropastoralists and arable crop farmers are all found there. Its proximity to NAPRI headquarters (approximately 15 km) was an additional criterion for administrative and financial reasons especially at the early stages of this type of the research.

It is too early at this stage to present the data gathered in the diagnostic phase of the research. Instead, let me note some of the achievements which might act as pointers for the future of livestock systems research in this country.

1. There was almost universal acclaim for the LSR proposal and NAPRI's administration is, in principle, totally committed to the systems concept; it has some funding and the LSR is now a programme within the institute.
2. The aerial survey of land-use patterns, water resources and animal population and distribution has been completed and data are being summarized. A follow-up ground reconnaissance survey is being conducted by the team's socio-economists.
3. Detailed questionnaires on fodder resources, animals, households, etc have been designed, reviewed and are now being reproduced.
4. Good relations are being established between research staff and livestock producers. Many of the latter have shown enthusiasm and willingness to cooperate or participate in research - though in some cases with the expectation of remuneration!

It has not been easy to attain such achievements, but the research continues. The team is every day gaining more experience.

THE FUTURE

Judging by these early experiences, there is no reason why the systems approach to livestock production should not continue in the future. One may even be tempted to assert that LSR is here to stay and that support for the concept is by now universal. The NAPRI systems team has drawn on the resources of the Agricultural Extension Research and Liaison Services (AERLS) and the Faculty of Veterinary Medicine of Ahmadu Bello University. There is no indication to suggest that other livestock-associated institutions would not support such research.

How will LSR perform in the future? It depends on policy makers' concepts of what livestock production is all about. We know about the individual components that constitute a production enterprise, but lack a coordinated, field-oriented approach to the problems of livestock production. Neither disease control nor injecting superior genes, for example, can alone bring about improvements in our livestock production. Nor can short-term measures do so. Researchers and developers must think of solutions with long-term implications. The various research disciplines must come together and function to support and complement one another. Solving the critical problems of the indigenous livestock producer should be the main focus of research. For LSR to succeed there should be:

1. Clear and realistic research policy that focusses on the most critical topic(s), defines goals and addresses itself to finding solutions with practical, long-term implications.
2. Definite and firm resource commitment that is flexible enough to permit the systems team to perform effectively.
3. Establishment of an effective feedback mechanism between the systems team, research stations, and extension and development agencies.

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The expected impact and future of
the ILCA Subhumid Zone Programme

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ABSTRACT

Joint research between ILCA and national institutes in Nigeria has led to the design and testing of interventions which will improve livestock productivity. Farmer responses and economic models suggest that several lines of research are making promising progress.

Understanding of the complex interactions that constitute livestock production systems has provided a better basis for research and development in Nigeria's livestock sector.

It is recommended that the basic objectives and techniques of the programme's livestock systems research be continued. Nine priority items for future research are suggested. Some descriptive and diagnostic studies are still necessary, but the future emphasis of the programme will increasingly be on component research and intervention testing. Meanwhile, the LSR approach will be transferred to national institutes.

INTRODUCTION

This paper discusses the potential impact of the interventions being developed and tested by the Subhumid Zone Programme. Livestock systems research (LSR) depends on cooperation between many individuals and agencies (Dillon and Anderson, 1983). There has thus been a collective effort also involving the National Animal Production Research Institute (NAPRI) and

various departments of Ahmadu Bello University (ABU), the Federal Livestock Department (FLD), the National Livestock Project Unit (NLFU), the State Governments of Kaduna, Plateau, Niger, Benue, and the Local Government Authorities where the case studies are carried out.

The most important party in this joint research is the producer. Whilst that is true of cropping systems research as well, the producers cooperating in LSR have to be particularly patient and understanding. They cannot expect to see results in one season, nor dramatic visual evidence of increased productivity. They have to put up with far more questioning and disturbance of their normal routines. In contrast, agronomic field recording frequently need not involve the farmer at all, and when it does so it is usually only once or twice a year, but weighing of animals and questions on the reasons for sales and sale prices go on throughout the year.

Most of the ILCA Subhumid Zone Programme's research is being conducted in three contrasting case study areas in the subhumid zone of Nigeria (Papers 3 and 11). One is an area of government-assisted settlement on a grazing reserve; the second is an area of agropastoral settlement amongst arable farming communities; the third, added in 1984, allows the programme to study mixed crop-livestock situations. The research centres about the single theme of animal nutrition. It does so either directly, through feeding trials, or indirectly through exploring such issues as land tenure, which affect the availability of land on which to grow fodder.

The diagnostic research, now largely completed, has established improved understanding of the systems and the complex inter-relationships within and between them (Papers 3 to 14). The new understanding has created a sounder basis for development planning as well as for future research in the subhumid zone as a whole. In particular it has explained land use and farming systems, and detailed the value of crop residues and how they are utilized by cattle (Papers 11, 13 and 14). At the same time it has revealed the difficulty of devising interventions that will improve feed resources when the cultivators/land owners do not own the livestock (Paper 15).

The design and testing phase of the research, which is now the main activity of the programme, has resulted in the development of interventions which form a coherent strategy for increasing livestock productivity. The strategy consists of:

1. Making better use of existing feed resources (strategic feeding).
2. Promoting increased output of improved forage while also boosting food crop production (new crop-forage techniques).
3. Using more productive animals (crossbred dairy production).

These interventions are discussed in more detail in the following sections.

STRATEGIC FEEDING

Dry-season supplementation has reached the farmer-managed, farmer-implemented phase in LSR (Paper 10), and is being promoted by the NLFU. As reported in Paper 19 it has not progressed as well as hoped, but the adoption and extension problems it is revealing are important to the research and development process and the success of future interventions.

It was known from the outset that there were inadequate feedstuffs on the market in Nigeria and that demand from other livestock would further reduce the quantities available for cattle and drive up prices. This has in fact occurred. At the start of the research cottonseed cake cost 0.06 Naira per kg (Synge, 1980). Only 4 years later, it now costs upwards of 0.3 Naira per kg. Its price has risen fivefold, while livestock values have only doubled over the same period. As can be seen from Table 9 in Annex 1, the present cost-price relationships result in negative incremental net cash flows until increased calving and decreased calf mortality generate increased livestock sales.

The data analysed so far provide evidence of improved calf viability, but the improved fertility reported by Synge (1980) and indicated in ILCA's earlier researcher-managed trials has so far not been manifested under farmer management (Paper 10). Possibly the supplementation only increases milk production without being sufficient to break the nutritional anoestrus typical of lactating cows under traditional management (Paper 6). Possibly too, the cows have not been getting the recommended quantities of feed (Paper 18) as pastoralists shared the rations among larger numbers of animals. Certainly, ILCA failed to detect the considerable variability in the effects of nutritional stress on animals: some animals are in effect starving to death. If feed becomes available, owners are bound to feed such animals. ILCM's observation is that there are on average three to five such animals per herd and that, given the high value of animals, saving them is an economically rational response (Paper 18). The difference between the value of an animal slaughtered in extremis and its value on recovery is estimated at about 400 Naira. That is equivalent to about half the annual supplementary feed bill or half the incremental sales revenue derived from milk.

If provision is made to feed all cows in order to break nutritional anoestrus as well as any animal in danger of dying or being sold in extremis, not only will livestock owners be more amenable to extension advice (Paper 18) but also the animals themselves are more likely to respond as they have done elsewhere (Paper 10). Alternatively, direct supplementary feeding of calves may be more efficient in reducing calf mortality and allowing owners to take off a higher proportion of milk from cows.

Table 10 of Annex 1 gives a summary of projected increases in output from supplementary feeding. Milk offtake would increase 58% and beef production 36%, providing a 21% per annum increase in protein production per stock unit.

If similar increases are projected for the whole of the Nigerian subhumid zone (Paper 2), an extra 2.7 million kg of protein worth some 95 million Naira per annum would result. This huge untapped potential suggests that there should be very attractive returns to research into improved cattle nutrition. However, the slim margins evident at the herd level (Annex 1,

Table 9) suggest that either a cheaper source of quality feed must be found and/or the cattle raised must be more productive than the unimproved Bunaji. ILCA is exploring both these options, through research on improved forage and crossbred cattle.

NEW CROP-FORAGE TECHNIQUES

Undersowing of cereal crops with Stylosanthes

The research on undersowing of cereal crops with Stylosanthes has shown that it is possible to maintain cereal yields at a reasonable level while producing useful quantities of high-protein fodder (Paper 15). However, time of undersowing is critical and the intervention is likely to be adopted only when land and animals are owned by the same person. It will be more appropriate when livestock are few relative to land area cultivated - as, for instance, in feeding draught animals - and where land will subsequently be left fallow. Nevertheless, farmers in one of ILCA's case study areas have shown considerable interest in undersowing.

Annex 2 analyses the trade-offs in terms of varying prices for the varying yields recorded. The sensitivity analysis allows readers to assess the merits of undersowing according to their own judgement of relative prices. This approach has been taken because it is impossible to obtain any consensus on the farm gate prices of Nigerian agricultural commodities. In Nigeria they vary; by district, by season, by year, according to quantities imported and due to actual or supposed political moves. In the last 12 months the farm gate prices recorded for sorghum grain have varied from 40 Naira per 100 kg bag to peaks approaching 200 Naira.

In ILCA's own case study areas there is no established market for fodder, although there is one in adjacent northern areas where grazing pressures are greater. Fodder marketing will probably spread southwards with increasing settlement. If it is assumed that crop residues are worth 0.05 Naira per kg and sorghum grain 0.40 Naira per kg, then the Stylosanthes hay would have to be worth between 0.10 and 0.20 Naira per kg to break even (Annex 2, Tables 1 and 2). At any value above that it would be profitable to grow. For example, at 0.25 Naira per kg of Stylosanthes hay returns per hectare would increase by 22%. The cost of lost grain will be a relatively

cheap price to pay for establishing the legume on land that will subsequently be left as a legume fallow. The benefits of planting Stylosanthes rather than relying on natural fallow have not been quantified, but there are encouraging results from bioassay trials and soil quality measurement (Paper 15). Although the fallow land that farmers can control is limited in heavily farmed areas, it could be an important source of feed during the nutritionally critical late wet season, when the presence of growing crops limits grazing.

If forage legumes can be found that compete less with the crop, so much the better (Paper 15). Sorghum is by no means the only cereal crop, and maize in particular is gaining in popularity. This trend could herald problems for the livestock sector owing to the earlier deterioration of the crop residue's feeding value. However, maize is much better suited to undersowing, and IICA's trials suggest that the trend towards it may be turned to the advantage of livestock by undersowing techniques (Paper 15).

Crop geometry adjustments to accommodate two-crop - one-forage mixture

By combining the undersowing of sorghum with soyabean and the inter-row sowing of Stylosanthes, subsistence crop yields can be maintained (by doubling the plant population per unit area) whilst growing considerable quantities of forage (Paper 15). Conditions for the use of this technique are much as indicated above for undersowing, but where the legume will be in rotation rather than left as a fallow crop.

The sensitivity analysis again suggests that the legume fodder need not command high prices for this to be a worthwhile approach.

Establishment and utilization of legume fodder banks

Fodder banks still need further testing and adaptation, but this intervention is receiving very encouraging support from producers and extension workers. The aim is to produce fodder for supplementing the low-protein diet from natural range for a selected proportion of the herd (Paper 16).

An economic appraisal of fodder banks is given in Annex 4. The assumptions used in the appraisal are considerably less ambitious than those used in typical livestock project analysis (Botswana, 1977; von Kaufmann, 1979). The fodder bank model priced in Annex 4 Table 1 is the 'blue-ribbon' one using metal posts and sheep-proof fencing. The utilization of bush poles (preferably for live fencing) and three-strand barbed wire would reduce costs considerably. As can be seen from Annex 4 Table 14, the cost of the 'blue-ribbon' model is equivalent to 12% of the herd value. On existing evidence the fodder bank would repay that in 2 to 3 years just by saving stressed animals. If the fodder bank is financed with loan capital at 7% per annum over 5 years, the repayments amount to about 24% of initial annual earnings.

Given the average Stylosanthes yields achieved in 1981 and 1982, it is cheaper to provide protein from fodder banks than from cottonseed cake (Annex 4, Table 4). When inflation is taken into account, the Stylosanthes has a distinct advantage because the recurrent costs are less. A further hidden advantage is that the labour input into the fodder bank may not have to be paid for by livestock owners or their families, since they may be able to fit fodder bank construction and maintenance into off-peak periods.

As in the case of feeding with cottonseed cake, the cash flows do not look very attractive in the early years. However, this conclusion is belied by the very strong interest of livestock owners (Paper 18). The fact that the milk benefits accrue largely to the women (supplementary paper) has not dissuaded the men from either using their own cash or incurring substantial debts to acquire fodder banks. Despite the poor season of 1983, when forage yields were half those of previous years, the drop-out rate among participants was low and several fodder banks were expanded (Paper 19).

The major deterrents to the adoption of fodder banks will be the difficulty of acquiring sufficient land, and the problems of operating a complex management system (Paper 16). Fire is also a serious hazard and, as 1983 proved, there will be years when poor rainfall limits yields (Paper 19).

The greatest danger that needs urgent resolution is the dependence on virtually one legume variety: Stylosanthes hamata cv Verano (Paper 16). New varieties resistant to anthracnose are urgently needed, as also are suitable legume/grass mixtures.

Use of fodder banks for improved crop production

Research on cereal cropping within fodder banks is being carried out for three reasons. Firstly, the improved fertility and texture contributed to the soil by legumes should be exploited for food cropping. Secondly, improved food crop yields from fodder banks will encourage livestock producers to obtain, and farmers to permit, the use of the necessary land for fodder banks. Thirdly, the presence of crops will make the fodder banks more secure because of the strong tradition of public respect for crops.

As reported in Paper 15 the results of this research are encouraging and conform to expectations based on Australian and other work, but there are not yet enough data on which to base an economic analysis. The trials need to be extended to include farm-level production so that the labour inputs can be determined. This work will have to be sensitive not only to the direct cost of labour but also to any opportunity costs, such as delays imposed on other operations.

CROSSBRED DAIRY PRODUCTION

Once pastoralists can produce their own fodder they will want to use it better by keeping more productive cattle. Crossbred Friesian x Bunaji cows have repeatedly shown the potential to give double the milk offtake of indigenous stock (von Kaufmann, 1979). They are more susceptible to endemic diseases, but experience suggests that this problem can be overcome by reasonably simple techniques (Paper 8).

No firm conclusions can yet be drawn, but the models in Annexes 5a and 5b suggest that, even with a low milk output of 712 litres per cow per annum, crossbred dairy production is economically viable if milk can be sold at current direct (producer-to-consumer) prices. These prices will probably be maintained or else rise for as long as the government limits powdered milk imports, which it will doubtless continue to do, given its determination to raise domestic milk production (Federal Ministry of Agriculture, 1981) and encourage the spread of crossbred animals. Crossbred dairy production is therefore an appropriate line of research for the medium or long term.

Given adequate nutrition and management, the milk offtake from just two crossbred cows approaches that from a whole herd of Bunaji cows under traditional management. This quantum jump in output is bound to cause problems in uptake: firstly, wives will find it difficult to dispose of the large extra quantities, and secondly, the producers' neighbours will suffer reduced prices. Milk collection schemes cannot operate unless there is surplus local production, which will not materialize until there is an adequate outlet. The Subhumid Zone Programme is preparing a research proposal which, if accepted, will shift the main location of ILCA's crossbred trials to the peri-urban areas of Kaduna. If a milk collection and marketing scheme can be successfully launched in these areas, further schemes can be designed for more remote locations.

The potential impact of crossbred dairy production is enormous. Crossbred genes could be spread very rapidly by artificial insemination. Through the Smallholder Fattening Scheme Nigeria has considerable experience in keeping small numbers of cattle on supplementary feed. The country's high population and many urban centres make milk marketing far more feasible than in many other African nations. Domestic demand for milk has been projected at 1 053 600 tonnes in 1985, with 576 900 tonnes being imported. The figure for imports is based on optimistic assumptions that the national herd will have grown to 13.9 million head, that 69% of all cows will be in milk, and that each will yield an offtake of 630 kg per annum. The truth is that Nigeria will need all the milk it can produce.

INDIRECT SPIN-OFFS FROM THE RESEARCH PROGRAMME

While impact at the producer level is the main objective of ILCA's programme, the research has had other spin-offs. A comparison between problems and attitudes in 1978 and those of today indicates some of the effects that ISR is having on policy making for livestock research and development in Nigeria.

Development policies in 1978

Despite evidence from van Raay (1975) and others that many of the Fulani were semi-sedentary, Nigerian development and extension agencies in 1978 were almost totally preoccupied with the need to induce the nomads to settle. The solution to the 'problem' of settlement was thought to lie in the creation of grazing reserves planned according to standard range management practice. The plans called for year-round rotational grazing, excluded cultivation and made no reference to linkages with agriculture. That only a small proportion of a national herd with a grazing requirement of over 30 million ha could be catered for by even the most ambitious grazing reserve programme, was a problem never properly addressed. Large sums of money were invested in infrastructure such as dams, access roads and firebreaks, buildings for extension staff and milk collection centres. None of these inputs were adapted to communal grazing/multiple ownership systems, and as a result there was little motivation for contact between extension staff and pastoralists.

Animal husbandry and forage innovations were limited to the keeping of a few demonstration cattle and the introduction of highly mechanized pasture development of dubious relevance to pastoralists. Sporadic attempts to increase production relied on the provision of subsidized unrationed feedstuffs, particularly at times of drought. Whilst a lot was being done for the pastoralists in terms of communal facilities such as watering points and range management schemes, routine veterinary services were virtually the only relevant and successful government input at herd level.

Understanding of livestock numbers and their distribution through time and space was based more on opinion than on verified facts. In particular, the subhumid zone was thought to be only a dry-season grazing area for nomadic

cattle, with little permanent settlement. Rapid remote sensing techniques had only been applied in a minor way for wildlife, and had yet to be developed for the study of livestock distribution and human settlement patterns.

Research policies in 1978

In 1978 there was little contact between livestock research and livestock development. The prevailing opinion, endorsed by ILCA, was that research was far ahead of development and that the great need was to implement what was already known. This was so strongly held that the ILCA team was not provided with any experimental plots or animals. All its work was to be done directly with pastoralists' herds on the basis of existing knowledge. This situation has been remedied by the combined generosity of the Kaduna State Government, the National Livestock Project Unit and the Federal Livestock Department, who helped the team acquire land and animals for research.

Production systems were not understood because they had not been studied, particularly as regards crop-livestock interactions. Research on livestock production was confined to research stations. Apart from veterinary work, contact with pastoralists was restricted to questionnaire surveys. Project funding for research was directed only towards pasture development on ranches, and in the event hardly utilized. NAPRI was not directly involved in ISR. And there were no sites for demonstrating ISR techniques and products to extension staff.

Whilst the need for improved nutrition for cattle in the subhumid zone had been widely recognized and promising legumes and grasses had been tested at research stations, little was being done to develop suitable techniques for pastoralists to grow or utilize their own forages.

Development policies in 1984

ILCA participated in the subsector review of the Nigerian livestock industry (Federal Ministry of Agriculture, 1981). Research results from the Subhumid Zone Programme were thus used to help formulate development policy. In particular, ILCA provided much of the baseline productivity

data on pastoral cattle. The ISR results helped redirect the thinking of policy makers towards the needs of settled pastoralists. The importance of crop-livestock interactions was recognized, as were the need to incorporate grazing reserves into the overall land-use system, the potential of dairying and the linkage between the sale of dairy and grain products (Supplementary Paper). The significance of these factors is already so widely accepted that it is easy to forget that it was not always so.

IICA data have been used to devise the settled pastoralist and mixed farmer models now being prepared for the Nigerian Second Livestock Development Project. Advice to pastoralists on forage production has replaced grazing control as the main function of grazing reserve extension staff. IICA has acted as a catalyst for development through on-site demonstrations in the course of its trials, and through helping to produce a promotional film for the National Livestock Project Unit. IICA has also conducted courses for extension staff.

Research policies in 1984

The members of the 1980 Livestock Subsector Review were repeatedly frustrated by the lack of reliable data on livestock numbers and distribution. Even when cattle were known to be in an area it was frequently not understood why, nor what association they had with other components of the physical and socio-economic environment. Estimates of the national herd varied by about 40%, which made all projections highly tenuous. The subsector review recommended a nation-wide aerial survey.

By 1984, rapid resource survey techniques had been developed which enabled the relationships between livestock, agriculture and infrastructural development to be quickly and cheaply determined. Nigeria's aerial survey results can now potentially be correlated with remote sensing data and verified by ground truthing. Photographic techniques have been developed and tested which allow cropping patterns to be enumerated even in mixed cropping systems.

As of 1984 the IICA team has had 5 years' practical experience in ISR and has developed methods for others to use. If the baton can be passed on to national teams (Paper 20), significant and more widespread impact will result.

ILCA has specific training activities in which many Nigerians have participated. Additionally, graduates on National Youth Service have been posted to the Subhumid Zone Programme, and personnel from State Ministries of Agriculture have been seconded to the programme for periods of 1 year. Visits to the programme by university staff and students have also been arranged to complement existing field training facilities.

FUTURE RESEARCH

The research objective set in 1979, namely to find ways of improving cattle nutrition, is still the focus of the ILCA Subhumid Zone Programme. Nothing that has since been discovered suggests that the objective is either inappropriate or unattainable, though it is certainly more complex than initially perceived. Research by national institutes and ILCA should therefore continue to follow the present lines, but with the emphasis changing even more towards component research and intervention testing. The following major research objectives have been identified:

1. New legume varieties must be found and management systems developed to suit them. The present dependence on just one variety of Stylosanthes is very dangerous because of the threat of anthracnose.
2. Legume-cereal crop interactions are of the utmost importance to the future of forage production in the zone. Work on identifying the best techniques and management systems for particular target groups must continue.
3. Crop-livestock interactions need to be studied further with a view to improving the feeding value of crop residues. Work on draught power should also be initiated.
4. Nutrition research needs to look more closely at the feeding of calves, since it may be more cost-effective to reduce calf mortality this way than by increasing milk production.
5. The number of crossbred cows and participant dairy producers should be expanded to provide a basis for statistical analysis. The research should be conducted closer to Kaduna urban markets.

6. The nutrition of cattle through fodder banks should continue to be a two-way study: effect on cow, effect on legume. The design of the research should reflect the opinions and practices of beneficiaries.
7. Animal health research should concentrate on diseases that may increase with or affect the adoption of interventions. Tick-borne diseases, reproductive disorders and trypanosomiasis are pertinent examples.
8. Possible interventions for small ruminants include disease control, improved male-to-female ratios and late wet-season feeding. These interventions should be tested on flocks belonging to both farmers and pastoralists.
9. Extension and its credit and supply back-up will have to become an important subject of research, the objective being to design interventions with minimum dependence on extension and credit whilst at the same time seeking to improve the effectiveness of essential extension services.

CONCLUSIONS

As it gains in experience, ILCA's Subhumid Zone Programme will contribute more to livestock research and development in Nigeria. Over time, increasing emphasis is being laid on component research and implementation testing. If the research is continued, its cost-effectiveness will thus improve. The past investment in understanding the system will increasingly pay off as essential knowledge, which was not available in 1978, is used to design more appropriate interventions for testing. At the same time this store of better knowledge will enable the programme to provide government with data that will help improve policy decisions. Finally, close cooperation between ILCA and NAPRI in future years should eventually enable the latter institute to take the lead and expand its activities in national LSR.

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Supplementary paper 1

Dairy subsector of the agropastoral
household economy

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ABSTRACT

A study was made of the dairy subsector of the agropastoral household economy. In contrast to reports on nomadic Fulani, milk was not found to be the basis for subsistence. The staple foods are cereals, provided primarily by the men from proceeds of cattle sales or from their own farms.

The pattern of resource control and decision-making in Fulani households is such that milk production is separate from milk processing and marketing. The women generally have little influence on decisions concerning cattle management. Milking is done by men and boys, who determine how much is extracted and how much is left for the calf.

The amount of milk a woman receives from the herd depends not only on the level of milk offtake but also on socio-economic variables. In the average Fulani household monitored in Abet, two women each receive about 3 kg of milk per day from the herd, more in the early wet season and less in the late dry season. Each woman decides independently how much of the milk allocated to her is consumed at home, how much is sold, the form of consumption and sales, and the extent of dilution.

The women try to generate more income from the portion of milk sold by diluting it when they expect demand to exceed supply on the market. The other major way of influencing nono (skimmed sour milk) income is to sell the milk together with prepared cereal foods, most commonly fura made from

millet. If they sell milk with fura, the women can earn about one third more per measure of milk than if they sold it as nono alone.

Dairy products are not the sole source of income for settled Fulani women; they also sell prepared foods and occasionally small livestock, and engage in petty trading.

The women have complete control over their income. They are expected to use part of it for food purchases such as vegetables or seasonings to supplement the cereals bought by the husband.

Because the men who pay for production inputs and manage the production and offtake of milk have no influence on milk marketing and the use of milk income, and expect little help from the women in meeting herd expenditures, it is unlikely that innovations to increase milk production will result in substantially higher milk offtake rates. The men express primary interest not in milk offtake but rather in calf survival and growth as a means of increasing herd size.

INTRODUCTION

The agropastoral household is by no means in the complete control of the male household head. Decision-making and control over inputs, products and revenues of production are influenced by other household members and, in some aspects, are virtually out of the hands of men. In designing and extending innovations in the production system, the pattern of resource control within the household must be taken into account.

It was evident from previous research that Fulani women have rights to milk from the cattle herd: when Stenning (1959), Hopen (1958) and Dupire (1963) carried out their studies in the 1950s, the main source of subsistence for nomadic and semi-nomadic Fulani was milk, either consumed at home or exchanged for grain, and the women did the milking, processing and marketing of milk and obtained the grain for family consumption. Because ILCA is testing innovations for intensifying settled rather than nomadic pastoralism and because these innovations involve milk production, a study was made of the economic role of settled Fulani women with emphasis on dairying.

In-depth studies were made of eight Fulani households in the Abet case study area by means of informal interviews with active household members and observations of their economic activities and interactions within the family and with other members of the pastoral and farming communities. Particular attention was given to the 16 women who received milk from the herds. Additional data were obtained on other Fulani households in the area during occasional visits as well as through informants from the case study households. Beginning in 1984, measurements are also being made of milk products processed, retained for family consumption, and marketed by 12 Fulani women with whom close rapport had been established over the previous 2 years of qualitative studies. Dairy earnings are recorded and related to type of product and rate of milk dilution so that income per litre of processed fresh milk equivalent can be calculated.

Compared with nomadic Fulani groups described in the literature, the diversification in production and income-earning activities of the settled Fulani to include cropping, trading, paid employment, etc, has been accompanied by a change in cattle production orientation. Milk is not the basis for subsistence in the agropastoral economy in the study area. The main source of household income is the sale of livestock: cattle, sheep, goats and poultry. This change in the relative importance of milk in the household economy has implications for the influence of women in the production unit and for externally initiated efforts to develop dairy production.

In the households studied, the women's prime economic role is still in dairying but there are two significant differences from earlier descriptions of nomadic Fulani:

1. Men or boys rather than women usually milk the cows and can thus control milk offtake rates.
2. The staple foods - cereals - are provided primarily by the men from proceeds of livestock sales or from their own farms rather than by the women from dairy proceeds.

HERD MANAGEMENT AND MILKING

Herd management is a male domain. The extent to which a herd thrives, multiplies and produces milk is seen as a reflection of the herd manager's abilities. The women may have had some herding experience as unmarried girls but, as a rule, are not involved in herding or other aspects of animal care. They generally have little influence on such herd management decisions as selection of grazing sites, length of grazing day, supplementation of cattle diet (e.g. with salt), and breeding decisions, all of which could influence milk yield.

However, on decisions concerning cattle sales, women are consulted or make their opinions felt. Animals which belong to the women or their children cannot be sold without the women's consent and even in the case of cattle belonging to the male household head, the women participate in discussions about the need to sell. If a man sells so many productive animals that he drastically reduces the milk supply to a wife, then - in the eyes of the Fulani community - she is justified in leaving him.

Among these settled Fulani milking has become, like herd management, a male domain. The cows are milked only once a day, in the morning; the evening milk is left for the calves. Neither men nor women in the case study household could remember ever having discussed the merits of milking only once daily, as opposed to the twice-daily milking reported in the literature on nomadic Fulani. Invariably, they said this is done because they and their fathers before them have always done so. However, conscious decisions concerning milking are made in the late dry season, when many Fulani stop milking weaker cows and a few stop milking entirely for some weeks. The herd manager makes these decisions and the women seldom ask for justification, for they are aware that grazing is poor at this time of the year and that some cows cannot even produce enough milk for their calves. The women are very conscious of the relationship between fodder (both quantity and quality) and milk yield, and use these concepts to explain fluctuations in milk quantities received from the herd.

Only if the cow belongs to her or her child by a previous marriage does a woman feel she has the right to decide whether or not a cow should be milked - e.g. at times of feed scarcity, or in the first days or weeks after calf

birth. The women are interested in the survival of their calves and generally rely on the judgement of the milker - the husband, son or hired herder - whether the cow is producing enough to be milked.

The decision as to how much is extracted at milking and how much is left for the calf is made primarily by the milker. The women feel they can exert little influence on their husbands but somewhat more on their children to milk more intensively, and therefore encourage them to help with the milking. The women believe that, if they were to do the milking themselves, they could extract more milk but still leave enough for the calves. The men, however, generally believe that the women would take more milk so they could sell more, and the calves would suffer.

These differences in viewpoint are related to different emphases given to production aims by men and women in the settled Fulani households. The men express primary interest in calf survival and growth as a means of increasing herd size. Larger herds are desired partially for reasons of prestige but also in order to have more animals available for sale when the man wishes to make large expenditures for himself or his family, e.g. purchase of bags of grain, bicycle or motorcycle, hiring labour, purchasing materials for house construction, marriage and child-naming ceremony expenses, or financing a pilgrimage to Mecca. Most of the women feel that the highest possible milk offtake is the most important production aim from their own point of view; some nevertheless consider the production of saleable animals to be more important for the family as a whole because of the greater income generated. All women are also interested in herd growth, reasoning that a larger herd would yield more milk. In summary, the women generally lay more emphasis than men on milk offtake as a production aim, but can also recognize the longer-term benefits resulting from the men's concern for calf survival and growth.

ALLOCATION AND UTILIZATION OF MILK

The amount of milk a woman receives from the herd depends not only on the level of milk offtake but also on the number of women in the household, their relationship to the household head, and the pattern of livestock ownership.

The manner of milk distribution from the husband's animals varies between households. The milk from specific cows may be given to specific women, or the combined milk from all cows may be divided among the wives, or all milk extracted on one day may be given to one wife and all milk extracted the next to another. The men point out that, according to Islam, co-wives must be treated equally; therefore, each wife receives an equal amount of milk from the husband's animals. Because no actual measurements were made of the milk allocated to each wife, this could not be verified. Only one man said he allocated milk according to need; i.e. according to the number and age of each wife's children.

A woman receives milk from all the cows which belong to her or which she is holding in trust for her children by a former husband as well as, in some cases, from animals which her present husband has given to their mutual children. A wife with more dependents might thus receive a greater proportion of milk from the total herd. Other women living in the homestead, e.g. mother or divorced sister of the husband, are also entitled to milk from the herd but, unless they own milking cows themselves, do not receive as large a share as the wives. Thus, every woman in the household has a right to receive milk but has little influence on the portion allocated to her unless she and her children own cattle within the herd.

To give an idea of the amount of milk a settled Fulani woman can expect to receive, the following calculations were made on the basis of production monitoring data. A herd of 40 cattle (average size of herds monitored in the Abet area) has 9 lactating cows on a yearly average. As the average settled Fulani household includes two women, each would receive milk from more or less 4.5 cows. At a mean milk yield of 0.7 kg/day, a woman would receive about 3 kg of milk per day - more in the wet season when production levels are higher and less than this average in the dry season.

Each woman decides independently how much of the milk allocated to her should be consumed in the household, how much should be sold, the form of consumption or sales (as whole or skimmed milk plus butter, fresh milk or soured), and the extent of dilution. Men appear to have little influence on the division between home consumption and sales. They may request their wives to give the children more milk, but they cannot demand this. The women's attitude is that the men have no right to complain if they are not

managing the herd well enough or milking intensively enough to supply the women with sufficient milk for both family and sales.

According to estimates made by the women, they generally sell about half the milk they receive from the herd. Measurements of home consumption and sales have confirmed this. Milk is thus providing the average cattle-keeping household in the Abet case study area with less than 10% of daily energy requirements (2300 kcal per adult equivalent), but a higher proportion of daily protein needs. The greatest part of total nutritional requirements is derived from cereals, which are the basis for all major dishes in these households.

MILK PROCESSING AND MARKETING

A woman has some degree of influence over the amount of income she can generate from the portion of milk sold, depending on the products sold and the method of selling. In the study area, nono (skimmed sour milk) and butter are the most common dairy products; whole milk, either fresh or soured, is seldom sold and, then, only on special request by customers.

The value of nono depends greatly on the way it is sold. If the buttermilk is added to the skimmed milk, as is most commonly the case, the water which was added during the butter-making process increases the total volume of liquid. Milk can be further diluted with water and kuka, a thickening agent made from the pulp of baobab pods. Dilution may be practised throughout the year but is greatest in the late dry season: in February and March of 1984, over half the measured liquid sold as nono consisted of water and kuka. At a given time of year, the extent of milk dilution appears to have little effect on price per measure of liquid; it therefore affects the price per kg of actual milk in the liquid. For example, in March 1984, women selling in Zonkwa received around 0.40 Naira per kg of liquid but between 0.75 ₦ and 1.10 ₦ per kg of actual nono, depending on dilution. The women, all of whom sell mainly to regular customers, claim they dilute to the extent that their customers accept it.

The other major way of influencing nono income is to sell nono together with prepared cereal foods, most commonly fura made from millet. According to the women's estimates as well as current measurements, if they sell with

fura they can earn about one third more per measure of nono than if they sold only nono. This is additional to profits made by processing purchased grains to fura. If few or no cows are being milked in her family's herd, a woman may purchase milk from households with larger herds and resell it with fura at a gain.

However, fura preparation (preparation of flour from grains, cooking, kneading, forming of balls) is demanding in terms of time and energy. The kneading of the cooked fura mass is particularly strenuous work. The women in the case study households usually sell milk every second day and, because almost all sell with fura, they or their daughters must spend about 2 hours every second morning on fura preparation. Older women and women without daughters of working age are not always able, for lack of sufficient strength or time, to make fura to increase the sales value of their nono.

A woman can also generate more income from her dairy products if she is prepared to sell directly to consumers or sell at markets where more favourable prices can be obtained, rather than selling to intermediaries - usually other Fulani women - who resell nono with fura, or resell nono alone at markets with higher demand than those close to the milk producers. In the study area, direct sales are far more common than sales to intermediaries.

The women in the case study households sell about twice a month at the local weekly market, whenever this falls on one of their normal selling days. They seldom visit more distant markets to sell dairy products, but more often to make purchases. Most of their selling is done about three times weekly in farmers' homes, fields, places of employment and meeting places within a few kilometres of the Fulani homestead. Most customers are regular, i.e. they buy from the same woman at least once a week. In some cases the customer is regarded as a close friend, and prices charged tend to be lower than on the market. The Fulani women value the social contacts involved in selling to regular customers and also value the services and gifts, such as bundles of millet at harvest time, which they receive from such farming households.

Most of the dairy earnings are in cash; the women seldom exchange directly for grains as described in earlier literature on nomadic Fulani, and when

they do, the grain is normally used to make fura to sell. Dairy income constitutes roughly one third of total cash income from the family herd (Table 1), and makes up a still smaller portion of total household income. However, it is significant that dairy earnings provide a steady source of cash, whereas the larger sums of money from livestock sales are available to the household only at lengthy and irregular intervals.

Table 1. Estimated income of settled Fulani household from cattle herd^{a/}.

	Average herd in Zonkwa area	Average herd of IICA participating Fulani
No. of cattle	50	40
Annual offtake	6	4.8
Annual income from cattle sales (₦):		
50% @ 700 ₦/head	2100	1680
50% @ 150 ₦/head	<u>450</u>	<u>360</u>
	2550	2040
Annual income from manure (₦)	<u>50</u>	<u>40</u>
Total annual non-dairy income (₦)	2600	2080
No. of milking cows (23%)	11.5	9.2
Annual milk offtake (litres) (0.7 litre/cow/day)	2938	2350
Whole milk equivalent marketed (litres) (50%)	1469	1175
Annual household income (₦) from milk marketed as butter and diluted <u>nono</u> with <u>fura</u> (0.80 ₦/litre)	1175.20	940.00
Annual dairy income/woman (₦)	587.60	470.00
Total annual household income from cattle herd (₦)	3775.20	3020.00

^{a/} Average household: 10 persons, including 2 women receiving milk from herd.

OTHER SOURCES OF WOMEN'S INCOME

Besides dairy products and prepared foods such as fura, the only other major source of income for women in this study is the sale of livestock - sheep, goats, poultry and, more rarely, cattle. Of lesser importance is petty trade, e.g. buying kerosene, salt or palm oil in large quantities and reselling them in smaller quantities in the local market or to neighbours. Although the sale of dairy products is still the main source of income for the women in this study, settled Fulani women are diversifying into income-

generating activities other than dairying. This may be because they have little direct influence over the amount of milk they receive from the herd, but also because there are more opportunities to engage in other activities when settled rather than nomadic. Moreover, there is a greater tendency to buy consumer goods which would have encumbered a household that was still mobile. The reason most commonly expressed by the women for seeking other sources of income is that they are not receiving enough milk to meet their needs and desires. Whatever the reasons for diversification, the facts remain that:

1. The agropastoral production unit as a whole is not primarily a dairy enterprise.
2. Even the women's subsector is not exclusively concerned with dairying.

TYPES OF EXPENDITURES BY WOMEN

The Fulani women have complete control over their income; they are not obliged to inform their husbands about their earnings or expenditures. The major food expenses of the household are for grains purchased in bulk by the husband. The women are expected to use part of their dairy earnings for small daily or weekly food purchases such as vegetables and seasonings to supplement the grains. However, in the dry season when milk production is low, the husband may also have to provide some money for such purchases. In any case, the largest category of expenditures by women is for foodstuffs and food preparation, e.g. machine-grinding of grains in the village or town.

In order to reduce food expenditures, most settled Fulani women keep kitchen gardens with a variety of vegetables, spices, and shrubs and trees bearing edible leaves and fruits. Some women also have small plots of okra, cocoyam or rice, although little money is invested in gardening. The small quantities of seed involved are usually saved from previous years or obtained as gifts from neighbours. Labour for making ridges is usually provided by husband or son, although some women reported having hired local farmboys to do this work.

Each woman purchases goods and supplies needed for her own hut and dependents, including cooking utensils, kerosene, toiletries and medicines. They buy all that is required for processing and marketing milk, including calabash bowls and butter churns, kuka to stretch the milk, and lime to paint the calabashes taken to market. Of their non-food expenditures, the largest are for clothing (in addition to that bought by the household head for his wives and children).

INVESTMENT IN AGROPASTORAL PRODUCTION

Occasionally, a woman uses her savings to buy a sheep or a goat. The former is kept by her husband or son with his own sheep; the latter is most commonly kept by the producer from whom it was bought. Most Fulani women regard small ruminants as a profitable form of investment, but regret that they can seldom accumulate enough to purchase animals. Only one case was encountered of a Fulani woman purchasing cattle (two head).

Most Fulani women in the study area personally own no or few (less than five) cattle, usually received from their parents, and make no contribution towards expenditures for cattle husbandry or grain farming. This is thought to be the man's responsibility. The women see little reason even to help pay for inputs such as supplementary feeds to increase milk production. However, in the few cases where women own or hold in trust a substantial portion of the herd (a quarter or more), the women contribute towards the purchase of the traditional salt supplement kanwa and towards cattle vaccination costs.

The main reason given by the women for their unwillingness to invest in the herd is that they cannot be sure that the benefits of their investment will be returned to them in the form of milk. Longer term benefits from herd growth are rendered uncertain by the possibility of divorce. The women also point out that the men's income from animals is considerably more than their own income from milk; thus, the men are better able to pay for production inputs. The Fulani men say they see little reason to extract more milk to give to their wives, because the women are not helping to buy feed and medicines for the animals or grains for the family. Investments in milk production which may appear profitable if calculated on a household basis could therefore encounter cash flow problems on account of the

decision-making patterns and largely separate cash cycles in men's and women's spheres within the Fulani household.

IMPLICATIONS FOR DEVELOPMENT OF DAIRY PRODUCTION

Innovations such as dairy crossbreds, supplementary feeding or fodder banks require expenditures by the production unit for inputs. In the study area, such innovations are not likely to increase milk offtake for human consumption as projected because the men who pay for the inputs have control over their allocation to specific animals as well as over milk offtake, and can direct the benefits of higher milk production into their own sphere, the production of animals per se. If the men were to extract the additional milk and give it to the women, they could exert little influence on the utilization of the additional income and could expect little help in meeting milk production expenditures. Better family welfare would be possible if higher milk extraction would lead to more milk being consumed in the household and/or additional dairy income being used to meet family needs rather than the women's personal wants, but this is not in the direct control of the men who make the investments in the herd.

Innovations in animal nutrition and breeding could lead via higher milk production to faster rates of calf and herd growth so as to permit higher rates of animal offtake from the herd. At prevailing prices in Nigeria, the sale of one additional healthy bull would bring the family more income than the entire annual dairy earnings of an average settled Fulani woman in the study households.

However, even if developments in agropastoral production lead to a greater emphasis on beef, the Fulani households will continue to take off milk and the women will continue their dairying activities, as long as they have access to dairy customers and have no other major source of income. If the men were to stop milking the herd entirely - and this has been considered by some Fulani men in the study area - they could achieve better calf nutrition, greater calf survival and possibly also higher fertility rates. However, for most Fulani men, this is not a realistic alternative over longer periods than a few weeks in the dry season, because a wife feels she has rights to some milk from the herd and might leave her husband if she were not satisfied in this respect. Moreover, the men value milk as part

of their own and their children's diet. Innovations to increase milk production could help to ensure that at least some milk can be extracted from the herd at all times of the year, even in the late dry season - in other words, that the milk demands of wives and children are met more adequately than at present - yet still permit the men to leave more milk for the production of animals.

However, such innovations are unlikely to permit the success of dairy development schemes based on production by settled Fulani pastoralists in the study area, because substantially greater quantities of milk will not be extracted from a system in which the men who manage the production and offtake of the milk have little or no influence on milk marketing and the use of milk income.

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Supplementary paper 2

Agropastoral herding practices and the grazing behaviour of cattle

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ABSTRACT

A study of grazing behaviour of herded cattle kept by settled Fulani pastoralists showed that a wide range of different feed resources are utilized, particularly during the dry season. Sorghum and millet residue grazing accounted for 12.6% of annual grazing time in Abet, a farming area, and for 6.6% in Kurmin Biri, a grazing reserve. It peaked in December with 65% of monthly grazing time in Abet and 50% in Kurmin Biri. Browsing accounted for 11.2% of annual grazing time in Kurmin Biri and 3.4% in Abet, with a peak in the late wet season, when browsing was 30% of monthly grazing time in March in Kurmin Biri and 8% in April in Abet.

Natural herbaceous vegetation was not differentiated in this study but includes fallow land, upland range, low-lying areas (fadama) and regrowth after burning on fallow and upland range. Fadama and regrowth after burning are utilized during the dry season, whereas fallow fields are preferred grazing during the early wet season.

Both herding and grazing time are however very short, with little more than 6 hours grazing per day on average over the year and only 5 hours per day during the late wet season. Compared with free-grazing animals, short herding time changes the diurnal pattern of grazing. When the day was divided into 2-hour periods the level of grazing was constantly high, above 70% for most of the year and around 50% in May, the transition period between wet and dry season. Walking accounted for most of the remaining

time, with little time spent on resting and ruminating during the herding day. Resting and ruminating account for almost half the time during daytime in the case of free-grazing animals.

Reasons for short herding and grazing times are discussed, and their implications for animal production are examined in view of the spatial and operational integration of farming and cattle herding and the possibilities of using different grazing resources.

INTRODUCTION

Grazing behaviour and grazing time of free-grazing cattle have been extensively researched. From the literature, Arnold and Dudzinski (1978) compiled data on the grazing time of beef and dairy cattle in the temperate and tropical zones. Much less, however, is known about the grazing behaviour and grazing time of herded cattle. Early work (e.g. Smith, 1961) merely stresses that restricted grazing and walking long distances have negative effects on cattle performance. In recent years more detailed studies of herded cattle have been made. Van Raay and de Leeuw (1974) pointed out that a wide range of different feed resources are used by pastoralists' herds in the semi-arid zone of Nigeria, particularly during the dry season.

This paper presents results of a study of grazing behaviour and forage resource utilization by herded cattle in the subhumid zone of Nigeria. The study was carried out over 2 years in Abet, a farming area, and over 1 year in Kurmin Biri, a government grazing reserve. Observations were made of the time when the herd left and returned to the camp (*ruga*) and predominant herd activities during the time out of confinement. These were classified into: walking, resting, watering, and grazing. Grazing was further subdivided into: grazing of natural range, browsing, and crop residue grazing. During the course of the study, it was decided to include grazing of burnt areas as an additional subdivision.

UTILIZATION OF FEED RESOURCES

As shown in van Raay and de Leeuw's study, pastoralists' cattle used a variety of grazing resources (Table 1). Grazing time on crop residues was about twice as long in the farming area as in the grazing reserve, whereas browsing accounted for eight times the grazing time in the latter than in the former area. In this study, crop residues included only sorghum and millet, but subsequent more detailed work on crop residue utilization in the farming area revealed that rice and soybean residues are also grazed to a considerable extent. Important browse species were Azelia africana, bamboo, Khaya senegalensis, Adenolichos paniculatus and Mucuna spp.

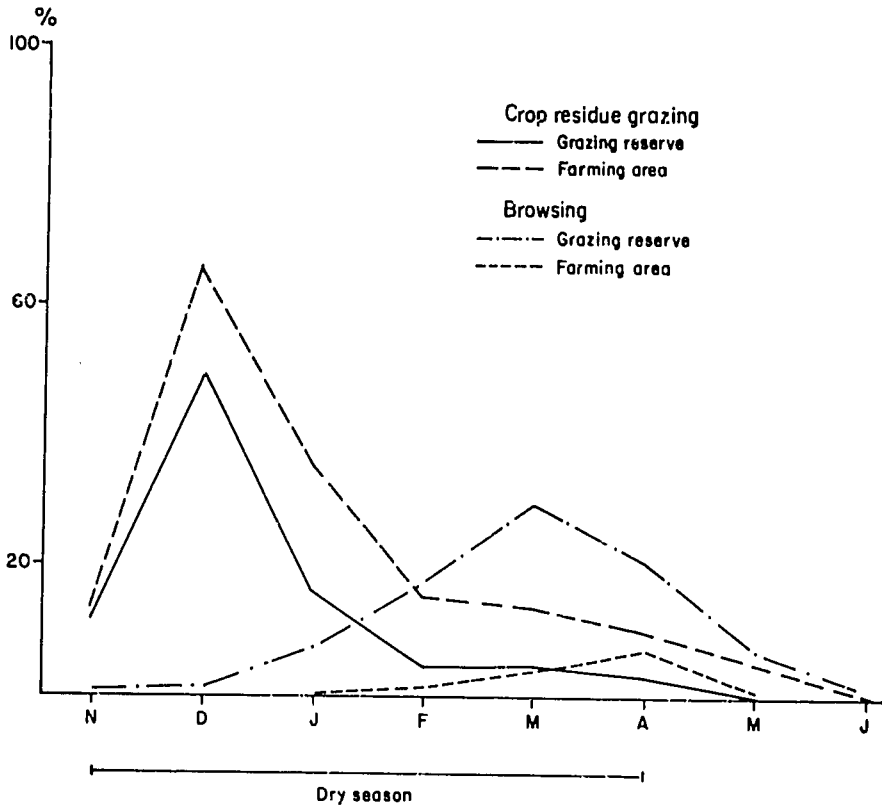
Both crop residue grazing and browsing were highly seasonal. A peak in crop residue grazing occurred in December after grain harvest, when it accounted for 65% of total grazing time in the farming area and 50% of total grazing time in the reserve. Browsing peaked in March, when it accounted for 8% of grazing time in the farming area and 30% in the reserve (Figure 1).

Table 1. Contribution (%) of different grazing resources to total grazing time.

Study area	Farming area (Abet)	Grazing reserve (Kurmin Biri)
Crop residues	12.6	6.6
Browse	1.4	11.2
Naturally occurring herbaceous layer	86.0	82.2
Average grazing time (hours/day)	6.1	6.2

Crop residues provided good-quality forage during the early dry season. Faecal nitrogen in December (the height of crop residue grazing) in the farming area was found to be 1.55%, corresponding to 9.7% crude protein, whereas by the late dry season it had dropped to 0.6% (Powell, personal communication). If faecal nitrogen falls below 1.3% animals respond to non-protein nitrogen supplements such as urea, indicating nitrogen deficiency in the diet ((Winks and Lainge, 1972).

Figure 1. Crop residue grazing and browsing as percentage of total grazing time in different months of the year.



In both study areas, more than 80% of total grazing time was spent on natural range (Table 1). During the second year of study, when regrowth on burnt areas was included as a distinct resource within natural range, the cattle in the farming area spent 19.3% of their total dry-season grazing time and 8.5% of their total wet-season grazing time on regrowth, which may contain more than 8% crude protein (Blair-Rains, 1978). The wet-season regrowth grazing was in the 2-month period before heavy rains began. Over the entire year, 13% of total grazing time was spent on recently burnt areas. In the case of cattle in the grazing reserve, corresponding figures were 22% of dry-season grazing, 7.9% of wet-season grazing, and 14.1% of total annual grazing.

Low-lying seasonally inundated (fadama) areas contributed primarily to dry-season grazing. The contribution of fallow land grazing was greatest during the early wet season. However, observations did not permit a detailed analysis of upland, fadama and fallow land grazing times.

Herding and grazing time

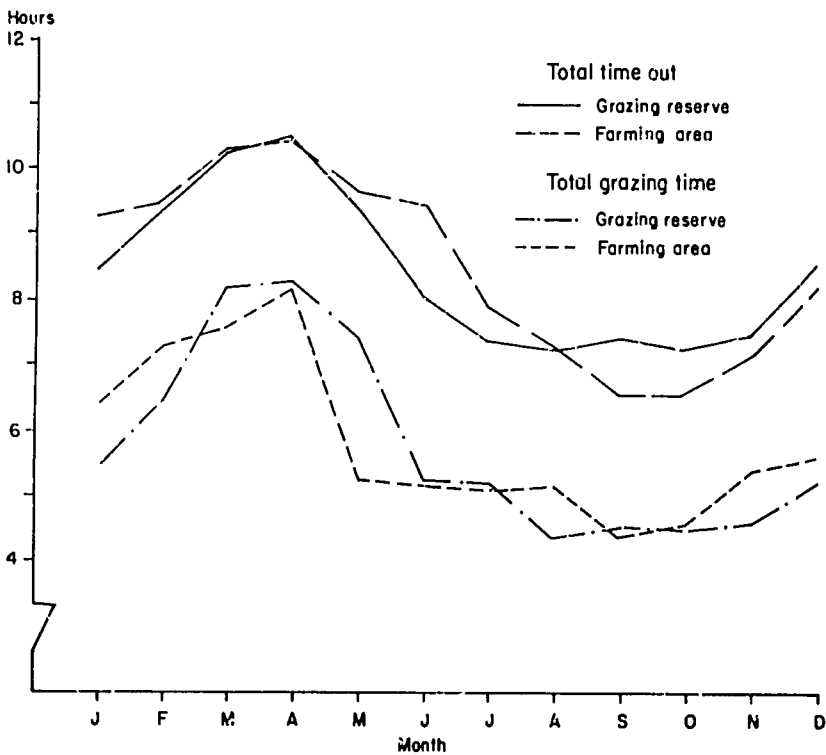
The cattle were herded for an average of 8.4 hours per day in the farming area and 8.8 hours per day in the reserve. The longest time out of confinement was recorded in April (period of scattered rains in the early wet season), when the monthly average was 10.8 hours per day in both study areas, and the shortest time in September (late wet season) with 6.9 and 7.5 hours per day in the farming area and reserve respectively. Walking accounted for about one quarter of herding time, whereas resting and watering together represented only 5% of total time out of confinement, with little difference between study areas (Table 2). Actual grazing time constituted roughly 70% of time out of confinement in both areas.

Table 2. Herd activities as per cent of total annual time out of camp.

Activity	Study area:	Farming area	Grazing reserve
Walking		20.6	25.5
Resting		4.6	2.5
Watering		1.7	1.5
Grazing		73.1	70.5
Average time out of camp (hours/day)		8.8	8.4

Herding and grazing time varied according to season. Longest herding time was recorded in April and shortest in September (Figure 2). Actual grazing time was little more than 5 hours per day in the wet season, reached 8 hours per day in the late dry season, and averaged only about 6 hours per day over the year as a whole. The general annual pattern of daily grazing time - longer in the dry than the wet season, with a peak when the first scattered rains fall - agrees well with the patterns of free-ranging domestic ruminants in similar climates (Smith, 1959; Wilson, 1961). However, the absolute daily grazing times of the herded cattle are very low compared with free-ranging animals.

Figure 2. Herding time (total time out) and grazing time of cattle in a farming area (Abet) and a grazing reserve (Kurmin Biri).



In the review by Arnold and Dudzinski (1978) of grazing studies in tropical and temperate areas, the average grazing time of beef cattle came to 9.5 hours/day; only 10% of the over 100 references indicated less than 7 hours/day and only 2% less than 6 hours/day. Stobbs (1974) found grazing times of up to 14 hours/day by dairy cattle in southern Queensland, Australia. Smith (1959) found similarly long grazing times by Zebu cattle in Zimbabwe when pasture quality was low. Moreover, night grazing by indigenous African cattle kept on pasture for 24 hours/day accounted for up to 25% of total grazing time (Haggar, 1968).

Restricted grazing

Effects of restricted grazing time on animal productivity have not been extensively researched. In Zimbabwe, Smith (1961) compared grazing behaviour and liveweight development of cattle allowed on pasture for 7 hours, 11 hours and 24 hours/day. The animals in the 7-hour treatment partly compensated for the shorter grazing day by deferring resting and ruminating until they were confined and by increasing feed intake per grazing hour. Nevertheless, they gained less or lost more weight than animals in the 11-hour and 24-hour treatments in the dry season, when pasture quantity and quality were low. Over the entire trial period of 16 months, liveweight gains per animal in the 7-hour treatment were only half those in the 11-hour and 24-hour treatments (37 versus 73 kg). These data suggest that short grazing time may be a factor contributing to the low productivity of pastoralists' cattle in the study areas.

Some reasons given by pastoralists for this relatively short grazing time were: increasing danger of worm infestation in early morning during the wet season; negative effect of wet-season dew on feed intake by cattle; difficulty of controlling animals with satiated appetite; and competition for labour between herding and cropping. Night grazing is avoided for fear of predators and thieves.

The arguments concerning control of satiated animals and labour competition deserve particular attention in the context of livestock-crop integration. Ethological studies show that towards the end of a grazing period some animals still feed, although probably more selectively, while others begin to ruminate or wander idly (Arnold and Dudzinski, 1978). A herd which

ceases to behave uniformly becomes more difficult to handle. The practice of grazing fallow and uncultivated fields adjacent to cropped land and grazing crop residues adjacent to unharvested crops demands tight herd control if crop damage is to be avoided. Cessation of herding before animal appetite is satisfied and behaviour begins to diversify reduces the danger of crop damage. Whereas young boys can handle herds in the dry season, it is necessary for older youths or adult men to accompany the cattle when grazing control is critical during the wet season and early crop residue grazing period. However, these people are also needed for land preparation, weeding and harvesting of their own fields. It is unlikely that the cattle can eat their fill during the short grazing time found in Nigeria. Fulani cattle allowed on pasture for 11 hours grazed for 7.5 hours daily in the wet season (Haggar, 1968).

TRANSHUMANT VERSUS SETTLED PASTORALISM

Transhumant herders, who use the study areas only in the dry season, leave camp each morning 1.5 - 2 hours earlier than the settled Fulani and, subtracting a mid-morning break in the camp for 0.5 - 1 hour, herd their cattle for about 1 hour/day longer. Those herders who bring cattle into the study areas during grain harvest herd their animals for up to 3 hours/day longer than do the settled Fulani in that period.

Reports from semi-arid savannas (Hopen, 1958; Barral, 1967; Riesman, 1977; Fricke, 1979) indicate that night grazing of cattle is practised by some transhumant groups. There is little information on productivity comparisons of these different pastoral systems. Wilson and Clarke (1976) found in Sudan that productivity was higher in nomadic than in settled cattle herds, yet recent work in Mali (Wilson, 1982) showed no significant difference in productivity indices between a transhumant and a settled cattle-keeping system. Van Raay and de Leeuw (1974) compared grazing strategies of nomadic and settled pastoralists in the semi-arid savanna of Nigeria, which has higher human and cattle population densities than in the subhumid savanna. The nomadic cattle were longer out of camp and generally grazed longer, but walked up to 30 km per day compared with a maximum of 14 km by settled herds. The settled Fulani were able to provide their cattle with a more varied and steady fodder supply within more confined areas, i.e. requiring less energy expenditures by cattle and herders. By virtue

of their closer association with cropping systems, settled Fulani appeared to have an advantage over nomads in terms of access to valuable grazing resources such as crop residues and fadamas.

In the study areas of the subhumid zone crop residue and fadama grazing is more abundant, relative to cattle density, than in the semi-arid zone and transhumant herds appear to have easy access to these resources. Camping and grazing of transhumant herds on farmland in the dry season is welcomed by the farmers, who appreciate the manure and the fact that the herds leave the area again before crop damage becomes possible. Transhumant pastoralists moving into these farming areas only seasonally are by no means disadvantaged and may even gain from their ability to utilize a wider ecological range of grazing resources than settled pastoralists; transhumant cattle are therefore likely to be more productive.

Herding and farming

The present systems of livestock-crop integration in the subhumid zone, whether involving settled or transhumant herds, are characterized by high labour inputs for animal control in order to make optimal use of space in farming areas. The restricted grazing time when pastoralism and cropping are spatially integrated is a constraint on animal productivity. However, partial compensation is gained through the herded animals' access to better quality feed on fallow and harvested land. Segregation of cattle keeping from cropping would sacrifice the better utilization of land resources possible within the present production systems and would lower the total animal and crop yields per unit area.

If the pastoralists could establish fenced pastures, at least selected productive animals could be allowed longer grazing times without extra labour requirements for herding. Such a combination of improved forage and a longer grazing day should bring substantial improvements in animal productivity. Expressed in terms of liveweight gain of the selected animals, increases of about 30 kg per head and year may be expected, calculated on the basis of Smith's (1951) data from Zimbabwe and the preliminary results of ILCA's fodder bank grazing experiments.

Diurnal grazing activity of herded cattle

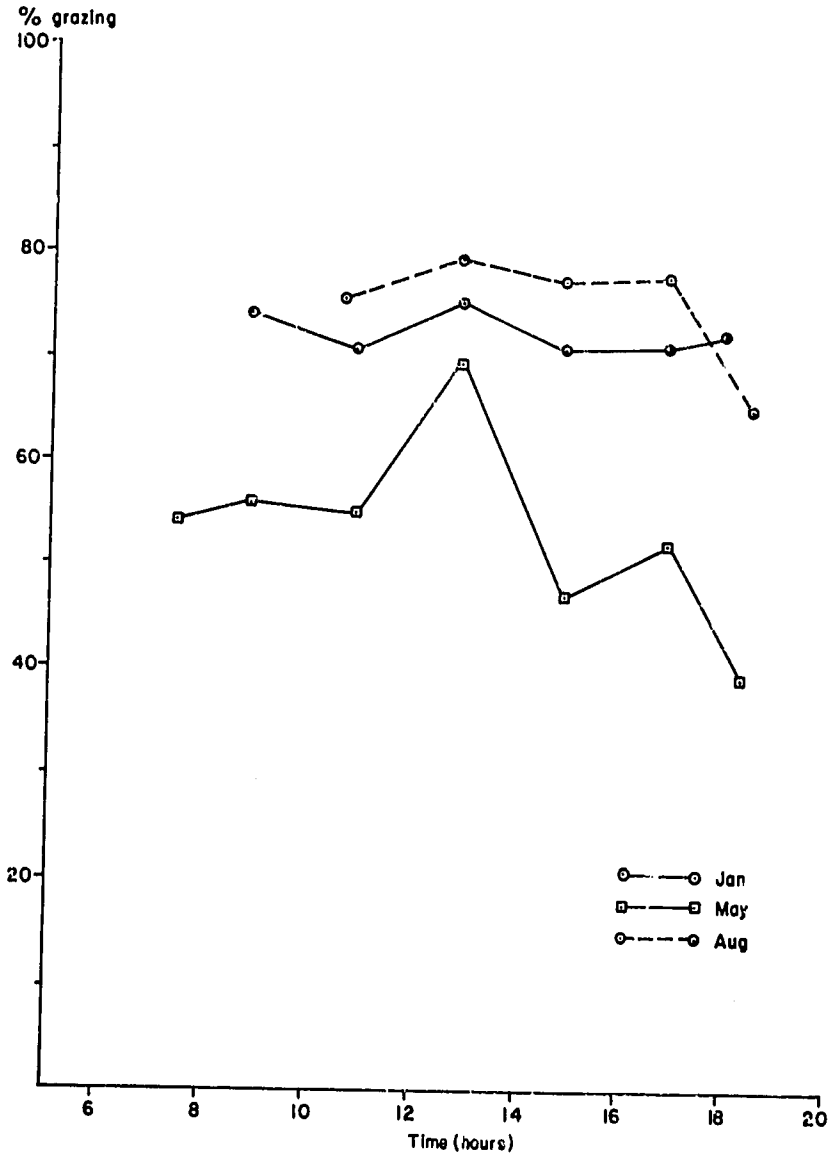
The grazing studies in Abet ará Kurmin Biri also presented an opportunity to examine the diurnal activity patterns of herded cattle. The diurnal grazing activity pattern of non-herded cattle in the tropics as well as in temperate zones has been well documented (e.g. Smith, 1959; Wilson, 1961; Arnold and Dudzinski, 1978). The general pattern includes a peak in grazing activity in the early morning, another in the late afternoon, and substantial grazing activity at night. Climatic factors, particularly high ambient temperatures, influence this general pattern, especially in the case of exotic cattle in the tropics. For example, Breinholz et al (1981) found in Ibadan, Nigeria, that almost 60% of the grazing time of Friesian cattle was during the night hours, whereas only 25% of the grazing time of indigenous African cattle was at night (Smith, 1959; Hagggar, 1968).

Management practices also affect grazing behaviour of cattle. For instance, a peak in grazing activity occurs immediately after a new strip of pasture has been allocated (Hancock, 1953). Less is known about the effect of herding on diurnal grazing pattern. The Fulani practice of confining the cattle overnight and well into the morning excludes both night grazing and the early morning grazing peak found in free-ranging cattle.

As shown in Figure 3, the diurnal feeding activity pattern of herded cattle differed markedly from that of non-herded cattle in that grazing continued throughout most of the day. This corresponds with a report from Smith (1961) that animals restricted to a grazing day of 7 hours grazed almost continuously while on pasture.

Although the White Fulani cattle, with their white hair and dark pigmented skin, are well adapted to high radiation, it is likely that even they suffer from heat stress during midday grazing, particularly in February and March when midday temperatures above 35°C are common. The short herding time and shortage of feed forces the animals to graze more or less continuously, thus preventing them from seeking shade and rest, as described by Lewis (1978). Utilization of fenced pastures for night grazing may be a means of alleviating this problem to some extent.

Figure 3. Diurnal grazing pattern of herded cattle.



Analysis of diurnal cattle activity reveals that another problem expressed by the Fulani in the case study areas - insufficient water for stock in the dry season - is not very severe. The cattle are watered at least once daily throughout the year. During the dry season, watering frequency is increased, and thrice daily watering is not uncommon. In this respect, management of stock in the subhumid savanna differs markedly from management in semi-arid or arid tropical areas, where animals are led to water only every second or even third day (King, 1983).

SUMMARY AND CONCLUSIONS

1. Herded cattle in the subhumid zone use a variety of different feed resources including crop residues, browse, low-lying seasonally inundated areas and fallow land. Crop residues are more important in a farming area whereas browse is used to a greater extent in a grazing reserve.
2. Utilization of these different resources demands control of animal movements combined with flexibility, which can be achieved only through the practice of herding. The need to herd, together with labour competition between cattle husbandry and cropping activities, leads to short grazing times for agropastoralists' herds, particularly in the late wet season.
3. The short herding times lead to a change in the diurnal grazing activity pattern of cattle to one of almost continuous grazing throughout the time out of confinement, even during the hottest time of the year.
4. It is suggested that short grazing time and reduced feed intake during the hot midday in the dry season contribute to the low level of cattle productivity.
5. It is further suggested that the use of fenced pasture for night grazing would enable cattle to extend grazing time and avoid stressful midday grazing, thus increasing feed intake, without sacrificing the flexibility and utilization of different grazing resources during the day as practised in the present agropastoral system.

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Discussion and Recommendations

DISCUSSION

Introduction

The symposium was characterized by the uniform and vigorous participation of the delegates. This made chairing the discussion sessions an interesting but difficult task - made more so by the very nature of farming systems research whereby all the work is interconnected, so that many of the questions were raised quite appropriately by different delegates in different sessions. It is not possible to report such long and detailed discussion verbatim, so the following is a synthesis of the most frequently discussed topics into single questions (Q), answers (A), statements (S) and responses (R). They are set out according to the session at which they were most strongly debated.

R. von Kaufmann. An introduction to the subhumid zone of West Africa and the ILCA Subhumid Zone Programme

Q: How does an innovation get passed on if national policy makers and research programmes do not obtain and disseminate information about them? What mechanisms exist for increasing the flow of information?

A: NAPRI and NLFU work closely with ILCA and have full knowledge and observation of everything done by ILCA. Since there is no point in proving that an innovation works in only one place, there are replicas of ILCA work funded by NLFU in Niger, Benue and Plateau States. State extension staff and the National Youth Service Corps are involved by secondment to ILCA. A film has been made in the vernacular by NLFU. Workshops for state extension staff can be organized. Finally, a government-appointed Technical Advisory Committee (TAC) regularly reviews ILCA's activities.

Q: Would not an all-encompassing national programme do better?

A: FLD, MAPRI and NLFU are the premier research and development agencies of government. They are trying to build ILCA findings into their work, and into the programmes of other government organizations. Information generated by ILCA/NAPRI research will be integrated into the country's Second Livestock Development Project, funded by the World Bank.

Q: But are there no better ways of measuring the effects of ILCA's work? How can we be sure we are reaching the right target groups? Can research be diversified to reach all kinds of farmers?

A: The Chairman of the recently constituted Kaduna - Karadua State River Basin and Rural Development Authority is a member of the Technical Advisory Committee (TAC). His opinion is that ILCA should be less cautious about releasing innovations because farmers will in any case adapt them according to their own circumstances, and this feedback is necessary for planning subsequent research. But ILCA cannot liaise with all such authorities.

Q: A solid organizational structure must be built, and better ways found of feeding research results into development. Perhaps a concrete proposal might result from the symposium?

A: The experience with ILCA's Humid Zone Programme in the south, where 60 farmers are now using alley farming in a pilot project promoted by NLFU, shows that the facilities for spreading adoption are there. Nevertheless, there is a need for a national framework to stimulate awareness throughout the country. Many findings buried in files could be useful ones.

A. Waters-Bayer. Settlement and land use by Fulani pastoralists in case study areas

- S: The Fulani settling in Kachia are not nomadic Fulani but transhumant, having wet-season sites further north. The percentage of truly nomadic Fulani settling dropped much earlier.
- S: Land pressure affects settlement patterns: in Abet, those with larger herds have difficulty in settling; smaller herds are more manoeuvrable; even so, larger herd owners have the capital to hire herders and so divide their animals into smaller groups.
- R: On the other hand, those who have been settled longer in Abet have larger herds. One large owner has 800-1000 animals.
- S: Fulani have access to land as long as good relations are maintained with the farmer.
- Q: Was there any experience with whole settlements moving?
- A: Interviews with transhumant Fulani showed that all had wet-season sites in the north; they had moved south for water, of which Abet has plenty.
- Q: Why had research moved so late into the Ganawuri area?
- A: It had been known from the literature that farmers there were going into cattle keeping. Aerial surveys had shown the close association of cattle with cultivation; subsequent ground surveys showed that the farmers themselves were also keeping cattle. Ganawuri thus offered a chance to test land-based innovations in an area with a different land tenure system in which land and animal ownership coincided in a crop - livestock enterprise. Limitations in resources for fieldwork made the selection of a site difficult. Ganawuri was chosen partly because it was easily accessible.

M. A. Mohamed-Saleem. The ecology, vegetation and land use of subhumid Nigeria

- Q: If soils in the subhumid zone are poor, such that vast inputs are needed to improve cropping, then why not concentrate on crop production?
- A: Soils in the subhumid zone are relatively good when compared with the more acid soils of the humid zone. A Land Resource Survey of the 1950s grades areas as good or bad according to the number of crops that can be grown. It covers ILCA study areas. Abet is a good area, and was early selected by the Fulani for biological reasons. The soils in some places may be poor only in the sense that a particular nutrient may be lacking. Correcting that deficiency could make the soil highly productive. As land pressure rises, pastoralists will find it harder and harder to farm, as only the unproductive land will be left for them.
- Q: The causal link between increased crop output, larger quantities of residues and higher numbers of cattle through higher feed availability will mean that cattle production will look after itself if crop output can be improved. So, why livestock research in the zone at all?
- A: The population of the zone is rising. If more people and animals continue to enter the zone, fodder resources must be increased. Even under present conditions, protein is a constraint. A legume is therefore the obvious answer, though not an easy one. One of the reasons why the zone was empty before was precisely because the soils were poor. In trials at Kachia non-supplemented cows died during the dry season, whereas supplemented animals survived. If the protein problem can be overcome the subhumid zone has enormous potential.
- S: Work on other zones, such as the arid and semi-arid, where problems are worse and populations are higher, is being done in other countries. Further north in Nigeria the legume approach would probably not be possible.

Q: Soils are poor, but the real problem is how to sustain resources for continuous production. Before pasture is improved it must be properly managed. This means stopping bad practices such as burning. Should not the first priority be to ensure better management of existing resources?

A: Fire is a very serious problem, yet where burning has been stopped vegetation remains low and of poor quality. The problem should be considered not from the point of view of animal production alone but also from that of crop production. Legumes cater for both points of view.

S: How does the increase in cattle population affect factors such as soil compaction and the insect fauna? There should be a concerted effort to monitor the ecology of the whole system, lest research solve one problem only to create others.

R: IICA is in fact studying transects in study areas, so some ecological monitoring is going on.

W. Wint. Tsetse, trypanosomiasis and cattle in a changing environment

Q: Around Vom, where land-use patterns are changing rapidly, riverine species of tsetse are still abundant, especially at river crossings. They are more or less dependent on cattle for blood meal. How does trypanosomiasis affect the economics of Fulani households?

A: It used to have disastrous effects because the disease was more widespread. Not much information is available, but it seems that reduced movement may well have contributed to a decline in the effects of the disease. Herds at Vom were found to be 30-40% positive for trypanosomiasis.

- S: However, what the Fulani think about the prevalence of tsetse is just as important as actual prevalence in determining herd movements. If the Fulani believe tsetse to be present in an area, they will not go there. They are aware of tsetse presence at river crossings and of the fly's association with transhumant cattle.
- S: The apparent disappearance of the fly should not give rise to a false sense of security. In supposedly cleared areas Fulani still claim their herds are affected. Official figures show a decline in government treatments, but the Fulani are in fact buying trypanocidal drugs and administering them without supervision, so the official figures are not necessarily a true indicator.
- S: Significant epicentres of fly infestation are still left. However, this means that control or eradication measures can be better targeted, with higher chances of success.
- Q: If local cattle are adapting, and if we assume that trypanosomiasis will continue to decline as population pressure rises, is it worthwhile importing trypanotolerant cattle? About 5000 N'Dama have been imported. Why?
- A: There are still areas where tsetse is a problem in the Middle Belt, and in the south there are areas of dense vegetation where tsetse will probably continue to be a problem for some time. Importing N'Dama cattle is only one of several strategies to combat the problem.
- S: In Burkina Faso, tsetse eradication has not been feasible everywhere. Imports of tolerant stock were therefore worthwhile. There is room for doubt about whether zebu breeds really do adapt to tryps, since much chemotherapy, official and unofficial, is practised. In West Africa, chemical resistance is already becoming a problem; there is severe risk of this, and the problem should be much more fully and widely discussed. ILCA/FAO studies show that the productivity of trypanotolerant breeds is just as good as that of other breeds in lightly infested areas.

Q: What are the historical reasons why the subhumid zone was underoccupied in the past? Was it low soil fertility or trypanosomiasis? Yet there were some people in the zone. What kind of cattle did they keep there 200 years ago? What was the level of tsetse challenge then compared to now?

A: The Fulani in Abet have kept cattle there for three or four decades, according to family histories and archives at Kaduna. Further south in Kafanchan animals were being kept by the Fulani as early as the late 1700s, according to oral tradition. These animals were zebu. There is some evidence that tsetse distribution expanded and contracted very considerably in the past. Tryps was once a severe threat to people - in one epidemic one third of the human population is said to have died, and mass migrations took place.

S: Drought is the main factor affecting settlement. In theory the pastoralist has to choose between two evils - drought and tsetse - but in practice people and animals are moving south out of the drought-stricken north. Hence in the next 5 to 10 years the humid and subhumid zones are going to become more heavily populated. The Sokoto Gudali breed is coming much further south than usual; people are even coming from Niger.

Q: Is there any evidence that Nigerian zebu cattle are becoming more adapted to tsetse challenge?

A: A preliminary survey has been done. In 1980 crossbreeds from Kano that were moved south into a tsetse area were positive for tryps within a week of arrival, whereas resident herds showed no signs of the disease. Between 1910 and 1920 vets from Vom had advocated moving cattle production out of infested areas. Instead, the cattle stayed and gained resistance.

S: Year to year changes in cultivation patterns can be assessed in broad terms using this survey method. More detailed information must be obtained from photographs. A zonal-wide survey can be carried out first, before smaller areas are identified for more detailed work.

S: Where chemical fertilizers are available the traditional fallowing period is diminishing as farmers focus on more productive land and bring it under permanent cultivation. The less productive land is being left fallow for longer, however, or is being abandoned altogether. Cultivation level could thus be an indicator of the productivity of the land. Aerial survey could first estimate productivity, which could then be checked through ground survey.

E.O. Otchere. Traditional cattle production in the subhumid zone of Nigeria

S: Age at first calving is very late, calving interval is over 2 years. With offtake at 10%, this herd should remain at a steady state. In Masailand, Kenya, herd productivity is twice as high, with better calving intervals and lower mortality. Differences in rainfall pattern and the nutritional value of grasses need to be investigated.

Q: Does ILCA go back to cattle owners with advice on how to improve their management?

A: The pastoralists contribute greatly to the programme; naturally ILCA reciprocates by passing on ideas for improvements to them.

Q: Whereas calves born in the wet season might have been expected to do better because their dams are better fed, wet-season calves die. What is the cause of this high mortality?

A: The grazing time is limited in the wet season, so the nutrition of both dam and calf is affected. Most deaths occur before 120 days of age.

Q: As regards the use of kanwa, what effect would the large calcium to phosphorus ratio have? Are there other sources of P?

A: The big gap may have adverse effects, but there is also evidence that crop residues contribute significantly to P intake. Calves could be supplemented directly.

Q: Why are steers above 10 years old being kept?

A: They are not used for draught, but are kept as a form of investment.

Q: Does herd movement have an effect on calving? Nomadic pastoralists avoid late dry-season calving because their animals are more exposed to disease when they migrate. Is mortality lower among the settled Fulani?

A: The herds monitored by ILCA are fairly sedentary, not usually moving more than about 5 km. ILCA does not have comparative data for nomadic and sedentary herds, but calf mortality is high in the monitored herds.

Q: The productivity index would suggest that herd size would gradually decline. Do the Fulani purchase animals in order to maintain herd size?

A: Yes.

Q: Calves from unmilked dams were heavier at 1 year than those from milked dams. Were any data available comparing mortality in the two groups of calves?

A: No.

W. Bayer. Traditional small ruminant production in the subhumid zone of Nigeria

S: In the productivity index given in the paper, dressing percentage is inaccurate because 30 to 40% of the meat actually consumed would theoretically be classified as offal.

- S: Potential goat offtake was 38%. The reasons given for sale indicated strong links between goat and crop production, with much of the cash being used to buy fertilizer.
- S: Fertility in goats was surprisingly low. Tethering apparently has a strong effect on feeding and reproduction. Health stress and nutritional problems arose mainly during the second half of the wet season, suggesting major emphasis should be placed on nutrition and a veterinary package.
- Q: Twinning rates could depend on many factors. Was any relationship detected between twinning rate and season?
- A: Twinning rate in sheep was 12%, in goats 14% (5% triplets). There was no seasonal effect on twinning, but a strong seasonal effect on birth and conception, especially in goats.
- Q: Over 80% of small ruminants are found in the far north of Nigeria. Have any studies on their productivity been carried out? In the existing study areas, have any studies on non-Fulani ownership been carried out?
- A: It is not true that 80% of small ruminants are found in the north. Sheep are uniformly distributed throughout the country, while goats are concentrated in the north and southwest.
- Q: Is ILCA's work on small ruminants in the subhumid zone complementary to the work in the humid zone?
- A: Yes; although the zone is different the problems are similar. The results of the ILCA subhumid work are very similar to the baseline study results in the south. While average kids/doe/year are less than 1 in the south, a figure of 1.6 has been found elsewhere. Some traits need further investigation so that they can be compared with results from the south.

S: Goats could be important in mixed species grazing systems, because of their potential for controlling bush encroachment. Bushes can be efficient in their use of soil moisture.

R: In bushy areas there can be some overlap between goats and cattle in the use of grazing areas, whereas on fallow land there is competition because of the absence of bush. Bush is now largely restricted to the less fertile soils. Whilst agreeing that there should be more attempts to control bush encroachment through browsing, it is recognized that many bush species appear unpalatable to goats and sheep. Recent studies in Uganda show that 90% of biomass was not being grazed and that most of the competing species were not being eaten.

J. Maina. Animal health in subhumid Nigeria

Q: What efforts have ILCA and NAPRI made to check animal disease in the southwest and southeast?

A: Animal diseases per se are not within the mandate of ILCA. Nor is NAPRI responsible for research on animal diseases. That is the responsibility of the National Veterinary Research Institute (NVRI) at Vom. There is no organization in charge of disease control throughout the country. Each state Chief Veterinary Officer is responsible for disease control in his state.

Q: Should dipping be suspended owing to low levels of tick infestation?

A: There is a strong case against the use of dips in grazing reserves. There are not enough ticks on animals to make dipping cost-effective. Dips are very expensive to maintain. They are often maintained sub-strength and this can promote tick resistance to acaricides. Water shortages can also cause problems. Intensive hand spraying can be used instead. Manual detickers always allow a certain number of ticks to remain on the animal, and this tends to maintain the cattle's resistance to tick-borne diseases.

- Q: As regards treatment with anthelmintics, have the life cycle of the prevalent anthelmintic species (which affects the choice of drugs) and the adaptability of the regime been taken into account in the cost/benefit analysis?
- A: A survey of epg of faeces has been carried out and used to determine the strategic dosing regime.
- S: An animal pathologist on the team to monitor changes in disease patterns would be useful.
- Q: Nutritional plane has an important effect on disease susceptibility. Would better feeding reduce dependence on drugs to control diseases?
- A: Better nutrition does not always help animals cope with disease; underpest occurs independently of nutritional status.
- S: Livestock units rather than numbers should be used in surveys. TIUs are inappropriate; rather, 400 kg should be used as the standard LU. ILCA should make regional comparisons using this unit.
- S: Care should be exercised in the use of LUs, since there is evidence that small animals eat more in relation to their body size than do big ones. On a linear basis 10 sheep = 1 head of cattle, but on a metabolic weight basis 5.5 small ruminants = 1 head of cattle. The literature records 80 to 100 g DM/kg of metabolic weight eaten per day, but in sheep and goats the figure can be far higher. Errors by a factor of two or three can be made.

M.A. Ibrahim. Veterinary traditional practice in Nigeria

- S: The occurrence of prolonged incurable symptoms caused by spiritual factors is not confined to the realms of human medicine; animal diseases too can be caused by demonic influences.

- R: The Fulani are well aware that the causes of diseases are not merely organic. By 'non-physical causes', however, they may not mean influences from the spirit world, but merely the invisible causes of disease, i.e. viruses etc.
- Q: Has there been any follow-up with a view to making use of findings in the field of veterinary traditional medicine, and to applying practices more widely?
- A: Follow-up is limited by the numbers of people available; such work would best be done by a team.
- S: One cause of confusion is that names may be given in Hausa, not Fulfulde. There is no definition of veterinary traditional medicine, as there is for human traditional medicine. It may be relatively easy to develop one.
- Q: Can the Fulani solve their animal health problems with a combination of existing and modern methods?
- A: It should not be too difficult to produce traditional medicines commercially.
- Q: What scientific evidence is there of the efficacy of traditional herbal remedies?
- A: Deparasitations of around 90% have been achieved with two plants which seem safe to use. Information has been collected on 30 plant species. Selection has been made on the basis of ease of collection. Plants have been screened for toxicity and for activity against helminthic infections. Seven out of 30 plants produced statistically significant deparasitations. The importance of reliable ethno-botanical information should be stressed: 4 of the 7 active plants were ones about which the author collected the information himself. No toxic effects were noted when 10 times the normal dose of certain plants was given to rats.

Q: In looking for support to continue the work, it would probably not be possible to follow the same route as traditional human medicine. It would be hard to convince policy makers in Nigeria. After disease description, what should the second step be? A blanket approach, comparing traditional medicine with modern practices? Or was a more purposive approach needed, finding ways of using traditional medicine to solve specific treatment problems?

A: The two approaches are not mutually exclusive. Using traditional remedies may prove more cost-effective, as drugs are so expensive. People once had money to buy drugs, but they don't any more. If there are alternatives to proprietary drugs, these should be developed. Traditional practice should not be seen as replacing commercial practice, but complementing it.

E. O. Otchere. The effect of supplementary feeding of traditionally managed Bunaji cows

Q: Why was there continuous milk recording?

A: The overall performance of animals throughout the lactation is monitored because of the carry-over effects.

Q: Why did supplementary feeding lead to longer calving intervals?

A: Similar 'suspect' results were recorded in Ivory Coast. Supplementary feeding appeared to have prolonged lactational anestrus and thus lengthened calving intervals. Reduced calf mortality thus can lead to reduced fecundity.

S: It might be necessary to advise the Fulani to feed only the most productive cattle in their herds.

R: This was a standard recommendation but the Fulani generally do not wish to discriminate between animals and consider survival feeding most important.

S: Disease problems manifest themselves mostly in the late wet season; tick infestation peaks in June and worm infestation in August. Strategies for disease control and supplementary feeding should be determined so as to help the Fulani cope with this difficult time of year and keep herd productivity at its highest possible level.

S: The Fulani are highly conscious of the cost of innovations. Cost is therefore the primary concern in the effort to introduce fodder banks. It is important to convince the Fulani of how cheap fodder banks can be. They are a cheaper way of providing protein supplementation than cottonseed cake, but some pastoralists still consider them too expensive. The use of local fencing materials to establish fodder banks as cheaply as possible should be examined.

A. Waters-Bayer. Settlement and land use by Fulani pastoralists in case study areas

S: The paper reinforces the belief that the study areas chosen are significant ones in terms of studying Fulani settlement.

Q: How long will the fragile balance in Abet last? Excessively high concentrations of Fulani in any one area should be discouraged.

A: Since the paper was written, one or two farmers in the Abet area have cultivated land close to Fulani rugas. Is this a way of trying to get rid of the Fulani?

Q: Potential conflict between the two communities is a major issue. From a government viewpoint the Kachia Grazing Reserve is a successful settlement area precisely because of the lack of conflict. But even in the case of Kachia, indigenous farmers demanded colossal amounts of compensation, feeling themselves to be disinherited. How can government find a balance that will keep everyone happy?

- S: The Kachia reserve has plenty of free land, but what is the tenure period? A 25-year lease? A 50-year lease? When the reserve was started in 1972 there was virtually no-one on that land. But the chance of obtaining compensation attracted farmers into the reserve so that they could file claims.
- Q: Why are there so few pastoralists settled in Kachia Grazing Reserve?
- A: The level of tsetse infestation in Kachia is not known, but Fulani always remember areas where they previously encountered the fly, and are unwilling to return there. This is the fundamental problem that has delayed the movement of pastoralists into the reserve. The road system, and hence marketing opportunities, round the reserve are good.
- Q: Cattle grazing compacts the land, making it more difficult to farm. Also, competition for land will increase as farmers move into fertilizer, which increases the profitability of cropping extra land. What alternative options are there for relocating the national herd?
- A: It is advisable to concentrate efforts in non-reserve areas, on finding a balance between Fulani and farming groups, and on promoting more secure forms of land tenure for Fulani, through negotiations.
- Q: Only a small percentage of Fulani will ever be able to own land. Can there be widespread practical application of ILCA's research without the introduction of laws covering shifting land tenure? Can ILCA do research with the aim of convincing government to change its policies?
- A: ILCA is obviously interested in government policy over land tenure, but cannot be involved in making that policy. ILCA has to take the status of land as 'given'. Like the weather, land tenure is 'environmental' to ILCA. The case study areas represent different land tenure situations. The most favourable situations for adopting particular interventions will be presented to extension services. However, some interventions would undoubtedly work better if the land tenure situation were to change.

- S: The government is not helping the Fulani. It gives the Fulani land but refuses them permission to pass it on to future generations, while still obliging them to find the money to develop it. The Fulani are not being enlightened about their rights.
- S: The pastoralist should not be regarded in isolation - there are other important groups. Ownership in itself does not determine the specific purpose for which land is used. Land allocated for livestock production may subsequently be used for other purposes. Perhaps it would be better to allocate land specifically for that purpose, and leave ownership undetermined.
- R: Government must take the lead in solving the land tenure problem. The success of the research on fodder banks depends on this. However, it is not impossible for Fulani in a non-reserve area to obtain land for fodder banks - this depends on their individual relations with the farming community, or on whether it is possible to purchase land. But what is their interest in establishing a fodder bank if, having done so, they then move on, leaving the fertile land to revert to the farmer? The oldest fodder bank is only 5 years old, and no Fulani has yet reached this stage, but when he does so all inputs, including the fence as well as the fertile land, will probably revert to the farmer.
- Q: To what extent have government officials taken action under the Land Use Decree, which empowers them to allocate land to Fulani for livestock production? The law favours livestock owners over crop farmers. Have Fulani been assisted in acquiring land?
- A: Obtaining land is an individual responsibility. If Fulani apply for land and have the resources to pay compensation, then government officials can file a report in support. The problem is few Fulani have such resources, and the government is not prepared to shoulder the responsibility for this.

S: There is concern over whether or not the Fulani are adequately informed about their rights. The Land Use Decree is a major reform, but it has not been implemented, and procedures now are no better than they were before the decree.

Q: Since major land tenure reforms are unlikely, should alternative development strategies be pursued that give the Fulani more advantages in their relationships with crop farmers?

S: The Fulani should be allowed to operate on their own. They don't want loans, because of the legal obligations and potential conflicts.

S: Leaving credit schemes to the private sector is problematic, since creditors feel unsafe and have no legal redress. As a result there is no money for development. The government will have to take control and be totally responsible.

R: State governments alone cannot take total responsibility for development. If pastoralists themselves invest, they care more about the results. No-one cares if the government goes it alone. What happens in the future will depend on finding a satisfactory compromise between what the individual can do and what government can do.

J. M. Powell. Cropping systems in the subhumid zone of Nigeria

Q: Why is ILCA involved in crop research?

A: Many Fulani have already settled or are settling now. As they are settling for the purpose of cropping, ILCA has to look at the cropping component as well as the livestock component of the production system. The author's research on crop residues etc is now relevant to about 50% of Fulani herds.

Q: Does the author recommend intercropping or monocropping? Did he test improved varieties of sorghum, maize etc?

- A: No improved varieties were tested, and monocropping is not recommended. All the work was done in the traditional system. The maize, from IITA, was slightly improved. Some work has been done with varieties from ICRISAT, etc, on sorghum, millet and groundnut varieties. It is true that some improved sorghums yield more leaf. But when management is left to the farmer, yields are not as good as those achieved on station. Nevertheless, some IITA varieties of soya are dual-purpose and are widely grown by farmers in the Abet area. They give a threefold increase in grain production and a slight increase in DM.
- S: Crop breeders have so far placed the emphasis on higher grain production. This has usually been achieved at the expense of DM production. Farmers reject these new varieties because their animals suffer. They know the importance of traditional cultivars, which are tolerant to drought and disease as well. ILCA should emphasize the importance of dual-purpose varieties. Some recent papers in the literature reflect growing awareness of this need. Monocropping is probably not advisable for small farmers under any circumstances, but improved varieties will be, if they satisfy both requirements. The value of some plant varieties as fencing material is also worth investigating, and bearing in mind as new varieties are bred.
- S: Most Nigerian agriculture consists of mixed cropping, so as well as being dual-purpose, new varieties must fit into mixed cropping systems.
- Q: How can we improve feed quality without reducing grain yield?
- A: Each new variety should be tested across a spectrum of crop mixtures to see how each could be improved.
- S. A. Ingawa. Socio-economic aspects of Abet farming households
- Q: Were data collected on farm size and non-farm income?

- A: The questionnaire was designed to follow up an earlier one on this subject. The information ILCA has on farm size was collected by Mark Powell, the team's agronomist, who collected data in the same area during the same year.
- Q: The large amount of income from livestock is surprising. What was the sample size, and how representative was it of the Abet area?
- A: The sample size was too small, and some data were lost in transmission. However, sampling was random, households being selected in cooperation with village heads. Data from 2 different years were confounded; data collection was done at the wrong time of year, when the season was starting, and it was done in a hurry. The author tried to make the best of a bad data set; nevertheless, the results differed little from those of Powell.
- S: Pig production should be investigated further, owing to its high contribution to farm income.
- S: Pig keeping in Abet is important, though not in the zone as a whole.
- R: On the contrary, Abet is very typical of pig keeping, but why are cattle numbers apparently so low?
- A: Low cattle numbers were recorded because farming households keep few cattle. It is not easy for farmers to raise cattle. They cost too much, and a substantial non-farm income is necessary to start the enterprise.
- J. M. Powell. Crop-livestock interactions in the subhumid zone of Nigeria
- Q: What is the Fulani strategy for manuring their own fields?
- A: The Fulani manure their fields every other year. They shift cattle to their own fields at the time of year when the N content of grass is highest (1.89% of DM, during the early wet season).

Q: Nutrients are being taken from one area (grazing) and deposited in another (cropping), so there are no net gains in available nutrients but there is a concentration. Is this concentration to some extent substituting for the expansion of the area under cultivation?

A: This is quite possible since the farmer's prime aim is to ensure enough food for his family, and fertilizer use has on occasion been shown to reduce the acreage planted.

Q: Is the concentration of nutrients in crop residues reflected in higher milk yields, owing to better nutrition in the early dry season?

A: For 6 to 8 weeks following harvesting the diet quality is good enough and should not be supplemented. Fodder banks should not be fed during this period. Phosphorus intake is four to five times higher than on natural range, and this has been put forward as an explanation of the higher conception rates recorded in this season. There is also a large increase in milk yields after residue grazing starts.

Q: How were the estimates of crop residue intake obtained?

A: The author followed traditional herds, and went to the fields they wanted to go to. Calculations were made on the basis of observations of animal behaviour.

S: Government strategy and thinking revolves around the idea of trying to separate the Fulani from indigenous farmers, giving them separate land. But cropping and livestock production are interdependent and should not be separated. The competitive labour requirements of the two mean that the Fulani will always be less efficient at cropping. Ways should be sought of prolonging the availability and high feed value of crop residues and efforts should continue to try to integrate forage legumes into the system.

M. A. Mohamed-Saleem. Integration of forage legumes into the cropping systems of Nigeria's subhumid zone

Q: In what ways is ILCA trying to integrate food crops and forage legumes?

A: Three methods of integrating food grain and forage cropping are being tried: introducing the forage into the crop; rotating forages and food crops; and introducing the food crop into the forage.

Q: Was there any effect from growing stylo on soil moisture penetration?

A: After 3 years under Stylosanthes hamata soil infiltration rates rise to 49 mm/hour compared with 15 mm/hour after 3 years' continuous grain cropping.

Q: Is any work being done on competition for soil moisture between crops and legumes?

A: The problems of competition (for soil moisture etc) are being looked at in farmers' plots.

Q: Can definite recommendations be made to farmers for the undersowing of stylo? At what stage is competitive interference lowest?

A: Six weeks seems to strike the best bargain: there is a 10% grain loss but this is well compensated by the gain in fodder. Total CP yields at 6 weeks are 450 kg/ha.

Q: Will the 10% grain loss with undersowing discourage the farmer? Can the crop geometry be further adjusted to make the technique even more acceptable to farmers?

A: This should be possible. Yet if the farmer has livestock or can sell fodder, the increased forage quality and quantity should compensate for the loss.

Q: At present, S. hamata is being used in fodder banks. Verano yields of DM are comparatively low. What is being done to investigate other stylo varieties?

A: Cook, hamata and Schofield are the only varieties commercially available. Anthracnose is a major threat to which there is as yet no answer. Other species are being tried experimentally. Late sowings confounded the results of some legume trials. No data on other species are available yet.

For a long time Schofield was grown with no disease problem; finally, it succumbed to anthracnose; the same might happen to S. hamata; could the problem be connected with biennials in the north behaving like annuals?

S: In Australia, where Schofield was bred, anthracnose has now completely wiped it out. Humidity tends to be lower in areas where it survives.

Q: How far has the author progressed with other legumes, e.g. Siratro?

A: There was a shortage of seed to extend this work. Multiplying and screening are now taking place. If predictions based on gut feelings have to be made, then tardius and capitata look like the best bets for tolerance to anthracnose. However, the former does not produce much seed, while the latter does not nodulate well.

S: The question of which varieties to use is an important one that also illustrates the links between on-farm and on-station research. On-farm work can define such criteria as soil conditions, management systems and farmer goals, but the work of screening and multiplication must be done on-station. S. hamata is a good seed producer, well suited to conditions subject to overgrazing and fire.

S: Where intercropping is advocated, the production of food grain legumes might be more advantageous than forages - e.g. cowpea, soya.

- R: Pastoralists do not use grain legumes; only farmers do. There are no difficulties in incorporating grain legumes into cropping systems, so long as they are dual-purpose - the residue is important. There is scope for improvement, however.
- Q: What is the repeatability of research, and how many years of results go into recommendations made to farmers? In Australia there are reports of a huge field of hamata that animals refuse to eat, whereas mixed swards (with grass) are grazed.
- A: The author's paper is not a completion report. He has 2 to 3 years' data and is hoping to get more. Seasons vary, giving different results. Locations also vary - undersowing is now being tested in Ganawuri. As regards the Australian case, the species not touched by animals was scabra, not hamata.
- S: Further selections of hamata should be made. It is a central American plant, and Antigua has a large collection. IICA should contact this source.
- S: The trade-offs between maximizing and optimizing output should be carefully considered. High yields of a legume might endanger its maintenance over a 5-year period. If they add too much N, legumes can run themselves out of the soil. The hamata 'child' should be carefully 'nurtured'. Its potential is excellent, and it should be used while other accessions are developed. It is applicable over a wide area of the zone. But other species that could be useful should be identified and collected in the areas where they originate. Genetic diversity is surprisingly high, and wild plants should be collected to ensure the greatest possible variety.
- S: NAPRI should be contacted in order to forge an integrated approach to these problems. If IICA's results are similar to those in Samaru, this will create a forum for agreeing on future work.
- R: IICA already cooperates very closely with NAPRI.

Q: Some soils still need fallowing, despite fertilizer inputs. Is there no way farmers can crop continuously?

A: Tropical soils need some rest. The rest periods required at various levels of input have been demonstrated. Cropping is possible for only 3 years out of 10 at traditional farming levels; with moderate fertilizer it is possible for 5 years in 10; and with high inputs, 8 years out of 10. So even at the highest levels, some rest is needed.

A: Because the cation exchange capacity of the soil is poor, organic matter content has to be built up by fallowing or by using high amounts of manure so as to keep the carbon level high.

A: Once the limitations of soils are known, they can be improved over time. The soil can be rested for a period sufficient to improve it. Legumes store nitrogen in the soil, releasing only a proportion of it to the subsequent food crop. Where the dry season is long N enters soil micro-pores, and is not leached at the rates previously thought, but is stored instead.

M. A. Mohamed-Saleem. The establishment and management of fodder banks

Q: What are the major changes the farmers have introduced to recommended practices for fodder bank establishment?

A: Some farmers are ploughing to prepare their seedbeds. Grazing out competitive grass after sowing the legume works well. Eight to 12 kg of seed are needed for establishment, rather than 1 to 2, because seed quality is so bad.

Q: What can be done using legumes to improve natural rangelands, on which animals depend for 85% of their feed? Can hamata become part of the grazing system? Humilis naturalized well in Australia, and in the Benue area of Nigeria. Hamata appears more aggressive, and IICA says it is spreading into areas adjacent to fodder banks. It can spread through seed establishment from faecal droppings. Will the spreading trend continue, and can it be stimulated?

- A: In an experiment on Cook and Leucaena, seedlings were found in the plot the following season, but these were weeded out. Grazing and burning prevent establishment. These plants were not establishing in strip trials either.
- S: Earlier rains at Fashola meant that the spread of hamata was spectacular. As a result there was an increased concentration of Fulani near the Fashola research station.
- R: Hamata undoubtedly spreads rapidly, but fire is a problem. Bush fires can wipe out stands overnight. Fire control must be implemented.
- S: There is concern at NLFU over the quality of commercial seed available. The price of seed, however, at 10 N/kg, is not as high as the author claims.
- R: The nature of harvesting may be the cause root of seed quality problems. Women are employed and paid for the amount harvested (rather than per hour). Quality must be controlled by the buyer. If necessary, repeated winnowing should be requested. For Verano, flotation may be a useful technique, but water shortage is a constraint. Seed stores better when sealed in a drum.
- Q: What is the most reasonable expectation for the longevity of a fodder bank?
- A: After a good start the most vigorous of legumes may disappear owing to the encroachment of grasses and weeds. Because these other species tend to invade, it is wise not to aim to maintain fodder banks over too many years. Instead, it would be better to resort to grain crops. Sequential use is probably best. The oldest fodder banks are 5 years old and the legume content is still satisfactory.
- W. Bayer. Utilization of fodder banks
- Q: What were the results of the controlled stylo grazing trials?

A: Supplementation did not completely cancel weight loss. Only rarely can weight losses be prevented altogether, though some reduction can be expected through the control of stocking rates. The total grazing time of 10 hours for all three groups disadvantaged the control group. Animals roam freely in the traditional systems, and they should have been allowed to graze for much longer than this. However, in this year's results, as opposed to last, the advantage of animal groups supplemented with stylo has been largely maintained. Stylo-fed animals are now substantially heavier, with considerable implications for fertility. (Last year, compensatory growth occurred, with both groups equal in weight by October).

Q: Did the animals receive any mineral supplementation?

A: The three groups were not fed any minerals, but they received salt.

Q: Was there any moulding in stylo caused by humidity?

A: When the dry season is reliable, leaf drop is eagerly consumed by the animals. There was no problem of moulding.

Q: What was the contribution of browse?

A: Approximately 20% of total grazing time in February/March. No comment can be made on the chemical properties of browse. A flush in growth occurs without burning, so that the peak in browse intake is not caused by burning. There is some lopping.

Q: Were the differences between Cook and hamata due to palatability or to amounts available in the fodder bank?

A: The main cause of decreased intake was the disappearance of palatable plant parts.

S: A mineral deficiency in animals is suspected. NAPRI/ILCA should define mineral status of animals more clearly. Their stiff gait suggests that P deficiency is a problem. Bone ash may also be used to

get more P into animals, but trials should be done on the acceptability of karwa.

Q: Karwa contains valuable trace elements; are there any constraints to its use as a feed?

A: There does not appear to be any reason why it can not be fed ad lib.

Q: How many animals should be put on fodder banks?

A: This should be based on the amount of protein (kg/ha) produced. It will vary between locations. Although there are seasonal trends in diet quality, 2 1/2 hours of fodder bank grazing were assumed at the start of work to be equivalent to 1 kg of cottonseed cake.

E. Taylor-Powell and S. Ingawa. Beneficiary reactions to the fodder bank trials

Q: What is the main constraint to research on the adoption of fodder banks?

A: The demand for fodder banks is outstripping the supply of inputs and ability of ILCA/NLPU to monitor the results.

Q: Is security of land use essential?

A: Pastoralists must have land security to participate - only three of the original participants did not have some form of security. Initial arrangements over land are generally made by the pastoralist himself. A period of control over the land lasting not less than 5 years is recommended. Two pastoralists with uncertain land rights opted out after 1 year. All the others who have so far participated are sure that they hold the land for this period. One pastoralist claims he has the land for as long as he wants.

Q: What type of land is most commonly used for fodder banks?

A: At present unexploited, not fallow, land is used for fodder banks.

Q: Why are firebreaks not always effective?

A: Fires sometimes start within the bank.

Q: Are fire and other risks major deterrents to adoption?

A: All benefits have risks attached - these are treated more in the paper on decision making; the objectives of the pastoralists are not uniform and their attitude to risk varies with their experience of the intervention. This topic is therefore most complex. Pastoralists are continually assessing the intervention and deciding whether to opt out or stay in and their reasons will have to be carefully evaluated over time.

Q: Overstocking on the banks is a considerable problem, as the benefits of the extra feed will be lost. What is ILCA doing about this?

A: Overstocking does not appear to affect regeneration of the bank. Pastoralists feel their animals are in good condition, and are being saved from starvation and death. Overstocking is therefore not perceived as a serious problem.

Q: Has ILCA had to adjust its perceptions as a result of observing fodder banks under pastoralist management?

A: Perceptions constantly change in systems research. ILCA did work on the feed value of natural herbage and crop residues. Crop residues turned out to be more valuable than we had thought. Pastoralists therefore quite rightly did not want to graze their animals on fodder banks during the period when residues were available. Selective grazing was advocated by ILCA, but the severity of malnutrition in pastoral herds had been underestimated. Although ILCA considered this uneconomic, pastoralists preferred to graze their whole herds on fodder banks, and in fact the banks can be paid for in terms of saved

animals. ILCA advised grazing during the evening, but pastoralists refused this, preferring to graze the banks early in the morning, as this fits in better with their social system. As far as possible fodder banks should be preserved until the end of the dry season. This is when they have their greatest value. Once an innovation is handed over the producers themselves teach the FSR team. The role of the FSR team is then to observe and adjust their recommendations accordingly.

E. Taylor-Powell and H. Suleiman. Extension implementation of ILCA interventions: Dry-season cow supplementation and fodder banks

S: FAO field programmes can help transfer technology. The Animal Health and Productivity Division regards ILCA's Nigerian programmes as very important. FAO has a programme to deliver support to crop and livestock production in the subhumid and humid zones. This programme is now entering the field-level stage. The programme has already enjoyed the support of ILCA and IITA. The need for support will be greater in the future. Programme activities are limited by a shortage of funds, but the situation is now improving. The Italian Government has helped establish a unit in Ouagadougou and will assist in project implementation. The programme covers seven countries. There is a regional project with still wider coverage to promote the selection and multiplication of trypanotolerant cattle. UNDP has a 5-person project to assist grazing reserves. This supports the national NLFU and FLD programmes, and is closely concerned with pastoral settlement. There are resources for addressing the problem of streptothrichosis; US\$ 400,000 is available to assist national research, and there is provision for the training of field staff. There is a need for the programme to operate closely with ILCA and NAPRI, but this will depend on support and the continuation of the ILCA programme.

Q: Fencing is a major cost item. Is it really necessary; are there any fodder banks without fencing? Don't pastoralists know how to handle animals, and can they not corral without using a fence?

...

A: The nomadic Bororo who enter the area during the dry season do not know about areas of restricted grazing. Fences are needed for this reason. Some farmers (as opposed to pastoralists) have said they would not need fencing as everyone recognized their land. It remains to be seen whether they are right.

M. S. Kallah. The future of livestock systems research in Nigeria

Q: It is commendable that aerial surveys are being included in the LSR work at NAPRI. In other survey work contact between air and ground groups has been poor. How is the team approaching the integration of aerial survey data into field research?

A: They are already integrated. Aerial survey is a good tool for gaining an overview of a huge area. Its principal aim is to provide information that will target ground surveys. The latter answer the questions that cannot be covered from the air. Ground teams go in on the basis of data from the air. Their answers are fed back into the aerial survey work.

Q: Aerial survey is relevant to the diagnostic phase of LSR, which should be carried out as quickly and cheaply as possible. Is it too expensive, and if not, does it have a role beyond this phase?

A: Aerial survey can also be useful at the extension phase. It is not expensive, given its speed and the information it yields. It is complementary to ground reconnaissance. The money saved by not doing aerial surveys could be invested instead in large teams of people for ground work. But costs for a large area are bound to be much higher if ground teams alone are relied on.

S: Aerial survey comes in at the descriptive phase, not the diagnostic phase, which is later on in the LSR process.

Q: Why is aerial survey used more in livestock systems research than in farming systems research?

A: There are differences between LSR and FSR. It is much easier to get a large representative sample in FSR. Livestock are mobile and take up more space. Aerial surveys thus have a special advantage in LSR; they can be carried out twice a year, covering large areas and large herds. Satellite imagery can also be brought in. Cattle can be placed by grid reference, giving the baseline position, before interventions. For example, work is being done in Lafia, where herds are not easily accessible. Sterile male tsetse flies are being released there as a tsetse control measure and aerial survey is being used to study cattle distribution before and after the release programme.

Q: Can aerial survey be used in determining natural vegetation cover?

A: Remote sensing can be used to obtain a natural vegetation index (NVI), indicating the extent of natural vegetation.

R. von Kaufmann. The expected impact and future of the ILCA Subhumid Zone Programme.

S: There are feeds other than cottonseed cake to try; for example, molasses - urea.

A: All possible sources of feed should be exploited but even then there will not be enough to meet more than a part of the needs of livestock in Nigeria. Forage legumes, especially if they are beneficial to cropping, provide the best prospect for providing sufficient supplementary feed.

S: Saving calves through supplementary feeding keeps cows milking and in a state of lactational anoestrus, and therefore extends calving intervals.

- S: Multiplication of promising forage varieties should be done concurrently with screening, not after. If left until after, the whole process takes 12 to 20 years.
- S: Good quality work has been done and both parties to the research have confidence in it. The carry-over effect from international to national research is very evident, and free from the normal bureaucratic entanglements. Each partner must further study how to fit into the overall research scheme of the country and the region. The approach adopted should model itself on that of IRRI. The Chinese and Nepalese national services see themselves as an integral part of international rice research, of which IRRI is the central point. Building a capacity with a cut-off point - "national programmes take it from here" - is an approach that is unlikely to work.
- S: All the same, more work could have been contracted out to NAPRI. The two institutes should work together, both on the research station and outside it. Much more cooperation should have taken place in the past. What about the future?
- R: ILCA has no mandate to be a technical assistance agency. Besides, there is no guarantee of continued support for the Subhumid Zones Programme from ILCA headquarters. Since the future can not be predicted, it remains for the host country to pick up the ball and run with it. There has to be a point at which national research takes over. However, very few institutes are based in the subhumid zone, and in any case no institutes in Nigeria have funds to take on new work. ILCA had in the past to do a certain amount of component research by itself; in any case, ILCA didn't know what it wanted NAPRI to do on its behalf, because of a lack of clarity over appropriate research directions and priorities. In the coming years, NAPRI must see what it can do. For a start, it can participate in the testing of new forage varieties. More component research can be done cooperatively.
- S: The problems of the farmer have still not been addressed on a wide enough scale. The farmer provides 95% of what Nigerians eat, yet his links with the rest of the community are poor. Extension services are deficient or lacking altogether, while scientists live in an ivory

tower and are more concerned with their Ph.Ds than with helping the farmers.

Wind-up session

- S: Research on crossbreeding is too timid. The present policy on crossbred dairy production is not successful. There is a lack of farmer acceptance of the crossbred enterprise. Breeds other than temperate breeds are needed for crossbreeding. India, parts of which have similar environments to some areas of Nigeria, should be regarded as a potential source. East African zebu types may also be suitable.
- S: At existing technical levels no crossbreeds will perform well. Crossbred dairy production is for sophisticated farmers only. Under harsh conditions in remote rural areas away from veterinary services, crossbred production should not be attempted because the farmer will be the loser.
- S: There are many institutional issues, and many politically sensitive ones. ILCA's Livestock Policy Unit compares policies in broad terms between countries, but more detailed studies by national institutes are needed. One example of the kind of study the unit does is on the effects of dairy imports on domestic production. Nigeria is one of the countries involved in this study. National institutes should do detailed studies of specific issues, while ILCA studies policies between countries.
- S: Much progress has been made since the first symposium of 1979. It is disappointing that the present meeting has not been open to a wider audience; after listening to the presentations and considering the results, one's regrets are even greater! Other African countries should have been invited. The papers should be distributed in French as well as in English.

- S: The legume work involved the study not of soil structure alone but of all soil properties. The word 'structure' should be changed to 'behaviour' or 'changes'.
- S: A lot of herds pass through the farming areas; some endanger fodder banks and supplies of crop residues. The idea that herds should stick to recognized corridors is not a new one. In fact to some extent it is already implemented in the traditional system - herds passing through Abet have traditional, recognized routes. They follow particular lines, occasionally veering off to a camp. If a farmer plants along a route he will lose his crop.
- S: In Burkina Faso there are cement markers that the government forces herdsmen to follow. This is effective; herdsmen do not stay, but quickly pass over the border into Ivory Coast. However, the efforts of the government now are to settle these animals. They are thinking of grazing reserves, but are less far advanced than Nigeria.
- S: Who is the audience for these papers? Many statements are as useful to the administrator as they are to the scientist.
- S: As regards the use of fencing, this has been opposed by IICA because of the expense and conspicuousness. The conventional wisdom is that arable communities will not allow pastoralists to fence lest it confer some degree of title to the enclosed land. However, due to the system of communal grazing, the stylo is constantly grazed and never properly established without the protection of a fence.
- S: There might be some value in studying fodder production in the south, and finding ways of transporting the feed northwards.
- R: IICA's Humid Zones Programme deals with the south.
- S: The symposium has been an event of national significance, covered by national media.

RECOMMENDATIONS

Report of the Subcommittee on Resolutions and Recommendations

Members:

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J.O. Akinola	
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A.N. Ema	
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The committee deliberated on the presentations and discussions of the symposium, and its recommendations follow below.

Livestock development in Nigeria is an important and critical aspect of the nation's overall economic development. Significant and widespread development in the livestock sector, which is presently dominated by traditional livestock producers, can only come about through the introduction of innovations which are adoptable by and acceptable to them.

The subhumid zone of Nigeria has considerable potential for increasing livestock production in the country, as it has the capacity to support increased livestock numbers as well as improved productivity per animal.

Livestock systems research (LSR) appears to hold considerable promise in generating interventions relevant to the conditions and circumstances in which the majority of livestock farmers operate. ILCA's research efforts, together with those of NAPRI, to develop and test such interventions and assist in their dissemination to livestock producers in the subhumid zone of Nigeria, are necessary to the ongoing search for effective ways of increasing their production and improving upon their welfare. These efforts are commendable.

In the light of the above and the proceedings of the symposium, the committee makes the following specific recommendations:

1. Dissemination of research results

The systems approach to livestock research is incomplete and ineffective unless there is an established plan and framework for channelling prospective interventions through extension systems into rural development programmes.

In this regard, there is a need for continuous feedback between the activities of ILCA, NAPRI, national universities, extension agencies, development programmes, farmers and other institutions involved in livestock research, production and dissemination.

2. Institutional support

It is important for agricultural administrators in the country to accept the fact that interventions designed for the development of the livestock sector will be neither successful nor effective, even if they are acceptable to livestock farmers, unless the necessary inputs and support services are also made available at the right time, in the right quantities and in the right place.

3. Disease control

There is a need to carry out exploratory research designed to identify traditional perceptions of animal diseases and the various traditional treatments being utilized by livestock farmers for their eradication. In this regard, the potential of traditional treatments for effective animal disease control should continue to receive attention.

With regard to research on animal health, it should be remembered that parasitic diseases, as well as nutrition-related diseases, are intricately associated with the adoption of interventions by traditional livestock farmers. Research efforts should therefore continue to be directed at the development of interventions which can effectively accommodate these as well as other animal health problems.

4. Introduction of crossbreds

Considerable caution is required before introducing germplasm that traditional methods of livestock production may be incapable of sustaining, thereby losing the confidence of livestock farmers in further interventions.

5. Integration of crop and livestock production

Conflicts in the relationships between livestock and crop farmers have constituted and will continue to constitute a very serious constraint in any effort to integrate livestock and crop production. It is therefore imperative that measures are taken to remove these conflicts. These measures should include, but would not necessarily be limited to, the following:

1. Research efforts aimed at monitoring and evaluating the nature of the evolving relationships.

2. Exploration of the possibilities of establishing well defined grazing corridors for migrating pastoralists.

3. In the long term, it is desirable for livestock producers to settle. However, when settling in one place they need an environment conducive to livestock production. Quite often government investment is needed to create this environment. In any case, access and secure title to land as well as other social services are important prerequisites for permanent settlement. There is therefore a need for livestock farmers to be made aware of their rights under the existing Land Use Decree, and to be assisted in exercising these rights.

6. Feed resources

The idea of fodder banks holds considerable promise. Research on further development and refinement should continue, along with research on the possibilities of developing feed gardens. However, there is a need to ensure that adapted legume seed supplies are readily available. This means that a system for providing adequate quantities of both legume and other forage seeds should be evolved. Possibilities include national seed companies, commercial seed companies, cooperative seed multiplication arrangements, etc.

In addition to the fodder bank concept, research should continue on improving the feeding value of crop residues and their utilization.

Furthermore, since native grazing lands in which grasses predominate constitute the basic feed source for livestock for most of the year, these grazing lands need to be closely monitored in terms of their vegetation and soil structure. Research efforts should also be directed towards developing interventions aimed at maintaining and/or improving them.

7. Scope of research

ILCA is currently concentrating its research efforts on developing and testing only those interventions that can succeed within existing institutional limitations, i.e. the existing extension set-up, government policy constraints, input delivery systems, etc. Given ILCA's mandate and structure, this limited scope is understandable. However, since the systems approach to research requires a systematic approach to all the important constraints operating in farming systems (including institutional ones) there is a need, within realistic limits, for ILCA's research efforts to explore interventions which will succeed provided they are accompanied by appropriate institutional changes.

ILCA needs the assistance and cooperation of NAPRI and other research centres in the country in this and other regards. For example, ILCA's diagnostic research has and will continue to indicate lines of relevant research which need to be pursued. Some of these, particularly the more academic and politically sensitive ones, can be more effectively investigated by researchers and postgraduate students in the country's research institutes and universities. The cost-effectiveness of this approach is quite obvious.

ILCA/NAPRI SYMPOSIUM

Oct 29 - Nov 2, 1984

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ACRONYMS/ABBREVIATIONS

ABU	Ahmadu Bello University
ADDM	apparent digestible dry matter
ADF	acid detergent fibre
AERLS	Agricultural Extension and Research Liaison Services
AI	artificial insemination
APMEPU	Agricultural Projects Monitoring Evaluation and Planning Unit
a.s.l.	above sea level
CBPP	contagious bovine pleuropneumonia
CGIAR	Consultative Group on International Agricultural Research
C	carbon
CP	crude protein
DCP	digestible crude protein
DM	dry matter
epg	eggs per gram
FB	fodder bank
FDPCS	Federal Department of Pest Control Services
FLD	Federal Livestock Department
FSC	Farm Service Centre
FSR	Farming Systems Research
GDP	gross domestic product
HI	harvest index
IAR	Institute of Agricultural Research
IBR	infectious bovine rhinotracheitis
ILCA	International Livestock Centre for Africa
IRRI	International Rice Research Institute
ITCZ	Inter-Tropical Convergence Zone
LSD	lumpy skin disease
LSR	Livestock Systems Research
min	minutes
N	nitrogen
N	Naira
NAPRI	National Animal Production Research Institute
NDF	neutral detergent fibre
NIOMAR	Nigerian Institute for Oceanography and Marine Research
NLPFU/LFU	National/Livestock Project Unit
P	phosphorus
SLAR	side-looking airborne radar
TAC	Technical Advisory Committee
TCRU	tissue culture rinderpest vaccine
TLU	tropical livestock unit