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# The Epizootiology of Trichiniasis in Wildlife

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## Abstract

Significant reservoirs of trichiniasis in wildlife have been demonstrated only in Iowa and Alaska. Limited findings in other states would indicate, however, that the problem exists in most of the United States. Based on present knowledge, scavenging is probably the primary mode of transmission with predation being of major importance only in the Arctic region where a significant reservoir of the disease is present in the rodent population. Both direct and indirect routes of transmission of the disease from wildlife to man are indicated with the direct route being demonstrated primarily through the ingestion by man of improperly cooked bear meat. The indirect route, wildlife to swine to man, has been demonstrated as a possibility in epidemiological studies in Iowa. An educational program must be developed to alert the hunter, trapper, and swine producer of the significance of wildlife trichiniasis. Studies on the distribution of the disease in the wildlife population of the U.S., the modes of transmission within and between wildlife populations, and means of breaking interrelationships of the wildlife and domestic cycles of the disease are essential to decreasing and eventually eradicating the disease in man and swine.

Control of trichiniasis in man can be accomplished by inspection of swine carcasses for trichinae and the elimination of infected carcasses from the food supply but the key to any eradication program in swine and man is a thorough understanding of the epizootiologic aspects of the disease in the wildlife reservoir. Knowledge must be accumulated regarding the distribution of the parasite in wildlife of the U.S., modes of maintenance of the disease in wildlife, and the relationship of the disease in wildlife species to the disease in man and swine. Unfortunately, with the exception of studies in Iowa and Alaska, only limited attention has been given to these phases of the problem. This report will review the current status of knowledge concerning trichiniasis in wildlife in the U.S. and hopefully will stimulate additional studies.

*Trichinella spiralis* is doubtlessly the most ubiquitous of helminth parasites since probably all mammals and a few birds are susceptible to infection. Natural infections have been reported in over 100 species of wild mammals including at least 58 species of carnivores, 28 species of rodents, 7 species of insectivores, and a more limited distribution among other diverse orders.<sup>25</sup>

Trichiniasis is highly endemic in the Arctic and is widely distributed in the temperate zone of the northern hemisphere. It was formerly thought that trichiniasis was relatively scarce in the tropics and southern hemisphere, a viewpoint which probably developed due to lack of intensive studies. Recent reports, although limited, indicate the disease is worldwide in distribution.<sup>5</sup>

At least 39 species of wildlife have been incriminated as reservoirs of trichiniasis in the United States. In an intensive study of the problem in Alaskan mammals, Rausch *et al.*,<sup>18</sup> isolated the parasite from 23 of 42 species examined. High prevalence rates were obtained from: polar bear, 52.9%; grizzly bear, 50.0%; wolverine, 50.0%; red fox, 40.8%; ermine, 35.3%; wolf, 33.1%; lynx, 23.5%; black bear, 21.7%; and coyote, 12.5%. Arctic fox, least weasel, snowshoe hare, seals, the white whale and 8 species of rodents were among the other animals found to be infected.

A study to determine the extent of wildlife trichiniasis in Iowa was carried out by Zimmermann and Hubbard<sup>20</sup> during 1953-68. During these 15 hunting and trapping seasons, 11,162 wildlife specimens including 52 species of mammals, birds, and reptiles were examined for trichinae. *T. spiralis* larvae were isolated from 16 species including: red and gray foxes, 6.4%; rat, 5.3%; mink, 5.0%; coyote, 4.3%; badger, 3.1%; striped skunk, 1.6%; spotted skunk, 1.3%; fox cubs, 0.8%; opossum, 0.8%; muskrat, 0.7%; raccoon, 0.6%; beaver, 0.5%; great horned owl, 0.4%; fox squirrel, 4.3%; least weasel, 20.0%; and wolverine, 100.0%. Only a single infected animal was found for the beaver, great horned owl, fox squirrel, least weasel, and wolverine. All but the latter species were native to Iowa. Four hundred ninety-seven specimens, representing 36 other species gave negative results. Included were 132 mice, representing 3 genera (*Peromyscus*, *Microtus*, *Mus*). The rat sample represented 944 dump rats and 324 farm rats with all of the 67 positives being dump rats.

The findings in the beaver, muskrat, and fox squirrel must be considered as accidental, possibly related to a temporary shortage of their normal food sources. The finding of a single trichina in a horned owl is considered abnormal. Although owls are exposed to possible infection with the parasite, generally only limited development of the parasite occurs in avian species. Four hundred twenty-two other birds of carnivorous food habits were found to be negative.

The wildlife were obtained primarily from 11 sampling areas,<sup>20</sup> which encompassed all but northeast Iowa. Each of the primary sampling areas yielded at least 3 infected species, including fox and mink. Infected striped skunk were obtained from 8 areas, spotted skunk from 5, opossum from 4, raccoon and coyote from 3, and badger from a single area. Seven infected species were obtained from one area in central Iowa while two other areas yielded 6 positive species. The widespread dispersement and numerous host species would indicate that trichiniasis in wildlife of Iowa is diffusely spread throughout the state which is in contrast to findings in some areas of Europe where the parasite is isolated in nidi of infections.

Fox and mink were included in each of the 15 seasons of study.<sup>20</sup> Two interesting facets were evident for these species. A somewhat cyclic pattern of infection was noted for both species. High initial prevalences were followed by an almost continual decrease for several years. The prevalences then increased to moderate levels, again followed by a gradual decline. Whether these patterns were related to cyclic population changes of animals which served as a source of infection or were related to other factors which affected the availability of normal food sources is not known.

The second interesting comparison between fox and mink deals with species prevalence rates for the primary sampling areas. The fox prevalences by area varied from 9.9% to 4.6% while those for mink ranged from 10.0% down to 1.0%. A ranking of prevalences for the two species by area revealed an inverse relationship, that is, those areas with high prevalences of infection in foxes had a low prevalence in mink, while those areas with high prevalences in mink generally had a low prevalence in foxes. These findings would indicate differing sources of infected food within geographic areas.

The intensity of the infections, as indicated by larvae per gram counts from the diaphragm, was generally high in mink and rats.<sup>20</sup> About 84% of the infected mink and 78% of the rats had counts exceeding one trichinae per gram while 48%

of the infections in mink and 33% of those in rats exceeded 100 per gram. The maximum count for mink was 3,451 and for rats was 18,890. More than 40% of the infections in foxes, raccoons, spotted skunks, and striped skunks contained one or more per gram. The large number of relatively high larval counts could indicate that infections in wildlife may cause morbidity and occasional mortality.

Other studies in the United States have been more limited in scope. Olsen,<sup>17</sup> in Colorado, reported a prevalence of 17.8% in dump rats, 3.0% in foxes, 1.0% in bobcats, and 0.5% in coyotes. Solomon and Warner,<sup>20</sup> in Virginia, isolated trichinae from 6 of 16 spotted skunks, 4 of 26 opossums, and a single long-tail weasel examined. Trichinae have been isolated from three species of wildlife in Maryland, namely badgers,<sup>10</sup> striped skunks,<sup>21</sup> and raccoons.<sup>22</sup> Other findings include muskrats in Ohio,<sup>5</sup> striped skunks in Louisiana<sup>4</sup> and North Dakota,<sup>7</sup> and Norway rats and white-footed mice from Illinois.<sup>13</sup> Infected mountain lions were reported from a Washington, D.C. zoo<sup>12</sup> and from Montana.<sup>24</sup> Wild pigs, rats, and mongooses have been reported as hosts in Hawaii.<sup>1</sup>

Although occasional human outbreaks have been attributed to the ingestion of improperly prepared meat from black bears, reports of studies on the problem in bears are somewhat limited. Three of 44 black bears from New York state were infected<sup>11</sup> while examination of 35 Vermont bears yielded negative results.<sup>8</sup> A study involving black bears was recently carried out as a cooperative project between personnel of the National Communicable Disease Center and the Departments of Conservation of 6 northeastern states. Five (1.3%) of 372 bears examined were infected with *T. spiralis* including 2 of 158 from New York, 1 of 77 from Pennsylvania, 1 of 60 from Vermont, and 1 of 28 from West Virginia. Negative results were obtained for 16 bears from New Hampshire and 33 from Maine. The trichina counts for the 5 infected bears ranged from 750 to 22 trichinae per gram, indicating that all were potential human health hazards if the flesh was consumed without proper preparation. In traceback of the infected Vermont bear (29 trichinae per gram) to the successful hunter, it was found that the bear meat was to be served at an annual feast of a game club. An abrupt substitution of meat was made thereby averting a possible outbreak.

Although the findings from states other than Iowa and Alaska are limited and generally not based on voluminous trichina-oriented studies, they would tend to indicate that the trichina problem is not restricted to Iowa and Alaska but is present in much of the United States. This can be confirmed, however, only by extensive studies in various regions of the country.

The widespread distribution of recognized hosts among various mammalian orders, along with their corresponding diversification of food habits emphasizes the problem of determining the sources of infections that perpetuate trichiniasis in nature. Even if all hosts were carnivores, the sources would not be easy to define. The problem of determining the sources of infection for foxes and mink in Iowa can be used for illustration. Primary mammalian sources of food for foxes in Iowa are cottontail rabbits, mice, and muskrats.<sup>10</sup> Of these, only the muskrat has been found infected in Iowa with only 2 of 291 examined being found infected.<sup>20</sup> Both infected muskrats were from the same area during the same trapping season. Thus none of the normal mammalian foods would tend to account for the prevalence of 6.4% found in Iowa foxes. Mice and muskrats comprise nearly all the mammalian food ingested by mink.<sup>22</sup> Again this does not explain a prevalence rate of 5.0%. Only for dump rats, and for bears in some areas, is there a logical, readily determined explanation. Disposal of infected meat scraps, including uncooked trichinous pork and wildlife carcasses, in open type garbage dumps provides an available source of infection for these and occasionally other scavengers.

The mechanics of transmission for most infections would seem to be somewhat easier to define although as indicated previously, more information is needed for

clarification of the problem. Scavenging is probably the primary mode of transmission in the contiguous 48 states with predation also being an important contributing mode in Alaska. The role of predation is minimized in all areas but the Arctic by the nearly universal failure to find a significant reservoir of the disease in any rodents except dump rats. Examination of several species of mice and farm rats in Iowa have yielded consistently negative results. Aged carnivores, such as foxes, have an increased probability of infection due to the possibility of more frequent exposure to the parasite. At death, these animals would provide an available source of infection for scavenging animals.

With the difficulty in defining sources of infection, attention must also be given to other possible modes of transmission besides scavenging and predation. Fecal transmission, which has been proven experimentally, for wildlife to pig transmission<sup>27,28</sup> may also produce wildlife to wildlife transmission. Mechanical transmission by necrophagous insects also has been documented as a plausible mode.<sup>14,18</sup> Although both modes would seem to be of lesser significance than scavenging or predation, more field information is needed to fully assay their role in transmission of the parasite. Other, as yet unknown modes also may have a role in the perpetuation of the disease problem.

With evidence of a significant wildlife reservoir of the disease, the role of wildlife in the epidemiology of trichiniasis in man must also be considered. Both direct and indirect routes of transmission from wildlife to man have been demonstrated. The direct route involves ingestion, by man, of improperly prepared flesh of trichinous animals. In the contiguous 48 states this is probably limited to bear meat. The low prevalence of the disease in other occasionally consumed mammals of carnivorous habits, such as opossums and raccoons, would minimize their importance as a possible source of human infection. In Alaska, bears, seals, whales, and possibly other carnivores may serve as sources of infection for man, while in Hawaii most human outbreaks have been traced to wild pigs. Human outbreaks traceable to ingestion of wildlife have been reported frequently. During 1961, for example, 18 of 290 human cases in the contiguous 48 states were traced to ingestion of bear meat.<sup>9</sup> In 1968, of 84 reported human cases, eight were attributed to bear meat, 2 to wild swine.<sup>15</sup> The 1968 bear meat outbreaks occurred in Alaska and were traced to two black bears. On examination, the meat from both bears was found to be heavily infected. The wild swine episode occurred in Hawaii.

The indirect route, that is wildlife to swine to man, has received little attention primarily because epidemiological investigations to determine the location of swine herds involved in human outbreaks in the U.S. have usually been unsuccessful. There has also been evidence that the cycle for man, swine, and related animals is independent of that in wildlife. The cycle in wildlife in the Arctic persists with little or no influence from man. Germany, with a wildlife reservoir comparable to that in Iowa, has an infective rate in swine of 1 per million compared to about 1 per 1,000 in the U.S. The low prevalence rate in swine of Germany would indicate that that wildlife cycle there is relatively independent of that in swine. A recent pilot study of the pooled sample method for packing house diagnosis of trichiniasis in swine was carried out in Iowa during an 8 month period of 1968-69 as a cooperative venture by the USDA and the pork industry. This study yielded an excellent opportunity to determine sources of infection for swine. Nine trichinous swine herds were investigated.<sup>2</sup> The practice of feeding wildlife carcasses to swine was determined from two farms. One of these involved a fur buyer, the other a trapper. Another farmer not only fed kitchen scraps from a restaurant to swine, a likely source of infection, but also lived a short distance from an open type garbage dump. Rat trails were evident in the snow between the dump and the swine rearing area. Thus the wildlife and swine cycles may be interrelated in Iowa. Since Iowa produces nearly 25% of the nation's swine, these findings are highly significant and point to a major problem area which must be solved.

The questions now arise as to what can be done to more fully define the problem in wildlife and to eliminate any relationships between the domestic and wildlife cycles of the parasite since it is realized that the disease cannot be eradicated in wildlife. First, there is a definite need for extensive studies by wildlife disease workers and ecologists to determine the problem in various geographic and ecological areas of the United States. Meaningful samples must be taken in each area from the various species with carnivorous feeding habits. Studies should also be made to ascertain how the parasite is transmitted and maintained within and between animal populations. Information is also needed as to whether the problem is confined to ecological niches or is diffuse throughout states or areas.

The evidence that the wildlife to swine to man cycle may occur brings forth other important, if not critical, needs. The swine producer, as well as hunters and trappers, must be made fully cognizant of the danger of feeding wildlife carcasses to swine. This danger includes not only trichiniasis but also other parasitic, bacterial, and viral diseases. This warning could be transmitted through the media of hunting and trapping oriented magazines as well as farm publications. If regulations are not already in effect prohibiting the feeding of uncooked wildlife carcasses to swine, such regulations must be established and strictly enforced. Warnings of the hazards of feeding carcasses could also be made on hunting and trapping licenses. Encouragement should also be given to hunters and trappers to either bury the carcasses in the field or dispose of them in some manner preventing their consumption by wildlife or swine.

The bear hunter also must be made aware of the trichiniasis problem. As the disease problem in swine decreases, bear meat will become increasingly significant as a source of human infection. This awareness also could be accomplished by an informational note on the license citing the possible hazard of ingesting improperly prepared bear meat and listing precautionary measures such as proper cooking or freezing procedures which should be carried out to destroy the parasite. Diagnostic services should be extended for the examination of bear carcasses in the states where bear hunting is permitted.

Another important step to alleviate partially the trichiniasis problem in wildlife would be the elimination of open garbage dumps. The current drive on environmental pollution may soon force conversion from this waste disposal system to other methods such as sanitary landfills in which rats, bears, and other wildlife have no opportunity to feed. If conversion cannot be made, an alternate would be to fence the dump areas to keep out large mammals and to establish rodent eradication programs within the confines.

All of these programs would help reduce the trichiniasis problem. Any progress in defining the problem in wildlife and in breaking the cycles between wildlife and man will contribute markedly to the control and eventual eradication of the disease in man and swine.

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