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Chapter

Livestock Feeds and Feeding in Semi-Arid Areas of Southern Africa

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Abstract

Livestock production is the major source of rural livelihoods in semi-arid regions of Southern Africa. However, nutrition is the major limiting factor of livestock production in these areas characterised by declines in rangeland productivity due to the increases in drought frequency, deliberate overstocking by farmers, and climate change and variability. For instance, the grazing resource is strongly influenced by seasonality of rainfall. Poor-quality cereal crop residues are the main dry season supplementary feed source, yet the predominant crops such as sorghum and maize are deficient in protein and other essential nutrients. Additionally, although conventional supplements, fodder crops and agro by-products are an alternative dry season supplementary feed source; they are costly and not readily available. They are also mostly based on staple food crops such as maize, creating competition in use between humans and livestock. Therefore, indigenous browse species remain a significant source of abundant and persistent animal feeds. Other innovations with the potential to improve feed availability include straw ammoniation and silages, veld reinforcement and rehabilitation, and strategic destocking. However, they are not readily adopted by farmers. There is thus a need to promote technologies that improve livestock feeds and feeding for sustainable livelihoods.

Keywords: livestock production, nutrition, sustainable rural livelihoods

1. Introduction

In the semi-arid areas of Southern Africa, livestock production underpins the socio-economic and political lives of the people. Meat and milk from livestock are important dietary protein sources. Livestock production also creates employment opportunities and provides household income. Furthermore, it promotes viability of small-scale cropping systems through provision of draught power and organic manure. Cattle, in specific, are socioculturally important as a measure of wealth. Actually, Zimbabwean small-scale farmers generally own 89% of the national cattle herd, with the livestock sector contributing 35% of the agricultural gross domestic product [1]. However, constraints to the increasing livestock productivity in semi-arid areas include water and feed shortages, diseases, and lack of research and markets. Of these, nutrition is the major factor in extensive livestock production systems, contributing more than 75% of the total variable costs of production [2, 3]. Thus, a comprehensive inventory of animal feeds and feeding systems in semi-arid areas will inform sustainable livestock production.

Rangeland productivity, i.e. the amount of available grazing and browse per square area per unit time, is a proxy indicator of sustainability of livestock-based rural livelihoods. In recent years, climate change and variability, among other factors, has resulted in the declines in the quality and quantity of the rangelands in semi-arid areas such as the South East Lowveld (SEL) of Zimbabwe [4–7]. Additionally, in these areas, while Transfrontier Conservation Areas (TFCAs) have been established mainly to facilitate sustainable livelihoods, global biodiversity conservation, regional peace, and sustainable socio-economic development of African communities through the cooperation at local and international levels [8], they are also likely to increase interaction between wildlife, livestock, and humans with adverse consequences. For instance, due to increased human and livestock populations in surrounding agricultural areas, cattle are likely to encroach more into wildlife areas in search of feed [9]. Therefore, a deeper comprehension of animal feeds and feeding will improve livestock production and consequently transform rural livelihoods.

Innovations in livestock husbandry are the activities and processes associated with the generation, production, dissemination, adaptation, and use of existing or new technical, institutional, and organisational knowledge [10, 11]. Although there are different innovations in livestock feeds and feeding, most of them have not been adopted by farmers [12]. For instance, [12] showed that discontinuance of urea treatment of maize stover for livestock supplementation was attributed to high labour requirements of preparing the stover, lack of monitoring by extension services, and inaccessibility of urea fertiliser. It is thus important for the policy to consider such factors as the economic environment, availability of local material, and social and human capital when promoting livestock production systems. In this chapter, we explore and explain different livestock feeds and feeding strategies that are mostly adopted in semi-arid areas. We also recommend other alternatives that have a potential of adaption for increased livestock production.

2. Materials and methods

2.1 Study site

The study was carried out in the semi-arid South East Lowveld (SEL) of Zimbabwe. The area is found at an altitude of 300–600 m above mean sea level [11]. It experiences mean maximum and minimum temperatures of 21.8°C in October and 13.3°C in June, respectively, and mean annual rainfall of 300–600 mm between November and March and is characterised by high interannual variability (coefficient of variation ≈ 4045%) [13]. The major soil types are basalt-derived vertisols. Other soil types include eutric fluvisols, leptosols, and chromic luvisols [14]. The two main land uses in the area are agricultural production in the communal areas and wildlife conservation in Gonarezhou National Park and Malipati Safari Area, both of which form part of the Great Limpopo TFCA that contains a wide range of wildlife species such as *Loxodonta africana* (the elephant), *Giraffa camelopardalis* (giraffe), and *Syncerus caffer* (African buffalo). A communal land is a land category characterised by collective or community land ownership [15]. Livestock production is the major source of livelihoods in the communal area, while small grains and maize are also commonly grown.

2.2 Data collection

Individual structured questionnaires were administered to 150 respondents randomly selected, representing approximately 12% of the total households in the study area. The questionnaire was designed to capture socio-demography and livestock production characteristics, specifically feed resources and farmer innovations in livestock feeding and management. The questionnaire was pretested before final administration. We also conducted two focus group discussions (FGD) with seven key informants each, representative of the pastoral, agro-pastoral, and crop-livestock production systems in the area. For the woody species, we carried out veld assessment. Using the point-centred quarter method [16], we established 53 30 m × 30 m plots at each sampling point along 9 transects randomly established, measuring between 10 and 15 km each. The plant species were identified with the help of the locals in addition to using field identification guides [17–19]. Canopy structure, tree height, growth habit, leaf, bark, and other tree structures were used to differentiate closely related trees. Trees rooted within the plot, or along plot margins with at least half of the rooted system inside the plot, were considered [20]. We also recorded altitude and location of each individual tree using a Global Positioning System (GPS) Unit. Samples of the species not identified in the field, as well as all the other species, were collected for verification at the National Herbarium in Harare, Zimbabwe.

3. Results and discussion

3.1 Feeds and feeding resources in the SEL

3.1.1 Grazing resource

The veld of the SEL is described as "*Aristida-Dactyloctenium-Eragrostis* other species grassveld". It has a carrying capacity of 0.084–0.14 tropical livestock units per hectare [6]. The grazing period ranges from November/December to April/May. The veld remains nutritious and palatable for livestock across seasons. The herbaceous layer is dominated by *Aristida adscensionis* L., *Dactyloctenium giganteum* B.S. Fisher & Schweick., *Eragrostis viscosa* [Retz.] Trin., *Chloris virgata* Sw., and on deeper soils with more moisture, *Urochloa* spp., *Panicum* spp., *Cenchrus ciliaris* L., and *Digitaria* spp. [21]. On well-managed grazing systems, cattle exhibit annual live weight gains of 15 kg/ha. However, herbaceous species structure and composition are strongly influenced by seasonality of rainfall. For instance, the biomass disappears rapidly in drought years or when the start of the rainy season is delayed (**Figure 1**) [6]. Therefore, there is a need for supplementary feeding, especially during this period of scarcity of the grazing resource.

3.1.2 Crop residues

In the SEL, poor-quality cereal crop residues (less than 4% crude protein) form the bulk of livestock supplementary feed in the dry season, which normally extends from May/June to October/November. The predominant crops are sorghum, millet, and maize. However, they are deficient in essential nutrients such as protein, phosphorus, calcium, and, to some extent, energy [22]. Such supplements have low feed intake resulting from low degradability and low digestibility. Therefore, they do not provide for optimum microbial growth in the rumen. As a result, animals raised on these low nutritive feeds exhibit poor condition and reduced reproductive performance [23]. Crop residues are managed in many ways

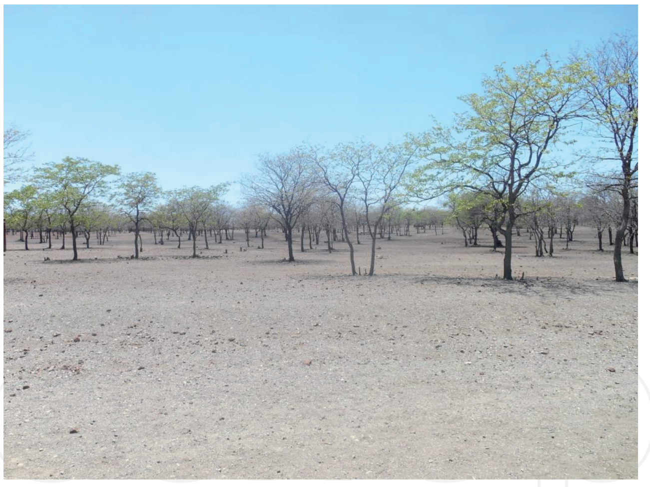

Figure 1.
The grazing resource during dry seasons in the South East Lowveld of Zimbabwe.

Figure 2.
Maize stover forms part of the bulk of cereal stover supplements in the dry season.

for livestock feeding. Cereal stovers are either grazed in situ or stored in stacks for supplementation during the dry season (**Figure 2**). During prolonged dry seasons, the first preference is for maintenance of productive animals such as lactating cows or the sick. Haulms from leguminous crops such as cowpea and groundnuts are also used in stall-feeding. Despite being of higher nutritive value than cereal stovers, they have limited availability as leguminous crops are not commonly cultivated at large scale. Recently, conservation agriculture has presented conflict of interest in utilisation of crop residues. Conservation agriculture is a farming method that utilises crop residues to retain moisture and enrich the soil [24]. Increased adoption of conservation agriculture creates limitations in the availability of crop residues for livestock feeding.

3.1.3 Browse trees

Indigenous browse species are an important source of animal feed in livestock-based rural livelihoods of semi-arid areas (**Figure 3**) [25, 26]. The natural vegetation of the SEL is predominantly *Colophospermum mopane* [J.Kirk ex Benth.], J. Léonard woodlands found in association with *Kirkia acuminate* Oliv., *Dalbergia melanoxylon* Guill. & Perr, *Adansonia digitata* L., *Combretum* spp., *Acacia* spp., and *Commiphora* spp. In addition, recently, a shrubby legume called *Neorautanenia brachypus* [Harms] C.A.Sm. was discovered as a medicinal feed that helps livestock to survive drought [6]. Other browse species of the SEL are presented in **Table 1**. Most indigenous browse species remain abundant, evergreen, and relatively high in protein, metabolisable energy, vitamins, and minerals across seasons [27]. Unlike herbaceous species, browse species are less susceptible to climatic fluctuations, with crude protein (CP) levels of approximately 10% even in the dry season [28]. However, early and increased dependence on browse by livestock in semi-arid areas of the

Scientific name	Vernacular/English name
Acacia albida	Shokoshoko/winter thorn
Acacia karroo	Muunga/sweet thorn
Acacia tortilis	Sesani/umsasane/umbrella thorn
Acacia xanthophloea	Kelenga/fever tree
Adansonia digitata	Mabuwu/baobab/muwu
Aloe cameronii	Mhangani/aloe
Berchemia discolour	Munyii/bird plum
Boscia albitrunca	Shukutsu/shepherd's tree
Brachystegia spiciformis	Musasa
Cassia abbreviata	Murumanyama/long-tail cassia
Cissus quadrangularis	Chiololo/chiolololoti/muvengahonye
Colophospermum mopane	Mopane/xanatsi/turpentine tree
Combretum apiculatum	Chikukutsi/red bushwillow
Combretum imberbe	Mutsviri/mondo/monzo/leadwood
Dichrostachys cinerea	Mupangara/ndenge/sickle bush
Diospyros mespiliformis	Musuma/tithoma/jackalberry
Ficus sycomorus	Muonde/mikuwa/sycamore fig
Hippocratea crenata	Sengeti/valley paddle pod
Hyphaene petersiana	Makwangwala/Ilala/real fan palm
Julbernadia globiflora	Mutondo
Kigelia africana	Pfungu/mumvewa/sausage tree
Lonchocarpus capassa	Mupanda/umchitamuzi/rain tree
Mimusops zeyheri	Hlatsva/Chechete/red milkwood
Neorautanenia brachypus	Zhombwe
Phragmites mauritianus	Shanga/reed grass
Salvadora persica	Dhungulu pokwe/mustard tree
Sclerocarya birrea	Mupfura/marula/mufura
Xanthocercis zambesiaca	Muhlaru/Musharo/Nyala berry

Adapted from Mudzengi et al. [36].

Table 1.
List of indigenous browse trees in the SEL.

SEL during the dry season limits their availability in the rest of the season [29]. Fresh leaves of species such as *C. mopane*, for instance, are high in tannins and lignin [30, 31]. Additionally, indigenous browse species normally attract multiple uses at the livestock-wildlife interface with the more visible, more dominant, and more frequent browse species having more uses than less apparent plants [32]. They are used as sources of firewood, timber, fruits, edible roots, bark and leaves, and human and ethnoveterinary medicines [33–36]. Competitive use increases vulnerability to overutilisation, unsustainable harvesting, and mismanagement.

3.1.4 Fodder crops

Fodder refers to any plants grown specifically as animal feed. They include a variety of pasture grasses like *Panicum maximum*, *Cenchrus ciliaris*, and *Chloris gayana*; pasture legumes such as *Vigna unguiculata*, *Dolichos lablab*, and *Macroptilium atropurpureum*; and fodder trees such as *Leucaena leucocephala*, *Acacia angustissima*, and *Calliandra calothyrsus*. However, most of them do not thrive in semi-arid areas such as the SEL due to high temperatures and low precipitation. Low adoption of fodder crop production is also attributed to lack of extension for farmer training, shortage of labour due to overlapping of the farming calendar with the main crop, high cost and unavailability of seed, and land scarcity. It is therefore important for farmers to maximise production of those species adaptable to their climatic conditions.

3.1.5 Conventional supplements, food industry, and agro-industrial by-products

There are different food industry by-products and agricultural wastes that are alternative dry season livestock feed supplements. These can be of animal and plant origin or of the fermentation industry. Animal by-products include blood, bones, meat and bone offals, fat, intestine and rumen contents, whey, tannery by-products, and poultry manure [1]. By-products of plant origin consist those of the milling industry (e.g. bran, waste flour), oil industry (e.g. soya bean and sunflower cakes), sugar industry (molasses), and citrus and horticulture waste. The fermentation industry produces grain, molasses, and brewer's waste, among a large array of other by-products. By-products of plant origin are the commonly used. For instance, in the SEL, molasses is readily available as the main sugarcane processing factories in Zimbabwe are located in that area. However, high cost of transportation

Figure 3.
Browse trees provide feed during the dry season when both the grazing resource and cereal stovers become limiting.

makes the product often quite expensive. Additionally, those of plant origin are also mostly based on staple food crops such as maize and soya bean, creating competition in use between humans and livestock.

3.2 Recommended innovations in livestock feeds and feeding

3.2.1 Straw ammoniation

Straw ammoniation is the process of addition of urea, liquid ammonia, or ammonium bicarbonate to poor-quality cereal crop stovers in order to improve their palatability, nutritive value, and digestibility. Of these three, urea is the most readily available and easiest to handle ammonia source. Nevertheless, in the SEL, as in most rural areas, urea treatment still is not a commonly used method improvement of the feeding value of cereal stovers due to lack of expertise in carrying out the procedure, as well as unaffordability for most rural resource-poor farmers. Additionally, if not done properly, urea-treated straw can be toxic to animals and cause air pollution.

3.2.2 Silages

Silage is forage produced from the fermentation process of chopped fresh green material under anaerobic conditions. These materials include fodder or forage grasses. Ensiling maize has been shown to improve feed digestibility and reduce methane gas production by 30% compared to feeding dry maize [37]. However, despite silages being advantageous in areas of water shortages, as well as reducing tannins due to the heat produced during the incubation period, silage production is not common among farmers.

3.2.3 Other strategies

Other potential technologies include intercropping cereals with ley (dual-purpose) legumes [38]. Ley legumes provide protein-rich fodder, improve the productivity of cereal crops by increasing the amount of nitrogen available for uptake, as well as offer a possible lower-cost alternative to nitrogen fertilisers [39, 40]. In addition to cut and carry systems for feeding fresh plant material, leaf meals can also be produced by drying harvested leaf material under shed. The commonly grown multipurpose trees include *Leucaena leucocephala*, *Calliandra calothyrsus*, and *Gliricidia sepium*. The leaf meal can then be incorporated in home-made livestock rations. Cutting and drying herbage from forage and multipurpose trees can also increase feed availability. Multipurpose trees can be grown in alleys as live boundaries, home gardens, and contour ridges and in woodlots.

3.3 Rangeland management

3.3.1 Principles of rangeland management

There are generally four fundamental principles of rangeland management which are important in order to improve condition and stability of the veld and consequently increase feed. They are rest, removal of top hamper, period of stay, and stocking density. Rest facilitates replenishment of plant growth reserves and also sets seed after defoliation. Top hamper is dead plant material accumulation which causes shading out of new shoots as they develop. It represents a nutrient bottleneck by preventing plant material from recycling back into the soil. It should therefore be removed. Another principle of rangeland management is control of period of utilisation by animals. This is important as too long periods result in overgrazing, while too short periods cause underutilisation which leads to top hamper and consequently reduced plant vigour. Stocking density refers to the number of animals that is kept on a given unit of area [41]. This has a direct relationship to the carrying capacity of the range. For instance, understocking causes selective grazing, which depletes palatable grass species. On the other hand, overstocking may degrade the range. For high stocks of reserve biomass, and for farmers with a relatively low degree of risk aversion, an "opportunistic" strategy is optimal, which matches the stocking rate with the available forage in every year [42]. On the other hand, the "resting in rainy years" grazing management strategies are recommended in which a lower stocking rate is applied in years in which current rainfall exceeds some threshold, and in years with current rainfall below this threshold, full stocking is optimal [39, 42–44].

3.3.2 Veld reinforcement

Veld reinforcement is the introduction, to the rangeland, of new grass or legume species in order to improve both the quantity and quality of the natural vegetation. Legume forages such as *Desmodium uncinatum*, *Macroptilium atropurpureum*, *Stylosanthes guianensis*, and *Cassia rotundifolia* can be used, while grass species including *Cynodon nlemfuensis*, *Paspalum notatum*, and *Panicum maximum* are also good for veld reinforcement.

3.3.3 Rangeland fertilisation

Rangeland fertilisation is the application of fertilisers such as ammonium nitrates on the rangelands in order to increase the quality and quantity of forage. However, this method is not highly recommended as fertilisers are expensive and at times not readily available.

3.3.4 Control of undesirable plants

Undesirable plants are not readily utilised by animals and may cause rangeland degradation. They include invasive species (e.g. *Dichrostachys cinerea)* and poisonous species (e.g. *Lantana camara* and *Solanum incanum*). They may be removed by stumping, ring barking, and application of chemicals such as arboricides, using hot prescribed fires or mechanical means like bulldozers, motorised saws, and brush cutters.

3.3.5 Range rehabilitation

Range rehabilitation is the restoration of the veld using such methods as gulley filling and planting grass lines. However, it is more feasible at small scale. Both communal and private enclosures have also been successfully used to rehabilitate rangelands [45, 46].

3.3.6 Strategic destocking

In the SEL, deterioration of rangeland productivity during prolonged dry season characteristic of the area is worsened by deliberate increases in cattle numbers by farmers who use the high cattle numbers as a hedge against losses during drought [6]. Therefore, it is recommended that farmers should adopt strategic destocking programmes that promote fattening of animals during periods of feed abundance and disposal while they are in good enough body condition to fetch high prices.

4. Conclusions

Livestock production in semi-arid areas is hampered by shortages of feed, especially in the dry season when the grazing resource becomes limiting. During this time, browse species play an important role as the most abundant and nutritious feed. Although crop residues are also a likely supplementary feed, they are of poor nutritive value. Potential technologies to improve such feedstuffs include urea treatment and ensilage. However, they are also not readily adopted by farmers due to lack of knowledge among other factors. It is therefore important to promote such innovations with the view to improve livestock production and hence rural livelihoods.

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Conflict of interest

The authors declare no conflict of interest.

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