The Genus *Oxyspirura* (Nematoda: Thelaziidae) from Birds in Louisiana

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ABSTRACT: The eyeworms of the genus *Oxyspirura* of birds in southern Louisiana were studied. The number of known avian hosts for oxyspirurids in North America is increased to 28 species. *Oxyspirura petrowi* is recorded for the first time from *Agelaius phoeniceus, Cassidix mexicanus, Quiscalus quiscula, Molothrus ater, Tyrannus tyrannus, Myiarchus crinitus, Anthus spinoletta, Richmondena cardinalis, Vireo griseus, Iridoprocne bicolor, Butorides virescens,* and *Bubulcus ibis.* New host records for *Oxyspirura pusillae* are *Centurus carolinus, Melanerpes erythrocephalus, Thryothorus ludovicianus, Toxostoma rufum, Quiscalus quiscula, Myiarchus crinitus, Richmondena cardinalis, Sialia sialis,* and *Dendrocopos villosus. O. petrowi* is considered as a species of wide geographic range, which exhibits considerable metrical variation, and demonstrates little host specificity. *Oxyspirura lumsdeni* is rejected as a species distinct from *O. petrowi.* The natural history and systematics of these oxyspirurids are discussed.

Although 72 "valid" species of the genus *Oxyspirura* are described as parasites of the eyes of birds, only four have been reported from North America, north of Mexico (Addison and Anderson, 1969a). Ransom (1904) reported *Oxyspirura mansoni* from Louisiana, Puerto Rico, and adjacent islands. Saunders (1928) found *O. mansoni* in domestic fowl in Florida and was successful in experimentally infecting pigeons, bobolinks, shrikes, and blue jays. Cram (1937) described a species identified as *Oxyspirura petrowi* Skrjabin (1929) from ruffed grouse, the prairie chicken, sharp-tailed grouse, the eastern robin, and the meadow lark in Michigan. More recently, *Oxyspirura pusillae* was described from the brown-headed nuthatch, *Sitta pusilla,* in Georgia (Wehr and Hwang, 1957). Both *O. petrowi* and *O. pusillae* are reported from the yellow-throat, *Geothlypis trichas,* in South Carolina (Wells and Hunter, 1960). *Oxyspirura lumsdeni* was described from ruffed grouse, sharp-tailed grouse, lesser and greater prairie chickens, and pheasant in southern Canada and the United States by Addison and Anderson (1969b), who considered the specimens described by Cram (1937) from some of the same hosts as this species.

The present investigation was initiated in order to determine the occurrence of oxyspirurid infections in wild bird populations and to determine the species occurring in southern Louisiana. Birds were collected from several study areas, all within a radius of 150 miles of New Orleans, Louisiana. Eyeworms were removed from infected birds, fixed briefly in glacial acetic acid, and stored in a mixture of 5 parts glycerin and 95 parts of 70% ethyl alcohol. Specimens were studied in glycerin mounts after evaporation of the alcohol.

The morphological and metrical variations of specimens from different hosts were examined in order to determine the validity of certain characteristics used in oxyspirurid systematics. This information was compared with the original descriptions of certain described species. All measurements are in millimeters unless otherwise indicated. Specimens from the various hosts collected in Louisiana are deposited in the USNM Helm. Coll. Numbering for *O. petrowi* (No. 71766–71779) and *O. pusillae* (No. 71780–71789) follows sequences of hosts in Table 1.

Results

Eyeworms were recovered from 21 species of birds (Table 1). They were identified as *Oxyspirura petrowi* and *Oxyspirura pusillae.* Of the 14 species infected with *O. petrowi,* all but the meadow lark and robin, and of the 10 infected with *O. pusillae,* all but the nuthatch, are recorded as hosts of the respective species for the first time. Three species of birds, the purple grackle, crested flycatcher, and cardinal, were found infected on different occasions with both *O. petrowi* and *O. pusillae.* All the speci-

Table 1. The hosts of *Oxyspirura petrowi* and *O. pusillae* in Louisiana. *Denotes new host record.

Host	Incidence	Number of parasites collected
Oxyspirura petrowi		
1. Meadow lark (*Sturnella magna*)	20/24	51
2. Red-winged blackbird (*Agelaius phoeniceus*)*	3/20	10
3. Boat-tailed grackle (*Cassidix mexicanus*)*	4/12	22
4. Purple grackle (*Quiscalus quiscula*)*	1/11	12
5. Cowbird (*Molothrus ater*)*	1/19	1
6. Eastern kingbird (*Tyrannus tyrannus*)*	1/10	2
7. Crested flycatcher (*Myiarchus crinitus*)*	1/16	1
8. Water pipit (*Anthus spinoletta*)*	1/6	1
9. Cardinal (*Richmondena cardinalis*)*	1/20	2
10. White-eyed vireo (*Vireo griseus*)*	1/10	1
11. Tree swallow (*Iridoprocne bicolor*)*	1/69	1
12. Eastern robin (*Turdus migratorius*)	1/22	4
13. Green heron (*Butorides virescens*)*	1/15	1
14. Cattle egret (*Bubulcus ibis*)*	1/14	1
Oxyspirura pusillae		
1. Red-bellied woodpecker (*Centurus carolinus*)*	20/36	164
2. Red-headed woodpecker (*Melanerpes erythrocephalus*)*	5/12	29
3. Hairy woodpocker (*Dendrocopos villosus*)*	1/12	1
4. Carolina wren (*Thryothorus ludovicianus*)*	4/33	17
5. Brown thrasher (*Toxostoma rufum*)*	3/22	3
6. Brown-headed nuthatch (*Sitta pusilla*)*	2/15	16
7. Purple grackle (*Quiscalus quiscula*)*	1/11	4
8. Crested flycatcher (*Myiarchus crinitus*)*	1/16	4
9. Cardinal (*Richmondena cardinalis*)*	1/20	1
10. Blue bird (*Sialia sialis*)*	2/7	8

ments collected constitute new geographic records for these parasites.

Specimens from the water pipit, green heron, and cattle egret consisted of a single immature female and two mature female worms, respectively. These are regarded as *O. petrowi* since they are morphologically identical to the females of that species. Specimens from the remaining hosts conform in most respects to the descriptions of *O. petrowi* found in Skrjabin (1929), Cram (1937), Baruš (1965), and Ybarra (1948); however, metrical variations occur in certain key morphological characters in specimens from different hosts (Table 2). Specimens from the meadow lark and boat-tailed grackle represent the extremes of metric variability in certain characters. Especially notable is the considerable variation in the length of the right spicule, even in specimens from the same host.

Oxyspirura lumsdeni was proposed as a new species by Addison and Anderson (1969b) primarily because of the presence of deirids, which Skrjabin (1929) did not mention in his description of *O. petrowi*, and the greater length of the right spicule. However, according to Baruš (pers. comm.) deirids are present on all specimens identified as *O. petrowi* collected from several species of birds in eastern Europe, including some of the same species from which Skrjabin described this species. Comparison of specimens from Czechoslovakia identified as *O. petrowi* from *Saxicola rubetra* and specimens of *O. lumsdeni* from tetraonids from Canada with those collected in the present study revealed that eyeworms from all these sources are morphologically indistinguishable and the specimens from birds in Louisiana are intermediate in size between those from Europe and Canada.

Practically all of the size relationships authoritatively reported for *O. petrowi* fall within the ranges reported for the specimens collected in the present study (Table 3). In addition, most of the latter ranges fall within those reported for *O. lumsdeni*. Therefore, and in view of the observed lack of host specificity, *O. lumsdeni* is indistinguishable from *O. petrowi* and is rejected as a synonym.

Oxyspirura (*Oxyspirura*) *petrowi* Skrjabin 1929

GENERAL: (Based on 40 male and 40 female specimens.) Spiruroidea, Thelaziidae, Thelaziinae, *Oxyspirura* Drasche in Stossich, 1897, subgenus *Oxyspirura* Skrjabin, 1931, *Oxyspirura petrowi* Skrjabin, 1929. Body slender, yellow to cream color, bluntly rounded anteriorly, sharply attenuated posteriorly. Cervical alae present. Cuticle transversely striated. Mouth with four submedian pairs and three circumoral pairs of cephalic papillae. Amphids present. Cuticularized buccal capsule undivided. Esophagus not discernibly divided into muscular and glandular portions. Deirids lateral just anterior to nerve ring. Excretory pore posterior to nerve ring. Gravid uterus variable in position and sometimes extending into the esophageal region. Vulva and anus in posterior quarter of body. Spicules unequal and dissimilar. No gubernaculum or caudal

Table 2. Comparison of metric characteristics of *Oxyspirura petrowi* from different hosts in Louisiana.

Host Specimens	Meadow lark 20 ♂♂, 20 ♀♀	Boat-tailed grackle 10 ♂♂, 10 ♀♀	Red-winged blackbird 5 ♂♂, 5 ♀♀	Robin 2 ♂♂, 2 ♀♀	Purple grackle 1 ♂♂, 3 ♀♀	Cardinal 1 ♂♂, 1 ♀♀	Eastern kingbird 1 ♂♂, 1 ♀♀
Male							
Length	6.44–8.63 (7.75)	6.35–7.93 (6.89)	7.13–8.10 (7.61)	(8.31)	7.50	6.85	7.27
Esophagus length	0.53–0.65 (0.60)	0.53–0.60 (0.56)	0.55–0.63 (0.59)	(0.77)	0.58	0.64	0.60
Nerve ring—distance from anterior end	0.11–0.17 (0.14)	0.11–0.14 (0.13)	0.12–0.13 (0.13)	(0.15)	0.14	0.15	0.15
Excretory pore—distance to anterior end	0.22–0.33 (0.26)	0.22–0.26 (0.24)	0.22–0.28 (0.26)	(0.28)	0.25	0.26	0.25
Right spicule length	0.17–0.32 (0.21)	0.12–0.15 (0.14)	0.13–0.14 (0.14)	(0.20)	0.16	0.19	0.23
Left spicule length	0.33–0.51 (0.44)	0.26–0.33 (0.30)	0.29–0.32 (0.30)	(0.42)	0.34	0.36	0.41
Female							
Length	8.90–12.50 (10.80)	8.00–11.50 (9.20)	7.70–9.82 (8.76)	(11.70)	10.50	11.95	11.70
Esophagus length	0.55–0.73 (0.64)	0.57–0.65 (0.60)	0.58–0.60 (0.59)	(0.76)	(0.61)	0.66	0.68
Nerve ring—distance from anterior end	0.11–0.16 (0.13)	0.12–0.15 (0.14)	0.13–0.14 (0.13)	(0.17)	(0.15)	0.12	0.15
Excretory pore—distance from anterior end	0.14–0.34 (0.26)	0.19–0.28 (0.25)	0.23	(0.26)	(0.27)	0.28	0.28
Vulva—distance to posterior end	0.51–0.70 (0.61)	0.52–0.61 (0.57)	0.50–0.60 (0.55)	(0.59)	(0.60)	0.55	0.60
Egg length	(0.041)	(0.039)	(0.040)	(0.040)	(0.038)	0.035	0.044
Egg width	(0.028)	(0.024)	(0.028)	(0.027)	(0.027)	0.024	0.020

Table 3. Comparison of the metric characteristics of *Oxyspirura petrowi* and *O. lumsdeni*.

Species Authority	*O. petrowi*			*O. lumsdeni* Addison and Anderson, 1969
	Skrjabin, 1929	Baruš, 1965	Present author	
Male				
Length	5.5–6.4	4.8–6.0	6.3–8.6 (7.4)	6.9–16.4 (11.8)
Width	0.22–0.28	0.19–0.22	0.14–0.29 (0.21)	0.19–0.39 (0.29)
Esophagus length	0.74	0.57–0.62	0.53–0.68 (0.59)	0.61–1.02 (0.81)
Nerve ring—distance from anterior end	—	0.33	0.11–0.17 (0.13)	0.16–0.23 (0.19)
Excretory pore—distance from anterior end	—	0.18–0.19	0.22–0.33 (0.25)	0.25–0.44 (0.33)
Right spicule length	0.125	0.148–0.152	0.121–0.320 (0.183)	0.200–0.260 (0.220)
Left spicule length	—	0.243–0.340	0.264–0.517 (0.381)	0.440–0.600 (0.520)
Female				
Length	9.2	5.9–6.2	7.70–12.35 (10.17)	11.4–22.5 (16.4)
Width	0.42	0.25–0.32	0.20–0.46 (0.31)	0.27–0.60 (0.41)
Esophagus length	0.95	0.62	0.55–0.73 (0.62)	0.55–0.110 (0.86)
Nerve ring—distance from anterior end	0.16–0.17	0.16	0.11–0.16 (0.14)	0.16–0.24 (0.19)
Excretory pore—distance from anterior end	0.30	0.39	0.14–0.31 (0.26)	0.27–0.46 (0.33)
Egg length	0.039–0.041	0.038–0.040	0.035–0.044 (0.039)	0.029–0.048 (0.038)
Egg width	0.026–0.028	0.026–0.028	0.015–0.031 (0.026)	0.022–0.036 (0.027)
Vulva—distance from posterior end	0.41–0.43	0.29–0.36	0.50–0.70 (0.59)	0.48–0.83 (0.62)

alae. Ventral caudal papillae present in male. Phasmids present in both sexes.

MALE: Length 6.27–8.63 (7.40). Maximum width 0.185–0.330 (0.237). Buccal capsule: Length 14–29 μ (21); width 13–23 μ (18). Esophagus 0.530–0.680 (0.590) long. Nerve ring 0.110–0.165 (0.137) and excretory pore 0.219–0.330 (0.255) from anterior extremity. Right spicule 0.121–0.320 (0.183) long and boat-shaped. Left spicule slender with sharp tip, 0.264–0.517 (0.381) long. Tail sharp-pointed, 0.181–0.330 (0.255) long. Preanal papillae 4 to 6 in number, asymmetrically arranged. Postanal papillae 4 to 6 in number, asymmetrically arranged. Phasmids usually lateral, 0.055–0.154 (0.111) from posterior extremity.

FEMALE: Length 7.70–12.35 (10.17). Maximum width 0.200–0.455 (0.308). Buccal capsule 18–28 μ (22) long and 15–26 μ (21) wide. Esophagus 0.550–0.730 (0.620) long. Nerve ring 0.110–0.158 (0.137) and excretory pore 0.136–0.308 (0.260) from anterior extremity. Vulva 0.500–0.700 (0.591) from posterior extremity. Anus 0.242–0.400 (0.328) from posterior extremity. Phasmids usually lateral 0.100–0.176 (0.136) from posterior extremity. Eggs embryonated, 35–44 μ (39) long, 15–31 μ (26) wide.

Additional descriptions and good figures of *O. petrowi* are found in Skrjabin (1929), Cram (1937), Baruš (1965), and Addison and Anderson (1969b).

Oxyspirura pusillae was obtained from 10 species of birds. This species is differentiated from other similar species of the subgenus *Yorkeispirura* with a gubernaculum by the presence of six preanal, two adanal, and four postanal papillae and by the greater length of the spicules. It is very similar to *Oxyspirura tsingchengensis* Hsü, 1933, but differs in having two adanal papillae and a cuticularized thickening around the vulva. Although Hsü (1933) did not mention the presence of a gubernaculum in this species, figure 42 of his description indicates its possible presence. Also, *O. pusillae* is similar to *O. mansoni* except the latter species supposedly lacks a gubernaculum. However, some authors state that this structure is present in *O. mansoni*, while others contend that it is absent. On the basis of existing descriptions, *O. pusillae* can be differentiated from these two species only on the basis of the cuticularized thickening of the vulva and possibly by the presence of a gubernaculum.

Oxyspirura (Yorkeispirura) pusillae Wehr and Hwang, 1957

GENERAL: (Based on 40 male and 40 female specimens.) Spiruroidea, Thelaziidae, Thelaziinae, *Oxyspirura* Drasche in Stossich, 1897, subgenus *Yorkeispirura* Skrjabin, 1931, *Oxyspirura pusillae* Wehr and Hwang, 1957. Body slender, white in color, rounded anteriorly, sharply attenuated posteriorly. No cervical alae. Cuticle smooth. Mouth terminal, with four submedian pairs and three circumoral pairs of cephalic papillae. Amphids present. Well-cuticularized buccal capsule divided by a distinct constriction into two cylindrical parts. Esophagus not discernibly divided into a muscular and glandular portion. Deirids present in the region of the excretory pore. Excretory pore ventral and posterior to nerve ring. Vulva and anus in posterior quarter of body. Vulva with cuticularized thickening at its opening. Spicules unequal and dissimilar. Gubernaculum present. No caudal alae present. Ventral caudal papillae present in the male. Phasmids present in both sexes.

MALE: Length 6.65–9.85 (8.39). Maximum width 0.140–0.240 (0.191). Buccal capsule: Anterior part 11–18 μ (14) deep and 11–24 μ (20) wide; posterior part 14–28 μ (22) deep and 10–22 μ (14) wide. Esophagus 0.820–1.350 (1.080) long. Nerve ring 0.156–0.284 (0.198) and excretory pore 0.194–0.367 (0.296) from anterior extremity. Right spicule stout, 0.149–0.242 (0.209) long. Left spicule slender, often with undulations, sharp-pointed, 1.710–2.330 (2.032) long. Gubernaculum 39–88 μ (56) long. Ventral caudal papillae asymmetrically arranged, three pairs preanal, one pair adanal, and two pairs postanal. Phasmids lateral, 32–73 μ (55) from tip of tail.

FEMALE: Length 7.93–14.78 (11.72). Maximum width 0.140–0.330 (0.262). Buccal capsule: Anterior part 11–22 μ (17) deep and 14–26 μ (22) wide; posterior portion 15–20 μ (22) deep and 11–20 μ (15) wide. Esophagus 0.890–1.480 (1.160) long. Nerve ring 0.176–0.253 (0.204) and excretory pore 0.249–0.354 (0.311) from anterior extremity. Vulva 0.670–1.200 (0.852) and anus 0.220–0.350

(0.267) from posterior extremity. Phasmids 31–81 μ (56) from tip of tail. Eggs embryonated, 42–48 μ (45) long, 18–33 μ (27) wide.

Good figures of *O. pusillae* are found in Wehr and Hwang (1957).

Apparently, neither *O. petrowi* or *O. pusillae* is pathogenic. Even in heavy infections with as many as 30 worms per eye, no gross or histopathology was demonstrated.

The rates of infection ranged from one to as many as 68 worms in a single bird. Host species which were more commonly infected also tended to be more heavily infected.

Although meadow larks and blackbirds are more commonly infected with *O. petrowi*, sufficient specimens of hosts were not collected to enable the determination of the overall incidence in these avian populations. Also, *O. pusillae* appears to be a common parasite of the red-bellied woodpecker and red-headed woodpecker in southern Louisiana. It was found more often in these birds than in the type host, the brown-headed nuthatch.

Discussion

Ransom (1904) concluded that eyeworms were not reported more frequently because they were often overlooked. This is apparent since they were commonly found in the present study. The number of naturally infected hosts of oxyspirurids known in North America is now increased to 28 species. Undoubtedly, additional hosts will be recordcd.

The ecology and natural history of these infections present some interesting speculations. *Oxyspirura petrowi* is encountered primarily in birds found in open fields, submarginal grasslands, and marsh lands. Its presence in a number of species of avian hosts representing several families, but all occupying comparable ecological niches, indicates that host specificity is not dependent on definitive host physiology. Rather, it is probably dependent on the occurrence of the intermediate host(s) which is restricted to a particular habitat. Likewise, *O. pusillae* is found in a series of unrelated avian hosts which are most commonly found feeding on trees, removing insects from under bark, decaying wood, and on leaves. Other birds which appear to be more rarely infected probably only occasionally enter this niche. Although their life histories are unknown, it appears that these oxyspirurids have arthropod, probably insect, intermediate hosts which are found in particular ecological situations. Evidently their occurrence is directly dependent on the contact of the definitive host with the ecological niche within which the intermediate host is most often found.

The occurrence of both *O. pusillae* and *O. petrowi* in the same host species, reported here and by Wells and Hunter (1960), also indicates the lack of host specificity in these species. However, double infections in the same host individuals have not been reported.

Addison and Anderson (1969b) found that the following species cannot be distinguished from *O. petrowi* on the basis of existing descriptions: *O. dicruricola* Jairapuri and Siddiqi, 1967; *O. indica* Singh, 1948; *O. kaitingensis* Hsü, 1933; *O. malabarica* Jairapuri and Siddiqi, 1967; *O. rysavyi* Baruš, 1963; and *O. yehi* Ali, 1960. On the basis of the present study, the following species cannot be distinguished from *O. petrowi*: *O. cochlearispiculata* Caballero, 1951; *O. laharpurensis* Jairapuri and Siddiqi, 1967; *O. lalagea* Ali, 1960; *O. matogrosensis* Rodriques, 1963; *O. otocompsa* Rasheed, 1960; *O. peipingensis* Hsii, 1933; and *O. streparae* Johnson and Mawson, 1941. Most of these species are based on a few specimens, or a single specimen, from a single host individual and locality. Hence, nothing is known as to what extent intraspecific variations may occur in populations from the same host and locality or from different hosts and localities. The result is a series of described species in which the taxonomy is unworkable and cannot be conclusively resolved until more data based on additional specimens and comparison with the respective types are forthcoming.

In view of the present findings, it is concluded that the genus *Oxyspirura* probably consists of fewer valid species than are now described. It is suggested that future investigators consider more carefully the abovementioned factors before proposing new species in this genus.

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Activity of Cambendazole and Morantel Tartrate against Two Species of *Trichostrongylus* and Two Thiabendazole-resistant Isolates of *Haemonchus contortus* in Sheep

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ABSTRACT: The activity of cambendazole and morantel tartrate against *Trichostrongylus axei*, *T. colubriformis*, and two thiabendazole-resistant isolates of *Haemonchus contortus* was determined in controlled anthelmintic trials with experimentally infected lambs. Morantel tartrate at 8 mg/kg and cambendazole at 20 mg/kg were, respectively, 99 and 94% effective against the BPL-2 isolate of *H. contortus*; against the AH-2 isolate the efficacies of morantel tartrate and cambendazole were 97 and 81%, respectively. Cambendazole was more effective (99%) than morantel tartrate (88%) against *T. colubriformis*, but both drugs were highly effective, 100 and 99%, respectively, against *T. axei*. Only the AH-2 thiabendazole-resistant isolate of *H. contortus* showed any evidence of drug resistance in these trials.

The occurrence of drug-resistant strains of nematode parasites of sheep (Colglazier, Kates, and Enzie, 1970; Hotson, Campbell, and Smeal, 1970; Kates et al., 1971; Smeal et al., 1968; Theodorides et al., 1970) shows the need for alternative broad-spectrum anthelmintics. Recent reports indicate that cambendazole (Baker and Walters, 1971; Benz, 1971a, b; Ciordia and McCampbell, 1971; Egerton and Campbell, 1970; Egerton et al., 1970; Hoff et al., 1970) and morantel tartrate (Cornwell and Jones, 1970a, b, c; Howes, 1968; McFarland et al., 1969) are both effective against many nematode parasites of domestic rumi-