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FIRST REPORT OF PARASITES FROM PINNIPEDS IN THE GALAPAGOS ISLANDS, ECUADOR, WITH A DESCRIPTION OF A NEW SPECIES OF *PHILOPHTHALMUS* (DIGENEA: PHILOPHTHALMIDAE)

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ABSTRACT: A new species of digenetic trematode and 2 species of ectoparasites from *Zalophus wollebaeki* Silvertsen, 1953 (Carnivora: Otariidae) in the Galapagos Islands, Ecuador, are reported. These include an eye fluke of *Philophthalmus* Looss, 1899 (Echinostomata: Philophthalmidae) as well as, to our knowledge, the first report of *Antarctophthirus microchir* (Trouessart and Neumann, 1888) Enderlein, 1906 (Arthropoda: Anoplura) and *Orthohalarachne diminuata* (Doetschman, 1944) Newell, 1947 (Arthropoda: Acarina) from this host and location. *Philophthalmus zalophi* n. sp. differs from the 4 other marine species of *Philophthalmus* (*P. andersoni* Dronen and Penner, 1975; *P. burrili* Howell and Bearup, 1967; *P. hegeneri* Penner and Fried, 1963; and *P. larsoni* Penner and Trimble, 1970) by its mammalian host, large body size, lack of tegumental spines, posterior length of seminal vesicle, placement of genital pore, size ratio of oral sucker to acetabulum, shape and size of testes, and size ratio of ovary to testis.

The Galapagos Islands are located at the equator approximately 1,000 km west of Ecuador. The archipelago consists of 13 major and a number of smaller islands. During a routine health examination of the pinniped populations on 5 of these islands in 2003, a previously undescribed species of eye fluke (*Philophthalmus* Looss, 1899) was collected.

Eye flukes of *Philophthalmus* (Echinostomata: Philophthalmidae) are cosmopolitan, occurring in various microhabitats in the orbits of birds. Nollen and Kanev (1995) listed 37 species for the genus, which they divide into 3 major groups: (1) non-eye dwelling species in the oral cavity and intestine of birds, (2) freshwater species in the orbit of wild and domestic birds, and (3) marine species in the orbit of birds. The latter group includes 4 species: (1) *Philophthalmus andersoni* Dronen and Penner, 1975 (California); (2) *P. burrili* Howell and Bearup, 1967 (Australia); (3) *P. hegeneri* Penner and Fried, 1963 (Florida); and (4) *P. larsoni* Penner and Trimble 1970 (Florida). All are described from experimental infections using laboratory birds. *Philophthalmus zalophi* is the first marine-acquired species of the genus described from an aquatic mammal and its naturally infected definitive host.

MATERIALS AND METHODS

From 26 February 2003 to 7 March 2003, 8 colonies of pinnipeds (6 Galapagos sea lions [*Zalophus wollebaeki* Silvertsen, 1953] and 2 Galapagos fur seals [*Arctocephalus galapagoensis* Heller, 1904]) were visited on 5 islands (Española, Fernandina, Floreana, Isabela, and San Cristóbal) of the Galapagos archipelago (Fig. 1). While under general anesthesia, animals were examined for eye flukes, and a sample was taken by 1 of us (M.D.D.). Time did not permit the opportunistic collection of total worms found in all of the eyes that were examined. Worms were removed from the conjunctiva using forceps and were placed in seawater during the examinations. On return to the vessel, worms were fixed in 70% ethyl alcohol. Worms were stained in Semichon's carmine, dehydrated by alcohol series, and mounted in Canada balsam. All measurements are in microns unless otherwise indicated, with the range followed by the mean, and they are reported as a pooled sample of worms from all islands. Drawings were made with the aid of a drawing tube. Paratypes of *P. andersoni* (USNPC 72991, 72992, and 72993) and *P. larsoni* (USNPC 71275) were examined during the present study.

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RESULTS

In addition to *P. zalophi*, 2 species of arthropods were found on *Z. wollebaeki*. Forty-two lice (Anoplura), identified as *Antarctophthirus microchir* (Trouessart and Neumann, 1888) Enderlein, 1906 were collected from 10 *Z. wollebaeki* on 4 (Española, Fernandina, Floreana, and San Cristóbal) of the 5 islands. Seven nasal mites (Acarina; *Orthohalarachne diminuata* [Doetschman, 1944] Newell, 1947) were collected from a single sea lion from San Cristóbal. The latter were found in the nose cone used to administer the anesthesia. No parasites were found on the 20 Galapagos fur seals (*Arctocephalus galapagoensis*) examined on the islands of Isabela and Fernandina.

DESCRIPTION

Philophthalmus zalophi n. sp.

(Fig. 2)

Description: Based on 46 specimens. Body aspinose, elongated, attenuated anteriorly, broadly rounded posteriorly. Length 4.0–8.1 (6.0) mm; maximum width 0.75–1.9 (1.8) mm. Oral sucker subterminal, 230–570 (321) long, 260–450 (377.5) wide; pharynx up to 50 long but often obscured by juxtaposition of oral sucker and pharynx; pharynx 235–430 (331) long, 229–420 (316) wide; esophagus 0–80 (50) long; ventral sucker 470–830 (616) long, 410–750 (566) wide; ratio of transverse diameters of oral and ventral suckers 1:1.8. Ceca simple, extending to near posterior end of body. Excretory bladder and main tubules simple, without branching. Testes spherical, lobed or smooth, tandem, in posterior fourth of body; anterior testis 350–870 (618) long, 370–850 (576) wide; posterior testis 450–925 (672) long, 400–710 (533) wide. Cirrus armed, seminal vesicle extending beyond posterior margin of acetabulum. Genital pore median, anterior to intestinal bifurcation. Ovary round to oval, median, pretesticular, 120–350 (232) long, 125–470 (233) wide; ovary to testis ratio 1:3.1. Eggs nonoperculate, those in anterior of uterus include miracidia with eyespots, 58–102 (78) long, 25–46 (33) wide. Vitellaria follicular, usually 1 intracecal with remainder extracecal, n = 4–10 (6) right, n = 4–7 (5) left, varying from 43 to 54% of the distance from anterior testis to acetabulum.

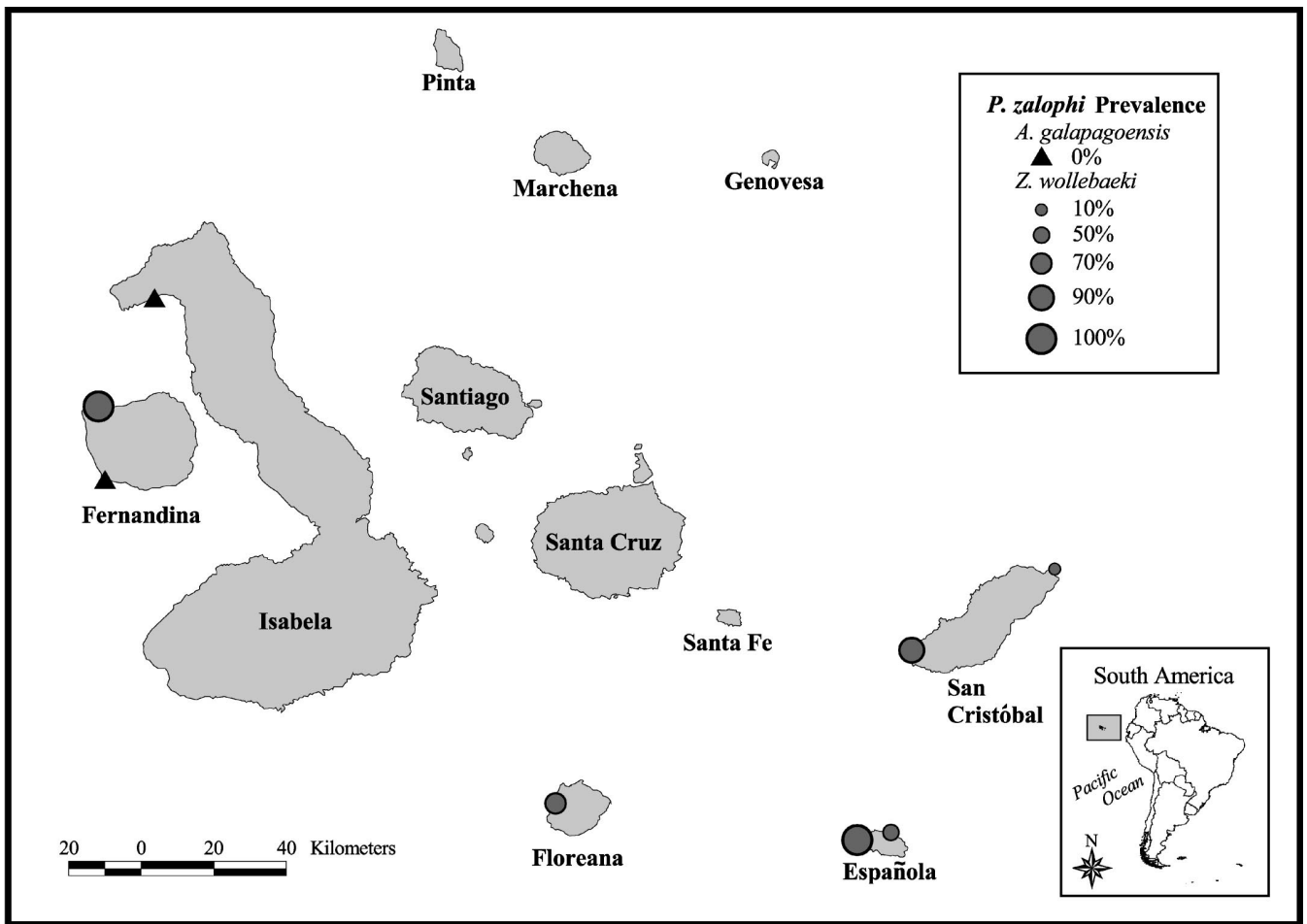


FIGURE 1. Galapagos Islands, Ecuador. Pinniped data collection sites with prevalence of *Philophthalmus zalophi* n. sp. collected per site.

Taxonomic summary

Type host: *Zalophus wollebaeki* Silvertsen, 1953; Galapagos sea lion; Otariidae.

Site of infection: Conjunctival lens of eye.

Prevalence: 80%.

Intensity: 1–47 worms per eye.

Type locality: San Cristóbal Island, Galapagos Archipelago, Ecuador; 1°22'S, 89°44.5'W.

Specimens deposited: Holotype (USNPC 94786); paratypes (USNPC 94787). Voucher specimens of *Antarctophthirus microchir* (USNPC 94788); *Orthohalarachne diminuta* (USNPC 94789).

Etymology: The species is named for the generic name of the type host.

Remarks

Philophthalmus zalophi differs from all other species in *Philophthalmus* by type of host (marine mammal), large body size (up to 8 mm, all others species under 6 mm), and larger ratio of ovary to testis (1:3.1 in *P. zalophi* and 1:2.4 or less for all other known marine species) (Table I). In addition, *P. zalophi* differs from each of the marine-generated species as follows: (1) *P. hegeneri* has tegumental spines, (2) the seminal vesicle

never reaches posterior to the acetabulum, and (3) the ratio of oral sucker to acetabulum is 1:2 or more (never exceeds 1:1.8 in *P. zalophi*). *Philophthalmus burri* and *P. larsoni* lack lobed testes, and the genital pore is below the cecal bifurcation. *Philophthalmus zalophi* most closely resembles *P. andersoni* in position of the genital pore (above the cecal bifurcation) and in the seminal vesicle extending posterior to the acetabulum. However, in addition to the general differences mentioned above, the testes in *P. andersoni* are wider than they are long and contain at least 1 flat surface (longer than it is wide, with no flat surfaces in *P. zalophi*).

DISCUSSION

Although species of *Philophthalmus* have been described previously only in birds, experimental infections have been documented in mammals. These experimental infections in mammals have been attempted with varying degrees of success depending on the eye fluke and host species. Inoculation of *P. gralli* Mathis and Leger, 1910 metacercaria directly into the eyes of rats and rabbits was successful, but the success rate of infection was lower than that achieved in chickens (Alicata and Ching, 1960). Attempts by Karim et al. (1982) to infect mice, guinea pigs, and a dog with *P. gralli* metacercaria, however,

TABLE I. Comparison of marine species of *Philophthalmus* with *P. zalophi*. Range (mean) measurements are shown in micrometers unless indicated otherwise.

	<i>P. andersoni</i> (Dronen and Penner 1975)*	<i>P. burrili</i> (Howell and Bearup 1967)†	<i>P. hegeneri</i> (Penner and Fried 1963)‡	<i>P. larsoni</i> (Penner and Trimble 1970)‡	<i>P. zalophi</i> §
Body size (mm)					
Length	3.5–5.1 (4.2)	2.8–3.7	1.86–5.46	4.1–6.0 (4.9)	4.0–8.12 (6.0)
Width	0.91–1.15 (1.0)	0.7–1.4	0.81–1.8	0.93–1.67 (1.66)	0.75–1.8 (1.1)
Oral sucker					
Length	200–210 (205)	210–300	250–490	253–560 (321)	230–570 (321)
Width	280–350 (303)	270–370	360–550	300–700 (412)	260–450 (372)
Pharynx					
Length	230–300 (270)	250–300	230–360	264–510 (342)	235–430 (331)
Width	250–310 (298)	240–280	200–360	254–660 (351)	229–420 (316)
Ventral sucker					
Length	450–690 (595)	400–550	650–930	425–750 (591)	470–830 (616)
Width	470–650 (537)		640–1030	529–710 (612)	410–750 (566)
Ovary					
Length	210–270 (227)	170–250	150–320	161–370 (241)	120–350 (232)
Width	210–260 (240)		180–340	195–380 (275)	125–470 (233)
Anterior testis					
Length	280–430 (390)	300–350	220–540	320–660 (436)	350–870 (618)
Width	410–600 (562)	400–550	250–720	220–840 (461)	370–850 (576)
Posterior testis					
Length	260–340 (318)	250–400	230–590	290–667 (478)	450–925 (672)
Width	360–522 (495)	500–550	230–790	260–660 (476)	400–710 (533)
Esophagus					
Length	130–190 (167)	150–250	130–410		0–80 (50)
Mature eggs (with miracidia)					
Length	72.5–77.5 (75)	90–95	50–75	56–70 (63)	58–102 (78)
Width		50	20–35	25–31 (28)	25–46 (33)
Vitellaria					
Right (n)	7		5–6	4–9 (6)	4–10 (6)
Left (n)	6		4–5	2–11 (6)	4–7 (5)
Distance (%)		68–75	35–60	16–84	43–54

* California, USA.

† Australia.

‡ Florida, USA.

§ n = 46; Galapagos Islands, Ecuador.

did not yield infections. Hamsters and rats became infected with *P. lucipetus* Rudolphi, 1819 after direct application of metacercaria to the eyes (Kanev et al., 1993), yet attempts to infect various mammals with *P. megalurus* Cort, 1914 (West, 1961) and *P. lucknowensis* Baugh, 1962 (Saxena, 1985) were unsuccessful.

Marine species of *Philophthalmus* have been described previously only in birds from regions far removed from the Galapagos Islands (Australia and the United States). Discovery and identification of *P. zalophi* in the marine mammal *Z. wollebaeki* creates the interesting question of how this host may have acquired this parasite. Accidental transmission to a new host, as described by McCoy (2003), can result from 2 sympatric hosts sharing a common propogule pool. Such a case could arise between marine birds with a sister species of *Philophthalmus* and sea lions sharing restricted habitats on the Ga-

lapagos Islands, such as the pools found on sandy beaches. The encystment of the cercaria on hard surfaces within the pools establishes a sister *Philophthalmus* sp. population that can be transferred readily to other hosts using the same metacercarial source. One specimen resembling *P. hegeneri* was collected from the eye of a yellow-crowned night heron (*Nyctanassa violacea*) in the archipelago on the island of Santa Cruz during a bird survey in 2002 (T. Walsh, pers. comm.). Young *Z. wollebaeki* were observed mouthing, in a playful manner, rocks and shells from the bottom of pools that contained infected sea lions (M. Dailey, pers. obs.). Results of comparing the different habitats used by the sea lions infected with *P. zalophi* and the uninfected fur seals further this hypothesis. The fur seals occupy steep volcanic outcroppings that are constantly awash in rough water and, hence, would not come in contact with the propogule pool. Conversely, the sea lions are found on sandy

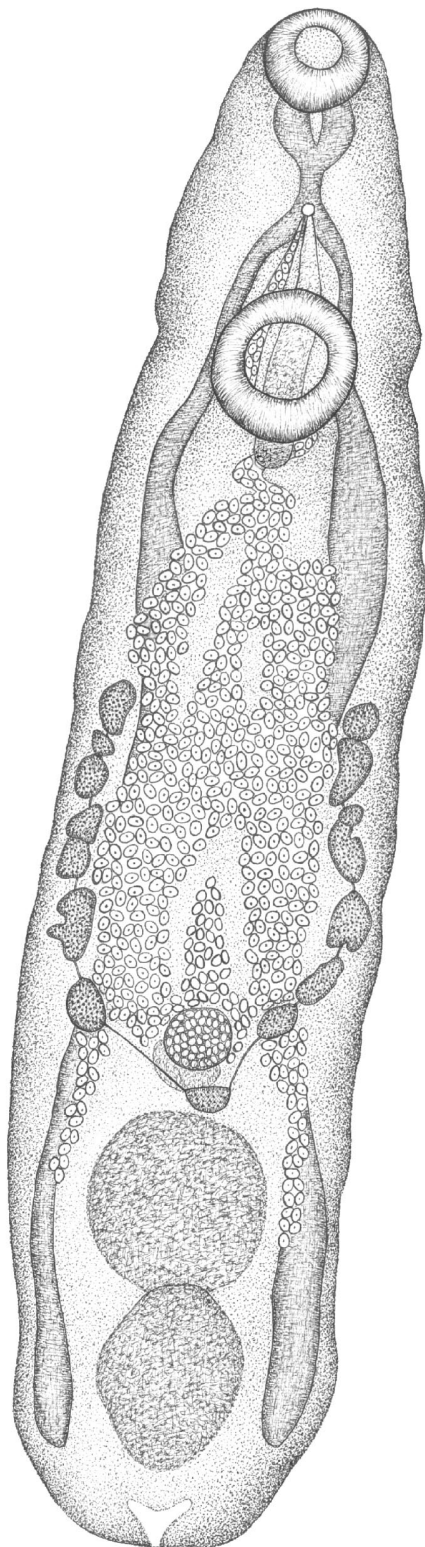


FIGURE 2. *Philophthalmus zalophi* n. sp., entire worm, ventral view. Bar = 1 mm.

beaches in quiet pools, where they are exposed to the available larval stages of *P. zalophi*.

Infections with *P. zalophi* documented in the present study were found only in sea lions from 3 to 8 mo of age. As mentioned above, young sea lions are very oral during this period of their development, and they were observed mouthing rocks and shells from the bottom of the pools that contained infected sea lions. Constant contact with the parasite population is needed to maintain infection, because diminished egg production through senescence has been observed in worms of the genus *Philophthalmus* (*P. gralli*) older than 60 days (Ismail and Issa, 1987). This appears to be the case in the Galapagos as well, because *P. zalophi* infections cease after the young sea lions' oral behavior ends at approximately 8 mo of age. If infection occurred by direct cercaria–eye contact while swimming, then sea lions of all ages would demonstrate the symptomatic eye closure seen in younger infected animals harboring the parasite.

Future observations regarding the presence of philophthalmid parasites in the eyes of water-foraging mammals may contribute additional reports of this genus in hosts other than birds.

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