INTRODUCTION

The semi-arid zone of West Africa covers nearly 1.5 million km² between the arid Sahara desert in the north and the Sudanese savannah in the south. It includes a small fringe of the Sahel and a larger Sahelo-Sudanese area in the south. There are two main seasons a year: a short (3-5 mo.) rainy season starting in June and a longer (7-9 mo.) dry season. Annual rainfall varies from 500 mm in the north to 900-1000 mm in the Sahelo-Sudanese south.

THE ENVIRONMENT

The soils are generally sandy and of windblown origin in the north. Their organic matter content is low. On the rocky outcrops and on the laterite crusts, one finds shallow skeleton soils, rich in major minerals. The dunes, the rocky outcrops and the laterite crusts constitute the higher areas, whereas the valleys with clay-loam soils form the lower parts. Slopes of varying degrees, with intermediate soils, make the transition between the two types. The rainwater runs in streams down from the heights to the valleys where it sometimes forms temporary lakes. The intensity of run-off varies with the topography and the texture of the soil, but in general only 75% of precipitation penetrates the soil (Penning de Vries and Djiteye, 1982).

VEGETATION

Two principal types of vegetation are found in the region. The northern part (Sahel) is the area of steppe and shrubland, made up essentially of annual grasses and woody plants of the genera Acacia, Balanites, Ziziphus, etc. In the south, savannah replaces the steppe; the grass canopy improves with the appearance of tall perennial grasses. The woody vegetation becomes more and more diverse and dense as one goes south.

The steppe is an open formation. The rate of recovery of the herbaceous stratum is poor; the xerophytic character of the grasses is very pronounced: short growing season grasses with narrow leaves in circles or basal rosettes. Depending on the density of the different elements, the steppe takes the form of trees, shrubland or grassland. The spatial distribution of these different forms is a function of the nature of the soil and of the topography. The sand dunes, with poor water holding capacity, and the slopes rarely have woody plants but
the herbaceous stratum, made up of annual grasses, is well developed. The most common species are *Cenchrus biflorus*, *Schoenefeldia gracilis*, *Eliornorus elegans*, *Borreria* spp., etc. The importance of the herbaceous stratum is a function of the development of the trees and shrubs. The perennial grasses with longer growing seasons which appear include *Andropogon gayanus* and *Diheteropogon hagerupii*. The transition zone between a dune area and an adjacent valley is generally formed by a compacted soil, impermeable and unsuitable for the establishment of vegetation. The last type is found locally between the dunes and valleys, separated by bare strips where only a few species with very short cycles (*Zornia*, *Dactyloctaninum*) are still able to survive. The poor nature of the soil and the irregular rainfall impose an important restriction on production.

Penning de Vries and Djiteye (1982) estimate the total herbaceous biomass production of this region as 1000-2000 kg dry matter per hectare. Although the energy value of this biomass is satisfactorily maintained up to the middle of the dry season, it must be emphasized that the nitrogen content becomes insufficient from the end of the rainy season, with the flowering of the grasses. The contribution of edible material from the forage trees in this period (leaves, flowers and pods) partially compensates for the poor quality of the herbaceous biomass. Nevertheless, many areas remain unexploitable because of the lack of water.

Like the steppe, the savannah can take various forms: grassy savannah, shrubby, woody and forested. The dominant species in the southern part of the semi-arid zone are the annual grasses with long cycles: (*Pennisetum pedicellatum*, *Andropogon pseudapricus*, *Diheteropogon hagerupii*) and the perennial grass *Andropogon gayanus*. The biomass production of the grass canopy reaches an average of 3.5 tonnes per hectare. The extent of this production explains why this zone can burn each year during the dry season. The bush fires destroy the reserves of dry grass, reduce the seeds and modify the form of the trees. As a general rule, the areas in the north part are of better quality than those of the south, where in addition, the tsetse fly appears in the region of the 14th parallel.

The semi-arid zone of West Africa is crossed by two of the major rivers of the continent: the Niger and the Senegal. Along the route, these rivers overflow their banks and flood entire regions in which important aquatic grasslands develop. In the *Echinochloa stagnina* flood plains of the central delta of the Niger, biomass production can reach 6-17 tonnes per hectare (Boudet, 1975).

The stocking capacity of the pastures of the semi-arid zone is strongly related to the rainfall (northern part) and the pattern of fires (southern part). Boudet (1975) calculated it at 50-60 kg/ha/year in the steppe and 80 kg on average in the savannas.

Furthermore, the state of the areas of the semi-arid zone is subject to major variations. If during the rainy period (3-5 months/year) the animals have at their disposal relatively abundant
and good quality forage, the situation rapidly reverses in the dry season; in the north, pastures which are still of acceptable quality have to be abandoned through lack of water, just as in the south, a great part of the biomass is wiped out by the fires.

THE SYSTEMS OF PRODUCTION AND THEIR CONSTRAINTS

The semi-arid zone of Africa supports 60 to 70% of the national cattle populations of the countries concerned. Except for some establishments of an experimental nature (state ranches, pilot farms, etc.), livestock management is conducted according to traditional systems. Two main systems of production can be identified:

The pastoral system

This system is found in the northern part of the zone where the irregularity of the rains prevents the establishment of crops. The principal product is milk and the main function of the cattle is to more or less provide for human subsistence. The pastoral system is characterized by temporal and spatial mobility. The periodic migrations here take the form of nomadism between water holes in the dry season. The livestock involved are relatively few (less than 10% in Mali).

The herds are composed of cattle, small ruminants (notably goats) and camels, all contributing to milk production. In addition, the small ruminants provide meat to the herders and the camels are used for transport. Crops (mainly milo) provide important complementary foods; the herders obtain this in exchange for cattle or milk from the settled population. The level of commercialisation of the cattle is minimal, but occasionally two or three old bullocks or infertile cows can be sold in order to meet tax obligations or for the purchase of consumable goods. As well as their economic functions, the livestock dominate all aspects of social life.

Jahnke (1984) identified three fundamental principles of herd management in the pastoral system:

- adaptation to the natural environment: the availability of water and the quality of pastures determines the migration of the total or part of the herd over distances and times in different years. The overall size of the herds and the distribution of species have the objective of guaranteeing regular provision of milk by the best utilization of available vegetation;

- the prevention of risks: the animals are divided up into different groups in order to divide the risks of disease and to adapt to the requirements for distant pastures in case of prolonged drought. The tendency for the herders to increase numbers and keep old females is also part of this same strategy.
adaptation to the institutional environment, characterized by a method of collective responsibility for pastures; increasing production by increasing numbers results from collective exploitation of pastures.

The productivity of livestock in the pastoral system is low (see Table 1), varying from one region to the other and between years. Camels and small ruminants are 1.5-2 times more productive than the cattle; but, on average, the annual productivity of the area varies from 26.2-31.4 kg/ha for milk and 2.6-3.1 kg/ha for meat (Jahnke, 1984).

Since the drought which started in the 1970s, there has been a major disturbance of the pastoral system. Faced with environmental degradation, an effort to adapt has resulted in certain cases in the settlement of some of the herders around permanent waterholes. At the same time, the distances involved in transhumance have been extended for the others. The proportion of cattle has been reduced in favour of small ruminants and camels, but overall, the equilibrium between present numbers and available forage resources remains precarious.

Table 1. The productivity of livestock in the pastoral production systems of tropical Africa.

<table>
<thead>
<tr>
<th>Production</th>
<th>Cattle</th>
<th>Camels</th>
<th>Sheep &amp; goats</th>
<th>Mixed herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg/head</td>
<td>66</td>
<td>248</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>kg/livestock unit</td>
<td>95</td>
<td>248</td>
<td>220</td>
<td>161</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg/head</td>
<td>9.6</td>
<td>7.4</td>
<td>3.5</td>
<td>-</td>
</tr>
<tr>
<td>kg/livestock unit</td>
<td>13.7</td>
<td>7.4</td>
<td>34.5</td>
<td>16.3</td>
</tr>
</tbody>
</table>

The agropastoral systems

These are the systems in which livestock production is practised in association with agriculture. This association may be close and complex, or livestock and crop production may, on the contrary, be parallel activities in their own right and can even belong to
different management units. In this case, the association comes down to geographical proximity. Two principal sub-systems of management can be distinguished according to the nature of cultivation practised: rain-fed farming (mainly milo) and irrigated farming (rice).

In the rain-fed mixed farming system, a minimum of agricultural activity is carried out near to the dwellings, to provide crops for family consumption. The milk also contributes to the food supply but may also obtain some (variable) income for the farmer. Within the same production unit, the livestock can provide the means of production as animal power and manure. They generally benefit from the crop residues and, more rarely, from agro-industrial by-products whose distribution is limited to draught animals.

Competition exists, however, between the two activities in the use of land; it is accepted that it is the crops and not the livestock which provide the principal basis for subsistence. The latter do not usually benefit from the right to graze during the cropping period. The migration of zebu herds towards the north occurs regularly and is sometimes seen as inevitable. At the southern limit of the region where the trypano-tolerant animals are found, this transhumance is not generally practised.

The irrigated mixed farming system applies to the central delta of the Niger and of the Senegal. The income derived from livestock rearing is relatively limited. Transhumance takes place, as a rule, in the rainy season towards the Sahel, but a milking herd of females remains permanently near the dwellings to provide milk. It is in the dry period, after the wetland grazing and crop residues have been used up, that the greater part of the herd descends towards the semi-humid zone to the south in search of pasture.

The existence of belts of traditional dairies around the big towns of the semi-arid zone is well known. With the growth in demand for milk and the progressive transfer of animals from the hands of the traditional herders to the new breeders (businessmen, civil servants, etc.), a rapid evolution is taking place among these establishments. Production of milk for the market and the high demand for rentable land are profoundly modifying the feeding techniques. There is an increased tendency to keep exotic breeds with higher potential and massive utilization of agro-industrial by-products takes place.

The productivity of livestock in the agro-pastoral systems varies greatly from one region to the other. As a general rule, however, it remains low, but output is still higher than that of the pastoral system. In all situations, it appears that the genetic potential of the animals is not achieved in the traditional system. The production of milk and meat is clearly inferior to that obtained from the same animals placed in controlled management conditions with improved nutrition and health.
With the drought of the last two decades, the evolution of agropastoral systems has not favoured livestock production; the wetlands have been transformed into rice paddies and entire regions that were traditionally devoted to pasture have been put into crops. The weakening of the traditional policies for utilizing the resources and the absence of pastoral codes in the different countries has led to poorer and poorer management of pastures, notably around the towns and in the flood areas.

STRATEGIES FOR IMPROVING PRODUCTION

The improvement of feeding systems aimed at increasing dairy production in the zone should be based on:

1. In the pastoral system of the northern area:
   - a proper balance between the stocking rate and the carrying capacity of the pastures;
   - a rangeland water development policy that respects requirements for rational rangeland management;
   - improving impoverished rangelands by restoring vegetation where it has died out and by enriching cover with, for instance, legume crops;
   - controlling major epidemic diseases to overcome the herders' obsession with disaster and pave the way for new attitudes in favour of smaller, more productive herds.

2. In agropastoral systems and peri-urban dairying:
   - the preparation of pastoral codes that describe grazing rights in order to curtail agricultural encroachment and allow for better resource management;
   - closer integration of agriculture and livestock production through the introduction of fodder crops, such as cowpea, or the application of more fertilizer (including manure) to increase crop yields and, consequently, crop residues that can be fed to animals;
   - better use of locally available agro-industrial by-products (bran, polishings, molasses as urea-molasses blocks, etc.) through the preparation of supplements formulated to meet the needs of the animals and adapted to rangeland conditions;
- gradual intensification in peri-urban livelihood development projects to meet market needs. More importance should be given to experiments and the development of fodder crops as such, wherever conditions allow.

Any improvement aimed at increasing dairy production should consider the sociological aspect, which is closely related to livestock in this region. Some solutions have been proposed here to increase the milk production in the different production systems.

REFERENCES

