

THE SEASONAL OCCURRENCE OF FASCIOLIASIS AND SOME OTHER
HELMINTHIC DISEASES OF SHEEP IN FOUR SELECTED SITES IN ETHIOPIA
(ASELLA, AWASSA, DEBRE BERHAN AND DEBRE ZEIT)

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ABSTRACT

Ethiopia, situated in the horn of Africa, shows wide variation in topography, climate and land use distribution. It has a high population of livestock. However, the prevalence of a number of important diseases has impeded the rational exploitation of this resource.

In recent years a nation-wide survey of livestock diseases is being conducted to identify, map infected areas and suggest appropriate measures amongst which parasitic diseases are given considerable attention. Accordingly, an investigation of the seasonal incidence of ovine helminthiasis in selected sites of various ecological zones was carried out for a period of one year to provide baseline information.

Thus, the local occurrence of the Helminth of the genera of Fasciola, Paramphistomum, Bunostomum, Chabertia, Dictyocaulus, Haemonchus, Nematodirus, Oesophagostomum, Ostertagia, Protostrongylus, Trichostrongylus, Trichuris, Skrjabinagia, Strongyloides and some unidentified nematodes and cestodes has been established in the four selected study sites. The relative frequency and temporal patterns of these parasites have also been studied. The results clearly show the bearing of various meteorological factors, particularly moisture, have on the seasonal incidence of the helminths infecting sheep.

Based on the findings some recommendations have been suggested.

1. INTRODUCTION

Situated between approximately 3° and 12° North latitude and 33° and 43° East longitude, Ethiopia covers an area of about 1,221,000 square kilometers (Mesfin W. Mariam, 1972). The altitude of the land ranges from regions below sea level at the Kobar Sink (120 metres) in the Danakil Depression to the highest mountain peak of the Ras Doshen with an altitude of 4,550 metres (Ethiopian Mapping Agency, 1981). The climate is generally classified as sub tropical with modifications influenced by the variation in altitude (Graber, 1975a). The land use distribution of Ethiopia comprises 68.8% agricultural land, 14.1% barren land, 9.9% water and water courses; land 7.2% forests open wood land and bush (Mesfin W. Mariam, 1969; Ethiopian Mapping Agency 1981). Out of the 841,100 square kilometers of agricultural land, 54.2% of the area is covered by pasture (Mesfin W. Mariam, 1969) which is inhabited by livestock.

According to the Ethiopian Mapping Agency (1981) Ethiopia has 29 million cattle, 24 million sheep and 18 million goats. Sheep and their products are the major small periodic sources of income for the rural communities (ILCA, 1977; Goll and Scott, 1978). The bulk of the local mutton and carpet-wool trade of Ethiopia is derived from small fat tailed sheep, which commonly graze on extensive parts of the Central and Southern Highlands (Scott and Goll, 1977). Out of the total meat produced 5.4% is mutton and out of the total hides and skins 38.4% are sheep's skins (Central Statistics Office, 1974). Livestock in Ethiopia

represent a national asset estimated at 2 billion Birr (Ministry of Agriculture, 1972). The data vividly shows the various uses and the immense potentials in sheep and other domestic animals that Ethiopia has (Gebrekiros Asegede, 1981).

Although Ethiopia has one of the highest livestock populations in Africa (Meigper 1970; Solomon H. Mariam, 1975), little has been done to improve the productivity and health status of the animals (Zerihun Eshetu, 1982). Among the major problems hindering full exploitation of these resources are animal diseases and the poor traditional management systems of domestic animals. Solomon H. Mariam (1975) stated that Ethiopians are still following the age-old methods of raising livestock, and most of the major animal diseases are prevalent in the country.

Losses caused by various factors are repeatedly reported to be high and presentation of a precise account is difficult (Gebrekiros Asegede, 1981). One of the major disease factors causing substantial losses are parasites. The losses incurred due to parasites can be categorized as direct and indirect losses (Beller, 1977). Direct losses are due to acute illness and death, premature slaughter (with consequent shortening of productive life) and rejection at meat inspection of the entire carcass or parts of it. Of greater importance are the indirect losses due to diminution of the potential productivity of livestock. Losses of the latter type, which are due to subclinical parasitic gastroenteritis have been either undiagnosed or ignored; or the measures

required to prevent these losses have been considered uneconomic and impractical (Brunsdon, 1968; Sauvage, et al., 1974). Allonby (1976) also asserted that subclinical cases cannot be over emphasized in terms of their detrimental effects on productivity and fecundity. The economic wastage through low weight gain was estimated to be 2,500 tons of meat on an annual slaughter of seven million sheep (Ministry of Agriculture, 1972).

Therefore, as a prerequisite for the control of losses, and the promotion of higher productivity in livestock, the necessity of a nation-wide survey of livestock diseases is a must, among which the subject of parasitic diseases stands at the forefront. In this respect some of the work conducted include " Bergeon (1968); Royal Veterinary College Ethiopian Research Team, RVCERT (1971); Ministry of Agriculture (1972); Graber (1973a, 1973b, 1973c); Graber (1975a, 1975b); Solomon H. Mariam (1975); Gaber (1976); Fesseha Gebreab and Gebrenegus Tesfamariam (1977); Scott and Goll (1977); Goll and Scott (1978); Graber, Delaveney and Gebrenegus Tesfamariam (1978); Bahru Gemechu and Ephrem Mamo (1979); Solomon H. Mariam (1979); Bekele Mamo (1980); and Gebrekiros Asegede (1981).

An investigation of the seasonal incidence of helminthiasis in selected sites in various ecological zones would provide essential information and would be invaluable for the formulation of local strategic control programs (UNDP/FAO, 1973). With this understanding a one-year investigation has been carried out at

Asella, Awassa, Debre Zeit, and Debre Berhan. The main objectives of the study in these sites were to:

- determine the local occurrence of ovine helminths,
- correlate the parasitic panorama with the bionomics of each study site and thus determine the factors that influence the variation in parasitic populations,
- determine the peak period of parasitic incidence, so as to make possible recommendations on the strategic control of ovine helminthiasis.

2. LITERATURE REVIEW

2.1 General Accounts

Parasitic life cycles show a tremendous range of variation in their degree of dependence on the external environment (Thomas, 1974). Whenever development of the infective stages of such parasites occur outside the body of the host, the physical factors in the environment are important in determining their survival and hence success in infecting the host (Thomas, 1974). Some of these environmental factors are constant and some are variable from year to year in any given area (Ollerenshaw and Rowlands, 1959).

Factors which are constant from year to year cannot be responsible for annual variations in the incidence of parasitic infestations. The relatively constant factors are observed in cases of geological formations, topography of the land and the field drainage systems (Gordon, 1957). In the geological formation some soils may be more retentive to water (clay soil) than others; the topography may hinder or facilitate natural drainage while the field drainage could be comprehensive or non-existent (Gordon, 1957). The existence of such constant environmental factors in a particular area, therefore, cannot be responsible for the annual variation in the incidence of the disease (Ollerenshaw and Rowlands, 1959; Wilson, 1974).

The development, propagation and infectivity of parasites, therefore, depends on the variable factors (Ollerenshaw and Rowlands, 1959; Thomas, 1974). These variable factors are largely climate and it is this dependence of the parasites on the climatic conditions which ultimately governs the varying annual incidence of disease (Gordon, 1957; Ollerenshaw and Rowlands, 1959; Levine, 1963; Boray 1967; Ollerenshaw and Smith 1969; Anderson, Levine and Boatman, 1970; Smith, 1982).

The meteorological factors of importance in the incidence of helminthic diseases can largely be categorized to be weather and climate. Weather is a composite of atmospheric conditions - temperature, barometric pressure, precipitation, humidity, wind direction and velocity, sunlight, cloud cover, and so forth at a particular time (Levine, 1963). He defined climate simply as the sum of weather conditions over a longer period in a particular place. Parasitologically, climate influences the overall distribution of species and determines the general epidemiological pattern, while weather influences the timing of specific events within a season and the magnitude of disease risk (Thomas, 1974). Levine (1963) summarized this by stating that climate establishes the general situation - weather determines the specific ones.

It is important to recognize that the level of the parasite population is determined by the interaction between

the high reproductive potential of the parasite and the available limiting factors (mainly meteorological) in the environment. Normally, these limiting factors maintain a high environmental pressure on the parasite, high mortality ensues and the population is maintained in check. Epizootics arise, they concluded, where there is a relaxation in the variable environmental pressure: there is an immediate response from the parasite, resulting in a population explosion.

The development and survival of the intermediate stages of the helminth parasites on pasture is clearly dependent on the existence of favorable physical condition in the microclimate at the soil surface (UNDP/FAO, 1973). The recognition of these seasonal patterns and their regulation by climate and other factors are examples of the ecologic approach to the problems of disease control (Gordon, 1957). In view of this, considerable progress has been made during recent years in the development of systems of forecasting the likely incidence of certain animal diseases from the prevailing weather conditions (UNDP/FAO, 1973). This has proved to be a significant warning system for farmers (Ollerenshaw, and Rowlands, 1959) by providing advance warning of impending disease and thus allowing for the prompt implementation of the appropriate control measures (UNDP/FAO, 1973). It renders the most useful knowledge in forecasting disease incidence, or pinpointing critical aspects

of disease processes which demand further experimental work (Ollerenshaw and Smith 1969). The development of such a forecasting system requires the detailed monitoring of disease levels over long periods and the correlation of these results with the macroclimatic data for the area under study (UNDP/FAO 1973).

Concluding with a lengthy quotation from the joint UNDP/FAO (1973) report:

... it is proposed therefore, to monitor the seasonal incidence of helminthiasis at various locations so that the practical application of a forecasting system may be fully investigated. Where facilities allow it is proposed that small groups of control sheep and goats be set-stocked at Agricultural Research Stations, and elsewhere as required, and that the concurrent level of infections be monitored by regular sample autopsies and quantitation of different species of helminths present each season. Such investigations would provide information as to the seasonal prevalence of various helminth species and enable correlations to be made with general weather conditions and the computation of the most appropriate forms of disease control.

2.2 The Definitive Host-Sheep (*Ovis aries*).

Sheep are members of the family Bovidae in the order of Artiodactyla, the even toed, hoofed mammals (Terrill, 1971).

About one billion sheep exist over most of the land areas of the world (Terrill, 1971; Owen, 1976). They are most heavily concentrated in the warmer parts of the temperate zones and are found in greater numbers in the southern hemisphere in Australia, New Zealand, and South America (Terrill, 1971). In Ethiopia, two major ecological patterns

can be identified with respect to the distribution of sheep (Ethiopian Mapping Agency, 1981). The highlands which receive more than 700 mm. of rainfall per year, are the areas where 82% of the rural population lives and where 75% of the total sheep are kept. The lowlands that receive below 700 mm. of rainfall annually, are inhabited by only 9% of the rural population who keep the remaining 25% sheep.

Ethiopians still follow the age-old traditional animal husbandry methods (Solomon H. Mariam, 1975). Modern animal husbandry techniques are not yet widely introduced in the country (Ethiopian Mapping Agency 1981). Under traditional husbandry system small ruminants are generally kept in small household flocks of less than ten animals of varying ages (ILCA, 1979a). Such small stock farming is wholly dependant on natural grazing (Steynberg and Hofmeyr 1969) except in cases where the feed for the sheep includes the preparation and feeding of the household refuse (ILCA, 1979b).

According to Bergeon (1963) and Graber (1978) sheep suffer parasitic infestations more than other livestock. Partly, they suffer heavier infestations because sheep graze succulent grasses which provide a favourable environment for the development and survival of worm larvae (ILCA, 1979b). For instance, sheep are the animals most prone to suffer from the acute form of fascioliasis, as they are most likely to graze in small habitats (Taylor, 1964).

2.3 The Helminth Parasites of Sheep in Ethiopia

Craber (1975b) has produced a concise check list of the helminth parasites of domestic and wild animals of Ethiopia. From this latest available list the parasites of sheep and their occurrence by administrative region have been extracted and presented in the Appendix (Table 13). Bekele Hamo (1980), working on 500 sheep samples collected from the Addis Ababa Abattoir, has confirmed the presence of these parasites in the country. However, he was unable to attribute the origin of these parasites to specific localities. Gebrekiros Asegede (1981) performed a survey using parasite-free tracer sheep in the Awassa (Sidamo) area for six months (June - November, 1979) and confirmed the presence of the parasites marked with an asterisk (Table 13) in that region. He has also added to the list by collecting Trichostrongylus colubriformis from sheep in the Awassa area.

In this study the major parasites of discussion are Fasciola hepatica and some nematodes. The major emphasis is placed on these parasites since they are the most damaging to their hosts in terms of lost productivity and reduced fecundity. No attempt was made to identify the cestodes encountered in this study. Thus, these worms are not mentioned in the literature review.

2.3.1. The Bionomics of Fascioliasis (Trematoda)

The first prominent study on the temporal patterns of fascioliasis was conducted in England by Ollerenshaw in

1965). With repeated experimentation and observations Rowcliffe and Ollerenshaw (1960) found that the critical temperature of $9.5^{\circ}\text{C} \pm 0.5$ was necessary for the faeces-free fluke eggs to hatch producing miracidia. There is no hatching of the fluke egg, no development of the parasite in the snail, nor even emergence of cercariae from the snail at temperatures below 10°C (Taylor, 1964; Soulsby, 1965; Ollerenshaw, 1966; 1971).

Once within the snail, the development of the miracidia in this intermediate host is as much affected by temperature and moisture as the eggs, both in the laboratory and under field conditions. In the laboratory, development in snails attains its maximum at 20°C in six weeks (42 days), while in outdoor observations the time ranges from 42 to 292 days (Taylor, 1964).

Finally, what remains to be mentioned is the longevity of metacercariae on pasture. In this context it suffices to state that metacercariae may survive for more than one year on pasture (Soulsby, 1965).

Subsequent studies in the temperate regions of the northern hemisphere have been carried out by Ollerenshaw and Rowlands (1959); Rowcliffe and Ollerenshaw (1960); Kendall (1966); Ollerenshaw (1966); Ross and Todd (1966); Over and Jansen (1966); Ross (1970); Ross and Morphy (1970); Ollerenshaw (1971); Nielson (1974); Helle (1974); Nilsson (1974); Holtenius (1974); Shaka and Mansen (1979); and others. **From**

the information available, the general seasonal pattern of the disease in these regions has been condensed and presented in Figure .

Some major deviations have been observed to this general pattern of the epidemiology of fascioliasis in these temperate regions.

In the far northern parts of Europe (Iceland and Northern Norway), where in spite of the presence of the intermediate snail host (*L. truncatula*) and the importation of infected sheep, the disease does not occur (Ollerenshaw, 1971). This is simply due to the fact that the average temperatures just exceed 10°C during July and August only, this being grossly insufficient to allow completion of the life-cycle (Ollerenshaw, 1971).

South of this region (Northern Scotland, Southern Norway, and at regions with high altitudes) summers are cooler and shorter, so that the life-cycle cannot be completed in one season (Ollerenshaw, 1971). On the other hand, in parts of southern Europe (Portugal), although temperatures permit development of the parasite through most of the year, moisture conditions are generally unfavourable for development (Ollerenshaw, 1965). The pastures in these different countries become almost, if not completely, sterilized by the cold, in the one instance and by dryness in the other (Taylor, 1964).

In Ethiopia, East Africa, in a study conducted on the epidemiology and anthelmintics control of ovine fascioliasis at the Debre Berhan Experimental Sheep Farm (Lat. 10°N, long 39°E with an altitude of 2900 metres) from 1973 to 1975. Scott and Coll (1977) have shown that the disease starts to appear in sheep in July, continuing up to January and February of the following year. This is preceded by the wet months occurring from March to October. The peak infection month was found to be November.

In northern Nigeria, West Africa, the climate is generally characterized by a rainy season from May to October and dry season from November to April (Schillborn van Veen, 1979).

In the study of ovine and bovine fascioliasis in this area, mainly caused by Fasciola gigantica, Schillborn van Veen (1980a) has observed that the majority of infections acquired by the snails was during the wet season and the beginning of the dry season. Shedding of cercariae mainly occurred during the middle of the dry season, as the infection rate in the snails was declining (Schillborn van Veen, 1980b). Most cases of acute fascioliasis in sheep were observed during the end of the dry season - April, May and June. However, timing may vary in northern Nigeria depending on the length of the rainy season and on the grazing habits of the animals (Schillhorn van Veen, 1980a).

In Malawi, Southern Africa, there are two main seasons: the dry season from May to October and the wet season from

FIGURE 1 : Diagrammatic Representation of the
Epidemiology of Ovine Fascioliasis
(Fasciola hepatica) in Great Britain
(from Soulsby, 1965 as adopted from
Ollerenshaw, 1959).

LEGEND : 1. Eggs Deposited
2. Miracidia Liberated
3. Snails Infected
4. Snail Population
5. Cercariae Shed from Present Year's
Infection (10°C)
6. Acute Disease
7. Chronic Disease
8. Cercariae Shed from Previous Year's
Infection
9. Disease from Previous Year's Infection

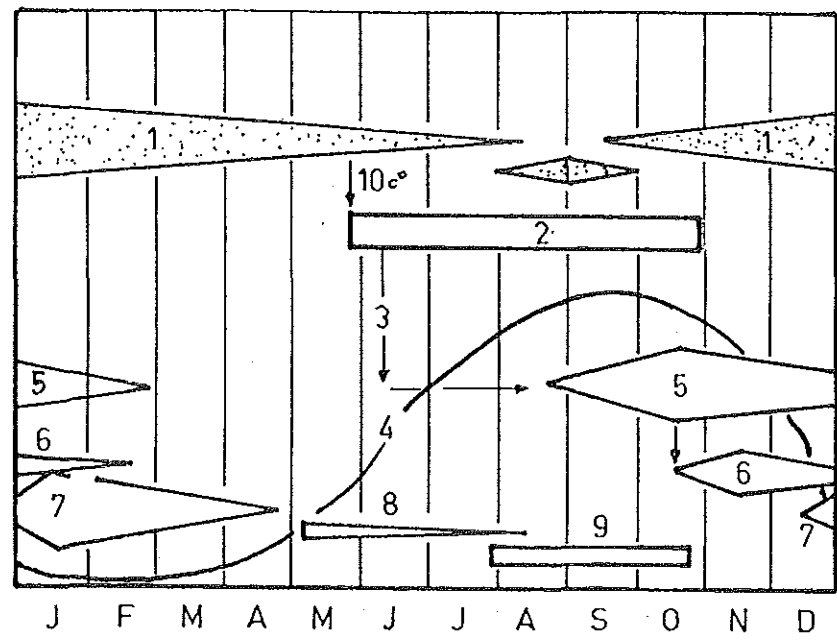


FIGURE 1

November to April with temperature ranging from 14°C to 29°C. (Encyclopedia Britanica, 1964). Mzembe and Chaudhry (1981) working in Malawi, found that from April to July the snails were infected with miracidia from Fasciola eggs dropped in the faeces of diseased cattle during the previous months. The parasites that passed through their development within the snail were finally released as the infective cercarial stage between July and October (Mzembe and Chaudhry, 1981) at the time when snail numbers were at a maximum (Mzembe and Chaudhry, 1979). This would account for reports of sporadic outbreaks of acute fascioliasis in August and September and for the high incidence of chronic fascioliasis in November to March of the following year (Mzembe and Chaudhry, 1981).

The situation in the tropics thus differs from that found in the temperate regions, by having a prolonged dry season with very high temperatures throughout the year, which renders the pastures helminthologically sterile (Chiejina and Sewell, 1974a). It follows then, that in tropical countries the most limiting factor is moisture, rather than low temperature, which is restricted to the few months of the rainy season. During these months, where the regularly occurring high temperatures are coupled with adequate precipitation, epidemics of fascioliasis follow. It is, therefore, difficult and dangerous to extrapolate the results obtained in one country to the conditions pertain-

ing in another (Soulsby, 1963; 1965), let alone adapting the control measures recommended in temperate regions to the tropics.

Therefore, in any area where the epidemiology of the disease is imperfectly known it should be possible to determine the probable course of the life-cycle of Fasciola spp. from an examination of temperature, moisture and other meteorological factors (Ollerenshaw, 1971). Since weather is the most important variable in the farming calendar, it is likely that further investigation will show that the incidence of a number of other diseases can be related to variations in the weather as well (Ollerenshaw, 1971).

2.3.1.1 The Snail Intermediate Hosts - (Lymnaea spp.)

The occurrence of fascioliasis is dependent on the presence of biotopes suitable for the parasite and is as such associated with specific ecological niches (Schillborn van Veen, 1980a). One of such necessities is the presence of the snail intermediate host in the environment, at the right place and season, for the disease to occur. It follows then, that the infection of parasite-free tracer sheep with metacercariae on pasture is related to climate and variation in snail populations (Ross and Morphy, 1970).

It is now well established by numerous workers that the liver fluke is transmitted by molluscs belonging to the family Lymnaeidae. Fasciola hepatica is transmitted by Lymnaea truncatula, or by snails which are not readily dis-

tinguishable from it, either on morphological grounds or on grounds of their ecological requirements (Taylor, 1964). Similarly, Fasciola gigantica is transmitted by snails belonging to the single superspecies Lymnaea auricularia while in Africa, the recognized vector is L. natalensis (Taylor, 1964).

The distribution and population density of the intermediate host is determined largely by moisture conditions (Ollerenshaw, 1971), unless actually frozen (Taylor, 1964). The main habitats of the snails are badly drained fields, shallow drainage ditches and wet areas around springs and streams (Ollerenshaw, 1971). He further stated that such areas tend to be more common on clay rather than on sandy soils, over impervious rather than on porous rocks, where the topography hinders natural drainage and where man-made drainage is inadequate.

The snail hosts present in tropical Africa are more aquatic than L. truncatula (Ollerenshaw, 1966). In West Africa, according Schillborn van Veen, 1980a, 1980b), the only intermediate host identified so far is the aquatic snail Lymnaea natalensis. The first generation of these snails acquire infection during the beginning of the rainy season - May, June. The majority of infections are acquired by the snails during the wet season - May to October - and the beginning of the dry season. The same worker also stated that shedding of cercariae then mainly occurs during the

middle of the dry season as the infection rate in the snails is declining. Young snails developing during the other times of the year in the northern Nigerian savanna did not show high infection rates. This is probably associated with the scarcity and turbidity of the water, and with a diminished faecal contamination, as most dung pads dry rapidly during the dry season.

In southern Africa, the ecology of the snails was studied at five different habitats spread throughout Malawi (Mzembe and Chaudhry, 1979). According to these workers, the population of L. natalensis showed large fluctuations during the year. They found that due to lack of suitable vegetation, caused by the flooding and rapid movement of water during the rainy season - November to March - there was a rapid decline in snail number at this time. In April and May, when water movement slowed and allowed the growth of suitable vegetation, the snail population began to increase again. The cold weather of June and July caused a temporary drop but from mid-July, when the temperature had begun to rise, through to October the number of snails increased, reaching a maximum in August.

In Ethiopia, the presence of both Lymnaea truncatula and L. natalensis has been reported (Bergeon, 1968; Graber, 1973b and 1975a). At the Debre Berhan Government Sheep Farm, the population of L. truncatula only appeared and expanded after the daily rainfall had become sufficient to provide

saturated conditons (5 to 13 mm. per day - July, August, September) (Goll and Scott, 1978). According to these workers, egg capsules were not seen until mid-August and insignificant hatching was observed. Infected snails were not found in the area until approximately three weeks after the appearance of *L. truncatula*.

2.3.2. The Bionomics of Nematode Parasites of Sheep.

The common gastro-intestinal nematode species frequently cause outbreaks of parasitic disease, and are constant sources of economic loss (Gordon, 1963). Despite this fact, little information is available concerning the seasonal incidence of the different species of nematodes (Tose, 1968). Further, the ecology of the free living stages is essential to a comprehensive understanding of the population dynamics of nematode parasitism in sheep (Gordon, 1957; Donald 1968; Rose, 1968; Gordon, 1973; Thomas, 1974). The pasture is, therefore, the site of deposition, development, and transmission of infection and meteorological factors affecting the pasture will affect the larval stage as well (Thomas, 1974).

The specific requirements of these larval stages for development and survival in the physical environment outside of their host include: favorable temperature, adequate moisture, sufficient oxygen, nutriment at some of the larval stages, protection from the lethal effects of freezing, heat from direct sunlight and desiccation (Olsen, 1974). However,

temperature and moisture are generally recognized as to dominant meteorological factors in the ecology of nematode parasites (Crofton and Whitlock, 1965a; Thomas, 1974).

Considerable research has also been conducted on experimental infections with single parasite species (pure infection groups) under one set of conditions (Schwabe et al., 1977) as well as controlled laboratory studies of parasites (Crofton, 1965; Crofton and Whitlock, 1965a, 1965b; Crofton et al., 1965 and others). These situations, however, bear little resemblance to the disease complexes seen in nature. Under natural conditions animals carry mixed infections which vary in their response to particular climatic conditions (Thomas, 1974) which in turn vary with the geographic region. It follows then that mixed parasitism, particularly in ruminants, represents a type of epidemiologically complex, multivariate problem that requires attention worldwide (Schwabe et al., 1977).

Levine (1963) was probably the first to develop an organized approach to this problem of mixed infection in a preliminary, methodological study. Levine argued that to report simply the numbers or percentages of animals infected with each species is unsatisfactory. He reasoned that a few worms of a particular species may be present in almost every animal without ever reaching harmful numbers whereas another parasite species might be found in fewer hosts, yet it might be abundant and economically important when present.

To demonstrate his methodology Levine (1963) employed the use of parasite profiles (emphasis original), which are bar-graphs depicting the relative percentages of the different genera or species of nematodes infecting sheep and cattle raised in Urbana, Illinois; Beltsville, Maryland; Davis and Hopland, California; Experiment, Georgia, and Central and North-east Texas. His findings are given in Figure 2.

It is clear from the parasite profiles that different species predominate in mixed gastro-intestinal parasitism of nematodes in different geographic areas (Schwabe et al., 1977).

In another observation, an annual cyclic pattern of nematode parasitism in sheep has been shown to occur. During the early parts of the year a marked increase normally takes place. This event has been designated the "spring rise phenomenon" (emphasis original) (Soulsby, 1965). Among others Rose (1968); Swan (1970) and Gordon (1973) have reported the existence of such a phenomenon in H. contortus infection in sheep. The same has also been reported for Nematodirus battus by Levine (1963); Smith and Thomas (1972). Lancaster and Hong (1971), while studying the Chillingham wild white cattle, found that Oesophagostomum eggs in the faecal samples examined showed a similar pattern.

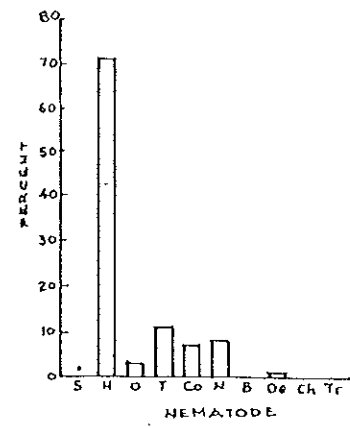
The literature on nematode parasites of ruminants in the tropics is very scanty. From the available material it

FIGURE 2 : Parasite Profiles of Sheep and Cattle from Different Regions. Percentages of Parasite Species or Genera Based on Total Number of Strongyloid Nematodes = 100%.

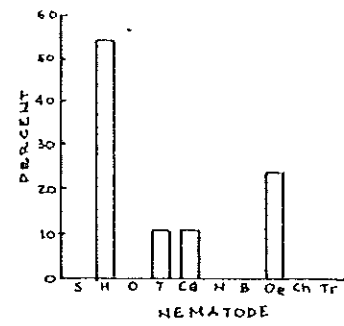
LEGEND : (a) Beltsville, Maryland - from sheep.
(b) Urbana, Illinois - from sheep.
(c) " " " "
(d) Davis and Hopland, California - from Sheep.
(e) Experiment, Georgia - from cattle.
(f) Central and Northern Texas - from cattle.

CODE : S. - Strongyloides papillosus
T. - Trichostrongylus spp.
Ta. - Trichostrongylus axei
B. - Bunostomum spp.
Ch. - Chabertia spp.
Ti. - Trichostrongylus colubriformis
H. - Haemonchus spp.
Co. - Cooperia spp.
N. - Nematodirus spp.
Oe. - Oesophagostomum spp.
Tr. - Trichuris spp.

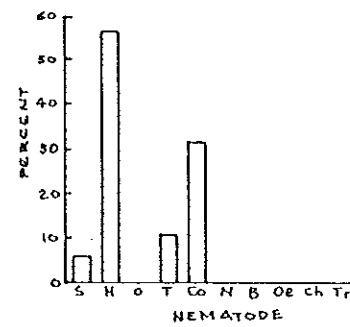
(after Levine, 1963).



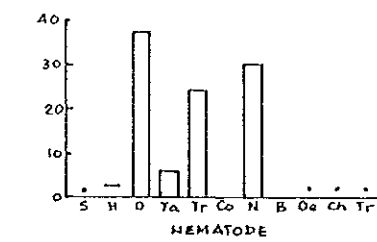
(a)



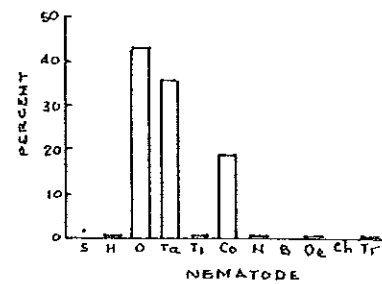
(b)



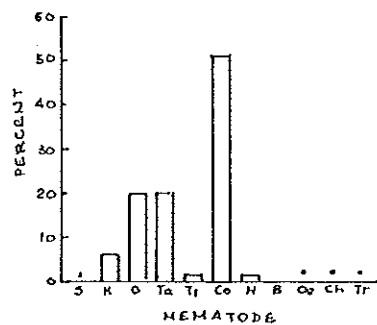
(c)



(d)



(e)



(f)

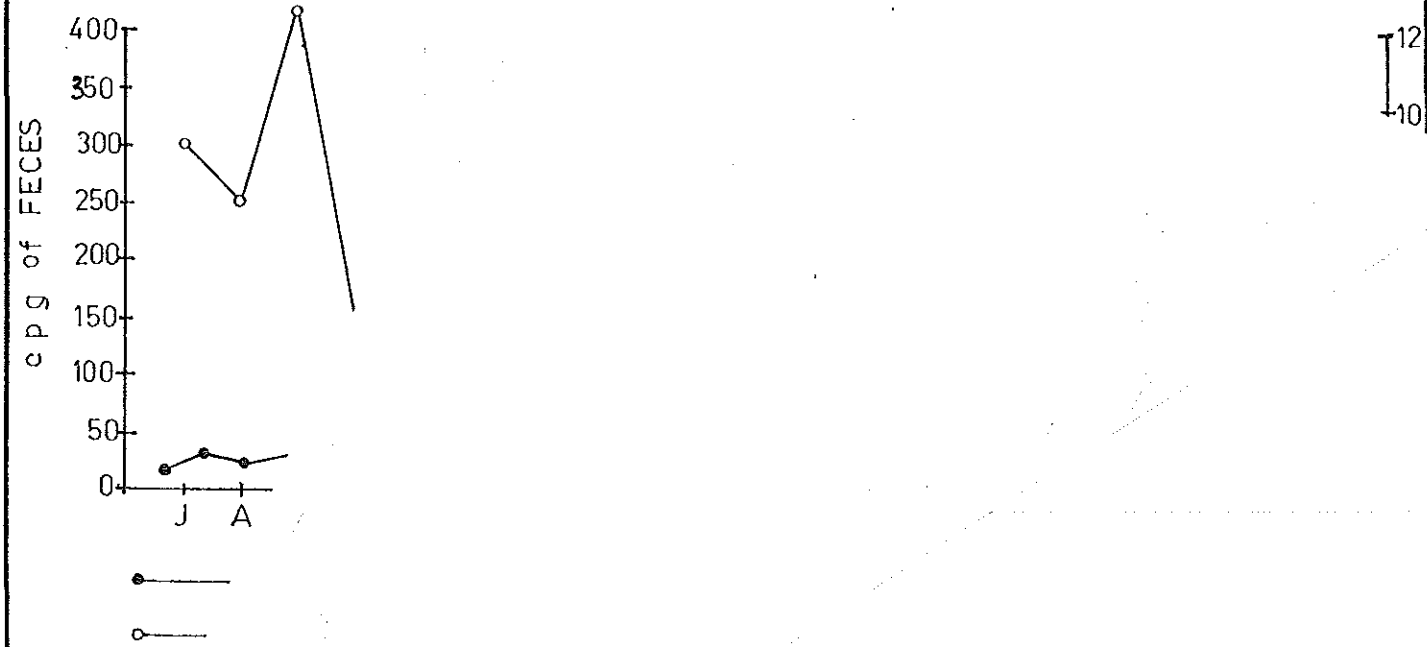
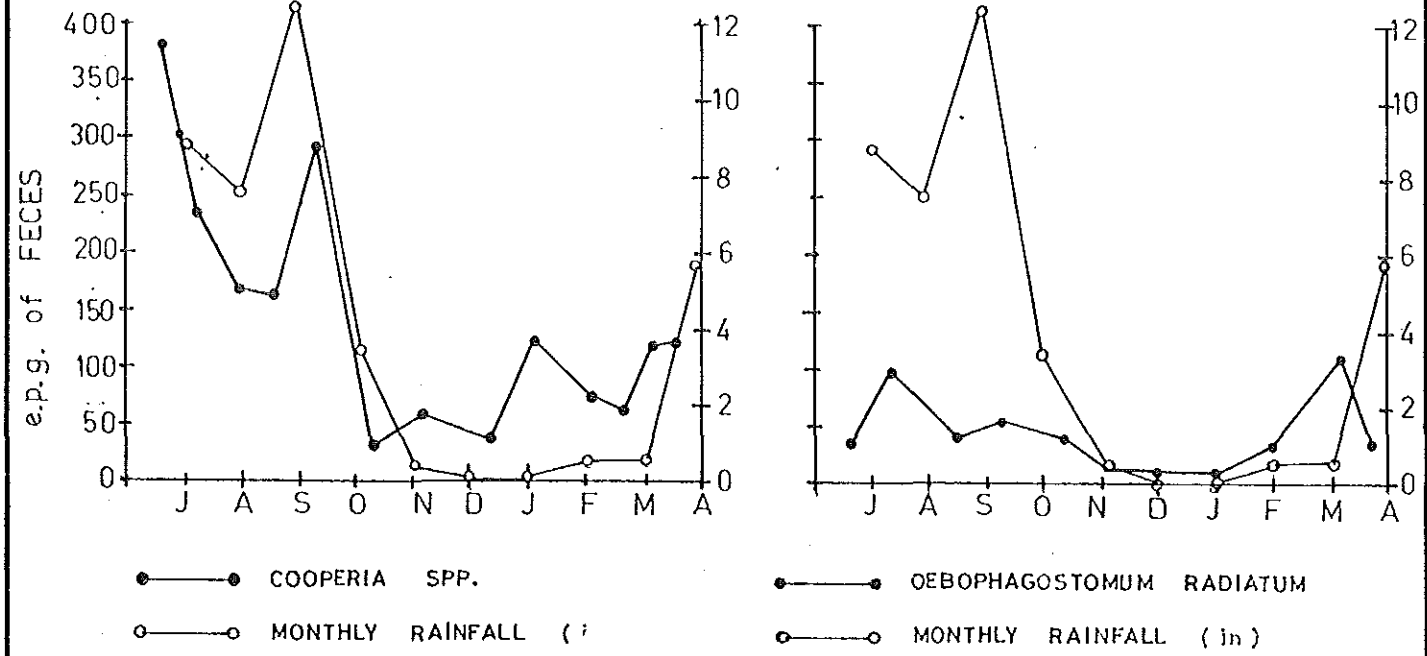
FIGURE 2

is inferred that, similar to the bionomics of fascioliasis discussed previously, the most limiting factor on the life cycles of nematodes in the tropics is moisture rather than temperature. Therefore appropriate caution must be applied when knowledge acquired in the temperate regions is used as reference for data collection in the tropics.

Hart (1964), working on the bionomics of nematode parasites of cattle in northern Nigeria, West Africa, stated that there is generally a marked fall in the egg counts of nematodes after months of suitable climatic conditions. According to the author, it is reasonable to assume that the infectivity of the pasture was high during the wet seasons and to suggest that there were reductions in the size of the adult worm burdens after the onset of the dry months. This is supported in the case of Haemonchus spp. by the small number of adult worms subsequently recovered at post mortem examinations carried out in December, 1962. The findings of Hart (1964) are shown in Figure 3.

Bekele Mamo (1980), working on samples collected from sheep slaughtered in the Addis Ababa Abattoir, found that infections with helminths were encountered in all the months through which the work was carried out - October, 1979 to March, 1980. A rise in the mean worm burden per sheep in January indicated the peak infection period within the given months. The worms H. contortus, O. columbianum, T. ovis,

FIGURE 3 : The Relationship Between Nematode Eggs
per Gram of Faeces of Cattle and Rainfall
in Northern Nigeria (after Hart, 1964).



and *C. ovina* particularly, attained their highest counts in September.

According to Gebrekiros Asegede (1981), the relationship between the nematode egg output of the untreated tracer sheep and the climate of the Awassa area were correlated in a study conducted for six months - June to November, 1979. In this study, a progressive rise in the egg output of the sheep was observed in the first four months (June to September), when the mean daily temperatures ranged between 19°C to 20°C and the monthly rainfall ranged between 50mm. to 80mm. The peak nematode egg output of the sheep was recorded in September, with a count of 6×10^3 EPG of faeces. Based on these findings he concluded that favourable conditions, including the optimum temperature of 20°C and monthly rainfall above 50mm., for the majority of sheep nematodes, are attained from July to October in the Awassa area.

3. MATERIALS AND METHODS

3.1 Locations of the Study

The investigations were carried out at four selected sites: Asella (Arsi); Awassa (Sidamo); Debre Berhan (Shoa) and Debre Zeit (Shoa) (Fig.4). These sites were selected on the basis of variation in climatic conditions and the sheep population which these sites provide. The availability of technical materials to facilitate the investigations, the availability of accomodation for the sheep, and the relative proximity and accessibility to the main laboratory in Addis Ababa have influenced the site selection considerably.

Asella lies at latitude $08^{\circ} 08' N$ and longitude $39^{\circ} 08' E$, with an altitude of 2,450 metres above sea level. The town is located on the western slopes of Mount Chilalo which has an altitude of 4,036 metres above sea level. Chilalo Awraja, in which Asella is located, has approximately 550,000 sheep which are mainly reared under traditional husbandry practices (Ethiopian Mapping Agency, 1981). A small flock is maintained under improved management for experimental purposes by the Arsi Rural Development Project (ARDP).

A close observation of the sheep pasture revealed that the location of Asella on the mountain slopes influences

FIGURE 4 : Routes and Locations of the 4 Selected Study Sites (Asella, Awassa, Debre Berhan and Debre Zeit).

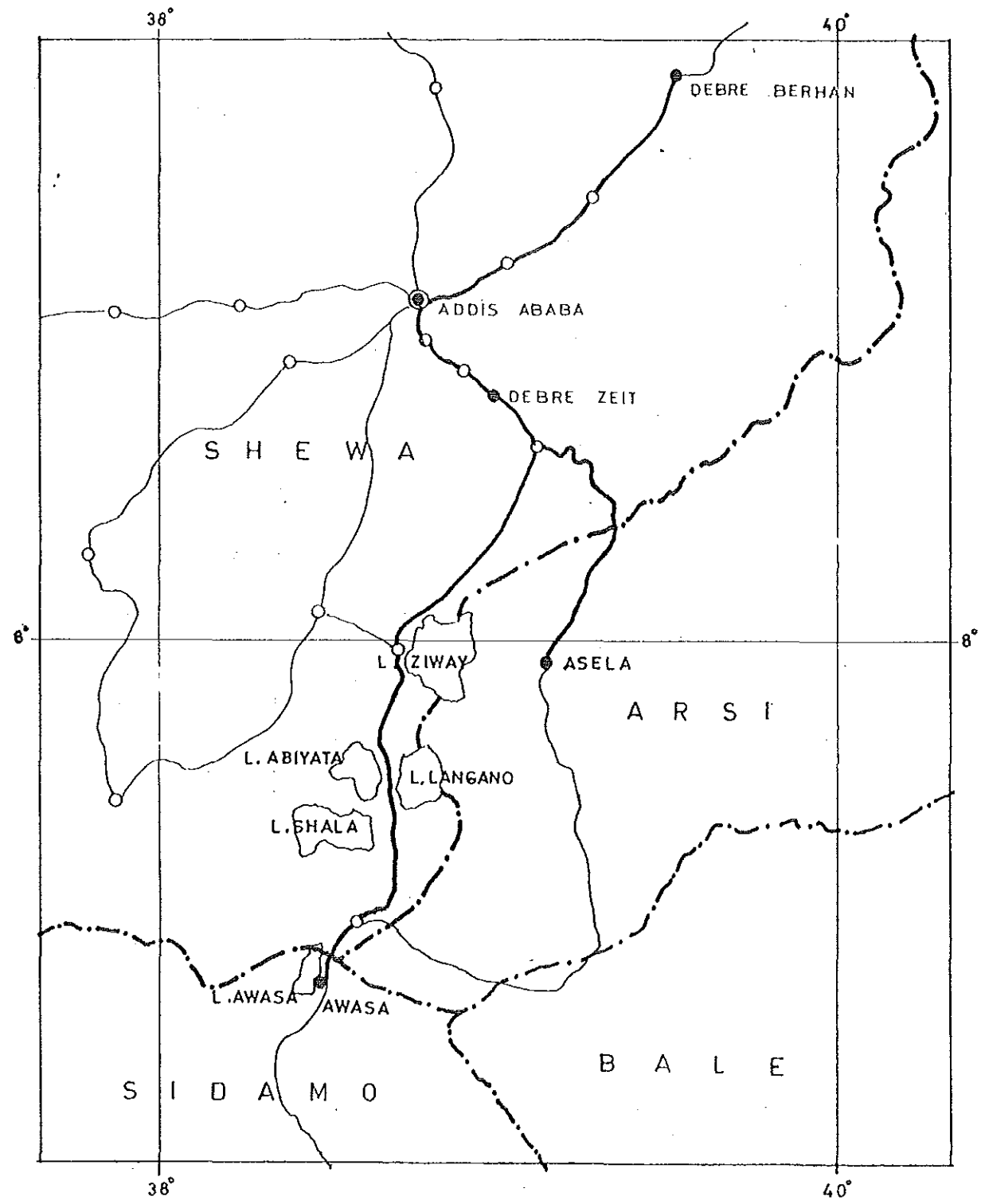


FIGURE 4

both the climatic character (rainfall, temperature, etc.) and the drainage pattern of the land. Heavy rains give rise to rapid run-offs which leave behind some scattered water-logged areas. Permanent streams which emanate from Mount Chilalo, drain the land westward down the escarpment of the Great Rift Valley to join Lake Zwai.

Awassa is located in the Great Rift Valley at latitude $07^{\circ} 30'$ and longitude $38^{\circ} 28' E$, with an altitude of 1,680 metres above sea-level. The town is situated along Lake Awassa, which considerably modifies the climatic conditions of the area and the life of the people and animals living in the vicinity. During the dry months, the flat grazing lands are dry except one large area to the north-west of the town. In the Sidamo Awraja where Awassa is located, it is estimated that there are 200,000 sheep kept under traditional husbandry methods (Ethiopian Mapping Agency, 1981).

Debre Berhan lies at latitude $09^{\circ} 31' N$ and longitude $39^{\circ} 28' E$, with an altitude of 2,780 metres above sea-level. This is a mountainous area dissected by rivers and streams. The area receives appreciably high rainfall. The grazing lands found around Debre Berhan are drained by these streams and pocketed by water-logged (marshy) areas.

The Tegulet-and-Bulga Awraja in which Debre Berhan is located maintains about 700,000 sheep that are reared under traditional husbandry management (Ethiopian Mapping Agency,

1981). There is one modern government farm stocked with merino sheep.

Debre Zeit lies at latitude $08^{\circ} 44'$ N and longitude $38^{\circ} 58'$ E, with an altitude of 1,850 metres above sea-level. The town is located on the escarpment of the Great Rift Valley. The topography of the Debre Zeit area is greatly altered by the geologic formations of crater lakes. As in Awassa, these lakes and the position of the town on the escarpment of the great valley, have a bearing on the climate of the area.

The Yerer-and-Kerreyu Awraja in which Debre Zeit is located has about 450,000 sheep kept under traditional management (Ethiopian Mapping Agency, 1981). The special feature of the area is the presence of two veterinary schools and one veterinary research institute. The extension activities of these organizations have greatly influenced livestock owners found in and around Debre Zeit, by providing professional advice and services.

The specific sites where the sheep were sheltered and grazed in the case of each study area are:

- Asella : The Arsi Rural Development Project (ARDP), Ministry of Agriculture.
- Awassa : The Awassa Junior College of Agriculture, Addis Ababa University.
- Debre Berhan : The International Livestock Center for Africa (ILCA), Debre Berhan Experiment Station, and,

- Debre Zeit : The Debre Zeit Junior College
of Agriculture and Research Center:
Addis Ababa University.

The animals were thus maintained in the premises of the organizations mentioned and they were allowed to graze in the vicinity under the custody of shepherds hired for the purpose.

3.2. The Animals

In this study the parasite-free tracer animal method using young sheep were employed. This method is **precise for** determining parasitic infections, monitoring the status of husbandry and source of parasitism. For this purpose young indigeneous sheep of both sexes were bought from local markets found in close proximity to each study site. The lambs aged six to eight months with an average weight of 13.3 kgs.

The animals were ear-tagged and weighed. They were treated with suspension of Rafoxanide 3% w/v (Ranide) and Tetramisole (Deuxamine) boluses at the rate of 15.5 mg. and 15.0 mg. per kg. of body weight, respectively, so as to completely de-worm them from possible infections by liver, lung and gastro-intestinal helminth parasites. The animals were vaccinated against prevalent infectious diseases and sprayed for external parasites. They were then quarantined from 20 to 30 days. Faecal samples of the sheep were examined before, and a few days after, administration of the anthel-

mintics. The sheep received a second administration of anthelmintics 7 to 8 days prior to their release, as a final clearance. Until their release for grazing, the sheep were kept in properly ventilated buildings with clean, concrete floors where hay, concentrate and clean water were given.

3.3 Procedures of the Study

3.3.1 Sheep Sample Survey Design

Experimental Sheep (Tracers): Three parasite-free experimental sheep, hereafter referred to as tracers, were released to graze for one month at each of the selected study sites (Asella, Awassa, Debre Berhan and Debre Zeit). The sheep were confined indoors for 12 weeks before slaughter for post-mortem examinations. This was to allow sufficient time for the development of the helminths that were picked during the grazing month.

Control I: Together with the tracers, one to two helminth-free sheep was (were) released at the start of the investigations in all the sites. At the end of each month they were treated with 15.5mg. and 15.0 mg. per kg. of body weight of Rafoxanide and Tetramisole, respectively. These sheep underwent post-mortem examination 12 weeks after the last drenching, at the completion of the investigation in all the study sites.

Controls II: One sheep at each station (de-wormed at the beginning of the investigation) was kept housed throughout

the study period and underwent post-mortem examination 12 weeks after the completion of the study. The purpose of keeping these sheep indoors was to show the helminth-free condition of the house.

Controls III: During some of the months that were suspected to be periods of high infections, an additional one to two sheep were released at each site at the start of the grazing months with the tracers, and control I. The Control III sheep were de-wormed before release. They were re-housed on the last day of the month, after being drenched with the appropriate doses of Rafoxanide and Tetramisole. After 12 weeks of their re-housing these sheep also underwent post-mortem examination to determine the effectiveness of the anthelmintics administered.

3.3.2. Post-mortem Worm Counts

The investigation has employed the direct determination of the worm burdens of the tracers and control sheep. For this purpose, the sheep were slaughtered for direct worm counts. At slaughter, the organs to be examined were transported in 10% formalin to the laboratory in Addis Ababa.

The Liver and the Gallbladder: The liver and the common bile duct were carefully removed from the duodenum. The gallbladder was ligated from the rest of the liver, emptied and washed in a beaker. The contents of the beaker were checked for adult Fasciola spp.

The bile ducts were opened with scissors and searched for adult flukes. The rest of the liver was cut into 1cm. thick slices and pressed between the fingers to expose flukes lodged in small liver ducts. In cases of heavy infections, the 1cm. slices were cut in cross section for detailed examination. At this time, if individual flukes were severed the numerical assessment was accomplished by counting the heads of the parasites.

The Lungs: These were first ligated, together with the trachea and the larynx, from the rest of the pharyngeal tissue. They were either examined immediately or transported to the laboratory in 10% formalin with the cut ends of the trachea tightly tied. The trachea, the bronchii, and the bronchioles were opened along the entire length with scissors and all worms visible were removed by forceps. The edges of the lungs were cut across and pressed between the fingers to observe if worms were sheltered in the smaller bronchioles.

The large lungworms are fragile and tend to form tight tangled masses. In cases of severed worms, the numerical assessment was conducted by counting the heads.

The Oesophagus, the Rumen and the Reticulum: The bulky nature of this part of the gastero-intestinal structure prohibited convenient packing and transportation. Therefore, these were examined immediately at the site of slaughter.

The oesophagus, the rumen and the reticulum opened and their contents caught in troughs. The internal linings

were carefully rubbed with the fingers under running water, to remove any worms adhering to them. The contents of the troughs were simply emptied gradually into watch-dishes or containers and all visible worms were collected.

The rest of the gastro-intestinal tract - the omasum, the abomasum, the small intestine, the large intestine to the anus were ligated from the peritonium for transport to the Addis Ababa laboratory, in plastic bags containing 10% formalin with their ends tightly tied.

The Omasum and the Abomasum: These organs were placed in a bucket and cut open along their lengths and all their contents were washed with a jet of water from a rubber hose. At the same time the inner linings were carefully rubbed manually to remove any adhering worms.

The contents of the bucket, averaging four litres, were gradually filtered through wire mesh screens with aperture of 1 mm. and 0.5 mm. The debris caught on the screens were washed with a jet of water until clear water passed through. During this process, all worms visible to the naked eye were collected.

The Small Intestine: The entire small intestine, starting from the sphincter at the duodenum upto the valve at the caecum, was sectioned into lengths of 1.5 to 2.0 metres. The sections were placed in a bucket and then each section had its contents flushed by a jet of water from a rubber hose.

The flushing was continued until clear water, free of intestinal contents, was observed at the outflow end. These pieces of the small intestine were then opened along their lengths and rubbed between the fingers to remove any worms adhering to them.

The contents of the bucket were filtered using wire mesh screens with apertures of 1 mm. and 0.5 mm. The debris caught on the screens was washed and all visible parasites were collected.

The Caecum, the Colon and the Rectum: The procedures used for the recovery of parasites from the small intestine were repeated to collect the worms found in the caecum, the colon and the rectum.

The worms thus recovered from all parts of the gastrointestinal tracts, the lungs and the livers were collected and washed in tap water. Then the worms were transferred to labelled, tightly closed vials, containing 10% formalin.

For identification and counting, the parasites were transferred to petri-dishes and observed with a stereoscopic microscope at 30X magnification. In the case of the nematodes, for detailed morphological studies, fixed slides were prepared using lactophenol cotton blue stain. The fixed and other wet-mount preparations were observed under the middle power objective (10X) of a compound microscope.

The identification of the helminths to the genus level was done according to the keys of Yamaguti (1958, and 1961);

Soulsby (1968) York and Maplestone (1969); Georgi (1974) and Dunn (1978).

The identification of cestodes to the genus and species level was not attempted. Therefore, the designation of "unidentified cestodes" has been used in this report.

Finally, the local occurrence and frequency of the worms belonging to different genera were determined, and recorded in respect to the specific study sites, tag numbers of the sheep and their grazing months (Appendix: Tables 8,9,10 and 11). Adapting the method used by Scott and Goll (1977) and Meek and Morris (1981), the monthly average number of worms per tracer sheep has been calculated for each identified genus and recorded in the same tables. These worm burdens per sheep per month have then been plotted against the months of the study period to show the seasonal patterns of some important helminths of sheep. It was also attempted to present the relationships of the temporal patterns of these parasites with some meteorological factors of the study months (rainfall, air temperature and relative humidity) of each site according to the data given in the Appendix (Tables 14, 15, 16 and 17).

4. RESULTS

4.1 Numbers, Sexes and Mortality Rates of the Sheep

A total of 153 sheep have been used in the study. These were stationed at the four selected sites for a period of twelve months, ranging from December 1, 1981 to November 31, 1982 at Asella and Awassa; October 1, 1981 to September 31, 1982 at Debre Berhan and November 1, 1981 to October 31, 1982 at Debre Zeit. The number of sheep placed at each site, their sexes and rates of mortality are given in Table I.

TABLE I. Mortality Rates of the Sheep of the Four Study Sites - Asella, Awassa, Debre Berhan and Debre Zeit.

Study Sites	Total No. of Sheep maintained	Tacer Sheep		Control Sheep		No. of deaths		Mortality Rates (%)
		M	F	M	F	M	F	
Asella	41	16	20	3	2	7	4	26.8
Awassa	41	22	10	4	5	2	1	7.3
Debre Berhan	41	15	19	1	6	8	5	31.7
Debre Zeit	30	16	8	2	4	1	1	6.7
Total	153	69	57	10	17	19	11	19.0

4.2 The Local Occurrence and Relative Frequency of the Helminths Recovered at the Post-Mortem Examination of the Tracer Sheep.

Post-mortem examination was conducted on 126 tracer sheep. The liver, lungs and gastro-intestinal tract were meticulously searched. As a result, a total of 15,415 helminth parasites were recovered from the tracers maintained in the four selected sites.

The local occurrence of the parasites has been determined. The relative frequency of each helminth has been plotted for the one year period of study. The results are given in Tables 2, 3, 4 and 5.

The post-mortem examination results of the control sheep of the four sites are given in the Appendix (Tables 12a, b, c and d).

4.3 The Monthly Incidence and Relative Frequency of the Helminths Recovered.

The 15,415 helminth parasites recovered during the post-mortem examinations from the 126 tracer sheep were obtained over a span of one year on a monthly collection basis at Asella, Awassa, Debre Berhan, and Debre Zeit.

The various genera identified, their worm counts and number of worms per sheep are given in the Appendix (Tables 8, 9, 10 and 11). The seasonal occurrence of the main helminth parasites in relation to the data on rainfall, air temperature and relative humidity of each site are given in Figures 5 - 8.

TABLE 2. The Local Occurrence and Relative Frequency of the Helminths in Asella Area.

Helminths recovered and identified	Worm count	Relative frequency as a percentage
Trematodes		
<i>Fasciola hepatica</i>	234	14.8
<i>Paramphistomum</i> spp.	1342	85.2
Cestodes		
Unidentified	32	
Nematodes		
<i>Bunostomum</i> spp.	3	0.2
<i>Chabertia</i> sp.	1	0.1
<i>Dictyocaulus</i> spp.	67	5.3
<i>Haemonchus</i> spp.	416	32.8
<i>Oesophagostomum</i> spp.	37	2.9
<i>Ostertagia</i> spp.	22	1.8
<i>Skrjabinagia</i> spp.	3	0.2
<i>Trichostrongylus</i> spp.	92	7.3
<i>Trichuris</i> spp.	626	49.3
Total No. of Helminths	2875	

TABLE 3. The Local Occurrence and Relative Frequency of the Helminths in Awassa Area.

Helminths recovered and identified	Worm count	Relative frequency as a percentage
Trematodes		
<u>Fasciola hepatica</u>	8	0.2
<u>Paramphistomum spp.</u>	3419	99.8
Cestodes		
Unidentified	37	
Trematodes		
<u>Bunostomum spp.</u>	7	0.3
<u>Haemonchus spp.</u>	1948	82.1
<u>Oesophagostomum spp.</u>	76	3.2
<u>Ostertagia spp.</u>	3	0.1
<u>Trichostrongylus spp.</u>	1	-
<u>Trichuris spp.</u>	339	14.3
Total No. of Helminths	5838	

TABLE 4. The Local Occurrence and Relative Frequency of the Helminths in Debre Berhan Area.

Helminths recovered and identified	Worm count	Relative frequency as a percentage
Trematodes		
<u>Fasciola hepatica</u>	323	14.0
<u>Paramphistomum</u> spp.	1986	86.0
Cestodes		
Unidentified	37	
Nematodes		
<u>Bunostomum</u> spp.	33	2.9
<u>Chabertia</u> sp.	1	0.1
<u>Dictyocaulus</u> spp.	64	5.7
<u>Haemonchus</u> spp.	33	2.9
<u>Oesophagostomum</u> spp.	9	0.8
<u>Ostertagia</u> spp.	22	2.0
<u>Strongyloides</u> spp.	3	0.3
<u>Trichostrongylus</u> spp.	7	0.6
<u>Trichuris</u> spp.	947	84.3
<u>Protostrongylus</u> spp.	4	0.4
Total No. of Helminths	3469	

TABLE 5. The Local Occurrence and Relative Frequency of Helminths in Debre Zeit Area.

Helminths recovered and identified	Worm count	Relative frequency as a percentage
Trematodes		
<u>Paramphistomum</u> spp.	31	100.0
Cestodes		
Unidentified	34	
Nematodes		
<u>Haemonchus</u> spp.	2078	65.6
<u>Nematodirus</u> sp.	1	-
<u>Oesophagostomum</u> spp.	726	22.9
<u>Ostertagia</u> spp.	246	7.8
<u>Trichostrongylus</u> spp.	51	1.6
<u>Trichuris</u> spp.	63	2.0
Unidentified nematodes	3	0.1
Total No. of Helminths	3233	

FIGURE 5 : The Relationship Between the Intensity of Infection by Dictyocaulus spp. in the Tracer Sheep and Rainfall, Air Temperature and Relative Humidity in Asella and Debre Berhan.

LEGEND : _____ Number of Worms per Sheep.
----- Monthly Rainfall, M.R., (mm).
..... Mean Daily Air Temperature, A.T., ($^{\circ}$ C).
-.-.- Relative Humidity, R.H., (%)

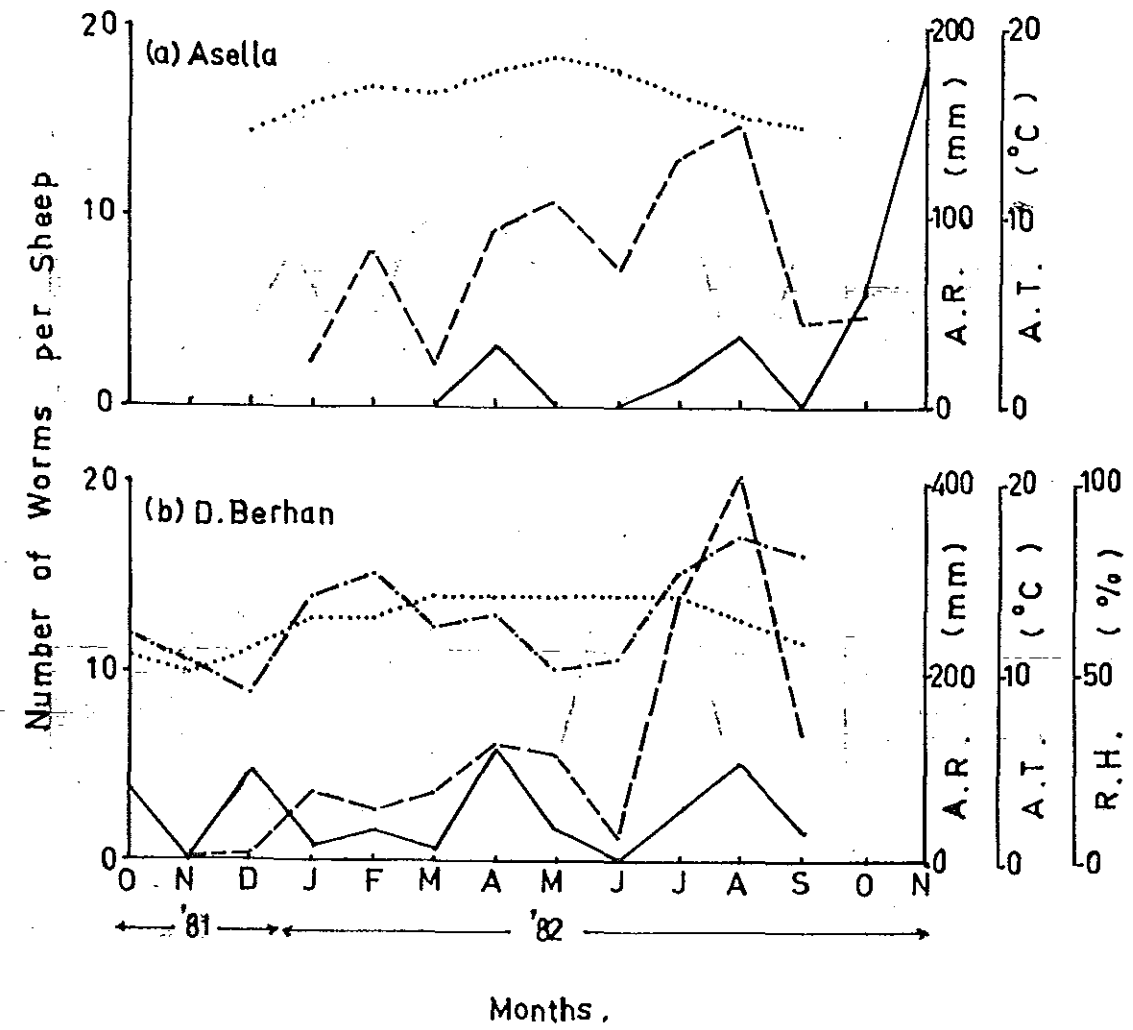


FIG. 5.

FIGURE 6 : The Relationship Between the Intensity of Infection by Fasciola Hepatica in the Tracer Sheep and Rainfall, Air Temperature and Relative Humidity in Asella, Awassa and Debre Berhan.

LEGEND : _____ Number of Worms per Sheep.
----- Monthly Rainfall, M.R., (mm).
..... Mean Daily Air Temperature, A.T., ($^{\circ}$ C).
-.-.- Relative Humidity, R.H., (%)

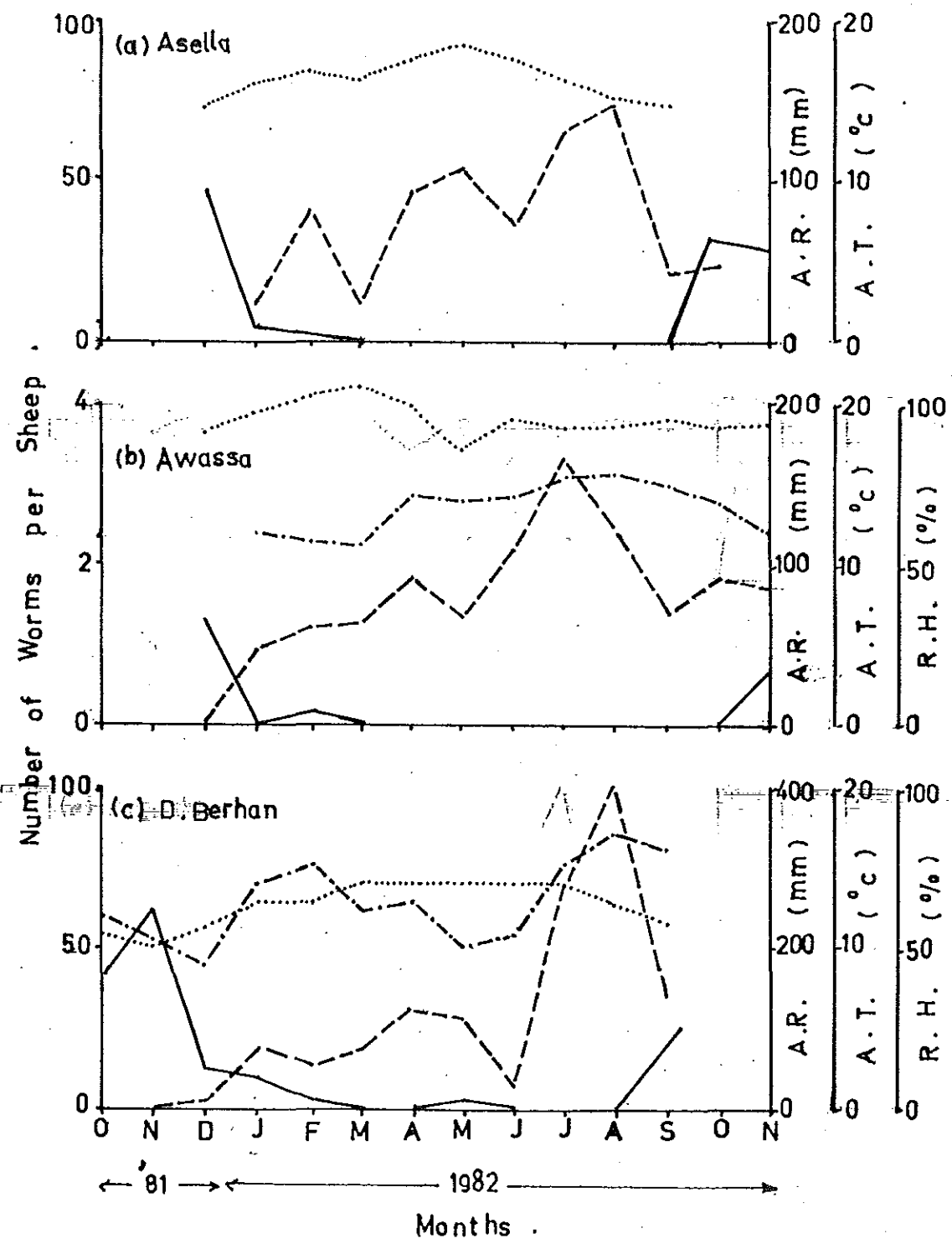


FIG. 6 .

FIGURE 7 : The Relationship Between the Intensity of Infection by Haemonchus spp. in the Tracer Sheep and Rainfall, Air Temperature and Relative Humidity in Asella, Awassa, Debre Berhan and Debre Zeit.

LEGEND : _____ Number of Worms per Sheep.
----- Monthly Rainfall, M.R., (mm).
..... Mean Daily Air Temperature, A.T., ($^{\circ}$ C).
-.-.- Relative Humidity, R.H., (%).

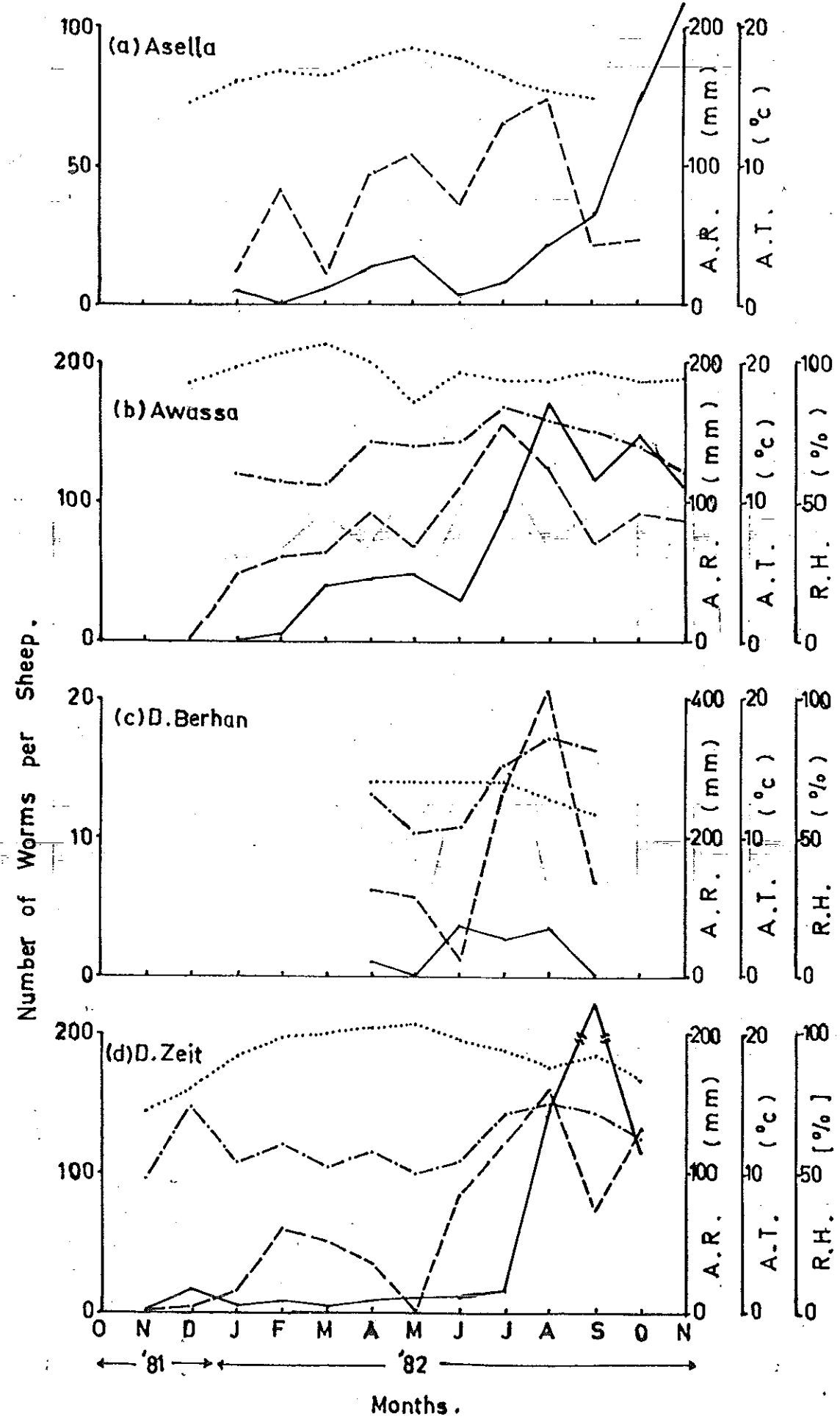


FIG. 7.

FIGURE 8 : The Relationship Between Intensity of Infection by Oesophagostomum spp. in the Tracer Sheep and Rainfall, Relative Humidity and Air Temperature in Asella, Awassa and Debre Zeit.

LEGEND : _____ Number of Worms per Sheep.
..... Mean Daily Air Temperature, A.T., (°C).
.... Monthly Rainfall, M.R., (mm).
-.-.-.-. Relative Humidity, R.H., (%).

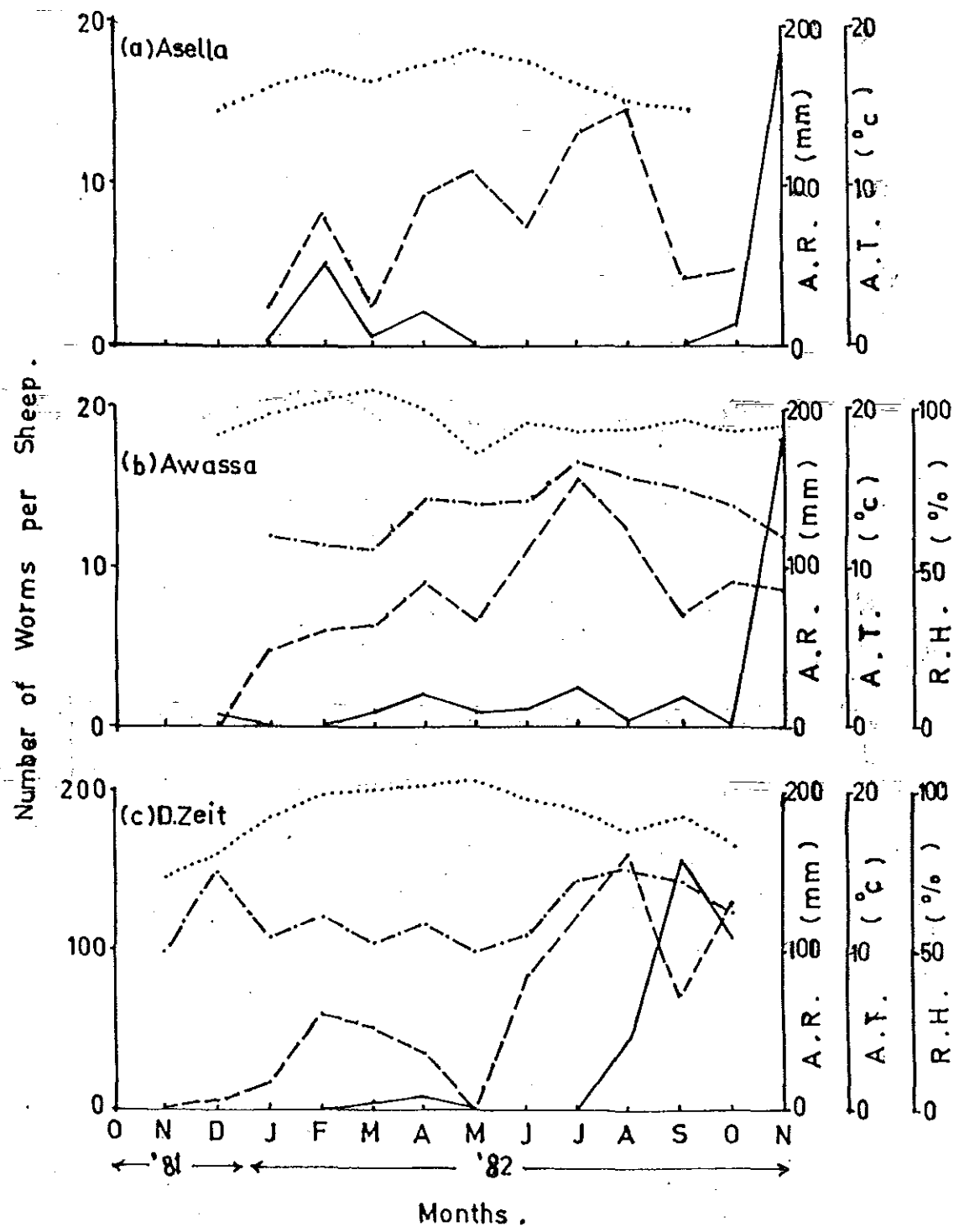


FIG. 8.

5. DISCUSSION AND CONCLUSION

5.1 Mortality Rates of Sheep in the Study.

In this study from a total of 153 tracer and control sheep maintained in the four selected sites 19.0% (29 sheep) died. The highest mortality was encountered at Debre Berhan 31.7% (13 sheep); followed by Asella 26.8% (11 sheep); Awassa 7.3% (3 sheep); and Debre Zeit 6.7% (2 sheep) (Table 1).

Of the causes for the deaths at Debre Berhan, chronic fascioliasis claimed the lives of five sheep. The first two of the deaths (DB-RE-004 and DB-RE-005) occurred in November; the third and the fourth (DB-ET-022 and DB-ET-023) died in December of 1981 and the fifth (DB-ET-024) in January of 1982. All the animals showed a high degree of emaciation, staring coat, disinclination to walk around and feed, and distended bellies before death. Similar clinical signs of chronic fascioliasis have been observed by Soulsby (1965; 1968); Reid, Armour and Jennings (1970); Rosely (1970); Reid and Doyle (1972); Dunn (1978); and others.

Furthermore, three sheep are believed to have died due to acute fascioliasis in Debre Berhan. The first died in October (DB-LE-001); the second (DB-RE-003) in November; and the third (DB-ET-021) in December of 1981. These sheep died suddenly. Upon post-mortem examination there were no adult flukes in the bile ducts, but there was some amount

of blood in their abdominal cavities. This is in agreement to signs of the disease described by Soulsby (1965; 1968); Dunn (1973) and others. The information gathered indicated that the probable cause for the deaths of the remaining animals is respiratory distress of non-specific etiology.

Death due to fascioliasis was not encountered in Asella. Two sheep (Ase-ET-004 and Ase-ET-009) were killed in December of 1981 due to paralysis of the hind quarter. The etiology for the disease is unknown. The probable cause for the deaths of the remaining nine sheep is mixed infection with helminth parasites.

In Awassa, out of a total of three deaths, two sheep (Awa-ET-011 and Awa-ET-016) died due to pneumonia in November of 1981. Post-mortem examination was not conducted on the third animal.

Out of the two deaths in Debre Zeit, the first, which was a control sheep (DZ-ET-089) died in January of 1981. Post-mortem examination was not conducted on the sheep. The second sheep (DZ-Me-031) is very likely to have died due to severe infections with Haemonchus spp. and Oesophagostomum spp. At the time of death, apart from being pregnant, the sheep showed a high degree of emaciation, submandibular oedema and severe diarrhea. At post-mortem examination the carcass was pale and watery.

5.2 The Local Occurrence of the Helminth Parasites Recovered

The specific occurrence of the various genera of helminths of sheep for each study site are given in Tables 2, 3, 4, and 5.

From the 126 tracer sheep placed at the four study sites, a total of 15,415 worms were recovered at post-mortem examinations of which 18.6% (2875 worms) were collected from the Asella area; 37.9% (5838 worms) from Awassa; 22.5% (3469 worms) from Debre Berhan; and 21.0% (3233 worms) from the Debre Zeit area (Table 6).

Graber, Delavenay and Gebrenegus Tesfamariam (1978), working on samples collected from 85 cattle from the Asella area, were able to confirm the presence of Paramphistomum daubneyi, Cotylophoron cotylophorum, Fasciola hepatica, Fasciola gigantica, Haemonchus contortus, Cooperia punctata, Cooperia pectinata, Trichostrongylus spp. and Bunostomum phlebotomum. Bekele Mamo, Feseha Gebreab and Shibru Tedla (1981) have also confirmed the presence of Dictyocaulus filaria in the same area. In addition to these worms, the present work has shown the occurrence of Chabertia sp., Ostertagia spp., Skrjabinagis spp. and Trichuris spp. (Table 2).

Gebrekiros Asegede (1981) in addition to the worms shown in Table 3, was able to confirm the presence of Dictyocaulus filaria, Mullerius capillaris, Moniezia benedeni, Moniezia expansa, Avitellina centripunctata and Stilesia

hepatica in the Awassa area. In this study it was not possible to identify the cestodes, as mentioned earlier, while the presence of mild cases of Fasciola hepatica have been established at Awassa. The prevalence of these trematodes in this area has been reported by Graber (1975a and 1975b) and Bahru Gemechu and Ephrem Mamo (1979).

In the Debre Berhan area the presence of Fasciola hepatica has been reported by Graber (1975a and 1975b); Scott and Goll (1977) and Bahru Gemechu and Ephrem Mamo (1979).

5.2.1 The Nematodes

There were 7932 nematodes recovered from the tracer sheep with a collection of 39.9% (3168 worms) from Debre Zeit; 29.9% (2374 worms) from Awassa; 16.0% (1267 worms) from Asella and 14.2% (1123 worms) from Debre Berhan (Table 6). These results clearly show that the nematode parasitism observed in the tracer sheep generally favored the lower altitudes that have relatively warm and humid climates (Debre Zeit: 1850 m and Awassa: 1680m above sea level).

From among the nematodes there were three exceptions to this pattern of distribution. The first, and the one that greatly favoured the higher altitudes, was Dictyocaulus spp. In this study, this particular parasite occurred in Asella and Debre Berhan.

TABLE 6. Worm Counts of the Helminths Recovered from the tracer Sheep at the Four Study Sites.

Study Sites	Nematodes	Trmatodes		Cestodes	Total Number of helminths
		<u>Paramphistomum</u> spp.	<u>F. hepatica</u>		
Asella	1267(16.0%)	1342(19.3%)	234(41.4%)	32(22.9%)	2875(16.6%)
Awassa	2374(29.9%)	3419(50.4%)	8(1.4%)	37(26.4%)	5838(37.9%)
Debre Berhan	1123(14.2%)	1986(29.3%)	323(57.2%)	37(26.4%)	3469(22.5%)
Debre Zeit	3163(39.9%)	31(0.5%)	-	34(24.3%)	3233(21.0%)
Total worm count	7932(51.5%)	5778(43.9%)	555(3.7%)	140(0.9%)	15415(100.0%)

The second and the third exceptions were Trichuris spp. and Haemonchus spp. which seem to occur across all the ecological zones of the study in considerable numbers. However, Trichuris spp. appeared to occur in favor of the wet and cool, higher altitudes of Debre Berhan, 84.3% (947 worms) and Asella, 49.3% (626 worms). The incidence of Trichuris spp. in Awassa was 14.3% (339 worms) and that of Debre Zeit was 2.0% (63 worms). On the other hand, Haemonchus spp. occurred in the relatively lower, warm and humid areas of Awassa 82.1% (1948 worms) and Debre Zeit 65.6% (2078 worms) while Asella and Debre Berhan showed 32.8% (416 worms) and 2.9% (33 worms) respectively (Tables 2, 3, 4 and 5).

The parasite profile (Fig. 9), drawn according to methods developed by (Levine, 1963), shows the relative incidence of the nematodes that were collected from the four selected sites during the 12 -month study period. Percentages of genera were calculated based on total number of nematodes recovered for each study site per year taken as 100% (Tables 2, 3, 4, and 5).

5.2.2 The Trematodes

The parasitism due to infections with Paramphistomum spp. in sheep did not show a clear-cut pattern (Tables 2, 3, 4, and 5). Work on the epidemiology of the parasite and its planorbid intermediate host is meagre in the country. According to Dunn (1978), the wide distribution

FIGURE 9 : Parasite Profile of Sheep from the Four Selected Sites. Percentages of Parasite Genera Based on Total Number of Nematodes = 100% for Each Site.

CODE : B. - Bunostomum spp.
D. - Dictyocaulus spp.
H. - Haemonchus spp.
Oe. - Oesophagostomum spp.
Os. - Ostertagia spp.
S. - Strongyloides sp.
Sk. - Skrjabinagia spp.
To. - Trichostrongylus spp.
Tu. - Trichuris spp.
P. - Protostrongylus spp.

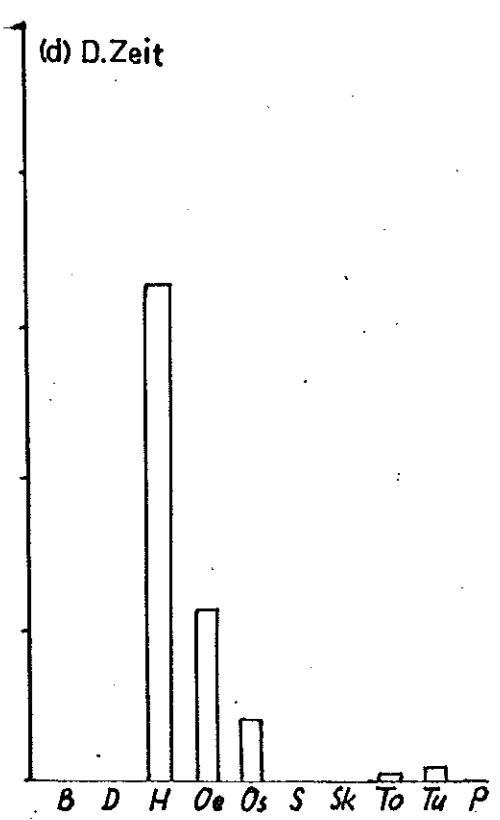
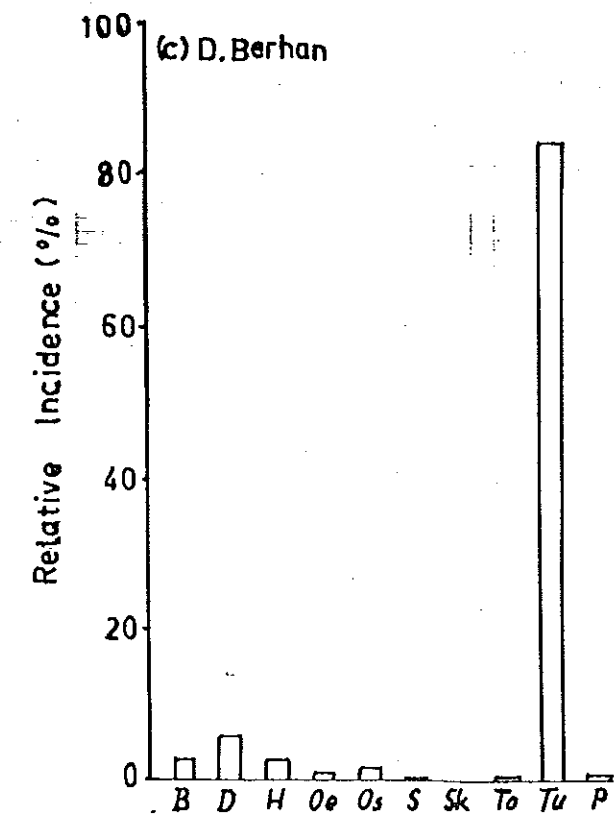
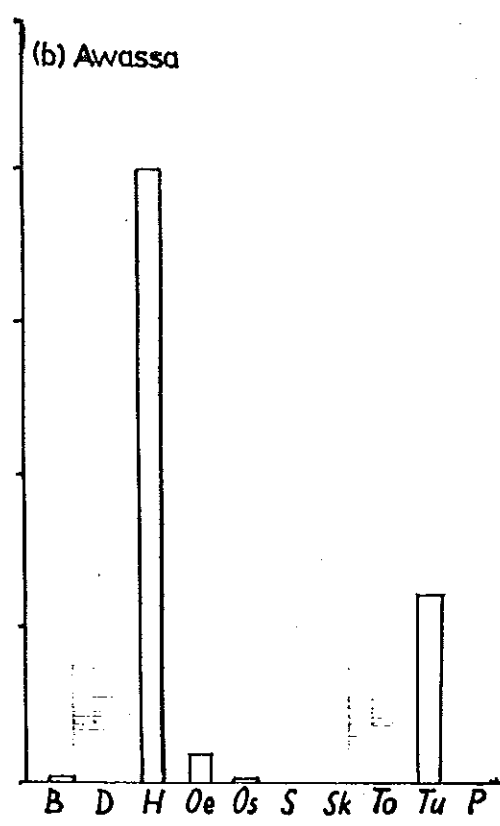
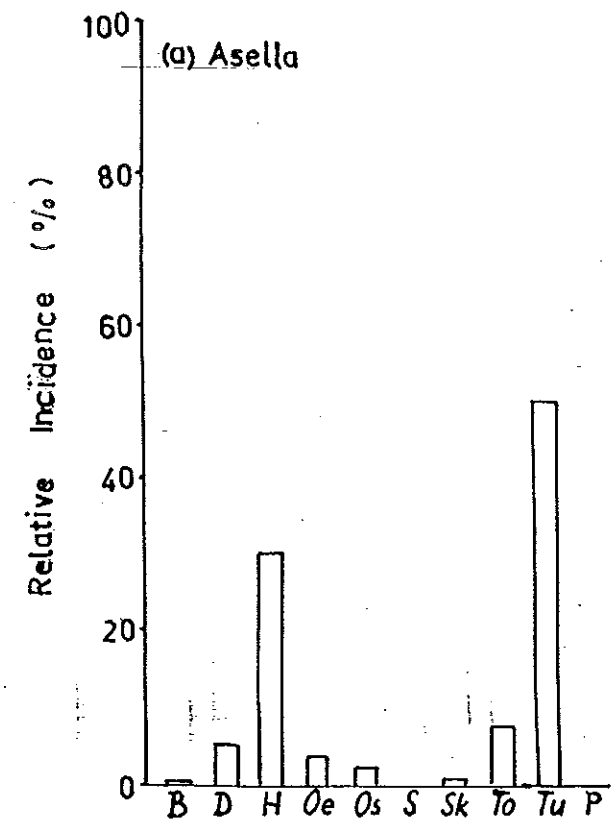


FIG. 9.

of the parasite is probably due to the broad ecological adaptation of the intermediate host to different temperatures, and its ability to survive for several years in dry soil in a state of aestivation. The same writer has also reported that as the dry season progresses the grazing dries and becomes less acceptable to the animals, and the area of green pasture lessens until all that is available is around water areas. The livestock therefore become concentrated on this diminished available grazing, and the snail population is also concentrated upon it, contaminating it heavily with metacercariae. This seems to account for the highest collection of Paramphistomum spp. in the Awassa area 50.4% (3419 worms), where relatively better grazing fields are observed around Lake Awassa. Such fields do not exist around the crater lakes of Debre Zeit, which are surrounded by steep slopes. Consequently, the lowest number of Paramphistomum spp. 0.5% (31 worms) were collected from the Debre Zeit area. The incidence for this parasite for Asella and Debre Berhan were 19.8% (1342 worms) and 29.3% (1986 worms), respectively (Table 6).

As for fascioliasis, the tracer sheep in Debre Berhan showed the highest incidence with 57.2% (323 worms), while 41.4% (234 worms) were recovered at Asella and 1.4% (8 worms) were at Awassa (Table 6). In this study Fasciola hepatica were not encountered in Debre Zeit. Thus, the parasitism due to Fasciola hepatica, unlike most nematodes, inversely

favoured the ecological zones of the higher altitudes that have wet and cool climates (Debre Berhan and Asella) Tables 2, 3, 4, and 5). These findings are related to the topographic, climatic and other requirements of the disease described by Ollerenshaw (1959); Ollerenshaw and Rowlands (1959) and Taylor (1964).

5.2.3 The Cestodes

The third group of helminths recovered at post-mortem examinations from the tracer sheep are the cestodes.

A total of 140 worms were recovered during the 12-month study period, with a collection of 22.9% (32 worms) at Asella; 26.4% (37 worms) at Awassa and Debre Berhan each, and 24.3% (34 worms) at Debre Zeit (Table 6). Euzeby (1967) has stated that the wide distribution of the cestodes is due to the oribatid intermediate hosts that favor moist pastures with a thick layer of humus. The pathogenicity of the cestodes is known to be severe in young sheep (Soulsby, 1965; Euzeby, 1967; Soulsby, 1968; Dunn, 1978).

5.3 Seasonal and Peak Incidence of the Helminths

Most of the helminth parasites recovered at the post-mortem examinations of the tracer sheep vividly showed the temporal patterns of infections in the four study sites (Fig. 5 to 8). Unlike the situation in the temperate regions, where temperature is the most limiting factor, in the tropics moisture variations seem to run parallel

to the seasonal fluctuations in the helminth populations of the four study sites. This is in agreement with observations made by Soulsby (1963), Ollerenshaw (1971), and Chiejina and Sewell (1974b).

5.3.1. The Seasonal Incidence of the Nematode Parasites of Sheep

The seasonal incidence of the nematode parasites recovered at the post mortem examinations of the tracer sheep generally showed similar patterns at the four study sites. During the 12 month study period, the infection due to nematodes generally showed two distinct rises where each rise was preceded by wet months. This is in agreement with the work of Hart (1964), Bekele Mamo (1980) and Gebrekiros Asegede (1981).

The first rise in the nematode infection occurred in the months of March, April and May, following the small rains of February and March. The second and the most severe infections by most of the genera recovered (except Trichuris spp.), generally occurred from August to November, following the heavy rains of July and August.

The climatic conditions that were pertinent to the development of the pre-parasitic stages of the helminths were generally similar during the two rises, except the marked increase in the amount of precipitation during the months when the heavy rains occurred (Table 7).

TABLE 7. Ranges in some of the Climatic Factors Observed at the Four Study Sites During the First and Second Rises in the Infections of the Tracer Sheep by Nematodes.

Climatic factors	First rise (Mar. to May)	Second rise (Aug. to Nov.)
Monthly rainfall	25.0 to 100.0 mm	70.0 to 400.00mm
Mean daily temp.	14.0 ^o C to 21.0 ^o C	12.0 ^o C to 20.0 ^o C
Relative humidity	50.0% to 70.0%	50.0% to 85.0%

The seasonal incidence of some of the important nematodes and those that showed a distinct temporal pattern for the 12-month study period are discussed below.

5.3.1.1 Haemonchosis

Haemonchosis, a killing-disease due to the avid blood sucking habit of the worm (Gordon, 1973), is a serious threat to the livestock industry in Ethiopia. The rate of prevalence ranges from 82.1% (1948 worms) in Awassa to 2.9% (33 worms) in Debre Berhan. The prevalence in Debre Zeit was 65.6% (2078 worms) and in Asella 32.8% (416 worms) (Tables 2, 3, 4, and 5).

In all the study sites except Debre Berhan there is a slight rise in Haemonchus spp. infection in April and May of 1982, following the small rains of March and

April of the same year (Fig.7). The heaviest infections in sheep for the study period occurred in August, September and October of 1982, following the heavy rains, and the pasture infections by the preparasitic larvae of Haemonchus spp. in June, July and August of the same year. However, the peak months of infection for the three sites were different. At Awassa it occurred in August; Debre Zeit in September; and Asella in November of 1982.

The temperature range for the three places was between 16.0°C and 19.5°C, while the maximum monthly rainfalls that were recorded in July and August ranged from 152 mm in Asella to 167 mm in Awassa.

From this one may infer that in field conditions, fairly warm places with mean daily temperatures above 15°C and a monthly rainfall of about 150 mm, could provide favourable grounds for the mass development of the pre-parasitic stages of Haemonchus spp. This finding seems to fit with the work of Gebrekiros Asegede (1981) carried out in the Awassa area from June to November of 1979.

5.3.1.2 Oesophagostomosis

Not only does the reaction to the infection by the larvae of Oesophagostomum spp. in the nodules result in severe wasting disease, but the damage to the gut makes it useless for processing (Dunn 1978). The heaviest infection of this disease in the tracer sheep occurred in Debre Zeit 22.6% (726 worms) followed by Awassa 3.2% (76 worms)

and Asella 2.9% (37 worms). The incidence of Oesophagostomum spp. in Debre Berhan throughout the study period was very low with 0.8% (9 worms) (Table 4). The actual trend seems to indicate a decrease in the incidence of Oesophagostomum spp. with increase in altitude. from the lower regions of Debre Zeit and Awassa, to the highest region of Debre Berhan.

The heaviest infection due to Oesophagostomum spp. took place in August, September and October of 1982, following the heavy rains of June, July and August of the same year. The peak incidence for Debre Zeit was recorded in September, and for both Asella and Awassa it was November of 1982 (Fig.8).

There was also a slight rise in the infection caused by Oesophagostomum spp. in late March and April of 1982, following the small rains of February and March of the same year.

There was a gap of one to two months between the peak rainfall months and the peak infection months by Oesophagostomum spp. The difference in the time-lag must have allowed the eggs to hatch and develop to the infective stage while the conditions of the environment were still favourably warm and wet. This is in agreement to the report that the preparasitic stages of Oesophagostomum spp. develop better in dull, showery (humid) and warm weather (Levine, 1963; Soulsby, 1965) (Awassa and Debre Zeit) rather than cool and wet places (Debre Berhan) with Asella being inter-

mediate between these two ecological ranges.

5.3.1.3 Dictyocaulosis

Dictyocaulosis is responsible for fatal epidemics in young stock, and is of considerable veterinary concern in most countries (Dunn, 1978; Dhar and Sharma, 1979). Dictyocaulus spp. were encountered in Asella and Debre Berhan only, with a similar incidence: 5.3% (67 worms) in the former and 5.7% (64 worms) in the latter (Tables 2 and 4). At both places the first and the smaller rises occurred in March and April of 1982, after the onset of the small rains in February of the same year. The second rise was from July to November of 1982, starting at the onset of the heavy rains in June of the same year (Fig.5).

The absence of Dictyocaulus spp. at the relatively warmer and drier areas of Awassa and Debre Zeit, seems to be due to desiccation of the first-stage larvae of the parasite that are dropped with the faeces of the definitive host. Clinical infections occur in the cooler ecological zones, since the larval stages do not survive well in warm, dry weather (Soulsby, 1965; Dhar and Sharma, 1979; Oakley, 1980):

5.3.2. The Seasonal and Peak Incidence of Fascioliasis in Sheep

Fascioliasis was found to be more severe in Debre Berhan than in any of the study sites. Besides the eight deaths caused by the disease, upto 109 flukes were recovered from

a single sheep (DB-RE-002) due to chronic Fascioliasis.

The disease caused by F. hepatica in Debre Berhan occurred from October of 1981 to February of 1982, and in September of 1982 following the heavy rains. There was also a slight rise in May of 1982 following the small rains. The peak infection month was November of 1981, with 64.0 worms per tracer sheep. The mean daily temperature ranged from 10.0°C to 14.0°C through the year providing well above the optimal requirements for the development of the larval stages of Fasciola spp. (Fig.6c). These findings, including the peak infection month, clearly correspond to the works of Scott and Coll (1977), who worked in Debre Berhan almost 10 years ago.

The disease is less severe in the Asella area, where cases of acute fascioliasis were not encountered. Chronic cases were observed with a maximum worm burden of 65 flukes in a single liver (Ase-ET-003). The occurrence of Fasciola infection in cattle of the Asella area has been reported by Graber, Delavenay and Gebrenigus Tesfamariam (1978).

In Asella, fascioliasis occurred during the period of December of 1981 to February of 1982 and in September and October of 1982. The peak infection occurred in December of 1981, with an average worm burden of 41.0 flukes per tracer sheep (Fig. 6a). Habitats harbouring metacercariae in the mountainous area of Asella are much less extensive and more focal in character probably contributing to a lower

incidence of fascioliasis (Taylor, 1964; Hammond, 1965).

Ovine fascioliasis is present in the Awassa area, but the incidence and magnitude of the infection is very low (Table 6). The infections by Fasciola hepatica were observed in the months of December of 1981, February and November of 1982. The maximum worm count encountered from a single sheep (Awa-ET-014) in Awassa was 4 flukes. The peak infection occurred in December of 1981 when 1.3 flukes per tracer sheep were recovered. Although this clearly indicated the presence of fascioliasis in the Awassa area, it does not seem to be of any significance both pathogenically and economically (Fig. 6b). The occurrence of mild fascioliasis in the region has been reported by Graber (1975a and 1975b) and by Bahru Gemechu and Ephrem Mamo (1979).

The post-mortem examinations of the tracer sheep in Debre Zeit revealed no infections due to Fasciola spp.

Scott and Goll (1977) and Goll and Scott (1978) have studied the bionomics of Fasciola hepatica and its intermediate host, Lymnaea truncatula, at the Debre Berhan Experimental Sheep Farm about twenty kilometres away from the present study sites. Their data, as well as facts and figures obtained in the present work, illustrate the following concerning the probable environmental conditions favouring the occurrence of fascioliasis in Debre Berhan.

Fasciola eggs are dropped with the faeces of chronically affected stock and wild animals on the pasture throughout

the year. The first snails appear in July following the onset of the heavy rains in June. The brooding months of the snails extend from mid-July to mid-October, with the maximum population of snails recorded in August. Temperatures in Debre Berhan ranged from 10.0°C to 14.0°C, well above the optimal requirements of 10.0°C and with the presence of adequate moisture (About 25.0 mm to 400 mm monthly rainfall in the infection months), the fluke eggs begin to hatch. The miracidia released from the eggs infect the new generation of snails that have emerged at the onset of the rains. At the beginning of September, the cercariae are released from the infected snails. From this time onwards metacercariae start to be available on the herbage to be picked up by grazers. The herbage infection with metacercariae increases, achieving its maximum in November (Fig. 6c). Following the November peak infection month, with the dry season gradually taking over, the snail population, the level of infection of the herbage and the subsequent infection of the definitive hosts, all slowly decline. By mid-February, infection of the herbage and the definitive hosts practically ceases with the onset of the dry months, coupled with relatively high temperatures, low relative humidity and heavy winds which greatly contribute to the high rates of evapo-transpiration and desiccation. The epidemiology of ovine fascioliasis in the Debre Berhan area is summarized in Fig. 10.

FIGURE 10 : Diagramatic Representation of the
Epidemiology of Ovine Fascioliasis
(Fasciola hepatica) in Debre Berhan.

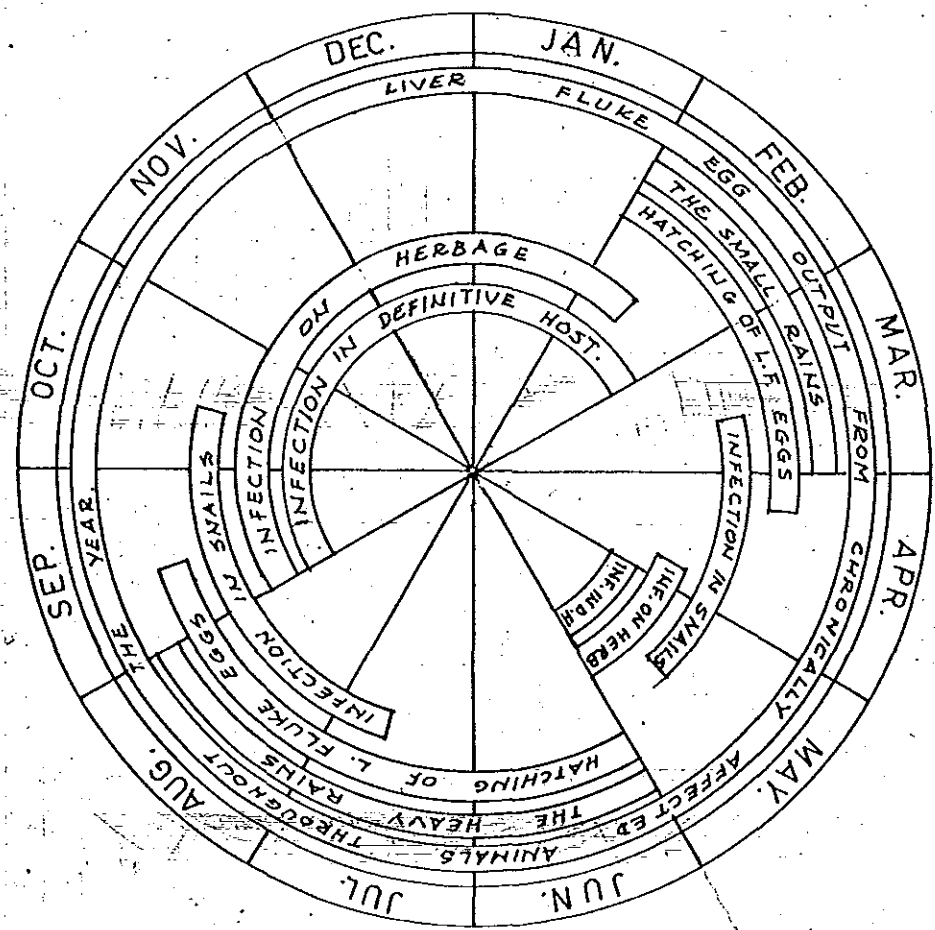


FIGURE 10.

The slight rise in the herbage infection of May following the small rains of February and March, does not seem to appear consistently every year. This is likely to be due to either the absence or the inadequacy of the small rains in some years (Fig. 6 and 10).

5.4 Some Suggested Recommendations Based on the Findings

In line with the findings obtained pertaining to the scope and magnitude of helminthiasis, mortality rates, preferable habitats for the helminths and the bionomics of the worms, some recommendations can be suggested to improve the productivity of sheep in the respective areas.

Of primary significance is the knowledge acquired on the local occurrence of the various helminths of sheep. In addition to this, time is an important factor in anticipating when to expect these parasites, whose place of occurrence has already been determined. When this elucidation of the nature of parasitism over a certain period of time is established through field trials in various climatic regions, it is possible to set down reasonably effective strategic control measures (Belschner, 1971; UNDP/FAO, 1973). This will eventually lead to the institution of a multi-faceted control scheme which includes the use of modern anthelmintics, molluscicides and proper management practices.

In the regions where the nematodes dominate the parasitic panorama (Awassa and Debre Zeit) with practically none, or an insignificant amount of Fasciola hepatica, the major

emphasis should be geared towards their control. Thus, monthly treatments with the appropriate doses of Tetramisole during the two rises in infection (March to May and August to November) are highly important with both prophylactic and therapeutic effects. Especially the later treatments of August to November, according to Feseha Gebreab, are curative and are also destined to remedy the consequences of parasitic infections of the rainy seasons (personal communication).

The slight occurrence of ovine fascioliasis in these regions (Awassa) can be effectively controlled by mapping and fencing off pastures harbouring snails (Hammond, 1965; Thafvelin, et al., 1974), to prevent animals from grazing on infected fields. According to Hammond (1965), the fencing can be done by planting sisal (Agave sisalana) which is also of economic importance, around the infected fields. The herbage from such fields can be cut, dried and converted into silage (Beller, 1977).

Extreme caution is necessary in regions where trematodes are the dominant parasites (Asella and Debre Berhan). The presence of relatively higher amounts of moisture in these regions seem to create favourable conditions not only for fascioliasis, but also for other ecologically adapted and highly pathogenic nematodes like Dictyocaulus spp. (Soulsby, 1965; Dhar and Sharma, 1979).

In such zones the use of both Rafoxanide and Tetramisole is recommended to kill worms of different groups and of diverse degrees of pathogenicity. The mapping and fencing of the snail breeding grounds, and the application of molluscicides whenever possible, can be of practical use during the wet months (March to April and July to October), when the snail population is very high. Farmers should also be persuaded to water their animals only at selected places of permanent springs, streams and rivers which are naturally unsuitable as habitats of *Lymnaea* spp. (Hammond, 1965; Erich, 1982).

In parts of Ethiopia where the traditional farming system of pastoralism is largely practiced at altitudes below 1,800m and movements of animals are uncontrolled (Ministry of Agriculture, 1972), it is very difficult to suggest specific recommendations on grazing management of livestock. According to Solomon H. Mariam (1979) about 4.5 million sheep are kept in the open rangelands of the country. This would then involve drastic changes if sheep from open country should be confined to fenced areas instead of being grazed in communal grounds (Erich, 1982). However, one important phenomenon that can be put to use in the rangelands is the concentration of large numbers of stock around water sources, as the grass and water become insufficient during the dry months (Ministry of Agriculture, 1972). Consequently, mass treatments of the animals can be adminis-

tered with minimal mobility of the veterinary team.

In general, on lands above 1,800 metres in Ethiopia, sedentary livestock farming is practiced (Ministry of Agriculture, 1972). Under such traditional husbandry systems, sheep are kept in small household flocks of less than ten animals of varying ages, foraging extensively, or in some localities by the sides of farm lands (ILCA, 1971). In these fields animals should be kept away from infected areas for at least the critical infection periods of March to May and August to November. Since the grazing grounds are limited, the mapping and fencing of the infected plots will not be as extensive as in the rangelands.

On the other hand, it is customary in this country for traders to buy sheep from rural markets and drive them on foot to highly-populated urban centers where the demand for mutton is very high. This movement of animals without any proper consultation with veterinarians should be monitored by the authorities concerned to prevent the contamination of pastures with parasites previously unknown to the various ecological zones through which the animals travel. The continued existence of the phenomenon can also be a serious set-back to any meaningful control scheme that may be adopted in the country.

An important hazard to the control of helminthism is also the presence of communally grazing wild animals which constantly serve as reservoir hosts of helminth parasites

and contaminate pastures throughout the year. Ways and means should be designed by the concerned authorities to see to it that game are maintained without causing serious hazards to the livestock industry.

In the final analysis, permanent economic benefit is obtained only by planned treatment of a whole flock, or better still a whole district, taking into account the biology of the parasites present (Beller, 1977). Thus, the production of a reasonably accurate forecast in time for the farmer to initiate suitable measures to fight diseases is of utmost importance (Kendall, 1966). In real terms, information about the expected incidence of disease in the coming months should be conveyed to farmers by radio, newspapers, leaflets, farmers' associations and other media as the need arises (Kendall, 1966). In any circumstance, suggested control strategies must be rigidly and meticulously adhered to over a number of years, if the full beneficial effects are to be realized (Heek and Morris, 1981).

Finally, it suffices to state that in a world where one looks for the spectacular, the insidious loss goes unnoticed (Soulsby, 1963). The losses of production which are caused by helminths of farm livestock can probably be reckoned in millions of any currency which one chooses (Soulsby, 1963). Since meteorological factors have profound influence on the geographic distribution of parasitic diseases and on local, seasonal occurrence of outbreaks (Gordon, 1967)

and since control measures suggested for one area may not be applicable to another (Hammond, 1965), further investigations into the epidemiological zones are invaluable to the livestock industry of Ethiopia.

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APPENDIX

TABLE 8. The Monthly Incidence, Worm Counts and Frequency of the Helminth Parasites Recovered at the Post-Mortem Examinations of the Experimental Sheep (Tracers) from the Asella Site.

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Dec. 1981	Ase-ET-033(F)	<u>Fasciola hepatica</u>	138	46.0
	Ase-ET-050(F)			
	Ase-ET-006(M)	<u>Trichuris</u> spp. cestodes	54 2	18.0 0.7
Jan. 1982	Ase-ET-005(M)	<u>Fasciola hepatica</u>	5	1.7
	Ase-ET-007(M)	<u>Haemonchus</u> spp.	15	5.0
	See-ET-010(F)	<u>Bunostomum</u> sp.	1	0.3
		<u>Trichuris</u> spp.	13	4.3
		<u>Paramphistomum</u> spp. cestodes	197 1	65.7 0.3
Feb. 1982	Ase-ET-030(F)	<u>Fasciola hepatica</u>	1	0.3
	Ase-ET-039(F)	<u>Paramphistomum</u> spp.	1128	376.0
	See-ET-040(M)	<u>Trichostrongylus</u> spp.	15	5.0
		<u>Trichuris</u> spp.	136	45.3
		<u>Oesophagostomum</u> spp. cestode	13 1	4.3 0.3

TABLE 8 cont'd

Grazing Months	Tag Number of Tracers	Parasitic Genera Identified	Worm Counts	No. of Worms/Tracer
March, 1982	Ase-ET-054(M)	<u>Hemonchus</u> spp.	20	6.7
	Ase-ET-055(F)	<u>Ostertagia</u> spp.	3	1.0
	Ase-ET-057(M)	<u>Trichostrongylus</u> spp.	33	11.0
		<u>Skerjabinagia</u> spp.	3	1.0
		<u>Oesophagostomum</u> spp.	1	0.3
	<u>Trichuris</u> spp.	223	74.0	
April, 1982	Ase-ET-059(M)*	<u>Paramphistomum</u> spp.	10	10.0
	Ase-ET-060(F)	<u>Haemonchus</u> spp.	15	15.0
	Ase-ET-061(M)*	<u>Ostertagia</u> spp.	16	16.0
		<u>Trichostrongylus</u> spp.	15	15.0
		<u>Trichuris</u> spp.	36	36.0
		<u>Dictyocaulus</u> spp.	6	6.3
	cestode	1	1.0	
May, 1982	Ase-ET-062(F)	<u>Haemonchus</u> spp.	36	18.0
	Ase-ET-064(F)	<u>Oesophagostomum</u> spp.	4	2.0
	Ase-ET-063(F)*	<u>Trichuris</u> spp.	28	14.0
		cestode	1	0.5
June 1982	Ase-ET-078(F)	<u>Haemonchus</u> spp.	3	3.0
	Ase-ET-076(F)*	<u>Trichuris</u> spp.	3	3.0
	Ase-ET-077(F)*			
	Ase-ET-085(M)*			

TABLE 8 cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
July 1982	Ase-ET-080(F)	<u>Haemonchus</u> spp.	27	13.5
	Ase-ET-084(F)	<u>Trichuris</u> spp.	5	2.5
	Ase-ET-083(M)*	<u>Dictyocaulus</u> spp.	4	2.0
		cestodes	11	5.5
Aug. 1982	Ase-Ne-007(F)	<u>Haemonchus</u> spp.	83	20.8
	Ase-Ne-44/66(F)	<u>Trichostrongylus</u> spp.	14	3.5
	Ase-Ne-008(M)	<u>Ostertagia</u> spp.	2	0.5
	Ase-Ne-018(F)	<u>Trichuris</u> spp.	102	25.5
		<u>Dictyocaulus</u> spp.	31	7.8
	cestodes	15	3.8	
Sept. 1982	Ase-Ne-027(F)	<u>Paramphistomum</u> spp.	7	1.0
	Ase-Ne-045(F)*	<u>Haemonchus</u> spp.	31	31.0
		<u>Trichuris</u> spp.	7	7.0
Oct. 1982	Ase-Ne-003(M)	<u>Fasciola hepatica</u>	32	32.0
	Ase-Ne-037(M)*			
	Ase-Ne-035(M)*	<u>Haemonchus</u> spp.	75	73.0
		<u>Trichostrongylus</u> spp.	3	3.0
		<u>Bunostomum</u> spp.	2	2.0
		<u>Chabertia</u> sp.	1	1.0
		<u>Oesophagostomum</u> sp.	1	1.0
	<u>Dictyocaulus</u> spp.	6	6.0	

TABLE 8. cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/ Tracer
Nov. 1982	Ase-Ne-073(M)	<u>Fasciola hepatica</u>	58	29.0
	Ase-Ne-008B(N)			
		<u>Paramphistomum</u> spp.	6	3.0
		<u>Haemonchus</u> spp.	111	55.5
		<u>Trichostrongylus</u> spp.	12	6.0
		<u>Ostertagia</u> sp.	1	0.5
		<u>Oesophagostomum</u> spp.	18	9.0
		<u>Trichuris</u> spp.	19	9.5
		<u>Dictyocaulus</u> spp.	20	10.0
Total No. helminth parasites recovered			2875	

*These sheep died either during quarantine time before release, or while on grazing and hence they were not either examined or used in the computation of the monthly worm frequencies.

TABLE 9. The Monthly Incidence, Worm Counts and Frequencies of the Helminth Parasites Recovered at the Post-mortem Examinations of the Experimental Sheep (Tracers) from the Awassa Site.

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Dec. 1981	Awa-ET-013(M)	<u>Fasciola hepatica</u>	4	1.3
	Awa-ET-014(F)			
	Awa-ET-015(M)	<u>Trichuris</u> spp.	13	4.3
		<u>Oesophagostomum</u> sp.	1	0.3
	cestodes	3	1.0	
Jan. 1982	Awa-ET-012(F)	<u>Paramphistomum</u> spp.	19	9.5
	Awa-ET-018(F)	<u>Haemonchus</u> spp.	3	1.5
		<u>Trichuris</u> spp.	17	8.5
		cestodes	1	0.5
Feb. 1982	Awa-ET-031(M)	<u>Fasciola hepatica</u>	2	0.7
	Awa-ET-032(M)	<u>Paramphistomum</u> spp.	3080	1026.7
	Awa-ET-036(M)	<u>Haemonchus</u> spp.	8	2.7
		<u>Trichuris</u> spp.	17	5.7
		cestodes	2	0.7
March 1982	Awa-ET-033(M)	<u>Haemonchus</u> spp.	119	39.7
	Awa-ET-034(M)	<u>Trichuris</u> spp.	14	4.7
	Awa-ET-035(M)	<u>Oesophagostomum</u> spp.	2	0.7
		cestodes	5	1.7

TABLE 9, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Apr. 1982	Awa-ET-037(M)	<u>Paramphistomum</u> spp.	52	17.3
	Awa-ET-065(M)	<u>Haemonchus</u> spp.	130	43.3
	Awa-ET-066(M)	<u>Trichuris</u> spp.	42	14.0
		<u>Oesophagostomum</u> spp.	5	1.7
		cestodes	4	1.3
May 1982	Awa-ET-067(F)*	<u>Haemonchus</u> spp.	45	45.0
	Awa-ET-068(M)	<u>Trichuris</u> spp.	14	14.0
	Awa-ET-038(F)	<u>Oesophagostomum</u> spp.	1	1.0
		cestodes	6	6.0
June 1982	Awa-ET-091(M)	<u>Paramphistomum</u> spp.	22	7.3
	Awa-ET-092(M)	<u>Haemonchus</u> spp.	93	31.0
	Awa-ET-093(F)	<u>Ostertagia</u> sp.	1	0.3
		<u>Trichostrongylus</u> sp.	1	0.3
		<u>Trichuris</u> spp.	9	3.0
		<u>Oesophagostomum</u> spp.	3	1.0
		cestodes	1	0.3
July 1982	Awa-ET-087(M)	<u>Haemonchus</u> spp.	277	92.3
	Awa-ET-088(F)	<u>Trichuris</u> spp.	16	5.3
	Awa-ET-089(M)	<u>Oesophagostomum</u> spp.	5	2.5
		cestodes	2	0.3

TABLE 9, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Aug. 1982	Awa-Ne-003(F)	<u>Paramphistomum</u> spp.	239	79.7
	Awa-Ne-007(M)	<u>Haemonchus</u> spp.	506	168.7
	Awa-Ne-042(M)	<u>Ostertagia</u> spp.	1	0.3
		<u>Trichuris</u> spp.	31	10.3
		<u>Oesophagostomum</u> spp.	1	0.3
	cestodes	3	1.0	
Sept. 1982	Awa-Ne-027	<u>Paramphistomum</u> spp.	7	7.0
		<u>Haemonchus</u> spp.	139	139.0
		<u>Trichuris</u> spp.	43	43.0
		<u>Oesophagostomum</u> spp.	2	2.0
		cestode	1	1.0
Oct. 1982	Awa-Ne-083(M)	<u>Haemonchus</u> spp.	291	145.5
	Awa-Ne-014(M)	<u>Trichuris</u> spp.	57	28.5
		cestode	2	1.0
Nov. 1982	Awa-Ne-036(F)	<u>Fasciola hepatica</u>	2	0.7
	Awa-Ne-065(F)			
	Awa-Ne-025(M)	<u>Haemonchus</u> spp.	337	112.3
		<u>Ostertagia</u> sp.	1	0.3
		<u>Bunostomum</u> spp.	7	2.3
		<u>Trichuris</u> spp.	66	22.0
		<u>Oesophagostomum</u> spp.	56	18.7
cestodes	7	2.3		
Total No. of helminth parasites recovered			5838	

TABLE 10. The Monthly Incidence, Worm Counts and Frequency of the Helminth Parasites Recovered at the Post Mortem Examinations of the Experimental Sheep (Tracers) from the Debre Berhan Site.

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Oct. 1981	DB-Ne-023(F)	<u>Fasciola hepatica</u>	81	40.5
	DB-Ne-000(F)			
	DB-LE-001(F)*	<u>Paramphistomum</u> spp.	948	474.0
		<u>Haemonchus</u> sp.	1	0.5
		<u>Bunostomum</u> spp.	33	16.5
		<u>Trichostrongylus</u> spp.	4	2.0
		<u>Trichuris</u> spp.	169	84.5
		<u>Oesophagostomum</u> spp.	8	4.0
		<u>Chabertia</u> sp.	1	0.5
		<u>Dictyocaulus</u> spp.	8	4.0
	<u>Protostrongylus</u> spp.	2	1.0	
Nov. 1981	DB-RE-004(F)	<u>Fasciola hepatica</u>	147	73.5
	DB-RE-005(F)			
	DB-RE-003(M)*	<u>Trichuris</u> spp.	71	35.5
	cestode	1	0.5	
Dec. 1981	DB-ET-022(N)	<u>Fasciola hepatica</u>	20	10.0
	DB-ET-023(F)			
	DB-ET-021(N)*	<u>Trichuris</u> spp.	42	21.0
		<u>Dictyocaulus</u> spp.	9	4.5
	cestodes	7	3.5	

TABLE 10, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Jan. 1982	DB-ET-024(M)	<u>Fasciola hepatica</u>	19	9.5
	DB-ET-025(F)			
	DB-ET-026(F)*	<u>Trichuris</u> spp.	36	18.0
		<u>Dictyocaulus</u> spp.	1	0.5
		cestode	1	0.5
Feb. 1982	DB-ET-044(F)	<u>Fasciola hepatica</u>	3	1.5
	DB-ET-045(F)			
	DB-ET-047(M)*	<u>Trichuris</u> spp.	70	35.0
		<u>Dictyocaulus</u> spp.	3	1.5
		cestodes	3	1.5
March 1982	DB-ET-046(F)	<u>Trichuris</u> spp.	26	13.0
	DB-ET-049(M)*	<u>Dictyocaulus</u> spp.	2	1.0
	DB-ET-043(M)	<u>Protostrongylus</u> sp.	1	0.5
April 1982	DB-ET-069(M)	<u>Haemonchus</u> spp.	2	1.0
	DB-ET-071(F)	<u>Trichostrongylus</u> sp.	1	0.5
		<u>Paramphistomum</u> spp.	151	75.5
		<u>Trichuris</u> spp.	277	138.0
		<u>Oesophagostomum</u> spp.	1	0.5
		<u>Dictyocaulus</u> spp.	12	6.0
		<u>Protostrongylus</u> sp.	1	0.5
		cestodes	7	3.5

TABLE 10, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/ Tracer
May 1982	DB-ET-073(F)	<u>Fasciola hepatica</u>	1	0.5
	DB-ET-074(F)	<u>Paramphistomum</u> spp.	472	236.0
	DB-ET-070(M)*	<u>Ostertagia</u> spp.	16	8.0
		<u>Trichuris</u> spp.	79	39
		<u>Dictyocaulus</u> spp.	3	
June 1982	DB-ET-027R(G)	<u>Paramphistomum</u> spp.	77	
	DB-ET-028R(M)	<u>Haemonchus</u> spp.		
	DB-ET-029(F)	<u>Trichuris</u> spp. cestodes		
July 1982	DB-ET-095(F)	<u>Paramphistomum</u> sr		
	DB-ET-096(M)	<u>Haemonchus</u> spp		
	DB-ET-097(F)	<u>Trichostron</u>		
		<u>Trichuris</u>		
	<u>Dictyoc</u>			
	cestod			
Aug. 1982	DB-ET-045(F)	<u>Haer</u>		
	DB-Ne-012(M)	<u>Ostert</u>		
	DB-Ne-022(M)	<u>Trichur</u>		
		<u>Dictyoc</u>		
	cestodes			

TABLE 10, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/ Tracer
Sept. 1982	DB-Ne-040(F) DB-Ne-400(N)	<u>Fasciola hepatica</u>	52	26.0
		<u>Paramphistomum</u> spp.	147	73.5
		<u>Strongyloides</u> spp.	3	1.5
		<u>Trichostrongylus</u> sp.	1	0.5
		<u>Trichuris</u> spp.	75	37.5
		<u>Dictyocaulus</u> spp.	3	1.5
Total No. of helminth parasites recovered			3469	

TABLE 11. The Monthly Incidence, Worm Counts and Frequency of the Helminth Parasites Recovered at the Post Mortem Examinations of the Experimental Sheep (Tracers) from Debre Zeit.

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/Tracer
Nov. 1981	DZ-ET-085A(M) DZ-ET-093(F)	<u>Haemonchus</u> spp.	2	1.0
		<u>Trichuris</u> spp.	12	6.0
		cestodes	2	1.0
Dec. 1981	DZ-ET-027(F)	<u>Haemonchus</u> spp.	29	14.5
		<u>Trichuris</u> sp.	1	0.5
		cestode	1	0.5
Jan. 1982	DZ-ET-041(F) DZ-ET-090(M)	<u>Haemonchus</u> spp.	4	2.0
		<u>Trichuris</u> spp.	3	1.5
		cestode	4	2.0
Feb. 1982	DZ-ET-051(M)	<u>Haemonchus</u> spp.	10	5.0
		<u>Trichuris</u> spp.	3	1.5
March 1982	DZ-ET-058(M)	<u>Haemonchus</u> spp.	2	2.0
		<u>Trichuris</u> spp.	8	8.0
		<u>Oesophagostomum</u> spp.	2	2.0
		cestodes	2	2.0

TABLE 11 cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/ Tracer
April 1982	DZ-ET-050(M)	<u>Haemonchus</u> spp.	2	2.0
	DZ-ET-489(M)*	<u>Trichuris</u> spp.	5	5.0
		<u>Oesophagostomum</u> spp.	3	3.0
		cestodes	2	2.0
May 1982	DZ-ET-081(M)	<u>Haemonchus</u> spp.	10	5.0
	DZ-ET-082(M)	<u>Trichuris</u> spp.	9	4.5
		cestodes	2	1.5
June 1982	DZ-Ne-023.1(M)	<u>Haemonchus</u> spp.	18	6.0
	DZ-Ne-248.1(F)	<u>Trichuris</u> spp.	4	1.3
	DZ-Ne-014.1(F)			
July 1982	DZ-ET-085B(M)	<u>Haemonchus</u> spp.	14	14.0
Aug. 1982	DZ-Ne-030(F)	<u>Haemonchus</u> spp.	297	148.5
	DZ-Ne-014(M)	<u>Trichuris</u> spp.	2	1.0
		<u>Oesophagostomum</u> spp.	89	44.5
		<u>Ostertagia</u> sp.	1	0.5
		<u>Trichostrongylus</u> spp.	2	0.5
		<u>Nematodirus</u> sp.	1	0.5
		<u>Paramphistomum</u> sp.	1	0.5
		cestodes	3	1.5

TABLE 11, cont'd

Grazing Months	Tag Number of Tracers	Parasite Genera Identified	Worm Counts	No. of Worms/ Tracer
Sept. 1982	DZ-Ne-028(M)	<u>Haemonchus</u> spp.	1338	669.0
	DZ-Ne-031(F)	<u>Trichuris</u> spp.	3	1.5
		<u>Oesophagostomum</u> spp.	307	153.5
		<u>Ostertagia</u> spp.	148	74.0
		<u>Trichostrongylus</u> spp.	31	15.5
		Unidentified nematode	3	1.3
		cestodes	12	6.0
Oct. 1982	DZ-Ne-044(M)	<u>Haemonchus</u> spp.	352	117.3
	DZ-Ne-060(M)	<u>Trichuris</u> spp.	13	4.3
	DZ-Ne-08/69(M)	cestodes	6	2.0
		<u>Oesophagostomum</u> spp.	325	108.3
		<u>Ostertagia</u> spp.	97	32.0
		<u>Trichostrongylus</u> spp.	18	6.0
		<u>Paramphistomum</u> spp.	30	10.0
Total No. of helminth parasites recovered			3233	

TABLE 12. Helminths Recovered at Post-Mortem Examinations of the Control Sheep at the Four Study Sites.

(a) Asella Area.

Tag Number of Control Sheep	Helminths recovered and identified		
	Trematodes	Nematodes	Cestodes
Ase-ET-001(M) ^I	<u>Paramphistomum</u> spp(3)	<u>Trichuris</u> spp.(7)	-
Ase-ET-002(F) ^I	<u>Paramphistomum</u> spp(2)	<u>Trichuris</u> spp.(5)	-
Ase-ET-060(F) ^{II}	-	-	-
Ase-ET-075(M) ^{III}	-	-	Unidentified
Ase-Ne-045(F) ^{III}	-	-	-

I Control I Sheep

II Control II Sheep

III Control III Sheep

() The figures in the brackets indicate the number of worms recovered.

4) Awassa Area.

Tag number of control sheep	Helminths recovered and identified		
	Trematodes	Nematodes	Cestodes
Awa-ET-016(F) ^I			
Awa-ET-017(N) ^I	<u>Paramphistomum</u> spp(12)	<u>Trichuris</u> spp(20)	-
Awa-ET-020(N) ^{II}	-	-	-
Awa-ET-086(F) ^{III}	-	<u>Trichuris</u> spp(2)	-
		<u>Oesophagostomum</u> sp(1)	-
Awa-ET-090(N) ^{III}	-	-	-
Awa-Ne-022(F) ^{II}	-	-	-
Awa-Ne-013(F) ^{III}	-	-	-
Awa-Ne-007(F) ^{III}	<u>Paramphistomum</u> spp(7)	-	-
Awa-Ne-031(N) ^{III}	-	<u>Trichuris</u> spp(5)	Unidentified(2)

(c) Debre Berhan area.

Tag number of control sheep	Helminths recovered and identified		
	Trematodes	Nematodes	Cestodes
DB-RE-001(F) ^I	-	-	-
DB-RE-002(M) ^I	<u>F. hepatica</u>	<u>Trichuris</u> sp (1)	-
DB-LE-003(F) ^{II}	-	<u>Trichuris</u> spp(15)	-
DB-ET-072(F) ^{III}	-	<u>Trichostrongylus</u> sp (1)	-
DB-ET-094(F) ^{III}	-	-	-
DB-ET-025(F) ^{III}	-	-	-
DB-ET-098(F) ^{III}	-	-	Unidentified(1)

(d) Debre Zeit area.

Tag number of control sheep	Helminths recovered and identified		
	Trematodes	Nematodes	Cestodes
DZ-ET-088(M) ^I	-	<u>Trichuris</u> sp (1)	-
DZ-ET-028(F) ^{III}	-	-	-
DZ-ET-042(M) ^{III}	-	<u>Trichuris</u> spp(3)	-
DZ-ET-053(F) ^{III}	-	<u>Trichuris</u> spp(2)	-
DZ-ET-056(F) ^{III}	-	-	-
DZ-ET-0996(F) ^{III}	-	-	-

TABLE 13. Check List and Regional Distribution of the Helminth Parasites of Sheep in Ethiopia (excerpts from Graber, 1975b).

Helminths	Place of Collection (Administrative Regions).
Trematodes	
<u>Fasciola hepatica</u> Linnaeus, 1758	throughout Ethiopia
<u>Fasciola gigantica</u> Cobbold, 1856	Shoa
<u>Paramphistomum cervi</u> Schrank, 1790	Shoa
<u>Paramphistomum microbothrium</u> Fischoeder, 1901	throughout Ethiopia
<u>Paramphistomum sukari</u> Railliet and Herry, 1909	Harrar, Mollo.
<u>Schistosoma bovis</u> Sontsino, 1876.	Tigray, Mollo, Shoa, Sidamo, Gemu Gofa, Gojjam.
Cestodes	
<u>Echinococcus polymorphus</u> Batsch, 1976*	throughout Ethiopia
<u>Moniezia expansa</u> Rudolphi, 1810.*	throughout Ethiopia
<u>Moniezia benedeni</u> Moniez, 1879*	throughout Ethiopia
<u>Avitellina centripunctata</u> Rivolta, 1874* .	throughout Ethiopia
<u>Stilesia globipunctata</u> Rivolta, 1874.	Gemu Gofa, Shoa.
<u>Stilesia hepatica</u> Wolffhugel, 1903* .	Shoa
<u>Cysticercus ovis</u> Cobbold, 1869.	Harrar
<u>Cysticercus tenuicollis</u> Rudolphi, 1810* .	throughout Ethiopia

TABLE 13. cont'd

Helminths	Place of Collection (Administrative Regions)
<u>Coenurus cerebralis</u> Clapham and Peters 1941.	Shoa
<u>Taenia multiceps</u> Laske, 1780.	unspecified
Nematodes	
<u>Strongyloides papillosus</u> Weld, 1856	throughout Ethiopia
<u>Truheris ovis</u> Abildgaard, 1795*	Sidamo, Shoa, Harrar, Wollo, Bale, Gemu Gofa.
<u>Bunostomum trigonocephalum</u> Rudolphi, 1808*	Sidamo, Shoa
<u>Oesophagostomum columbianum</u> Curtice, 1808*	throughout Ethiopia
<u>Oesophagostomum renulosum</u> Rudolphi, 1803	Shoa
<u>Chabertia ovina</u> Railliet and Herry, 1909	Shoa
<u>Ostertagia circumcincta</u> Stadelmann, 1894	Kaffa, Shoa
<u>Haemonchus contortus</u> Radolphi, 1803*	throughout Ethiopia
<u>Protostrongylus refescens</u> Leuhart, 1865	Harrar.
<u>Dictyocaulus filaria</u> Rudolphi, 1809*	throughout Ethiopia
<u>Mullerius capillaris</u> Muller, 1889	Bale
<u>Skerjabinema</u> spp. Mereschlchagin, 1926	Shoa
<u>Gongylonema pulchrum</u> Molin, 1857	Shoa
<u>Ostertagia elongata</u> Rhoetti, 1943	unspecified
<u>Trichostrongylus colubriformis</u> Giles, 1982*	Sidamo

TABLE 14. Meteorological Data of the Asella Site* for the Study Period.

Source: National Meteorological Services, Addis Ababa.

(Asella - alt.: 2450m, Lat. N.: 07° 52' Long. E.: 39° 08')

Months	Monthly Rainfall (mm)	Mean Daily Air Temp. °C
December, 1981	-	15.1
January, 1982	29.0	15.7
February "	84.0	16.8
March "	23.0	16.7
April "	95.0	17.8
May "	107.0	18.5
June "	71.0	18.0
July "	133.0	16.4
August "	152.0	15.6
September "	47.0	15.5
October "	48.0	-
November "	-	-

* The meteorological data for this site were recorded at Kulumsa, Lat. No.: 08° 08'; Long. E.: 39° 08'; about eight kilometres away from Asella.

TABLE 15. Meteorological Data of the Awassa Site for the Study Period.

Source: National Meteorological Services, Addis Ababa.

(Awassa - alt.: 1680m, Lat. N.: 07°30', Long. E.:38°29')

Months	Monthly Rainfall mm.	Mean Daily Air Temperature °C	Relative Humidity %
December, 1981	-	18.4	-
January, 1982	49.6	19.8	60.0
February "	59.2	20.6	59.0
March "	62.6	20.8	59.0
April "	92.1	20.3	73.0
May "	70.8	17.2	72.0
June "	121.1	19.5	74.0
July "	166.3	18.6	78.0
August "	117.1	18.9	78.0
September "	72.7	19.3	76.0
October "	95.9	18.6	73.0
November "	84.4	18.9	61.0

TABLE 16. Meteorological Data of the Debre Berhan Site for the Study Period.

Source: ILCA, Addis Ababa.

(Debre Berhan - alt.: 2780m, Lat. N.: 9°31', Long. E.: 39°28')

Months	Monthly Rainfall mm.	Mean Daily Air Temperature °C	Relative Humidity %
October, 1981	24.3	11.0	59.0
November "	-	10.0	51.0
December "	2.0	11.0	44.0
January, 1982	34.0	13.0	69.0
February "	29.0	13.0	75.0
March "	35.0	14.0	51.0
April "	61.0	14.0	66.0
May "	57.0	14.0	52.0
June "	14.0	14.0	53.0
July "	233.0	14.0	77.0
August "	401.0	13.0	87.0
September "	81.0	12.0	82.0

TABLE 17. Meteorological Data of the Debre Zeit Site for the Study Period.

Source: DebreZeit Junior College of Agriculture and Research Center.

(Debre Zeit - alt.: 1850, Lat.N: 08°44', Long.E: 38°58')

Months	Monthly Rainfall mm.	Mean Daily Air Temperature °C	Relative Humidity %
November, 1981	-	16.1	49.0
December "	3.3	15.9	73.0
January, 1982	17.8	17.8	54.0
February "	60.5	19.4	59.0
March "	51.0	19.9	52.0
April "	31.0	20.0	58.0
May "	-	20.4	49.0
June "	84.0	19.4	55.0
July "	121.3	18.6	70.0
August "	157.1	17.7	75.0
September "	72.9	18.2	71.0
October "	121.9	16.4	62.0