The prevalence and economic importance of bovine fasciolosis in Kenya—an analysis of abattoir data

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ABSTRACT

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A retrospective study covering a period of 10 years (1990–1999) was carried out using post mortem meat inspection records at the Veterinary Department Headquarters at Kabete to determine the prevalence and economic importance of bovine fasciolosis in Kenya. Meat inspection records from abattoirs in 38 districts distributed over seven out of the eight provinces of Kenya were examined. Prevalence of fasciolosis was calculated as the number of cattle found to be infected with *Fasciola*, expressed as a percentage of the total number of cattle slaughtered. Using the average weight and market price of a bovine liver, the monetary loss occasioned by condemnation of *Fasciola* infected livers was calculated. A survey was also carried out at Dagoretti slaughterhouse complex in Nairobi to determine the relative occurrence *of F. gigantica* and *F. hepatica* in slaughtered cattle. Cattle slaughtered at Dagoretti slaughterhouse originate from all parts of the country.

A total of 5 421 188 cattle were slaughtered in the seven provinces of Kenya during the 10-year period and 427 931 (8%) of these cattle were infected with *Fasciola*. The region with the highest prevalence of fasciolosis was Western Province (16%) followed, in descending order, by Eastern Province (11%), Nyanza Province (9%), Rift Valley Province (8%), Central Province (6%), Nairobi Province (4%) and Coast Province (3.5%). The total economic loss incurred by the country during the 10-year period as a result of condemnation of the infected livers was approximately US$2.6 million. The total annual economic losses during this period ranged from approximately US$0.2–0.3 million. The highest total economic losses for the 10-year period were recorded in Western Province (US$0.8 million) and Central Province (US$0.7 million).

A total of 1 584 cattle originating from five provinces of Kenya were slaughtered at Dagoretti slaughterhouse over a period of two months of which 147 (9.3%) were infected with liver flukes. All the liver flukes obtained from the infected livers were identified as *F. gigantica*.

It is concluded that fasciolosis is prevalent in cattle in all provinces of Kenya, that it causes great economic losses as a result of condemnation of infected livers, and that *F. gigantica* is the main species of liver flukes affecting cattle in Kenya. Local climatic factors, cattle trade, rustling and population numbers, and the presence of the snail intermediate hosts are probably the main factors influencing the incidence of the disease in the various regions of the country.

Keywords: Cattle, economic losses, *Fasciola gigantica*, fasciolosis, Kenya, prevalence

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INTRODUCTION

Fasciolosis is a parasitic liver infection of wild and domestic ruminants caused by trematodes of the genus *Fasciola,* which have a worldwide distribution (Soulsby 1986). Fasciolosis causes economic losses in livestock as a result of mortalities, abortions,

retarded growth, reduced meat and milk production, condemnation of infected livers and emaciated carcasses, and cost of animal treatment (Gracey & Collins 1992). Infections with *Fasciola* also predispose animals to other infections (Ogunrinade & Ogunrinade 1980). Two species of *Fasciola* (*F. gigantica* and *F. hepatica*) are believed to cause fasciolosis in ruminants in Kenya, with *F. gigantica* being the most important species (Froyd 1959; Bitakaramire 1969). No recorded studies have, however, been carried out to determine the relative occurrence of the two species of *Fasciola* in cattle.

The prevalence of fasciolosis in cattle in many parts of the world has been reviewed by Megard (1978). In Africa, Megard (1978), quoted prevalence rates of 37 % in Sudan, 45 % in Cameroon, 30–90 % in Ethiopia, 16% in Uganda, 62% in the Central Africa Republic and 50% in Rwanda. There are only a few scanty reports on the prevalence and economic importance of fasciolosis in cattle in Kenya, in spite of the well-known importance of the disease in livestock in the country (Bitakaramire 1968, 1973; Cheruiyot 1983; Anon. 1986). The existing accounts of fasciolosis in Kenya are based on local surveys in some areas of the country, often covering a few months or years. Bitakaramire (1968) and Cheruiyot (1983) for instance only determined the prevalence of fasciolosis at the Kenya Meat Commission (KMC) abattoir over a period of 12 and 4 years, respectively. Ogeto (1993) determined the prevalence of fasciolosis in Kericho, Nakuru, Nyandarua, Machakos, Kilifi and Kwale Districts in Kenya, while Waruiru, Mbuthia & Kimoro (1992) determined the prevalence of liver flukes in calves in a single division of Nyeri District. Both these studies were based on data obtained during a period of 12 months. Similarly, Maingi & Gichigi (1999) determined the prevalence and economic importance of fasciolosis in cattle slaughtered in local abattoirs in Nyandarua District over a period of 12 months. Thus, no clear picture of the national prevalence of fasciolosis has emerged from these reports. The only study that reported the national prevalence and economic importance of the disease in cattle is that by Anon. (1986). In this study, post-mortem meat inspection records and data from Veterinary Investigation Laboratories (VIL) were examined from five provinces of Kenya, for the period 1980–1984. The climatic changes that have occurred in Kenya in the recent past, such as prolonged draught, flooding and the *El Nino* rains, may have had an effect on the prevalence and economic importance of fasciolosis since the study by Anon. (1986) was carried out. It was therefore considered necessary to reassess the situation. The objective of the present study was therefore to determine the prevalence and economic importance of fasciolosis in slaughtered cattle from various parts of Kenya during the 10-year period from 1990–1999 as well as the relative occurrence of *F. gigantica* and *F. hepatica*. The importance of carrying out surveys on the prevalence and economic importance of a disease is to determine its importance in the livestock industry so that it can be given the attention it deserves and whether or not to institute control measures. If the information obtained covers a number of years, such surveys can indicate not only whether there has been a change in its prevalence and/or economic importance during that period, but also possibly the factors to which these can be attributed.

MATERIALS AND METHODS

Calculation of prevalence and economic losses

Field reports sent to the Veterinary Department Headquarters at Kabete from 38 districts distributed in seven of the eight provinces of Kenya during the period 1990–1999, were used to calculate the prevalence and economic importance of bovine fasciolosis in Kenya. The 38 districts and the provinces in which they are located are Homa Bay, Kisii, Siaya and Kisumu Districts in Nyanza Province, Nakuru, Kericho, Kajiado, Laikipia, Trans Nzoia, Uasin Gishu and Koibatek Districts in Rift Valley Province, Thika, Kirinyaga, Nyandarua, Nyeri, Maragua, Kiambu and Muranga Districts in Central Province, Kitui, Mbeere, Machakos, Embu, Meru and Makueni Districts in Eastern Province, Mombasa, Malindi, Kwale, Kilifi, Taita Taveta and Lamu Districts in Coast Province, Lugari, Vihiga, Busia, Kakamega, Mt. Elgon, Teso and Bungoma Districts in Western Province, and Nairobi District in Nairobi Province. Meat inspection records from North Eastern Province were not available for analysis in this study.

All the abattoirs in these districts are classified as local as opposed to export slaughterhouses and are patterned in the traditional slaughter-slab system. Adult cattle slaughtered in these slaughterhouses are usually brought there through the cattle trade system by trekking or transport by road. Meat inspection in the abattoirs is carried out by veterinarians or meat inspectors from the Ministry of Health using standard procedures as described by Gracey & Collins (1992). Records of the total number of cattle slaughtered and the number that were positive for fasciolosis were obtained. Unfortunately, these records give no indication of the severity of

the condition. The national and provincial prevalence of fasciolosis was calculated as the number of cattle found to be infected with *Fasciola* expressed as a percentage of the total number of cattle slaughtered. The economic losses due to condemnation of infected livers were determined by placing a monetary value on the total number of livers condemned. Using an estimated average weight of 3 kg for a bovine liver and a market price of approximately US$2.0, the quantity in kilograms and economic loss in US$ were calculated.

Determination of the relative occurrence of species of *Fasciola*

In the second part of the study, the relative occurrence of the two species of *Fasciola,* i.e. *F. hepatica* and *F. gigantica,* in cattle slaughtered at Dagoretti slaughterhouses in Kenya was determined. Dagoretti slaughterhouses are the largest slaughterhouses in Kenya and the animals slaughtered there originate from almost every part of the country. During a period of 2 months, visits were made to the slaughterhouses to collect samples of liver flukes from cattle. During these visits, the livers of all the slaughtered animals were thoroughly inspected for the presence of liver flukes. Infected livers were sliced using a sharp knife and liver flukes were removed using blunt forceps. A minimum of six liver flukes was obtained from every infected liver except where the liver had less than six flukes. The flukes were preserved in universal bottles containing 70% alcohol and transported to laboratories at the University of Nairobi for examination. Details that were recorded during meat inspection for each animal from which samples were collected were age, sex and origin of the animal, number of liver flukes present in the liver and extent of the liver damage.

In the laboratory, the liver flukes collected were measured and classified into species based on the size and morphological features described by Reinecke (1983) and Soulsby (1986) as follows: They were transferred to Petri dishes on a table under which was a clean white paper. A thin, transparent piece of glass was placed on top them and their sizes measured using a ruler. Liver flukes that were less than 40 mm in length, leaf-shaped with broad shoulders and pointed posterior ends were classified as *F. hepatica.* Those that were more than 40 mm in length, were more elongate than leaf-shaped with sloping shoulders and had a rounded posterior end were classified as *F. gigantica.* Other characteristics used were that flukes that were grey in colour after preserving in 70% alcohol were classified as *F. hepatica*, while those that were transparent were classified as *F. gigantica.*

RESULTS

Table 1 shows the calculated provincial and national prevalence of bovine fasciolosis during the period 1990–1999. Cases were recorded in abattoirs in all provinces throughout the 10-year period. Western Province had the highest 10-year mean provincial prevalence of fasciolosis (16%) and the highest annual prevalence of between 14.7% and 20.6%, during 9 of the 10 years. The exception was 1991 when the prevalence of fasciolosis in this province was 8.6%. Eastern Province had the second highest mean provincial prevalence (11.3%), followed by Nyanza Province (8.9%), Rift Valley Province (8.3%), Central Province (6.1%), Nairobi Province (3.9%) and Coast Province (3.5%). There was a slight increase in the prevalence of fasciolosis in the majority of the provinces during the 10-year period except in Coast Province where prevalence

TABLE 1 Annual and provincial mean prevalence of fasciolosis in cattle in seven provinces of Kenya and the national mean prevalence, for each year during the period 1990–1999, based on the abattoir meat inspection records

Province	Year										Provincial Mean
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
Western	15.1	8.6	17.0	17.1	14.7	19.7	20.6	17.8	18.5	17.1	16.1
Eastern	11.3	11.5	10.3	12.5	12.8	15.4	15.3	5.8	13.5	12.8	11.3
Nyanza	11.7	10.1	13.0	9.7	14.0	8.4	4.6	5.3	7.7	8.9	8.9
Rift Valley	7.4	6.2	6.0	6.3	9.6	9.2	10.3	10.8	10.9	9.0	8.3
Central	5.0	4.4	4.5	4.7	6.1	6.8	7.7	8.4	7.4	9.7	6.1
Nairobi	2.8	2.0	3.4	2.6	2.8	4.3	5.9	5.5	4.3	5.1	3.9
Coast	3.0	3.8	3.5	2.9	4.3	3.7	3.8	3.3	3.2	3.5	3.5
National mean	7.3	6.0	7.4	6.6	8.2	9.3	9.8	7.9	8.9	9.2	7.9

remained low (minimum 2.9 % to maximum 4.3 %) and in Nyanza Province where there was a decrease in prevalence from 1993 onwards. The overall mean provincial prevalence of fasciolosis was significantly different (P = 0.0035). The mean national prevalence were 7.3 % in 1990, 6.0 % in 1991, 7.4 % in 1992, 6.6 % in 1993, 8.2 % in 1994, 9.3 % in 1995, 9.8 % in 1996, 7.9 % in 1997, 8.9 % in 1998 and 9.2 % in 1999. The average national prevalence of fasciolosis for the period under study was 7.9 %.

Table 2 shows the total number of cattle slaughtered in each of the seven provinces during the 10-year period, the number found to be infected with *Fasciola* at post-mortem meat inspection and the calculated losses in kg and US$ as a result of liver condemnation. A total of 427 931 out of 5 421 188 bovine livers were condemned in all seven provinces during the period of 10 years, due to fasciolosis. This amounted to a loss of approximately US$2,567,586. Western Province recorded the highest total loss due to condemnation of infected livers (US$759,960) followed by Central Province (US$669456).

Although Central Province recorded a low mean prevalence of fasciolosis during the 10 years (6.1 % in Table 1), the total number of cattle that were slaughtered (1 834 301) and those whose livers were condemned due to fasciolosis (111 576) were many, which was reflected in the high economic loss. The province with the lowest loss was Nairobi, which recorded a loss of US$73,488.

In Table 3, the total number of cattle slaughtered in the country during each of the 10 years, the number infected with *Fasciola* and the calculated losses in kg and US$ as a result of liver condemnation are presented. There was a decrease in the total number of cattle slaughtered in the entire country from 1994–1999, compared to the previous years. The total national economic loss due to condemnation of infected livers did not however, vary significantly from year to year. The year in which the greatest financial losses occurred in the country was 1992 with a loss of US$298,836 followed by 1996 with US$277,686. The lowest economic loss occurred in 1999 (US$208,254).

TABLE 2 The number of cattle slaughtered in seven provinces of Kenya during the period 1990–1999, the number found to be infected with Fasciola at post-mortem meat inspection and the calculated economic loss due to condemnation of infected livers

Province	Number of cattle slaughtered	Number infected with Fasciola	Total weight condemned	Economic loss in US$
Western	785 873	126 660	379 980	759,960
Eastern	599 900	67 881	203 643	407,286
Nyanza	159 814	14 237	42 711	85,422
Rift Valley	731 438	60 634	181 902	363,804
Central	1 834 301	111 576	334 728	669,456
Nairobi	314 758	12 248	36 744	73,488
Coast	995 104	34 695	104 085	208,170
Total	5 421 188	427 931	1 283 793	2,567,586

TABLE 3 The total number of cattle slaughtered in Kenya each year during the period 1990–1999, the number found to be infected with Fasciola at post-mortem meat inspection and the calculated economic loss due to condemnation of infected livers

Year	Number of cattle slaughtered	Number infected with Fasciola	Total weight condemned	Economic loss in US$
1990	623 748	45 480	136 440	272,880
1991	645 831	38 543	115 629	231,258
1992	673 425	49 806	149 418	298,836
1993	615 411	40 503	121 509	243,018
1994	553 322	45 698	137 094	274,188
1995	487 876	45 340	136 020	272,040
1996	472 282	46 281	138 843	277,686
1997	513 056	40 581	121 743	243,486
1998	459 123	40 990	122 970	245,940
1999	377 114	34 709	104 127	208,254
Total	5 421 188	427 931	1 283 793	2,567,586

TABLE 4 Number of cattle inspected at post-mortem at Dagoretti slaughterhouse in Nairobi during a period of two months. the province of origin of the animals. the number infected with liver flukes and the species of Fasciola recovered

	Province of origin								Total
	North Eastern	Central	Nairobi	Western	Rift Valley	Eastern	Coast	Nyanza	
Number inspected	17	119	0	41	1 273	134	0	0	1 584
Number infected with *Fasciola* (%*)	3 (17.6 %)	34 (25.6 %)	0	6 (14.6 %)	80 (6.3 %)	24 (17.9 %)	0	0	147 (9.3 %)
Number with *Fasciola gigantica*	3	34	0	6	80	24	0	0	147
Number with *Fasciola hepatica*	0	0	0	0	0	0	0	0	0

(%*) Percentage of cattle infected with *Fasciola* out of the total inspected

Table 4 shows the number of cattle inspected at post-mortem meat inspection at Dagoretti slaughterhouse during a period of 2 months, their origin, the number infected with *Fasciola* and the species of *Fasciola* obtained from the livers. A total of 1 584 cattle from five provinces of Kenya were inspected, the majority (80 %) of which originated from the Rift Valley Province. Out of the total number of cattle slaughtered, 147 (9.3 %) were infected with liver flukes, all of which were *F. gigantica.* All the cattle slaughtered were adults. Of these 66 (45 %) were females and 81 (55 %) were males. Three of the 147 infected (2 %) females had extensively damaged livers. Six (4 %) had less than two flukes each and had no visible liver damage. Eight (5.4 %) had between 50 and 100 flukes with their livers being extensively damaged, while 130 (88.4 %) had between six and 35 liver flukes, with moderate liver damage.

DISCUSSION

The greatest limitation to a proper evaluation of the economic importance and epidemiology of the livestock diseases in slaughtered cattle in Kenya is the possibility that the animals may not be indigenous to the various localities where they are slaughtered. This is due to the predominantly extensive animal husbandry practices, the complexity of trade and cattle rustling. For these reason, recourse on examination of abattoir records is often justified because of the difficulty of monitoring disease prevalence in cattle. Meat inspection records from North Eastern Province were not available for examination in this study. The records were unavailable because the Veterinary Department has not taken over the meat inspection services from the Ministry of Health in this province. Cattle from this province are, however, slaughtered in other provinces and the results obtained in this study could therefore validly represent the national prevalence of fasciolosis.

The prevalence of fasciolosis observed in this study in various ecological zones in Kenya is similar to that which was reported in Kenya by Anon. (1986) and in Nigeria by Fabiyi & Adeleye (1982). Areas that receive high rainfall showed higher prevalence than the dry areas. Western Province was found to have the highest prevalence of fasciolosis in cattle, probably because of the high rainfall in the region, which varies annually from 1 200–2 200 mm (Kenya Atlas 1991) and the high presence of the intermediate host snail, *Lymnaea natalensis* (Brown 1980). This shows that rainfall has direct influence on the occurrence of liver flukes. High prevalences of the disease are reported in wetter parts of Kenya where flood plains exist in which there are accumulations of large water masses favouring the survival of *L. natalensis* (Bitakaramire 1969). These water masses increase the risk of acquisition of the infection (Ogunrinade & Ogunrinade 1980). Other possible reason for the high prevalence of fasciolosis in Western, Eastern and Nyanza Provinces is the high population of livestock in this area (Kenya Atlas 1991), which may help to perpetuate the disease. Moreover, cattle in these provinces are mainly kept under an extensive livestock production system in which they graze outdoors and are taken to drink water at wells, springs, accumulated water masses and rivers. This increases the contact between the *Fasciola* eggs and the snail intermediate hosts in addition to providing a good environment for hatching of the eggs and transmission of metacercariae to animals as they drink water and feed on the watercress (Bitakaramire 1973; Rondelaud, Vignoles, Abrous & Dreyfuss 2001).

Coast Province recorded the lowest prevalence of fasciolosis partly because of the low population of snail intermediate hosts in this province. *Lymnaea natalensis* is hardly ever found in the coastal region of Kenya (Brown 1980). Parts of the coastal region receive very little rainfall (less than 250 mm per annum) and there are very few, if any, fresh water masses. In these areas, there is apparently insufficient moisture to maintain snail life for the continual propagation of *Fasciola* organisms. The other probable reason for the low prevalence of fasciolosis is the high temperatures experienced in Coast Province, which does not favour the development of *Fasciola* eggs. Anon. (1986) categorised coast province as one of the areas of Kenya with less than 10 % prevalence of bovine fasciolosis, which is in accordance with the findings in the present study.

The prevalence of fasciolosis in cattle in Kenya has been reported by several authors (Bitakaramire 1968, 1973; Cheruiyot 1983; Anon. 1986; Waruiru *et al.* 1992; Ogeto 1993; Maingi & Gichigi 1999). The overall prevalence of fasciolosis in livestock in Kenya reported in this study were slightly lower than those reported by most of the previous authors who used slaughterhouse data. For example, Bitakaramire (1973) reported a prevalence of 13–21 %. Cheruiyot (1983) reported a national prevalence of 10–13 %, Ogeto (1993), estimated a 13 % prevalence rate. Anon. (1986), categorised the prevalence rates in various parts into low (below 10 %), medium (between 10–30 %), and high (over 30 %) using both the meat inspection data and Veterinary Investigation Laboratory (VIL) data. In comparison

to the reports based on slaughterhouse data (Bitakaramire 1973; Cheruiyot 1983), the prevalence (7.9%) obtained in the study reported here is lower. This could partly be due to extensive use of anthelmintics against liver flukes and drugs to kill snails. Anon. (1986) attributed the observed reduction in the prevalence of fasciolosis in his study to increased use of anthelmintics. The low prevalence may also be attributed to provision of better services to farmers by private veterinary practitioners who have increased in number in various parts of the country in recent years. Improved systems of reporting and routine meat inspection methods in most slaughterhouses and slaughter-slabs in Kenya recent years (Ndirangu 2001) might also have enlightened many farmers on the economic importance of fasciolosis, leading to improved parasite control. It could also be suggestive of improved animal husbandry techniques as observed by Olusi (1996). The prevalence rate obtained in this study is also lower than the 36.5% reported in Uganda (Magona, Olaho-Mukani, Musisi & Walubengo 1999) and the 21 % reported in Ethiopia (Tegene 1994) possibly because of environmental factors.

Variation in the prevalences of fasciolosis was obtained from one year to the other. This may be associated with climatic changes, which affect field conditions and influence the frequency of contact between cattle and metacercaria.

The survey showed that severe financial losses occurred in Kenya during the 1990–1999 period due to condemnation of *Fasciola*-infected livers. The total loss was estimated to be Ksh. 192 568 950 (US$2,567,586) or an average US$256,758 annually. Bitakaramire (1968) reported a loss of US$10,000 annually from the Kenya Meat Commission (KMC) between 1954 and 1965, while Cheruiyot (1983) reported a loss of US$4,150 annually from KMC between 1975 and 1978. Anon. (1986) reported a national loss of US$4,012,500 annually, a figure that was derived mathematically and considering all directly and indirectly related losses due to fasciolosis. Bovine fasciolosis had been recognised to be one of the livestock diseases of economic importance in Kenya by Cheruiyot (1983). Therefore, there is a need not only to intensify and improve the control methods of fasciolosis in livestock in Kenya in order to minimize this economic loss but also to educate the public so that they are aware of its importance.

All the cattle that were found to be infected with *Fasciola* at Dagoretti slaughterhouse suffered from *F. gigantica* infection; none were infected with *F. hepatica.* Although the majority of the cattle inspected originated only from Rift Valley Province, the results of this study indicate that *F. gigantica* is the predominant species of *Fasciola* infecting cattle in Kenya. This is in agreement with the report of Bitakaramire (1969).

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REFERENCES

ANONYMOUS. 1986. *Agricultural Research Foundation Report of 1986 on the Distribution and Economic Impact of Liver Fluke in Kenya.*

BITAKARAMIRE, P.K. 1968. Bovine fasciolosis in Kenya. *Bulletin of Epizootic Diseases in Africa,* 16:107–113.

BITAKARAMIRE, P.K. 1969. Studies on *Fasciola gigantica* infection in Cattle. Ph.D. thesis, University of East Africa.

BITAKARAMIRE, P.K. 1973. The incidence of fascioliasis in different breeds of cattle in Kenya. *Bulletin of Epizootic Diseases in Africa*, 21:145–152.

BROWN, D.S 1980. Report of the distribution in Kenya of Freshwater snails of medical and veterinary importance as intermediate host for Trematodes parasite. Experimental Taxonomy Unit, Zoology Department, British Museum (natural history) 1980.

CHERUIYOT, H.K. 1983. Bovine helminthes parasites of economic importance 1976-1980. *Bulletin of Animal Health and Production in Africa.* 31:367–375.

FABIYI, J.P. & ADELEYE, G.A. 1982. Bovine fascioliasis on the Jos plateau, Northern Nigeria with particular reference to economic importance. *Bulletin of Animal Health and Production in Africa,* 30:41–43.

FROYD, G. 1959. The incidence of liver flukes and gastrointestinal parasites of cattle in Kenya highlands. *Bulletin of Epizootic Diseases in Africa,* 7:179–182.

GRACEY, F.J. & COLLINS, D.S. 1992. *Meat hygiene*, 9th ed. London: Bailliere & Tindall.

KENYA ATLAS. 1991. Forth edition, drawn, printed and published by survey of Kenya, Nairobi, Kenya Government.

MAINGI, N. & GICHIGI, M.N. 1999. The prevalence and economic importance of *Fasciola* and other helminth infections in cattle and sheep in Nyandarua District of Kenya. *Bulletin Animal Health and Production in Africa*, 47:29–32.

MAGONA, J.W., OLAHO-MUKANI, W., MUSISI, G. & WALUBENGO, J. 1999. Bovine *Fasciola* infection survey in Uganda. *Bulletin of Animal Health and Production in Africa*, 47:9–14.

MEGARD, J.P. 1978. *Fasciolosis in Black Africa.* Paris: Merck, Sharp & Dohme Research Development.

NDIRANGU, P.N. 2001. The prevalence and distribution of hyadatidosis in Kenya and the role played by intermediate host. M.Sc. thesis, University of Nairobi.

OGETO, C.O. 1993. An epidemiological survey of bovine fascioliasis in selected districts in Kenya. M.Sc. thesis, University of Nairobi.

OGUNRINADE, A.F. & OGUNRINADE, B.I. 1980. Economic importance of fascioliasis in Nigeria. *Tropical Animal Health and Production in Africa,* 12:155–160.

OLUSI, T.A. 1996. The prevalence of liver helminth parasites of ruminants in Maiduguri, Borne State, Nigeria. *Bulletin of Animal Health and Production in Africa,* 44:151–154.

REINECKE, R.K. 1983. *Veterinary Helminthology.* Durban: Butterworths.

RONDELAUD, P., VIGNOLES. M., ABROUS, G. & DREYFUSS. G. 2001. The definitive and intermediate hosts of *Fasciola hepatica* in the natural watercress beds in Central France. *Parasitology Research*, 87:475–478.

SOULSBY, E.J.L. 1986. *Helminths, arthropods and protozoa of domesticated animals.* 6th ed. London: Bailliere & Tindall.

TEGENE, N. 1994. Bovine *Fasciola* infection survey in Ethiopia. *Bulletin of Animal Health and Production in Africa*, 42:199.

WARUIRU, R.M., MBUTHIA, P.G. & KIMORO, C.O. 1992. Prevalence of gastrointestinal parasites and liver flukes in calves in Mathira Division of Nyeri District. *Bulletin of Animal Health and Production in Africa*, 41.291–296.