Jpn. J. Vet. Res. **42**(1): 1–18 (1994)

THEILERIOSIS IN ZAMBIA: ETIOLOGY, EPIDEMIOLOGY AND CONTROL MEASURES.

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(Accepted for publication: March 9, 1994)

ABSTRACT

In Zambia, theileriosis manifests itself in the form of Corridor disease (CD), caused by *Theileria parva lawrencei*, and East Coast fever (ECF), caused by *T. parva parva*. Of the approximately 3 million cattle in Zambia, 1.4 million are at risk to theileriosis. ECF is found in the Northern and Eastern provinces of the country, while CD appears in Southern, Central, Lusaka and Copperbelt provinces. Theileriosis is a major constraint to the development of the livestock industry in Zambia, with losses of about 10,000 cattle per annum. The disease is spreading at a very fast rate, over-flowing its original borders. The epidemiology is complicated by, among other factors, the wide distribution of the tick vector, *Rhipicephalus appendiculatus*, which is found all over the country. The current strategy of relying on tick control and therapeutic drugs as a way of controlling the disease is becoming increasingly difficult for Zambia. This is because both curative drugs and acaricides are very costly. Immunization against theileriosis using the infection and treatment method as a way of controlling the disease is becoming increasingly accepted, provided local *Theileria* stocks are used. This paper reviews the incidence of theileriosis in the last 2 years, 1991 and 1992. It also gives a historical perspective of the disease, epidemiology and control measures presently in use.

Key words: Theileriosis, East Coast fever, Corridor disease, *Theileria parva*, Zambia

INTRODUCTION

Zambia has a human population of about 8.5 million (estimated 1989) and has an area of 751,000 square kilometers. The annual human population growth rate is estimated at 3.5% with a population density of 9.4 per square kilometer. It has a

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cattle population of approximately 3 million, 257,000 of which are dairy cows. It has 80,000 sheep, 420,000 goats, 221,000 pigs and about 14 million chickens [6].

Theilerioses are protozoan infections of wild and domestic *Bovidae* which occur throughout much of the world. Organisms that cause these diseases are protozoan parasites belonging to the genus *Theileria* (Theiler, 1904). Two species of this genus, *T. annulata* and *T. parva* cause severe clinical disease in cattle that impedes dairy and beef farming and its improvement in countries in Africa, Asia and the Middle East. The most economically important species in Africa is *T. parva*. This parasite is transmitted by *Rhipicephalus appendiculatus* (Neumann, 1901) ticks and causes an often fatal, lymphoproliferative disease of cattle in Eastern, Central and Southern Africa. The case fatality rate in fully susceptible animals approaches 100% if not treated. Of the 63 million cattle raised in this region, over 24 million are at risk from *T. parva* infections [12].

Three *Theileria parva* subspecies, namely, *Theileria parva parva*, *Theileria parva lawrencei* and *Theileria parva bovis* are purported to exist. Although serologically and morphologically identical, they can be distinguished based on certain biological and epidemiological characteristics of the parasites in cattle [31]. Most cattle infected with *T. parva parva* die during a phase of high parasitemia, thus allowing ticks to pick up the parasite and transmit it to other cattle [11]. Therefore, *T. parva parva* can be maintained by a cattle population, but *T. parva lawrencei* might not be. This parasite behaviour necessitates the study of *T. parva lawrencei* in buffalo. *T. parva parva* and *T. parva bovis* are primarily transmitted between cattle, however, the disease caused by *T. parva parva* is generally more severe with a greater abundance of parasites and a higher mortality rate than is observed in *T. parva bovis* infections. *T. parva lawrencei* is a buffalo-derived parasite and is similar in virulence to *T. parva parva*, but generally produces fewer intraerythrocytic piroplasms intralymphocytic schizonts during the course of disease in cattle than in *T. parva parva* infections.

There has been a number of problems encountered in the field when immunizing against *T. parva lawrencei* by infection and treatment and culture methods. Young [32], and Radley et al. [24, 25] found that *T. parva lawrencei* immunized cattle were generally resistant to challenge with *T. parva parva*, but *T. parva parva* immunized cattle died on challenge with *T. parva lawrencei* from buffalo. Another example worth mentioning is that cattle challenged with a lethal dose of *T. parva lawrencei* die before the piroplasm stage appears in the blood [32].

Historical background of theileriosis in Zambia

The actual origin of theileriosis in Zambia is not known. It is highly assumed, like in the neighbouring countries of Malawi, Mozambique and Zimbabwe, that classical East Coast fever (ECF) in the Eastern and Northern provinces originated from East Africa (from the then Tanganyika or German East Africa). Several hypotheses exist

on the origin Corridor disease (CD) in the Southern province:

—spread from Eastern / Northern ECF infected areas,

—spread from buffalo, and

—spread from Zimbabwe (the so-called January Disease caused by *T. parva bovis.*).

However, the first recorded case of theileriosis in Zambia was in the Nakonde area of Northern province in 1922. According to the annual reports of the Veterianary Department of Zambia, no cases of the disease were diagnosed within the country from 1928 to 1945. In 1946 theleriosis was diagnosed in Mbala district in Northern province, and in 1947 in Chipata district in Eastern province. Since 1947 theileriosis has spread within the Northern and Eastern provinces, throught much of which it is now established enzootically.

In 1977 / 78, a malignant form of theileriosis was detected in the Hufwa area of Monze district, in Southern province [5]. Based on the criteria set by Neitz [19], this disease was diagnosed as "CD". According to Neitz [19], this form of theileriosis was distinct from classical ECF because: (1) ticks were not infected after feeding on infected cattle, due to the absence of intraerythrocytic piroplasms in the blood of infected cattle: (2) the mortality of cattle in the buffalo inhabited "corridor" area caused when cattle were moved outside the buffalo zone: (3) only a few macroschizonts of small dimensions were found in the tissue smears of infected cattle: (4) splenectomy caused a recrudescence of piroplasm parasitemia: and (5) a carrier state occurred in buffalo in contrast to *T. parva parva* infection in cattle. Neitz [19] considered that these characteristics of the buffalo parasite were enough to toxonomically separate it from *T. parva* so he created a new species, *T. lawrencei* which is now known as *T. parva lawrencei.* It is fairly certain that prior to 1977 Southern province was free of the disease. The disease has since then become endemic in this region, which is an important cattle-raising area containing about 1.2 million head, approximately 45% of the national herd.

Epidemiology of theileriosis in Zambia

Five *Theileria* species and subspecies are known to exist in Zambia. These are *T. parva parva, T. parva lawrencei, T. mutans, T. velifera* and *T. taurotragi.* The most economically important of these are the *T. parva* transmitted mainly by the tick ectoparasite, *R. appendiculatus.* Infection of susceptible cattle with *T. parva parva* results in the virulent form of the disease known as ECF. *T. parva lawrencei* on the other hand, causes mild infections in the African buffalo (*Syncerus caffer*) but causes lethal infections known as CD when transmitted to cattle by ticks which have previously fed on infected buffalo or infected cattle. CD appears in Southern, Central and Lusaka provinces (Fig. 1). Recently, a number of cases have been recorded in the Copperbelt province. ECF is found in the Northern and Eastern provinces of the

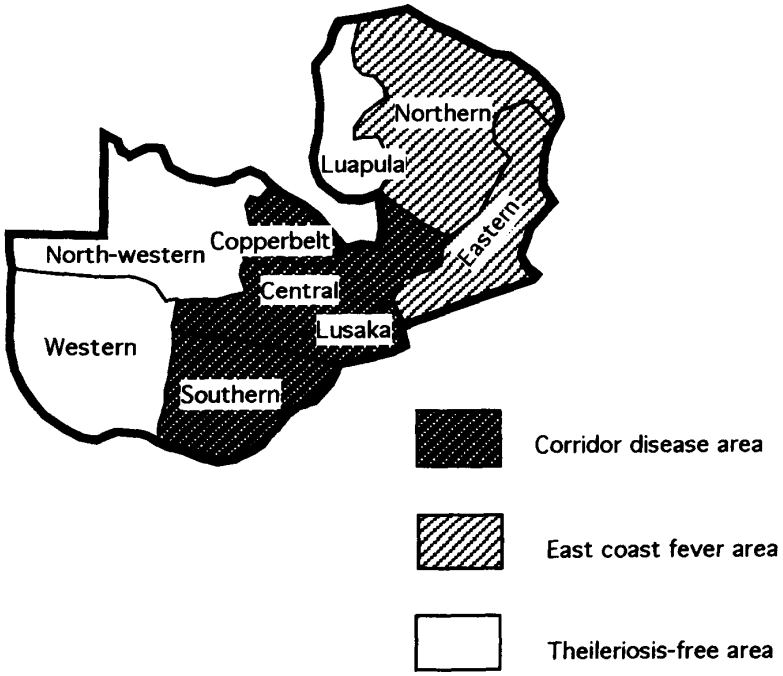

Fig. 1. The distribution of *Theileria parva* in Zambia.

country (Fig. 1). The economic significance of the other three *Theileria* species is not known. Nevertheless, they appear to cause only comparatively mild disease conditions such as transient fever and anemia.

—Factors affecting geographical distribution of theileriosis in Zambia.

Theileriosis persistence in an area is dependent upon the presence, in sufficient numbers of the host, the agent and the vector tick all at the same time [9]. In Zambia, three cattle sub-populations exist: one in the Western and North-western provinces, another in the Sourthern, Central, Lusaka and Copperbelt provinces and the third in the Eastern and Northern provinces. The vector *R. appendiculatus* is found throughout the country even in areas where theileriosis has not yet been reported (Fig. 2). The pattern of seasonal occurrence of *R. appendiculatus* is determined by climate [10, 26, 29]. The seasonal cycle is determined by the adults, which are only active under warm, wet conditions when photophase (day length) exceeds approximately 11 hours [21]. In Zambia, *R. appendiculatus* is, however, most abundant in the highest areas (1000–2000 metres above sea level) with moderate to high rainfall (600mm or more), moderate temperatures (18–30°C), soils which hold sufficient moisture during the dry season and sufficient vegetation cover [27].

In many cattle breeding areas in which vector and host distribution overlap, livestock have either been infected or are at risk of being infected. Within these

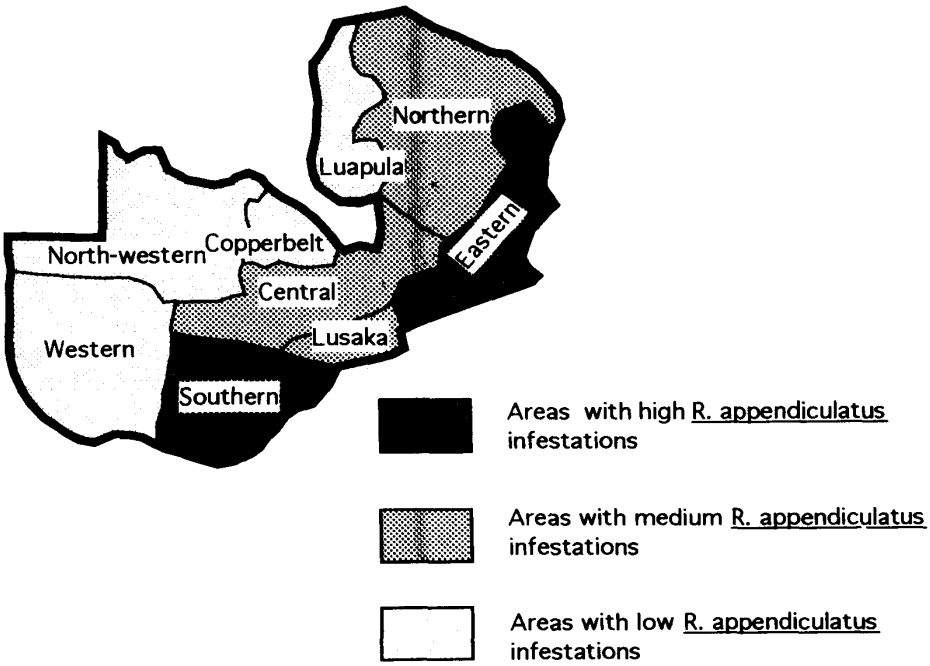

Fig. 2. The distribution of *Phipicephalus appendiculatus*, the vector of *Theileria parva* in Zambia.

areas, cattle populations may be divided into two groups:

(i) cattle kept on enclosed grazing under excellent standards of tick control i.e. commercial and state farms, on which the opportunity for introduction and subsequent spread of theileriosis is minimal as long as the management practices do not deteriorate.

(ii) cattle maintained under poor to moderate vector control standards or under no vector control. Grazing and watering points are communal (traditional sector) or more or less enclosed (settlement schemes). Unlike in other countries where group (i) i.e. commercial sector is most affected, in Zambia, the disease tends to be more active in the latter group.

—Disease patterns and occurrence rates

Depending upon the suitability of local environmental conditions for the vector, traditionally managed herds can be divided into 3 populations:

(i) Populations in areas unsuitable for the vector; here, vector numbers are too low to allow the disease to become established. These are the low-lying valleys of both Southern and Eastern provinces.

(ii) Populations in areas marginal for the vector; here the disease occurs in the form of periodic epizootics of varying size depending upon the climate and other

factors. These are in the areas of intermediate altitude between low-lying and highland areas.

(iii) Populations in areas suitable for the vector; here the abundance of ticks is sufficient to allow maintenance of the disease, the major determining factor being the standard of vector control.

Within an infected area, the pattern of theileriosis occurrence may take the form of a) epizootic b) enzootic occurences and c) enzootic stability.

a) Epizootic occurrence

This is observed in newly-infected heads at the periphery of an infected area, especially in herds in areas marginal for the vector and in herds within enzootic areas in which previously high-level vector control standards have been relaxed allowing the infection to penetrate. Average mortality rates are reportedly in the order of 20% but could be as high as 100% in exceptional cases as recorded in Choma district, Southern province [7].

b) Enzootic occurrence

Under certain conditions, such as moderate standards of vector control, reasonable tick infestation rates, favourable climate, theileriosis occurrence rates decline slowly as more and more animals that survive acquire some resistance to infection, eventually stabilizing in the third to fourth year of infection. Mortality rates may be in the order of 5%–10% with about 16% latent infection [7].

c) Enzootic stability

This may eventually be reached within 4–5 years after first infection (Epidemiology Unit and F.A.O., 1986). Mortalities are mainly in calves and may vary from 0–1.4% [7]. Epizootic may occur in an enzootically stable area if susceptible cattle are brought in. Latent infection may be closer to 100% animals over 12 months old and up to 97% among calves [7].

Current theileriosis situation in Zambia

A total of 20,022 theileriosis cases was recorded by the Veterinary Department in 1991 (Tables 2 and 3). Out of which 2,596 were ECF cases with Northern province recording 468 cases, while Eastern province recorded 2,128 ECF cases (Table 4). In 1991 the highest number of ECF cases in both the Northern and the Eastern provinces occurred between January and March (Fig. 3 and Table 3). Rainfall could be an influencing factor as adult *R. appendiculatus* activity is highest during this period. A small peak occurring between April and June could be due to nymphal activity confirming the assertions made previously [1, 20, 22], on the role of *R. appendiculatus* nymphs in the epidemiology of theileriosis. This peak is, however, highly dependant on whether the prevailing climatic conditions, temperature and moisture are favourable for tick development or not. There is a steady decline in the number of ECF cases recorded from June to October. With the onset of the rains in

Table 1. *THEILERIA* SPECIES IN ZAMBIA

Species	Disease caused	Vector
T. parva	East Coast fever	*R. appendiculatus*
T. parva lawrencei	Corridor disease	*R. zambeziensis*
		Rhipicephalus spp.
T. mutans	benign theileriosis	*Amblyomma* spp.
		Rhipicephalus spp.
T. velifera	benign theileriosis	*Amblyomma* spp.
T. taurotragi	benign theileriosis	*R. appendiculatus*
		Rhipicephalus spp.

Table 2. TOTAL NUMBER OF MORTALITIES AND CASES DUE TO CORRIDOR DISEASE IN 1991 & '92 BY MONTH

MONTH	1991		1992	
	CASES	MORTALITIES(%)	CASES	MORTALITIES(%)
JAN.	3,591	1,657(46.1)	2,487	2,008(83.7)
FEB.	1,846	1,072(58.1)	1,482	1,036(69.9)
MAR.	1,041	293(28.0)	1,053	643(61.0)
APR.	1,832	524(28.6)	1,518	952(62.7)
MAY	2,750	1,488(54.1)	2,269	820(36.1)
JUN.	2,961	2,295(77.5)	2,821	518(18.4)
JUL.	990	450(45.5)	1,280	307(24.0)
AUG.	1,046	451(43.1)	559	306(54.7)
SEPT.	391	106(27.1)	221	99(44.8)
OCT.	221	79(35.7)	184	60(32.6)
NOV.	221	60(27.1)	178	22(12.4)
DEC.	536	242(45.1)	542	52(9.6)
TOTAL	17,426	8,717	14,594	6,903

Table 3. TOTAL NUMBER OF MORTALITIES AND CASES DUE TO EAST COAST FEVER IN 1991 & '92 BY MONTH

MONTH	1991		1992	
	CASES	MORTALITIES(%)	CASES	MORTALITIES(%)
JAN.	329	39(11.9)	160	63(39.4)
FEB.	380	66(17.4)	347	48(13.8)
MAR.	468	92(19.7)	272	84(30.9)
APR.	200	25(12.5)	149	48(32.2)
MAY	285	76(26.7)	396	205(51.8)
JUN.	226	26(11.5)	194	104(53.6)
JUL.	191	30(15.7)	114	39(34.2)
AUG.	167	47(28.1)	95	23(24.2)
SEPT.	125	56(44.8)	86	27(31.4)
OCT.	8	0	23	4(17.4)
NOV.	2	0	50	13(26.0)
DEC.	215	58(27.0)	24	3(12.5)
TOTAL	2,596	515	1,910	661

Table 4 TOTAL NUMBER OF MORTALITIES AND CASES DUE TO EAST COAST FEVER IN 1991 & '92 BY PROVINCE

PROVINCE	1991		1992	
	CASES	MORTALITIES(%)	CASES	MORTALITIES(%)
EASTERN	2,128	414(19.5)	1,329	436(32.8)
NORTHERN	468	101(21.6)	581	225(38.7)
TOTAL	2,596	515	1,910	661

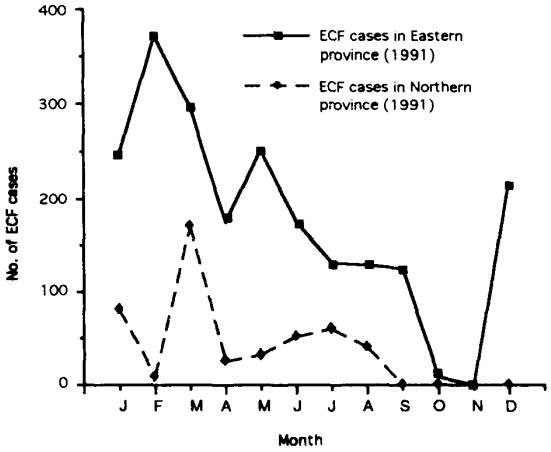

Fig. 3. The number of East Coast fever (ECF) cases in Northern and Eastern provinces as recorded by the Veterinary Department, Lusaka in 1991 by month.

November adult tick activity resumes and the number of ECF cases increases again. The picture was much the same in 1992 in both provinces (Fig. 4).

Of 17,426 CD cases recorded in 1991, 15,409 was in the Southern province, followed by 1,739 in Central province, 152 in the Copperbelt province, and 126 in Lusaka province (Table 2 and 5).

In both 1991 and 1992, the highest number of CD cases in Southern province were recorded during the month of January, (Table 2 and Fig. 5). A small peak occurring between March and July due to high nymphal activity was recorded (Fi. 5). There were, however, CD cases, in low numbers, recorded throughout the year. The epidemiology of CD in Central province in both 1991 and 1992 was rather different from the usual pattern with more cases being recorded between March and August in 1992 (Fig. 6.). A small peak was recorded in the month of November in 1991 and in December in 1992. The Copperbelt province had 152 and 364 recorded CD cases in 1991 and 1992 respectively Tables 4 and 5. A total of 8,717 mortalities due to CD was recorded in 1991 out of which Southern province recorded the highest (7,895), followed by Central province with 715 deaths (Table 5). Lusaka and Copperbelt provinces recorded 83 and 24 mortalities, respectively (Table 5).

In 1992, deaths due to CD were rather lower than in 1991 (Table 2 and 5). Southern province, however, still recorded the highest mortalities (5,893) while Central province in second place recorded an increase (838). The Coppebelt province recorded 172 cases while Lusaka province had none in 1992 (Table 5). Mortalities due to ECF in 1991 were only 515 in both Northern and Eastern provinces where the disease occurs (Table 4). Eastern province recorded 414 while Northern province had only 101. There was, however, a slight increase in the number of mortalities due to ECF in 1992 with Eastern province recording 436 and Northern province recording

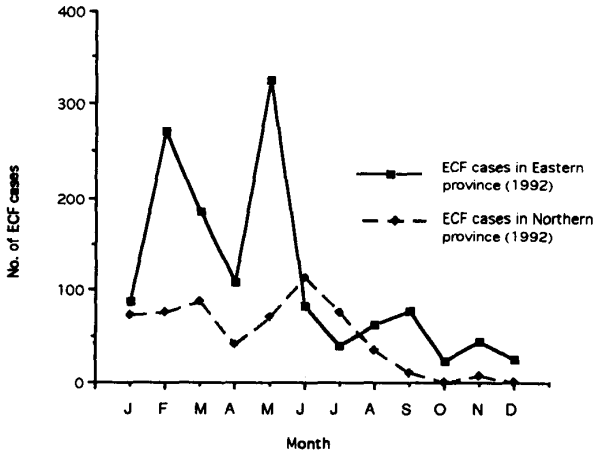

Fig. 4. The number of East Coast fever (ECF) cases in Eastern province and Northern province as recorded by Veterinary Department, Lusaka in 1992 by month.

Table 5. TOTAL NUMBER OF MORTALITIES AND CASES DUE TO CORRIDOR DISEASE IN 1991 & '92 BY PROVINCE

PROVINCE	1991		1992	
	CASES	MORTALITIES(%)	CASES	MORTALITIES(%)
SOUTHERN	15,409	7,895(51.2)	8,198	5,893(71.9)
CENTRAL	1,739	715(41.1)	6,032	838(13.9)
LUSAKA	126	83(65.9)	0	0
COPPERBELT	152	24(15.8)	364	172(47.3)
TOTAL	17,426	8,717	14,594	6,903

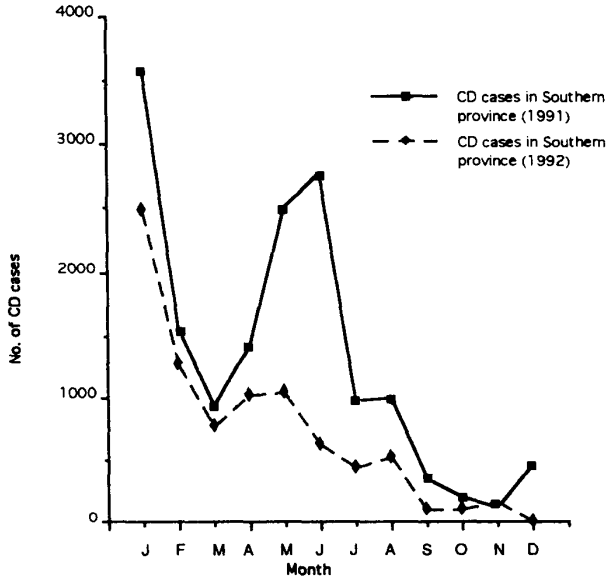

Fig. 5. The number of Corridor disease (CD) cases in Southern province as recorded by the Veterinary Department, Lusaka 1991 and 1992 by month.

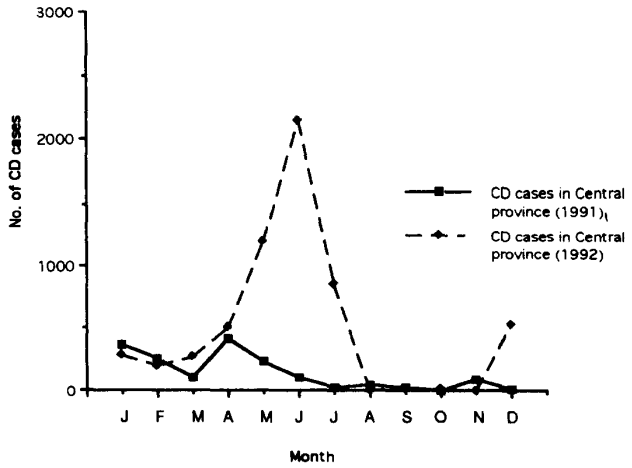

Fig. 6. The number of Corridor disease (CD) cases in Copperbelt province as recorded by the Veterinary Department, Lusaka in 1991 / 1992 by month.

225 (Table 4).

This information is derived from annual veterinary reports of the Government of the Republic of Zambia submitted to the Veterinary Headquarters in Lusaka by auxiliary veterinary personnel through their respective provincial officers. The reports provide data on disease diagnosis, treatments, recoveries and mortalities in the field. The diagnosis of theileriosis in Zambia is based on the demonstration of schizonts (Koch's blue bodies) in lymph node biopsy smears and of piroplasms in blood smears from clinically sick animals or schizonts from spleen impression smears of dead animals. At times, the diagnosis is complemented by the indirect fluorescent antibody test [3, 4] using *T. parva* antigens. Unfortunately, these personnel have very limited equipment and resources to carry out their work effectively, and therefore, the above data may only represent a fraction of the actual theileriosis situation in Zambia.

Observations

As can be seen from the figures above, the spread of ECF is some how slow in both Eastern and Northern provinces where the disease is prevalent. This could be due to fewer cattle and they are found in small isolated pockets in both provinces. Moreover, a massive immunization programme, using local *Theileria* stocks, is being carried out by the Belgian Animal Disease Project in Eastern province since 1982 [2]. The project has so far, over 50,000 calves have been successfully vaccinated.

The CD situation in the Southern province where the "Muguga cocktail", from Kenya was used to immunize cattle by the F.A.O., funded project from 1983 to 1986 is different. The initial results of this project were very encouraging [18] but later the disease spread very rapidly with high morbidity and mortality. The "Muguga cocktail" is composed of two Kenyan *T. parva parva* and one Kenyan *T. parva lawrencei* stocks. These are foreign *Theileria* strains introduced into Zambia and worse still into area where little or no information on the available local strains is available. It is known that immunized cattle, as well as those that recover naturally from *T. parva* infections or following treatment, are "carriers" of the infection and therefore, can serve as a source of infection for others [8, 9, 13, 15, 28, 33, 34].

The epidemiology of theileriosis in Zambia has become very complex. In fact one wonders whether it is still correct to refer to the disease in Southern province as CD. It is very likely that we are presently dealing with a mixed infection of *T. parva parva* and *T. parva lawrencei*. The buffalo is no longer necessary in the disease transmission cycle. Its transmission cycle is no longer restricted only to buffalo-tick-cow, but cow-tick-cow transmission has become even more frequent. It has become difficult if not impossible to distiguish CD cases from ECF. As mentioned elsewhere, it was originally possible to distinguish the two by the number of schizonts in infected lymphocytes or piroplasms in erythrocytes where-by ECF would have more and CD less. The situation nowadays is such that the number of schizonts and piroplasms in

both cases is the same, posing the question whether we are dealing with two disease complexes or just one. There is, therefore, a need to isolate and characterized *Theileria* parasites in Zambia. The next question would be whether to continue the ban on movement of cattle from Nouthern and Eastern provinces.

Other factors responsible for the rapid spread of CD in the Southern province are abundant tick-carrying wildlife ; communal drinking and grazing areas ; lack of adequate dipping facilities ; illegal cattle movements for both social and economic purposes ; development of tick resistance to acaricides and the high cost of imported curative drugs.

Control of theileriosis in zambia

There are four main ways of controlling theileriosis in Zambia ; a) vector control ; b) cattle movement control ; c) chemotherapy, and d) immunization.

a) Vector control

The use of acaricides to kill the tick vector still remains the most effective method of controlling tick-borne diseases in Zambia. The problem here is the high cost of acaricides. The Zambian governments policy on dipping / spraying varies depending on the season of the year. In the rainy season, i. e. November to March, dipping / spraying is done twice a week. Dipping / spraying is done once very fortnight in the dry season when the tick activity / tick numbers are less. This approach is likely to change now because theileriosis out-breaks in recent years occur almost throughout the year, especially in the last 2 years or so. This brings up the question of possible involvement of other tick-vectors such as *R. evertsi*, *R. zambeziensis* and *R. compositus*, whose role in the epidemiology of this deadly disease in Zambia requires further investigations. For example, in Zambia, *R. evertsi* is present in large numbers from March to November and is very active from July to October [16]. *R. compositus* is found on cattle in large numbers during September and October, but it could be present as early as July and as late as November and February [16].

b) Cattle movement control

Another method of theileriosis control is cattle movement restriction from theileriosis-specified areas. Movement of livestock is subject to the issuance of stock movement permits by veterinary officers. Movements within endemic areas are allowed. However, movements from endemic areas to non-endemic areas are allowed on the following conditions :

—the animals to be moved must test negative serologically by indirect immunofluorescent antibody test.

—they are treated with acaricide before they are moved to insure that they are tick-free.

—they are subjected to compulsory quarantine under close veterinary supervision.

In addition to this, if the animals are meant for slaughter, they must be branded with slaughter brands and must be slaughtered under veterinary supervision within 24 hours of their arrival at destination.

Cattle in both the Eastern and Northern provinces, where ECF appears, are not allowed to be moved to other provinces for fear of the spread of the disease. The above mentioned conditions, therefore, only apply partially in these two provinces.

c) Chemotherapy

Oxytetracyclines are effective in controlling theileriosis if given at the same time as infection as applied in the "infection and treatment method" to block both parasite and disease development. The following regimes are used to treat patent disease:

—Halofuginone (Hoechst / Rousel) Terit® 1mg/kg per os.

—Buparvaquone (Coopers / Wellcome) Butalex® 5mg/kg i.m.

—Parvaquone (Coopers / Wellcome) Clexon® 20mg/kg i.m.

Terit seems to be very active against the schizont stage while Clexon seems active against all stages of the parasite life cycle in cattle [17]. The only constraint here is the high cost of these drugs. A 40 ml bottle of Clexon, for example, costs about 25 US$. And yet this is only enough for the treatment of one adult animal since a second dose has to be given after 48 hours (one animal costs about 100 US$).

d) Immunization

So far the most prominent and widely used method of immunization against both forms of theileriosis in Zambia and elsewhere is the so called "infection and treatment method" [23]. Cattle are infected with a normally lethal dose of infective tick stabilate on day zero, followed by a single injection of a long-acting oxytetracycline to suppress both parasite and disease development [30]. This method was used by Animal Disease Control project of the Food and Agricultural Organization from 1983 to 1986 in the Southern province except foreign that *Theileria* stocks from Kenya were used. The initial results of this project were very encouraging, but later the disease spread very rapidly over-flowing beyond it's original borders. It is at the moment being used in the Eastern province by a Belgian funded project, using local *Theileria* strains, and has so far successfully vaccinated over 50,000 calves. From the low figures of theileriosis cases reported in this province, this method can be very effective as a way of controlling theileriosis so long as local *Theileria* strains are used.

Conclusion

Clearly, theileriosis is a major constraint to the development of the livestock industry in Zambia. The current strategy of relying on tick control to control the disease is becoming increasingly difficult for Zambia because of several shortcomings. Acaricides are very costly and must be bought with hard currency, a scarce commodity in Zambia. In areas heavily infested with ticks, cattle herds are walked long distances to acaricide dip-tanks or spray races as often as once every fornight for

treatment; this freqeuntly erodes land, pollutes the environment with toxic residues and may also be contributing to growing tick resistance to acaricides, in addition to over-dosing and under-dosing. It is, moreover, difficult to maintain correct acaricide strength (dipstrength) due to the short supply of water resulting in poor management of cattle diptanks. This is compounded by the country not having any form of control on the type of acaricides and pesticides being brought into the country. There is also no specific legislation regarding their safe use nor their safe disposal after use.

Curative drugs are equally expensive. For chemotherapy to be effective, the disease must be diagnosed early enough so that treatment can be given at the start of clinical disease. This is, however, difficult in *T. parva* infections because in most cases the disease becomes clinically apparent only when it has reached an advanced stage. The slow spread of theileriosis in the Eastern province proves that immunization using the infection and treatment method can be effective. This method would not only reduce losses associated with theileriosis but also reduce acaricide costs, since acaricides would then be applied strategically rather than universally. Although the immunization method of infection and treatment has been adopted in a number of countries, including Zambia, it still remains problematical for several reasons. One of the most important being "antigenic diversity". Immunity produced in an animal against one stock of the parasite may not protect against challenge with another. The second most important reason being the question of "carrier status" in immunized animals. Animals that recover naturally from *T. parva* infections or following treatment or immunization, are "carriers" of the infection and, therefore, can serve as a source of infection for others [8, 9, 33, 34]. To avoid introducing foreign strains or stocks into new areas, field immunizations against theileriosis using the infection and treatment method should be carried out using parasite populations that have been isolated from areas where immunizations are to be carried out, at least until the question of "carrier state" is cleared.

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