ANIMAL RINGWORM
in
PUBLIC HEALTH

Diagnosis and Nature

By

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PREFACE

Animal ringworm is a public health problem whose magnitude has only recently been recognized. During the past decade, field studies in various sections of the country have shown it to be much more widespread than was previously believed and have led to the conclusion that many thousands of animals in close contact with humans are infected.

Cats and dogs are especially susceptible and are frequently the source of human infections. Veterinarians who examine their animal patients for ringworm point out that as many as one cat in five and about one dog in ten are affected. Incidence in farm animals is believed to be lower than in house pets, but infections among them are not at all uncommon. Calves and adult cattle that are confined seem most susceptible, but there is a significant incidence rate for horses, too. Even wild animals experience infections, as revealed recently through surveys in the Southeast.

As these facts have emerged, there has been an increase in the number of requests for information on animal ringworm. How is infection diagnosed? What is its epidemiology? How should it be treated? What can be done to prevent spread among pets, especially cats and dogs? The important objective of such inquiries is, of course, the prevention of human infections.

To answer these and similar questions for persons concerned with animal ringworm and its public health significance, Dr. Georg and her colleagues have prepared this manual which brings together essential facts from their past presentations. These presentations, made in response to requests for assistance, have included lectures at veterinary meetings, both national and international, training courses presented by the Center, and commentary to accompany demonstrations and displays.

The manual holds much of value for practicing veterinarians and physicians and for laboratory workers on whose skill they may depend. For the health officer, the public health nurse, and the sanitarian, it is an excellent source of background information to guide their epidemiologic investigations. For students, both in veterinary medicine and other branches of medical science, it should prove to be one of the most valuable publications on animal ringworm. It is my belief that the information set forth in this booklet, combined with advances in therapy, opens new possibilities for control of this age-old disease.

James H. Steele

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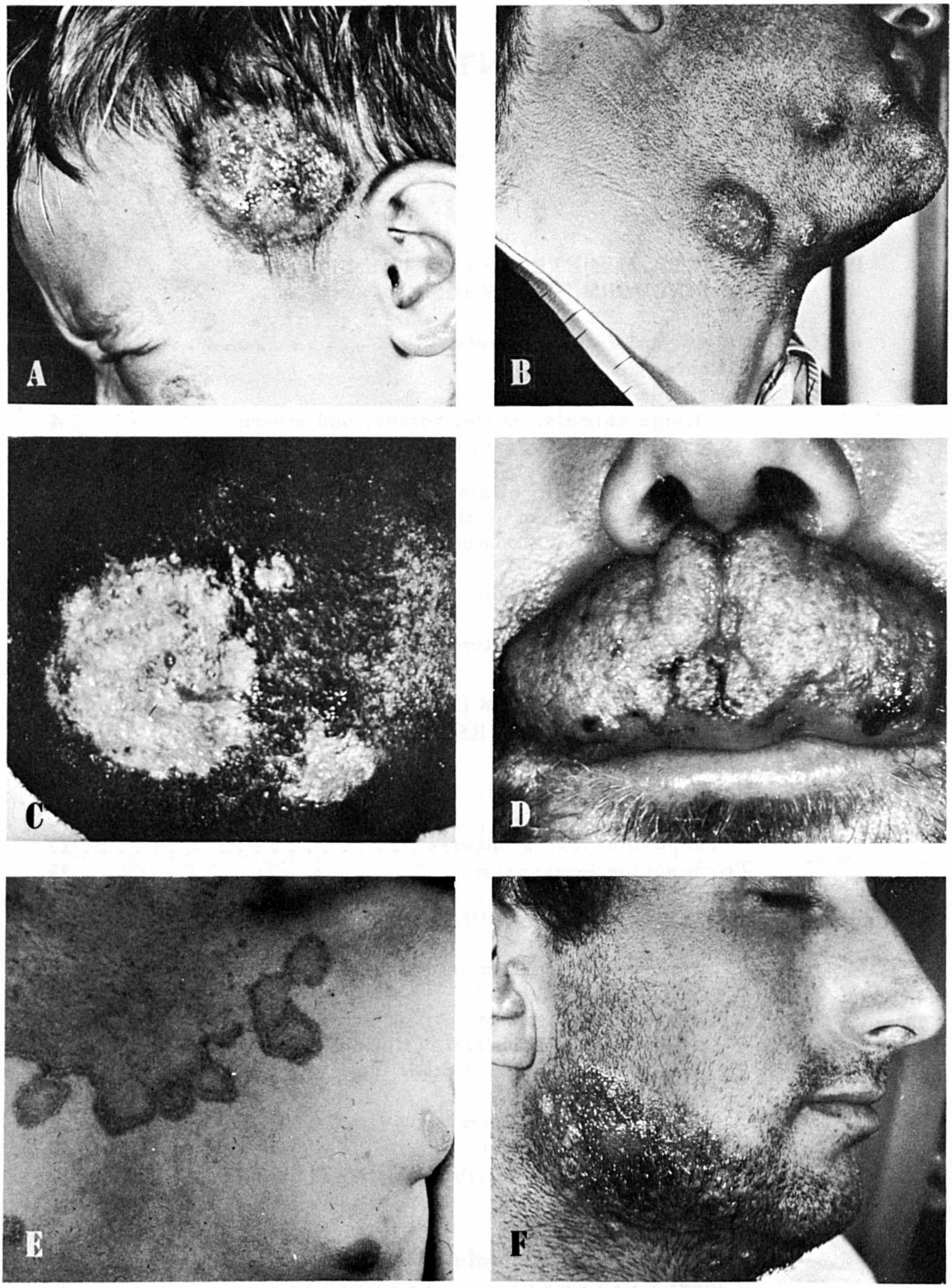

Plate I.

A. *T. verrucosum* infection in farm child. B. Kerionic lesions on face of a farmer due to *T. verrucosum*. C. Suppurative scalp lesion due to *T. mentagrophytes*. D. Lesion on upper lip of farmer due to *T. mentagrophytes*. E. Circinate lesions on neck and chest of farm worker due to *T. mentagrophytes*. F. Suppurative lesions on bearded area of face due to *T. mentagrophytes*.

INTRODUCTION

Animal ringworm is an important public health problem since this disease is frequently transmitted to man. Ringworm-infected domestic animals constitute a constant source of infection for persons who have pets or who live in rural areas where they have contact with farm animals. In addition, ringworm-infected wild animals may be an indirect source of human infections, for infected hairs shed from such animals, particularly mice and rats, frequently contaminate farm premises or homes. The role of animals as vectors of human fungus diseases has been reviewed by a number of authors (*14,58,61,70,92, 124*).

Until recently we have had little knowledge of the prevalence of ringworm infections in animals and little information regarding the frequency of the transmission of these infections to humans. In the past few years, however, several epidemiological studies and surveys have thrown considerable light on the subject. The Mycology Unit in cooperation with the Veterinary Section of the Communicable Disease Center has been conducting a survey of ringworm of animals in the United States, and similar surveys have been carried out in Great Britain (*2,82,104,110*).

The results of these studies have shown the high prevalence of ringworm in animals and have given considerable evidence on the manner in which these infections are transmitted to humans. These studies have also pointed up the importance of accurate diagnoses by cultural methods as well as the need for better methods of treatment and control. In the survey conducted by the Communicable Disease Center the use of cycloheximide agar, a selective medium which inhibits the growth of bacteria and saprophytic fungi, has greatly improved methods for the isolation of dermatophytes from heavily contaminated materials such as animal skin and hair samples.

The individual dermatophyte species have varying degrees of host specificity. Some are primarily animal pathogens. These are the so-called zoophilic fungi which commonly cause ringworm in animals. Although animals appear to be the natural hosts for this group of fungi, such infections are readily transmissible to humans. Six dermatophyte species which commonly cause ringworm in animals have been found to be important in relationship to human infection. These include *Microsporum canis, M. distortum, Trichophyton verrucosum, T. mentagrophytes* var. *granular, T. equinum,* and *T. gallinae.*

Another group of dermatophyte species is called "anthropophilic," because they are primarily human pathogens. Examples of such dermatophytes are: *Microsporum audouinii, Trichophyton tonsurans, T. rubrum, T. violaceum,* and *T. schoenleinii.* In general, it is difficult to produce experimental infections in laboratory animals with these fungi, and transmission from humans to animals is indeed very rare.

A third group of dermatophytes appears to have no specific preference for animals or man. These are the "geophilic fungi" or the soil-inhabiting fungi which have the ability to invade the keratinized tissues of both human or animal hosts and produce disease. Such fungi are *Microsporum gypseum* and *Keratinomyces ajelloi.*

Human infections due to the anthropophilic fungi are particularly common in urban areas and are largely accountable for epidemics of ringworm, particularly ringworm of the scalp, among school children in this country as well as elsewhere in the world. Infections are usually chronic in nature, and little tissue reaction is a common characteristic. Such infections are extremely resistant to treatment, and constitute a serious problem among school children and in some adults as well. Animal contacts are of no importance in anthropophilic ringworm.

Human infections due to the zoophilic fungi are common in both urban and rural areas. In urban areas *Microsporum canis*, the common agent of ringworm of cats and dogs, may account for 10 to 80 percent of the ringworm of children and adults. Lesions may occur on any exposed areas of the skin or scalp and are frequently acute in nature with considerable tissue reaction. Infections primarily acquired from a cat or dog may subsequently be passed among large groups of humans. Extensive human epidemics by human to human transfer, however, are not common.

As one would expect, infections due to the zoophilic fungi are common in rural areas. Here the common agent of ringworm of cattle, *Trichophyton verrucosum*, and the common agent of ringworm in rodents, *T. mentagrophytes* var. *granular*, frequently produce ringworm in both children and adults. Lesions tend to be acute and suppurative in nature and generalized reactions are not uncommon. Examples of ringworm among rural individuals are shown in Plate I. Such infections may be acquired directly from contacts with infected animals or indirectly by contacts with contaminated feed or farm premises. Frequently very young children, who appear to be highly susceptible to infection, contract infections indirectly through infected animal hairs which cling to the adult farmer's clothing.

Infections due to the "geophilic fungi" or those keratinophilic fungi such as *Microsporum gypseum*, which lives a saprophytic existence in the soil, may be acquired either by man or animal directly from contact with soil containing this organism. There is evidence also that animal infections due to *M. gypseum* may be secondarily transferred to other animals or to humans.

The diagnosis of ringworm in animals is dependent upon the demonstration of fungal elements in the skin and hair of the infected animal and/or the isolation of pathogenic fungi in culture. Since the disease may simulate a number of dermatologic conditions, or may be inapparent clinically, the isolation of a known dermatophyte species is essential.

This publication deals with: I. Practical methods for the diagnosis of ringworm in animals, and II. Review of ringworm in animals, its transmission to man and public health aspects.

PART I.
PRACTICAL METHODS FOR THE DIAGNOSIS OF RINGWORM IN ANIMALS

A. COLLECTION OF CLINICAL MATERIALS

1. **Equipment:** Sterile scalpels, sterile tweezers (hair pulling type), Wood's lamp,* paper envelopes.

2. **Methods:** Examine the animal for areas with loss of hair, erythema, scaling, or heavy crusts, which may or may not show suppuration beneath them. Lesions are usually circular and are most frequently seen on the head of the animal near the eyes, nose, or mouth. In some cases the infection may be more generalized with scaling and loss of hair occurring over large areas of the body. These are generally more marked on the friction areas, or along the edges of the ears.

a. Large animals: cattle, horses, and others

When dealing with large animals, heavy crusts should be removed, and scrapings taken from the outer borders of the lesions. A hair-pulling tweezer may be used to pluck hairs. The stubs of broken hairs, which usually are greyish and thickened, are most apt to be infected. Crusts often enclose many infected hairs which are epilated when the crust is removed. Small bits of the crust should be obtained for study. All specimens should be placed in clean paper envelopes and labeled.

Do not place scrapings in closed containers such as rubber-stoppered tubes. In such a container the specimen remains moist, and contaminating bacteria and saprophytic fungi will grow on the hairs and skin scrapings, thus making the isolation of pathogenic fungi more difficult. Spores of pathogenic fungi are resistant to drying and will remain viable in a specimen for many months *(105,148)*.

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*The Wood's lamp is an ultraviolet light with a special nickel oxide filter that allows maximum radiation at about 3,660 angstrom units. Several commercial lamps are available in small hand models which are useful in the diagnosis of some types of both animal and human ringworm.

b. Small animals: dogs, cats, and others

With small animals it is of great value to carry out a preliminary examination under a Wood's lamp in a completely darkened room. If fluorescent hairs are seen (infected hairs glow with a bright yellow-green color), pluck out several such hairs and place them in a clean paper envelope. The Wood's lamp is extremely useful in detecting certain types of ringworm infection. Even minimal infections where only a few hairs are involved, and which may be inapparent under normal lighting conditions, may be detected by use of a Wood's lamp. It is important to remember, however, that fluorescence of infected hairs occurs only when certain dermatophyte species are involved. The following dermatophytes regularly produce fluorescent hairs: *Microsporum canis*, *audouinii*, and *distortum*. In some cases, however, even these fungi fail to produce fluorescence. This is especially true in the early stages of an infection, or after an animal has been under treatment. If no fluorescent hairs are observed, the animal should be re-examined under normal lighting conditions for loss of hair, crusts, etc. as described above. Abnormal areas should be scraped, and the scrapings placed in a clean paper envelope. Hairs should be plucked also, particularly the stubs of broken hairs, and placed in the specimen envelope.

Clinical materials (hairs and skin scrapings) from suspected cases of ringworm should be taken to the laboratory for direct examination and cultural studies. If the specimen is to be mailed to a diagnostic laboratory, the specimen envelope should be sealed and placed in a second envelope. It is well to accompany specimens with data concerning species and age of the animal, location and character of the lesions, address of the owner, and any information regarding evidence of human contagion.

B. STUDY AND CULTURE OF CLINICAL MATERIALS

1. Direct examination of clinical materials

a. If a Wood's lamp is available, the dish or envelope of skin and hair scrapings may be examined in a darkened room. If fluorescing hairs are seen, these should be selected for further examination and culture. If no fluorescence is seen, hairs and skin scrapings may be selected at random from the clinical material for study. Broken-off hairs or hairs which show greyish-white collarettes at their bases are most apt to be infected.

b. Place a hair and a few skin scrapings in a drop of 10 percent potassium hydroxide on a glass slide. Add a coverslip and heat the slide by placing on the microscope lamp or by holding for a few seconds over a Bunsen burner. DO NOT BOIL. If a Bunsen burner is not available, allow the preparation to stand 15 to 20 minutes for clearing before examination.

c. Examine under the low power of the microscope with reduced light for the presence of fungus elements. Note the size and distribution of spores on the hairs. For more accurate study, examine with the high power lens (450 X or 475 X).

The important characteristics of the ringworm fungi seen by direct examination of tissues are shown in charts I and II.

2. Culture of clinical materials

a. Media. Sabouraud's dextrose agar at pH 5.5 is the standard medium used for the isolation of the ringworm fungi from clinical materials. This medium is available in powdered form from several commercial sources. However, for the isolation of fungi from heavily contaminated materials such as animal hair and skin scrapings, better results may be obtained by use of the cycloheximide-chloramphenicol medium. This selective isolation medium is made of Sabouraud's dextrose agar with the antibiotics: chloramphenicol and cycloheximide. Chloramphenicol inhibits the growth of most contaminating bacteria, and cycloheximide suppresses the growth of many saprophytic fungi. The characteristics of the ringworm fungi are not changed by these antibiotics, but their isolation is greatly facilitated *(62)*. The preparation of this medium is described in the appendix. Similar desiccated media are commercially available.

b. Inoculation of tubes. Tubes are inoculated by placing hairs or skin scrapings (use a sterile scalpel or inoculating needle) on the slanted surface of the medium. It is well to push the specimen partially into the agar.

c. Incubation. Tubes are incubated at room temperature (25° to 30° C.). Clinical material from suspected cases of cattle ringworm should be incubated at 37° C. as well as at room temperature. (*T. verrucosum*, the common cause of cattle ringworm, develops slowly at room temperature.)

d. **Examination of cultures.** Tubes should be examined every 4 to 6 days. If saprophytic fungi appear, it is well to subculture to fresh tubes any colonies suspected of being ringworm fungi. Culture tubes should be held for at least four weeks before being considered negative. The colonies of ringworm fungi are studied to determine their gross and microscopic characteristics. The diagnostic cultural characteristics of the ringworm fungi found in animals are presented in charts III and IV.

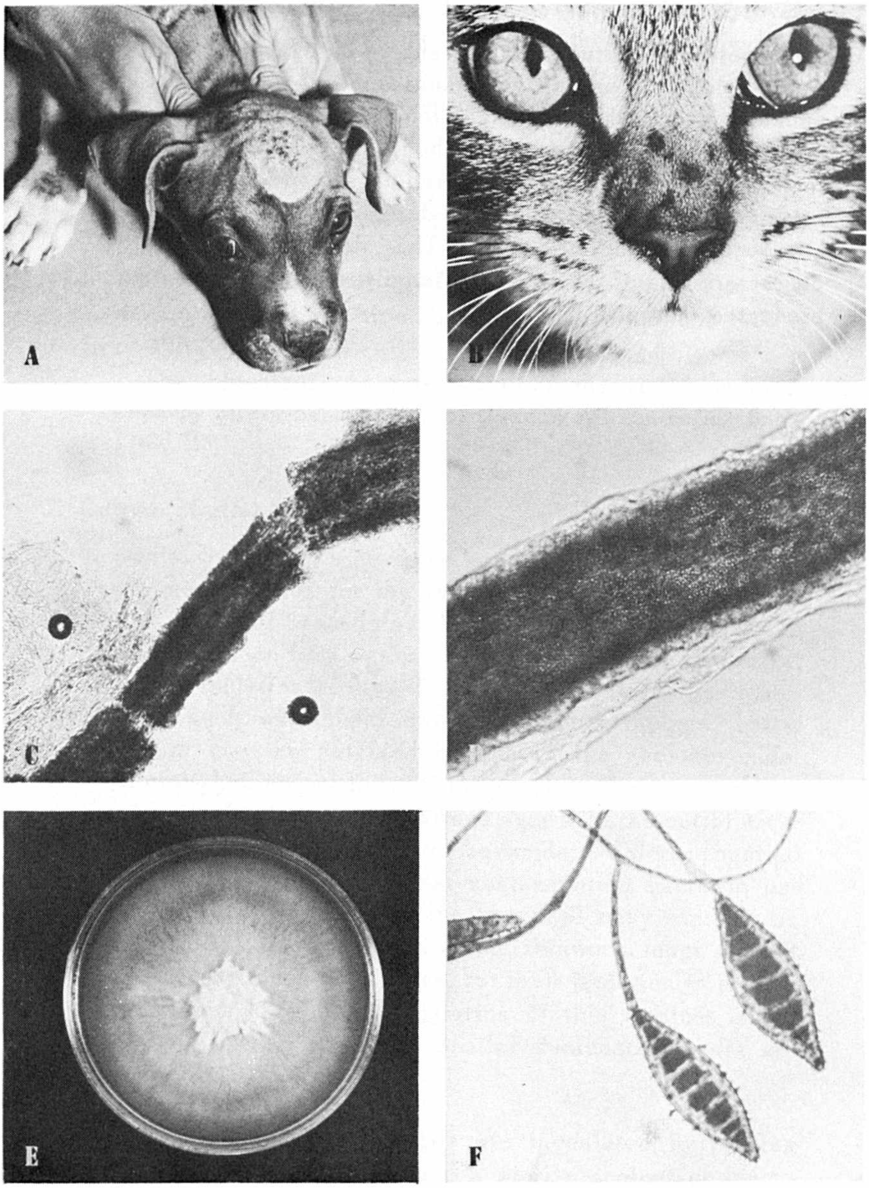

Plate II.
A. Heavily crusted lesions on dog caused by *M. canis*. B. Loss of hair on nose of adult cat due to *M. canis* infection. C. Hair invaded by *M. canis* showing sheath of tiny spores, 200X. D. Hair invaded by *M. canis*, 475X. E. Colony of *M. canis* on Sabouraud's dextrose agar. F. Characteristic macroconidia of *M. canis*.

PART II

REVIEW OF RINGWORM IN ANIMALS, ITS TRANSMISSION TO MAN AND PUBLIC HEALTH ASPECTS

MICROSPORUM CANIS INFECTIONS

Diagnosis

With the proper techniques, fungus-infected skin will show branched septate mycelium and arthrospores. These spores are at first rectangular and appear as segments of a closely septate mycelium. At maturity they round up and appear as chains of beads. This picture of mycelium and chains of arthrospores in skin scrapings is similar for all types of ringworm infections regardless of the etiologic agent involved. The manner of the fungus invasion of the hair, however, is distinct for each fungus species involved. In *M. canis* infections, the hair is covered with a sheath of very small spores. These spores are 2 to 3 microns in diameter, and usually cannot be seen clearly unless examined under the high power of the microscope. Under a magnification of 400 to 475 X they can be distinguished easily. They are packed together tightly in a mosaic over the surface of the hair. If the spores are disloged from the hair, it is found that branching mycelial filaments are present in the interior of the hair. This type of hair invasion is designated as "small-spored ectothrix" and is characteristic of infections by several *Microsporum* species: *M. canis*, *M. audouinii*, and *M. distortum*.

In order to determine the species involved, it is necessary to isolate the pathogenic fungus in culture. Growth appears in a few days on Sabouraud's dextrose agar or similar media, with or without antibiotics. The culture may be identified on the basis of its gross and microscopic characteristics by the fifth to seventh day. Chart III lists the diagnostic characteristics of this fungus. As noted in the chart, the usual culture has a white fluffy surface and develops a brilliant yellow pigment on the reverse side of the colony. Occasionally this yellow pigment may be missing. Some rare isolates may have a glabrous surface (a smooth, skin-like surface without the characteristic fluffy white aerial growth). The macroconidia, which are the most important diagnostic characteristic of this fungus, are usually present in large numbers in the fluffy surface growth. Occasionally they are few in number, and in glabrous cultures they may be lacking. However, the transfer of such cultures to wort agar* or rice grain medium** usually stimulates production of macroconidia.

Review of M. canis infections in animals

M. canis is the most common cause of ringworm in cats and dogs. It also has been found to cause ringworm in horses and monkeys, and occasionally in other animals. Although this fungus was first isolated from dogs *(20)*, it is apparently much more common in cats. Young animals are infected most frequently. *M. canis* has never been isolated from nature, and appears to be essentially a zoophilic fungus; however, it is frequently transmitted to man. Fortunately the disease does not become epidemic in man, but in areas where *M. canis* infections in animals are common, it may become an important public health problem. *M. canis* infections in cats and dogs appear to be the chief source of *M. canis* infections in humans. Although pet cats and dogs are numerous in both urban and rural areas, *M. canis* ringworm in the United States is largely an urban disease *(64)*. In surveys of human ringworm infections (other than tinea pedis) in the United States, *M. canis* accounts for 3 to 67 percent of the infections in most urban areas where epidemic *M. audouinii* infections are common *(95,140)*. However, in some areas, particularly in Texas, the prevalence has been reported as high as 85 percent *(139)*. Infections are most commonly seen in children, but are occasionally seen in adults who have had contacts with ringworm-infected pets. Subsequently, the infections may be passed to close human contacts. One report *(135)* gives evidence of the transmission of *M. canis* by a kitten to eight humans, but in such an outbreak it is always difficult to ascertain how many of the individuals concerned contracted the infection independently from the same source. Human-to-human transfer does occur, although the infection appears to become attenuated after 4 to 6 transfers in a series. In Great Britain, where *M. canis* is common as a cause of ringworm in children and adults, it tends to run in localized areas. Lawson and McLeod *(93)* have reported an intensive outbreak in Great Britain stem-

*Wort agar is available commercially in dehydrated form.

**Rice grain medium is prepared by autoclaving rice grains with water (1 part rice to 4 parts water) in small flasks.

ming from a breeder's cattery where 12 animals were shown to have *M. canis* infections. Nine kittens sold from this cattery were responsible for 22 human infections. Of the 42 persons exposed to these kittens, 14 of 15 children (93 percent) and 8 of 27 adults (30 percent) were shown to have become infected. Recently, British public health authorities have instituted campaigns to track down human cases to their animal source and to enforce treatment or disposal of the animal reservoir *(89)*. It would appear that control of *M. canis* infections in cats and dogs is basic to the prevention of human infection. This could be achieved by accurate diagnosis by veterinarians, by inspection and regulation of cat and dog breeding establishments, and by elimination of strays. An efficacious treatment would be needed for this type of control to be effective.

Cats

There are numerous reports in the literature of the isolation of this fungus from cats *(41,78,89,97,99)*. In the Communicable Disease Center survey conducted over a period of 3½ years, 325 feline specimens yielded dermatophytes. Of these, 318, or 97.8 percent, were *M. canis*.

M. canis infection in the cat is often difficult to detect clinically. The cat may appear completely normal or show only small scattered areas of alopecia on the face or ears. In a study of ringworm in cats by Menges and Georg *(107)*, it was reported that of 82 cats in a single cat breeding establishment which were later shown by culture to be infected by *M. canis*, 18, or 22 percent, had no visible lesions. In many of these, however, a few fluorescent hairs or a single fluorescent whisker (usually broken) could be detected by use of the Wood's lamp. Some of the cats in this group had neither lesions nor fluorescent hairs, yet *M. canis* was obtained through culture. The absence of clinical signs of infection is particularly common in cats 1 year or older. Kittens exhibit lesions more frequently, and severe clinical cases are sometimes observed where scaling and hair loss may be extensive.

Onychomycosis or infection of the claws due to *M. canis* has been described by LaTouche *(91)*. Under the Wood's lamp, infected claws appear in various shades of green with various degrees of brightness. Under normal lighting conditions, whitish opacities are the striking feature of infected claws; however, such opacities may be present in the absence of *M. canis* infection. Scrapings from infected claws reveal the presence of branched mycelium and *M. canis* can be readily obtained upon culture.

Dogs

There are numerous references to the isolation of *M. canis* from ringworm-infected dogs *(78,92,99,125)*. In the Communicable Disease Center survey, 495 canine specimens yielded dermatophytes. Of these, 329, or 66.5 percent, were *M. canis*. In the dog, as in the cat, infections may be perceptible only with the aid of the Wood's lamp. More commonly, however, one finds clearly defined areas of scaling as well as discrete circular areas with loss of hair at their centers, and often with vesiculation at the borders. Stumps of broken, greyish colored hairs about 2 to 3 mm. in length appear here and there in the lesions, especially at the borders. In severe cases, heavy crusts may be formed or the infection may be generalized with scaling, erythema, and loss of hair over widespread areas.

Horses

M. canis infection in horses was first described by Bodin in 1896 *(19)*. The etiologic agent was designated as "*M. audouinii* var. *equinum*." The name *M. equinum* was given to this fungus by Gueguen in 1904 *(71)*. However, studies by Conant in 1935 *(35)* and in 1941 *(37)* clearly demonstrated that these strains were identical with *M. canis*.

There are several references to epizootics in horses due to *M. canis*. These have occurred particularly in army quarters where large numbers of animals were kept *(12,22, 30,94,116)*. Hoerlein *(78)* described a case of *M. equinum* (*M. canis*) infection in a horse in the United States, and also followed the development of lesions in an experimentally infected horse. The animals characteristically showed patchy loss of hair and scaliness of the skin. Hoerlein described the animals as having a "moth-eaten appearance." Ainsworth and Austwick *(2)* in their survey of animal ringworm in Great Britain have recorded one outbreak of ringworm in horses due to *M. equinum* (*M. canis*), and have recently sent us isolates from three other outbreaks. In the Communicable Disease Center survey, only 2 isolates of *M. canis* have been obtained from horses to date. A review of ringworm in horses by Georg *et al. (66)* describes *M. canis* ringworm in the horse and compares it with other types of ringworm disease in this animal.

Other animals

It is interesting that *M. canis* infections appear to be common in the monkey. The first isolation of this fungus from a monkey was by Emmons. This strain was first considered to be a new species by Conant *(36)*, and named *M. simiae*. However, in later studies, Conant equated this fungus with *M. canis (37)*. In the Communicable Disease Center survey over a 3½-year period, of 29 specimens from monkeys, 16, or 55 percent, yielded *M. canis*; and of 52 specimens from chinchillas, 2 have yielded *M. canis*.

MICROSPORUM GYPSEUM INFECTIONS

Diagnosis

In the case of *M. gypseum* infections, the Wood's lamp is of little value. Although it is stated in many texts that all *Microsporum*-infected hairs fluoresce under the Wood's lamp, no fluorescent hairs were observed in 138 specimens of animal hairs from which *M. gypseum* was isolated at the Communicable Disease Center. This lack of fluorescence of *M. gypseum*-infected hairs has also been noted in some human infections *(39,149)*.

Microscopic examinations of skin scrapings in KOH preparations reveal septate, branching mycelium and masses of arthrospores of various sizes. Infected hairs contain mycelial filaments in their interiors. On the surface of the hairs one finds irregular masses of large spores, some of which are in chain formation. These spores (arthrospores) are quite variable in size, ranging from 5 to 8 microns. They are much larger than the arthrospores formed by *M. canis*. Thus, hairs infected by *M. gypseum* present quite a different microscopic appearance than those infected by other *Microsporum* species.

For final identification, cultures must be made. *M. gypseum* grows readily on Sabouraud's dextrose agar, with or without antibiotics, at room temperature. The culture is identified on the basis of its gross and microscopic characteristics by the fourth to fifth day. Chart III lists the diagnostic characteristics of this fungus.

Review of M. gypseum infections in animals

M. gypseum infections in both animals and man have not been recorded frequently in the past. The first isolation of *M. gypseum* was apparently by Sabouraud *(131)*, who in 1894 referred to the fungus as "Trichophyton du chien." It was

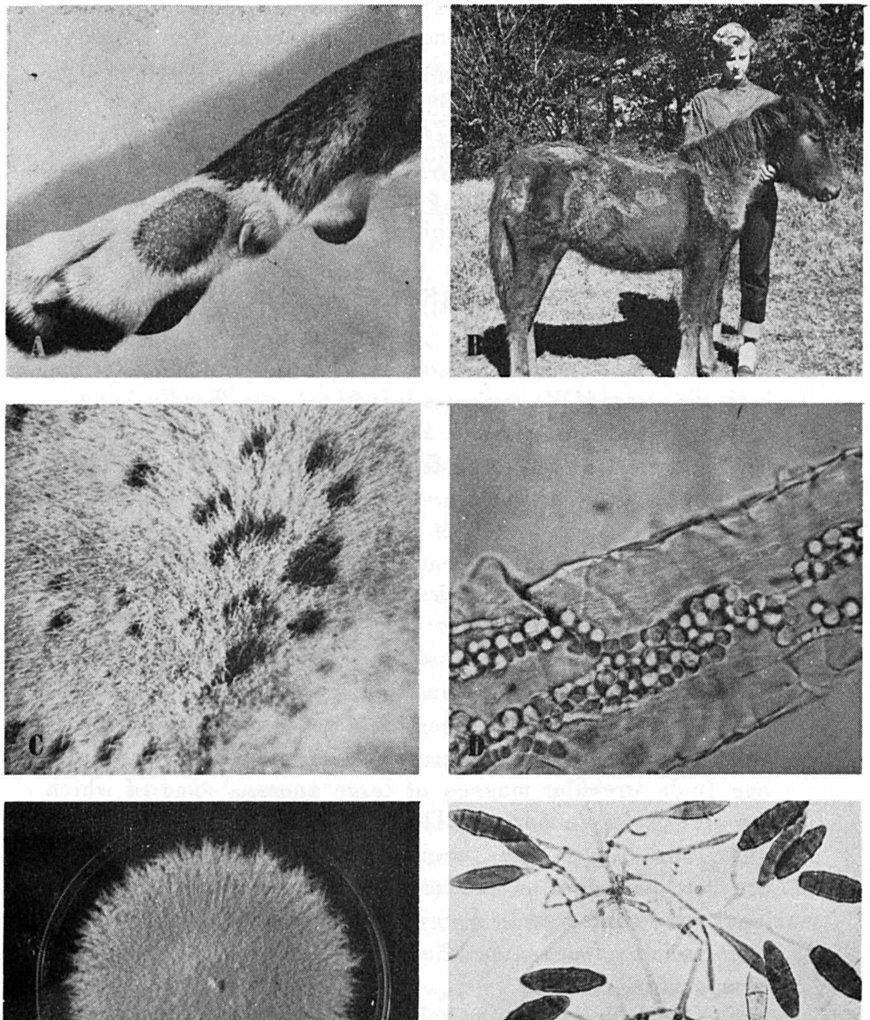

Plate III.

A. Lesion on leg of dog due to *M. gypseum*. B. *M. gypseum* infection in the horse. C. Areas of hair loss on skin of horse due to *M. gypseum*. D. Hair invaded by *M. gypseum* shows mycelium in its interior and masses of large spores on its surface. E. Colony of *M. gypseum* on Sabouraud's dextrose agar. F. Characteristic macroconidia of *M. gypseum*.

further studied by Bodin who named it *Achorion gypseum.* Not until 1928 was this fungus placed in the genus *Microsporum* by Guiart and Grigorakis *(72)*. A review of the literature by Ajello in 1953 *(3)* indicated that only 61 isolations of this fungus from animals had been recorded. Nine of the reports were concerned with outbreaks among horses involving 50 animals, 4 cases were reported in monkeys, 1 in a dog, 4 in cats, 1 in a tiger, and 1 in a chicken. Therefore, this review suggested that *M. gypseum* infections in animals were rare. Data from the Communicable Disease Center survey, however, indicate that *M. gypseum* infections are quite common in animals, especially in the dog and the horse. This is not surprising in view of the fact that recent demonstrations indicate that *M. gypseum* is a common soil saprophyte. In 1948 the findings of Mandels *et al. (98)* and in 1952 Cooke *(38a)*, who recovered this fungus from wool fabric buried in soil, had suggested that *M. gypseum* probably existed in soil as a saprophyte. Definite proof of saprophytism was finally obtained in 1952 by Gordon *et al. (68)* when a soil sample collected in Tennessee yielded the characteristic macroconidia of *M. gypseum*, which never are produced on the tissues of living animals. Subsequently, by a modification of the hair-baiting technique of Vanbreuseghem *(144)*, Ajello *(3)* isolated this fungus from 37 (31.9 percent) of 116 soil samples taken from various localities in Tennessee and Georgia. Later analyses of foreign and domestic soils by various workers have given similar results *(4, 45, 56, 69, 77)*. The worldwide distribution of *M. gypseum* in soil where it exists as a free-living agent indicates that *M. gypseum* is essentially a soil-inhabiting fungus that only occasionally parasitizes animals and man. Soil must be considered the main source of infection for both animals and humans, and only infrequently are infections transmitted from animal to animal or from animal to man.

Dogs

In the Communicable Disease Center survey, 495 canine specimens yielded dermatophytes. Of these, 114, or 23.2 percent, were *M. gypseum.* Menges and Georg *(109)* published a review of 46 of these cases, involving 13 breeds of dogs. All 46 showed lesions which, in general, were circular with scaling, erythema, and occasional suppuration; and 7 had generalized infections. The majority of the infections were in the "under-one-year" age group, although animals up to 8 years of age were involved. Twenty-nine of the infected dogs were males, 17 were females. Prior to this report, only 2 canine cases of *M. gypseum* infection had been recorded *(55,131)*.

Cats

Of 325 feline specimens which yielded dermatophytes in the Communicable Disease Center survey, 4 yielded *M. gypseum*. These cases have been described by Kaplan *et al. (83)*. All of these cats presented lesions ranging from slight loss of hair with scaling to the development of eczematoid areas or kerions (raised, boggy lesions, suppurating at many points). The ages of the animals varied from 4 weeks to 3 years. Prior to this report only 6 authenticated feline infections had appeared in the world literature *(3,11,55,122,136,141)*.

Horses

Until 1956 there were only 8 reports of *M. gypseum* outbreaks among horses *(12,22,32,94,116,132,143)*. All of these cases were reported from Europe with the exception of 2 from Madagascar. In 1 report *(116)* 40 horses in a Belgian remount station were infected, which indicates that *M. gypseum* may produce epizootics in horses.

In the United States the first authenticated equine infection due to *M. gypseum* was that reported by Kaplan *et al.* in 1956 *(84)*. Again, the next year, they described an epizootic involving 8 horses and a dog on 1 farm premise *(87)*. The infected horses were from 6 months to 12 years in age. The lesions showed the development of heavy crusts which later fell off, leaving areas with hair loss and stubs of broken-off hairs and giving a rather characteristic moth-eaten appearance to the animals. The fact that epizootics have been seen in animals suggests that animal passage increases the virulence of soil strains which have relatively low virulence as observed by animal inoculation experiments. This laboratory's studies of the strain isolated from the epizootic in horses indicated a high degree of virulence for the laboratory guinea pig, whereas soil strains collected from the pasture where the animals had been kept had very little virulence for the guinea pig.

Other animals

In the Communicable Disease Center survey of wild animals captured in southwestern Georgia, 4 isolations of *M. gypseum* have been made from wild mice (*Peromyscus* *polionotus*) and 3 from wild rats (*Rattus norvegicus*). It is noteworthy that these wild mice and rats did not present visible lesions.

Four *M. gypseum* infections in monkeys *(76,79)* have been recorded, 1 in a tiger *(94)*, 1 in a chicken *(142)*, and 1 in a donkey *(30)*.

TRICHOPHYTON MENTAGROPHYTES INFECTIONS

Diagnosis

Since *T. mentagrophytes*-infected hairs do not fluoresce, the Wood's lamp is of little value in determining the presence of an infection. Skin scrapings from the active edge of a lesion or fragments of the crusts examined in KOH mounts reveal branching mycelium and arthrospores, as seen in all types of ringworm. Infected hairs, however, present a more specific picture, with branched mycelium in their interiors and their surface covered with a sheath of small spores 3 to 5 microns in diameter. These external spores are arranged in chains, but are often packed together in a mass. This type of hair invasion was referred to by Sabouraud as "microide ectothrix" or small-spored ectothrix in contrast to the large-spored ectothrix as seen in hairs infected by *T. verrucosum. Microsporum canis* also produces small-spored ectothrix infections; however, here the spores are smaller, 2 to 3 microns in diameter, and they are packed together in a mosaic. *M. canis*-infected hairs may also be distinguished from *T. mentagrophytes*-infected hairs by the fact that they fluoresce.

Final identification of the fungus organism is made by cultural studies. *T. mentagrophytes* grows readily on Sabouraud's dextrose agar with or without antibiotics at room temperature. Characteristics of the culture are given in chart IV. Occasionally a strain is isolated which does not produce macroconidia. The use of wort agar has been found most helpful in stimulating their production. Strains which produce considerable deep red pigment can be distinguished from *T. rubrum* with the *in vitro* hair culture method described by Ajello and Georg *(5)*.

T. mentagrophytes develops many different colonial forms and pigments in culture. Because of this fact, many different "species" have been described on the basis of colony form and pigments. However, it has been shown that characteristics such as surface texture and topography, as well as pigments, are not stable characteristics; and most of these so-called "species" represent the same organism. It is

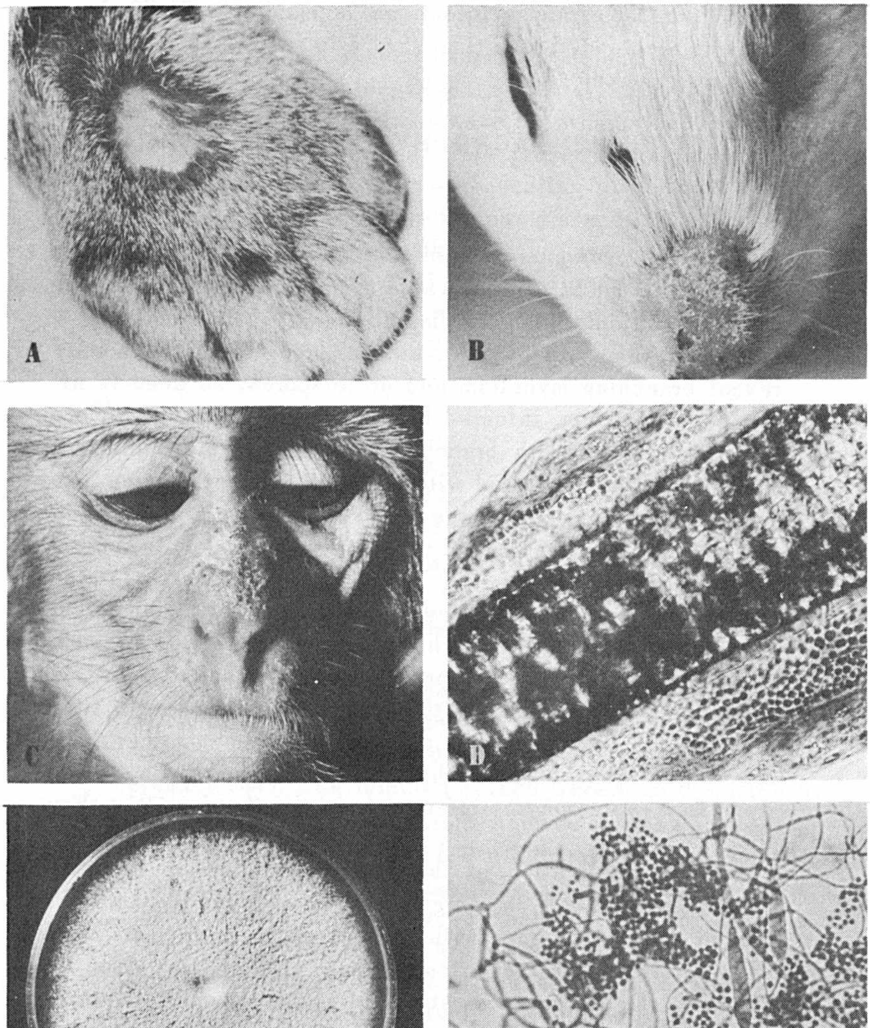

Plate IV.

A. Cat's paw showing loss of hair due to *T. mentagrophytes* infection. B. Spontaneous ringworm in a guinea pig due to *T. mentagrophytes*. C. Monkey with lesions on the face due to *T. mentagrophytes*. D. Hair invaded by *T. mentagrophytes*. Edge of hair shows masses of small spores on its surface. E. Colony of *T. mentagrophytes* (var. *granular*) on Sabouraud's dextrose agar. F. Microconidia and macroconidia of *T. mentagrophytes*.

interesting that certain colony types are most commonly associated with animal ringworm and human infections contracted from animals, while other varieties are usually associated with chronic tinea pedis of humans.

In general, a flat, granular type colony, *T. mentagrophytes* var. *granulosum* is isolated from animal ringworm. When this type of culture is obtained from human ringworm lesions – usually suppurative lesions on the exposed parts of the body – the physician or dermatologist has reason to suspect that there has been an animal source for the human infection.

A second variety, *T. mentagrophytes* var. *quinckeanum*, sometimes seen in animal infections, particularly in mice epizootics, has a heaped and folded colony with a downy to velvety surface. This type of colony has been occasionally isolated from human ringworm where mice were the source of infection.

A flat, downy colony, *T. mentagrophytes* var. *interdigitale* is usually associated with chronic tinea pedis of man. Only rarely has this type of colony been isolated from lower animals.

Laboratory studies have demonstrated that *T. mentagrophytes* var. *granulosum* isolated from animal ringworm frequently converts to *T. mentagrophytes* var. *interdigitale* after prolonged culture on artificial media. Also, that by repeated guinea pig passage (repeated skin infections using the retroculture from one pig to inoculate the second, etc.), *T. mentagrophytes* var. *interdigitale* originally isolated from human tinea pedis may be converted to *T. mentagrophytes* var. *granulosum (28,47,60).* This association of colony type with source is not, of course, absolute, but it is a useful fact in epidemiological studies. Moreover, that one colony type may be converted to another gives proof that they are merely colonial variants of a single species. Microscopic studies of all of these varieties gives further evidence of their oneness, for all possess a similar microscopic morphology even though the quantity of spores produced is variable.

Review of T. mentagrophytes infections in animals

T. mentagrophytes infections occur among a wide group of animals. Recent studies indicate that small pets, especially dogs, and many wild animals, particularly rodents, are important reservoirs of this parasitic fungus. In the Communicable Disease Center survey, *T. mentagrophytes* has been isolated from the following animals: rats, mice, chinchillas, opossums, guinea pigs, dogs, cats, horses, 1 cow, and 1 kangaroo. In the survey by Ainsworth and Austwick in Britain *(2)*, *T. mentagrophytes* was isolated from dogs and cats. It is also known that this fungus infects rabbits, muskrats, squirrels, foxes, monkeys, sheep, and pigs.

As one would expect, human ringworm due to *T. mentagrophytes* is commonly seen in rural areas. In a survey of rural and urban ringworm by Georg *et al. (64)*, *T. mentagrophytes* var. *granulosum* accounted for 31, or 49.2 percent, of 63 infections (excluding tinea pedis) among rural dwellers in central Michigan, but this variety of *T. mentagrophytes* was not isolated from any of 108 infections observed in urban communities in this area.

In contrast to *T. verrucosum* infections, which usually can be traced to contacts with infected cattle, the source of human *T. mentagrophytes* infections in rural areas is not often easy to discover. Although large farm animals are occasionally infected by *T. mentagrophytes*, in the series of studies carried out by this laboratory neither horses nor cows were found to be important sources of human *T. mentagrophytes* infections. As with *T. verrucosum*, however, there is considerable evidence that *T. mentagrophytes* infections may be transmitted from animals to man or from animal to animal by contaminated materials such as feed, equipment, etc. In a number of epidemics that have occurred in horses the disease was apparently transmitted from animal to animal by contaminated brushes and harnesses. In the severe "favus" epidemics due to *T. quinckeanum* (*T. mentagrophytes* var. *quinckeanum*) which occurred in Australia in 1918 *(24)* and in similar outbreaks in Germany *(137)* and Czechoslovakia *(52)*, human infections were contracted apparently by the handling of grain and straw contaminated by ringworm-infected mice. The fact that wild mice and rats may harbour this fungus on their fur, as evidenced by the Mycology Unit's survey of wild animals, gives weight to the assumption that certain areas of farm premises, especially feed bins and barns, may be contaminated by spores and infected hairs shed by these animals. It is felt that rodents play an important role in the transmission of *T. mentagrophytes* infections in rural areas. The ubiquity and great numbers of infected wild mice and rats would constitute a much more likely source of infection than the occasional case of *T. mentagrophytes* infection that occurs among pets or farm animals.

Horses

T. mentagrophytes was described as a cause of ringworm in the horse by Sabouraud in 1893 *(130)*. Since that time a number of reports have been made concerning equine ringworm due to *T. mentagrophytes*, including rather extensive epizootics among large groups of horses *(22,30,94,116,121)*. In the Communicable Disease Center survey only 1 case of equine ringworm due to this fungus was found; likewise, Ainsworth and Austwick *(2)* recorded 1 equine case in the survey in Britain. Reviewing ringworm in the horse, Georg *et al.* *(66)* describe the *T. mentagrophytes* infection and compare it with other types of ringworm infections in this animal.

Dogs and cats

Few reports of *T. mentagrophytes* infections in dogs and cats have appeared in the literature *(29,88,102,131)*. The recent survey by the Communicable Disease Center, however, indicates that *T. mentagrophytes* is a fairly common cause of ringworm in dogs and an occasional cause of ringworm in cats in the United States. During a 3½ year period of study, 495 dog-hair specimens yielded dermatophytes. Of these, 45, or 9.1 percent, were *T. mentagrophytes*. Of 805 cat-hair specimens which yielded dermatophytes, 3 were *T. mentagrophytes*. In the British survey *(7)* *T. mentagrophytes* was isolated in 6 instances from dogs, and twice from cats. In a review of *T. mentagrophytes* infections in 18 dogs and in 2 cats by Georg *et al.* *(67)*, various degrees of involvement and tissue reaction were observed, ranging from loss of hair in small areas to heavily crusted and inflamed lesions involving large areas of the animal's body. Fuentes has reported inapparent infections in the cat due to *T. mentagrophytes* *(55)*.

Other domesticated animals: cows, rabbits, sheep, and pigs

There are few references to *T. mentagrophytes* infections in cattle. Sabouraud described a "Trichophyton du veau" in 1894 *(131)* which appears to have been *T. mentagrophytes*. More recently, Meude and Webb *(114)* described an outbreak of *T. mentagrophytes* infection among calves in Great Britain. In the Communicable Disease Center survey, one isolation of *T. mentagrophytes* was made from a cow.

Vilanova and Casanovas *(146)* described a *T. mentagrophytes* epizootic among domesticated rabbits in Spain. The lesions were often quite inconspicuous, with scaling and loss of hair as the only clinical signs of the disease. Fourteen human infections involving 8 children and 6 adults were traced to direct or indirect contact with these ringworm-infected rabbits. Similarly, in Brazil Rocha-Furtado *(127)* (1947) has reported epidemics of *T. mentagrophytes* infections in children which also appear to have had infected rabbits as the source.

Guilhon, Charton, and Durieux *(73)* have reported 3 *T. granulosum* (*T. mentagrophytes*) infections in sheep.

Sabouraud *(131)* described a "Trichophyton du porc" in 1894 which appears to have been *T. mentagrophytes.* Recently McPherson *(103)* has also described ringworm of the pig and here it is very clear that the causative agent was *T. mentagrophytes.*

Breeding stock of fur-bearing animals: chinchillas and silver foxes

Ringworm infections of the chinchilla have become an important economic problem. During the past few years our laboratory has confirmed several outbreaks of *T. mentagrophytes* ringworm from chinchillas in Maryland, Georgia, Connecticut, Alabama, and Canada. In all cases infections had spread rapidly involving large numbers of animals. Initial lesions, represented by the breaking-off and falling-out of hair, frequently occur near the base of the tail or around the mouth. In some cases the lesions first appear as scab-like plaques which can be felt through the fur, but loss of hair is soon apparent. In other cases large, raised, suppurating lesions have developed. Young animals up to 6 months are most commonly affected. Spontaneous recovery occurs in some animals with no permanent damage to the pelts. However, segregation and treatment of infected animals, and disinfection of premises is important in controlling an epizootic. In describing an epizootic which occurred in Canada, Blank *et al.* *(16)* pointed out that the rather common affection in chinchillas known as "fur slipping" is probably caused by *T. mentagrophytes.*

An epidemic among silver foxes being bred for pelts has been described by Flatla *(50).*

Laboratory guinea pigs, mice, and rats

Spontaneous *T. mentagrophytes* infections among laboratory animals have been noted by many workers, and there are numerous records of infection of laboratory personnel through the handling of such animals.

In Argentina Negroni *(117)* isolated *T. mentagrophytes* from 2 guinea pigs that had developed crusty lesions around their eyes and ears. Fuentes and Aboulafia *(54)* did the same with apparently healthy guinea pigs from a number of breeding colonies maintained by various laboratories in Cuba. In Georgia Menges and Georg *(108)* have reported an epizootic which occurred among several thousand guinea pigs where *T. mentagrophytes* was isolated from 130 of 151 animals cultured. Occurring chiefly on the head but also on the back, the lesions were circular and scaly, with erythema and loss of hair. In addition, *T. mentagrophytes* was occasionally isolated from animals without visible lesions. Although the lesions frequently underwent spontaneous healing, the fungus could be isolated from the skin and fur long after this apparent healing. The fact that animals may carry infective fungus elements with no visible lesions suggests the importance of culturing new stock and of holding newly acquired animals in quarantine before adding them to the regular stock.

T. mentagrophytes ringworm has been reported among other laboratory rodents. Parish and Craddock *(119)* described an epizootic involving 50 percent of a group of 2,000 laboratory mice, and Catanei *(31)*, Booth *(21)*, and Dolan *et al.* *(44)* have also reported *T. mentagrophytes* infections in mice and rats. At CDC we recently observed infections in 10 laboratory rats from New Jersey.

Wild animals

The reports by Charles *(34)* from Maryland, and by Errington *(48)* from Iowa indicate that *T. mentagrophytes* may be epizootic among wild muskrats. Adams *et al.* *(1)* have described an outbreak of *T. mentagrophytes* infection involving 35 percent of a population of Snoeshoe hares on an island in Flathead Lake, Montana; DeLamater *(42)* has described an infection in a squirrel; and Emmons *(46)* has isolated *T. mentagrophytes* from a ringworm infection in a monkey.

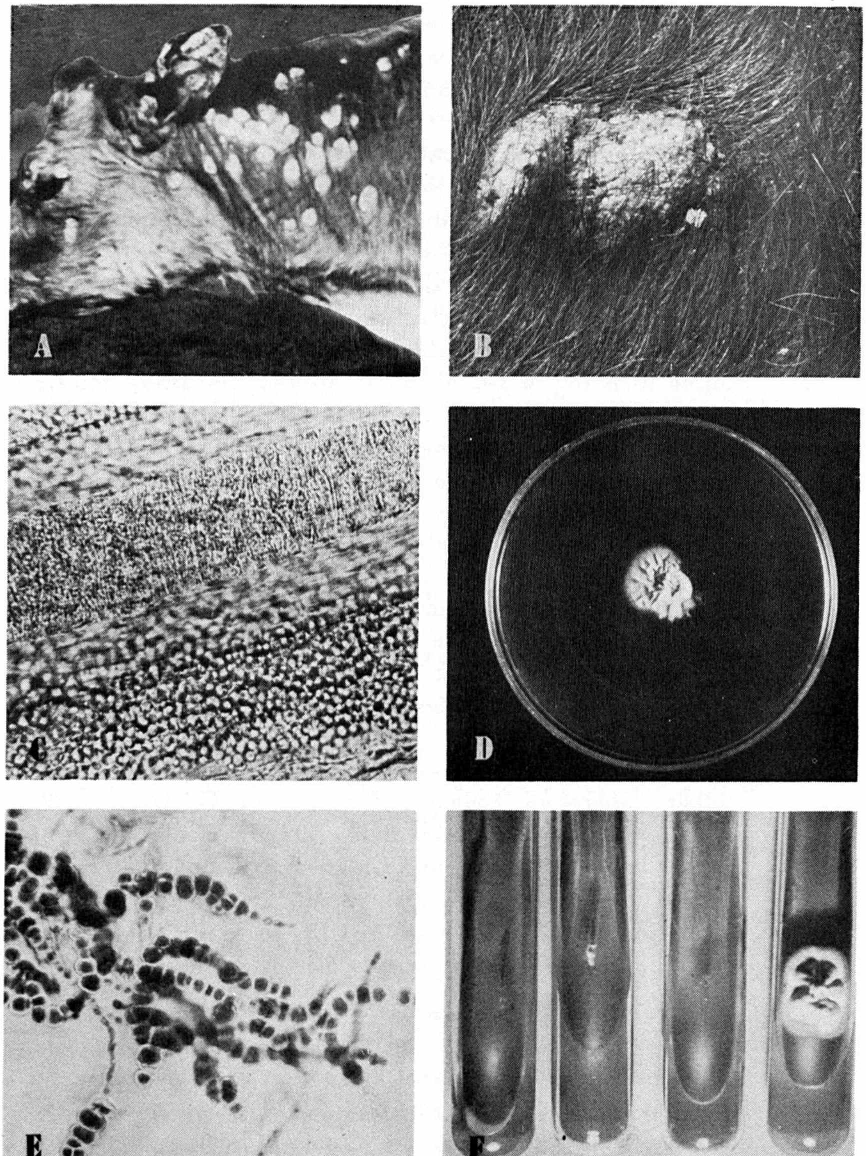

Plate V.

A. Calf infected by *T. verrucosum*. B. Close-up of heavily crusted lesion on cow hide. C. Hair invaded by *T. verrucosum*. Edge of hair shows masses of large spores on its surface. D. Colony of *T. verrucosum* on Sabouraud's dextrose agar. E. Masses of chlamydospores in culture of *T. verrucosum* grown at 37° C. F. Nutrition tubes showing requirement for vitamins. Left to right: casein, casein + inositol, casein + thiamin, casein + thiamin and inositol. This strain requires a combination of thiamin and inositol.

A survey of wild animals captured in southwestern Georgia by the Communicable Disease Center *(111)* revealed that ringworm of wild animals due to *T. mentagrophytes* is by no means uncommon. From 21 species of 1,142 wild animals, 88, or 7.7 percent, yielded the dermatophytes *Microsporum gypseum* and *T. mentagrophytes.* To date, our laboratory has isolated *T. mentagrophytes* from the following animals trapped at random: 16 mice (*Peromyscus polionotus, P. gossypinus, Mus musculus*), 23 rats (*Sigmodon hispidis, Rattus norvegicus, R. rattus*), and 7 opossums (*Didelphis virginia* and *D. marsupialis*). It is noteworthy that none of these animal hosts from which dermatophytes were recovered exhibited any skin lesions.

TRICHOPHYTON VERRUCOSUM INFECTIONS

Diagnosis

The examination of skin scrapings or fragments of the crusts reveals branching mycelium and chains of arthrospores, as seen in all types of ringworm infections. The infected hairs, however, show a more specific picture. The interior of the hairs may show branching mycelium, but on the outside of the hair there is a characteristic sheath composed of chains of very large spores 5 to 8 microns in diameter. Such hair invasion is called "large-spored ectothrix" (the "megalosporon" of Sabouraud). Infected hairs do not fluoresce under a Wood's lamp.

To complete the laboratory diagnosis, cultures should be made. Although *T. verrucosum* will grow on Sabouraud's dextrose agar at room temperature, the growth is so slow that the fungus takes several weeks to appear and is frequently overgrown by the more quickly developing bacteria and saprophytic fungi that may be present in the inoculum. The growth of *T. verrucosum* may be stimulated by the addition of thiamin* to the medium, and by incubation at 37° C. The use of antibiotics to inhibit the growth of bacteria and saprophytic fungi, as described in Part I, is of especial value in the isolation of this slow-growing fungus. Identification of the fungus is based on the gross and microscopic characteristics of the fungus culture. Characteristics of the culture are given in chart IV. A physiological characteristic

* The thiamin medium is described in Part I.

which is useful in the identification of this organism is the fact that all strains have a complete requirement for thiamin or a combination of thiamin and inositol. Nutritional tests for demonstrating this growth requirement have been described by Georg and Camp *(63)*.

Review of T. verrucosum infections in animals

Cattle

Ringworm in cattle appears to be common in the United States as well as in other parts of the world. The vast majority of these infections (98 to 100 percent in most areas) are due to *T. verrucosum*. Recent reports indicate that this disease of cattle is common in New York State *(78)*, Pennsylvania *(51)*, Iowa *(27)*, New Hampshire *(80)*, Michigan *(64)*, Canada *(13)*, England *(2,90,104,113)*, Europe *(70)*, and Australia *(97)*.

T. verrucosum is likewise a common cause of human ringworm in rural areas, and there is ample evidence that human infections are directly or indirectly contracted from cattle *(17,51,64,70,128)*. Aside from the public health importance of this disease, *T. verrucosum* infections in cattle have economic importance as disfiguring lesions impair the appearance of stock that is to be sold. There is evidence also that grossly infected calves do not gain weight as rapidly as noninfected stock.

Ringworm of cattle occurs largely in calves, although it is occasionally seen in adult animals. In the Communicable Disease Center survey, 61 specimens of cattle hair yielded dermatophytes. All isolates in this series (except one *T. mentagrophytes*) were *T. verrucosum*. The majority of the specimens were from young animals (under 2 years of age). These findings agree with those of McPherson *(104)* and indicate the high susceptibility of young stock. The spread of infection is often low with only one or two animals in a herd becoming infected. However, when animals are kept together in large groups or in close quarters, infection may spread rapidly and 50 to 60 percent of a herd become infected. Epizootics occur most commonly among very young calves. McPherson concludes from his studies that incidence of infection in a herd depends on the proportion of calves in the total stock.

In the study of rural ringworm in Michigan *(64)* a seasonal distribution was evidenced in human *T. verrucosum* infections. In this group, 83.9 percent of the cases occurred from November through April. This corresponded to the seasonal prevalence of ringworm in cattle in Michigan as reported for the year 1954 by the Michigan Veterinary Service *(112)*. According to this report, ringworm was diagnosed among 1,539 herds of cattle for the months of November through April. In contrast, during the summer and fall months, May through October, only 346 herds were reported as infected. Thus 81.6 percent of the herd infections occurred in the winter and early spring months. In surveying ringworm in cattle in northern Britain, McPherson (104) did not find any significant change in prevalence correlated to season, location of the herd, nutritional status, lighting of the cattle sheds, or the presence of lice on the cattle.

Since Walker *(148)* has shown that *T. discoides* (*T. verrucosum*)-infected hairs remain viable in storage under laboratory temperature for 15 months or longer, the importance of cleansing and destroying fungus spores on the floors, woodwork, stanchions, and scratching posts in the barn environment should be stressed. Although most cases of human infection can be traced to direct contact with a ringworm-infected calf, a significantly large number of infections apparently have been transmitted indirectly *(64,129)*. Transmission among a herd of cattle no doubt occurs this way also. Walker *(148)* demonstrated the presence of *T. discoides* (*T. verrucosum*)-infected hairs on a scratching post used by most of the cattle in a herd, and Blank *(13)* described the development of infection in a newly purchased cow which had been placed in a stanchion previously occupied by a ringworm-infected cow.

Ringworm lesions in cattle range from areas of slight scaling and loss of hair to clearly circumscribed plaques 1 to 4 inches in diameter covered with greyish white crusts which may become very thickened. The lesions are most numerous on the head around the eyes or muzzle and frequently on the neck, but other parts of the body may be affected. In young calves, where the infection may be extensive, large areas over the top of the head, back, and rump may be covered with heavy crusts. In an active lesion the crust is firmly attached, and when forcibly removed, moist, bleeding areas remain. Pus may be found under the crusts, and if pruritus is present, raw areas are seen. Around the edge of the lesions, and in the crust itself, stubs of broken-off infected hairs may be found. When a lesion begins to heal, the heavy crust is lost and dry scaly patches with hair loss are seen.

Other animals

In spite of the fact that one of the first isolations of the fungus later known as *T. verrucosum* was from an outbreak of ringworm involving 40 horses *(19)*, this fungus has rarely been reported as causing ringworm in horses. Other reports in the literature include isolation from a donkey (19), a dog (8), a goat (7), and sheep (30,57,74).

In the course of the Communicable Disease Center survey, *T. verrucosum* has been isolated from donkeys, a burro, and a horse. In their survey in Great Britain Ainsworth and Austwick *(2)* recorded one isolation from a horse. It is interesting that the horse had been pastured with cattle which were heavily infected with *T. verrucosum.*

TRICHOPHYTON EQUINUM INFECTIONS

Diagnosis

With the proper techniques, fungus-infected skin will reveal branched septate mycelium and arthrospores, as seen in all types of ringworm infections. Infected hairs, however, reveal a more specific picture. The interior of the hairs contains branched mycelium, but on the outside of the hair one finds chains of rather large spores, 3.5 to 8 microns in diameter, with an average size of 5.8 microns. This type of hair invasion is best described as "ectothrix with medium-sized spores in chains." The size of the spores is intermediate between those of *T. mentagrophytes* (3.0 to 5.0 microns) and the extremely large-spored *T. verrucosum* (8 to 10 microns). Sabouraud described the hair invasion of *T. equinum* as "ectothrix megaspore" in contrast to the "microide" type produced by *T. mentagrophytes.*

To complete the laboratory diagnosis, cultures must be made. *T. equinum* grows readily on Sabouraud's dextrose agar, with or without antibiotics, at room temperature. Characteristics of the culture are given in chart IV. A physiological characteristic which is useful in the identification of this fungus is the fact that *T. equinum* has a complete requirement for nicotinic acid. For a detailed description of this fungus see Georg *et al. (66).*

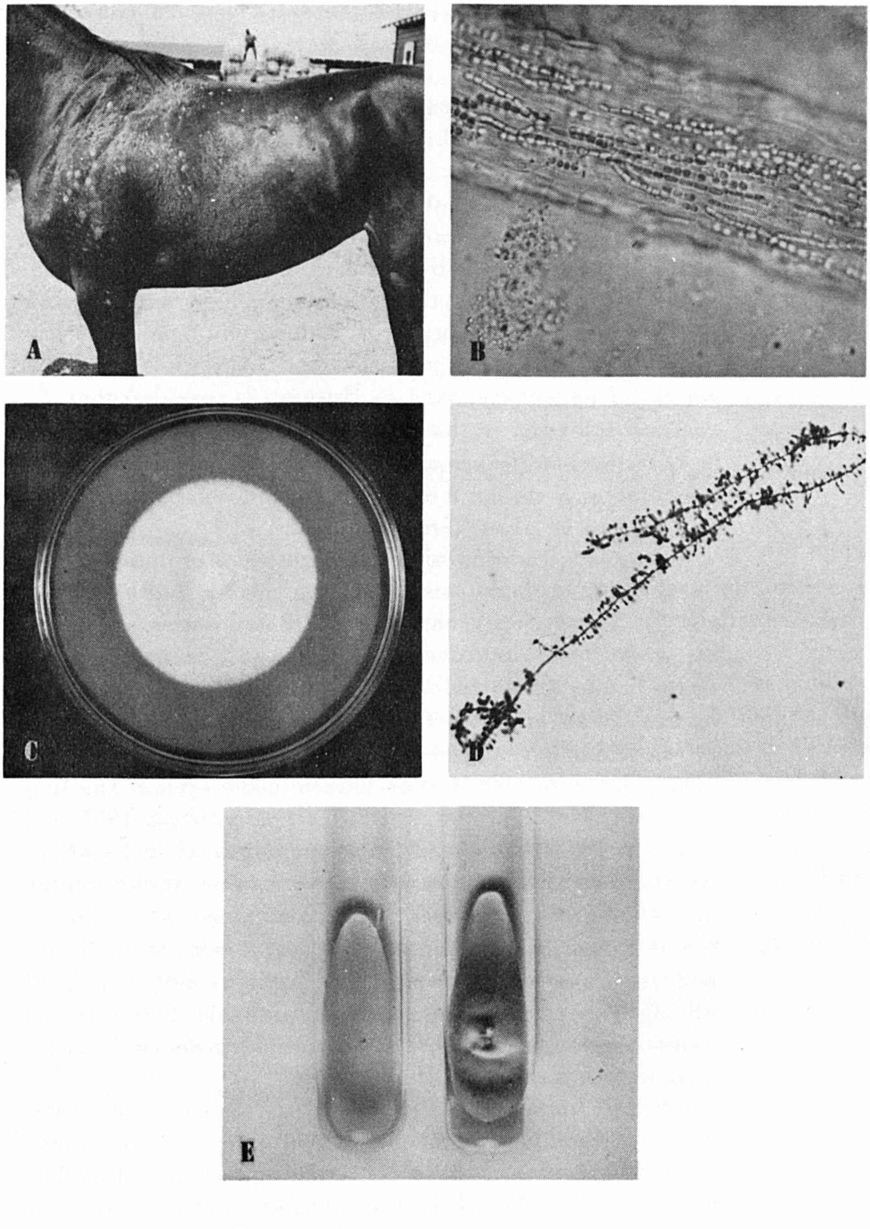

Plate VI.

A. Horse infected by *T. equinum*. B. Hair invaded by *T. equinum* shows chains of large spores on its surface. C. Colony of *T. equinum* on Sabouraud's dextrose agar. D. Microconidia of *T. equinum*. E. Nutrition tubes showing requirement for nicotinic acid. Left to right: casein, casein + nicotinic acid.

Review of T. equinum infections in animals

Horses

T. equinum appears to be the most common cause of equine ringworm in the United States, Europe, and South America. Of 26 equine infections recorded in a study by the Communicable Disease Center during 1957 *(64)*, 57.7 percent were due to this organism. The other 11 represented 4 other species.

The literature indicates that *T. equinum* has caused much ringworm in horses in the past. It was first described from France by Matruchot and Dassonville in 1898 *(101)*. Since that time there have been a number of well authenticated reports from Europe and South America *(22,94,96,116,132)*. Ainsworth and Austwick's recent survey of animal mycoses in Britain *(2)* revealed that *T. equinum* infection in the horse is common in that country. In describing a number of epizootics which spread rapidly from stable to stable, they found that the incubation period appeared to be about three weeks.

A number of strains of this fungus were isolated in the United States and Canada during our animal ringworm survey. The majority came from isolated cases of equine ringworm. Several strains, however, came from an epizootic described by Batte and Miller *(6)* which developed in race horses in several Atlantic Coast stables. These horses are continuously moved as the racing season progresses southward in the fall and northward in the spring. The fungus was first isolated from this epizootic in 1953 and again in 1955. Prolonged treatment appeared to be effective in controlling the spread of the disease in the treated animal; however, reinfection and new cases arose due to the introduction of infected animals into a stable. Colts and yearlings were the most susceptible, but animals of all ages became infected. It is probable that infected hairs which remained on brushes and combs and saddle gear were a source of infection.

Infected horses usually present a number of ringworm plaques. Isolated lesions are scattered over the hindquarters and shoulders, while others are grouped together in the saddle area where they tend to become confluent. Lesions first appear as swellings which can be felt through the hair, and in these areas the hairs become matted and "glued-together." Slight traction allows the removal of these hairs in a single block, the remainder being held at their base by a scaly crust. The lesions enlarge by loss of peripheral hairs. A review of equine ringworm by Georg *et al. (66)* describes *T. equinum* ringworm in the horse and compares it with other types of ringworm disease in this animal.

Human contagion has occurred in a number of epizootics of *T. equinum* ringworm, but the number of cases is apparently low *(22,96,101,133)*.

Other animals

We have observed a *T. equinum* infection in a dog *(66)*, a young Doberman Pinscher that showed generalized loss of hair and scaling. However, the infection disappeared spontaneously in 3 to 4 weeks. The dog was born and raised in a rural area where direct or indirect contact with horses could have occurred, and it appears most likely that the source of infection was infected horses.

TRICHOPHYTON GALLINAE INFECTIONS ("favus" of poultry)

Diagnosis

Material should be scraped from the edges of lesions or crusts on the combs, wattles, or any affected area of the skin. The feathers are not invaded by the fungus, but infected skin scales may be found at the base of the feathers. KOH preparations show many short, thick, branched, and twisted bits of mycelium and chains of spherical arthrospores.

To complete the laboratory diagnosis, cultures should be made. Growth appears after 7 to 14 days on Sabouraud's dextrose agar, with or without antibiotics, at room temperature. The culture is identified on the basis of its gross and microscopic characteristics. Chart IV lists the characteristics of this fungus species. For a detailed description of *T. gallinae*, see Georg *(59)*.

Review of T. gallinae infections in animals

Chickens

Ringworm or "favus" in chickens was first described by Megnin in 1881 *(106)* as a disease which produced a fine moldiness on the combs and cheeks of chickens. In the United States, where the disease is also known as "white comb," it was first described by Beach and Halpin in 1918 *(10)* after several outbreaks had occurred in Wisconsin over a period of several years. Riedel *(126)* also reported an outbreak of the disease in 1950, and Bullis *(25)* has described an outbreak that involved 125

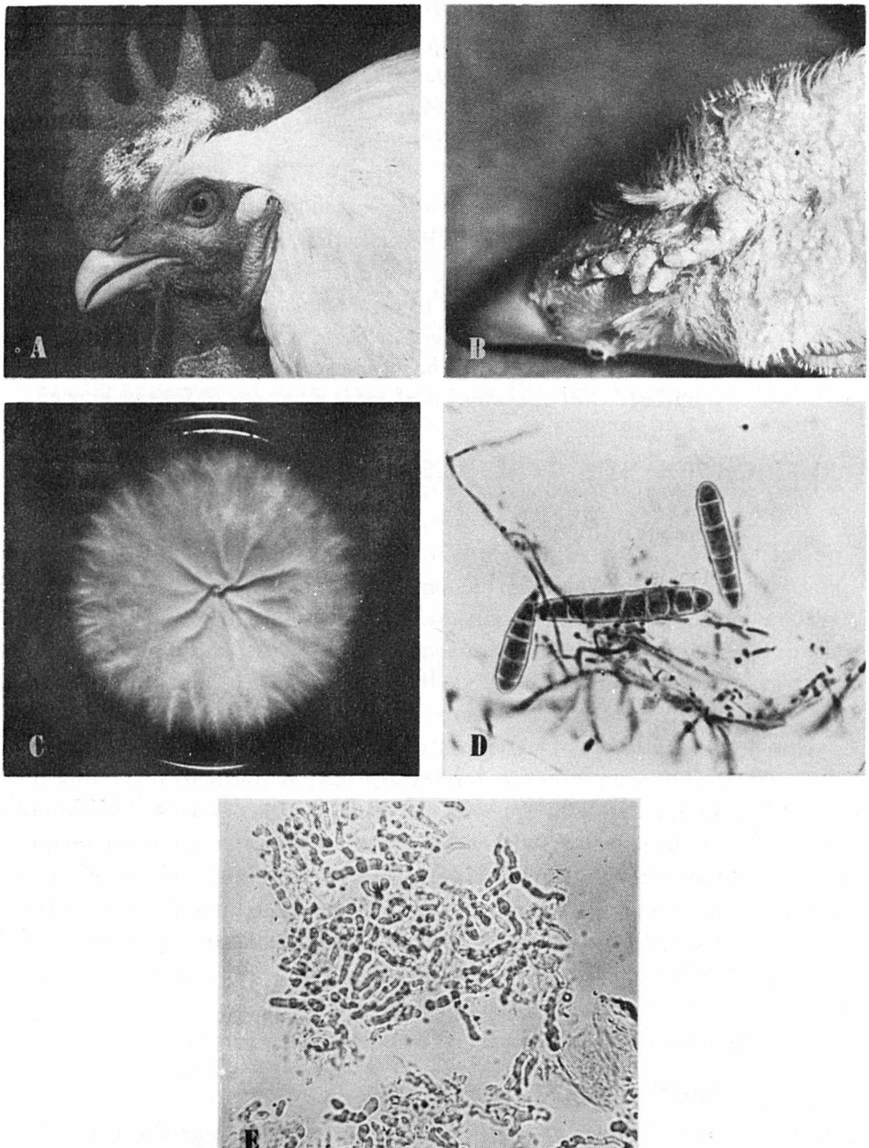

Plate VII.

A. *T. gallinae* infection on the comb and wattles of a rooster. B. Close-up of a hen showing infection of the skin due to *T. gallinae*. C. Colony of *T. gallinae* on Sabouraud's dextrose agar. D. Macroconidia of *T. gallinae*. E. Skin scraping from infected rooster showing mycelial elements.

of a group of 500 chickens. However, in none of these outbreaks in the United States was the causative fungus clearly described.

T. gallinae infections are apparently not uncommon in South America. Dr. A. Cury, of the Institute Oswaldo Cruz at Rio de Janeiro, has sent us two cultures isolated from infected cocks in Brazil. In the recent survey of ringworm in animals in Great Britain by Ainsworth and Austwick *(2)*, one case of *T. gallinae* infection in fowl was recorded. This outbreak has been described by Carnagan *et al. (26)*.

Recently the CDC laboratory studied a *T. gallinae* culture isolated from a scalp lesion on a four-year-old Puerto Rican girl. A field investigation was undertaken to determine the source of the child's infection. It was found that the family owned five apparently healthy chickens which were the favorite pets of the child. Upon close examination, however, minute dry scales were found on the comb of one of the chickens. *T. gallinae* was isolated from this chicken. The disease was then reproduced on chickens in this laboratory using the culture isolated from the child. This case has been reported by Torres and Georg *(134)*. This is the second authenticated case of *T. gallinae* in a human being. The first record of the isolation of *T. gallinae* from a human was by Sabouraud *(133)* in a footnote in "Les Teignes," 1910.

Other animals

T. gallinae infection of wild birds has been reported by Patiala *(120)* in Finland. These infections are a conspicuous disease in the black grouse (*Lyrurus tetrix*), which is a common game bird in that country.

Baudet *(9)* has reported an infection in a dog which had been confined for two months to a small enclosure where chickens had been kept.

RARE CAUSES OF RINGWORM IN ANIMALS

Microsporum audouinii

Diagnosis

The clinical picture of *M. audouinii* infections in animals appears to be similar to that seen in *M. canis* infections. *M. audouinii*-infected hairs fluoresce brightly under a Wood's lamp, and show the same characteristic sheath of small spores (2 to 3 microns) as do *M. canis*-

infected hairs. As a result, *M. audouinii* infections can be differentiated from *M. canis* infections only by cultural methods. The cultural characteristics of *M. audouinii* are listed in chart III.

Review of M. audouinii infections in animals

M. audouinii is considered to be a "human type" or anthropophilic fungus, and indeed its occurrence in animals is exceedingly rare. It is the most important agent of epidemic ringworm in schoolchildren in the United States, and in recent years thousands of cases have been reported from all sections of the country. Infections are transmitted both directly and indirectly from child to child, with no evidence that animals play any role in its transmission.

Experimental studies indicate that it is difficult to infect laboratory animals such as guinea pigs and rabbits with most strains of *M. audouinii*; nevertheless, there are 3 reports in the literature of spontaneous infections in dogs *(81,115,132)*, 1 in a monkey *(138)*, and 1 in a guinea pig *(147)*. A report of *M. audouinii* infection in rabbits has been made by Ravaioli and Tonolo from Italy *(123)*. However, it is clear from the description of the lesions in the rabbits, as well as the characteristics of the fungus isolated, that the authors were dealing with ringworm due to *Trichophyton mentagrophytes*.

These few cases do not indicate that animals constitute a reservoir for human infections. But the fact that lower animals can become infected by this dermatophyte would suggest that they may on rare occasions be a source of human infections. It is possible that extensive cultural studies of animal contacts of human cases might revise our present concepts of the part played by animals in the epidemiology of *M. audouinii* infections in man.

Dogs

The first report of *M. audouinii* infection in a dog was that of Sabouraud in 1908 (*132)*. A second case was reported by Murrell in 1951 *(115)*. In this latter case, the boy who owned the dog subsequently became infected, and the child presumably got the infection from the dog. The lesion on the dog was in the form of a circinate eczematous plaque on the lower jaw. Kaplan and Georg *(81)* described the third case of *M. audouinii* infection in a dog. This case occurred

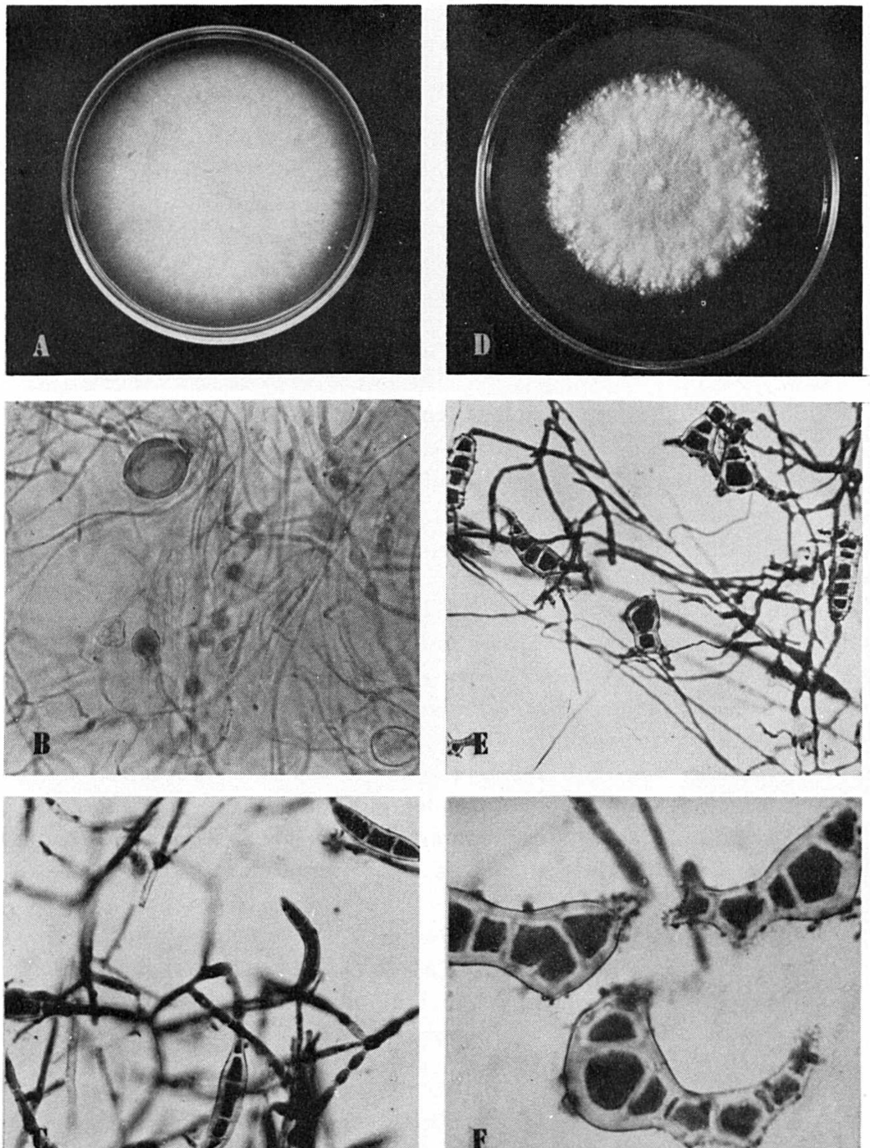

Plate VIII.

A. Colony of *M. audouinii* on Sabouraud's dextrose agar. B. Mycelium and chlamydospores of *M. audouinii*. C. Macroconidia of *M. audouinii*. These poorly developed spores are only very rarely observed. D. Colony of *M. distortum* on Sabouraud's dextrose agar. E. Macroconidia of *M. distortum*, 475X. F. Macroconidia of *M. distortum*, 1200X.

in a Boxer puppy with multiple circular, scaly, erythematous areas of alopecia up to 3 mm. in diameter on the abdomen, chest, and left front leg. It is interesting that in this case, 2 children in the household had been found to have tinea capitis with fluorescing hairs approximately 2 weeks before the puppy was acquired. Unfortunately, cultural studies had not been performed on the children. Here it would appear, if the children had *M. audouinii* ringworm, that the infection in the children may have been transmitted to the dog. Since this report, 2 further cases of *M. audouinii* infections in dogs (one in a Terrier and one in a Boxer) have been studied by this laboratory.

Microsporum distortum

M. distortum was first encountered in New Zealand by DiMenna and Marples in 1954 *(43)*. They described this fungus as a new species after isolating it from 12 human cases of ringworm. Clinically, the infections appeared to be similar to *M. audouinii* infections. These workers could not demonstrate any animal source of these infections.

In 1957, Kaplan *et al. (85)* described the isolation of *M. distortum* from 4 monkeys and 1 dog in the United States and described 6 possible human contact infections. *M. distortum* appears to have been introduced into the United States by monkeys imported from Central America. Clinically, the infections simulate those due to *M. canis* or *M. audouinii.* Infected hairs fluoresce under a Wood's lamp, and show a sheath of small arthrospores 2 to 3 microns in diameter. *M. distortum* infections can be differentiated only by cultural studies (see chart III).

The cultural characteristics of *M. distortum* may be found in the report by Kaplan *et al. (85)*. Since their report, this laboratory has studied one isolate from a human infection which was apparently contracted from an infected monkey *(23)*.

Trichophyton schoenleinii (clinical favus in animals)

The literature is very confusing concerning the etiology of favus in animals. This is undoubtedly due to the fact that many different species of dermatophytes can produce a disease clinically known as favus.

Favus of both man and animals is characterized by the development of yellowish to greyish-white cup-like crusts or scutulae which adhere to the skin in great masses. These crusts are made up of epithelial debris, mycelium, and

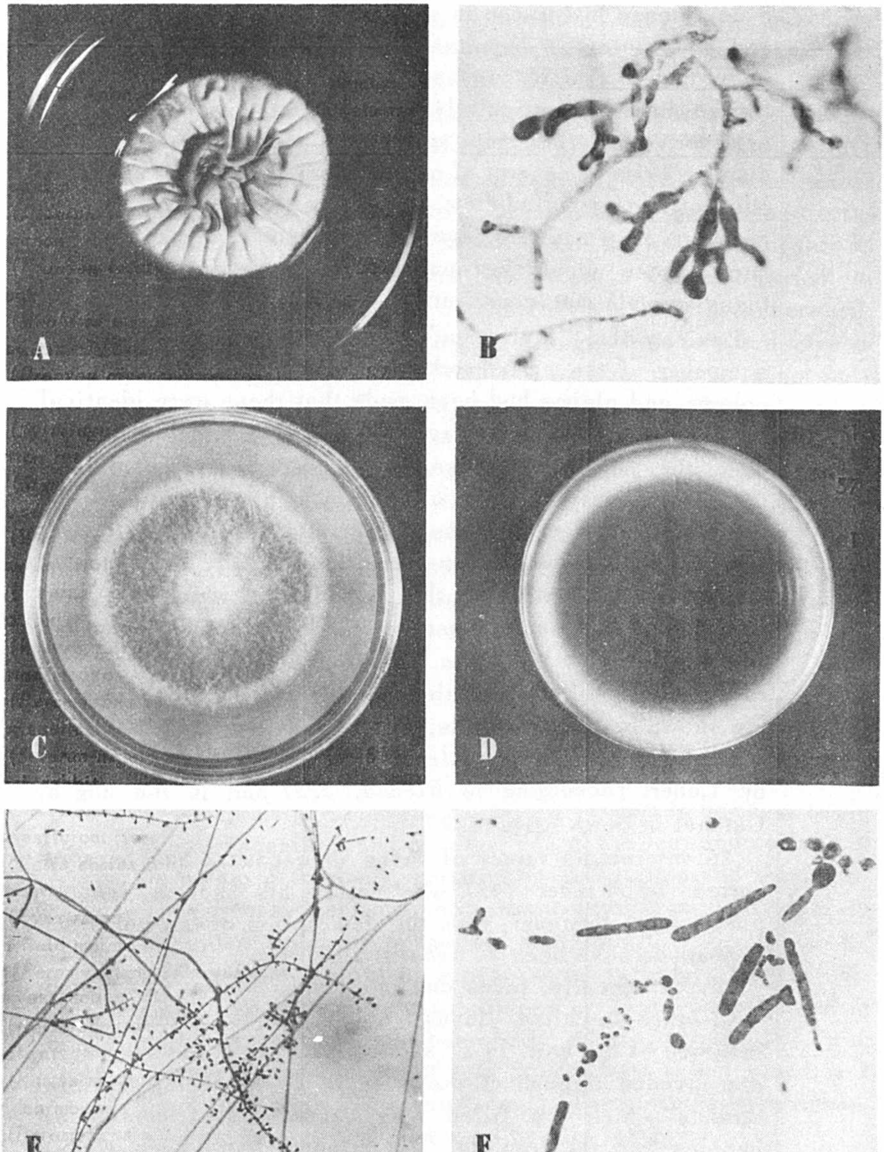

Plate IX.

A. Colony of *T. schoenleinii* on Sabouraud's dextrose agar. B. Irregular hyphae or "chandeliers" of *T. schoenleinii*. C. Colony of *T. rubrum* on Sabouraud's dextrose agar. D. Reverse of *T. rubrum* colony showing dark red pigmentation. E. Microconidia of *T. rubrum*. F. Characteristic pencil-shaped macroconidia of *T. rubrum*.

masses of irregularly shaped arthrospores often arranged in chains.

The classical favus of man is caused by *T. schoenleinii.* This disease is common in southern Europe and North Africa and constitutes an important public health problem. Human favus due to this fungus has been seen occasionally in the United States, particularly in our port cities. Recently, however, we are becoming aware that endemic areas for this disease exist in several of our southern States. The infection has not been reported from animals in this country, but this organism is a potential agent of disease in dogs, cats, and mice, hence should be sought for in endemic areas where these animals may constitute a reservoir.

Lesions of a "favic type" had been observed in mice by a number of the early workers in the field of medical mycology, and claims had been made that these were identical to the lesions of human favus due to *T. schoenleinii.* However, the majority of these reports were based on clinical impressions only. Of the few reports which were accompanied by descriptions of cultures, Sabouraud accepted only two, those of DuBois and of Unna and Franck *(120).* The report of DuBois is interesting in that a hedgehog which had been confined in the same house where the infected mouse had been caught also had favic lesions and *T. schoenleinii* was recovered from both animals. Photographs of these animals are shown in "Les Teignes," pages 546 and 547 *(120).*

Favus due to *T. schoenleinii* has been reported in the cat by Lebert *(according to Richou, 125)* and in the dog by Catanei in North Africa *(29).*

An interesting report of favus in a canary has been reported by Fisher *(49)* who named his isolate *Achorion passerinum.* However, from the description of the fungus, it appears to have been *T. schoenleinii.*

Microscopically, favus due to *T. schoenleinii* is different from other so-called "favus" disease in the manner of the invasion of the hair. In *T. schoenleinii* infections, the hairs are invaded throughout their length by branching mycelial strands which are filled with vacuoles that contain air bubbles and fat droplets. The infected hairs become dull, greyish, and brittle. They seldom break off but are depilated as a whole. Permanent alopecia may result from this disease. Final identification of the fungus agent is made by cultural studies. Characteristics of the fungus culture may be found in chart IV.

Clinical favus due to other fungi

Clinical favus, as evidenced by the development of heavy cup-like crusts or scutulae, may be produced by a number of dermatophyte species. The commonest cause is usually attributed to "*Trichophyton quinckeanum.*" Epizootics in mice due to this organism have been described by a number of authors *(15,24,38)*. Workers in this laboratory who have had an opportunity to study a number of cultures from "favus" in mice which have been designated as "*T. quinckeanum*" are of the opinion that this is not a distinct species but merely a colonial variant of *T. mentagrophytes* (*T. mentagrophytes* var. *quinckeanum*). However, after isolating this fungus from infected mice in Canada, Blank *(15)* is of the opinion that it is not only distinct from *T. mentagrophytes* but should be placed in the genus *Microsporum* as *M. quinckeanum.*

Other dermatophyte species which can produce clinical favus in animals and humans are: *M. gypseum, T. verrucosum, T. violaceum,* and *T. gallinae.*

Since all of the above fungi may at times produce a similar clinical picture, it is only by isolation and study of the etiologic agent that correct identification can be made.

Trichophyton rubrum

T. rubrum is a common cause of ringworm in humans, being most frequently found in infections of the feet and nails, and on areas of the body, particularly the axillae and the groin. The disease is apparently transmitted from individual to individual by direct or indirect contact.

T. rubrum infections appear to be extremely rare in animals. The first authenticated case of *T. rubrum* infection in animals was that of Chakraborty *et al. (33)* in 1954, who reported the isolation of this fungus from skin lesions in 1 dog and 2 cows in Calcutta, India. The cultures were subsequently studied and confirmed by this laboratory.

The second report was that of Kaplan and Gump, 1958 *(131)*. This was an infection in a one-year-old Boxer who exhibited a single, raised erythematous plaque which later developed a dry, scaly appearance with loss of hair. It is noteworthy that the owner of this dog had a mild case of tinea pedis for several years duration, and had the habit of rubbing the dog with his bare feet. Cultural studies of scrapings from this man's feet revealed that his infection was also due to *T. rubrum*. In this case there is good presumptive evidence that the infection was transmitted from the owner to the dog.

T. rubrum is essentially an anthropophilic fungus; however, as evidenced by these reports, it can produce infections in animals. A description of the fungus may be found in chart IV.

Trichophyton violaceum

The first reference to animal infection by *T. violaceum* was by Bloch in 1911 *(18)*. This author described a case of spontaneous favus in a mouse due to *Achorion violaceum* (*T. violaceum*). However, the description of the fungus isolated, as well as the ease with which experimental infections were produced in guinea pigs, leaves considerable doubt that the culture actually was *T. violaceum*.

In the recent literature, however, there are two well authenticated reports of *T. violaceum* infections in animals. These were spontaneous ringworm infections of cattle in Yugoslavia. Ozegovic and Grin *(118)*, in a study of 289 cases of cattle ringworm infections in Bosnia and Herzegovenia, found 93.3 percent due to *T. verrucosum* and 6.7 percent due to *T. mentagrophytes*. However, they found one case of ringworm in a calf to be due to *T. violaceum*. Similarly Hajsig *(75)*, also from Yugoslavia, found *T. verrucosum* to be the common cause of ringworm among 19 infected cattle studied. But among this group he found one calf which had a mixed infection due to *T. verrucosum* and *T. violaceum*.

T. violaceum is the most important cause of human ringworm in Yugoslavia as well as in many of the southern European and Mediterranian countries. It seems likely that here, where *T. violaceum* infections are extremely high in the human population, that animal infections due to this anthropophilic organism are most likely to occur. They are probably secondary to human infection.

T. violaceum may be isolated from clinical materials by methods described in Part I. A description of the fungus may be found in chart IV.

Keratinomyces ajelloi

K. ajelloi was isolated by Vanbreuseghem from Belgian soil in 1952 *(145)*. The fungus had been recovered by baiting moistened soil samples with filaments of human hair. At about the same time and by a similar technique, Ajello *(3)*

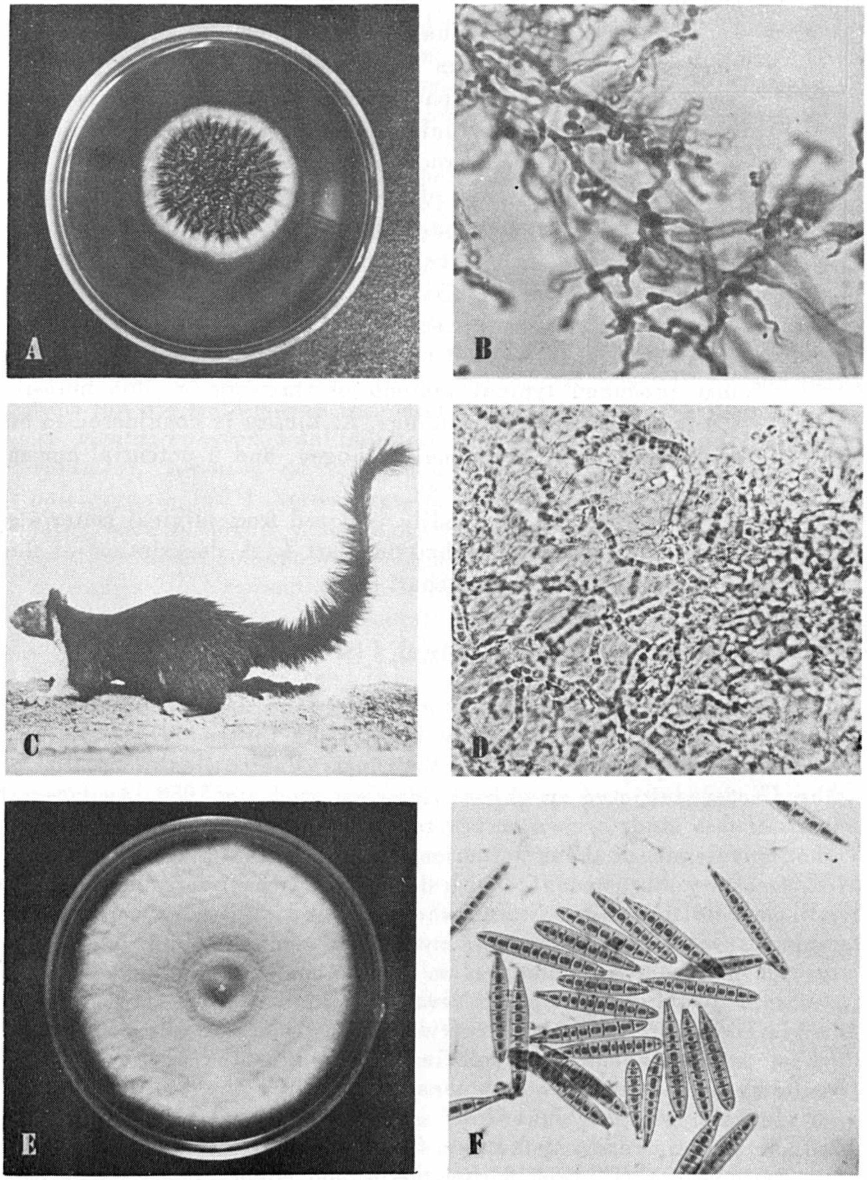

Plate X.

A. Colony of *T. violaceum* on Sabouraud's dextrose agar. B. Irregular mycelium of *T. violaceum*. C. Giant Malabar squirrel, the only animal species in which spontaneous *K. ajelloi* infection has been observed. (Courtesy of New York Zoological Gardens). D. Skin scraping from spontaneous *K. ajelloi* infection. E. Colony of *K. ajelloi* on Sabouraud's dextrose agar. F. Characteristic macroconidia of *K. ajelloi*.

isolated this same organism from Tennessee and Georgia soils. Since this time, *K. ajelloi* has been found to have wide distribution in the soil in many areas of the world *(40,53,100)*.

The morphological characteristics of the fungus growth and the fact that it was keratinophilic suggested that this organism might have pathogenic properties, but repeated attempts to produce infections in experimental animals resulted in failure. Proof of its pathogenicity, however, was provided by a case of spontaneous skin infection which occurred in a Malabar giant squirrel at the Chicago Zoological Park *(65)*. Communicable Disease Center studies of the skin scrapings from this animal revealed fungal elements, and *K. ajelloi* was repeatedly isolated. The strain isolated from the squirrel proved to be pathogenic to the guinea pig, and produced typical lesions of ringworm in this animal. On the basis of these findings, *K. ajelloi* is considered to be a dermatophyte, an animal pathogen, and a potential human pathogen.

K. ajelloi may be readily isolated from clinical materials by the methods described in Part I. A description of the fungus may be found in chart III.

SURVEY OF RINGWORM OF ANIMALS IN THE UNITED STATES

Recognizing the fact that animal ringworm is of definite public health importance, the Mycology Unit of the Communicable Disease Center, in cooperation with the Veterinary Public Health Section of the Center, initiated an animal ringworm study in 1953. An integral part of this study was a survey to determine the fungi involved and the prevalence of these infections in our lower-animal population. This survey was conducted with the cooperation of veterinarians from all parts of the United States who submitted clinical materials from animals with skin lesions for mycologic study. In addition, a companion survey was carried out on wild animals trapped in southwest Georgia by personnel of the Newton Field Station of the Communicable Disease Center. It is noteworthy that the wild animals did not show any cutaneous abnormalities at the time the specimens were collected. The findings from these studies for the 18-month period of January 1956 to June 1957 are presented in Tables I and II, adapted from a report by Kaplan, Georg, and Ajello.*

As noted in Table I, during the period covered, specimens from 2,361 domestic animals with skin lesions were examined. These materials were submitted by veterinarians from 35 States in all sec-

* Kaplan, W., Ajello, L., and Georg, L.: Recent developments in animal ringworm and their public health implications. Ann. N. Y. Acad. Sci. 70:636-649, 1958.

tions of the country. Pathogenic fungi were recovered from animals residing in 29 different States. From the total number of specimens studied, 642 (27.2 percent) were found to be positive by culture. Nine dermatophyte species and *Trichosporon cutaneum** were isolated and identified from the clinical materials submitted. These were: *Microsporum canis, M. gypseum, M. audouinii, M. distortum, Trichophyton mentagrophytes, T. equinum, T. verrucosum, T. rubrum, Keratinomyces ajelloi*, and *Trichosporon cutaneum*. As might be expected, the majority of these dermatophytes are specialized zoophilic parasites of lower animals. However, two of the species, *M. gypseum* and *K. ajelloi*, are soil organisms, and two others, *M. audouinii* and *T. rubrum*, are essentially human pathogens.

During the period covered by this report, hair specimens from 2,350 wild animals were cultured (Table II). Twenty-one different animal species, comprising rodents and larger mammals, are included in this series. From these animals, *M. gypseum* was recovered in 3 instances, once from a Norway rat (*Rattus norvegicus*), and twice from the old field mouse (*Peromyscus polionotus*). The dermatophyte *T. mentagrophytes* was isolated from 6 opossums (*Didelphis marsupialis*), 1 cotton rat (*Sigmodon hispidus*), 1 old field mouse (*P. polionotus*), and 1 Norway rat (*R. norvegicus*). In addition, 74 isolates were obtained of a fungus which at that time was referred to as the "red Microsporum." This organism was recovered from 11 opossums (*D. marsupialis*), 1 raccoon (*Procyon lotor*), 2 skunks (*Mephitis mephitis*), 1 cottontail rabbit (*Sylvilagus floridanus*) 57 cotton rats (*S. hispidis*), 1 house mouse (*Mus musculus*), and 1 Norway rat (*R. norvegicus).*The "red Microsporum" is now considered to be a new species and has been recently described by Ajello** as *Microsporum cookei*. Although this fungus is closely related to the dermatophyte species, all experimental attempts to demonstrate pathogenicity for man or animals have been unsuccessful. Thus the public health importance of this new fungus species remains to be determined.

It should be pointed out again that none of the wild animals studied exhibited any skin or hair abnormalities. Hair specimens had been collected simply from areas around the nose and around the base of the tail from each animal examined. Although *M. gypseum* and *T. mentagrophytes* are recognized as potential pathogenic fungi, in none of the animals from which they were recovered in this series was there any evidence of skin or hair invasion.

The survey of ringworm in animals conducted by the Communicable Disease Center, as well as similar programs which have been developed in Great Britain, indicate that ringworm in animals is a common dermatologic condition with definite public health implications.

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*Kaplan, W.: Piedra in lower animals. A case report of white piedra in a monkey and a review of the literature. J. Am. Vet. M. A. 134:113-117, 1959.

**Ajello, L.: : A new microsporum and its occurrence on soil and on animals. Mycologia, 51:69-76, 1959.

TABLE 1

DOMESTIC ANIMAL RINGWORM SURVEY, JANUARY 1956 TO JUNE 1957: DERMATOPHYTES ISOLATED BY HOST SPECIES

Host Animal Species	Number Speci-mens Exam-ined	Organisms Isolated										Total Posi-tive	Percent Positive
		Microsporum canis	*M. gypseum*	*M. audouinii*	*M. distortum*	*Trichophyton mentagrophytes*	*T. equinum*	*T. verrucosum*	*T. rubrum*	*Keratinomyces ajelloi*	*Trichosporon cutaneum* †		
Dog	1659	252	68	1	1	41			1	3*		368	22.1
Cat	524	193	4			3						200	38.1
Cattle	58							29				29	50.0
Horse	56	2	12				4					18	32.1
Monkey	21	10			4						1	15	71.4
Chinchilla	12	1				2						3	25.0
Guinea pig	9					6						6	66.0
Rabbit	8											0	0.0
Donkey	2						1	1				2	100.0
Sheep	5											0	0.0
Malabar squirrel	1									1		1	100.0
Chicken	1											0	0.0
Parakeet	4											0	0.0
Chimpanzee	1											0	0.0
Total	2361	358	84	1	5	52	5	30	1	1 + 3*	1	642	27.2

* *K. ajelloi* strains not shown to be pathogenic.

† *T. cutaneum*. (This organism is not an agent of ringworm, but causes a disease of the hair shafts known as white piedra. This disease has been described in lower animals by Kaplan.)

TABLE 2

WILD ANIMAL RINGWORM SURVEY, JANUARY 1956 TO JUNE 1957: FUNGI ISOLATED BY HOST SPECIES

Host Animal Species	Number Specimens Examined	Fungi Isolated		
		Microsporum gypseum	*Trichophyton mentagrophytes*	*Microsporum cookei*
Opossum (*Didelphis marsupialis*)	379		6	11
Raccoon (*Procyon lotor*)	552			1
Skunk (*Mephitis mephitis*)	246			2
Gray fox (*Urocyon cinereoargenteus*)	87			
Cottontail rabbit (*Sylvilagus floridanus*)	205			1
Cotton rat (*Sigmodon hispidus*)	336		1	57
House mouse (*Mus musculus*)	91			1
Gray squirrel (*Sciurus carolinensis*)	3			
Red fox (*Vulpes fulva*)	18			
Cotton mouse (*Peromyscus polionotus*)	18			
Fox squirrel (*Sciurus niger*)	51			
Marsh rabbit (*Sylvilagus palustris*)	4			
Domestic cat (feral) (*Felis domestica*)	26			
Bobcat (*Lynx rufus*)	61			
Old field mouse (*Peromyscus polionotus*)	61	2	1	
Harvest mouse (*Reithrodontomys* sp.)	4			
Roof rat (*Rattus rattus*)	76			
Golden mouse (*Peromyscus nuttalli*)	1			
Wood rat (*Neotoma floridana*)	1			
Otter (*Lustra canadensis*)	1			
Norway rat (*Rattus norvegicus*)	129	1	1	1
Total	2,350	3	9	74

APPENDIX

Formula of the selective isolation medium for pathogenic fungi

CYCLOHEXIMIDE-CHLORAMPHENICOL MEDIUM*

Composition:

Sabouraud's dextrose agar (2% agar content)	
Cycloheximide**	0.5 mg./ml.
Chloramphenicol***	0.05 mg./ml.

Preparation:

1 Liter

(1) Suspend 65 gm. dehydrated Sabouraud's dextrose agar (to which has been added 5.0 gms. agar) in 1000 ml. water. Heat to boiling.

(2) After removal from heat, add chloramphenicol (50 mg. suspended in 10 ml. 95 percent alcohol) to the medium.

(3) Add cycloheximide solution (500 mg. in 10 ml. acetone).

(4) Mix well and distribute into tubes.

(5) Autoclave at 118° C. for 10 min. Slant and allow to harden.

Note: For the isolation of *T. verrucosum* from animal hairs, it is an advantage to add thiamin (0.01 mg./liter) to the above medium. Both thiamin and the antibiotics, chloramphenicol and cycloheximide, are heat stable at an acid pH, and therefore may be autoclaved in the medium.

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*Two essentially similar media, in dehydrated form, are available commercially: Mycosel Agar (Baltimore Biological Co.) and Mycobiotic Agar (Difco Co.)

**Acti-dione, trade name for cycloheximide, is distributed by the Upjohn Co., Kalamazoo, Michigan.

***Chloromycetin, trade name for chloramphenicol, is distributed by Parke Davis and Co., Detroit, Michigan.

Trade names are used for identification purposes only, and their use does not constitute endorsement of these products by the Public Health Service.

CHART I

PRELIMINARY DIAGNOSIS OF RINGWORM IN ANIMALS FROM CLINICAL MATERIALS

Microsporum and Keratinomyces Infections

Animals Affected	Location and Appearance of Lesions	Wood's Light Examination	Direct Examination in KOH Mounts		Fungus Species
			Skin Scrapings	Hair	
COMMON: Cats Dogs **OCCASIONAL:** Horses Monkeys **RARE:** Chinchillas (2 cases reported)	Scattered lesions, but especially on head. Adult cats and dogs: infections may be clinically inapparent, or may be represented by loss of hair only. Young animals: lesions usually more clearly defined. Discrete circular areas of hair loss with scaling and occasionally vesicular borders are common. Heavy crusts may develop in these areas. Severe clinical cases may appear in both young and adult animals, with heavy crusted areas or widespread loss of hair, scaling and erythema. Horse: lesions particularly in harness areas ("girth itch")	Bright yellow-green fluorescence of infected hairs	Mycelium and chains of arthrospores	Sheath of small spores (2-3 μ) in mosaic, completely surrounds hair at base. Easily dislodged from hair in preparation. Mycelium within hair running parallel to its length	*Microsporum canis*
COMMON: Dogs **OCCASIONAL:** Cats Horses Wild rodents	Infection may be clinically inapparent. Often a single lesion on head or leg or scattered discrete lesions over body. Circular areas with loss of hair and some scaliness, or heavy yellowish-brown crusts which later fall off leaving a "moth-eaten" appearance to animal. Hairs loose at edges of crusts. Some hairs embedded in crusts	No fluorescence	Mycelium and masses of very large arthrospores, some in chains	Large spores (5-8 μ) in chains or in irregular masses on surface of hairs. Mycelium within hair, running parallel to its length	*Microsporum gypseum*

RARE: Dogs (3 cases reported) Monkey (1 case reported) Guinea pig (1 case reported)	Single or scattered lesions, circular with loss of hair, scaling, and some erythema. Eczematous lesions reported	Bright yellow-green fluorescence of infected hairs	Mycelium and chains of arthrospores	Sheath of small spores (2-3 μ) in mosaic, completely surrounds hair at base. Easily dislodged from hair in preparation. Mycelium within hair running parallel to its length	*Microsporum audouinii*
OCCASIONAL: Monkeys **RARE:** Dogs (1 case reported)	Single or scattered lesions, circular with loss of hair and scaling	Bright yellow-green fluorescence of infected hairs	Mycelium and chains of arthrospores	Same as above	*Microsporum distortum*
EXTREMELY RARE: Malabar giant squirrel (1 case reported)	Scattered lesions with hair loss and scaling	No fluorescence	Mycelium and chains of arthrospores	Mycelium within hairs. No distinct sheath of spores about hairs	*Keratinomyces ajelloi*

CHART II

PRELIMINARY DIAGNOSIS OF RINGWORM IN ANIMALS FROM CLINICAL MATERIALS

Trichophyton Infections

Animals Affected	Location and Appearance of Lesions	Wood's Light Examination	Direct Examination in KOH Mounts: Skin Scrapings	Direct Examination in KOH Mounts: Hair	Fungus Species
COMMON: Mice Rats Dogs Cats Rabbits Chinchillas Guinea pigs OCCASIONAL: Horses Cows Muskrats Opposums Squirrels Foxes RARE: Pigs	Most common on head near mouth and eyes, or at base of tail, but may be anywhere on body. Infection may be clinically inapparent. Usually find irregularly defined areas of the hair loss with considerable scaling. Heavy crusts may form. Occasionally pustules form at edges of lesion and suppuration beneath crusts. Horse: lesions particularly in harness areas ("girth itch"). Wild rodents: infections often clinically inapparent. In rodent epizootics, lesions may be heavy raised crusts of "favic type"	No fluorescence	Mycelium and chains of arthrospores	Sheath or isolated chains of spores (3-5 μ) on surface of hair. Mycelium within hair	*Trichophyton mentagrophytes*
COMMON: Cattle RARE: Horses Donkeys Burros Dogs Sheep	Usually on head or neck, but may be scattered on body, legs, or tail. In calves lesions may be very extensive. Coin-sized or larger distinct plaques with heavy greyish-white crusts. When crusts are removed, moist, bleeding areas are seen. Old lesions lose heavy crusts, show scaliness and broken-off hair stumps	No fluorescence	Mycelium and chains of arthrospores	Sheath or isolated chains of large spores (5-10 μ) on surface of hair	*Trichophyton verrucosum*

COMMON: Chickens Turkeys **RARE:** Wild birds Dog (1 case reported)	*White powdery scaliness which tends* to form concentric rings on comb and wattles. Later heavy white crusts form in these areas ("white comb" or "favus of chickens"). In rare cases infection may spread over body which shows scaliness of the skin. Does not involve the feathers	No fluorescence	Mycelium and chains of arthrospores	Feathers not affected	*Trichophyton gallinae*
COMMON: Horses **RARE:** Dog (1 case recorded)	Scattered lesions especially in saddle area ("girth itch"). Circular lesions with matting of hair followed by hair loss and development of crusts. As lesions heal crusts fall off leaving bald areas and giving the animal a "moth-eaten" appearance	No fluorescence	Mycelium and chains of arthrospores	Sheath or isolated chains of spores (3.5-8 μ) on surface of hair. Mycelium within hair	*Trichophyton equinum*
OCCASIONAL: Dogs Cats Mice Monkeys	Commonly on the head, and occasionally on the back. Heavy yellowish crusts frequently depressed at their centers to form "cups" or "scutulae." Crusts may be aglomerated to form large masses. These are tightly adherent to the skin which bleeds when they are removed	Not reported in animals. (In human infections, none or dull whitish fluorescence has been reported)	Masses of very irregular mycelium and arthrospores some in chains	Hair invasion not reported in animals. In human infections, hairs are invaded throughout their length by branching mycelium which contain vacuoles and fat droplets	*Trichophyton schoenleinii*
RARE: Dogs (2 cases reported) Cows (2 cases reported)	Single or scattered lesions showing loss of hair, scaling, and erythema	No fluorescence	Branching mycelium	Hair invasion rare. In experimental animal infections, chains of spores have been observed on outside of hair, and mycelium within hair	*Trichophyton rubrum*
RARE: Cows (2 cases reported)	Lesions similar to those caused by *T. verrucosum* in cattle	No fluorescence	Branching mycelium	Not reported in animals (endothrix in humans)	*Trichophyton violaceum*

CHART III

CULTURAL CHARACTERISTICS OF RINGWORM FUNGI ISOLATED FROM ANIMALS

Microsporum and Keratinomyces Species		
Fungus Species	**Colony – Sabouraud Dextrose Agar with or without Antibiotics**	**Microscopic Characteristics**
Microsporum canis (Syn: M. *lanosum*, M. *felineum*, M. *equinum*)	Growth rapid. Surface at first white, silky, with bright yellow pigment in peripheral growth. After 2-4 weeks, surface dense, tan, cottony, sometimes in irregular tufts or concentric rings, often with central knob of heavier growth. Reverse side of colony bright yellow, becomes dull orange-brown. Rare strains show no pigment on reverse. Grows well on rice grains	Macroconidia numerous, 8-15 celled, spindle-shaped, often terminating in a distinct knob, and with thick, verrucose walls. Microconidia few, clavate, usually sessile on the hyphae
Microsporum gypseum (Syn: M. *fulvum*, *Achorion gypseum*)	Growth rapid. Colony flat with irregularly fringed border and coarsely powdery surface ranging from light ochre to deep cinnamon brown. Tufts of white, fluffy, sterile (plemorphic) growth develop rapidly on surface of colony. Reverse side of colony, dull yellow to tan, rarely pinkish to red. Good growth on rice grains	Macroconidia numerous, 3-9 celled, ellipsoid, shorter and broader than those of *M. canis* and with thinner, rough walls. Microconidia rare, clavate, usually sessile on the hyphae

Microsporum audouinii	Colony slow growing, flat, velvety, with whitish-tan to brownish surface. Reverse side of colony, light salmon, orange-tan, or non-pigmented. Growth on rice grains very poor	Mycelium usually sterile with many chlamydospores. Microconidia usually rare, clavate, sessile on the hyphae. Macroconidia usually absent, but small numbers found in some strains. When present, are large, irregularly spindle shaped, thick walled with a smooth or rough surface. Abortive and bizarre shaped macroconidia are most commonly seen
Microsporum distortum	Growth rapid. Colony flat with a tendency to develop radial grooves. Surface velvety to fluffy, white to tan. Some strains have little aerial mycelium, and appear waxy. Reverse side of colony colorless to dull yellowish-tan. Good growth on rice grains	Macroconidia numerous. They are thick walled with a rough surface, and markedly distorted in shape. Microconidia pear-shaped, sessile on the hyphae
Keratinomyces ajelloi	Growth rapid. Colony flat or somewhat heaped and folded. Surface finely powdery or downy, cream to tan or orange-tan in color. Areas of white fluffy (pleomorphic) growth develop rapidly. Reverse side of colony is colorless or a deep bluish-black	Macroconidia numerous. They are long and slender with paralled walls tapering at each end (cylindrofusiform) and composed of 8-12 cells. The walls of macroconidia are wide (thicker than those of *M. canis*) and have a smooth surface. Microconidia abundant in some strains, rare in others, ovate to pyriform sessile on the hyphae

CHART IV

CULTURAL CHARACTERISTICS OF RINGWORM FUNGI ISOLATED FROM ANIMALS

Trichophyton Species		
Fungus Species	**Colony – Sabouraud Dextrose Agar with or without Antibiotics**	**Microscopic Characteristics**
Trichophyton mentagrophytes (Syn: *T. gypseum*, *T. granulosum*, *T. quinckeanum*	Growth rapid. Colony flat, or heaped and irregularly folded. Surface coarsely granular to powdery to downy, or cottony, white to cream, occasionally yellow or pink. Reverse side of colony, rose-brown, occasionally yellowish, orange, or deep red	Microconidia very numerous, small globose to slender and elongate borne singly along hyphae or in pine-tree-like terminal clusters. Macroconidia rare or abundant in some strains, 2-5 celled, thin-walled, slightly club-shaped, spindle-shaped, or long and nearly pencil-shaped. Tightly wound spirals, nodular bodies may be numerous
Trichophyton verrucosum (Syn: *T. faviforme*, *T. album*, *T. discoides*, *T. ochraceum*)	Growth very slow, may not appear until 10 to 14 days incubation. Colony usually small, heaped and folded, occasionally flat and disc shaped. Colonies at first glabrous and waxy, sometimes developing white or yellow powdery or downy surface growth. No growth on vitamin-free media. Most strains require thiamin and inositol, some require thiamin only. Growth more rapid at 37° C.	On Sabouraud's dextrose agar, usually only a thin irregular mycelium with chlamydospores. If grown at 37° C., chlamydospores very numerous and form heavy chains. On thiamin enriched media, mycelium is more regular and microconidia may be numerous. They are small and delicate borne singly along hyphae. Macroconidia extremely rare, 3-5 celled, thin, smooth walls, vary considerably in size and shape

Trichophyton equinum	*Growth rapid. Colony flat, but develops folds* with age. Surface at first white and fluffy with bright yellow pigment in peripheral growth. Later surface becomes flatter and velvety and cream to tan. Reverse side of colony at first bright yellow, later pink to deep red-brown. No growth on vitamin-free media. **All strains require nicotinic acid**	Microconidia few to many, generally thin and elongate. Macroconidia very rare with thin, smooth walls
Trichophyton schoenleinii (Syn: ***Achorion schoenleinii***)	Growth slow, usually irregularly heaped and folded, tough and leathery, tending to crack the agar. Surface white to tan, glabrous and waxy or white with powdery or downy surface growth. Occasional strains grow largely submerged in the agar. All strains will grow in a vitamin-free medium. Grows as well at room temperature as at 37° C.	Mycelium highly irregular. Coarser hyphae tend to become knobby and clubbed at ends (chandeliers). Chlamydospores usually numerous. Microconidia very rare. Macroconidia absent
Trichophyton rubrum (Syn: ***T. purpureum***)	Growth slow. Colony flat or heaped, with a white fluffy surface. Occasional strains with a powdery or velvety surface which becomes highly folded. Such strains are at first white to cream in color, but later become a deep rose. Reverse side of most isolates show a red to deep purplish-red pigmentation. This disappears in subcultures. Rare strains lack this deep red pigment on first isolation, may be yellowish-orange on reverse	Microconidia rare in most fluffy strains, thin and delicate and occurring only along sides of hyphae. Microconidia common in velvety or granular strains, more globose and occurring along the mycelium and in pine-tree-like clusters. Macroconidia rare in most strains, but most common in granular cultures, usually elongate and thin with parallel sides and blunt ends, 3 - 8 cells
Trichophyton violaceum	Growth very slow. Colony heaped and verrucose. Surface glabrous, at first cream then lavender becoming deep purple. Old cultures may develop downy surface growth, may lose purple pigment.	Mycelium thin, irregular with chlamydospores. Microconidia usually not found

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