POTENTIAL IMPORTANCE OF SHEEP AND GOATS IN AREAS AFFECTED BY TRYPANOSOMIASIS

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ABSTRACT

Although trypanosomiasis has a world-wide distribution, it assumes its main importance in Africa where the disease is difficult to control because of its transmission by the tsetse flies. The disease is economically more important in cattle than in any other domestic animal species. Certain breeds of cattle are less affected than others in that they are trypanotolerant. With the use of trypanosomal drugs, raising of trypanotolerant breeds of cattle could be a viable enterprise in the tsetse belt.

Certain breeds of sheep and goats also seem to possess trypanotolerance and have potential value in trypanosomiasis area. The mechanis of this trypanotolerance is not known, but it is possible that it is the same as for cattle. Sheep and goats have an additional advantage over cattle in that they are less attractive to tsetse flies.

Sheep and goat production allows a faster turn-over of capital because of higher fertility, multiple births and short generation interval. Their small size and low individual value bring them within the reach of people of the low income groups.

To make better use of sheep and goats, there must be good management systems. Good local breeds should be selected and these could be crossbred with the high-yielding exotic breeds. There should be also good grazing systems and proper stocking rates. The disease control programmes should include control of trypanosomiasis and other intercurrent diseases.

If these factors are given adequate attention, it should be possible to obtain considerable benefits from sheep and goats in trypanosomiasis affected areas.

CHAPTER I

INTRODUCTION

The greater proportion of the human population in the developing countries experiences an acute and growing shortage of both calories and protein for consumption (FAO, 1962). Wright (1961) states that at least half of the world's population is either undernourished or suffering from malnutrition. According to Jasiorowski (1972), the average daily per capita consumption of animal protein in the developing countries is 11 grams compared with 49 grams in the developed countries. This low level is regarded as insufficient to meet the minimum for normal growth and healthy mental development. F.A.O* recommends that at least 10% of total daily protein intake should be of animal origin. Animal protein is particularly important for pregnant and nursing mothers and children (Devendra, 1974).

Besides the insufficient supply in terms of quantity, the qualitative lack must be emphasised. Lack of or insufficient good quality animal protein leads to protein-calorie malnutrition. The adverse effects of such undernutrition on any population include not only weight loss and reduced physical activity, but also lack of mental alertness and coherent and creative thinking, apathy, depression, irritability, decreased disease resistance and, in children, permanent retardation of mental development (Fisher et al, 1972; Daly and Jones 1974). Two diseases, kwashiorkor and marasmus are also manifest in children above six months of age (Devendra and Burns, 1970;

Naraya Roa, 1973). There is thus a need for improved livestock and meat production if the problems presented by malnutrition are to be overcome.

The main methods of promoting livestock production lie in the control of disease, in better feeding and improved breeds (FAO, 1962). One of the greatest constraints to increased productivity and steady marketing of livestock in Africa is the problem of disease in animals (Griffin, 1978). Jasiorowski (1972) estimates that disease losses account for 15% of the production cost in developed countries and between 30 and 40% in developing countries.

Of all the livestock diseases endemic to the African continent, trypanosomiasis has been regarded as the biggest single factor which limits the numbers and productivity of cattle, sheep and goats (Urquhart, 1974). Hornby (1952) states that trypanosomiasis is unique among diseases in that it is the only one which by itself has denied vast areas of land to all domestic animals other than poultry. The areas of complete denial are all in Africa and add up to perhaps one quarter of the land surface of this continent. Finelle (1974b) has made a rough estimate of the economic importance of the disease in cattle, sheep and goats and the losses appear to be staggering.

All the avalable evidence seems to emphasise that Trypanosomiasis is particularly important in cattle, a factor that has been recognised by a joint F.A.O/W.H.O expert committee on trypanosomiasis (1969). Pagot <u>et al</u> (1975) have pointed out that the problem is pronounced in countries lying within the area of distribution of the tsetse fly. This area, commonly referred to as "the tsetse belt of Africa", lies between 14°N and 20°S, extending to 29°S in the Mozambique area. Trypanosomiasis is more difficult to control in the tsetse belt than elsewhere because in this area, it is cyclically transmitted by tsetse flies whereas outside the tsetse belt, mechanical transmission takes place, a mode that is much less efficient (Hagan et al 1976).

The low incidence of trypanosomiasis usually observed in sheep and goats has led to the commonly held belief that the disease is milder in these animals. This can partly be explained by the fact that sheep and goats are seldom fed on by Glossina species (Weitz, 1963; Boyt, 1971). There is evidence indicating that they show a high degree of resistance to trypanosome infections (Boyt, 1971) and this has attracted the suggestion that they could be used as an alternative to cattle in tsetse infested areas. But then there is other evidence to show that some of these animals can be very susceptible and deaths can be frequent (Losos and Ikede, 1972). But on the whole, most of the indigenous breeds of sheep and goats in the tsetse belt are less affected by trypanosomiasis than the cattle breeds.

Since trypanosomiasis is regarded as the biggest single factor which limits the numbers and productivity of livestock in the tsetse belt (Urquhart, 1974) the scope of this discussion will be limited to how best sheep and goats may be utilized in general continuation and expansion of food production, and contributing to a well balanced livestock industry and various national economies in the tsetse belt.

2. Definition, Aetiology, terms and Geographical distribution, Species affected, Transmission and Clinical picture

2.1. Definition

Trypanosomiasis refers to a group of closely allied parasitic diseases of man and animals caused by species of flagellate protozoa belonging to the genus Trypanosoma (Leach and Roberts, 1965; Hoare, 1972; Finelle, 1973 a; Robertson, 1976). The organisms inhabit the elsewhere because in this area, it is cyclically transmitted by tsetse flies whereas outside the tsetse belt, mechanical transmission takes place, a mode that is much less efficient (Hagan et al 1976).

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2.2 Aetiology

The important trypanosomes of mammals are divided into two sections, the Stercoraria and the Salivaria, according to the development in their vectors and vertebrate hosts, and into eight sub-genera and numerous species on the basis of morphological differences (Table I). Most of the pathogenic trypanosomes belong to the Salivaria. The more important pathogens of livestock are *T. vivax*, *T. congolense*, *T. simiae* and *T. brucei*, although all the species listed in the salivaria group, except *T. rhodesiense* and *T. gambiense*, can cause disease in animals. *T. rhodesiense* and *T. gambiense* which may be regarded as biological variants of *T. brucei* (Maclennan, 1974), and *T. cruzi* are pathogenic to humans. *T. evansi* is mainly a pathogen of camels and horses, although dogs, pigs, elephants can also be affected; and silent infections occur in cattle and horse.

The rest of the species listed in the table, some of which have a cosmopolitan distribution, are non-pathogenic. They are, however, commonly found in domestic and wild ruminants and other mammals in the course of surveys and it is essential that they should be differentiated from the pathogenic species (Hoare, 1970).

2.3 Terms and Geographical Distribution of Trypasnosomal Diseases (See Map, plate 1)

The collective and colloquial term Nagana, a Zulu word for depression or low spirits (Leach and Roberts, 1965) refers to trypanosomiases of domestic livestock caused by T. vivax, T. uniforme, T. congolense, T. simiae, T. brucei and T. suis in areas of Africa infested by tsetse flies. The area affected is an enormous block of land mass, the tsetse belt, which extends from the southern edge of the Sahara at approximately 14°N to Southern Angola at 20°S, extending to 29°S in the Mozambique area. Within the area outlined above lie over 10 million square kilometers and of this total, over 6.25 million square kilometers, which adds up to about a quarter of land surface of the continent, is largely denied to cattle and many other domestic animals because of the tsetse-transmitted trypanosomiases (Leach and Roberts, 1965; Finelle, 1974a; Hagan et al 1976) considerable area of potential good pastures, not utilized for arable farming nor yet fully grazed still exist in the tsetse belt, but are inaccessible to cattle mainly due to heavy infestation by tsetse flies. T. vivax has spread from this area to central and South America, West Indies and Mauritius, where tsetse flies do not exist.

Surra, an Arabic word for rotten (Cross and Patel 1922) refers to diseases of domestic animals caused by T. evansi and the related trypanosomes. They occur in North Africa, the Middle East and Asiatic Countries, including Russia, India, Indo-China, Islands of the Indian and Pacific Oceans and Central and South America.

Dourine, the Venereal disease of horses and donkeys caused by T. equiperdum occurs in North Africa, South West Africa, Middle East,

APPROXIMATE DISTRIBUTION OF PATHOGENIC TRYPANOSOMES
OF DOMESTIC ANIMALS

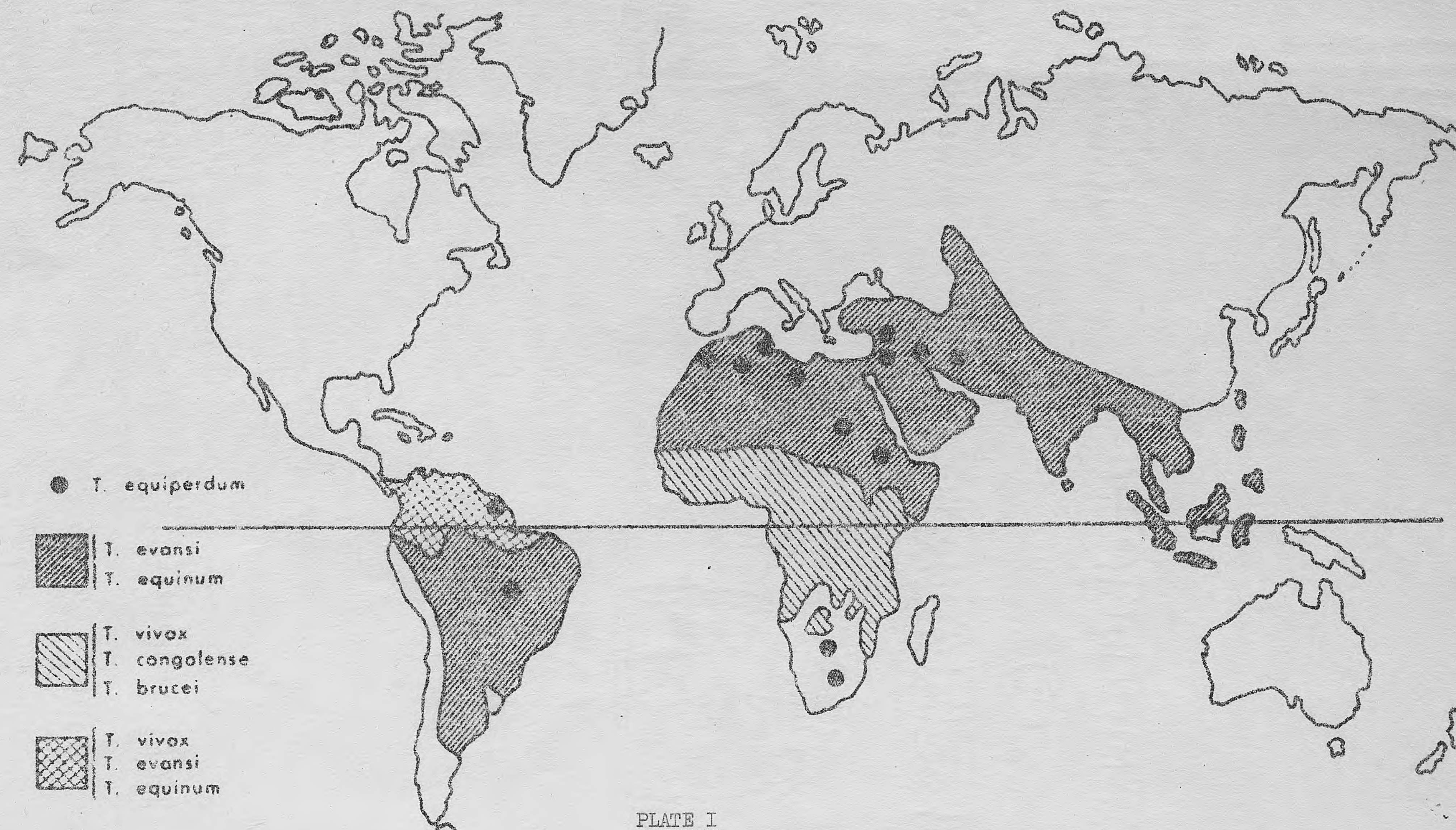

PLATE I

Russia, Brazil and Mexico. Sleeping Sickness, named so because the patient at one stage is unable to keep awake (Ford, 1971), is a disease of man caused by T. rhodesiense and T. gambiense and it also occurs in tsetse areas of Africa.

Chagas' disease is a disease of man and to a less extent dogs, cats and pigs, caused by T. Cruzi. It is widespread and important in South and Central America and it also occurs in Southern U.S.A.

2.4 Species of animals affected

Most species of pathogenic trypanosomes are primarily parasites of wild game, which acquire symptomless infection and long-lasting parasitaemia, and in Africa the wild game provide an extensive reservoir of infection (Ashcroft, 1959; Finelle, 1974a). All species of domestic animals are susceptible to infection with one or more species of the salivarian trypanosomes (Robertson, 1976), but the infections are economically of greatest importance in cattle. Cattle infections caused by T. congolense and T. vivax are by far the most serious, both for frequency and for economic influence (Finelle, 1973a). In domestic ruminants, T. vivax is most important and widespread in West Africa while T. congolense takes up this role in Eastern Africa (Stephen, 1970; Ford 1971).

2.5 Transmission

Transmission of trypanosomes from mammal to mammal is effected mainly by blood sucking flies of the order Diptera and in Africa, the most important of these is Glossina (tsetse), of which about 22 species are involved. In the tsetse flies, trypanosomes multiply and undergo cyclical development and the flies may remain infective to mammals for many weeks. This, therefore, makes this mode of transmission efficient.

The salivarian trypanosomes are normally maintained in wild animals by transmission cycles involving tsetse flies which are usually divided into three groups according to their preferred habits - forest, riverine and savannah species (Jordan, 1974).

It is only when man or his livestock stray into the territory of this sylvatic cycle, or when infected tsetse stray out of it, that domestic trypanosomiasis may be the result (Maclennan, 1974; Leeflang, 1978). The forest tsetse are least important as their habitat is unsuitable for livestock production whereas the riverine tsetse become important when the livestock is watered directly from the rivers. Savannah tsetse have the greatest impact on livestock production and development because they are more effective vectors than others as they occupy vast areas of land, have higher infection rates and cattle are among their preferred hosts (Leach and Roberts, 1965). Mechanical transmission by both tsetse and other biting flies like Tabanidae and Stomoxys can occur, but the method is less efficient. However, *T. vivax* is well established in parts of Africa at a distance from the tsetse (Maclennan, 1974; Hagan *et al*, 1976).

2.6 Clinical features

The appearance and course of trypanosomiasis is very variable. The disease may be mild, with a short or chronic course, sometimes leading to eventual recovery; alternatively, infections can be severe, short-lasting or chronic, ending in death. The more usual picture is one of intermittent parasitaemia, fever, anaemia, loss of condition, reduced productivity and frequently high mortality (Robertson, 1976). Oedema is a feature of the disease in horse and dog.

3. Economic importance

Trypanosomiasis is still one of the principal constraints, restricting growth of livestock industry, particularly in tropical Africa

(Finelle, 1973a). This remark chiefly applies to cattle which are, economically, by far the most severely affected, with other species including pigs, horses, donkeys and camels involved in more local contexts, while the small ruminants suffer to a lesser degree (Leach and Roberts, 1965).

The information and data available relating to socio-economic consequences of Africa trypanosomiasis in cattle are fragmentary and frequently approximate but they nevertheless serve to illustrate the importance of the disease. Generally there are two sets of consequences, the direct and indirect, the seriousness of which vary from place to place.

3.1 The direct consequences

These consist of economic losses due to the disease and expenditures incurred in controlling it (Finelle 1974b). They comprise:

(a) Mortality of breeding and trade cattle. Mortality due to trypanosomiasis can be quite heavy. Randall (1958) writes that the cattle population in Busoga district, Uganda, fell from 126,000 in 1943 to 88,000 in 1949 due to mortalities caused by trypanosomiasis. The cattle population in the same district then rose to 156,000 by 1958 following an Antrycide treatment campaign that started in 1950.

(b) Disease, which manifests itself in emaciation and retarded growth in young stock, immunosuppression, abortions and temporary sterility. Godfrey _et al_ (1964) demonstrated that unthriftiness due to trypanosomiasis in N'Dama herds causes infertility and Stephen (1966) working with N'Dama and Zebu cattle showed that the disease causes retarded growth and late sexual maturity. Ige and Amodu (1975) observed long periods of anoestrus and irregular oestrus cycles in N'Dama cattle following trypanosome infection.

(c) The cost of preventive operations: chemoprophylaxis, tsetse control and development of trypanotolerant breeds. There is no doubt that the cost involved in the control of the disease, especially controlling tsetse using methods like bush clearing, ground and aerial sprays and reduction of game population, is quite enormous. Finelle (1974b) gives, as example, the cost of deforesting barrier zones in Northern Nigeria in 1970, which varied between U.S.A. $3,500 and 4,000 per square kilometer.

(e) The cost of research on animal trypanosomiasis control.

3.2 Indirect consequences affect:

(a) human health: as the shortage of meat and milk causes protein deficiencies which are particularly harmful to children, nursing and pregnant mothers.

(b) agriculture: the lack of draught animals and manure reduces agricultural output;

(c) production: the disease limits the development of the cattle industry, whether by way of improving the productivity of the local breeds by cross breeding with exotic stock or by introduction of the high-yielding exotic stocks which are highly sensitive to the disease; and the presence of the disease causes livestock to be concentrated in limited grazing areas leading to overuse and deterioration of the land.

(d) the deficit in animal production compels the countries affected to import meat and dairy products, which is a drain on the foreign currency.

The foregoing account serves to illustrate the point that trypanosomiasis is one of the major factors affecting cattle industry in tropical Africa. In this area most people feed on cereals, legumes, tuberflours and little food of animal origin because there is not enough of it. The foods of animal origin contain high quality-protein, which is highly digestible and assimilable, and it is biologically complete, ie, it contains the indispensible amino acids in the right proportions (Narayana Roa,1973).

In order to remedy the human malnutrition situation in the tsetse belt of Africa, alternative meat and milk production systems, other than the existing ones which are based mainly on cattle, must be established. Establishment of trypanotolerant breeds of cattle, game ranching, sheep and goat production, poultry, rabbit, pig and fish farming would go a long way towards improvement of human nutritional standards. They would supply milk and milk products, meat, fish, poultry meat and eggs which, in addition to being a source of complete protein and more nutritive, supplement plant protein (Narayana Roa, 1973), and bring about socio-economic benefit.

As it is the ordinary peasant farmer that supplies both the rural and urban people with animal protein, it is necessary to take a closer look at the proposed production systems and pick out which one(s) he can possibly afford and manage.

4. Production Systems

4.1 Establishment of Trypanotolerant breeds of cattle.

Trypanotolerance qualities of several West Africa small, humpless cattle breeds including N'Dama, Mutura and other West African shorthorns have long been known. Although authoritative descriptions of their characteristics and data on their performance and productivity have been produced (Mason, 1951; Stewart, 1951; Chandler, 1952 & 1958; Hill and Upton, 1964; Roberts and Gray, 1971&1973a&b; Toure, 1975), at present the knowledge of the mechanism and the genetics of trypanotolerance and the breeding of trypanotolerant animals is inadequate. It seems, however, to depend on two groups of factors, hereditary and acquired characteristics (Finelle, 1973b).

Trypanotolerance is not an absolute quality. It is quite fragile and can be broken easily. Trypanotolerant cattle can become infected as easily as susceptible cattle, but are able to withstand the infection (Chandler, 1958). This ability depends mainly on previous challenge, nutritional status and the level of tsetse challenge.

Introduction of trypanotolerant cattle has some major draw backs. The operation requires considerable organisation and resources, training of new stock-raisers and it is slow to start. The breeds themselves have small size, and have low milk yield. And because of their low production, milk is only available for human consumption at the expense of the calf. The breeds can co-exist with the infection, but then the infection leads to retarded growth rate and reduced fertility. Raising of trypanotolerant cattle in tsetse area cannot, for a long time to come, improve the human nutritional status.

4.2 Pig and Poultry production

Where nutrition, management and disease control are satisfactory, an annual production of up to 300 eggs per hen can be achieved; 2 kilogram broiler chicken can be produced in 2-2$\frac{1}{2}$ months and a 60 kilogram porker in 6 months. To achieve this level of production, selected fast-growing breeds of pigs and strains of poultry, and properly balanced feeds, must be used. This would involve expenditure the peasants cannot afford. The bulk of feeds comes from cereal grains and their use for this purpose would mean direct competition between man and livestock for the available grain.

The existing production systems along the lines of village poultry and pig raising where the stock involved have to scavenge most of the time can hardly produce enough meat and eggs to meet the human requirements. The African village hen produces about 40 undersized eggs per year. The problem is made much worse by the Moslem community that cannot eat pig meat.

4.3 Rabbit farming

In many countries rabbit meat production is still in its infancy. But the production systems both on large and small scales are very similar to those used for the intensive production of broiler chickens. They are high cost/high capital investment systems (Portsmouth, 1962). Considerable skill is required in selecting and maintaining good breeds, provision of proper housing, feedstuffs and instituting proper disease control measures. Obviously these are some of the things a peasant farmer cannot afford. And besides this some tribes will just not eat rabbit meat. And so rabbit meat production is not an attractive proposition to the peasant farmer.

4.4 Game ranching

Game would appear to offer great possibilities as a source of protein for human consumption (FAO, 1962). But before systematic game cropping can be introduced on a large scale, much more information is needed concerning the numbers of wild game in the area in question, their grazing habits, reproduction rate, annual increase, losses from disease and other causes and their migratory movement. In any case for any greater utilization of wild ungulates for meat and milk production to be realised, they must first be domesticated (Lee M Talbot et al, 1965).

4.5 Fish Farming

Fish farming initially needs high capital investment which the poor peasant farmers cannot afford. Exploiting wild fish from seas, lakes and rivers would be beneficial but the problem is that very few countries infested by tsetse border the Seas; and there are not many inland lakes and big rivers to provide enough fish for human consumption.

4.6 Sheep and goat production

Since the other forms of animal production do not produce enough protein to meet man's requirements in the tsetse areas of Africa, it is desirable, and it should be possible, to intensify sheep and goat production in these areas so as to obviate the existing and often large local animal protein deficiencies. In any case these animals compete least with human beings as far as food demands are concerned (de Haas and Horst, 1977).

CHAPTER II

1. THE POTENTIAL PRODUCTIVITY AND CHARACTERISTICS OF SHEEP AND GOATS

The potential productivity of the existing indigenous tropical sheep and goat breeds is far greater than the level of production generally attained (Payne, 1963). In the past not much work has been done about methods of sheep and goat raising and no assessment made into the potential of sheep and goat raising as a livestock enterprise in the tsetse belt.

The discussion in this chapter touches on origin, distribution, breeds, utility, productivity and suggested improved management and husbandry practices for expanding numbers and marketable off-take of sheep and goats in the potential development areas.

good.

1.1 Zoological classification and origin of sheep and goats

(a) Goats are classified in the family Bovidae tribe caprini, genus caprus and species C.hircus (domestic goat). The classification of breeds varies according to the ideas of certain authors, based on either origin, use, body size or shape and length (Miller and Sturtz, 1976).

(b) Sheep:

Sheep are classified in the family Bovidae, subfamily Caprinae and all the domestic sheep are included in the genus Ovis aries (Williamson and Payne, 1978). It is believed that the goat was probably the second animal to be domesticated after the dog, and Zeuner (1963) observes that sheep were domesticated at about the same time as goats, long before development of crop agriculture. The domestication of sheep started in the Middle East and from this area the domestic sheep gradually spread into Asia, Europe and Africa. Unlike the sheep, the origin of the domestic goat remains to be clearly established although the available evidence indicates that the Bezoar of South West Asia is the main ancestor. The Abyssinian ibex and the bezoar are also thought to be involved in the ancestry of goats in North and East Africa (Devendra, 1978).

2. Distribution, adaptation, breeds and utility

2.1 The world distribution

The world goat population is nearly 380 million, with about 67% of these in the area between latitudes 30° North and South (Mcdowell, 1972). 54% of these are found in the tropics (table 2) and of these tropical goats, 46% are in Africa (French, 1970)

The densest populations are in Africa and Indian subcontinent while the sparsest populations are found in Australia and the Pacific areas (Miller and Sturtz, 1976). The indigenous breeds in the warm climates vary in size, with the dwarf types predominating in the humid tropics while the large ones are kept in the semi-desert areas of the Middle East. The population of sheep in the tropic and subtropic regions in 1974 was about 460 million which was 45% of the world total sheep population (Devendra, 1976). In Africa the total sheep population has increased in the recent years (Table 3).

2.2 Adaptation

Sheep and goats, unlike cattle, can endure the harsh, drought conditions prevailing in some of the tropical areas (Griffin, 1978).

Goats are probably the most important of the domestic animals in the tropics (Devendra and Burns, 1970). They are the hardiest (Lowe, 1943) and are capable of adapting themselves to a wide range of invironmental conditions, including the harsh ones. They have ability to withstand both hot and cold conditions, provided the humidity is not high. They generally do well in drier tropics; especially on light sandy soils (Devendra, 1978), and hence in Africa, the greatest concentrations are found in East Africa, N. Nigeria and Morocco. Goats, especially the small breeds, are also adapted to the wet humid tropics where housing should be provided to prevent high mortality in kids during the wet season.

According to Williamson and Payne (1978) sheep in the tropics appear to thrive best in semi-arid uplands where the vegetation is of the short-grass or steppe type. Because of their small size, sheep and goats can utilize marginal and small plots of land and mountain areas not suitable for cultivation and they can also be tended by young or aged people. Where pasture is adequate sheep graze and goats browse on a variety of plant species, but where the pasture is sparse or thorny scrub predominates, sheep and goats become economically more important than cattle as they can then both browse (Heady, 1960; French, 1970). Better still, goats have a high tolerance of feeds deficient in protein, phosphorus and sodium (French, 1970; Mcdowell, 1972).

Goats have a higher digestive capacity for fibrous (liquified) material (Devendra, 1971) and their food spectrum is wider than that of sheep. French (1944) in Tanzania showed that goats usually looked healthier than sheep in the same flock.

Sheep and goats can travel long distances and require less frequent watering than cattle, and hence they can graze far from water points. Cattle require daily watering during the dry season while sheep and goats can be watered every two days during the dry season and every four or five days during the wet season when the forage moisture content is high.

Goats have been blamed world over as the main cause of soil erosion by overgrazing. Hornby (1941) points out that the goat does not deserve the blame, and according to Campbell et al (1962) and Harvey and Rigg (1964) there is little reliable information concerning the effects of goat on vegetation. It has been suggested that cattle, and possibly sheep, initially remove the ground cover by overgrazing. The resulting vegetation of shrub and trees can only support goats and so goats found on such land are blamed for something they did not cause (Staples et al, 1942; Hornby and Van Rensburgh, 1948).

2.3 Breeds

2.3.1 Goats:

At present, a number of non-descript types or breeds exist which are inadequately described or assessed in terms of their productive potential. Devendra (1974) estimates that there are about 300 breeds and types of goats in the world, the majority of which are in the tropics. According to Mcdowell (1972), of the 140-odd breeds so far fully described, about 55% are indigenous to the warm climates; and Devendra (1974) states that the tropics, as a whole, comprise an important reservoir of well adapted and varied goat breeds suited to different physical and nutritional environments.

The existing goat breeds and varieties in the tsetse belt of Africa have been elaborately described by Mason (1951) and Mason and Maule (1960) (See table 4). Available descriptions about occurrence, appearance and traits, among others, frequently deal primarily with more qualitative considerations rather than with actually observed quantitative performances, ie (milk yield, fertility and weight gain (Devendra, 1966; Epstein, 1969; Devendra and Burns, 1970; Joubert, 1969 & 1973).

All the indigenous breeds and varieties mentioned above have developed more through genetic isolation and natural selection

(Survival of the fittest) than through man's deliberate intervation. The production levels of these unimproved breeds are very low, but some of them appear to offer valuable genetic material for improvement of productivity whether in their country of origin or elsewhere (Devendra and Burns, 1970). Certain very useful and economically important traits are apparent among some tropical goat breeds, the more outstanding of which are listed in Table 5; and illustrations of some of the common indigenous breeds in East and West Africa are shown (plates 2, 3 and 4).

2.3.2. Sheep

The classification of tropical sheep breeds has been made using phenotypic characteristics (Mason, 1951; Mason and Maule, 1960; Williamson and Payne, 1978). This classification is neither absolutely correct, as some features overlap, nor does it include all the tropical breeds. It does, however, include the majority of the major breeds (Williamson & Payne, 1978). Some of the sheep breeds and varieties in the tsetse areas are given in table 6; and an illustration of the predominant indigenous breed in West Africa is shown (plate 5).

2.4 Utility

Because of the low individual value, the majority of sheep and goats are kept by small holders or small farmers who are unable to maintain a cow or a buffalo in rural and rural- fringe areas or mountain areas where it is not possible to cultivate the land. Between the two species goats appear to have greater importance than sheep mainly as a source of meat in the tsetse belt.

According to Miller and Sturtz (1976), the goat is a multipurpose animal and in many tropical and sub-tropical countries it is kept for meat, hair, skins, milk, manure and as beast of burden. But the primary function of this species in the tsetse belt has been meat

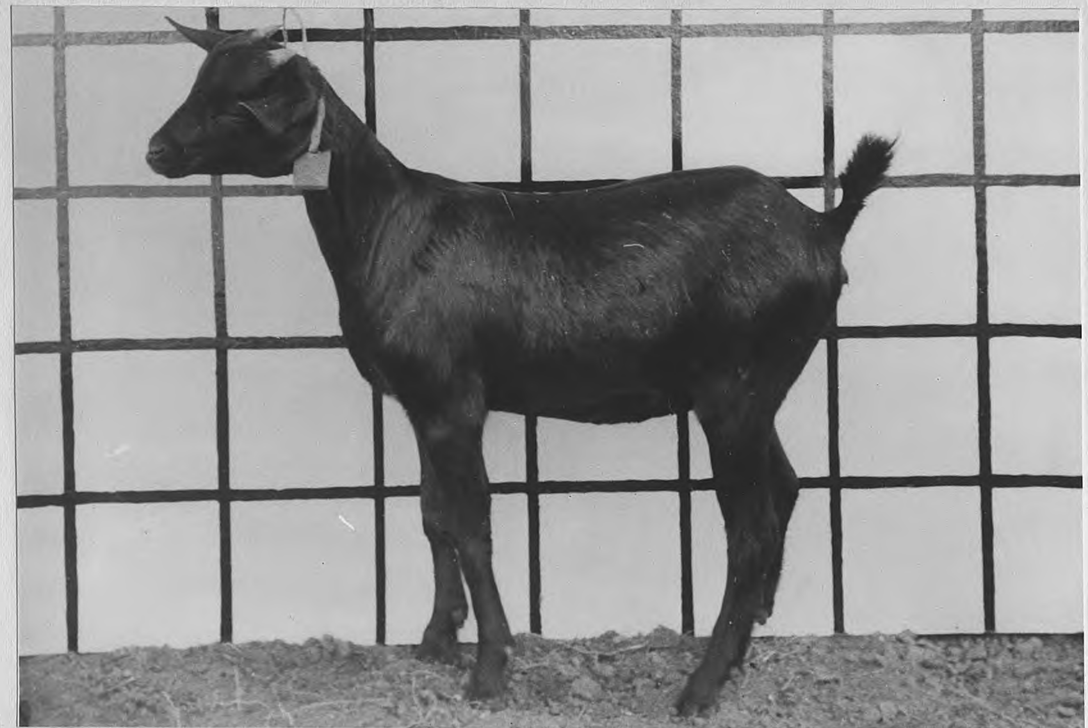

PLATE II.(Mason and Maule, 1960). A female small East African goat. An indigenous hardy,meat breed. Adult live weight is about 20-30Kg.

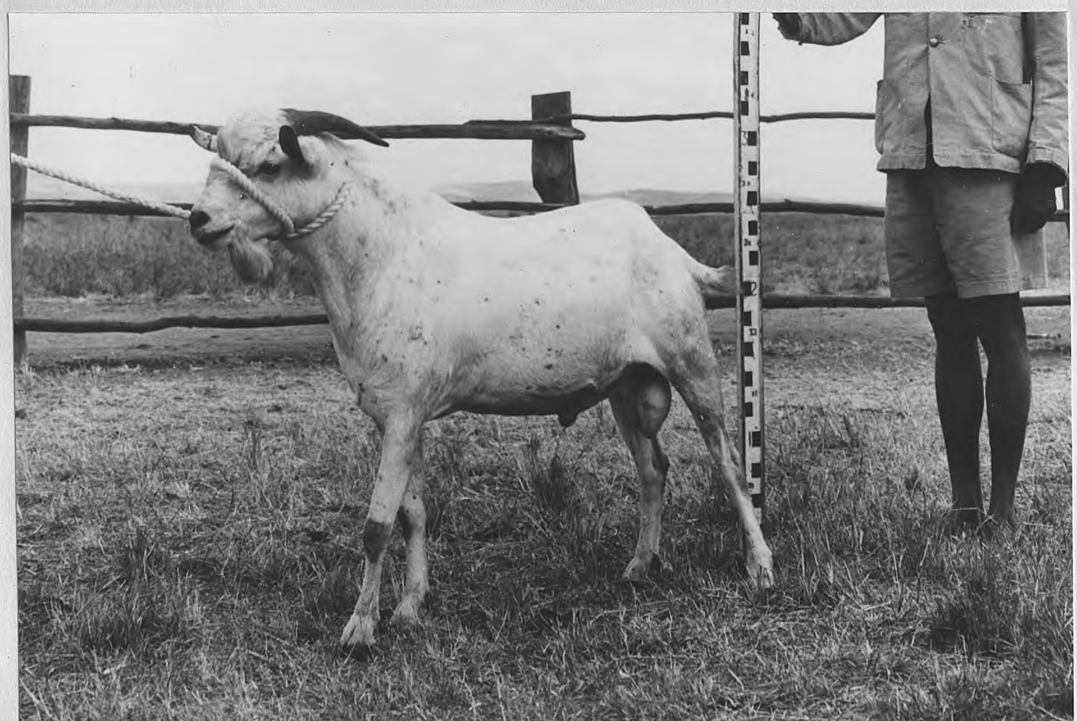

PLATE III.(Mason and Maule, 1960). A male Galla goat. A meat breed. Adult males weigh 30-40Kg., females weigh 25-30Kg. It thrives well in dry areas.

PLATE IV.(Mason 1951). A female West African dwarf goat. A hardy meat breed. Adults weigh about 18-20Kg.

PLATE V.(Mason 1951). West African dwarf sheep. A hardy meat breed. Adults weigh 20-30Kg.

production as the majority of the breeds are the dwarf types although in some of the West African countries and Southern Sudan milk production is important. There is no reason why milk production should not become equally important elsewhere, in tsetse areas, if proper breeds are introduced. Goat meat is relished in all countries where there is a tradition for meat consumption from both sheep and goats. Both goat and sheep meat is free from most taboos (Oltenacu, et al, 1976).

Goat skins are a very useful by-product and form a significant export trade from Nigeria, Niger, Uganda and Somalia (Devendra, 1974). Other useful by-products from sheep and goats include horns, hooves blood and bone meal.

The small carcasses and daily milk yields of sheep and goats make a big contribution to the nutrition of the local people in developing countries where food preservation technology is still in its infancy. The milk is commonly consumed fresh, but sometimes in its preserved form - cheese, butter, ghee and yoghurt. Goat milk can be consumed by people allergic to cow's milk and it is more digestible than cow's milk (Devendra and Burns, 1970; French, 1970).

Miscellaneous functions of sheep and goats include their value as source of income, investment, prestige in their ownership, slaughter during festive and religious occasions, production of manure and experimental animals. Goats are sometimes used in bush control (French, 1970, Teague, 1973).

3. PRODUCTIVITY

3.1 Kidding and Lambing rates

Wilson (1958) notes that the goat has been neglected by the agricultural scientists working in the fields of reproduction, growth and nutrition because of its comparatively little importance in the tropics. Most of the recent and relevant information mainly concerns sheep. However, some work on goat productivity is gaining momentum.

Age at first kidding or lambing is important as parturition at an early age leads to a greater population turnover. Generally sheep and goats in the tropics reach sexual maturity at 4 to 6 months and male kids at 3 months (I.L.C.A., 1976; Devendra, 1978). Females are best not mated until they are about 10 to 12 months old (Wilson, 1976 a,b; Ngere, et al, 1977) at which age they will have passed the active growing period. This makes the generation interval about 15-17 months. Ideally first mating should not be allowed until the doe/ewe reaches three quarters of the expected mature body weight (de Haas and Horst, 1977).

Both tropical ewes and does are aseasonally polyoestrus while the temperate ones are seasonally polyoestrus; and this may persist in the tropics as seasonality is genetically determined. The duration of oestrus cycle is 18 to 21 days in both species, and oestrus lasts for about 24 to 36 hours, with ovulation occurring from 12 hours after the onset. The fertility and fecundity in both species are quite high, but goats on the whole are more prolific than sheep. Conception rate is governed by nutritional status of the dam and the male's libido among some of the tropical breeds appears to be quite high at all times (Wilson, 1976a,b). But Moule (1970) reports that tropical climatic environment affects the reproductive performance of both temperate rams and ewes. I.L.C.A. (1977) reports conception rates of 73% and 87% among the West African dwarf sheep.

Short gestation period in both species (approximately 5 months) and higher frequency of multiple births contribute to higher annual fertility than cows (Fitzhugh, 1976). This means that milk production starts five months after initial mating.

Multiple births are common in both species, twins, triplets and quadruplets being recorded frequently and single births are mainly confined to primipara (I.L.C.A., 1977). There is a good deal of evidence that prolificacy increases with age. Fertility in sheep and goats appears to be maximum at about 5 to 6 years, and so is milk production in the dairy goat (Devendra, 1978).

Twins accounted for 14% of all the births among the ewes in S. Durfur, Sudan, and the high number of twin births of 16% among the does yielded an estimated kidding rate of over 200% per year and a life production of 9 to 10 kids per doe (Wilson and Clarke, 1975). I.L.C.A. (1977) gives the twinning rate of West African dwarf ewes and does as being about 8% and birth rates of 150-160% per year.

It is possible to get a short lambing or kidding interval, giving two lambs per year although this is seldom achieved. The widespread and popular notion of three parturitions in 2 years, giving a birth rate of 150% per year per dam reflects the most probable situation. And in most cases this gives at least 3 lambs per ewe and 4 kids per doe.

3.2 Growth rates

Lambs and kids tend to be earlier maturing, than calves, allowing them to reach desired slaughter weights and conditions at younger ages, often less than a year. Feeding trials suggest that sheep are five to six percent more efficient than cattle in use of energy for maintenance and growth (Fitzhugh et al, 1978). Goats approach their mature weight from 2 to 2½ times as rapidly as cattle in the tropics, although the energetic efficiency for milk production is approximately the same (French, 1970). Wilson (1976a,b) working with the indigenous breeds of sheep, goats and cattle in S. Durfur, Sudan, states that meat production per kilogram of breeding female, at 0.253 kg. up to 6 months of age of the young, is almost six times the production of cattle; and for each kilogram live weight of breeding females, goats produced 1.5 and 8 times the weight of meat produced by sheep and cattle respectively under similar conditions.

Growth rate of the young depends on breed, age of the dam, litter size and birth weight. Single birth offspring grow faster than multiple births. Male offspring, too, grow faster than females, (Sacker and Trail,1966a,b). More data on productivity of some of the breeds in the potential development areas are given in table 8.

3.3 Existing population sizes in potential development areas.

FAO (1977) gives the figures for the existing sheep and goat populations in the tsetse areas (see table 9).

The table indicates that the populations have decreased over the last decade. Goats appear to be more important in West and Central Africa than elsewhere. For example, the ratio of sheep to goats is 1:2 in Chad and 1:3 in Nigeria (Devendra, 1974); and it is also stated that in Zaire, there are more goats than any other class of livestock (Devendra and Burns 1970). FAO (1976) quotes figures of about 30 million sheep and goats, against 8 million cattle, in tsetse areas of West and Central Africa. These numbers are not enough to meet the existing demand. There is therefore a need to improve production systems in order to bring about eventually an overall improvement in the food and economic situations.

4. Management and Production Systems

4.1 Production Systems

Goat production systems in the tropics including the tsetse areas, are of three major types: Subsistence production involving small holders producing for family use; Large flocks that are nomadic or migratory and larger sedentary flocks (Gall, 1975). The same systems equally apply to sheep. The last two are extensive, that is, animals are not kept in relative confinement. In sedentary systems, both the flocks and those who tend them remain in one location while nomadism involves moving the stock from place to place as seasonal feed and water become available. Fitzhugh et al (1978) point out that truly nomadic patterns are followed in Eastern African countries. The advantage of pastoral nomadism is that grassland resources that cannot be used in any other way are exploited.

In the majority of cases village herding is a common practice, whereby the herds are taken outside the village and grazed along the roadsides, lanes and rough terrain not in cultivation. Extensive production is probably the most popular system of sheep and goat production (Devendra, 1976) and sheep and goats are often grazed with cows (Williamson and Payne, 1978). Intensive production of sheep and goats is not a common practice in the tropics, although it might be practised in some places. Lyne Watt (1942), for example, reports stall feeding of sheep and goats as being common among the Kikuyu tribe of Kenya. Tethering system of both sheep and goats is a common practice among the subsistence farmers. In all these systems, the stock are maintained on natural, unimproved pastures.

4.2 Management and husbandry practices

In general there has been little selective breeding of indigenous goat breeds in the tropics (Mcdowell, 1972). The situation has not been any better for sheep. Other management practices like proper and adequate feeding, mating and weaning at the right time, care of the young and disease control programmes have been inefficient. This has led to low productivity. Fitzhugh et al (1978) observe that feed supply remains the single most important limiting factor among the constraint to ruminant livestock production.

In order to increase productivity, planned and organised management systems must be introduced. Cross-breeding exotic goat breeds for milk, such as Toggenburg, Anglo-Nubian, Saanen and British Alpine or any of the improver tropical breeds (see table 5) for milk and meat production might be an advantage. Any of the improver breeds of sheep listed in table 7 might be tried. The pure-bred of high-grade European breeds are not suitable for use in the tropics because of the hot climate and disease problems, but the half-grade or even three-quarter grades have proved themselves useful for milk and meat production (Lowe, 1943).

Under both extensive and intensive systems, good pastures and proper stocking rates must be ensured and supplementary feeding using crop residues and concentrates mainly consisting of agro by-prodcuts, such as maize bran and cotton seed cake might be considered. Flushing of the dams (King, 1978) increases multiple births and improves milk production and hence mothering ability, leading to fast growth rate of the offspring.

Housing should be provided for goats to use at night and young kids and lambs at all times to prevent high losses in latter age groups due to pneumonia. No elaborate housing is necessary, but what is provided should be light, well ventilated, well drained and easily cleaned (Devendra, 1978).

Artificial insemination has not been used much in the tropics because it has many problems, viz; lack of trained technicians, problem of oestrus detection and shortage of superior sires (Sands and Mcdowell, 1978). It would, however, be an advantage to use in oestrus synchronisation programmes.

Other desirable husbandry practices would include the use of proper male:female ratio for mating, milking twice a day, giving the young colostrum from its dam starting on its first day of life, weaning at proper age, castration of male kids to forestall objectionable smell, disease control programmes and trimming overgrown hooves.

Improved management and husbandry systems lead to increased off-take rates so that fewer sheep and goats are needed to meet the demand (Fitzhugh, 1976).

CHAPTER III

1. TRYPANOSOMIASIS IN SHEEP AND GOATS

1.1 Susceptibility

Sheep and goats are susceptible to infection with *T. brucei*, *T. congolense*, *T. vivax* and *T. simiae* (Stephen, 1970). But there is little information on the distribution and economic importance of the disease in small ruminants caused by the above pathogenic species of trypanosomes (Losos and Ikede, 1972) in spite of the fact that the disease has been recognised for decades as the greatest obstacle to increased productivity of livestock in Africa (Griffin, 1978). The disease in sheep and goats has been dismissed by many workers as being unimportant (Kramer, 1966, Stephen, 1970, MacLennan, 1970).

Until recently, no specific studies on the natural occurrence of trypanosomiasis in sheep and goats had been conducted and with the emphasis on cattle production, most earlier reports on the disease in sheep and goats have been subjective from stock raisers whose main interest was with cattle (Griffin, 1978). However, the situation has lately taken a different turn. More recent surveys and epidemiological studies on the disease in sheep and goats show that these animals can be, and often are severely affected by the disease, and it may be of greater importance than hitherto suggested.

The clinical syndrome in these animals has been thoroughly described (Losos and Ikede, 1972) and these authors also write that the infection and disease occur both in West and East Africa.

1.2 Infection rates observed in the field

In one recent, but smaller, survey Kramer (1966), using Godfrey and Killick-Kendrick's survey method examined sheep and goats at Nsukka, in a *G. palpalis* and *G. tachinoides* area in Eastern Nigeria, where the flies had an infection rate of 6.6%. He found 14% West African Dwarf goats and 11% West African Dwarf sheep infected with either T. congolense or T. vivax. Mornet (1954) considered sheep and goats to constitute 4% of all animals infected with T. congolense and he thought that this was a low figure as small ruminants are rarely included in trypanosomiasis surveys. In a WHO research project in the trypanosomiasis endemic area of Lambwe Valley, a G. pallidipes area in Kenya, Robson and Ashkar (1972) visited 146 homesteads in 150 km^2 and examined the domestic stock by blood film. They reported that 9.6% of cattle, 1.9% of sheep and 3.2% goats examined were infected with either T. congolense or T. vivax. Another 8 areas were visited and examinations revealed that 17% of cattle, 5% of sheep and 2.1% of goats were infected mostly with T. congolense followed by T. vivax with T. brucei as the least common species. A survey by Zwart et al (1973) amongst cattle, sheep and goats in Kiboko area, Machakos district of Kenya, infested with G. pallidipes and a few G. longipennis and G. brevipalpis, showed that sera from 80% of the cattle, 39% of the sheep and 44% of the goats examined contained antitrypanosomal antibodies detectable by an indirect fluorescent antibody test (IFT). With standard trypanosome detection method (STDM), plus lymph node puncture in sheep and goats, the positive results were 15%, 10% and 6% for cattle, sheep and goats respectively. T. brucei, T. congolense and T. vivax were found in 5 sheep while T. congolense was found only in 3 goats. Leach (1973) using blood films found an incidence of 2% infection among about 2000 village sheep and goats kept where G. palpalis and G. tachinoides occurred in moderate density.

More recently, seasonal fluctuations in disease incidence in sheep and goats exposed to savannah tsetse species, G. pallidipes and few G. longipennis and G. brevipalpis, have been demonstrated in Kiboko area, Kenya (Griffin and Allonby, 1979b). Infection rates with T. congolense of up to 85% in Karakul sheep and 60% in Saanen -Galla cross-bred goats were recorded, with maximum rates occurring shortly before rains when tsetse numbers had increased. Generally infection rates were higher, anaemia more severe and mortality greater in exotic breeds than indigenous ones. High seasonal incidences of trypanosomiasis have also been reported in cattle (Esuruoso, 1974, MacLennan, 1970, Squire, 1951).

1.3 Sheep and goats as reservoirs of infection

The importance of sheep and goats in transmission of the disease to other domestic stock has been underlined by Mahmoud and Elmalik (1977) and they demonstrated that T. congolense isolate from healthy-looking goats caused overt disease when inoculated into calves. In other transmision experiments, Gordon (1930) concludes that sheep and goats act as reservoirs of T. vivax.

Mackenzie and Cruickshank (1973) report that Blackhead Persian sheep in an endemic area were easily infected with T. congolense and intermittently with T. vivax, and Mackenzie et al (1975) report two naturally contracted cases of T. simiae in sheep one of which rapidly died and the other ran a mild chronic course. Boyt (1971) suggests that indigenous breeds of sheep and goats under high tsetse challenge are unthrifty, with late abortions and anoestrus as a common feature in breeding stock. Sheep and goats may act as reservoirs of T. brucei subspecies transmissible to man (Robson and Rickman, 1973) and Rickman (1974) incriminated goats in transmission of sleeping sickness to man.

2. Experimental trypanosomiasis in sheep and goats

Sheep and goats have been used in experiments, both in the field and laboratory, to study the course of the disease and the pathology due to pathogenic species of trypanosomes.

Gray (1961) used sheep and goats to study the antigens of various trypanosomes; and Kilgour et al (1975) used them to study isoenzymes of T. vivax isolates from cattle. Immuno-suppression due to experimentally transmitted T. congolense infections in sheep and goats have been studied and the records show that there is some degree of suppression. . Thus recently, Griffin and Allonby (in preparation) have shown that there are severe effects produced by T. congolense infection in two breeds of goats with intercurrent Haemonchus contortus infection; and partial suppression of antibody response to Brucella melitensis vaccine in goats infected with T. congolense. Mackenzie et al (1975) demonstrated that humoral response to Vibrio foetus antigen in Blackhead Persian was lower in infected than uninfected sheep by T. congolense, and that this immuno-suppression started early in the course of the disease. In their studies of homidium resistant strains of T. vivax using cattle, sheep and goats, Ilemobade et al (1975) indicated that sheep and goats are not as readily infected as cattle, but asserted that the differences depended on the strains used. They also supported the view that, under natural conditions, T. vivax appears to be more pathogenic to cattle than to sheep and goats, but T. congolense is readily infective to sheep and goats. In another experiment, Ikede and Losos (1972) demonstrated hereditary transmission of T. vivax in sheep. The infected lamb died four hours after birth.

Recently, an experiment on the epidemiology and trypanosomiasis of sheep and goats has been conducted by Griffin and Allonby (1979b) in Kenya and Edwards et al (1956a,b) followed the course of the disease in sheep and goats in both natural and experimental infections with T. brucei, T. congolense and T. vivax and recorded acute, subacute, chronic and cryptic forms accompanied by anaemia, with remission in some cases and death in others.

3. Clinical signs and Pathology of the disease in sheep and goats.

3.1 Clinical signs

The clinical signs, Pathology and Pathogenesis of trypanosomiasis in sheep and goats have been studied in detail and they are very similar to those observed in cattle. The most outstanding features of the disease are intermittent fever, parasitaemia, developing anaemia, weight loss, weakness, recumbency and death (Stephen, 1970).

3.1 Pathology and Pathogenesis

The available literature on the pathology of the disease caused by species of trypanosomes that are of greatest economic importance in Africa has been reviewed by Losos and Ikede (1972). They divide these species into those that invade and are confined to the plasma of blood vessels, ie, the haematic group composed of T. congolense and T. vivax; and the humoral group, made up of T. brucei group organisms which occur in intercellular and body cavity fluids as well as plasma. The lesions produced in the host depend on the distribution of parasite.

The humoral group, causes extensive inflammatory, degenerative and necrotic changes in tissues of sheep, goats and cattle. In sheep, T. brucei caused progressive anaemia, loss of weight, debilitation, oedema, enlargement of lymph nodes central nervous signs, ocular signs in late stages and a high mortality (Ikede and Losos, 1975 a) and Ikede (1974) reports severe ocular lesions. Invasion of the sheep's cerebral spinal fluid is also recorded (Ikede and Losos 1975b.) and lesions in pituitary gland, thyroid and adrenal cortex with adrenal cortical hypertrophy and thyroid atrophy are also reported (Ikede and Losos, 1975c).

Anaemia plays a big role in the pathogenic effect of the haematic group. Studies on pathology and pathogenesis of T. vivax in goats show that the parasite is restricted to blood system (Van den Ingh et al 1976). The same workers report acute and chronic forms of the disease with microthrombi present in the former and absent in the later. They relate thrombus formation to high parasitaemia and attribute formation of haemorrhages, oedema of the lungs and other tissues and necrotic changes in several organs to ischaemia resulting from thrombus formation. Veenendaal et al (1976) suggest that platelet aggregation and a decrease in blood serotonin are correlated with peaks of parasitaemia in T. vivax infections of goats and bradykinin activity in chronic infections was not regarded as a major pathogenic factor in the disease although it was thought to contribute to vascular permeability and haemodilution early in the infection.

The exact mechanism of anaemia is still doubtful. Accounts of normochromic, monocytic anaemia have been given (Losos and Ikede, 1972, Clarkson 1968) with a similar picture to that described in cattle. Anosa and Isoun (1976) attribute severe anaemia observed in T. vivax infection of sheep and goats to haemodilution and decreased red blood cells (R.B.C.). An increased loss of circulating red blood cells was observed by Griffin and Allonby (1979b); and Holmes and Mamo (1975) suggest that a decrease in R.B.C. during infection with T. congolense leads to a compensatory increase in plasma volume and haemodilution. T. vivax infection had the same effect in sheep (Clarkson, 1968). Mackenzie and Cruickshank (1973) attributed the severe anaemia observed in both natural and experimental T. congolense in Blackhead Persian sheep to erythrophagocytosis on large scale throughout the reticulo-endothelial system. Phagocytosis of both red and white cells occurs only at times of crisis. Recently, Mackenzie et al (1978) artificially infected sheep with T. congolense and showed that phagocytosis is due to the coating of R.B.C. and Leucocytes with trypanosomal antigen and the cells are thus regarded as foreign. They also suggest that high levels of parasitaemia inhibit reticulocyte release from erythropoietic tissues.

4. Resistance

Low incidence of trypanosomiasis in sheep and goats has led to the assumption often made that these stock suffer less than cattle from disease although there is little supporting evidence (Leach and Roberts, 1965). One may then ask "To what extent do sheep and goats suffer from trypanosomiasis?" The answer would be that although indigenous breeds of sheep and goats cannot be kept in tsetse areas with impunity, they are nevertheless, capable of surviving for much longer periods than cattle and in lightly infested areas, they may carry on almost indefinitely. According to FAO (1976) sheep and goats are more numerous in trypanosomiasis areas of Africa than are cattle. For example, about 30 million sheep and goats and 8.4 million cattle live in tsetse areas of West and Central Africa; and it is well known that the dwarf sheep and goats of West Africa can live under conditions of high tsetse challenge.

Several reports have indicated that certain breeds of cattle are more trypanotolerant than others (Chandler, 1952 & 1958; Desowitz, 1959; Fiennes 1970; Roberts and Gray, 1973a,b). Recently, trypanotolerance has been demonstrated in breeds of sheep and goats indigenous to East Africa and experimentally infected with T. congolense (Griffin and Allonby, 1979). These workers have shown that exotic breeds of sheep e.g. Karakul and goats e.g. Saanen -Galla cross have a higher natural infection rate, a more severe anaemia and a greater weight loss than the indigenous breeds e.g. Blackhead Persian and Somali sheep and Galla goat. Lowe

(1943) reports that the native goats in Tanzania flourished in sleeping sickness areas where cattle had completely been wiped out.

The above account suggests that indigenous sheep and goats have at least a certain degree of resistance to trypanosomiasis.

4.1 Mechanism of Resistance

4.2 Feeding preferences of tsetse

Tsetse flies are known to be selective in hosts upon which they feed (Weitz and Jackson, 1955) and this was confirmed in a survey by Weitz and Glasgow (1956). Sheep and goats were for a long time thought to possess natural resistance to trypanosomiasis, but Weitz (1963) working on origins of tsetse flies blood meals demonstrated that sheep and goats are seldom fed on by *Glossina*. In tsetse areas where sheep and goats were abundant, Jordan *et al* (1962) recorded 0.4% of feeds in *Glossina morsitans submorsitans* from sheep and goats and no feeds from these animals were recorded in *G. palpalis*, *G. tachinoides* and *G. longipalpis*. England and Baldry (1972) working on attractiveness of various baits to tsetse found that *G. pallidipes* preferred ox to sheep and goats, and Pilson *et al* (1978) in their assessment of relative attractiveness of cattle, sheep and goats to *G. morsitans* and *G. pallidipes* in Rhodesia came to the conclusion that overall, with stationary bait animals, cattle were much more attractive to hungry tsetse than sheep and goats. More recently, Boyt *et al* (1978) assessed attractiveness of cattle, donkeys, sheep and goats to *G. morsitans* and *G. pallidipes* in presence of wild game by blood meal analysis. They showed that both cattle and donkeys were fed on by tsetse in presence of game and that cattle were fed on more frequently than sheep and goats in presence of game.

4.3 Trypanotolerance

According to FAO (1976) trypanotolerance is used to describe the state of dynamic premunition of certain animal species or breeds which can be infected by trypanosomes without suffering excessively, and in the case of trypanotolerant livestock, to describe domestic ruminants which have this property. However, the term is not scientifically accurate, but has an accepted meaning: trypano-resistance would be more precise. Resistance to trypanosomes may be absolute, for example, *T. simiae* does not infect cattle. In other cases the resistance is relative, and here breed and individual differences become apparent within the species, one breed or member being less susceptible than another (Soltys, 1963).

Very few studies have been done on trypanotolerance in domestic animals other than cattle. Wild animals are trypanotolerant; and Fiennes (1970) notes the absence of symptoms in wild ungulates harbouring pathogenic trypanosomes and Hoare (1972) emphasises the same facts.

It is generally believed that trypanotolerant breeds are always of small size. For example, it is well known that the dwarf sheep and goats of West Africa can live under conditions of high tsetse challenge. Recent studies in Kenya (Griffin and Allonby, 1979b) have shown that indigenous breeds of both sheep and goats exhibit greater tolerance towards the disease than exotic breeds. In Senegal there are small sheep and goats in the same areas, as the N'Dama cattle, which are considered to be trypanotolerant and on occasions trypanosomes have been found in blood samples of healthy-looking Djankole sheep (FAO, 1976).

4.5 Mechanism of trypanotolerence

Several breeds of cattle have been noted historically for qualities of trypanotolerance including N'Dama, Muturu and other West African shorthorns (Finelle, 1973b), but the biological bases underlying this phenomenon remain incompletely understood.

4.6 Immunological aspects of trypanotolerance

4.6.1 Resistance to infection

Several studies have shown the ability of N'Dama and Muturu cattle to withstand trypanosome challenge better than the Zebu breed. Chandler (1952) exposed herds comprising N'Dama, N'Dama-Zebu cross-breds and Zebu cattle to challenge by G. palpalis and G. tachinoides in one location and G. morsitans in another. The results showed that the degree of tolerance observed among Zebu cross-breds was greater than that observed among pure Zebu, but less than that observed among pure N'Dama cattle. In further studies, Chandler (1958) showed that a group of N'Dama cattle which had been previously exposed to infection and another group of cattle of the same breed which had not previously been exposed possessed a degree of tolerance to the pathogenic effects of with a number of strains of T. congolense and T. vivax from different geographical origins.

Desowitz (1959) believes that the breed resistance of N'Dama cattle to trypanosomes is due to acquired immunity. He demonstrated that N'Dama cattle born and bred in tsetse area had scanty transient parasitaemia after artificial challenge with T. vivax, but were soon apparently self-cured. However, N'Damas born and bred in tsetse-free areas had primary infections like Zebus born and bred in tsetse area, characterised first by a series of parasitaemia crises and then a chronic phase. Stephen (1966) found that N'Dama calves possessed greater resistance to trypanosomes than Zebu calves of similar age although both types of animals suffered severely from the disease. Ferguson (1967) demonstrated that a Muturu herd maintained in a light G. palpalis area had a a higher resistance than had been anticipated. In their experiment, Roberts and Gray (1971) showed that N'Damas and Muturus exhibited similar degree of resistance to pure and mixed *T. congolense* and *T. vivax* infections, but this resistance was higher than the Zebus'. In their further studies, Roberts and Gray (1973b) showed that Zebus were more severely affected by trypanosomie infection than either Ndamas or Muturus and the Muturus were more affected than N'Damas. Apart from Griffin's and Allonby's work referred to above, not much work has been done on resistance in sheep and goats to trypanosome infection. But it is possible that similar mechanisms operate in both cattle and the small ruminants.

4.6.2 Production of antibodies

It has been shown that trypanotolerant cattle produce antibodies when exposed to infection with trypanosomes. Sheep and goats, too, do the same. Laveran and Mesnil (1902) reported that the sera taken from goats and sheep, following recovery from *T. brucei* infection, exerted a protective action in mice when mixed with a homogenous species, but was not protective against *T. equinum*. Van Saceghem (1922) successfully used immune serum for treatment of goats infected with *T. congolense*. Protective antibodies were also demonstrated in sera of people infected with *T. congolense* and no such antibodies could be found in sera of uninfected persons (Heckenroth and Blanchard, 1913).

Chandler (1958) studied the production of antibodies to *T. congolense* and *T. vivax* in N'Dama using immune lysis and lysis proctection tests. He indicated that antibodies were not elaborated except as a response to infection and that they were species specific. Desowitz (1959) demonstrated that N'Dama cattle with a long history of exposure to trypanosome challenge exhibited hyperimmune reactions in response to

T. vivax challenge, rapidly produced high levels of antibodies which were maintained for up to 1½ years. Agglutinating and precipitating antibodies have also been demonstrated in trypanotolerant cattle (Gray, 1966).

4.6.3 Serum protein changes

Although Oduye and Fasami (1971) found no differences between serum protein values in normal N'Dama and Zebu cattle, Desowitz (1959) demonstrated an increase in globulin levels and the presence of a third gamma-globulin component in hyperimmune N'Dama. This component was absent in Zebus and partially immune N'Damas. Gidel (1962) reports that trypanotolerant cattle in enzootic areas had higher beta-globulin levels than cattle under lower risk of infection.

CHAPTER IV

1. DISEASE AND PARASITE CONSTRAINTS

The non-trypanosomal disease and parasite problem is recognised as a severe constraints to sheep and goat production in many regions of the world (Allonby, 1976) and the tsetse belt is no exception. Losses from morbidity and mortality among sheep and goats caused by some major epizootic diseases are great; and production losses in both quality and quantity of meat and milk from sick and unthrifty animals represent an even greater loss (Fitzhugh et al, 1978). Immunosuppresive effects of trypanosomiasis exacerbate the general disease situation. More emphasis is therefore needed on preventive action to limit the development and spread of diseases especially under the production systems where most epizootic diseases spread like wildfire among the stock.

The major diseases of sheep and goats that may be specific or of special importance in the tsetse belt are briefly described below. But as might be expected, the degree and type of problems each one of them causes vary considerably from one country to another.

1.2 Brief description of the diseases and their control

Foot-and-mouth Disease

This is an extremely acute, contagious disease of cloven-footed animals characterised by high fever and vesicle formation in the mouth, feet, teats and in the rumen. It is caused by a virus of which seven types have been recognised. The virus is transmitted by direct contact; and it may also be spread by wind.

Although mortality rates are low, morbidity rates approach 100% and the disease assumes its importance in the very low productivity it causes among the animals affected.

Outbreaks of the disease in non-endemic areas are generally eliminated by slaughter of all infected and exposed animals. This method cannot be applied in Africa where the disease is endemic. In the tsetse belt where the disease is well entrenched, vaccination programme combined with quarantine measures and embargo against imports of meat and animal products is the method of choice in cattle. The use of specific, but polyvalent inactivated vaccines at a frequency of three times in the first year and thereafter two times a year, a method used on cattle, might be tried for sheep and goats.

Blue tongue

This is a non-contagious seasonal disease of sheep characterised by congestion of the buccal and nasal mucosa and coronary tissue of the hooves leading to lameness and anorexia. It is caused by an Orbivirus (Buxton and Fraser, 1977), of which there are at least twelve strains. The virus is transmitted by Culicoides.

The disease is widespread in Africa, occurring when the climate is warm and wet. Sheep is the only animal which is clinically affected, but indigenous African sheep rarely show any clinical signs (Robertson, 1976). Mortality can be as high as 90% among the exotics, and there is also serious loss of weight, abortion and break in fleece staple. In endemic areas control consists of annual vaccination of sheep with polyvalent vaccine at least a month before the rains start, and non-pregnant ewes should be done at least three weeks before mating.

Rift Valley fever

The disease is a viral infection of ruminants and man transmitted by Culicine mosquitoes. Overt disease is common in sheep and in particular infections of very young lambs are usually fatal. Control measures include moving the stock to high altitudes during the rains and vaccination, at least a month before the rains, with an attenuated vaccine.

Nairobi Sheep Disease

The disease is a tick-borne infection of sheep and goats characterised by fever and gastro-enteritis and it causes high mortality among the exotics. It is caused by a Bunyavirus that is transmitted by Rhipicephalus appendiculatus.

Sheep and goats reared in endemic areas do not require prophylactic vaccination, but vaccination should be done prior to importation into endemic areas.

Sheep Pox

A virus disease that is transmitted by direct contact, probably by droplet inhalation. The malignant form occurs in lambs and mortality can be as high as 50%. An aluminium gel adsorbate vaccine exists that confers one year's immunity on the animal

Contagious ecthyma (orf)

It is a benign pox of sheep and goats, characterised by development of exuding proliferative lesions. Common sites in lambs and kids are the lips and muzzle and in ewes, the teats. It is caused by a Parapoxvirus that is spread by contact. The disease has a world-wide distribution and primary infections occur most frequently in lambs and kids three to six months old. The affected young stock usually fail to nurse and die. Vaccination using live vaccines is often an effective preventive measure.

Paste des Petits Ruminants

This is a rinderpest-like disease of sheep and goats characterised by necrotic stomatitis and intestinal and lymphoid tissues changes which resemble those of rinderpest in cattle. It is caused by a paramyxovirus which possesses antigenic links with bovine rinderpest. Aerosols are the major mode of transmission. The disease is endemic in West Africa and can cause heavy mortalities among sheep and goats in the non-endemic foci. Segregation of all newly purchased animals combined with the use of rinderpest vaccine is the most effective preventive measure.

Anthrax

Anthrax is a peracute or acute febrile disease of all mammals caused by *Bacillus anthracis* and often characterised by a rapidly fatal bacteraemia and toxaemia. It has a world-wide distribution.

In all ruminants, especially in sheep and goats, the peracute form of disease is most usual. Transmission of the bacterial spores is by ingestion of contaminated animal products or drinking water. Annual prophylactic vaccination using a living spore vaccine is practically the only means of control. Dead infected animals should be burned or buried.

Brucellosis

The disease is characteristically caused by *Brucella melitensis*. In the goat the disease can be septicaemic and may be acute, causing death, but the sheep appears to be more resistant. On the whole sheep and goats are the preferential hosts for *Brucella melitensis*. The disease is endemic in Kenya.

Transmission is by alimentary route and an abortion storm occurs after the third month of pregnancy in virgin areas. The disease is a zoonosis, causing Malta fever in man. Man gets infected by drinking contaminated milk.

Eradication by test and slaughter with segregation of healthy stock is often impracticable because of the primitive nature of husbandry methods, but would be the most desirable thing to do.

Control programmes must include the maintanance of good sanitary and husbandry methods together with the use of vaccines. Killed H38 vaccine and the living attenuated Rev1 vaccine are recommended for use in 3-8 months old goats only.

Brucella ovis occurs in East Africa as well and can cause a big infertility problem in rams. Vaccination of rams at 4 months old and again 2 months before mating with Brucella ovis adjuvant and Brucella melitensis vaccines might be protective.

Clostridial diseases

These are most important in ruminants especially where sheep are reared intensively. Latent infections are common; and the organisms multiply when the environment is suitable, for example in necrotic wounds or animals on high plane of nutrition. Several group disease entities are recognises:-

(a) Blackleg, caused by Clostridium chauvoei is an acute febrile disease of cattle and sheep with a world-wide distribution. Transmission in sheep is infection of skin wounds and the disease causes fever, lameness and gas-filled swellings and rapid death. Vaccination of ewes at least a month before lambing using a toxoid confers immunity on lambs through colostral antibodies.

(b) Enterotoxaemia (overeating disease) is a clostridial disease that affects young sheep and nursing heavy milk ewes and feedlot lambs consuming high grain diets. The rich diet provides a suitable medium for rapid multiplication of C. perfringens type D, the causative agent with toxin production that causes rapid death. Regulation of the diet to lower energy consumption, administration of toxoids and antitoxins or feeding of antibiotics are the usual control measures.

Heart water

This is a rickettsial disease of ruminants caused by Cowdria ruminantium transmitted by Amblyomma ticks. The disease occurs in Africa south of Sahara. Sheep and goats from endemic areas undergo inapparent infections, but animals from non-endemic areas suffer overt disease. regular dipping with reliable acaricide at weekly interval controls the tick vector and reduces the disease incidence.

Babesiosis

Two species of Babesia, B. motasi, a large form and Brucella ovis, a small form are responsible for the disease in sheep and goats. The disease in tropical Africa is transmitted by the ticks, of genus Rhipicephalus. Indigenous sheep and goats in endemic areas usually suffer a mild infection and are immune thereafter, but the exotics suffer an overt disease. The tick control measures are the same as for Amblyomma mentioned above.

Footrot

Although this disease is not usually fatal it is of considerable importance and compounds the problems of managing sheep in the wet humid tropics. It is mainly a problem of the exotic sheep. It is caused by several organisms, but the main one is Fusiforms nodosus. Periodic trimming of the feet and walking the flock through foot-baths containing either 10% formaldehyde or 30% copper sulphate controls the disease.

Mange

Infestation by mange mites occurs both in sheep (sheep-scabs) and goats and it is caused by one or other of the mange mites. It is a more serious disease in goats than sheep. Eradication of mange is usually undertaken by quarantine and compulsory dipping of the stock regularly using BHC.

Parasitic gastro-enteritis

Helminth parasites impose a heavy burden on ruminant productivity throughout the world. Ubiquitous intestinal worms, such as Trychostrongyles and Haemonchus, cause heavy losses in cattle and sheep, both in decreased productivity and high mortality in lambs and calves. A wet warm environment is most conducive to build up of worm populations. Goats are usually not affected because of their browsing behaviour (Lowe, 1943) but when they are, heavy mortalities occur, especially in kids.

Management practices, such as rotational grazing to break the parasitic life cycle plus regular treatment with antihelmintics, such as thin bendazole and Levamisole are generally effective in reducing or even eliminate the parasite load.

Liver Flukes (Fasciola Species)

Sheep, like cattle are susceptible to attack by the liver flukes, mainly Fasciola hepatica. In the tropics, this becomes a problem in highland areas like East Africa. Goat may be infested. In lowland areas, F. gigantica becomes inportant in sheep and, sometimes, goats.

Control measures include effecting proper drainage in grazing areas and the use of Molluscicides in swampy area. Regular drenching of the stock using fasciolicidal anthelmintics is also effective.

Contagious Caprine Pleuropneumonia (C.C.P.P.)

The causative agent of C.C.P.P. is *Mycoplasma mycoides* variety *capri*. It is a serious disease of goats and sometimes sheep. For example, Clifford (1977) found that C.C.P.P. was a serious problem among goats in West Africa with sheep less frequently affected.

Quarantine and slaughter policies help to control the disease.

CHAPTER V

DISCUSSION AND CONCLUSION

DISCUSSION

Although trypanosomiasis has a world-wide distribution, it assumes its main importance in Africa where it has been regarded as the biggest single factor which limits the numbers and productivity of livestock in the tsetse belt (Urquhart, 1974). The disease is more difficult to control in the tsetse belt than elsewhere because in this area trypanosomiasis is cyclically transmitted by tsetse flies whereas outside the tsetse belt, mechanical transmission takes place, a mode that is much less efficient (Hagan et al,1976). Hornby (1952) emphasises this point and states that trypanosomiasis is unique among diseases in that it is the only one which by itself has denied vast areas of land in Africa to all domestic animals other than poultry.

The cattle industry is particularly severely affected, with other species involved in more local contexts. The exact socio-economic importance of African trypanosomiasis is extremely difficult to assess as the data available are fragmentary and frequently very approximate (Finelle, 1974b). The same author has made a tentative estimate of the consequences of trypanosomiasis control on cattle numbers in Africa and the disease stands out to be a major constraint.

In cattle, the disease causes direct losses from the death of breeding, trade and working animals; and indirect losses from emaciation, retarded growth in young stock, abortions, reduced breeding efficiency and various organic lesions.

The disease has also direct and indirect effects on human health, nutrition (meat, milk and protein shortages) and socio-economic development. The control of the disease places a continuous strain on national finances. The deficit in animal products compels countries where trypanosomiasis is rife to resort to imports of meat and dairy products, a practice harmful to their balance of trade (Finelle, 1974b).

Various methods have been applied in the control of animal trypanosomiasis. The control of the disease may be effected either by its control in the animals or by preventing its transmission by controlling the tsetse flies (Finelle, 1974a).

Attempts at controlling the tsetse populations by application of insecticides, clearance of vegetation in their breeding sites, the use of biological methods such as parasites or predators of tsetse pupae and adults' and the release of sterilised males have been made (Hagan *et al*, 1976). Campaigns to destroy game animals, which act as reservoirs of infection and source of food of *Glossina* in some areas, and fence them off in others, have been undertaken.

The results of these attempts have shown that there is not an effective method of economic control of the disease. For any benefits to be realised, a combination of two or more methods must be used. Chemoprophylaxis offered some hope because it sometimes allowed animals to build up immunity. This method has had a draw back because of the development of drug resistance by *T. congolense* and *T. vivax*. This problem is compounded by the development of direct resistance to some drugs being accompanied by cross resistance to others.

The use of trypanotolerant animals in combination with chemoprophylaxis is a method that might be successful in a livestock production enterprise.

Trypanotolerance is a quality associated usually with cattle. The work that has been done on trypanotolerant breeds of cattle has shown that trypanotolerance depends on two groups of factors: hereditary and acquired immunity (Desowitz, 1959; Finelle, 1973b). These breeds have no resistance to trypanosomiasis when raised in tsetse-free areas and they may die of an acute disease when infected (Finelle, 1973b). Trypanotolerant breeds have a hereditary capacity to produce and maintain trypanosome antibodies for a long time, but the production of antibodies is set off by infections contracted while the animal is still protected by the mother's antibodies (Desowitz, 1959). Subsequent production of antibodies is maintained and strengthened by subsequent infections, but it can be reduced and even eliminated by factors like malnutrition, overwork, intestinal parasitism and infectious diseases (Finelle, 1973b).

Other animal species exhibiting trypanotolerance should be considered in livestock production enterprises in the tsetse belt. Sheep and goats are strong candidate species. Very few studies have been done on trypanotolerance and productivity in sheep and goats in the tsetse belt. Most of the existing literature on trypanotolerance in sheep and goats is subjective (Griffin, 1978) and in most cases it is based on general observations rather than experimental data. For example, FAO, (1976) states that sheep and goats are more numerous than cattle in trypanosomiasis areas of Africa and that the Dwarf sheep and goats of West Africa can live under the conditions of high tsetse challenge. Recent studies in Kenya (Griffin and Allonby, 1979b) have shown that indigenous breeds of sheep and goats have a higher resistance to trypanosomiasis than the exotic breeds. However, there is other evidence to show that sheep and goats can be very susceptible to various species of pathogenic trypanosomes and infections may cause high mortality (Losos and Ikede, 1972).

The mechanism of trypanotolerance in sheep and goats has not yet been experimentally established. But by extrapolation, the mechanism of trypanotolerance operating in cattle should be the same for trypanotolerant breeds of sheep and goats.

Sheep and goats are seldom fed on by Glossina species (Weitz, 1963) and this contributes to the low prevalence of trypanosomiasis observed in sheep and goats; and a much higher reproduction rate whereby losses can be made good, accounts for the presence of sheep and goats where cattle cannot be found in some of the tsetse areas (Hornby, 1952).

But on the other hand trypanosomiasis can cause heavy economic losses in sheep and goats if no trypanosomal drugs are used for curative or prophylactic purposes (Griffin and Allonby, 1979a). There is therefore a need to control the disease in sheep and goats and the use of drugs could offer the best chance.

Sheep and goats are hardy, highly adaptable to a broad range of different environments and can utilize rough grazing (Oltenacu et al, 1976). Their small size and relatively low individual value bring them within the capacity of low income households both for care and purchase price. They can also efficiently utilize marginal and small plots of land. There is also a faster turn-over of capital because of higher fertility and multiple births, short gestation period of 5 months allowing possibly two crops a year, earlier sexual maturity and young age at slaughter, often less than a year. Their small carcasses are easier to market and can be consumed in a short time which is important where preservation facilities are lacking.

To make better use of sheep and goats good breeds need to be identified. There are a few candidate breeds from which selection could be done: Galla, Red Sokoto, Mubence, Boer and the Nubian for goats and Blackhead Persian, the Somali and Dorper for sheep.

Of the two species goats seem to be better than sheep and will probably be preferred. For example, shrubs and coarse vegetation are unattractive and can hardly be consumed by sheep and cattle while goats thrive in this situation (Devendra, 1974).

There is also a need to set up trials to evaluate the comparative performance of various breeds under improved and unimproved environmental conditions. A reduction in the number of breeds in general use is desirable to allow for the more extensive use of chosen improved breeds. Cross breeding indigenous breeds with the exotics improves the overall productivity of various national herds. Correct husbandry practices such as provision of fencing and appropriate grazing management to prevent overgrazing and to control numbers improves productivity.

One needs to keep an eye on the non-trypanosomal disease problem that might upset the small ruminant production schemes.

CONCLUSION

The productivity from sheep and goats and their contribution to livestock development in the tsetse areas is already noteworthy. Greater production approaching maximum performance might be obtained from these animals if both genotype and environment are improved. In livestock programmes, improvements that come from environmental control are closely associated with other factors. These include reducing losses from diseases such as trypanosomiasis and parasitism, improving management, and increasing the litter size per dam. In this way efficient production of sheep and goats will be able to contribute to balanced human nutrition and to the economies of various countries in the tsetse belt.

APPENDIX I

TABLE I

Classification of the genus Trypanosoma showing the principal species infecting mammals (after Hoare, 1972).

Genus: Trypanosoma

Section	subgenus	Type Specis	Other Species
1. Stercoraria:	Megatrypanum	*T. theileri*	*T. melophagium*, *T. avium*
	Herpetosoma	*T. lewisi*	*T. duttoni*
	Schizotrypanum	*T. cruzi*	*T. vespertilionis*
	Endotrypanum	*T. schaudinni*	--
2. Salivaria	Duttonella	*T. vivax*	*T. uniforme*
	Nannomonas	*T. congolense*	*T. simiae*
	Pycnomonas	*T. suis*	
	Trypanozoon	*T. brucei*	*T. rhodesiense*, *T. gambiense* *T. evansi*, *T. equinum* *T. equiperdum*

TABLE 2

The goat population of the World in 1973

	Number ('000)	As percentage of world population
World	391,375	
Tropics	210,301	54
Other	181,074	46
Africa	114,735	29
Tropics	90,752	23
Other	23,983	6

Source: FAO, 1974 as quoted by Devendra, 1978.

TABLE 3

World distribution of sheep, 1972

	Number ('000)	As percentage of world population
World	1,056,684	
Tropics	204,122	19.3
Other	852,562	80.7
Africa	143,301	13.6
Tropics	72,901	6.9
Other	70.400	6.7

Source: FAO, (1973) as quoted by Williamson and Payne, 1978.

TABLE 4

Some breeds of goats in countries in the tsetse belt

Breed:	Variety	Country	Important trait	Adult live weight in Kg Male	Female
(a) Indigenous breeds:					
Southern Sudan	-	Southern Sudan	Meat		
Eritrean and Abyssinian:	Galla - Sidamo	Ethiopia	Meat	-	-
	Arusi - Bale	Ethiopia	Meat	-	-
	Danakil	Ethiopia	Meat	-	-
Somali:	Abgal	Somali	Meat	37	28
	Ogaden	Somali	Meat	43	31
	Galla	Somali	Meat	30-40	25-30
East African:	Small East African	East African Countries	Meat	25-45	25-45
	Mubende	Uganda	Skin	45	28
	Kigezi	Uganda	Meat	25	20
	Boran	Kenya	Meat	-	-
	Nyasaland	Malawi	Meat	-	-
Congo	-	Zaire	Meat	30	25
Southern African	Northern Rhodesia	Zambia	Meat	-	-
	Southern Rhodesia	Rhodesia	Meat	-	-
	Pafuri	Mozambique	Meat	-	-
West African Dwarf	-	West African Countries	Mear	18-20	18-20
Maradi (Red Sokoto)	-	Niger, Nigeria	Skin	20-25	20-25
(b) Upgraded/Exotic breeds					
Boer	-	Tanzania	Meat, Milk	-	-
Saanen	-	Kenya, Ghana	Milk	-	-
Saanen - Local Cross	-	Kenya, Ghana	Milk	-	-
Toggenburg	-	Uganda	Milk	-	-
Toggenburg	-	Uganda	Milk	-	-
Anglo - Nubian	-	-	Milk	-	-

Source: Mason (1951), Mason and Maule (1960) and Devendra, 1978

APPENDIX IV

TABLE 5

Suggested improver breeds in the tropics

Breeds:	Important trait	Climate of origin
Barbari	Meat, Milk, prolificacy	Tropical, dry
Black Bengal	Meat, prolificacy, Skin	Tropical, dry
Boer	Meat	Sub-tropical, dry
Creole	Meat	Tropical, dry
Fijian	Meat	Tropical, dry
Jamnapari	Meat, Milk	Tropical/Sub-tropical, dry
Kambing Katjang	Milk	Tropical, humid
Ma T'ou	Meat	Sub-tropical, humid
Damascus	Milk	Sub-tropical, dry
Nubian	Milk	Tropical, dry
Meradi (Red Sokoto)	Skin	Tropical, dry
Mubende	Skin	Tropical, dry/humid

Source: Devendra, 1974

TABLE 6

Some breeds of sheep in countries in the tsetse belt

Breeds	Country	Important trait	Adult live weight in Kg Male	Adult live weight in Kg Female
(a) Indigenous breeds				
Masai	Kenya, Tanzania	Meat	27-36	24-27
West African Dwarf	West African Countries	Meat	20-30	20-30
Southern Sudan	S. Sudan	Meat	25	15-20
Somali	Somalia, Kenya	Meat, Skin	33	-
East African Blackheaded	East African Countries	Meat	40	25
East African Long-tailed	East African Countries	Meat	-	-
Congo Long-legged	Zaire	Meat	30	30
Congo Dwarf	Zaire	Meat	-	-
Fulan	Niger, Senegal Cameroon, Chad	Meat	30-50	30-50
Rhodesia	Central Africa	Meat	40-45	25-35
(b) Upgraded/Exotic breeds				
Dorper	East and Central Africa	Meat	-	54-63
Blackhead Persian		Meat	68	52
Karakul	Kenya	Meat	-	-
Corriedale	Kenya	Wool	-	-
Romney Mash	Kenya	Wool	-	-
Merino	Kenya	Wool	-	-

Source: Mason (1951), Mason and Maule (1960) Williamson and Payne (1978)

TABLE 7

Suggested Improver breeds in the tsetse belt

Breed	Important trait
Dorper	Meat
Karakul	Meat
Backhead Persian	Meat

Source: As above

TABLE 8

Productivity Data for some of the sheep and goat breeds in the tsetse belt

(a) Age at first parturition and parturition interval

Breed	Age 1st Lambing/Kidding	Lambing/Kidding interval	Reference
East African Blackheade sheep	533 ± 8 Days	255 ± 2 Days	Sacker and Trail (1966a)
East African Mubende goat	567 ± 12 Days	297 ± 8 Days	Sacker and Trail (1966bb)
Red Sokoto goat	427 ± 14 Days	332 ± 6 Days	Haumesser (1975)
West African Dwarf Goat	362 Days	258 Days	Vohradsky and Sada (1973)

(b) Parturition and Twinning rates

Breed	Lambing/Kidding rate	Twinning rate	
East African Mubende goat		30%	Sacker and Trail (1966b)
West African Dwarf goat	184%	56%	Vohradsky and Sada (1973)
West African Dwarf sheep	115%	15%	Matthewman (1977)

(c) Live weight at different age:

Breed	Live Weight (Kg) at: Birth	2 months	5 months	12 months	36 months	
East African Mubende	2.1	7.1	12	20	-	Sacker and Trail (1966b)
East African Blackheaded sheep (Male)	2.5	10	15.5	24	-	Sacker and Trail (1966a)
West African Dwarf goat	1.4	-	-	13	25	Vohradsky and Sada (1973)
West African Dwarf sheep	1.3	-	5.8	-	9.8	Ngere (1973)

APPENDIX VII

TABLE 9

The existing numbers of sheep and goats in Potential development areas

Numbers in thousands

	1969-71	1975	1976	1977
Sheep	98808	79915	82681	86670
Goats	99169	98058	101248	95535

Source: FAO 1977

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