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Research Note

Survey of Helminth Lung Parasites of Bobcats (*Lynx rufus*) from Alabama, Kansas, New Mexico, Oklahoma, and Virginia, U.S.A.

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ABSTRACT: Lung tissue from 52 bobcats, *Lynx rufus*, from Alabama, Kansas, New Mexico, Oklahoma, and Virginia were examined for the presence of lung-inhabiting parasites by gross inspection and histological examination. Parasites identified included *Metathelazia californica*, *Troglostrongylus wilsoni*, *Vogeloides felis*, and *Paragonimus kellicotti*. No parasite was discovered in bobcat lungs from New Mexico or Virginia. Distributions of *M. californica* and *V. felis* infections have been extended to include bobcats from Alabama, Kansas, and Oklahoma. The distribution of *P. kellicotti* has been extended to include bobcats from Alabama and Oklahoma, whereas that of *T. wilsoni* now includes bobcats from Alabama.

KEY WORDS: bobcat, *Lynx rufus*, lungworms, *Metathelazia californica*, *Paragonimus kellicotti*, pulmonary parasites, *Troglostrongylus wilsoni*, *Vogeloides felis*.

This study was undertaken to determine the occurrence and prevalence of lung-inhabiting helminths infecting free-ranging bobcats from several previously unsurveyed regions in the United States. Samples of lung tissue were obtained from 52 hunter-trapped bobcats in Alabama, Kansas, New Mexico, Oklahoma, and Virginia. Subsamples from individual bobcats were fixed in 10% neutral buffered formalin, embedded in paraffin, cut into 5-μm-thick sections, stained with hematoxylin and eosin, and examined microscopically. Tissue not embedded were examined grossly for parasites and dissected under ×10 magnification. Complete or partial nematodes were removed, cleared with lactophenol, and examined microscopically.

Three nematodes, *Metathelazia californica*, *Vogeloides felis*, and *Troglostrongylus wilsoni*, and 1 trematode, *Paragonimus kellicotti*, were detected. Nematodes were identified on the basis of gross specimen morphology using descriptions by Pence and Stone (1977) for *M. californica* and *V. felis* and Sarmiento and Stough (1956) for *T. wilsoni*. Characters used to identify specimens were as follows: *M. californica*, size (female width = 184–236 μm, male width = 104–125 μm), occurrence in lung parenchyma, and presence of cuticular hypodermal tuberculations; *V. felis*, size (female width = 442–589 μm, male width = 162–346 μm), occurrence in bronchi, and presence of cuticular ridges; *T. wilsoni*, size (female width = 340–420 μm, male width = 310–390 μm), occurrence in either bronchi or alveoli, and female ovovivipary. *Paragonimus kellicotti* were identified in histological sections based on the appearance of internal organs embedded in a parenchymous matrix surrounded by a spined tegument (Gardiner and Poynton, 1999).

Representative specimens, consisting of complete or partial adult parasites or histological preparations of each species, are deposited in the U.S. National Parasite Collection, accession numbers: 92627, 92631, and 92632 (*M. californica*); 92626 (*T. wilsoni*); 92628, 92629, and 92630 (*V. felis*); and 92633 and 92634 (*P. kellicotti*). Prevalence is reported in this study, but full lungs were not available for examination; thus, intensity of parasite infection in individual bobcats could not be determined. Prevalence estimates were calculated by combining data gathered from dissections and histologic examination. The study examined partial lung samples from a small host sample and probably underestimates true prevalence levels.

Postmortem autolysis of some specimens prohibited uniform evaluation of pathological changes associated with the presence of parasites. However, when detectable, pathological changes were similar to that previously reported for *M. californica* and *V. felis* by Pence and Stone (1977) and *P. kellicotti* (Snyder et al., 1991). Infections with *V. felis* were characterized by mild to moderate hyperplasia to moderate squamous metaplasia with prominent peribronchiolar lymphoid aggregates. Infections with *M. californica* and *T. wilsoni* elicited a response characterized by proteinaceous edema. No published report describes pathological changes in a bobcat lung infected with

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Table 1. Prevalence of lung-infecting helminths in bobcats from 11 states in the United States.

State	*n*	*Capillaria aerophila* (%)	*Filaroides rostratus* (%)	*Metathelazia californica* (%)	*Paragonimus kellicotti* (%)	*Troglostrongylus wilsoni* (%)	*Vogeloides felis* (%)	Reference
Alabama	8	—	—	38	13	13	25	Present study
Arkansas	5	—	40	—	40	—	—	Snyder et al. (1991)
California	1	—	—	100	—	—	100	Skinker (1931)*
Georgia	6	—	—	—	17	—	—	McKeever (1957)
	1	—	—	—	100	—	—	Jordan and Byrd (1958)
	10	—	10	—	10	10	—	Watson et al. (1981)
Kansas	14	—	—	7	—	—	7	Present study
Nebraska	75	4	—	—	—	—	7	Tiekotter (1985)
North Carolina	16†	—	13†	—	8	—	—	Miller and Harkema (1968)
Oklahoma	19	—	—	58	5	—	42	Present study
Texas	9	—	—	—	—	22	—	Little et al. (1971)
	66	3	—	73	—	—	80	Stone and Pence (1978)
Virginia	24	—	96	33	21	22	13	Klewer (1958)
West Virginia	143	25	45	6‡	16	73	—	Watson et al. (1981)

* Nematodes were redescribed by Pence and Stone (1978).

† Prevalence estimate includes 4 bobcats from South Carolina.

‡ Presumed *M. californica*, however, reported as *Metathelazia* sp.

T. wilsoni. We observed a proteinaceous edema in the lungs of a single bobcat infected with *T. wilsoni* from Alabama.

Published reports from each state on the prevalence of individual helminths infecting bobcat lungs and the results of this study are summarized in Table 1. In this study, 5 of 8 (63%) bobcats from Alabama were infected with 1 or more lung-inhabiting helminths. Two of the 5 (40%) lung samples from Alabama had mixed infections of *M. californica* and *V. felis*, whereas the other 3 (60%) were single infections with *P. kellicotti*, *T. wilsoni*, or *M. californica*. Two of the 14 (14%) bobcats examined from Kansas harbored helminths, both of which were single infections of *M. californica* or *V. felis*. Fourteen of the 19 (74%) bobcat lung samples from Oklahoma were infected: 5 (36%) had mixed infections of *M. californica* and *V. felis*, 6 (43%) harbored single infections of *M. californica*, 2 (14%) had single infections of *V. felis*, and 1 (7%) was infected with *P. kellicotti*. No lung-inhabiting helminth was observed in a bobcat examined from New Mexico or Virginia ($n = 4$ and 7, respectively).

The distributions of *M. californica* and *V. felis* are extended to include bobcats from Alabama, Kansas, and Oklahoma and that of *T. wilsoni* to Alabama. The distribution of *P. kellicotti* is extended to include bobcats from Alabama and Oklahoma. These lung-inhabiting helminths are widely distributed in bobcats throughout the United States, occurring without conformance to any recognizable geographic pattern. However, *Capillaria aerophila* and *Filaroides rostratus*, previously reported in bobcat lungs, were not found during this study (Table 1). They may not have been detected because of the small sample size or partial lung samples examined in this study. Alternatively, ecological or geographical factors may affect their distributions. Neither *Cytauxzoon felis* (Kocan and Waldrup, 2001) nor *Toxoplasma gondii* (Dubey and Odening, 2001) were detected in the 52 samples examined, although both have been observed previously in histological preparations of bobcat lungs. Their absence may be the result of limited life-cycle stages in lung tissue, or again, ecological or geographical factors may affect their distributions.

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LITERATURE CITED

Dubey, J. P., and K. Odening. 2001. Toxoplasmosis and related infections. Pages 478–519 *in* W. M. Samuel, M. J. Pybus, and A. A. Kocan, eds. Parasitic Diseases of Wild Mammals, 2nd ed. Iowa State University Press, Ames, Iowa.

Gardiner, C. H., and S. L. Poynton. 1999. An Atlas of Metazoan Parasites in Animal Tissues. Registry of Veterinary Pathology, Armed Forces Institute of Pathology, American Registry of Pathology, Washington, D.C. 63 pp.

Jordan, H. E., and E. E. Byrd. 1958. *Paragonimus* in wild and domesticated animals in Georgia. Journal of Parasitology 44:470.

Klewer, H. L. 1958. The incidence of helminth lung parasites of *Lynx rufus rufus* (Shreber) and the life

cycle of *Anafilaroides rostratus* (Gerichter, 1949). Journal of Parasitology 44(supplement):29.

Kocan, A. A., and K. A. Waldrup. 2001. Piroplasms (*Theileria* spp., *Cytauxzoon* spp., and *Babesia* spp.). Pages 524–536 *in* W. M. Samuel, M. J. Pybus, and A. A. Kocan, eds. Parasitic Diseases of Wild Mammals, 2nd ed. Iowa State University Press, Ames, Iowa.

Little, J. W., J. P. Smith, F. F. Knowlton, and R. R. Bell. 1971. Incidence and geographic distribution of some nematodes in Texas bobcats. The Texas Journal of Science 22(4):403–407.

McKeever, S. 1957. Observations on *Paragonimus kellicotti* Ward from Georgia. Journal of Parasitology 44:324–327.

Miller, G. C., and R. Harkema. 1968. Helminths of some wild mammals in the southeastern United States. Proceedings of the Helminthological Society of Washington 35(2):118–125.

Pence, D. B., and J. E. Stone. 1977. Lungworms (Nematoda: Pneumospiruridae) from west Texas carnivores. Journal of Parasitology 63(6):979–991.

Sarmiento, L., and B. D. Stough. 1956. *Troglostrongylus wilsoni* (Stough, 1953) n. comb. (Nematoda: Metastrongylidae) from the lungs of the bobcat (*Lynx rufus rufus*). Journal of Parasitology 42(1):45–48.

Skinker, M. S. 1931. Three new parasitic nematode worms. Proceeding of the United States National Museum 79:1–9.

Snyder, D. E., A. N. Hamir, V. F. Nettles, and C. E. Rupprecht. 1991. Lesions associated with pulmonary parasites in bobcats (*Felis rufus*) from Arkansas. Journal of Wildlife Diseases 27(1):170–174.

Stone, J. E., and D. B. Pence. 1978. Ecology of helminth parasitism in the bobcat from west Texas. Journal of Parasitology 64(2):295–302.

Tiekotter, K. L. 1985. Helminth species diversity and biology in the bobcat, *Lynx rufus* (Schreber), from Nebraska. Journal of Parasitology 71(2):227–234.

Watson, T. G., V. F. Nettles, and W. R. Davidson. 1981. Endoparasites and selected infectious agents in bobcats (*Felis rufus*) from West Virginia and Georgia. Journal of Wildlife Diseases 17(4):547–554.

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Research Note

First Report of the Acanthocephalan *Plagiorhynchus cylindraceus* in the Terrestrial Isopod *Porcellio scaber*

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ABSTRACT: Terrestrial isopod populations were examined from 5 different sites on the Penn State–Altoona campus in Altoona, Pennsylvania, U.S.A. Length and sex of each isopod were recorded before it was examined for acanthocephalan parasites. Three isopod species were found: *Armadillidium vulgare*, *Porcellio scaber*, and *Oniscus asellus*. The acanthocephalan parasite *Plagiorhynchus cylindraceus* was found in *P. scaber* from a single site (site prevalence, 2.5%). This is the first report of natural infection of *P. scaber* by *P. cylindraceus*.

KEY WORDS: *Plagiorhynchus cylindraceus*, *Porcellio scaber*, *Armadillidium vulgare*, *Oniscus asellus*, acanthocephalan, isopod, Crustacea, Isopoda, Pennsylvania, U.S.A.

Plagiorhynchus cylindraceus is an acanthocephalan parasite of passerine birds in North America. Mature worms live in the gut of their definitive avian host. Eggs are passed out in the feces and are then consumed by terrestrial isopods, which serve as the intermediate host (Schmidt and Olsen, 1964). The eggs hatch and develop into acanthor larvae and eventually into cystacanth larvae. During the parasite's development, isopod females are castrated (rendered sterile). When an infected isopod is eaten by the definitive host, the worm everts its proboscis, attaches to the intestinal lining of the bird, and matures to complete the life cycle (Schmidt and Olsen, 1964).

Plagiorhynchus cylindraceus infections occur in natural isopod populations at low prevalence (Schmidt and Olsen, 1964; Moore, 1983). Although *Armadillidium vulgare* is the only terrestrial isopod

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species from which natural infections of *P. cylindraceus* have been documented (Coady and Nickol, 2000), experimental infections have been demonstrated in other isopod species in laboratory culture (Schmidt and Olsen, 1964). *Plagiorhynchus cylindraceus* cystacanths have also been discovered in shrews, which can serve as paratenic hosts (Nickol and Oetinger, 1968; Coady and Nickol, 2000). The study reported here assessed 3 terrestrial isopod taxa for naturally occurring infections of *P. cylindraceus*.

Isopods were collected from under rocks, under logs, and along curbs in 5 woodland and parking lot sites on the Penn State–Altoona campus in Blair County, Pennsylvania, U.S.A. (40°32′N; 78°24′W), in September and October 2001. Isopods were preserved in 70% ethanol immediately after collection. Each isopod was identified using available keys (Eddy and Hodson, 1982; Oliver and Meechan, 1993) and dissected to assess acanthocephalan infection. Isopod taxon, length, sex, brooding condition, and parasite load were recorded. Parasite voucher specimens (P-2003-704) are deposited in the University of Nebraska State Museum, Lincoln, Nebraska, U.S.A.

Three isopod species were examined: *A. vulgare* ($n = 1{,}117$), *Porcellio scaber* ($n = 506$), and *Oniscus asellus* ($n = 2$). *Plagiorhynchus cylindraceus* cystacanths were found in specimens of *P. scaber* from a single sample site. Six of 256 individuals were infected (2.3%) with cystacanths at intensities of 1, 1, 1, 2, 3, and 5. There was no significant difference in the length of infected (10.0, 7.3–12.2, ±1.7) and uninfected (8.6, 3.1–13.6, ±2.1) *P. scaber* (analysis of variance: $F = 0.83$; $P = 0.851$). This is the first report of natural infection of *P. scaber* by *P. cylindraceus*, although there have been reports of successful experimental infections (Schmidt and Olsen, 1964).

The natural prevalence of *P. cylindraceus* in isopod populations is usually low, ranging from 0% to 0.15% (Nickol and Dappen, 1982). The prevalence reported in this study is consistent with this pattern. Generally, low infection rates may be the result of host resistance (Dappen and Nickol, 1981) or low infective egg encounter rates for intermediate hosts even when prevalence in the definitive host is high (Moore, 1983).

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LITERATURE CITED

Coady, N. R., and B. B. Nickol. 2000. Assessment of parenteral *Plagiorhynchus cylindraceus* (Acanthocephala) infections in shrews. Comparative Parasitology 67:32–39.

Dappen, G. E., and B. B. Nickol. 1981. Unaltered hematocrit values and differential hemocyte counts in acanthocephalan-infected *Armadillidium vulgare*. Journal of Invertebrate Pathology 38:209–212.

Eddy, S., and A. C. Hodson. 1982. Taxonomic Keys to the Common Animals of the North Central States. Burgess Publishing Co., Minneapolis, Minnesota. 205 pp.

Moore, J. 1983. Responses of an avian predator and its isopod prey to an acanthocephalan parasite. Ecology 64:1000–1015.

Nickol, B. B., and G. E. Dappen. 1982. *Armadillidium vulgare* (Isopoda) as an intermediate host of *Plagiorhynchus cylindraceus* (Acanthocephala) and isopod response to infection. Journal of Parasitology 68:570–575.

Nickol, B. B., and D. F. Oetinger. 1968. *Prosthorhynchus formosus* from the short-tailed shrew (*Blarina brevicuada*) in New York State. Journal of Parasitology 54:456.

Oliver, P. G., and C. J. Meechan. 1993. Woodlice. Linnean Society of London, Shrewsbery, U.K. 135 pp.

Schmidt, G. D., and O. W. Olsen. 1964. Life cycle and development of *Prosthorhyncus formosus* (Van Cleave, 1918) Travossos, 1926, an acanthocephalan parasite of birds. Journal of Parasitology 50:721–730.