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Helminths of South Dakota Coyotes

Elizabeth C. Schitoskey

HELMINTHS OF SOUTH DAKOTA COYOTES

BY

ELIZABETH C. SCHITOSKEY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

/ Raymond L. Linder   ‒   Date
    Thesis Adviser

Charles G. Scalet   Date
Head, Department of Wildlife
and Fisheries Sciences

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ABSTRACT

From September 1976 through January 1978, 343 coyote (Canis latrans) carcasses were obtained for this study from South Dakota Department of Game, Fish and Parks trappers and from fur buyers. Coyotes were necropsied, internal organs were examined for helminth parasites, and parasites located were collected and identified. Nematodes found included Toxascaris leonina in 215 of 290 (74%), Toxocara canis in 1 of 290, Physaloptera rara in 160 of 290 (55%), Physaloptera preputialis in 1 of 290, Pterygondermatites cahirensis in 28 of 290 (10%), Ancylostoma caninum in 38 of 290 (13%), Uncinaria stenocephala in 1 of 290, Dermatoxys veligera in 1 of 290, Filaroides osleri in 121 of 337 (36%), and Trichinella spiralis in 1 of 343. Cestodes located were Taenia pisiformis in 130 of 290 (45%), Taenia hydatigena in 5 of 290 (2%), Taenia macrocvstis in 3 of 290 (1%), Taenia multiceps in 4 of 290 (1%), and Mescestoides sp. in 19 of 290 (7%). The acanthocephalan Oncicola canis occurred in 3 of 290 coyotes (1%). Neither Echinococcus granulosus nor Echinococcus multilocularis , 2 parasites with human health implications, were located in this study. The presence of Taenia multiceps may pose a health hazard to individuals working with wild canids in South Dakota as well as being of veterinary significance to the livestock industry. It is doubtful that coyotes play an important role as a sylvatic reservoir for trichinosis in South Dakota.

The coyote, _Canis latrans_, is distributed in many widely varying habitats throughout North America. Because of dissimilarities in the availability of prey species and diversity in environmental conditions, the parasitic species prevalent in coyotes vary in different geographical locations. While parasites of coyotes have been studied in Minnesota (Erickson 1944), Utah (Butler and Grundmann 1954), Kansas (Gier and Ameel 1959), Michigan (Dunatchik 1967), Texas (Smith 1967, Thornton et al. 1974), Alberta (Holmes and Podesta 1968), Iowa (Franson et al. 1978) and other areas, no extensive investigation of parasites of coyotes from South Dakota has ever been reported.

This study was designed to determine the species and relative prevalence of parasites of coyotes in South Dakota. Coyotes from 3 different areas of the state (Custer, Harding, and Gregory counties) were examined because acquisition and pathogenicity of parasites is affected by environmental conditions and geographic locations. It was hoped that this would minimize the possibility of overlooking a species which was endemic to one area of the state but not found elsewhere. No attempt was made to statistically compare results from the 3 areas because the method of obtaining coyotes for the study made identification of precise collection locations impossible. Nevertheless collection of material from different areas proved valuable because several of the species of parasites identified were found in only one county.

Coyotes usually serve as the definitive host for parasitic helminths. Identification of coyote parasite species provides information about the food habits of coyotes because of intermediate host specificity. Most

helminths parasitizing coyotes have little harmful effect. Controlling infections of those species which are pathogenic to coyotes in wild populations would be impossible or impractical. However, coyotes may be reservoir hosts for parasites of game animals and other wildlife as well as playing a role in transmission of pathogenic parasites to domestic animals and man. Therefore knowledge of coyote parasites may contribute to formation of management plans leading to control of parasitic diseases in other wildlife and domestic animals. Identification of coyote parasites which are transmissible to man may have public health significance. Three species of coyote parasites which can be a health hazard to individuals working with coyotes in laboratories or fur businesses are Echinococcus granulosus, Echinococcus multilocularis, and Taenia multiceps. If these parasites are endemic to an area, individuals working with coyotes need to be warned to take precautions to prevent infection. Coyotes may also serve as reservoirs for the sylvatic cycle of Trichinella spiralis; they may indirectly spread trichinosis to man by fecal transmission to livestock.

The objectives of this study were to determine the species and relative prevalence of helminths of coyotes in Harding, Custer, and Gregory counties in South Dakota and to identify species of coyote parasites endemic to South Dakota which could be of economic importance to the livestock industry or a health hazard to man or other wildlife species.

METHODS

Coyotes for this study were collected from September 1976 through January 1978 by South Dakota Department of Game, Fish and Parks trappers in Harding, Custer, and Gregory counties and fur buyers in Custer and Gregory counties. Skinned carcasses were stored in freezers until they could be transported to laboratory facilities at South Dakota State University. A research technician in Harding County necropsied coyotes from that area and froze viscera for parasite examination at a later date. Specimens were frozen in plastic bags with data cards attached containing name of collector, date, and locality of collection. All coyotes were necropsied or frozen as soon as possible after death to minimize post-mortem migration of endoparasites to abnormal locations (Meyer and Olsen 1971). Some carcasses were partially decomposed when I obtained them.

During necropsy, the skinned carcasses were examined for subcutaneous worms. The musculature, mouth, nose, body cavity, esophagus, and urinary bladder were examined for evidence of parasitic infection. The stomach, intestines, heart, lungs, kidney, and liver were removed and frozen in a labelled plastic bag for future examination.

Samples of diaphragm, tongue, and masseter muscle were removed during necropsy and preserved for trichinosis examination. The compression method described by Gould (1970) was used to detect encysted trichinae. One gram samples of diaphragm, tongue, and masseter muscle were teased into thin portions which were compressed between 2 clamped glass slides and examined with a dissecting microscope or under low

power with a compound microscope. The primary disadvantage of the
compression method is that infections of less than one trichina per gram
of muscle will usually not be identified. Artificial digestion of muscle
samples is frequently used in wildlife trichinosis studies to recover
trichinae because the use of a large sample size may identify minimal
infections (Zimmermann 1971). This method was not used in the present
study because larvae were presumed dead after long storage in the
freezer (Steele 1970) and dead larvae or calcified cysts may be destroyed
by the artificial digestion method.

Most intestinal helminths were recovered by flushing the intestinal
contents from sections of intestine with a plastic hose. Gier and Ameel
(1959) reported that flushing efficiently removes hookworms, tapeworms,
and other helminths from the intestines of coyotes examined several hours
after death. This method appeared effective when used with previously
frozen intestines in this study. Intestinal contents were flushed onto
a set of graded screens and washed with water. Large helminths were
trapped on a number 10 screen and removed with forceps; smaller helminths
were trapped on a number 25 screen, washed into a black plastic tray for
examination with a magnifying glass, and retrieved with forceps or an
eye dropper. Flushed intestinal sections were split lengthwise and the
mucosa was examined with a dissecting microscope. The caecum was split
and carefully examined for caecal worms.

Stomach contents were washed and separated over a set of graded
screens. Large helminths were removed with forceps and smaller helminths
were washed into a black tray for examination and retrieval. The mucosal

lining of the stomach was examined microscopically for helminths.

The surface of the liver was examined for cysts or spots indicative of parasite infection. The liver was then sliced and examined macroscopically for helminths. The kidneys were split and checked for giant kidney worms, Dioctophyma renale. The surface, musculature, and cavities of the heart as well as associated blood vessels were examined macroscopically for heartworms. The trachea and bronchi were opened and checked for lungworms; mucus was frequently removed from the trachea and examined microscopically. Nodules removed from the trachea were teased apart to locate worms. Lung tissue was palpated for cysts and abnormal tissue was examined microscopically.

Cestodes, acanthocephalans, and nematodes were fixed in AFA solution. Nematodes were stored in 70% ethyl alcohol and 5% glycerine. They were cleared by allowing the alcohol to evaporate, or gradually replacing the alcohol-glycerine mixture with glycerine. Most nematodes were examined in temporary glycerine mounts. Cestodes and acanthocephalans were stored in 70% alcohol. Cestode scolices with rostellar hooks were identified by removing the rostellum from the scolex and making camera lucida drawings of the hooks or superimposing camera lucida images on previous drawings of the hooks of known species (Riser 1956, Freeman et al. 1961, Esch and Self 1965). Identifications made by hook shape and measurement were confirmed by examining differential characteristics of proglottid structures on prepared slides. Selected cestodes were stained with Semichon's acetic-carmine, destained in 70% acid alcohol, dehydrated, cleared with xylene, and mounted in Permount.

RESULTS AND DISCUSSION

Of 343 coyote carcasses examined in this study, 116 came from Gregory County, 71 from Harding County, and 156 from Custer County. I examined the diaphragm, tongue, and masseter muscles from 342 animals for trichinosis and the body cavity, heart, lungs, kidneys, and liver of 337 coyotes for parasites. Helminths from the digestive tracts of 290 coyotes were collected and identified. Parasites were found in 287 (99%) of the 290 animals examined completely; 284 (98%) had parasites in their digestive tracts. The parasite load ranged from 1 to 560 helminths per infected coyote. I identified 16 species of parasites (Table 1). Individual infected animals were parasitized by from 1 to 7 species of helminths. Multiparasite infections (infections with more than one parasitic species) were present in 229 (79%) of the coyotes examined completely.

Butler and Grundmann (1954) reported that 54 (72%) of 75 intestinal tracts from Utah coyotes were infected by helminths. In a Kansas study, parasites occurred in the stomach or intestines of 97% of 1850 coyotes (Gier and Ameel 1959). Dunatchik (1967) found parasites in 66 (99%) of 67 Michigan coyotes. Ninety-two percent of 75 Alberta coyotes harbored helminths (Holmes and Podesta 1968).

NEMATODES

Nematodes were the most prevalent group of parasites both in number of coyotes infected and in number of worms recovered. Nematodes occurred in 275 (95%) of 290 coyotes. Butler and Grundmann (1954) found nematodes in the intestinal tracts of 29 (39%) of 75 Utah coyotes.

Table 1. Coyote parasites located in this study.

Species	Hosts Infected	Hosts Examined	Percent
Nematodes			
Toxascaris leonina	215	290	74
Toxocara canis	1	290	
Physaloptera rara	160	290	55
Physaloptera preputialis	1	290	
Pterygondermatites cahirensis	28	290	10
Ancylostoma caninum	38	290	13
Uncinaria stenocephala	1	290	
Dermatoxys veligera	1	290	
Filaroides osleri	121	337	36
Trichinella spiralis	1	343	
Cestodes			
Taenia pisiformis	130	290	45
Taenia hydatigena	5	290	2
Taenia macrocystis	3	290	1
Taenia multiceps	4	290	1
Mesocestoides sp.	19	290	7
Acanthocephalans			
Oncicola canis	3	290	1

Seventh-two percent of 1850 Kansas coyotes were infected with intestinal nematodes (Gier and Ameel 1959). Dunatchik (1967) reported that nematodes parasitized 80% of 67 Michigan coyotes.

Toxascaris leonina

The ascarid Toxascaris leonina was the most common coyote nematode in this study (Table 1). It infected 215 (74%) of 290 coyotes. Parasite load per infected animal ranged from 1 to 357 and averaged 31. Although the adult stage of T. leonina is usually found in the small intestine, I also located it in the stomach, caecum, and body cavity. The abnormal locations were probably due to migration after death of the host. Fourth stage larvae were frequently found in the stomach as well as the intestines. Toxascaris leonina has a direct life cycle. Although no intermediate host is required, a mouse may function as a transport host (Levine 1968). Gier and Ameel (1959) located T. leonina in the intestines, stomach, esophagus, or caecum of 33% of 1850 Kansas coyotes. Incidence during the 11 years of the study varied from 11 to 68%. The yearly average number of worms per infected coyote varied from 7 to 12. Butler and Grundmann (1954) reported that T. leonina was the predominant nematode in Utah coyotes; 28 (37%) of 75 Utah coyotes were infected with the parasite. In a later study, Grundmann (1957) recovered T. leonina from 2 coyotes from the Great Salt Lake Desert of Utah. Toxascaris leonina occurred in 1 of 67 Michigan coyotes (Dunatchik 1967) and 52% of 75 Alberta coyotes (Holmes and Podesta 1968). Conder and Loveless (1978) located T. leonina in 29% of 17 central Utah coyotes. Toxascaris leonina infected 56 (39%) of 144 Iowa coyotes (Franson et al. 1978).

Toxocara canis

Toxocara canis is a common dog ascarid which is infrequently found in coyotes. I recovered 3 adult females and 2 adult males from the small intestine of a young coyote from Custer County (Table 1). The life cycle of T. canis is direct. Prenatal infections frequently occur in dogs (Levine 1968). Although the parasite does not seriously affect adult dogs, pneumonia caused by migration of T. canis larvae in the lungs may be fatal to pups. Toxocara canis occurred in 1 of 75 Utah coyotes (Butler and Grundmann 1954). Holmes and Podesta (1968) found the nematode in 1% of 75 coyotes in Alberta. Conder and Loveless (1978) reported T. canis from 1 of 17 central Utah coyotes.

Physaloptera

The stomach worm Physaloptera rara was found in 160 (55%) of 290 coyotes (Table 1). The closely related P. preputialis was located in one coyote from Custer County. The number cf worms per infected animal ranged from 1 to 194 with an average of 17. The intermediate hosts of P. rara are crickets, grasshoppers, or beetles. Gier and Ameel (1959) reported that experimental infection of coyote pups with 50 or more P. rara resulted in anemia and poor growth. They believed that coyote pups with 50 or more P. rara would probably not survive. However, the number of P. rara found in adult coyotes is usually only mildly detrimental. Olsen et al. (1937) reported Physaloptera sp. from the stomach of a Minnesota coyote. Erickson (1944) located P. rara in 5% of 65

Minnesota coyotes and Physaloptera sp. in 12%. Gier and Ameel (1959)

found Physaloptera sp. in 51% of 1850 Kansas coyotes; most of the

parasites were identified as P. rara but about 3% were P. preputialis.

During the 11 years of their study, the annual incidence of infection

varied from 20 to 64%. The yearly average parasite load per infected

animal was consistently under 10 worms. Physaloptera sp. infected 3 of

18 Texas coyotes examined by Smith (1967). Physaloptera rara occurred

in 61% of 67 Michigan coyotes (Dunatchik 1967). Three of 13 Texas

coyotes examined by Thornton et al. (1974) contained Physaloptera sp.

Conder and Loveless (1978) found Physaloptera sp. in 6% of 17 central

Utah coyotes. Physaloptera sp. infected 96 (67%) of 144 Iowa coyotes

(Franson et al. 1978).

Pterygondermatites cahirensis

Pterygondermatites cahirensis was found in the small intestine of

28 (10%) of 290 coyotes and in the stomach of one coyote (Table 1).

Infestations ranged from 1 to 8 worms with an average of 3 per infected

animal. Of the 71 worms retrieved, 56 (79%) were gravid females. The

female-male ration (FMR) was 3.7. The species was located in coyotes

from Harding, Custer, and Gregory counties. The life cycle of P.

cahirensis is unknown although it may require 2 intermediate hosts, an

unknown invertebrate and a reptile (Levine 1968). Little is known about

the pathogenicity of P. cahirensis. The parasite was previously reported

from the small intestine of a Colorado coyote (Hall 1914). Young and

Pence (1979) recovered 552 specimens of P. cahirensis from 55 (37%) of

150 coyotes from west Texas. Sixty-nine percent of 455 specimens

examined to determine sex were females; the FMR was 2.25. Young and Pence (1979) determined that the FMR of P. cahirensis is above unity and is positively correlated with the worm burden in the coyote.

Ancylostoma caninum

Ancylostoma caninum, a common hookworm of dogs all over the United States, was found in the intestines of 38 (13%) of 290 coyotes and in the stomach of 3 coyotes during this study (Table 1). The number of worms per infected animal ranged from 1 to 19 with an average of 5. Of the 207 A. caninum specimens examined, 126 (61%) were female. The female to male ratio (FMR) was 1.6. Roche and Patrzek (1966) reported that FMRs for hookworms are usually higher than unity. They determined experimentally that length of A. caninum infection in dogs and FMR are positively and significantly correlated. Gier and Ameel (1959) reported that experimental infections of dog or coyote-dog hybrid pups in excess of 75 hookworms caused anemia; heavy infections may be fatal. Pups may acquire prenatal or postnatal infections from their mother. Mitchell and Beasom (1974) concluded that the severity of hookworm infestations in many young host animals may account for some of the natural mortality in wild populations of coyotes. Erickson (1944) reported A. caninum in 3% of 65 coyotes in Minnesota. Gier and Ameel (1959) located this hookworm in 25 of 1850 coyotes examined in Kansas. During the 11 years of their study, incidence varied from 16 to 50%. The yearly average number of worms per infected coyote ranged from 4 to 10. Ancylostoma caninum occurred in 33% of 67 Michigan coyotes (Dunatchik 1967). The species infected 18 Texas coyotes examined by Smith (1967). Ancylostoma

caninum was found in 1% of 75 Alberta coyotes by Holmes and Podesta
(1968). Thornton et al. (1974) recovered A. caninum from 13 Texas
coyotes. Ancylostoma caninum ova were recovered from 89% of 75 fecal
samples taken from collected coyotes and 90% of 188 coyote scats
collected on roads in south Texas (Mitchell and Beasom 1974).
Ancylostoma caninum infected 72 (50%) of 144 Iowa coyotes (Franson et
al. 1978). This species was located in 12% of 17 central Utah coyotes
(Conder and Loveless 1978).

Uncinaria stenocephala

Two female specimens of Uncinaria stenocephala, a carnivore
hookworm with a more northerly distribution, were collected from a
coyote pup from Custer County (Table 1). The life cycle and
pathogenesis of U. stenocephala are similar to Ancylostoma caninum.
Uncinaria stenocephala was found in 16% of 75 Alberta coyotes by Holmes
and Podesta (1968).

Dermatoxys veligera

The stomach of a coyote from Custer County contained 19 pinworms,
Dermatoxys veligera (Table 1). Instances of coyote pinworm infection
are rare and are considered spurious parasitism resulting from ingestion
of the normal host (Skinker 1931, Butler and Grundmann 1954). Skinker
(1931) reported Passalurus nonannulatus from the intestine of a
Washington coyote. Two species of pinworms, Dermatoxys veligera and
Passalurus nonannulatus, were recovered from a Utah coyote by Butler
and Grundmann (1954). Both of these species are commonly found in the
caecum of rabbits.

Filaroides osleri

Filaroides osleri is a minute lungworm usually found in nodules at the tracheal bifurcation although they may be found from the larynx to the secondary bronchi (Morrison and Gier 1978). In this study F. osleri nodules were located in 121 (36%) of 337 coyotes (Table 1). The number of nodules per infected animal ranged from 1 to 19 with an average of 6. Nodules were from 1 to 12 mm in diameter. Individual worms within the nodules were not always counted because of the difficulty of teasing them out intact. Nodules from which worms were counted contained from 1 to 23 worms. The intermediate host of F. osleri is unknown. Infections in the definitive host are chronic and rarely fatal though young dogs may die of suffocation if nodules are large enough to obstruct the wind passages (Levine 1968). Filaroides osleri is not highly pathogenic to coyotes (Pence 1978). Price (1928) examined a coyote in Texas with 5 nodules at the tracheal bifurcation. Erickson (1944) reported the parasite in 4 (6%) of 65 Minnesota coyotes. Filaroides osleri infected 17 (25%) of 67 Michigan coyotes (Dunatchik 1967). Holmes and Podesta (1968) found F. osleri in 11 (15%) of 75 Alberta coyotes. Four of 13 south Texas coyotes examined by Thornton et al. (1974) were infected with F. osleri. The parasite was located in 18% of 17 central Utah coyotes (Conder and Loveless 1978). Pence (1978) reported F. osleri infections in 24 (25%) of 94 Texas coyotes. Cysts of F. osleri occurred in 68 (17%) of 395 Great Plains coyotes (Morrison and Gier 1978); during this study 14 (19%) of 72 coyotes examined from South Dakota had F. osleri . In a subsequent study, Morrison and Gier (1979) located

F. osleri in 39 (22%) of 181 coyotes from the Southwest. In their 2
studies, the number of cysts ranged from 1 to 30, the diameter of cysts
ranged from 1 to 25 mm, and number of worms per cyst ranged from 1 to 20.

Trichinella spiralis

Larvae of Trichinella spiralis, the nematode which causes
trichinosis, were found encysted in the tongue and masseter muscle of 1
of 343 coyotes examined (Table 1). The infected animal was a 4½ year-
old male from Gregory County. Trichinella spiralis has a worldwide
distribution and has been reported from over 100 species of animals.
The parasite is spread by consumption of infected flesh or feces.
Wildlife can serve as a significant reservoir for fecal transmission of
T. spiralis infections to domestic animals (Zimmermann 1970). Rausch et
al. (1956) found Trichinella larvae in 1 of 8 coyotes from Alaska. Olsen
(1960) reported that 1 of 645 coyotes from the Rocky Mountain region of
Colorado had Trichinella larvae. In an Iowa study, 9 (4%) of 207
coyotes had trichinosis (Zimmermann and Hubbard 1969).

Nematodes located in other studies

The kidneys and abdominal cavity of 337 coyotes were examined in
this study, but no giant kidney worms (Dioctophyma renale) were located.
The giant kidney worm is found occasionally in wild canids but is more
common in mustelids. In North America the mink (Mustela vison) is the
main definitive host (Fyvie 1971). Aquatic oligochaetes serve as
intermediate hosts; fish may become transport hosts by eating the
oligochaetes. In California, a young female coyote had external signs
of pregnancy caused by a thickened fibrotic kidney capsule containing

4 adult giant kidney worms (Brunetti 1959). Holmes and Podesta (1968) examined 75 coyotes in Alberta, Canada and found a single female giant kidney worm in the abdominal cavity of one coyote. Fyvie (1971) reported that giant kidney worms were found in the right kidney or abdominal cavity of 8 (1%) of 854 coyotes from Ontario, Canada.

The canine heartworm (Dirofilaria immitis) was not located in any of the 337 hearts examined in this study. No canine heartworm infection has been reported from wild carnivores or domestic dogs in South Dakota. The original enzootic areas of the canine heartworm were the Atlantic and Gulf coastal areas (Otto 1972). While the distribution of canine heartworm disease appears to be spreading widely, the southeastern coastal areas still have the highest incidence of infection, and rates fall off as distance from the coast increases. Though overall incidence is low, widespread pockets of canine heartworms exist in some areas of the Midwest with high densities of mosquitoes, the intermediate host. Minnesota has a high rate of infection in domestic dogs (Schlotthauer and Griffiths 1964); Schlotthauer (1964) found heartworm in the red fox (Vulpes fulva), but a survey of coyotes and timber wolves (Canis lupus) in the state for heartworm disease was negative (Erickson 1944). In an Iowa study, 25 (6.5%) of 385 canine blood samples contained D. immitis microfilariae; however, the 48 samples from the quarter of the state adjacent to South Dakota were negative (Alls and Greve 1974). Ameel (1955) found adult heartworms in 8 of 954 Kansas coyotes he examined. Monson et al. (1973) reported finding heartworms in 2 of 51 coyotes examined in New York. Thornton et al. (1974) found heartworms in the

right ventricles and pulmonary arteries of 3 of 13 coyotes from Texas.
Graham (1975) reported adult heartworms in 9 (8%) of 111 northeastern
Kansas coyotes and 2 (10%) of 20 eastern Colorado coyotes. Adult
heartworms were recovered from the right ventricles of 8 of 220 coyotes
examined from southwestern Iowa (Franson et al. 1976). Since coyotes
may harbor sexually mature heartworms, they may serve as reservoir
hosts (Monson et al. 1973, Gier and Ameel 1959), but wild mammals are
not considered to be significant reservoirs by some investigators
(Schlotthauer 1964, Otto 1969).

Sperry (1941) found the spirurorid _Protospirura numidica_ in 5
western states while doing an extensive coyote food habits study.
Butler and Grundmann (1954) reported the parasite in the intestinal
tract of 1 of 75 Utah coyotes. During his food habits study, Sperry
(1941) located the spirurorid _Mastophorus muris_ in stomachs of coyotes
from Colorado and Washington. The parasite is usually found in the
stomachs of rodents; an arthropod serves as the intermediate host.
Mastophorus muris is closely related to _Protospirura numidica_ and
Yamaguti (1961) lumps the genera together as _Protospirura._

Spirocerca lupi is a spirurorid which usually occurs in nodules in
the walls of the esophagus, stomach or aorta. The life cycle requires a
coprophagous beetle as intermediate host (Bailey et al. 1963). Many
species of vertebrates may serve as transport hosts after consuming
coprophagous beetles (Bailey 1972). The carnivore definitive host may
become infected by eating either the intermediate or transport host;
severe infections can be fatal. No evidence of _S. lupi_ infection was

discovered in the current study. Spirocerca lupi occurred free in the stomach of 1 (1%) of 67 Michigan coyotes (Dunatchik 1967). Smith (1971) examined 107 Texas coyotes and found S. lupi lesions on the wall of the esophagus in 6 (6%) and S. lupi aortic aneurysms in 67 (63%) of the coyotes. Thornton et al. (1974) reported adults of S. lupi located on or in the wall of the esophagus of 3 coyotes and multiple aneurysms from S. lupi in the arch of the aorta in 9 of 13 Texas coyotes. Spirocerca lupi occurred in the aorta of 59 (33%) of 181 coyotes from the Southwest (Morrison and Gier 1979). Conder and Loveless (1978) located Spirocerca sp. encysted in the liver of a coyote from central Utah. The parasite is almost nonexistent in the northern and far western states (Bailey 1972).

Voge (1956) reported the presence of Thelazia californiensis in California coyotes. This species is a spirurorid found in the lachrymal ducts or on the surface of the eye; it can cause blindness. During the current study, eyes were not examined. Presence of this species in South Dakota coyotes is improbable because T. californiensis has been found only in the Southwest and Oregon (Levine 1968).

Gier and Ameel (1959) found the whipworm (Trichuris vulpis) in the caecum of 6% of 1850 Kansas coyotes. Trichuris vulpis infected 10 (7%) of 144 Iowa coyotes (Franson et al. 1978). The whipworm life cycle is direct. Most whipworm infections in dogs do not cause serious effects, although heavy infections can be fatal (Levine 1968).

Capillaria aerophila is a spirurorid lungworm with a direct life cycle though it may be acquired by eating an earthworm transport host (Levine 1968). No C. aerophila infections were identified in this study.

The first report of C. aerophila in coyotes was by Dunatchik (1967) who found 28 worms in 1 of 67 Michigan coyotes. Holmes and Podesta (1968) located C. aerophila in 4 (5%) of 75 coyotes in Alberta, Canada. Capillaria aerophila infections were identified in 151 (38%) of 395 coyotes from the Great Plains by Morrison and Gier (1978). Their identifications were made in the field primarily by the presence of heavy stringy mucus in the bronchi. Twenty-four (75%) of 36 lungs considered positive by field examination were confirmed in the laboratory. Morrison and Gier (1978) believed that detection of stringy mucus at the tracheal bifurcation was an accurate means of detecting C. aerophila infections. They reported that 25 (35%) of 72 South Dakota coyotes were infected with C. aerophila although they gave no indication whether these were field identifications based on the presence of stringy mucus or if the identifications were confirmed in the laboratory. In a subsequent study Morrison and Gier (1979) found C. aerophila in 7 (4%) of 181 coyotes from the Southwest. These were light infections with only a small amount of mucus present. Morrison and Gier (1979) concluded that field determinations of C. aerophila based on presence of thick stringy mucus are unreliable for light infections.

Masses of Capillaria hepatica ova were found in the liver of a juvenile female coyote from southern Saskatchewan but no adult parasites were located (Wobeser and Rock 1973). Capillaria hepatica is normally a parasite of rodents and lagomorphs; this is the only record of C. hepatica from a wild carnivore.

Capillaria plica was found in the urinary bladder of 2 of 67 Michigan coyotes (Dunatchik 1967). The life cycle of C. plica is indirect with earthworms serving as intermediate hosts (Levine 1968); several mammals including dogs, fox, and raccoons (Procyon lotor) are the usual definitive hosts. Capillaria plica does not seriously affect dogs.

Crenosoma vulpis was located in the lungs of 1 of 67 Michigan coyotes (Dunatchik 1967); this is the only record of the parasite from a coyote. Crenosoma vulpis is more commonly found in the bronchi of dogs or foxes which have become infected by consuming the snail or slug intermediate host (Levine 1968). Severe infections in foxes can be fatal (Anderson 1971).

CESTODES

Cestodes occurred in 142 (49%) of 290 coyotes in this study. Forty-eight (64%) of 75 Utah coyotes were infected by cestodes (Butler and Grundmann 1954). Cestodes occurred in 95% of 1850 Kansas coyotes (Gier and Ameel 1959). Freeman et al. (1961) found cestodes in 140 (41%) of 339 coyotes and 8 (24%) of 34 coyote-dog hybrids in Ontario. Dunatchik (1967) reported that cestodes parasitized 78% of 67 Michigan coyotes. Tapeworms are usually not a serious threat to the health of coyotes.

Taenia pisiformis

Taenia pisiformis, the most prevalent species of cestode in coyotes, occurred in 130 (45%) of 290 coyotes (Table 1). Parasite load ranged from 1 to 212 with an average of 39 per infected coyote. The

intermediate host of this cestode is usually the rabbit, a common source of food for the coyote (Ameel 1955). The species and relative abundance of taenioid tapeworms present in the intestines may be an indication of the prey species or carrion in the diet of the coyote (Erickson 1944, Butler and Grundmann 1954). In a survey of 65 Minnesota coyotes, Erickson (1944) found T. pisiformis in 39%. Self and McKnight (1950) identified cestode specimens from 69 coyotes collected at Wichita Mountain Wildlife Refuge in Oklahoma as T. pisiformis. Butler and Grundmann (1954) found 55% of 75 Utah coyotes infected with this parasite. Gier and Ameel (1959) found T. pisiformis in 95% of 1850 Kansas coyotes. During the 11 years of their study, the yearly average infection ranged from 32 to 55 tapeworms per infected coyote. Freeman et al. (1961) reported the parasite in 66 of 68 selected cestode infected Ontario coyotes and 6 of 6 coyote-dog hybrids. The parasite occurred in 72% of 67 Michigan coyotes (Dunatchik 1967) and in 18 Texas coyotes examined by Smith (1967). Taenia pisiformis was found in 31% of 75 Alberta coyotes (Holmes and Podesta 1968). Conder and Loveless (1978) located T. pisiformis in coyotes from central Utah. Taenia sp. infected 125 (87%) of 144 Iowa coyotes (Franson et al. 1978).

Taenia hydatigena

Five Harding County coyotes were found to be infected with Taenia hydatigena (Table 1). Definitive hosts for T. hydatigena include the coyote, the wolf, the bobcat (Lynx rufus), dogs and cats (Leiby and Dyer 1971). Although the normal intermediate hosts are wild ruminants, the cysticercus larval stage is also found in domestic ruminants, rodents,

and hares. Boddicker (1966) in a study of parasites of wild ruminants in South Dakota found cysticerci of T. hydatigena in 1 of 3 bighorn sheep (Ovis canadensis), 4 of 30 mule deer (Odocoileus hemionus), and 5 of 83 white-tailed deer (Odocoileus virginianus). While 12 of the mule deer came from the Harding County area, none of these deer were infected with T. hydatigena cysticerci. Boddicker (1966) felt that extensive predator control in that area may have affected distribution of the parasite by limiting the population of the coyote definitive host. The parasite was found in mule deer from the Black Hills area and Washabaugh County and in white-tailed deer from the Black Hills area and eastern South Dakota. The infected bighorn sheep may have acquired the parasite in Colorado before being transplanted to the Badlands National Monument. The coyote undoubtedly serves as a reservoir for T. hydatigena infection of wild ruminants in South Dakota and may transmit the parasite to domestic ruminants. Light infections of T. hydatigena in cattle cause little damage though heavy infections may be fatal (Morgan and Hawkins 1949). Usually T. hydatigena cysticerci have little harmful effect upon the ruminant intermediate host (Sweatman and Plummer 1957). Erickson (1944) reported that 31% of 65 Minnesota coyotes were infected with T. hydatigena. The parasite was found in 2 of 75 Utah coyotes (Butler and Grundmann 1954). Three of 68 selected cestode infected coyotes in Ontario had T. hydatigena in their intestinal tracts (Freeman et al. 1961). Taenia hydatigena occurred in 5% of 67 Michigan coyotes (Dunatchik 1967). Holmes and Podesta (1968) found T. hydatigena in 1% of 75 coyotes in Alberta.

Conder and Loveless (1978) located T. hydatigena in coyotes from central Utah.

Taenia macrocystis

Taenia macrocystis was located in 3 Harding County coyotes (Table 1). Rabbits serve as the intermediate host. Specimens from Utah coyotes were originally identified as T. rileyi by Butler and Grundmann (1954); Riser (1956) reexamined them and determined that they were T. macrocystis.

Taenia multiceps

Taenia multiceps was recovered from 4 of 290 coyotes in this study (Table 1). The coenurus larval stage of T. multiceps occurs in wild and domestic ruminants, lagomorphs, rodents, and occasionally humans. In ruminants the coenurus cyst develops in the brain or spinal cord causing gid disease which is frequently fatal. In lagomorphs or rodents the infection may also be subcutaneous or intermuscular (Leiby and Dyer 1971). Human infections with T. multiceps larvae are infrequent but usually fatal; they result in symptoms similar to those of a brain tumor (Faust and Russell 1957). Although the canid definitive host is usually not seriously affected by infection with adult T. multiceps, 2 coyotes which were each fed half of a coenurus cyst from the brain of a sheep died within 14 days (Hall 1911, Hall 1912). Coyotes may serve as an important sylvatic reservoir of this parasite in South Dakota. Hunters, trappers, fur handlers, and wildlife personnel working with wild canids should take precautions to prevent infection. Erickson (1944) found T. multiceps in 2% of 65 Minnesota coyotes. Butler and Grundmann (1954)

reported that 4 of 75 Utah coyotes had $\underline{T}$. multiceps; Grundmann (1958) found a single infected coyote in Utah. Voge (1955a) verifies the presence of $\underline{T}$. multiceps in California coyotes. Taenia multiceps occurred in 6% of 67 Michigan coyotes (Dunatchik 1967). In Alberta, Holmes and Podesta (1968) located $\underline{T}$. multiceps in 4% of 75 coyotes. Conder and Loveless (1978) reported $\underline{T}$. multiceps in 47% of 17 central Utah coyotes.

Mesocestoides

Mesocestoides sp. was found in 19 (7%) of 290 coyotes (Table 1). Genus determination was made on the basis of type of attachment structures on the scolices and position of the genital atrium. Speciation of the genus Mesocestoides has been controversial since the late 1800's (Hall 1919, Hoeppli 1925). While many earlier authors recognized a number of species of Mesocestoides parasitic in mammals, Witenberg (1934) merged them in the species $\underline{M}$. lineatus. Later authors continued to use a number of species of Mesocestoides and named new species. Wood and Haldiman (1957) believed that many of the alleged species were actually morphological adaptations of a single species to a variety of hosts and differing localities. Yamaguti (1959) listed 22 species of Mesocestoides. According to Ulmer and James (1976) the genus is monotypic and all described species are probably $\underline{M}$. lineatus, but other authors continue to recognize several species.

The life cycle of most species of Mesocestoides is very complex and incompletely known. An unknown arthropod probably serves as the

first intermediate host; the second larval stage, the tetrathyridium,
occurs in reptiles, amphibians and small mammals. James and Ulmer
(1967) located tetrathyridia in frogs and toads from South Dakota. A
vertebrate transport host may serve as a third host in the life cycle
before the definitive host is infected (Leiby and Dyer 1971). The
cestode can multiply by asexual means not only in the intermediate or
transport hosts, but also in the definitive host (Eckert et al.1969).

Human infections with Mesocestoides tapeworms are infrequent; 13
cases have been reported including 3 from the United States (Chandler
1942, Gleason and Healy 1967, Gleason et al. 1973). Although this
parasite is transmissible to man through a complicated life cycle,
the importance of the coyote as a reservoir is negligible. In
addition, it is doubtful that the role of the coyote as a reservoir for
domestic dog infection has much importance.

Mesocestoides sp. was located in 1 of 68 selected cestode
infected Ontario coyotes (Freeman et al. 1961). Chandler (1944)
proposed the name M. kirbyi for a new species of tapeworm recovered
from coyotes in California. Mesocestoides kirbyi was reported from
California coyotes (Voge 1955a) and an Alaska coyote (Voge 1955b).
Butler and Grundmann (1954) found the parasite in 8 of 75 Utah coyotes.
One of 75 Alberta coyotes was parasitized by M. kirbyi (Holmes and
Podesta 1968). In another Utah study, Conder and Loveless (1978)
observed M. kirbyi in 3 of 17 coyotes they surveyed for parasites.

Voge (1953) reported M. variabilis in a California coyote, kit fox
(Vulpes macrotis), and bobcat; tetrathyridia believed to be larvae of

M. variabilis were located in several species of snakes and lizards. However, Voge (1955b) reviewed the taxonomy of North American cestodes of the genus Mesocestoides and proposed that M. variabilis be regarded as a synonym of M. corti. Mesocestoides corti was collected from a California coyote (Voge 1955a) and from 3 of 1850 coyotes examined in Kansas (Gier and Ameel 1959). The low incidence of infection with M. corti in the Kansas study led Gier and Ameel (1959) to conclude that either the unknown intermediate hosts were not regular items in coyote diets or the intermediate hosts had a low incidence of infection themselves.

Wood and Haldiman (1957) reported a single mature specimen of Mesocestoides lineatus from a Kansas coyote. While they claimed a new host record for the species, if Witenberg (1934) and Ulmer and James (1976) are correct in their hypothesis that all of the previously described species of Mesocestoides are actually M. lineatus, then this is not a new host record but rather a record of the first correct use of the name for a cestode from a coyote. However, Gier and Ameel (1959) delegated this same specimen to the species M. corti.

Grundmann (1956) identified a new species M. carnivoricolus from the badger (Taxidea taxus), the bobcat, and the coyote in the Great Salt Lake Desert region of western Utah. He recovered tetrathyridia which he assumed to be the second larval stage of M. carnivoricolus from the deer mouse (Peromyscus maniculatus) and the canyon mouse (P. crinitus). Grundmann (1956) considered mites to be the logical hosts of the first larval stage of the tapeworm though this hypothesis has not been proven.

Cestodes located in other studies

Freeman et al. (1961) reported recovery of Taenia crassiceps from the small intestine of 1 of 6 coyote-dog hybrids in Ontario; the parasite was not found in 339 coyotes examined in the same study. Though other wild canids may serve as definitive hosts, no natural infections of T. crassiceps from coyotes have been reported; an attempt to establish experimental infections in 5 coyotes failed (Freeman 1962). Rodents are the intermediate hosts (Leiby and Dyer 1971). Cysticerci have been recovered from a meadow vole (Microtus pennsylvanicus) from northern South Dakota (Leiby and Whittaker 1966) but infection of coyotes by T. crassiceps appears unlikely.

Erickson (1944) reported 3% of 65 Minnesota coyotes were infected with Taenia krabbei. One of 75 Utah coyotes had T. krabbei (Butler and Grundmann 1954). Holmes and Podesta (1968) found T. krabbei in 1% of 75 Alberta coyotes. Conder and Loveless (1978) located T. krabbei in coyotes from central Utah. Moose (Alces alces), mule deer, and caribou (Rangifer tarandus) are the intermediate hosts (Leiby and Dyer 1971).

Hamilton (1940) described an apparently new species, Taenia laruei, from the small intestine of an Oklahoma coyote, but Leiby and Dyer (1971) state that this cestode should be regarded as species inquirenda.

Freeman et al. (1961) found Taenia laticollis in 1 of 68 selected cestode infected coyotes in Ontario. The black-tailed jackrabbit (Lepus californicus) and the varying hare (L. americanus) are the intermediate hosts (Leiby and Dyer 1971).

Erickson (1944) reported Taenia rileyi in 5% of 65 Minnesota coyotes. Taenia rilevi was reported from 5% of 67 Michigan coyotes (Dunatchik 1967). Normal definitive hosts for T. rileyi are the Canadian lynx (Lynx canadensis) and the bobcat. Specimens from Utah coyotes were identified as T. rileyi (Butler and Grundmann 1954), but Riser (1956) reexamined them and determined they were T. macrocystis. Rodents serve as intermediate hosts for this species.

Holmes and Podesta (1968) reported Taenia twitchelli in a coyote in Alberta, a new record for coyotes. Taenia twitchelli is a common parasite of the wolverine (Gulo gulo). The porcupine (Erethizon dorsatum) is the intermediate host (Leiby and Dyer 1971).

The double-pored dog tapeworm (Dipylidium caninum) is common in domestic dogs but is seldom found in coyotes. Butler and Grundmann (1954) reported that the tapeworm was present in 1 of 75 Utah coyotes. Gier and Ameel (1959) found D. caninum in 3 of 1850 Kansas coyotes. Fleas and lice are the intermediate hosts (Leiby and Dyer 1971).

Diphyllobothrium sp. was recovered from 5% of 75 Alberta coyotes (Holmes and Podesta 1968). This was a new record for the coyote. The parasite was probably obtained by eating fish, the intermediate host.

Hydatid disease caused by the cosmopolitan tapeworms Echinococcus granulosis or E. multilocularis is a major public health and economic problem in some areas including northern North America (Schiller 1960, Schantz and Schwabe 1969). Neither E. granulosis nor E. multilocularis was located in this study. The larval stage of E. granulosus causes hydatid cysts which can be fatal in the ungulate or human intermediate

host. The definitive host is a domestic or wild canid. Sweatman
(1952) reported E. granulosus in a single Ontario coyote. In a parasite
study prompted by a search for E. granulosus, Butler and Grundmann
(1954) did not locate the parasite in 75 Utah coyotes. Holmes (1961)
recovered E. granulosus from 2 of 15 Alberta coyotes. Freeman et al.
(1961) reported E. granulosus in 2 of 339 Ontario coyotes.
Echinococcus granulosus occurred in 2% of 67 Michigan coyotes
(Dunatchik 1967). Eight percent of 75 Alberta coyotes were infected
with the parasite (Holmes and Podesta 1968). Liu et al. (1970) found
E. granulosus in 7 (4%) of 173 California coyotes. While wolves and
domestic dogs are more common reservoir hosts for this parasite,
coyotes may be locally important in the maintenance of sylvatic
echinococcosis (Holmes 1961, Romano et al. 1974, Loveless and Andersen
1975, Samuel et al. 1976). Leiby et al. (1970) reported the closely
related species, E. multilocularis, in 7 of 111 North Dakota coyotes,
115 of 830 North Dakota red fox (Vulpes vulpes), 1 of 222 South Dakota
red fox, 14 of 277 Minnesota red fox, and 1 of 200 Iowa red fox. The
larval stage of E. multilocularis causes alveolar hydatid cysts in the
liver of rodents, insectivores, or humans. Larval infections are
usually fatal (Leiby and Dyer 1971). Two of 190 meadow voles and 4 of
518 deer mice from southwestern North Dakota had hydatid cysts of E.
multilocularis in their livers (McKenna et al. 1977). Since E.
multilocularis is indigenous to southwestern North Dakota, has been
found in South Dakota red fox, and infects potential coyote prey species,
the possibility of infection of South Dakota coyotes exists. Were this

to occur, it could pose a health threat to South Dakota hunters, trappers, and fur handlers.

ACANTHOCEPHALANS

Acanthocephalans are rare in canids; only one species of thorny-headed worm, Oncicola canis, has been reported from canids in the United States. Oncicola canis was recovered from 3 (1%) of 290 coyotes in this study (Table 1). One of the infected animals harbored 3 gravid female O. canis in its intestines while the other infected coyotes each had a single female.

Kaupp (1909) identified 4 helminth specimens from a dog in Texas as a new species of Acanthocephala, Echinorhynchus canis. Hall and Wigdor (1918) reported E. canis from a dog in Texas and reclassified the parasite as Oncicola canis. Van Cleave (1921) reexamined a specimen collected from a Nebraska dog in 1897 and recorded as Echinorhynchus sp. and determined that it was O. canis. Price (1928) found O. canis in a Texas coyote, a new host record. The parasite was present in 4 of 10 Texas coyotes examined by Smith (1967). The intermediate host of O. canis has not been identified but it is probably an unknown arthropod. Van Cleave (1921) and Price (1926) believed the nine-banded armadillo (Dasypus novemcinctus) was the normal intermediate host and attributed range limitations of O. canis to that factor. Price (1929) reported that acanthocephalid larvae he examined from the esophagus of a turkey poult were probably O. canis; Van Cleave (1953) felt that this was probably an accidental infection. Chandler (1946) found O. canis larvae encysted in 5 of 8 eastern Texas

armadillos but hypothesized that since a high percentage of the larvae were dead and calcified, the armadillo served as a means of destruction of infected arthropod intermediate hosts rather than as an intermediate host itself. Van Cleave (1953) believed that an unknown arthropod served as the essential first intermediate host and the armadillo was the essential second intermediate host. Subsequent distribution records make that appear unlikely. Schmidt (1968) reported O. canis from an Alaskan lynx, a new host record. Since the parasite is found in areas where there are no armadillos, it is probable that the armadillo is either a non-essential transport host or else an accidental host not involved in transmission of O. canis to canids.

TREMATODES

No trematodes were located in this study. Cram (1926) located the trematode Alaria sp. in the small intestines of 3 of 6 Oregon coyotes. LaRue and Barone (1932) identified A. oregonensis from an Oregon coyote. Erickson (1944) reported that 2% of 65 Minnesota coyotes were parasitized by Alaria mustelae. Alaria canis was found in 24% and A. mustelae in 2% of 67 Michigan coyotes (Dunatchik 1967). Holmes and Podesta (1968) examined 75 Alberta coyotes and found that 33% had A. americana and 4% had A. arisaemoides in their intestinal tracts. Thirteen Texas coyotes studied by Thornton et al. (1974) were infected with A. americana. Canids become infected with Alaria sp. by consuming the frog intermediate host or possibly a rodent transport host.

Metorchis conjunctus, a liver fluke, was recovered from 5% of 75 Alberta coyotes (Holmes and Podesta 1968). This was the first record in

a coyote though the trematode is found in other northern carnivores.

Cram (1926) found a massive infestation of Nanophyetus salmincola, the salmon poisoning trematode, in the small intestine of a coyote from Washington. Donham and Simms (1927) fed fish containing N. salmincola cysts to 2 adult coyotes and 2 coyote pups; within 2 weeks after consuming the infected fish, 1 adult coyote and both pups died of salmon poisoning disease. Large numbers of mature flukes and fluke eggs were found in the intestines when the coyotes were autopsied. Schlegel et al. (1968) reported that the small intestine of 1 of 3 western Oregon coyotes they examined harbored 72,000 adult Nanophyetus salmincola. The raccoon and the spotted skunk (Spilogale putorius) are the principal natural definitive hosts. The life cycle requires both snail and fish intermediate hosts. Salmon poisoning flukes are infected with a Neorickettsia which causes salmon poisoning disease in the definitive host; the disease is usually fatal to canids (Meyer and Olsen 1971).

IMPLICATIONS

Several species of parasites present in South Dakota coyotes may be harmful to the health of coyote pups; severe infections of Physaloptera rara, Ancylostoma caninum, or Uncinaria stenocephala may be fatal. While infections of these species in captive animals can be treated successfully, controlling parasites in wild coyote populations is usually impractical or impossible.

None of the helminths parasitizing South Dakota coyotes have serious pathogenic effects on healthy adult coyotes unless the helminths are present in abnormally high numbers. This is not surprising since

during the evolution of a parasitic species it was not advantageous to destroy its host; continued existence of the host species was necessary for continued existence of the parasitic species. Few parasitic species have survived that are capable of rapidly destroying their normal hosts unless the parasites are present in abnormally high numbers. Most parasitic species have evolved definite adaptations to avoid hyperinfestation and consequently disease or death of their hosts (Croll 1966).

Although many species of parasites are harmful to their hosts in some degree, the pathogenic effects tend to be more severe when the pathogenic effect iteself benefits the parasitic species. With few exceptions, when a parasite has an indirect life cycle pathogenic effects are more severe in intermediate hosts than in definitive hosts. This is an evolutionary adaptation which is beneficial to a parasitic species. If the pathogenic effect reduces the stamina, increases the conspicuousness, disorients, or alters the responses of the intermediate host, it increases the vulnerability of the animal to predation by the definitive host (Holmes and Bethel 1972). Coyotes serve as definitive hosts for all species of parasites identified in this study. While these species seldom have serious pathogenic effects on coyotes, they may have debilitating effects on intermediate host species.

Coyotes serve as reservoir hosts for several parasitic species which may have serious pathogenic effects on intermediate host species. In South Dakota, coyotes serve as reservoir hosts for Taenia multiceps, a species with both veterinary and public health significance; T.

multiceps may be debilitating or fatal to big game animals, livestock,
and humans. Although no Echinococcus multilocularis was located in
this study, the presence of E. multilocularis in potential prey species
in South Dakota (McKenna et al. 1977) makes future coyote infections
a possibility; this species can cause fatal hydatid cysts in humans.
Controlling these parasites in wild animal populations is usually not
feasible. However wildlife personnel and fur handlers working with
coyotes in South Dakota should be aware of the possibility of
infection. As man alters the habitat of wildlife, the probability of
hyperinfection of normal hosts and infection of abnormal hosts by
parasitic species increases. This occurs particularly when activities
of man result in the overcrowding of a host population since the
intensity of parasitic infection is frequently dependent on the density
of the host. The coyote may play an increasingly important role as a
reservoir host of potentially harmful parasitic species.

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