Biotechnical options

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Introduction

Let me begin by reminding you that ILCA is one of the International Agricultural *Research* Centres with a mandate to carry out a programme of research supported and extended by documentation and training "to assist national efforts which aim to effect a *change* in production and marketing systems in tropical Africa ..."

Let me quote also Baker (1977)'s selection from the ILCA prospectus (1974). "The system approach is valuable in research planning not so much in identifying problems, which are often self-evident, as in selecting what are likely to be the most profitable approaches to problem solving. This is especially relevant to livestock production in Africa where improvement in yield or output is as likely to come from social change or from range improvement as it is from genetic change in the animals themselves."

The truth of this has been shown in the constraints to production and opportunities for improvement identified by the leaders of our pastoral research teams in their papers to this workshop. One might well argue that most, if not all, of the problems they have specified could have been listed *before* ILCA's systems research programmes began - indeed most of these problems were already identified or identifiable from the large amount of research information then available. What was lacking was knowledge of the best ways of solving the evident problems, given that many optimistic attemps to introduce new methods based on improved Western models had been dismal failures. It was not clear whether the technology had been wrong, and just did not work in the different physical environments of Africa, or whether the social and economic conditions in which the technology had been

used had prevented it from being applied in such a way as to effect the improvements of which it was potentially capable.

Sandford has outlined the considerations which seem to be most important from the social and economic view points in identifying the scope for improvement in pastoral production. We must also consider the biological or technical possibilities which are available for pastoral systems, and try to sort these into some ranking of applicability considering not only the likelihood of technical success but also their relevance and feasibility.

Technical features of pastoral systems

African pastoral systems are subsistence-oriented, and based on milk production - milk, not only to rear the calves which will ensure long-term continuity of the system, but also to form the mainstay of human nutrition. These systems are not easily forced into the mould of conventional Western beef production and many earlier attempts to develop such enterprises have failed.

The zebu-type cow in these extensive grazing areas may appear unproductive, indeed the milk yields recorded in ILCA pastoral studies are quite modest. Consider a cow giving an offtake of 1 l/day; in terms of human nutrition she is producing as much as a castrate gaining 1 kg/day*. Her biological effeciency is high judged by the value of her output of high quality food in relation to the amount and value of the forage she has eaten.

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* 1 000 ml milk at 14% total solids = 140 g nutrients
  1 000 Lwt gain = 600 g bodywt (30% skin, bone, inedible tissues)
  = 600 x 0.70 edible tissues (70% water)
  = 600 x 0.70 x 0.30 g edible DM
  = 126 g nutrients

Table 1. *Estimated yield (ml/day) of cows in ILCA pastoral programmes.*

Country	Milk offtake for human use (measured) (ml/day)	Milk intake by calf (estimated from weight gains) (ml/day)	Total (ml/day)
Ethiopia	1140	2560	3700
Kenya	720	(2500)	(3220)
Mali	730	1620	2350

Considering the harsh conditions under which they live small ruminants too reach high levels of individual production. Even though individual production may be high, cattle herd productivity could be raised substantially if:

- fewer calves died, and more were reared to sell or to milk;
- calves grew faster and matured earlier;
- cows calved first at an earlier age; and/or
- cows calved more frequently thereafter.

Table 2. *Reproductive performance of sheep and goats in semi-arid Africa.*

Country	Age at 1st parturition(d)	Parturition interval(d)		Litter size		No. of young/ female/yr	
		Goats	Sheep	Goats	Sheep	Goats	Sheep
Mali	470	270	250	1.21	1.05	1.63	1.51
Kenya	550	320	320	1.25	1.04	1.42	1.19
Sudan	-	230	280	1.52	1.13	2.37	1.49

If more calves were reared better and either sold earlier or calved earlier, lactating cows could form a higher proportion of the herd, giving higher efficiency of production per unit of forage eaten, or per unit area of grazing land used.

Milk yield is the key to most improvements since increases in yield would make it possible to reduce calf losses, improve growth rate of calves and thus to meet the implicit objectives of the pastoralist while also making possible an increase in the turnoff of surplus male cattle to meet national development needs.

The results of ILCA's systems analysis have shown the importance also of smallstock - particularly their role as a rapidly renewable liquid asset, easily converted into cash or exchanged to meet short-term needs, and of a convenient size to provide meat for domestic, religious or social celebrations. Their shorter gestation and high fecundity provides valuable flexibility and their behaviour makes it possible to exploit types of pasture or browse not eaten by cattle. The almost universal use of young males for slaughter sale or exchange has shown up clearly in ILCA surveys.

Table 3. *Age and sex structure of flocks in Sahel transhumant systems.*

Age (months)	Sheep (a)		Sheep (b)		Goats	
	Males	Females	Males	Females	Males	Females
0 - 6	11	13	6	10	)	)
7 - 14	6	12	9	19	) 22)	) 23)
15 - 21	4	11	3	8	) 6)	) 49)
over 21	7	36	7	38	)	)
TOTAL	28	72	25	75	28	72

Just as the type of livestock kept and their role has strong common features, so too the constraints identified can be grouped into those which are common to most pastoral systems and some more specific to a particular region or system. This distinction depends largely on the overriding influence of climate, mainly rainfall and its seasonal distribution; we shall examine how this dominates the husbandry of cattle and small ruminants and contributes, directly and indirectly, to many of our problems.

The effect of climate on nutrition

The ILCA team in Mali has recorded the amount and quality of forage available, and the liveweight changes of cattle and small ruminants in the systems relying on the Niger delta (Dicko et al, 1981).

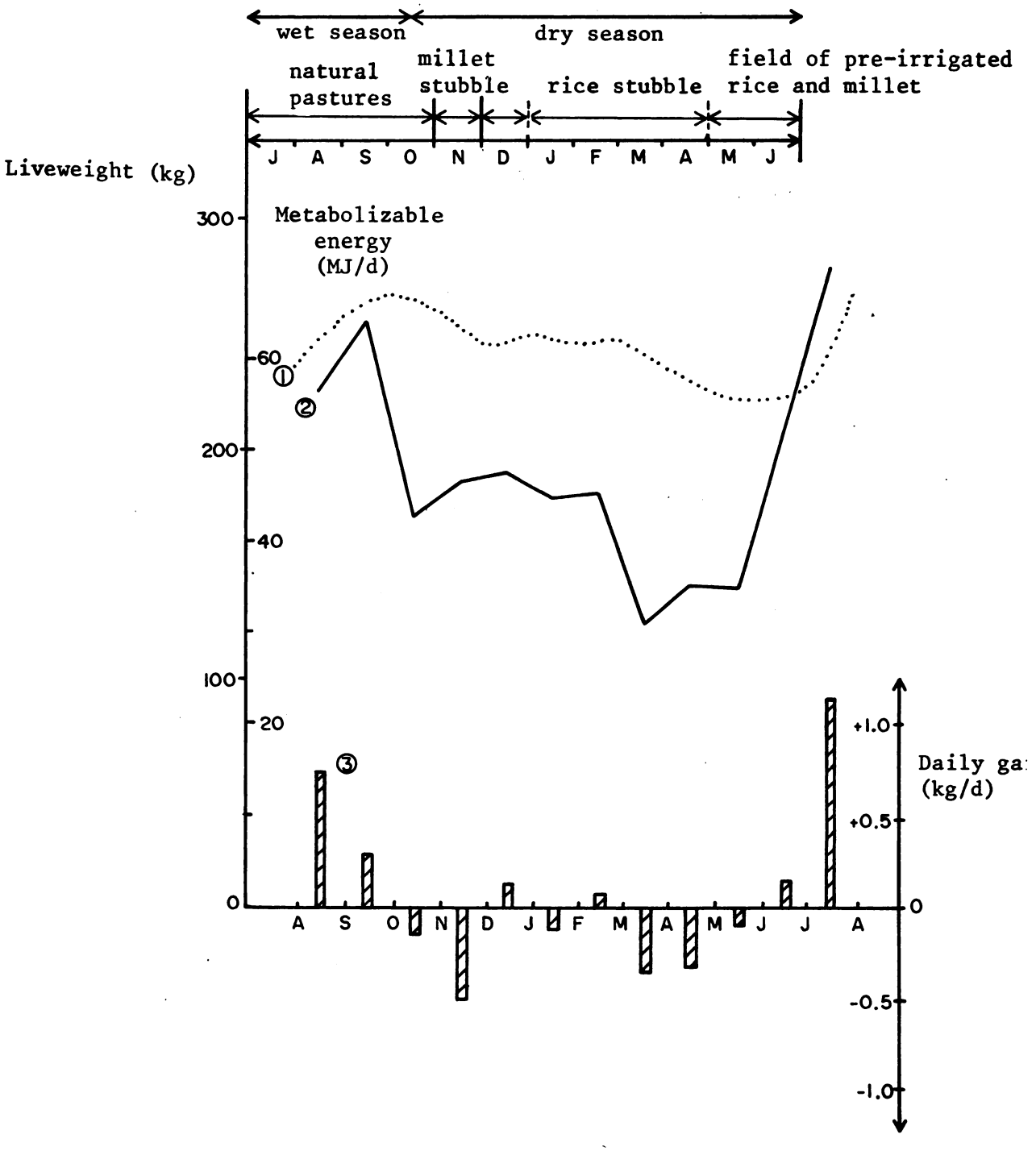

Fig 1. *Seasonal trends in liveweight (1) and metabolisable energy intake (2).*

Fig. 1 shows the seasonal pattern of changes in liveweight in cattle in Mali. Similar patterns have been found in many other tropical climates, and it is evident that the annual weight increase made during the short wet season when feed is abundant and of good quality is partly lost over the following months of the dry season, particularly in the few weeks immediately preceding the following season's green growth. This means that yearly net gains are low, maturity is delayed, and first calving is at four or five years of age. Cows, which usually conceive towards the end of the wet season, calve after a long period of under-nutrition during the following dry season. It means also that cows which calve a little late and do not conceive again before the dry season begins are likely to enter a long period of lactational/nutritional anoestrus and will not conceive until their calf has been weaned or until the following year's wet season. Thus the herd will include too many cows which calve only every second or even third year.

The classical solution to this predictable yearly problem of feed shortage is to move, either between wet and dry-season grazing areas where land is still plentiful, or to arable areas where crop residues are available. Lack of water means that grazing areas within reach of dry-season wells or ponds soon become overgrazed; the high concentrations of livestock may help the spread of diseases, and poor nutrition is made worse by the need to walk long distances each day or two.

Options available for improvements

Problems arising from aridity

Not only mean annual rainfall and its variation, but also its distribution, greatly influences pasture growth and therefore secondary productivity of livestock. Unreliable early rains can cause repeated sequences of germination and seedling death; very heavy rains cause massive runoff and fill surface ponds and streams, but poor infiltration into the soil means that pasture growth is poorly sustained. Rainfall distribution may be so unreliable that there is no possibility of permanent use of land by livestock - Bille (1983) has suggested

that a monthly rainfall of less than 60 mm gives very little or no grass growth (in the Ethiopian rangelands) and the probability that rainfall will reach this minimum figure in any one month is the best biological distinction between wet and dry months. Judged by this criterion some areas of the northeastern Ethiopian rangelands, for example, will have no effective primary production at least one year out of ten except in natural hollows. Baker (1975) pointed out that the Karamoja area of Uganda could expect one year in four to be so dry as to seriously reduce crop and pasture growth and cause losses of animals. This problem cannot be solved by the creation of more watering points, and such areas can be exploited in the long term only under a nomadic system permitting emergency access to areas which have more reliable pasture growth. If this becomes impossible, it will be necessary for governments to organise emergency drought relief in the form of livestock or human food, or emergency purchase of excess stock.

Areas with a well-defined but erratic bimodal rainfall are better suited to livestock grazing than to introduction of cropping. Loss of browse through land clearing might even harm livestock production more than it would benefit from the dry-season crop residue grazing.

Rainfall cannot be controlled, but by systematic recording over the pastoral area it is possible to arrive at valuable estimates of reliability of monthly rainfall. This, in the long run, may make it possible to plan more stable systems of utilisation and development. This is clearly an option requiring governmental or regional projects' initiative, and might well be linked to modern methods of satellite remote sensing, to give advanced warning of failure of rainfall, and to provide long-term and large-scale monitoring of rangeland conditions.

Problems of undernutrition

Inadequate nutrition in the dry season may occur as a long-term problem because of progresive loss of dry-season grazing areas, associated with increasing pressure of populations or with ethnic or political rivalries. For such cases the options lie with govern-

ments, through development planning or market and pricing structures aimed at increasing the sale of surplus stock and thus reducing the pressure on grazing resources.

Undernutrition occurs in normal years in most pastoral areas, and many options are available to pastoralists for reducing or avoiding its effects.

1. If it is not too serious, its effects can be minimized as far as possible by sale of stock and by careful management, relying upon the following wet season's gains to restore livestock to normal weight and productivity. This depends on the reliability of the compensatory growth phase and is the *laissez-faire* strategy adopted in many areas in Africa and overseas. It fails if the rains fail, particularly in areas where lack of marketing facilities makes it difficult or financially catastrophic to sell animals in a period of widespread feed shortage.

2. Provide additional feed by improvement of grazing resources. Pasture improvement by fertilizing and oversowing legumes is a well proven technique. Success depends on selection of suitable seeds and provision, by pelleting or otherwise, of any necessary plant nutrients and rhizobial inocula. Technically it is an attrative option, but success depnds also on restricting first-season grazing so that seedlings can establish, grow to maturity and set seed. This cannot be done on communally grazed land and this option, while technically feasible, is therefore not applicable in most African pastoral areas. It has been shown, however, that some systems recognize the right of a person to reserve an area for his own use - as the *olepolole* reserved for calves or milking cows in the Kenyan Maasailand. In northern Nigeria it has been found that pastoralist Fulani may fence off an area of several hectares by agreement with landholding sedentary farmers and that productive pastures of *Stylosanthes* species can be grown on this to provide good quality forage for the dry season. While this will not be possible for truly nomadic pastoralists it may become possible for transhumant herders with a recognized main camp, particularly under some form of herders' association or similar form of regulation of grazing rights.

3. Supplementary feeding. The technology of using protein concentrates (peanut or cotton-seed meal) or a cheaper non-protein nitrogen source (urea) is well established in developed pastoral countries. Compounded grain/molasses/urea supplements are easily made by appropriately simple village or small-scale industry. These are used in northern Nigeria, and the widespread practise of giving salt to animals in the Sahel suggests that, after a brief research study to define the nutrients most needed, herders might quickly adopt an improved type of nutrient supplement particularly if its cost of production or transport were subsidized by the government, as is the case with fertilizers in many countries.

In Mali considerable use is made of cowpea and groundnut haulms as supplementary feed, and ILCA has active programmes in both Mali and northern Nigeria developing improved methods and testing new varieties of legumes for use as an intercrop or in rotation with the traditional sorghum or millet. Whatever supplement proves to be best, economics require that it should be given to the animals most likely to benefit and not wasted where no response is to be had. This means that young females mating, calving or lactating for the first time should be given preference, as also cows whose poor condition might prevent their conceiving or rearing a vigorous calf. Newly weaned calves may well repay extra feeding. This is an intervention available to the individual herder when supplementary feed is available.

4. Modify grazing management. ILCA has shown that heavier grazing in the early wet season will make more feed available in the early dry season. This requires agreement or control over livestock numbers and some right of exclusive use of the extra pasture thus produced. The revival of earlier forms of social/territorial organisations, or the creation of new herders' associations may make this option possible.

In many areas valuable browse species could be encouraged by selective clearing of others. Browse could be used more efficiently by careful selective cutting of branches to encourage regrowth, or by judicious use of fruit in the dry season (Cissé, 1982). This, too, might require some form of agreement among herders using a particular area - there are precedents for such rational utilisation methods.

5. Modify livestock management. Where pasture is inadequate, particularly if this is associated with bush encroachment it may be better to reduce numbers of sheep or cattle and increase camels or goats, which are better able to subsist on browse. The association of goats with degenerated pasture land does not necessarily mean that goats cause degeneration. Their selectivity in browsing enables them to produce on land where sheep and cattle, mainly grazers, cannot thrive. Their higher quality intake is obtained only at the cost of lower quantity - Schwarz and Said (1981) found that nutrient intake of goats in the dry season was only 1/4 to 1/9 their nutrient intake in the wet season, but protein intake was 1/3 of the wet-season level. Further research is needed to study grazing and browsing habits and the effects of different methods of stocking on browse production and regeneration.

More dry-season forage could be made available by the establishment of more water points, ponds or wells to extend the pastoral area available for grazing in the dry season. This requires government or regional action, combined with careful assessment of the probable effects on the vegetation of increased or more prolonged grazing pressure. Where no great harm is to be expected and where some communal control of livestock numbers can be assured this is perhaps one of the most attractive options.

In agropastoral areas sedentary farmers have available new short-cycle varieties of cereals which generally require reasonable soil fertility. This can be maintained best by animal manuring, and farmers are putting in extra wells in order to attract pastoralists to bring their cattle to the farmers' fields in the dry season (Fulton and Toulmin, 1982). This interdependence between farmers and herders will become more and more important in the future.

Within the power of individual pastoralists is the possibility of better matching feed requirements to feed supply by controlling the times of mating and of weaning. To some degree conception in cows is dependent on their response to improved nutrition during the two to three months of the wet season and calvings tend to cluster in the late dry season following. The need of pastoralists for a year-round supply of milk probably accounts

for a more even spread of calvings seen for example in Wilson (1982). Whether it is possible to reduce neonatal and later deaths, and to improve overall productivity by control of mating times or by supplementary feeding of bulls or of cows calving out-of-season needs study in different systems.

Stock numbers could certainly be reduced by large-scale sale of surplus animals in the late wet or early dry seasons. This is a common feature of "stratified" or more highly developed pastoral industries but depends on the existence of marketing, transport and either abattoir or fattening facilities commensurate with the annual surplus cattle turnoff. This needs attention by government or development project planners but in the long run is essential to a rational exploitation of extensive pastoral regions.

The individual pastoralist could well be encouraged to cull the least productive of his stock, rather than keep cows indefinitely in the hope of getting a calf some day. This is logical if keeping extra cattle is felt to be at no cost to the individual since the land is communally owned but, in the longer term, pastoralists must be persuaded that a chronically diseased cow or one of genetically poor productivity is a liability and not an asset.

Separate management of different classes of cattle is already widely practised and has some advantages in both nutritional and health terms. It facilitates the gathering and holding for vaccination or sampling of large numbers of stock, particularly if combined with government establishment of dipping and similar facilities in the vicinity of the wells near which animals congregate in the early dry season. Dry stock could be grazed far from water in this season, allowing pregnant and lactating cows and calves to be given closer attention. Developments such as this call for some organisation of pastoralists as well as government policy initiatives.

Specific problems of particular systems

Young stock mortality

Young stock mortality is a problem in Ethiopia and in the Sahel with a two-year average of 28% deaths in calves. Research is needed to

establish to what extent this is due to undernutrition because of high milk offtake for human consumption, particularly from cows rearing male calves which are considered to be less valuable than female calves. In small ruminants mortality was 32% before weaning. The extent to which this was the result of disease or of other causes is not known. This represents an important field of potential improvement but requires further research. Losses in smallstock are similarly high in Kenya, but losses of calves are much lower. In Ethiopia and Mali the death rate in male calves is higher than in females, substantially because of competition with humans for limited milk supplies and preferential treatment of heifer calves. Improved nutrition and milk production would lead to a substantial increase in the number of surplus male calves reared for sale.

Bush encroachment on grazing lands

Research is needed into the long-term stability of grazing resources in relation to grazing pressure, stocking rate and type of stock used. Growth of productive browse shrubs and trees does not mean a reduction in total primary production, and the spread of browse species that may be used in the dry season should help to correct the lack of feed that usually occurs then. Again, the fact that land is common-owned means that no pastoralist is prepared to spend his time and effort to selectively clear undesirable species, or to safeguard young browse seedlings during their vulnerable years by reduced grazing pressure. Creation of pastoralists' associations is a very necessary first step in the better husbandry of grazing resources.

Epidemic diseases

Vaccines are available for some of the infectious or tick-borne diseases that have in the past wiped out herds and flocks. Research is continuing at ILRAD and there may one day be vaccines for East Coast fever and trypanosomiasis. There is an urgent need for more dipping or spraying and injection yards, better distributed over major pastoral areas. In the absence of any regulation or control of grazing, the development of rotational systems to reduce the number of tick or helminth larvae is impossible. In other countries it has been possible to introduce more resistant breeds of livestock, but

zebu-based cattle and local breeds of smallstock are probably the most resistant livestock available. Apart from manual removal of ticks no management or genetic means seem to be available, and pastoralists must rely on veterinary and chemical methods of control, which in turn depend on active, well motivated extension, advisory and veterinary services in the zone affected.

Good versus poor herdsmen

Apart from identifiable single causes of production losses, evidence from ILCA's studies in Mali and in Kenya shows that there are large differences between herds and flocks, within the same general type of husbandry.

Table 4. *Production indices* for* (a) *Mbirikani group ranch, Kenya and* (b) *two agropastoral systems in Mali (goats and sheep combined).*

	Production index			
	(a)		(b)	
	Goats	Sheep	Millet	Rice
Best flock	676	692	816	1 200
Worst flock	101	257	312	226

* $\frac{\text{Average litter size x survival to weaning x 150 day weight}}{\text{Ewe weight postpartum}}$

Research is needed to identify the features of individual herd or flock management responsible for these large differences. In Kenya Grandin has shown that productivity is associated with the wealth of the "owner" or with herd or flock size, but it is claimed that great skill is involved in grazing management in the early wet season and that this has great influence on yearly productivity (Swift, 1982). If these special skills can be described and understood, it might be possible to raise poorer managers to near the

level of the best, without introduction of any alien technology. Wilson (1982) proposed an intervention pathway for small ruminants combining many of these ideas. The series of improvements proposed merits careful study, since it is based on many years' experience in several countries.

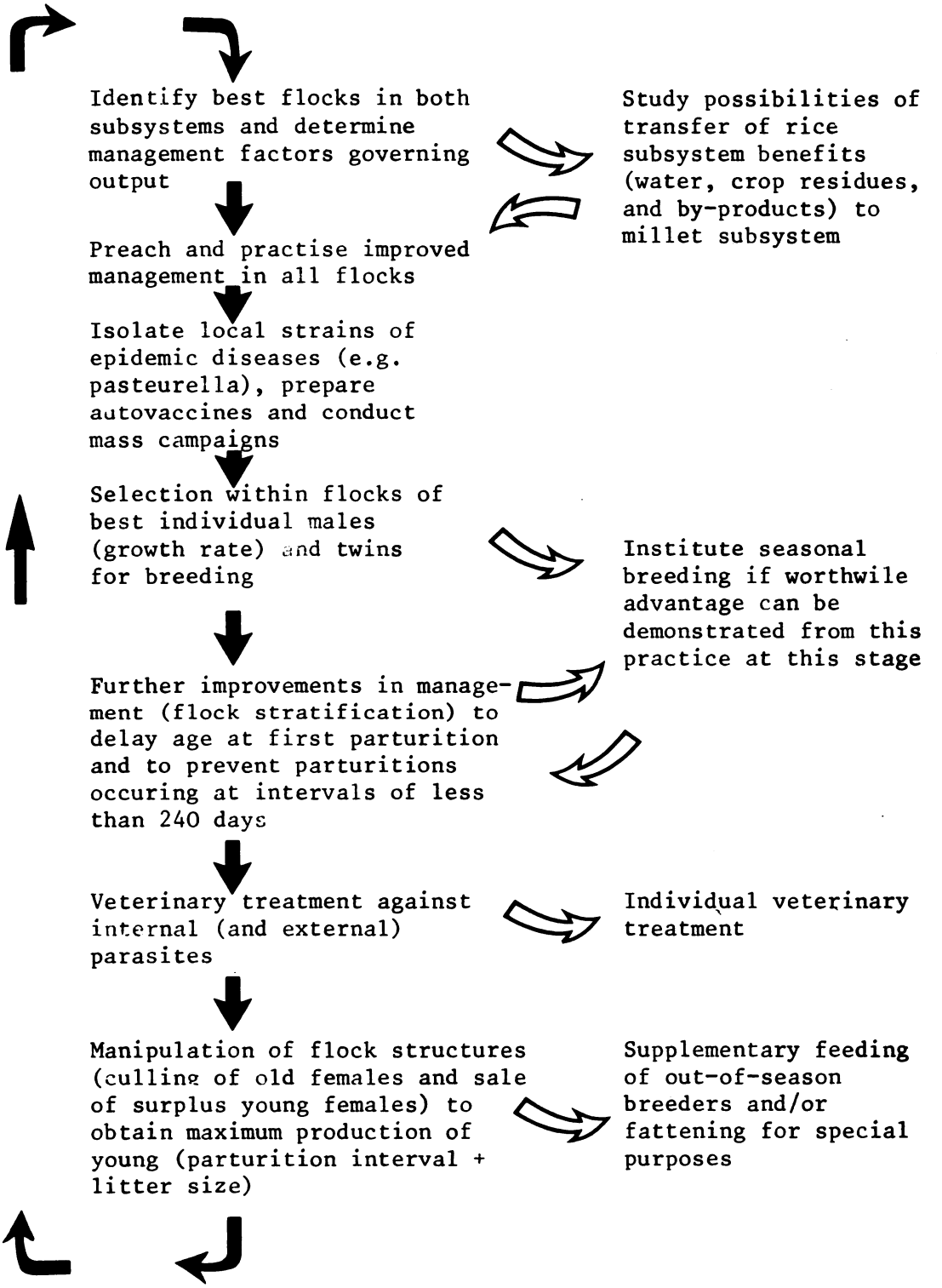

Fig 2. *Intervention pathways for small ruminants in the agropastoral system.*

Conclusions

The argument that a systems approach is valuable, not just in identifying problems but in deciding the most effective means of problem-solving, is amply borne out by ILCA's experience. The examples quoted here all show the value of understanding the interrelationships among the causes of lowered livestock productivity. This makes it possible to direct attention to the root of the trouble, rather than to be misled by superficial symptoms. Thus, calf deaths result from the interplay of human needs and milk production, determined by level of nutrition, which is itself the complex result of primary forage production and its exploitation by individually managed herds and flocks.

Increased numbers of water sources may solve an immediate feed problem by making large areas available for dry-season grazing, but this may be harmful in the long run to the stability of some fragile plant associations.

Improvement of grazing resources by proven technology of legume oversowing depends on the prior creation of some form of associations of herders with an interest in regulation of livestock numbers and grazing pressures on the area of land for which they are responsible.

Because of the overriding influence of aridity, and the communal use of land not many of the options of technology are applicable in purely pastoral systems. Those that are relevant often depend on prior government initiative or some form of social-territorial organisation, but there are some ways in which pastoralists could help themselves. More possibilities exist in agropastoral systems, and in forms of transhumance which allow pastoralists to become responsible for, and to benefit from, a defined area of land.

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Options bio-techniques

Résumé

Dans le document précédent, il a été procédé à l'examen des questions les plus importantes aux plans social et économique en ce qui concerne l'identification de l'envergure des améliorations de la production pastorale. Il est également important de considérer les possibilités biologiques ou techniques d'amélioration des systèmes pastoraux et d'essayer de classer celles-ci par ordre d'applicabilité, en tenant compte non seulement des possibilités de succès au plan technique mais aussi de l'opportunité et de la factibilité des techniques en question.

Le document passe en revue certains des aspects techniques des systèmes pastoraux d'Afrique. Ces systèmes visent à assurer la subsistance des éleveurs et se fondent sur la production de lait. La productivité du troupeau bovin pourrait être augmentée de manière substantielle si la mortalité chez les veaux régressait, si on élevait plus de veaux et de génisses pour la vente que pour la production de lait, si la croissance des veaux était plus rapide et s'ils atteignaient la maturité plus tôt, si le premier vêlage des vaches intervenait à un âge plus précoce et si les vêlages subséquents étaient plus fréquents.

L'équipe du CIPEA au Mali a enregistré la quantité et la qualité du fourrage disponible et les changements de poids vif des bovins et des petits ruminants du système du delta du Niger. Il est évident que l'accroissement pondéral annuel enregistré au cours de la petite saison des pluies lorsque le fourrage est abondant et de bonne qualité se perd partiellement lors des mois de la saison sèche suivante, particulièrement pendant les semaines qui précèdent immédiatement la prochaine saison de croissance. La solution classique de ce problème prévisible chaque année consiste à effectuer des déplacements soit entre les zones de pâturage de saison sèche et de saison des pluies, dans des zones où les ressources en pâturages sont abondantes, soit dans des zones de culture où des sous-produits agricoles sont disponibles.

Les variations et la distribution de la pluviosité moyenne annuelle influencent considérablement la croissance des ressources pastorales et partant, la production secondaire de bétail. Des pluies précoces irrégulières peuvent être à la base de séquences répétées de germination de courte durée; les grosses averses peuvent entraîner un ruissellement abondant et remplir les mares et les cours d'eau de surface; mais une infiltration insuffisante dans le sol signifie une croissance inadéquate des pâturages. Les zones à pluviométrie clairement définie mais irrégulière sont plus adaptées aux pâturages qu'à l'introduction de cultures. La perte de ligneux par le défrichage pourrait causer au bétail un préjudice que ne pourrait compenser le pâturage des sous-produits agricoles en saison sèche.

Une nutrition inadéquate pendant la saison sèche peut constituer un problème à long terme à cause de la perte progressive de zones de pâturage de saison sèche associée à l'accroissement de la pression de la population ou aux rivalités ethniques et politiques. La malnutrition sévit dans les années normales dans la plupart des zones pastorales et les éleveurs disposent de plusieurs solutions pour en réduire ou éviter les effets. Ceux-ci peuvent être minimisés par la vente de bétail et par une gestion appropriée, basée sur les gains de la saison des pluies suivante pour restaurer la productivité du bétail et améliorer ses performances pondérales. Du fourrage supplémentaire peut être fourni par l'amélioration des ressources pâturables - fertilisation et ensemencement de légumineuses par exemple. La complémentation fourragère peut être pratiquée: la technique qui consiste à utiliser des concentrés de protéines ou une source non protéique d'azote moins coûteuse est bien établie dans les pays à élevage développé. Le CIPEA a également démontré que l'intensification du pâturage au début de la saison des pluies produit plus de fourrage au début de la saison sèche. Lorsque les pâturages sont inadéquats, en particulier lorsque cette insuffisance est liée à l'empiétement des broussailles, il serait peut être plus approprié de réduire le nombre des ovins et des bovins et d'augmenter ceux des chameaux ou des chèvres qui supportent mieux un régime basé sur la consommation de ligneux. On pourrait développer la quantité de fourrage en mettant en place beaucoup plus de points d'eau, de mares

ou de puits en vue de l'extension de la zone pastorale disponible pour les pâturages de saison sèche.

La mortalité des jeunes animaux constitue un problème en Ethiopie et au Sahel où,en deux ans, on a enregistré 28% des décès chez les veaux. Il conviendrait d'entreprendre des recherches en vue de déterminer le rôle joué par la malnutrition du fait des taux élevés de prélèvement de lait pour la consommation humaine, en particulier pour ce qui est des vaches ayant mis bas des veaux auxquels on attribue une valeur inférieure à celle des génisses. Il est nécessaire d'entreprendre des recherches sur la stabilité à long terme des ressources pâturables, eu égard aux pressions sur les pâturages, aux taux de charge et aux types de bétail utilisés. La nécessité d'aménager des périmètres où pourraient s'effectuer des bains détiqueurs, des pulvérisations et des injections devient urgente, de même que celle d'une meilleure distribution de ces périmètres dans les zones pastorales. Il est nécessaire d'entreprendre des recherches pour identifier les caractéristiques de la gestion des troupeaux de bovins ou de petits ruminants qui expliquent les grandes différences entre les troupeaux de bovins et les troupeaux de petits ruminants élevés dans la même zone.