Aspects of productivity
of
traditionally managed Barotse cattle
in the Western Province of Zambia

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Aspects of productivity of traditionally managed Barotse cattle in the Western Province of Zambia

Proefschrift

ter verkrijging van de graad van

doctor in de landbouw- en milieuwetenschappen

op gezag van de Rector Magnificus,

Dr. C.M. Karssen,

in het openbaar te verdedigen

op woensdag 2 november 1994 om vier uur

in de Aula van de Landbouwuniversiteit te Wageningen.

Stellingen.

1. De invloed van de leefomgeving en het management op de productiviteit van traditioneel gehouden rundvee in Afrika is aanmerkelijk groter dan die van chronische infecties met inwendige parasieten. **-Dit proefschrift-**

2. De al of niet bestaande relatie tussen veehouderij en ecologische degradatie in onder andere Afrika vraagt eerder een grotere mate van betrokkenheid bij veeteeltontwikkeling dan het veronachtzamen ervan. **-Dit proefschrift-**

3. Bij het vaststellen van ontwikkelingsdoelstellingen dient terdege rekening te worden gehouden met socio-economische aspecten, die als betrekkelijk vaststaande randvoorwaarden moeten worden gezien. **-Dit proefschrift-**

4. Routinematige bestrijding van teken in de traditionele veehouderij in Afrika is, zeker bij afwezigheid van de parasiet Theileria parva, veelal niet economisch verantwoord, en kan daarnaast een potentieel gevaar inhouden, door de ontwikkeling van premuniteit te blokkeren. **-Pegram, R.G., A.D. James, G.P.M. Oosterwijk, K.J. Killorn, J. Lemche, M. Ghirotti, Z. Tekle, H.G.B. Chizyuka, E.T. Mwase and F. Chizhuka (1991). Studies on the economic impact of ticks in Zambia. Exp. Appl. Acarol., 12:9-26.-**

5. De verdere ontwikkeling van duurzame landbouw en veehouderij zou zeer gediend zijn met een eenduidige definitie van het begrip duurzaamheid. **-Symposium Duurzame Dierlijke Productie, Eisen vanuit markt, milieu en maatschappij. Studievereniging "De Veetelers", 29 Januari 1992, Ede-**

6. Een bedrijfsvoering, die gericht is op het handhaven van een zo hoog mogelijk gezondheidsniveau, verhoogt de kwaliteit van de veehouderij. **-Julicher, C.H.M., E.G.M. van Klink, G. de Peuter, D.L. Schumer, G.H.J.M. Versteijlen (1993). De Toekomst van de Diergezondheid. "Wie zal het een zorg zijn?!" Ministerie van Landbouw Natuurbeheer en Visserij, Den Haag-**

7. Gezien het ontbreken van natuurlijk bos, het vrijwel ontbreken van vrijlevend grootwild en de hoge veebezetting past Nederland bescheidenheid in de discussie over het kappen van tropisch regenwoud, de olifantenjacht en overbegrazing in de derde wereld.

8. Bij uitbraken van een belangrijke Veewetziekte worden door de sector veelal meer de genomen maatregelen als de betreffende ziekte als probleem ervaren.

9. Om het begrip grondgebondenheid in de biologische veehouderij vorm te geven zullen de veehouderij, het daarvoor beschikbare voederareaal én het beschikbare areaal om de geproduceerde mest op af te zetten onderdeel uit moeten maken van één en hetzelfde systeem.

10. Het dumpen van goedkoop Europees vlees op markten in west Afrika, waar vooral vee vanuit de Sahel wordt vermarkt, is niet alleen een bedreiging voor de ontwikkeling van de welvaart van veehouders en de ontwikkeling van gerelateerde activiteiten, maar houdt ook een bedreiging in voor de pogingen de verwoestijning te beperken.

11. Identificatie- en registratieregelingen voor dieren, primair opgezet ten behoeve van diergezondheid en residutracering, dienen een rol te spelen in kwaliteitsbeheersings- en garantiesystemen, mede omdat dit een positief effect zal hebben op het draagvlak voor deze regelingen.

12. Geen enkele overheid is in staat de 200 jaar vooruit te zien die noodzakelijk zijn om tropisch hardhout op werkelijk duurzame wijze te produceren en te oogsten.

13. Dat een gedeelte van de theorie ten aanzien van regulering van de voedselopname van Ketelaars en Tolkamp mogelijk ook op mensen van toepassing kan zijn, valt onder andere af te leiden uit het feit dat babies hun fles minder ver leegdrinken, naarmate de speen minder makkelijk melk doorlaat. **-Ketelaars, J.J.M.H., and B.J. Tolkamp (1991). Toward a New Theory of Feed Intake Regulation in Ruminants. Ph.D. thesis, Landbouwuniversiteit Wageningen.-**

14. Het kusje is waarschijnlijk de enige natuurlijke pijnbestrijdingswijze waarvan zelfs door de grootste bestrijders van kwakzalverij de curatieve werking niet wordt betwijfeld.

Stellingen behorende bij het proefschrift "Aspects of productivity of traditionally managed Barotse cattle in the Western Province of Zambia", van Ed van Klink, 2 november 1994 te Wageningen.

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Contents

CHAPTER 1.

Introduction.

1.1. Introduction.

In many areas in sub-Saharan Africa the human population grows considerably faster than the agricultural production. This resulted in a net decrease in per capita food production (Brumby, 1986a, Simpson, 1984). Pritchard (1988) reported that the decrease is as high as one percent annually. As a result of this, the region becomes more and more dependent on food imports (Congress of the US, 1984, ILCA, 1983, World Bank, 1981 and 1984). Improvement of food security is therefore a primary aim of development activities (Eicher, 1982). Eicher also stated, that improvement of food security should focus on agricultural production as a whole, and not on the development of crop husbandry alone.

The consumption of protein is considerably lower in developing countries than in developed countries. In developed countries 34 % of the consumed energy, and 56 % of the protein originates from livestock; in developing countries these figures are 8 and 21 % respectively (Reid and White, 1980). Jasiorowski (1975) indicated, that the consumption of animal protein stands at 75 grams per day per person in developed countries, whereas in developing countries this is 5 grams. McDowell (1972) argued, that, if attempts are being made to improve the protein content of the food, in many instances people are unlikely to accept new types of food. Often they are already used to, or are already using livestock and livestock products. The production of animal protein is far below levels anywhere else in the world (Dwinger, 1988). Anteneh (1984) showed, that the growth in meat production is slower than the growth of the human population. While the human population increased by 2.8 % annually, the meat production increased by 1.6 % per annum. Especially in southern Africa this growth has declined.

Apart from reasons of food quality, livestock plays an important role in arable agriculture, which is another reason for specific attention to livestock development (Brumby, 1986b). The provision of draught power and transport is an important input in crop husbandry (Anderson, 1985, Airey and Buckland, 1984, Gryseels, 1988, Gryseels and Anderson, 1983, Jahnke, 1982, Matthewman, 1987). The use of animals for traction is on the increase in many parts of Africa (Milimo, 1985, Munzinger, 1982). Manure is another important input supplied by livestock (Brumby, 1986a, Jahnke, 1982). Powell and Mohammed-Saleem (1987) gave quantitative information on the importance of livestock for nitrogen and phosphorus cycles on crop land. Herds of, on average, 50 animals were kraaled on cropland for two to three consecutive nights. They deposited, depending on the season, 41 to 104 kg of Nitrogen and 10 to 15 kg of Phosphorus per hectare per herd.

In many areas livestock graze land which is less suitable for crop production, thus providing the best possible means of extracting value from such land (Airey and Buckland, 1984, Gow, 1987, Pritchard, 1988). In economical terms, as providers of finance (McDowell, 1972), livestock is indispensable in many areas of Africa.

For the reasons mentioned here, livestock and livestock development is important in Africa. The studies described in this thesis were carried out in the framework of the Livestock Development Project in the Western Province of Zambia (De Rooij and Wood, 1990). The studies concern themselves with productivity of cattle in the traditional livestock keeping system of the Western Province. In order to provide insight in the meaning of the notion of traditional livestock keeping, in the livestock development approaches and in research into productivity and influences on productivity, an overview of literature on these aspects is given. This overview is aimed at providing arguments for carrying out productivity research in traditional livestock keeping systems in the field, i.e. in (privately owned) herds that are representative for the livestock keeping practices of the farmer population for whom the results of the research are intended. It is also aimed at giving grounds for directing research at practically applicable results.

1.2. Traditional livestock keeping in Africa.

1.2.1. General.

Of the livestock in Africa 75 to 80 % is maintained under traditional management (Brumby and Trail, 1986, Dicko, 1990). In the Western Province of Zambia, where the studies on which the following chapters report, have been carried out, the cattle industry is entirely traditional.

Traditional management generally implies, that hardly any, or no inputs are introduced into the system, and that communal use of grazing resources is the rule. The livestock management is generally aimed at risk aversion, rather than at commercially optimal exploitation of the livestock (De Leeuw, 1990). The vast majority of the livestock is kept in agro-pastoral systems, in which the livestock production is integrated in the overall farm production (Brumby, 1986a, Brumby and Trail, 1986, McIntire and Gryseels, 1987). Strict pastoralism, in which the owners do not engage to any extent in agricultural activities, is numerically less important (Gall, 1981).

1.2.2. The importance of livestock in the rural economy.

Owning livestock generally means, that larger areas can be cultivated, because of the availability of draught power. Also the productivity of fields can be improved through the use of manure. Several authors argued, that livestock owning farmers realise higher yields than those who do not own livestock (Anteneh, 1984, Brumby, 1986a, Brumby, 1986b). In case of a calamity such as drought, livestock may contribute importantly to the extent the owners can cope with it. Campbell (1984) illustrated this, by comparing livestock owning, strictly pastoral Maasai, settled Maasai, who engaged in crop husbandry, while also owning livestock, and a people, settled in the same area, who cultivated land, without owning animals. The settled Maasai were most successful in overcoming the situation.

Livestock are frequently the source of income in situations where crop production is mainly subsistence oriented (Eicher, 1982, Crotty, 1980, ILCA, 1980, Jahnke, 1982, Jarvis, 1980, McDowell, 1972, Schneider, 1984, Winrock Int., 1978). ILCA (1982) showed, that livestock is also of great importance in commercial sense. The estimated annual income from livestock in Africa was in the range of 10 billion US$ in the early eighties, of which 50 % was attributed to direct animal products (meat, milk, skins, fibre). The rest was accounted for by services and non-food products such as manure and traction. Game and fish accounted for 3.5 billion US$, and the grain output was valued at 8.5 billion US$. Masiga (1990) reported an annual contribution of livestock production to overall agricultural production of 14 billion US$, of which 5 billion are indirect benefits.

1.2.3. Constraints to livestock production.

Livestock production in Africa is depressed as a consequence of the variability in fodder availability and quality ('t Mannetje, 1981). This is mainly caused by climatic variation. In tropical regions the amount of rainfall is the limiting factor, as opposed to the situation in temperate zones, where temperature is the main influence (McDowell 1972).

Dry periods cause a considerable reduction in the quality and quantity of the fodder (Mosi et al., 1976), and place considerable stress on performance, such as conception and milk production (Chandler, 1971).

McDowell (1972) also mentioned diseases and parasites as constraints. Holtzman (1982) suggested, that reduction in productivity as a result of diseases may be as high as 50 or 60 %. The numbers of animals annually dying of animal diseases are considerable as well. ILRAD (1984) mentioned an estimated 50 million cattle and 100 million sheep. The seasonal reduction in condition as a result of malnutrition may be of importance in the susceptibility for diseases and parasites (McDowell, 1984). The African trypanosomiasis, transmitted by tsetse flies, largely determines the livestock distribution on the continent, preventing the possible use of large areas of favourable pastures, and highly influences the productivity of animals kept within tsetse infested areas (Jordan, 1990).

Though McDowell (1972) suggested, that pressure of stock numbers on the land may be a constraint too, Jarvis and Erikson (1986) found indications, at least for some specific cases, that cattle numbers increased, in spite of warnings of overstocking. They suggested that this casts some doubt as to the seriousness of overgrazing as a productivity constraint. Contrary to "common belief" (Harding, 1968), several authors did not agree to the thesis, that livestock are an important causative agent in the desertification of large areas of Africa (Haaland, 1979, McDowell, 1984). Haaland argued, that cutting trees to feed iron furnaces has been a much more important cause, and that cropping has contributed as well. Livestock should in this context rather be seen as the ultimate, residual users of a range, that allows no other use any more. McDowell suggested, that livestock may even have played a role in slowing the desertification process down. Animals consume hard pod tree seeds, which become more sensible to moist after passing through the ruminant digestive system. The "mainstream view" to the problem of desertification, as it was termed by Sandford (1983), however false, did cause to some extent disinterest in the wellbeing of livestock keepers.

1.3. Livestock research.

Extension, aimed at improving farm performance, often does not seem to attain the response expected. In many cases the messages are not adapted to the local circumstances (Abalu et al., 1987, Biggs, 1980). They often do not fit in the regular farming practices in a technical sense. Furthermore, in many cases execution of technical recommendations is not possible due to influences of non-technical, for example sociological, nature. Thorough knowledge of the local situation is therefore of prime importance (Dickie and O'Rourke, 1984). Farming systems research (and development) aims at identification of farmers' needs, and formulation of research on the basis of that. This research is aimed at increasing farmers welfare, especially directed towards the small farmer with few resources (Norman and Gilbert, 1981, Shaner et al., 1981). Interventions applied often tend to improve the cash position of the farmer, while increasing his dependency on input and output markets (Baker et al., 1983, Norman et al., 1982). Interdisciplinarity is a typical characteristic of this type of research (Shaner et al., 1981, Sollod et al., 1984). Abassa et al. (1987) argued, that improvement efforts, tackling separate problems, generate less success than those, using an integrated approach, aimed at improvements of managerial, genetic and environmental nature. Behnke (1985) referred to measuring the profitability of livestock enterprises, and attempting to compare subsistence and commercial livestock production. He indicated, that information derived from biological measures of herd productivity should be combined with economic assessments, and with the impact of the livestock enterprise on the nutritional status of the people engaged in it.

The complexity of agro-pastoralist and pastoralist structures in Africa makes it difficult, if not impossible, to give a framework for development, appropriate to the whole region (Little, 1984). Little argued, that study of specific socio-economic indicators allows for comparison between regions. Apart from socio-economic aspects, ecological zones are likewise of importance in characterising regional differences, and directing research approaches (Jahnke, 1982, Abalu et al., 1987) and research priorities (Pratt, 1984). The ecological zones as distinguished by Jahnke (1982) are the arid, semi-arid, sub-humid and humid zones. The climate is the determining factor in characterising the zones. Since day length is more or less uniform, and temperature is only of importance as a determining influence if it is extreme, it is predominantly rainfall that determines the zonation. In the arid zone the average annual rainfall is less than 500 mm., in the semi-arid zone it is between 500 and 1000 mm., in the sub-humid zone it is between 1000 and 1500 mm. and in the humid zone it is more than 1500 mm. There is a close correlation between land use and rainfall, and therefore the zonation is also expressed in terms of the average annual number of growing days. In the arid zone less than 90 growing days are counted, in the semi-arid zone 90 to 180, in the sub-humid zone 180 to 270 and in the humid zone more than 270. The range in ecological conditions in sub-saharan Africa is very broad, and obviously the approach and priorities in research will differ between arid and semi-arid areas and humid areas.

Notwithstanding the clear importance of integrated research, studies into specific aspects of productivity do of course take place. The use of animal draught power, and the need to expand the use of animals for traction was discussed by Anderson (1985) and Gryseels and Anderson (1983). Both authors discussed the possibilities of using crossbred dairy cows for traction. Matthewman (1987) gave an overview of the literature on the use of cows for animal traction. Generally oxen are preferred because of their bigger size, but in situations where land or fodder resources are a limiting factor, cows are frequently used.

Animal nutrition, and especially the quality and possibilities of the natural range and its' influences on productivity are important subjects of specific research as well (Coppock et al., 1986, 't Mannetje, 1981, Mosi et al., 1976). Jennings and Holmes (1985) studied the use of supplementary feeds in dairy enterprises on tropical pastures in the commercial sector. The use of Non Protein Nitrogen licks and the effect of bush clearing on the quality of the pasture was described by Pratchet (1983). Improvement of the range was also a subject of Verboom (1965 and 1966).

Aspects of productivity of pastoral systems were studied by Cossins (1985) and Potter (1979). Cossins showed, that the Borana pastoral system produces nearly four times as much protein, and six times as much food energy per hectare than climatically comparable Australian commercial ranches. Potter demonstrated the effect of stocking rate on life weight gain, per animal as well as per hectare. He showed that the weight gain per animal decreases, but the total weight gain per hectare increases considerably, when the stocking rate is increased. He argued, that land is a more important production unit than the individual animal. Traore and Wilson (1988) discussed the influence of the environment and of pathological factors on mortality and morbidity in ruminants in Mali, and Wilson (1985) studied reproductive aspects of the productivity of sedentary cattle in the same region. Both publications report an important influence of the nutritional status and the season on productivity.

Socio-economic factors are often mentioned as key determinants in many development related research activities. Ownership, processes of decision-making and revenue distribution, and the position of livestock and livestock owners in society determine to a considerable extent the ability of livestock owners to follow recommendations (Little, 1984, Ariza-Nino and Shapiro, 1984, Crotty, 1980, Jarvis, 1980).

1.3.1. Livestock productivity research in the southern African subregion.

Much of the research into livestock productivity in the region has been directed to comparing a variety of local cattle breeds with each other, or with imported breeds. Subjects of these comparisons were traits such as calving percentage, weaning percentage and mortality (Hetzel, 1988, Tawonezvi, 1984). Most of the cattle breeds of southern Africa belong to the group of the Sanga breeds (Mason and Maule, 1960, Epstein, 1971), animals that usually have a small cervical hump. Apart from the Barotse of Western Province, the Tswana, Tuli, Afrikander, Mashona, Tonga and Nkone belong to this group. Most of the comparisons are done under relatively controlled farm situations, and often at a higher level of management than normally experienced (Thorpe et al., 1980a, 1980b, 1981, Animal Production Research Unit, 1981, Animal Productivity Research Team, 1969, 1971). Some results of these comparative productivity studies are given in table 1. In general the indigenous breeds react favourably to improvements of the management, in terms of productivity. Under relatively optimal conditions, imported breeds tend to perform better. The local breeds cope better with less favourable circumstances, although they do experience the influence of the environment (Block, 1958).

Some research into the potential of indigenous cattle for milk production was done by Walker (1962). Four breeds originating from Zambia were compared for duration of lactation period and milk yield. The Angoni and Tonga produced 758 and 636 litres per lactation of 290 days. The Barotse and Lundazi produced 1046 and 1068 litres in 302 and 305 days respectively.

1.4. Livestock development policies.

The necessity of agricultural development in Africa has already been explained. Progress in the agricultural sector is not only of importance for the improvement of the food

Table 1. Results of various comparative studies into the productivity of indiginous Sanga and Zebu cattle breeds of the Southern African subregion. (Source (mainly): overview given by Hetzel, 1988).

breed	calving rate (%)	birth weight (kg)	preweaning mortality (%)	weaning rate (%)	weaning weight (kg)
Zambia: Animal Productivity Research Team (1969, 1971)*					
Africander	71		5.1	67	172[1]
Mashona	83		3.7	80	151
Angoni	85		4.1	81	150
Zambia: Thorpe et al. (1980a, 1980b)*					
Barotse	78	26	5.3	74	167[2]
Boran	75	25	8.3	69	170
Angoni	83	23	2.7	80	147
Zambia: Thorpe et al. (1981)**					
Africander	54	31	5.1	51	174[3]
Barotse	58	27	6.6	54	163
Boran	66	27	2.3	65	169
Angoni	69	24	6.4	65	149
Botswana: Animal Production Research Unit (1981)*					
Africander	68		8	62	174[4]
Tswana	80		6	75	179
Tuli	87		5	82	176
Bonsmara	83		11	74	204
Brahman	72		13	63	184
Zimbabwe: Tawonezvi (1984)**					
Africander	56		16.7	46	184[5]
Tuli	70		8.8	64	184
Mashona	76		10.9	68	172
Nkone	63		11.7	56	187
Brahman	70		17.5	58	207

[1] weaning age 6.7 months [2] weaning age 7.5 months [3] weaning age 8 months
[4] weaning age 7 months [5] weaning age 8.5 months

* environment termed high performance by Hetzel (1980)
** environment termed low performance by Hetzel (1980)

availability and security. Mellor (1986) argued, that development of the agricultural sector leads to increased employment and expanding incomes, of which generally 60 to 80 % is spent on foodstuffs. In itself this stimulates the agricultural development, while causing a spill-over effect to other sectors of the economy. Simpson (1984) argued, that in the small farm or subsistence sector, of which the majority of cases is agro-pastoral by nature, development is needed to make more efficient use of available resources, and to increase commercialisation. Research in pastoral systems shows, that in general pastoralists are mostly well adapted to the difficulties of their environment (De Leeuw and Konandreas, 1982, Cossins, 1985). If productivity is expressed in terms of biomass (kg live weight/hectare), the offtake is in the range of 16 to 28 % of the total amount of liveweight per hectare present (De Leeuw and Konandreas, 1982). De Leeuw and Konandreas termed this quite efficient.

In the past, livestock development projects were often aimed at increasing the bulk of the productivity. They were aimed at meeting demands of (predominantly) the urban population, through large scale schemes. Introduction of highly productive breeds for immediate utilisation or crossbreeding was often part of these efforts, mostly in the dairy sector (Gregory et al., 1982, Trail, 1981). The objectives of the livestock owners, sometimes conflicting with this general goal, were often overlooked (Atherton, 1984). At present, the development of the possibilities of the producers is the main area of interest. At the same time it is attempted to balance these interests with meeting national economic goals (Atherton, 1984). The National Beef Scheme, initiated in the seventies in Zambia, is one such example (Third National Development Plan 1978-83, 1979). It aimed at increasing the availability of beef on urban markets, through the establishment of rural Cattle Development Area programmes.

Livestock development policies have in general two main objectives: increased animal production, or rather, increased animal output and rangeland conservation (Lawry et al., 1984). Since the larger part of African cattle in the traditional sector is maintained on fragile lands (Bremer et al., 1984) the development of this sector is a complex matter. A holistic project approach and coordination of activities between development agencies is important (Gow, 1987). Van Rootselaar and Wood (1990) emphasised the importance of making land use planning part of livestock development policies.

Specific examples of attempts to organise the range land management are the Grazing Cells in Botswana (Sweet, 1987) and the Group Ranches in Kenya (Oxby, 1982, Peacock, 1987). The Grazing Cells as they were operated in Botswana had two main objectives:

- to provide a practical demonstration of improved range condition and cattle performance through grazing management and stock control,
- to enable comprehensive evaluation of different grazing systems for rehabilitation of degraded land.

A cell would measure 3 by 3 kilometres, and was supposed to be stocked with 150 weaners annually, preferably steers, which were supposed to be kept in the cells for 2 years. In the Group Ranches programme a specific area was demarcated and assigned to groups of people (Maasai), who were then legally the sole users of the range. The main difference with commonly known ranches is, that not an individual holds legal rights to the land, but the group. Grazing blocks are also a way of organising the use of grazing land, but without transferring legal ownership rights of the land to the users. The fact that no rights are transferred distinguishes the grazing blocks from the group ranches (Oxby, 1982).

Peacock (1987) described the impact of the Group Ranches scheme on traditional power structures. As a result of the initial reduction of the influence of the tribal hierarchy, individual livestock owners took advantage of the relative "anarchy". They disregarded the range management decisions for which purpose the scheme was set up, grazing their animals whereever they pleased. After a period the group reverted to the traditional structures of authority, which seemed to improve the situation. Peacock argued, that these problems could have been foreseen and prevented if a thorough knowledge of the traditional system was acquired first.

Sweet (1987) also described difficulties in the execution of the Grazing Cell scheme. Farmers were not particularly interested. The main causes were, that fencing off pieces of land and giving them to just a few individuals to use in an already overcrowded area, was not exactly popular. Also the cooperative organisation was relatively alien to the users. The potential beneficiaries did not see enough advantage.

In various areas in the Sahel zone range enclosure took place as an individual initiative, in response to increased pressure on land (Behnke, 1986). In Sudan it was done to protect grassland for fodder production for the market. In another area in Sudan it was done to protect part of the grazing range against transient nomadic livestock for dry season use. In Somalia fencing off started when farmers anticipated land shortages due to livestock influxes as a result of the introduction of boreholes. In all cases, farmers who did not initially participate, found themselves in severe land shortages. Livestock development policies should take note of what is already happening, in order to be able to streamline, rather than counteract events.

Both Peacock (1987) and Sweet (1987) emphasized strongly the necessity to study local structures and situations carefully, before planning activities. It is necessary to make sure that interventions are not conflicting with interests and structures of importance to the target group. Some form of grazing range control is, however, deemed necessary. Lawry et al. (1984) further argued, that communal land use in some form should be maintained. The herds are generally too small to form a viable economic unit on individually owned ranches, while ecologically sound management measures require a considerable area on which to plan grazing. Development programmes should concern themselves with the establishment of institutions at various levels to control the use of the communal range.

Dickie and O'Rourke (1984), discussed three main constraints to range livestock development, of ecological, political/economic and social nature. They also emphasized the need for range management advisors to be very well aware of local situations and structures, and to include user groups as participants in planning, implementation and evaluation of projects. Gow (1987) stated, that national governments should also be committed to livestock development in the extensive traditional sector.

The damage done to the livestock industry in Africa as a result of animal diseases and parasites is considerable (Holtzman, 1982, ILRAD, 1984). Increasing the output could therefore start with reducing losses as a result of disease, through improvements in the veterinary care (Pritchard, 1988). As far as important epizootic diseases, such as rinderpest, are concerned, considerable efforts have been made in the past (De Haan and Nissen, 1985). However, as De Haan en Nissen pointed out, the economic difficulties of many of the governments in Africa bear the danger in them, that achievements of the past are lost, because the necessary cost of the veterinary services can not be borne any more. ILCA (1988) described, that in all 22 countries, in which it carries out its' programmes, the livestock services are entirely financed from central government funds. Especially since the oil crisis of the early seventies this has caused increasing problems. Masiga (1990) mentioned poor policy and inadequate budgeting as contributing causes to the decline in the standard of the veterinary care. Staff expenditure has risen in spite of the budgetary setbacks, at the cost of operational expenditure. A reorganisation of veterinary and livestock services is therefore highly required, introducing cost recovery measures and involving the private sector (De Haan and Nissen, 1985, De Rooij and Wood, 1990). In the context of the Pan African Rinderpest Campaign, started in 1986, improvements in the performance and efficiency of the veterinary services involved in the rinderpest eradication effort are therefore considered key objectives in the project (Taylor, 1990).

Epidemiological assessments and the economic evaluations of both the diseases and their means of control (Putt et al., 1987) should guide the development of livestock health provision. This should be both cost effective, and effectively improving the disease situation. Systems of disease surveillance and subsequent action are more cost effective than the previously advocated mass vaccination campaigns. They also have a positive influence on the veterinary infrastructure (Zessin and Carpenter, 1985). Simplification of veterinary techniques, reducing the cost of equipment and equipment maintenance, reducing the risk of failure could play a role as well. The use of Vaccinia virus as a carrier of rinderpest vaccine is one such example (Pritchard et al., 1985). The provision of veterinary services is generally very well accepted by livestock producers (Aronson, 1981). As such it is a good entry for an approach to development in which the responsibility for improvements in the animal health provision lies with the owners themselves. Sollod et al. (1984) used the phrase "Veterinary Anthropology" for an approach to livestock research and development, which is problem oriented and which tries to integrate component findings of ecological, biological and social nature.

Veterinary measures have a positive influence on the productivity of the livestock in Africa. Because of this, and in view of the ecological threats and the (alleged) role of livestock in this respect, increasing output as an objective of livestock development efforts is a more appropriate phrase than increasing production per se (Lawry et al., 1984). Livestock management decisions, aimed at risk aversion, as is common in most of the traditional livestock management systems in Africa (De Leeuw, 1990), result in a productivity approach which is more or less complementary to commercial ranching, in which production for the market is the main aim. If risks are reduced, the farmers may be more willing to sell animals. This implies, that when productivity is improved, offtake shall have to follow suit. As Matthewman (1980) described, farmers will readily react to commercialisation efforts, if uncertainty and disease risks are minimised. The structure of the marketing operation itself influences commercialisation of both the cattle trade and the society. This is illustrated by the auction yard systems operated in Kenya. Not only the farmers sell their animals, but traders of all kinds make use of the opportunity to display and sell their goods (Airey and Buckland, 1984). Marketing aspects are of prime importance in the design of livestock development policies.

1.5. Cattle in the Western Province of Zambia.

Zambia is a landlocked country in southern central Africa. Figure 1 shows a sketch map of the continent with Zambia outlined on it. The isolines of growing days in the southern African subregion are also indicated (Jahnke, 1982). As can be seen, Zambia is for the larger part located between the 180 and 90 days isolines, which means, that on average the country experiences between 90 and 180 vegetation growing days per year, terming it semi-arid on the schedule given by Jahnke (1982).

On the map in figure 2 some geographic characteristics of the Western Province are indicated, as well as the situation of the province on the map of Zambia. In the west the province borders on Angola, in the south on the Namibian Caprivi Strip. The province shares borders with the North Western Province in the north, and with the Central and Southern Provinces in the east (Resource atlas for Zambia, 1985).

The map in figure 3 shows the approximate delimitations of the Barotse floodplain and of the Sesheke floodplain and Machile flats. These areas are essential as seasonal grazing grounds for transhumant cattle (Resource atlas for Zambia, 1985). The approximate extent of the tsetse infestation is also indicated (Corten et al., 1988). Since tsetse control efforts are currently being undertaken in the western part of the tsetse infested area, the present situation may not be entirely reflected.

Figure 1. Sketch map of the African continent indicating the outline of Zambia, the isolines of growing days (90, 180 and 270 growing days per year) and the highland areas in the southern African subregion (Jahnke, 1982).

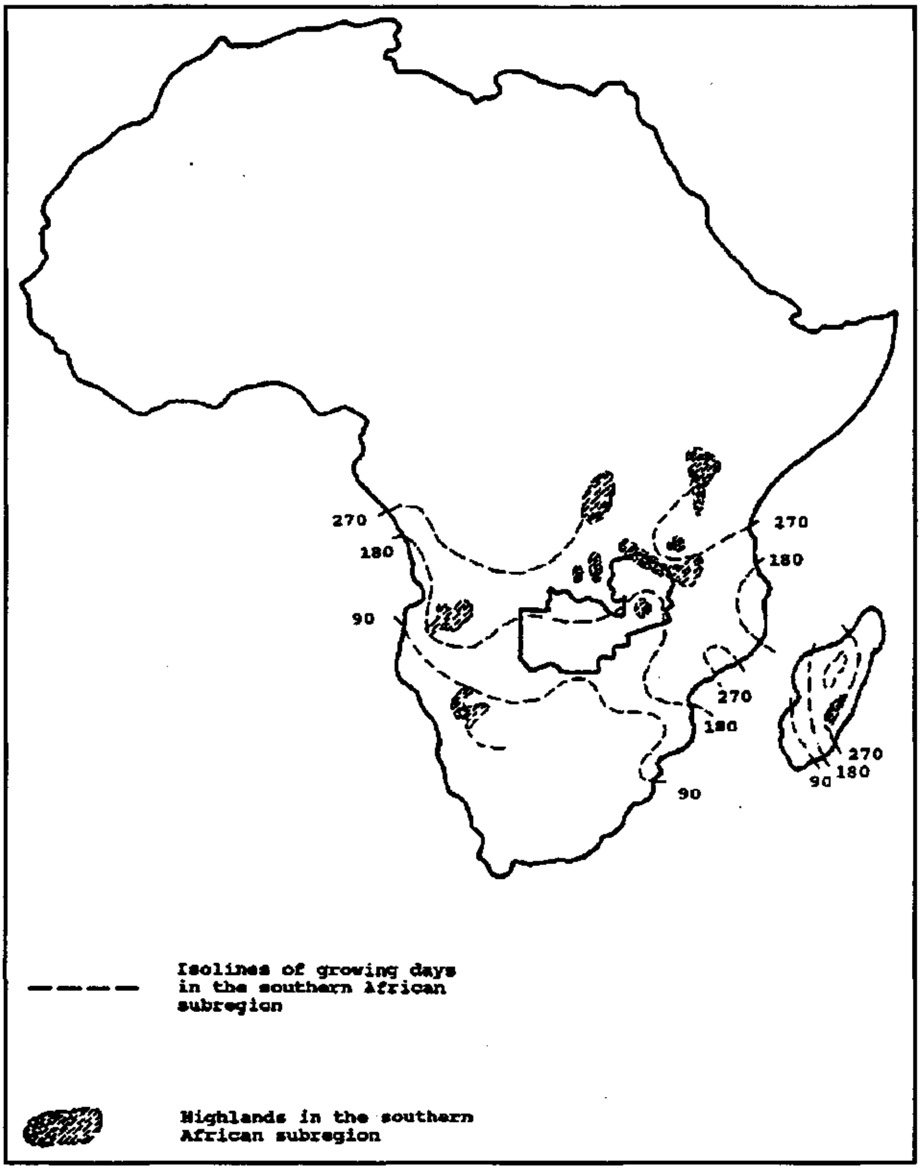
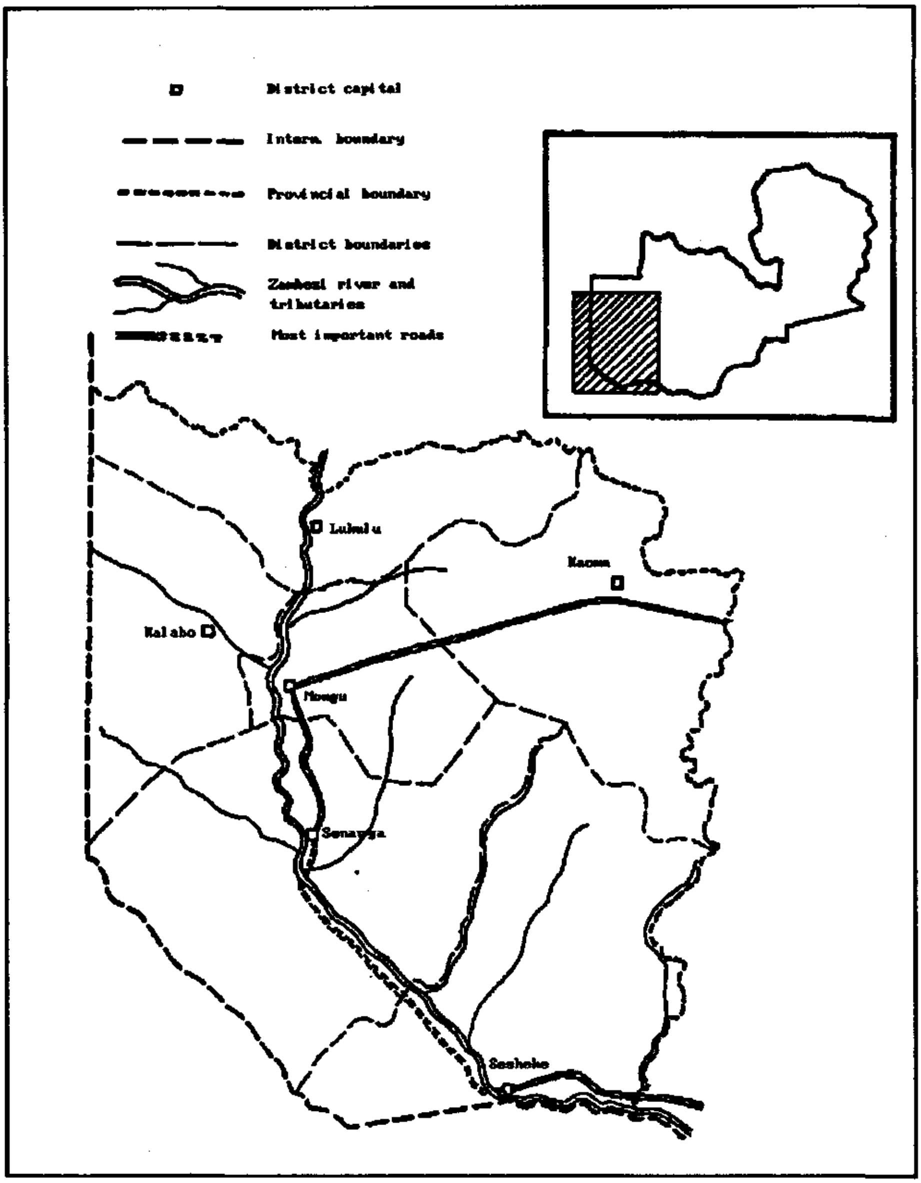


Figure 2. The main geographic features of the Western province of Zambia (source: Resource atlas of Zambia, Longman).

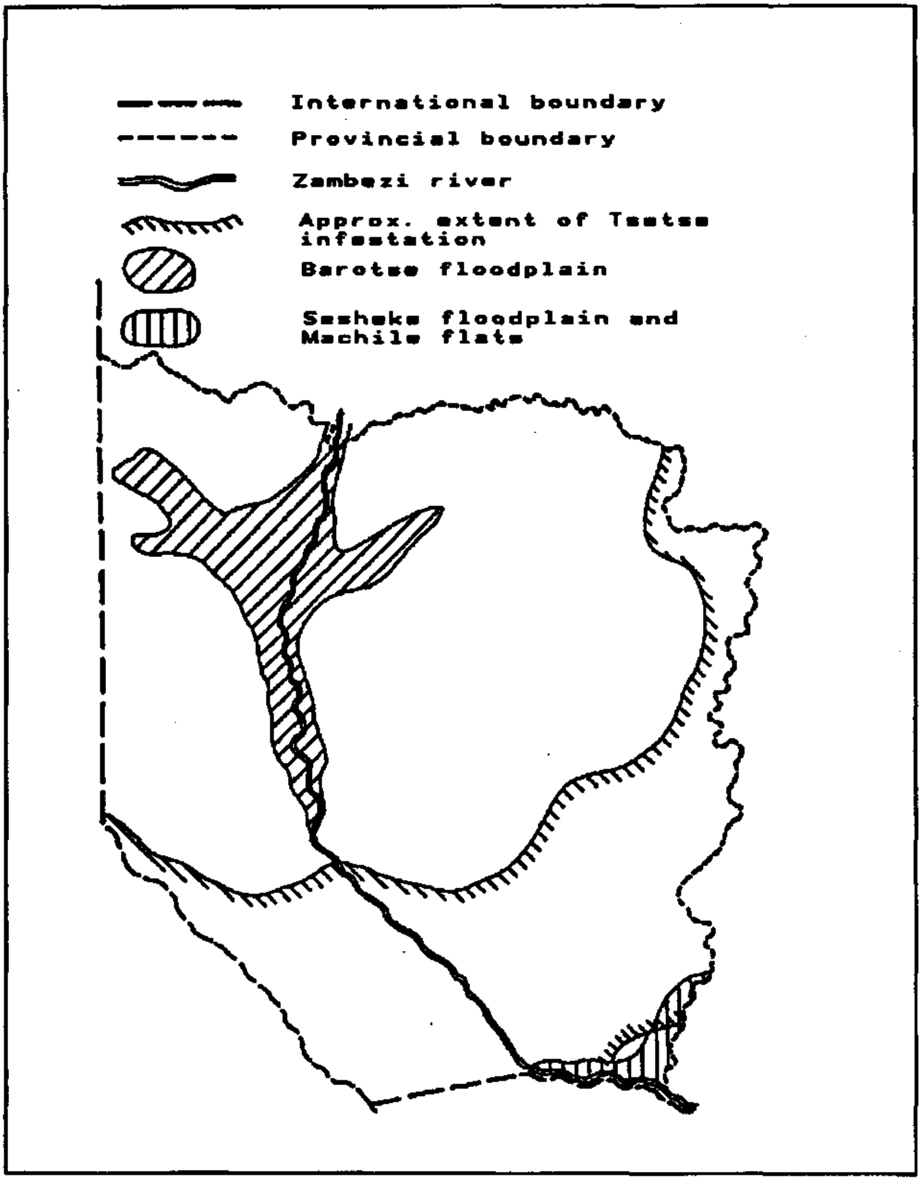


The Western Province of Zambia is for the larger part covered with savannah woodland, interspersed with grassy depressions without trees, the so called dambo's, and river valleys and plains. Of the plains the floodplain of the Zambezi river, or Barotse plain, is the biggest and most important. The soils consist predominantly of permeable, relatively infertile Kalahari sands (Trapnell and Clothier, 1957, Verboom and Brunt, 1970). With the exception of the north-eastern district Kaoma, the province has limited suitability for crop cultivation. The possibilities for extensive livestock keeping are quite good. Due to the permeability of the top soils, there is little danger that trampling of the vegetation results in irreparable damage, and the risks of erosion are relatively small (Van Gils, 1989).

The province is inhabited by the Lozi and a number of smaller, affiliated tribes; hence the name Bulozi, or Barotseland (Barotse being the Tswana word for Bulozi (Prins, 1979)), under which the province was known before independence (Gluckman, 1941, Hermitte, 1974). Cattle keeping has been a practice in the province for a considerable period (Roberts, 1976, Van Horn, 1977). As providers of manure and animal traction the cattle has been indispensable in the mixed farming system of the province (Puzo, 1977, Peters, 1960). Especially since the second half of the 19th century the importance of cattle for the provision of draught power has increased (Kimmage and Wood, 1988). The Lozi have a quite well established chieftainship with a centralised power structure, of which the King, or Litunga, is the central person (Mainga Bull, 1973). This power structure has to a large extent survived the colonial era, as a result of the fact that Barotseland has been a British protectorate from the late 19th century untill independence, and not a formal colony (Van Horn, 1977). Cattle have long been mostly in possession of the nobility. Especially since the introduction of migrant labour and the subsequent adoption of a partly monetary economy, more and more commoners also acquired cattle (De Rooij and Wood, 1990).

The livestock population virtually entirely consists of cattle. At present the cattle population approximates 500,000, while the goat population of the province stands at about 6700. There are around 3700 pigs in the province and the number of poultry is approximately 210,000 (Van Klink et al., 1990a, DVTCS, Western Province, 1990). The approximate distribution of the cattle population is shown in the map of figure 4. Cattle is considered of prime importance for the following reasons (in

Figure 3. Map of the Western Province of Zambia, indicating the extent of the Barotse and Sesheke floodplains, and the approximate boundaries of the Tsetse infested area (Corten et al., 1988).



order of importance):

- agricultural use (manure, draught power),
- security (to pay debts, or to be used in case of an immediate cash requirement),
- food (meat, milk),
- investments (store of wealth, reserve for old age),
- for social purposes (brideprice, gifts, ceremonies) (Beerling, 1991).

Fines are one form of debts for which cattle is often used (Gluckman, 1955). The livestock is generally privately owned, and herded together with the animals of other owners, under the supervision of a herdkeeper (Dicko, 1990, Beerling, 1986).

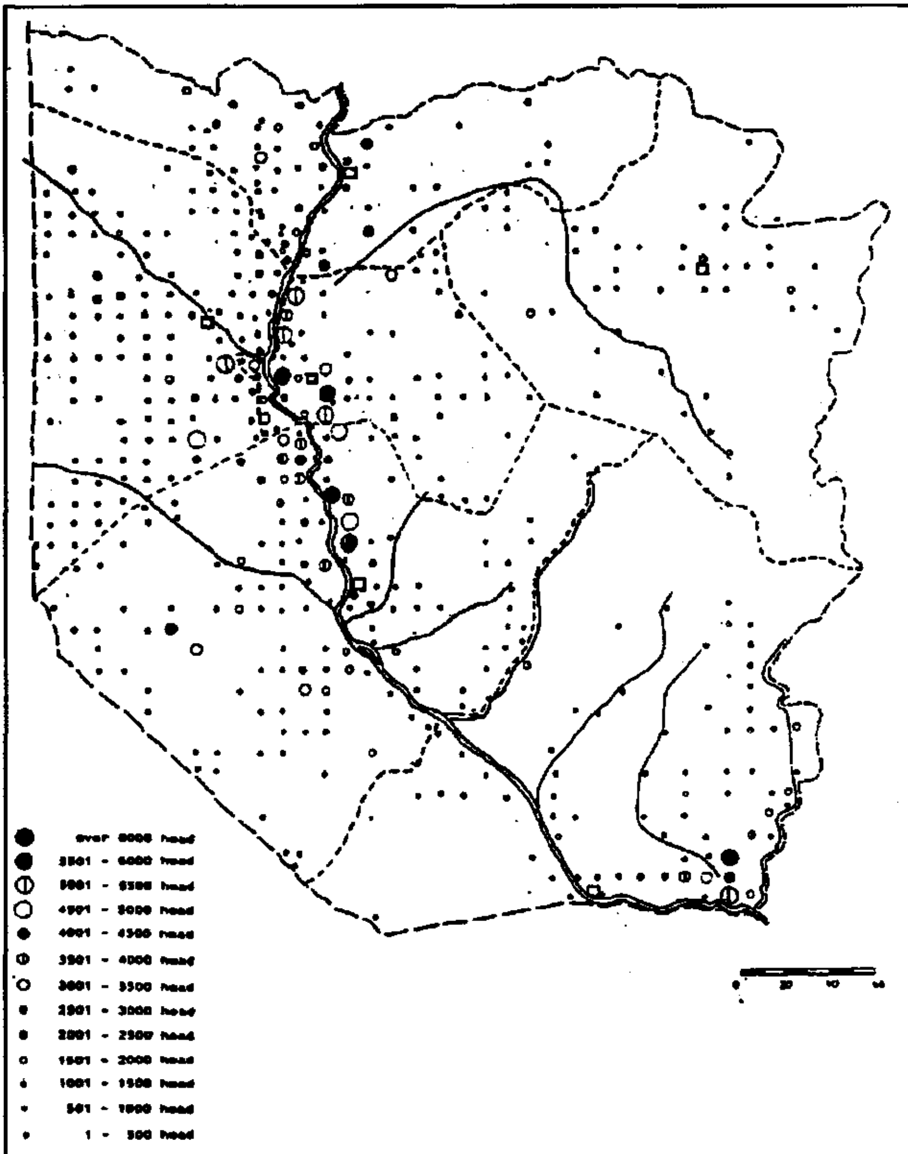
The Western Province is considered a quarantine area against the introduction of Contagious Bovine Pleuropneumonia. This implies, that a buffer zone is maintained along the western border with Angola, separated by a cordon line from the rest of the province. Across this line the transport of cattle is severely restricted, while stringent regulations for the export of cattle out of the province are also in force (Wood, 1983).

Van Horn (1977) identified factors that caused a decline in the agricultural production in Barotseland. An important influence was, and probably is, the labour migration to the South African mines, and, later, to the mines in Zambia on the Copperbelt. The relative labour deficit resulting from this reduced the workable size of existing fields, and the possibilities of moving into and preparing new fields. At the same time labour migration opened possibilities to buy, rather than grow the food required, because of the increasing use of money. The serious economic situation in which Zambia finds itself at present causes a decrease in the dependability on salaries, through the high inflation rate and the reduction on food subsidies. Higher dependence on crop production for home consumption, requiring manure and draught power, and the need for a cash source increase the economic importance of cattle.

1.5.1. Production traits.

The cattle of the Western Province are Barotse, which is a Sanga breed (Epstein, 1971). The animals are large, with heavy bones, and lyre shaped, spreading horns of 60 to 70 cm. length. The height at the withers averaged 137 cm. for 3 year old males, and 129 for 3 year old females at Mazabuka Research

Figure 4. The distribution of the cattle population of the Western Province, Zambia, as found in the 1989 Annual Livestock Census.



Station in the Southern Province of Zambia. Under normal range conditions the adult bulls can weigh around 580 kgs., and the adult females around 400 kgs.; under improved range conditions this could increase to 630 and 455 respectively, while on European farms in the Southern Province weights of 710 and 485 kgs. respectively were found. They have a small, and in females virtually absent, cervico-thoracic hump, and a moderately developed dewlap. Most common colours are brown, black, dark red and fawn (Mason and Maule, 1960).

Barotse cattle are quite reasonable meat producers. Mason and Maule (1960) reported a daily weight gain of 1.31 kgs. in young steers in a particular trial, done in Mazabuka. Cruickshank et al. (1976) carried out feeding trials in which Barotse steers received food supplements during 120 days, resulting in a 19 % increase in beef carcass production. The milk potential of the breed for commercial purposes is moderate. Walker (1962) found a production of around 1000 litres in 300 days. Under normal conditions in the Western Province however the production for human consumption is not more than approximately 1 litre per day (Lutke-Entrup, 1971). Bessel and Daplyn (1977) found a milk production of around 122 litres per lactation.

Apart from research, in which the productivity of the Barotse is compared with other Sanga and Zebu breeds (Thorpe et al., 1980a, 1980b, 1981, Walker, 1962, Hetzel, 1988) under "improved" range management conditions, some research in the traditional sector has been done, in which either attention was given to the productivity of the Barotse as well as to that of other breeds (Bessel and Daplyn, 1977, Perry et al., 1984), or in which the productivity of the Barotse was specifically studied (Abraham, 1979, Lutke-Entrup, 1971). Table 2 shows some of the results of studies in the traditional sector, for the Barotse breed. Matthewman (1980), reporting on research in several areas of traditional cattle keeping, devoted some discussion to the effects that improvements of productivity in the traditional sector, predominantly through improvements in the veterinary care, would have on the output. Matthewman and Perry (1985) gave, on the basis of productivity parameters studied in a number of locations in Zambia, indications on how to use the herd structure as an indicator of productivity. Research on grazing and range land improvement was reported by Kulich (1976).

1.5.2. The Department of Veterinary and Tsetse Control Services and the Livestock Development Project Western Province.

After independence, the government of Zambia established free veterinary services for livestock owners, as a contribution to the development of the traditional livestock farming systems. The organisation of the Department, as in many other African countries (Masiga, 1990), has a pyramidal structure: veterinary assistants as field workers, under the supervision of District Veterinary Officers, who in their turn are responsible to the Provincial Veterinary Officer. The head of the Department is the Director. The distribution of cattle posts and crushpens in the Western Province, which are in principle the "extension and treatment units" for the veterinary assistants, is shown on the map in figure 5.

As in many parts of Africa, the adequacy of the services rendered has declined as a result of the economic situation. Donor assistance to the Department of Veterinary and Tsetse Control Services in the Western Province started in 1983, and primarily focused on technically upgrading the level of the veterinary services (De Rooij and Wood, 1990). In this first phase the inventory of disease occurrence and the design of control policies received most of the attention (Chizyuka et al., 1987).

Trypanosomosis is present in the south western parts of the province, and in parts of Kaoma district, along the borders with the Kafue National Park (Corten et al., 1988, DVTCS, 1990). The tsetse infestation has progressed from a virtual absence of tsetse flies after the rinderpest epidemics of the late 19th century. The flies then became extinct, except in a few small pouches in the Okavango delta, south of the Western Province, and in the Kafue park in the East. Since then the infestation has advanced steadily until the position as expressed in the map of figure 5 was reached (Clarence-Smith, 1977, Van Klink et al., 1990b). Brucellosis is endemic, as well as Black Quarter in a number of foci, and Haemorrhagic Septicaemia is becoming increasingly important (Chizyuka et al., 1987, Corten et al., 1988, DVTCS, 1990, De Rooij and Wood, 1990).

In the design of control measures the search for more cost effective methods was important. The CBPP control regulations in force were revived and improved. Emphasis was put on the improvement of support from and understanding by the farmers in

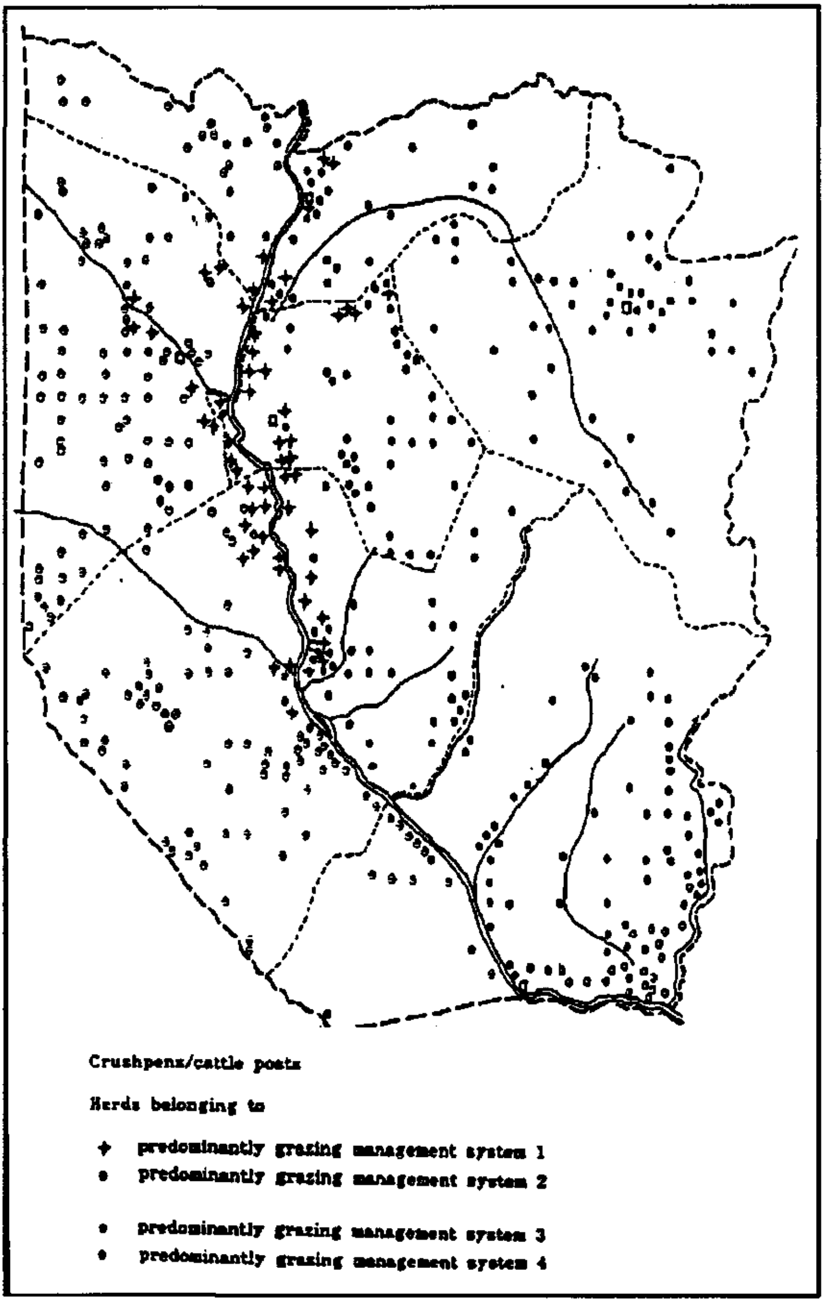
Table 2. Results of some studies into productivity of herds of Barotse cattle in traditional management circumstances.

reference	average herd size	herd structure	bull : cow ratio	calving %	calving season	mortality calves	mortality adults	offtake
Lutke-Entrup (1971)	39			58.9		30 % (within a few days)		3 %
Revell (1975)	55		1 : 15	67.9	May-October	19.4		
Bessel and Daplyn (1977)	40	43 % cows 13 % oxen over 3 years 14 % calves	1 : 20	41.4	June-August	35 % (up to 1 year of age)		
Abraham (1979)	68			14.8	June-November	23.5 % (26.4 in male calves, 20.7 in female calves)	7 %	
Perry et al. (1984)	34	40 % cows	1 : 14	44	May-November	20 %	5 %	4 %

the area affected by the most stringent quarantine and control measures, on the basis of a socio-economic study by Wood (1983). A programme of regular inoculation campaigns against trypanosomiasis, using Isomethamidium chloride, is carried out since 1985 (van Klink et al., 1990b). Regular vaccinations against Foot and Mouth Disease are carried out along the southern border, while vaccinations against Haemorrhagic Septicaemia and Black Quarter are carried out in well identified areas of prevalence (De Rooij and Wood, 1990).

The operational cost of the Department in the province became heavily dependent on donor support. Only some 20 % of the total operational cost was borne by the Department, of which 85 % were personnel costs (De Rooij and Wood, 1990). It soon became clear, that if sustainable veterinary services were to continue, this could not be attained within the existing structure of free veterinary services. Therefore, the Livestock

Figure 5. The distribution and approximate location of cattle posts and crushpens in the Western Province, Zambia.



Development Project Western Province, as the project was termed from 1988, directed an increasing part of the attention to the restructuring of the veterinary services, in which cost recovery was to become a major issue, as well as maintaining the standard of the veterinary services.

In the project evaluation report of 1987 (Chizyuka et al., 1987) the objectives of the Livestock Development Project are described. They include:

- to provide a sustainable infrastructure for disease control (including cost recovery measures (De Rooij and Wood, 1990),
- to assist in the formulation of a cattle development policy,
- to develop an integrated animal husbandry and animal health extension package for the traditional farmer.

In order to provide the necessary background and information to achieve these objectives, the Livestock Development Project engaged in a programme of research involving several disciplines. Apart from animal husbandry and health, it included grassland expertise, sociology and economy.

The attention of research in the first phase of the project was mainly directed to the disease situation, and was therefore predominantly veterinary technical by nature. In the second phase means were to be found to increase the sustainability of the services rendered. The focus of the research carried out in connection with this aim was directed much more towards identifying ways in which cost recovery, and participation of the livestock owners in financing the activities of the Department could be put into practice (De Rooij and Wood, 1990). Wood (1986) detailed the socio-economic research requirements deemed appropriate for the goals of the Livestock Development Project. This research, part of which, incidentally, already started well before the official start of the Livestock Development Project in 1988, included studies into the assessment of benefits derived from cattle (Baars, 1987), the position of livestock and livestock owners in society (Beerling, 1991) and the ownership structures and the ways by which people acquire or dispose of animals (Beerling, 1986).

The Livestock Development Project at present employs an operational socio-economic analysis team, which carries out the research in this field on the basis of the proposal (Wood, 1986). Analyses of part of the research, and the implications of the results for the planning of sustainable service provision were discussed by Wood (1988).

Optimisation of the productivity of the livestock is considered an important field of attention of the project. Of course, if farmers are to pay for the services rendered, it is important that they do posses the means to do so. As was mentioned before, De Leeuw (1990) indicated, that risk-aversion, rather than commercial use can be considered the main aim of the traditional farmer. Increased commercial use, however, is likely to be the result of reduction of the risks faced by the farmer (Matthewman, 1980). The nutritional status of the animals is of great importance in relation to productivity and since the animals solely depend on the natural range for their food provision. Therefore Livestock Development Project started an extensive survey into the ecology of the range and into the carrying capacity, i.e. the theoretical number of animals that can be supported by the available fodder in the province (Jeanes and Baars, 1990).

Information about technical aspects of productivity proved to be largely lacking, or was relatively outdated. This information was thought to be important, in order to identify areas of constraints in the livestock management, which might aid in the assessment of the need for particular veterinary measures, and in order to be able to give indications about the development and structure of the provincial herd through the use of a provincial herd model (De Rooij and Wood, 1990). The project therefore initiated relatively objective studies into the productivity of the traditionally managed cattle, making use of herds from the whole of the province. This herd monitoring programme started early 1986.

1.5.3. Herd monitoring by the Livestock Development Project.

In order to approach as much as possible an objective assessment of the productivity of the cattle in the Western Province a programme was started of physically monitoring a number of privately owned herds. The monitoring was to be carried out over a prolonged period of time, in four of the six districts of the province. In principle 12 monitoring herds in each of the four districts were to be established (De Rooij and Wood, 1990). Since one herd in Senanga District split up shortly after the start of the programme, the actual maximum number of herds that was involved was 52.

Practical difficulties necessitated, that the selection of the herds was not entirely done at random. Since the monitoring exercise involved two weekly attention by the veterinary assistants of the camps where herds were based, it was decided to select herds from the relative vicinity of the veterinary assistants residence. In practice the herds were chosen on the basis of recommendation by the veterinary assistants. In general this also meant, that the kraal owners involved gave maximum cooperation to the scheme. The kraal owners have also been greatly involved in a number of the socio-economic surveys that were carried out (Beerling, 1986, Baars, 1987).

In practice, the veterinary assistants were expected to pay two-weekly visits to the herds, and to record any changes that had occurred in the herds since the previous visit. This included the calves being born, the date they were born and their sex, the date animals died, were sold or slaughtered, or were moved out of the herd for other reasons, and the date on which cows were milked for the first time, or were dried of, as well as the reason for which they were dried of, either because of weaning or of death of the calf. Assessing into some detail the reason why animals were slaughtered or moved out of the herd, or to whom animals were sold, and whether or not the meat of animals that died was used, provided insight into practicalities and socio-economic aspects of livestock keeping.

1.6. The aim of the thesis.

The overall aim of the thesis is, to evaluate the use of longitudinal physical monitoring of herds of cattle under traditional management for the description of productive performance and identification of factors that influence productivity. This evaluation should provide insight in the suitability of herd monitoring for the provision of basic information for extension and solutions for constraints to productivity.

In order to carry out this evaluation, the following hypotheses were formulated:

1. Mortality in cattle in tradionally managed herds is importantly influenced by environmental factors.

2. Reproductive performance and girth in cattle in tradionally managed herds is importantly influenced by environmental factors.

Environmental factors may include climate and season, grazing circumstances and the management of the herds.

3. In traditional herds of cattle in the Western Province of Zambia, multiple ownership is the custom, and transfers between herds importantly influence the herd composition (Beerling, 1986).

The information collected over the period April 1986 till April 1988 was used to test these hypotheses. In order to describe the grazing circumstances, the productivity calculations have been linked with grazing management characteristics of the various areas and management practices in which herds involved in the Herd Monitoring Programme were based, as described by Jeanes and Baars (1990). Beerling (1986) described qualitative aspects of ownership, of means of acquiring and disposing of animals, and of transfers between owners and herds. The results of the herd monitoring programme were used to provide quantitative information on these subjects.

The observations on the subjects related to these hypotheses are reported in Chapter 2.

4. Climatic factors are determinant in the exposure of cattle to helminth infections.

5. Productivity (mortality, reproduction and girth) of traditionally managed cattle can be influenced favourably by regular treatment against intestinal parasites and liverflukes.

6. Helminth parasites are more important determinants of productive performance than environment, climate and management.

The intervention trials carried out to test these hypotheses were started after the completion of the first part of the study. The information collected between February 1989 and August 1991 has been used to test these hypotheses. Since the supervision of the scheme necessarily increased, the number of herds being monitored had to be reduced. Out of the original 52 herds, 20 were involved in this part of the programme.

In Chapter 3, attention is given to literature on the influence of climate on exposure of cattle and on influences of helminth infections on productivity as found in several regions of sub-Saharan Africa. The results of the intervention study are presented in Chapter 4.

Factors affecting productivity and their relevance for livestock development are discussed in Chapter 5. In this chapter, environmental, climatic and managerial factors, as well as socio-economic influences and influences of diseases are discussed. Remarks are included on the relevance for extension and further research.

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CHAPTER 2.

Productivity study

2.1. Herd monitoring in traditional cattle husbandry of Western Province, Zambia, I: Organisational design, data management, descriptive aspects, and the herd structure of trial herds in four Grazing Management Systems.

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Introduction.

In many countries in subsaharan Africa, the provision of veterinary service has been free of charge for livestock owners (ILCA, 1988). Meeting the cost involved in the provision of livestock services has become increasingly difficult for most of the governments (Masiga, 1990, De Haan and Nissen, 1985). Achievements accomplished in the (recent) past, such as were attained in the JP15 rinderpest campaign, are in danger of being lost as a result of this (De Haan and Nissen, 1985). In many African countries there is a need for rigorous restructuring of the veterinary service through involvement of the private sector as well as the design of cost recovery measures (Taylor, 1990).

In Zambia, the Department of Veterinary and Tsetse Control Services is at present in the process of investigating the possibilities for restructuring, and designing the policies by which this could be brought about. In the Western Province of Zambia, the Livestock Development Project is instrumental in facilitating this process (De Rooij and Wood, 1990). In this framework a series of research activities has been initiated in order to establish the position and economic importance of cattle in the rural society (Wood, 1986, Baars, 1987). Since the productivity of livestock in tropical countries is importantly influenced by the quality and quantity of the available fodder ('t Mannetje, 1981), an extensive study of the grazing resources has been conducted (Jeanes and Baars, 1990).

Objectively obtained, quantitative information on the productivity of cattle in the province was also not available. Therefore a study into the productivity of local cattle, aimed at providing this information, was part of the research programme. Apart from describing the productive performance, the study aimed at evaluating the influence of environmental

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factors, such as climate, grazing resources and herd management, on productivity. It was expected that the information would also enable the identification of constraints for productivity.

This paper gives a description of the project area and outlines the organisational design and the data management application that was developed for use in the productivity study. A comparison is made of the herd structure in the trial herds and the mean herd structure in the province.

I. The project area.

The Western Province of Zambia is located between the 90 and 180 growing days isolines, terming it a semi-arid region (Jahnke, 1982). The main soil type of the Western Province consists of Kalahari sands, covered with savannah woodland, interspersed with grassy depressions, which are called dambos (Verboom and Brunt, 1970). An important feature is the Zambezi river, which runs from north to south through the province, and which forms the south-eastern border of the area. Figure 1 shows a sketch map of the province. In this figure the outlines of four Grazing Management Systems are indicated, of which table 1 gives the main characteristics (Jeanes and Baars, 1990). In systems 1 and 2 the animals are mainly kept under a management system in which transhumance takes place. The animals are trekked twice a year over distances of ten to forty kilometres to and from the floodplains of the river. In figure 2 the relation between the annual rainfall pattern, the waterlevel in the Zambezi river and the movement of the animals in the respective systems are indicated. In system 1 the animals move out of the plain only when the floods force them to do so, while in system 2 the animals are moved out when water shortages on higher land are over and regrowth of grass starts after the onset of rains. In systems 3 and 4 the animals are kept under sedentary management. These systems mainly differ in terms of fodder and water availability.

II. Organisational structure and data collection.

The productivity study, the Herd Monitoring Programme, was aimed at providing basic productivity parameters, at enabling identification of constraints faced by livestock owners, and it was to be used for the construction of provincial herd models to allow projections of future developments in the livestock population. Earlier research into productivity involving cattle in the Western Province were

Table 1. Major characteristics of the Grazing Management Systems of Western Province, Zambia, as identified by Jeanes and Baars (1990).

System number	System name	Transhumant/ sedentary	Grazing area	Landunit/ vegetation characteristics	Main water resources
1	Bulozi plain system	transhumant	Floodplain: ±June - February Upland: ± March - May	Floodplain, plain edges: grass Upland: savannah woodland	Plain season: Zambezi river, oxbows, lagoons Flood season: upland rivers, pools
2	Sesheke system	transhumant	Floodplain: ± June - November Upland: ± December - May	Floodplain: grass Upland: savannah woodland	Plain season: Zambezi rivers, oxbows, lagoons Flood season: pools
3	Eastern valley system	sedentary	Dambos/river valleys: ± May - October Upland/plain edges: ± November - April	Dambos, river valleys, plain edges: grass Upland: savannah woodland	Whole year: upland rivers, sometimes pools, hand dug wells
4	Western plain system	sedentary	Dry plains: ± June - March Plain edges: ± March - June	Dry plains: grass, bush groups Plain edges: grass, woodland	North: whole year: upland rivers South: wet season: pools, waterponds dry season: waterponds, some rivers on the edge of the area, hand dug wells

often designed as questionnaire surveys, and covered only limited areas or limited periods (Lutke-Entrup, 1971, Bessel and Daplyn, 1977). In the present study 52 herds, distributed over the province, were purposively selected and physically monitored over a prolonged period of time, in order to obtain relatively objective information.

Figure 1. Map of the Western Province of Zambia, showing the district boundaries and the approximate limits of the Grazing Management Systems (Jeanes and Baars, 1990).

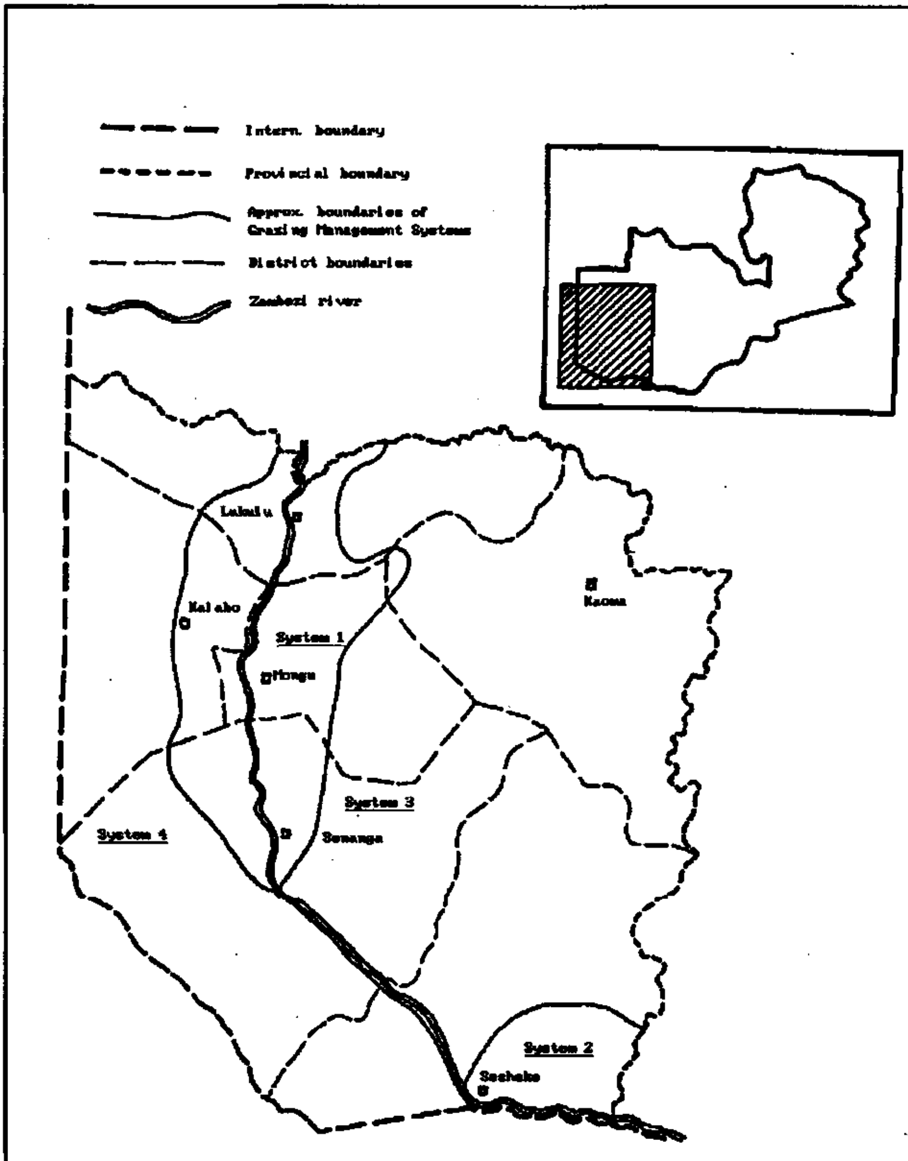
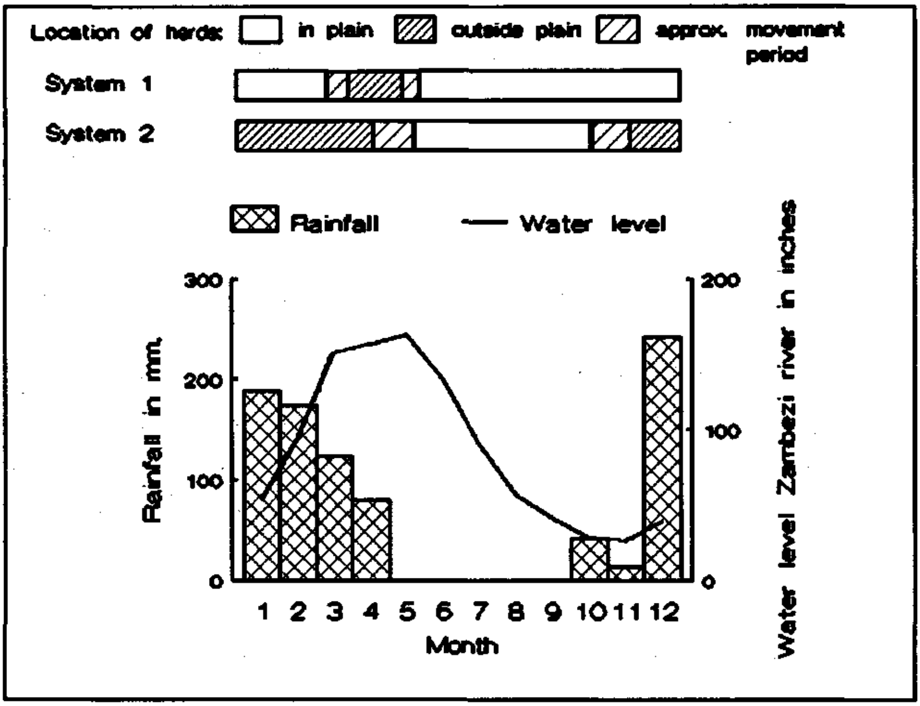


Figure 2. Rainfall figures and the waterlevel of the Zambezi river in 1989 in the Western Province of Zambia. In the bars above the graph the location through the year of the herds in the two transhumant systems is indicated. The waterlevel is given in inches.



All herds were visited every two weeks by (Senior) Veterinary Assistants ((S)VA), and every three months by the District Veterinary Officers (DVO) of the districts in which the herds were based. Each animal was individually identified by an eartag with a number, while each herd was identified by a letter code. The (S)VAs were expected to record all events happening in the herds, related to births, deaths, slaughters, sales, transfers and new entries. During the three-monthly visits by the DVOs this information was checked and entered on field lists. At the same time girth measurements were taken to be used for the evaluation of growth. In table 2 the details are listed of the records that had to be collected.

Table 2. Contents of the records that were collected during the regular visits by the (Senior) Veterinary Assistants (SVA) and the District Veterinary Officers (DVO) in the Herd Monitoring Programme of the Livestock Development Project Western Province.

	First visit and new entries	Consecutive visits ((S)VA: every 2 weeks, DVO: every 3 months)
Cows	- Eartagging - (estimated) age or birth date - With calf or not - Date of birth of calf - Being milked or not - Date milking started - If not with calf: calf dead or weaned - Date of death or weaning of the calf - Aborted or not - Date of abortion	- date of calving - Sex of the calf - Colour of the calf (for identification purposes) - date of start milking - date milking stopped - date suckling stopped and reaso of stopping; death or weaning of th calf - date of abortion - date and reason of removal (death sale, slaughter or transfer)
Males, Oxen and youngstock below the age of 2 years	- Eartagging - Girth measurements and condition scoring of youngstock	- Girth measurements and conditio scoring of youngstock - date and reason of removal (death sale, slaughter or transfer)

Using the Panacea(c)[2] general purpose data management programme, applications were designed for the management and processing of the data (Pan Livestock Services, 1987a, 1987b).

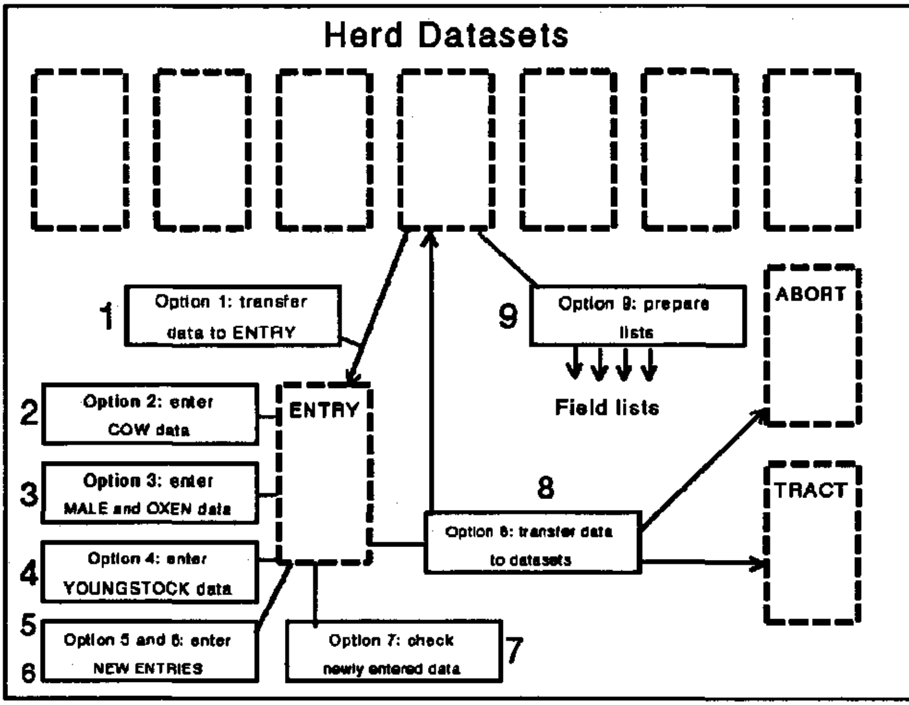
III. Data management.

Figure 3 shows a flow chart of the procedures and datasets involved in the data management application (Hanks, 1986, 1987). Each herd is represented by one dataset. In the herd datasets, all animals are in principle represented by one record.

An important aim of using this application, is the protection of the information that has already been collected. Before entering new data, part of the information in the herd dataset is copied to a separate dataset called ENTRY. Only animals still present in the herd will appear in ENTRY, while information on removed animals remains untouched. Through a

2 (c) Pan Livestock Services Ltd., Reading, UK.

Figure 3. Flowchart showing the procedures involved in the data recording application used in the Herd Monitoring Programme of the Livestock Development Project Western Province.



series of options, information can be entered for each of five categories of animals; 1. cows over the age of two years, 2. males and oxen over the age of two years, 3. youngstock (all animals below the age of two years), 4. new cows and 5. new males, oxen and youngstock. Using option 7, the ENTRY dataset can be checked for errors or incomplete information. The checklist it produces enables field staff to correct errors at the time of the next visit. Option 8 can be used to transfer the data to the herd datasets. Information on already existing animals will be updated in the respective record, if alterations have taken place. New records will be produced for cows with new lactations, newborn calves and new entries into the herd. Abortions and draught power data are appended to the appropriate datasets.

Another option produces printouts of the herd datasets, on which all animals that were present at the time of the last recorded visit will appear. On the field lists the animals are categorised in three of the five categories mentioned earlier: cows; males and oxen; or youngstock. The new entries (categories 4 and 5) will appear in their appropriate list. The field lists serve as check lists for the DVOs carrying out the three monthly visits, and at the same time allow the entry of the new information. After the visit the field lists are sent back to update the computerised information.

IV. Data summary and analysis.

For the evaluation of the influences of environmental factors on productivity the information was used to describe variables that were as much as possible objectively measurable. The variables evaluated are the girth, the percentage of the animals that die or are slaughtered in a one year period, and lactation related intervals as a measure of reproductive performance, including the calving interval, the interval between the birth of a calf and the moment the farmer starts milking, the period the cow is milked, the age at which the calf is weaned and the interval between weaning and the birth of the next calf. The percentage of animals sold from the herd in a one year period was also evaluated.

The girth was used as a measure of growth. Logistically it was not possible to physically weigh animals. Although Corten (1988) describes a formula for the calculation of weight from the girth measurement, the girth was used in the statistical evaluation also, since it could be easily measured. Applying the formula of Corten would introduce an extra error in the analysis.

The percentage of animals that die or are slaughtered is an important factor in describing productivity. It determines the margin for growth of the herd and the extent of the possibilities to sell animals. Logistic Regression analysis (Hosmer and Lemeshow, 1989) was used to evaluate the Odds Ratio (OR) for animals to die or be slaughtered.

The calving interval was used rather than calving percentage or weaning percentage. The great variety in the herd compositions and the age at first calving made it difficult to define a proper denominator for the calving percentage. The age at weaning was also greatly variable, as usually the farmers did not actively bring about weaning, making it difficult to use the weaning percentage as well. Calves were often weaned by the cows by the time the next calf was about to be born. Therefore the choice was made to use the calving interval and to evaluate deaths of calves independently.

The other intervals mentioned were used since a rather large influence of the condition of the animals on the lengths of the periods mentioned, either with (interval calving-start milking, length of the milking period) or without (age of the calf at weaning, interval between weaning and the next delivery) the direct influence of the herd manager, was expected. The calving intervals and the other lactation characteristics were evaluated using analysis of variance.

Sale of animals is an important way of putting animals to productive use (Beerling, 1991). Sales figures give an indication of the potential of herds or groups of herds to generate financial benefits. Theoretically it could be argued that herds performing at a high productivity level would have more animals available for sale; as Matthewman (1980) states, if risks are reduced, farmers are likely to respond to commercialisation efforts. However, selling animals remains the decision of the owner or caretaker, and this decision is made for individual animals for well defined individual reasons (Beerling, 1986, 1991). In the Herd Monitoring Programme the sales figures are defined as the percentage of the total number of animals that are sold in a one year period.

The data management programme was also used to design applications for the production of data summaries in preparation of the analyses. One of the applications summarises the information used for the evaluation of reproductive performance.

Another application produced herd productivity profiles of groups of herds, giving impressions of the mortality, sales and slaughter percentages for various age categories over one year periods, on the basis of animal years. This makes allowance for the dynamic nature of the herd structure. There appeared to be a considerable movement of animals between herds. The herd structures in groups of herds in the four Grazing Management Systems mentioned in table 1, arrived at in this manner, were compared with the results of the annual livestock census carried out by the Department of Veterinary and Tsetse Control Services in 1988 (Van Klink et al., 1990). The herd structures from both sources are given in table 3.

Table 3. Herd structure as found for herd groups consisting of the herds from four Grazing Management Systems of Western Province, Zambia, calculated over the period 1/4/87 till 31/3/88 (period II), and as found in the annual livestock census of 1988, carried out by the Department of Veterinary and Tsetse Control Services.

GMS	source	Females		Males		Oxen		Total	Mean size
		n	%	n	%	n	%	n	n
1	study	585	66.3	126	14.3	172	19.5	883	80.3
	census	125147	67.7	29022	15.8	30215	16.3	184384	76.0
2	study	354	64.4	83	15.1	113	20.5	550	110.0
	census	24750	66.2	6157	16.5	6395	17.2	37302	99.0
3	study	472	61.2	117	15.2	182	23.6	771	59.3
	census	68640	62.8	18964	17.7	18142	19.5	105746	49.1
4	study	213	66.4	60	18.7	48	14.9	321	64.2
	census	106734	64.2	28883	17.9	27854	17.1	163471	52.0

IV. General remarks and discussion.

Though in both Grazing Management System 1 and 2 transhumance is practiced, there is a striking difference between the practice in both systems (table 1, figure 2). In Grazing Management System 1 the herds seem to have their base in the floodplain. Only when they are forced to do so by the rising floods, the caretakers take their animals out of the floodplain onto higher grounds. As soon as the receding floods allow them to return, they do so. In Grazing Management System 2 the reverse seems to be the case. Here, the animals do not move into the floodplain untill water and food shortages force them to move closer to the river banks in the course of the dry season. As soon as the rains start, the grass starts regrowing and the water situation improves, the caretakers move their animals out of the floodplain. A reason for the difference between the two systems is not easy to discern. The cattle population pressure is higher in and around the Bulozi floodplain than in the Sesheke area. Therefore less space may be left in the higher grounds around the Bulozi floodplain for all cattle that have to move out during the floods (Van Horn, 1977). Because of their long stays in the plains the amount and quality of the fodder and the available acreage is under some pressure when the floods are rising. The animals then move out to areas where the cattle population is already relatively high. Since the floodplains in the Sesheke area are smaller, it might be that too little grazing resources in the plains are available. It would however seem, that the decisions to move animals out of the plains are made out of shortage in grazing resources in the Bulozi system, whereas in the Sesheke system not the pressure on the grazing in the plains, but the availability of even better grazing elsewhere determines the decision.

The herds were not chosen at random. Logistic difficulties related to attainability by the veterinary staf and a "workable" herd size, as well as the capability and willingness of the herd managers to participate in the programme made it inevitable to make a weighted choice for the herds to enroll in the study.

Faugére and Faugére (1986) described systems for the collection of data with the aim of evaluating individual performance of small ruminants. The data collection process of the survey presented in this paper is also based on individual records. These were not primarily used for the evaluation of individual performance, but for the evaluation for environmental factors influencing productivity. The automated systems designed for it could if required be adapted to suit them for the purpose of individual performance evaluation. This could play a part where selection and breeding programmes are persued. This was however not the scope of this programme, nor of the Livestock Development Project.

The information necessary for the calculation and evaluation of the parameters chosen is relatively easy to obtain. As Matthewman and Perry (1985) stated, it is difficult to obtain exact information on the herd dynamics in the traditional livestock systems in Africa and it is therefore essential to use the minimum available data to develop methods of productivity assessment. They used the herd structure as a basis for describing performance, taking the view that fertility and mortality are directly reflected in the herd structure. This method will be appropriate for the description of the performance of individual herds. It would be less suitable for the statistical evaluation of environmental influences on performance. Though it is very useful and simple, it does not account for transfers between herds as another factor in bringing about the herd structure (Beerling 1986). In the present study the choice was made to base the information on records drawn from individual animals. At the same time most of the parameters, specifically those, related to reproduction, could be calculated directly from the recorded data.

The application used for the recording and management of field data proved to be a satisfactory field tool. The background information provided by the updated field lists frequently draws the attention of the field worker to discrepancies, which in most cases can be corrected. The information already recorded is not altered before any new results are checked and found correct.

Though some differences between the structures of the herd groups from the four Grazing Management Systems and those found in the census occurred, they were not found to be significant (table 3). Information on the composition of herds in the province was also given by Bessell and Daplyn (1977) and by Perry et al. (1984). Bessel and Daplyn (1977) found 42 % cows, 13 % oxen over 3 years, and 14 % calves in 42 herds in Mongu district. Perry et al. (1984) found a comparable percentage of cows. This is fairly comparable with the number of females over the age of three years as found in the herd monitoring programme, as well as with the number of oxen over three years. Both publications indicate rather smaller herds than found in the herd monitoring exercise, as well as in the census.

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(submitted for publication.)

2.2. Herd monitoring in traditional cattle husbandry of Western Province, Zambia, II: survival rates of calves, mortality and slaughter figures, and sales figures.

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Introduction.

In Africa, approximately 80 % of the livestock is kept under traditional management (Dicko, 1990, Brumby, 1986, Brumby and Trail, 1986). In many cases livestock is maintained in environments less suitable for crop production, and is therefore often of major economic importance to their keepers. In the Western Province of Zambia cattle keeping has been a well established practice for at least the last 300 years (Roberts, 1976). As a result of climatic factors, and a relative labour deficit, the crop production in the province is largely below self-sufficiency level (Van Horn, 1977). In the mixed farming system of the area, cattle as providers of manure and draught power are indispensable (Peters, 1960, Puzo, 1977). Cattle are equally important as a means of accumulating wealth and provision of security, as well as provision of cash income if so required (Beerling, 1986).

In the framework of the Livestock Development Project in the Western Province, operating within the structures of the Department of Veterinary and Tsetse Control Services, a series of studies has been carried out, in order to establish the importance and position of the cattle industry (Wood, 1986, De Rooij and Wood, 1990). Baars (1987) reported on economic aspects of the cattle inductry, while Beerling (1986, 1991) discussed socio-economic features. Publications dealing with productivity of cattle are often outdated to some extent and touch only on limited aspects of cattle keeping (eg. on milk production only, or on offtake only), or were based on information that was gathered in a limited area (Gluckman,

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1941, Lutke-Entrup, 1971, Bessell and Daplyn, 1977, Rennie, 1982). Therefore, a research programme in the field of productivity of the local cattle was initiated. Apart from providing basic productivity data, the study was aimed at identification of constraints on productivity. Mortality is an important parameter for the evaluation of productive performance and of factors affecting performance. Slaughter and sales figures may give an impression of the capability of herds to produce surplus animals for offtake. As such, they also give information on factors influencing performance.

In this paper, the mortality and slaughter figures and the sales figures as found in the productivity study are evaluated. The aim of this evaluation is mainly to identify environmental, climatic and managerial factors influencing the performance in these respects. Mortality among young calves is much higher than among adult cattle (Perry et al., 1984, Bessel and Daplyn, 1977). In order to illustrate this, survival rates of calves at intervals during their first year of age were calculated.

Materials and methods.

The Herd Monitoring Programme.

The organisational design and data management of the programme were presented in an earlier paper (Van Klink et al., 1994). The programme involved regular visits of privately owned herds by (Senior) Veterinary Assistants (fortnightly), and District Veterinary Officers (three-monthly). During the fortnightly visits all events, such as births, deaths, slaughters, sales and other removals that happened in the period since the preceding visit were recorded. During the three-monthly visits new animals were eartagged, and the information was checked on the basis of fieldlists.

Climate.

In Zambia a mild, though relatively dry tropical climate prevails. In this study a devision of the year in four seasons is used, each spanning a three month period, fairly coinciding with the climatic seasons: season 1 is the late rainy season from January to March; season 2 the dry and cool season from April to June; season 3 is the hot dry season from July to September; season 4 is the early rainy season from October to December. Since a considerable annual variation specifically in the amount of rainfall is seen, the survey period was split into two one year periods for the purpose of analysis. In period I the amount of rainfall was lower than in period II.

Project area.

A more detailed description of the project area was given by Van Klink et al. (1994). The province consists of six districts. In four districts, Mongu, Kalabo, Senanga and Sesheke, herds were situated that were involved in the study. No monitoring herds were based in Lukulu and Kaoma. Herds were based in each of the four Grazing Management Systems, as described by Jeanes and Baars (1990).

Herds.

In each district twelve herds cooperated. In one of the districts a herd split up shortly after the start of the programme, bringing the total number involved to 52. Approximately 6000 head of cattle were involved in the exercise over the whole period. The herds consisted of Barotse cattle, a long horned Sanga breed (Mason and Maule, 1960). The herds were monitored over a two year period, from first April 1986 to 31st March 1988, though not all were involved the complete period.

Monitoring procedures.

The herds were visited once every two weeks by the (Senior) Veterinary Assistants ((S)VA) of the areas where the herds were based. During these visits all changes that had occurred in the herds were recorded. Once every three months the District Veterinary Officers of the districts in which the herds were located entered the information gathered on field lists, produced by a computer application, designed for the herd monitoring schedule, using the Panacea(c)[3] general purpose data management programme (Van Klink et al., 1994). Updated field lists were produced after entering the information received from the field after each visit.

Parameters evaluated.

Mortality was defined as the number of animals that died within a one year period as a percentage of the total number of animals that had been present in the herds during that one year period. The slaughter figures and the sales figures were defined in the same manner.

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[3] (c) Pan Livestock Services Ltd., Reading UK.

The survival rates of calves were defined as the number of male and female calves that were still alive at the age of one month, three months, six months and one year, as a percentage of the number of calves born in a one year period. The resulting percentage provides a descriptive impression of the course of calf survival through the first year.

Calculations.

The mortality and slaughters and sales figures were determined by calculating the number of animals that died, were sold or were slaughtered, as proportions of the total number of animals that were present during each of the two one year periods. The Logistic Regression statistic was used to evaluate the influence of variables on the mortality and slaughters and sales figures (Hosmer and Lemeshow, 1989). With this statistic, outcome variables with discrete values, such as the proportions mentioned, can be evaluated. The procedure calculates the Odds Ratio (OR). The OR indicates the strength of association between a factor to be evaluated and the event being described (Martin et al., 1987). The OR is the ratio between the probability that an event is happening under one of the values of an independent variable, as compared to the probability that it happens under another value of the same variable, the reference. If the OR is close to 1, the chance that the factor plays a part as an influence on the event being described is little; the bigger the difference with 1, be it negative or positive, the bigger the influence of the factor is likely to be. In logistic regression, the OR is given by e^{β}. If an independent variable has more than two values, as was the case for Grazing Management Systems (1, 2, 3 and 4), sex (male, female and ox) and seasons (1, 2, 3 and 4), the logistic regression uses the reference value to determine the values of β for each of the other values of the independent variable being evaluated. Covariance matrices and values of β provide the statistical relations between all values of the independent variable.

Results.

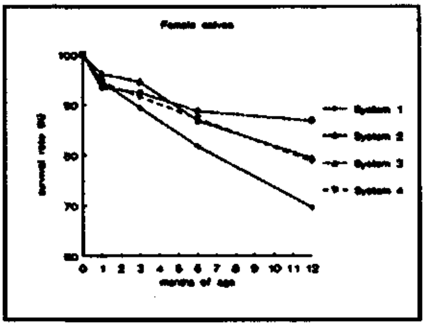
Table 1 provides specified information on the removal reasons used for the analyses of which the results are given in table 1. Slaughters seem to take place in the majority of cases if animals are old or sick. Most slaughters can therefore be regarded as emergency slaughters. For this reason the mortality and slaughter figures were pooled in table 1 and figure 2.

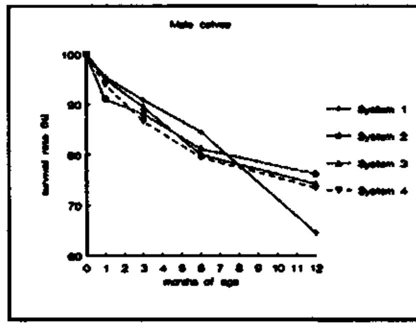
Table 1. Reasons for removal of animals from traditionally managed cattle herds from four Grazing Management Systems in the Western Province of Zambia, as found in the period 1/4/86 till 31/3/88.

Grazing Management System:	1		2		3		4	
Removal reason	no.	%	no.	%	no.	%	no.	%
Sold:	101		50		78		81	
- not specified		25.7		16.0		21.8		23.5
- locally for breeding		5.0		2.0		6.4		4.9
- locally for slaughter		13.9		-		7.7		8.6
- to private trader		29.8		32.0		37.2		27.2
- to institutional trader		25.7		50.0		26.9		35.8
Slaughtered:	33		19		32		32	
- not specified		6.1		5.3		-		3.1
- old age, sickness, weakness		66.7		63.2		71.9		84.4
- for ceremony		-		10.5		3.1		3.1
- for meat, money		27.3		21.1		25.0		3.1
- for other purposes		-		-		-		6.3
Died:	146		84		143		93	
- not specified		27.4		39.3		14.0		32.3
- meat consumed, sold		47.9		44.0		66.4		49.5
- meat discarded		24.7		16.7		19.6		18.3
Overall total number	280		153		253		206	

Figure 1 shows a descriptive image of the proportion of the female and male calves surviving the first month, the first three months, the first half year and the first year after birth in the four grazing management systems, for male and female calves. Differences are most prominent at the age of 12 months, both in female and male calves. Only the differences in the female calves show significant differences in χ^2-analysis. In Grazing Management System (GMS) 1 the survival rates at the age of one year seem lower than in the other systems described,

Figure 1. Survival rates of calves in herd groups consisting of herds from four Grazing management Systems of Western Province, Zambia, between 0 and 365 days of age, over the period 1/4/86 till 31/3/88.





both for male and female calves. The lines representing the survival rates of the female calves in GMS 2, 3 and 4 are consistently higher than those of male calves in all systems, and that of female calves in GMS 1. The survival rates of the male calves and of the females in GMS 1 stay approximately in line untill the age of 6 months. The survival rates of male calves in GMS 2, 3 and 4 are less steep over the last 6 months, while that of the female calves in GMS 1 is practically as steep as before the age of 6 months. That of the male calves in GMS 1 is much steeper in the last 6 months. At the same time the survival rate of female calves at the age of one year is significantly highest in Grazing Management System 2. This is not seen in the male calves.

In table 2 the results of the logistic regression analysis of the removal figures are given. If various values of independent variables differed significantly, this is indicated by different characters in the superscript. In the mortality and slaughters significant influences could only be found for the sex, the age and the herd, while in the sales figures differences could also be seen for Grazing Management System and for transhumance or sedentarism. Increasing age seems to have a decreasing influence on the chance of dying or being slaughtered, while the chance of being sold increases with age.

In figure 2 the results of part of a model of logistic regression analysis is shown, in which mortality, slaughter and sales figures are analysed as proportions of the removed

Table 2. Statistical evaluation of removal figures of cattle from the Western Province, Zambia, calculated over the period 1/4/86 till 31/3/88.

		Deaths and slaughters			Sales		
variable	N	%	β^*	s.e.	%	β^*	s.e.
intercept	6424		-3.0686	0.4119		-4.0732	0.7975
GMS 1	1940	9.2	0.2651	0.4088	5.2	0.5526^{a}	0.7861
GMS 2	1369	7.5	-0.0475	0.3368	3.7	0.0430^{ab}	0.6580
GMS 3	1774	9.9	0.1346	0.2063	4.4	-0.4052^{b}	0.3490
GMS 4	1342	9.3	ref.		6.0	ref.^{ab}	
S	3625	9.5	0.2086	0.3510	5.1	0.8768^{a}	0.7092
T	2800	8.4	ref.		4.5	ref.^{b}	
F	3917	8.8	0.7459^{a}	0.1395	2.8	-1.9204^{a}	0.2520
M	1064	16.3	1.3170^{b}	0.1567	4.0	-0.5836^{b}	0.3416
O	1443	4.6	ref.^{c}		11.0	ref.^{c}	
period I	3341	9.4	ref.		4.7	ref.	
period II	3084	9.0	-0.1169	0.0980	5.0	0.0366	0.2049
Age out of herd in days		9.1	-0.0002^{1}	0.0000	4.8	0.0008^{1}	0.0001
Herd effect (random)			0.3282^{1}	0.0725		0.5623^{1}	0.1491

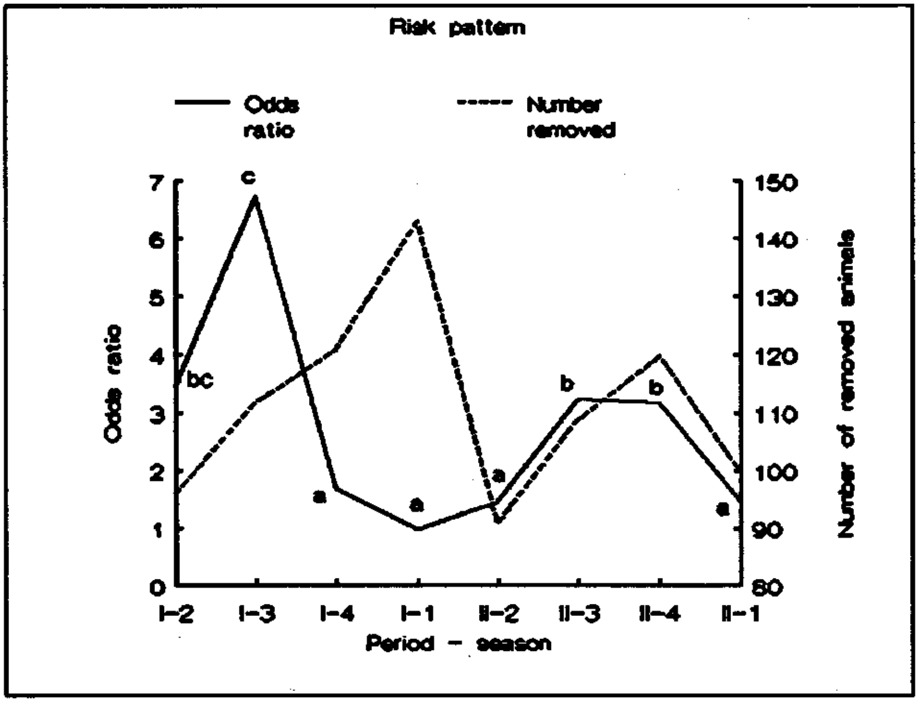
[*] Values with different letters in the superscript differ significantly ($p<0.05$).

[1] Effect significant ($p<0.05$).

GMS = Grazing Management System

animals only. This was done in order to evaluate whether an influence of seasonal variation on removal figures could be identified. The odds ratios of the pooled mortality and slaughter figures are shown in the figure, together with the total number of animals removed because of death, slaughter or sale in the respective seasons. The complete model also contained most of the variables used in table 1. Significant differences are found in all cases. The level of the mortality/slaughter figure in period I, season 1 is used as reference value.

Figure 2. Part of a logistic regression model used for the evaluation of seasonal effects on mortality and slaughter in traditionally managed cattle in the Western Province, Zambia, over the period 1/4/86 till 31/3/88. The risk pattern is displayed as a solid line and should be read against the left Y-axis. The value of period I/season 1 is used as reference (Odds Ratio = 1). The interrupted line gives the total number of animals removed (through death, slaughter and sale) in each period/season and should be read against the right Y-axis.



Discussion.

Apart from establishing that most slaughtered animals were slaughtered for emergency reasons, table 1 also shows, that the number of animals sold was far smaller than the number that died or was slaughtered. Though all meat of slaughtered animals and most of the meat of animals that died is consumed or sold, these animals should be regarded as losses, because the revenue from these animals is usually considerably less than that of animals sold (Beerling, 1986). Sales "outside the system", to traders who will in practically all cases destine the animals for slaughter outside the village, mostly the abbatoir in the main town or in abbatoirs outside the province, are the most important proportion of the sales. Local sales, either for slaughter or breeding, are of virtually no importance. As far as generation of revenue is concerned, the animals sold into the cattle trade are the most important factor.

Figure 1 shows that the average survival rates of calves after one year range between 65 and 90 percent. The survival rates after one year seem slightly higher for female animals in all Grazing Management Systems (GMS). Survival chances for calves in GMS 1 seem smaller than in all other systems. The survival rate up to 6 months of female calves is comparable to that of male calves in all systems, while that of both male and female calves in GMS 1 drop considerably below that of male calves in other systems.

As can be seen from table 2, the mortality and slaughter figures are significantly higher for males and females than for oxen. Cows are on average kept in the herd much longer than oxen. Their average age is therefore higher, which may be the reason that mortality is higher in cows. The high mortality rate in bulls might suggest that selection of bulls to be castrated is partly based on the general health of the animals. The weaker and more vulnerable animals are not castrated, but have a bigger chance of dying. Significant differences between the sexes are particularly caused by the mortality. If slaughter figures are evaluated separately no significant differences between the sexes are found. All sexes seem to have as much chance of being slaughtered in emergency. Another significant difference between emergency slaughter values that is not found in the combined figure is that between the periods. In period I the number of animals slaughtered was higher than in period II (2.2 % versus 1.7 %, the average percentage slaughtered being 1.8). If evaluated separately, the decreasing influence on mortality of increasing age is seen again, but the slaughter values show an increase with increasing age. Both are significant influences. The reason for the increasing influence of increasing age of the Odds Ratio for slaughter in emergency is, most likely, that if calves are dying, the decision to slaughter them is less often taken than if adult animals are dying, because the meat of (young) calves is rarely, if ever, eaten.

The influence of age on the OR for death and emergency slaughter is significant. The fact that the value is negative, is caused by the high calf mortality as is illustrated by the survival rates in figure 1. There is a significant influence of the herd in which the animals are based. This indicates that the way in which the herd owner goes about his management may be of importance. Analysis of day-to-day management decision-making related to the productive performance in individual herds may produce useful extension material. This could relate to decisions on grazing areas to be chosen, the amount of time spent on grazing and on kraaling, the moment of the day that animals are released, the moment they are milked and the amount of time the calf is allowed to suckle. The size, amount of space per animal and the construction of the kraals, as well as of the youngstock kraals or pens may be factors. Environmental differences of a more local nature than those described as Grazing Management Systems may of course also be of importance. Analysis of the ways herd owners handle their environment could also give information for use in extension.

A mortality figure of 5 % for adult animals is given by Perry et al. (1984). This is slightly lower than the value found in the present study. The calf mortality figures shown in figure 1 are lower than those mentioned by Bessel and Daplyn (1977) and Lutke-Entrup (1971). Bessel and Daplyn (1977) only mention an estimated calf survival rate up to the age of one year of 65 %. The corresponding mortality is much higher than was found in the herd monitoring programme. Lutke-Entrup (1971) indicates that 30 % of the calves die within a few days. The data cited from the three sources mentioned were collected through questionnair surveys. In a comparison with 3 other African breeds at the Central Research Station at Mazabuka, Zambia, a weaning percentage of 74 %, corresponding with a calf mortality of 26 % was reported for the Barotse breed (Thorpe et al., 1980a, Thorpe et al., 1980b). The animals grazed the plains of the Kafue river part of the year and the adjoining upland during the remaining period. The station is located at an altitude of 990 metres. In comparable studies at Mochipapa Research Station, at an altitude of 1370 metres, the environment was considered less productive than that at Mazabuka. The Grazing land consisted of unimproved acid zandveld with large, periodically waterlogged depressions. In these less favourable environments the calf mortality in the Barotse breed was 46.2 % (Thorpe et al., 1981). Perry et al. (1984) and Revell (1975) find mortality figures that are comparable with those found at present; a calf mortality of 20 % and 19.4 % respectively.

In the sales figures significant differences are only found between Grazing Management Systems 1 and 3. This may be related to the level of activity of institutional cattle buyers and differences in the infrastructure between these systems. The sales percentage in the transhumant herds is significantly lower than in the sedentary herds. This may mainly be caused by the high sales percentage in Grazing Management 4, in which practically all herds are sedentary. The reason for the relatively high sales percentage is, that the area is very dry and the results of growing crops are often insecure, making it necessary to generate money to buy food.

Increasing age has, in the sales figure, as opposed to the mortality, an increasing influence on the OR. Farmers tend to choose old animals for sale, and preferably oxen. Young animals, calves in particular, are hardly ever sold, and certainly not for slaughter outside the village. If animals still have to prove their abilities and are fertile, the farmer will prefer to keep them. Risk-averting behaviour is best served with keeping as much as possible reproductive potential in the herd (Matthewman, 1980).

Perry et al. (1984) mention an offtake of 4 %, consisting of 2 % local slaughter, and 2 % sales. The slaughter figure in this study is approximately the same, the percentage of animals sold to traders is however around 4 %. The overall sales percentage in the province seems to be rising. This is consistent with the rising trend in the annual cattle sales from the province (Van Klink et al., 1990).

Evaluating the removal figures due to mortality and slaughter as a proportion of the total number of animals removed because of death, slaughter and sale, in order to assess the possible influence of climate and season on mortality and emergency slaughters, as was done to obtain the logistic regression results partly shown in figure 2, is to some extent artificial. Also the number of records involved in the model is considerably smaller. Therefore a probability level ($p<0.10$) was chosen other than 0.01 or 0.05.

The odds ratio for mortality (and emergency slaughter) was found to be highest for season 3, the hot dry season, particularly during period I. In period II the mortality/slaughter figures in season 3 and 4 are in the same range. In season 3 the constraint on fodder availability may be the most important cause. The OR in season 3 of period I is very high, compared to all other OR values. The poor wet season preceding period I may be the cause of this. Climatic variation between years are likely to cause the difference between the two periods. It does however not explain clearly why the OR in the early rainy season, season 4, of period I is considerably lower than in season 3, and also lower than in season 4 of the subsequent period. The grazing management practices may also have been an influence. Relatively high rainfall figures for instance, providing good regrowth of the vegetation, and therefore good survival conditions for the livestock, may cause constraint for herds that are highly dependent on floodplain grazing, particularly in Grazing Management System 1, because the floodplains would be flooded and therefore inaccessible for a longer time. It was however not possible to evaluate the relation between period, season and Grazing Management System further, because the proportions would become too small for statistical evaluation.

In the logistic regression model used for this figure, the values of β for seasonal effects on sales figures are exactly the reverse as those for mortality and slaughter. The sales figures are mostly highest in season 1 of each period. This is the time of the year that farmers have used most of their stored stapple crop and are waiting for the new harvest. The sales figures may be strongly related to the cash need resulting from the necessity to buy food in this time of year. If the cropping season has been poor, the sales peak would be higher and wider. The poor rainfall early in period I, causing the higher odds ratio for mortality/slaughter, may therefore also be the cause for a higher sales level in season 1 of period I.

In conclusion, it can be stated that the number of animals lost through death and slaughter is far larger than the number sold. Decreasing the mortality figure, most notably that of calves, would mean an important improvement of the performance of the herds. Though the limitations of the Grazing Management System in which the herds are located and the climate dictate considerably the possibilities of farmers to adjust their ways, the fact that an influence of the herd, and therefore the management of the individual herds was identified, makes it worthwhile to assess individual herd performance and management in order to derive extension information about coping with the environment in the most favourable way.

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2.3. Herd monitoring in traditional cattle husbandry of Western Province, Zambia, III: reproductive performance, lactation intervals and growth.

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Introduction.

In traditional livestock management systems in Africa, ruminants depend entirely on natural pastures for their maintenance (Gow, 1987, Sandford, 1983). The quality of these pastures highly depends on climatic conditions ('t Mannetje, 1981, Pratt, 1984). Dry seasons can produce long periods in which the quality and quantity of the food is below maintenance standards (Coppock et al. 1986), having a negative influence on performance in terms of weight gain (Mosi et al., 1976) and reproduction (Chandler, 1971, Matthewman, 1980). Especially conception is affected negatively (Wilson, 1985). This is also caused by the fact that the intake of fodder of poor quality is depressed (Ketelaars and Tolkamp, 1991). The management practice of transhumance is a way of attempting to counteract part of the negative climatic influences (Dicko, 1990). In the Western Province of Zambia, transhumance over distances of up to 40 Km. takes place in part of the cattle population (Jeanes and Baars, 1990, van Klink et al., 1990). The cattle industry in Western Province is part of a mixed farming system, in which cattle play an important role, through the provision of draught power and manure (Puzo, 1977, Peters, 1960).

A survey was carried out in the province to assess, whether the use of a longitudinal herd monitoring system (Van Klink et al., 1994) allows the identification of environmental, seasonal and managerial influences on productivity. The survey was carried out by the Livestock Development Project Western Province (De Rooij and Wood, 1990). In this paper the results related to weight and reproductive performance are presented.

Materials and methods.

Herds.

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A total number of 52 herds with approximately 6000 head of Barotse cattle, a long horned Sanga breed, were involved in a two year monitoring programme. Not all herds have been monitored for the full period of 2 years. In the first year, a total of 45 herds were monitored, in the second year 34 (Van Klink et al., 1994).

Area.

The area in which the study was carried out has been described by Van Klink et al., 1994. The Kalahari sands, that cover most parts of the province, are for the larger part relatively infertile (Verboom and Brunt, 1970). Four Grazing Management Systems (GMS) were distinguished on the basis of differences in management, fodder and water availability (Jeanes and Baars, 1990, Van Klink et al., 1994). In GMS 1 and 2 transhumance is most common, while in GMS 3 and 4 sedentarism is predominant. Transhumance in GMS 1 and 2 differ in terms of the length of the period spent in the floodplains and on higher grounds. GMS 3 and 4 differ predominantly in terms of water and fodder availability.

Climate.

The climate of the area is characterised by a wet season, which starts around the months October/November, and which lasts till early April. Then a dry, and considerably colder season starts, becoming hotter in the course of July. For the purpose of analysis of the influence of the season, the year was divided in four three month periods, paralel with the change of seasons taking place. Season 1, the late wet season, runs from January to March; season 2, the cool dry season, from April to June; season 3, the hot dry season, from July to September; season 4, the early wet season or growing season, from October to December.

Monitoring procedures and calculations.

The monitoring procedures and the manner in which primary calculations of the parameters involved were carried out, based on the Panacea(c)[2] general purpose data management programme, have been described by Van Klink et al., 1994. The statistic

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[2] (c) Pan Livestock Services Ltd., Reading UK.

programme Dbstat [(c)3]was used to carry out analyses of variance to evaluate influences of environmental and managerial factors on the means of lactation intervals. The lactation intervals evaluated are the calving interval, defined as the period between two consecutive calving dates of cows; the interval between calving and start milking, defined as the period between the date of birth of a calf and the date on which farmers start milking the mother; the period the cows are milked, defined as the period between the date that farmers start milking a cow and the date milking is stopped; and the age at weaning, defined as the age of the calf at the moment that the mother refuses to let the calf suckle any longer. Farmers generally do not actively interfere in weaning. The last interval measured is that between the date the calf is weaned and the date the next calf is born. Analyses of variance were also used to evaluate influences on the weight of animals, expressed by the girth measurements (Nicholson and Sayers, 1987, Corten, 1988). The girth measurements were taken three-monthly, at the time District Veterinary Officers visited the herds for the verification of the collected data (Van Klink et al., 1994).

Results.

In table 1 the models are presented that were used for the evaluation of girth measurements and of the lactation intervals in days. For the sake of clarity only those parts of the models used, in which significant differences were found, have been displayed in the tables 3, 4 and 5.

Table 2 gives descriptive statistics on the female animals present in the herds and the number of calvings that has been recorded during the survey. A relatively large proportion of the animals is in the herds for short periods. These animals include, apart form deaths, slaughters and sales, also transfers between herds for a variety of reasons. This figure may be of influence on the percentage of animals that calve in the herd. In Grazing Management System 4 this percentage is low, combined with a high proportion of animals that stay in the herd for short periods. Simple distribution statistics (χ^2-analysis) shows that significant differences between systems seem to exist in the proportion of animals that move between

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Table 1. Variables in models of Analyses of variance used for the evaluation of some productivity traits in traditionally managed cattle in the Western Province of Zambia.

lactation intervals for complete lactations of <u>cows that were milked and of which the calves were weaned</u> and as affected by:	the calving intervals, on the basis of <u>all completed lactations</u> and as affected by:	the girth measurements in three age groups, corrected for age and as affected by:
Parity Grazing Management System (GMS) Calving season GMS*Parity GMS*Calving season	Parity Grazing Management System (GMS) Calf weaned/dead (A) Cow milked/not milked (B) Calving season Removal age calf (C) (A*B) (A*C)	Grazing Management System (GMS) Sex Season Herd movement practice[&] System*season

& Transhumance or Sedentarism

herds, the percentage of animals present that have calved during the survey, the proportion of these that calved once, more than once, or that calved three times during the survey period, and between the proportion of first calvings before the age of four years.

Figure 1 shows the distribution of the calving intervals on the basis of their duration. As can be seen from figure 1a the majority of the calving intervals has a duration of between 12 and 22 months (around 60 %), with a relatively wide peak between 12 and 16 months duration, and a steadilly decreasing proportion untill a duration of 22 months (from around 7 to around 3 %). Around 24 months calving interval duration a relatively sharp peak, including around 21 % of all calving intervals, can be found. Figure 1b shows, that with the exception of Grazing Management System 1, the Grazing Management Systems do not seem to differ importantly as regards the distribution of calving intervals according to their duration. In Grazing Management System 1 however, the proportion of calving intervals with a duration of between 12 and 18 months is relatively low, compared to the others, and the proportion with a duration of between 24 and 30 months is relatively high compared to the others. No differences were found between the proportions of the calving intervals between 18 and 24 months and above 30 months.

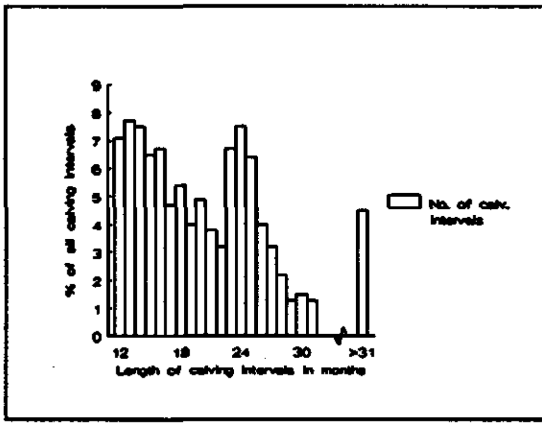
Table 2. Descriptive quantitative data on calvings in groups of cattle herds from four Grazing Management Systems in the Western Province, Zambia.

Grazing Management System	1		2		3		4	
A. Total number of females present during the survey older than 2 years	858		433		552		517	
Number present for less than one year (% of A.)	181	(21.1)	76	(17.6)	99	(17.9)	125	(24.2)
B. Total number of calvings during the survey	737		371		518		378	
C. Total number of animals that have calved during the survey (% of A.)	474	(55.2)	202	(46.7)	299	(54.2)	206	(39.9)
Number of animals that calved once during the survey (% of C.)	234	(49.4)	61	(30.2)	118	(39.5)	48	(23.3)
Number of animals that calved more than once during the survey (% of C.)	240	(50.6)	141	(69.8)	181	(60.5)	158	(76.7)
Number of animals that have calved three times during the survey (% of C.)	23	(4.9)	28	(13.9	38	(12.7)	24	(11.7)
D. Total number of first calvings recorded	183		164		183		149	
No of recorded first calvings before the age of four years (% of D.)	131	(71.6)	109	(66.5)	133	(72.7)	121	(81.2)

Table 3 shows the values found in part of the models used for the lactation intervals, only for those animals that were milked and that weaned their calf. In all intervals significant differences between Grazing Management Systems (GMS) were found. The calving interval was significantly longer than in any of the other systems in GMS 1. In the interval calving-start milking significant differences existed between GMS 1 and the systems 2 and 4, in which that of GMS 1 was considerably longer (124 days as opposed to 51 and 80 days respectively). That of GMS 2 was significantly shorter than that of GMS 1 and 3. The length of the milking period was shorter in GMS 3 (222 days) than in GMS 1 and 2 (over 300 days). GMS 2, showing the longest milking period, also differed significantly from GMS 4. The weaning age is shortest in GMS 3, differing from GMS 1 and 2, but not from GMS 4. GMS 4 did not differ from GMS 2. In the interval between weaning and the next delivery, only GMS 2 and 3 differred significantly. Another important influence in some

Figure 1. The distribution of recorded calving intervals in traditionally managed cattle from the Western Province of Zambia, on the basis of their length.

a. Distribution of the duration of all calving intervals recorded.



b. Distribution of the duration of calving intervals from four Grazing Management Systems in six month blocks. The values of the calving intervals of 12 to 18 months and 24 to 30 months particularly Grazing Management System 1 show significant differences from the expected value in X^2 analysis ($p<.005$).

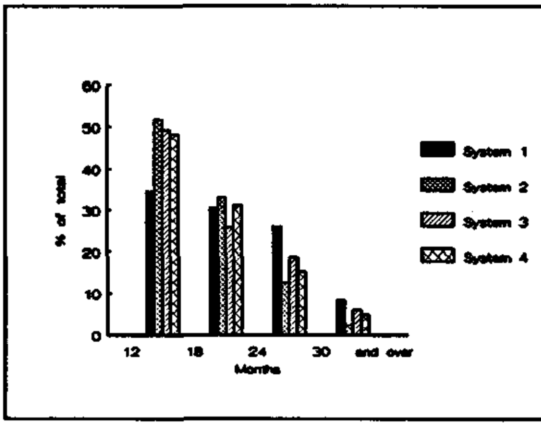


Table 3. Estimated values of part of the models used in the analysis of variance of relevant lactation intervals for complete lactations of cows that were milked and of which the calves were weaned, in traditionally managed cattle in the Western Province, Zambia.

Variable		Number	Calving interval (days)		Interval calving-start milking (days)		Length of milking period (days)		Age calf at weaning (days)		Interval weaning-next delivery (days)	
			Value	s.e.	Value	s.e.	Value	s.e.	Value	s.e.	Value	s.e.
Overall mean ± s.e.		316	581	± 11.7	88	± 5.5	299	± 9.5	405	± 9.6	176	± 7.0
Grazing Management System	1	102	$650^{a\&}$	± 20.3	124^{a}	± 9.6	338^{ab}	± 16.5	468^{a}	± 16.6	182^{ab}	± 12.1
	2	81	571^{b}	± 28.1	51^{b}	± 13.3	358^{b}	± 22.9	425^{ac}	± 23.0	146^{a}	± 16.7
	3	70	543^{b}	± 22.8	95^{ac}	± 10.7	222^{c}	± 18.5	350^{b}	± 18.6	193^{b}	± 13.6
	4	63	560^{b}	± 22.1	80^{bc}	± 10.4	277^{ac}	± 18.0	377^{bc}	± 18.1	183^{ab}	± 13.1
Season calved	1	42	593	± 29.0	107^{ab}	± 13.7	308^{ab}	± 23.6	442^{a}	± 23.8		
	2	93	548	± 20.0	101^{a}	± 9.4	255^{a}	± 16.3	365^{b}	± 16.4		
	3	110	603	± 16.9	80^{ab}	± 8.0	311^{b}	± 13.7	407^{ab}	± 13.8		
	4	71	580	± 23.2	64^{b}	± 11.0	322^{b}	± 18.9	406^{ab}	± 19.0		
Parity	1	77	640^{a}	± 20.6								
	2	70	582^{ab}	± 21.4								
	3	72	573^{ab}	± 22.2								
	4	53	548^{b}	± 25.5								
	>4	44	562^{ab}	± 28.5								

[&] Values related to the same variable with different superscripts within respective columns differ significantly ($p<.005$).

of the intervals proved to be the season in which the animal calved. The interval between calving and start milking is significantly shorter when the calf was born in the early wet season, or the growing season, than if the calf was born in the early dry season. The length of the milking period was also significantly shorter if the calf was born in season 2 than if it was born in seasons 3 and 4. In the weaning age significant differences were only found between calves born in season 1 and 2, in which that of calves born in season 1 was the longest. Parity proved to be of some influence only on the calving interval; The calving interval of the first parity was longest, but it differed significantly only from parity 4, which had the shortest duration.

In table 4 part of the results of the model used for the evaluation of 719 calving intervals of which complete records were available is displayed. If the calf died, and also if the cow was not milked, the calving interval was extended significantly. The significant differences found between the systems or the parities are roughly comparable to those given in table 3. Here also the calving interval is longest in GMS 1. In this case this value is significantly different only from GMS 2. The calving interval is also longest in the first parity, significantly longer than in the third and fourth parity.

Part of the results of the model used for the evaluation of the girth measurements is given in table 5. Differences between the Grazing Management Systems are small in all age groups. In the age group between 0 and 1 year, the animals in GMS 3 have a significantly bigger girth size than in all other age groups. In the age group between 1 and 2 years, GMS 3 still differs significantly from GMS 1 and GMS 4. In the age group over 2 years, the animals in GMS 1 appear to be significantly smaller than in all other systems. There is a clear difference between the sexes. In the group between 0 and 1 year the females are smaller than the males. In the second age group no significant difference could be seen between the males and the females, but a distinct difference existed with the oxen. In the third age group the difference between females and oxen is considerable. In all age groups seasonal influences can be identified. In season 1, the late wet season, the animals appear to have the biggest girth, while in the second half of the year, the hot dry season and the early wet season, the girths are smallest. When the combined effects of season and herd movement practice (transhumance or sedentarism) are assessed, it appears, that within the transhumant or sedentary

Table 4. Estimated values of part of the model used for the evaluation of calving intervals on the basis of all completed lactations with complete records in traditionally managed cattle in the Western Province of Zambia.

Variable		Number	Calving interval (days) Value	s.e.
Overall		719	599	± 7.9
Parity	1	219	632[a]	± 10.2
	2	179	602[ab]	± 10.7
	3	138	574[b]	± 11.3
	4	104	592[b]	± 12.6
	>4	79	595[ab]	± 14.5
GMS	1	199	621[a]	± 10.4
	2	166	575[b]	± 11.7
	3	197	609[a]	± 10.5
	4	157	591[ab]	± 10.9
Calf weaned/dead	Weaned	587	566[a]	± 5.1
	Dead	132	632[b]	± 14.7
Cow milked	Yes	354	580[a]	± 10.7
	No	365	618[b]	± 9.0
Regression coefficient for covariable Removal age calf			0.86647	± 0.03194

* Values with different superscripts differ significantly (p<.005).

GMS = Grazing Management System

groups similar differences between the seasons can be seen, with the exception of the sedentary group of over two years. Here it would seem that the girth sizes are more stable than in the transhumant group.

Discussion.

The percentage of cows over the age of two years that have calved in the respective Grazing Management Systems (GMS) as shown in table 2 should be judged with two remarks in mind. The

Table 5. Estimated values of part of the model used for the evaluation of girth sizes (in cm.), in traditionally managed cattle in the Western Province of Zambia. The values in the model are corrected for age.

		Age group 0 - 1 year		Age group 1 - 2 year		Age group over 2 years	
Variable		Value	s.e.	Value	s.e.	Value	s.e.
Number in group		1023		627		322	
Average girth		95.85		122.26		151.34	
Average age (mths)		6.35		18.02		59.47	
GMS (System)	1 (T)	94.70[a*]	± 0.41	118.85[a]	± 0.85	148.75[a]	± 1.32
	2 (T)	94.65[a]	± 0.54	122.99[ab]	± 1.23	154.09[ab]	± 1.73
	3 (S)	97.22[b]	± 0.51	124.06[b]	± 0.73	154.50[b]	± 1.43
	4 (S)	94.49[a]	± 0.68	121.07[a]	± 1.29	153.66[ab]	± 2.51
Sex	F	94.17[a]	± 0.35	120.59[a]	± 0.62	147.66[a]	± 1.09
	M	96.35[b]	± 0.38	120.41[a]	± 1.12	-	-
	O	-	-	124.22[b]	± 0.83	157.84[b]	± 1.29
Season	1	99.36[a]	± 0.44	126.99[a]	± 0.71	157.20[a]	± 1.42
	2	94.60[b]	± 0.61	123.95[a]	± 1.05	152.47[ab]	± 1.58
	3	91.44[c]	± 0.56	116.21[b]	± 1.28	151.22[ab]	± 2.52
	4	95.64[b]	± 0.53	119.82[b]	± 0.93	150.11[b]	± 1.40
System* Season	S*1	100.11[a]	± 0.65	127.89[a]	± 0.92	156.66	± 1.82
	S*2	95.16[b]	± 0.97	127.14[a]	± 1.59	153.82	± 2.42
	S*3	91.14[c]	± 0.84	115.81[b]	± 1.75	153.35	± 3.38
	S*4	96.99[b]	± 0.87	119.41[b]	± 1.55	152.50	± 2.44
	T*1	98.62[a]	± 0.59	126.08[a]	± 1.05	157.74[a]	± 2.06
	T*2	94.04[b]	± 0.69	120.77[b]	± 1.26	151.11[ab]	± 1.91
	T*3	91.76[b]	± 0.72	116.61[b]	± 1.79	149.09[ab]	± 2.84
	T*4	94.29[b]	± 0.60	120.22[b]	± 0.93	147.73[b]	± 1.49

[*] Values with different superscripts differ significantly ($p<.005$)

GMS = Grazing Management System

T = Transhumance
S = Sedentarism

results may have been influenced by the proportion (between 17.6 and 24.2 % depending on the GMS) of animals that has been in the herds for less than a year. Another disturbing factor is, that the age of most of the animals in the early phases of the monitoring programme had to be estimated. All cows over the age of two years were considered to be ready for conception. The mean age at first calving, which did not show significant differences between systems and is therefore not elaborated on extensively, is around 1350 days. This value is highly variable, and the youngest ages at which cows were found to calve were indeed not much higher than two years. Because of the relatively large transfer figure, the uncertainty, to some extent, about the age of the younger animals at the start of the survey, and the broad range of ages at first calving, it was decided not to use calving percentage as indicator of reproductive performance, but to use the results of this table as indicative information on the fertility only.

In Grazing Management System 1 a relatively large percentage (55.2) of the animals do calve, especially if compared with Grazing Management Systems 2 and 4 (46.7 and 39.9 % respectively). The percentage that calved only once is also highest (49.4 % as opposed to 30.2 (GMS 2), 39.5 (GMS 3) and 23.3 (GMS 4)). In Grazing Management System 4 the percentage of animals that calve is smallest (39.9), but the percentage that has its first calving below the age of four years is by far the highest in this system (81.2 %, as opposed to between 66.5 and 72.7 % for the other systems), as is the percentage of animals that calve more than once (76.7, as opposed to between 50.6 and 69.8 % for the other systems). The percentage of animals that calve three times within the survey period is lowest in GMS 1. In the other systems this value is roughly three times bigger.

In accordance with Revell (1975) seasonality in calving, though not mentioned in the results, was found in the survey. Roughly 70 % of the calvings took place between May and November, corresponding with conceptions between September and February. Some differences seemed to be present between the systems; in GMS 1 70 % took place in the five month period of July to November, with a distinct peak (23 % of all calvings) in September; in GMS 2 70 % took place in a 7 month period from May to November; in GMS 3 70 % took place in a six month period from May to October, and in GMS 4 from June to November. In GMS 2, 3 and 4 the calvings were more or less evenly distributed over the months in the periods mentioned. In Mali the same relation between conception period and wet season was found (Wilson, 1985). The results displayed in figure 1a support the findings on seasonality in conceptions. Around 50 % of the animals have a calving interval between one year and 20 months, meaning that most of their deliveries would take place within the calving season. The animals will have to be in an optimal condition for conception at the time of siring (Chandler, 1971). For around 20 % of the animals the dependency on a favourable season for conception seems to be very critical; if they do not attain the desired condition within three months after the birth of their calves, they will not become pregnant before the next season, exactly one year later, resulting in calving intervals of almost exactly two years. For the animals that have a calving interval of less than two years attaining the required condition is apparantly less criticaly connected to a period of the year. Figure 1b shows, that relatively many of the animals having a calving interval of two years are present in Grazing Management System 1. The information in table 2, that in Grazing Management System 1 the proportion of cows calving only once during the survey is biggest, also supports these findings.

The results shown in table 3 also support the findings relating to the calving interval in Grazing Management System 1. It is significantly longer than in any of the other Grazing Management Systems. Where GMS 1 combines a long milking period and a high weaning age with a long interval between birth and start of milking, a long interval between weaning and the next delivery and a long mean length of the calving interval, GMS 2 shows the same length of the milking period and the same weaning age, while farmers decide to start milking the animals earlier, the next delivery comes considerably sooner and the calving interval is in the same range as that of GMS 3 and 4. Assuming that the amount of milk taken from any cow does not differ very much, the average amount per day per cow being 0.7 liters (Bessel and Daplyn, 1977), and realising that body condition is essential for both conception and milk production capability (Nicholson and Sayers, 1987) it would appear that the cows in GMS 2 are in the best position for optimal performance, if compared with the other systems. Fertility is influenced by the nutrition of animals (Nadaraja, 1978). This may suggest that the nutritional stress is least severe in GMS 2.

In view of the importance of body condition for milk production (Nicholson and Sayers, 1987) it may be argued, that the significant influences of the season, found for the interval between calving and the start of the milking period, the length of the milking period and the age of weaning of the calf, is also explained by differences in condition. It would seem that for animals that calve in the first half of the wet season (season 4), in a period when regrowth of vegetation is at its fastest, the nutritional status allows milking at an earlier stage than in the other seasons, although the difference is only significant with the value of season 2. Cows calving in season 4 also appear to have a relatively long milking period. Here also, the difference is only significant with season 2. The moment cows are being milked for the first time and the length of the period animals are being milked are decided upon by the farmers. It would appear that farmers use the nutritional condition of the animal as an indication to determine when, and possibly if, to start milking; they are likely to postpone milking when animals deliver during or shortly before the dry season, when the nutritional stress is at its highest.

The moment the calves were weaned seemed to be influenced by pregnancy of the cow. Once the cow is pregnant for around three months, she refuses to let the calf drink. If cows deliver in season 2, the weaning age is 365 days, shorter than the values of the other seasons and significantly lower than that of animals that calve in season 1. It would suggest, that animals that calve either in season 1 or season 2 are likely to conceive as soon as the environmental circumstances are favourable, early in the next wet season. The duration of the calving interval of cows calving in season 1 is similarly longer than that of cows calving in season 2. These differences are however not significant. Influences of GMS and parity probably contribute more to determining the duration of the calving interval.

An influence of the parity can only be identified on the calving interval. Both table 3 and table 4 show this effect. None of the other intervals mentioned in table 3 is influenced by parity. The calving interval is longest after the birth of the first calf. The relatively high maturing age of cattle on tropical pastures (Mason and Maule, 1960) is likely to be the cause of this. While the animals are still growing it may be more difficult to get them in calf than when they have fully matured (Peters, 1983).

The conclusions of Nicholson and Sayers, drawn for Boran cattle in Kenya (1987) that body condition is a major influence on milk production, and through that also on calf survival, and on reproductive performance, could be applied to the results of table 4. This analysis was aimed mainly at identifying influences of the way in which the calf was removed from its mother, through weaning or death, and of milking on the calving interval. Both did show significant differences. The calving intervals appear to be longest when the cows are not milked, and when the calves have died. It is likely that the condition of the animals also plays a role here. As already stated, farmers obviously decide if animals are to be milked, and it may be expected that they also base their judgement on the condition of the animals. The findings regarding the influence of parity and of GMS is comparable to those of table 3.

The interactions of season and GMS and of parity and GMS, included in the models for analysis of variance, did not show additional information or clear significant differences. Calving intervals of Barotse cattle derived from literature range from around 600 days (Revell, 1975, Lutke-Entrup, 1971) to around 880 days (Bessel and Daplyn, 1977, Perry et al., 1984).

All other Grazing Management Systems seem to lag behind in girth, compared to GMS 3 (table 5), but this difference is made up for when the animals grow older, except in GMS 1, where the animals over the age of 2 years appear to be smaller than in all other groups of that age. It may seem, that the nutritional stress, suggested to be present in GMS 1 by the reproduction results already discussed, can be identified in the growth as well. A clear influence of the season can also be identified. The highest pressure on the development of the animals is seen in the late dry season, specifically in the animals up to the age of 1 year, while in the wet season compensation of the growth takes place and the condition of the animals is at its best in the late wet season. In the literature compensatory growth in Sanga cattle was described by Smith and Hodnett (1962). Wilson (1987) described seasonal effects in cattle in Mali; weight was not only related to the season, but also to the season of birth, which influence seemed to last throughout life. The difference in girth between female and male calves is not found in the age group of 1 to 2 years. The reason for this may be, that the biggest males in this age group are castrated, since it is preferable to choose well developed animals for workoxen. It may be the case, that the body conformation and size also determines the moment the animals are castrated; smaller animals may be castrated later, thus contributing as males to the analysis of this age group. The males were no longer included in the analysis of the group over the age of 2 years, since their number is too small. The relation of the rangeland condition and the growth of the animals is also mentioned by Block (1958), who described a relatively good adaptability of the Barotse breed to adverse nutritional circumstances, and Cruickshank et al. (1976), who reported considerable results in feeding trials with Barotse steers.

The results given indicate that season is a major influence on performance, both in reproduction and in weight. The nutritional stress caused periodically by the changes of season is a factor that can hardly be influenced in traditional lifestock systems characterised by a very low input level. Improving reproductive performance may best be attained by trying to influence the calving season in such a way, that as many cows as possible are sired in the first half of the wet season. The current practice is, that bulls graze with the herd all year round, and that it would be rather difficult to separate them part of the year. Some attention may also have to be given to the cow/bull ratio if siring seasons are to be maintained. Influences of the Grazing Management Systems were also identified. The Grazing Management Systems give an indication of the environment in which the herds are maintained. The management decisions of the farmers are highly dictated by the circumstances. As far as nutritional stress resulting from environmental characteristics is concerned, improvements may mainly have to be sought in thorough analysis of the grazing practices and decision making relating to grazing, aimed at developing extension messages containing recommendations for pasture selection. These recommendations should in that case try to aim at improving body condition as soon as possible after the start of the wet season. Through this, it may be possible to have the cows in the best possible condition for conception in the early wet season. Seasonal, nutritional stress is often aggravated by indiscriminate burning of old grass in the dry season, depleting the standing hay stocks (Matthewman, 1980). Discouraging this practice may at least contribute to some extent to maintaining weight and condition.

Genetic differences between animals from the respective GMS in terms of for example body confirmation and metabolism could theoretically have played a role, but it is impossible to evaluate this effect with the present material. This is also the case with inbreeding. Maybe selection for shorter calving intervals, or rather, for lower dependency on favourable conditions for conception, is possible. For this it would be necessary that a system of individual performance evaluation would be developed, such as was proposed by Faugére and Faugére (1986) for small ruminants. This system would have to be suitable for use by the individual farmers. Multiple ownership in herds however (Beerling, 1990) is likely to make it more difficult to encourage farmers to follow recommendations aimed at improving performance of individual animals than to follow recommendations aimed at day-to-day decisions related to the herd as a whole.

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(submitted for publication.)

2.4. Herd monitoring in traditional cattle husbandry in the Western Province, Zambia, IV: ownership of cattle and transfers of animals between herds.

E.G.M. van Klink[1], J.J.F.M. Corten[1], M.M. Mumbuna[2] and G.G.M. van 't Klooster[1].

Introduction.

Livestock development efforts often do not attain their objectives, because the extension messages or interventions planned are not followed by the target group (Abalu et al., 1987, Biggs, 1980, Beerling, 1990). The interests of the farmers are in many cases of a different nature than the goals set by development projects. It is essential to identify not only the constraints that are faced and are felt as such by farmers, but also the factors that determine both the willingness and the ability of farmers to follow recommendations or to accept development measures. It is difficult to describe socio-economic factors that are of general value for livestock development, for which reason thorough knowledge of the local situation is necessary before recommendations can be designed (Little, 1984, Dickie and O'Rourke, 1984, De Rooij and Wood, 1990). The research necessary to acquire such knowledge is by nature interdisciplinary (Shaner et al., 1981, Sollod et al., 1984). Ownership of livestock and its distribution, as well as caretaker systems in which farmers assume the task of looking after animals owned by third parties are important socio-economic aspects influencing design of development policies (Little, 1984).

In the Western Province of Zambia, cattle are of economic importance and play an important role in the subsistence agriculture, by providing draught power (Kimmage and Wood, 1988), manure, milk, meat and a source of financial security (Beerling, 1991). In the framework of the Livestock Development Project Western Province a set of studies was carried out to acquire knowledge on socio-economic aspects of livestock

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keeping (De Rooij and Wood, 1990). An extensive research proposal, outlining the socio-economic information required as a base for policy design, has been drafted (Wood, 1986). A major study concerns the ways people acquire and dispose of animals (Beerling, 1986). Baars (1987) discussed economic aspects of livestock keeping. The various reasons for which cattle are important to the farmers are reflected upon by Beerling (1991), and a study on the distribution of benefits was carried out (Beerling and Mumbuna, 1988). Ownership of individual animals in herds, relations between various owners in a herd and movement between herds appeared in the studies mentioned here to influence greatly the ways in which yields are distributed. Wood (1988) discussed the implications of the results for the design of livestock development policies and veterinary service restructuring.

The herd monitoring programme carried out by the Livestock Development Project (De Rooij and Wood, 1990) provided the opportunity to quantify the ownership of animals in a number of herds and the importance of movements of animals between herds. This paper presents the results of that quantification. Some consequences of these factors for livestock development policies are briefly discussed.

Material and methods.

The study area, the climate and the herds involved in the schedule have been described by van Klink et al. (1994a).

In 49 of the herds involved in the herd monitoring programme the ownership of all individual animals were recorded, in a cross-sectional survey, at the start of the programme. Also the relations between the owners of the animals and the caretakers of the herds were recorded. The owner of an individual animal has the power to decide on the ultimate disposal of an animal, through slaughter or sale (Beerling, 1990). An owner of a herd, or rather herd keeper or caretaker, on the other hand, is not necessarily owner of the animals in the herd. The herd owner bears responsibility for the herd, but it is possible that he does not posses any of the animals in the herd (Beerling 1990).

In all herds involved, all entries of animals into and removals of animals from the herds occurring were recorded every two weeks by veterinary assistants, over a period of two years. Apart from the dates on which removals from and entries into the herds took place, they were required to indicate the reason for which the animals were removed or entered.

Once every three months the District Veterinary Officers of the districts in which the herds were based visited the herds in order to verify the information provided by the veterinary assistants. During these visits check lists were used, on which the situation at the time of the previous three monthly visit was reflected. These check lists were automatically produced, using an application on the basis of the general purpose data management programme Panacea[3].

Results.

In table 1 the ownership distribution in 49 of the herds involved in the study is presented. The herd keepers generally own the largest number of animals. In one herd the herd keeper did not possess any animal. The wife (or in some instances wives) of the herd keeper owned 2 animals on average in her husbands herd. The children and relatives of the herd keeper owned an average of about 6 animals, while non-relatives owning cattle in the herd owned 5 animals on average.

Male owners appear to be by far the largest category. Nevertheless it is clear that women do own cattle, and sometimes even considerable numbers. In one herd all cattle were said to be the property of two women.

Figure 1 A shows the percentage of the total number of animals owned by the various types of owners. The keepers of the herds owned 43.6 % of the animals in them, the wives of the herd keepers 3.1 % and the children 13.2 %. In most cases the herds consisted predominantly of animals owned by the direct family. A total of 91.7 % of the animals is owned by the herd keepers or their family and relatives. The rest of the animals is owned by non-relatives, who have entrusted their animals to the care of the herd keepers.

Figure 1 B represents the number of herds with various numbers of owners. The number of owners in a herd can vary greatly. The number is rarely very large. In 38 herds the number of owners is less than 10, in 29 herds less than 6. In figure 1 C the number of owners in a herd is related with the herd size. This relation proved to be significant ($p<.005$).

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[3](c) Pan Livestock Services Ltd., Reading, UK.

Table 1. The ownership distribution of 3196 head of cattle in 49 herds in the Western Province of Zambia.

Type of owner	number	Total number of animals owned	Mean number of animals owned	Range
A. Herdkeeper		1394	28.4	0 - 94
B. Wife of A.		100	2.0	0 - 17
C. Children of A.	72	423	5.9	0 - 29
D. Relatives of A.	176	1014	5.8	0 - 18
E. Others	53	265	5.0	0 - 23
I. Male owners	224	2470	11.0	0 - 94
II. Female owners	111	639	5.8	0 - 30
III.Sex owner unknown	30	87	2.9	0 - 14

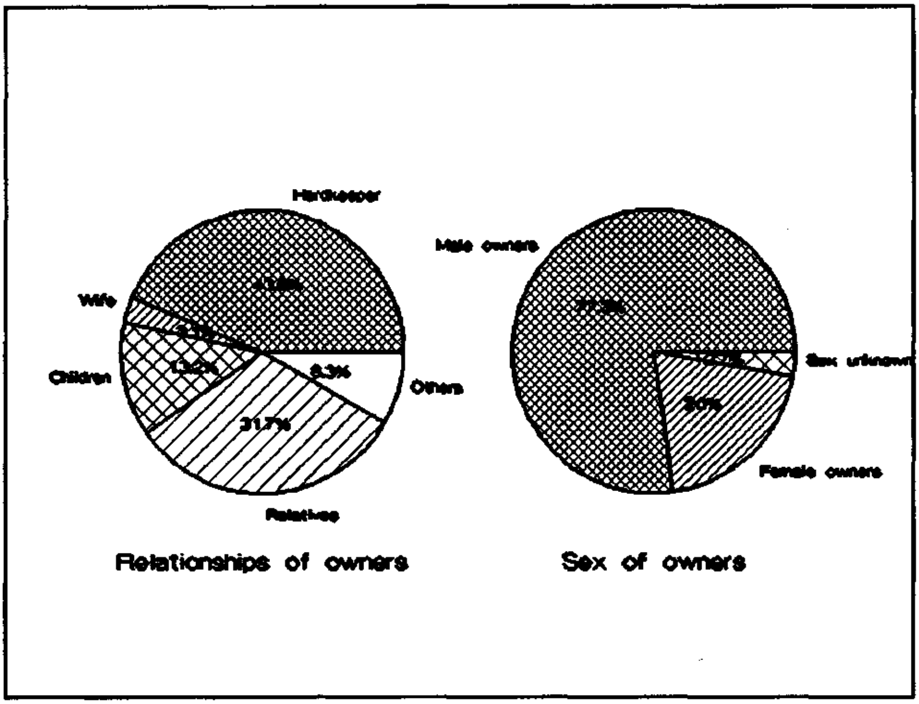
In table 2 the total number of changes in the herds that occurred over a two year period is represented. A distinction was made between "true" entries and removals, meaning that animals were not present in the cattle population of Western Province before, or were totally removed from the cattle population of the Western Province, and transfers between herds within the cattle population of the province. All "true" entries are animals that were born in the herds, and all "true" removals are animals that died or were destined to be slaughtered, either through local slaughter, usually in emergency, or through being sold for slaughter. Around two thirds of all changes belong to either "true" entries or "true" removals.

The rest of the changes are transfers between herds within the system. Of the entries, 28.8 % in this group are purchases,

Figure 1. Ownership in 49 herds from the Western Province of Zambia.

A. Proportion of the herd owned by various types of owners.

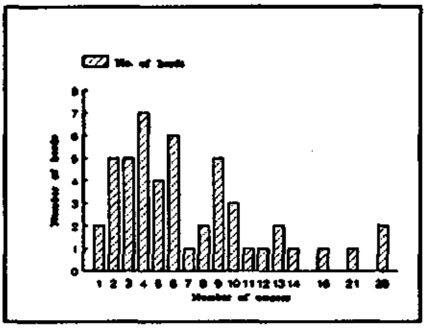
A.



B. Number of herds with various numbers of owners.

C. Relation between herd size and the number of owners.

B.



C.

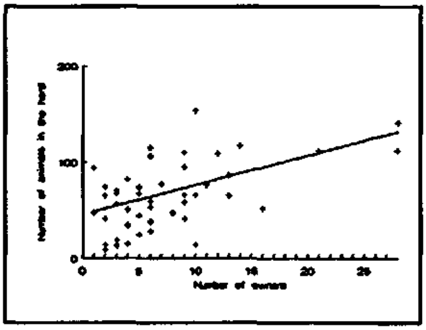


Table 2. Distribution of reasons of 1677 entries and 1364 removals of animals from herds in the Western Province of Zambia, recorded between 1/4/86 and 1/4/88.

	Entries (A.)				
	True entries (A1.)			Transfers into herds (A2.)	
Reason		% of A.	Reason	% of A2.	% of A.
Born		63.3	Bought	28.8	10.6
			Herding	23.6	8.7
			Reclaimed	19.8	7.3
			Exchanged	11.5	4.3
			Brideprice	8.7	3.2
			Inheritance	2.7	0.9
			Hire or loan	2.4	0.9
			Gifts	1.5	0.5
			Payments	0.7	0.3
			Not specified	0.3	0.1
	Total A1.	63.3		Total A2.	36.7
	Removals (B)				
	True removals (B1)			Transfers out of herds (B2)	
	% of B1.	% of B.		% of B2.	% of B.
Died	53.0	35.1	Reclaimed	44.8	15.1
Sold for slaughter	33.1	22.1	Herding	19.3	6.5
			Brideprice	12.2	4.1
Slaughtered	13.7	9.1	Exchanged	11.1	3.8
			Inheritance	3.5	1.2
			Sold	3.3	1.1
			Payments	1.9	0.7
			Lost	1.7	0.6
			Gifts	0.6	0.3
			Not specified	1.6	0.5
	Total B1.	66.3		Total B2.	33.7

and another 19.8 % consists of the animals that were reclaimed from elsewhere; animals, owned by the herd keeper or his family, that were kept in another herd under a herding arrangement. Exchanges of animals for other items or animals, and animals received as brideprice account for 11.5 and 8.7 % of the transferred entries respectively. The other reasons for which animals enter the herd are numerically less important.

By far the largest part of the removals in this group are the animals that are taken back by their original owners, i.e. animals that have been kept in the herds for others (44.8 %). Removals because of exchanges (11.1 %), brideprice payments (12.2 %) and animals taken out to be kept in other herds (herding arrangements) (19.3 %) also account for a considerable proportion (table 2).

Discussion.

Ownership proved to be a complicated concept (Beerling 1986, 1991). This is caused by the fact that in the Lozi language the word "owner" has a broader meaning than legal ownership only. Only after research into the social structure and context of ownership was started (Beerling 1986), the concept could be operationalized. Only when the first qualitative analyses of the ownership concept were carried out, quantitative approaches as presented here, and studies into benefits and the economic position of cattle in society could be started (Baars, 1987, Beerling and Mumbuna, 1988, Beerling, 1991).

In practically all cases animals from several owners are present in the herds in Western Province (Beerling, 1990). The majority of the animals in the herds are owned by the herd owner, his family and relatives (table 1 and figure 1A). The number of animals owned by "outsiders" is small. Normally the herdowner will possess the largest number as well as proportion of animals. The number and proportion of animals owned by the wives of herdowners is small. Women often leave the animals they own in the herds of their fathers, rather than transferring them to the herd of their husbands (Beerling, 1986). Wives are not considered member of the family in the Lozi kinship system. This, and the fact that divorces occur relatively frequently, is the reason for women to leave their animals in the herds of their fathers or other male relatives.

Beerling (1991) presented an analysis of ownership on the basis of information from herds in two of the districts in the province. The proportions of animals owned by the various owner categories differ, but general conclusions that can be drawn are mostly comparable with those of the present study. The herd keeper ownes on average the largest proportion of the animals, and of the rest of the animals the majority belongs to the children and relatives of the herd keeper.

Beerling (1991) stated, that, according to persistent rumours, large numbers of animals are in fact owned by Lozi, residing in the capital and other important towns, far away from the Western Province. This situation would hamper livestock development efforts, since these cattle owners would consider cattle purely as private investment. Furthermore, absentee ownership, as it is termed, interferes with decision making processes. Beerling (1991) could however not find evidence for this rumour. Absentee ownership does occur, but the proportion of animals owned by absentee owners is not disproportional to the shares of other cattle owners in the herds.

The number of animals owned by any of the respective groups is greatly variable. Children and relatives own almost six animals per person, and 13 and 32 % of the total number of animals respectively. Other owners possess five animals on average and 8 % of all animals. Herdowners are responsible for the day-to-day management of the herds, but since individual animals are owned by a number of other people, decision making on the fate of individual animals is quite complicated. The actual owner of an animal would for instance not decide on selling it without consulting the herd owner, while the herd owner would not decide on his own on the purchase of drugs for specific animals.

Male owners possess almost twice as many animals per person as female owners, while male owners posses almost 80 % of all animals. The number of female owners is considerably smaller. Apparently women can and do own cattle, but it seems to be less self-evident than with men. Benefits derived from cattle are likely to reach women in many cases only in indirect ways (Beerling, 1991). For example, revenue from the sale of milk or the hiring of oxen owned by them, does not reach them directly, or may not even reach them at all. The cause for this is, that their animals are normally left under the care of a male relative, and that women are rarely, if ever, involved in the day-to-day management of the herds. Contrary to what Waters-Bayer and Bayer (1984) found for the settled Fulani of Abet in Nigeria, women are also not involved in activities such as milking. Mubonda (1993) recommends that efforts should be made to increase the involvement of women in cattle keeping and the measure to which they benefit from cattle. This is of particular importance in view of the fact that cattle are considered the main, if not the only, important source of income (Mwafulirwa and Moll, 1991) and therefore of relative independence and development of personal prosperity.

Figure 1B shows that the number of cattle owners per herd may vary greatly. In one herd the owner indicated that he did not possess any of the animals, while two other herd owners claimed to own all animals in the herd. It is possible that this statement was made, because these farmers considered questions about the ownership of their animals rather prying. The experience of the enumerator in dealing with such sentiments may therefore have been of influence.

A regression analysis carried out on the relation between the size of the herds and the number of owners (figure 1C) shows, that the total number of owners of these three groups increases significantly with the increase of the herd size ($p<.005$). The number of children owning cattle has the biggest influence, though not at the same confidence level ($p<.05$). The number of relatives or other owners is less important in this relation. The size of the herd and the number of owners involved are likely to be of great influence on the complexity of decision making.

No "true" entries other than births were recorded in the herds. Rarely, if ever, does importation of cattle in considerable numbers from outside the province take place. The cattle keeping system of the Western Province can be considered as a closed system (De Rooij and Wood, 1990). Only one third of the "true" removals are animals that are sold for slaughter. The other two thirds are slaughtered locally, usually in emergency (Van Klink et al., 1994b), or died in the herds. This is an enormous loss in economic sense. Although the meat of animals that died is often eaten and the animals that were slaughtered in emergency are also consumed or sold, the revenue this generates is far below that earned by selling it for slaughter outside the province (Beerling, 1986).

One third of all entries into and removals from the herds concern animals that are transferred from one herd to another for a number of reasons (table 2). Transfers in the framework of herding arrangements are by far the largest group. Owners of animals not necessarilly take up the care of (all of) their animals themselves. Often they decide to place animals in the care of other herd owners. Women hardly ever take care of their own animals; they will normally place them in the herds of their father or brothers (Beerling, 1986).

Several types of herding arrangements exist. They can be distinguished by the relation between the owner of the animal and the caretaker, which may be a family member, or a non-family relation or friend. Also the character of the agreement; whether or not an award is granted, and what the reward should be, determines the type of the herding arrangement. The duration of the arrangement is also a distinguishing factor. For family for instance, herding may be done for considerable periods without an award being granted. For non-family relations the duration may be variable and normally one or more animals, often offspring of the animal that is given into the care of the herd manager, will be given as reward (Beerling, 1986).

Changes in the herds related to herding arrangements include animals entering the herd for herding, or being reclaimed from other herds, and animals removed from the herd because of herding or because of being reclaimed by the original owner. Around 40 to 60 percent of all transfers between herds are related to herding arrangements. It may be that part of the animals that were reportedly entered into the herd because they were bought, were in fact animals that were reclaimed from other herds and were placed by owners other than the herd owner under his care. The entry reason was normally given by the herd owner, and the owner of the individual animal appeared not to have been asked. It would probably explain in part the discrepancy between the proportion of animals bought and the proportion of animals sold, and between the proportion entering the herd because of being reclaimed and the proportion being removed for the same reason. It would probably show that the percentage of animals entering the herd because of being reclaimed would prove to be in the same range (around 45 %) as the proportion leaving the herd for this reason. Similarly the percentage bought probably would be in the same range (around 3 %) as the percentage sold.

Brideprice payments are still an important reason for transfer of animals between herds. Roughly the same number and proportion of animals have entered and were removed from the herds for this reason. The brideprice is normally paid to the parents of the bride. In most cases the animals will remain in the herd of the father of the bride, although one animal seemed to have been removed from the herd most likely because the mother of the bride transferred her share of the brideprice to the herd of her own father.

The importance of transfers within the livestock industry of Western Province has been clearly illustrated in this study. About 250 - 300 animals change herds per year in this group of herds. On the total number of animals of 2500 to 3000 this is a frequency of 8 - 12 %.

As in many African traditional livestock systems, in the Western Province, animals are individually owned, while herds are often composed of animals of different owners, under the responsibility of a caretaker (Beerling, 1986). It is likely that the caretaker decides on the day-to-day affairs in the herd, such as where to graze, when to release the animals from the kraal, whether to milk an animal and at which moment of the day the animals are to be milked. Decisions on individual animals, not being his property, are likely to be more complicated; this may include disposal, transfer, slaughter, but also application of veterinary treatments or vaccinations. In view of the main objective of the Livestock Development Project, improvement of the veterinary service infrastructure and cost-recovery (De Rooij and Wood, 1990), further research into the decision making process in the framework of the complex ownership relations is necessary.

Transfers between herds are of great importance, both numerically as in socio-economic sence (Beerling, 1986). The relatively high transfer rate may again complicate the decision making process. It could even be argued, that, especially if great distances are covered while transferring, they may pose veterinary risks. Spread of certain clostridial infections (e.g. blackleg) or haemorrhagic septichaemia may be influenced, also because the transport, usually on hoof, from one herd to another, may cause stress leading to depression of immunity. On the other hand, reasons for cattle owners to place animals under the care of others may include spreading the risk of loosing the complete herd in case of severe outbreaks of disease (Beerling, 1986). Other reasons may be letting the animals benefit from good pastures in desired areas away from home, or having them sired by unrelated bulls in order to prevent inbreeding. While it is generally accepted, that the more frequent changes in herd composition take place, the more productivity and health may be impaired, both by disruptions of the social order in the herd and by the presence of health hazards, sound management reasons often play a role in bringing one's animals under the care of others.

It may be that long-term herding arrangements and the movements these involve are affecting productivity less than situations where animals stay in the herds for short periods only. Especially those animals may pose health hazards or spread disease agents, mainly because of the transport stress mentioned earlier. It remains however difficult to demonstrate, let alone quantify, the effects of relatively frequent movements of animals between herds on productivity, including reproductive performance, and herd health in the rural setting of the traditional livestock keeping systems in Africa. As Beerling (1986) also mentioned, herdkeepers of large, thriving herds may often receive more animals in herding arrangements than less succesfull herd owners, resulting in ever larger herds with ever more animal tranfers taking place.

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CHAPTER 3

Internal parasite infections and productivity.

3.1. Introduction.

Diseases are considered to be a major constraint to animal production in the tropics (Ristic and McIntyre, 1981). Various transmissible and infectious diseases are widespread in the tropics. Ristic and McIntyre (1981) specifically mention diseases caused by helminth parasites. Important as they are, the influence of helminth parasites is often not recognised, because their effects are masked by those of malnutrition (Troncy, 1989). Acute clinical disease as a result of infections with helminth parasites is relatively rare. Especially in young animals infections with particular types of intestinal worms (e.g. haemonchosis, strongyloidosis) do sometimes cause serious disease symptoms if the parasites are present in relatively large numbers. But other types (fasciolosis, the strongyloses) generally cause a chronic subclinical wasting disease, which is often masked by nutritional factors (Armour, 1981, Hope Cawdry et al., 1977). Apart from wasting, anaemia (Kaufmann and Pfister, 1990) or hypoalbuminaemia (Ross et al., 1970) is often found. In liverfluke infections the biggest damage is done by migrating young flukes, through direct damage to liver tissue (Owen, 1984).

If not causing acute clinical disease, the chronic conditions brought about by parasite infections affect the health status of the animals in the longer term and depress the productivity of the animals (Holmes, 1986). Milk production may be affected (Black and Froyd, 1972, De Rond et al., 1990), and growth reduced (Chick et al., 1980, Hope Cawdry et al., 1977, Abdalla, 1989, Parent et Samb, 1984). Fertility may also be adversely influenced (Oakley et al., 1979), resulting in lower conception rates and lower calf weights at birth. The patholigical changes, caused by the presence of the parasites in the intestines and the liver, that are responsible for this, may vary, depending on the parasite or parasites involved (Soulsby, 1968). In liverfluke infections anaemia, hypoalbuminaemia and jaundice are caused by the destruction of livertissue, and through loss of blood from the vessels. In infections with intestinal nematodes malabsorbtion can result from inflammatory reactions in the intestines. <u>Haemonchus spp.</u> cause anaemia, as a result of blood-letting.

In Africa, the liverfluke <u>Fasciola gigantica</u> is common (Schillhorn van Veen, 1980b). The most common intermediate host of <u>Fasciola gigantica</u> is <u>Lymnea natalensis</u> (Schillhorn van Veen, 1980a). In areas, where the climate is moderate (e.g. the

Ethiopean highlands) Fasciola hepatica is common (Lemma et al., 1985).

In a number of areas in Africa inventories have been carried out of the variety of species of intestinal nematodes in cattle and small ruminants. In eastern Zaire, a total of 21 species of intestinal nematodes were found (Chartier, 1990). Connor et al. (1990) found Haemonchus contortus as the most predominant nematode in goats in Tanzania, while Oesophagostomum columbianum and Strongyloides species were also found. Kaufmann and Pfister (1990) found Haemonchus contortus and Cooperia species (C. punctata and C. pectinata) as the most abundant species, and Bunostomum phlebotomum and Oesophagostomum radiatum were also of importance. Inventories carried out in Zimbabwe (Eysker et al., 1990, Pandey, 1990) showed, that in cattle Cooperia species were the most abundant strongylid types found, followed by Haemonchus placei and Bunostomum phlebotomum. In Transvaal, South Africa, Malan et al. (1982) identified Cooperia species, Haemonchus placei and Oesophagostomum radiatum as the most important nematodes present in cattle.

In the Western Province of Zambia some research has been carried out into the prevalence of liverfluke (Fasciola gigantica) infected livers and liverfluke egg shedding (Jorgensen and Kamukwai, 1977, Silangwa, 1972, 1973) and intestinal parasite egg shedding (Bongers, 1987, unpublished data).

In order to relate environmental factors in the province to the pattern of infections with liverflukes and intestinal helminths, an overview is given of literature on research in this field in other areas in Africa. The goal was to assess the significance of factors discussed in this literature for the situation of the Western Province. Also an overview on the effects of infections or of treatments on productivity is given. The aim of this overview is to provide background for the design of a series of field studies into the effect of antiparasitic treatment on productivity and for the subsequent discussion on appropriate control strategies.

3.2. Epidemiologic background of liverfluke infections in Africa.

In the epidemiology of liverfluke infections the following three main phases have to be distinguished:

- the intermediate host, the size of its population, the exposure of the vertebrate host to it and the period of the year or season that infection occurs,
- the presence of the liverflukes in the vertebrate host, the severity of the infection, its effects, and the way the host responds to it,
- the presence of a patent infection, i.e. an infection in which egg shedding is found.

3.2.1. The intermediate host and exposure of the vertebrate host.

Schillhorn van Veen (1980a, 1980b) describes the relation between the population dynamics of the intermediate host Lymnea natalensis and the presence of Fasciola gigantica infections in cattle in Zaria, in Nigeria. The snail population builds up in the course of the rainy season, and declines with the reduction of the size of pools when the dry season has started. Most infections with Fasciola gigantica were reported from the end of the rainy season till the middle of the dry season. By the end of the dry season acute fasciolosis could be seen. Babalola and Schillhorn van Veen (1976) described an abbatoir survey in Bauchi in Nigeria, where an average of 31.7 % of the livers was found with an infection. Peaks were found in March/April and in September/October, marking the start and the end of the rainy season. In the period before the rainy season acute clinical fasciolosis in cattle was found. Probably the poor nutritional status of the animals was of importance in the occurrence of acute clinical cases of fasciolosis. Babalola and Schillhorn van Veen (1976) quoted Graber (1971), stating that the nutritional status of the animals often determines the severity of the disease. The anaemia and hypoalbuminaemia caused by fluke infections are compensated more easily, if the nutritional status is high, than if the animals suffer food shortages. It is likely, that resistance against parasites and parasitic infections is depressed in times of sub-optimal provision of fodder. The high prevalence at slaughter of infected livers in the period just after the rainy season is more an expression of the culling policy of the owners, who probably cull animals in bad condition before the start of the dry season. They concluded that the infection is usually acquired in the second half of the dry season, when the cattle graze the floodplains of the Niger and other rivers. Schillhorn van Veen et al. (1980) reported on results of surveys of slaughter slabs in the same region. Slaughter slabs are small scale local slaughtering facilities, usually literally only consisting of a concrete slab, sometimes equiped with a low wall, and very rarely with a beam and tackle. They indicated that 65.4 % of the cattle was found infected, with peaks at the start of the dry season. These peaks may also have been the result of increased culling of animals in depressed condition. It is remarkable, that in the survey on slaughter slabs peaks at the start of the dry season were found, while in the abbatoir both at the end and at the start of the wet season peaks were found. The cause for this may be, that the animals that are slaughtered at the local slabs are generally animals of which the general condition is very poor, as a result of which they are not admitted for slaughter at abbatoirs. Although, as stated by Babalola and Schillhorn van Veen (1976) culling may have influenced the prevalence rate of infected livers in the abbatoir survey, it is probable, that the animals slaughtered at local slaughter slabs are an even more selected group.

Tembely et al. (1988) discussed the prevalence of liverfluke in Mali on the basis of slaughterhouse surveys. Particularly in the Sahelian zone of Mali, in which cattle graze periodically on the floodplains and inland deltas of the Niger and Senegal rivers, the level of infection with Fasciola gigantica is high. The percentage livers found with an infection in this zone was 50 %. In the considerably drier subdesertic zone the prevalence was low, less than 10 %. In the Sudanese zone the prevalence was slightly above 10 %. In this publication the relation between climatic zone, and with that the husbandry practice related to this zone, and infections is emphasized. Especially exposure of the animals during the periods that they are grazing the floodplains was reported to play a part.

Scott and Goll (1977) showed a relation between Fasciola hepatica infections in tracer lambs in the Ethiopian Highlands and the rain periods. Most infections occurred between August and January, with peaks in the number of flukes found at postmortem examination in October/November. The rainfall in the area was concentrated between May and September, with the highest amount of rain in July. The pattern of infections closely followed the rainfall pattern with a time lag of approximately three months. During the rainfall periods the conditions for exposure of the intermediate host to miracidia are optimal. After a development phase in the snail, metacercariae are released. Around three months after the wet season the infections become detectable in the vertebrate host, because the development from miracidium to metacercaria is completed in the snail, the (infected) snails concentrate in smaller pools in the course of the dry season, and the vertebrate hosts also draw nearer to these pools, because the quality of the grazing remains reasonable near water, and because they require the water for drinking.

3.2.2. Effects of liverfluke infections in the vertebrate host.

Infection of the vertebrate host with massive numbers of juvenile flukes may cause acute fasciolosis, as a result of direct damage of liver tissue during the migration of the flukes (Schillhorn van Veen, 1980b, Soulsby, 1968). This condition is often seen in infected small ruminants, and relatively rare in cattle. A subacute syndrome, caused by young adult flukes from the moment they enter the bile ducts is much more common in cattle (Schillhorn van Veen, 1980b). In this syndrome anaemia is found, and the condition of the animals is slowly declining. It may, in areas where both diseases are found, at times be confused with trypanosomosis. A chronic form is caused by adult flukes, resident in the bile ducts. Small numbers of flukes can cause a chronic wasting disease.

The infection with juvenile flukes causes fibrosis of the liver. Once the flukes enter the bile ducts, calcification and thickening of the bile duct walls starts, as Kendall and Parfitt (1975) described for Fasciola hepatica. Similar changes are found in livers infected with Fasciola gigantica. These processes, together with the development of immunity, contribute to the resistance of the vertebrate host against new infections. Partly as a result of these changes in the liver tissue, the host also appears to be able, to some extent, to reject the parasites (Kendall and Parfitt, 1975). Because of this, the percentage livers found with a liverfluke infection in any period can be considered to reflect some of the seasonal influence. Hughes (1985) found, that rejection of flukes was caused by an increasing inability of the flukes to feed as a consequence of the pathological changes. It must be borne in mind, that the infections are always abbatoir findings. The presence of an infection affecting its' condition may influence the decision to slaughter a particular animal.

3.2.3. Egg shedding.

Babalola and Schillhorn van Veen (1976) found that liverfluke infections became patent in the last month before, and in the first month after the rainy season in Nigeria. This is directly after the period that the highest prevalence of fluke infections in slaughterslab surveys was found. Scott and Goll (1977) found in their experiments with sheep and Fasciola hepatica that egg shedding started around November/December, when the number of flukes found in livers were at their highest. The highest numbers of eggs were excreted between February and June.

3.2.4. Remarks on epidemiological aspects of liverfluke infections in the Western Province of Zambia.

In the Western Province of Zambia, some research into the snail population has been carried out (Animal Disease Control Project, 1987, unpubl. data). The distribution of the snail population is related to periodically flooding rivers. The snail population declines in the course of the dry season with the reduction in size of pools that are formed when the rivers are flooded. Since the floods are still high at the start of the dry season, the pools become smaller later in the dry season than was reported for the Nigerian situation described by Schillhorn van Veen (1980a, 1980b). In these pools relatively heavy concentrations of (infected) snails may be present. High numbers of cercariae may be discharged in the pools, while increasing numbers of livestock use the pools as watering point. These factors have been described for sheep and Fasciola hepatica in the Ethiopian highlands (Lemma et al., 1985).

Of the cattle that grazed the Zambezi floodplains in Senanga district 50 to 80 % were infected with Fasciola gigantica (Jorgensen and Kamukwai, 1977). Infected livers were found all year through. The largest number of infected livers was found between January and June. Silangwa (1972, 1973) found extremely high prevalences of liverfluke in abbatoir surveys of Barotse cattle slaughtered in Mongu, Western Province. On average 89.6 % of all livers were condemned between 1944 and 1964. Of 192 livers examined in January and February 1967 and 1968, 98.4 % were positive. These peaks are found around 2 to 3 months after the start of the rainy season. The high prevalence may have been related to the fact, that the livers were examined in a period with favourable conditions for the development of the intermediate host, as was indicated by Jorgensen and Kamukwai (1977).

In the Western Province, grazing the floodplains of rivers is undoubtedly an important factor in acquiring liverfluke infections. The majority of the animals graze the plains of the Zambezi river at least part of the year. Not only the transhumant cattle, but also large numbers of the sedentary herds staying on the higher grounds around the floodplains graze on it part of the year. Specifically in the period immediately after the floods, around July to September, the animals are exposed to liverfluke infections. September generally marks the end of the dry season, when also the nutritional condition of the animals is worst. As was also seen in Nigeria by Babalola and Schillhorn van Veen (1976), typical acute clinical signs of liverfluke infections can be seen in cattle around this time (personal observation, ADCP, 1987).

Jorgensen and Kamukwai (1977) found egg shedding throughout the year in the Western Province, but the highest levels of egg excretion were found between May and August, the dry season. The egg shedding therefore seems to increase around 2 to 3 months after the peak percentage of fluke infections found in livers. This may be related to the fact that reinfection delays patency of liverfluke infections (Kendall and Parfitt, 1975). Eggs require around 17 days to hatch, after which the intermediate host can be infected. The development in the snails takes 75 days in the warm season and 175 days in the cold season (Soulsby, 1968). With egg shedding peaking in the Western Province from May onwards, the period that snails are discharging the largest number of cercariae may start around August or September. The cold season in the Western Province starts around April and lasts till around July, when a hot period starts. This period may therefore coincide with the period that cattle are most likely to be infected with metacercariae, the infective stages of liverfluke.

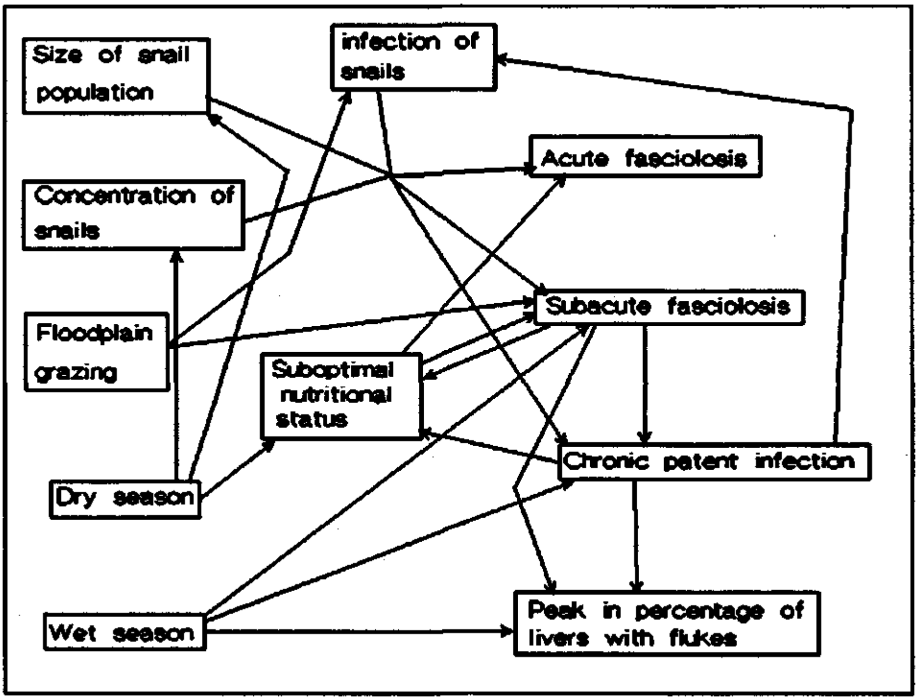
In figure 1., a diagram is shown of the hypothetical interrelations between risk factors involved in the epidemiology of _Fasciola gigantica_ infections. In table 1., some of the influences mentioned in literature are given. Their possible significance for the Western Province is indicated.

3.3. Epidemiologic background of intestinal parasite infections in Africa.

A relation between intestinal parasite infections and climatic conditions is suggested by several authors. Several phases have to be distinguished here as well:

- the survival of pre-infective and infective stages outside the hosts,
- the behaviour of the parasites in the host, including the means of survival through unfavourable periods, the

Figure 1. Diagram, showing the theoretical interrelations between risk factors relevant for the epidemiology of liverfluke infections in sub-Saharan Africa.



effects of infections on the host and the reaction of the host to infection,

- the shedding of parasite eggs and the contamination of the pasture.

3.3.1. Parasite survival outside the host.

Kaufmann and Pfister (1990) found in The Gambia that N'Dama cattle, treated and worm free at the start of the dry season, were not re-infected in the course of the dry season; outside the host, eggs and larvae cannot survive the dry season. Under humid conditions (relative humidity of 80 %) the survival time of larvae on the soil ranged from less than three weeks for Haemonchus to 9 weeks for Cooperia and Oesophagostomum in a laboratory experiment (Lyaku et al., 1988). Okon and Akinpelu (1982) indicated that rainfall is critical in the survival chances of helminth eggs and particularly of larvae, and that temperature is of less importance. Magzoub et al. (1990) describe pasture infections of camels with helminths in the Sudan and found larvae of Haemonchus on the pasture only in the wet season. Larvae of Trichostrongylus spp. however survived for a period well after the wet season. They appeared to be more able to survive under arid conditions than the larvae of Haemonchus spp.

3.3.2. The parasite in the host.

The host becomes infected through ingestion of the infective stages of the parasites. The effects of infections may vary, depending on the number of infective larvae ingested, the species of parasites ingested and the condition and the age of the host. The history of the host is also of importance. Animals that have been exposed to parasites before, are generally less severely attacked. After first infections, the hosts develop immunity against the parasites. This immunity provides resistance against reinfection (Ploeger, 1989).

The immunity, acquired after first infection, also enables the animals to reject the infection in the long run. The acquired immunity is more or less effective, depending on the level of the first infection and of subsequent exposure, and more specifically on the genus. Ploeger (1989) indicated, in studies in Dutch dairy cattle, that the immunity against Nematodirus spp. is very effective. Infections with this parasite therefore generally only occur in calves. This is also, though to a lesser extent, true for Cooperia spp. and Dictyocaulus viviparus. Provided that animals have been exposed to infection with these parasites in their first grazing season, they will hardly become reinfected with them, and clinical effects will be practically unnoticed. In adult cattle, Ostertagia spp. and Trichostrongylus spp. are more common.

Specifically in young calves acute gastro-enteritis, resulting in diarrhoea may be caused (Ploeger, 1989). If the numbers of infective larvae ingested are smaller, the animals are older or have been exposed before, the clinical symptoms may vary. If the symptoms are subacute, generally no diarrhoea, but a chronic wasting accompanied by anaemia (Kaufman and Pfister, 1990) or hypoalbuminaemia (Ross et al., 1970) is found. In chronic infections, the animals may only show a slightly impaired body condition. It is well possible in chronic infections, that no apparent signs, that can be attributed to helminth infections, can be seen.

Table 1. Climatic factors relevant for the occurrence of liverfluke infections in sub-Saharan Africa, as derived from literature. In the columns on the other African regions, factors that may be of comparable importance in the Western Province, Zambia, are marked with an asterix.

Factor	Nigeria (Babalola and Schillhorn van Veen, 1976, Schillhorn van Veen, 1980a, 1980b)	Mali (Tembeli et al., 1988)	Ethiopia (Scott and Goll, 1977, Lemma et al., 1985) (sheep, Fasciola hepatica, Lymnea truncatula)	Western Province, Zambia (Jorgensen and Kamukwai, 1977, Silangwa, 1972, 1973, ADCP, 1987)
The size of the population of Lymnea natalensis and exposure of livestock to infective metacercariae.				
Snail population growth in the rainy season	++*	+[1]	++*	++
Floodplain grazing	++*	+	?	++
Dwindling size of watering pools in the dry season	++*	?	?	++
Presence of infections with Fasciola gigantica in livestock.				
Late dry and early rainy season infections with young flukes	++*	?	?	++
Nutritional status and acute fasciolosis	++*	?	?	++
Rainy season and level of adult fluke infections	+[2]	?	++*	++

(continued on next page.)

In sub-Saharan Africa the infections occur in the wet season. Pandey (1990) reported on the results of abbatoir surveys into the prevalence of intestinal helminths in Zimbabwe. Both in sheep and in cattle the highest prevalence and level of infection was found towards the second half of the wet season. Kaufmann and Pfister (1990) reported heavy infections in the wet season in N'Dama cattle of The Gambia. In

(Table 1. continued.)

Factor	Nigeria	Mali	Ethiopia	Western Province, Zambia
Fluke egg shedding and infection of the intermediate host.				
Peak in egg shedding in the dry season	+[3]	?	++*	++
Peak in egg shedding in relation to the peak in infection level	+[4]	?	+[5]	++[6]

++ Factor considered important
\+ Factor important but emphasis of relation differs from the Western Province situation (see footnotes)
? Factor not mentioned

1 Exposure of livestock mainly during dry season plain grazing
2 Highest level of fluke infections found at end of dry season/early rainy season
3 Peak in late wet season and early dry season
4 Peak directly after highest level of fluke infection
5 Level of egg shedding parallel to level in adult flukes present, peak well after the wet season
6 Highest egg shedding several months later than peak in adult fluke infection

the dry season no adult Haemonchus contortus was found; the parasite survives the dry season as an inhibited larva in the host. Cooperia survives as an adult in the host.

3.3.3. Egg shedding and pasture contamination.

Egg shedding patterns also follow the seasons, with the highest levels of egg shedding, often expressed by the number of eggs per gramm (EPG), found in the wet season. Chiejina and Emehelu (1986) described this for Nigerian cattle. Connor et al. (1990) found this effect in goats in Tanzania. The rainfall is of great significance in the egg shedding pattern, as indicated for goats in Tanzania by Connor et al. (1990) and for cattle in the Transvaal region of South Africa by Malan et al. (1982). At the onset of the rains at the start of the wet season, both authors report a sharp rise in the faecal egg counts. The pasture becomes contaminated from that moment onwards. With the development of adult helminths in the host, the pasture contamination, and consequently the number of animals infected, as well as the level of the infections, increases. If large numbers of animals share the same pasture, the contamination is more serious than if the number of animals is smaller and the area grazed is larger (Muenstermann and Tome, 1989, Eysker et al., 1990).

3.3.4. Remarks on epidemiological aspects of intestinal helminth infections in the Western Province.

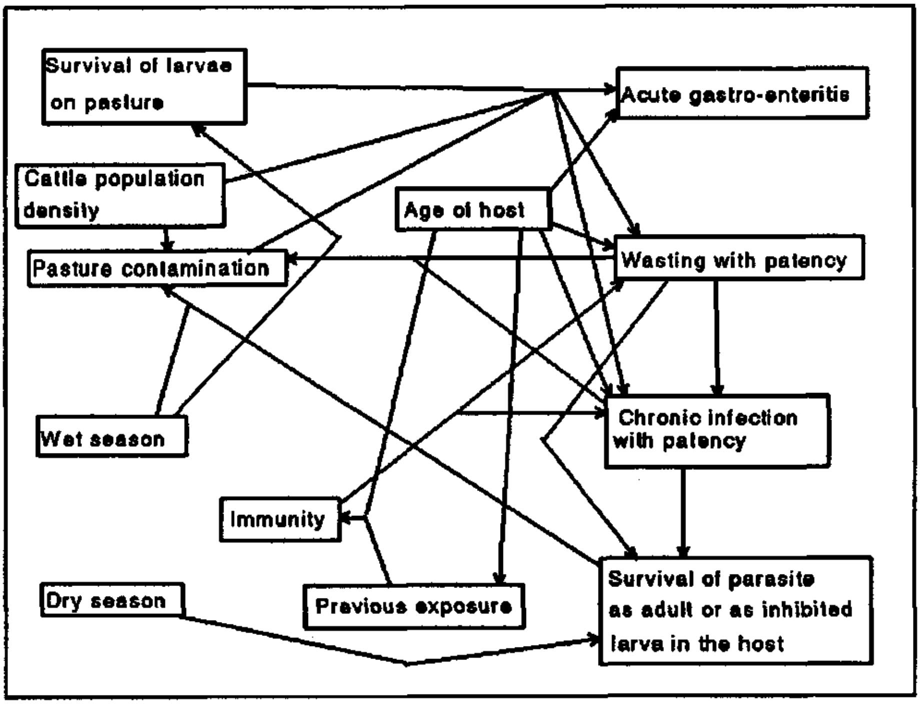
In the Western Province of Zambia detailed research into the prevalence of helminths has sofar not been carried out. Unpublished data (Bongers, 1987) on the proportion of dung samples collected throughout the year, being positive for intestinal helminth eggs, do show a seasonal pattern in egg shedding, with the highest proportion of positive samples in the second half of the rainy season.

Figure 2. shows risk factors theoretically involved in the epidemiology of intestinal helminth infections. It is likely, that results as reported here for other parts of Africa apply to Western Province as well, because of similarities in influences of climatic factors. Some of these factors and their probable relevance for the Western Province are given in table 2. The rainy season is the most critical period for helminth infections. The parasites survive the dry season either as an inhibited larva or as an adult in the host. The inhibited larvae will start developing into adults when the rains have started. In this period pasture contamination starts to build up and the amount of infective larvae increases in the course of the rainy season. The number of parasites in the animals will also increase as the rainy season progresses. As in Nigeria (Okon and Akinpelu, 1982), rainfall may be the most critical factor in determining the survival time of larvae on the pasture. The low temperatures in the cold dry season following the rainy season may also be a factor. The worm burden in the animal is likely to be largest when the dry season starts.

3.4. Research on influence of infections on productivity.

Research into the effects of infections with intestinal parasites and liverflukes on productivity is generally restricted to on-station experiments where groups of animals that respectively were and were not treated with anthelmintics or flukicides are compared with each other under relatively well defined conditions. Field experiments are generally limited to small ruminants. A consideration in this may be, that in such experiments the animals are often owned by the

Figure 2. Diagram, showing the theoretical interrelations between risk factors relevant for the epidemiology of infections with intestinal helminth parasites in sub-Saharan Africa.



research institution and placed under the care of regular herd owners. Obviously it is cheaper in such cases to use small ruminants for this.

In the literature named, the productivity traits assessed mostly are growth and weight gain, growth rate, conception rates and birth weights of calves. Milk quality, milk yield and feed conversion are also mentioned.

3.4.1. Liverflukes.

Considerable differences in the effects of infections with liverflukes on productivity are described. Chick et al. (1980) found a clear negative effect of moderate Fasciola hepatica infections on the growth of 12 month old Hereford steers in New South Wales, Australia. Especially after the first 12 weeks

Table 2. Climatic factors relevant for the occurrence of infections with intestinal helminths in sub-Saharan Africa, as derived from literature. In the columns on the other African regions, factors that may be of comparable importance in the Western Province, Zambia, are marked with an asterix.

Factor	The Gambia (Kaufmann and Pfister, 1990)	Nigeria (Okon and Akinpelu, 1982, Chiejina and Emehelu, 1986)	Tanzania (Lyaku et al., 1988, Connor et al., 1990)	Sudan (Magzoub et al., 1990)	Zimbabwe (Pandey, 1990)	South Africa (Malan et al., 1982)	Western Province (Bongers, 1987)
Pasture contamination							
Humidity and survival of eggs and larvae	+*	+*	+*	+*	?	?	?
Parasite infections in the host							
Wet season and level of infection	+*	?	?	?	+*	?	+
Highest level of infection in second half of wet season	?	?	?	?	+*	?	+
Dry season survival in the host as adult or inhibited larva	+*	?	?	?	?	?	?

(continued on the next page.)

(Table 2. continued.)

Egg shedding							
Peak in egg shedding in the (second half of the) rainy season	?	+*	+*	?	?	+*	+
Peak in egg shedding prior to wet season ("rains rise")	+	?	?	?	?	?	?

\+ Factor considered important
? Factor not mentioned

after infection differences of between 5 and 22 kg body weight were found at an average weight of around 320 kg, depending on the stocking rate and the number of metacercaria administered. The daily weight gain did not differ greatly between the groups in the subsequent period from week 12 till week 32, but the uninfected controls did maintain their initial advantage. Hope Cawdry et al. (1977) found a similar effect of Fasciola hepatica infections in beef cattle in Ireland. The weight gain losses found were in the range of 8 to 9 % over the first half year after infection. Higher infection levels caused weight gain reductions up to 28 % in the first half year. Liddel (1972), describing research into the effects of a molluscicide, also indicated a negative effect of infections on productivity.

Knapp et al. (1971) however, could not identify negative effects of low numbers of Fasciola hepatica (mean number of flukes recovered 6 months after treatment were 9.6 for untreated controls and 4.4 for treated animals). Weight gain was even reduced in animals with naturally acquired infections treated with oxyclozanide at a dose rate of 15 mg./kg. body weight. The feed conversion was slightly higher in the treated group (10.69 kg of feed/kg of weight gain as opposed to 9.84 for the untreated controls), and the cost of food per kg. of growth was higher ($ 0.69 per kg of weight gain, $ 0.64 in untreated controls). Knapp et al. (1971) did not discuss the cause of the fact, that treated animals did not perform as well as the controls. They considered the drug to be well tolerated at the dose rate used, since no adverse signs of toxicity were observed. It would seem, that inapparent toxic effects may still have been present. Owen (1984) could also not identify significant differences in growth of calves that were 5 to 7 months of age at the start of the trial with low levels of Fasciola hepatica infections in Papua New Guinea, in comparison with treated animals. The liverfluke infection levels were determined by introducing fluke-free tracer calves in the herd for three month periods and subsequently killing them to count the number of flukes present. The number of flukes in tracer calves never exceeded 20, which is considered to be a low level of infection (Oakley et al., 1979). The trial lasted 18 months. It was suggested, that compensatory food intake masks the effect, or that mineral deficiencies may have played a part. Also the fact that most damage is done by the early stages of the liverflukes, which are generally less affected by most drugs may be the reason for not finding significant effects. The low level of infection may also have caused the lack of significance.

Oakley et al. (1979) described the effects of _Fasciola hepatica_ infections in dairy heifers. They found, that the level of infection was determinant in the expression of the effect of the infection. A group of infected animals having a high level of nutrition (i.e. fed to gain 680 grams per day) needed more concentrate feed (1,345 kg., as opposed to 1,220 kg. in a period of 326 days) to achieve their condition and had a lower growth rate than uninfected controls with the same nutritional status. Over a 326 day period the uninfected control animals gained 698 grams, and the infected animals 680 grams per day. The same condition was in some cases not reached. In a group with a low nutrition level (in which the infected animals were fed the same quantity of concentrate as the high level control group, and the uninfected animals were fed to maintain the same live-weight gain as the low level infected group) the differences in growth rate were less pronounced, while the _F_eed _C_onversion _R_ate for _C_oncentrates (Conc. FCR) was significantly influenced. The Conc. FCR for the infected animals was 5.90, and for the fluke free controls 4.18. The conception rate and the calf birth weight of the high level control group was significantly higher than all other groups. The conception rate was 93 % in this group, 62 % and 81 % in the infected groups and 81 % in the uninfected low level group. The calf birth weight in the uninfected high level group was 42 kg., as opposed to 39.0 and 40.2 kg for the infected, and 36.25 in the low level uninfected control.

Black and Froyd (1972) found an influence of _Fasciola hepatica_ infection on the quality of milk. The Total Solids content of milk was measured once a month. In cattle herds where liverfluke infections were present, Total Solids content was 12.36 % on average over a three month period starting in November. After treatment with oxyclozanide in early February, the average Total Solids content over the following 5 months was 12.54 %. In untreated controls the average over the same 5 month period was 12.08 %. In herds where no fluke infections were present no effect of oxyclozanide on milk quality could be identified. It was stated, that the liver is involved in metabolic processes leading to the synthesis of milk protein, fat and lactose. These processes may be hampered, resulting in impaired milk quality, by the damage caused by the presence of liverflukes. Since, however, most components of milk are synthesised in the mammary gland itself (Dils et al., 1977, Mepham, 1977, Jones, 1977), a more plausible explanation could be, that the reduction of the milk total solids content is an exponent of the more general effects of liverfluke infections. Hypoalbuminaemia and anaemia, the severity of which depends on the severity of the infection and the condition of the animal (Graber 1971), are likely to be instrumental in this. The efforts to compensate for these pathofysiological effects may affect the availability of amino-acids and free fatty acids in the bloodstream. It may also be possible that osmotic changes in the blood as a result of the hypoalbuminaemia has a direct effect on the solids content in the milk.

Apart from the direct effects on the productivity of animals, the effects of treatment on the contamination of the environment in which animals live may be of importance in liverfluke infection cycles. Armour et al. (1973) described a reduction of the pasture contamination through treatment of sheep infected with <u>Fasciola hepatica</u>.

The effects of flukicides on several stages of <u>Fasciola hepatica</u> are discussed by Boray et al. (1983) and Presidente and Knapp (1972). Boray et al. stressed the importance of efficiency of flukicides against young as well as old stages of liverfluke. They studied results of treatments with triclabendazole in sheep, infected through intraruminal injection of 200 metacercariae (medium infection level) or 500 metacercariae (heavy infection level). The efficiency was measured by treating half of the animals and retrieving flukes after slaughter from both treated and untreated animals. From the numbers of flukes recovered from both treated and untreated animals the efficiency can be calculated. At a dose of 2.5 mg./kg. the efficiency of the drug against 8 and 12 week old flukes was 90 and 98 % respectively. At a rate of 5 mg./kg. the efficiency was 92 % against 4 week old flukes, 98 % against 8 week old flukes and 100 % against flukes of 12 weeks of age. The efficiency of triclabendazole depended on the dose rate, rather than on the level of the infections. Presidente and Knapp described the efficiency of rafoxanide against young flukes of 6 weeks of age in Holstein-Friesian steer calves. The calves were inoculated by stomach tube with 200 metacercariae per day for 5 consecutive days. Half of the three groups of 10 animals were inoculated with cattle strain metacercariae and the other half with sheep strain metacercariae. One group was used as controls, while the other two greoups were treated at dose rates of 7.5 and 10.0 mg./kg. body weight respectively. The efficiency found in this experiment was 58.8 % against 6 week old flukes. No difference was found between the dose rates, while the differences in efficiency between the strains of flukes were inconclusive. Both references do not discuss the reason for the fact that young stages of flukes are often less affected by drugs than older stages. There may be a relation with the drug reaching therapeutic concentrations in the bile system, rather than in the blood or (liver) tissue. Older fluke stages live in the bile system, while young flukes migrate predominantly through the parenchyma of the liver, and may therefore be less exposed to these therapeutic concentrations.

Productivity effects of Fasciola gigantica have, apparently, rarely been subject of research. It is assumed that Fasciola gigantica produces similar effects as Fasciola hepatica. Clinically and pathologically, the effects of the presence of Fasciola gigantica infections in cattle are indeed comparable, although acute fasciolosis, as reported by Babalola and Schillhorn van Veen (1976), and as observed in the Western Province, is rarely, if ever, reported in cattle resulting from Fasciola hepatica infections.

3.4.2. Intestinal helminths.

In many cases research into the effects of intestinal parasites on productivity is carried out by evaluating the effect of treatment on growth. Abdalla (1989) studied the effect of treatment with Avermectine on the growth rate of stabled calves and sheep in an on-station trial. The treated animals had a higher growth rate, but the differences were not significant, probably because of the relatively small size of the sample and the short duration of the trial. Bianchin and Honer (1987) note in their review of research on productivity and intestinal parasites in field experiments, particularly in extensively managed Nellore cattle in the Cerrado region in Brazil, that a positive effect of treatment on growth could be found. Also Chiejina and Emehelu (1986) found favourable effects of treatment on growth in Nigerian cattle in an on-station trial. Each of the treatment schedules tested improved the growth of the animals significantly. Kaufmann and Pfister (1990) found better growth of N'Dama cattle and a lower weight loss during the dry season. The daily growth rate of treated animals was 403 gr. per day, and that of untreated controls was 270 gr. per day. The weight loss during the dry season was not quantified in this paper. Parent and Samb (1984) compared Avermectine and Tetramisole for their influence on growth of Zebu-N'Dama cross calves in Senegal and found a considerable difference between the two drugs, Avermectine proving the most effective in improving the growth. In this on-station trial, over a period of 120 days, the weight gain in a group treated with Avermectine proved to be 7.64 kg higher than that in a group treated with Tetramisole. The initial mean weights of the two groups were 99.42 kg and 97.29 kg respectively, and the mean weights after 120 days were 141.04 kg and 132.28 kg respectively.

De Rond et al. (1990) not only evaluated the effects of Avermectine and Febantel on growth, but also on age at first service, milk yield and EPG. This study was done in Dutch Friesian dairy cattle in Sri Lanka. On the basis of growth per day, the period necessary to arrive at a body weight of 230 kg., at which weight the animals were sired for the first time, was calculated. After treatment with Avermectine, the age, or rather the weight for first service would be reached 96 days earlier than in untreated animals. After treatment with Febantel, this weight would be reached 43 days earlier. The milk yield was improved by 112 kg. the Febantel treatment, and 118 kg. for the Avermectine treatment, over a period of 133 days. The benefits of reduced age at first service and improved milk yield outweighed the cost of the drugs.

Connor et al. (1990) noted, that goats receiving treatment against internal parasites in Tanzania had a considerably better growth rate than untreated controls. Treated animals weighed 13.32 kg on average 22 weeks after the start of the treatment schedule, and untreated controls weighed 11.94 kg. on average. Around the start of the schedule the average weights in both groups were around 10.5 kg. Muenstermann and Tome (1989) found improvement of growth in treated sheep and goats in on-station experiments in Kenya. In a trial period lasting from September 1985 to April 1986 treated goats and sheep gained 9.4 kg. on average, and untreated controls 7.3 kg. on average. In a second phase, between May 1986 and November 1986, untreated animals gained 1.8 kg., and treated animals gained 3.5 kg.

Ploeger (1989) studied relations between the productivity parameters girth, body weight and milk production and infection levels of intestinal parasites, measured on the basis of serology, egg and larval counts in faecal samples and pepsinogen values in serum samples, in field studies in commercial dairy herds in The Netherlands. Several age categories were included in the studies. Apart from significant relations between infection levels and negative influences on growth, liveweight and milk production, positive influences, particularly on growth, in the second grazing season, were found of infections in the first grazing season. This was the result of immunity acquired during the first season. Barger and Gibbs (1981) found in an experimental setting that dairy cows infected with 15,000 infective trichostrongylid (Ostertagia and

Cooperia spp.) produced 2.16 kg./day less milk than uninfected controls. The experiments were carried out with Holstein and Jersey cattle in the USA.

3.5. Discussion.

In the epidemiology of both Fasciola gigantica and intestinal helminth infections, the management, the environment and the seasonal variation appear to be of importance. Management factors may include the choice of watering points, particularly for liverfluke infections, or the choice of pasture, mainly for intestinal helminth infections. Hand dug waterponds or wells may be a less suitable habitat for the intermediate host of the flukes than periodically flooded riverloops and pools. Heavily grazed pastures are more likely to pose a threat of infection with intestinal helminths than pastures with low densities of cattle.

Floodplain grazing, mostly associated with the dry season, is instrumental in the exposure of cattle to infections with liverflukes. In the Western Province of Zambia, the use of the floodplains for grazing is not just restricted to the dry season. In the central plains, the animals graze the floodplains for the larger part of the year. Normally they are only moved out when the waters rise too high towards the end of the wet season. The floods subside in the course of the dry season, and the animals will be taken back to the plains as soon as the waters have gone down far enough. From that moment onwards, normally from around June or July, the highest exposure is likely to take place, also because the intermediate host concentrates in ever smaller pools of stagnant water. In the southern plains, along the Namibian border, the animals are moved to the plains in search of water, and are moved out again as soon as the rains have started and pools develop on higher ground. It may be possible, that peak exposure takes place more strictly in the dry season in these plains, and that the exposure may be more prolonged in the central plain.

In intestinal helminth infections, the wet season seems to be of great importance. After having survived the dry season in the vertebrate host, either as an inhibited larva or as an adult, the infections become patent, i.e. the parasites end their inhibited stages, mature, and start producing eggs, when the rains start. After the first infective stages have developed on pasture, the level of the infections in the hosts starts to increase, as well as the number of animals infected. With these infections becoming patent, the contamination of the pastures increases in the course of the wet season. In the second half of the wet season the risk of exposure is at its' peak.

* Strategic treatment against intestinal nematodes as well as liverflukes should aim at two main goals. Firstly, it should clear an animal from an infection, secondly, it should reduce, or rather prevent, the contamination of the pasture.

Todd argued, that treatment of animals against intestinal nematodes in an environment in which they re-infect themselves again is useless (Anon., 1979). Graber and Perrotin (1983) suggested one treatment against intestinal nematodes at the end of the wet season to prevent the survival of infections in the animals through hypobiotic larvae, and one treatment at the end of the dry season to prevent recontamination of the pastures. It could be considered to give extra treatments during the dry season in order to reduce the weight loss incurred during that period. Chiejina and Emehelu (1986) on the other hand, discussed treatment schedules in which the emphasis was placed on wet season treatments, because the re-infection chances are greatest during that period. The basic argument for the recommendation of treatment in this case is the presence of the parasites, and hence impaired health, and the beneficial effect of routine treatments on growth. Prevention of pasture contamination is a far less important aim in this context. It can be argued, that regular treatments, aimed at reducing the level of the infection in animals, without causing complete sterility, can prevent heavy adverse effects of the presence of the parasites, while at the same time allowing the animals to develop a good premunity, based on regular re-infection. As was already mentioned, Ploeger (1989) found clear indications that previous infections reduced the severity of the consequences of subsequent infections.

In the Western Province, attempts at prevention of the contamination of the pasture through treatment is not likely to produce any results. It could only produce effect if all herds using the same communal grazing grounds would follow the treatment schedule, but even then, several of the parasite species may have reservoirs in wild animals grazing the same land. Treatment should therefore only be given if an effect on the animal itself is pursued. Treatment schedules should concentrate in the second half of the rainy season, when pasture contamination is building up and the challenge is highest. A treatment just after the rainy season could allow the animal to dispose of any adult worm burden. This could probably reduce the size of the weight loss incurred during the dry season.

Strategic treatment against liverflukes is often associated with the period of the year most suitable to reduce the infection of the intermediate hosts (Armour et al., 1973, Simpson et al., 1985). In European cattle and sheep it is often recommended to apply a treatment against Fasciola hepatica in the early winter period (Black and Froyd, 1972, Horchner et al., 1970), when the animals are stabled, i.e. aimed at preventing patent infections at the start of the grazing season. Scott and Goll (1977) treated sheep in the Ethiopean Highlands against Fasciola hepatica in November and January. The wet seasons in this region begin in June and last untill September. A short wet season appears in March. Owen (1984) carried out an experiment with calves in Papua New Guinea, into the effects of five different treatment schedules. Only the results of a schedule in which treatments were given once every three months approached significance. Armour (1981) mentioned this treatment schedule as the most appropriate for the treatment of liverflukes in tropical cattle.

In the Western Province a seasonal pattern in the infective cycle of Fasciola gigantica exists. As was already stated for intestinal helminths, designing a strategic treatment schedule against liverflukes is not likely to be of great significance in reducing the risk of liverfluke infections, since the pastures and watering points are communally used, and infected game use the same pastures and watering points. The aim of treatment should therefore be to keep the infection at a moderate level, allowing the animals at the same time to increase the resistance against reinfecting young flukes, both through premunity and through changes in liver tissue (Kendall and Parfitt, 1975). Mainly because of the fact that infections occur throughout the year, the schedule recommended by Armour (1981) and proven effective for Fasciola hepatica by Owen (1984) would probably be the most appropriate for the Western Province as well.

An infection with intestinal nematodes or liverflukes may be an important factor affecting productive potential of livestock. It is however by no means the only factor influencing performance. Productivity of traditionally managed livestock in Africa is highly related to the seasons, the quality of the forage and the management abilities of the farmer. Malnutrition (Troncy, 1989), or rather a suboptimal nutritional status, can in itself be the result of all these factors mentioned. A low level of nutrition may mask subclinical infections (fasciolosis: Oakley et al., 1979). Environmental circumstances are therefore at least as important as the presence of the parasites in considering the necessity and viability of regular treatments.

The input in traditional livestock systems is generally low, compared to the benefits (Baars, 1987). If extra inputs are needed, the benefits resulting from these inputs should be clear. The objectives of livestock keeping in traditional systems determine to some extent which beneficial results of treatment are considered important. Beneficial effects of treatment should be easily measurable. Treatments are only economically justifiable if the costs are outweighed by the improvements. In the benefit definitions used by Baars (1987) the herd increase, and the resulting improved availability of animals (for sales, barters, and probably for draught power, milk and manure supply) is likely to be the main feature to be studied to determine whether an economic gain is to be derived from routine treatments.

As De Leeuw (1990) discussed for examples of pastoral and agro-pastoral systems in several areas in sub-Saharan Africa, and Matthewman (1980) discussed for the Zambian situation, farmers will generally aim at increasing the size of their herds, or rather, at reducing the risks of decreasing herd size. Reducing mortality and improving reproductive performance is therefore of greater importance than optimizing growth rate of individual animals. Growth rate as such is hardly of importance. In the Western Province of Zambia, supplement feeding of traditionally managed cattle is rarely, if at all, done. Animals are not primarily kept for sale, and most animals will be sold at an advanced age. No special efforts or inputs are needed for the animals to reach their adult weight. Improved growth rate is however of indirect importance, since the age of sexual maturity is a function of growth (Ogink, 1993, p.27, Peters, 1983), and this is related to the age at first calving.

Since mating is normally not supervised, but is left to nature in the traditional cattle husbandry system in the Western Province, decreasing mortality is likely to be a more obvious and visible result of treatment for the Western Province cattle owner than improving reproductive performance. From the point of view of the cattle owner it is therefore probably the most important parameter.

Nevertheless, increasing reproductive performance remains an important prerequisite in view of the general aim of increasing the herd size. Increasing reproductive performance can be expressed by the increasing number of calves being born per unit of time and lowering the age at first calving. Parameters to indicate the increasing number of calves are the calving interval, expressed as the period between the birth of a calf and the birth of the next calf of the same cow, and the calving percentage, expressed as the number of calves being born during the year divided by the number of cows present in the same time span.

Increase of the herd size and growth rate of animals are both values that would be relatively easy to quantify in economic sense. The cost-benefit ratio of treatment policies can be derived in a simple manner from these aspects. Longitudinal studies into these benefits are a way of determining the effect of treatment under field conditions. In field research in the Western Province of Zambia into the effects of regular treatments against intestinal nematodes and liverflukes on productivity these factors were therefore envisaged for evaluation.

In the trials carried out for this research, the treatment schedules were primarily aimed at reducing the level of the infections of intestinal parasites and liverflukes as much as possible, in order to evaluate the effects on the productive parameters most effectively, given the local conditions and the fact that the choice was made to carry out field trials, rather than on-station trials. Since it is not likely that any advantage is gained, if a treatment schedule against liverfluke infections is based on the seasonal pattern, for the liverfluke infections a schedule of four treatments a year at three monthly intervals was used. For the intestinal helminths a seasonal variation in the effects of infection was expected. Therefore in the trials involving treatments against intestinal helminths a schedule was used, in which treatments were given at six week intervals in the rainy season and at three month intervals in the dry season, six treatments a year.

Whether the treatment schedules as used in the trials are also suitable for practical use, can be evaluated on the basis of the effects and the costs of the treatment. It is likely, that a treatment schedule, aimed at reducing the consequences of infections for the animal, should be less intensive than that used in the trials. This may particularly be the case for the treatment against intestinal helminths. The economic viability of the treatment schedule of choice remains a critical issue.

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CHAPTER 4

Intervention study

4.1. The use of a herd monitoring programme for the evaluation of the influence of antiparasitic treatments on the productivity of traditionally managed cattle in the Western Province of Zambia I: interventions with Triclabendazole and Rafoxanide.

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Introduction.

In the Western Province of Zambia the liverfluke Fasciola gigantica is present in most of the cattle, as is illustrated by the results of surveys of livers at abbatoirs, where over 90 percent of the livers were positive (Silangwa, 1972, 1973), and studies into egg deposition, where between 50 and 80 percent of the animals appeared to excrete eggs, depending on the season (Jorgensen and Kamukwai, 1977). Liverfluke infections can, without causing clinical disease, impair the productive performance of livestock. Babalola and Schillhorn van Veen (1976) mentioned general weight loss, lowered milk production and impaired reproductive performance, without quantifying these values, and the direct financial loss as a result of massive liver condemnations. Black and Froyd (1972) discussed the influence of liverfluke infections on the quality of milk. Simpson et al. (1985) argued that in financial terms the benefits of treatment against liverflukes outweigh the costs, on the basis of cost-benefit estimates derived from questionnaires among several production and veterinary specialists in Florida, USA. The benefits were derived from estimated reductions in death loss, weight loss and reproductive loss (loss in calf crop).

In this paper the question is adressed whether it is possible to evaluate the effect of flukicide treatments on productivity by carrying out field studies with a clinical nature, with the use of a herd monitoring programme, that has been used for the assessment of general productivity data (Van Klink et al., 1994a-d), given the logistic difficulties of working in a rural area within the framework of a livestock development project (De Rooij and Wood, 1990). Apart from the treatment, the age of the animals and environmental aspects such as the Grazing Management System and season were included in the analysis.

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Materials and methods.

Area and climate.

A description of the area in which the trials were carried out and the climate has been given by Van Klink et al. (1994a). Herds based in the Grazing Management Systems (GMS) 1 and 2 were used in the intervention trials. Both are transhumant systems, meaning that the herds graze the flood plain of the Zambezi river part of the year, where they are exposed to fluke infections (Jorgensen and Kamukwai, 1977). They are moved over a distance of 10 to 40 kilometers to higher grounds for the rest of the year. In GMS 1 the animals graze the floodplains for the largest part of the year, moving out of the floodplains when the rising water forces them to do so. In GMS 2 the animals only graze the floodplain in periods that watershortages on higher grounds force them to stay close to the river.

Experimental herds and treatment schedule.

A total of 6 privately owned traditionally managed herds of cattle, maintained in the Grazing Management Systems mentioned (three in each GMS) in the Western Province of Zambia were involved in the flukicide intervention trials. For field logistic reasons and because of the desired intensive level of supervision the number of herds involved is fairly small. The herds were monitored during the complete treatment period, using the automated herd monitoring system described by Van Klink et al. (1994a). The monitoring was carried out through two-weekly visits by Veterinary Assistants and three-monthly visits by District Veterinary Officers, aided by computer produced checklists.

Because of the relatively small number of herds involved in the trials, it was not possible to achieve sample sizes large enough to allow demonstration of realistic statistical differences in values of parameters expressed as proportions. They were expected to be large enough to demonstrate statistical differences in values of parameters expressed as means.

Split-herd trials were conducted, and a control and a treatment group within each of the six herds was formed, by ranking the animals according to age, within the sexes, and assigning them alternately to either the treatment group or the control group. Treatment and control groups were grazed together. A treatment schedule with Triclabendazole[2] was applied in the treatment groups of three of the herds, and one with Rafoxanide[3] was applied to the treatment groups in the three others. Treatments were given four times a year at intervals of three months. The dosage of the treatments was determined on the basis of weight assessments using the girth measurements and a girth-weight conversion table developed for cattle in the Western Province (Corten, 1988). The exact treatment dates were planned by the District Veterinary Officers of the districts in which the herds were based, but the treatments were always given within a period of two weeks in the months February, May, August and November. The treatments started in February 1989 and continued until August 1991. Statistical analysis was based on the results recorded between 1st August 1989 and 31st July 1991.

For the analysis of the productive performance all animals below the age of two years and all female animals were involved in the trial. At the start of the survey period, in August 1989, around 400 animals were involved in the Triclabendazole trial, and around 300 in the Rafoxanide trial. Newborn calves were automatically assigned to the same group as the mother, either treatment or control. The treatment period started 6 months earlier than the survey period; in this manner a possible start-up period, in which the treatment should develop its effect, was kept outside the analysis. For this reason it was deemed necessary to assign new entries from outside the herds to the control group, assuming that, since these animals normally originated from herds in the same environment, they would have had a comparable exposure to liverfluke infections before entering the herd. The total numbers of animals that were involved in the treatment and control groups during the complete survey period were 234 treated and 260 control animals for the Triclabendazole trial, and 130 treated and 223 control animals for the Rafoxanide trial.

Records taken and parameters measured.

During the two-weekly visits the Veterinary Assistants recorded all changes that occurred in the composition of the herds; births, new entries, removals through death, sales, slaughters, with the dates on which the events took place, and

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[2]Fasinex; Ciba-Geigy Ltd., Basle, Switzerland.

[3]Ranide; Merck, Sharpe and Dome, Haarlem, The Netherlands.

the dates at which farmers started to milk animals, when they stopped milking, and when calves stopped suckling. During the three-monthly visits the animals in the treatment group were treated, the girth of all animals was measured and the information gathered by the Veterinary Assistant was checked against the checklists. Faecal samples were taken at each visit of 5 animals from the control group and 5 animals from the treatment group for examination on the presence of liverfluke eggs. For the concentration of the eggs, sieves with decreasing mesh sizes were used. The faecal samples were scored positive or negative for the presence of fluke eggs, and the numbers of eggs were counted. Samples were considered to be positive if at least one egg was found.

Because of the negative influence of liverfluke infections on productivity (Babalola and Schillhorn van Veen, 1976, Simpson et al., 1985), mainly on growth and weight, reproductive performance, milk production and general condition, the information was used to determine the following productivity parameters:

1. the girth measurements as an approximation of weight,
2. the calving interval, defined as the period between two consecutive births,
3. the age at weaning of the calf,
4. the interval between weaning and the next delivery.

Since general condition is likely to play an important role in farmers decisions to milk cows (Van Klink et al., 1994b), the following parameters were also analysed:

5. the interval between the birth of calves and the moment the farmers start milking the mothers,
6. the length of the milking period.

For the calculation of calving intervals and the intervals between weaning and the next delivery only those intervals were included, in which the end date, or the date the new calf was born, was at least 9 months later than the start of the survey period. For the intervals from weaning to the next delivery, the lengths of the milking period and the ages at weaning only those records were included, referring to animals delivering after the start of the survey period. For the analysis of length of the milking period, weaning age and interval between weaning and the next delivery only the records were used of cows that weaned their calves. Though deaths as a direct consequence of fluke infections in cattle are rare (Babalola and Schillhorn van Veen, 1976), the influence of infections on general health and condition may exert effects on mortality as well. Therefore statistical analyses were carried out of the probability that animals died or were slaughtered.

Calculations.

For the evaluation of the lactation intervals and of the girth measurements, analysis of variance was used. In table 1 the models of the analysis of variance used are given. Apart from the intervention, environmental factors as well as animal characteristics were included in the model; in the case of girth this included sex and season measured, in the case of the lactation intervals it included parity, and in the case of the calving interval the fate of the calf (either death or weaning). In all cases the herds were included, and interactions of the various factors with the intervention.

Deaths and slaughters were statistically evaluated using Logistic Regression analysis (Hosmer and Lemeshow, 1989). The probability that an animal would die or be slaughtered is expressed by e^{β}. The statistics of β are evaluated by the Logistic Regression analysis. Two one year periods, 1st August 1989 till 31st July 1990, and 1st August 1990 till 31st July 1991, were evaluated. In the Logistic Regression model, the intervention was included, together with sex, herd and the periods (first or second). The age at removal (or, in animals not leaving the herd, the age on 1st February 1990 (first period) and 1st February 1991 (second period)) was included as random effect. Because of the sample size the results of the analysis of deaths and slaughters should be viewed as indicative.

Results.

Positive faecal samples were found only in the first few months of the programme. Therefore, no further analysis of the faecal samples has been carried out.

In the Triclabendazole group an estimate of the mean girth size of 87 centimeters was found for the animals below the age of 1 year (500 records), and of 114 centimeters for the animals between 1 and 2 years of age (401 records). No significant differences in either age group could be found for the effect of treatment. In the group of animals below 1 year of age significant effects did appear for sex, 86 centimeters for females and 88 for males. In both age groups significant differences were found for the influence of the herd and the season. When the interactions were observed, significant differences, if any, could only be seen along the lines of herd and season, and not in the intervention part of the interaction.

Table 1. The full model used for the analysis of variance of girth measurements as indicators of weight and of lactation intervals in intervention trials involving flukicide treatments in traditionally managed cattle in the Western Province of Zambia.

Girth	Calving Interval	Interval calving-start milking	Length of milking period (weaned calves)	Age of calf at weaning (weaned calves)	Interval weaning-next delivery (weaned calves)
Intervention: - Treatment - Control Sex - Female - Male Herd Season[&] Intervention * Herd Intervention * Season[&]	Intervention: - Treatment - Control Parity: - 1 to >4 Fate of calf: - Dead - Weaned Herd Intervention * Parity Intervention * fate of calf Intervention * Herd	Intervention: - Treatment - Control Parity: - 1 to >4 Herd Intervention * parity Intervention * Herd	Intervention: - Treatment - Control Parity: - 1 to >4 Herd Intervention * Herd	Intervention: - Treatment - Control Parity: - 1 to >4 Herd Intervention * parity Intervention * Herd	Intervention: - Treatment - Control Parity: - 1 to >4 Herd Intervention * parity Intervention * Herd

& Season: 1=January-March, 2=April-June, 3=July-August, 4=September-December

In the Rafoxanide group significant differences were found for sex, herd and season in both age groups. The estimates for the mean girth sizes found were 90 centimeters for animals under the age of 1 year (313 records), and 116 for animals between 1 and 2 years of age (247 records). In the age group between 1 and 2 years, a significant difference between treatment and control group was found. The estimate for the girth size of treated animals was 117 centimeters, for the controls 114 centimeters. In the interactions the difference patterns of herd and season could be recognised.

Hardly any significant differences could be identified for the lactation intervals. The estimated value for the calving interval was 651 days in the Triclabendazole group (99 records), 676 in the Rafoxanide group (71 records). No differences could be identified between any of the variables in the model. In the interval calving-start milking a difference was found between the herds, in the Triclabendazole group (110 records). The mean value was 94 days, and in the Rafoxanide group (108 records) it was in the same range. In the interval between weaning and the next delivery, with a mean estimated value of 315 days in the Triclabendazole group (71 records) and 247 in the Rafoxanide group (47 records), also differences were found between herds. In the Rafoxanide group a difference was found between treated (215 days) and untreated (278 days) animals.

In figure 1 the reasons for removal of animals are given for both treatment schedules. Exchanges between herds for any reason were not included in the figure. The largest part of the animals slaughtered had to be slaughtered because of disease or weakness. In all cases the number of animals sold was less than the animals that died and were slaughtered. No significant differences in sales figures could be found between the treatment and control animals in each schedule.

Table 2 shows the results of the Logistic Regression analysis of the removal figures. For illustration, the number of animals dying of being slaughtered in the two one year periods as a proportion of the total number of animals present in these periods are indicated. No significant differences were found for the effect of treatment in both groups. Significant effects were found for herd and age in the Rafoxanide group, and for herd and sex in the Triclabendazole group.

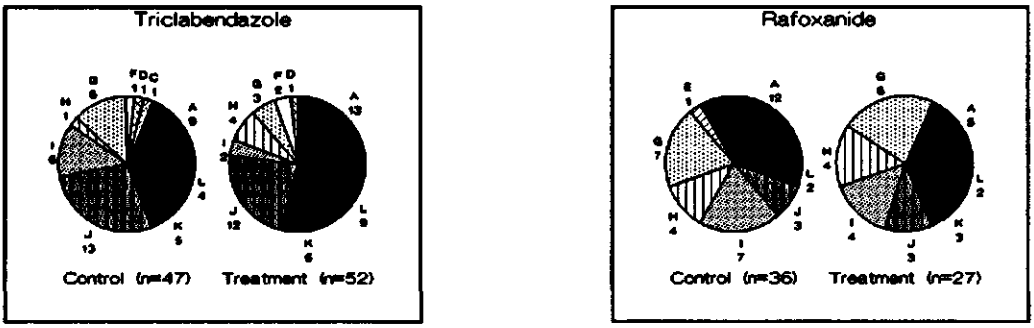
Discussion.

The schedule of the flukicide treatments was designed on the basis of literature on the interval between infection and potential patency through egg shedding (Soulsby, 1968, Armour, 1981). The aim of this intensive schedule was to determine whether an effect of radically suppressing fluke infections on productivity could be found.

No technical reason could be found for the fact that hardly any fluke eggs have been found. Although attempts were made to rule out the possibility of maltreatment of the samples during transport to the laboratory this cause cannot be alltogether excluded. However, examination of faecal samples has several limitations (Armour, 1981, Troncy, 1989). Eggs are expelled intermittently, depending on the evacuation of the gall bladder, and their number is never an indication for the severeness of the infection. In many cases no eggs are found, or the counts are low, even in high infection levels.

As in many parts of Africa, and in many African ruminant species (Ogunrinade, 1984, Schillhorn van Veen, 1980), Fasciola

Figure 1. Number of animals sold, slaughtered and died between the first of August 1989 and the first of August 1991 in herds involved in intervention trials involving flukicide treatments, carried out in a traditional cattle keeping system in the Western Province of Zambia.



A = Sales
B = Slaughter for ceremony
C = Slaughter for money/meat
D = Slaughter because of sickness
E = Slaughter because of accident
F = Slaughter because of weakness
G = Death after sickness, meat consumed/sold
H = Death after sickness, meat discarded
I = Sudden death, meat consumed
J = Sudden death, meat discarded
K = Death after emaciation, meat consumed
L = Death after emaciation, meat discarded
M = Death, not specified

gigantica is widespread in the Western Province, as was demonstrated by a high percentage of liver condemnations, positive livers and positive faecal samples (Silangwa, 1972, 1973). The largest egg excretion rates are reported to take place in the early dry season, and the largest number of infected livers between January and June (Jorgensen and Kamukwai, 1977). Treatment against the fluke does however not seem to influence productivity, although even low numbers are suggested to cause loss of production (Babalola and Schillhorn van Veen, 1976, Chick et al., 1980, Hope Cawdry et al., 1977). The reason for this may be, that most of the damage is done by young flukes, that are difficult to approach by any treatment (Mohammed-Ali and Bogan, 1987), that the infection level is moderate, or that the effects of the fluke infestation is masked by low nutritional levels (Owen, 1984, Oakley et al., 1979; both in F. hepatica infections). Contrary to the last remark Simpson et al. (1985) argued that the effects of treatment would be better when nutritional levels are lower. Both Rafoxanide and Triclabendazole are reported to be

Table 2. Results of the logistic regression analysis of deaths and emergency slaughters in trials involving flukicide interventions in traditionaly managed cattle from the Western Province, Zambia, calculated over the period 1/8/89 till 31/7/91.

	Triclabendazole				Rafoxanide			
variable	No. of animals in group	% d./sl.[#]	β	s.e.	No. of animals in group	% d./sl.	β	s.e.
intercept	805		-1.3492	0.3286	563		-2.7427	0.5651
Control	433	8.8	ref.		355	6.7	ref.	
Treatment	372	10.5	0.1379	0.2543	208	10.6	0.4327	0.3207
Herd 1	212	22.6	2.1327[a]	0.4005	143	13.3	1.5317[a]	0.5289
Herd 2	368	5.7	0.5666[b]	0.4274	298	7.4	0.7379[b]	0.5140
Herd 3	225	3.6	ref.[b]		122	4.1	ref.[b]	
F	655	7.8	ref.[a]		457	7.4	ref.	
M	150	17.3	0.9112[b]	0.3253	106	11.3	-0.0276	0.4177
Period I	419	11.2	ref.		306	9.8	ref.	
Period II	386	7.8	-0.2310	0.2581	257	6.2	-0.4846	0.3289
Age out (per month of age)		9.6	-0.0012	0.0033		8.2	-.0098[1]	0.0042

[#] d./sl. = deaths and emergency slaughters
[*] Values with different letters in the superscript differ significantly ($p<0.05$)
[1] Effect significant ($p<0.05$)

effective against young flukes in sheep (Rafoxanide: over 90 % effective against flukes of four weeks and older (Armour and Corba, 1970, Armour et al., 1973), Triclabendazole: over 90 % effective against flukes aged four weeks and older (Boray et al., 1983)); Presidente and Knapp (1972) found a low effectivity of Rafoxanide (58.8 %) against young (6 week old) F. hepatica in cattle.

Knapp et al. (1971) could not identify positive effects of treatment with oxyclozanide on body weight gain and feed efficiency in moderate fluke infections (4 to 10 flukes per liver on average). Kendall and Parfitt (1975) suggested, that alterations in the livers, caused by the infection, influence the rate at which the host rejects the flukes, the reinfection rate as well as the accessibility of the flukes for flukicide drugs. Treatment of old fluke infections is therefore not viable.

The circumstances under which the trials have been carried out may undoubtedly have played a role in the observation, that in general the results obtained in the trials do not show clear advantages in terms of productivity for the treatments involved in the studies. Logistically there are limitations to the size of the sample that can be surveyed in a reliable manner, when working with privately owned herds in a vast rural area. Conducting trials under these circumstances depends on the willingness to participate by farmers and personell alike. For the sake of close supervision, the groups of herds involved had to be manageable.

Notwithstanding the fact that for logistic reasons the number of animals involved was not very large, the size of the sample was thought to be sufficiently large to identify significant differences between treated and untreated animals larger than those between eg. Grazing Management Systems as found by Van Klink et al. (1994b), for the dependent variables with continuous values, such as the lactation intervals and the girth measurements. If the formula for sample size determination (Martin, Meek and Willeberg, 1986, p. 45, Fleiss, 1986, p. 369) is applied to eg. the differences between the girths in the age group over the age of two years in GMS 1 and GMS 3 (Van Klink et al., 1994b), a difference of roughly 7 cm. in girth, and the expected standard error is estimated at around 3 cm., less than 20 animals in both treatment group and control group should be sufficient to identify this difference.

The environmental circumstances not explained by the models used may, however, still be substantial, influencing the reliability of the results. Whether this would be of importance for the practical implications of the results of the trial depends entirely on the economic value of existing differences; the cost-benefit relation between the maximum amount of investment and the minimum amount of improvement of productive performance required. This economic validation has not been carried out in the framework of this trial.

The sample size for the determination of the influence of treatment on deaths and slaughters proved to be far from adequate. The fact that no effects of treatment could be measured, should likely entirely be contributed to this. The sample size would have to be increased, or the survey prolonged substantially to meet the requirements demanded by the formula. Both the logistic difficulties in the field mentioned earlier, and the fact that the surveys are carried out in a development project, that counts the use of results, rather than research as such among its objectives, limits the possibilities to attain this. The results of the analysis of deaths and slaughters obtained in this study should be viewed together with the results of girth and lactation intervals. In the following discussion the results of all analyses will be reviewed, as obtained in this study. Conclusions will be drawn mainly on the basis of the results of the continuous dependant variables, bearing the remarks made sofar in mind.

The weight of animals in the first two years of age does not seem to be influenced significantly by the treatments given, except in one year old animals in the Rafoxanide herds. The girth measurements of treated animals in this group are slightly bigger. The effects of sex, herd or season are in most cases significant. The influence of the environment and management would seem to be of greater importance. Van Klink et al. (1994a-d) also found influences of the environment and management.

The present information does not allow conclusions as to the economic relevance of the effect seen in the one to two year old animals in the Rafoxanide group. In the traditional system of the Western Province, weight is of limited direct importance. The management is not aimed at producing young animals for sale. The importance of improved weight through treatment lies probably only in the fact that these animals may mature earlier and contribute to the increase of the herd at an earlier stage.

In the lactation intervals very few significant effects could be found. The treatments did not have any influence on the calving interval, the interval between calving and milking, the length of the period a cow is milked and the age at which the calf is weaned. The fact that the interval between weaning of the calf and the next delivery was shorter in the group treated with rafoxanide than in the control group, may be an indication, that the body condition of the treated animals allows them to continue suckling for some time while already being pregnant. In the control group, and in the entire Triclabendazole group, the cows seem to have weaned their calves before conceiving.

In figure 1 an attempt was made to differentiate between several reasons for slaughter or death, to assess whether a difference in this pattern could be seen between treated and untreated animals. The only conclusion that can possibly be drawn from the results is, that the proportion of animals sold does not show a difference clearly indicating the advantage of any of the treatments. If treatments would have had a clear effect, more animals would probably be available for sale, but the farmers would probably decide to keep exactly these animals in the herd. The slaughters were evaluated together with the deaths in this paper, because figure 1 shows that in most of the cases animals were slaughtered because of emergencies; sickness, old age, accidents or weakness.

In none of the trials the effects of the treatments on the probability of mortality and slaughter was significant (table 2). Significant effects could only be found for herd, i.e. the effect of the management, and age at removal (Age out). It may be expected, that improvement in performance of the herd may be attained primarily through improvement of the performance of the herd manager.

For the situation in the Western Province the results of the present trial do not justify the recommendation of regular treatment schedules. The results of the lactation intervals and girth measurements analyses do not show clear advantages of treatment. It is not possible to draw independant conclusions on the effects on deaths and slaughters, but it may be assumed that differences here are not likely to be more outspoken than in the analyses of the continuous variables. As Michel (1972) pointed out for treatments against intestinal nematodes, treatment should be economically justifiable, i.e. the gain should be bigger than the necessary investment. In a traditional livestock management system, in which hardly any or no external inputs take place, the benefits should be relatively direct and easily measurable. Recommendations should at least be based on evaluation of the effects of treatments, also in economical sence.

Preventing heavy infections with liverflukes could probably best be achieved by adjusting the grazing practices. Since communal grazing is practiced throughout the province, it is unlikely that infection can be prevented entirely. It may be possible to prevent the occurrence of acute liverfluke disease, as does occur in small numbers in certain periods of the year, by carefull day-to-day planning of the grazing area and carefull use of watering points. The use of man-made waterponds is likely to be preferable above watering animals in ox-bows and creeks that are periodically supplied with water by the rivers. Especially while drying up, these river branches contain large numbers of the snail Lymnea natalensis, the vector of Fasciola gigantica (ADCP, unpublished data, 1986). There appears to be a greater role for a veterinary extensionist than for a veterinary technician. Further study may have to be directed more towards the development of this type of extension messages than towards developing recommendations on routinely using drugs for liverfluke control.

On the basis of the results obtained it is difficult to answer the question whether the herd monitoring programme is suitable for use in clinical field trials. The fact that the differences that could be identified in the present surveys are fairly comparable with those found in productivity surveys carried out earlier would suggest, that the data collection in this manner is sufficiently accurate, and that adaptations in the trial design would improve the output of the trials.

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(submitted for publication.)

4.2. The use of a herd monitoring programme for the evaluation of the influence of antiparasitic treatments on the productivity of traditionally managed cattle in the Western Province of Zambia II: interventions with Avermectine and Thiabendazole and a combination of Rafoxanide and Thiabendazole.

E.G.M. van Klink[1], L. Schoonman[1], G.M. Bbalo[1], and I. Muhongo[1].

Introduction.

Intestinal nematodes and liverflukes in ruminants are often present without causing apparent disease. Infections do however exert pressure on the general condition of animals (Abdalla, 1989, Michel, 1972). Even when present at moderate levels of infection, the pressure on the condition, caused by internal parasites, depresses the productivity in various ways (Maingi and Gichigi, 1992). Growth (Chiejina and Emehelu, 1986) and milk production (Barger and Gibbs, 1981) may be affected, and the capability to compensate weight loss (Kaufmann and Pfister, 1990) may be impaired. Several treatment schedules have been proposed for traditionally managed livestock (Bianchin and Honer, 1987, Chiejina and Emehelu, 1986, Connor et al., 1990, Majok et al., 1993). If any schedule is to be adopted it is necessary to evaluate the effects of treatment on the productive performance of the animals for which it is intended, particularly taking into acount the benefit in economic terms that is to be gained.

This paper describes the evaluation of the use of a herd monitoring programme that has been used earlier for the evaluation of general productivity traits (Van Klink et al., 1994c) in the Western Province of Zambia (De Rooij and Wood, 1990), for the assessment of the effect of treatments against gastro-intestinal parasites and a combined treatment against gastro-intestinal parasites and liverflukes (Fasciola gigantica) on productivity. Apart from assessing the effects of treatment on productivity the question was put forward whether the programme was suitable for the purpose, given the logistic difficulties of the rural area in which the study was carried out.

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Material and methods.

Area and climate.

The area and the climate in which the trials were carried out were described by Van Klink et al. (1994c). Herds based in Grazing Management Systems (GMS) 1, 3 and 4 were involved in the trials involving treatment against gastro-intestinal parasites, and herds from Grazing Management Systems 1 and 3 in the combined treatment. In GMS 1 the animals are maintained under transhumant management, which means that they are based in the floodplains of the Zambezi river for the larger part of the year, and move out of the floodplains over distances of 10 to 40 kilometers when the waterlevel of the river rises. The herds in GMS 3 and 4 are sedentary, which means that they do not move over considerable distances. In GMS 3 the animals are mainly maintained in upland river valleys and the high land surrounding the floodplain. The area of GMS 4 is considerably drier, and few upland rivers are present. The animals depend largely on man-made wells for their watersupply.

Experimental herds and treatment schedule.

The number of herds involved in each trial, the treatment schedule and the type of animals involved in the evaluation is given in table 1. The total number of herds involved had to be kept limited because of the required level of supervision and for logistic reasons. In each herd a treatment and a control group was formed, approximately equal in size and age composition, by ranking the animals according to age, within the sexes, and alternately assigning them to either the control group or the treatment group. The dosage of the treatments was determined on the basis of weight assessments using the girth measurements and a girth-weight conversion table developed in cattle in the Western Province (Corten, 1988).

All animals below the age of two years were included in the trials involving treatment against gastro-intestinal parasites, and all animals below the age of two years and all female animals in the combined treatment trial. At the start of the survey around 180 animals below the age of 2 years were present in the Avermectine[2] group, equally devided over treatment and control, around 90 were present in the

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[2] Ivomec; Merck, Sharpe and Dome, Haarlem, The Netherlands.

Table 1. Treatment schedules, anthelmintic and flukicide agents used and number of herds per treatment type of an intervention trial into the effect of treatment on productive performance in traditionally managed cattle in the Western Province, Zambia. In each of the herd the animals of the age group indicated were devided over a treatment and a control group.

	Thiabendazole	Avermectine	Rafoxanide and Thiabendazole
Number of herds in trial	5	6	3
Treatment schedule	6/year, dry season: interval 3 months, wet season: interval 6 weeks	6/year, dry season: interval 3 months, wet season: interval 6 weeks	4/year Rafoxanide, 6/year Thiabendazole
Type of animals involved in analysis	All animals <2 years	All animals <2 years	All animals <2 years, all females

Thiabendazole[3] trial herds. Around 270 animals below the age of two years and female animals were present in the combined treatment trial herds. The total numbers of animals having been involved during the complete survey period for each group were 149 treated and 195 control animals in the Avermectine trial, 73 treated and 103 control animals in the Thiabendazole trial, and 164 treated and 223 control animals in the combined trial, consisting of treatments with Rafoxanide[4] and Thiabendazole.

The automated herd monitoring system described by Van Klink et al. (1994c) was used to process the information of the monitoring of the herds for a period of two and a half years. The monitoring was carried out through two-weekly visits by Veterinary Assistants and three-monthly visits by District Veterinary Officers. The treatments started in February 1989, and the records taken in the period 1st of August 1989 till 31st of July 1991 were included in the analysis.

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3 Thibenzole; Merck, Sharpe and Dome, Haarlem, The Netherlands.

4 Ranide; Merck, Sharpe and Dome, Haarlem, The Netherlands.

At every three-monthly visit 5 individual faecal samples from animals in the treatment group and 5 individual faecal samples from animals in the control group were taken. The samples were purposively taken from the first 5 animals in each group that passed through the crush of the holding facility. The samples were checked for the presence of helminth eggs, in particular strongylus-type eggs, using a flotation method with sodium-chloride (Troncy, 1989). All samples containing at least one egg were termed positive. During these visits the treatments of the animals were done and girth measurements were taken.

For the analysis of the productivity the following parameters were used: the girth, as an indicator of weight (Nicholson and Sayers, 1987), and deaths and slaughters, in the trials involving treatment against gastro-intestinal parasites. Since in the combined treatments, adult cows received a flukicide treatment, parameters related to reproduction and lactation were also included. Apart from girth, and deaths and slaughters, in these herds the calving interval, interval between calving and the moment cows are being milked for the first time, the length of the milking period, the age at weaning of the calf, and the interval between weaning and the next delivery as a measure of reproductive performance and general condition, were also evaluated. For evaluation of calving interval only those were included, of which the second calving date was at least 9 months after the start of the survey. For all other intervals the records were used, related to deliveries taking place after the start of the survey. For evaluation of Length of milking period, age at weaning and interval between weaning and next delivery the records were used of cows that weaned their calves. These analyses only bear relation to the flukicide treatment, since the duration of the survey was too short to evaluate long term effects of treatment against gastro-intestinal parasites given in the first two years of life.

Calculations.

Due to the necessarily small number of herds, it was not possible to achieve statistically reliable sample sizes for parameters measured as proportions, e.g. deaths and slaughters. For parameters measured as means, e.g. the calving interval, the sample sizes were deemed to be sufficiently large. The results of the evaluation of deaths and slaughters should therefore be viewed as indicative.

The models of the analysis of variance used for the evaluation of girth measurements and lactation intervals given by Van Klink et al. (1994a) for the evaluation of flukicide intervention trials were used in this study as well. The models consisted of the intervention, i.e. treatment or control, and herd. In the analysis of the girth, sex, season and interactions between the intervention and the other factors mentioned were included. In the analysis of the lactation intervals the parity was included, and in the case of the calving intervals also the fate of the calf, i.e. whether the calf had died or was weaned. Also in this case interactions between the various factors were used.

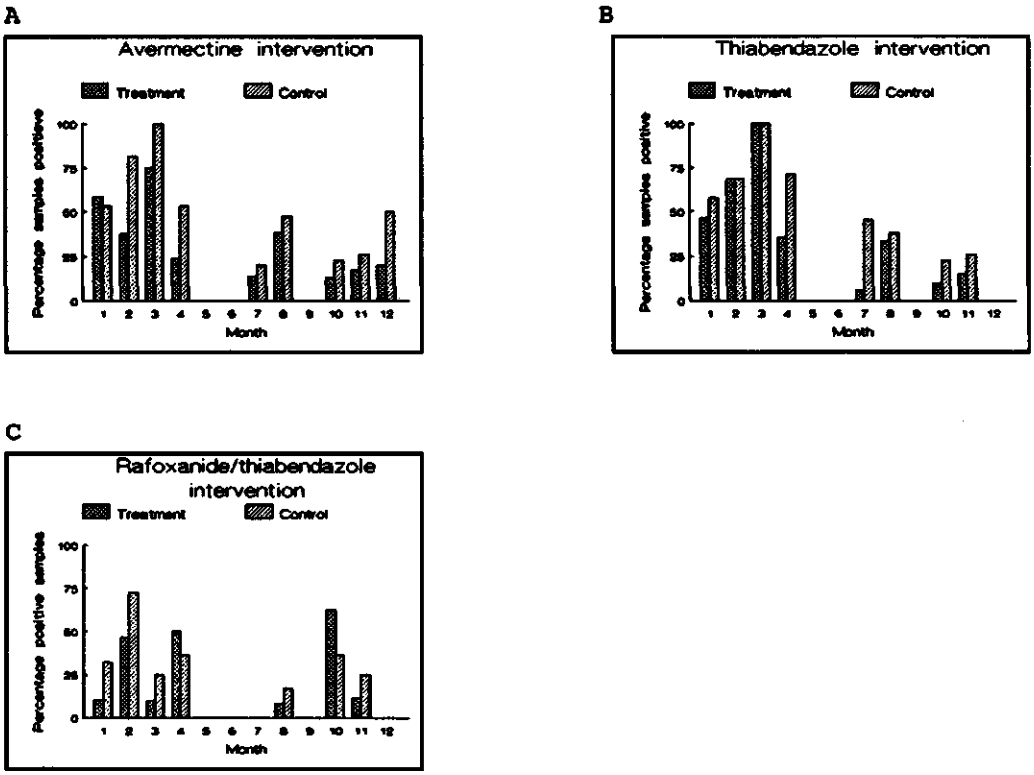
For the statistical evaluation of deaths and slaughters, Logistic Regression analysis was used (Hosmer and Lemeshow, 1989). Deaths and slaughters were evaluated over two one year periods, covering the total length of the survey period. The Logistic Regression calculates the Odds Ratio (OR) of an event happening under defined circumstances as compared to a reference situation. It expresses the OR as a power of the number ϵ, and statistically evaluates the power, β. If the OR is 1, i.e. β is 0, there is no difference between the two situations. The more the OR deviates from 1, the more the two situations differ. In the model used for evaluation of deaths and slaughters, the model included, apart from the intervention, also the herd, the sex and the period. The age at removal was included as random effect. For animals not removed the age was defined as the age in days at a date 6 months after the start of each period.

Results.

In figure 1 the percentages of the faecal samples found positive for helminth eggs is shown for the calendar months the samples were taken. The highest percentage of positives were found during the wet season, between November and April. Generally the percentages positive samples were highest in the control groups.

Only in the Avermectine group the estimates of the girth sizes were significantly different between treated and control animals, both in the group of animals of less than one year of age (treated animals: 94 cm., controls: 91 cm.), and in the group of animals between one and two years of age (treated animals 121 cm., controls: 119 cm.). Neither in the Thiabendazole group, nor in the combined treatment group significant differences between treated and untreated animals

Figure 1. Percentages of faecal samples found positive for helminth eggs found at various moments of the year in herds involved in intervention trials consisting of treatment against gastro-intestinal parasites (A and B), or a combined anthelmintic and flukicide treatment (C), in the Western Province of Zambia.

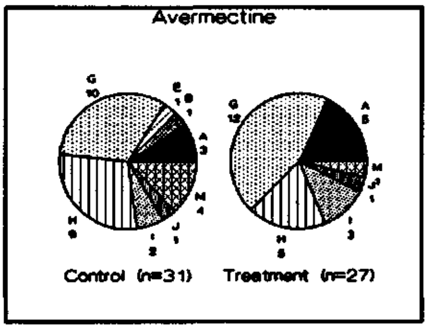


could be found. Significant differences did exist in all groups between seasons; In the first six months of the calendar year the girth measurements were generally significantly higher than in the second six months of the year. In the group of animals below the age of one year as well as in the group of animals between one and two years in the Thiabendazole trial significant differences were seen between herds. In the combined treatment group a significant difference between herds was only seen in the animals between one and two years of age.

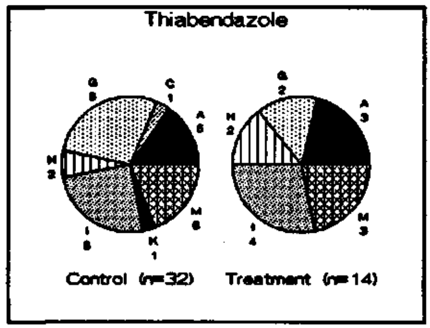
In none of the lactation intervals evaluated in the combined treatment trial, significant differences in length

Figure 2. Number of animals sold, slaughtered and died between the first of August 1989 and the first of August 1991 in herds involved in intervention trials consisting of treatment against gastro-intestinal parasites (A and B), or a combined anthelmintic and flukicide treatment (C), in the Western Province of Zambia.

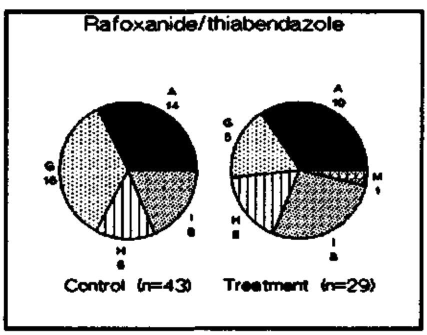
A



B



C



A = Sales
B = Slaughter for ceremony
C = Slaughter for money/meat
D = Slaughter because of sickness
E = Slaughter because of accident
F = Slaughter because of weakness
G = Death after sickness, meat consumed/sold
H = Death after sickness, meat discarded
I = Sudden death, meat consumed
J = Sudden death, meat discarded
K = Death after emaciation, meat consumed
L = Death after emaciation, meat discarded
M = Death, not specified

could be found between treated and non-treated animals. The only significant differences that could be identified were found between herds, for the calving interval and the interval between calving and the start of milking.

The removals of animals from the herds because of deaths, slaughters and sales are given in figure 2. Practically all slaughters took place because of disease, weakness or accident. Since these slaughters can be considered as emergency slaughters, they are evaluated together with deaths. Although the proportion of animals sold seems slightly bigger in all treatment groups, differences are not significant.

Table 2. Results of the logistic regression analysis of deaths and emergency slaughters in intervention trials in cattle herds from the Western Province, Zambia, calculated over the period 1/8/89 till 31/7/91.

	Avermectine				Thiabendazole				Rafoxanide and thiabendazole			
variable	No. of animals in group	% d./sl.[#]	β	s.e.	No. of animals in group	% d./sl.	β	s.e.	No. of animals in group	% d./sl.	β	s.e.
intercept	436		-4.0809	1.0402	211		-2.6452	1.1161	592		-3.1326	0.4655
Control	248	9.7	ref.		116	20.7	ref.		318	9.1	ref.	
Treatment	188	10.6	0.0649	0.3261	95	10.5	-0.7686	0.4215	274	6.9	-0.3209	0.3173
Herd 1	115	8.7	1.8657[ab&]	1.0361	26	3.8	ref.		276	3.3	ref.[a]	
Herd 2	65	15.4	2.5977[a]	1.0394	32	21.9	1.8574	1.1070	255	10.2	1.2311[b]	0.3985
Herd 3	58	13.8	2.4396[a]	1.0519	60	16.7	1.3364	1.0728	61	21.3	2.0937[c]	0.4657
Herd 4	81	11.1	2.1815[a]	1.0433	44	9.1	0.7595	1.1459				
Herd 5	43	14.0	2.4422[a]	1.0755	49	24.5	2.0023	1.0678				
Herd 6	74	1.4	ref.[b]									
Females	211	9.0	ref.		102	16.7	ref.		460	6.7	ref.	
Males	225	11.1	0.2555	0.3307	109	15.6	-0.1925	0.3974	132	12.9	0.4383	0.3839
Period I	220	12.3	ref.		106	12.3	ref.		291	8.3	ref.	
Period II	216	7.9	-0.4823	0.3312	105	20.0	0.4799	0.4007	301	8.0	-0.0663	0.3102
Age out (per month of age)	436	10.1	-0.0094	0.0155	211	16.1	-0.0208	0.0194	592	8.1	-0.0041	0.0035

(legend next page.)

(legend Table 2.)

\# d./sl. = deaths and emergency slaughters
& Values with different letters in the superscript differ significantly ($p<0.05$)

The results of the logistic regression analysis of deaths and slaughters are given in table 2. The percentage of all animals present in the two one year periods evaluated, that died or were slaughtered, is indicated as illustration. At a .95 confidence level, significant differences were only seen between herds. The herd effect could not be identified in the Thiabendazole group at this confidence level. At a confidence level of .90, both treatment and herd showed significant effects in the Thiabendazole group on deaths and slaughters. The percentage of the animals that died or were slaughtered in the control herds in this trial was twice as high as in the control groups in the other trials. Treatment effects were not found in the other trials, at this confidence level.

Discussion.

The patterns of the faecal samples found positive for helminth eggs are well comparable with patterns found earlier in the Western Province (Bongers, 1987, unpublished data) and with egg shedding patterns in neighbouring countries with a comparable climate (Malan et al., 1982). Both egg shedding and worm burdens are highest in the wet season (Pandey, 1990). The percentage positives were slightly, though not significantly lower in the treatment groups. Treatment has reduced the proportion of animals that deposit eggs, while not completely preventing reinfection, allowing for the development of resistance. The levels of the EPG's were always very low. They were therefore not included in the figures. The low levels of the EPG's may mean that helminthiasis is not a severe problem. Eysker et al. (1990) relate high worm burdens to overstocking, and Jeanes and Baars (1990) argued that the carrying capacity of the Western Province was not reached by far. However, EPG's do not always seem to be an indication of the seriousness of the infection (Parent and Samb, 1984). Though the carrying capacity of the province as a whole has not been reached yet, it is quite possible that locally and periodically overgrazing does occur.

The sample sizes were considered to be sufficient to determine differences between values of the lactation intervals and the girth. The sample sizes proved however to be by no means big enough to evaluate reliably the results of the analysis of deaths and slaughters. Whether effects of treatment do or do not exist can not be concluded from the results of the Logistic Regression alone. Prolongation of the surveys, or repeating the study with a considerably larger number of experimental units could improve the usefulness of this statistic. It may however be logistically difficult to maintain the operation of a survey of the required size, depending on the cooperation of individual farmers and on the reliable and uniform approach by a larger number of personel involved, as was already concluded by Van Klink et al. (1994d).

The fact, that at a confidence level of .90 the treatment with thiabendazole proved to reduce the Odds Ratio for death and slaughter significantly, is undoubtedly related to the high percentage of animals that died or were slaughtered in the control group. It is possible that in some of the herds in this trial a clinical problem of gastro-intestinal parasitism existed.

Van Klink et al. (1994a) found significant effects on girth sizes of seasonal influences and of influences of the Grazing Management System and the sex. The effects of sex and season found in the present survey are comparable with those by Van Klink et al. (1994a). Whether or not the significant difference between treated and non-treated animals found in the Avermectine trial would make regular Avermectine treatments viable depends on the economic validation of the effect and the intensity of the schedule chosen. Parent and Samb (1984) found a highly significant effect of Avermectine. Parent and Alogninouwa (1984) found a significant difference in the average weight of calves at birth and after 80 days, when the mothers were treated in the field with Avermectine in the last months of gestation and during the dry season.

In considering the fact that never an influence of the treatments could be found, it may be argued, that the unexplained influences, not included in the models, may still have been of great importance. As was discussed, the sample size may have been too small in practice, although, as indicated, the size seemed theoretically sufficient. Specifically a positive influence on the calving interval would have been a usefull effect; improvement of the reproductive performance would in traditional systems be of greater significance than improvement of growth. Weight or girth may be the parameter of choice to asses the presence of an effect, but it would not be sufficient to use it as direct measurement of the economic benefit (income) of treatment under circumstances of traditional livestock management. Traditional farmers are rarely, if ever, aimed at producing ready to slaughter animals for a specific market. Normally their main aim would be to increase the herd size, or rather, reducing the risks of decreasing their numbers. Growth of animals takes place without any input; if animals have to be sold, normally adult, even old, animals will be chosen. Improvement of growth may be of indirect importance through decreasing the maturing age, resulting in early participation of the animals in reproduction. Improvement of reproductive performance is directly measurable and would be an argument for further study into the economic viability of regular treatment.

In figure 2 information related to sales, slaughters and deaths has been brought together for each of the treatment and control groups to illustrate the reasons for removal in some detail. As was also shown by Van Klink et al. (1994b), practically all animals are slaughtered because of emergencies, and were therefore evaluated together with deaths. No influence of treatment on the relative frequencies of death or slaughter for reasons of sickness, emaciation or weakness or of sudden death could be identified.

As was already stated, it is difficult to draw conclusions from the results of the mortality analysis on its own, in terms of the effect of treatment. Particularly the influence of the herd may be important, since it signifies the influence of the herd management on the performance of the animals. This means that most likely the biggest progress in the performance can be found in improving the animal husbandry and herd management practices.

Treatment schedules against intestinal nematodes are often recommended on the basis of the effectivity of the drug against the parasites (Bianchin and Honer, 1987, Graber and Perrotin, 1983, Maingi and Gichigi, 1992, Majok et al., 1993). The cost-effectiveness of treatments is less often mentioned (Chiejina and Emehelu, 1986, Muenstermann and Tome, 1989). The cost-effectiveness of treatments is, however, of prime importance (Michel, 1972). The improvement of performance should also be directly measurable, particularly in low-input traditional management systems. In the material used for the trials carried out in the Western Province no justification for regular treatments could be found. Recommendations should therefore be restricted to treatment of clinical disease suspected of being caused by intestinal parasites. Further research may be aimed at assessing whether treatments could be of use in relieving the adverse effects on productivity of local and periodical overstocking. Here also, the economic aspects of treatment are of major importance.

As was also remarked by Van Klink et al. (1994d) a clear answer to the question whether longitudinal herd monitoring of privately owned herds is a suitable manner of effect assessment in field trials with a clinical nature such as is reported in this paper, is not easy to give. The results suggest, that comparable differences in productivity can be identified between variables as in the general productivity survey carried out using the same system. It is obvious, that the predictive power of the trials can be improved by alterations in the trial design. These alterations should primarilly aim at increasing the sample size, but under field conditions, as were encountered in the Western Province, the risk is eminent, that practical difficulties become prohibitive in the execution of the trial.

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4.3. Reviewing the results of the intervention trials; reflections on economic consequences of treatment, the statistical demands of trial design and feasibility of treatment.

4.3.1. Introduction.

The intervention trials reported in the chapters 4.1 and 4.2 showed only a few significant differences between treated and untreated animals. If present, the magnitude of these differences was in most cases small. Significant differences were found in the girth sizes of the age group between 1 and 2 years of age in the Rafoxanide trial and in the girth sizes of both the age group of 0 to 1, and of 1 to 2 years of age in the Avermectine trial. In all cases a larger mean estimated girth size for treated animals was found. A significant difference was also found in the interval between weaning and the next delivery in the Rafoxanide trial. Treated animals had a shorter mean estimated interval than untreated animals.

Inspite of the significant differences found, the conclusion drawn from the results of the trials had to be, that on the basis of the material available no justification could be found for routine treatment of animals against either intestinal helminths or liverflukes. The justification of routine treatments can not be based on effects alone, but should be evaluated for their economic advantage as well (Michel, 1972). In this evaluation not all parameters used in the trial have the same economic importance.

In this chapter the question is discussed whether or not the parameters of greatest importance in the evaluation of the economic advantage of routine treatments in different husbandry systems in the Western Province can be adequately measured in the field. Furthermore, attention is given to the question what alternatives are available if adequate measurements are difficult or impossible. The results obtained for these parameters will be discussed in relation to the trial design. Since the trial design may have influenced these results, the influence of statistical requirements on the trial design is discussed. The fact, that the results found for these parameters did not lead to the conclusion that routine treatments are beneficial, will be discussed. Also, examples will be worked out of values of the chosen parameters in relation to economically viable treatment schedules.

4.3.2. Parameters of economic importance.

Liverfluke infections and intestinal helminth infections are regarded as serious threats to their animals by the livestock owners in the Western Province. The parasites are blamed for suboptimal body condition. Directing the intervention evaluation programme towards liverfluke and intestinal helminths was therefore considered a priority (Project Document of the Livestock Development Project Western Province, 1987, Chizyuka et al., 1987). Other intervention possibilities either would inevitably result in lack of cooperation from the farmers, or were extremely difficult to design under the circumstances of the project area.

As stated in Chapter 3, farmers consider increase of the herd size as the most desired, though indirect, effect of treatment. Losses, particularly through death, calving percentage or calving interval, and age at first calving, in this order of importance, should therefore be regarded as the most important parameters to be evaluated.

Deaths and emergency slaughters, as one percentage, were expressed as the number of animals dying or being slaughtered on the total number of animals that were present in the herds in a one year period. As such, it is a clear and simple parameter. Improvements in this trait are immediately visible for livestock owners.

Using the calving interval seemed easier than using the calving percentage in the field trials as carried out in this research. In order to use the calving percentage, it would be necessary to calculate the number of cow years, or the mean number of cows, in the herds, on the basis of the number of days in the herd at risk. In the productivity study (Chapter 2) and the intervention trials, the composition of the herds proved to vary through the year. Many of the animals that do not calve or calve only once may have been in the herds for short periods. Animals brought into the herd as a result of herding arrangements or on loan may often only stay in the herd for a few weeks or months. If the mean number of cows present, or cow years, is used for the calculation, it is possible to account for changes in the herd composition. However, deciding which animals to include in the calculation can hardly be done. Since the age at first calving is widely variable, and subfertile animals sometimes stay in the herds for considerable periods before being culled, choosing animals older than a certain minimum age would be arbitrary. Choosing animals that have calved at least once may also be difficult, since the history of animals that have been in the herd for short periods only is often unknown. Furthermore, it is questionable whether the expression "cow years" would be understandable for the livestock owners, if used for extension.

It was therefore decided to use the calving interval, since this parameter could be derived rather objectively from recorded calving dates, although it only accounts for cows that calved at least twice during the study period. It was considered, that the calving interval was an easy, and reasonably informative parameter to evaluate influences of environment, management, climate and treatment.

As already indicated, in the present studies, the age at first calving proved to be greatly variable. While the mean age at first calving was around 3 years and 8 months, it varied from around 2 years to 6 years. The age at first calving was not significantly affected by the factors in an analysis of variance model in which Grazing Management System, husbandry system and calving season were included as independent variables. Moreover, cattle owners may also not consider it an important parameter. Service of heifers takes place largely without any attention of the herd manager. The current practice is, that heifers are grazed with the rest of the herd, and that the bulls present in the herd perform their duties without any supervision as to the moment or frequency of servicing. The age at first calving as a parameter will therefore not be discussed. Girth, or rather growth, bears a relation to sexual maturity (Ogink, 1993), and through this to age at first calving. However, the precise relation of girth with and influence of girth on sexual maturity is not known under the local field circumstances of the trials. Also, it is questionable whether all heifers are sired, and conseive as soon as they have sexually matured. Therefore the influence of treatment on the girth cannot be evaluated in relation to age at first calving.

It may be argued, that treatment effects should have a certain minimum magnitude for routine treatments to be economically justifiable. The difference in the number of calves born in treated and untreated groups and the difference in mortality between treated and untreated groups should be valued, and the costs of treatment should be compared with this value in order to decide whether treatment should be regarded as feasible and justifiable. At this point it is also important to decide upon the optimal treatment schedule. In the trials reported here, the treatment schedules were relatively intensive, since the first objective was to identify differences in productivity between treated and untreated animals. It was originally planned to identify differences between treated and untreated animals in terms of productivity, and if they were present, evaluate them in economical terms. Next, it would have been worthwhile to determine the optimal treatment schedule and treatment moment. Since productivity differences were not found to be significant, these last steps could not be carried out.

In order to illustrate the importance of differences between treated and untreated animals for the evaluation of the economic viability, an example for a treatment against intestinal nematodes, and for a flukicide treatment will be discussed. In the assessment of the economic viability, the price of the drug and the average amount of the drug necessary per animal is of importance, as well as the type of animals the treatment is intended for. Furthermore, it is necessary to know the value of animals.

The cost of the complete scheme with which the favourable effect may be attained should not exceed the potential increase in the value of the herd that is the result of treatment. Baars (1987) expressed the value of the increase as the value of individual adult animals at sale, because increase in herd size with one animal means one more animal available for sale. Using the Zambian national currency at the level of 1987 (1 Zambian Kwacha = approx. 0.20 US$), from which year the information originates, the net increase in herd value used was 689 K (Zambian Kwacha) per animal. Mwafulirwa and Moll (1991) expressed the value of individual animals in the herd as the value of the average animals, on the basis of the average liveweight of animals in the herd. At an average weight of 259 kilograms, at 14 K per kilogram liveweight at the 1990 level (1 Zambian Kwacha = approx. 0.03 US$), the value of an average animal would be 3626 K. The advantageous effects of treatments can be considered as extra income, above the regular economic result of livestock production. It would therefore probably be most appropriate to use the sales value of animals rather than the value of the average weight. If reduction in mortality and increase in the number of calves born as a result of treatment would amount to 1 percent, the cost of the treatment schedule should not exceed this figure per 100 animals per year. For farmers to accept routine treatments as advantageous, the costs should probably be well below this figure.

In the examples, prices of drugs and of animals will be used as provided by the project consultant of the Livestock Development Project (De Rooij, personal communication) at the 1994 level. In the drug retail scheme that is run by the project, Flukazole has replaced Rafoxanide, and Albendazole has replaced Thiabendazole. Since the prices for these drugs are reasonably comparable with those of the drugs that were used for the intervention trials, the 1994 prices of the new drugs mentioned will be used in the comparison.

4.3.2.1. Assessing the economic viability of treatments against gastro-intestinal parasites.

In the intervention trials, the treatments against gastro-intestinal parasites were only given to young growing animals untill the age of two years. Adult animals will have acquired a certain level of premunity against intestinal helminths. The damage done by these parasites will therefore be limited. Routine treatment should support the growing animals and protect them against massive, and devastating infections, while not preventing reinfection entirely. In the intervention trials it was found, that also in the treated group egg shedding occurred. In calculating the effect-cost balance, the same principle, treatment of young animals only, is used.

On the basis of the average weight of the animals below the age of two years, of the division of the animals on the range of the weight, and of the dose rate of Albendazole (1 bolus for each 60 kilogrammes of body weight), the approximate number of boli can be calculated. An approximation of the weight can be made using the formula for the calculation of weights from the girth measurements, derived by Corten (1988), using around 450 records of weights and girths of Barotse cattle. The approximations of the weights can be made using the average girth measurements found in the productivity study, reported on in Chapter 2. Approximately 210 boli will have to be used to treat 100 animals. At a price of 110 Zambian Kwacha per bolus, the cost of one treatment for a group of 100 animals below the age of two years can be estimated at 23.100 Kwacha.

The sales price of animals is 220 Zambian Kwacha per kilogramme live weight. At an estimated average body weight at sale of 356 kilogrammes (Baars, 1987), one animal would generate 78.320 Kwacha. This shows, that, if routine treatment would reduce mortality by one percent, this effect should be attained by a schedule consisting of maximally 3 treatments annually.

As is discussed in Chapter 3.1., the risk of infections with intestinal helminths increases during the course of the wet season. A treatment schedule should be concentrated in this period. It could be considered to give three treatments at 6 week intervals in the last three months of the wet season, when the contamination of the pasture is at its' peak. In that case, one treatment would be given early January, one half February and one at the end of March, just before the onset of the dry season. Obviously, variations on this schedule are imaginable. The first treatment could for example be given earlier, in the course of November or December. If a schedule of this kind is used, the animals, while grazing on contaminated pastures, are exposed to moderate infection levels. In this way, they do have a chance of developing premunity against intestinal helminths. Ploeger (1989) demonstrated, in commercial dairy cattle in The Netherlands, that the extent to which young animals are exposed to (moderate) helminth infections influences their capability of coping with these infections in later life.

4.3.2.2. Assessing the economic viability of flukicide treatments.

The flukicide trials were given to all youngstock below the age of two years, and to all cows over the age of two years. Oxen and bulls over that age were not treated, since in this group, apart from mortality, no parameters related to increasing the size of the herd were to be measured. It is likely, that in practice the same line of thought would be followed, although farmers may consider treatment of oxen to increase their work output. This would, however, only be viable, if the oxen were used to the maximum of their ability. There is no evidence that this is the case. In the evaluation of treatment therefore, a schedule will be considered in which the same animal categories are included that were involved in the intervention trial.

The dose rate of Flukazole is half a bolus per 75 kg. of body weight. On the basis of this, and on the basis of the weight range in the group to be treated, the approximate number of boli needed for one treatment of 100 animals would be around 156 boli. At a price of 120 Zambian Kwacha per bolus, the cost of one treatment for a group of 100 animals can be estimated at 18.720 Kwacha.

If only mortality is taken into account, and it would be reduced by one percent through routine treatments, the schedule that produces this effect should consist of not more than 4 treatments annually. The calving interval may however also be influenced by treatment.

In the intervention trials, differences in the calving intervals were found in favour of treatments, although they were not significant. An impression of the number of extra calves being born in the herds as a result of treatment can be derived through calculated calving percentages from the calving intervals measured. A calculated calving percentage can be derived by deviding 365 by the calving interval and multiplying the result with 100. The differences in calculated calving percentages between treated and untreated cows range from 1 % (in the Rafoxanide trial) to 7 % (in the combined Rafoxanide/Thiabendazole). The extra revenue resulting from this could be between 39.160 and 227.128 Kwacha.

The revenue earned through the treatment is, in the examples mentioned, big enough to finance the drugs for a treatment schedule comparable to that used in the intervention trials, i.e. a schedule in which four treatments per year are given. Such a schedule is in line with the schedule, proposed by Armour (1981) and evaluated by Owen (1984). Treatment should probably at least be carried out at three monthly intervals around the periods that the animals are exposed most severely, i.e. when they graze the floodplains.

4.3.3. Statistical aspects of the intervention trials.

As was stated in the introduction, the trial design may have played a role in the results obtained. Therefore, attention is given to statistical aspects of the intervention trials that were carried out. Statistical aspects to be discussed are the sample size and the choice of the trial herds.

The sample size is a critical factor in the design of trials. Martin et al. (1987, p. 45) show formulae for the determination of sample size both for parameters with absolute values, where the result is expressed as a proportion, and for parameters with continuous values, where the result is expressed as a mean. These formulae were also presented by Putt et al. (1988) and Fleiss (1986) respectively.

All records were taken on the basis of information on individual animals. The analysis unit was also the individual animal. The herd, therefore, had to be included in the models used for the evaluation of the Odds Ratio for death and slaughter, as well as for the evaluation of calving interval and the lactation intervals, and the girth, in order to account for its influence.

4.3.3.1. Sample sizes for the evaluation of mortality.

The overall percentage of animals dying or being slaughtered found in the productivity study was 9.1 %. A value in this range can be chosen as the expected value for the group of untreated animals, for example 10 %, and 6 % as the value for the treated group. At a confidence level of .90, and a power of .80, the approximation of the sample size following from the formula (Martin et al., 1987, Putt et al., 1988) would be 565 subjects for treatment and control groups each. At higher confidence or power levels the number of subjects would have had to be considerably larger.

If the results of the logistic regression in all intervention trials are observed, a favourable effect, i.e. a decrease in the Odds Ratio for death and slaughter as a result of treatment was found for the Thiabendazole treatment (a mortality of 20.7 % in the control, and of 10.5 % in the treated group). To obtain these results significant at a .90 confidence level and a power of .80, the sample sizes as a result of the formula should have been 156. The Thiabendazole treatment was in fact significant at the .90 level, but the percentage animals that died or were slaughtered, also in the control group, was much higher than in the other trials (Chapter 4.2). Some attention is given to this in the discussion of Chapter 4.2.

For the logistic regression models (Hosmer and Lemeshow, 1989) used for the analysis of the Odds Ratio for death and emergency slaughter, the number of animals in the sample was below the calculated requirement, even if considering, as stated by Putt et al. (1988), that "given the degree of arbitrariness which will usually be involved in assuming values for the true proportions, it is to be expected that the indicated sample size will never be better than a rough approximation".

Although the number of deaths, together with the emergency slaughter figure, should be regarded as the most important parameter, it was logistically impossible to engage enough herds in the trials to meet the theoretical requirement of at least 565 animals per group. The level of supervision had to be high, since the African livestock owners rarely are used to record keeping. Also, the field staff involved needed intensive supervision in the correctness of their record keeping and the correct determination of dose rates and application of treatments. Another important element is how to motivate enough farmers to participate in the trials for a considerable length of time. This is an element which also plays a part in the choice of the trial herds, which will be discussed later. The investment of time and personnel could not be increased in the research, even considering that demands of reachability determined partly the choice of trial herds involved.

Notwithstanding the fact, that an adequate sample size greatly enhances the predicting power of any trial, practical limitations and implications (Baars and Egger, 1993) as well as cost considerations (Martin et al., 1987) may be of influence on the possibilities in any given situation. Circumstances may arise in which preference has to be given to less powerfull results (Meinert and Tonascia, 1986).

4.3.3.2. Sample sizes for the evaluation of the calving interval.

In the productivity study, the mean calving interval was around 580 days. The values found in this study were used for determination of the approximate sample sizes. In order to find significant differences between the calving intervals larger than 600 days (slightly higher than the overall average) for untreated and 530 days (an improvement of roughly 20 days if compared with the shortest calving intervals in the productivity study) for treated animals, with a standard error of around 50 days, the number of subjects in the sample should be 8 for both treatment and control group, at a confidence level of .90 and a power of .80 (Fleiss, 1986, Martin et al., 1987). Martin et al. (1987) recommended, that if the sample size would fall below 10, the number should be doubled. In this case a sample size of 16 subjects would have to be chosen.

The results of the intervention trials show, that in all interventions in which the calving interval was evaluated, i.e. all liverfluke treatments, the treated cows had a shorter calving interval, but in all cases the differences were not significant. If the formula is applied, in the Triclabendazole intervention the same results would have been expected to be significant with a sample size of 12 per treatment and control group each. In the Rafoxanide intervention the sample size had to be 110, and in the combined Rafoxanide and Thiabendazole treatment a calculated approximate sample size of 7 (i.e. a sample size of 14) had to be sufficient.

The number of records, as calculated from the results of the productivity study, were well above the required number. For the evaluation of the calving interval in the intervention trials, the sample sizes were therefore expected to be sufficiently large. If multivariate analysis of variance is performed, each of the values of each independent variable or of each combination (interaction) of independent variables, i.e. each cell of the model, should contain at least a certain minimum number of records or observations. Often 5 observations per cell are considered to be the minimum (Greenland, 1985). This affects the adequacy of the theoretically calculated sample size. The more independent variables, and interactions of independent variables, are incorporated in the model, the more subjects should be involved in the trial. The models used in the intervention trials met the requirement of having at least 5 subjects per cell.

Apart from the reasons already mentioned for the decision to use the calving interval rather than the calving percentage, sample size considerations are also of importance. In order to find differences in the range of 1 to 7 %, significant at a confidence level of .90 with a power of .80, if the proportions are in the range of 50 to 60 %, the sample sizes would have to be from 603 for the biggest difference to over 30000 for the smallest. As was the case with the mortality, it is impossible to meet these requirements under the field conditions encountered in these trials.

4.3.3.3. The choice of test herds and animals.

The herds involved in the trial were not chosen at random. The conditions under which cattle is kept in the province made it difficult to choose trial herds randomly. Firstly, the farmer had to be willing to cooperate. They had to register events in the herds in between visits by the veterinary assistants. Secondly, the infrastructure in the province demanded that herds had to be chosen that were easy to reach on a regular basis.

From a statistical point of view, random selection of herds and randomly assigning animals or herds to either treatment or control groups is preferrable (Martin et al., 1987). The logistic circumstances in the study may therefore undoubtedly have played a part in the fact that no significant results could be obtained. The direction and magnitude of some of the independent variables, as found in both the productivity study, in which 52 herds were involved, and the intervention trials, in which 3 to 6 herds were involved, were very similar. The herds in the intervention trials were chosen from those involved previously in the productivity study. This suggests that the sample of herds involved in the intervention trials did not substantially differ from the complete group of 52 herds. However, also the sample of 52 herds could not be randomly chosen for reasons already mentioned.

In the trials the animals were assigned to either treatment or control group, matched for age and sex. The helminth exposure level of the animals was not used in matching them. This would pose considerable practical difficulties. Faecal sample results, for example, cannot be used for this purpose, since they do not reliably represent the infection level. Serological methods do not give information on the status of the infection of the moment either. Also, the infection level may vary greatly through time. Animals that have a comparable helminth exposure level at a certain moment, do not necessarily continue to have the same status. It was therefore assumed, that exposure to infection was fairly equal for all animals.

4.3.4. Viability of routine treatments.

If only the cost of the drug on purchase for the livestock owner is taken into account, even small improvements of some productivity parameters would seem to make routine treatment justifiable. At present, no fees for services rendered are charged by the Department of Veterinary and Tsetse Control Services. Since introduction of fees for services is being planned, the costs of application, i.e. of labour and of the assistance of the veterinarian or the veterinary assistant, may in due course influence the outcome of the examples negatively. The measure of this influence depends on the proportion of the total application costs that will be constituted by the drug costs.

Hardly any significant differences were found for treatment, while factors related to management and environment did show significant differences, both in the productivity study (chapters 2.2 and 2.3) and in the intervention study (chapters 4.1 and 4.2). The importance of environmental factors, specifically illustrated by the differences in productivity between Grazing Management Systems, between periods and between herds, suggests, that much more may still be gained through improvements in animal husbandry practices, management and optimal use of grazing resources.

As Michel (1972) has stated strongly, it is not justified to invest in drugs to attain a certain set of goals, if there are other, cheaper ways of attaining the same goals. One of his examples dealt with steers, being treated against intestinal worms shortly before being stabled for the winter, while they were not expected to reach their slaughter weight before the end of the stabling season. The animals are expected to overcome the infection largely during the stabling season if they are not treated. The cost of the extra feed, necessary to allow the animals to make up for the retardation in growth as a result of intestinal helminth infections is far less than the cost of de-worming.

Following this line of thought (Michel, 1972), and taking into consideration that animals in the Western Province are not raised for a ready-to-sale weight, and that treatment did not significantly improve productivity, it is not justified to recommend routine treatments. Moreover, nutritional factors (Troncy, 1989, Oakley et al., 1979), on which management and environment exert a critical influence, mask the effect of infection and, therefore, of treatment.

4.3.5. Discussion and conclusions.

The local logistic circumstances under which the intervention trials were carried out, have exerted an influence on the results of the trials. The fact, that herds to be involved in the herd monitoring programme could not be chosen at random, is one of these circumstantial factors. More important, the sample sizes did not allow firm conclusions regarding the Odds Ratios for death and emergency slaughters. The results of the evaluation of the Odds Ratios were therefore in this respect primarily regarded as indicative and descriptive. Somewhat unfortunate as it may be, carrying out a study of this kind in the framework of a livestock development project means, that there are limitations to the extent of and the available resources for research.

It was decided to try and establish as much of the goals as possible within the prospected project period (Project Document of the Livestock Development Project Western Province, 1987, Chizyuka et al., 1987). Therefore, both treatments against intestinal helminths and against liverflukes, as well as a group in which both treatments were given, were included in the research. Because of the fact, that logistic difficulties associated with physical monitoring of sufficient animals, to meet the requirement of the outcomes measured as a proportion, would prove prohibitive for the execution of the research, it was decided to carry out the trials as described.

The consideration, that field logistic difficulties determined the possibilities of the trial design, also underlies evaluation of some ways of overcoming the problem of insufficient sample size. Increasing sample size could be attained for example by carrying out fewer different trials, but even then, with the number of animals available for the exercise, the requirement would not be met. Meta-analysis, in which treatments are pooled and analysed for their effect against the pooled controls, could be another possibility (Willeberg, 1993). Even if this method would be used, the sample sizes may be too small.

Another possibility is to use a sequential sample size design (Meinert and Tonascia, 1986, p. 72), in which the trial is continued over a prolonged period of time. The sample size involved in the trial at any given time can be smaller in this type of design. Trials carried out using this design are continued untill the difference between treated and untreated groups exceeds a predefined boundary value. The duration is determined by the running development of the results. Logistically it may seem easier to carry out trials for a longer period in a relatively small number of herds. However, there is rarely time enough in livestock development projects to carry out trials for a relatively long period of time (Chizyuka et al., 1987). Furthermore, motivation of personnel and herd owners involved may in the long run become increasingly difficult. One element in this respect may be the fact, that a split herd trial is used. If improvements become detectable in the treated half of the herd, it is very well possible that the owner of the herds will in the long term insist on treatment of the entire herd. It is therefore highly unlikely, that it would be possible to establish a sample, large enough to meet the minimum requirements as discussed, or maintain a research situation in the field long enough, even if the resources from the project were not as limiting.

For the calving interval, the number of records available seemed to be sufficiently large, in view of both the minimal sample size and the minimal number of records per cell (Greenland, 1985). The situation in which trials are carried out may also be connected with the sample size and the model that is chosen for the evaluation of parameters. For well controlled on-station trials, or trials in which all subjects are maintained together, the sample size may possibly be smaller than in the case of field trials. Because the circumstances are more easily controlable, simpler statistical models can be used for these trials. The following two examples of relatively small sample sizes may be mentioned. Chick et al. (1980) used 6 groups of 8 Hereford steers to identify significant effects on growth of three levels of fluke infections and two stocking rates in an on-station trial in Australia. Especially in the first 12 weeks of the trial, effects of both were significant. In a trial carried out at the Faculty of Veterinary Medicine in Khartoum, Sudan, in order to assess the effect of treatment with Avermectine on growth, Abdalla (1989) could not prove significant advantages of treatment. The trial consisted of 20 sheep, divided in a treatment and a control group, and 20 cattle, also divided in a treatment and control group. The fact that no significant differences were found, was attributed to both sample size and the short duration of the trial. A much larger sample size, though the trial was carried out in a single herd, was used by Parent and Samb (1984). The significant positive effect of Avermectine on growth, if compared with treatment with tetramisole, was detected in a trial in which 100 out of 600 newly bought calves were randomly selected. Of this group of calves, 50 were treated with Avermectine and 50 with Tetramisole. The animals, N'dama-Zebu crosses, were maintained for fattening in the Cap Vert region of Senegal.

For field trials, analysis models are in general likely to be more complex, and, as already mentioned, a minimal number of observations or records per cell will be required. Nevertheless, in the trial reported by Parent and Alogninouwa (1984), in which the influence on calf weight and mortality of Avermectine treatment of dams in the last months of pregnancy, a total of 45 treated animals and 35 control animals were involved. The animals were privately owned Djakoré (Gobra-zebu and N'dama crosses) in various villages in the Rethba region of Senegal. A considerable significant difference in growth was found. Also, the Avermectine group showed no calf mortality while the mortality in the control group ranged around 10 %.

The unit of analysis was the individual animal. This was possible, because a split-herd design was used in which both treated and untreated animals grazed in the same herd. In order to accomodate for the fact that several herds were used, the herd had to be included in the models. Using the herd as unit of analysis, for example by assigning complete herds to either the treatment or the control groups, would have made it necessary to involve larger numbers of herds than were used in the trials. It would have caused considerably larger difficulties in matching and in the practical execution of the trials. As was already stated in chapter 3, it was assumed, that the influence of the treatment group on the exposure of the control group was limited, because of the fact that pastures are communaly used, and that reservoirs of infection in game animals existed. Using individual animals as units of analysis, and treatment and control groups within each herd, was therefore justified.

Besides the question, whether or not the results of the trials have been influenced by the circumstances under which the trials were carried out, there is evidence that intestinal nematodes are not most important factors in affecting productivity. The results of the faecal sample examinations, as well as the unpublished data of Bongers (1987), show, that the extensity of the infections with intestinal nematodes, i.e. the proportion of the herds infected, is generally moderate. Although the EPG not necessarily reflects the status of the infection (Parent and Samb, 1984), the fact that all EPG's were consistently low would suggest, that the levels of infection in the hosts was also not more than moderate.

Liverflukes are widely present (Jorgensen and Kamukwai, 1977). Apart from the incidental and individual cases of acute fasciolosis, however (personal observation), the animals are able to manage this infection quite well (Kendall and Parfitt, 1975). As factors influencing productivity, liverfluke infections seem to have little practical importance.

As was already stated, it is unlikely that treatment plays a significant part in reducing pasture contamination, both for liverflukes and for intestinal helminths. Influencing the exposure of the animals is therefore also not an argument for treatment.

The non-significant, but indicative favourable, results obtained in the trials for the most important parameters, should not raise even the slightest suggestion that treatment would have a beneficial effect on productivity. Cattle owners may administer the drugs injudiciously, or may not be able to follow routine schedules. While probably being convinced of undertaking the right action, they may invest large sums of money without gaining any returns.

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CHAPTER 5

General discussion.

5.1. The aim of the thesis.

The general aim of the thesis, assessing the use of longitudinal herd monitoring in a traditional cattle keeping system for the description and identification of influences on productivity, should be evaluated in connection with the relevance of the results for livestock development in the Western Province. The results should therefore be viewed in relation to the objectives that were formulated for the programme. These were identification of constraints and specific veterinary needs, resulting in the formulation of appropriate extension messages, and studying the structure of the provincial cattle population.

Factors influencing productivity may be many, and variable of nature. Describing and identifying them should go together, if possible, with suggestions for adjustments or improvements aimed at improving productivity. These factors may also exercise influences on each other. Factors of socio-economic, as well as of environmental nature may influence the possibilities to adjust technical aspects and management in the Western Province herds.

In this chapter, the influences of management, environment and of socio-economic factors on productivity, as derived from the studies carried out for this thesis, with, where appropriate, their interrelationships, are discussed. The aims of this chapter are to examine the possibilities of productivity improvement (5.2., 5.3., 5.4.), within the limits determined by the interrelated influences on productivity and by socio-economic patterns (5.5.), and to elaborate on approaches for productivity improvement and on extension and further research.

5.2. Herd management in relation to productivity.

The productive performance of herds is likely to be influenced considerably by its' direct environment. In Chapter 2, paragraphs 2 and 3, an influence of the herd, i.e. the herd management, on several productivity traits was identified. Some of the aspects of herd management that may be of significance are the kraaling practices, the milking practices and decisions related to the day-to-day choice of grazing.

*   One of the prime reasons for keeping cattle in many traditional systems in Africa is the provision of manure (Beerling, 1991). The manure is normally accumulated by

kraaling the cattle on the field where it is to be applied. By shifting the kraal every few days a layer of manure is spread over the field, which is normally ploughed and sowed or planted in the following wet season. Shifting of the kraal is done once every 3 to 5 days, depending on the season. In the wet season the period is shorter, because the soil becomes too wet and dirty for the animals to spend the night (Baars, 1989). There are cases in which the necessity or desire to collect manure forces the animals to remain in the kraal, not only for the night, but also for part of the day. This may, especially in the dry season, compete with grazing time to an extent, that the body condition of the animals comes under pressure. This obviously will have consequences for the productivity in terms of growth, of milk yield, fertility, health and mortality.

Manure collection is not always practiced. In transhumant herds often no kraal shifting is done when the animals graze the floodplain, since they are not camped on the fields during that period (Chapter 2.1, table 1, fig. 2). In the Bulozi floodplain animals may in those cases be tethered to poles by a rope attached to one of the front legs. Also, manuring is practiced less frequently in the south of the province. A reason for this is difficult to determine. Some experiments carried out in the Masese Agriculture Development Area Project suggest, that a reason may be, that the rains come with less reliability in this area than in the north of the province. Manured maize grows faster, and with better yields, but seems far more sensitive to drought conditions (De Vries, 1989).

Since kraals have to be mobile, they normally consist of fences made out of branches, thorn bush, or poles with (barbed) wire, put in a square or circle. Often at times that manuring is practiced, a square shape will be preferred. Also the kraal for the suckling calves, that are kraaled separately from their mother at night, is in principle built in the same manner. Sometimes very young calves die after heavy rains and it is common knowledge among many of the farmers, that the rains cause this mortality, undoubtedly as a result of chilling, since calf pens are normally not roofed (personal observation).

Another factor that may play a part in the health of calves is, that shifting of calf-pens is done less frequently than shifting of the kraals for the adult cattle, because the contribution of the calves to the manure deposition is fairly small. This could in some instances, especially in times of rains, lead to the calf-pen becoming filthy. The practice of regularly removing manure from the pen is practically unknown.

Especially if the pen remains moist, it is likely that infective agents are able to survive and a build-up of infection occurs.

Roofing calf pens may seem desirable, but it has important consequences that have to be adressed with care. Firstly, roofed pens will require more labour input to be shifted. Secondly, the sun will no longer be able to dry out the soil in the pen. Propagating the use of roofed pens should therefore go together with developing a conscience for hygiene, through litter provision and regular removal of the manure.

* Another factor often mentioned as negatively influencing productivity, in particular calf survival, is competition for milk between calf and man. This means, that as a result of milking of the cows, too little milk is left for proper growth and healthy development of the calf. In the Western Province two main practices regarding milking can be distinguished. Cows are milked only once a day, and the presence of the calf is essential for the release of milk by the dam. One of the practices is, that cows are milked in the morning before being released for grazing. The calves are kraaled separately from their dams, and are released one by one in the morning. They are allowed to suckle for a few moments, and then the cow is milked. Another practice is to release the animals in the morning and have them return to the kraal for milking around mid-day. Whether competition for the milk plays a role in the Western Province is questionable. As is shown in Chapter 2.3., on average it takes 80 days after the birth of a calf before the mother is milked for the first time. Furthermore the amount of milk derived for human consumption per cow per day is small, less than 1 litre per day (122 litres per lactation, Bessel and Daplyn, 1977).

* A next important factor in relation to productivity may be the day-to-day choice of the pasture to be grazed. A very thorough knowledge of the quality of the grazing potential of the direct environment of the village where the herd is based is required of the herd manager. Not all herd managers will posses the necessary skills in equal measure. Furthermore the possibilities of choosing grazing grounds for ones' cattle are highly variable, as is the seasonal variety in the fodder quality. Herd managers should have the possibility to assess, in a relatively easy manner, the quality of the fodder in their environment. This should first of all be addressed through extension. The extension efforts should provide the farmer with simple knowledge to gain an impression of the amount of fodder

present on a particular pasture, and, within the possibilities, of the nutritive value of the grass and herbage. The farmer should be taught how to look at a pasture, how to use his senses. Factors, that could be involved in judging the nutritive value of fodder, could include height and density of the forage, and the leaf content as related to the stem content. Another usefull tool is body condition scoring of the animals (Nicholson and Sayers, 1987). Many farmers already seem to take the body condition of their animals into account in deciding, for example, whether an animal is to be milked or not. It is a factor of which many farmers are already aware, but it is desirable, that farmers are provided with the possibility, through extension, to use body condition scoring as a tool in daily management.

It should be borne in mind, that harvesting and storage of fodder crops for later use is an unknown phenomenon in the Western Province. It is likely that too large a labour investment is necessary in relation to the advantages that may be expected for this to be practical. Providing herd managers with knowledge to assess the quality of their grazing grounds, supporting the choice of pastures, is a prime extension task.

* A complicating factor in the management of grazing resources is the availability and position of herdsmen. Gluckman (1973) and Van Horn (1977) described the consequences of labour migration for the standard of agriculture in the Western Province. Apart from reducing the surface of the arable land in the province, it also resulted in a shortage of herdsmen to look after the animals. Another cause was, that young boys spend more time at school than before. The result may have been, that the abilities for herding cattle of those still available for the job were less than before. It became for example increasingly difficult to send herdsmen away during the floods to the best grazing grounds. The position and social status of herdsmen must have suffered from this development. At present the social status of herdsmen is low (Beerling, 1986). The wages are also quite low, and it is therefore difficult to attract skilled people for the job. There is a clear indication, that in situations where the herd manager or his direct family are themselves responsible for herding the cattle, the productive performance is positively influenced.

* Burning of grassland may also complicate pasture management. It is often practiced to rejuvenate the vegetation. Matthewman (1980) mentions indiscriminate burning as a serious threat to the nutritional status of cattle. Burning of the

grass is often done for reasons completely different from rejuvenation of the vegetation with the object to improve the quality of the fodder for the animals (Frost, 1992). It may be done for example to deplete coverage for game, in order to facilitate hunting. The Forestry Department practices early dry season burning to prevent destructive bush fires later in the season. In the flood plains burning is often practiced in order to reduce undergrowth when the plains are flooded, so that fishing becomes easier. Lastly, especially directly around villages, burning is practiced to reduce coverage for possibly dangerous vermin and snakes. Though these reasons may often be rational in themselves, they are destructive in relation to the provision of fodder for the cattle. Therefore, in order to meet demands of all users of the rangelands, an integrated approach to management of pastures is needed.

If the object is to improve the quality of the fodder, the timing of the burning is essential. There must be at least some time of the growing season left to allow for regrowth, or the burning should be done only shortly after the new rains have started. The timing of the burning practices discussed here bears no relation to this, and are therefore, from the point of view of fodder provision to be considered as highly undesirable. In view of the importance of cattle for the rural economy of the province (Mwafulirwa and Moll, 1991) it seems necessary to formulate priorities in this matter. It should however be borne in mind, that burning practices may be carried out, out of necessity, by people that do not own any cattle and are therefore reliant on, for example, fishing or hunting. Utmost care in formulating these priorities is therefore necessary. In land use planning the integrated approach mentioned earlier should be expressed, and the position of these other users of the grazing range should play a role.

It is possible to influence herd management practices through extension (Vijfhuizen and Mumbuna, 1990). It is essential, that the extension messages are aimed at local solutions. The extensionist should stand close to the livestock owners and should understand their particular needs. At present, extension is still too much transferred from standard information. This information is often too general in nature and too little applicable to the situation of individual cattle owners. Also, the important influence of socio-economic factors should be recognised in extension.

The fact that there is an influence of the herd management on productivity, should make it possible to identify elements from the day-to-day management of individual herds that determine the level of the productivity. These elements may include:

- the moment in the day that cows are milked,
- the criteria on which the herd manager decides which cows to milk, and when to start,
- the moment in the day that the herds are released for grazing and are taken back to the kraal,
- the presence or absence of herdsmen and their relation to the herd manager, and the part they play in determining which grazing grounds to use,
- the criteria the herd manager uses to determine which pastures to use,
- the moment in the day the animals are taken to drink,
- the ways in which calves are taken care of,
- kraal shifting practices (e.g. frequency) for the kraal for adult animals as well as the calf pen,
- amount of space per animal in the kraal,
- breeding practices (choice of bulls, servicing supervision).

A study into these aspects could also include aspects such as the ownership division in the herd, the number of owners in the herd and their relation to the herd manager. Such an effort may deliver the background information for extension messages that are optimally adapted to the local situation. A system of assessment of individual herd performance is needed for this. The herd monitoring system as it was used in the study could be used for the processing of the productivity data. In the course of the herd monitoring programme a computer application was developed that calculates some productivity traits in individual herds or in any type of group of herds. This application was used in this thesis only to calculate the average herd composition presented in Chapter 2. It could be an instrument to evaluate management aspects of productivity, although it does not allow for direct statistical analysis. Schoonman et al. (1992) gave a proposal for a study into the relation between both technical and socio-economic factors and productivity of individual herds aimed at developing relevant extension.

5.3. Environmental factors in relation to productivity.

Chapter 2.2. and 2.3 show, that influences of several environmental factors on productivity traits could be identified. Seasonal influences were clearly present in the girth assessment and could also be found in some of the lactation intervals and in a seasonal calving pattern. Climatic influences, i.e. in this respect chiefly the influences of annually varying rainfall, seemed to be present in some traits, identified by comparing the values of these traits in two consecutive periods of one year (period I and period II). However, the differences found in this manner should be regarded as indicative. There were differences between the two periods in the amount of rainfall, but it would probably be better to make a comparison of more one year periods.

* Between the Grazing Management Systems (Jeanes and Baars, 1990) also differences in several traits could be found. The descriptions of the Grazing Management Systems are probably rather rough, but a careful conclusion may be, that the different systems do exert different influences on productivity. In a herd performance study (Schoonman et al., 1992), aimed at identifying more detailed influences at herd level, aspects related to the grazing environment would probably have to be taken into account in a more detailled manner. This may for example include the distances covered each day for grazing and watering, which may differ considerably per herd. Such a study is likely to produce useful descriptive results. It may be appropriate to use these descriptive results in risk analysis and risk modelling methods, bearing in mind the possibilities and restrictions in the design of the study. These methods provide possibilities to assess the relative importance of the aspects involved in daily management (Cohrssen and Covello, 1989).

* Taking into account the fact that animals dying or being slaughtered in emergency outnumber the animals being sold, mortality can be considered as one of the constraints identified. Especially among calves the mortality seems to be high. The mortality is one of the traits, for which environmental and climatic factors, but in several instances also influences of the management in the herd were identified.

* Long calving intervals may be considered another constraint. Age at first calving was not statistically evaluated at length in this thesis, but since the average ranges around 3 to 4 years it could be argued that it is also a productivity trait worth giving attention to. More so, since the variety in ages of first calving is quite large. This is also true for the calving interval. This would suggest, that there is room for improvement of these traits. The difficulty with these traits however is, that their effect in the sense of

performance is less clear to farmers than for instance mortality. There were no farmers involved in the study who practiced some means of oestrus detection or breeding control. In all cases bulls, running freely with the herd, sired the cows in heat in an uncontrolled manner. This, together with the apparent feeling that gestation could hardly be influenced, would probably cause this constraint to be felt differently by the farmers themselves.

* The girth measurement was chosen for the evaluation of growth, because of its ease of use in the field. Growth is in itself not a very important economic factor, because hardly any traditional livestock keeper invests in growth, at least not in the Western Province. Practically all livestock is grazed on natural grassland, and very few, if any livestock owners use supplement of feedstuffs. Two main reasons for not investing in growth are, that the loss of weight in the dry periods cannot be compensated for in an economically sensible way, and that the livestock is not fattened for a specific (optimal) age or weight. Sales of animals are not the main economic aim of the herd manager. Animals will be sold when (immediate) cash needs arise, and the herd manager will sell animals that he can spare, in the case of cattle usually old oxen or cows. Little or no direct gain is therefore to be derived from investments in growth. The animals that are normally chosen to be sold will have attained their weight in the cheapest possible way, by grazing the natural grass.

Growth is, however, of indirect importance; animals that grow well and are in good body condition are usually healthy, are less likely to die or be attacked by disease and will be fertile (Ogink, 1993). Good growth in the wet season will help the animal to cope with the adversities of the dry season. For the evaluation of productivity performance it is therefore a useful trait.

Body condition scoring was also done during each three-monthly visit. It was considered as being at least as important as growth. It appeared however, that it could not be used for statistical evaluation, because there was too large a bias of the observer, in spite of the fact that a more or less standardised body condition evaluation schedule was used. As already stated, body condition scoring is a good tool for the herd manager, to support day-to-day decisions on his management of both the herd and the individual animal, especially if only one observer is involved in the scoring (Nicholson and Sayers, 1987). As such, attention should be given to it in terms of extension.

It has become very clear in the course of the herd monitoring study, that ample arguments were provided for the importance of an integrated veterinary and zootechnical approach to research and extension in the field of productivity improvement.

5.4. Parasites in relation to productivity.

As shown in Chapter 4.1. and 4.2., hardly any advantage of regular treatment against intestinal parasites or liverflukes could be detected, based on this study design. In Chapter 4.3. some attention was given to possible causes for this as a result of the trial design. The fact that field trials were used here may have posed some problems regarding the organisational aspects of the trial and possibly on the reliability and repeatability. These issues of dilemma between scientific study design requirements and logistic feasibilities have been extensively addressed in recent literature (Noordhuizen et al., 1993).

Nevertheless, field trials can potentially give more information than (more, possibly even too much conditioned) on-station trials. Environmental and management aspects can influence the overall effect of treatment against parasites. Infection of the pasture, and grazing management decisions are some of these aspects, as is the influence of the quality of the physical environment on the capability of the animals to cope with parasitic infections. The practicability of the results for the development project in which the survey is carried out, determines whether or not concessions in the reliability and repeatability of the results can be tolerated. Some of the factors, involved in both the productivity study and in the intervention study, related to both the management and the environment, did show the same pattern of influence in both studies. This suggests that the repeatability of these results may be quite good. The influence of treatments is in any case not dramatic.

Assuming that the results are reliable enough to conclude that routine treatments against helminths and liverflukes are not viable, some consideration should be given to the reasons for the fact that these groups of parasites apparently do not cause insuperable problems. As was stated in Chapter 4, the numbers of intestinal helminth eggs found in the samples taken in the course of the study were low, if compared with EPG values found in literature. This may well mean that the infection pressure is in fact moderate, though acute clinical cases of helminthosis are seen at times. These cases are generally isolated cases in young animals, mostly in the second half of the wet season. It may be possible that a predisposing suboptimal condition (e.g. because of another disease, insufficient fodder quantity or quality, insufficient grazing by the animal as a result of lameness) plays a part. Because the cases are often presented in a relatively advanced stage, the underlying causes are rarely, if ever, identified. On the other hand, low EPG's not necessarily mean that the infection rate is also low. The level of the EPG is not always related to the seriousness of the clinical problem (Parent and Samb, 1984).

The presence of liverfluke eggs could hardly ever be demonstrated, although from own observations as well as from literature (Jorgensen and Kamukwai, 1977, Silangwa, 1972, 1973) it is clear that liverflukes are abundantly present in the floodplain areas of the province. Acute fascioliasis is sometimes seen, especially in the late dry season, when the animals in relatively poor condition concentrate on the floodplains, as was also seen by Babalola and Schillhorn van Veen (1976) in Nigeria.

In the case of the helminth infections a relatively low infection pressure may have been present. As regards the liverfluke infections it can hardly be assumed that this is also the case, in spite of the fact that no eggs have been found. Still, treatment did not give a measurable improvement of the productivity. In this case the environment may be of greater importance than the presence of the flukes. The positive effects of treatment may have been masked by variations in range conditions and fodder quality. In the wet season in particular, the adverse effects of infections may be masked by the better fodder quality. Since the animals graze away from the floodplain for part of the wet season re-infection is probably also prevented, while the animals may be capable of ridding themselves from the flukes (Kendall and Parfitt, 1975). The masking effect of the environment is mentioned by Oakley et al. (1979). Four groups of 15 British Friesian calves were used in the study. Two groups were artificially infected with metacercariae. One uninfected group (group 1) was fed to gain 680 gr. per day, one of the infected groups (group 2) was also fed to gain 680 gr. per day. The other infected group (group 3) was fed the same quantity of fodder consumed by group 1, and the second uninfected group

(group 4) was fed to gain the same amount of weight per day as group 3. Infection proved to have a limiting effect on growth rate and food conversion. The effect on growth was masked in the animals on a lower plane of nutrition (groups 3 and 4 compared), but not that of the food conversion. Simpson et al. (1985), however, saw clear advantages of treatment in particular in periods that food stress is present. This conclusion was drawn from calculations, carried out on the basis of estimates of damage done by liverflukes, given by veterinary and production specialists in Florida, USA. The estimates were divided in two levels, low and high, with the assumption that the actual values would fall within those limits.

Apart from the low infection pressure of the intestinal helminths, it is possible that rapid re-infection after treatment annuls the effect of treatment (Anonymus, 1979). If this is the case, even an intensive schedule as was followed in the trials, especially during the wet season, is apparently not able to produce favourable results. Because of the communal use of grazing lands, it is an illusion to think, that grazing rotation schemes, to prevent re-infection, combined with supportive treatments, can be introduced in the traditional system of the Western Province.

The conclusion from the results of the trials must be that for the time being anthelmintic and flukicide treatments should be restricted to clinical manifestations of the diseases. Improvement of productivity is more likely to be attained by improving the management skills of the livestock owners, and the capability to cope with the specific characteristics of all their resources.

5.5. Economic and socio-economic aspects of cattle keeping in relation to productivity.

In the culture and socio-economic structures of the people of the Western Province cattle have played a dominant part for a very long period (Roberts, 1976). Socio-economic characteristics of the cattle keeping practice in the province undoubtedly are related to the way management decisions are reached (Wood, 1988). These socio-economic characteristics include for instance ownership of individual animals in relation to the ownership of herds, and management responsibility for individual animals and herds. Management decisions may, in their turn, be of importance for the productivity of the herds. These management decisions pertain to day-to-day decisions on what pastures to graze, which cows to milk and at what moment, when to release herds for grazing and when to take them for watering, and decisions on disposal and purchase.

If livestock development efforts in traditional African livestock systems aim at improvement of the productivity, or at solving productivity constraints, it is of importance to assess as much as possible where social and cultural structures may be related to the productivity of animals. More so, since these structures may determine to a considerable extent whether or not farmers are able to follow development recommendations (Dickie and O'Rourke, 1984). Dickie and O'Rourke distinguished, among others, the following political-economic and social factors as constraints to livestock production:

1 agricultural demands (in particular competition for grazing land)
2 trade conditions (trade infrastructure and pricing development)
3 customs concerning animal husbandry (ownership and responsibility)
4 traditional land use (communal grazing, grazing rights)

5.5.1. Agricultural demands.

In the Western Province of Zambia, demands of agriculture are not a real constraint to livestock production. The area of arable land is by no means competitive to available grazing land (Van Horn, 1977). In fact, agriculture and animal husbandry are complementary to each other. Cattle is indispensible in large areas of the province for the provision of draught power and manure (Beerling, 1991).

5.5.2. Trade conditions.

Trade conditions do play a key role in the Western Province (De Rooij and Wood, 1990). As a result of logistic difficulties, cattle purchases are not equally distributed over the province, and prices are influenced markedly. In the more remote areas, especially west of the Zambezi river and towards the Angolan border, prices of cattle are considerably lower than in the vicinity of the larger roads east of the Zambezi. Most of the cattle sold in the province is transported to Lusaka, the capital of Zambia, to Livingstone or to Ndola for slaughter. De Rooij and Wood (1990) strongly pleaded for access of third parties to the abbatoir in Mongu, the main town of the

Western Province. This abbatoir is operating far below its' capacity at present. A cause may be, that the buyers operating in the service of the Zambia Cold Storage Corporation, the owners of the abbatoir, do not have enough freedom of bargaining. As a result of this, cattle buyers from other origin, often private traders, have an advantage in the field. The consequence is, that a large contingent of animals leave the province alive, while it would have benefitted the economy of the province in various ways, if the animals could have been made to value within the Western Province. Not only the direct earnings of the cattle sellers could be improved, since transport costs are lower, but the employment possibilities in the province could also benefit. As in many rural (and urban) areas in Africa, there is a great shortage of formal employment, and it is well imaginable that, if the possibilities to slaughter animals within the province would be improved, it would become increasingly interesting to set up meat and by-products processing industries in the province. In this manner, the economy of the whole province would benefit from this spin-off effect of livestock development (Mellor, 1986).

5.5.3. Customs concerning animal husbandry.

Multiple ownership and transfers of animals between herds (Beerling, 1986, Beerling, 1991) are some customs concerning animal husbandry that can be mentioned as influential factors in animal production. The proportional importance of cattle transfers for various reasons as well as the variations in ownership involvement in the herds was illustrated in Chapter 2.4. In this study no attempt has been made to evaluate the productive performance in relation to the transfer rate or the number of owners involved in the herds. It proved to be impossible for the following reasons. Including them in the models as independent variables proved very difficult. Especially regarding ownership, the variety was too big. Classification was also not very practical, since apart from the number of owners, also the relation of the owners with the herd manager should be weighed.

The number of owners involved in any herd ranged between 1 and more than 25 (Chapter 2.4). Generally one person is ultimately responsible for day-to-day decisions concerning the herd. This herd manager will however not be able to make all possible decisions regarding individual animals (Beerling, 1986). The decision making process in the herds is still subject of research in a Livestock Development Project (De

Rooij and Wood, 1990). Some fields to which decision making concerning individual animals may pertain are sales and financial investment, for example in the purchase of drugs.

The owners involved in any herd mostly belong to the direct family of the herd manager, who is often at the same time head of the family. Decisions to sell animals will probably be made by the owner of the particular animal, but will often not be effectuated without consulting, nor without the consent of the herd manager. It should be noted, that sale of animals usually comes up only when an acute cash requirement necessitates this (Beerling, 1986). It is obvious, that such far-reaching decisions as reducing the family herd, should be made after careful consideration. Given the circumstances, this is absolutely common sense. Since sales of animals normally occur for specific financial purposes, the revenue will not be readilly available for the advancement of the herd itself. As such, it is at least questionable whether this practice should be regarded as a real constraint to production. This situation may change if cost-recovery measures for the services rendered by the Department of Veterinary and Tsetse Control services (Chizyuka et al., 1987), and probably by other institutions (e.g. extension services), are effectuated. The consequence may be that some form of financial input into the herd has to be found.

Transfers of animals between herds, occurring in a frequency of approximately 10 % of the number of animals per herd per year (Chapter 2.4), may be another factor complicating the design of cost-recovery measures (De Rooij and Wood, 1990). Placing animals under the care of others implies a transfer of responsibility. The extent to which responsibility is taken up is again likely to influence decision making regarding the individual animal. This may be closely related to the purpose of transferring animals (Chapter 2.4). If a herd manager borrows animals, for example for manure, draught power or milk, it may be argued that he will necessarily have a higher level of interest in the health of these animals, than if cattle is placed under his care by others, in which situation the original owner of the animals is the principle beneficiary of the arrangement.

Another factor related to cattle transfers that may have consequences for productivity, is, that transfers may constitute health hazards. It may be, that certain infectious diseases are introduced and spread through transfers of animals, as was also stated in the discussion of Chapter 2.4.

It is well possible, that for example the spread of Blackleg (Clostridium chauvoei infection) may be linked with transfers of brideprice cattle (personal observation). Normally, relatively young animals are chosen for this. The disease occurs mostly in animals between 6 months and two years of age (Selman, 1981), and infected animals may spread it when transferred during the incubation period.

Another disease of which the clinical occurrence may be associated with transfers, or rather with transports of animals, is Haemorrhagic Septicaemia (associated with Pasteurella multocida infection). In the Western Province foci, from which Haemorrhagic Septicaemia spreads periodically, were associated with sites where concentrations of animals occurred regularly. These sites were places where trade cattle crossed the Zambezi river on their way from the west of the province to the abbatoir. In the case of this disease the numbers of animals on transfer is often considerable. In transfers between herds often only one or only a few animals are taken from one herd to the other. Determining whether these transfers are important in the behaviour of diseases in general terms may be difficult under field conditions. Simulation modelling and risk assessment procedures on the basis of field information on the location of clinical cases or outbreaks and transfers could be an appropriate tool to study the risks of introduction and spread.

While transfers may constitute health risks, one of the aims of transferring cattle to herds of others is, to spread the risk of loosing animals through epidemic (e.g. Heamorrhagic Septicaemia), or endemic (e.g. trypanosomiasis) diseases. This seems a contradiction, but it does show, that a clear and well reasoned rationale is the basis of decisions to transfer animals. Benefitting from good grazing or from prime breeding bulls are likewise sound management reasons that seemingly are of bigger importance than the supposed hazards to health. Modelling may again be able to provide possibilities to quantify the risks of transfers and weighing them against the benefits resulting from them.

As was stated, quantification of the influence of ownership and transfers on productivity was not carried out in this study. In an individual herd performance study with the aim of deriving practically useful extension information, it may however be of importance to include these factors in the assessment. Nevertheless, it should be borne in mind, that factors such as these should be regarded predominantly as conditional aspects, rather than variables that can be influenced to a considerable extent.

5.5.4. Traditional land use.

The main characteristic of traditional land use is communal use of grazing resources. No livestock or herd owner has private rights or title deeds to certain delineated stretches of land. This is also true for land used for cultivation. This, however, does by no means mean, that no order whatsoever underlies the use of the land. Gluckman (1973) shows through his reports on court cases in the local and royal courts in the Western Province, that a complex of arrangements and formal assignment of land use rights are in force. This may be more strict for cultivated land than for grazing land, but it is common knowledge, that if a herd manager wants to permanently shift his herd to a new settlement area, he will have to acquire the permission of the local chiefs responsible for the traditional government in the area.

Since no individual ownership rights are in force, it can hardly be expected that investment in improvement of the grazing resource takes place. Since the climatic and soil fertility factors are far from stimulating in this respect, it is not likely that this would be importantly different if individual title deeds to land did exist. Improvement of the use of the grazing resource cannot lie in privatising landownership. The Socio-Economic Analysis Team and the Rangeland Management Team in the Western Province (1992) concluded, in a study carried out to provide information for policy making, as well as to identify extension requirements, that grazing management practices and the use of fodder and water resources are rational and efficient, given the circumstances in the province. Though considerable stretches of potential grazing land remain unused (Socio-Economic Analysis team and Rangeland Management Team, 1992), this situation prevails for sound reasons. Often lack of proper watering points is the direct cause (Jeanes and Baars, 1990).

Land use planning is considered an important issue in livestock development (Van Rootselaar and Wood, 1990). Research into structures that underlie communal land use is therefore important. This is important for policy making in livestock production, but also to know how to direct extension messages. Dickie and O'Rourke (1984) mentioned that range management advisors should base their advice on an ecologically, economically, as well as on a culturally sound basis. As regards this cultural aspect, they cited a Maasai elder, to illustrate the importance of being well aware of the local social situation regarding grazing land use. This man, chairman of a livestock village in Tanzania, remarked that good technicians performed poorly because they did not understood that the elders are the deciding power. If there is no awareness of this situation, the message will never come across. The study into traditional grazing management by the Socio-Economic Analysis Team and the Rangeland Management Team (1992) was aimed at determining the structures pertaining to the decision process on the use of grazing land in the Western Province.

While it would seem quite possible to alter constraints to production resulting from the cattle trade practices, this is quite different from factors that are predominantly culturally and sociologically determined. It could be argued, that if a result of livestock development efforts aimed at improving veterinary services is, that risks of epidemic diseases and endemic disease occurrence are reduced, there may be less reason for transfers of animals between herds. However, for example the practice of settling brideprice with cattle, involving transfer of the animals it concerns, is not likely to disappear. Multiple ownership and communal grazing resource use will, for perfectly sound reasons, undoubtedly continue to prevail in the province. The importance of carrying knowledge about these factors is therefore that it enables the design of development measures fitted to the local circumstances (Little, 1984).

In the Western Province, research into socio-economic aspects of cattle keeping will have to continue. Ownership, land tenure and grazing rights, transfers and mutual relations between herd owners, and relations between herd owners and owners of cattle in the herd should, where possible, be related to productivity and risks of productivity loss. It is likely, that field studies of this kind will predominantly be descriptive, since the logistic possibilities for analytical studies may be small. Modelling on the basis of the information brought forward through the field studies could prove to be useful as well. The aim of this research should primarily be, to assess the possibilities of productivity improvements within the limits of the socio-economic context. The information resulting from it should come available in a shape in which it can be used for the formulation of locally applicable extension messages.

As an example, the formation of grazing management or land tenure committees can be mentioned. The existing social structures pertaining to grazing rights allocation may possibly be chanelled in this manner, and a forum may be formed in which also land use rights of parties concerned, other than cattle keepers, are arranged. This may, for instance, improve the situation concerning indiscriminate burning of grazing land. The traditional authorities, at present key figures in the allocation of land, should be involved in processes of this kind.

5.6. The usefulness of longitudinal herd monitoring.

In the course of the herd monitoring study the choice to make use of a longitudinal observational study proved to be a good one. Variation between years and long intervals between the birth of calves necessitate a longer observation period. It could even be argued that the period on the basis of which the results of Chapter 2 are reported is still relatively short. Increasing the number of years would increase the reliability and would particularly allow conclusions for long term climatic variation. The character of a survey of this kind in a development project demands, however, a practical approach to the execution of the study.

It should be remembered that a field survey in the framework of a development project cannot develop into a long term scientific exercise. The duration of this part of the monitoring study allowed (possibly partly indicative) conclusions to be drawn already. The same is true for the second part of the programme, which is reported in Chapter 4.1. and 4.2.

Physical herd monitoring does seem to produce useful results to be used directly for the project in which it is carried out. General productivity data are obtained in a relatively objective manner, and in a relatively short period.

5.7. Conclusions in relation to productivity and livestock development and perspectives.

As was pointed out already in Chapter 1, an integrated approach to livestock development, not only taking into account the position of livestock in the farming system, but also socio-economic aspects of the livestock industry, is preferable. Keeping this in mind, and overviewing the results obtained in the surveys reported in this thesis as well as those presented by other authors on the cattle of the Western Province, some conclusions can be reached, that may serve as elements or conditions for livestock development efforts that are, or are to be, persued in the Western Province.

- The veterinary component is important in livestock development efforts in general, not only because it contributes to improved health, to reduction of losses, and to sustainability, but also because it can be a very good starting point for further integrated veterinary and zootechnical livestock development efforts. As far as specific veterinary measures are concerned, organised veterinary interventions should aim at reducing and controlling the prevalence of the important communicable diseases (Haemorrhagic Septicaemia, Foot and Mouth Disease, Trypanosomiasis etc.). This can be expected to reduce losses more significantly than for example the antiparasitic treatments studied here.

  Which diseases the attention should be directed to, is subject to careful consideration. Not just the presence of the disease or the disease agent, but more so the physical damage caused by it to both individual animals and the livestock population, and knowledge of the extent of the risks to which animals are exposed, are elements in this assessment. Tick-borne diseases for instance, for which obligatory anti-tick dipping or spraying is practiced in many parts of Africa, proved to be of little importance in most of the traditional herds in Zambia. In the absence of East Coast Fever a solid premunity generally exists against most of the tick-borne diseases. If calves are infected at a young age, they mostly develop an immunity without showing clinical signs. Regular re-infection produces the premunity. Rigorous tick control disrupts the premunity and may cause losses if it can not be continued. Tick control should be restricted to treatments of animals that physically suffer from the tick burden. Calves born early in the dry season may not attain an infection before the tick population rises in the wet season. They are often not young enough to become infected without having clinical disease and developing premunity. In these animals rarely clinical problems may be seen, usually as a result of heartwater (caused by <u>Cowdria ruminantium</u>).

  Additional veterinary activities provide relatively easy entrances in local livestock areas. Through improvement of the veterinary service provision to individual livestock owners at field level, the demand of farmers for possibilities to have individual animals treated for clinical disease can be met. Even at field level, however, the attention should not only be directed towards veterinary activities. Also in the provision of services to individual livestock owners an integrated, multidisciplinary approach should be persued.

- Socio-economic features of the cattle keeping system should be regarded predominantly as conditions, giving the direction for the development efforts. The possibilities to influence them are very small and indirect. Furthermore it is highly questionable whether it should be endeavoured to change or disrupt stable social and cultural relations for the sake of improved productivity. It is very likely that this produces the opposite effect of what is aimed for.

- The design of cost-recovery measures for veterinary services is one of the aims of field studies. The shape these measures take will have to be modelled carefully, taking socio-economic features, and especially the decision making process, into consideration. Financial inputs in the herds, specifically if aimed for example at treatment of individual animals with drugs or vaccines, may be influenced by the multiple ownership existing in the herds in the Western Province. De Rooij and Wood (1990) mentioned that charging farmers for services at the crushpen where treatments take place, may result in partial coverage of the herds with such treatments if he cannot be sure of reimbursment of the charges by the other owners of cattle in the herd. The herd manager will often want to confer with the other owners in the herd before taking a decision. It will in those cases inevitably take more time before a decision is reached (Beerling, 1986). Another aspect is, that if farmers perceive a specific service as being of little value, the use of that particular service may decline, which could have negative implications on health (De Rooij and Wood, 1990). Apart from charges for specific services, cost-recovery measures can take the shape of revenue collection through a provincial tax on cattle owners, or a levy on cattle exported from the province.

- There is ample room for optimisation of the conditions for trade. A better use of the locally based abbatoir is likely to provide possibilities for the development of activities related to valuation of cattle products. This would constitute a contribution to employment development.

- Although the vulnerability of the grazing grounds is not considered to be very high (Van Gils, 1989), and the upper limits of the grazing capacity of the province has not been reached by far, a growing cattle population as a result of livestock development efforts requires a continuous attention for the grazing conditions and the ecology (Jeanes and Baars, 1990). This requires a rangeland monitoring system (Jeanes and Baars, 1990), as well as attention to the possibilities of opening as yet unused grazing areas.

- Given the multiple ownership in herds, extension aimed at productivity improvement should aim predominantly at measures that influence the productivity of the herd as a whole. They would have to relate to herd management aspects and efficient use of grazing resources.

The variability in performance between animals is considerable. This would imply, that there is scope for improvement of individual performance as well. It is likely that, if improvements involve financial investments in the herd as a whole, they will not be persued by farmers, since their impact is hardly in balance with the investments. It would however probably be interesting to consider the possibilities of giving extra attention to and investing in just a few individual animals in a herd. Such extra attention could for example comprise:

- harvesting and storage of roughage (maize stalcks, possibly hay) to be fed during the dry season (this may be workable if it is done for a few animals only),
- strategic feed supplementation (maize bran and other crop residues), to support the animals during the dry season and to improve condition around mating time,
- controlled siring, including the choice of bulls as well as determining the optimal moment of service,
- extra calf care, e.g. colostrum provision, roofed calf pens, calf pen hygiene.

It would be efficient to choose animals for this individual productivity performance programme that are already above average. In order to be able to do this, it must be possible to identify these animals in a herd. The record keeping and data processing system used in the herd monitoring study is suitable for this. It is hardly thinkable that this system could be used in any herd that is supposed to engage in improvement of the productivity of some individual animals. Good manual record keeping may be much simpler, provided that it is done reliably and consistently.

In view of the fact that unemployment rates are high in the rural area, and that hardly alternative education facilities are available for school-drop-outs, it could even be considered to establish a secondary school for practical animal husbandry. This would open possibilities for young people to engage in a type of lightly commercialised cattle keeping, in the herds of, for example, their fathers, with some animals that already are their property. Another possibility could be that pupils are given animals owned by the school, in a formal herding arrangement, to start on their own, or in an already existing herd. An added advantage is, that in this manner people that do not possess cattle can be started in cattle keeping. It would probably increase the possibilities for women to engage in cattle keeping as well.

The concept of establishing a level of commercialised cattle keeping within a traditional cattle keeping tradition is likely to be confronted with several problems. Firstly the question should be answered whether it would be accepted by the cattle keepers. Secondly, research should be aimed at the logistic possibilities of such a programme. This pertains to determining which supplement feeds are best to use, and are best available, and which feeding strategy would be most advantageous. It also relates to the market for the product, especially milk. Furthermore, a thorough identification of proper and workable cattle management requirements, in as far as they differ from general extension, would be necessary. While being probably worthwhile considering, establishing such a system would still require a lot of thought and research, and a lot of attention to infrastructure requirements.

Traditional livestock systems in Africa in general operate, as in the Western Province of Zambia, within the limits of their environment, both physical and social. In general terms, their management is well adapted to these limits (De Leeuw and Konandreas, 1982, Cossins, 1985). It does however not mean, that there would be little or no room for improvement of management and production. Carefull study of these limits should provide means of rationalisation of management and optimisation of the use of the available resources. Herd owners often consider productivity constraints, especially if they are caused by the physical environment, to be inevitable. If livestock development projects aim at productivity improvement, one of the issues to adress would therefore be to convince herd owners as well as owners of individual animals, that several of these factors may be influenced by them.

The fact that a large variation in the productive performance of animals is present, and that an influence of the herd management on productivity is likely to be present, suggests, that perspectives for the improvement of productivity are present. It is very well possible, that relatively simple adjustments in the day-to-day management of the herds would already produce favourable productivity effects. These adjustments could, for example, include a rational choice of pastures, attention to pasture and water quality, distances to be covered, but also practices and timing of releasing animals from the kraal, the amount of time the animals are allowed to feed and kraal shifting frequencies. Further research should aim at identifying decisive factors in daily management practices, in order to incorporate the results in extension messages. It is essential that these extension messages become more problem oriented, in stead of the current practice, in which standard extension messages "from the book" are common. Extension workers should therefore not only be equiped with their technical knowledge, but also with the tools to assess local situations, to identify problematic issues and to produce locally applicable solutions.

Epidemiological modelling of productivity aspects of the traditional livestock management systems in the Western Province, and possibly in sub-Saharan Africa in general, may prove a useful tool in the assessment of environmental and managerial risks to productivity. It could, for example, assist in determining the impact of diseases, taking into account the frequency of transfer of animals, as well as the composition and direction of transfers. Such a tool could also assist in assessing the effects of interventions, such as vaccinations, treatment and control programmes. It may also be able to provide back ground information on the influence of socio-economic aspects of cattle keeping. If epidemiological modelling is considered, further field research will have to aim at providing the basic information necessary for this.

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Summary.

In sub-Saharan Africa, traditionally managed livestock is important because of the provision of draught power and manure, the provision of security and investment possibilities, for the provision of meat and milk, and for social purposes (eg. brideprice, gifts). In the Western Province of Zambia, cattle are the only livestock of significance. The soils of the province virtually entirely consist of Kalahari sands, that are not very suitable for crop production, but with a good suitability for extensive cattle keeping. Cattle in the province belong to the Barotse breed. This is a Sanga breed, with a moderate to reasonable potential for meat and milk production, when compared with other local breeds, and if maintained under improved range conditions.

A livestock development project in the Western Province (Prov. Vet. Officer (1987), Livestock Development Project Western Province, Project Document) operates within the Department of Veterinary and Tsetse Control Services. It is aimed at providing a sustainable infrastructure for disease control, at assisting in the formulation of a cattle development policy, and at developing an integrated animal husbandry and animal health extension package for the traditional farmer. In order to establish its goals, the project has engaged in a programme of research activities. In this research, animal husbandry and animal health, but also grassland expertise, sociology and economy were involved. Part of the research programme was the herd monitoring programme.

The aim of this thesis is, to evaluate the use of longitudinal physical monitoring of herds of cattle under traditional management for the description of productive performance and identification of factors that influence productivity. This evaluation should provide insight in the suitability of herd monitoring for the provision of basic information for extension and solutions for constraints to productivity.

The herd monitoring programme is aimed at collecting quantitative information on the productivity of cattle in the province. Knowledge of these aspects was needed for the identification of constraints to productivity, for the assessment of the need for specific veterinary measures, and in order to give indications on the structure and development of the provincial herd.

A total of 52 herds was involved in the first phase of the research (Chapter 2.1.). These herds were based in four of the six districts of the province. Herds were based in each of four Grazing Management Systems (GMS). The Grazing Management Systems differed in terms of grazing area and its' use, vegetation, main water resources, and largely in the practice of transhumance (periodically moving herds to other grazing grounds) or sedentarism (herding the animals from one permanent basis). All animals in the herds were individually identified through eartags, and the records were taken at the level of the individual animal.

Deaths and slaughters were evaluated together, because slaughters should generally be considered emergency slaughters (Chapter 2.2.). Statisticaly significant effects on the combined death and slaughter figures were found of sex, age and the herd. Sales figures were also significantly influenced by Grazing Management System and husbandry system. Significant seasonal influences on death and slaughter figures, as well as on sales figures, could also be identified. The overall sales figures were smaller than the death and slaughter figures. Deaths and emergency slaughters must be seen as absolute losses, even though the meat of these animals is often still eaten or sold. The revenue this generates is, however, far less than that generated by sales of animals.

The percentage of cows that calve differs considerably between Grazing Management Systems (Chapter 2.3.). This figure is, however, influenced by the proportion of animals that move into and out of the herds, and that spend less than a year in the herd. This proportion also differs considerably between herds.

Significant influences on the mean lengths of calving intervals were found of the Grazing Management System (GMS) and the parity. Cows of which the calf died, or was not weaned, and which were not milked also showed a longer calving interval. The calving intervals are longest in GMS 1. Also seasonality in calving seems to be most clear in this GMS. In GMS 2, the interval between the birth of a calf and the moment the farmer starts milking the cow is significantly shorter than in most of the other GMS. At the same time the length of the period that the cows are milked is longest, and the interval between weaning of the calf and the birth of the next calf is shortest.

The season in which the calf was born also significantly influenced the interval between calving and the moment the cow was milked for the first time, the length of the milking period and the age of the calf at weaning. The girth was generally influenced by GMS, sex and season. In GMS 1 the negative influence of environmental circumstances on productivity seemed biggest, in GMS 2 smallest.

The number of owners involved in the herds that were included in the programme varied considerably (Chapter 2.4.). Most owners in a herd belonged to the family or relatives of the herd owner. The majority of cattle owners are men, and the average number of animals owned by men is twice as big as that owned by women. The number of owners in a herd was positively related to the size of the herd. One third of all removals from, and entries into the herds consisted of transfers from one herd to another, mostly because of herding arrangements. Also brideprice payments are an important reason for transfers of animals. The ownership and the transfers between herds are likely to influence decision-making processes in the herds. Transfers may pose risks of infection, but may also be aimed at reducing risks because of disease outbreaks.

Diseases, in particular those caused by helminth parasites, are considered important constraints to productivity in the tropics (Chapter 3). Livestock owners also often consider parasitic diseases as a major reason for depressed body condition and consequently for depressed productivity. In the Western Province, the liverfluke Fasciola gigantica has a high prevalence. As in many other areas of Africa, floodplain grazing is an important factor in the epidemiology of this parasite. A seasonal influence is also present in many areas in Africa.

A distinct seasonal influence is identified in many areas in Africa on the epidemiology of intestinal helminths. This is importantly related to the survival chances of the larval stages outside the vertebrate host. In the dry season no larval activity on pasture is found. The lack of moisture, rather than the temperature, seems to be the major determinant.

The extent to which animals suffer from infections with intestinal helminths and liverflukes is partly determined by previous exposure. After previous exposure the animals develop resistance against re-infection, as a result of which the number of helminths that mature, as well as the adverse effects of infection are reduced. This is the result of development of immunity, and also, specifically in liverfluke, of fibrosis and calcification of liver tissue.

The influence of infections with liverflukes and intestinal helminths on productivity is often evaluated through measuring the effects on growth or weight. In the Western Province, however, animals being sold for slaughter are normally selected from older animals. Therefore reproductive performance and parameters such as mortality and slaughter figures would be more important.

In the second phase of the research, the intervention programme, two routine treatments against liverfukes (either Rafoxanide or Triclabendazole) were included, as well as two routine treatments against intestinal helminths (either Avermectine or Thiabendazole), and one combined routine treatment against both groups of parasites (both Rafoxanide and Thiabendazole). A total of 20 herds was involved in the intervention trials.

Hardly any significant differences could be identified for the influence of treatment against liverflukes (Chapter 4.1.). In the Rafoxanide group, part of the treated animals had a slightly larger girth. Also a significantly shorter interval between weaning and the next delivery was found for treated animals in this group. In both girth and the intervals related to reproduction and lactation differences were found for other factors than the treatment, such as season, herd and sex. Deaths and slaughters for emergency were not significantly influenced by treatment against liverflukes. Significant differences could be identified for the herd in this analysis.

The intervention, involving treatments against intestinal parasites and a combined treatment against intestinal helminths and liverflukes, also showed significant influences of season, sex and herd in several of the parameters, but hardly any of treatment (Chapter 4.2.). In the Avermectine trial, the girth of treated animals was larger. A significant effect of treatment on deaths and slaughters, at a confidence level of .90, was found in the Thiabendazole group. It is likely, that a clinical problem of gastro-intestinal parasitism was present in these herds. Analysis of faecal samples showed, that the largest percentage positive samples was found in the second half of the wet season.

The intervention trials seemed to produce little or no favourable effects of treatment against either liverflukes or intestinal helminths (Chapter 4.3.). It is possible, that part of these results can be explained by the circumstances under which the trials were carried out and the trial design. More importantly, it is likely, that both liverflukes and intestinal helminths, though present, are in general not a serious problem. The low numbers of eggs found in faecal samples suggest this. Individual cases do occur, and large percentages of animals are likely to be infected, but the physical damage done by these infections is either small, masked by other factors, or is a far less influencial factor than factors such as nutrition, management or grazing environment.

Even small differences between treated and untreated animals could economically justify the use of routine treatments, even if the schedules are relatively intensive, if the cost of application is not included. However, management of the herd and management of environmental factors are more important elements in improvement of productivity.

Several aspects of the herd management can be mentioned as influences on the productivity of the herds (Chapter 5). These include collection of manure, causing pressure on grazing time, the frequency of kraal shifting, especially for calves, day-to-day choice of pastures to graze, the quality of herdsmen, and uncontrolled burning of grassland. Competition between calf and man for the milk of the cows is not likely to be an important negative influence in calf health.

Further research into day-to-day management factors in relation to the productive performance of animals and herds is necessary to provide the basis for extension. Ownership division, the number of owners and their relation to the herd owner and, if possible, environmental factors should be included in this research.

Economic and socio-economic factors are determinant factors in livestock development. Customs concerning animal husbandry, trade conditions and communal land use management are of importance.

Samenvatting.

In Afrika, ten zuiden van de Sahara, is traditioneel gehouden vee van belang vanwege trekkracht en mest, bestaanszekerheid en de mogelijkheid te investeren, vanwege vlees en melkvoorziening en om een aantal sociale (bijvoorbeeld bruidsprijs, giften) redenen (Hoofdstuk 1). In de Western Province in Zambia is rundvee het enige vee van betekenis. De bodem in de provincie bestaat bijna geheel uit Kalahari-zand, voor het merendeel niet erg geschikt voor akkerbouw, maar wel geschikt voor extensieve veehouderij. Het rundvee in de provincie behoort tot het Barotse-ras. Dit is een Sanga-ras, redelijk geschikt voor melk- en vleesproductie in vergelijking met andere lokale rassen, wanneer ze onder goede omstandigheden worden gehouden.

Een veeteeltontwikkelingsproject in de Western Province (Provincial Veterinary Officer (1987), Livestock Development Project Western Province, Project Document) werkt onder het Department of Veterinary and Tsetse Control Services (de Veterinaire Dienst). Het heeft als doel het tot stand brengen van een goede infrastructuur voor dierziektenbestrijding, het leveren van een bijdrage aan een veeteeltontwikkelingsstrategie, en het tot stand brengen van een geïntegreerd voorlichtingspakket met zowel zoötechnische als veterinaire elementen voor de traditionele veehouder. Om deze doelen te bereiken, is een aantal onderzoeksactiviteiten gestart. In dit programma wordt aandacht geschonken aan dierhouderij en diergezondheid, maar ook aan expertise op het gebied van grasland, sociologie en economie. Een onderdeel van het researchprogramma was het herd monitoring programma.

Het herd monitoring programma is erop gericht, kwantitatieve informatie te verzamelen over de productiviteit van het vee in de provincie. Kennis hierover was nodig, om knelpunten in de productiviteit aan het licht te brengen, om een inschatting te maken van de behoefte aan specifieke veterinaire maatregelen, en om informatie te verschaffen omtrent de structuur en de ontwikkeling van de rundveepopulatie in de provincie.

Het doel van dit proefschrift is, het gebruik van fysiek monitoren van traditioneel gehouden kuddes rundvee over langere perioden, teneinde productiviteit te beschrijven en factoren te identificeren die productiviteit beïnvloeden, te evalueren. Deze evaluatie dient inzicht te verschaffen in de geschiktheid van monitoring van kuddes voor het verzamelen van

basisinformatie, ten behoeve van de voorlichting en voor het vinden van oplossingen voor knelpunten voor de productiviteit.

In totaal waren 52 kuddes bij de eerste fase van het onderzoek betrokken (Hoofdstuk 2.1.). Deze kuddes waren gevestigd in vier van de zes districten in de provincie. Ze waren gevestigd in elk van vier Grazing Management Systems (GMS). Deze verschillen van elkaar voor wat betreft het graasgebied en het gebruik ervan, de vegetatie, de belangrijkste watervoorziening, en in het al dan niet algemeen zijn van transhumance (het op regelmatige basis verplaatsen van het vee naar andere graasgronden) of sedentarisme (het weiden van het vee vanuit één permanente basis). Alle dieren in de kuddes werden individueel geïdentificeerd door middel van oormerken, en de informatie werd op basis van individuele dieren vastgelegd.

Omdat slachtingen vrijwel altijd noodslachtingen zijn, zijn de sterfte en de slachtingen gezamenlijk geëvalueerd (Hoofdstuk 2.2.). Statistisch significante effecten van geslacht, leeftijd en kudde op sterfte en noodslachting kon worden aangetoond. Verkoopcijfers werden ook significant beïnvloed door het Grazing Management System en het houderijsysteem (transhumance of sedentarisme). Zowel op sterfte en slachtingen als op verkoop werden seizoensinvloeden gevonden. Het percentage verkochte dieren was kleiner dan het aantal dat stierf of werd geslacht. Sterfte en slachtingen moeten als absoluut verlies worden gezien, hoewel het vlees van gestorven dieren vaak nog wel wordt gegeten of verkocht. De inkomsten die daaruit worden betrokken zijn echter veel lager dan wanneer levende dieren worden verkocht.

Het percentage koeien dat kalft verschilt aanzienlijk tussen de Grazing Management Systems (Hoofdstuk 2.3.). Dit percentage wordt echter sterk beïnvloed door het aantal dieren dat aan kuddes wordt toegevoegd of eruit wordt verwijderd, en dat minder dan een jaar in de kudde aanwezig is. Ook dat laatste aantal dieren verschilt sterk tussen kuddes.

Er bestonden significante verschillen in de tussenkalftijden voor de diverse Grazing Management Systems en voor verschillende pariteiten. Als koeien niet worden gemolken, of als het kalf sterft, blijkt de tussenkalftijd langer te zijn. De tussenkalftijd is het langste in GMS 1. In dit GMS was ook het meest duidelijk een afkalfseizoen te herkennen. In GMS 2 was het interval tussen de geboorte van het kalf en het moment dat de koe voor het eerst gemolken wordt significant korter dan in de meeste andere. Tegelijkertijd duurt de lactatieperiode het langst, en is het interval tussen spenen en het volgende kalf het kortst.

Het geboorteseizoen van het kalf beïnvloedt het interval tussen de geboorte en het moment dat de koe voor het eerst gemolken wordt, de lengte van de lactatieperiode en de speenleeftijd van het kalf. De borstomvang, als afgeleidde parameter van het gewicht, wordt met name beïnvloed door GMS, geslacht en seizoen. In GMS 1 lijken de omgevingsfactoren het meest de productiviteit negatief te beïnvloeden, in GMS 2 het minst.

Het aantal eigenaren van dieren in de kuddes in het programma was zeer variabel (Chapter 2.4.). De meeste mede-eigenaren in een kudde behoren tot de familie van de kudde-eigenaar. Het belangrijkste deel van de dieren is in het bezit van mannen, en mannen bezitten gemiddeld twee maal zoveel dieren als vrouwen. Het aantal eigenaren dat dieren bezit in een kudde is significant gerelateerd aan de grootte van de kudde. Ongeveer een derde van de dieren, die de kudde in of uit gaan, doet dat vanwege verplaatsingen tussen kuddes, met name vanwege verzorgingsovereenkomsten. Betaling van de bruidsprijs is ook een belangrijke reden voor verplaatsingen van dieren. Het verschijnsel dat er meerdere eigenaren in een kudde zijn, en de frequentie waarmee dieren worden overgeplaatst, kunnen de besluitvorming over dieren in de kudde beïnvloeden. Dierverplaatsingen kunnen ook zekere risico's van infectieoverdracht met zich meebrengen, maar kunnen ook juist gericht zijn op het spreiden van gezondheidsrisico's.

Ziekten, met name veroorzaakt door gastro-intestinale parasieten, worden gezien als een belangrijke belemmering voor productiviteit in de tropen (Hoofdstuk 3). Veehouders beschouwen parasitaire ziekten ook veelal als een belangrijke oorzaak voor slechte lichaamsconditie en daardoor voor lage productiviteit. In de Western Province komt de leverbot Fasciola gigantica veel voor. Zoals in veel andere gebieden in Afrika, speelt het begrazen van de overstromingsvlakte van rivieren een grote rol in de epidemiologie van deze parasiet. Voor vele gebieden in Afrika is er ook een seizoensinvloed gevonden.

Een duidelijke seizoensinvloed is ook gevonden in veel delen van Afrika op de epidemiologie van maag-darmwormen. Dit heeft te maken met de overlevingskansen van de larvale stadia buiten de gastheer. In het droge seizoen wordt geen activiteit van larven gevonden op de weidegronden. Het gebrek aan vocht, en niet zozeer de temperatuur, lijkt hier de belangrijkste remmende factor.

De mate waarin dieren te lijden hebben van infecties met maag-darmwormen en leverbotten is deels afhankelijk van eerdere infecties. Na voor het eerst een infectie op te lopen, ontwikkelen ze een zekere weerstand tegen her-infectie, waardoor wordt het aantal wormen dat tot volle wasdom komt kleiner is, terwijl ook de negatieve gevolgen van de infectie minder ernstig zijn. Dit is het resultaat van immuniteitsontwikkeling, en in het geval van leverbotinfecties ook van calcificatie en fibrosering van de lever.

De invloed van infecties met leverbotten en maag-darmwormen op de productiviteit wordt veelal gemeten door het effect op de groei of het gewicht. In de Western Province worden dieren, die voor de slacht verkocht worden, echter gewoonlijk gekozen uit de oudere dieren. Parameters die betrekking hebben op de voortplanting en sterfte en verkoopcijfers zijn daarom belangrijker.

Ter bepaling van de indicatie, dieren routinematig te behandelen tegen leverbotten of maag-darmwormen, is de kosten-batenverhouding een belangrijk onderdeel van de discussie. Daarom waren in de tweede fase van het herd monitoring programma de effecten van behandelingen op productiviteit onderwerp van onderzoek. Een daaropvolgend doel was, de economische implicaties van deze behandelingen te meten, om de levensvatbaarheid van de gebruikte behandelingsschema's te bepalen, of om de maximale kosten van een levensvatbaar schema vast te stellen.

In de tweede fase van het onderzoek, het interventieprogramma, werden twee routinematige behandeling tegen leverbotten (óf Rafoxanide, óf Triclabendazole), zowel als twee behandelingen tegen maag-darmwormen (óf Thiabendazole, óf Avermectine), en een behandeling tegen beide groepen parasieten uitgevoerd (zowel Rafoxanide als Thiabendazole). In totaal waren 20 kuddes bij het interventieonderzoek betrokken.

Er werden vrijwel geen significante verschillen aangetoond voor de invloed van behandeling tegen leverbotten (Hoofdstuk 4.1.). Alleen in de Rafoxanidegroep werd een een iets grotere borstomvang gevonden voor een deel van de behandelde dieren. In deze groep werd ook een korter interval tussen het spenen van het kalf en de geboorte van het volgende gevonden bij de behandelde dieren. Zowel bij de borstomvang, als bij de intervallen die met voortplanting en lactatie te maken hebben, werden significante verschillen gevonden voor andere factoren dan behandeling, zoals het seizoen, de kudde en het geslacht. Sterfte en noodslachtingscijfers werden niet significant door behandeling tegen leverbotten beïnvloed. Significante verschillen konden in deze gevallen worden gevonden voor de kudde.

In de proeven, waarbij behandelingen tegen maag-darmwormen werden toegepast, werden eveneens significante invloeden gevonden van het seizoen, het geslacht en de kudde voor verschillende parameters, maar bijna geen van de behandelingen (Hoofdstuk 4.2.). In de Avermectinegroep was de borstomvang van behandelde dieren groter. Bij de Thiabendazolegroep werd bij een betrouwbaarheid van .90 een effect van de behandeling gezien. Waarschijnlijk was in deze kuddes klinische maag-darmwormziekte aanwezig. Bij analyse van mestmonsters op parasieteneieren blijkt, dat het grootste aantal positieve mestmonsters werd gevonden in de tweede helft van het regenseizoen.

Het interventieprogramma liet weinig of geen gunstige effecten van behandeling tegen hetzij leverbotten, hetzij maag-darmwormen zien (Hoofdstuk 4.3.). Het is mogelijk, dat een deel van deze resultaten verklaard kan worden door de omstandigheden waaronder het onderzoek werd uitgevoerd en het ontwerp van de trial. Een belangrijkere reden is waarschijnlijk, dat zowel leverbotten als maag-darmwormen, hoewel aanwezig, in het algemeen geen groot probleem zijn. De lage aantallen eieren die in de mestmonsters werden gevonden wijzen daar ook op. Individuele gevallen komen voor, en grote percentages dieren zullen waarschijnlijk geïnfecteerd zijn, maar de fysieke schade die door deze infecties wordt veroorzaakt is echter slechts klein, of wordt door andere factoren gemaskeerd, of is een factor van veel minder invloed dan factoren zoals voeding, management en graasgebied.

Zelfs bij kleine verschillen tussen behandelde en onbehandelde dieren, en zelfs bij relatief intensieve behandelingsschema's, kan uit economisch oogpunt al rechtvaardiging voor routinebehandelingen worden afgeleid, als hierbij de toedieningskosten niet worden berekend. Management van de kudde en van omgevingsfactoren zijn echter belangrijkere voorwaarden voor productiviteitsverbetering.

Verschillende aspecten van de dierhouderij kunnen genoemd worden als mogelijke invloeden op de productiviteit van de kuddes (Hoofdstuk 5). Hiertoe behoren het verzamelen van mest, waardoor de graastijd onder druk komt, de frequentie waarmee de kraal wordt verzet, vooral voor kalveren, de dagelijkse keuze van de te begrazen weide, de kwaliteit van herders en het ongecontroleerd branden van graasgronden. Het onttrekken van melk voor humane consumptie ten koste van het kalf heeft waarschijnlijk geen belangrijke invloed op de gezondheid van de kalveren.

Verder onderzoek naar het dagelijkse management in relatie tot de productiviteit van runderen en kuddes is noodzakelijk om de basis te leveren voor voorlichting. In dit onderzoek zouden ook aspecten zoals de verdeling van het eigendom, het aantal diereigenaren en hun relatie tot de eigenaar van de kudde aan de orde moeten komen, evenals, indien mogelijk, omgevingsinvloeden.

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Curriculum Vitae.

Engelbertus Gerardus Maria van Klink werd geboren op 19 november 1956 te Alphen aan den Rijn. Na het doorlopen van het Gymnasium β aan het Christelijk Lyceum aldaar, werd in 1975 met de studie diergeneeskunde te Utrecht begonnen. In 1983 studeerde hij af. Na enige tijd betrokken te zijn geweest bij de geörganiseerde dierziektebestrijding, en na anderhalf jaar werkzaam te zijn geweest als onderzoeksassistent bij de Vakgroep Voedingsmiddelen van Dierlijke Oorsprong van de Fakulteit Diergeneeskunde te Utrecht, vertrok hij in 1985 naar de Western Province in Zambia. Hier werd het onderzoek verricht op basis waarvan dit proefschrift is samengesteld. Hij vervulde de funktie van District Veterinary Officer in het district Sesheke in de Western Province gedurende een periode van tweeëneenhalf jaar. Daarna is hij gedurende eenzelfde periode werkzaam geweest als Veterinary Research Officer in Mongu, de hoofdplaats van de Western Province. Sinds maart 1991 is hij als beleidsmedewerker werkzaam bij de Veterinaire Dienst van het Ministerie van Landbouw, Natuurbeheer en Visserij te Den Haag.

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Photograph cover: Jan van der Spree, Gouda
Span of oxen with sledge, wood carving,
Senanga, Western Province, Zambia.