ROLE OF TICKS AND ACARICIDES IN THE EPIDEMIOLOGY Off DERMATOPHILOSIS IN NIGERIA

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C E R T I F I C A T I O N

This thesis entitled "Role of Ticks and Acaricides in the Epidemiology of Dermatophilosis in Nigeria," by Shehu Na'Allah Alhaji Saidu meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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D E C L A R A T I O N

This is to certify that I carried out the work reported in this thesis in the Department of Veterinary Surgery and Medicine and in the Bacteriology and Entomology Laboratories of the Departments of Veterinary Pathology and Microbiology and Parasitology and Entomology respectively, under the supervision of Professors I.A. Abdulkadir, P.B. Addo and Dr. R.I.S. Agbede.

The work of other investigators is duely acknowledged and referred to. No part of this thesis has been submitted elsewhere for a degree or diploma.

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A B S T R A C T.

Various reports have incriminated arthropods, ticks (particularly Amblyomma variegatum) and biting insects,(e.g. Stomoxys sp, and Lyperosia sp.), in the transmission of dermatophilosis. Similarly, various forms of medications (e.g. antibiotics and acaricides) have been used against dermatophilosis without any appreciable and sustained success in the cure or prevention of dermatophilosis.

It is against this back-ground, that this work has been designed to further investigate the role of these arthropods in a survey under field conditions as well as examine one of them (A. variegatum) under laboratory conditions as an agent of the disease transmission. Similarly, some of the acaricides commonly used in Nigeria for the control of external parasites were also used, both in-vitro and in-vivo, to determine their effect,if any, on bovine dermatophilosis.

The first observation made in the study was that 70% ethyl alcohol was not lethal to A. variegatum for up to 15 minutes exposure but it proved to be a good antiseptic on the cuticular surface of the tick not only against D. congolensis but also against other bacteria.

This became an important tool during the experimental transmission studies of the work.

Attempts to isolate D. congolensis from A. variegatum developmental stages (eggs, larvae and nymphae) using direct smear and culture examination, was only possible in 2 out of the 24 egg batches of ticks collected from Dermatophilus-infected cattle. Further, only one larval batch out of the 24 larval batches from such ticks was found to harbour the organism and that attempts to transmit D. congolensis with twelve such larval batches proved abortive.

However, nymphae of A. variegatum were seen to efficiently acquire infection after they were exposed to Dermatophilus-infected bovine scrotum. Such infection was also maintained by the nymphae during moulting to the adult stage and that one of four batches of such adult ticks transmitted the infection to the ears of New Zealand white rabbits.

A. variegatum was shown to complete its life cycle (from engorgement time) in 151 to 256 days and that it efficiently used rabbits as its sole source of blood meal.

In the survey aspect of the study, it was observed that dermatophilosis (16%, 1.8%) and infestation by ticks (30.4%, 11.6%) were more prevalent during the rainy season than in the dry season. There was also a close association of these two conditions as Dermatophilus lesions were found to be more diffuse and matted at sites where the two conditions occurred together. This observation was similar to those of herdsmen who believe that ticks, particularly A. variegatum, are the main 'transmitters' of dermatophilosis. Ticks which were observed to infest cattle most commonly include A. variegatum, Boophilus sp. Hyalomma sp. and Rhipicephalus sp.

Infestation by insects (especially Stomoxys sp. and Lyperosia sp.) was found to be more common in the dry season; with these insects infesting mainly the head, neck, thorax and the back.

These sites were also observed to develop pin-point Lermatophilus lesions and the herdsmen commonly associate these lesions with these insects. Other insects encountered during the survey include the house fly (Musca sp.) and Hippobosca sp.

Skin conditions, other than dermatophilosis, encountered during the survey and their prevalence included besnoitiosis (0.08%), demodectic mange (10.53%) sarcoptic mange (6.86%), dermatomycosis (4.89%), lousiness (2.78%), tick abscess (9.25%), rinderpest-skin-disease (0.91%), wart (4.20%) and nonspecific wounds (0.21%). They were observed to occur singly or in mixed infections with other skin conditions including dermatophilosis.

Economically, dermatophilosis was seen to cause losses mainly through decrease in milk yield by the damage of the teats and udder. Other losses associated with the disease include damage to hides and decrease in animal market value by up to 50% of their normal prices if culled due to the disease.

Three of the four acaricides used in the study (Ifizona^{R}, Triatix^{R} and CBM8^{R}) were bactericidal

to D. congolensis in-vitro at dilutions up to 4 to 5 times weaker than these acaricides are ordinarily used in dips. In addition to the in-vitro effect, Ffizona^{R} was seen to cause clinical recovery in up to 75% of the Dermatophilus-infected cattle during the course of dipping or bathing for two to six weeks.

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INTRODUCTION

Dermatophilosis is an exudative cutaneous disease of domestic and wild animals and to a lesser extent man, caused by the Actinomycete, Dermatophilus congolensis. Among domestic animals, cattle, sheep, goats and horses are susceptible, while the deer, giraffe, gazelle, and zebra among wild animals are also suceptible to the organism (Van Saceghem, 1915; Bull, 1929; Mackenzie and Simpson, 1956; Dean et al., 1961; Nicolet et al., 1967; Austwick, 1969; Kistner, et al., 1970; Smith and Cordes, 1972; Bida, 1973; Gordon, 1976a and Vos and Imes, 1976).

The organism survives in nature under dry conditions in scabs as a mycelium though few zoospores could be seen. The mycelium is the predominant form in skin lesions on susceptible hosts. It is very antigenic, though antibodies produced against it are not protective (Richard et al., 1976; Bida and Kelley, 1976). It is also resistant to dessication; being viable for up to 42 months as zoospores in scabs (Oppong, 1976).

The disease caused by D. congolensis has been reported all over the world with reports from Africa, Asia, Australia, Europe, South America and the United States of America (Van Saceghem, 1915; Henderson, 1927; Hudson, 1937; Harriss, 1948; Dean, et al., 1961; Roberts, 1967a). It is more prevalent during the rainy

season when predisposing factors like arthropods, wetness, and tree branches are most abundant (Stewart, 1972 a,b). To what extent these factors affect the establishment and spread of the disease is not completely known.

It has been shown that the organism is transmitted from one animal to another through body contact, in the presence of skin discontinuity (Le Riche, 1968). Arthropods are also incriminated in the transmission of the disease though their extent of involvement is not fully understood (Oduye, 1976a). When established, the disease has been reported to affect only the skin. The skin pathology due to the disease is well documented (Bida, 1973 and Oduye, 1976b). Similarly, its diagnosis can be achieved by clinical examination of skin scabs, direct smear examination and cultural isolation of the organism from scabs.

The disease has been treated with antiseptics, antibiotics, antifungals and local preparations, with variable results (Roberts and Graham, 1966). However, acaricides have recently been reported to have valuable results (Presler, 1973 and Van Breuseghem et al., 1976). The disease has been reported to be of great economic importance due to damage to hides and skin, loss of condition and possibly losses in production. The exact extent to which these losses affect livestock production are yet to be fully

determined.

It is against these backgrounds that this study has been set up to determine:

1. The extent of involvement of arthropods in the epizootiology of dermatophilosis by
   a. examining the disinfecting effect of 70% alcohol on D. congolensis and Amblyomma variegatum.
   b. examining the possibility of D. congolensis infecting A. variegatum.
   c. examining the eggs and larvae of engorged A. variegatum, collected from both clinically Dermatophilus-infected and uninfected cattle for D. congolensis.
   d. examining the possibility of transovarial and stage to stage (with emphasis of nymph to adult stages) transmission of D. congolensis using A. variegatum.

2. The opinion of herdsmen on the possible modes of transmission of D. congolensis in cattle.

3. The extent of association between D. congolensis, other arthropods and other organisms in dermatophilosis.

4. The in-vitro and in-vivo effects of some common acaricides on D. congolensis and their possible therapeutic use.

CHAPTER ONE

LITERATURE REVIEW

Introduction:

Dermatophilosis (Streptothricosis) is an acute or chronic infection of the epidermis of man, domestic and wild animals resulting in an exudative epidermitis with scab formation. The condition is caused by the bacterium Dermatophilus congolensis (syn. Streptothrix congolensis).

Historical Background:

The disease due to D. congolensis infection had been known by many names partly because of lack of knowledge of the nature of the causative agent on one hand and the various manifestations of the disease in the different hosts in which the organism causes the disease. Thus as early as 1910's Van Saceghem (1915), in the Belgium Congo, drew attention to the disease in cattle when he referred to it as Dermatose contagieuse (Impetigo contagieux) while referring to a serious epizootic dermatitis that occurred with heavy mortality. Later, Hornby (1920) in Northern Rhodesia described a disease he called 'contagious impetigo'. Similarly Reid (1921) described cases of the disease in cattle which he called dermatomycosis.

In an annual report of the Veterinary Department of Nigeria, Henderson (1927) referred to a disease in Nigerian cattle and in a horse as streptothricosis. This name has been used through the years by other workers like Zlotnik (1955), Plowright (1956), Austwick (1958) and Pier et al.(1963) among others. Streptothricosis was used on the basis that, at that time, the organism Streptothrix sp was suspected as the aetiological agent of the disease.

Bull (1929) also described a skin disease of sheep which he called dermatomycosis (lumpy wool) and named the causative agent as Actinomyces dermatonomus, implying that the disease was caused by a fungus. Mason and Bekker (1934) and Shulz (1955) in South Africa reported the occurrence of the disease in cattle and sheep and named it mycotic dermatitis.

Kaplan and Johnston (1966) seemed to be the first to use dermatophilosis for the condition caused by D. congolensis when they described the disease in a horse in the United States of America (U.S.A). Since then this name has been used more commonly than most of the other names described before. During the 1973 International Symposium on "Dermatophilus Infection In Animals and Man" held in Ibadan, Nigeria, the name of the disease to be used was extensively discussed and no one name emerged as most appropriate for the disease. At this symposium, Kaplan argued that

dermatophilosis was more appropriate because traditionally, many diseases were named after their causative agents. For this reason the term dermatophilosis is used in this thesis.

The disease has also been known with many vernacular names like 'Senkobo Scab' in Rhodesia, 'Kirchi' in Nigeria, 'U ashin - Gishu' skin disease in Kenya and 'Drodo Boka' in Madagascar among others (Lane, 1915; Curson, 1920; Anon, 1923; Hudson, 1937 and Buck, 1948). These vernacular names would seem to indicate that the disease was well known and identified by the natives before the report of Van Saceghem (1915).

Aetiology:

Nomenclature: The first report on the causative agent of dermatophilosis seemed to be that of Van Saceghem (1915, 1916) when he referred to it as Dermatophilus congolensis (D. congolensis). He first regarded it as a fungus, though he later changed it to a bacterium on submitting preparations to Mensil and Finory (Austwick, 1958). Bull (1929) also regarded the agent of dermatophilosis as Actinomyces dermatonomus (A. dermatoromus) on the basis of morphology and cultural characteristics.

Van Saceghem (1934) named the organism as Tetragenus congolensis on the basis that the organism could exist

saprophytically as a tetragene while he also called the invasive filamentous form as D. congolensis. Henry (1952) quoted by Austwick (1958) also named the organism as Nocardia congolensis possibly because it resembled members of the Actinomyces sp. Thompson (1954) reported isolating an organism from straw-berry foot-rot (S.F.R) of sheep and named it Rhizobium sp. He observed that its sequence of barred filaments and developmental cycle had a striking resemblance to that of the well known genus Rhizobium. Streptothrix bovis has also been used for the organism causing dermatophilosis. Snijders and Jansen (1955) compared S. bovis with A. dermatonomus and concluded that there was very little difference between them.

Austwick (1958), while reviewing the nomenclature of the various manifestations of the disease in cattle and sheep, argued that A. dermatonomus should be regarded as D. dermatonomus on the basis that the causative agents were similar in both morphology and pathogenicity and that the name Dermatophilus should have precedence over the genus Actinomyces.

Similarly, Thompson and Bisset (1957) referred to the organism as Polysepta pedis while Austwick (1958) proposed Dermatophilus pedis for the organism causing straw-berry foot rot. Austwick (1958) seemed to recognize three separate species of the organism as Dermatophilus congolensis , D. dermatonomus and

D. pedis based on the clinical manifestations and animal species involved. He further classified the organism under the order Actinomycetales as earlier done by Buchanann (1917, 1918), in the family Dermatophilaceae. Gordan (1964), after a close examination of seventeen strains from various animal species, concluded that all isolates could be accomodated in the species D. congolensis with the others (D. dermatonomus and D. pedis) as synonyms. Waksman (1967) also reported Pine and George (1965) as having agreed with Austwick's (1958) classification. Further, Abu-Samra (1978) and Macadam and Haalstra (1971), following bacteriological examination of 38 and 53 strains respectively, concluded that the strains they examined were identical and that the minor differences often observed were not sufficient enough to subdivide the genus, Dermatophilus.

Biology: Growth requirements: Dermatophilus congolensis has been grown in various culture media such as 10% blood agar, brain heart infusion (B.H.I) agar and broth, beef infusion-peptone broth and tryptone broth (Plowright, 1958; Gordon and Edwards, 1963 and Gordon 1964). Plowright (1958) reported that 5% ox-blood agar was most suitable for isolating individual colonies of D. congolensis. Gordon (1964) reported that the organism does not grow on sabouraud dextrose agar or on potato dextrose Czapek's solution

or tomato-catmeal agars. Chodnik (1956) reported that the organism grew better in solid than in liquid media and that filaments predominate in the solid media while the coccoid elements seemed to be the only form in liquid media.

The organism grows both aerobically and micro-aerobically and no growth is seen under strict anaerobic conditions (Plowright, 1958; Roberts, 1961, 1963 Gordon, 1964)

Morphology: Gross, microscopic and biochemical characteristics of D. congolensis have been reported by various workers and the reports are summarized in Table 1.1. Recently, Isitor et al. (1984) reported observing virions in two out of seven samples of dermatophilus lesions. To what extent these virions play a role in dermatophilosis remains to be determined.

Distribution:

The distribution of dermatophilosis is world wide with reports from Europe, the Americas, Australia, Asia, Middle East and more commonly Africa (Fig. 1.1 and Appendix 1.1)

Prevalence: The prevalence of dermatophilosis is influenced by such factors as environmental conditions, arthropods population and distribution and inter-current diseases (Plowright, 1956 and Macadam, 1962,

1964). Various reports have indicated that the disease is seen more during wet weather when the temperature and relative humidity are high (Chodnik, 1956; Obeid, 1976). However, Macadam (1961) could not substantiate the high prevalence of the disease even under situations simulating the high humidity.

Hart (1967) reported that the prevalence of the disease in Great Britain was observed to be low between shearing time and autumn with the disease increasing in prevalence from autumn to winter. Moreira et al. (1970) and Portugal (1970) reported that the incidence of the disease was greater during summer and that the increase in the disease incidence was related to the degree of environmental humidity and temperature.

Arthropods, like Stomoxys calcitrans, Lyperosia sp., mosquitoes and Amblyomma variegatum have been suspected to influence the occurence of dermatophilosis

(Plowright, 1956; Macadam, 1962; Roberts, 1967a). The incidence of dermatophilosis is seen to increase with the increase in the population of these arthropods. Arthropod population is directly influenced by environmental conditions. Intercurrent diseases like rinderpest have also been reported to increase the incidence of the disease (Plowright, 1958).

The prevalence of the disease is seen to vary from one area to another (Lloyd, 1976). Similarly, altitude seems to influence the prevalence of the disease as Obeid (1976) reported higher prevalence in Northern Sudan, where the altitude is higher than in the South, where the altitude is low.

The prevalence of the disease in various species of domestic animals is seen to vary with age and sex.

Lloyd (1976) reported that the disease is more prevalent in adults than in younger cattle and more in males (prevalence, 12.37%) than in females (prevalence, 7.1%). However, Bida (1973) could not find any difference between sex in the cattle he examined.

Mortality due to dermatophilosis by itself is low. Magallanes et al. (1959) from Uruguay reported a mortality rate of 10-50% during an outbreak of the disease in sheep. In Nigeria, Oduye (1975a) reported mortality rate of 2% in cattle.

Animal Species Susceptibility:

Dermatophilosis has been reported in various species of domestic and wild animals as well as in cold blooded animals and to a lesser extent in man (Dean et al. 1961; Pier et al., 1963 and Frese and Weber, 1971). It is said to affect animals in both high and low plane of nutrition, though Egerton (1964) reported that the disease is more serious in the latter.

Among domestic animals, cattle, sheep and goats seem to be most affected (Van Saceghem, 1915; Bull, 1929; Hall, 1933 and Bentink-Smith et al., 1961). Bwangamoi (1976a) reported susceptibility ratio among cattle, goats and sheep as 9:4:1. In Nigeria, Bida and Dennis (1976) reported the disease in both exotic and indigenous cattle with the former being more severely affected with the disease. They further reported that N'Dama and Muturu cattle were tolerant

to dermatophilosis, though their crosses with other zebu and exotic cattle were susceptible. Coleman (1967) reported that he could not establish artificial D. congolensis infection with N'Dama cattle. He could only induce artificial infection in an N'Dama cattle following stress with internal parasitism as well as in crosses of N'Dama with Brahama, Angus and Jessey cattle.

Austwick and Davies (1958) reported breeds susceptibility in sheep and observed that Cluns, Suffocks, Kerry Hills and Cheviots had 60, 40, 40 and 20% respectively. Schulz (1955) reported that the high susceptibility of merino sheep might be associated with their type of wool. Further, Hart (1976) reported that thin wooled sheep showed more disease than those with coarse wool. Thus Austwick (1976a) observed that introduction of coarser wooled rams appeared to breed out the susceptibility to Dermatophilus infection.

Dermatophilosis has also been reported in camels, horses and donkeys (Hudson, 1937; Stableforth, 1937; Bentink-Smith et al., 1961 ; Oduye 1975a; Aub-Samra et al. 1976). Reports of the disease in poultry and pigs are scanty while among rodents the cotton tail rabbit is also susceptible (Sansi, 1968; Stankushev et al., 1968 and Shotts and Kistner, 1970). Balabanov and Boussafou (1977) could not observe any lesions of dermatophilosis in 1100 pigs they examined. More recently, Lomex and

Cole (1983) reported clinical cases of dermatophilosis in a herd of pigs in America. Abu-Samra et al. (1976) regarded the fowl as refractory to D. congolensis infection. Blancou (1973) reported fifteen confirmed cases of dermatophilosis in dogs in Madagascar and observed that the clinical signs were similar to those seen in cattle. He further reported that all the affected dogs had history of contact with cattle. The seal and the lizard have also been reported by Frese and Weber (1971) and Simmons et al. (1972) to be infected with the organism.

To date, twelve persons have been reported to be infected with D. congolensis (Dean et al., 1961; Kaminski, 1971 and Londero et al., 1973). Similarly, owl monkeys, rhesus monkeys, cynomolgus monkeys and sequirell monkeys are also susceptible (King et al., 1971; Fraser and Garcia, 1971; McClure et al.,1971).

Among wild animals, dermatophilosis has been reported in the deer, giraffe, Thompsons gazelle, zebra, fox chamois, columbian ground squirrel, polar bear and antelope (Mackenzie and Simpson, 1956; Dean et al.,1961; Nicolet et al. 1967; Austwick, 1969; Kistner et al.,1970; Smith and Cordes, 1972; Gordon, 1976a and Vos and Imes, 1976).

Transmission

Non-arthropods:

Field Observations

Skin discontinuity: Various agents have been reported to cause skin discontinuity and in the process induced an increased prevalence of D. congolensis infection. Moule and Southerland (1947) and Seddon (1953) indicated that cattle skin abrasion was more important than wetness of the skin in the prevalence of dermatophilosis in Australia. Further, Harris (1948), in the United Kingdom, believed that pastures with spiny plants could account for lesions of the lips, feet, and legs. He also observed that a flock of sheep in constant contact with 'bract of whim' developed Dermatophilus lesion while another flock in an adjacent field with no whims did not develop any lesions. Austwick (personal communication to Roberts, 1967a) observed that lesions at the axilla and groin of sheep might be caused by penetration of sharp seeds of tall grasses. Zlotnik (1955), following a field study in West Africa, reported that thorny bushes and tree branches contributed significantly in the development of D. congolensis infection. He further suggested that the organism might live saprophitically on the bovine skin or tree branches.

Austwick and Davies (1958) in the United Kingdom (U.K.) considered skin damage as facilitating the invasion of the organism. Oduye (1976a) in Nigeria

reported observing more lesions along the extremities in animals that grazed in areas with thorny bushes.

Bida (1969) seemed to incriminate the cattle tick-birds in causing skin discontinuity and subsequent invasion of the skin by the organism. Nobel et al. (1976) in Israel believed that rough concrete floors in the presence of wetness abraded the skin and increased the prevalence of bovine dermatophilosis.

Moisture: There seemed to be two schools of thought on the role of moisture in the establishment and maintenance of dermatophilosis. In one extreme, moisture, in the form of rainfall, dew formation and high humidity, has been reported to increase the prevalence of the disease (Beaton, 1933; Mettam, 1939; Harris and Harding, 1950; Austwick and Davies, 1958; Wilson, 1959 and Thorne, 1966). At the other extreme, moisture has been regarded as speeding up the rate of healing in affected animals or not to have any effect at all (Macadam 1962, and MacGregor, 1965).

Body Contact: Seddon (1929) observed that lambs could become infected by rubbing against their infected mothers. He further suggested that the amniotic fluid on the coats of lambs at birth possibly permitted the organism to grow and invade the skin during the first few days of post natal life. His observations were corroborated by Le Riche (1968) and Bida (1969) who further observed that body contact transmission might be aided by wetness,

dipping, showering or yarding sheep together. Macadam (1976), in the Gambia, reported that a flock of sheep that had been free of the disease for seven years developed the disease after introduction of infected sheep.

Bull (1929), Plowright (1956) and Soltys (1964) did not seem to believe that there could be spread of the disease through contact even in wet weather.

Experimental Transmission:

Methods tried in the transmission of D. congolensis include scarification and injection via the intradermal, subcutaneous, intravenous and intraperitoneal routes, the use of moisture and body contact.

Scarification: Dermatophilus infection has been reported to develop following the application of emulsions of D. congolensis scabs onto scarified skins of rabbits, mice, sheep, goats, cattle and the horse (Best, 1928; Bull, 1929; Beaton, 1933; Edgar and Keast, 1940 and Bugyaki, 1959). In addition, Bull (1929) reported D. congolensis lesions following the application of an emulsion of D. congolensis on the intact skin of the forehead of sheep which persisted for up to three months. However, Hudson (1937) and Mammerikx (1961) could not demonstrate any lesions by pouring known D. congolensis culture on the intact skin of sheep and cattle respectively.

Scarification along with the application of D. congolensis culture, has also produced D. congolensis infection (Bull, 1929; Horgan and Haseeb, 1948; and Macadam, 1961). In such cases, lesions on cattle appeared 10 days later and disappeared after 28 days. Dermatophilus congolensis has also been transmitted by the intradermal and subcutaneous routes to rabbits, sheep and calves (Bull, 1929; Abu-Samra et al., 1976). The intravenous, intramuscular and intraperitoneal routes have been reported not to result in skin lesions although the organism could be demonstrated at the site of infection and in the liver of mice (Bull, 1929; Hart et al., 1967; Abu-Samra et al., 1976). Large intravenous doses of the organism have been reported to either cause anaphylactic shock or death of affected rabbits (Van Wettere, 1967 and Abu-Samra et al., 1976).

Moisture: There seem to be three schools of thought on the role of moisture in the establishment and spread of dermatophilosis. At one extreme, moisture was believed to be important in the establishment and maintenance of D. congolensis infection (Curasson and Mornet, 1941; Austwick and Davies, 1958; Bida, 1969; Austwick, 1976b; Nobel, et al., 1976 and Davis and Philpott, 1980). At the other extreme, moisture increased the rate of healing (Best, 1928; Macadam, 1961), while between these Hart (1961) and Hart et al. (1967) believed that the amount rather than the period of wetness was more important.

Bida (1973) demonstrated that artificial infection was more marked in animals kept outside than those sheltered from rain. Davis and Philpott (1980) demonstrated that runoff water containing D. congolensis and followed by about a month frequent wetting produced lesions on experimental goats.

Body Contact: Bull (1929) reported that he could not achieve transmission of D. congolensis by close body contact among sheep for up to 10 months.

Arthropods

Field Observations

Biting and non-biting insects and ticks have been suspected in transmission. Lyperosia spp, Stomoxys spp., Musca spp., mosquitoes and Glossina spp. have been incriminated in the transmission of the disease.

The Horn Fly (Lyperosia spp): The prevalence of dermatophilosis has been reported to increase with the increase in the prevalence of Lyperosia spp.(Calderbank, 1951; Wilson, 1959; Bida, 1969; Oduye, 1976a). The bovine hump, a common site of the lesions, has been reported to be the favourite site for these flies. Spraying cattle with benzene hexachloride against these flies reduced the prevalence of dermatophilosis (Wilson, 1959).

Stable flies (Stomoxys spp): Stomoxys spp. have been suspected in the initiation and spread of Dermatophilus lesions along the posterior portion of the hump, where swarms of these flies are often seen (Macadam, 1962; 1964; Bida, 1969 and Oduye, 1976a). These lesions were often of the brush type (Macadam, 1964).

Mosquitoes (Genera not specified): Mosquito bites have been reported to result in extensive and often fatal Dermatophilus infections in lambs in Kenya and in Papua-New Guinea following floods and severe infestations (Hudson, 1937; and Roberts, 1967a).

The House fly (Musca spp.): Oppong (1976) in Ghana suggested that the house fly might be capable of mechanically transmitting the organism between cattle.

The Tsetse fly (Glossina spp): Stephen and Broomfield (1959) in Vom, Nigeria, during an experimental study of bovine trypanosomiasis using Glossina spp. in Eruce boxes, reported observing Dermatophilus lesions at the sites bitten by these insects and concluded that these insects could be instrumental in the transmission of the organism. Oduye (1976a) also associated these flies with bovine dermatophilosis in Borno State, Nigeria.

Mites (Demodex sp, Chorioptes sp): Demodex sp. and Chorioptes sp. have been reported to increase the prevalence of D. congolensis infection (Beaton, 1955;

Mornet and Thiery, 1955; Shotts et al.,1967 and Oduye, 1976a). These mites were believed to produce skin discontinuity through which D. congolensis invades to establish its infection.

Short-nosed Lice (Haematopinus sp): The cattle louse, Haematopinus eurysternus has been reported by Macadam (1964) to be responsible for bovine dermatophilosis at the tail brush.

Ticks (Amblyomma sp, Boophilus sp.): Ticks have been reported to be probable vectors in the spread of D. congolensis infection (Beaton, 1955; Campbell, 1955; Coleman, 1967). Among the ticks, Boophilus sp. and Amblyomma variegatum seem to be most incriminated and that sites commonly associated with ticks like the groin, teat, and ears are usually seen to be infected with D. congolensis (Campbell, 1955; Bida, 1969 and Oduye, 1976a). Tick control, through the use of pesticides like Gammatox^{R} and Coopertox^{R}, was seen to reduce the prevalence of the disease (Campbell, 1955; Flowright, 1956; Macadam, 1964; and Bida 1969).

Experimental Transmission;

The use of arthropods to effect experimental transmission of D. congolensis has been tried with Stomoxys spp, Musca spp, Glossina spp and Amblyomma sp. There do not seem to be any experimental trials on the use of Lyperosia sp, mosquitoes, mites and lice.

Stomoxys spp: Philpott and Ezeh (1978) reported production of D. congolensis lesions on cattle using these flies that had previously fed through Dermatophilus lesions. They reported that they observed multiple discrete lesions on the wet areas bitten by the flies and that the organism was seen in stained smears and culture of the lesions.

The house fly (Musca sp.): Philpott and Ezeh (1978) exposed these flies to chronic bovine dermatophilus lesions which were previously made wet with water for 30-45 minutes. Following this exposure, the flies were then fed on 'susceptible' zebu cattle after which they observed only one insignificant lesion.

Glossina spp.: Macadam (1970) showed that these flies could transmit D. congolensis by feeding them on cattle through sterile boxes. The flies were first fed on chronic dermatophilus lesions on cattle and then transferred to shaved sites on susceptible cattle. The lesion developed after seven days.

Ticks: Among ticks, Amblyomma variegatum and Hyalomma asiaticum have been tried in experimental transmission. Beaton (1955) produced D. congolensis lesions on the back of a goat by applying a saline emulsion of A. variegatum previously collected from a heavily Dermatophilus-infected cow. Similarly, Macadam (1962) demonstrated dermatophilus lesions on the ears of rabbits using A. variegatum that had fed previously

on dermatophilus-infected cattle. He also applied the ticks along with D. congolensis culture onto the ears of cattle and reproduced the disease. He further reported that the lesions developed slowly and became characteristic only by the 34th day. He also produced dermatophilus lesions on the ears of cattle with only A. variegatum without culture.

Bida (1973) collected 500 Amblyomma spp. and ground them in groups of five. He examined them in smear and culture with negative results. He concluded that this tick might not act as a reservoir of infection though could cause injury to the skin thereby providing a ready portal of entry for the organism.

The only report of transmission of D. congolensis with Hyalomma asiaticum was that of Kuseltan (1967).

Pathogenesis

Infection with D. congolensis starts when some of the predisposing factors like skin discontinuity and favourable environmental conditions prevail in the presence of the organism.

The organism under such conditions, germinates and invades the tissues producing branching filaments. This results in local inflammatory reaction in the form of serous exudate and necrosis of the invaded tissues. In the process, polymorphic nuclear leucocytes ingest some of the zoospores. Roberts (1967a) reported that

such ingested zoospores are destroyed in rabbits while in guinea pigs and sheep, these zoospores successfully germinate and begin to penetrate surrounding tissues. The branching filaments radiate laterally and involve hair follicles. Bida and Dannis (1976) observed that the ostia of hair wool follicles might act as primary sites for invasion in the epidermis. Roberts (1965), Searcy (1967) and Oppong (1970) reported that D. congolensis infection is mainly superficial and confined to the epidermis. However, dermal invasion might occur when infected hair follicles sheaths rupture (Lida, 1973 and Amakiri, 1976). The organism, within the hair follicle multiplies in external root sheath and the hair papilla leaving the actual hair shaft intact. The body then reacts by accumulating lymphoid cells around the hair follicle and penetrating into the hair papilla. As the infection progresses, lymphocytes infiltrate the surrounding tissue and stimulate proliferation of the malphigian layer around the hair follicle. These lymphocytes later undergo degeneration and disintegrate while the superficial malphigian layer becomes cornified. At this stage, the mycelium breaks out of the hair follicle and infiltrates the cornified superficial skin layer which soon becomes cast off and separates from the skin in the form of a scab. This process continues so long as mycelia and susceptible hair follicles are available (Roberts, 1967a).

Symptomatology.

Incubation Period:

The incubation period of D. congolensis infection has been reported by Harriss (1948) in sheep to be 2 to 4 weeks following introduction of these animals to infected pasture. Abdussalam and Blackmore (1948) reported the incubation period in goats, rabbits and guinea pigs to be two to five days while Macadam (1962) reported the incubation period following tick attachment as 34 days. Kaminski (1971) reported the incubation period in man to be 48 hours. Munro (1978) reported the disease in kids of four to five days after birth, indicating that the incubation period could well be shorter.

Clinical Signs:

Disease due to D. congolensis infection has been reported by Zlotnik (1955) to occur either as acute or chronic, with the latter being more frequent and that lesions of the disease have been seen at almost all parts of the body (Harriss, 1948; Schulz, 1955; Flowright, 1956; Oduye, 1976a).

Dermatophilosis has also been reported by Mornet and Thiery (1955) to manifest as ichtyotic, nodular, tumorous and leproid forms while Kelley (1976) and Londero (1976) regarded these manifestations as restricted crusty, generalized crusty and nodular forms.

From their descriptions of the disease, it seems that they were all referring to different stages of the same disease. The differences in the types of reaction could also be due to the variation in the body area, predisposing factors as well as extent and age of the lesions.

Clinical signs due to dermatophilosis in domestic animals have been given by Schulz (1955), Chodnik (1956), Austwick (1958) and Bridges and Romane (1961).. These signs include lacrimation, nasal discharge, and skin eruption, characteristic of the disease. Others include loss of wool in wooly sheep, pain to touch, soft and soapy skin, general debility, lameness and death in severely affected animals. Nobel et al. (1976) also reported milking cows to show inappetance and reduced milk yield. The clinical manifestation of the disease in man and other primates has been given by Dean et al. (1961), Gordon (1976a) and Kaplan (1976).

Pathology:

Clinical Pathology:

Amakiri (1972) reported finding alkaline phosphotase in abundance in the upper epidermis, including the stratum corneum of Dermatophilus infected skin and concluded that this might be due to increased metabolic activity in the upper epidermis in Dermatophilus infection. He further observed that there was no breed

variation in the level of this enzyme and that this enzyme was absent in healthy skin. Gaulier et al. (1972) reported increased serum fibrinogen, decreased cholesterol and calcium:phosphorus ratio along with changes in serum protein followed the development of the disease closely. They also believed that such changes could be due to liver and kidney lesions due to hyperactivity of the reticulo-endothelial system.

Kapu (1975) reported lowered mean serum zinc, calcium, magnesium and potassium levels in cattle with dermatophilosis. He further reported that there was no significant difference in serum copper level between Dermatophilus-infected cattle and normal animals. However, Gbodi (1980) did not observe any significant difference in the serum values of magnesium, zinc, calcium, potassium, copper and sodium between infected and normal calves. He further observed that mineral deficiency on its own might not predispose to the disease.

Gross Pathology:

Gross lesions of dermatophilosis in domestic animals have been reported by Bull (1929), Roberts (1967a) and Bida and Dennis (1976). Lesions start as papules to vesicles which rupture to release sero-fibrinous fluid with subsequent matting of the hair on drying.

Dilman (1967) described dermatophilosis lesions as paint-brush, tumorous, leproid, wart and matted confluent forms while Oppong (1973) regarded them as exudative, crusty and scaby forms. Njoku (1976) suggested that the types of lesions were nothing other than different stages of the disease as well as the effects of various predisposing factors. The size of dermatophilosis lesions has been given by Bull (1929) and Harriss (1948) to be 2 - 7cm in diameter.

Histopathology

Histopathological lesions of dermatophilosis in domestic animals are restricted to the integument (Schulz, 1955; Zlotnik, 1955; Bida, 1973; Oduye, 1976b and Amakiri, 1976). Tissues for histopathology will thus consist of biopsy specimens containing both unaffected and affected skin with overlying crust.

Stains for preparation of tissue sections for dermatophilosis include haematoxylin and eosin, Grams, Giemsa, gram-weigart and Grocott silver-methenamine stains (Chodnik, 1956; Roberts, 1961; Pier et al., 1963; Amakiri, 1973; Gordon, 1976b and Oduye, 1976b).

Histopathological reactions of D. congolensis infection in domestic animals have been reported by Harriss (1948), Pier et al. (1963); Oduye (1976b) and Oppong (1976). These reactions are regarded as exudative, crusty and scally. Spores and filaments of

the organism are often identified in the cornified layers and inside the hair follicles sheath and rarely in the exudate or in the papillary layer of the dermis (Bwangamoi, 1976a; Amakiri, 1976).

Dermatophilus congolensis does not seem to penetrate the duct or fundus of the sweat glands, blood vessels or lymphatics, though it has been observed in the sebaceous glands (Roberts, 1965; 1967a; Amakiri 1976).

Diagnosis:

Diagnosis of dermatophilosis involves the use of history, clinical findings, bacteriology, pathology, serology and endemicity of the disease in a given area.

History of additions of infected animals commonly results in the introduction of the disease in new herds or areas (Nobel, et al., 1976). Clinical findings suggestive of dermatophilosis include the presence of gross lesions, though Kaplan (1976) observed that clinical signs are not pathognomonic in the diagnosis of the disease.

Pathological lesions could be used to arrive at a tentative diagnosis. Thus close examination of paint-brush or scaby lesions, which on removal exhibit concave, moist and oily surface is often used for field diagnosis of the disease.

Bacteriological diagnosis involves taking a portion of the scaby lesions making thin smears stained in Giemsa's, Gram's or methylene blue stains. These show the characteristic filamentous and coccoid forms of the organism. Media such as 10% blood agar with or without 10% carbon dioxide tension, and brain heart infusion media are commonly used for isolation and identification of the organism (Plowright, 1958; Haalstra, 1965; Weber et al., 1970 and Macadam and Haalstra, 1971). Hussel and Neubert (1973) in Germany recommended the use of tuberculosis medium of Wagener and Mitscherlich as this medium allowed the organism to grow rapidly and in a characteristic manner. They further observed that mitscherlich green at 1:4000 inhibited the growth of the organism while glycerine favoured it.

Serological tests used for the diagnosis of D. congolensis include fluorescent antibody test, precipitin and indirect haemaglutination tests, chromatography and complement fixation test (Pier et al., 1964; Kwapinski, 1966; Kwapinski and Simmons, 1967 and Richard et al., 1976). Laboratory animal inoculation has also been used to identify the organism (Bida,1969).

Differential diagnosis

Disease due to D. congolensis infection can be confused with other skin diseases of domestic animals. Some of these diseases include demodectic mange,

scabies, contagious pustular dermatitis (C.P.D.), pox diseases, dermatomycosis, pyoderma, lumpy skin disease (L.S.D.) globidiosis and besnoitiosis (Harriss, 1948; Oduye, 1974).

Disease due to demodectic mange and scabies can be differentiated from dermatophilosis by identifying the mites from skin scrapings. Contagious pustular dermatitis is also differentiated from dermatophilosis by its failure to infect guinea pigs, rats and mice. Viral isolation and serological tests could be used to differentiate the two diseases (Abdussalam and Blackmore, 1948; Harriss, 1948 and Horgan and Haseeb, 1948).

Pox diseases could be differentiated from dermatophilosis in that the former are accompanied by systemic involvement. Further, viral isolation serves to differentiate the two diseases (Bida et al., 1975). Dermatomycosis is differentiated from dermatophilosis by isolating the fungus in sabouraud's dextrose agar plates since D. congolensis does not grow in this medium (Gordon, 1964).

Lumpy skin disease is differentiated from dermatophilosis in that the former is accompanied by systemic involvement as well as large tumorous skin erruptions. Viral isolation along with histopathological examination of affected skin serve to differentiate the two diseases (Bida et al., 1976). Bovine cutaneous besnoitiosis could be differentiated from dermatophilosis by isolating the Besnoitia sp. cysts in tissue

sections (Oduye, 1974 and Kumi-Diaka et al., 1981)

Treatment:

Various methods that include either or both topical and parenteral medications have been used in the treatment of dermatophilosis with variable results. Thus Bull (1929), Heath (1958) and Oduye (1975b) used various drugs to externally treat and or prevent the disease. Roberts (1967a) observed that parenteral treatment had higher curative effect than external application. Further, Blancou (1976) believed that parenteral treatment produced the most dependable curative results. He further observed that external treatment was mainly preventive though curative effects could be seen in incipient cases.

Roberts (1967b) believed that for any chemotherapeutic agent to be effective, it would have to be present in the epidermis at a fully bactericidal concentration for a brief period or at a bacteriostatic concentration for a long period.

Drugs so far used in the treatment of dermatophilosis include antibiotics, antimycotics, antiseptics, and various preparations by local livestock owners. Spontaneous cure has also been reported in mildly to moderately infected animals, especially with advent of dry season (Bida and Dennis, 1976). Recovery seems to be also influenced by various factors such as the

Nobel et al. (1976) reported parenteral administration of a combination of penicillin and streptomycin at therapeutic levels along with topical application of organic iodide disinfectant with clinical improvement in five days after the start of the therapy. Kaplan (1976) reported good results using 15,000 units of benzathine procaine penicillin intramuscularly in two monkeys suffering from dermatophilosis. However, Blancou (1976) reported that the use of penicillin and streptomycin was less effective than before and suggested the use of chloramphenicol, tetracycline and spiramycin to replace penicillin and streptomycin.

Moreira et al. (1970) used a dose of 70mg dihydrostreptomycin per kg. body weight along with topical washing with 10% aqueous formol solution with satisfactory results. However, Saidu et al. (1978) could not achieve cure with a five day course of combiotic (250mg. streptomycin and 200,000 I.U. penicillin per ml) intramuscularly along with topical administration of 2% lysol solution.

Apart from penicillin and streptomycin, tetracyclines have also been used in the treatment of dermatophilosis; though certain strains of D. congolensis have been reported by Blancou (1976) to be resistant to terramycin. Oduye (1975a) reported successful application of aureomycin spray either alone or in

combination with sulphur ointment ir groundnut oil, following scab removal, to treat cattle with dermatophilosis. More recently. Ilemobade et al. (1979) used terramycin/LA at 20mg per kg body weight intramuscularly to effect cure in severely affected cattle with dermatophilosis. However, Ogwu et al. (1981) could not observe any significant recovery rate following the use of this drug. Further, Gbodi and Ndife (1982) observed that they could only achieve 33% cure with this drug and that cure rates were better when L.A. tetracycline/ zinc sulphate combination was used.

Chloramphenicol has been used in the treatment of dermatophilosis with variable results. Saidu et al. (1978) reported that seven day course of chloramphenicol at 2gm/day intramuscularly along with bandaging the affected legs of a suffolk ram and soaking the legs with 2% Almask- DR (Quaternary Ammonium compound) did not yield any good result.

Sulphur compounds have also been tried in the treatment of dermatophilosis. Pier et al. (1963) did not observe any appreciable response with sulphapyridine and sulphathiazole ointments in curing dermatophilosis. However, Bida and Dennis (1976) reported that 50 parts of sulphadimidine, and 50 parts of dixanthagen in 950 parts mineral oil proved successful particularly in early stages of the disease. They recommended that

this medication should be applied every other day for a week without prior removal of scabs.

Other antibiotics reported to be effective against dermatophilosis include amphotericin A, bacitracin, chloramycetin, neomycin and polymixin B (Blancou, 1976).

Antimycotics: Reports on the use of antifungals against dermatophilosis are scanty. Blancou (1976) reported that grieseofulvin had irregular and generally poor results against D. congolensis. Earlier trials of antifungals against D. congolensis infection was on the assumption that D. congolensis was a fungus.

Antiseptics: Various antiseptics have been used in the topical treatment of dermatophilosis. Among these are gentian violet, aluminium salts, quarternary ammonium salts, copper sulphate, and weak organic acids. These agents have been used in both in-vitro and in-vivo with the work of Bull (1929) being possibly the first report of in-vitro trials using copper sulphate. He showed that copper sulphate was inhibitory to D. congolensis at 1:1000 to 1:8000 dilutions. He also showed that iodine and mercuric chloride were inhibitory to D. congolensis at these dilutions. Heath (1958) observed that copper sulphate was useful for protection against the disease but useless for curing it. Kane (1958) also reported that treatment with copper sulphate along with arsenic and phenols were without success.

Later Hart et al. (1967) carried out extensive in-vitro studies on the effect of various agents on D. congolensis. They showed that 0.1 percent crystalline potassium aluminium sulphate was inhibitory to D. congolensis. They further showed that mercuric chloride and potassium chromate were also inhibitory against D. congolensis in-vitro. They concluded that trivalent compounds were more inhibitory to motility of D. congolensis than bivalent or monovalent compounds. They also showed that among the inorganic compounds, mercuric chloride, lead acetate, potassium chromate, copper sulphate and aluminium chloride were most active against D. congolensis.

Oduye (1975 a,b) also reported the use of organic agents such as carbolic acid, picric acid and linseed oil in treating the disease.

Disinfectants have been used in combination with other agents particularly antibiotics. Nobel et al. (1976) reported successful treatment of the disease using organic iodides topically along with parenteral antibiotic medication.

Insecticides: Insecticides have been used in the treatment and prevention of the disease. Beaton (1955) reported that arsenical dipping as well as its administration internally has some prophylactic and

curative effect. He however observed that external application was of little success. Curasson and Mornet (1941) reported that arsenical dips had a definite preventive action on the disease. Zlotnik (1955) reported that cattle dipped in benzene hexachloride (BHC) or D.D.T.^{R} developed the disease and the use of arsenic on these cattle led to disappearance of the disease. He also reported arsenic to be bactericidal while BHC and D.D.T.^{R} were not. Macadam (1962) believed that the reduction in incidence of dermatophilosis in dipped animals was mainly due to the control of arthropods and not necessarily due to the effect of insecticides on the organism. Van Breuseghem et al. (1976) showed that Copper-tox^{R} and Altik^{R} were bactericidal against D. congolensis.

Spontaneous recovery: Dermatophilus infection has been reported to show spontaneous remission in various species of animals. Beaton (1955) reported that spontaneous recovery was frequently observed and associated it with the decrease in atmospheric humidity. This observation does not agree with that of Macadam (1961) who reported that high humidity actually led to early healing contrary to earlier belief that high humidity aggravated the onset and spread of the disease.

Bida and Dennis (1976) were of the opinion that spontaneous recovery was mainly associated with early

lesions. Severe lesions were seen to persist for long and often extended to the next rainy season; such animals became foci of infection and spread in the herd and possibly to other neighbouring herds in the area.

Moreira and Barbosa (1976) and Londero (1976) also reported spontaneous cure in cattle. More recently, Blancou (1976) associated spontaneous cure with breed susceptibility. He observed that certain animals had total resistance to infection while others that became infected might have accelerated recovery. He also reported spontaneous recovery to vary from 10 to 20 percent. It should be noted that spontaneous recovery may be associated with many factors such as the periods of onset of infection, location of infection in animal, animal susceptibility, age and climatic and geographical areas. It seems that animals that become infected towards the end of the rainy season would recover earlier compared to those infected early in the rainy season.

Immunity:

Various reports have indicated that there is no protective immunity in *D. congolensis* infection (Stableforth 1937; Nisbet and Bannatyne, 1955). Similarly, Richard *et al.* (1976) observed that circulating antibodies offered little or no protection

to re-infection in rabbits and deer and they could be repeatedly infected without apparent diminition in severity of lesions even though the animals had developed precipitins to D. Congolensis. However, Roberts (1966) showed that protective response to infection was not connected with circulating antibodies but was associated with delayed hypersensitivity which in itself was not fully protective.

Antigens of D. congolensis have been studied with a view to determining their immunologic reaction. Bida and Kelley (1976) reported that D. congolensis had three antigenic components as whole cell, somatic and flagella antigens (WCA, SA, and FA respectively) with the WCA being most immunogenic as antibodies to it persisted longest. Gordon (1976b) observed that there was antigenic homogenicity among strains of D. congolensis.

Serological techniques used to screen animals for dermatophilosis include precipitin test, indirect haemagglutination test (IHA) and passive haemagglutination test (PAA). Kwapinski (1966) used diffusion precipitation and immunoelectrophoresis tests and showed that exoantigen complexes of D. congolensis were not serologically related to the other Actinomycetales, Corynebacterium, and Arthrobacter strains.

Richard et al. (1976) reported that precipitin test under normal conditions could not detect animals

with acute dermatophilosis but could detect animals with chronic infections. They further showed that the IHA test could detect animals infected once. Their work also indicated that circulating antibodies could be detected with agar-gel precipitin tests while PHA could also be used to detect "carrier animals" or animals with occult infections described by Stewart (1972b).

Bida and Kelley (1976) reported that components of D. congolensis induced the production of circulating agglutinin and precipitin antibodies, They further observed that such antibodies did not increase the resistance of scarified skin or the destruction of the Dermatophilus zoospores and that antibodies might not be capable of reaching the epidermal infected areas to produce any apparent protection.

Roberts (1967a) and Davis and Philpot (1980) believed, that immunological response in D. congolensis infection was associated with delayed hypersensitivity (DHS) without stimulating the production of large quantities of circulating antibody. This DHS was associated with an accelerated infiltration of skin lesions by neutrophils accompanied by a decrease in filamental penetration of follicular sheaths and stimulation of early healing. Davis and Philpott (1980) associated chronic lesions to DHS especially through arthropod infection.

Host Differences: As in any other infectious disease, cattle seem to show individual variation in their susceptibility to D. congolensis infection. Thus Oduye (1975a) and Bida and Dennis (1976) reported that N'dama, Muturu and Baole cattle in Nigeria were relatively resistant to natural infection by D. congolensis. Oduye (1975a) further observed that Chad Brahma and Arab Zebu cattle were recurrently infected without showing any evidence of protective immunity. This led Oduye (1976a) to postulate that there is an intrinsic factor or factors in these animals which either favour or hinder the development of the disease. Amakiri (1984) reported that bovine skin thickness might not have anything to do with differences in breed susceptibility to dermatophilosis as he could not observe any significant difference between the thickness of the skin of White-Fulani (Bunaji) and that of N'Dama cattle. However, breed susceptibility differences in these cattle could be due to the higher percentage of lymphocytic and neutrophilic cells in the skin of healthy N'Dama compared to White Fulani cattle along with the genetic differences and other cellular resistance factors (Amakiri, 1977).

Economic Significance

At the 1968 conference in Abidjan[1], dermatophilosis was ranked second only to contagious bovine pleuro-

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1. Abidjan Conference on Agricultural Resource Priorities for Economic Development.

pneumonia as economically important diseases in the livestock industry in Africa (Doutre and Orue, 1968).

Lloyd (1976) reported that dermatophilosis was of little significance in the temperate zones but that its economic importance had been recognized in the tropics, particularly West and Central Africa. The disease is of most economic significance in cattle, due to the losses to hides, meat and productivity. To date, nothing much has been done to quantify economic losses, though Lloyd (1976) has identified, more closely, the areas of economic losses in the cattle industry.

Losses to hides and skins.

These are most important as they are important sources of revenue especially for African countries. Damage to hides is seen mostly at slaughter and the affected hides are rejected by the tanners. Hide losses occur more often during the rainy season when the disease is most prevalent. Bwangamoi (1976b) reported that dermatophilosis lowered the value of approximately 1% of all hides he examined.

Lloyd (1976) attributed 2.3 to 12.8% of hides lost to be due to dermatophilosis alone from four abattoirs in Northern Nigeria between 1961 and 1972. The abattoir is, however, not the best source of estimating hide losses since it only gives official figures

for slaughter animals and not necessarily the total number of cattle slaughtered in a given area. Green (1957) and Bwangamoi (1969) reported that dermatophilosis hides were greatly pitted on the grain surface and consequently, such hides had no economic value in the leather industry.

It is almost impossible to estimate total losses to hides caused by dermatophilosis due to such factors as poor animal population figures, poor livestock movement recording system and inadequate methods of disease reporting. Livestock movement is for the most part unchecked thereby making it difficult to assess the prevalence and incidences of the disease in any locality. Green (1956) reported that the disease reduced the market value of skins in East Africa by 25%. In Nigeria, Lloyd (1976) estimated that as many as 168,000 hides were spoilt annually by the disease amounting to a total loss of about 10.33 million naira in revenue.

Losses through Milk:

As much as 20% reduction in milk production has been reported in cattle with dermatophilosis (Memery and Thiery, 1960 and Nobel et al., 1976). Severe cases involving the udder have also been observed by the author. In some of these cases, the

cows were nursing calves and that such calves had to be fed by the use of foster mothers or by bucket feeding. Lloyd (1976) reported culling cows with severely affected udders involved with chronic dermatophilosis. He reported that in 1959, 48% of the calving heifers and 64% of the bulling heifers were affected with the disease and that 28% of them had to be culled.

Lesions on the teats would also result in pain during milking, and milking or sucking in such cows could be impossible. With the traditional livestock husbandry in Nigeria, calves from such cows could suffer severe malnutrition with subsequent weight loss, retarded growth and delayed maturity or even death.

There does not seem to be any report of dermatophilosis involving the udder in other species of domestic animals to the extent of causing significant economic losses to milk production of these animals.

Effect on Meat Production and Carcass Quality:

Dermatophilosis is strictly an epidermal disease, and as such it does not seem to have any serious direct effect on the flavour or appearance of the meat provided that secondary bacterial infection does not set in (Lloyd, 1976). However, animals suffering from severe form of the disease especially exotic stock, are often

associated with severe loss in weight if not treated early in the course of the disease. This loss in weight could be due to pain on walking in animals with leg lesion resulting in inability to walk and graze well (Oduye, 1975a). Kelley and Bida (1970) and Bida (1973) reported that about one million cattle, based on 10 - 12% prevalence rate are annually affected with dermatophilosis in Nigeria and among these, approximately 287,000 were likely to be severely affected.

Dermatophilosis is a debilitating skin condition resulting in premature culling of affected animals at the end of the dry season (personal observation). Affected animals usually attract low prices for two reasons. Firstly, severely affected animals lose weight resulting in reduction in the price per kilogram weight of the carcass. Secondly, the value of the hide of such animals is low for either tanning or consumption.

Another source of meat loss is that young animals, especially heifers, with lesions on the vulva and udder, are often culled before reaching maturity. Mortality is low even among severe cases and in such cases the whole carcass is lost. Other severe cases slaughtered in extremis are also often unfit for human consumption for aesthetic and health reasons. Lloyd (1976), following a restricted study, showed that the growth rate of dermatophilosis bulls was

comparable to that of apparently normal bulls and that such affected bulls were capable of spontaneous recovery.

Effect of Dermatophilosis on Draught Animals.

Dermatophilosis has been reported by workers like Lloyd (1976) to have adverse effect on draught cattle especially in that the disease had high prevalence during the rainy season when the services of these animals are most needed. Draught cattle in Nigeria are used in pairs and are often associated with stress of work during the farming season. This stress increases the susceptibility and severity of the disease resulting in premature culling with subsequent loss in production. Dermatophilus lesions in these group of cattle are most often seen along the lines of regular beating on the skin of the rump and back and where the wooden bar carrying the plough is placed.

Effect of Dermatophilosis on Reproduction:

Kumi-Diaka et al.(1980),following a study of 1274 cattle, reported that there was no apparent correlation between spermatogenesis and scrotal dermatophilosis and that the increase in the thickness of the scrotal wall was not observed to affect the normal course of spermatogenesis. They further reported that the organism was restricted to the epidermis of the scrotal skin. However, Sekoni (1983)

reported that scrotal dermatophilosis resulted in sterility of a Friesian bull six months after lesions became conspicuous on the entire scrotal wall. The sterility could be due to poor or inadequate heat regulation of the testicles through the affected scrotum. Loss in reproduction in general, is in a lot of cases indirect; as severely affected bulls with leg lesions might find it painful to walk towards cows on heat let alone mount and serve them. Animals with lesions at the axilla and knee similarly suffer from pains on movement and hardly stretch their legs. This would make mounting difficult and painful.

Cows have been reported to have lesions around the vulva and the udder and that lesions in these areas are much harder to treat due to tall coverage (Abdullahi, 1981). Thus, animals with vulva lesions might refuse to be served by bulls when on heat due to pains as the bull attempts to introduce his penis into the vagina of the affected cow. This leads to loss of at least one estrous cycle, assuming that the cow is able to clear the disease either through medication or by spontaneous recovery before the next cycle.

Control

Control of dermatophilosis could be best achieved by the control of predisposing factors. This could be done by proper management methods and effective

control of environment.

Proper management methods include close watch on additions, quarantine, management of grazing areas, isolation of infected animals, tick control and prompt culling of affected animals. Macadam (1976) recommended isolation, treatment and slaughter of those which failed to show any improvement despite all the improvement in management practices. He also recommended dipping and quarantine of new animals for six weeks before such animals could be put in with the rest of the animals in the farm.

Hart (1967) suggested culling and animal selection as methods of controlling dermatophilosis in sheep. Animal selection towards tolerance to dermatophilosis might not be feasible in cattle as Oduye (1976a) reported that though the N'Dama and Muturu are resistant to dermatophilosis, their crosses with other breeds are susceptible to the disease.

Dipping has been advocated as a method of control by various workers. Plowright (1956) and Macadam (1962) have shown that acaricide dipping reduced tick infestation thereby indirectly controlling dermatophilosis. Further, Presler (1973) and Van Breuseghem et al. (1976) have shown that certain acaricides have direct effect on D. congolensis.

Vaccination as a method of control has been reported as being unsuccessful by Perreau and Chambron (1966) though Chamoiseau and Lefevre (1973) reported that 1.0gm of whole culture of D. congolensis administered intradermally proved clinically protective in rabbits. Chamoiseau et al. (1973) observed that cattle vaccinated subcutaneously with a live vaccine in an adjuvant gave reasonable protection against the disease in the field. Provost et al. (1976) in the Sudan, also reported successful production of D. congolensis vaccine capable of inducing protection against bovine dermatophilosis. None of these observations have been reproduced repeatedly with consistent result.

Environmental control has been suggested by Bugyaki (1959) and Macadam (1964). They suggested that thorns, tree branches, ticks, tick birds, which favoured the establishment and spread of lesions of dermatophilosis should be removed or controlled with a view to controlling the establishment and spread of the disease.

Table 1.1: Gross Microscopic and Biochemical Characteristics of Dermatophilus Congolensis.

Morphology		Catalase	Oxidase	Oxidative fermentation	Triple Sugar Iron Agar	Nitrate Reduction	Indole Production.	Urea	Citrate	Motility	Gelatin liquefaction	Litmus milk	Methyl red test	Voges-Proskauer	Haemolysis	Temperature (°C)	Glucose	Fructose	Lactose	References
Colonial	Microscopic.																			
Dirty white to Yellow orange colonies that sticked to medium	Gram positive filaments and spores	-									+	+			+	35	+	+		Plowright (1958)
"	"	+				+				+		+	+	+			+	+		Gordon (1964)
"	"	+			→		-	+			+	-	-	+	37					Macadam Haalstra (1971)
"	"	+	-					+	-			-	-	+	37	+	+		-	Lloyd and Ola Ojo (1975) Abu-Samra (1978)

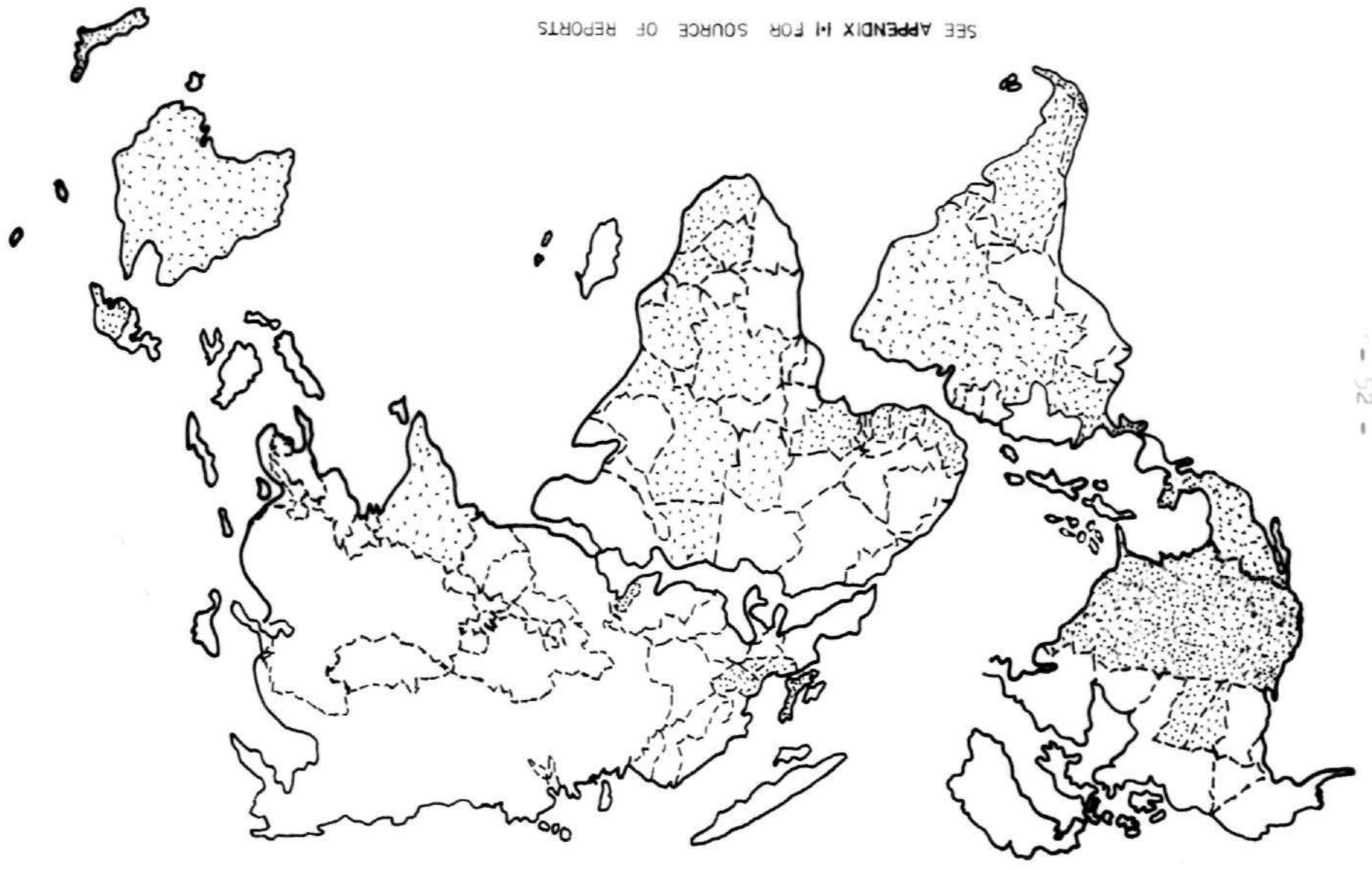


FIGURE 1-1 GLOBAL DISTRIBUTION OF DERMATOPHILOSIS

SEE APPENDIX I-1 FOR SOURCE OF REPORTS

CHAPTER TWO

SURFACE DECONTAMINATION OF AMBLYOMMA VARIEGATUM

INTRODUCTION.

Although normal methods for preserving arthropods include the use of 70% alcohol or 5% glycerol (Mohammed, 1974) or 7-10% formalin (Service, 1980), there does not seem to be any report in relation to the direct effect of 70% ethyl alcohol (70% alcohol) on live Dermatophilus congolensis or Amblyomma variegatum. Further, the minimum period of exposure within alcohol which could free the outer cuticle of the tick of micro-organism (especially D. congolensis) without killing the tick has not been investigated. The technique of preventing contamination of the ova and the larvae post-oviposition during incubation has not been studied either.

It is against this background that this work has been designed to investigate the following:

(1) the decontamination effect of 70% ethyl alcohol on A. variegatum cuticular surface without killing the tick and

(2) the effectiveness of either nail polish or a drop of cyanoacrylate adhesive ('Glue', pen-like-glue) in sealing the anus of A. variegatum during incubation to prevent defecation.

MATERIALS AND METHODS

Source of engorged ticks

Partially engorged female A. variegatum were collected from clinically dermatophilus-free cattle in universal bottles and brought to the laboratory where they were used for viability tests in 70% ethyl alcohol, decontamination and anal sealing experiments.

Viability of A. variegatum in 70% ethyl alcohol

Fifty ticks were divided into five groups of ten each and each group was placed in petri dishes and 70% ethyl alcohol added until submerged. The activity of the ticks in the alcohol was examined over periods of 2,5,10, 15 and 20 minutes by assigning one time interval to a group. To another group of ten ticks was added normal saline solution as a control.

Viability of D. congolensis in 70% ethyl alcohol.

To six sterile test tubes were added 0.5ml. 48 hour brain heart infusion broth cultures of D. congolensis. For five of the tubes, 2ml 70% ethyl alcohol were added and mixed for a time interval. These time intervals were 30 seconds, 1,2,5 and 10 minutes. To the sixth tube, 2ml sterile buffered physiological saline (PBS) was added as control. At the end of each specific exposure period, the contents of each tube were mixed and loopfuls taken and inoculated into blood agar (BA) plates. The plates were then incubated aerobically at 37°C and examined daily for three days.

Contamination of ticks (A. variegatum) with D. congolensis and exposure to alcohol and PBS.

Five ticks collected from the field were contaminated with known 48 hour broth cultures of D. congolensis. The ticks were then submerged in 70% alcohol for two minutes. They were then removed and pressed on BA plates. The plates were then incubated and examined as earlier described.

Five other ticks were also contaminated with the D. congolensis broth culture but washed five times in PBS. The ticks were pressed on BA plates in between each washing. Loopfuls of the PBS, used for washing the ticks were also inoculated onto BA plates and similarly incubated and examined for D. congolensis.

Sealing anus with pen-like-glue and nail polish

Fifty engorged female A. variegatum were collected and brought to the laboratory where they were divided into three groups of 20, 20 and 10.

The anus of each of ticks in the first group of 20 was sealed with Nail Polish[R'] and the polish allowed to dry. The ticks were then placed individually in sterile incubation tubes and kept in the incubator at 28°C and 80% relative humidity. The viability of each tick was determined daily by its leg movements. They were also examined for egg deposition and subsequent hatching to larvae over a period of two months.

The anus of each of the ticks in the second group of 20 was similarly sealed with a drop of pen-like-glue[2] and examined as for the ticks sealed with nail polish. The remaining group of ten ticks were left as control without any anal sealing but were similarly examined for viability, egg deposition and hatching to larvae.

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1. Nail Polish[R] - Cutex, Chesborough Ponds Inc. Lagos, Nigeria.

2. Pen-like-glue Cyanoaerylate adhesive O'Glue- Selleys Supaglue, Australia.

RESULTS

Viability of A. variegatum in 70% ethyl alcohol

Amblyomma variegatum was seen to remain active in 70% alcohol for up to 15 minutes exposure beyond which activity was markedly reduced. One hundred per cent (100%) to 85% of ticks exposed to 70% alcohol for 2, 5, and 10 minutes laid eggs which hatched to larvae. After 20 minutes exposure, only two out of the ten ticks laid eggs which hatched to larvae. Ticks not exposed to 70% alcohol were seen to remain active throughout the exposure period.

Viability of D. congolensis in 70% ethyl alcohol.

Following exposure of D. congolensis to 70% ethyl alcohol growths were seen only in exposures at 30 seconds and one minute, beyond which no growths of the organism was seen.

Contamination of ticks (A. variegatum) with D. congolensis and exposure to alcohol and PBS.

No D. congolensis or any other bacteria ware recovered from the cuticular surface of the ticks after 1 minute or longer time interval exposure in 70% alcohol.

From the five washings in PBS and the corresponding cuticular surface of the ticks, only Staphylococcus aureus, S. epidermidis and Pasteurella sp. were recovered. No E. congolensis was isolated in this case.

Sealing anus with pen-like-glue and nail polish

Sealing tick anus with nail polish caused high mortality of A. variegatum (60.0%), starting at 24 hours following application of the polish. Few ticks (25.0%) whose ani were sealed with the nail polish, survived and laid eggs which subsequently hatched to larvae. However, most of the ticks (75.0%) whose ani were sealed with the glue, survived and laid eggs which hatched to larvae. Ticks, whose ani were sealed lost a lot more moisture through transpiration via cuticle compared with those without sealed anus. Nine (90%) out of the ten ticks without anus sealed laid eggs which hatched to larvae. There was no appreciable difference in the activity of the ticks with ani sealed with the glue compared with those without anal sealing.

DISCUSSION.

Viability of A. variegatum in 70% ethyl alcohol

From the study, 70% ethyl alcohol appeared to be non-lethal to adult A. variegatum for up to 15 minutes exposure as the ticks were capable of ovi-position. The eggs also remained viable as they hatched to viable larvae.

Viability of D. congolensis in 70% ethyl alcohol

Seventy percent (70%) ethyl alcohol proved to be a good antiseptic against D. congolensis. This finding will enable the use of this alcohol to devoid surfaces of D. congolensis.

Contamination of ticks (A. variegatum) with D. congolensis and exposure to alcohol and PBS.

The fact that no D. congolensis or any other bacteria were recovered from the cuticular surface of A. variegatum indicated that 70% alcohol could be used to decontaminate the cuticular surface of A. variegatum. This finding would enable attempts at transmission studies with this tick since all external contaminations on the tick would have been removed.

Washing ticks with PBS did not appear to be an effective method of freeing the tick surface of bacteria. The fact that D. congolensis did not grow in any of the PBS washings or from the cuticular surfaces of the ticks could have been due to overgrowths by the other faster growing bacteria isolated.

Sealing anus with pen-like-glue and nail polish.

The higher mortality caused by nail polish compared to the pen-like-glue could suggest that the former had some chemicals toxic to the ticks. On the

other hand, the low mortality rate in ticks with pen-like-glue would suggest that the glue has minimum toxic effect on the ticks and that sealing the anus does not seem to have any significant effect on the viability of the ticks for the period observed.

From this work, it appears that the cuticular surface of a tick could be completely decontaminated with 70% ethyl alcohol after only one minute exposure and this does not have any adverse effects on the viability of the tick itself., By the same token, sealing ani of ticks with pen-like-glue, to prevent faecal contamination of the ova, does not have any appreciable adverse effect of the ticks for the duration of the incubation period.

CHAPTER THREE

TRANSMISSION STUDIES OF DERMATOPHILUS CONGOLENSIS WITH AMBLYOMMA VARIEGATUM

INTRODUCTION

Ticks have been reported to transmit various infectious agents such as protozoa, bacteria, viruses and rickettsia. Causey et al. (1974) reported isolating Dugbe, Bhaja, Thogo and Congo viruses from Amblyomma variegatum among others and suggested that these ticks might act as sources of the viruses for cattle, sheep and goats and other susceptible hosts. Similarly, Lee et al. (1971) successfully isolated 17 of 42 of Jos virus strains from A. variegatum. Ilemobade (1976) reported that A. variegatum could transmit Cowdria ruminantium trans-stadially from the larval to the nymphal stages as well as from the nymphal to the adult stage and that the organism was never transmitted transovarially. Irvin et al. (1972) and Young et al. (1977) reported that Amblyomma spp. were efficient transmitters of Theileria mutans and that the ticks transmitted the parasite trans-stadially from the nymphal to the adult stage.

Non-infectious problems known to be induced by ticks infestations include tick- toxicosis and sweating sickness. Amblyomma variegatum along with other

arthropods has also been incriminated in the transmission of D. congolensis by Plowright (1956) and Macadam (1962). Plowright (1956), in a field dipping programme with an acaricide, observed that dipped cattle did not become infected with D. congolensis while undipped cattle developed the disease. Similarly, Macadam (1962) reported successful lesion production using this tick alone and with D. congolensis culture onto the ears of rabbits and cattle. Oppong (1976) reported isolation of D. congolensis from A. variegatum.

The actual role played by A. variegatum and other ticks in the development of dermatophilosis is not clear apart from the circumstantial evidence arising from the similar seasonal prevalence of both the disease and the ticks. This study, therefore, was designed to examine more closely the role of the eggs, larval, nymphal and adult stages of A. variegatum in the transmission of D. congolensis.

MATERIALS AND METHODS

Ticks:

Source: Adult engorged female A. variegatum were collected from Fulani herds with either grossly dermatophilus infected or uninfected cattle depending on the aspect of the study, and brought to the laboratory in separate universal bottles.

Incubation: In the laboratory, the ticks were weighed, washed for two minutes in 70% ethyl alcohol and rinsed in sterile PBS and then placed individually in sterile incubation tubes. The tubes were identified and kept in an incubator at 28 $\pm$ 5^{o}C and =80% relative humidity in order to lay eggs and hatch to larvae. Ticks from grossly infected cattle were identified as group A while ticks from clinically healthy cattle were in group B.

Some of the eggs and larvae from 24 such ticks from group A and twelve such eggs and larvae from group B were used in determining the presence of D. congolensis. Few of the eggs and the hatched larvae from each tick, were separately and asceptically macerated with a sterile mortar and pestle at room temperature. A portion of each of the macerated eggs and larvae was streaked on separate Blood agar (BA) plates, incubated and examined for D. congolensis. The rest of each of the macerated eggs and larvae was smeared, stained with Grams stain and examined under microscope for D. congolensis. The rest of the larvae from all the ticks in the two groups (A and B) were used for the trans-ovarian transmission aspect of the study.

Another set of six adult engorged female A. variegatum ticks for use in the trans-stadial transmission

study were collected from grossly uninfected cattle and incubated to lay eggs and hatch to larvae as previously stated. Some of the eggs and larvae from each of these ticks were similarly examined for D. congolensis.

One hundred to 200 larvae from each of the ticks found negative for D. congolensis were then attached to groups of two rabbits each via four earbags in order to feed and engorge .

Few of the engorged larvae and the subsequent nymphae that moulted from them (from each tick) were also macerated asceptically and examined by culture and direct smear as described above. The remaining nymphae from each tick were used for trans-stadian transmission aspect of the study.

Experimental animals:

1. Rabbits: Six months to one year old New Zealand White rabbits from the National Veterinary Research Institute, Vom, Nigeria, were used. They were identified using ear numbers and were housed individually , or in pairs in cages. They were fed on rabbit pellets[1] and water ad libitum throughout the study.

2. Bunaji Bull: A Bunaji Bull naturally infected with D. congolensis was used as a source of

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1. Rabbit Pellets: Pfizer Livestock Feeds Nig. Ltd. Ikeja, Nigeria.

infection for some of the nymphae described above to be used as experimental adults in the trans-stadial transmission aspect of the study. The bull had dermatophilus lesions at the head, neck, thorax, abdomen, extremities and the scrotum. The D. congolensis isolated from the scrotal lesions was identified according to standard keys (Gordon 1974).

Trans-ovarian Transmission Studies of D. congolensis

Four groups of two rabbits each were used for each set of the study. Before the start of each set of the study, swabs of rabbit ears and cages were taken and incoulated onto BA plates. The plates were incubated and examined for D. congolensis.

Both ears of each rabbit in the first group were shaved 24 hours prior to larval attachment. Autoclaved earbags were applied on each ear of all rabbits in the four groups 24 hours prior to larval attachment (Fig. 3.1)

Larvae from 10 ticks in group A above and six ticks from group B above were used in the study.

About two hundred larvae from each tick in group A were attached to each of the ears of the rabbits in groups 1 and 2 using autoclaved ear bags. Similarly, about 200 larvae from each tick in group B were

attached to each of the ears of rabbits in group 3. The rabbits in group 4 were left without any larvae as controls but had the ear bags.

To determine the onset of dermatophilosis lesions on the ears of all rabbits, the ears were examined three times per week for six weeks. Skin scrapings were made from all suspected lesions. A portion of the suspected scraping was used to prepare microscopic glass slide smears, stained with Gram's stain and examined for D. congolensis. Another portion was used to inoculate B.A. plates, incubated aerobically at 37°C for three days, with daily gross and microscopic examination for D. congolensis. Skin biopsies were also taken from such suspected lesions and processed for histopathology using Gram's, Giemsa and haemotoxylin and eosin stains and examined for D. congolensis.

Trans-stadian transmission studies of D. congolensis.

Nymphae negative for D. congolensis, from four of the six ticks for trans-stadian transmission aspect of the study, were then attached, using scrotal bag, to the scrotum of the naturally infected Bunaji bull (fig. 3.2) in order to feed and engorge. These ticks constitute the experimental ticks for the study. Engorged nymphae were then collected, cleaned and incubated (as previously described) and allowed to moult to the adult stage. Again few of the engorged

nymphae and later the emerging adults from each tick were separately macerated and examined for D. congolensis by direct smear and culture as earlier described. The rest of the adult ticks from each tick were used as experimental ticks for the trans-stadian transmission study.

Nymphae from the remaining two ticks were attached to rabbits in order to engorge. Similarly, few of the engorged nymphae and later the emerging adults from these two ticks were examined for D. congolensis. The rest of the adult ticks from these two ticks served as controls for the trans-stadial transmission study.

Four groups of two rabbits each (involving four ears) were used to determine the possible transmission of D. congolensis for each tick. The first group of rabbits had their ears shaved 24 hours prior to tick attachment.

About twenty fully emergent adult male and female ticks from each tick, that fed as nymphae on the infected scrotum of the above bull, were attached to the ears of each rabbit in groups 1 and 2, via autoclaved ear bags.

Similarly about 20 fully emergent adults from the control ticks were attached to the ears of the rabbits in group 3 via ear bags. No ticks were attached to the ears of the rabbits in group 4.

All rabbits were examined three times a week for two months for evidence of dermatophilus lesions. The rate of attachment, engorgement, and onset of dermatophilus lesions for these ticks were recorded. Skin biopsies from suspected lesions were taken to the laboratory where they were divided into two portions.

The first portion was crushed with few drops of sterile distilled water and smeared on microscopic glass slides, air dried, fixed under the flame and stained with Gram's stain. The slides were then examined for D. congolensis under oil immersion magnification of the microscope. Some of the crushed lesion was also cultured on 10% sheep BA plates by sprinkling the crushed material on plates. The identities of all colonies that appeared on the plates were determined using colonial, microscopic and biochemical characteristics according to standard techniques (Macadam and Haalstra, 1971 and Gordon, 1974).

The second portion of the suspected skin lesion was fixed in 10% formalin and processed for histopathology, using the haematoxylin and eosin (H & E), Gram's and Giemsa stains and examined for D. congolensis. Other characteristic histopathological lesions of D. congolensis infection were also looked for.

RESULTS

Dermatophilus congolensis in eggs and larvae from engorged Amblyomma variegatum.

Weights of individual ticks from cattle were found to be between 0.60 gram and 5.0 gram. Tick weights of 2.5 to 3.5 gram were found to be best for high number of oviposition and subsequent larval hatching. Most of the engorged ticks heavier than 4.0 gram were seen to die without any egg deposition.

Eggs of two ticks (H_4 and H_9) out of the 24 ticks in group A were positive for D. congolensis on direct smear and culture examinations while none of the eggs from ticks in group B was positive for the organism. The larvae from the eggs that were positive were however negative for the organism.

Larvae from one tick (G_2) out of the 24 ticks in group A was positive for D. congolensis on both direct smear and culture examination. However, none of the larvae from group B was positive for D. congolensis.

Trans-ovarian transmission studies of D. congolensis.

For the pre-oviposition, oviposition to hatching, larval pre-feeding and larval feeding periods of the ticks used in this study were 8.1 $\pm$ 3.9, 54.4 $\pm$ 5.9, 8.1 $\pm$ 5.6 and 8.3 $\pm$ 2.5 days respectively.

Culture of swabs from rabbit ears and cages prior to tick attachment were positive for Proteus sp., Pseudomonas sp. and Staphylococcus aureus only.

All groups 1 and 2 rabbits exposed to larvae from group A ticks were seen to develop hyperaemia at tick attachment sites as early as three days post larval attachment. Cutaneous nodules were seen eight days post attachment and persisted for as long as 18 days post attachment. With the exception of F_2, H_1, and H_5 in group A larvae, none of the other larvae of group A and group B produced any lesions resembling those of D. congolensis infection. However, even from those which developed scabs (F_2, H_1 and H_5) the organism could not be recovered. None of the rabbits in the control (group 4) showed any lesions throughout the course of the study.

Trans-stadian transmission studies of D. congolensis

Tick life cycle: Amblyomma variegatum required a minimum of 151 and a maximum of 256 days to complete its life cycle from engorgement time (Table 3.1 and Appendix 3.1). The pre-oviposition and oviposition to hatching periods of the tick were 8 to 17 and 57 to 62 days respectively. The larvae attached onto the ears of the rabbits in 24 to 48 hours and completed their engorgement in 6 to 9 days post attachment. Similarly, the nymphae (experimental) that attached

to the scrotum of the bull (A_1, B_6, B_7 and B_8 ticks) and those (control) that fed on the rabbits (B_2 and B_{6R}) completed their meal in 5 to 12 days. Adult female ticks completed their meal on rabbits in 8 to 14 days while male ticks were seen to feed for as long as 39 days or longer (Appendix 3.1).

Larval Infestations: All the eggs and larvae (pre-feeding and post-feeding) from both the experimental (A_1,B_6, B_7 and B_8) and control (B_2 and B_{6R}) ticks collected from the field were negative for D. congolensis on both direct examination and culture (Table 3.2 and Appendices 3.2 and 3.3)

None of the larvae from both the experimental and control ticks produced any skin lesions compatible with D. congolensis infection. The only visible lesions were hyperaemia and swelling at the tick attachment sites and these lesions disappeared by the tenth day post attachment of ticks. No D. congolensis could also be recovered from the attachment sites of these ticks.

Nymphal Infestations: All the nymphae (both experimental and control) were negative for D. congolensis before attachment to either the bull or rabbits (Table 3.2). However, all the four experimental nymphae upon engorgement on the infected bull scrotum,

were positive for D. congolensis on direct smear examination in three out of four examinations (Appendix 3.4). Both filamentous and coccoid forms of the organism were easily demonstrable under oil immersion magnification of the microscope (fig. 3.3). None of the corresponding culture attempts revealed D. congolensis. Only Staphylococcus epidermidis, Proteus sp. and Pseudomonas sp were observed on BA plates (Appendix 3.5). None of the post-attachment nymphae of the B_2 and B_{6R} control ticks showed any evidence of D. congolensis either on direct smears examination or on culture and isolation (Table 3.2).

Adult Infestations: Emerging adult ticks (A_1, B_6, B_7 and B_8) that fed on the infected scrotum of the bull as nymphae were positive for D. congolensis on direct smear though no positive isolations were observed on culture (Table 3.2). These ticks were seen to attach on the ears of rabbits readily, though males tended to attach better than the females of all the ticks.

The sites of adult tick attachments looked hyperaemic by day 3 post attachment and by day 7 post-attachment, crusts were observed on the ears of rabbits with A_1 adult ticks (fig. 3.4). Such crusts were found to be positive for D. congolensis on direct smear examination while attempts to isolate the organism on

culture proved difficult as S. aureus tended to overgrow the plates. These sites continued to be positive for D. congolensis on direct examination for up to 20 days post attachment of ticks (Appendix 3.6). None of the rabbits exposed to B_6, B_7 and B_8 ticks developed lesions compatible with dermatophilosis (Appendices 3.7, 3.8 and 3.9). However, like the rabbits exposed to A_1 ticks, most rabbits with ticks attached, developed tick bite dermatitis and isolates from such lesions were mostly Staphylococcus sp. and Proteus sp.

None of the rabbits exposed to B_2 and B_{6R} control ticks developed any lesions compatible with dermatophilosis. Similarly, none of the rabbits that had no ticks attached developed any dermatophilosis or any dermatitis lesions.

Histopathological lesions of groups 1 and 2 rabbits infested with A_1 ticks indicated extensive penetration of the epidermis by filaments of D. congolensis. The follicle sheats were most affected. There were hyperkeratosis, acanthosis and folliculitis. There were also extensive granulocytic infiltration in the dermis especially at the dermal-epidermal function (Fig. 3.5)..

DISCUSSION

Dermatophilus congolensis in eggs and larvae from engorged A. variegatum

The inability of ticks weighing less than 1.0 gram to produce eggs could be due to the fact that they had not engorged enough blood necessary for egg production. On the other hand, the mortality in ticks weighing more than 4.0 gram could be attributed to toxic indigestion arising from excessive ingestion of blood meal.

The presence of D. congolensis in the eggs of two ticks and in the larvae of one tick collected from grossly infected cattle would suggest an endogenous contamination (adult to ova) since possible exogenous contamination has been eliminated by the 70% ethyl alcohol.

The endogenous contamination could not however be an efficient method of transferring the organism since the organism could not be demonstrated in the corresponding larvae. For the same reason, it was difficult to explain the source of the organism in the larvae of one tick only as obtained in the study.

Trans-ovarian transmission studies of D. congolensis

The absence of characteristic dermatophilus lesions on rabbit ears as well as the inability to

isolate D. congolensis from the ears of the rabbits exposed to the larvae in group A would suggest the absence of the organism in the larvae. The absence/ very low level of recovery of the organism in both the eggs and larvae of these ticks further suggest non-trans-ovarian transmission.

The presence of Proteus sp. Pseudomonas sp. and S. aureus in the cultures of the rabbit ears confirm observation of the skin being a microhabitat for microorganisms (Noble, 1975).

From the examination of the eggs, larvae and rabbit ears exposed to larvae from group A ticks, it would seem unlikely that D. congolensis could be trans-ovarially transmitted by A. variegatum.

Trans-Stadian Transmission Studies of D. congolensis

From this study it has been shown that A. variegatum was capable of completing its life cycle solely on rabbits since ticks in the control (group B ticks) were fed on rabbits only.

The fact that all eggs, larvae and pre-attachment nymphae of both the experimental and control ticks, obtained from uninfected animals, were negative for D. congolensis and no lesions compatible with those of dermatophilosis were observed on rabbit ears to which these

larvae were attached would suggest that these eggs and larvae were neither harbouring the organism nor capable of transmitting the organism at any stage. However, the presence of the organism in the nymphae and the resulting adults after being attached to the infected bull would suggest them being infected. Further, the resulting infection in the ears of the rabbits exposed to the A_1 adult ticks would suggest the tick harboured as well as transmitted the organism. It might be that the nymphae could be infected with the organism which then resisted the digestive as well as the moulting processes of the tick and got transmitted to the next stage.

The Dermatophilus lesions produced in rabbits by the ticks in this study persisted for 20 days post-attachment. This is in contrast to that reported by Macadam (1962) in cattle when he reported that the lesion persisted for up to three months.

The isolation of Pseudomonas sp., Proteus sp. and Staphylococcus epidermidis from the cultures of engorged nymphae and adults as well as isolation of S. aureus from the adult ticks and crusts from the rabbit ears would suggest contamination which might have inhibited the growth of D. congolensis. Proteus sp. is a fast growing organism and would cover up the medium before D. congolensis is able to produce any visible colonies (Addo, 1985).

The absence of growths from cultures of swabs from rabbit ears and rabbit cages would similarly suggest that there was no contamination with D. congolensis before the start of the experiment. Thus, the crusts and D. congolensis observed from rabbits exposed to A_1 adult ticks must have come from these ticks. These ticks had earlier on fed on an infected Bunaji bull as nymphae. It then follows that an infected nymph would pass the organism to the adult which can then transmit it to a susceptible host. This transmission would have resulted through either or both of two possibilities. First, it might be contaminative with the tick carrying the organisms through its various stages. Secondly, the tick might have transmitted the organism biologically since both the filamentous and zoospore forms of the organism were observed in both the post engorgement nymphae and in the adult ticks used in the study. Ear bags would not have harboured the organism since they were all autoclaved before the start of the study. Further, it is unlikely that the organism lives saprophytically on rabbits, since natural disease does not seem to exist in rabbits (Macadam 1962).

The incubation period for lesion development as seen in this study was shorter than that recorded by Macadam (1962) when he attached ticks from infected cattle to the ears of rabbits.

Table 3.2: Direct, Microscopic and Cultural Examinations of Amblyomma variegatum Eggs, Larval, Nymphal and Adult Batches for Dermatophilus congolensis.

Batch	Eggs		Larvae				Nymphae				Adults		Remark
			Pre-attachment		Post attachment		Pre-attachment		Post-attachment		Pre-attachment		
	Direct Smear	Culture	Direct Smear	Culture	Direct Smear	Culture	Direct Smear	Culture	Direct Smear	Culture	Direct Smear	Culture	
A_1*	-	-	-	-	-	-	-	-	+	-	+	-	Infected
B_6*	-	-	-	-	-	-	-	-	+	-	+	-	"
B_7*	-	-	-	-	-	-	-	-	+	-	+	-	"
B_8*	-	-	-	-	-	-	-	-	+	-	+	-	"
B_2**	-	-	-	-	-	-	-	-	-	-	-	-	Not Infected
B_{6R}**	-	-	-	-	-	-	-	-	-	-	-	-	"

KEY:

* = Experimental batches of Amblyomma sp.

** = Control " " " "

\- = Negative result

\+ = Positive result

Fig. 3.1: Rabbit with ear bag.

Fig. 3.2:- Dermatophilus infected bovine scrotum with scrotal bag.

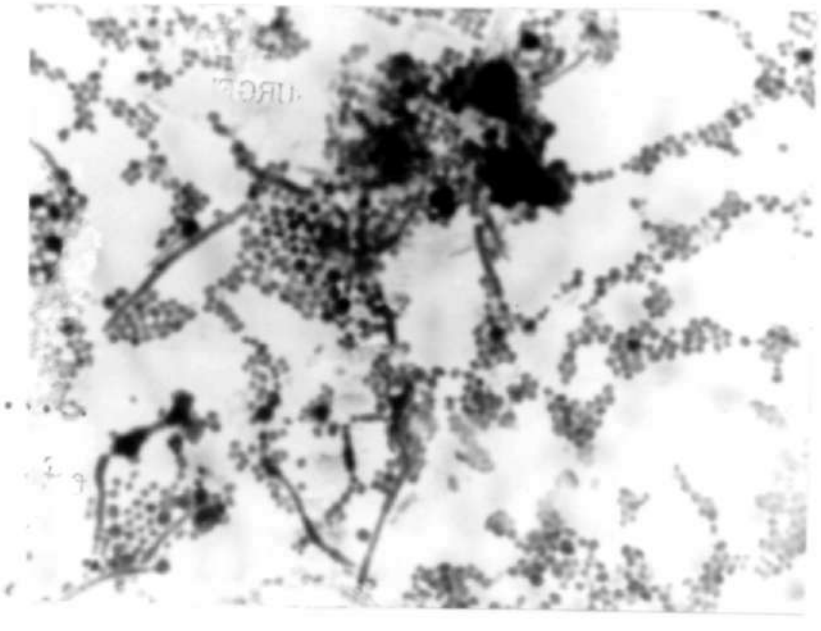




Fig. 3.3:- Filamentous (a) and coccoid (b) forms of Dermatophilus congolensis. (Grams stain, oil immersion objective magnification).

Fig. 3.4:- Ear of rabbit with crusts of dermatophilus lesions (arrows).

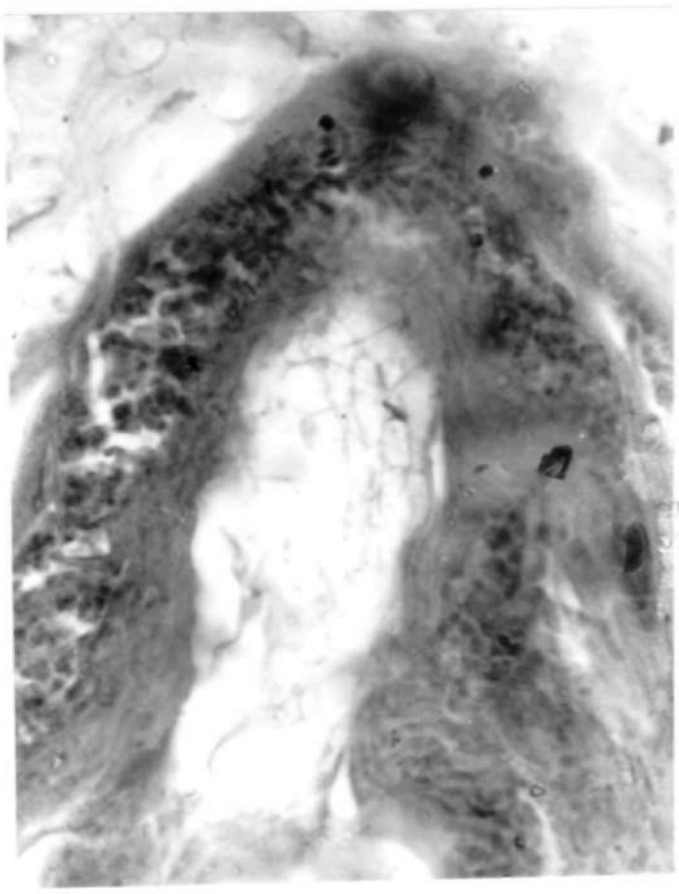


Fig. 3.5: Rabbit ear skin section with *Dermatophilus congolensis* infection. (H&E x 400). (Arrows show the filamentous forms of the organism in hair follicle).

CHAPTER FOUR

ROLES OF PREDISPOSING FACTORS IN DERMATOPHILOSIS

INTRODUCTION.

Dermatophilosis has been reported to be more prevalent during the rainy season when predisposing factors like thorns, tree branches, wetness of the skin and arthropods are most prevalent (Bull, 1929; Bida, 1969; 1973; Macadam, 1970 and Oduye, 1975b). Among arthropods, Oduye (1976a) incriminated insects as predisposing factors for dorsal lesions of dermatophilosis, ticks for axillary and genital lesions, and thorns for leg lesions. There does not seem to be any report of a closer examination of the relationship between predisposing factors, arthropods in particular, and dermatophilosis under field conditions.

This study has therefore been designed to determine:

1. The seasonal prevalence of dermatophilosis and ticks infestation in cattle and relation between them.

2. The correlation between infestation by ticks and lesion distribution in bovine dermatophilosis.

3. Susceptibility to dermatophilus infection and ticks infestation on different breeds of cattle.

4. Other arthropods infesting cattle as they relate to bovine dermatophilosis.

5. Modes of transmission as viewed by herdsmen.

6. Concurrent bovine dermatophilosis with other skin conditions.

7. Economic significance of bovine dermatophilosis.

MATERIALS AND METHODS

Area Studied: The former Zaria Province (now part of Kaduna State of Nigeria) constituted the area for the study.

Animals surveyed: Cattle from traditional herds and government owned farms in Zaria and Kaduna towns were used in the study.

A total of 216 herds, involving 12,352 cattle were surveyed. Among the herds surveyed, herd size ranged from three to 220 with a mean of 53.98±42.

Period of study: The study was conducted during the dry and wet seasons of October 1982 through April, 1984.

Survey Methods:

Arthropods/dermatophilosis relation: All animals in each herd surveyed were physically examined for the presence of ticks and their predilection sites. This was also done for other arthropods, dermatophilosis and other skin conditions.

Identification of arthropods and skin conditions: Ticks were identified using type museum specimens present in Entomology Laboratory of the Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria, Nigeria, as reported by Hoogstraal(1956) while the other insects were identified using keys and illustrations by Soulsby (1982). Skin conditions were diagnosed using their characteristic clinical signs and laboratory examination for the causative agents.

Degree of susceptibility of breeds of cattle to dermatophilosis and infestation by ticks: The affects of dermatophilosis and ticks infestation were determined on the five breeds of cattle (Bunaji, Pure Friesian, Bunaji-Friesian, Sokoto Gudali and Sokoto Gudali-Charolais crosses) encountered during the study.

Questionnaire: The views of herdsmen on the possible modes of transmission of D. congolensis were sought as per the questionnaire (Appendix 4.1).

Economic significance of dermatophilosis: The opinions of the herdsmen as well as herd observation on causes of losses due to dermatophilosis were documented using the questionnaire.

RESULTS

The seasonal prevalences of dermatophilosis and tick infestation.

Dermatophilosis was most prevalent during the rainy (wet) season (May to September, 16.04%) and was seen to regress in the dry season: (October to April, 0.87 - 1.82%) (Table 4.1). Similarly, the prevalence of infestation by ticks was highest during the rainy season (30.4%) and regressed thereafter in the dry season (11.6% - 27.11%) (Table 4.1).

Arthropods/dermatophilosis relation.

The seasonal body distribution of dermatophilosis and tick infestation are presented in Tables 4.2 and 4.3. During the rainy season, dermatophilosis was most prevalent at the external genitalia and least at the ventrum while in the dry season dermatophilosis was most prevalent at the back and neck, with the ventrum and tail hardly becoming infected (Appendix 4.2).

Infestation by ticks during the rainy season was seen to involve all. parts of the body evenly while in the dry season ticks were more prevalent at the extremities, external genitalia and the ventrum)(Appendix 4.3).

Occurrence of dermatophilosis or tick infestation as individual conditions on cattle during the rainy and dry seasons are presented in Appendices 4.2 and 4.3 respectively. The seasonal prevalence of dermatophilosis in association with tick infestation is presented in Table 4.4. Dermatophilosis was associated with ticks mainly at the external genitalia, extremities and the tail base. Ticks associated with dermatophilosis were mainly Amblyomma variegatum and Hyalomma spp, and such association was seen mostly during the rainy season. Dermatophilus lesions produced at tick sites were diffuse, matted, thickened and often oily (Fig. 4.1).

Insects were seen to alight randomly on both dermatophilus-infected and dermatophilus-free cattle. Stomoxys spp, and Lyperosia spp, were seen to particularly disturb dermatophilus infected cattle around the head, hump, and back, making such animals restless. Hippobosca spp. were also seen to bite at dermatophilus lesions.

Degree of susceptibility of breeds of cattle to dermatophilosis

Among the five breeds of cattle examined, Bunaji cattle were most abundant, followed by the Sokoto Gudali, Pure Friesian, Bunaji-Friesian and least was the Sokoto Gudali-Charolais crosses.

The prevalence of dermatophilosis in these cattle was highest in the exotic cattle and their crosses and least in the indigenous breeds. The prevalence of infestation by ticks was highest in Sokoto Gudali-Charolais crosses (96%) and least in Gudali (8.6%). Pure Friesian, Bunaji-Friesian and Sokoto Gudali - Charolais breeds of cattle were seen only in government owned farms where dipping schedules were practised.

Arthropods infestations

Ticks: Ticks encountered during the survey included Amblyomma variegatum, Hyalomma spp., Boophilus spp. and Rhipicephalus spp. (Table 4.5). Amblyomma variegatum and Boophilus spp. were most prevalent and were seen throughout the year while Hyalomma spp. was less prevalent and Rhipicephalus spp. was rare. Both A. variegatum and Boophilus spp. were more prevalent during the rainy season; with prevalence rates of 89.37% and 84.56% respectively. Their dry season

prevalence rates ranged from 43.77 to 55.44% and 57.14 to 79.7% respectively.

It was observed that the herdsmen attached great importance to A. variegatum and Hyalomma spp. only. According to them, these ticks cause diseases especially dermatophilosis. Thus they selectively hand-pick them twice daily and they use fire to kill them. They hardly pick Boophilus spp. as they regard them to be harmless. During hand-picking, they paid particular attention to the perineum, external genitalia, axillae and the lower limbs; areas most frequented by A. variegatum and Hyalomma spp.. Cattle in government farms were dipped with acaricides, though some of them were still found to be infested by ticks.

Insects: Insects observed infesting cattle included the house fly (Musca sp.), Stomoxys sp., Lyperosia sp. and Hippobosca sp. (Table 4.6). Stomoxys sp. and Lyperosia sp. were more prevalent during the dry season and were seen to bite mainly around the head, neck, hump and the back. The housefly was seen to alight at almost all parts of the body. Hippobosca sp. was seen to predominantly disturb the neck, hump, brisket, axillae and the ventrum parts of cattle.

Modes of transmission as viewed by herdsmen.

Agents considered by the herdsmen to transmit D. congolensis to cattle are presented in Table 4.7 and are grouped as ticks, insects and others.

Ticks: Ticks of the genera Amblyomma and Hyalomma were considered by the herdsmen to be the main 'transmitters' of dermatophilosis. Tick picking sites were also considered to result in tick abscess and/or dermatophilosis. Tick birds (Buphagus africanus africanus) were also reported by the herdsmen to be attracted to ticks on cattle and that dermatophilosis often developed at these sites. The main prediclection sites of these birds were the head, neck, thorax and the back (fig. 4.2).

Insects: Stomoxys spp., Lyperosia spp, Musca spp. and Hippobosca spp. were reported by the herdsmen to alight on both Dermatophilus-infected and disease-free cattle. The herdsmen observed that such disease-free cattle later developed dermatophilosis. They believed that Dermatophilus lesions at the hump and back were mainly due to insect bites.

Others: The herdsmen did not consider thorny bushes, horns and North-South migration to be significant factors in transmitting dermatophilosis.

Skin conditions other than dermatophilosis

Skin conditions encountered during the survey included besnoitiosis, demodectic mange, dermatomycosis, lousiness, rinderpest-skin lesions, sarcoptic mange, tick-abscess, wart (Papillomatosis) and wounds (Table 4.8). Among these demodectic mange was most prevalent (10.52%) while besnoitiosis was least (0.08%). Both dermatophilosis and demodectic mange were more prevalent during the rainy season than in the dry season (Table 4.8).

Lousiness was more prevalent during the dry season and was seen mainly around the head, neck, thorax and to a lesser extent at the tail tip of calves. Tick abscesses were most often associated with infestation by A. variegatum and they occurred mainly following forceful tick removal. Rinderpest-skin-lesion was seen in herds that had confirmed outbreaks of rinderpest. Such outbreaks were reported to reduce affected herds by up to 90% of their original sizes. Dermatophilosis was seen to occur in mixed infections with most of the skin conditions (Appendix 4.4).

Clinical besnoitiosis was seen in only one herd of 25 heads of cattle (prevalence 12%) throughout the course of the study. Clinically, the disease was characterized by fever, wrinkling of the skin, especially around the axilla and the stiffle joints,

in between the thighs, scrotum, and the vulva. Other clinical observations among the affected animals were lameness, mild anoraexia and weight loss. No mortality due to the disease was observed in any of the affected animals, though they had to be slaughtered for aesthetic reasons.

Economic significance of bovine dermatophilosis.

The opinions of herdsmen on the sources of losses on bovine production due to dermatophilosis are presented in Table 4.9. Lesions at the udder were reported to be the main sources of losses and that affected cows refused their calves to suckle. Furthermore, most of the affected udders ended up being destroyed. Culling was also reported by the herdsmen to account for as much as 50% losses due to very low prices at which such cattle were sold.

DISCUSSION

The Seasonal Prevalence of Dermatophilosis and Tick Infestation.

From the study, the seasonal prevalence of dermatophilosis and infestation by ticks were both found to be higher during the rainy season than in the dry season. This supports earlier observations (Kelley and

Bida, 1970; Bida, 1975 and Oduye, 1976a). These increased prevalences could be due to the increased predisposing factors that are necessary before the establishment of D. congolensis infection.

Arthropods/dermatophilosis relation

Dermatophilosis and arthropods infestation appeared to have definite patterns in body distribution and that the former seemed to be influenced by the latter. Dermatophilus lesions associated with tick infestation were observed mainly during the rainy season when these ticks were most prevalent. However, dermatophilus lesions associated with insects were more prevalent during the dry season. The difference in the type of pathology between the tick-dermatophilus and the insect-dermatophilus sites could be because ticks are more 'persistent' feeders than insects and so they could produce more delayed hypersensitivity (DHS) reaction with their saliva. Davis and Philpott (1980) experimentally produced chronic dermatophilus lesions with chlordinitrobenzene which mimmicks tick saliva. They observed that the lesions so produced were in every respect similar to that of natural dermatophilosis associated with tick infestation. Field observations where dermatophilosis was associated with ticks was also chronic, diffuse and matted (Bida, 1969, 1973; Oduye, 1976a and

Oppong, 1976). The tick hypostome, in addition to the tick saliva, could cause tissue reaction, thereby resulting in the chronic lesions so often seen.

Similarly, lesions produced at insect predilection sites were pin-point and discrete as these insects do not release 'persistent' saliva that will result in prolonged DHS reaction. Thus there seemed to be arthropod/dermatophilosis relation. Flowright (1956), Bida (1969) and Kelley and Bida (1970) reported that control of external parasites significantly reduced the prevalence of dermatophilosis. Flowright (1956) and Macadam (1964) reported observing new lesions with the increase in the intensity of A. variegatum and S. calcitrans infestations. Also, Macadam (1962) transmitted D. congolensis to the ears of rabbits and cattle using adult A. variegatum.

Degree of susceptibility of breeds of cattle to dermatophilosis.

The mean herd size as well as distribution of breeds as obtained in this study compared well with those reported for the same area under study by Kelley and Bida (1970) and Abdulkadir (1983). There does not seem to be any change in the dermatophilosis

herd infection rate with that reported by Bida and Dennis (1976).

From the study, there appears to be breed susceptibility differences in both dermatophilosis and tick infestation as the exotic breeds and their crosses seemed to be more severely affected by the two conditions in the same environment. It could be that these breeds are more naturally (innate) susceptible to dermatophilosis and tick infestation, although Memery and Thiery (1960) argued that adaptation to the environment alone might have a role to play in dermatophilosis.

Arthropods infestations

The higher prevalences of A. variegatum and Boophilus spp, as observed in this study agreed with those of Plowright (1956) and Mohammed (1974). A. variegatum and Boophilus spp and to a lesser extent, Hyalomma spp could be regarded as most important economically among ticksinfesting cattle in Nigeria. The hand picking control method as practised by the herdsmen does not seem to be an efficient method of control as some of the cattle still come down with dermatophilosis and tick-borne diseases. However, it might succeed in reducing the losses that

could have been incurred through the destruction of the teat and udder and dermatophilosis of the extremities, often seen associated with these ticks. The non-picking of Boophilus spp. by the herdsmen clearly showed that they were ignorant of the havoc these ticks could cause.

Possible modes of transmission as viewed by herdsmen

The belief of the herdsmen that arthropods cause skin discontinuity which lead to establishment of dermatophilosis, (since the organism lives saprophytically on the skin) agreed with observations of other workers (Zlotnik, 1955; Roberts, 1967a and Oduye, 1976a)

Ticks seemed to be the main agents suspected by the herdsmen to transmit D. congolensis. Their suspicion is supported by the work of Plowright (1956), Bida (1969) and Oduye (1975a). The tick picking as practised by the herdsmen could result in dermatophilosis in many ways. Firstly, the site of tick removal constitutes a discontinued skin, a factor in favour of D. congolensis infection. Secondly, the hand of the tick-picker could be contaminated with the organism so that as he removes ticks from an animal he transmits dermatophilosis at the tick attachment site. This could also account for the role of tick-birds (Buphagus africanus africanus, 'charki' in Hausa)

and D. congolensis to follow since the former has legs and mouth parts that might aid in the invasion. The inflammatory exudate that is produced following the entery of D. folliculorum bovis might also aid D. congolensis to germinate and establish its infection.

The low prevalence of bovine besnoitiosis as observed during this study might be due to the usual inapparent infection associated with the disease (Oduye, 1974). The economic significance of demodectic mange and besnoitiosis in Nigerian cattle could be due to damage to hide and weight loss which results in low market value of both the animal and the hide.

Possible economic significance of bovine dermatophilosis

From the observations in this study and views of the herdsmen, the economic significance of dermatophilosis seems to arise from damages to hides, udder, teat, progressive weight loss and general low market value of affected animals. Accurate determination of these losses in monetary value is difficult to arrive at due to the reporting system, the migratory habits of the herdsmen in search of good feed and water and inaccurate slaughter figure return and lack of statistical figure of livestock population in Nigeria.

From this study, arthropods seem to act as important predisposing factors in dermatophilosis and that there seems to be a definite dermatophilosis/arthropod relationship. Apart from arthropods, factors considered by the herdsmen to play a role in establishing Dermatophilus infection include tick-birds, thorns, North-South migration and new additions of Dermatophilus-infected animals. These beliefs by the herdsmen have been reported by other workers though not much experimental studies have been made to test the beliefs. From the study, it seems that the main economically important bovine skin conditions are dermatophilosis, demodectic mange and besnoitiosis as they result in damages to hides, weight loss, and low market value of severely affected cattle.

Table 4.1: Seasonal prevalence of dermatophilosis and infestations by ticks on cattle in Kaduna State of Nigeria.

Condition	May-Sept 1983	Oct.-Dec. 1983	Jan.-April 1984
Dermatophilosis	5,883* (16.04%)**	3,792 (1.82%)	2,408 (0.87%)
Infestation by ticks	5,883 (30.40%)	3,792 (27.11%)	2,408 (11.60%)

KEY:

* = Nos. animals examined during the period

** = Percent animals examined infected with condition.

Table 4.2: Body distribution of dermatophilosis in cattle during the year.

Season	No. animals examined	Head	Neck	Ext. genitalia	Legs	Back	Ventrum	Tail
May-Sept. 1983	5,853	83* (1.41%)**	53 (0.90%)	85 (1.45%)	81 (1.38%)	82 (1.39%)	19 (0.32%)	45 (0.08%)
Oct-Dec. 1983	3,792	6 (0.16%)	20 (0.53%)	19 (0.50%)	12 (0.32%)	45 (1.19%)	2 (0.65%)	7 (0.18%)
Jan-Apr. 1984	2,405	2 (0.08%)	7 (0.29%)	4 (0.16%)	3 (0.12%)	15 (0.62%)	0 (0.00%)	0 (0.00%)

KEY:

* = Number with dermatophilus lesions at site

** = Per cent with dermatophilus lesion at site

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Table 4.3: Variation of body distribution of ticks on cattle during the year.

Season	No. Cattle examined.	Head	Neck	Ext. genitalia	Legs	Back	Ventrum	Tail
May-Sept 1983.	5,833	89* (1.51%)**	116 (1.97%)	244 (4.19%)	156 (2.65%)	46 (0.78%)	49 (0.83%)	110 (1.87%)
Oct-Dec. 1983.	3,792	139 (3.67%)	310 (8.15%)	474 (12.50%)	433 (11.41%)	179 (4.72%)	497 (13.11%)	187 (4.95%)
Jan.-Apr. 1984.	2,408	12 (0.50%)	30 (1.25%)	126 (5.23%)	66 (2.74%)	4 (0.17%)	65 (2.70%)	30 (1.58%)

KEY:

* = Number of animals with ticks at site

** = Per cent animals with ticks at site.

Table 4.4: Ticks: dermatophilosis association, and seasonal prevalence in Kaduna State of Nigeria.

Season	No. Cattle examined	Head	Neck	Ext. genitalia	Legs	Back	Ventrum	Tail
May-Sept 1983.	5,833	19* (0.32%)**	11 (0.19%)	59 (1.00%)	27 (0.46%)	10 (0.17%)	9 (0.15%)	38 (0.65%)
Oct-Dec. 1983.	3,792	1 (0.03%)	2 (0.06%)	14 (0.52%)	4 (0.12%)	2 (0.06%)	0 (0.00%)	3 (0.09%)

KEY:

* = Number of animals with mixed infections at site

** = Per cent animals with mixed infections at site.

Table 4.5: Seasonal prevalence of three tick genera infesting cattle in Kaduna State of Nigeria.

Tick genera	May - Sept 1983	Oct - Dec. 1983	Jan. - April 1984
Amblyomma spp.	89.37%*	55.4%	43.77%
Boophilus spp.	84.56%	79.70%	57.14%
Hyalomma spp.	3.96%	7.21%	10.92%

KEY:

* Per cent 216 herds examined with tick infestation.

Table 4.6: Seasonal prevalences of insects infesting cattle in Kaduna State of Nigeria.

Insect	May - Sept 1983	Oct - Dec. 1983	Jan. - April 1984
Hippobosca spp.	15.39% *	26.99%	27.59%
Lyperosia spp.	9.81%	46.94%	26.32%
Musca spp.	76.29%	79.20%	90.93%
Stomoxys spp.	9.27%	43.80%	29.83%
Others	3.96%	0.00%	0.00%

KEY:

* Per cent of 216 herds examined with infestation by insect.

Table 4.8: Seasonal prevalence of bovine dermatoses in Kaduna State of Nigeria

Period	No Cattle Examined	Demodectic Mange.	Dermato-mycosis	Dermato-philosis	Lousiness	Rinderpest Skin-lesion	Sarcoptic Mange	Tick-abscess.	Wart)(Papilloma-tosis.)	Wound
May - Sept (1983)	5883	20.7*	9.28	16.04	0.63	0.0	6.66	11.41	3.33	0.63
Oct.-Dec. (1983)	3792	9.92	5.34	1.82	7.25	2.33	12.80	16.26	8.80	0.0
Jan.-April (1984)	2408	0.45	0.06	0.87	0.47	0.40	1.13	0.08	0.49	0.0

KEY:

* = Per cent animals with skin condition.

Table 4.9: Herdsmen's views on economic significance of bovine dermatophilosis on livestock production.

No. Herds sampled	Reduced milk yield %	Udder destruction. %	Teat damage %	Vulva damage %	Scrotum damage %	Mating difficulty %	Infertility %	Effect on calving. %	Reduced selling price %	Culling %
213	36.00*	36.23	8.55	9.86	2.74	7.00	2.72	0.00	26.00	13.21

KEY:

* = Per cent herds surveyed indicating losses through this item.





Fig. 4.1: Dermatophilus lesion at tick attachment site.

Fig. 4.2: Tick birds (arrows) on bull.

CHAPTER FIVE

EFFECTS OF ACARICIDES ON DERMATOPHILOSIS

INTRODUCTION

Various forms of medication such as antibiotics, antimycotics, antiseptics, acaricides and various other preparations have been used in an attempt to treat dermatophilosis. The use of antibiotics has been reported to have variable results (Roberts and Graham, 1966; Saidu et al., 1978 and Ogwu et al., 1981)

Blancou (1976) observed that antimycotics had irregular and generally poor results against D. congolensis while antiseptics such as quarternary ammonium compounds have a questionable therapeutic value against D. congolensis. However, cresol and copper sulphate salts had effects only when associated with an ixodicide.

The use of acaricides against D. congolensis infection dates back to the reports of Curasson and Mornet (1941) and Zlotnik (1955) when they reported that arsenicals had definitive preventive action against the disease. These reports were later followed by that of Plowright (1956) in Nigeria who showed

that Gammaexane[R] dips were preventive against D. congolensis infection. Presler (1973) and Van Breuseghem et al. (1976) showed that Coppertox[R] and Altik[R] were bactericidal against D. congolensis in vitro.

This work has been designed to study the in-vitro and in-vivo affects of selected acaricides on D. congolensis.

MATERIALS AND METHODS

Acaricides

Four commonly available acaricides, Pfizona[R][1], Delnav[R][2]; Triatix[R][3] and CBM8[R][4] were used in the in-vitro and in-vivo experimental studies.

Dermatophilus congolensis culture.

The Dermatophilus congolensis strain used in this study was obtained from scabs collected from a confirmed dermatophilus-infected Friesian X Bunaji.

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1. Pfizona[R]-20% W/V 2-chloro-1- (2,4 dichloro-phenyl vinyl diethyl phosphate), Pfizer (Nig.) Ltd. Ikeja, Nigeria.
2. Delnav[R] DFF - 100% W/V Diexanthion, Cooper McDongall and Robertson Ltd. Barkhamstead, England.
3. Triatix[R] - 12.5% W/V, Amitraz, The Wellcome Foundation Ltd., London, England.
4. CBM8[R] - base of carbamate, T.A.D. Pharmazeutishes Werk GMBH D-2190 Cuxhaven, F.W. Germany.

cow. Pure culture of the organism was prepared using Haalstra's (1965) method of isolation. The colonial, microscopic and biochemical characteristics of the strain of the organism used are presented in Table 5.1.

In-vitro trial

Two separate experimental protocols were used in the in-vitro trial.

Protocol I: The four selected acaricides were diluted in double dilution as shown in Table 5.2 using distilled water. The dilutions were then incorporated in blood agar (BA)[1] and brain heart infusion (BHI)[2] broth from which growth plates and tubes were prepared respectively.

The BA plates and BHI tubes were incubated aerobically overnight at 37°C to ascertain their sterility. Any plate or tube that indicated contaminant growth were discarded from the experiments.

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1. Blood agar base - Code CM55 batch no. 206 17146.
   Oxoid Ltd, London SE 1 9HF.

2. Brain Heart Infusion - Code 225 batch no. 302 27134
   Oxoid Ltd.,
   Basingstoke, Hants,
   England.

Fourty eight hour blood agar culture of known Dermatophilus congolensis described earlier was then inoculated onto the acaricide - incorporated plates and tubes for all the dilutions mentioned above.

Four of each of plain BA plates and BHl tubes were also prepared using distilled water alone and similarly, incubated overnight and then inoculated with the pure culture of the D. congolensis strain as controls. All the inoculated plates and tubes were then incubated aerobically at 37°C for 7 days with daily examinations for the growth. Gross examination consisted of identification of colonies with characteristics compatible with D. congolensis. Microscopic examination consisted of Gram's staining of direct smears and examination for Gram positive branching filaments and zoospores characteristic of D. congolensis. Similarly, biochemical tests were carried out to further determine the identity of the organism under study.

Protocol 2: The 48 hour blood agar culture of known D. congolensis described earlier was also inoculated into plain BHl broth tubes and incubated aerobically at 37°C for another 48 hours.

Meanwhile, 8ml of each acaricide at a dilution commonly used for external parasite control, was added

into two sets of five sterile tubes each (Table 5.3). To a third set of five sterile tubes were added 8ml sterile distilled water as control.

Following the incubation, 2ml of the 48 hour D. congolensis BHI broth culture were added to the first and third sets of tubes (Table 5.3). To the second set of tubes 2ml of sterile BHI broth were added. All tubes in the three sets were shaken to mix the contents and the respective tubes were allowed to stand for zero, 30 seconds, 30 minutes, 1 hour and 2 hours (Table 5.3).

After the exposure of the organism to the acaricides for the specific periods, all the tubes were again shaken to mix the contents and loopful from each tube was then used to inoculate four sets of plain BA plates, which were then incubated aerobically at 37°C for 7 days with daily examinations for the presence of D. congolensis.

In-vivo trial*

Experimental trial: Two acaricides, Pfizona^{R} and Delnav^{R} were used at concentrations recommended for

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* The choice of herds for this trial was governed more by availability of the herd for the trial rather than breed; variation in breed is not by design.

the control of external parasites (Table 5.2).

Delnav^{R} was used as a dip solution while Pfizona^{R} was used to bath and dip Dermatophilus infected cattle twice weekly and response noted over an eight week period. Lesion regression was considered as a positive response (healing) to the treatment. This lesion regression should involve dropping of scabs, appearance of new hair growths and normalization of the skin appearance.

Delnav^{R} was used in a herd of 25 heads of Gudali-Charolais cattle in which all the 25 cattle were infected at various levels with D. congolensis (Table 5.4). Pfizona^{R} as a dip was used in two herds, with the first herd being that used for Delnav^{R} after being dipped for eight weeks without any appreciable sign of lesion regression. The herd was then left untreated for two weeks before being transferred to Pfizona^{R} trial. The second herd dipped in Pfizona^{R} consisted of 36 heads of pure Friesian cattle in which all the cattle were infected at various levels with D. congolensis (Table 5.5). The level of infection

of these cattle was determined by physical examination and scored before the start and at the end of the study (Appendix 5.1).

Field trial: Pfizona^{R}, a' a bath, at concentration recommended for use against external parasites was also used in infected Fulani cattle between October, 1982 to December 1983 during both dry and rainy seasons. On the whole, 32 infected Fulani herds involving 2,173 cattle were used during the field trial. All cattle used were of the Bunaji breed. Known dermatophilus infected cattle in these herds under study, were left unbathed during the course of the study as controls. The rate of lesion regression was recorded.

RESULTS

In-vitro trial

Protocol 1: Three of the four acaricides used, Pfizona^{R}, CLM8^{R} and Triatix^{R} inhibited the growth of D. congolensis in both the LA plates and LHl tubes at concentrations much weaker than those commonly used in the control of external parasites (Table 5.2).

No growths of the organism were seen in Pfizona^{R} containing plates and tubes at up to

1:2000 dilution. Growths were seen at 1:2800 dilution and beyond. Delnav^{R} inhibited the growth of the organism at 1:400 dilution, a dilution two and a half times stronger than that normally used for controlling external parasites.

CLM8^{R} inhibited the growth of the organism at up to four times dilution weaker than normally used to control external parasites. For this acaricide, D. congolensis colonies were seen at 1:6000 dilution, a dilution six times weaker than recommended for external parasite control.

Triatix^{R} inhibited the growth of the organism at up to four times weaker dilution than recommended for use against ectoparasites. Growths of the organism were only observed at four and a half times weaker dilution than recommended for use in dips.

Dermatophilus congolensis was seen to grow in all the control plates and tubes. Colonies appeared in most cases, within 24 hours post-inoculation. In both the control and experimental plates that allowed the growth of the organism, minute dirty white colonies that impregnated and stuck to the M. media were observed. By 48 hours beta haemolysis was observed (Fig. 5.1) while at 72 hours the colonies were yellowish to orange and still stuck to the medium and

were difficult to pick. Microscopically, by 24 hours post inoculation, only filamentous form of the organism were seen (Fig. 5.2). At 48 hours, a mixture of branching filaments and zoospores were demonstrable (Fig. 5.3), while from 72 hours onwards, colonies were predominantly made of zoospores (Fig. 5.4).

Protocol 2: The 48 hour BHI broth culture used in the study consisted predominantly of zoospores. The results of exposure of the organism to the acaricides is presented in Table 5.3. No growths of D. congolensis were seen in the BA plates in some of the exposures in set 1 and not in all the plates in set 2 which contained Pfizona^{R}, CBM8^{R} and Triatix^{R} solutions. However, growths were observed in all the plates in the exposures for set 1 of Delnav^{R} and in all the plates in set 3 used as control for all the acaricides.

Pfizona^{R} inhibited the organism at a minimum exposure of 30 seconds. The organism grew in Triatix^{R} and CBM8^{R} at exposures of zero and 30 seconds only. Longer incubation in these acaricides resulted in total growth inhibition even after 7 days incubation. Exposure to Delnav^{R}, however, for all time intervals did not stop the growth of the organism.

Gross and microscopic characteristics of the organism obtained from the plates were in every respect

identical to that obtained following the primary isolation of known Dermatophilus sp. as described earlier.

In-vivo trial

Experimental trial: The prevalence of dermatophilosis in each of the two herds before they were dipped with Pfizona^{R} was found to be 100%. The levels of infection as well as the rates of lesion regression for the two herds are similarly presented in Tables 5.4 and 5.5. Delnav^{R} did not seem to cause lesion regression in the first herd even after eight weeks dipping. Pfizona^{R} resulted in lesion regression in 21 of the 25 cattle in herd 1 and in 17 of the 36 cattle in herd 2 by the end of the eight week dipping programme. Lesion regression in these cattle was first seen two weeks after the commencement of dipping and by four weeks, lesions on most of the cattle were markedly reduced (Figs. 5.5 and 5.6). By the sixth week, 21 of the 25 cattle affected in herd 1 had almost completely lost their lesions.

Lesions at the head, neck and back were seen to regress fastest while those at the udder and vulva and to a certain extent the fetlock tended to persist in most cases. Lesion regression was evidenced

by feeling off of scabs, followed by new hair growth and complete disappearance of any signs of dermatophilosis lesions in affected areas (fig. 5.7).

Three out of the remaining four infected cattle in herd 1, whose lesions failed to regress after dipping, died of the disease. They had at least 90% of their body surface covered with lesions of the disease. Before death, the animals were emaciated and became recumbent but fed well until death (Fig. 5.8). They had no significant gross pathological lesions apart from those on the affected skin. Histopathological lesions consisted of hyperkeratosis, acanthosis and infiltration of filaments of D. congolensis into the epidermal layer and within the depths of several hair follicles (Fig. 5.9). They were also observed within the cornified epithelium of the hair shafts. The fourth non-recovered animal maintained the disease and had to be salvaged to avoid reinfecting the already cured animals.

Field trial: The prevalence of dermatophilosis in these herds ranged from 1.8 to 27.0% with a mean of 8.6%. The disease was seen to be more prevalent during the rainy season and that body surface coverage with dermatophilosis lesions was more often seen during the rainy season (Appendices 5.2 and 5.3).

In the dry season lesions were more often seen along the back and the hump. Some of the lesions at fetlock, udder, vulva and scrotum were seen to persist from the rainy to the dry season trial despite dipping.

The level of infection was in most cases low, with lesions being predominantly at the back, extremities, udder, vulva and scrotum or a combination of these sites being involved in one diseased cattle.

A total of 103 cattle were bathed with Pfizona^{R} during the field trial out of which 78 (75.7%) had near to complete lesion regression by the end of the eight week study period (Table 5.6). The process of lesion regression was similar to that described for the dipping programme. Similarly, the lesions at the vulva, udder and scrotum tended to persist beyond the eight week period of the study. However, there was a marked reduction of the lesions at these sites by the end of the study.

None of the unbathed infected cattle showed any appreciable lesion regression during the course of the study. The majority of them were culled by the Fulani herdsmen for fear of spread of the disease to other animals or death of the affected animals because of poor condition.

DISCUSSION

In-vitro trial

Following the inoculation, three of the four acaricides used in the in-vitro study (protocols 1 and 2) inhibited the growth of D. congolensis at dilutions much weaker than those recommended for external parasite control. Pfizona^{R} seemed to be most inhibitory (5x) followed by CLM8^{R} (4x) and then Triatix^{R}(4x) while Delnav^{R} was never inhibitory to D. congolensis in-vitro.

This inhibitory action of the three acaricides would tend to suggest that they were either bacteriostatic or bactericidal. The fact that they were able to inactivate the organism in 30 minutes would suggest that they were bactericidal. This is supported by the fact that no growths were observed in plates when they were streaked and incubated for as long as 7 days. Similar findings have been reported by Thorold (1950), Presler (1973) and Van Breusegham et al. (1976) for other acaricides.

From the study, there did not seem to be any detrimental effect of autoclaving temperatures on the acaricides (Protocol 1) since these acaricides dilutions prevented the growth of the organism

despite autoclaving during the preparations of the plates and tubes. Thorold (1950) also did autoclave his acaricide along with the media but he only obtained growth in his control plates.

In-vivo trial

The prevalence of dermatophilosis in the two herds dipped with Pfizona^{R} was much higher than in the Fulani herds. This could be due to breed susceptibility differences since the two herds consisted mainly of pure Friesian and Charolais crosses. These breeds have been shown to be more susceptible to *D. congolensis* infection than indigenous breeds of cattle like the Bunaji encountered in this study (Lida, 1975; Oduye, 1976a; Lida and Kelley, 1976; Lida and Dennis, 1976 and Lloyd, 1976). For the same reason, the disease was more severe in the exotic breeds and their crosses in the two herds dipped with Pfizona^{R}. The prevalence of the disease as seen in the Fulani herds agreed well with that earlier reported by Lida and Dennis (1976) and Oduye (1975b, 1976a).

The results of the *in-vivo* trials tended to confirm the results of the *in-vitro* study in that affected animals were observed to shed their lesions

in two to six weeks following the commencement of dipping or bathing with Pfizona^{R}. Thus the effect of bathing or dipping was not only on the ectoparasites but also on the organism itself. This finding is significant in that dermatophilosis along with ticks and tick-borne diseases are of great economic importance in Nigeria.

The three animals that died in herd 1 dipped with Pfizona^{R} must have died of the disease as there were no significant pathological (gross and histo-pathological) lesions other than those on their skin. Further, these animals were alert and fed well up to the time of death. The gross and histopathological lesions as seen in these animals agreed with those earlier reported for dermatophilosis (Lida, 1973; Amakiri, 1976 and Oduye, 1976b).

These animals had at least 90% of their body surface (skin) covered with dermatophilus lesions. The normal healthy skin is charged with thermo-regulatory mechanism, sebaceous secretory, sweat glands excretory and vitamin D synthesis functions. With this level of body surface coverage with lesions, one could safely assume that these functions would be adversely affected.

This study seems to be the first time an organophosphate (Pfizona^{R}), a carbamate (CBM8^{R}) and Amitraz (Triatix^{R}) have been systematically compared and shown to act directly against D. congolensis. The ineffectiveness of Delnav^{R} indicates that not all organophosphates preparations are effective against D. congolensis.

Table 5.1: Colonial, microscopic and biochemical characteristics of the Dermatophilus congolensis used in the study.

Colonial	Microscopic	Catalase	Oxidase	Oxidative fermentation.	Triple sugar iron gar	Nitrate reduction	Indole Production	Urea	Citrate	Motility	Gelatin liquefaction.	Litmus milk	Methyl red	Voges-Proskauer	Haemolysis	Temp (°C)	Glucose	Fructose	Lactose	References
Dirty whits to yellowish orange colonies that stuck to media.	Gram positive filaments and spores	+	+	-	-	-	-	-	+	+	+	+	-	-	+	37	+	+	-	This study
"	"	+			-							+	-	-		37			-	Mason and Bekker(1934)[1]
"	"	-								+		+			+	35 37	+	+		Plowright (1958)[2]
		+				+			+			+	+	+			+	+		Gordon (1964)[3]
		+			-		-	-	+		+		-	-	+					Macadam and Haalstra (1971)[4]

1. Mason, J.H. and Bekker, J.G.(1934). Onderstepoort J. Vet. Sci. and Industry 3: 211.
2. Plowright, W.(1958). J. Comp. Path. 68: 133-147.
3. Gordon, M. (1964). J. Bact. 88: 509-522.
4. Macadam, I. and Haalstra, R.T.(1971). Trop. Anim. Health. Prod. 3: 225-231.

Table 5.2: Inhibitory effects of acaricides on D. congolensis in vitro (Protocol 1).

Acaricides	Dilutions																Remarks.
	1:400	1:700	1:800	1:1000	1:1400	1:1600	1:2000	1:2200	1:2800	1:3200	1:4000	1:6000	1:6400	1:8000	1:10000	1:12000	
Pfizone(R) (1:400)*	-	ND	-	ND	ND	-	-	ND	+	+	ND	ND	+	ND	ND	+	Inhibitory at up to 5x weaker dilution than recommended for use and growths seen only at 7x weaker dilution as used in sprays/dips.
Delnav(R) (1:2000)*	-	ND	+	ND	ND	+	ND	+	ND	+	+	ND	ND	+	ND	ND	Inhibitory only at concentrations 2½x stronger than recommended for use in sprays/dips
CeMe(R) (1:1000)*	ND	ND	ND	-	ND	ND	-	ND	ND	-	+	ND	ND	ND	+	ND	Inhibitory at upto 4x weaker dilution than commonly used in sprays/dips. Growths seen at 6x weaker dilution than commonly used in sprays/dips
Triatix(R) (1:700)*	ND	-	ND	-	-	ND	-	-	+	ND	+	ND	ND	ND	+	ND	Inhibitory at upto 4x weaker dilution and growths seen at 4½x weaker dilution than commonly used in sprays/dips.
Control (Plain BA plates)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	Normal behaviours of the organism in ordinary BA media.

KEYS:

* = Concentrations commonly used.

ND = Not Done.

\+ = Growths seen.

\- = No growth seen.

Table 5.3: Bactericidal action of acaricides on Dermatophilus congolensis (Protocol 2).

Set	Pficona(R)	Exposure time					Set	CDMB(R)	Exposure time				
		0	30Secs	30min	1hr	2hr			0	30Secs	30min	1hr	2hr
1.	Culture + Acaricide	+	-	-	-	-	1	Culture + Acaricide	+	+	-	-	-
2.	Sterile broth + Acaricide	-	-	-	-	-	2	Sterile broth + Acaricide	-	-	-	-	-
3.	Culture + Sterile water	+	+	+	+	+	3	Culture + sterile water.	+	+	+	+	+

	Delnav(R)	Exposure time						Triatix(R)	Exposure time.				
		0	30Secs	30min	1hr	2hr	Set		0	30Secs	30min	1hr	2hr
1.	Culture + Acaricide	+	+	+	+	+	1	Culture + Acaricide	+	+	-	-	-
2.	Sterile broth + Acaricide	-	-	-	-	-	2	Sterile broth + Acaricide	-	-	-	-	-
3.	Culture + Sterile water.	+	+	+	+	+	3	Culture + Sterile Water.	+	+	+	+	+

KEY:

+ = Growth

- = No growth.

Table 5.4: In-vivo affects Of Delnav$^{(R)}$ on Dermatophilus congolensis infected cattle (Dipping at 1:2200 dilution).

Breed	Herd Size	No. Infected (%)	Types of infection			Lesion Regression Rate			Total (%)
			Mild	Moderate	Severe	Mild	Moderate	Severe	
Gudali-Charolais	25	25(100)	15	8	2	$\frac{0*}{15}$	$\frac{0}{8}$	$\frac{0}{2}$	0.0%

* = $\frac{\text{No with lesion regression}}{\text{No. infected in group.}}$

Table 5.5: In-vivo affects of Pfizona(R) on Dermatophilus congolensis infection (Dipping at 1:400)

Herd No.	Breed	Herd Size	No. Infected (%)	Degree of infection before dipping			Lesion Regression Rate			Total (%)
				Mild	Moderate	Severe	Mild	Moderate	Severe	
1	Gudali-Charolais	25	25(100)	15	8	2	15*/15	6/8	0/2	84.00
2.	Pure Friesian	36	36(100)	16	5	15	14/16	3/5	9/15	72.22
	Total.	61	61(100)	31	13	17	29/31	9/13	9/17	78.11

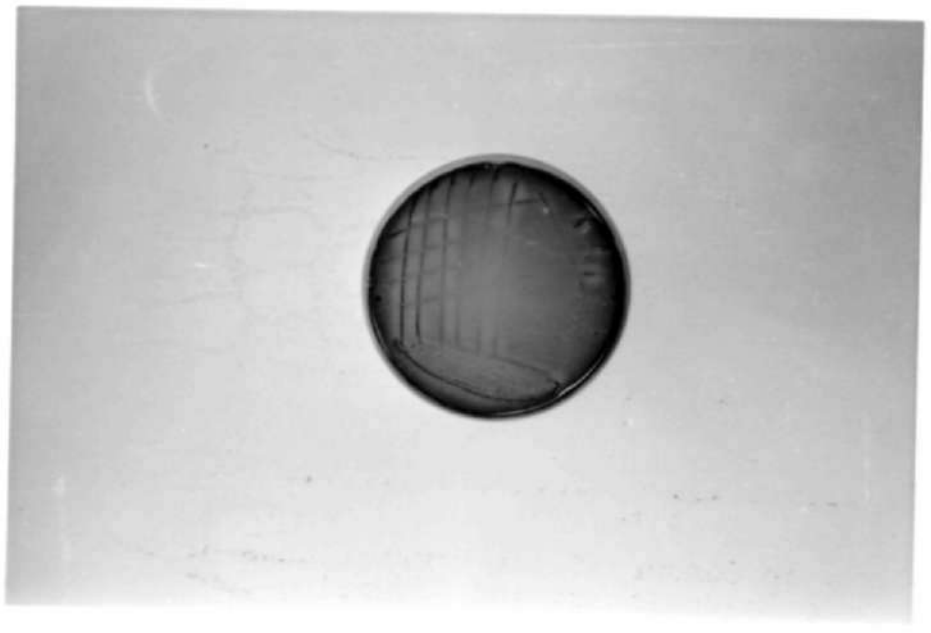
* = No. with lesion regression / No. infected in group.

Table 5.6: In-vivo affects of Pfizona(R) on Fulani Dermatophilus infected zebu cattle (bathing at 1:400) between October m1982 and December, 1983.

No.	Herd Size	No. Infected	Prevalence (%)	No. Treated	No. Recovered	(%) Recovered
1.	23	3	13.0	2	2	100.0
2.	47	4	8.5	3	2	66.7
3.	89	3	3.4	3	2	66.7
4.	95	4	4.2	2	2	100.0
5.	47	4	8.5	3	3	100.0
6.	129	5	3.9	3	3	100.0
7.	133	6	4.5	4	3	75.0
8.	134	3	2.2	3	2	66.7
9.	40	5	12.5	3	2	66.7
10.	50	2	4.0	1	1	100.0
11.	57	1	1.8	1	1	100.0
12.	14	2	14.3	1	0	0.0
13.	89	3	3.4	2	2	100.0
14.	47	7	14.9	4	3	75.0
15.	7	1	14.3	1	1	100.0
16.	50	1	2.0	1	0	0.0
17.	24	1	4.2	1	0	0.0
18.	81	4	4.9	2	1	50.0
19.	65	7	10.8	4	3	75.0
20.	81	3	3.7	3	3	100.0
21.	40	3	7.5	2	2	100.0
22.	100	27	27.0	10	6	60.0

Table 5.3 (Continued).

No.	Herd Size	No. Infected	Prevalence (%)	No. Treated	No. Recovered	(%) Recovered
23.	182	11	6.0	7	5	71.4
24.	101	17	16.8	10	8	80.0
25.	107	11	10.3	7	6	85.7
26.	92	10	10.9	6	4	66.7
27.	83	8	9.6	5	4	80.0
28.	42	5	11.9	3	2	66.7
29,	14	2	14.3	1	1	100.0
30.	27	2	7.4	2	2	100.0
31.	18	2	11.1	2	2	100.0
32.	65	2	3.1	1	0	0.0
To-tal	2173	169	8.6	103	78	75.7



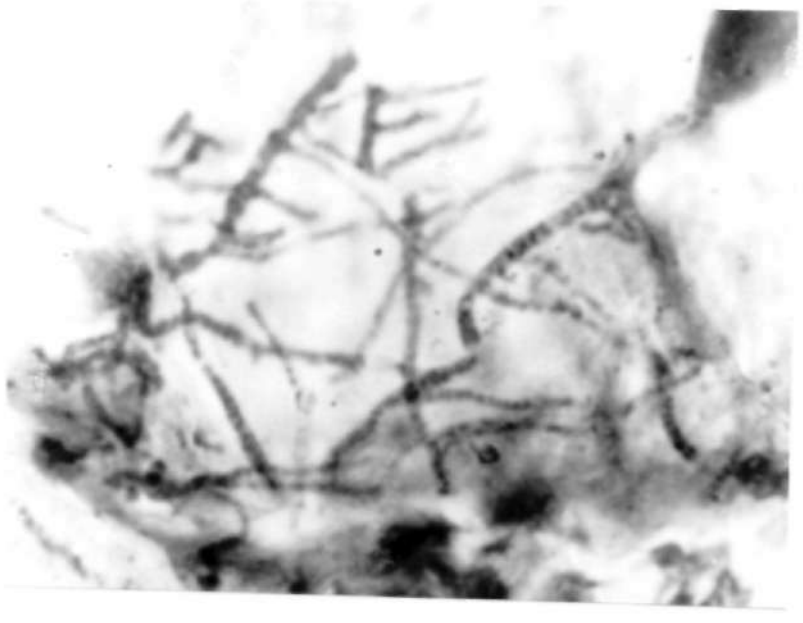
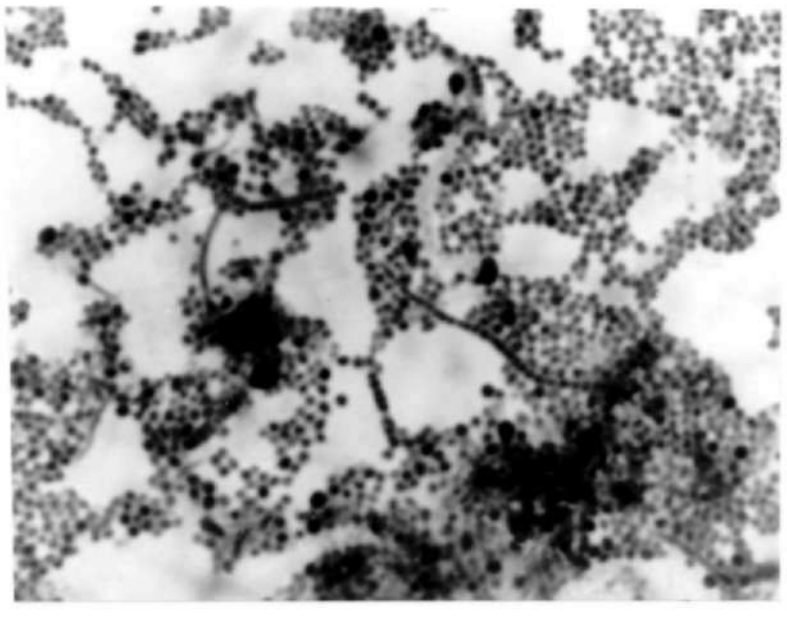


Fig. 5.1: Colonial appearance of 48 hour culture of Dermatophilus congolensis

Fig. 5.2: Gram-stained direct smear of a 24 hour blood agar culture of Dermatophilus congolensis.



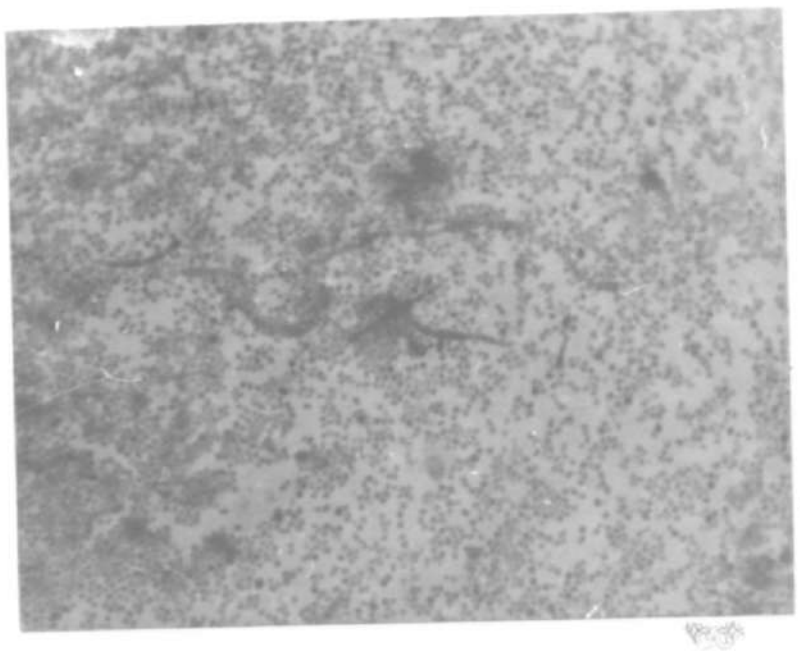
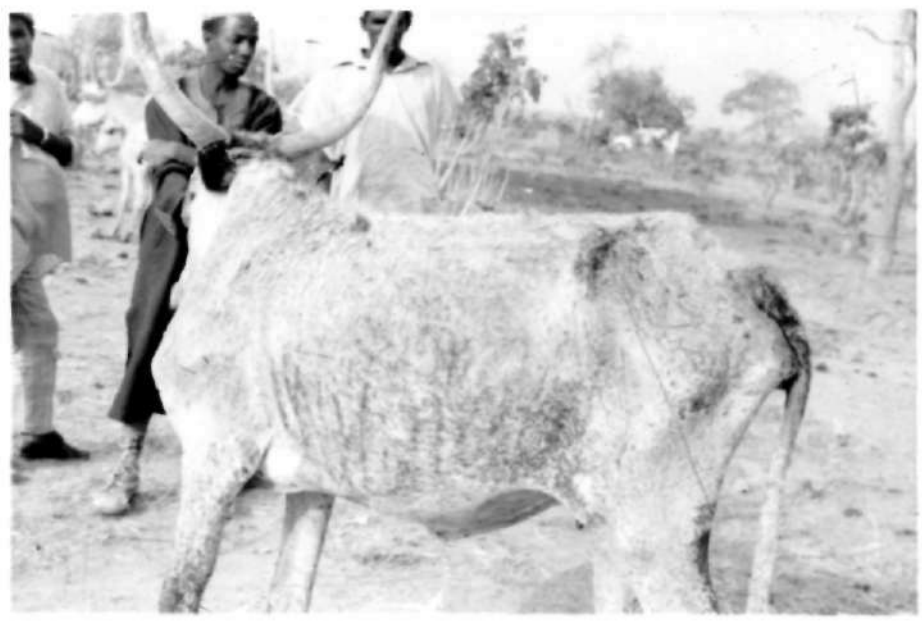


Fig. 5.3: Gram-stained direct smear of a 48 hour blood agar culture of Dermatophilus congolensis.

Fig. 5.4: Gram-stained direct smear of a 72 hour blood agar culture of Dermatophilus congolensis.



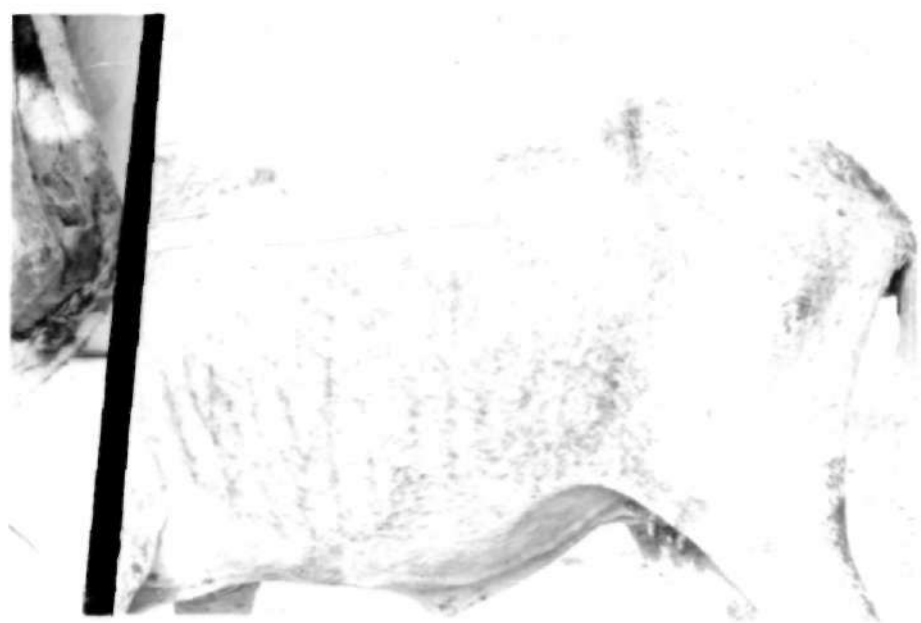


Fig. 5.5: Initial lesion regression in Zebu cattle receiving bath with Pfizona^{R} at 1:400 dilution.

Fig. 5.6: Advanced lesion regression in Zebu cattle receiving bath with Pfizona^{R} at 1:400 dilution.





Fig. 5.7: Almost complete lesion regression in Zebu cattle after six weeks of bathing with Pfizona^{R} at 1:400 dilution.

Fig. 5.8: Recumbent dermatophilus infected cow.

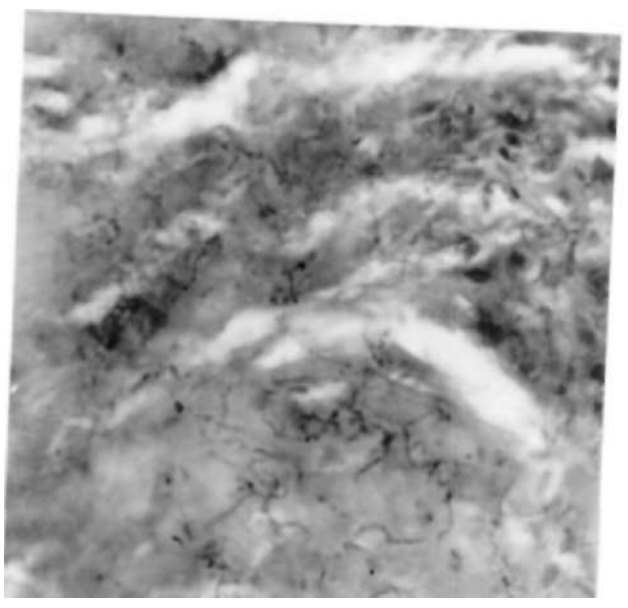




Fig. 5.9:- Skin section of dermatophilus infected cow showing Dermatophilus congolensis filaments (see arrows) (H.&.E. x 400).

CHAPTER SIX

THESIS SUMMARY AND CONCLUSIONS

Introduction

Little seems to be known as the roles of arthropods and acaricides in dermatophilosis. Field surveys on the disease have tended to incriminate arthropods (particularly Amblyomma variegatum, Stomoxys sp. and Lyperosia sp.) in the transmission, spread and maintenance of the disease in nature. Among the acaricides, organochlorides were reported to have some prophylactic effect on the disease. In order to determine the specific roles of arthropods in the transmission and acaricides in chemoprophylaxis of dermatophilosis, A. variegatum and specific acaricides were examined under both laboratory and field conditions. The issue of economic significance of the disease was also examined by the use of questionnaire.

Laboratory and Field Studies

For A. variegatum to be said to transmit D. congolensis, the organism must be demonstrated outside as well as inside the tick or the tick must be experimentally contaminated. It was observed in this study that 70% ethyl alcohol was not lethal to A. variegatum ticks for up to 15 minutes exposure (which was sufficient enough to kill all non-spore forming bacteria on the cuticular surface of the ticks) and that such exposed ticks laid eggs which hatched to larvae.

In order to prevent contamination of the cuticular surface of the ticks, attempts were made, using nail polish and pen-like-glue to seal the ani of the ticks during incubation. The pen-like glue (cyanoacrylate adhesive) was found to be more effective than the nail polish because it sealed the anus effectively and was not lethal to the ticks. Seventy five percent (75%) of the ticks whose ani were sealed

with the glue laid eggs which hatched to viable larvae whereas 60% of the ticks whose ani were sealed with nail polish died within 48 hours while the others died later. Thus eggs or larvae which were obtained from ticks whose cuticular surfaces were washed in 70% alcohol and whose ani were sealed with pen-like-glue could be assumed to be free from environmental contamination with D. congolensis. It seems plausible to conclude that any D. congolensis obtained from the eggs and larvae of such ticks could have come from within the ticks. Therefore the finding of D. congolensis by both direct smear and culture examinations, in two egg batches out of 24 ticks collected from Dermatophilus infected cattle (group A) and one larval batch from ticks after the alcohol exposure and anus sealing (group A) suggest that these ticks could have

been infected by the organism. None of the eggs and larval batches from ticks (group B) collected from clinically normal cattle was positive for D. congolensis.

The larvae arising from group A ticks did not transmit the organism to rabbits. Thus trans-ovarial transmission of D. congolensis, even if it could occur in this tick, has not been demonstrated in this study. On the other hand, four nymphal batches of A. variegatum, earlier on screened and found to be negative for D. congolensis, were found to acquire D. congolensis infection when they were fed on Dermatophilus infected bovine scrotum. Such infection was observed to be maintained by the ticks to the adult stage of all the four batches and that one out of the four such adult batches

of the ticks was observed to produce Dermatophilus lesions when attached to the ears of New Zealand white rabbits. Therefore, transstadial transmission of the organism by A. variegatum seems to be a more likely means of transmission of the organism in nature. This finding is in agreement with field observation, in which ticks particularly A. variegatum and Hyalomma spp. were found in close association with Dermatophilus lesions in the rainy season.

Sites where both these problems occurred together included the external genitalia, axilla, and the extremities. This was also the

observation of the herdsmen interviewed who associated A. variegatum with possible transmission of the disease. Thus they hand de-ticked the two genera of ticks mentioned above without paying such particular attention to other ticks like Boophilus spp. which they regarded as harmless.

Apart from ticks, insects were also observed to be closely associated with the disease in the dry season when both problems were found to occur most commonly around the head, thorax and the back.

Insects most commonly observed to be associated with Dermatophilus lesions included Stomoxys sp. and Lyperosia sp. though other insects like Musca sp. and Hippobosca sp. were also observed to alight on both Dermatophilus and non-Dermatophilus lesion sites. The herdsmen also had a similar observation when they associated the thorax, hump and back Dermatophilus lesions to be due to these insects. They tended to pay less attention to inanimate objects in the transmission of the disease.

Apart from dermatophilosis, other skin conditions encountered during the survey

included besnoitiosis (0.08%), demodectic mange (10.52%), dermatomycosis (4.89%), sarcoptic mange (6.88%) lousiness (2.78%), tick-abscess (9.25%), papillomatosis (4.21%) and wounds from other causes (0.21%). Among these conditions, demodectic mange was second only to dermatophilosis in prevalence while besnoitiosis was least. Lousiness was more prevalent in the dry season and was seen mainly around the head, neck, thorax and the tail tip of calves.

The prevalence rates of these skin conditions as determined in this study agreed with those earlier reported (Oduye, 1975). However, there does not seem to be any detailed work on the relationship between dermatophilosis and these other skin conditions.

The main sources of losses due to bovine dermatophilosis observed during the study include lesions on the teats, and udder resulting in decreased milk production and refusal of affected cows to allow their calves to suckle. Hide destruction and failure of affected cattle to attract less than 50% their normal price when culled were also observed to account for some of the losses. Losses determined in this study were mainly qualitative and similar results have been reported elsewhere. There is an urgent need to quantify these losses as it is only when these are arrived at that the actual economic importance of the disease can be determined.

An attempt was made in this study to control the disease, using acaricides.

It was observed that three out of the four acaricides (Ffizona^{R}, Triatix^{R}, and CBM^{R}) used were inhibitory to D. congolensis in-vitro at dilutions four to five times weaker than those normally used in dips. The fact that Ffizona^{R} proved effective in causing up to 75% clinical cure, when used twice weekly, in a dip solution or as a bath at 1:400 dilution on infected cattle over two to six weeks period, would suggest that these acaricides may have promising results as chemotherapeutic or chemoprophylactic agents against the disease. Thus these acaricides deserve a special attention for their possible additional use in cattle especially when many of the commonly available antibiotics have, over the years, proven their ineffectiveness against the disease.

The fourth acaricide, Delnav^{R}, did not have any effect on D. congolensis at both in-vitro and in-vivo trials. This indicates that not all organophosphate preparations inhibit D. congolensis either in-vitro or in-vivo or both.

Recommendations:

(1) From this study, arthropods, especially Amblyomma variegatum, Lyperosia sp. and Stomoxys sp. seem to have a definite relationship with dermatophilosis. Thus closer examination of these arthropods is needed to determine the mechanism of their roles.

The role of ticks in particular, either as biological or mechanical vectors, needs further investigation. In this regard, a much higher number of the eggs, larvae, nymphae and adult A. variegatum ticks from dermatophilus-infected cattle should be examined on the same line as has been done in this study.

Further, systematic dissection as well as sequential histopathological sectioning study of A. variegatum, Lyperosia sp. and Stomoxys sp. and possibly Boophilus sp. could help in determining the location of D. congolensis in these arthropods. There is also the need to examine the larvae and more of the nymphae of A. variegatum for their infectivity with D. congolensis and their subsequent transmission of the organism in the next instar.

(2) During this study, it was observed that dermatophilus lesions tended to vary with the parts of the body depending on the type of arthropods biting such sites. Thus, there is need to examine the salivary secretions of the ticks and insects commonly infesting cattle with a view to highlightening the cause and effect of such secretions in the pathogenesis of the disease.

(3) From this and earlier studies, it is evident that dermatophilosis is least prevalent in the dry season. Thus there is the need to determine in detail the mechanism of survival of the causative agent in nature especially with due regards to definate seasonal changes in the Savannah region of Nigeria.

(4) During this study, dermatophilosis was shown to occur in mixed infection with other skin conditions. It is possible that some of the conditions especially demodectic mange, might predispose to infection with D. congolensis. For example, the serous exudate which often results following initial infection with

D. fuloclorum bovis could serve as a nutrient for D. congolensis zoospores to establish infection.

The role of these skin conditions in dermatophilosis therefore needs to be determined.

(5) Dermatophilosis, as shown in this study, causes appreciable losses in the cattle industry. There is the need to quantify the losses through the hides, milk yield, reproduction and beef production. Such determinations should also be extended to losses annually occuring due to loss of working hours by draught cattle. Until these losses are accurately determined, losses through this disease will always remain a matter of estimate.

(6) Research efforts towards getting effective treatment against dermatophilosis have continued. The finding that Pfizona^{R} could be used to cure dermatophilus-infected cattle is an important step towards the success. However, the mode of action of this acaricide needs to be determined with a view to possibly

evolving a more specific drug that could be used parenterally or topically in the treatment and/or control of D. congolensis infection. The in-vivo effects of the other two acaricides used in this study as well as other acaricides commonly used in Nigeria also need to be further investigated.

This study, has shown that arthropods, particularly A. variegatum, could be significant in the epidemiology of dermatophilosis. It has also been shown that certain acaricides especially Pfizona^{R} could be used to treat and/or control dermatophilosis.

Thus arthropods do not only transmit blood parasites alone but are also involved in the transmission of bacteria like D. congolensis. Further, certain acaricides like Pfizona^{R} could not only be used against arthropods but also against dermatophilus infection.

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Appendix 1.1: Global Distribution of Dermatophilosis

Continent	Country	Species Affected.					References
		Bovine.	Ovine	Caprine	Equine	Others	
Africa (North)	-	-	-	-	-	-	-
(West)	Benin	+	-	-	-	-	Assogba (1979)
	Gambia	-	+	-	-	-	Macadam(1976)
	Ghana	+	-	-	-	-	Chodnik(1956 Oppong(1973)
	Nigeria	+	+	+	+	-	Henderson (1927) Plowright (1956 Oduye(1975a,b)
(Central)	Congo (Peoles Rep.)	+	+	+	+	+ Zebra	Balabanov & Boussafou (1977)
	Sudan	+	+	-	-	+ Camel	Anon(1922) Abu-Samara et al.(1976)
	Zaire (Belgian Congo)	+	-	-	-	-	Van Saceghem (1915)
(East)	Kenya	+	+	-	+	+ Zebra	Hudson(1937) Green (1956, 1957, 1960)
	Tanzania.	-	-	-	+	-	Bwangamoi (1969)
	Uganda	+	-	-	-	-	Bwangamoi (1968).
(South)	Zimbabwe (Rhodesia.)	+	+	-	-	-	Mammerikx (1961)
	South Africa	+	+	-	-	-	Bekker (1928) Schulz (1955)

Appendix 1.1 (Cont.)

Continent	Country	Species Affected.					References
		Bovine.	Ovine	Caprine.	Equine.	Others	
	Malawi	+	-	-	-	-	Kaminjolo and Kama (1981)
America (North)	Canada	+	-	-	-	-	Higgins et al. (1979,
	Guatemala	+	-	-	-	-	Kubes & Rine (1972)
	Mexico	+	-	-	-	-	Campos-Nieto (1979)
	United States	+	+	-	+	+ (deer, man, cotton tail rabbit.)	Bentink-Smith et. al.(1961) Bridges & Romane (1961) Dean et al. (1961). Shotts & Kistner(1970).
(South)	Argentina.	+	+	-	+	-	Perez Catan & Di Rocco(1963, 1965, 1966).
	Brazil	+	+	+	+	+ (man)	Buff D'Apice & D'Apice(1962) Barbosa et al. (1967, 1968, 1970). Londero et al. (1973)
	Chile	+	+	-	-	-	Flores et al. (1963) Zamora & Kruze (1973) Kruze et. al. (1975)
	Colombia.	+	+	-	-	+	Adams et al. (1970). Navarrete & Trheebilack (1979). Wobeser & Gordon (1969).
	Uruguay	-	+	-	-	-	Magallanes et al. (1959)

Appendix 1.1 (Cont.)

Continent	Country	Species Affected. Bovine.	Ovine	Caprine	Equine.	Others	References
Australia	Australia.	+	+	-	-	-	Bull (1929) McKenzie(1977)
	New Zealand	+	+	+	+	-	Anon (1979) Smith et al. (1967).
Europe (West)	Germany (West)	+	+	-	-	-	Weber et al. (1970 , 1975) Mumme & Supper (1982)
	Netherlands.	+	-	-	-	-	Dijkstra and Zandstra(1975).
	United Kingdom	+	+	-	+	-	Stableforth (1937) Kane et al.(1955) Nisbet and Bannatyne (1955). Hart(1976).
(East)	Hong Kong	-	-	-	+	-	Yip et al. (1970).
	India	+	-	-	-	-	Singh and Sikder (1971) Kharole et al. (1975).
Middle East	Israel	+	-	-	-	-	Nobel et al. (1971, 1976).
	West Indies	+	-	-	-	-	Informal FAO Publication.

Appendix 3.1: Life cycle of *Amblyomma variegatum* ticks at laboratory conditions of 28+± 5°C and relative humidity ≈ 85%.

Period	Condition	Mean ± S.D. (days)	Range (days)
Pre-oviposition	Laboratory	10.33 ± 3.04	8-17
Oviposition to hatching	"	58.50 ± 1.11	57-62
Larval pre-feeding	"	36.17 ± 7.38	20-41
Larval feeding	Rabbits	6.67 ± 1.11	6-9
Larval pre-moulting	Laboratory	15.00 ± 2.89	9-18
Nymphal pre-feeding	"	23.50 ± 12.96	13-48
Nymphal feeding	Rabbits and Bulls.	7.67 ± 2.49	5-12
Nymphal pre-moulting	Laboratory	23.30 ± 3.09	19-27
Adult pre-feeding	"	10.67 ± 2.92	6-14
Adult female feeding	Rabbits	10.00 ± 4.20	8-13
Adult male feeding	"	29.25 ± 9.91	>8

S.D. = Standard deviation.

Appendix 3.2: Direct smear and cultural examinations of eggs of Amblyomma variegatum for Dermatophilus congolensis.

Tick Batch No.	No. and type of Examinations.							
	Direct 1st smear.	Culture	Direct 2nd smear	Culture	Direct 3rd smear	Culture	Direct 4th smear	Culture
A_1*	-	-	-	-	-	-	-	-
B_6*	-	-	-	--	-	-	-	-
B_7*	-	-	-	-	-	-	-	-
B_8*	-	-	-	-	-	-	-	-
B_2**	-	-	-	-	-	-	-	-
B_6R**	-	-	-	-	-	-	-	-

KEY

* = Experimental batches of A. variegatum

** = Control " " "

*** = Negative for D. congolensis.

Appendix 3.3: Direct smear and cultural examination of larval batches of Amblyomma variegatum for Dermatophilus congolensis.

Tick Batch No.	No. and Type of Examinations.							
	1st		2nd		3rd		4th	
	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture.
A_1*	-	-	-	-	-	-	-	-
B_6*	-	-	-	-	-	-	-	-
B_7*	-	-	-	-	-	-	-	-
B_8*	-	-	-	-	-	-	-	-
B_2**	-	-	-	-	-	-	-	-
B_6R**	-	-	-	-	-	-	-	-

KEY:

* = Experimental batches of A. variegatum

** = Control " " "

*** = Negative for D. congolensis

Appendix 3.4: Direct smear and culture examinations of batches of engorged nymphae of Amblyomma variegatum that fed on scrotum of Dermatophilus-infected Bull or on rabbit ears.

Batch	No. and type of examination.							
	1st		2nd		3rd		4th	
	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear.	Culture
A_1*	+	-	+	-	+	-	-	-
B_6*	+	-	+	-	+	-	-	-
B_7*	+	-	+	-	+	-	-	-
B_8*	+	-	+	-	+	-	-	-
B_2**	-	-	-	-	-	-	-	-
B_6R**	-	-	-	-	-	-	-	-

KEY:

* = Experimental batches of A. variegatum that fed on bull

** = Control " " " " " on rabbit ears.

\+ = Positive for D. congolensis

\- = Negative " " "

Appendix 3.5: Bacterial contaminants from engorged nymphae that fed on the scrotum of a Dermatophilus-infected bull.

Tick BATCH No.	GRAPE	Gram stain	Catalase.	Oxidase	Oxidative fermentation	Nitrate reduction	Indole reduction	Urea	Citrate	Motility	Methyl red test	Voges Proskauer test	Identification
A_1	a) Rod	-	+	+	-	-	-	-	-	+	-	-	Pseudomonas sp.
	b) Rod	-	+	+	-	-	-	-	+	+	-	-	Pseudomonas sp.
B_6	Cocci	+	+	-									Staphylococcus epidermidis
B_7	a) Cocci	+	+	-									S. epidermidis
	b) Rod	-	+	-									Proteus sp.
B_8	Cocci	+	+	-									S. epidermidis

- = Negative

+ = Positive.

Appendix 3.6: Direct smear and culture examinations of rabbit ears exposed to A_1 and B_6R Amblyomma variegatum adult ticks for D. congolensis

Rabbit Group (tick)	Rabbit Nos.	Days post-attachment of ticks to rabbits									
		7		13		16		20		23	
		Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture
1(A_1)	4	-	-	-	-	+	-	-	-	-	-
	27	-	-	+	-	+	-	-	-	-	-
2(A_1)	28	-	-	-	-	+	-	-	-	-	-
	34	-	-	+	-	+	-	-	-	-	-
3(B_6R)	20	-	-	-	-	-	-	-	-	-	-
	22	-	-	-	-	-	-	-	-	-	-
4 (No ticks)	25	-	-	-	-	-	-	-	-	-	-

KEY:

- = Negative for D. congolensis

+ = Positive for D. congolensis

Appendix 3.7: Direct smear and cultural examinations of rabbit ears exposed to B_6 and L_2 Amblyomma variegatum adult ticks.

Rabbit Group (tick)	Rabbit No.	Days post-attachment of ticks to rabbits.									
		5		10		12		24		33	
		Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture.
1(E_6)	2	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-
2(E_6)	7	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-
3(E_2)	12	-	-	-	-	-	-	-	-	-	-
	13	-	-	-	-	-	-	-	-	-	-
4(No ticks)	15	-	-	-	-	-	-	-	-	-	-
	16	-	-	-	-	-	-	-	-	-	-

KEY:

- = Negative for D. congolensis.

Appendix 3.8: Direct smear and cultural examination of rabbit ears exposed to B_7 and B_2 Amblyomma variegatum adult ticks.

Rabbit Group (ticks)	Rabbit No.	Days post-attachment of ticks to rabbits.									
		5		10		12		24		33	
		Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture
1(B_7)	33	-	-	-	-	-	-	-	-	-	-
	35	-	-	-	-	-	-	-	-	-	-
2(B_7)	39	-	-	-	-	-	-	-	-	-	-
	40	-	-	-	-	-	-	-	-	-	-
3(B_2)	37	-	-	-	-	-	-	-	-	-	-
	38	-	-	-	-	-	-	-	-	-	-
4 (No ticks)	41	-	-	-	-	-	-	-	-	-	-
	42	-	-	-	-	-	-	-	-	-	-

KEY:

- = Negative for D. congolensis.

Appendix 3.9: Direct smear and cultural examinations of rabbit ears exposed to B_8 and B_6R Amblyomma variegatum adult ticks.

Rabbit Group	Rabbit No.	Days post-attachment of ticks to rabbits.									
		5		10		12		24		33	
		Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture	Direct smear	Culture
1(B_8)	4	-	-	-	-	-	-	-	-	-	-
	27	-	-	-	-	-	-	-	-	-	-
2(B_8)	28	-	-	-	-	-	-	-	-	-	-
	34	-	-	-	-	-	-	-	-	-	-
3(B_6R)	22	-	-	-	-	-	-	-	-	-	-
	36	-	-	-	-	-	-	-	-	-	-
4 (NO ticks)	3	-	-	-	-	-	-	-	-	-	-
	25	-	-	-	-	-	-	-	-	-	-

KEY:

- = Negative for D. congolensis.

Appendix 4.1: Questionaire on tick-dermatophilosis relationship on cattle in Kaduna State of Nigeria.

1. Sheet No. ____

2. Date: ____ 3. Season D / W

4. Herd Size ____ 5. Breed ____

6. Types of ticks on body: A / B / H / R

7. Distribution of dermatophilosis and ticks on body:

(a) Head (h) Dermato. / Ticks ____ / ____

(b) Back (B) Dermato. / Ticks ____ / ____

(c) Neck (N) Dermato. / Ticks ____ / ____

(d) Ventrum (V) Dermato. / Ticks ____ / ____

(e) Ext. Genitalia (G) Dermato. / Ticks ____ / ____

(f) Tail (T) Dermato. / Ticks ____ / ____

(g) Leg (E) Dermato. / Ticks ____ / ____

8. Presence of Insects Yes / No and Location H / N / G / E / B / V / T

9. Skin diseases

Besnoitiosis	Demodectic - Mange	Sarcoptic Mange.	Lousiness.	Ringworm.	Rinderpest skin disease	Tick-abscess.	Wart.	Wound.

10. Method of dermatophilosis introduction to herds.

Ticks	Insects	Thorns	Migration.	Mixing.	Addition	Tick birds	horns

11. Economy:

Milk yield.	Udder damage.	Test damage	Vulva	Scrotum	Mating difficulty.	Pregnancy failure	Calving interference.	Calling	Price

Appendix 4.2: Wet season body distribution of bovine dermatophilosis and infestation by ticks in Kaduna State of Nigeria.

Condition	No. Cattle examined	Head Head	Neck	Ext. genitalia	Leg	Back	Ventrum	Tail
Dermatophilosis alone	5883	83* (1.41%)**	(0.90)	85 (1.45)	81 (1.38)	82 (1.39)	19 (0.32)	52 (0.88)
Ticks infestation alone	5883	89 (1.51)	116 (1.97)	224 (4.15)	156 (2.65)	46 (6.78)	49 (0.82)	110 (1.87).
Dermatophilosis + ticks infestation	5883	19 (0.32)	11 (0.19)	59 (1.00)	27 (0.46)	10 (0.17)	9 (0.15)	38 (0.68)
No dermatophilosis or ticks infestation	5883	5692 (96.75)	5703 (96.94)	5515 (93.74)	5619 (95.12)	5745 (97.65)	5806 (98.70)	5663 (96.60).
Total	5883	5883	5883	5883	5883	5883	5883	5883

KEY:

* = No. of animals with condition at this site.

** = Percent of animals with condition at this site.

Appendix 4.3: Dry Season body distribution of bovine dermatophilosis and ticks infestation in Kaduna State, Nigeria.

Condition	No. Cattle examined	Head	Neck	Ext. genitalia	Leg	Back	Ventrum	Tail
Dermatophilosis alone	6349	12* (0.19)**	31 (0.49)	25 (0.39)	19 (0.30)	68 (1.07)	5 (0.08)	12 (0.19)
Ticks infestation alone	6349	166 (2.62)	349 (5.50)	620 (9.77)	515 (8.11)	196 (3.09)	583 (9.18)	237 (3.73)
Dermatophilosis Ticks infestation	6349	6 (0.09)	7 (0.11)	30 (0.47)	9 (0.14)	10 (0.16)	3 (0.05)	12 (0.19)
No Dermatophilosis or Ticks infestation.	6349	6165 (97.10)	5962 (93.91)	5724 (90.1[illegible])	5806 (91.45)	6075 (95.64)	5758 (90.69)	6088 (95.89)
Total	6349	6349	6349	6349	6349	6349	6349	6349

KEY:

* = No. of animals with condition at site.

** = Percent " " " " "

Appendix 4.4: Bovine skin conditions occurring **in mixed infection with** dermatophilosis.

Conditions	Lousiness.	Demodectic Mange.	Sarcoptic Mange	Dermatomycosis	Tick Abscess	Besnoitiosis	Wart	Rinderpest skin lesion
Dermatophilosis	-	+	+	+	+	+	+	-

KEY:

\+ = Mixed infection seen.

\- = No mixed infection seen.

Appendix 5.1: Dermatophilosis lesions scoring criteria.

Form of Disease	% Body lesion coverage
Mild	Animals with less than 25% body coverage.
Moderate	More than 25% but less than 50% body covered with lesion.
Severe	More than 50% body surface covered with lesions.

Appendix 5.2: In-vivo rainy season affects of Pfizona(R) bath on Fulani dermatophilus-infected zebu cattle.

Herd No.	Herd size	No. Infec-ted.	Preva-lence (%)	No. Treated	No. Recover-ed	% Recovered
1.	23	3	13.0	2	2	100.0
2.	47	4	8.5	3	2	66.7
3.	40	5	12.5	3	2	66.7
12.	14	2	14.3	1	0	0.0
14.	47	7	14.9	4	3	75.0
15.	7	1	14.3	1	1	100.0
20.	81	3	3.7	3	3	100.0
21.	40	3	7.5	2	2	100.0
22.	100	27	27.0	10	6	60.0
23.	182	11	6.0	7	5	71.4
24.	101	17	16.8	10	8	80.0
25.	107	11	10.3	7	4	85.7
26.	92	10	10.9	6	4	66.7
27.	83	8	9.6	5	4	80.0
28.	42	5	11.9	3	2	66.7
29.	14	2	14.3	1	1	100.0
Total	1085	126	12.1	72	54	74.1

Appendix 5.3: In-vivo dry season affects of Pfizona(R) bath on Fulani dermatophilus-infected zebu cattle.

Herd No.	Herd size	No. Infec-ted.	Preva-lence (%)	No. Treated	No. Recover-ed.	% Recovered
3.	89	3	3.4	3	2	66.7
4.	95	4	4.2	2	2	100.0
5.	47	4	8.5	3	3	100.0
6.	129	5	3.9	3	3	100.0
7.	133	6	4.5	4	3	75.0
9.	134	3	2.2	3	2	66.7
10.	50	2	4.0	1	1	100.0
11.	57	1	1.8	1	1	100.0
13.	89	3	3.4	2	2	100.0
16.	50	1	2.0	1	0	0.0
17.	24	1	4.2	1	0	0.0
18.	81	4	4.9	2	1	50.0
30.	27	2	7.4	2	2	100.0
31.	18	2	11.1	2	2	100.0
32.	65	2	3.1	1	0	0.0
Total	1088	43	4.6	31	24	70.6