Sylvatic Trichinosis in British Columbia

Potential threat to human health from an independent cycle

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TRICHINOSIS, ALTHOUGH APPARENTLY ERADICATED from hogs in British Columbia (*1, 2*), remains a common helminthic infection in a wide range of wildlife species (*2*). In British Columbia, the bear seems to be the principal link between the wildlife reservoir and the disease in man, as evidenced by several outbreaks of trichinosis from bear meat. The latest outbreak occurred in 1971 and affected 17 people (*3, 4*). The present study was therefore designed to determine the prevalence and distribution of *Trichinella spiralis* in wild mammals in southern and central British Columbia and thus to increase our knowledge of existing sylvatic cycles of the disease and their potential threat to human health.

Trichinosis in North American Wildlife

Bears. Despite an increasing number of outbreaks of trichinosis due to bear meat in Canada (*5–10*) and the United States (*11–17*), relatively few studies have recorded the prevalence of trichinosis in bears on this continent. Surveys in Alaska between 1949 and 1953 revealed infection rates as high as 53 percent in polar bears, 50 percent in grizzly bears, and 22 percent in black bears (*18*). In 1960, the prevalence in black bears in New York State was more than 6 percent (*19*), whereas in Vermont a 1964–65 survey of black bears (mostly young) failed to demonstrate ursine trichinosis—although human disease due to such bears had been reported (*20*). In a 1968–69 study of 372 black bears in 6 northeastern States, including New York, infection rates ranged between 0.2 and 2.5 percent; although this prevalence was relatively low, it was 4 times greater than that found in garbage-fed swine and 13 times greater than that in grain-fed swine in the United States (*21*). From 1966 to 1972 in the U.S. northern Rocky Mountain region, 58 percent of grizzly and 12 percent of black bears were found to be infected (*22*). In 1975, 3.6 percent of black bears in the Lake Superior region were reported to be positive (*23*). In the Province of Quebec between 1971 and 1973, of 96 black bears examined, 1 was infected (*24*). In 1973, 105 black bears examined in the Province of Alberta were found free of trichinae (*25*).

Carnivores. Trichinosis studies in Alaskan wildlife between 1949 and 1953 showed the infection in 41 percent of red foxes, 35 percent of ermines, 33 percent of wolves, 50 percent of wolverines, 24 percent of lynxes, 13 percent of coyotes, and 7 percent of Arctic foxes; 2 least weasels harbored larvae, whereas test results on martens, minks, and otters were negative (*18*). Between 1953 and 1968, trichinae were detected in 9 species of carnivorous terrestrial mammals native to Iowa—20 percent in least weasels, 6 percent in foxes, 5 percent in minks, 4 percent in coyotes, 3 percent in badgers, 2 percent in striped skunks, 1 percent in spotted skunks, and 1 percent in raccoons; also, 1 wolverine was found to be positive (*26*). In Colorado, 3 percent of foxes, 1 percent of bobcats, and 1 percent of coyotes were infected (*27*). Badgers and raccoons were found to be infected in Maryland, as were striped skunks in both Louisiana and Maryland (*28–31*). Between 1966 and 1972 in the U.S. northern Rocky Mountain region, 55 percent of mountain lions, 17 percent of bobcats, 8 percent of martens, 40 percent of fishers, 50 percent of wolverines, 17 percent of striped skunks, 7 percent of red foxes, and 25 percent of coyotes were infected with *T. spiralis* (*22*). In a study in Quebec between 1971 and 1973, *T. spiralis* was found in 3 of 33 raccoons, 2 of 21 coyotes, 1 of 5 wolves, 3 of 17 foxes, and 1 of 2 lynxes (*24*).

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Table 1. Large species of wildlife examined for trichinae and results, British Columbia, 1972–75

Species	Kootenays		Southwestern British Columbia [1]		Other regions [1]		All regions			
	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Total	Percent positive
Grizzly bear *(Ursus arctos horribilis)*	4	4	2	...	7	3	13	7	20	35.0
Marten *(Martes americana)*	99	49	...	...	...	...	99	49	148	33.1
Wolverine *(Gulo luscus)*	6	3	2	...	...	...	8	3	11	27.3
Bobcat *(Lynx rufus)*	41	7	1	1	...	...	42	8	50	16.0
Black bear *(Ursus americanus)*	108	16	16	2	45	5	169	23	192	12.0
Coyote *(Canis latrans)*	249	32	1	...	35	...	285	32	317	10.1
Lynx *(Lynx canadensis)*	42	5	4	...	...	...	46	5	51	9.8
Cougar *(Felis concolor)*	46	5	...	...	...	...	46	5	51	9.8
Weasel *(Mustela frenata)*	23	3	7	...	...	...	30	3	33	9.1
Skunk *(Mephitis mephitis)*	24	1	1	...	...	...	25	1	26	3.8
Mink *(Mustela vison)*	40	1	...	...	1	...	41	1	42	2.4
Other[2]	483	...	99	...	15	...	597	...	597	...
Total	1,165	126	133	3	103	8	1,401	137	1,538	8.8

[1] The southwestern British Columbia areas from which the small and large species were sampled included Vancouver, Richmond, Surrey, Delta, Burnaby, North Vancouver, West Vancouver, Maple Ridge, Langley, and Coquitlam. The other areas of British Columbia outside the Kootenays from which specimens for large wildlife species were obtained included Manning Park, Vancouver Island, Lillooet, Harrison Lake, Oliver, Williams Lake, Kamloops, LacLaHache, Stuart Lake, Babine River, Manson Creek, Germanson Lake, and Halfway River.

[2] Includes muskrat, wolf, deer, moose, beaver, otter, porcupine, rabbit, raccoon, badger, fox, snowshoe hare, seal, mountain goat, and big horn sheep.

Rodents. In Alaska between 1949 and 1953, seven species of wild rodents were found positive for trichinae *(18)*. The prevalence was 8 percent in narrow-skulled voles, 4 percent in red squirrels, 4 percent in red-backed voles, 3 percent in beavers, 1 percent in muskrats, and 1 percent in grey squirrels and brown lemmings. In Iowa between 1953 and 1968, 3 species were found to be infected—fox squirrels 4.3 percent, muskrats 0.8 percent, and beavers 0.4 percent; 132 mice and 13 other small rodents were negative *(26)*. In Ohio in 1967, tests results for muskrats were reported to be positive *(32)*.

British Columbia Wildlife Study, 1972–75

A comprehensive study of the prevalence of trichinosis in wildlife was conducted jointly between 1972 and 1975 by the British Columbia Ministries of Health and Agriculture, the British Columbia Fish and Wildlife Branch, and the Animal Pathology Division, Health of Animals Branch, Agriculture Canada. In 1972 and 1973, throughout the Kootenays (the southeastern area of British Columbia) large numbers of specimens of various wild animals were collected for laboratory analysis, and preliminary findings were reported by four of us (Schmitt, Saville, Friis, and Stovell) in 1976 *(2)*. Besides the ongoing wildlife survey in the Kootenays, in the summer of 1974 numerous samples were collected from more than 60 species, most from the Vancouver area and a few from scattered areas in the southwestern part of the Province. In 1974 and 1975, samples were obtained from more than 100 large mammals that had been killed in the central and south-central areas of the Province.

Field procedures. The fieldwork for the project was done by teams of university biology students during the summer months. Samples were obtained throughout the year also, from the staff of the Fish and Wildlife Branch, veterinarians, trappers, and the general public.

The student teams were supplied with mouse-traps and rodent leg traps. They were left to their own discretion whether or not to use firearms. Using mainly peanut butter for bait, the teams set traps along stream beds, in partly cleared areas, and wherever the habitat seemed promising. The smaller specimens were left whole, and the larger rodents were dissected in the field to remove the diaphragmatic muscle. All specimens were then frozen and shipped to the laboratory for examination. From large mammals, 1-inch muscle samples were taken from diaphragm, rib, tongue, or cheek muscle, and then frozen or placed in 10 percent formalin in watertight bags.

Laboratory methods. Muscle tissue was sliced with a scalpel to about 4 mm thickness. A digestive solu-

tion was composed of 1.0 percent pepsin in 0.8 percent saline solution and adjusted to a pH of 1.0 with concentrated hydrochloric acid. The slices of muscle were placed in a petri dish containing the digestive solution and allowed to remain in it for approximately 1 to 1½ hours. Each tissue was then placed in a compressorium and scanned at a magnification of ×50. Detail was observed at a magnification of ×100 (*33*).

Results

From mid-1972 to mid-1975, almost 9,000 specimens from a wide variety of large and small wildlife species were examined for the presence of larvae of *T. spiralis*. The parasite was found in 11 species of large and 4 species of small mammals. Tables 1 and 2 show details of numbers examined and the proportions found positive. Although the overall infection rate for larger mammals was almost 9 percent, the rate for the smaller species (mostly rodents) was less than ½ of 1 percent. The incidence was 0.6 percent in white-footed mice, 0.4 percent in ground squirrels and red squirrels, and 0.3 percent in shrews. Of the larger species, martens, coyotes, and black bears accounted for more than 75 percent of positive cases. Of the 148 martens examined, one-third showed *T. spiralis* infection. Of 317 coyotes, 32 (about 10 percent) were infected; this proportion was only slightly less than the 12 percent of the 192 black bears found to harbor the parasite. Bobcats exhibited a high rate of positive specimens, 16 percent of 50 examined. Grizzly bears with 35 percent positive and wolverines with 27 percent positive had an even higher infection rate. However, the numbers of specimens examined for the grizzly bears and wolverines were somewhat smaller, and thus the figures are less reliable indicators of the level of infection in the particular species. Five positive samples were recovered from 51 specimens of both lynx and cougar, an infection rate of 10 percent. Altogether, the eight species named accounted for all but about 4 percent of the positive samples obtained from the larger wildlife species.

For the most part, the specimens from larger species sampled came from the Kootenay area; for the 247 specimens obtained from the southwestern mainland and elsewhere in southern and central British Columbia, the infection rate was about 5 percent, somewhat below the rate of 11 percent recorded for the Kootenay group. However, it would be necessary to obtain a larger number of specimens from southwestern British Columbia to determine the significance of this difference. A much lesser proportion of specimens from the smaller wildlife species was taken from outside the Kootenay area. No trichinae were detected in these 434 specimens, all of which were collected from the southwestern mainland. All 372 muskrats trapped in the Kootenays were found free of trichinae, as were 632 domestic cats and 213 dogs from the Vancouver area. Also reported to be negative were 14 rats (*Rattus norvegicus* and *Rattus rattus*) and 54 birds, mostly scavengers or carnivores from the Vancouver area, as well as 33 beavers, 10 raccoons, 10 opossums, 5 porcupines, 3 wolves, 3 badgers, 2 otters, and 2 foxes killed in various parts of southern British Columbia.

Discussion

The findings of this study indicate that trichinosis is widespread in wild mammals in the southern and central parts of British Columbia. The enforcement of Federal sanitary and garbage feeding regulations, in effect for more than half a century, has led to the virtual eradication of trichinosis from domestic pigs

Table 2. Small species of wildlife examined for trichinae and results, British Columbia, 1972–75

Species	Kootenays		Southwestern British Columbia [1]		Other regions [1]		All regions			Percent positive
	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Total	
Shrew (*Sorex vagrans*)	192	1	137	...	...	...	329	1	330	0.3
White-footed mouse (*Peromyscus maniculatus*)	2,134	13	110	...	...	...	2,244	13	2,257	0.6
Ground squirrel (*Spermophilus columbianus*)	1,639	6	...	...	...	...	1,639	6	1,645	0.4
Red squirrel (*Tamiasciurus hudsonicus*)	680	3	...	...	...	...	680	3	683	0.4
Other [2]	2,184	...	187	...	...	...	2,371	...	2,371	...
Total	6,829	23	434	...	...	...	7,263	23	7,286	0.3

[1] See footnote 1, table 1.
[2] Includes other varieties of mice, squirrels, marmots, and chipmunks.

(*1,2*). The demonstration of trichinae in 15 wildlife species in the absence of porcine trichinosis, a reportable disease since 1971, seems to confirm that sylvatic trichinosis exists as an independent cycle.

Infected carnivores provide a constant source of food for other predators and carrion-eating species including rodents. The possibility of fecal transmission as an integral part of the cycle must be kept in mind (*34*). Cannibalism is another possible mechanism of intra-species spread (*23*). Skinned and decapitated carcasses of bear and other trophy animals left on the ground by hunters at the point of kill are a readily available source of fresh meat for other bears (*23*) and many smaller species of wildlife, including rodents. In the absence of porcine trichinosis in the Province, garbage dumps probably play a minor role in the transmission of the disease.

The importance of small mammals in the transmission of *T. spiralis* deserves further study. It has been speculated that rodents, a vital food source of carnivores, may be an important link in the disease chain in wildlife (*18*). Contrary to the supposition that wild rodent trichinosis is minimal in temperate zones (*35*), in this study *T. spiralis* was demonstrated in four species of small, predominantly vegetarian mammals. While shrews, mice, and ground squirrels had low levels of infection, the incidence in their predators was relatively high, possibly because of large numbers of these animals consumed, particularly by coyotes and martens. To our knowledge, this is the first report of *T. spiralis* in ground squirrels and nonsynanthropic mice on this continent.

Because adequate numbers of specimens from larger animals were difficult to obtain in southwestern British Columbia, the sampling of wild mammals was augmented by the inclusion of domestic carnivores; the majority of these were obtained from the larger urban Vancouver environment. Although these species depend largely on human food sources (including uncooked meat scraps), in the case of cats particularly they also inevitably execute a predatory role. By the selection of principally older animals subjected to euthanasia, most of the 845 cats and dogs in the sample had survived a number of seasons and likely at least one peak in rodent population. The total absence of positive findings in these two domestic species as well as the negative results in the 434 wild rodents trapped in southwestern British Columbia is an interesting comparative observation and perhaps deserves further study. These findings would certainly confirm the absence of *T. spiralis* in human food sources in the urban area.

As a result of escalating meat prices and the need to blend and extend meat in modern cuisine, game, including bear meat, has become an increasingly important source of food. Whenever human trichinosis follows ingestion of uninspected meat or meat-containing products, the possibility of bear or other game meat as the vehicle or as an adulterant must be considered; even though pork or beef may be claimed to be the sole ingredient, it should not be incriminated without demonstration of larvae *and* proof of species origin (*1, 4*).

The natural reservoir of the parasite may also present an important potential source of trichinosis for swine and thereby indirectly for man (*36, 37*). However, further study is required to determine the comparative virulence for swine of *Trichinella* strains from wildlife species (*38*).

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SYNOPSIS

SCHMITT, N. (West Kootenay Health Unit, Trail, British Columbia), SAVILLE, J. M., GREENWAY, J. A., STOVELL, P. L., FRIIS, L., and HOLE, L.: *Sylvatic trichinosis in British Columbia. Potential threat to human health from an independent cycle. Public Health Reports, Vol. 93, March-April 1978, pp. 189–193.*

The results of a 3-year study of trichinosis in British Columbia wildlife, based on the testing of more than 9,000 tissue specimens from a large variety of animal species, indicated that trichinosis is widespread among wild mammals in the southern and central parts of British Columbia. This continuing survey has established that the disease is carried by at least 15 species of terrestrial mammals, including 3 species of rodents. The finding of *Trichinella spiralis* in ground squirrels and nonsynanthropic mice may be the first reported in North America.

Although trichinosis appears to be eradicated in domestic pigs in British Columbia, a sylvatic cycle of the disease continues to exist independently and poses a potential threat to human health. It is possible for human beings to contract trichinosis by consuming inadequately cooked meat from certain wildlife species, especially bears, as well as meat products (such as pork or beef sausage) to which game meat has been added; several local outbreaks were caused by this source. Another hazard of unknown potential is the spread of trichinosis from the wild animal reservoir—from rodents in particular—to domestic pigs and thus to man.