FUNGI AND ANIMALS:

DERMATOMYCOSIS IN ANIMALS AND MAN

by

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CONTENTS

GENERAL INTRODUCTION AND REVIEW OF THE LITERATURE.

Dermatomycosis which is also referred to as dermatophytosis or ringworm is a disease of the skin and its appendages (hair, claws, nails and feathers) caused by a group of mycelial fungi called dermatophytes which are able to invade keratinised tissues. The dermatophytes affecting animals were first named about the turn of the century (Mégnin 1881, Bodin 1896, Sabouraud, Suis & Suffran 1908, Zollikofer & Wenner 1908, Chaljes 1910). The few references in British literature were primarily concerned with the disease in man and a scarcity of information on the veterinary aspect of the disease in Britain obtained until about 10 years ago. Ainsworth (1949) in his review of the fungi pathogenic for man and animals in Britain covered the period from the late 19th century until 1947. In 1951 Riddell noted that a survey of animal dermatophyte infections had never been made in Britain and Ainsworth (1954) said "Although ringworm is such a familiar and well-established condition, there are surprisingly few satisfactory published records of ringworm fungi from animals in this country." That this was not confined to Britain can be seen from the statement of Georg (1954) that "The literature presents little information as to the prevalence of ringworm infections in animals or of the

relative prevalence of the various fungus species in animal ringworm infections in the United States." During the period 1952 - 1954, a survey of the fungi associated with disease in domesticated animals in Britain was sponsored by the Agricultural Research Council and in a subsequent report Ainsworth & Austwick (1955a) recorded a list of pathogenic fungi, including dermatophytes, together with their incidence in the various animal hosts. La Touche,(1952, 1953, 1955) provided valuable information on the incidence of Microsporum canis infection in dogs and cats in Yorkshire while Mortimer (1955) studied ringworm in cattle in the eastern part of England. In 1955 also, Blank comprehensively reviewed the world incidence of human and animal dermatomycosis. In the United States of America Monges & Georg (1955, 1957) conducted surveys of animal ringworm that included cases in wild as well as captive animals. McPherson (1957a) reported on the incidence of ringworm of cattle in Scotland and the northern counties of England. Thus, from 1952 onwards interest in animal ringworm grew steadily both in this country and in the United States.

In 1950 a diagnostic service pertaining to the examination of samples of skin and of hair from cases of suspected ringworm of animals was begun by me in the University of Glasgow Veterinary School and the first part of the thesis is a consideration of the results of these data. Following the

concern of the Medical Mycology Committee of the Medical Research Council in the possible animal reservoirs for some types of human ringworm, an investigation to correlate human and animal ringworm in the west of Scotland was started in 1954; this forms the second part of the work. The third part is concerned with the use of griseofulvin in the treatment of ringworm in animals.

The various parts of the work could not have been accomplished without the help of many people. In Parts I and II the animal material was submitted by numerous veterinary surgeons and for the correlation of human and animal ringworm the co-operation of medical dermatologists and mycologists was necessary. Correlation of human and animal cases was achieved by joint collaboration with Dr. J. C. Gentles, medical mycologist of this University but I was solely responsible for the laboratory investigation of all specimens of animal origin. The interpretation of the laboratory results and of the epizootiological data is mine. In Parts I and III, I had the co-operation of Mr. I. M. Lauder of the Glasgow University Veterinary School who was mainly responsible for interpreting the clinical aspects of the disease. The mycological and histopathological descriptions are mine and I was solely responsible for the therapeutic experiment in cats. The work

was carried out in the Department of Veterinary Pathology and in the Veterinary Hospital of the Glasgow University Veterinary School.

Although samples of hair and of skin scrapings were submitted from many parts of Britain the overwhelming majority of specimens came from Scotland and in the first part of the thesis it is proposed to deal only with those.

P A R T I.

A SURVEY OF ANIMAL DERMATOMYCOSIS IN SCOTLAND.

LABORATORY METHODS.

Specimens of hair and of skin scrapings from animals suspected of ringworm were mounted in 40 per cent. aqueous potassium hydroxide and kept in a moist chamber for 1 - 2 hours. The concentration of potassium hydroxide usually recommended is 20 per cent. but in the case of animal material, much of which consisted of thick scab the stronger solution was found to give better results. The moist chamber consisted of a glass dish 25 x 15 x 5 mm. deep, provided with a perspex top and accommodated 12 glass slides. Six glass rods, placed in pairs in the bottom of the dish and covered by a piece of muslin, supported the glass slides. It is often recommended that potassium hydroxide preparations be submitted to gentle heat but it was found difficult to heat scabbed material sufficiently to clear it without causing undue fragmentation of the hairs; the disintegrated hairs, each surrounded by a sheath of arthrospores, rendered diagnosis difficult. In addition, the heating process led to crystallisation of the potassium hydroxide. Placing the hydroxide mount in a moist chamber allowed clearing of the skin debris and hairs, with minimal disintegration of the hairs. Gentle pressure on the

coverslip produced a flat field for microscopical examination.

Staining by the periodic acid-Schiff method and by the modified Gram technique of Lewis (1950) was carried out for some time in addition to the method of clearing in caustic potash with results that agreed with those of Gentles & Dawson (1956), namely that staining did not yield any increase in the number of positive cases. The specimens, with the exception of those from cattle, were also examined for fluorescence by means of Wood's light in a darkened room.

During the first 4 years of the work the specimens were cultured on Sabouraud's dextrose-agar of the following formula:

Peptone	10 grammes
Dextrose	40 "
Agar	15 "
Distilled water	1000 ml.

Since material from animals is often very heavily contaminated by bacteria and saprophytic fungi, it was later decided to use the nutrient agar, incorporating penicillin and streptomycin, which was recommended by Austwick (1954) and which has the following composition:

Beef extract (Lab. Lemco)	10 grammes
Peptone	10 "
Sodium chloride	5 "
Agar	15 "
Distilled water	1000 ml.
Penicillin	20 units per ml. of medium
Streptomycin	40 " " " " "

(The antibiotics, dissolved in sterile water, were added to the medium prior to pouring.)

That medium was very effective in suppressing bacterial growth but it had no effect on the growth of saprophytic fungi which, in the case of bovine samples was found to occur more quickly than that of Trichophyton verrucosum. The addition of another antibiotic, cycloheximide* at 0.5 mg. per ml. had been shown by Georg (1953) to be effective in inhibiting the growth of saprophytic fungi. Austwick's medium was employed for about 6 months until cycloheximide became available in this country when the selective medium of Georg was preferred for purposes of cultivation during the remainder of the work.

The proximal few mms. of hairs, or a small piece of scabbed material which usually contained small hair stubs, were used as inocula. If, under Wood's light, hairs were found with the yellowish-green colour indicative of infection by Microsporum canis or M. equinum, the fluorescing parts were used for inoculation. Three agar slopes were prepared from each specimen, using 4 inocula per tube, and cultures were incubated at 26° C. for 3 weeks before they were discarded if they proved negative. Lactophenol was used for routine microscopic examination of cultures.

Material for the histopathological study of lesions was

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* 'Actidione'. Upjohn & Co. Ltd., Kalamazoo.

procured by means of a scalpel in the case of cattle but for cats the apparatus described by Evans, Nisbet & Ross (1957) was used. This apparatus is a hollow bit, with an inside diameter of 5 mms., operated by an electric drill turning at 2000 r.p.m. The biopsied material was fixed in formol saline or in picro-formol; the sections of skin were stained by haematoxylin & eosin, by periodic acid-Schiff, by toluidine blue, by Van Giesen as well as by the method of Gordon & Sweet.

GENERAL RESULTS.

Specimens from 728 animals were examined and the presence of a dermatophyte was confirmed both by microscopy and culture in 252 (34.6 per cent.) cases, by culture alone in 32 (4.4 per cent.) instances and only by microscopy on 60 (8.2 per cent.) occasions. The numbers, the types of hosts and the data on results of laboratory examinations are given in Table I (page 9).

TABLE 1.

RESULTS OF LABORATORY EXAMINATION OF SPECIMENS FROM VARIOUS ANIMAL HOSTS SUSPECTED OF RINGWORM.

(Figures in brackets denote percentages.)

Host	No. of animals	Micro. + Cult. +	Cult. + only	Total cult. +	Micro.+ only	Total positive
Cattle	283	183 (64.7)	5 (1.7)	188 (66.4)	45 (15.9)	233 (82.3)
Horse	98	20 (20.4)	4 (4.1)	24 (24.5)	3 (3.1)	27 (27.6)
Dog	221	21 (9.5)	13 (5.9)	34 (15.4)	7 (3.2)	41 (18.6)
Cat	105	27 (25.7)	8 (7.6)	35 (33.3)	4 (3.8)	39 (37.1)
Mouse	6	1 (16.7)	0	1 (16.7)	0	1 (16.7)
Chinchilla	12	0	2 (16.7)	2 (16.7)	0	2 (16.7)
Goat	3	0	0	0	1 (33.3)	1 (33.3)
Totals	728	252 (34.6)	32 (4.4)	284 (39.0)	60 (8.2)	344 (47.2)

Table 1 reveals that laboratory corroboration of suspected dermatomycosis was obtained in 344 (47.2 per cent.) cases over the whole series, but that such confirmation varied widely where the species of animal is concerned. Diagnosis was established most often in cattle (82.3 per cent.), probably because the condition is not often confused with other cutaneous abnormalities and the lesions are conspicuous and easily recognisable. Again, the submitted ringworm scab usually contained many affected hairs which were readily

visible in macerated specimens and since parts of these hairs together with their sheath of arthrospores were used for inoculation of culture media, growth of a dermatophyte was obtained in a high proportion of cases (188, 66.4 per cent.). In respect of the horse, dog and cat, differential diagnosis is more difficult and clinical lesions are less easily identifiable than are those of cattle. For those 3 hosts the percentages of positive laboratory results were: horse 27.6, dog 18.6 and cat 37.1. Five specimens from cattle, 4 from horses, 13 from dogs, 8 from cats and 2 from chinchillas produced positive cultures although they were negative on microscopical examination.

Specimens were also received from a number of other species viz.: monkey, donkey, pig, hare, squirrel, rat, otter, budgerigar and hen but all gave negative results.

NOMENCLATURE AND SYNONOMY OF ANIMAL DERMATOPHYTES.

There have been numerous classifications of the dermatophytes based on criteria which have included the clinical signs of the associated disease, the form of the fungus in the hair and the morphology of the dermatophytes when grown on culture. Mainly on clinical grounds, Sabouraud (1910) recognised 4 genera of dermatophytes viz.: Microsporum

Trichophyton, Achorion and Epidermophyton but as a result of a special study of macroconidial morphology, Emmons (1934) suggested that the genus Achorion should be discarded and that the attached species be distributed between Microsporum and Trichophyton. Such a classification is still used in Britain and America. Synonyms of the dermatophytes about to be discussed are given in the Medical Research Council Memorandum (1958) and by Ainsworth & Austwick (1959). Especially in their relation to references in earlier literature, those relevant to the present study are as follows:

CURRENT NAME.	SYNONYMS.
Trichophyton verrucosum Bodin var. discoides (Sab.) Georg*	T. discoides Sabouraud
T. verrucosum Bodin	T. faviforme Auct.
T. mentegrophytes (Robin) Blanchard	T. granulosum Sabouraud
T. quinckeanum (Zopf) MacLeod & Muende	Achorion quinckeanum (Zopf) Blanchard
T. violaceum Bodin	A. violaceum Bloch
T. gallinae (Mégnin) Silva & Benham	A. gallinae (Mégnin) Sab.
T. gallinae	M. gallinae Grigoraki
Microsporum canis Bodin	M. felineum Newborn M. lanosum Sabouraud
M. gypseum (Bodin) Guiart & Grigoraki	A. gypseum Bodin

* The only variety of T. verrucosum isolated during the period covered by this thesis.

Dermatophytes were isolated from 284 animals and the distribution of the various fungi is shown in Table 2 which indicates that 8 species of dermatophyte were isolated from 6 hosts; the distribution of the fungi was as follows:

T. verrucosum from cattle, horse and dog,

M. canis from dog and cat,

T. mentagrophytes from calf, horse, dog, cat, mouse and chinchilla,

T. equinum Gedoelst from the horse,

M. equinum (Delacroix & Bodin) Guéguen from the horse,

T. quinckeanum from dog and cat,

M. gypseum from a dog,

T. rubrum (Castellani) Ota, from the dog.

Unidentified species of Trichophyton were recovered from the horse, dog and cat.

Thus 4 dermatophytes (T. equinum, M. equinum, M. gypseum and T. rubrum) were each found on only one host, and T. mentagrophytes had the widest host range, having been recovered from all 6 hosts which yielded dermatophytes. All the isolates of T. mentagrophytes were of the granular type which is accepted as the zoophilic variety of the dermatophyte (Kaplan, Georg & Ajello 1958).

Dermatomycosis in individual animal hosts will now be considered in detail.

TABLE 2.

THE DERMATOPHYTES AND THEIR OCCURRENCE IN VARIOUS HOSTS.

HOST.	T. spp.	T. rubrum	M. gypseum	T. quinckeanum	T. mentagrophytes/M. equinum	M. equinum	T. equinum	T. mentagrophytes	M. canis	T. verrucosum	TOTALS.
Cattle	-	-	-	-	-	-	-	1	-	187	188
Horse	1	-	-	-	1	5	13	1	-	3	24
Dog	1	1	1	1	-	-	-	5	20	5	34
Cat	1	-	-	4	-	-	-	5	25	-	35
Mouse	-	-	-	-	-	-	-	1	-	-	1
Chinchilla	-	-	-	-	-	-	-	2	-	-	2
Totals	3	1	1	5	1	5	13	15	45	195	284

(1) INFECTIONS OF CATTLE.

MYCOLOGICAL ASPECTS.

Specimens were examined from 283 cattle on 194 premises and 233 (82.3 per cent.) animals were positive (Table 1, page 9); 183 (64.7 per cent.) were positive by microscopical and cultural means and 5 (1.7 per cent.) by culture alone. Generally when a fungus was visible on the hair it grew in artificial media but 45 (15.9 per cent.) specimens positive on microscopical examination failed to develop under laboratory conditions. Fifty (17.7 per cent.) cases were negative both culturally and microscopically, a seemingly high proportion of such results until it is added that some specimens were taken at a late stage of the disease when lesions had practically healed.

Dermatophytes isolated.

From 188 culturally positive specimens only 2 species of dermatophytes were recovered, T. verrucosum on 187 occasions and T. mentagrophytes once. The occurrence of T. mentagrophytes in a calf has been reported by Gentles & O'Sullivan (1957a).

CLINICAL ASPECTS.

(A) Age incidence.

McPherson (1957a) has said that "Age appears to have a

marked effect on the incidence (of bovine ringworm), calves under 10 months being more susceptible than mature cattle." In this survey of 224 cases, as indicated by Table 3, the incidence of disease was found to be highest (66.1 per cent.) during the first year of life and was 86.6 per cent. for the period from birth to the age of 2 years. Information regarding 995 clinically affected animals in contact with proved cases of ringworm further supported the above finding.

TABLE 3.

AGE INCIDENCE IN 224 CONFIRMED CASES OF BOVINE RINGWORM

Age	No. affected	Incidence
0 - 3 months 4 - 12 "	41 107	148 (66.1 per cent.) in first year of life
13 - 18 " 19 - 24 "	34 12	46 (20.5 per cent.) in second year of life
+ 2 years	30	(13.4 per cent.) after second year

(B) Seasonal incidence.

Bovine ringworm is popularly held to be a disease of housed animals, which tends to prevail during the winter months and to disappear in consequence of improved nutrition and the effect of sunlight when the cattle are put out to grass in the springtime. Ainsworth & Austwick (1955a) on

admittedly limited data, did not recognise any seasonal incidence. Contrary to general belief, McPherson (1957a) reported that "The changes in overall incidence with the season are not statistically significant the percentage of infection showing no trend to a decreased incidence in the spring and summer months. In infected herds only, there is a significant association between season and degree of infection which appears to be due to the relatively high incidence in the April to August period."

Table 4 gives the incidence, measured by monthly totals of specimens, among the animals of this series, most of which happen to have come from infected herds.

TABLE 4.
MONTHLY TOTALS OF 233 PROVED CASES OF BOVINE RINGWORM

Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	Totals
17	41	51	32	26	6	173 (74.2 per cent.)
May	June	July	Aug.	Sep.	Oct.	
20	11	8	5	9	7	60 (25.8 per cent.)

It will be noted that of the 233 confirmed cases, 173 (74.2 per cent.) were encountered during the period, November to April, compared with 60 (25.8 per cent.) in the months May to October inclusive. The disease was still present at the end of the summer months so that some cattle returned to the farm

buildings after the summer grazing, with lesions of dermatomycosis on them. Walker (1955) recovered T. verrucosum from a rubbing-post recently used by infected cattle and McPherson (1957b) showed that the arthrospores of the same dermatophyte survived in skin scrapings which had been stored at room temperature for 4½ years so there seems to be little doubt that buildings occupied by infected cattle may remain contaminated for years. Thus, cases of dermatomycosis may not only be carried over from one season to the next by infected animals but may originate also from contaminated premises.

(C) The Lesions in Bovine Ringworm.

(a) Location.

The distribution of lesions on a number of proved cases of ringworm is shown in Table 5, from which it can be seen that a total of 355 sites was affected on 195 cattle, many of the animals having lesions on more than one part of the body.

TABLE 5.

LOCATION OF THE LESIONS OF RINGWORM IN 195 CATTLE.

(Figures in brackets denote percentages.)

Head	Neck	Trunk	Hind-quarters	Limbs	Total No. of lesions
153 (78.5)	66 (56.9)	80 (69)	52 (44.8)	4 (3.4)	355

Most frequently of all the head was affected, 153 (78.5 per

cent.) of the animals having lesions there alone or in conjunction with changes elsewhere. The neck was involved in 66 (56.9 per cent.) animals, the trunk in 80 (69 per cent.) and the hindquarters, including the rump, tailhead, tail and perineum in 52 (44.8 per cent.) cases. The legs were infrequently implicated and indeed only 4 (3.4 per cent.) cases were diagnosed. In an outbreak involving 63 animals, Ford (1956) found that the neck was most frequently affected. In 116 animals, in which detailed information was available regarding the distribution of lesions on the head the locations were: eyes 60 (51.7 per cent.), ears 39 (33.6 per cent.), face 27 (23.3 per cent.), nose 8 (6.9 per cent.) and poll 4 (3.4 per cent.). The lips were not affected in any of the cases. Ford (1956) reported that lesions occurred in about equal numbers around the eyes, on the cheeks and the face, and on the ears. In the animals of this series the eyes were affected nearly twice as frequently as were the ears or the face.

(b) Clinical appearance.

The incubation period of ringworm in cattle is 2 - 3 weeks although microscopical evidence of fungal infection may be present within a week (Lauder & O'Sullivan 1958). The very early lesion, which may be easily missed because of the

Fig. 1. T. verrucosum infection on the head of a calf. Asbestos-like scabs around eyes, bases of ears and on the face.

Fig. 2. T. verrucosum infection on the body of a calf. Some thickly crusted lesions have become confluent.

overlying hair, is a papule which slowly increases in size. Inflammatory exudation causes the proximal parts of the hair-shafts to coalesce. Many hairs fall out but some may break off and the hair stubs persist in the grey or yellowish-brown plaque which is firmly adherent to the underlying skin. Coalescence of adjoining lesions often occurs whereby in badly affected animals, little of the normal skin is to be found over large areas of the body. The mature ringworm scab has a dry asbestos-like appearance (Figs. 1 & 2) and, if it is scraped off there is exposed a raw, bleeding surface on which a fresh scab quickly forms. When infection of the hair follicles is suppressed whether as a result of spontaneous recovery or in consequence of effective therapeutic measures, the scabs become loosened and fall off to leave healthy skin behind.

(c) Histopathological data.

The opportunity to study the histopathology of the condition arose during the course of artificially induced infections of calves by T. verrucosum. Although that work is fully described in Part III of the thesis, the mycological aspects may appropriately be considered at this stage.

Infection begins on the surface of the skin when fungal hyphae penetrate the superficial layers of the stratum corneum and grow downwards into the hair follicle (Fig. 3). Within

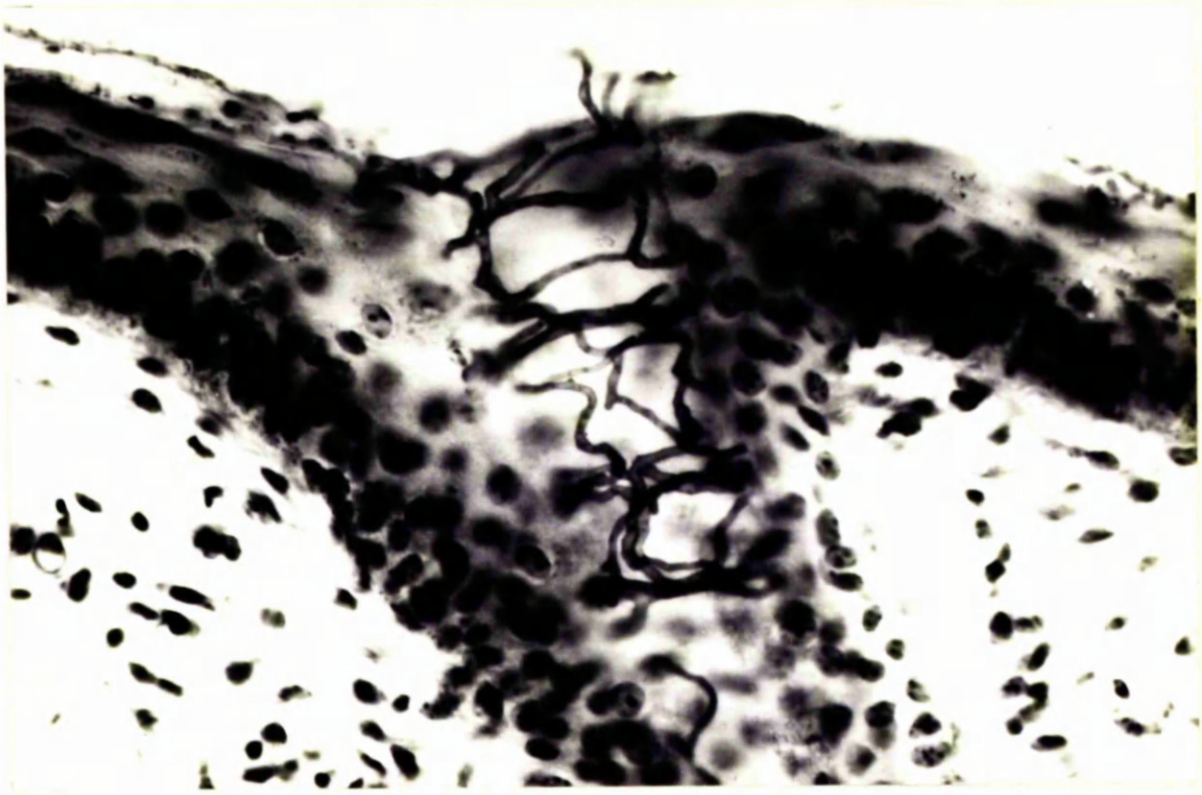

Fig. 3. Hyphae of T. verrucosum present in stratum corneum and growing downwards into a hair-follicle. Stained P. A. S. x 660.

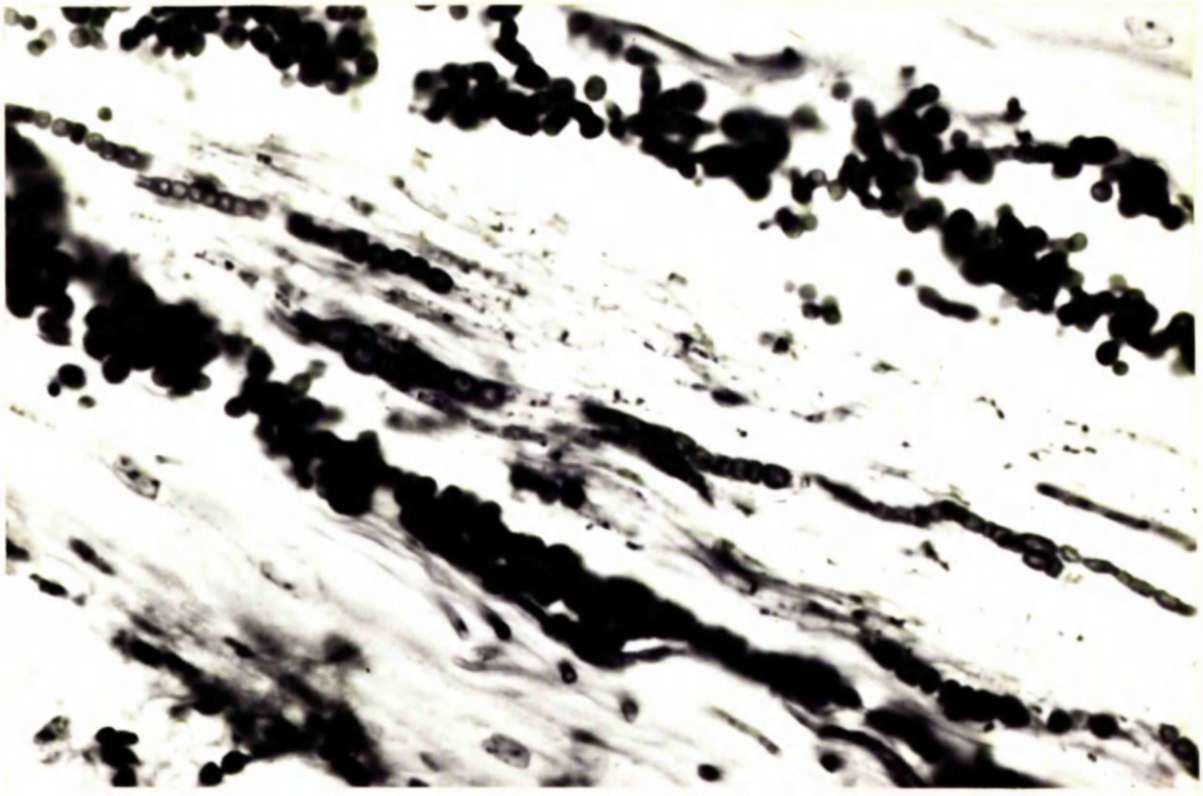

Fig. 4. V. S. hair affected with T. verrucosum. Arthrospores outside the hair-shaft; hyphae in cortex show arthrospore formation. P. A. S. x 880.

the follicle, proliferation of the hyphae proceeds not only in the cornified layers of the root-sheath but also in the space around the hair-shaft. The fungus then penetrates between the over-lapping cells of the cuticle of the hair to enter the hair cortex (Fig. 4) and extend as far as the keratogenous zone. There, the hyphae stop short and appear as finger-like processes which were first described by Adamson (1895) and since have been called Adamson's fringe. Outside as well as within the hair, the hyphae divide transversely to form arthrospores and when the ectothrix arrangement of large arthrospores is seen microscopically in preparations of macerated bovine material, it is indicative of infection by T. verrucosum.

DIFFERENTIAL DIAGNOSIS IN CATTLE.

The thick grey scab of a mature ringworm lesion is not generally to be confused with any other abnormality of the skin. Sometimes however, the cutaneous lesions of mucosal disease, of hyperkeratosis (X disease) and of sarcoptic mange have to be so differentiated. Again, the early lesions of angleberries may simulate the developing ringworm lesion. Laboratory examination of a skin-scraping is necessary to determine whether or not the condition is dermatomycosis.

DISCUSSION OF BOVINE DERMATOMYCOSIS.

Ringworm in cattle is widespread throughout Scotland; to the list of counties in which infected beasts were found by McPherson (1957a) may be added Ayr, Clackmannan, Dunbarton, Lanark, Renfrew, Ross and Stirling.

Although most stock-owners consider the condition to be of little importance, ringworm is not without adverse effects and deaths have been occasionally attributed to it. Economic loss occurs when affected animals are put up for sale and cattle for export may not leave the country while they have ringworm lesions. Furthermore, infection may be transferred from cattle to the horse, dog and also to man. It has been shown (Gentles & O'Sullivan 1957b) that infected cattle constitute the main reservoir for animal-type ringworm lesions of human beings in the west of Scotland. The public health aspect of cattle ringworm is therefore important, especially in rural areas.

Since the laboratory confirmation of the disease was high (82.3 per cent. of 283 animals) it would seem that the clinical diagnosis of the condition is satisfactory, particularly when the mature scab is present. However, at an early stage of the disease it may be difficult to decide whether the cause is fungal or not. Diagnosis by microscopy is a simple

matter because the affected hair-stubs within the scabs are surrounded by a thick sheath of large arthrospores, measuring 5 - 8 μ. Since bovine ringworm is so rarely caused by a dermatophyte other than T. verrucosum, it may be presumed that the large-spored ectothrix fungus seen in bovine material does in fact belong to T. verrucosum. By means of a culture medium containing antibiotics, the final identification of the dermatophyte is also relatively simple. In this series of cases, attempts to cultivate the fungus were unsuccessful in 45 (15.9 per cent.) instances which were positive microscopically. Fifteen of those cases occurred before the selective medium of Georg (1953) became available and the cultures were overgrown by saprophytic fungi. A further 25 specimens came from animals with a history of recent treatment with a fungicidal dressing. It is of interest to note that inasmuch as 5 (1.7 per cent.) cases yielded a dermatophyte from material that was negative on microscopical examination, minimal infections are likely to escape detection unless multiple inocula are employed in each instance.

Out of 188 cases confirmed by culture, T. verrucosum was recovered in all but one which yielded T. mentagrophytes. The significance of that finding is discussed in Part II of the thesis.

There is little doubt that young cattle are more frequently affected than older ones and indeed, 86 per cent. of the infections recorded in this work occurred in animals under 2 years of age. However, ringworm may affect adult animals, the probable explanation being that they escaped infection at an early stage of life.

There is disagreement on whether the condition is seasonal or not. Sellers, Sinclair & La Touche (1956) say that the lesions of ringworm commonly disappear during the spring and summer months, perhaps coincidentally with the natural course of the disease but they quote Blakemore, Ottoway, Sellers, Eden & Moore (1950) who remarked that calves on an adequate supply of vitamin A did not develop as widespread lesions as did stock deficient in that accessory factor. McPherson (1957b) claims that the ultra-violet light available during the average Scottish summer is insufficient to penetrate the mature scab from a lesion of bovine ringworm. My figures indicate that the case-incidence is lower during the period June to October.

The disease persists mainly through transmission of the infective agent from animal to animal and also by the transfer of viable fungal elements from the contaminated woodwork in cattle-houses and from rubbing-places such as railings, gates

and trees. Since the vigorous use of such scratching-places may cause trauma of the skin, the simultaneous inoculation of a dermatophyte would then create the conditions necessary for the spread of infection. Thus, animals may become infected while indoors or when they are at grass and the higher incidence of cases encountered during the winter months is explicable by the greater opportunity for contact with sources of contamination.

T. verrucosum is an obligatory parasite of cattle. The few cases of infection of other animals are usually traceable to a bovine source; similarly, human infection depends on a cattle reservoir because transfer from human to human is of short duration. There is little, if any, evidence that the fungus may exist in soil or in other natural substrate so that human infections might cease to exist were the animal reservoir to be eliminated. Thus, a determined effort ought to be made to eradicate T. verrucosum infection of cattle.

(2) INFECTIONS OF HORSES.

Ringworm in horses has been known since the end of the last century (Bodin 1896, Matruchot & Dassonville 1898) and the reported causative dermatophytes together with some of the more important references, are as follows:

Trichophyton equinum (MacKinnon 1936, Ainsworth & Austwick 1955a, Georg, Kaplan & Camp 1957a),

T. mentagrophytes (Brocq-Rousseau 1926),

T. verrucosum (Baudet 1932, Brocq-Rousseau, Urbain & Barotte 1927, Jillson & Buckley 1951),

T. bullosum (Lebasque 1934),

Microsporum equinum (Bodin 1896, Neefs & Gillain 1931),

M. canis (Georg, Roberts, Menges & Kaplan 1957b),

M. gypseum (Ajello 1953, Thorold 1953).

T. bullosum, reported from a horse by Lebasque in 1934, has so far not been recorded again so that the author may have been dealing with one of the commoner dermatophytes and certainly his description of the fungus was not at all clear. The American mycologists, George et al. (1957a), do not recognise M. equinum as a separate species and consider it as a synonym of M. canis. Their records of M. canis in horses may therefore refer to M. equinum.

MYCOLOGICAL ASPECTS.

There were 27 (27.6 per cent.) positive cases in the 98 animals examined (Table 6); 20 (20.4 per cent.) were positive both microscopically and culturally, 4 (4.1 per cent.) were positive only on culture and 3 (3.1 per cent.) proved only microscopically positive.

TABLE 6.

RESULTS OF LABORATORY INVESTIGATION OF 98 CASES OF SUSPECTED EQUINE RINGWORM.

(Figures in brackets denote percentages.)

	Culture pos.	Culture neg.	Totals
Micro. pos.	20 (20.4)	3 (3.1)	23 (23.5)
Micro. neg.	4 (4.1)	71 (72.4)	75 (76.5)
Totals	24 (24.5)	74 (75.5)	98

Dermatophytes isolated.

Although there were 24 animals from which dermatophytes were recovered, one animal was affected simultaneously by 2 fungi (T. equinum and M. equinum). In respect of the 25 dermatophytes isolated, the following frequency was noted: T. equinum 14 (56 per cent.), M. equinum 6 (24 per cent.), T. verrucosum 3 (12 per cent.), T. mentagrophytes 1 (4 per cent.) and Trichophyton sp. 1 (4 per cent.).

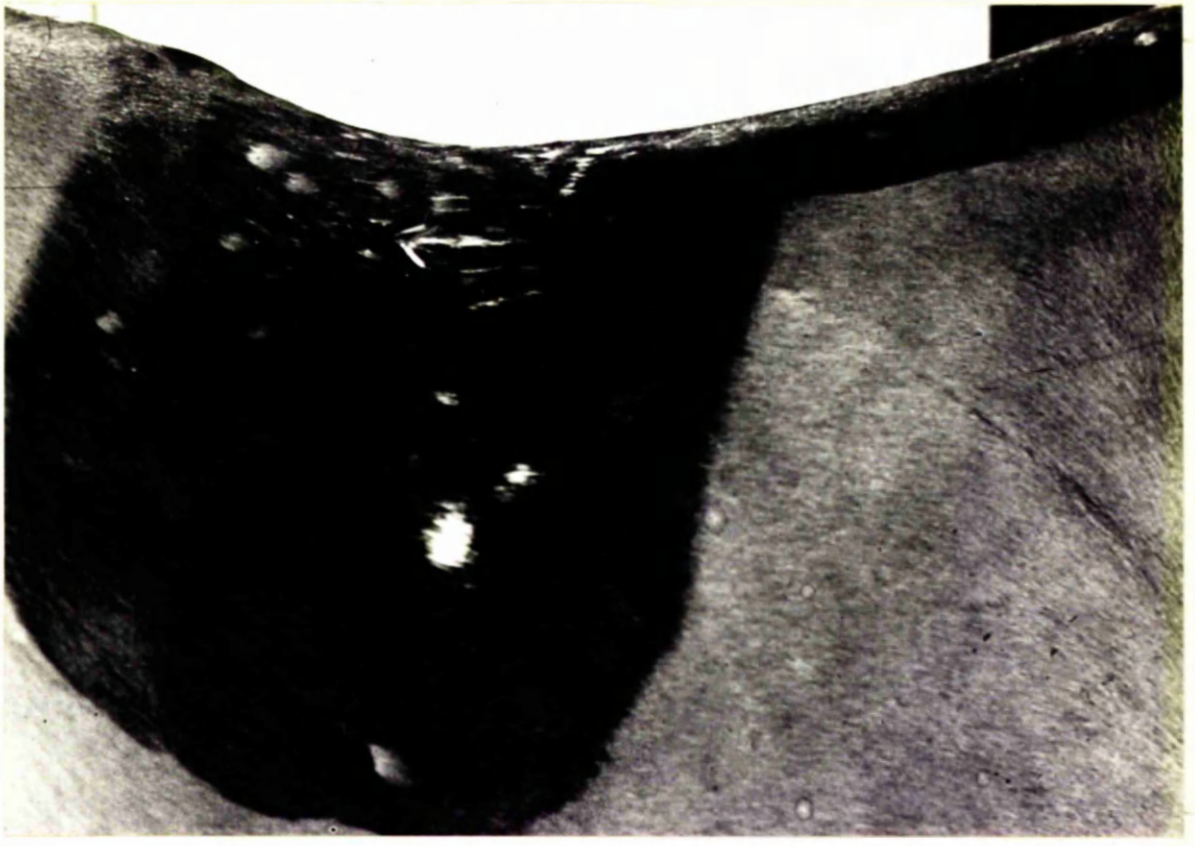

Fig. 5. Equine ringworm (T. equinum). Areas of alopecia in the saddle-region.

Fig. 6. Equine ringworm (T. equinum). Irregularly shaped lesions on left shoulder.

Thus T. equinum was the dermatophyte most frequently recovered from horses. It was isolated from 7 horses in a Scottish Hunt and also from a riding establishment where there were 30 ponies. Sixteen of the ponies had lesions that clinically resembled ringworm and, although 3 were positive by microscopical means, T. equinum was isolated from only one of them. Next in frequency as a cause of ringworm was M. equinum which was isolated on 6 (24 per cent.) occasions. A single case of infection by T. mentagrophytes was encountered in a hunter.

CLINICAL ASPECTS.

(A) Sex incidence.

There were 13 males and 7 females in a series of 20 horses for which information regarding their sex was available, but it is not possible to say whether one sex is more susceptible than the other, since the number of animals at risk remains unknown.

(B) Age incidence.

The age of 14 animals was given and the incidence was as follows:

0 - 6 months	1 animal
7 months - 3 years	2 animals
+ 3 years	11 animals

Thus 11 of the 14 animals (78.6 per cent.) were over 3 years old and the average of their ages was 8⅓ years.

(C) Seasonal Incidence.

The monthly totals of specimens from the 27 cases of ringworm in the horse are shown in Table 7. More cases were encountered during the 6 months from November to April inclusive in which there were 20 (74.1 per cent.), than from May until October when there were 7 (25.9 per cent.).

TABLE 7.
MONTHLY TOTALS OF 27 PROVED CASES OF EQUINE RINGWORM.

Nov. 1	Dec. 6	Jan. 5	Feb. 5	Mar. 1	Apl. 2	Totals 20 (74.1 per cent.)
May 1	June 2	July 0	Aug. 1	Sep. 2	Oct. 1	7 (25.9 per cent.)

(D) The Lesions in Equine Ringworm.

(a) Location.

In respect of 19 horses most of which presented more than one lesion the distribution of the cutaneous changes was: trunk 13 (68.4 per cent.), neck 11 (57.9 per cent.), hindquarters 8 (42.1 per cent.), head 6 (31.6 per cent.) and limbs 6 (31.6 per cent.). The majority of the lesions was thus located on the trunk and neck; the region of the head was not so frequently affected as it was in cattle. Lesions occurred more often on the hindquarters than on the head of the horse

Fig. 7. T. equinum ringworm on neck of horse. The early lesions appear as raised areas.

Fig. 8. Ringworm of the horse (T. equinum). Trunk and hindquarters showing many discrete, tufted lesions.

and the legs were more frequently involved than in cattle. Of 11 horses in which detailed information regarding the distribution of body lesions was available, in 8 (72.7 per cent.) the saddle region was affected (Fig. 5), in 4 (36.4 per cent.) it was the region of the girth, in 3 (27.3 per cent.) the flank was affected and in 2 (18.2 per cent.) the lesions occurred on the shoulders (Fig 6).

(b) Clinical appearances.

There was not any difference in the appearances of the lesions produced by T. equinum, M. equinum or T. mentagrophytes. They began as circular areas, 0.5 cm. in diameter, which were slightly raised above the level of the surrounding skin (Fig. 7) and which at first were detectable only by palpation through the animal's coat. After a week, the lesions developed into tufts which were easily visible (Fig. 8) especially when they were viewed against the grain of the hair. Removal of the tufts left bald, circular patches each measuring 1 - 3 cms. in diameter (Fig. 9). The lesions did not tend to coalesce and in a badly affected animal the coat presented a moth-eaten appearance. Occasionally, crusted lesions were present and sometimes scabs were seen attached to the hairs (Fig. 10) at some little distance from the skin surface.

One of the cases investigated was a mixed infection of

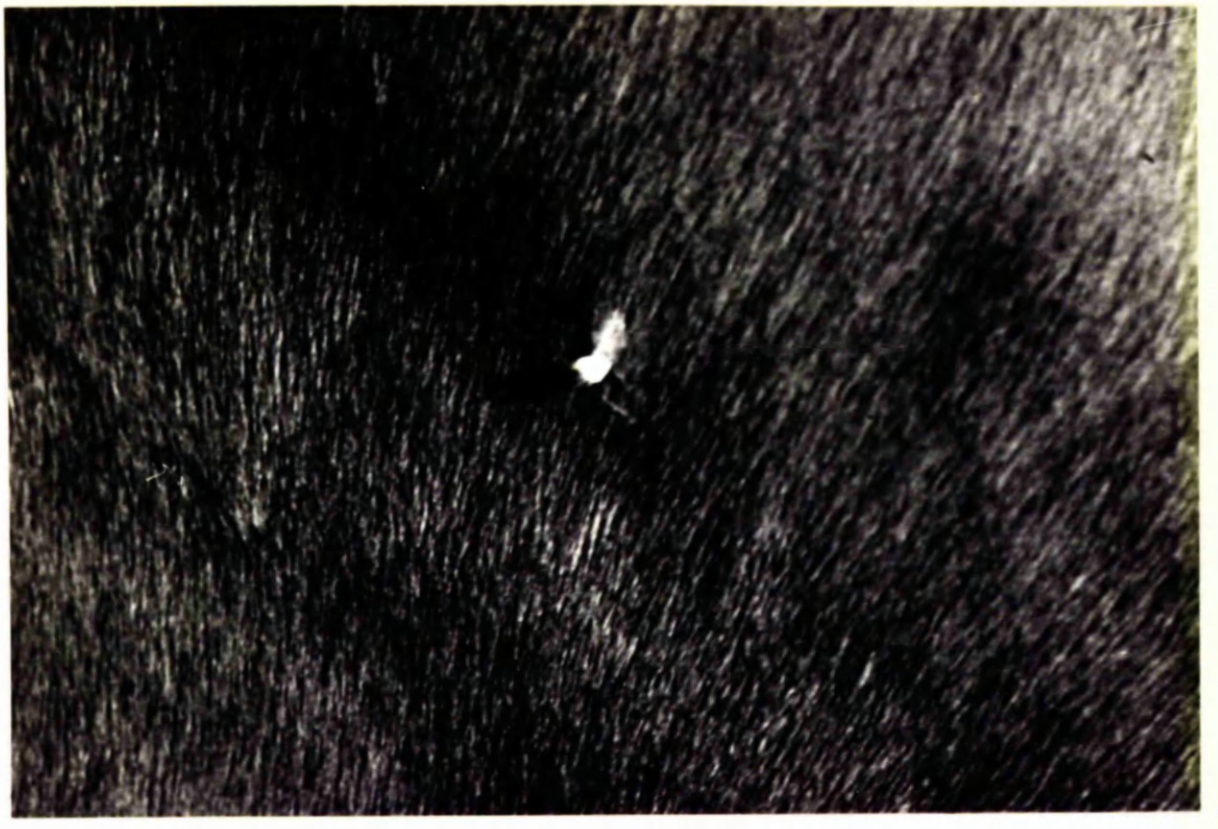

Fig. 9. Ringworm of the horse (T. equinum). A tuft partially removed to show bare area of skin.

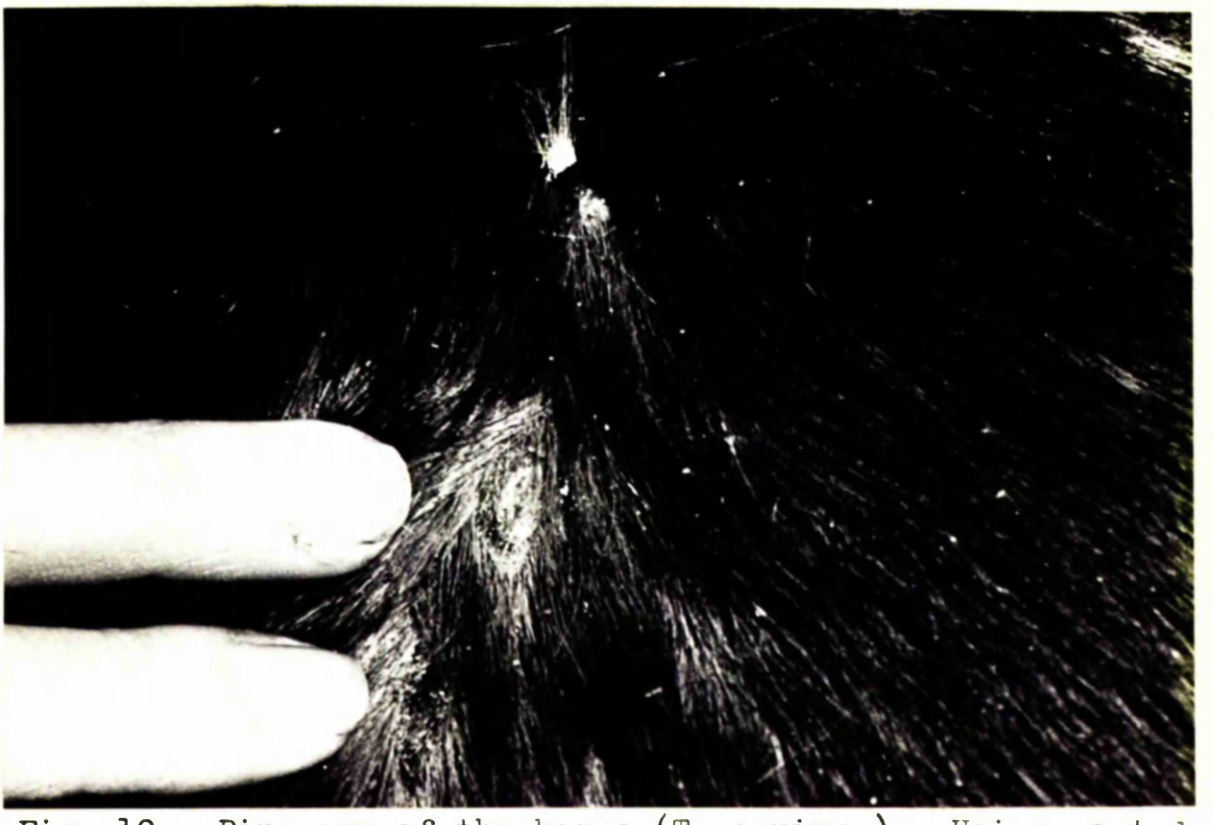

Fig. 10. Ringworm of the horse (T. equinum). Hairs parted to show new hair-growth. Separated scab with adherent hairs may be seen in upper part of photograph.

T. equinum and M. equinum in a hunter. Clearly demarcated circular areas, 1 - 3 cms. in diameter, occurred over the point of the right hip (Fig. 11). The neck and shoulders showed small areas of slightly increased grey scaliness. A patch of hairs at the root of the tail, the ventral surface of a scab from the same area and material from neck lesions fluoresced characteristically under Wood's light. Nine weeks after the first visit the parts of the rump formerly affected were found to be unusually conspicuous because the hair was not only growing again but also at a rate exceeding that of the surrounding coat. From the fluorescent material M. equinum was isolated and T. equinum was recovered by culturing a specimen which did not fluoresce. The clinical appearances of the lesions gave little indication that 2 genera of dermatophytes were present on this horse.

Although ringworm in horses due to T. verrucosum has been known for half a century (Brocq-Rousseau, Urbain & Barotte 1910), the condition has been reported from Britain only within the last few years (Ainsworth & Austwick 1955b). As far as Scotland is concerned the isolation of the organism from horses on 3 different premises reported here is the first of its kind to have been recorded. One of the cases was in a 7-years old trotting pony which was stabled with 3 other horses.

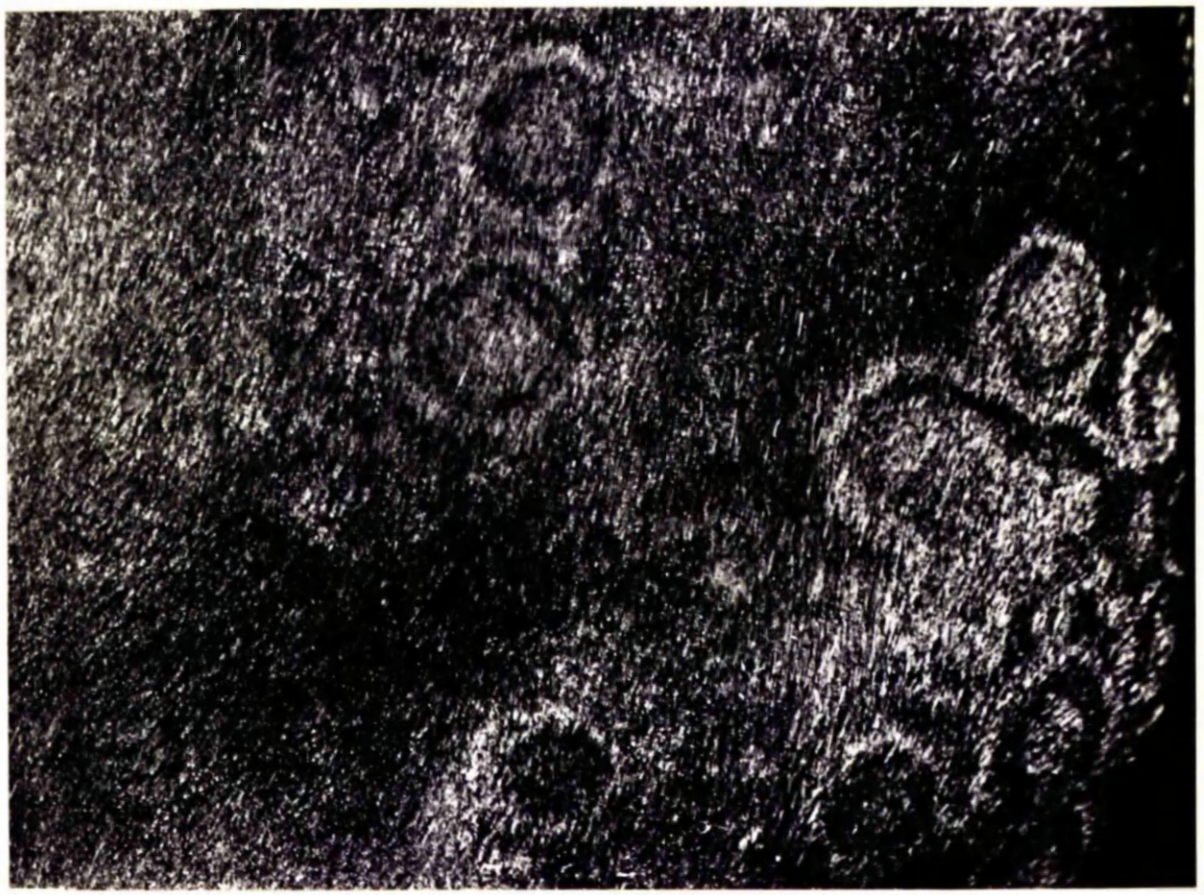

Fig. 11. Equine ringworm (mixed infection of M. equinum and T. equinum). Clearly demarcated, circular areas on the hindquarters.

Confluence of circular lesions on the croup, saddle-region and breast gave rise to large, irregularly shaped, bare areas with smooth, brown centres which were raised above the surrounding skin (Fig. 12). Removal of a plaque revealed a smooth area in which new hair was visible and such bared patches were more deeply pigmented than the surrounding skin (Fig. 13). There was a rectangular patch, 5 cms. long on the forehead, a slightly crusted spot 1.5 cm. in diameter occurred on the pectoral region and 2 scabbed spots were present on the outer aspect of each hind limb but the region of the girth was clear. Two foals and a stallion, stabled with the affected animal and groomed with the same instruments, remained free from infection. T. verrucosum was also isolated from a foal on a farm on which there were 2 other horses that showed lesions of the croup almost identical with those found on the trotting pony; specimens from the in-contact animals on the farm were negative by laboratory methods.

DIFFERENTIAL DIAGNOSIS.

Angleberries may be mistaken for ringworm as may be the lesions on the legs of horses produced by the mange-mite, Chorioptes bovis. The so-called 'rain-rash', which is characterised by matting of the hair over a wide area of the

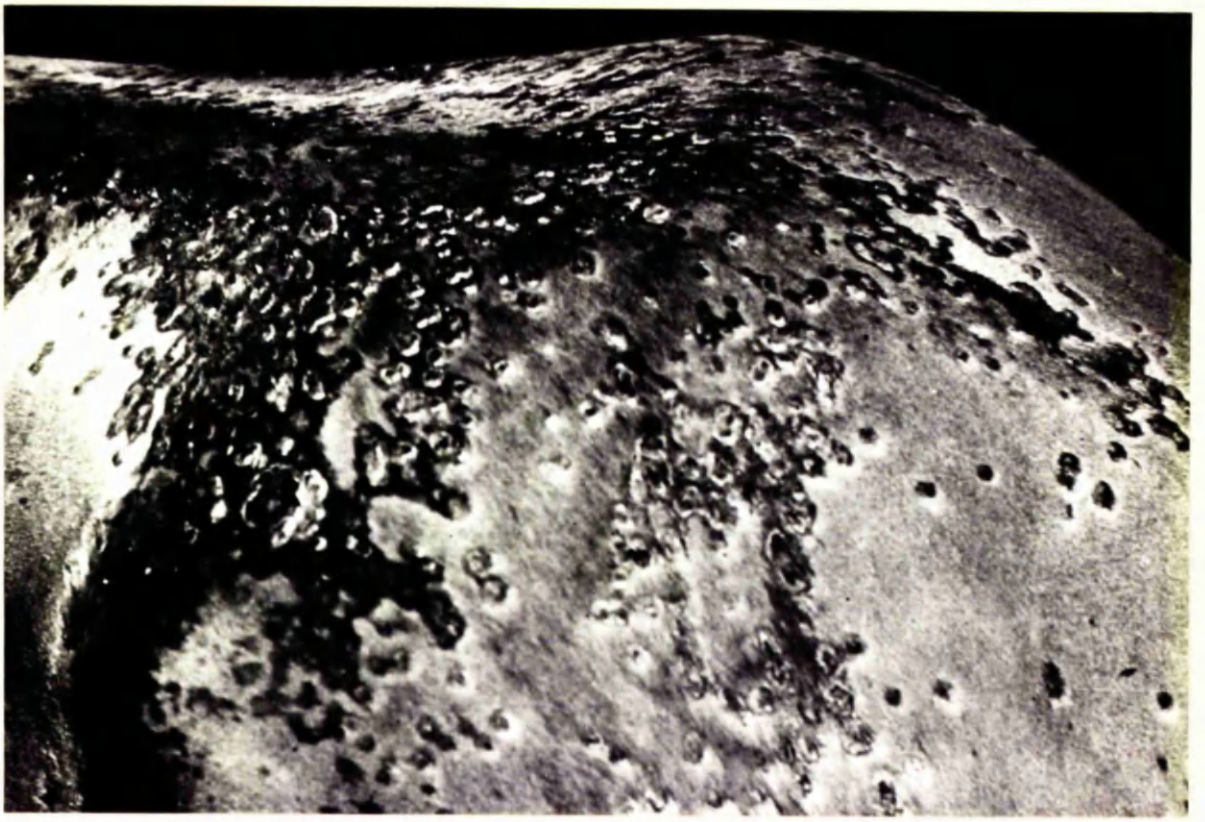

Fig. 12. Equine ringworm (T. verrucosum). Coalescence of mainly circular, crusted lesions on trunk and hindquarters.

Fig. 13. Equine ringworm (T. verrucosum). Removal of smooth plaque to show bared area.

croup, has to be differentiated from dermatomycosis. In the case of dermatitis caused by Dermatophilus sp., Scarnell (1961) has described a tufting effect with raising of the hairs out of their normal level and he noted that the lesions were scabbed and often appeared roughly circular. Distinction of that disease from ringworm is possible only by laboratory examination.

DISCUSSION OF EQUINE RINGWORM.

Four of the 7 dermatophytes found in association with ringworm in horses were isolated in Scotland and the species most often encountered was T. equinum; it was recovered from 56 per cent. of 27 cases. Lebasque (1933) reported that 60 per cent. of all cases of equine ringworm in France were due to M. equinum while T. equinum accounted for 28 per cent. On the other hand, according to Georg et al. (1957a), T. equinum appeared to be the most common cause of ringworm of the horse in the United States, Europe and South America. It was found causing dermatomycosis among hunting horses and riding ponies in my series and on each of the premises there was opportunity for animal to animal spread. The reports by Matruchot & Dassonville (1898) in France, Neefs & Gillain (1931) in Belgium, MacKinnon (1936) in Uruguay, Batte & Miller (1953)

in U. S. A. and Ainsworth & Austwick (1955a) in Britain also dealt with outbreaks of T. equinum ringworm in groups of horses.

Batte & Miller (1953) found that it was beneficial to disinfect harness and grooming kit with the fungicidal compound Captan (N-- trichloromethyl mercapto-4-cyclohexine 1,2-dicarboximide). This was an indication that the spread of infection among animals was thought to be not always direct. In the outbreak among hunting horses mentioned above, spread of infection may have been indirect since the same clippers had been used on several of the animals. Similar dissemination may occur in infections caused by the other species of dermatophytes which were isolated from horses.

Six (24 per cent.) cases of equine ringworm were found to be associated with infection by M. equinum, which the American authors, Conant (1935) and Georg et al. (1957a) do not recognise as a valid species. A specimen from one of my early cases of horse ringworm, sent to Dr. Riddell at St. John's Hospital for Diseases of the Skin, London, was reported as an atypical strain of M. canis. However, since pigment was not produced on artificial media and the macroconidia were shorter and stouter than those of M. canis, the dermatophyte was probably M. equinum.

The lesions produced by T. mentagrophytes were indistinguishable from those associated with T. equinum or with

M. equinum so that laboratory investigation was necessary to identify the type of ringworm which was present. This may have little practical application yet, in so far as a rodent is the probable source of the organism, the epizootiology of infection by T. mentagrophytes differs from that due to T. equinum or M. equinum, both of which are nearly always parasitic on the horse.

The 3 cases of ringworm caused by T. verrucosum were isolated ones that happened on premises containing other horses. This dermatophyte is found mostly on cattle and the affected horses were in contact with infected cattle. The epizootiological pattern of this type of ringworm seems to depend upon contraction of infection from cattle without further spread among the horses in a stable.

The early, dry and raised papule, previously noted to distinguish bovine ringworm and to be more readily recognisable by palpation than by sight, is more easily seen in the horse since it is customary for the hair of that animal to be closely clipped. The early signs of equine ringworm are much the same whatever dermatophyte happens to be present. Ainsworth & Austwick (1959) and Georg, Kaplan & Camp (1957a) say that a similar clinical picture obtains with all the dermatophytes that affect the horse. Although the number of horses affected

by T. verrucosum in this series was small, the lesions were rather more crusty and more acutely inflamed than were those of infection by T. equinum or by M. equinum to which extent there is some analogy with human infections by anthropophilic and zoophilic species of dermatophytes. In man, infection by anthropophilic fungi, e.g. M. audouini, is less severe than that provoked by animal fungi such as T. verrucosum, in which the lesions are of an acute inflammatory character. Thus, the anthropophilic fungus appears to have become adapted to man whereby a reaction to its presence is seldom violent. Further, as has been shown by Georg (1949), T. equinum demands an adequate supply of nicotinic acid which is to be found in equine hair but not in that of other animals. Thus, T. equinum is so adapted to the horse that the host reaction is likely to be much less violent than that produced by the bovine dermatophyte, T. verrucosum.

Even with a limited number of proved cases, it was apparent that equine ringworm tended to prevail during the winter months when horses spend longer periods in stables and so are exposed to greater risk of contact with infected animals, or with contaminated grooming kit and premises.

Batte & Miller (1953) reported that colts and yearlings were most susceptible to ringworm but that animals of all ages

might become infected. One horse in an outbreak investigated by English (1961) did not become infected and she quoted Brocq-Rousseau, Urbain & Barotte (1927) to the effect that older horses show greater resistance. On the other hand, it was my experience that most cases occurred in horses, the average age of which was $8\frac{1}{2}$ years. It must be added that Batte & Miller (1953) were dealing with a racing establishment where the breeding programme provided that young animals as well as old were at risk. In the case of the premises investigated in Scotland, the horses were mostly broken to harness and had been trained for various purposes such as fox-hunting, trotting and as riding ponies, so that few of the animals were under one year old.

In the discussion of bovine ringworm, it was noted that T. verrucosum was readily transmissible to man and that cattle were the chief reservoir of infection. Not only are the main agents of ringworm of horses, T. equinum and M. equinum, less readily transferred to human beings but ensuing infections also tend to be of a mild and transient character (English 1961). Nevertheless, since equine ringworm may be present on establishments where there is close association between man and horse as in riding schools, the danger of transfer of infection from the horse cannot be regarded as unimportant.

(3) INFECTIONS OF DOGS.

The dermatophytes reported as responsible for ringworm in dogs together with some of the more important references are as follows:

M. canis (Georg, Roberts, Menges & Kaplan 1957b, La Touche 1952),

M. gypseum (Ajello 1953, Georg et al. 1957b),

M. distortum (Di Menna & Marples 1954, Kaplan, Georg, Hendricks & Leeper 1957),

M. audouini (Sabouraud 1908, Murrell 1951, Kaplan & Georg 1957),

T. mentagrophytes (Catanei 1936, Georg et al. 1957b),

T. quinckeanum (Schneider 1954, Blank 1957),

T. verrucosum (Kral 1955, Gentles & O'Sullivan 1957a),

T. rubrum (Chakraborty, Ghosh & Blank 1954, Kaplan & Gump 1958),

T. schoenleini (Lebert) Langeron & Milochevitch (Catanei 1936),

T. gallinae (Baudet 1940).

In the survey under review 6 of the 10 listed fungi were isolated.

MYCOLOGICAL ASPECTS.

Out of 221 cases, 41 (18.6 per cent.) proved to be positive (Table 8); 21 (9.5 per cent.) were positive both microscopically and culturally, 13 (5.9 per cent.) were positive only by culture and 7 (3.2 per cent.) were positive

only by microscopical means.

TABLE 8.

RESULTS OF LABORATORY INVESTIGATION OF 221 CASES OF SUSPECTED CANINE RINGWORM.

(Figures in brackets denote percentages.)

	Culture pos.	Culture neg.	Totals
Micro. pos.	21 (9.5)	7 (3.2)	28 (12.7)
Micro. neg.	13 (5.9)	180 (81.4)	193 (87.3)
Totals	34 (15.4)	187 (84.6)	221

Dermatophytes isolated.

On the 34 occasions when dermatophytes were recovered, the following frequency was observed: M. canis 20 (58.8 per cent.), T. mentagrophytes 5 (14.7 per cent.), T. verrucosum 5 (14.7 per cent.) and 1 isolate (2.9 per cent.) each of T. quinckeanum, T. rubrum, Trichophyton sp. and M. gypseum. On 3 of the 5 occasions when T. verrucosum was recovered and on the single occasion when T. rubrum was isolated, the material was negative microscopically. M. distortum, M. audouini, T. schoenleini and T. gallinae were not encountered.

CLINICAL ASPECTS.

(A) Sex incidence.

Infections occurred more frequently in males than in females, there being 13 (59.1 per cent.) males and 9 (40.9 per cent.) females among the 22 animals about which information was available. These figures are presented as factual data and little evidence was found to suggest that sex is an important factor in the incidence of canine ringworm.

(B) Age incidence.

The information regarding 32 animals contained in Table 9 indicates that 68.8 per cent. of cases occurred in dogs during the first year of life and that, although the disease is recognised to occur more frequently in young dogs, infection was present to a considerable extent (18.7 per cent.) in animals which were more than 2 years of age.

TABLE 9.

AGE INCIDENCE IN 32 CASES OF CANINE RINGWORM.

Age	Number affected	Percentage
0 - 6 mths.	20	62.5
7 - 12 "	2	6.3
13 - 24 "	4	12.5
2 - 3 years	1	3.1
+ 3 "	5	15.6

(c) Seasonal incidence.

The seasonal occurrence of canine ringworm with reference to the main causal dermatophytes is shown in Table 10. M. canis was encountered more frequently during the period May to October, when 16 (80 per cent.) of 20 cases occurred. Although 8 of those cases were from one outbreak among boxers, M. canis was found in highest incidence during the summer months. On the other hand, infections by T. mentagrophytes and T. verrucosum tended to be more prevalent during winter and spring inasmuch as 4 of 5 infections with T. mentagrophytes took place between November and April, while T. verrucosum was recovered from 4 out of 5 specimens submitted during the period January to April.

TABLE 10.

BI-MONTHLY TOTALS OF M. canis, T. mentagrophytes and T. verrucosum ISOLATED FROM 30 DOGS.

	M. canis	T. mentagrophytes	T. verrucosum
Jan. - Feb.	1	1	1
Mar. - Apl.	2	1	3
May - June	2	-	1
July - Aug.	8*	1	-
Sep. - Oct.	6*	-	-
Nov. - Dec.	1	2	-
Totals	20	5	5

*Eight of those 14 animals were from one kennel.

(D) Breed of dog affected.

Out of 30 cases, 9 breeds of dogs were found to be affected and on 28 (93.3 per cent.) occasions the animals belonged to the short-haired variety. The breeds of dogs affected together with the associated dermatophytes are shown in Table 11.

TABLE 11.

BREEDS OF DOGS AND CAUSAL FUNGI IN 30 CASES OF CANINE RINGWORM.

Breed	M. canis	T. mentagrophytes	T. verrucosum	M. gypseum	Micro. positive only	Totals
Boxer	11	1	1	1	2	16
Staffordshire Bull-terrier	1	2	-	-	-	3
Cross-bred terrier	2	-	-	-	1	3
Labrador	1	-	1	-	1	3
Boston terrier	1	-	-	-	-	1
Greyhound	-	1	-	-	-	1
Poodle	1	-	-	-	-	1
Pointer	1	-	-	-	-	1
Spaniel	-	-	1	-	-	1
Totals	18	4	3	1	4	30

Irrespective of the causative dermatophytes, not only were boxer dogs more frequently affected (16 positive cases from 5 premises) but the breed was also found to harbour 4 species of organisms, namely M. canis, M. gypseum, T. mentagrophytes and T. verrucosum. None of the other breeds was affected with more than 2 dermatophytes. In the United States, Kral (1955) noted that short-haired breeds were most frequently affected with ringworm due to T. verrucosum.

It is now proposed to deal with the condition associated with each of the causal dermatophytes.

I. RINGWORM CAUSED BY M. canis.

Infection by M. canis has been encountered in most parts of the world and if it is reported from the human population, sooner or later it will be isolated from domestic animals, such as the dog and cat. Marples (1958) says that in New Zealand M. canis is the predominant cause of ringworm of the human head and trunk and that infection is contracted commonly from kittens but sometimes also from dogs. The same organism prevails in ringworm of dogs in the United States (Georg 1960) and has been reported as well from many European countries, including France (Nicolas & Lacomme 1906), Britain (La Touche 1952, Gentles & O'Sullivan 1957b), Ireland (Young 1956), Finland (Sonck 1958) and Norway (Lindqvist 1960).

In this survey, M. canis was the dermatophyte most often recovered from the dog and was isolated from 20 (58.8 per cent.) out of 34 proved cases. All the isolates were procured from individual animals with one exception, namely a kennel of 13 boxer dogs, in which 11 pups of 6 weeks of age exhibited severe and widespread lesions and 2 adult dogs were also affected. M. canis was isolated from 8 of the pups as well as from both adult dogs. The animals were examined at intervals over a period of 6 months, at the end of which time the infection was not any longer demonstrable. At initial inspection, the lesions of the young animals were situated mainly on the almost hairless abdominal skin (Fig. 14) and consisted of circular areas, up to 2.5 cms. in diameter and each surrounded by a raised inflammatory ring. At this stage the pups did not exhibit significant fluorescence under Wood's light. Seven days later the weal was no longer evident but the site was marked by slight exfoliation. Under Wood's light, evidence of widespread infection was then noted in 5 animals and small bare spots had appeared on the head, trunk and limbs. After another week or two the oldest lesions were clearly defined; most had reached 2.5 cms. in diameter, many had developed a grey discoloration and some were raised above the surface of the surrounding skin. Numerous new

Fig. 14. Ringworm of a pup (M. canis). Circular lesions each with raised periphery, on thorax and abdomen.

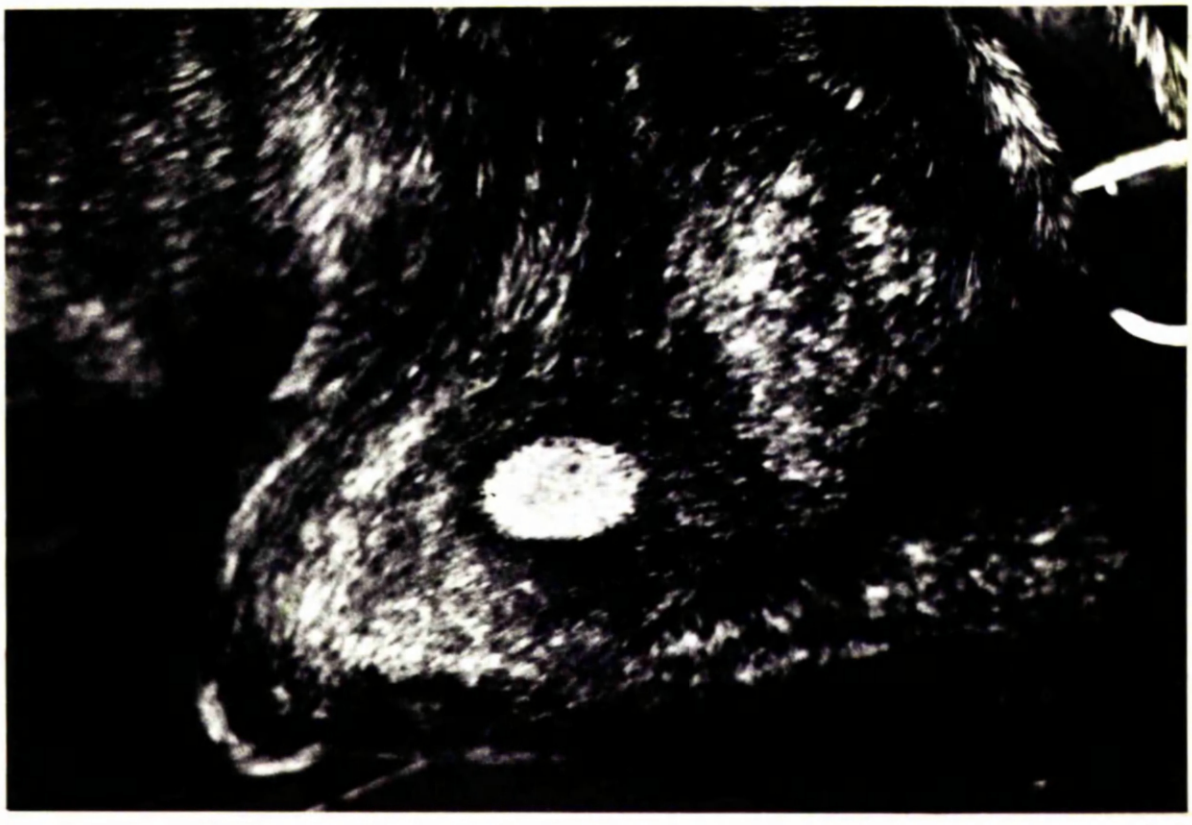

Fig. 15. Ringworm of adult dog (M. canis). Circular, alopecic area near the right elbow.

lesions had then become apparent as palpable, small, discrete spots of crusted exudate with tufting of the bases of the hairs. The crusts did not fluoresce but, when they were removed, that property was detectable towards the base of a few hairs that protruded from the underside of the scab. Many of the small lesions became hairless but did not increase in size, while the original lesions came to be darkly pigmented and covered by thickened, fairly smooth skin. One pup, kept at the University of Glasgow Veterinary Hospital, appeared to have recovered completely after 3 months. The rest of the litter, which remained in the owner's premises, developed a systemic viral infection about 6 weeks after ringworm had been diagnosed. In those animals the dermatomycosis spread much more widely and persisted for as long as 6 months, a probable consequence of the concurrent viral infection.

The 2 adult dogs which were not so badly affected as were the pups, had alopecic, scaly lesions on the limbs (Fig. 15) while small, discrete spots were present on the head and trunk.

Although Wood's light is a useful aid to diagnosis, not all cases of microsporosis show typical fluorescence. Out of 20 cases of M. canis ringworm in this series, only 9 were found to exhibit the phenomenon while in the United States, Kaplan, Georg & Ajello (1958) found that barely one third of

hairs infected by M. canis fluoresced. In my series of cases there was hardly any difference detectable between fluorescent and non-fluorescent lesions inasmuch as only 5 out of 10 of the proved cases among the boxer dogs fluoresced yet the lesions were clinically similar to those which did not fluoresce. The lesions produced by M. canis in dogs were not confined to any particular region of the body (Fig. 16 & 17). Young (1956) reported the occurrence of infection on the claws of a dog. In the cases of this series that were examined clinically involvement of the claw was not encountered.

II. RINGWORM CAUSED BY T. mentagrophytes.

This kind of dermatomycosis was not found to be as common as that due to M. canis, and amounted only to 5 (14.7 per cent.) cases, 4 of which involved animals of the short-haired variety. The lesions were found on the head, particularly on the nose, in the region of the eye and on the ear, but occurred sometimes on the chest and limbs and in general were not significantly different from those due to infection by M. canis. In one case however, favic spots, 1 - 2 cms. in diameter, were noted on the dorsum of the nose of a male dog, 2 years of age.

III. RINGWORM CAUSED BY T. verrucosum.

This fungus is the common cause of bovine ringworm throughout the world (Blank 1955) and has been only occasionally

Fig. 16. Generalised canine ringworm (M. canis). Irregular areas of alopecia with pronounced scaliness.

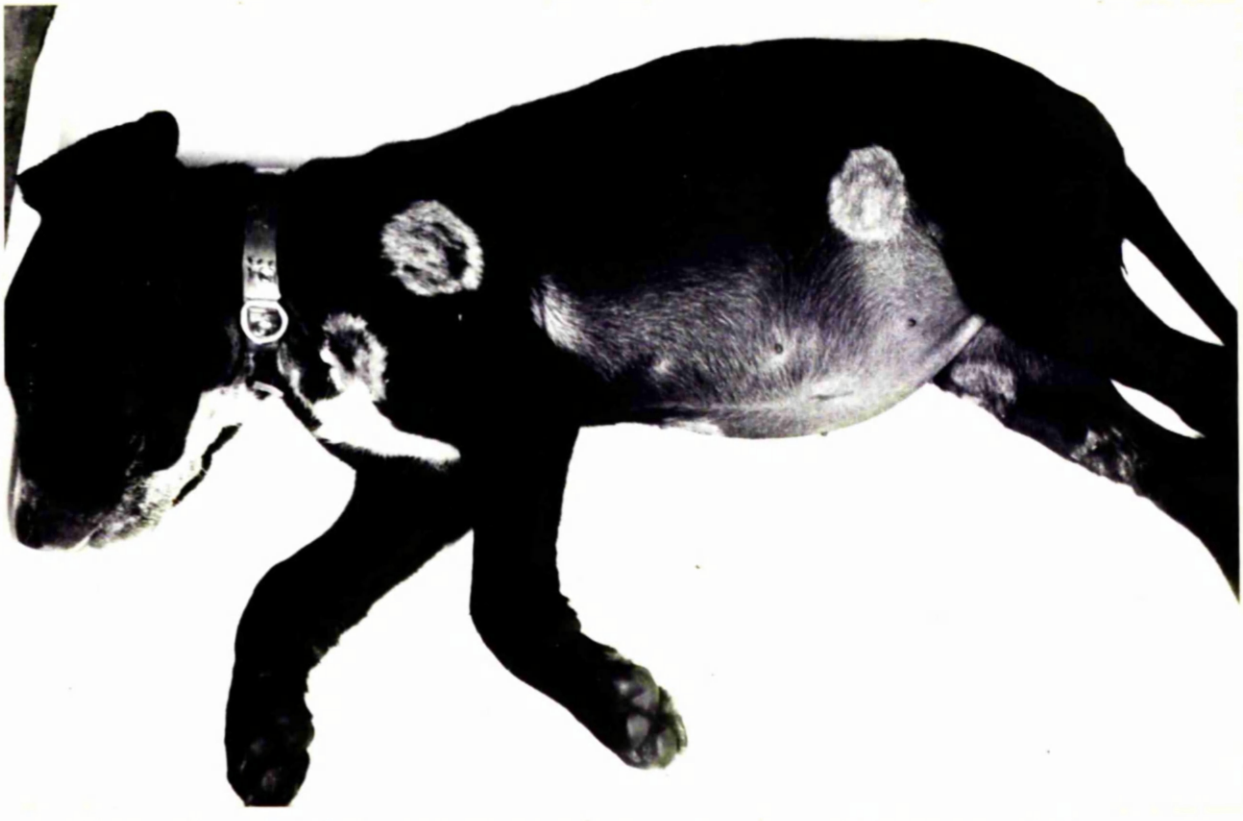

Fig. 17. Canine ringworm (M. canis). Circumscribed lesions on shoulder, trunk and hind leg.

reported from other species, e.g. the dog, horse, sheep and goat (Ainsworth & Austwick 1959). Outside Great Britain, only 2 cases in dogs appear as yet to have been recorded. Baudet (1935) described a single case in France and Kral (1955) reported the condition from the United States where dogs of the short-haired variety, such as boxers and Dobermann Pinschers, were most commonly affected. In this survey, although the number of dogs was small, infection by T. verrucosum was found to be as frequent (14.7 per cent.) as that due to T. mentagrophytes. Of the 5 canine cases caused by T. verrucosum 2 have already been reported (Gentles & O'Sullivan 1957a). In only one of the additional cases were adequate details available. The animal involved was a 3 months old, brown boxer pup and had been born in a calf-pen in which clinically affected calves had recently been housed. According to the owner of the animal the condition had been in existence for a week when it was examined by a veterinary surgeon who found a lesion on each ear and another on the hind part of the body. On the lateral surface of the left ear was an irregularly round and thickly crusted patch, 4 cms. in diameter (Fig. 18). At a similar position on the right ear was a slightly bared spot, about 0.5 cms. in size, with a raised border and which showed some superficial

Fig. 18. Canine ringworm (T. verrucosum). Heavily encrusted lesion on lateral surface of left ear-flap.

desquamation. A rather similar lesion, again with an elevated margin, was to be seen on the lumbar region. The lesions persisted for 7 weeks by which time new hair had started to grow. It is noteworthy that all the canine cases ascribable to infection by T. verrucosum had much the same chance of contact with cattle as did those of similar aetiology in the horse which have been mentioned earlier in the thesis (page 31).

IV. RINGWORM CAUSED BY M. gypseum.

M. gypseum has been estimated to account for 26 per cent. of the cases of canine ringworm in the United States (Georg, Roberts, Menges & Kaplan 1957b) where the organism has also been isolated from the soil (Ajello 1953). Stockdale (1958), Alsop & Prior (1961) and Dawson & Gentles (1961) have recovered it on a number of occasions from British soil. In view of American experience, my finding of only one case among 221 suspected dogs may appear exceptional. However, Alsop & Prior have indicated that heavy concentration of the fungus may be a prerequisite of infection. Certainly, more epizootiological data are necessary before the difference in case-incidence between America and this country become explicable.

The single case encountered by me is the first recorded in Britain and concerned a 2 years old, male boxer on which lesions

were first observed 7 days before it was examined by a veterinary surgeon. On the lateral surface of the left ear-flap there was a grey, domed scab which, subsequent to the application of an emollient ointment, fell off to expose a circumscribed, raw and slightly pigmented area with a red base. Another lesion of similar character was present on the right flank. Because the dog often shook its head and since many ear-mites (Otodectes cynotis) had been found in the red aural wax, the lesion on the ear-flap was presumed to be of traumatic type. Microscopic examination of material from the ear, mounted in caustic potash, revealed the presence of a large-spored, ectothrix fungus that ensheathed the hairs; significant fluorescence under Wood's light was not detectable. The artificially cultivated strain of dermatophyte developed numerous rough-walled macroconidia with slightly rounded ends similar to those typical of M. gypseum. The lesions were not detectable 5 weeks after the initial examination.

V. RINGWORM CAUSED BY T. rubrum.

According to English (1958) this anthropophilic fungus is very prevalent among human patients at various dermatological clinics in Britain. There have been very few records of the isolation of T. rubrum from dogs. The case now reported is the first of its kind in Britain. However, it was encountered

at an early stage in the survey and later, when its precise significance was realised, neither clinical details nor any history of the disease was obtainable. Although microscopical examination proved negative, T. rubrum was recovered and its identity was subsequently confirmed by Dr. Gentles.

VI. RINGWORM CAUSED BY T. quinckeanum.

One case emerged early in the survey but beyond a report to the effect that the animal was a 2 months-old pup and that the lesions occurred on the face, clinical details were not available. Hairs from a lesion were positive microscopically and the associated culture, which was identified by Dr. Gentles, proved to be one of T. quinckeanum. This is the first recorded instance, in Britain, of canine dermatomycosis due to infection by T. quinckeanum.

DIFFERENTIAL DIAGNOSIS IN THE DOG.

Definitive diagnosis of canine ringworm is extremely difficult and is not possible by clinical means alone. Although material for this survey was being selected by veterinary surgeons from cases which they believed to be ringworm, dermatophytes were isolated from only 34 (15.4 per cent.) out of a total of 221 animals; 7 other animals were microscopically positive but did not yield any dermatophyte. Obviously, many

cutaneous conditions of the dog may resemble ringworm and these include ectoparasitism by the mange mites Otodectes, Sarcoptes and Demodex. As has been reported in the case of microsporosis due to M. gypseum (page 48), the lesion of the ear was first regarded as a sequel of pruritus caused by otodectic mites. Mange associated with Demodex folliculorum and with Sarcoptes scabiei may occur on any part of the body and, at an early stage when the lesion is hairless and circular, the condition may closely resemble ringworm. Various forms of eczema and lesions of the skin attributable to dietetic or to hormonal imbalance may simulate those of dermatomycotic origin.

DISCUSSION OF CANINE RINGWORM.

Of the fungi reported as causing canine dermatomycosis, only 4 species were not encountered in this survey and all 4 happened to be unusual causative agents of ringworm of the dog. There is not any evidence that M. distortum is present in Britain but the organism has been reported from New Zealand (Di Menna & Marples 1954) and also from the United States of America (Kaplan, Georg, Hendricks & Leeper 1957) where one case in a dog has been described and pet monkeys, of Cebes and Ateles sp., have been identified as the main reservoir of

infection. M. audouini, an anthropophilic dermatophyte commonly responsible for epidemic tinea capitis of children, has been reported from dogs on only 3 occasions during the past 50 years or so (Sabouraud 1908, Murrell 1951, Kaplan & Georg 1957). T. schoenleini, another anthropophilic fungus that causes favus of man has been recorded from dogs only in Algeria (Catanei 1936) where the organism is widely prevalent in the human population. T. gallinae is a dermatophyte of birds that at the start of this century was apparently common in Britain but is now of very rare occurrence (Ainsworth 1954). Carnaghan, Gitter & Blaxland (1956) reported an isolated outbreak in England. To some extent, the rarity of those dermatophytes may account for my failure to recover them from the dogs under review.

Of the 34 dermatophytes isolated, M. canis was recovered most frequently (58.8 per cent.); there were 5 cases (14.7 per cent.) each, of T. mentagrophytes and T. verrucosum. The other 4 dermatophytes, T. quinckeanum, T. rubrum, Trichophyton sp. and M. gypseum, were solitary isolations. The only other comparable survey of canine ringworm is that done in the United States by Georg, Roberts, Menges & Kaplan(1957b) who isolated 3 dermatophytes as follows: M. canis from 170 (66.9 per cent.), M. gypseum from 66 (26 per cent.) and T. mentagro-

phytes from 18 (7.1 per cent.) out of 254 cases.

Lesions of the dog did not vary significantly in regard to the causal dermatophyte but showed a gradation from circular areas of scaliness with alopecia to heavily encrusted patches and tended to persist for 3 to 6 months.

Not all cases of M. canis infection fluoresced but in this series there was a higher percentage of such positive cases than was experienced by Kaplan, Georg & Ajello (1958) in the United States. Nevertheless Wood's light is a useful aid to diagnosis of ringworm caused by M. canis, especially in cases of minimal infection. Lewis, Hopper, Wilson & Plunkett (1958) have said that hairs affected by certain strains of M. gypseum fluoresce characteristically green but the concensus of opinion is that the fungus does not behave in this manner. Fluorescence was not seen in the one dog affected by that fungus in the survey.

The relatively high incidence of infection by T. verrucosum among dogs of this series reflects the high frequency of bovine ringworm. Local surveys of the kind under review are necessary not only to discover the prevailing species of dermatophytes which are present but also to determine their relative occurrence and particular importance. Undoubtedly, cattle constitute the main reservoir of human trichophytosis caused by T. verrucosum but infection of man may also arise indirectly via the

dog.

Whereas it is established that dogs and cats are the reservoir for infections with M. canis both in animals and man, the source of infection by T. mentagrophytes has yet to be determined. From time to time, the latter organism has been recovered from all the domestic animals (Blank 1955) and also from many wild species (Georg 1954, Marples 1961) and in some cases, affected animals were clinically normal (Fuentes, Bosch & Boudet 1954, Mackenzie 1961). Thus, not only is T. mentagrophytes pathogenic for man but its wide prevalence in the animal kingdom is a potential danger to human beings, a problem that is more fully discussed in Part II of this thesis.

Although T. rubrum is a common human dermatophyte it has been reported only 3 times from animals. In India, Chakraborty, Ghosh & Blank (1954) found it in a dog and in 2 cows while Moss & Dyson (1955) and Kaplan & Gump (1958) reported it from dogs in the United States. The owner of one of the dogs mentioned by Kaplan & Gump had ringworm of the feet caused by T. rubrum and he admitted the habit of rubbing the dog with his bare feet. In the absence of any known extra-human reservoir, animal infection by T. rubrum presumably originates from man.

In 22 out of 32 dogs (68.8 per cent.) ringworm was diagnosed mycologically during the first year of life and in 6 (18.7 per cent.) animals which were over 2 years old. The case-incidence thus appears to be higher in young dogs but, since infection was encountered also in adult animals, the development of a solid age-immunity is manifestly not a feature of the disease.

More cases of trichophytosis due to infection by T. mentagrophytes or by T. verrucosum occurred during the winter and spring than were encountered throughout the summer and autumn. The reverse was the case with microsporosis caused by M. canis, even after inclusion of the outbreak among boxers that happened during the summer months. In the United States Kaplan & Ivens (1961) reported that infections due to T. mentagrophytes were most frequent in the months of November and December and that the majority of M. canis infection also arose during the winter period October to February inclusive. More information is necessary on the epizootiology of dermatophytosis before the pattern of seasonal incidence can be explained. Since most cases of infection of cattle by T. verrucosum occur during the winter and spring (see page 16) and since cattle are the main reservoir of the parasite, it may be reasonably presumed that dogs at risk have more opportunity to acquire infection

during those periods of the year.

Irrespective of the causal fungus, boxers showed most frequently the signs of ringworm and that breed was most commonly affected of the 7 from which M. canis was recovered. Short-haired animals were almost the only type encountered with dermatomycosis and, perhaps because of the character of the coat, the lesions of ringworm are more easily detectable. However, as is the case with infection by T. verrucosum, exposure to infection is probably the most important single factor in the development of the disease. Controlled experiments are required to determine whether, or not, there is any breed susceptibility to ringworm or whether the type of coat is significant.

Although the incidence of canine ringworm in the west of Scotland has proved to be of a low order, the causal fungi are pathogenic also for man whose close association with dogs furnishes every opportunity for him to acquire the infective agent. From a public health point of view the reservoir should be eliminated by suitable therapeutic treatment.

(4) INFECTIONS OF CATS.

The dermatophytes reported as aetiologically responsible for ringworm of cats, together with the more important references, are as follows:

M. canis (Davidson & Gregory 1933, La Touche 1952),

M. gypseum (Kaplan, Georg & Bromley 1957),

T. mentagrophytes (Georg, Roberts, Menges & Kaplan 1957b),

T. quinckeanum (Blank 1957, La Touche 1959),

T. schoenleini (Stevenin 1938).

Three of the above species were recovered but dermatomycosis due to either M. gypseum or T. schoenleini was not encountered.

MYCOLOGICAL ASPECTS.

There were 39 (37.1 per cent.) positive cases out of 105 animals examined (Table 12); 27 (25.7 per cent.) were positive both microscopically and culturally, 8 (7.6 per cent.) were positive only by culture and 4 (3.8 per cent.) were only microscopically positive. As with the other species of animals involved in this survey, specimens

which were positive to microscopical examination were mainly (87.4 per cent.) also positive by cultural methods and those negative on microscopy generally (89.2 per cent.) failed to produce a culture.

TABLE 12.

RESULTS OF LABORATORY INVESTIGATION OF 105 CATS SUSPECTED OF RINGWORM.

(Figures in brackets denote percentages.)

	Culture pos.	Culture neg.	Totals
Micro. pos.	27 (25.7)	4 (3.8)	31 (29.5)
Micro. neg.	8 (7.6)	66 (62.9)	74 (70.4)
Totals	35 (33.3)	70 (66.7)	105

Dermatophytes isolated.

Of the 35 pathogenic fungi recovered, the following frequency of species was observed: M. canis 25 (71.4 per cent.), T. mentagrophytes 5 (14.3 per cent.), T. quinckeanum 4 (11.4 per cent.) and Trichophyton sp. 1 (2.9 per cent.).

CLINICAL ASPECTS.

(A) Sex incidence.

There were 12 (57.1 per cent.) females and 9 (42.9 per cent.) males among the 21 animals for which information was available and sex did not seem to have any effect on the incidence of infection.

(B) Age incidence.

Data on 31 animals are shown in Table 13 where it is evident that cases were more frequent during the first year of life, when 25 (80.6 per cent.) of the animals were affected. However, the condition occurred also in 6 (19.4 per cent.) cats over 1 year old.

TABLE 13.

AGE INCIDENCE IN 31 CASES OF FELINE RINGWORM.

Age	Number affected	Percentage.
0 - 6 months	7	22.6
7 - 12 "	18	58.0
13 - 24 "	3	9.7
+ 2 years	3	9.7

(C) Seasonal incidence.

The seasonal incidence of ringworm in 33 cats is shown in Table 14 which indicates that infection by M. canis

prevailed throughout the period July to October when 17 (51.5 per cent.) cases were encountered. Fifteen of those cases, however, came from a single group of cats to which stray animals were constantly being added so that not only was the feline population changing but the new animals were being introduced into a heavily infected environment. Hence the relation of incidence to season may be merely apparent and, in fact, may reflect only the time at which specimens were selected. The 5 cases caused by T. mentagrophytes occurred between September and April and the 4 due to T. quinckeanum happened during the period January to May.

TABLE 14.

BI-MONTHLY TOTALS OF DERMATOPHYTES ISOLATED FROM 33 CATS.

	M. canis	T. mentagrophytes	T. quinckeanum
Jan. - Feb.	3	-	2
Mar. - Apl.	2	1	-
May - June	-	-	2
July - Aug.	15*	-	-
Sep. - Oct.	2	2	-
Nov. - Dec.	2	2	-
Totals	24	5	4

* All from a single premises.

The morbid condition associated with each of the causal dermatophytes in cats will now be described.

I. RINGWORM DUE TO *M. canis*.

Twenty five (71.4 per cent.) of 35 proved cases of ringworm occurred in cats residing in 10 premises. In one establishment alone, 15 out of 24 cats were found to be infected and the condition appeared to be of enzootic character. The owner took in stray cats which, if they were not already infected, quickly became so after admission. The lesions varied from discrete, barish areas, 6 - 13 mms. in diameter with slight scaliness, to generalised encrusted patches over the head, body and limbs. Although it was recorded by La Touche (1955), involvement of the claws was not encountered in any of the 15 cats examined on this premises. Out of 20 cats observed under Wood's light, 15 (75 per cent.) proved positive and 5 (25 per cent.) did not manifest any fluorescence.

Since the 25 affected cats of this series came from only 10 premises, ringworm caused by *M. canis* is comparatively rare in this part of the country. Further evidence of the low incidence of the condition was obtained when, during the month of September 1955, all the cats (mostly, stray animals), brought for destruction to a veterinary clinic in Glasgow, were investigated under Wood's light and by means of scrapings taken

from any suspicious areas. Out of 103 animals so examined, none yielded any evidence of dermatomycotic infection.

II. RINGWORM DUE TO T. mentagrophytes.

In the United States Georg et al. (1957b) noted that ringworm caused by T. mentagrophytes was fairly common in the dog but was only occasionally encountered in the cat. Loss of hair together with circular scaly areas were given as the main manifestations. Ainsworth & Austwick (1955b) described infection by T. mentagrophytes in cats as producing lesions which resembled favus.

Of the 35 cats of this series, 5 (14.3 per cent.) living in quite separate premises were found to be affected by the parasite. One animal had 2 circular, bald areas, 13 mms. in diameter, but in 2 others heavily encrusted areas occurred on the left elbow and the left paw and in the latter situation, the lesion was typically favic, i.e. it consisted of a saucer-like crust with raised edges. One cat had a single lesion behind the right ear together with another patch between the scapulae.

III. RINGWORM DUE TO T. quinckeanum.

In the survey conducted by Ainsworth & Austwick (1955b) T. quinckeanum was not encountered and the same authors (1959) quote only one reference to the occurrence of the organism in

cats viz., that of Blank (1957). Since then La Touche (1959) has described artificially induced infection of kittens as well as the spontaneous disease and in the latter, favic crusts occurred on the ears, fore-limbs, the hips and the tail.

The 4 unconnected cases of T. quinckeanum ringworm of this series constitute a first record for Scotland. One of the kittens was 4 months, another only 6 weeks, old but the ages of the other 2 were not ascertainable. The lesions occurred on the ear, forehead and elbow in the form of crateriform crusts with raised edges similar to the favic scutula described by La Touche (1959).

DIFFERENTIAL DIAGNOSIS IN THE CAT.

In general, the diseases of the skin mentioned in reference to canine ringworm are to be found also in the cat. Feline mange occurs in various forms. Ear-mange, caused by Otodectes cyanotis, affects mainly the auditory meatus but may also produce lesions located on the external surface of the ear. Body-mange associated with Demodex folliculorum may simulate ringworm in so far as circular areas of alopecia may be manifest. Again, should it affect the region of the head, mange produced by Notoedres cati and by Sarcoptes scabiei, may be characterised by scabbed lesions not unlike those of

dermatomycosis. Eczema of the cat assumes a variety of forms and, since it is essentially a dermatitis, the lesions of which may be circular in character, it may call for distinction from ringworm. While it is impossible to establish the type of ringworm on clinical or on microscopical evidence alone, the presence of the yellowish, saucer-like lesions of favus is strongly suggestive of infection by T. quinckeanum and a greenish fluorescence under Wood's light is a certain indication that the case is one of M. canis infection.

DISCUSSION OF FELINE RINGWORM.

Of the 5 dermatophytes reported as causal agents of ringworm in the cat, 3 were isolated. Infection by M. gypseum or by T. schoenleini was not encountered. Despite its prevalence in soil M. gypseum is declared by Kaplan, Georg & Bromley (1957) to occur rarely in cats in the United States and the organism has yet to be isolated from cats in Britain. T. schoenleini is primarily an anthropophilic dermatophyte and the case of infection of a cat reported by Stevenin (1938) probably originated from a human being.

The commonest fungus recovered was M. canis which accounted for 71.4 per cent. of the 35 dermatophytes that were isolated. Because the lesions of natural cases were

mainly of minimal type, in sharp contrast with the severe inflammation seen in canine infection, it may be that the cat is the more natural host for this fungus. As was discussed in connection with T. verrucosum infection of horses (page 35), fungi not adapted to a particular host generally produce a marked inflammatory reaction in that animal. Thus, in man, M. canis gives rise to acute inflammatory ringworm (Beare 1958). Conversely, a fungus already adapted to a host generally provokes a minimal grade of inflammation (Barlow & Chattaway 1958), e.g. infection by M. audouini in children and by M. canis in cats. Rebell, Timmons, Lamb, Hicks, Grove & Coalson (1956) observed that in 76 kittens affected by M. canis the cutaneous changes were minimal and comprised erythema, mild induration, light scaliness and occasionally slight encrustment. They further found that positive fluorescence of the hairs persisted for 180 days. La Touche (1952, 1953) found that the majority of naturally infected cats did not present any obvious lesions and that Wood's light was essential for their discovery but that, occasionally, a more severe reaction might lead to the formation of a crust. Reiss, Caroline & Leonard (1955) noted that, in experimentally infected cats, the lesions varied from slight erythema with some loss of hair to scaling and crusting; the mean duration of clinical signs

in 6 cats examined by them was 23 days and that of positive fluorescence was 121 days. During the course of an experiment to test the efficiency of griseofulvin against M. canis infection in cats, the writer observed that in untreated control animals detectable thickening of the skin occurred 18 days after inoculation and persisted for 79 days. Cultures of M. canis were recovered, and positive fluorescence was noted, 127 days after inoculation. The histological changes in the skin of the cats were similar to, but less marked, than those of cattle. Encrustment occurred in all of the cats but to a lesser degree than it did in cattle (O'Sullivan 1961).

Wood's lamp is a useful aid to the diagnosis of feline ringworm caused by M. canis because many cases present only minimal clinical signs and, sometimes, positive fluorescence by affected hairs was the only evidence of the existence of disease. However, 25 per cent. of 20 cases failed to show positive fluorescence so that a negative result with Wood's light does not preclude a subsequent diagnosis of infection by M. canis.

Infection by T. mentagrophytes and by T. quinckeanum occurred to about the same extent which was well below that of infection by M. canis. T. mentagrophytes is the only dermatophyte which has been encountered on all the species of

animals as yet discussed viz.: ox, horse, dog and cat although the association of the parasite with other hosts is recorded later in this work. The lesions produced by T. quinckeanum were situated mainly on the fore-part of the body and, as this fungus is the causal organism of mouse favus (Vanbreuseghem 1958, La Touche 1959), it is understandable that the paws, elbows and head of the predatory cat are the areas most at risk by contamination from an infected mouse.

Ringworm in cats is more frequent in the first year of life although infection of adult cats was encountered. Cases of infection by T. mentagrophytes occurred in winter and spring and those due to T. quinckeanum happened only in the spring. Since the majority of the cases of M. canis ringworm occurred on one premises, it is not possible to say whether the summer incidence reported in the dog, occurs also in the cat.

The epizootiology of cat ringworm resembles that of the canine disease. Although they are primarily of zoophilic type, the causal fungi may cause severe ringworm of man so that, bearing in mind the close contact which obtains between humans and cats, effective control of the feline disease is essential. The available evidence suggests that the disease is not common in cats in this part of the country although it has been reported more frequently from other parts of Britain.

In 1950 Walker noted that M. canis derived from dogs and cats was the predominant cause of human microsporosis in Leeds, Coventry and Portsmouth. Again in the Leeds area, La Touche (1952) found that the incidence of infection of man declined sharply after the feline source had been removed from the household. Many of the cats examined by him did not present any obvious lesions and the infection was detectable only under Wood's light. Since fluorescence is not always manifest, it may be very difficult to diagnose the condition and to obtain a mycological cure. Further work is necessary before more accurate methods of diagnosis become available and lead to the elimination of this reservoir of human ringworm.

(5) INFECTION OF OTHER HOSTS.

Other than cattle, horses, dogs and cats, 3 species of animals yielded evidence of dermatomycosis, namely: the laboratory mouse, chinchilla and goat (Table 15). Out of 6 mice only one proved positive to both microscopical and cultural examination. Cultures were obtained from 2 out of 12 chinchillas although specimens from all 12 animals were microscopically negative. Of 3 goats only one showed microscopical, but not any cultural, evidence of ringworm.

TABLE 15.
RESULTS OF LABORATORY INVESTIGATION OF MICE, CHINCHILLAS AND GOATS SUSPECTED OF RINGWORM.

	Number of animals	Micro. result.		Culture result.	
		Pos.	Neg.	Pos.	Neg.
Mouse	6	1	5	1	5
Chinchilla	12	0	12	2	10
Goat	3	1	2	0	3

Infection of the Mouse.

The earliest reports of ringworm of the mouse date back to the middle of the 19th century (Bennett 1850) but did not include cultural examination so that the causal fungus was not identified. Since then, 4 species of dermatophytes have been isolated and, together with some of the

more important references, are as follows:

T. mentagrophytes (Du Bois 1929, Parish & Craddock 1931, Catanei 1942 and Booth 1952),

T. quinckeanum (Adamson 1909, Connor 1932, Vanbreuseghem 1950 and La Touche 1959).

T. schoenleini (Sabouraud 1908),

T. violaceum as Achorion violaceum (Bloch 1911).

Of the 6 mice investigated only one, which was clinically normal was positive by laboratory methods. Although numerous hairs were examined only a few were found to carry a small number of hyphae and T. mentagrophytes was isolated from the case. In France, Du Bois (1929) described an epizootic, among mice, of ringworm associated with T. mentagrophytes. The same organism was isolated by Parish & Craddock (1931) and by Booth (1952) from laboratory mice in Britain and the United States respectively and it was recorded by Catanei (1942) in mice in Algeria. My single case was a white mouse which was kept as a pet by a young boy who suffered from ringworm due to T. mentagrophytes. T. quinckeanum was not encountered in mice although it is established that they are the reservoir for this infection. However, the number of mice examined in this series was too small to be a significant sample. Ringworm in mice is not without importance if only because the condition is transmissible to people who handle affected animals.

Infection of the chinchilla.

Only 2 species of dermatophytes, namely T. mentagrophytes and M. canis, have been reported as causing dermatomycosis in chinchillas. Blank, Byrne, Plummer & Avery (1953) isolated T. mentagrophytes from chinchillas suffering from 'fur-slipping'. Those observers as well as McPherson (1960) noted that a moth-eaten appearance of the coat was an early sign of the condition and that desquamation of the skin of the nasal region occurred. Menges & Georg (1957) reported the isolation of M. canis from a chinchilla. Twelve animals were examined from 10 premises in the present series and although all the specimens proved negative by microscopical means, cultures of T. mentagrophytes were recovered from 2 different premises. On the head of one animal there was a bare patch that increased from an initial diameter of 8 mm. to one of 3 cms. within 2 days and was associated with complete alopecia and desquamation of the exposed skin. Pruritus was not conspicuous since the animal was not observed to rub the lesion and the condition resolved quickly after treatment by griseofulvin. The other animal, a 16-months old female, showed a small crusty spot on the dorsum of the nose. On yet another premises, 4 chinchillas presented circular alopecic areas but repeated attempts to detect or to isolate a fungus were unsuccessful. Differentiation from a dietetic disturbance was not easy because the disappearance of

the cutaneous abnormality in the last-mentioned animals coincided with a dietary change. In the chinchilla, dermatomycosis is potentially a serious disease since anything which interferes with the condition of the skin and hair is almost certain to affect adversely the market value of the pelts.

Infection of the Coat.

Baudet (1932) isolated a faviform trichophyton (= T. verrucosum) from above the left eye of a goat and Catanei & Izac (1941) recovered a large-spored ectothrix fungus which, they said, resembled T. langeroni. I examined a specimen from a kid and although a large spored ectothrix dermatophyte was noted on the hairs, a culture was not procured. Possibly, the fungus was T. verrucosum which had been acquired from cattle and was of minimal viability because of its location on an unsuitable host.

DISCUSSION OF, AND CONCLUSIONS FROM, THE SURVEY OF ANIMAL DERMATOMYCOSIS IN SCOTLAND.

Investigation of 728 animals, comprising the ox, horse, dog, cat, mouse, chinchilla and goat suspected of ringworm infection, revealed that 344 (47.2 per cent.) were positive, that only 252 (34.6 per cent.) were positive both by microscopy and culture, that 32 (4.4 per cent.) were positive only on culture and that 60 (8.2 per cent.) were positive only by microscopy. Forty five (75 per cent.) of the 60 specimens which were only microscopically positive came from cattle and this finding indicates that there may be difficulty in isolating a dermatophyte from bovine material that is known to be positive. This is due, partly, to the fact that T. verrucosum grows slowly and, partly, to heavy contamination that usually arises from saprophytic moulds and bacteria. Moreover, if material has been recently treated with a fungicidal dressing, the viability of the dermatophyte may be adversely affected. In the early part of the survey before the introduction of the cycloheximide medium (Georg 1953), there were 15 microscopically positive cases in which the slow-growing dermatophyte became overgrown by saprophytic fungi and bacteria. During the latter part of the work 25 cases, in which a culture was not obtainable had histories of recent antifungal treatment.

The material for examination was submitted by veterinary surgeons from animals suspected of dermatomycosis yet the proportion of positive laboratory results varied greatly. In cattle there were

82.3 per cent. proved cases, in horses 27.6 per cent., in dogs 18.6 per cent. and in cats 37.1 per cent. The small numbers of proved cases in horses, dogs and cats suggest that differential diagnosis is more difficult in these animals and, perhaps, that the lesions are not so readily detectable as they are in cattle. Even in cattle, in which ringworm lends itself to diagnosis on olinical signs alone, definitive diagnosis requires other methods of investigation.

Dermatophytes were isolated on 285 occasions and the relative frequency was as follows: T. verrucosum, 195 (68.2 per cent.); M. canis, 45 (15.8 per cent.); T. mentagrophytes, 15 (5.3 per cent.); T. equinum, 14 (4.9 per cent.); M. equinum, 6 (2.1 per cent.); T. quinckeanum, 5 (1.8 per cent.); M. gypseum, 1 (0.3 per cent.); T. rubrum, 1 (0.3 per cent.); Trichophyton spp., 3 (0.9 per cent.). Thus, not only were most of the specimens identifiable as T. verrucosum but also, nearly all of the isolates of this dermatophyte came from cattle, the remainder originating from horses and dogs. Apart from the single isolation of T. mentagrophytes from a calf, the only dermatophyte found on cattle was T. verrucosum. Circumstantial evidence strongly suggests that both equine and canine infection by the latter fungus resulted from contact with infective cattle.

M. canis occurred in only dogs and cats, from which latter species a slightly greater number (55.5 per cent.) of isolations

was effected. Because the canine lesions were generally of more highly inflammatory character, it would appear that, despite the specific name canis, the fungus is not as well adapted to exist on dogs as it is on cats. Not all cases showed diagnostic fluorescence under Wood's light and indeed, the phenomenon was not seen in 50 per cent. of 18 dogs and in 25 per cent. of 20 cats. Nevertheless, Wood's light is useful in the diagnosis of M. canis ringworm of those animals.

T. mentagrophytes occurred in all 6 species of hosts. Most of the 15 isolations were made from dogs and cats (33.3 per cent. in each) with additional solitary recoveries from a calf, a horse and a mouse. The organism was the only dermatophyte procured from the mouse and the chinchilla. Since T. mentagrophytes is a cause of human dermatomycosis its lack of host specificity constitutes a hazard to public health, although infection of domesticated animals is less important in that respect than is rodent infection.

All the isolates of T. equinum were from the horse and, since this dermatophyte has its specific nutritional requirements fulfilled by horse hair (George 1949), one would not expect to encounter it in other animals. In one case it was found in association with M. equinum and, although cases of dual infection are not rare in man, it was the only instance of its kind encountered in the survey. There was not any

clinical indication that the horse was affected by 2 distinct dermatophytes apart from the finding that the lesions associated with M. equinum fluoresced.

T. quinckeanum was isolated on 4 occasions from cats and once from a dog but was not encountered in the few mice examined although those rodents are considered to be the reservoir of infection for other animals as well as for man. Both M. gypseum and T. rubrum were obtained only once from a canine source, an experience that is rather surprising in respect of M. gypseum in view of its high incidence in dogs in U. S. A. and its frequent occurrence in soil. T. rubrum was the only anthropophilic dermatophyte recovered from an animal which, in turn, possibly contracted infection from a human being.

The incidence of ringworm was not clearly associable with either sex in any of the animals investigated. Generally, dermatomycosis was seen more frequently in young animals, e.g. calves, pups and kittens, but evidence was obtained that adult animals also were affected. Since clinical signs are unlikely to recur on animals which have recovered from ringworm (see page 111), the presence of lesions on adults probably indicates that they had not been exposed to infection at an earlier stage of life. The prevalence of the disease in the young did not apply to the horses in this series since 11 (78.6 per cent.) of 14 animals were over 3 years of age.

In cattle, the head, the trunk and the neck were usually

involved but the limbs were seldom affected. The disease is spread mainly when an animal rubs itself against an infected animal or a contaminated rubbing-post and, since they are unlikely to make such contact, the legs are less frequently involved. In horses, areas subject to rubbing, such as the regions of the saddle and the girth were found to be most often affected. The lesions of the limbs probably arose in consequence of grooming. Neither in the dog nor in the cat was selective localisation of lesions observed although there seemed to be some correlation between the assocation of T. quinckeanum infection of the forepart of the cat and the role of the mouse as the natural reservoir of infection.

Kral (1955) maintened that short-haired dogs were most commonly affected by T. verrucosum and, in this series such varieties were most often afflicted by ringworm of whatever cause. However, since comparatively few long-haired animals were encountered, it may be that the type of the coat is not altogether as significant as it may seem and exposure to infection would then remain the chief factor in the occurrence of the disease.

In the main, more cases were encountered during the winter months than during the summer. The majority of cases of infection by M. canis in dogs, however, were seen between May and October. Since most horses and cattle are housed during the winter, the opportunity for the spread of infection is then greater than at any other time of the year. On the other hand,

the bovine disease does not completely disappear during the summer months so that some dissemination of ringworm takes place while animals are at grass.

In the different species of animals, although the lesions varied in severity, ringworm was essentially a chronic dermatitis attended by thickening of the skin and loss of hair. In cattle there was excessive formation of scab and, when the latter was shed, healthy skin remained without any sign of residual infection. In the horse, encrusted lesions occurred mainly in the few cases of infection by T. verrucosum but were never as marked as they were in cattle. In horses, too, clinically recovered animals did not appear to remain as carriers of infection. The lesions of dogs and cats varied from mere alopecia to formation of a scab although favic scutula were conspicuous in infection by T. quinckeanum. Even so, clinically normal dogs and cats sometimes showed positive fluorescence under Wood's light.

Several of the dermatophyte species which were isolated, are new host records. Thus, T. rubrum, T. quinckeanum and M. gypseum have not previously been recorded from the dog in Britain while the isolation of T. quinckeanum from a cat and of T. verrucosum from a horse are new records from these animals in Scotland.

The survey has provided information concerning the occurrence and the distribution of some dermatophytes among animals

in Scotland. It has been shown, for instance, that T. verrucosum is common in this area and that ringworm of other animals is not an important veterinary problem although, should the disease become established on premises devoted to the breeding of cats, dogs or chinchillas, serious consequences may follow. In the cat, infection may persist for as long as 6 months and any abnormality of the skin in chinchillas is an obvious source of loss. A high incidence of bovine ringworm involves considerable economic loss if only because the saleable value of affected animals is reduced. Moreover, infected cattle constitute an extensive reservoir of human infection by T. verrucosum. Ringworm of domestic pets, although it may be comparatively unimportant from a veterinary point of view, in this area, is another source from which man may contract the disease. Clearly then, ringworm of animals is a matter of the utmost importance to public health.

A number of problems remain to be solved. Thus, many aspects of epizootiology have yet to be investigated. Again, how does the disease persist between outbreaks ? Are particular sites of the body affected or is infection of a random nature ? Why is it that some cases of M. canis infection fluoresce and others do not ? Is the type of coat of any significance in the onset of canine ringworm ? Further investigation into natural and artificial infection of animals by the various dermatophytes is needed before a satisfactory comprehension of dermatomycosis becomes available.

PART II.

A CORRELATION OF HUMAN AND ANIMAL DERMATOMYCOSIS IN SCOTLAND.

Some of the dermatophytes affecting man are almost completely host specific and they are only rarely found on animals. Such anthropophilic species include M. audouini, T. rubrum, T. schoenleini, T. tonsurans var. sulfureum and T. violaceum. Zoophilic fungi such as T. verrucosum, T. mentagrophytes and M. canis are encountered most often on animals although they are transmissible to, and may cause ringworm of, man. Yet a third group, the geophilic dermatophytes e.g. M. gypseum and Keratinomyces ajelloi Vanbreuseghem which occur naturally on soil can on occasion become parasitic on man and animals (Dawson & Gentles 1961).

The second part of the thesis deals with the public health aspect of ringworm insofar as many human infections are attributable to dermatomycosis of animals.

The literature at the beginning of the century showed a keen awareness of the infectivity for man of dermatophytes of animal origin (Zollikofer & Wenner 1908, Sabouraud 1908). Identification of the causal fungus from humans was generally determined satisfactorily but too often the identity of the dermatophytes affecting animals was left to conjecture. With the re-awakening of interest in medical and veterinary mycology in the 1950's the animal reservoir of human dermatomycosis was

stressed. Thus the surveys of Walker (1950), Carlier (1954), Rook & Frain-Bell (1954) in Britain and Kaplan, Georg & Ajello (1958) in the United States of America showed that a high proportion of human cases was due to zoophilic fungi. Walker (1950) and Carlier (1954) reported that such infection was mostly caused by species isolated from dogs and cats. Mortimer (1955) said that, although cattle ringworm was the commonest mycosis of animals in Britain, man was most frequently infected from domestic pets. In the United States Kaplan et al. (1958) showed that many human infections were due to animal fungi and, in addition, they reported that although M. gypseum was a, not uncommon, cause of ringworm in animals, it did not appear to be an important human pathogen. Walker (1950) maintained that control of ringworm caused by zoophilic fungi in man which at that time accounted for 27 per cent. of all dermatophytoses, called for the co-operation of the veterinary and medical professions. Six years later, the Medical Mycology Committee of the Medical Research Council met a Committee of the British Veterinary Association to discuss the possibility of increasing the facilities for diagnosis of ringworm of animals. (British Medical Journal, 1956). About this time also, a group of medical dermatologists, veterinary surgeons and mycologists met in Glasgow to attempt a correlation of human and animal ringworm in the west of Scotland. In addition to the main purpose

of the work of correlation, an opportunity of studying animal ringworm was afforded since there had been little done in that respect in Britain, the only survey being that of Ainsworth & Austwick (1955). Because Glasgow contained a large population of domestic pets and was within easy reach of large numbers of cattle it was felt that the suspected animal reservoir for some types of human ringworm was available for study. Material from dermatologists was submitted to Dr. Gentles of this University while that from veterinary surgeons was investigated by me. The laboratory procedures were conducted separately but there was close collaboration with Dr. Gentles for the correlation of cases.

The results of the first 2 years of the work were publish - ed (Gentles & O'Sullivan 1957b) and since then, additional data have been added on a further 61 cases.

INFECTION DUE TO T. verrucosum.

Of the 115 cases where T. verrucosum was isolated from human patients (Table 16), 45 suspected animals were proved to be infected with this dermatophyte, 9 were found to have a large-spored, ectothrix infection and 7 were known to have been clinically affected although free from infection when examined. Specimens were not obtained from 50 of the cattle although the animals were reported to have been clinically affected. On 4

TABLE 16.

Summary of results of 224 cases when an animal was suspected to be the source of a human ringworm infection.

HUMAN DATA.	ANIMAL DATA.											
	T. verrucosum.	*T. mentagrophytes.*	*M. canis.*	*T. equinum/M. equinum.*	*M. audouini*	*T. rubrum*	*T. tonsurans* var. *sulfureum*	Micro. pos. only.	Negative	No specimen	Totals (human)	Per cent. pos. (human)
T. verrucosum	45[a]	-	-	-	-	-	-	9	7	54	115	51.3
T. mentagrophytes	3[b]	1[a]	-	-	-	-	-	-	5	14	23	10.3
M. canis	3[b]	-	6[a]	-	-	-	-	-	1	5	15	6.7
T. equinum/M. equinum	-	-	-	-	-	-	-	-	-	-	-	-
T. tonsurans var. *sulfureum*	1[b]	-	-	-	-	-	-	-	5	3	9	4.0
T. rubrum	-	-	-	-	-	-	-	-	1	5	6	2.7
M. audouini	-	-	-	-	-	-	-	-	1	-	1	0.4
Micro. pos. only.	8	-	-	1	-	-	-	1	1	5	16	7.1
Negative	10	-	-	-	-	-	-	1	2	9	22	
No specimen	17	-	-	-	-	-	-	-	-	-	17	
Totals (animal)	87	1	6	1	-	-	-	11	23	95	224	
Per cent. pos. (animal)	38.8	0.4	2.7	0.4	-	-	-	4.9	-	-		

N.B. The human data are read from left to right; the animal data from top to bottom.

a. Cases when the source was confirmed by culture of the same dermatophyte from both man and animal.

b. Cases when different dermatophytes were cultured from man and suspected animals.

occasions contact with animals was denied and with the exception of those 4 cases there is little doubt that all of the infections by T. verrucosum in man, (111, 49.5 per cent.) originated from cattle. Walker (1950) recognised that T. verrucosum was the commonest cause of bovine ringworm in Britain and that infection in man occurred in agricultural areas all over the country. Rook (1956) in Cambridge found that 82.5 per cent. of 40 human cases were in either direct or indirect contact with cattle known to be infected. In rural areas of the United States Georg, Hand & Menges (1956) noted that T. verrucosum and T. mentagrophytes were the causal fungi of human infections to an almost equal degree. There was a correlation between infection by T. verrucosum and the occupation of the patient in the present series in that the affected adults with 3 exceptions, were farm workers and all affected children, except 1, lived or played on a farm. Walker (1955) recovered the organism from infected skin scales on rubbing-posts and there is no doubt that in addition to direct contact with affected animals, indirect contact with fences, wooden partitions in calf-pens etc., is responsible for some human infections.

The highest rate, namely 51 per cent., of infections in human patients occurred between January and April while only 16 per cent. of infections occurred during the last 6 months of the year (Gentles & O'Sullivan 1957b). Georg, Hand & Menges

(1956) reported that 83.9 per cent. of 31 human cases were encountered between November and the end of April and that during this period 81.6 per cent. of 1539 herds of cattle were affected as against 18.4 per cent. of the herds from May until the end of October. During the winter months while the cattle are housed, farm workers are in close contact with infected animals and the high incidence from January to April is not unexpected. On the other hand, during spring and summer there is less contact between humans and the lesions of affected animals not only because the animals are at grass but because there are fewer lesions on the cattle and consequently there is a lower incidence of human infection at that period. The head and neck of cattle have been shown to be the parts most frequently affected (page 17), while in man the arms were infected in nearly 50 per cent. of cases (Gentles & O'Sullivan 1957b). This relationship is understandable since cattle attendants, working with bare arms, come into close contact with the forepart of animals when tying them up or restraining them for various purposes such as tuberculin-testing or when actually treating lesions of ringworm.

INFECTION DUE TO T. mentagrophytes.

In contrast to infection by T. verrucosum where the source is cattle, the origin of human infection with T. mentagrophytes is difficult to find. Muende & Webb (1937) isolated

T. mentagrophytes from cattle in Britain and subsequently the common belief was that those animals were often affected by that fungus. However, it was noted (page 14) that its occurrence on cattle in Britain is rare and this view is shared by Ainsworth & Austwick (1955a) and by Sellers, Sinclair & La Touche (1956). T. mentagrophytes has, in fact, a very wide host range Georg (1954) reporting it from the cat, guinea-pig, chinchilla, fox and opossum. Blank (1955) extended the list to include the horse, dog, mouse, rat, rabbit, squirrel, muskrat and fallow deer. McPherson (1956) recovered it from dermatomycosis in the pig and Marples (1961) isolated it from hedgehogs.

Since T. mentagrophytes is a common dermatophyte in man there has been considerable speculation regarding its source. Beare & Cheeseman (1953) and Carlier (1954) stated that cattle were the probably source of infection, by that dermatophyte, in man and Rook (1956) believed that some human infections by it were indisputably from cattle. However, bovine ringworm due to T. mentagrophytes is so rare in Britain that cattle are not the usual source of that type of human infection. The commonest animal hosts are rodents (Georg, Hand & Menges 1956) and it has been established (Fuentes, Bosch & Boudet 1954, Georg et al. 1956, Lonsdale 1958 and Mackenzie 1961) that they may carry the fungus without clinical evidence. It is of interest that

the only correlated case of infection by T. mentagrophytes, in my series, concerned a boy and his pet mouse the latter showing cultural, but not clinical, evidence of infection. Two dogs, suspected as sources of human ringworm and which were negative by laboratory methods, may also have been examples of clinically normal carriers but it is more likely that they were instances of wrong sources for human infections having been suspected.

INFECTION DUE TO M. canis.

M. canis is a common cause of ringworm in cats and dogs (Zollikofer & Wenner 1908, Georg 1954, La Touche 1955b) and there are many records of its transfer to human beings (Sabouraud, Suis & Suffran 1908, Marples 1951, La Touche 1952). On 15 occasions animals, suspected as being the source of M. canis infections in humans were investigated and it was confirmed that 6 patients had become infected from animals namely, 3 from dogs and 3 from cats. Since the only reservoir for this type of human infection was cat and dog my results agree with the general opinion that domestic pets are responsible for the spread of this mycosis to humans. Only 2 premises were traced as the origin of human infections and on each occasion the disease in the animals was of epizootic character, there being a total of 15 cats and 14 dogs affected.

The outbreak in dogs was described on page 43 of this thesis and the other premises which housed 24 cats and 6 dogs had 15 infected cats and 1 infected dog (see page 60). In those 2 outbreaks, 6 adult cats and 3 adult dogs were affected and although there is little doubt that the disease occurs more frequently in young animals, the age immunity is not as solid as that claimed by Beare & Cheeseman (1953).

The small number of correlated cases indicates that M. canis ringworm is rare in the west of Scotland and further evidence of its scarcity was reported on page 60, in regard to the investigation of cats brought for destruction to a veterinary clinic. In addition, in the survey reported in Part I, there were only 45 (15.1 per cent.) isolations of that organism from 326 dogs and cats suspected of ringworm.

INFECTION DUE TO OTHER DERMATOPHYTES.

Bodin (1898) said that human infection with M. equinum was of a mild nature and Sabouraud (1908) noted that there were few recorded cases of T. equinum infection in man. English (1961) reported that 4 out of 7 people at risk with horses infected by T. equinum had mild clinical lesions and that T. equinum was recovered from only 1 of the patients. Two people, in the present series, became transitorily affected with ringworm probably acquired from horses. One was the owner of the animal reported on page 30 where infect-

ion was associated with 2 dermatophyte namely, M. equinum and T. equinum and only microscopic evidence of infection was obtained from the human patient. The second person, positive again only on direct examination, was in close contact with a horse infected with T. verrucosum.

M. audouini, T. rubrum and T. tonsurans var. sulfureum were isolated from 16 patients who maintained that their infections were acquired from animals. On each occasion the animal in question was investigated and it was established that those dermatophytes were not present on the suspected animals. Thus, correlation between the human and animal infection was not obtained in those 16 cases and it is clear that, without cultural investigation of both human and animal, such cases might well have been attributed, on purely circumstantial evidence, to the suspected animal source. On 7 occasions (Table 16, page 82), animals were wrongly suspected as the source of human infection because 7 people maintained that cattle were the source of their ringworm and although the cattle were indeed infected (with T. verrucosum) the humans harboured quite different dermatophytes namely, T. mentagrophytes 3, M. canis 3 and T. tonsurans var. sulfureum 1.

From the results it is clear that cattle are the main reservoir of human infections by zoophilic fungi in the west of Scotland. This is understandable because it is mainly an

agricultural area, with many dairy farms and some beef herds of cattle, where the incidence of bovine ringworm is high. Moreover, it seems clear that the incidence of ringworm in cat, dog and horse is low in this part of Britain. Small animals were named as the source of 36 human infections but only 7 of such cases were relatable to affected animals namely, M. canis 6 and T. mentagrophytes 1 (see Table 16, page 82).

SUMMARY AND CONCLUSIONS.

The results are given of an investigation, in the west of Scotland, of 224 cases of human ringworm which were suspected to be of animal origin. Dermatophytes were cultured from 169 (75.4 per cent.) human cases and the isolates were: T. verrucosum 115 (51.3 per cent.), T. mentagrophytes 23 (10.3 per cent.), M. canis 15 (6.7 per cent.), T. tonsurans var. sulfureum 9 (4.0 per cent.), T. rubrum 6 (2.8 per cent.), M. audouini 1 (0.4 per cent.). Thus, zoophilic dermatophytes were isolated from 153 (68.3 per cent.) and anthropophilic species from 16 (7.1 per cent.) of the humans. On 52 (23.2 per cent.) occasions the same dermatophyte was cultured from the human and suspected animal while in 6 (2.7 per cent.) cases a different zoophilic fungus was isolated from each source. Cattle were found to form the main animal reservoir of human infection, there being 111 (49.5 per cent.)

cases correlated with ringworm due to T. verrucosum in humans. That conclusion is contrary to the views expressed by Walker (1950) whose survey covered Britain, Carlier (1954) working in Birmingham and Mortimer (1955) in Cambridge who have said that the domestic pet is the most frequent source of human infections with zoophilic fungi.

In all, there were 95 (42.4 per cent.) animal cases confirmed by culture, the dermatophytes being T. verrucosum 87 (38.8 per cent.), T. mentagrophytes 1 (0.4 per cent.), M. canis 6 (2.8 per cent.), M. equinum & T. equinum 1 (0.4 per cent.). An anthropophilic dermatophyte was not, on any occasion, isolated from an animal. A small-animal source, namely dog, cat and mouse, was confirmed for only 7 human infections. Microscopical but not cultural evidence of human infection, contracted from a horse was noted. None of the human infections with T. mentagrophytes was found to originate from cattle.

It is confirmed that in this area, animals form a reservoir of ringworm infection but that cattle rather than small animals, for example domestic pets, are the main source of human infection. Evidence has been produced that a number of human infections may be wrongly attributed to an animal source or to a wrong species of animal. Full cultural investigation of the human being and of the animal should obviate these errors.

PART III.

TREATMENT OF DERMATOMYCOSIS IN ANIMALS.

Since the lesions of dermatomycosis are superficial and generally readily visible the traditional method of treatment has been the topical application of various medicaments. There have been many such substances recommended but none has proved satisfactory under controlled experimental conditions. McPherson (1959) examined over 150 preparations, *in vitro*, in an attempt to find a cure for bovine ringworm but with little success. O'Brien & Sellers (1958) with similar lack of success, tested some recommended proprietary, antifungal drugs by topical application. The intravenous injection of sodium iodide was found to be inefficacious (Ford 1956) and Jones, as quoted by McPherson (1959), found that 78 different treatments have, from time to time, been advocated. It is established that spontaneous cure of bovine ringworm occurs approximately 4 months after initial infection (O'Brien & Sellers 1958) and since it is often impossible to know the exact stage that the lesions have reached it is difficult to assess satisfactorily the merits of any treatment. The position was accurately summarised by Pillsbury (1955) when he said "the general lack of specific, chemotherapeutic, antifungal compounds is nowhere better illustrated then in ringworm."

The failure of topical treatment to cure the condition was not due to the inability of antifungal agents

to arrest the activity of the dermatophyte but because they could not penetrate the keratin of the skin (Barlow 1958) and so reach the invading fungus. The continued ineffectiveness of topically applied drugs led Wilson (1955) to say "the ideal antifungal drug even for the superficial mycoses would seem to be one which could be safely administered internally in amounts sufficient to endow the cells eventually destined to produce keratin with power to resist fungi completely, this power persisting as they became keratinised, and the drug thus exerting its effects from within outward." It was therefore of the greatest importance when Gentles (1958) reported successful treatment of experimental infections, due to M. canis and T. mentagrophytes, in guinea-pigs by the oral administration of the antibiotic, griseofulvin.

Griseofulvin was first reported by Oxford, Raistrick & Simonart (1939) as a metabolic product of Penicillium griseofulvum. Brian, Curtis & Hemming (1946) isolated, from P. janczewskii, a substance which they called 'curling-factor' because its fungistatic action was associated with malformation of the tips of growing hyphae. Grove & McGowan (1947) showed that 'curling-factor' and griseofulvin were identical. The chemical structure was established by Grove, MacMillan, Mulholland & Rogers (1952) who described it as a thermostable substance insoluble in water but soluble in acetone and in chloroform and

with the formula : 7 - chloro - 4: 6: 2' - trimethoxy -6' - methylgris - 2' - en - 3 ; 4 - dione. There were indications that the antibiotic was potentially of value in the treatment of fungal diseases in plants (Napier, Turner & Rhodes 1956) and subsequent field trials proved successful (Rhodes, Cross, McWilliam, Tootill & Dunn 1957). Brian (1949) demonstrated that its fungistatic properties were exerted on the chitin component of cell-walls and that it was ineffective against those fungi which had cellulose cell-walls. He also showed that since it only affected hyphal tips there appeared to be no translocation of the antibiotic within the hyphae. However, Blank, Taplin & Roth (1960) said that its effects were greater than those reported by Brian and that the actively metabolising, fungal cells were killed but that older cells were not so drastically affected.

The presence of active griseofulvin in the hair of guinea-pigs, given the drug orally, was reported by Gentles, Barnes & Fantes (1959) there being approximately 6 µg. of griseofulvin per gram of hair. Because their extraction methods were insufficient to break chemical bonds those authors postulated that the drug was not chemically bound to, but was in some way incorporated in, the keratin of the hair. Gentles & Barnes (1960) said that the compound was deposited in the keratogenous cells of the skin and hair and that the unchanged griseofulvin which remained within the cells when they differentiated to keratin

would persist and thus render the keratin resistant to fungal invasion.

It would thus seem that griseofulvin behaves exactly as Wilson (1955) prophesied that the ideal antifungal drug would act. It can be given safely by mouth, it is taken up by the keratogenous cells of the skin and hair and thus exerts its fungistatic action from within outwards.

(1). TREATMENT WITH GRISEOFULVIN OF EXPERIMENTAL INFECTIONS DUE TO *T. verrucosum* IN CATTLE.

Following the successful treatment of ringworm in guinea-pigs by the oral administration of griseofulvin (Gentles 1958) it was decided to test this substance in calves, artificially infected with *T. verrucosum*. Ringworm in cattle is widespread in nature and is an important reservoir for human dermatomycosis (Gentles & O'Sullivan 1957b), hence a specific cure is desirable. An orally administered drug would be advantageous because the topical application of antifungal substances to large areas of many cattle in an infected herd is time-consuming. It would also be of interest to discover if an animal with a digestive apparatus quite different from that of a rodent could be successfully cured by an orally administered drug. The decision to use experimentally infected animals and not to start with a field trial of established infections, was in order to know the exact date of the infection and so obviate

the indecision as to the possible efficacy of the drug. This trial was done in co-operation with Mr. I. M. Lauder and was reported (Lauder & O'Sullivan 1958). It was established that 60 mg./kg. of griseofulvin when given per os, daily, for 5 weeks starting on the day of inoculation, prevented the establishment of infection. Calves which were inoculated on the same day and which received no treatment developed lesions typical of ringworm. Those animals were then treated with oral griseofulvin and they were cured at the end of 3 weeks' treatment. Sections of biopsied skin showed that infection was established in the hair-follicles 2 weeks before the appearance of the clinical signs of the disease and conversely that in the process of cure the fungal elements had disappeared from the follicles although the infected scab was still present on the skin surface (Lauder & O'Sullivan 1958).

Although the drug prevented the establishment of infection on the inoculation site, the optimal dosage schedule was not ascertained; also, the protection afforded by griseofulvin was not challenged by subsequent experimental inoculation and although treatment of established infection was successful, the number of treated animals was small. In another experiment, therefore, also done with the co-operation of Mr. Lauder, 19 heifer calves (17 Ayrshire and 2 black and white, cross-bred animals) and an Ayrshire bull-calf, all 2 months old, were

housed, fed, and inoculated with T. verrucosum as in the previous experiment. Biopsies were taken from the affected sites and processed as previously (Lauder & O'Sullivan 1958) with the addition that the skin sections besides being stained by haematoxylin and eosin and periodic-acid Schiff were also stained by toluidine blue to examine for any increase in mast cells.

Five and a half weeks after inoculation, 19 of the calves had developed marked clinical lesions with histological evidence of dermatophyte infection. The remaining calf, apart from slight early scaling, did not show clinical or microscopical evidence of infection and so it was withdrawn from the experiment. The affected calves were divided into 5 groups and griseofulvin was administered at therapeutic and also high-level doses for 5 to 20 days as shown in Table 17. The high-level dose, approximately 6 times the dosage which had cured the calves in the first experiment, was given to test for possible toxic reactions.

TABLE 17.

DOSING SCHEDULE FOR ADMINISTRATION OF GRISEOFULVIN TO CALVES, EXPERIMENTALLY INFECTED BY *T. verrucosum*.

Group	Calves	Dosage	Duration of Treatment
I	3	50 mg./kg.	5 days
II	3	45 "	10 "
III	5	45 "	20 "
IV	4	350 "	20 "
V	4	------	------

Results:

(a). Histological:

Of the 4 groups of treated animals, infection was not present in Group II, 14 days after the start of 10 daily doses at 45 mg./kg. and the remaining groups showed reduced infection at this time (Table 18). There was not any follicular infection in Groups II and III, 21 days after the start of 10 and 20 daily treatments respectively at the dosage rate of 45 mg./kg. and infection was then minimal in Groups I and IV. Infection in Group I was confined to one calf (No. 37) which had received 5 daily treatments at 50 mg./kg. and infection was not present in this calf after a further 2 weeks. Two of the

TABLE 18.
PERCENTAGE OF INFECTED HAIR-FOLLICLES IN CALVES INFECTED BY *T. verrucosum* AND TREATED WITH ORAL GRISEOFULVIN.

GROUP	CALF No.	DAYS AFTER START OF TREATMENT.									
		0	3	5	7	10	12	14	16	18	21
I	34	64	35	11	7	7	-	0	-	-	0
	37	78	88	-	36	-	-	2	-	-	1
	38	60	-	34	-	3	-	-	-	-	0
	Avge.	67	61	22	21	5		1			0.3
II	33	72	50	26	3	1	-	0	-	-	0
	35	26	11	-	4	-	-	0	-	-	0
	36	70	-	42	-	4	-	-	-	-	0
	Avge.	56	30.5	34	3.5	2.5		0			0
III	42	56	62	50	16	10	-	0	-	-	0
	43	67	56	-	-	-	-	1	-	-	0
	45	70	-	43	-	-	-	-	-	-	0
	49	63	-	-	10	-	-	-	-	-	0
	50	10	-	-	-	7	-	-	-	-	0
	Avge.	53	59	46.5	13	8.5		0.5			0
IV	31	70	60	30	27	16	14	15	4	5	0
	32	80	43	-	-	10	-	-	13	-	3*
	39	70	-	34	-	-	15	-	-	4	4*
	41	50	-	-	19	-	-	8	-	-	2
	Avge.	67.5	51	32	23	13	14.5	11.5	8.5	4.5	2
V	44	70	75	-	-	-	-	-	-	-	6
	46	80	-	64	50	-	-	-	-	-	18
	47	62	-	-	-	40	-	-	-	-	24
	48	65	-	-	-	-	-	44	-	-	46
	Avge.	69									23.5

(-) = No biopsy taken. * = Killed for necropsy.

0 = Infection not present in follicles.

▬▬ = Duration of treatment with griseofulvin.

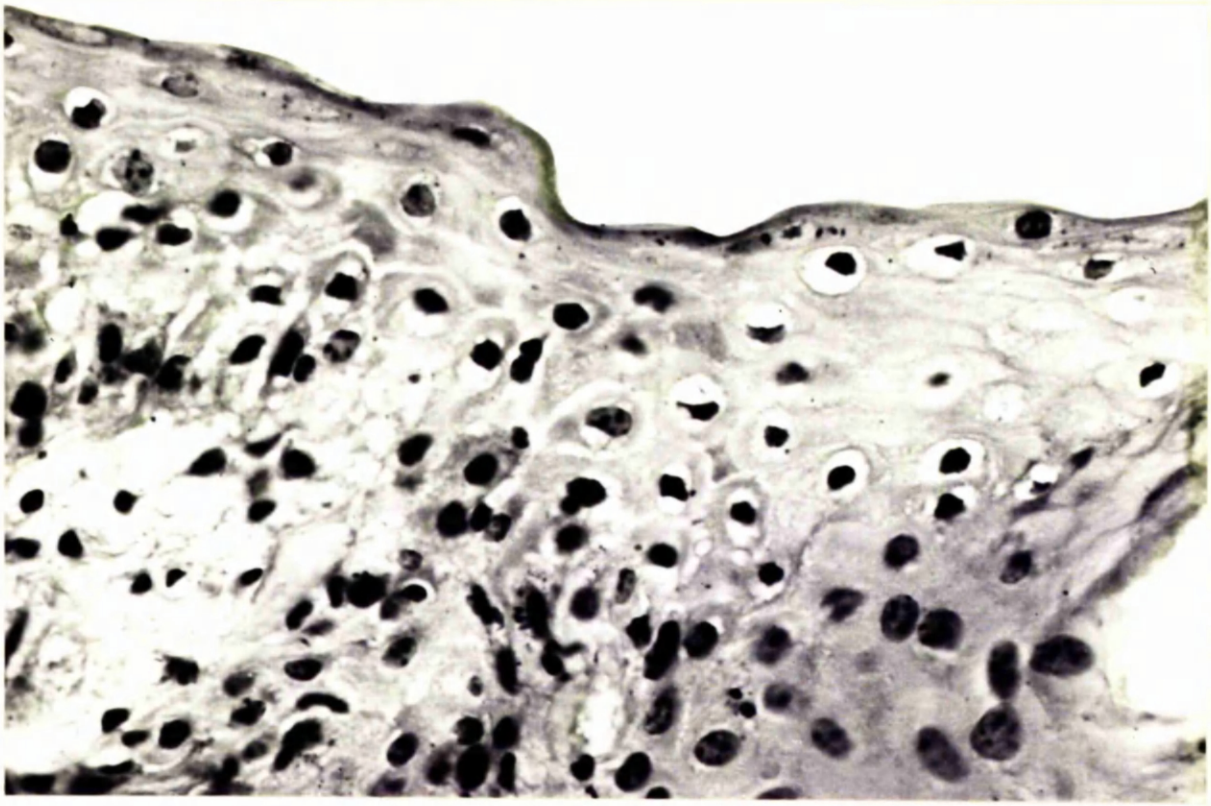

Fig. 19. Bovine ringworm. T.S. skin to show epidermal oedema (spongiosis). P.A.S. x 600.

Fig. 20. Bovine ringworm. Proliferation of stratum malpighii of epidermis (acanthosis). P.A.S. x 180.

3 calves in Group IV, on which lesions persisted 3 weeks after the beginning of 20 daily treatments at 350 mg./kg., were then killed for evidence of possible toxic effects of the drug. The remaining infected animal in that group was clinically cured in a further 3 weeks.

The effects of the proliferation and extension of the dermatophyte included spongiosis (Fig. 19) and acanthosis (Fig. 20) with some hyperkeratinisation. The surmounting of dermal papillae by stratified accumulations of parakeratotic cells dilated with serum, as described by Sellers, Sinclair & La Touche (1956), can be seen in Fig. 21. The bases of the hair-follicles became markedly increased in volume because of cellular infiltration (Fig. 22). There was not any increase of dermal connective tissue although the volume became greatly enlarged by oedema and the accumulation of histiocytes and lymphocytes (Fig. 23). Micro-abscesses were occasionally seen in association with infected follicles (Fig. 24). The numbers of eosinophils and plasma cells were increased but mast cells were not seen at any stage. Growth in volume, due to increased activity, of the sebaceous glands together with the dilatation of the apocrine (sweat) glands contributed to the thickening of the skin. Fungal invasion of the sebaceous glands, as recorded and illustrated by Sellers et al. (1956), was not observed.

Fig. 21. Bovine ringworm. Swollen parakeratotic cells. P.A.S. x 160.

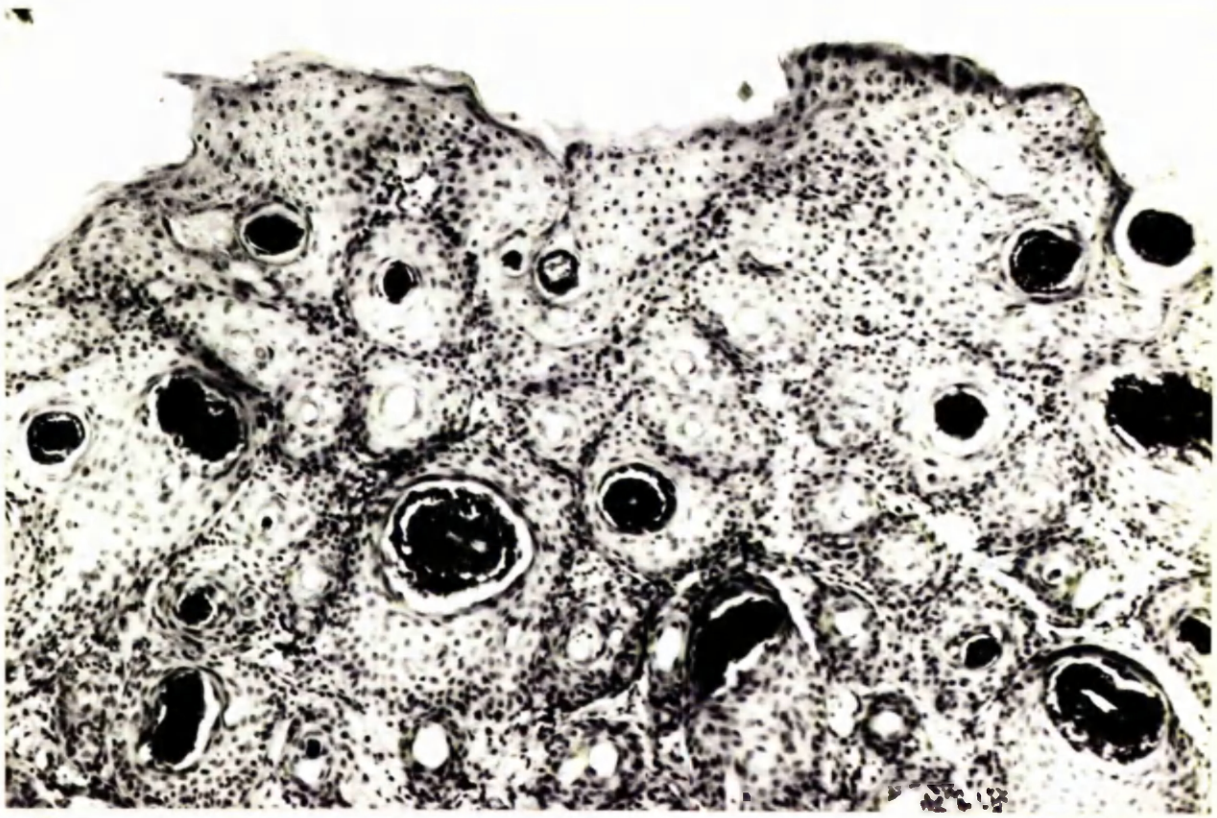

Fig. 22. Bovine ringworm. Cellular infiltration at the bases of the hair-follicles. P.A.S. x 220.

Regression to the normal state on treatment with griseofulvin took place by dermatophyte components being carried out from infected follicles with the growing hair, followed later by the casting of the accumulated scab containing viable fungal elements. Decrease of the dermal cellularity and of the epidermal and dermal oedema completed the healing process. With the casting of the epidermal scab there was little, if any, scarring since the epidermis had not been destroyed and replaced by connective tissue during the disease process.

(b). Clinical.

At the end of 2 weeks from the time of inoculation changes were recognizable in only 2 animals, the skin at the site of infection being more difficult to pluck into a fold. At the end of 3 weeks similar changes were palpable in 50 per cent. of cases, skin scale was excessive in 70 per cent., some loss of hair was seen in 20 per cent. and erythema with or without a few small blood scabs in a few animals. Two of the animals did not have detectable lesions. At this time 1 calf had slight lesions which disappeared completely in the subsequent $2\frac{1}{2}$ weeks. At the end of $5\frac{1}{2}$ weeks, 19 animals had developed lesions with marked loss of hair and formation of grey scale or crust. There was a good deal of erythema of the areas not yet overlaid by scale and some rawness and blood scabs associated with lick marks were visible. Measurement of a fold of skin at the beginning and

Fig. 23. Bovine ringworm. Oedema, and increased cellularity, of the dermis. P.A.S. x 160.

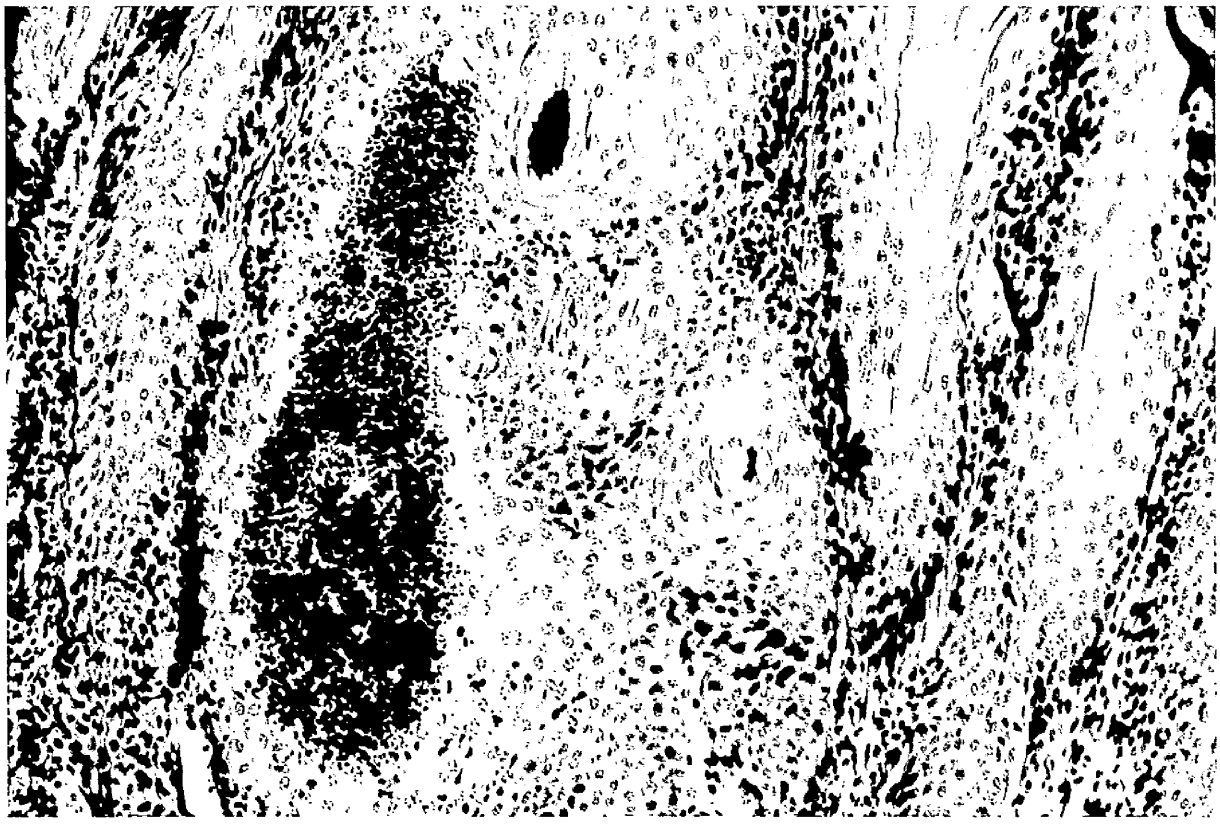

Fig. 24. Bovine ringworm. Micro-abscess in association with an infected follicle. P.A.S. x 170.

end of the 5½ week period showed an average increase of thickness amounting to 27 per cent. Lesions, which occurred elsewhere than at the experimental site in 17 animals, varied in size, number and distribution on individual animals but were commonest under the chin and on the neck, while the body, the perineum and limbs were less often affected.

Five and a half weeks after inoculation, treatment began on 15 calves (Table 18, page 98). At the end of 1 week's treatment there was little, or no, change in the treated animals but at the end of 3 weeks all the animals showed a distinct improvement which was rather less marked in group I. The average measurement of a skin-fold reduced by 12 per cent. The lesions of the animals in the untreated, control group became more extensive during this period and the thickness of the skin was increased by 12½ per cent. Clinical examination was not carried out during the next 3 weeks but at the end of that time, that is, 6 weeks after the start of treatment, all but 2 of the treated animals were cured. The 2 exceptions, Nos. 37 and 38, both in Group I, were almost cured but retained small areas of crust.

Three weeks after the start of treatment i.e. 8½ weeks after initial inoculation, while the 4 calves in the control group were clinically affected, they received treatment at the following levels: 3, 6, 14 and 24 mg./kg. for 6 days. The

2 which received 14 and 24 mg./kg. showed no sign of infection, histologically, 14 days after the start of treatment and they were clinically cured in a further 1 to 3 weeks. During this period the 2 calves which received the low and apparently ineffective dosage (3 and 6 mg./kg.) retained clinical lesions and were affected for a further 3 weeks.

(c). Re-inoculation Experiment:

Eight and a half weeks after the initial inoculation, an attempt was made to reinfect 18 of the calves with field material from a source different from that of the original inocolum. A suspension of ringworm scab was applied to a clipped area on the left croup and 3 weeks later, 14 calves were clinically positive but in a further 3 weeks only 7 beasts showed evidence of infection. In those animals the lesions, which were mostly minimal and more readily discovered by palpation than by inspection, consisted of some small blood scabs with perhaps a little extra scaliness and a darkening of the skin pigmentation. Two animals, Nos. 42 and 45, had more obvious lesions accompanied by loss of hair. In the former there was also encrustment which persisted for 2½ months and it was the only animal the lesion of which was positive both histologically and on examination of material macerated in potassium hydroxide. Calf No. 42 was re-inoculated, on a fresh site, 2 months after the first challenge inoculation and that time it failed to

develop any lesions.

(d). Toxicity:

Paget & Walpole (1958) reported that in rats, given massive parenteral doses e.g. 2 gm./kg. intraperitoneally and 100 to 200 mg./kg. intravenously, there was inhibition of mitosis of actively dividing cells which was especially marked during spermatogenesis. The calves in this series gained weight normally and did not show any signs of illness. Those in group IV received a large dose of griseofulvin, approximately 6 times the estimated therapeutic dose, in order to reveal possible toxic effects. Oxalated blood samples were examined from all the animals in this group at the beginning and end of the 20 day period of administration of the drug. Blood was also taken from 6 other animals at the end of the period of treatment. P.C.V., haemoglobin, total red and white cell determinations were made and the only abnormality occurred in calf No. 41 which received the high dosage. Total red cells dropped from 8,500,000 to 4,100,000 per c. mm. and white cells from 12,000 to 5,700 per c. mm. Histological examination of tissues from calves in the high dosage group did not reveal any abnormality in testis, liver, spleen, lymphatic gland, small intestine or bone marrow. It is clear that oral administration of doses ranging from 45 mg./kg. to 350 mg./kg. per os is not attended by any signs of toxicity in cattle. Paget & Walpole

working with laboratory animal reported in 1960 that orally administered griseofulvin was non-toxic.

(2). TREATMENT, WITH GRISEOFULVIN, OF NATURALLY-OCCURRING BOVINE RINGWORM.

Farm X:

During the winter of 1958-59, in association with Mr. Lauder, I had an opportunity of observing the epizootiology of ringworm occurring under natural conditions among cattle. The herd consisted of 150 beasts, mainly Friesian bull-calves and bullocks with a few Ayrshire animals. Young calves, one-month old, were bought in and after passing through a series of calf-houses with animals of the same age they were put on the hill at the age of 18 months. Ringworm was an important problem on this farm and at the time of my first visit, a number of animals were affected, some showing the blood-scabs typical of early infection while others presented the asbestos-like scabs of mature lesions. From these latter, T. verrucosum was isolated.

Griseofulvin was being used on cattle, experimentally infected by T. verrucosum, at the time and it was thought that the drug might be tested under field conditions. The drug was given by mouth, daily, for 14 days in a saccharine suspension at approximately 45 mg./kg. body weight. At the beginning, the antibiotic was given individually to each animal but later it was incorporated in the ration of milk-substitute given to

groups of calves.

Field trials such as this are often unsatisfactory because the identification of individual animals is sometimes left to guesswork by the busy stockman and the dosing of the animals may occasionally be overlooked. Despite those difficulties it was noted that of the 62 animals clinically affected and treated, 39 (62.9 per cent.) were cured 5 to 6 weeks after the start of treatment and at that time a further 12 (19.3 per cent.) were markedly improved, there being no crusty scabs present and the lesions showed mainly some scaliness. The remaining 11 (17.7 per cent.) animals which were improved 6 weeks after the beginning of treatment were clinically normal in from 12 to 16 weeks. Since this period is about the same as that for spontaneous recovery it was thought that perhaps the treatment had not followed the prescribed course in those animals.

On 2 occasions there was evidence of possible reinfection. One animal which had been cured, showed a lesion above the left eye 19 weeks after the beginning of treatment and material from it was positive by direct microscopy but a culture was not obtained. In the other case, the original eye lesions had disappeared 5 weeks after the commencement of treatment but in a further 16 weeks a lesion measuring 1 cm. above the right eye and another measuring 0.5 cm. to the right of the nose were seen. A scraping from the lesion near the eye was negative on

laboratory examination.

During the period of treatment newly arrived animals, whether affected or not, were given griseofulvin and animals in contact with clinical cases were also treated and so the prophylactic property of the drug was utilised. In previous years when the animals were put to grass most of them were grossly affected with ringworm. In marked contrast to this, in April 1959 after the animals had been treated successively during the previous winter, only 6 out of 150 beasts (4 per cent.) were showing lesions and those were minimal.

Farm Y:

The animals on this dairy-farm numbered 52 and comprised the following: 4 cows, 1 bull, eighteen 9-months old bullocks, twenty-four 18-months old heifers and 5, 18-months old bullocks. Those mainly affected with ringworm were the 18-months old animals which had widespread lesions, on the head, neck and hindquarters, from which T. verrucosum was isolated. Twelve of the heifers were given griseofulvin at the rate of 20 mg./kg. for 8 days and a similar number was left untreated. Eleven days after the beginning of treatment, and without my knowledge, all were scrubbed with washing soda and a proprietary, anti-fungal preparation applied topically to all the affected animals. Seven weeks after the start of treatment, some of the animals which were worst affected were said to be those which had been given griseofulvin. Six weeks later, one animal in the treated

group was still badly affected but the others were improved although some crust remained on a few animals. Identification of the animals proved very difficult on this farm and I was not sure that treatment had been administered in the manner that it was recommended.

Farm Z:

On this farm 4 Aberdeen-Angus bulls, 8-months old, which were being prepared for the Spring sales were noticed to have lesions of ringworm from which T. verrucosum was isolated. None of the animals was badly affected but areas of greyish-yellow crust, up to 2.5 cms. in diameter were noted on the head, neck and trunk. Four weeks after a 7-day course of treatment, at the rate of 20 mg./kg., of griseofulvin per os. there was a noticeable improvement. New hair was growing but some crust was still present on a lesion near the eye and there were some grey scales on a lesion of the shoulder. A scraping from the eye lesion was microscopically positive but failed to produce a culture. Scrapings taken on the same day from lesions on 2 other animals proved to be culturally and microscopically negative. Four weeks later, i.e. 8 weeks from the start of treatment the animals were clinically clear although not examined by me.

(3). TREATMENT, WITH GRISEOFULVIN, OF RINGWORM IN SMALL ANIMALS.

The drug was given in spontaneous cases of ringworm of 4 dogs (3 boxers and 1 fox terrier). The boxers were affected

by T. mentagrophytes, T. verrucosum and M. gypseum respectively while the fox terrier showed lesions associated with M. canis. Treating the dogs with 30 mg./kg. of griseofulvin daily for 2 to 7 weeks, the period of cure from the start of treatment was: T. mentagrophytes infection 10 weeks, T. verrucosum 7 weeks, M. canis 3 weeks and M. gypseum 2 weeks.

La Touche (1960) and MacPherson (1960) have reported that griseofulvin cured dermatomycosis of chinchillas. I had one case in which infection with T. mentagrophytes showed a quick response to the administration of the drug. A bare patch, 3 cms. in diameter, on the head of an affected animal started to regrow hair within 7 days of the start of daily treatment at the rate of 40 mg./kg.

The elimination of feline dermatomycosis especially of that caused by M. canis, is of great importance particularly because the cat is the main reservoir for M. canis ringworm of man (Marples 1951, La Touche 1952, Gentles & O'Sullivan 1957b). In a study of the use of griseofulvin in the treatment of artificially-induced infection by M. canis in cats (O'Sullivan 1961) it was learned that the mean duration of clinical signs in 6 treated cats was 12½ days as against 79 days in a control animal (Table 19). The mean duration of fluorescence was 24 days from the start of treatment in those animals which received oral and topical treatment and which had their hair

clipped while it was 90 days in those receiving the drug only by mouth. Positive cultures of M. canis were recovered for 55 days in those getting oral and topical treatment and having their hair clipped, and for 118 days in those receiving only oral griseofulvin. Information concerning the histopathology of the condition in the cat was obtained from the study of biopsies. It was noted that epidermal hyperplasia and dermal thickening were not so marked as they were in cattle. In addition to the usual inflammatory cells which were seen in both cattle and cats there was an obvious increase in mast cells in the latter. Also, the accumulation of distended, parakeratotic cells seen in cattle was not a feature of ringworm of the cat.

TABLE 19.

SUMMARY OF THE RESULTS OF TREATMENT OF FELINE INFECTION BY M. canis.

	Mean duration, in days, of:		
	Clinical signs	Positive fluorescence	Positive culture
Oral and topical treatment + clipping	11	24	55
Oral treatment alone	14	90	118
Control	79	127	127

DISCUSSION ON TREATMENT OF RINGWORM IN ANIMALS.

Oral griseofulvin is the first, and only, treatment which has been shown to cure ringworm infection under experimental conditions. There have been numerous reports of successful cures with topical substances. Thus, Forster (1957) using 0.25 per cent. hexadecamethylene-1:16-bis(isoquinolium chloride) reported that a clinical cure could be obtained in all cases after 2 to 3 applications at intervals of 3 to 4 days. Cautley (1960) stated that a borotannic drug cured a high percentage of cases in a relatively short time. In neither of those reports, however, was the duration of infection given and it was not clear if spontaneous cure had taken place. In 1958, O'Brien & Sellers using, among other agents, the one advocated by Forster did not agree with his findings and stated that experimental infections, in which clinical observations were supported closely by cultural and histological procedures, were necessary in the assessment of antifungal agents. The work reported here is the first that deals with treatment of calves by oral griseofulvin and the criteria stipulated by O'Brien & Sellers were employed in the experiments. The use of artificially infected animals and controls ensured that spontaneous recovery would not influence the results, and cultural and microscopic examinations were employed to supplement clinical findings.

It is abundantly clear that griseofulvin is effective against both artificially induced, and spontaneous, ringworm not only in the prevention of the establishment of the condition but also in the curing of existing infection. Because of the high cost of the drug an effort was made to find the minimal, effective, curative dose. The first successful dosage rate was 60 mg./kg. for 3 weeks but equally good results were obtained with 45 mg./kg. for 10 to 20 days and there was an indication that even lower doses would be effective. A low dosage, 20 mg./kg. for 8 days, was used, apparently unsuccessfully on farm Y and while the lack of success may be attributable to the dosage, there was doubt about the accurate identification of the animals. The same dosage rate was used, successfully, on farm Z where the number of beasts was small and since they were being prepared for sale, the regular daily dosing of correctly identified animals was more certainly accomplished.

Because there was evidence that the overlying scab was still infective although there were no longer any fungal elements in the hair follicles, such animals will remain a source of infection until the scabs have disappeared. The calves which had been clinically affected were challenged and although they showed lesions, those were minimal and of short duration. The inocula which were used for re-infection were more concentrated than animals would be exposed to, under natural conditions, and it is

therefore unlikely that mature lesions would recur in a cured, clinical case. Hoerlein (1945) noted that a recovered heifer showed immunity a year after recovery. It follows that, although young calves are more susceptible than older ones, the resistance of the animals in the older age-group is due not only to increased age but probably also to an acquired immunity following a previous infection.

As the individual treatment of cattle affected with ringworm is time-consuming and even impracticable in the case of beef-herds where the cattle are seldom handled, it is of interest that on farm X the griseofulvin was administered in the group-ration of milk-substitute. In addition to the saving of time there was the added advantage that all animals in the group were treated whether they were affected or not and consequently unaffected animals were probably prevented from becoming infected.

Although Paget & Walpole (1958) reported that griseofulvin was toxic to rats when given parenterally, in large doses, oral administration of the drug, in the present series, was found to have neither clinical nor histological toxic reaction. Bedford, Busfield, Child, McGregor, Sutherland & Tomich (1960) demonstrated that the increase of the oral dose a hundredfold in rats produced only a fourfold increase in blood level of the antibiotic. In 1960, also Paget & Walpole reported that the compound when given by mouth was without hazard in laboratory animals.

Although most of the data on treatment of the animals under review related to cattle some information on the effect of griseofulvin on ringworm of small animals, especially of cats, was forthcoming. Uvarov (1961) reviewing the literature on the use of the drug in animals, noted that canine infection was cured in 1 to 5 weeks. In my small series of canine cases the variation of time of cure was from 2 to 10 weeks. Since all dermatophytes are equally sensitive to the effects of griseofulvin the variation in the time of cure cannot depend on differing causal fungi. In the case of infection by T. verrucosum, in the dog, which took 7 weeks to be cured there was a thick scab on the ear-flap and since the vascularity in this position is less than that in other parts of the skin the production of keratin is probably slower and such a scab tends to remain for a considerable time. It would be advisable to have such a scab softened and removed in addition to the oral medication with griseofulvin.

There is no doubt that in the treatment of cats it is important to supplement oral with topical treatment in order to limit the spread of infection. Clipping the hair is a further safeguard in this respect because the distal part of the hair is still infective for a considerable period after the fungal elements have been cleared from the follicles. The hair of cats grows at the rate of 0.04 - 0.18 mm. per day and 11.4 cms. in a year (Uvarov 1960) so that unless infected hair is clipped the

cat may remain, for a long period, a source of infection to itself, to other cats and also to human beings.

There is still much to be learned regarding the use of the drug in the treatment of dermatomycosis in animals and although it has been clearly established to be efficacious, various factors influencing its efficacy have not been fully investigated. One such factor is the influence of differential keratin production in various parts of the body and this may be associated with the fact that lesions on dependant parts, for example ear-flaps, take longer to resolve than do those on the trunk. Also, the cost of griseofulvin is prohibitive, at the moment, for general use on large animals and it would be useful to investigate the effects of large doses of the drug administered at intervals as used with success in treating ringworm of the human head (Kirk & Miles 1960).

GENERAL SUMMARY.

Laboratory investigation of 728 animals (cattle, horse, dog, cat, mouse, chinchilla and goat) in Scotland, suspected of ringworm, revealed that 344 (47.2 per cent.) were positive; 252 (34.6 per cent.) both by microscopy and culture, 32 (4.4 per cent.) only on culture and 60 (8.2 per cent.) only by microscopy. Dermatophytes were isolated on 285 occasions as follows: Trichophyton verrucosum, 195 (68.2 per cent.); Microsporum canis, 45 (15.8 per cent.); T. mentagrophytes, 15 (5.3 per cent.); T. equinum, 14 (4.9 per cent.); M. equinum, 6 (2.1 per cent.); T. quinckeanum, 5 (1.8 per cent.); M. gypseum, 1 (0.3 per cent.); T. rubrum, 1 (0.3 per cent.) and Trichophyton sp., 3 (0.9 per cent.).

Material was submitted from animals suspected as having ringworm yet 374 (54.7 per cent.) specimens were negative. There were fewer positive results in horse, dog or cat than in cattle and this probably indicates that differential diagnosis is more difficult in those animals than in cattle.

T. verrucosum was the dermatophyte most frequently recovered and 96 per cent. of the isolates were from cattle, the remainder being from horses and dogs. Apart from a single isolation of T. mentagrophytes the only fungus found on cattle was T. verrucosum. M. canis was recovered only from dogs and cats where it

occurred in almost equal proportions. Wood's light was a useful aid to diagnosis especially when clinical lesions were absent but all cases did not show positive fluorescence. It was absent in 9 of 20 canine, and 5 of 20 feline, cases. All 6 species of host which had ringworm, harboured T. mentagrophytes but most of the 15 isolations of that organism came from dogs and cats (33.3 per cent. in each). It was the only dermatophyte recovered from the mouse and the chinchilla. Since T. mentagrophytes is a cause of human dermatomycosis its wide host range makes it a potential public health hazard although domestic animals are not so important in this respect as are rodents. T. equinum was found only on horses and on one occasion it was present in association with M. equinum, the only instance of a double infection encountered in the survey. T. quinckeanum was recovered from 4 cats and a dog but not at all from mice which are the reservoir of that dermatophyte. M. gypseum and T. rubrum were single isolates from dogs and since the incidence of M. gypseum ringworm in that host is high in the United States and the fungus is a ubiquitous soil saprophyte, it was thought unusual that only one isolate was obtained. T. rubrum was the only anthropophilic dermatophyte recovered from an animal in the series.

The incidence of ringworm was not particularly

associated with either sex in any of the species of animal investigated. The age and seasonal incidence, the appearance and location of lesions and the differential diagnosis for each host were considered. The histopathology of ringworm was studied in biopsied material from cattle and cats. The isolations of T. rubrum, T. quinckeanum and M. gypseum from dogs, during the survey, are new host records from Britain, while T. quinckeanum from a cat and T. verrucosum from a horse are new isolations from those animals in Scotland.

In the course of an investigation to correlate human and animal ringworm the same zoophilic dermatophyte was isolated from suspected animals and from human patients on 52 (23 per cent.) occasions and on 6 (2.7 per cent.) a different zoophilic fungus was recovered from each source. Sixteen people, who suspected animals as the probable source of their infection, harboured anthropophilic dermatophytes and in none of those instances was the same fungus recovered from the suspected animal. Cattle were found to be the main animal reservoir of infection there being 111 (49.5 per cent) confirmed human cases while only 7 (3 per cent.) human infections were traced to a small-animal source. Thus, 118 (52.6 per cent.) human cases were correlated with zoophilic dermatophytes in animals. Other 7 people named cattle as the source of their infection and

although the cattle were infected (by T. verrucosum) the humans harboured quite different dermatophytes namely: T. mentagrophytes, 3; M. canis, 3; T. tonsurans var. sulfureum, 1. On 15 other occasions, anthropophilic fungi were isolated from humans but not from the suspected animal. Thirty six small animals were suspected as the source of human ringworm but confirmation was established in only 7 of them. It is true to say, then, that on 57 (25.4 per cent.) occasions either an animal source was wrongly given or a wrong animal was suggested. Animals form a reservoir for human ringworm in this area but cattle rather than domestic pets are the main source of human infection.

The treatment of dermatomycosis in animals is discussed and results are given of the use of oral griseofulvin against spontaneous infections in cattle, dogs and a chinchilla and against experimentally induced ringworm in cattle and cats. It is shown that establishment of infection may be prevented and clinical cases cured. The mode of action of the drug is considered and the public health significance of clinically cured animals, which may still be carriers, is discussed.

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FUNGI AND ANIMALS.

DERMATOMYCOSIS IN ANIMALS AND MAN.

by

JAMES GILDEA O'SULLIVAN.

(SUMMARY).

Thesis for the degree of Ph. D.,
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1962.

FUNGI AND ANIMALS: DERMATOMYCOSIS IN ANIMALS AND MAN

by

James Gildea O'Sullivan

(Summary).

Laboratory investigation of 728 animals, comprising the ox, horse, dog, cat, mouse, chinchilla and goat, suspected of ringworm in Scotland, revealed that 344 (47.2 per cent.) were positive; 252 (34.6 per cent.) both by microscopy and culture, 32 (4.4 per cent.) by culture alone and 60 (8.2 per cent.) only by microscopy. Dermatophytes were isolatedMicrosporumasions viz: Trichophyton verrucosum, 195 (68.2 per cent.); Microsporum canis, 45 (15.8 per cent); T. mentagrophytes, 15 (5.3 per cent.); T. equinum, 14 (4.9 per cent.); M. equinum, 6 (2.1 per cent.); T. quinckeanum, 5 (1.8 per cent.); M. gypseum, 1 (0.3 per cent.); T. rubrum, 1 (0.3 per cent.); and Trichophyton sp., 3 (0.9 per cent.). There were fewer positive results in horse, dog or cat than in cattle, a probable indication that differential diagnosis is more difficult in those animals than in cattle.

T. verrucosum was the dermatophyte most frequently recovered and 96 per cent. of those isolates were from cattle, the remainder being from horses and dogs. Apart from a single isolation of T. mentagrophytes, the only dermatophyte found on cattle was T. verrucosum. M. canis was recovered only from dogs and cats where it occurred to an almost equal degree. Wood's light was a useful diagnostic aid but not all cases fluoresced. It was absent in

9 of 20 canine, and 5 of 20 feline, cases. All 6 species of host, affected by dermatophytes, harboured T. mentagrophytes and most isolations were from dogs and cats. It was the only dermatophyte recovered from mouse and chinchilla. Since it causes human dermatomycosis the wide host range of this fungus constitutes a potential public health hazard although domestic animals are less important in this respect than are rodents. T. equinum, found only on horses, was present, on one occasion, in association with M. equinum. T. quinckeanum recovered from 4 cats and 1 dog was not isolated from mice which are the reservoir of that fungus. M. gypseum and T. rubrum were single isolates from dogs and since the incidence of M. gypseum ringworm in that host is high in the United States and the fungus is a ubiquitous soil inhabitant, it was thought unusual that there was only one canine isolate in the present series. T. rubrum was the only anthropophilic dermatophyte recovered from an animal.

The incidence of ringworm was not particularly associated with either sex of the animals investigated. Age and seasonal incidence, appearance and location of lesions and differential diagnosis for each host were considered. The histopathology of bovine and feline ringworm was studied in biopsied material from experimental infections The isolation of T. rubrum, T. quinckeanum and M. gypseum from dogs are new British host records while T. quinckeanum from a cat and T. verrucosum from a horse are new isolations from those animals, in Scotland.

During an investigation to correlate human and animal ringworm, the same zoophilic dermatophyte was recovered from suspected animals and from humans on 52 (23 per cent.) occasions; on 6 (2.7 per cent.) a different zoophilic fungus was isolated from each source. Sixteen people, suspecting animals as the probable source of infection, harboured anthropophilic dermatophytes and in no instance was the same fungus recovered from the suspected animal.

Cattle were the main reservoir of infection, there being 111 (49.5 per cent.) confirmed human cases while only 7 (3 per cent.) human infections were traceable to a small-animal source. Thus 118 (52.6 per cent.) human cases were correlated with zoophilic fungi in animals. Seven people named cattle as the source of infection and although the cattle were infected (by T. verrucosum) the humans harboured different dermatophytes namely, T. mentagrophytes, 3; M. canis, 3; T. tonsurans var sulfureum, 1. On 15 occasions anthropophilic fungi were isolated from humans but not from suspected animals. Thirty six small animals were thought to be the source of human ringworm but it was confirmed in only 7 of them. Thus, on 57 (25.4 per cent.) occasions either an animal source was erroneously given or a wrong animal was suggested. Animals form a reservoir for human ringworm, in this area, but cattle rather than domestic pets are the main source of human infection.

Treatment of animal dermatomycosis is discussed and results

are given of the use of oral griseofulvin against experimentally induced ringworm in cattle and in cats and against spontaneous infection in ox, dog and chinchilla. Establishment of infection was prevented and clinical cases were cured. The mode of action of the drug is considered and the public health significance of clinically cured animals, which may still be carriers of infection, is discussed.