OBSERVATIONS ON RURAL AND URBAN RINGWORM*

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The purpose of this report is to compare and contrast the salient features of urban and rural ringworm as seen in a study area of northeastern Michigan, and to discuss in detail evidence for the animal origin of human ringworm infections.

The patients included were observed by one of the authors (E. A. H.) during a five-year period (1949–1954) in his dermatological practice, and specimen materials were sent to the Communicable Disease Center for examination and culture.

The study area was comprised of several medium-sized industrial cities (Saginaw, Midland, Bay City, and Mount Pleasant), a number of small towns, and many farms distributed throughout 13 Michigan counties. The several types of fungus infections were studied with reference to the place of residence of the patient, his occupation, the type of lesion presented, and human or animal contacts or factors in the home environment that may have been important in transmission of the disease.

MATERIALS AND METHODS

Case histories and descriptions of clinical symptoms were obtained, and specimens of hair, and/or skin scrapings were collected. When possible, patients were asked to bring clinical materials from animals that they had contacted and that they suspected as being the source of their infections.

All clinical materials were mailed to the CDC, where direct examinations in KOH preparations were made and culture media were inoculated. Only cases verified by the isolation of dermatophytes were included in this study.

Towards the end of the survey Mr. Gerald Mitchell, a student from the Michigan State University School of Veterinary Medicine, was assigned to the area by the Communicable Disease Center to investigate the home premises of as many of the patients as possible. Animals were examined for the presence of skin lesions, and when such were found, specimens of hair and of skin scrapings were collected for culture studies. Soil samples were collected also. These were cultured by baiting moistened samples with sterilized human hair, as described by Ajello (1).

FUNGUS SPECIES ISOLATED

In the series of 173 cases studied, the etiologic agents involved were distributed among the three dermatophyte genera as follows: Trichophyton, 97 cases (56.0%); Microsporum, 71 cases (41.1%); and Epidermophyton, 5 cases (2.9%). The

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Table 1

Age and sex distribution of ringworm infected patients

<table>
<thead>
<tr>
<th>Type of Infection</th>
<th>Etiologic Agent</th>
<th>No. of Cases (Total—173)</th>
<th>Percent of Total</th>
<th>Age Groups 1-13 Years (Total—121)</th>
<th>14-20 Years (Total—9)</th>
<th>20 Years or Older (Total—43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Ringworm</td>
<td>T. mentagrophytes (granular variety)</td>
<td>32</td>
<td>19.0</td>
<td>5 Female</td>
<td>11 Male</td>
<td>3 Female</td>
</tr>
<tr>
<td></td>
<td>T. verrucosum</td>
<td>31</td>
<td>17.4</td>
<td>14 Female</td>
<td>10 Male</td>
<td>0 Female</td>
</tr>
<tr>
<td>Urban Ringworm</td>
<td>M. audouinii</td>
<td>55</td>
<td>31.8</td>
<td>8 Female</td>
<td>43 Male</td>
<td>0 Female</td>
</tr>
<tr>
<td></td>
<td>T. tonsurans</td>
<td>18</td>
<td>10.4</td>
<td>7 Female</td>
<td>7 Male</td>
<td>0 Female</td>
</tr>
<tr>
<td></td>
<td>T. mentagrophytes (downy variety)</td>
<td>8</td>
<td>4.6</td>
<td>0 Female</td>
<td>0 Male</td>
<td>1 Female</td>
</tr>
<tr>
<td></td>
<td>T. rubrum</td>
<td>8</td>
<td>4.6</td>
<td>0 Female</td>
<td>0 Male</td>
<td>0 Female</td>
</tr>
<tr>
<td></td>
<td>E. floccosum</td>
<td>5</td>
<td>2.9</td>
<td>0 Female</td>
<td>1* Male</td>
<td>1* Female</td>
</tr>
<tr>
<td></td>
<td>M. canis</td>
<td>14</td>
<td>8.1</td>
<td>6 Female</td>
<td>7 Male</td>
<td>0 Female</td>
</tr>
<tr>
<td></td>
<td>M. gypseum</td>
<td>2</td>
<td>1.2</td>
<td>1 Female</td>
<td>1 Male</td>
<td>0 Female</td>
</tr>
</tbody>
</table>

* Lesions on skin or nails only.

Fairly equal distribution of infections due to trichophytons and microsporums reflected the fact that almost equal numbers of urban and rural patients were studied and the fact that Epidermophyton infections are rare in both areas. Data on relative frequency of the fungus species isolated are included in Table I.

For purposes of discussion, the various types of dermatophyte infections have been grouped under the headings “Rural Ringworm” and “Urban Ringworm.” These are defined as follows:

I. Rural ringworm: Infections caused by T. verrucosum and T. mentagrophytes (granular variety). These organisms appear to be associated consistently with rural infections, and, as will be pointed out in the discussions which follow, there is considerable evidence that they are contracted from animals or from habitats where both domestic and wild animals live.

II. Urban ringworm: Infections due to M. audouinii, M. canis, T. tonsurans, T. mentagrophytes (downy variety), T. rubrum, and E. floccosum. These organisms are associated largely with urban infections, and with the exception of M. canis are not of animal origin.

M. gypseum infections appear to be equally common in both rural and urban environments. This equality of prevalence probably results from the basically saprophytic nature of the organism. Recent studies by Ajello (1) have shown that this organism exists as a very common saprophyte in soil, and it is probable that both humans and animals frequently become infected from the same source in both urban and rural environments. Human cases of M. gypseum infections are quite rare in this country and elsewhere (1, 2, 3). The two M. gypseum cases seen in this series occurred in city dwellers.
RESULTS

Rural ringworm and urban ringworm will be discussed separately with regards to: 1. Age and sex distribution, 2. Site of lesions and tissue reactions, 3. Contacts and environment, and 4. Seasonal distribution. This will be followed by a general discussion of each of these two types of ringworm. The data is summarized in 5 tables.

I. Rural ringworm

A. Age and sex distribution. Of the 63 infections due to T. verrucosum and T. mentagrophytes (granular variety), 40 (63.5%) were found in children under 14 years of age. Twenty-three cases (36.5%), however, occurred in adolescents and adults. Studies of a number of small family epidemics gave clear evidence that although the adolescent or adult farm worker was frequently the first to acquire an infection, it was transmitted readily to young children. More frequently, infections occurred only in young children, with occasional transmission to one or both of the parents, usually the mother who treated the children’s lesions. In one family, 4 children, all under 8 years of age, had developed T. verrucosum infections but none of the adults in the family were infected.

No significant difference in sex distribution was observed among persons infected with T. mentagrophytes and T. verrucosum.

B. Location of lesions and tissue reactions. In the 63 cases of rural ringworm caused by T. mentagrophytes and T. verrucosum, lesions always occurred on exposed areas of the body, with approximately equal distribution on the scalp, face, and neck. In 26.9 per cent of the cases, secondary lesions occurred on covered areas of the body. In no case, however, were lesions found only on clothed parts of

<table>
<thead>
<tr>
<th>Location of ringworm lesions</th>
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<tbody>
<tr>
<td><strong>Type of Infection</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rural Ringworm</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Urban Ringworm</td>
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</tbody>
</table>
the body. In general, children exhibited scalp lesions primarily and body lesions secondarily. Adult males most frequently had lesions on the bearded areas of the face and neck and occasionally on the wrists. In women, lesions were usually on the smooth skin of exposed areas of the body.

The tissue reactions in rural ringworm generally were of the suppurative type, particularly when the lesions occurred in hairy areas of the body such as the

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**Plate I. Examples of Rural Ringworm**

a. Kerionic lesion on farm child’s scalp due to *T. verrucosum*.

b. Kerionic lesions on face of a farmer due to *T. verrucosum*.

c. Suppurative lesion on scalp of a young child due to *T. mentagrophytes* (variety granular).

d. Kerionic lesion on upper lip of a farmer due to *T. mentagrophytes* (variety granular).

e. Circinate lesions on the glabrous skin on neck and chest of farm worker, due to *T. verrucosum*.

f. Suppurative lesions on the beared area of the face due to *T. mentagrophytes* (variety granular).
A rural and urban ringworm.

In this series, 53.9 per cent of the patients developed kerions (well-defined, raised, boggy lesions suppurating at many points); 14.3 per cent showed suppuration associated with the hair follicles, but did not develop kerions. The remainder of the infections in the rural ringworm group, 31.8 per cent, developed only irregular, erythematous scaling areas. In those cases where infections occurred only on the glabrous skin, approximately half of the lesions observed were circinate, with raised, erythematous, often vesicular borders.

Generalized reactions occurred rather frequently in all of these patients. In 19.0 per cent, a history of fever, localized pain, or swollen and painful regional lymph glands was elicited. Allergic manifestations in the form of “ids” were seen in 11 per cent.

<table>
<thead>
<tr>
<th>Type of Infection</th>
<th>Etiologic Agent</th>
<th>No. of Cases (Total: 123)</th>
<th>Local Tissue Reactions</th>
<th>Generalized Reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Ringworm</td>
<td>T. mentagrophytes (granular variety)</td>
<td>32</td>
<td>Kerion</td>
<td>Suppurative</td>
</tr>
<tr>
<td></td>
<td>T. verrucosum</td>
<td>31</td>
<td>Kerion</td>
<td>18</td>
</tr>
<tr>
<td>Urban Ringworm</td>
<td>M. audouinii</td>
<td>55</td>
<td>Kerion</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>T. tonsurans</td>
<td>18</td>
<td>Kerion</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>T. mentagrophytes (downy variety)</td>
<td>8</td>
<td>Kerion</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>T. rubrum</td>
<td>8</td>
<td>Kerion</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>E. floccosum</td>
<td>5</td>
<td>Kerion</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M. canis</td>
<td>14</td>
<td>Kerion</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>M. gypseum</td>
<td>2</td>
<td>Kerion</td>
<td>2</td>
</tr>
</tbody>
</table>

* 1 case appeared as a typical lupus erythematosus.

scalp, or the beard of adult males. In this series, 53.9 per cent of the patients developed kerions (well-defined, raised, boggy lesions suppurating at many points); 14.3 per cent showed suppuration associated with the hair follicles, but did not develop kerions. The remainder of the infections in the rural ringworm group, 31.8 per cent, developed only irregular, erythematous scaling areas. In those cases where infections occurred only on the glabrous skin, approximately half of the lesions observed were circinate, with raised, erythematous, often vesicular borders.

Generalized reactions occurred rather frequently in all of these patients. In 19.0 per cent, a history of fever, localized pain, or swollen and painful regional lymph glands was elicited. Allergic manifestations in the form of “ids” were seen in 11 per cent.

C. Contacts and environment. Of 63 patients with ringworm due to T. verrucosum and the granular form of T. mentagrophytes, 69.9 per cent lived on farms, 22.2 per cent resided in small towns (largely farming communities), and only 5 (7.9%) were city dwellers.

Since the highest percentage of these patients came from farms or farming communities, many (74.4%) gave a history of contact with cattle and other farm animals. In 21 of the T. verrucosum cases and in 2 of the T. mentagrophytes cases, a definite history of contact with ringworm infected cattle was obtained. In a
number of instances the presence of ringworm among the patient's cattle had been confirmed clinically by veterinarians, and in 8 cases *T. verrucosum* was isolated from cattle suspected as the source of the patient's infection.

Among this group, about half of the patients gave a history of contact with pets such as dogs, cats, or rabbits. In 2 of the *T. mentagrophytes* cases, a definite history of contact with ringworm-infected dogs was elicited, but in neither case was it possible to obtain materials from these animals for confirmation by culture.

D. Seasonal distribution. Evidence for the seasonal distribution of infections was noted only in the *T. verrucosum* cases. In this group, 83.9 per cent of the cases occurred during late fall, winter, and early spring months (November through April). This corresponded rather closely to the seasonal incidence of ringworm in cattle in Michigan as reported for the year 1954 by the Michigan Veterinary Reporting Service (4). According to this report, ringworm was diagnosed among 1539 herds of cattle for the months of November, December, January, February, March and April. In contrast, during the summer and fall months of May, June, July, August, September and October, only 346 herds were reported as infected. Thus, 81.6 per cent of the herd infections occurred during the late fall, winter, and early spring, while only 18.4 per cent occurred in the summer and early fall months.

II. Urban Ringworm

A. Age and sex distribution. For the past 10 to 15 years, *M. audouinii* ringworm has been epidemic in Michigan, where large numbers of cases have been seen in most cities. In that area, as elsewhere in the United States, infections were largely confined to children of prepubertal age.
In our study, all but 4 of the 55 cases of *M. audouinii* infection were in children under age 12. Two of the 4 exceptions were boys 13 and 14 years old, the other 2 were women aged 30 and 46. There were four times as many cases in boys as in girls.

During the period of study another type of epidemic ringworm, that due to *T. tonsurans*, appeared in several urban areas in northeastern Michigan. Infections due to this fungus were encountered on 18 occasions, 10 times in males and 8 in females. One patient was a child of Mexican origin whose family had only recently moved to Michigan from Texas.

Of the 18 *T. tonsurans* infections, 15 were in children ranging in age from 18 months to 14 years; 3 infections were seen in adults.

With regard to the other types of urban infections, the number of cases was so few that no significant deductions could be made regarding age and sex distribution. It is interesting, however, that these infections, with the exception of those due to *M. canis*, were largely in adults. The *M. canis* infections observed were largely in children, and were equally distributed between girls and boys.

It should be emphasized that this survey does not indicate the prevalence of cases of tinea pedis or tinea unguium in the communities investigated. The majority of such infections are self-treated and so mild and chronic in nature that only occasionally are they brought to the attention of dermatologists.

B. Location of lesions and tissue reactions. In the urban ringworm infections, generalizations concerning locations of lesions and types of tissue reactions cannot be made. The two epidemic types were similar, however, in these respects: scalp lesions were present in 92.7 per cent of the *M. audouinii* cases and in 77.7 per cent of the *T. tonsurans* cases. Only in a few instances lesions were observed on covered areas of the body, but again, as in rural ringworm cases, these always developed secondarily to lesions on exposed areas of the body.

The low degree of tissue reaction that developed in the urban ringworm was in decided contrast to that seen in the rural ringworm. In urban epidemic types of ringworm, very little tissue response was evident. Only 4 of 55 *M. audouinii* cases, or 7.2 per cent, developed a suppurative reaction while 78.2 per cent merely showed scaling of the skin. In 7.2 per cent loss of hair was the only change observed. Of the *T. tonsurans* cases, 22.2 per cent developed suppuration, and 77.8 per cent had superficial types of skin reaction. In 3 cases loss of hair was the only reaction observed. It is interesting to note that the infection of one of these patients rather closely resembled lupus erythematosus. It has been reported previously that *T. tonsurans* infections frequently resemble other dermatological conditions such as seborrhea or simple dandruff (5, 6), lupus erythematosus (5, 7), folliculitis, alopecia areata (5), erythema streptogenes, and impetigo circinata (8).

Generalized reactions were rare in this group. Only two persons with *M. audouinii* infection showed allergic skin reactions.

With regard to the other types of urban ringworm—those due to *T. rubrum*, *T. mentagrophytes* (downy variety), and *E. floccosum*—it is significant that all lesions occurred on covered areas of the body, and that all patients developed only superficial tissue reactions. In one case an "id" reaction developed.
PLATE II. EXAMPLES OF URBAN RINGWORM DUE TO T. tonsurans

a. Superficial lesion on scalp of young boy. Shows only irregular hair loss.

b. Circinate lesion on arm of young girl. Erythema and vesiculation present.

c. Small lesion on scalp shows only loss of hair.

d. Scattered scalp lesions showing loss of hair and beginning of suppuration.

e. Chronic lesion showing scattered loss of hair and remaining stubs of broken-off infected hairs.

f. Small kerionic lesion on scalp of young adult.

The majority (78.6 per cent) of the 14 M. canis patients presented lesions on the scalp, and in no case were primary lesions seen on covered areas of the body. About half of these individuals showed suppurative reactions, and in two, generalized reactions occurred.

C. Contacts and environment. Of the infections grouped together as “urban
RURAL AND URBAN RINGWORM

60.2 per cent of the patients lived in cities, 29.6 per cent lived in small towns, and only 10.2 per cent lived on farms. In this group, 9.2 per cent gave a history of contact with cattle, but in no case was there evidence that these animals had ringworm lesions. On the other hand, in the two epidemic types of ringworm, there was considerable evidence of contacts with ringworm-infected children. Of the 55 M. audouinii cases, 54 gave a history of contacts with other infected persons, generally children, and in 50 per cent of these, studies by culture had shown these contacts to have had a similar infection. In the T. tonsurans series, 61 per cent gave a history of contact with individuals with ringworm lesions, and in 4 cases T. tonsurans was obtained from these contacts.

Little significant information on the source of infection could be obtained among the group of T. rubrum, T. mentagrophytes (downy variety), and E. floccosum infections, except that in the case of one of the E. floccosum infections of the groin, the patient's husband was known to have had a similar infection.

In the group of M. canis cases, a large number (85.7%) gave a history of contacts with cats and dogs. Family group infections were common in the M. canis series.

D. Seasonal distribution. There was no evidence for seasonal distribution among the urban ringworm group of infections.

DISCUSSION

I. Rural Ringworm

A. Dermatophyte species involved

Rural ringworm is largely caused by certain species or varieties of the genus Trichophyton. In this series, about equal numbers of cases were due to T. verrucosum and to the granular variety of T. mentagrophytes.

T. verrucosum has been recognized as an important cause of rural ringworm in the United States only during the past few years. Although Davidson, Gregory, and Birt (9) had reported 28 cases from Canada in 1934, only one case, that of Gammel and Work in 1938 (10) had been recognized in the United States previous to 1947. In that year, Fowle and Georg (11) isolated 14 strains of T. verrucosum from a group of suppurative ringworm infections among farmers in central Pennsylvania, and presented evidence that these infections had been acquired from ringworm-infected cattle.

Ringworm of cattle has been recognized as a common disease in the United States for many years. It seems unusual that T. verrucosum, which we now know to be the common cause of this disease, had not been isolated more frequently in this country prior to 1947, and it is strange that the role of cattle ringworm as the source of ringworm in farmers and their families had not been appreciated. However, the fact that T. verrucosum grows with extreme slowness on Sabouraud dextrose agar, the medium routinely used for the isolation of dermatophytes, undoubtedly accounts for its infrequent isolation from both humans and cattle. Nutritional studies by several workers (12, 13, 14) have, however, revealed the reason this fungus grows poorly on routine media. T. verrucosum has absolute nutritional requirements for certain vitamins. About 90 per cent of the strains...
studied require thiamine and inositol for growth, about 10 per cent require only thiamine, and one strain has been found which requires thiamine, inositol, and pyridoxine. These vitamins are present only in trace amounts in the routinely used Sabouraud dextrose agar and therefore the growth of the fungus is greatly limited on such a medium. In addition, it has been shown that the optimum temperature for the development of this fungus is about 37°C, in contrast to that for other dermatophyte species, which grow best at 25–30°C. As a result of these observations, a thiamine-enriched medium containing antibiotics to inhibit the growth of bacteria and saprophytic fungi and an incubation temperature of 37°C have been recommended by the Communicable Disease Center for the isolation of *T. verrucosum* from clinical materials (15).

With improved methods for isolation and identification of *T. verrucosum* growing numbers of reports of *T. verrucosum* recovery from patients in many rural areas of the United States have appeared (16, 17). The disease appears to be especially common in Canada (18, 19, 20). A recent report* indicates that *T. verrucosum* is the commonest dermatophyte isolated at the Provincial Laboratory in Alberta, Canada. Data presented here indicate that this parasite is also common in rural Michigan.

The granular variety of *T. mentagrophytes* is an equally important cause of suppurative ringworm in rural areas of North America (21, 22). As has been pointed out, the downy variety of this organism is a common cause of ringworm of the feet and nails, infections which are widespread in urban areas.

Recent studies on the relationship between the downy and granular varieties of *T. mentagrophytes* by Georg (21) have shown that the virulence of the downy type culture can be enhanced by animal passage, and this increase in virulence may be accompanied by a morphological change to the granular type of growth. This appears to explain the reason that granular cultures are so commonly isolated from acute, suppurative lesions, and suggests the reason this type of infection occurs so commonly in rural areas. Further evidence for the animal origin of suppurative infections due to *T. mentagrophytes* is discussed below.

**B. The animal origin of rural ringworm infections**

The importance of animals as a source of human ringworm infections in rural areas has become increasingly apparent in the United States, Canada, and England during the past several years. A number of recent studies by physicians, veterinarians, and mycologists (18, 22, 23, 24, 25) have given considerable information on this subject. The study in northeastern Michigan, herein reported, adds further evidence for the animal origin of rural infections. This will be discussed separately with regard to each of the two important fungus species involved.

(1) ***T. verrucosum* ringworm.** *T. verrucosum* infections appear to be almost entirely of bovine origin. In the United States and England this fungus is by far the most important cause of ringworm in cattle, the incidence during the winter months being particularly high (4). It is interesting that the disease appears to

* Personal communication from Dr. J. W. Carmichael, Provincial Laboratory, Alberta, Canada.
be common in the northern portion of the United States and throughout Canada and England, where winters are cold and damp and animals are kept in barns for long periods of time. However, in a survey of ringworm of animals being conducted by the Communicable Disease Center, *T. verrucosum* has been isolated frequently from cattle throughout the United States.

In our investigations of the farms from which the human *T. verrucosum* cases were drawn, we found that usually a history of ringworm in the cattle on the premises could be elicited. According to the information gathered from farm owners, infections of the cattle, as manifested by lesions, had been present concurrently or slightly previous to the time that a member, or members, of the family had developed lesions. By the middle of summer, when our field investigations were made, most of the cattle were free of lesions. In eight cases, however, we observed animals with lesions that yielded isolations of *T. verrucosum*. In some cases the farm owners stated that their cattle had had lesions every winter for a number of years. Many reported having had a severe outbreak one year and no evidence of ringworm the next.

Lesions found on cattle varied from slight scaling and loss of hair to thick, very hard, grey to brownish crusts. Often the crusts were tightly adherent, and their removal left moist, hemmorhagic areas. In old lesions the crusts flaked off easily and revealed hairless or nearly bald areas of skin. Lesions were most commonly seen on the head around the eyes and the muzzle but in severe infections were found also along the back and rump and occasionally on the legs and even on the tail. The greatest number of infections occurred in young feeder animals, most of which had been confined to feed lots. However, infections occurred in young animals as well as old and in both dairy cattle and beef cattle. In some herds only one or two animals had lesions, but in others 50 per cent of the animals were infected.

Isolations of *T. verrucosum* from other species of animals have been reported. These include the horse, donkey, dog, goat, sheep and burro (26). However, such infections appear to be rare and it is interesting to speculate whether these animals acquired their infections through contacts with infected cattle.

In the Michigan series, 8 patients became infected through contact with other infected humans. In all these persons, the contacts had been proved to be infected with *T. verrucosum*. In most instances infections were transmitted among siblings or from fathers to their children. One patient, an adult female, apparently had contracted the infection from her children. In two children, the infections may have been contracted from their playmates, though there was no proof that they had not had contact with farm animals. Aside from these two cases, infections were limited to single families.

Evidence for the seasonal occurrence of these infections was noted. Of 31 cases, 77.4 per cent were contracted during the late fall, winter, and spring months (October through May). This appears to correspond with the seasonal increase of skin lesions in cattle reported by the local veterinarians.

It is interesting that only once has any of the authors seen a case of *T. verrucosum* infection in an urban resident. That one case, seen in New York City
several years ago (by Georg), was in an employee of an abattoir. This worker regularly carried undressed beef on his shoulders, and the skin of his neck and shoulders was in contact with the animal hides. Several ring-shaped lesions developed in these skin areas and *T. verrucosum* was isolated from them. Following a court proceeding, the patient was awarded workman’s compensation for the period of his illness on the basis of the fact that he probably had acquired his infection through contact with infected cow-hides in the course of work.

*T. verrucosum* infections may be acquired indirectly also. Rook and Frain-Bell (24) cite the case of a child who developed a lesion on the head, apparently through contact with the gate of a cow-shed. The child’s father, knowing the calves to be infected, had not allowed her to touch them but had permitted her to watch them through the gate. However, the gate had many areas worn smooth by the infected animals as they rubbed their heads and necks against its posts. These authors also cite the case of a child who placed a calf’s chain around her neck and later developed ringworm in the area that it touched. There were a number of instances in the Michigan series where indirect transmission probably occurred. In five children under 4 years of age and in one 15-month-old baby, infections developed before any occurred in the adults of the family. It seems
probable that infected cattle hair, or spores from such hairs, may have been carried on the clothing of the adults to the young children.

Trauma or a pre-existing skin lesion undoubtedly increases susceptibility to infection. In the Michigan series, 2 of the young children developed infections in skin areas where lesions of allergic eczema had occurred previously. In a case reported from Pennsylvania by Fowle and Georg (11), a farmer developed an infection on his neck in a spot where he had recently sustained an acid burn. It is noteworthy that the majority of infections in the adult male occur on the bearded areas of the face and neck. It may be that infected cattle hairs or fungus spores are transferred by the farm worker’s hands to his face and neck, and that the many small cuts or abrasions suffered while shaving provide a favorable environment for the growth of the fungus.

(2) *T. mentagrophytes* (granular) infections. In contrast to *T. verrucosum* infections, which usually can be traced to contacts with infected cattle, the source of *T. mentagrophytes* infections in rural areas often is not easy to discover.

A number of *T. mentagrophytes* infections reported in animals have been among horses, where the disease is commonly known as “girth itch.” Epizootics due to this fungus have been reported in Europe (27) and Africa (28). Although in these reports instances of transmission from horse to man are recorded, the very small equine population which we now have in rural areas of the United States would not appear to constitute the main source of *T. mentagrophytes* infections in farmers and their families. In none of the 32 cases observed in the Michigan series was there a history of contact with ringworm-infected horses.

Cattle infected by *T. mentagrophytes* have been suggested as a possible source of human infections. However, few instances of this type of ringworm in cattle have been recorded in this country. In a study of 45 cases of suspected ringworm in cattle from different parts of the United States, we have isolated only one strain of *T. mentagrophytes*, the other isolates all being *T. verrucosum*. Ainsworth and Austwick (23) have had a similar experience in their survey of cattle ringworm in Britain, where they isolated *T. verrucosum* exclusively from the 41 cases that they studied.

In the Michigan series only two patients in the group with *T. mentagrophytes* infections reported having seen ringworm lesions on their cattle. In one of these cases, where hair specimens were obtained from the suspected cattle source, the fungus recovered was *T. verrucosum*. No evidence was obtained, therefore, that either horses or cows were important sources of *T. mentagrophytes* infections in the series.

*T. mentagrophytes* infections are by no means confined to large farm animals. In fact, recent studies indicate that small pets, especially dogs, and many wild animals, particularly rodents, may be the important reservoirs of this fungus parasite. In our study of domestic and wild animal ringworm, to date *T. mentagrophytes* has been isolated from the following animals: 18 rats (12 *Rattus norvegicus*, 1 *Sigmomdon hispidus*, and 5 *Rattus rattus*), 12 mice (11 *Peromyscus polionotus* and 1 *Mus musculus*), 10 chinchillas, 141 guinea pigs, 6 dogs, 2 cats, and 1 kangaroo. In the survey by Ainsworth and Austwick in Britain (23), *T.
mentagrophytes was isolated in 18 instances from dogs, and twice from cats. It is known that this fungus also infects rabbits, muskrats, opposums, squirrels, foxes, and monkeys (26).

In the Michigan series, 15 of the 32 patients with T. mentagrophytes infections
stated that they had had contacts with either dogs, cats, or rabbits. In only 2 cases, however, was it stated that ringworm lesions had been observed on dogs owned by the patients.

It has been our experience, as well as that of Fuentes (29), that *T. mentagrophytes* frequently may be isolated from animals that show no visible lesions. In fact, all of our isolates from wild mice and rats were from animals which had been trapped at random, and which had no visible signs of disease. In the epizootic of *T. mentagrophytes* ringworm in guinea pigs recently studied by this laboratory (30), the fungus frequently was isolated from animals long after their lesions had disappeared. Apparently the fungus survives on the skin and fur of animals for long periods of time. Although it undoubtedly grows and obtains nutrition from these tissues, the growth is so slow that no visible lesions develop. Visible lesions probably develop following trauma, or the fungus elements are transmitted by contact and produce lesions only in highly susceptible animals such as young or undernourished individuals. This appears to be similar to the manner in which *T. mentagrophytes* persists on apparently healthy skin and nails of human feet as has been observed in a number of surveys (31, 32, 33).

Infections may also be transmitted indirectly from animals to man by contaminated materials and equipment. In a number of the *T. mentagrophytes* epidemics in horses, there is evidence that the disease was transmitted from animal to animal by contaminated brushes and harnesses. In the severe "favus" epidemics due to "*T. quinckeanum*" (most probably *T. mentagrophytes*) which occurred in Australia in 1918 (34) and recently in Germany (35), infections were apparently contracted by handling grain which had been contaminated by ringworm infected mice.

Although *T. mentagrophytes* has been found growing on cow dung in a barn where ringworm-infected cattle were being kept (36), this does not appear to be conclusive evidence that this fungus exists as a free living saprophyte in nature. A recent report by Lurie and Borok (37) of the isolation of *T. mentagrophytes* from soil taken from a bat-infested cave in South Africa also has been offered as evidence that this fungus exists as a saprophyte in nature. Here, again, there is the possibility that the soil may have been contaminated by ringworm-infected animal hairs. Of the very large number of soil samples which have been cultured over a number of years at the Communicable Disease Center, *T. mentagrophytes* has never been isolated, although the dermatophyte *M. gypseum* was isolated from about a third of the samples studied (1). In this series, of the 44 soil samples collected from the premises where a number of the *T. mentagrophytes* infections in humans were seen, the only dermatophyte readily isolated by the hair baiting technic was, again, *M. gypseum*.

The fact that wild mice and rats may harbour this fungus on their fur, as evidenced from our 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 animals would constitute a much
more likely source of infection than the occasional case of clinical *T. mentagrophytes* ringworm seen in dogs.

As with *T. verrucosum* infections, trauma or pre-existing skin lesions in humans undoubtedly increase their liability to become infected. The majority of infections in adults are in the male, on the shaven areas of the neck and face.

II. Urban Ringworm

A. Dermatophyte species involved.

In the series of cases from Northeastern Michigan urban ringworm was divided largely between *Microsporum* and *Trichophyton* species. The two epidemic types of ringworm, those caused by *M. audouinii* and *T. tonsurans*, made up the bulk of the urban type ringworm. Both of these parasites are anthropophilic in nature, and are transmitted from individual to individual. As would be expected, human epidemics occur where people live in close association and where the possibility for human contacts is great. In most urban areas of the United States, *M. audouinii*, which is epidemic among school children, is by far the most important cause of ringworm of the scalp. It has been discussed in detail in a number of publications, and its occurrence and control have recently been reviewed by Casper and Malone (38). The outbreak in Michigan appears to be similar to those seen in other parts of the country.

In the last few years, *T. tonsurans* has risen to second place as an important cause of tinea capitis in urban areas of this country (39). In the southwestern states, particularly some areas of Texas and southern California, infections caused by *T. tonsurans* are almost as prevalent among school children as those due to *M. audouinii*. The majority of cases are found among Latin-Americans who have recently emigrated from Mexico.

The *T. tonsurans* infections now being observed in Michigan have occurred in an area where Mexican itinerant workers are employed in large numbers and where the Latin-American population is rapidly increasing. *T. tonsurans* ringworm, which previously had been unknown in this area, has now become endemic and poses an important public health problem. It seems that endemic areas may develop in any section of the country where Latin-American populations become established.

*T. rubrum*, *T. mentagrophytes* (downy variety) and *E. floccosum* also appear for the most part to be associated with diseases of city dwellers. Infections due to this group of fungi are most numerous in individuals living under conditions of close physical association, as in camps and institutions, however, the epidemiology of these infections is largely unknown.

B. Evidence for animal origin of urban ringworm infections

*M. audouinii* has been isolated only three times from animals—twice from dogs and once from a monkey (40, 41, 42). *T. rubrum* has been isolated once from a dog and once from a cow (43). There are no authenticated records of the isolation of *T. mentagrophytes* (downy variety), *T. tonsurans* or *E. floccosum* from animals.
M. canis infections, on the other hand, are largely of animal origin. This fungus is the common cause of ringworm in cats and dogs in this country, as well as elsewhere in the world, and there is well-authenticated data that the disease is readily transmitted to humans (44, 45, 46, 47). Although pet cats and dogs are numerous in both rural and urban areas, M. canis ringworm in the United States appears to be largely an urban disease. Numerous cases of infections caused by this organism are seen regularly in large city clinics (48). In the Michigan series, 11 of the 14 cases observed were in city dwellers and only 3 occurred among farm children. In a survey of ringworm in animals currently being carried on by the Communicable Disease Center, 131 cases of M. canis infections in cats and dogs have been studied. Of these, 123, or 93.8 per cent, occurred in animals from urban areas. There are a number of reports in the European literature of epidemics of M. canis ringworm in horses (49, 50, 51, 52, 53, 54). In many of these reports the organism is referred to as M. equinum, but studies by Conant (55) have shown conclusively that this fungus is identical to M. canis. One case of M. canis infection in a horse has been recorded in the United States by Hoerlein (56). There is no doubt, therefore, that farm animals may be a source of some human Microsporum infections, although such an occurrence appears to be rare in this country.

SUMMARY

1. Rural and urban ringworm infections as exemplified by a series of cases from northeastern Michigan, have been compared with reference to the fungus species involved, the type of individual affected, the nature of the lesion produced, and factors in the home environment which may have been important in transmission of the disease.

   In general, rural ringworm is of animal origin. Human lesions occur in both children and adults and never become epidemic. Lesions tend to be suppurative in nature and generalized reactions are not uncommon. Two species, T. verrucosum and T. mentagrophytes (granular type), are the important causes of rural ringworm in the United States.

   Urban ringworm is divided between human epidemic types and ringworm contracted from cats and dogs. The two species which cause epidemic ringworm in the United States are M. audouinii and T. tonsurans. Infections contracted from cats and dogs are usually due to M. canis.

2. Evidence for the animal origin of rural ringworm is discussed in detail. T. verrucosum infections are directly related to contacts with ringworm-infected cattle. Rural T. mentagrophytes infections probably result from direct or indirect contacts with a variety of animals. The role of rodents as reservoirs and possible agents of transmission of T. mentagrophytes ringworm is discussed.

3. An epidemic of T. tonsurans ringworm in northeastern Michigan has been described. The disease, previously unknown in this area, has become endemic in sections where Mexican laborers have settled.

REFERENCES


