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EXTRAORDINARY PREVALENCE AND INTENSITY OF A PARASITIC NEMATODE IN TROUT AND WHITEFISH FROM THE DESCHUTES RIVER

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ABSTRACT—In the spring and summer of 2020, we found cysts of the nematode *Eustrongylides* spp. in Brown Trout (*Salmo trutta*), Rainbow Trout (*Oncorhynchus mykiss*), and Mountain Whitefish (*Prosopium williamsoni*) in the Deschutes River. The prevalence and maximum intensity of infection exceeded the range of published accounts for *Eustrongylides* spp. across a wide range of species. Because the 1st intermediate host is likely to be a tubificid worm, also known as a sludge worm or sewage worm, this exceptional prevalence of *Eustrongylides* spp. infection raises questions about conditions in the river that may be contributing to the high infection rate in fish.

Key words: *Eustrongylides*, nematode, parasite, *Prosopium williamsoni, Salmo trutta*

The nematode *Eustrongylides* spp. is a generalist parasite with a multi-host life cycle. The definitive host is a piscivorous bird, commonly a heron, egret, or merganser duck (Measures 1988a). First and 2nd intermediate hosts include an aquatic oligochaete and a fish, respectively (Cooper and others 1978; Lichtenfels and Stroup 1985). At least 14 orders of fish have been documented as 2nd intermediate hosts (Measures 1988b).

In March 2020, a Mountain Whitefish (*Prosopium williamsoni*) collected from the Deschutes River near Sunriver, Oregon (Deschutes County), exhibited extreme distension of the abdomen. With the 1st cut for dissection there was an outrush of clear watery liquid, and the distended flanks of the fish collapsed. Inspection of the viscera revealed 7 coin-shaped cysts 7–10 mm in diameter and 1–3 mm thick (Fig. 1A). Each cyst contained a long slender worm identified as the nematode *Eustrongylides* spp. on the basis of length (some individuals >70 mm), the presence of 2 rings of labial papillae at the anterior end, a prominent buccal capsule, long muscular esophagus, and a terminal anus (Hoffman 1999). The cysts were mostly in the coelomic cavity of the fish, attached to mesentery and lying adjacent to the outside of the stomach.

Between April and October 2020, a survey of trout and whitefish from this same area of the Deschutes River revealed a startlingly high prevalence of *Eustronglydes* spp. infection, but no further cases of fish with abdominal edema. We found cysts in 64 of 65 (98%) Mountain Whitefish, 13 of 13 (100%) Brown Trout (*Salmo trutta*), and 2 of 3 (67%) Rainbow Trout (*Oncorhynchus mykiss*), excluding 2 juvenile Rainbow Trout (16 cm in length) considered too young to have yet acquired the parasites (Kaeding 1981). One whitefish yielded 85 cysts (Table 1), but exhibited no obvious signs of morbidity. Based on size (see Table 1) and gonadal development, all fish included in our assessment were mature adults estimated to be >3-y old (Stubbing 2002; Thompson and Davies 2011).

The overall prevalence (98%) and mean intensity (13 parasites fish^{-1}) exceeded values found in 25 published reports of *Eustrongylides* spp. infection in multiple host species (Table 2). The maximum intensity of 85 larval *Eustrongylides* spp. cysts in the 1 whitefish we collected was greater than all but 1 published report, that being a European Catfish (*Siluris glanis*) with a total of 256 encysted worms (Novakov and others 2013).

Human infections with *Eustrongylides* spp. only occur through consumption of raw or undercooked fish containing live parasites. Published reports of human infections within the US have been linked to people consuming live-bait minnows (*Fundulus* spp.; Guerin and others 1982; Eberhard and others 1989). There appears to be little risk from eating infected trout or whitefish if properly prepared for consumption. While the presence of nematode cysts can be disturbing to people who discover them when cleaning fish for consumption, more than 99% of the cysts we observed were confined to the coelomic cavity and would be removed when the fish was cleaned. We did find 3 encysted worms in the hypaxial muscles of 1 Brown Trout, but they were obvious, easily

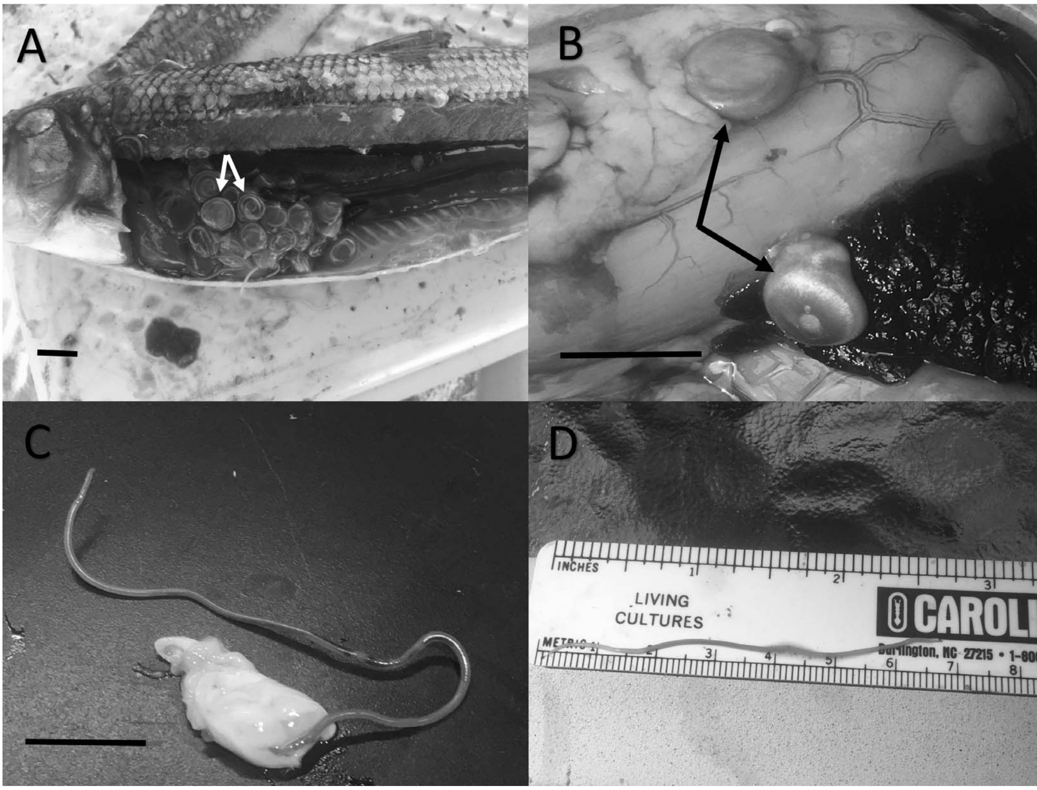

FIGURE 1. *Eustrongylides* spp. in *Prosopium williamsoni*. A: multiple encapsulated cysts in coelomic cavity. White arrows point to 2 of more than 15 cysts visible. B: 2 encapsulated cysts lying on the outside of stomach and liver. C: Stage 4 larval emerging from punctured capsule wall. D: Stage 4 larval stretched out on scale. Black scale bars = 10 mm.

removed, and would have been quickly killed by even moderate cooking.

With the exception of 1 whitefish with extreme abdominal edema, we did not find evidence of morbidity from *Eustrongylides* spp. Kennedy and Lie (1976) reported that the parasite appears to have little impact on the health or condition of trout. It should be noted, however, that increased mortality resulting from parasite infection can be inferred indirectly by various statistical methods (Crofton 1971; Lester 1984; Ferguson and others 2011), but is generally hard to detect from field sampling. While a detailed statistical analysis is beyond both the scope and purpose of this report, we provide a categorized historgram showing numbers of whitefish versus infection intensity (Fig. 2), which, with a larger sample size, could yield an estimate of number of parasites above which increased mortality is likely occurring.

We found numerous reports of mortality associated with *Eustrongylides* spp. infection in a wide variety of piscivorous predators including Red-sided Garter Snakes (*Thamnophis sirtalis*

TABLE 1. Summary of *Eustrongylides* spp. infections in salmonids from the Deschutes River.

Species	*n*	Length (cm) mean (range)	Total infected	Prevalence (%)	Mean intensity	Maximum intensity
Onchorynchus mykiss	3	34 (28–43)	2	67	6	9
Prosopium williamsoni	65	27.5 (20–36)	64	98	16	85
Salmo trutta	13	45.5 (38–53)	13	100	5	17
All species combined	81		79	98	13	85

TABLE 2. Summary of published *Eustrongylides* spp. reports. * = wet season; ** = dry season; n/a indicates data not available.

Source	Parasite	Host	*n*	Prevalence (%)	Mean intensity	Max intensity
Branciari and others (2016)	*E.* spp.	*Perca fluviatilis*	1536	6.8	n/a	3
Branciari and others (2016)	*E.* spp.	*Micropterus salmoides*	1536	1.9	n/a	1
Branciari and others (2016)	*E.* spp.	*Atherina boyeri*	768	0.1	n/a	1
Kaeding (1981)	*E. tubifex*	*Salmo trutta*	99	18.5	1.6	<9
Kaeding (1981)	*E. tubifex*	*Onchorynchis mykiss*	176	18.8	1.7	<9
Coyner and others (2003)	*E. tubifex*	*Gambusia holbrookii*	50373	0.6	n/a	3
Coyner and others (2003)	*E. tubifex*	*Lepomis gulosus*	82	7.3	n/a	n/a
Coyner and others (2003)	*E. tubifex*	*Lepomis machrochirus*	106	2.8	n/a	n/a
Coyner and others (2003)	*E. tubifex*	*Micropterus salmoides*	43	4.7	n/a	n/a
Coyner and others (2003)	*E. tubifex*	*Pomoxis nigromaculatus*	18	5.6	n/a	n/a
Cullinan (1946)	*E. Ignotus*	*Fundulus heteroclitus*	3507	13.3	n/a	n/a
Ibiwoye and others (2004)	*E. Africanus**	*Clarias gariepinus*	n/a	26.5	n/a	n/a
Ibiwoye and others (2004)	*E. Africanus***	*Clarias gariepinus*	n/a	32.9	n/a	n/a
Measures (1988c)	*E. tubifex*	*Lepomis gibbosus*	751	16.5	~2	15
Measures (1988c)	*E. tubifex*	*Ambloplites rupestris*	435	9.0	>1<2	2
Measures (1988c)	*E. tubifex*	*Perca flavescens*	176	6.3	>1<2	n/a
Muzzall (1999)	*E. tubifex*	*Perca flavescens*	100	3.0	n/a	17
Muzzall (1999)	*E. tubifex*	*Perca flavescens*	100	95.0	7.4	27
Muzzall (1999)	*E. tubifex*	*Perca flavescens*	100	74.0	4.1	13
Novakov and others (2013)	*E.* spp.	*Siluris glanis*	52	11.5	n/a	256
Rosinski and others (1997)	*E. tubifex*	*Perca flavescens*	240	80.4	6.2	48
Sattari and others (2002)	*E. excisus*	*Esox lucius*	n/a	5.0	n/a	5
Sattari and others (2002)	*E. excisus*	*Neogobius fluviatilis*	n/a	36.0	n/a	8
Sattari and others (2002)	*E. excisus*	*Neogobius caspius*	n/a	14.0	n/a	1
Sattari and others (2002)	*E. excisus*	*Ponticola kessleri*	n/a	50.0	n/a	11

parietalis; Lichtenfels and Lavies 1976), Great Blue Herons (*Ardea herodias*; Winterfield and Krazacos 1977), Snowy Egrets (*Egretta thula*; Weise and others 1977), and Red-breasted Mergansers (*Mergus serrator*; Locke and others 1964). Although Great Blue Herons and Red-breasted Mergansers are widely distributed along the Deschutes River, we found no reports of local mortality connected to *Eustrongylides* spp. infection.

Temperature and water quality can influence infection by *Eustrongylides* spp. Measures (1988c)

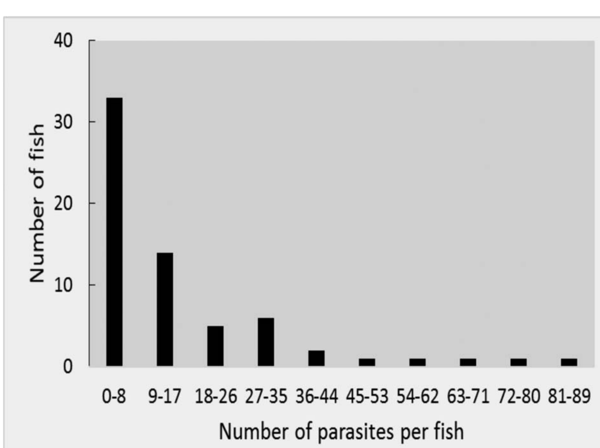

FIGURE 2. Categorized frequency distribution of *Eustrongylides* spp. in *Prosopium williamsoni* from the Deschutes River, and the confluence of Spring and Deschutes Rivers in 2020.

reported that development of larvae in the 1st intermediate host proceeded at 20 and 25°C, but not at ≤15°C. A study of *Eustrongylides tubifex* in trout in the Firehole River of Yellowstone National Park, Wyoming, showed infection occurring in a section of the river warmed by geothermal input, but not in the colder upstream section (Kaeding 1981). Kennedy and Lie (1976) suggested that infection by *Eustrongylides* spp. is tied to lentic or lacustrine conditions, consistent with the 1st intermediate host being an aquatic oligochaete that resides in soft nutrient rich sediments. Pollution of natural water bodies can create favorable conditions for tubificids and thus contribute to the presence and prevalence of these parasites (Measures 1988a). Coyner and others (2003) reported that the prevalence of *Eustrongylides ignotus* in Eastern Mosquitofish (*Gambusia holbrooki*) fell from 54 to 0% within 3 y of the cessation of treated sewage discharge at a northern Florida wetland even though the density of oligochaetes did not change during this period.

The earliest written account of *Eustrongylides* spp. in trout from the Deschutes basin appears to be a 1996 Oregon Department of Fish and Wildlife (ODFW) report (Fies and others 1996). ODFW fish biologists, however, were aware of the nematodes as early as 1981 (B Hodgson, pers. comm). The absence of systematic surveys for this parasite in the Deschutes basin precludes comparison of infections across time or location.

It is worth noting that the human population of Deschutes County grew from 66,000 in 1980 to over 200,000 at present. Residential growth has been extensive upstream of the Sunriver community, with a majority of homes using septic systems with drain fields or sand filters. Because the 1st intermediate host for *Eustrongylides* spp. is typically a tubificid worm often associated with warm eutrophic waters, it seems appropriate to ask whether changes to water quality and temperature may be contributing to the current high prevalence of this parasite in the Deschutes River. Because baseline data is unavailable, investigations are warranted to: (1) determine whether or how the distribution and prevalence of the parasite may vary in time and space in the Deschutes River and its tributaries; (2) identify the 1st intermediate host and conditions that may be contributing to the high prevalence of *Eustrogylides* spp. infections; and (3) understand possible impacts of this parasite on game fish and fish-eating birds in the Deschutes River system.

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