from *Coccyzus americanus* and *Viguiera pari* sp. n. from *Parus carolinensis* and *Parus bicolor* (Nematoda: Spiruridae). Proc. Helm. Soc. Wash. 40: 102–107.

Williams, O. O. 1929. Revision of the nematode genus *Torquatella* with a description of *Torquatella crotophaga* sp. nov. Univ. Cal. Pub. Zool. 33: 169–178.

Occurrence of *Ascarophis* (Nematoda: Spiruridea) in *Callianassa californiensis* Dana and Other Decapod Crustaceans

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ABSTRACT: Four species of *Ascarophis* were collected from the hemocoel of decapod crustaceans in California and Washington. Two species were found in the hemocoel of *Callianassa californiensis* Dana. One species was recovered from the body cavity of *Pagurus samuelis* (Stimpson) and *P. granosimanus* (Stimpson), and a fourth species was found in *Pachycheles pubescens* Holmes and *Pugettia producta* (Randall). The infective stage juveniles of the first three species are described. The nematodes occurred in capsules produced by the crustacean host.

Adults of the spirurid genus *Ascarophis* occur in the alimentary tract of marine fish or elasmobranchs. Except for the following reports, the intermediate hosts of the majority of *Ascarophis* species are unknown. Uspenskaya (1953) recovered *A. filiformis* Poljansky and *A. morrhuae* Beneden from decapod crustacea, and Petter (1970) found the latter nematode in the crab, *Carcinus maenas* Penn. Uzmann (1967) described an *Ascarophis* sp. from *Homarus americanus* and Feigenbaum (1973) recorded this genus of parasites from *penaeus* shrimp. Tsimbalyuk et al. (1970) found *A. pacificus* in crustacea on the shores of the Sea of Okhotsk, while Poinar and Kuris (1975) discussed the effect of an *Ascarophis* infection on the shore crab, *Hemigrapsus oregonensis* (Dana), in California.

The following paper discusses the incidence of *Ascarophis* infection in *Callianassa californiensis* and other decapod crustacea in California and Washington and describes the infective-stage juveniles of three *Ascarophis* species encountered.

Materials and Methods

The majority of decapod crustaceans sampled for *Ascarophis* infections were collected from the region of Bodega Bay, California, from 1972–75. A list of these crustaceans is presented in Table 1. Representatives from this list were also collected from Hood Canal, Washington.

The hosts were carefully dissected in seawater and examined for nematodes. Host capsules containing parasites were removed, opened, and the nematodes killed in hot (80C) seawater. The specimens were then fixed in TAF and processed to glycerin for examination.

Because of the abundance of *Callianassa californiensis* Dana and the high incidence of *Ascarophis* in this host, additional data were obtained from host populations collected near Gaffney Point at Bodega Bay.

Results

All nematodes found in the decapod crustaceans sampled belonged to the genus *Ascarophis*. The incidence of infection for the various hosts is given to Table 1. All nematodes were in the infective stage and four separate species could be distinguished on the basis of morphology.

Two species of *Ascarophis* occurred in *Callianassa californiensis* (Table 1). Both species

A and B were located in granular capsules attached to the wall of the pyloric stomach (Figs. 1, 2). Since adult nematodes were not available, identification was not possible, and the juveniles were distinguished on morphological features. The smaller species (B) was more abundant than the larger (A), and the incidence of infection for both ranged from 0–75%. The factors determining the rate of infection were not clear; however, larger adult hosts were more commonly infected than the smaller juveniles. Up to 20 specimens of species B were collected from a single host, whereas usually only one or two specimens of species A occurred in infected *Callianassa*. Rarely both species occupied the same capsule. The capsules varied from spherical to elliptical in shape and ranged from 0.3–1.8 mm to 1.0–3.6 mm in size. Most capsules were of sufficient thickness to prevent the nematode from escaping, although the parasite moved about easily in the central cavity. Electron microscopic studies showed that the capsules were formed by muscle cells responding to the parasite. Further details on this host reaction are reported elsewhere (Poinar and Hess, in press).

A description of the two species of juvenile *Ascarophis* recovered from *C. californiensis* is given below. In the quantitative portion of the description, the number following the character represents the average value for that character while the numbers in parentheses show the range. All measurements are given in microns unless otherwise specified.

Table 1. Incidence of *Ascarophis* infections in decapod crustaceans collected from Bodega Bay, California.

Crustacean	No. examined	No. infected with *Ascarophis*	Mean % infected
Callianassa californiensis Dana	77	26	33.8
Cancer antennarius Stimpson	2	0	0
Cancer gracilis Dana	4	0	0
Cancer magister Dana	11	0	0
Cancer productus Randall	10	0	0
Emerita analoga (Stimpson)	6	0	0
Hemigrapsus nudus (Dana)	25	0	0
Pachycheles pubescens Holmes	11	2	18.2
Pachygrapsus crassipes Randall	14	0	0
Pagurus granosimanus (Stimpson)	19	1	5.3
Pagurus hirsutiusculus (Dana)	67	0	0
Pagurus samuelis (Stimpson)	81	7	8.6
Petrolisthes cinctipes (Randall)	9	0	0
Petrolisthes eriomerus Stimpson	7	0	0
Pugettia producta (Randall)	11	1	9.1
Upogebia pugettensis (Dana)	24	0	0

Description of *Ascarophis* species A. *Ascarophis* Beneden (Hedruridae: Spirurida) (Figs. 2, 3–5)

The nematodes occur in granular capsules attached to the pyloric stomach; cuticle with yellowish tinge, smooth or with fine annules; head containing four papillae and two amphids; lateral lips project up and inward; mouth opening elliptical; rectal cells distinct; caudal mucron indistinct. Quantitative data ($n = 8$): Length, 8 (6–10) mm; greatest width, 156 (123–192); width at head, 28 (23–31); length of stoma, 78 (52–87); length of muscular portion of pharynx, 432 (317–480); length of glandular portion of pharynx, 1,552 (1,200–1,700); distance from head to nerve ring, 140 (108–154); distance from head to excretory pore, 198 (169–216); length of tail, 104 (78–130); length of indistinct mucron at tip of tail, 3.5 (2–5); width of mucron, 6 (5–7).

Description of *Ascarophis* species B (Figs. 1, 6–8)

Cuticle with whitish tinge, smooth or with fine annulations; head containing four papillae and two amphids; lateral lips project up and inward; mouth opening elliptical; rectal cells distinct; caudal mucron not pronounced. Quantitative data ($n = 10$): Length, 3.7 (3.5–4.0) mm; greatest width, 78 (65–92); width at head, 15; length of stoma, 96 (90–102); length of muscular portion of pharynx, 374 (347–400); length of glandular portion of pharynx, 947 (847–1,078); distance from head to nerve ring, 142 (123–171); distance from head to excretory pore, 194 (162–244); length

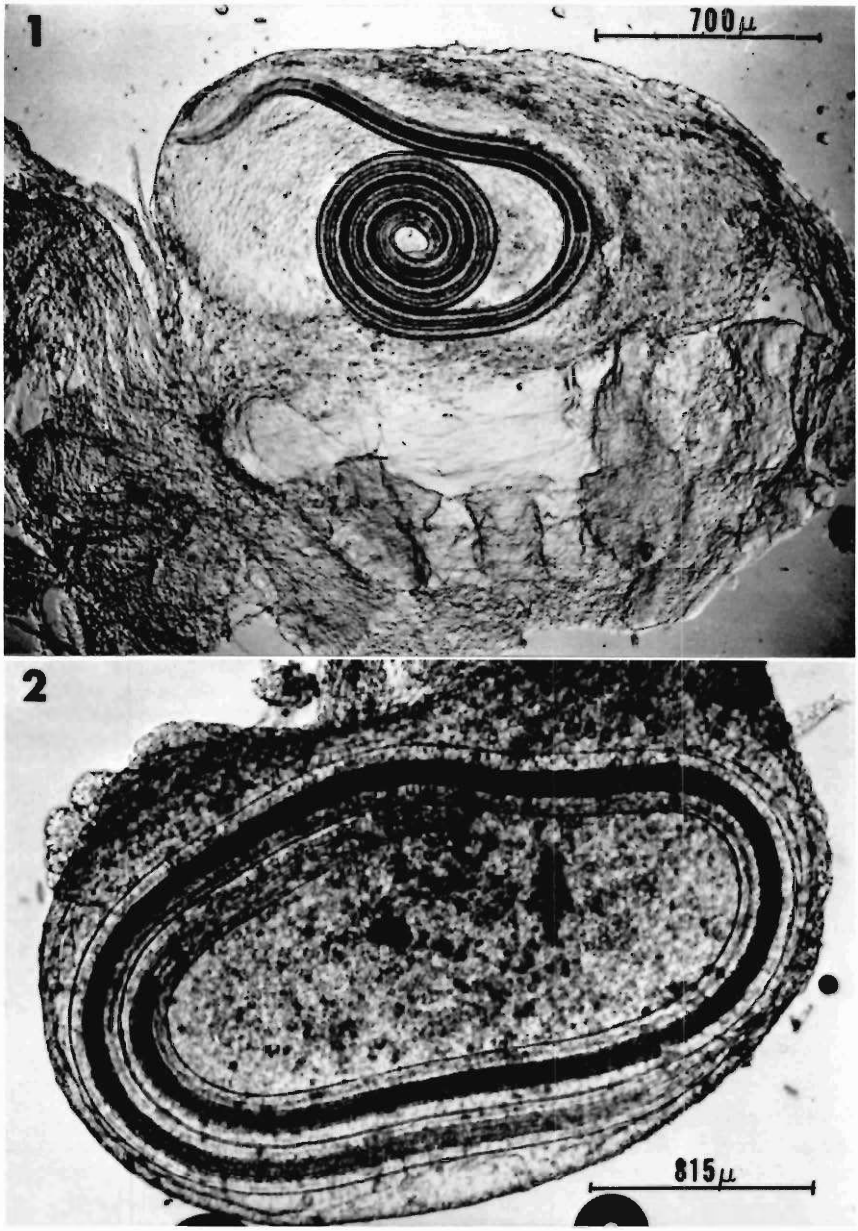


Figure 1. *Ascarophis* species B enclosed in a host capsule attached to the pyloric stomach of *Callianassa californiensis.*

Figure 2. *Ascarophis* species A enclosed in a host capsule connected to the pyloric stomach of *C. californiensis.*

of tail, 83 (53–110); length of mucron at tip of tail, 7 (3–13); width of mucron, 7 (6–13).

DIAGNOSIS: The two above-described juveniles differ from those of *A. morrhuae* Beneden and *A. pacificus* Zhukov by lacking a zone of cuticular serrations. They differ from the *Ascarophis* that occus in *H. oregonensis* and other crabs by their shorter length, shorter muscular and glandular portions of the pharynx, and shorter distances from their head to nerve ring and excretory pore. They differ from the juveniles of *A. filiformis* by their shorter stoma length. The *Ascarophis* sp. described by Uzmann (1967) in the American lobster has a longer glandular portion of the pharynx and a greater distance from the head to nerve ring and excretory pore than the *Callianassa* juveniles. Specimens studied here all came from infected *Callianassa* at Bodega Bay. The same hosts ($n = 28$) sampled at Hood Canal, Washington, were free from nematode infection.

A third species of *Ascarophis* occurred in specimens of *Pagurus samuelis* and *P. granosimanus* (Table 1). These nematodes occurred in fine capsules generally attached to the dorsal wall of the abdomen near the junction of the cephalothorax.

Some capsules were located next to the dorsal wall of the abdominal muscle. The incidence of infection was low, and although *P. hirsutiusculus* occurred in the same habitat as the other two species, it was never found infected with *Ascarophis*.

DESCRIPTION: Third-stage *Ascarophis* juveniles from *Pagurus* spp. (Figs. 9–11). White nematodes coiled in membranous capsules of their host; cuticle smooth except for a zone of serrations starting shortly behind the excretory pore and continuing to about one-half the length of the glandular pharynx; head with four papillae and two amphids; lateral lips projected up and inward; rectal cells and caudal mucron distinct. Quantitative data ($n = 10$): Length, 8.5 (6.9–10.6) mm; greatest width, 74 (69–77); width at head, 15 (11–15); length of stoma, 154, (143–169); length of muscular portion of pharynx, 704 (639–770); length of glandular portion of pharynx, 3,025 (2,541–3,388); distance from head to nerve ring, 182 (146–200); distance from head to excretory pore, 234 (216–254); length of tail, 104 (84–115); length of mucron at tip of tail, 14 (11–16); width of mucron, 7 (6–9).

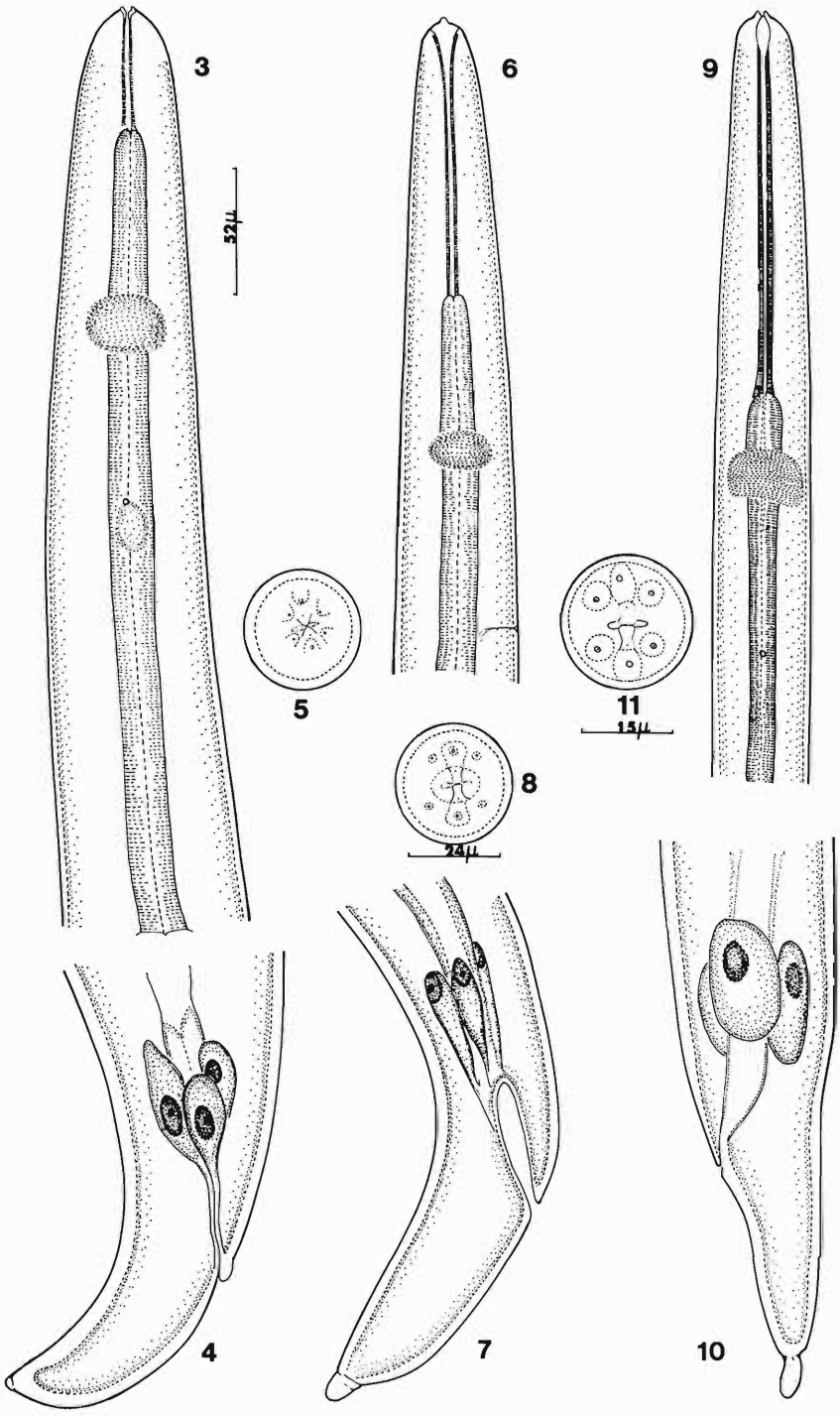
DIAGNOSIS: The presence of a zone of cuticular serrations separates this species from all other described *Ascarophis* juveniles except *A. pacificus* and *A. morrhuae*. However, the present species possesses a longer muscular and glandular pharynx than the above two species. It is closest in morphology to *A. pacificus*.

A fourth species of *Ascarophis* was recovered from *Pugettia producta* and *Pachycheles pubescens* (Table 1). This species was identical to the previously described juveniles collected from *Hemigrapsus oregonensis* and *Pachycheles rudis* (Poinar and Kuris, in press). The nematodes were enclosed in host capsules that were associated with the hepatopancreas in *P. pubescens*. In *P. producta*, the capsules occurred on the pyloric stomach, mouthparts, and under the carapace. This species was also collected from *P. producta* at Hood Canal, Washington (three infected out of 28).

Discussion

The findings reported here represent new host records in relation to *Ascarophis* infections. Previous authors reporting *Ascarophis* infections in decapods (Tsimbalyuk et al., 1970; Petter, 1970; Uspenskaya, 1953; Feigenbaum, 1973) did not mention finding the nematodes in host capsules. In fact host reactions by crustaceans to spirurid nematodes are considered rare, although Uzmann (1967) found an *Ascarophis* coiled in "lenticular cysts" in the American lobster. In the present study, all nematodes recovered from the hemocoel of decapods were contained in granular host capsules, similar in part to responses produced by insects to spirurid nematodes (Poinar, 1969). The two instances in *C. californiensis* when *Ascarophis* was not in these typical granular, thick capsules resulted in encapsulation by host blood cells. These nematodes were moribund and may have been eventually killed by the reaction (Poinar and Hess, in press).

Such effective hemocytic host reactions may explain the apparent host specificity of these *Ascarophis* infections. Although the range of the crustacean hosts overlaps geographically and ecologically, thus allowing various decapods equal access to *Ascarophis* eggs, a definite



infection pattern occurs. Thus, the two nematode species in *C. californiensis* were found only in this host whereas the species in *Pagurus* spp. was found only in hermit crabs. Only the fourth species shows a wider host distribution. Although the "habitual" or preferred invertebrate host of the latter is *H. oregonensis*, the nematodes also develop to the infective stage in *Pachycheles* spp. and *P. producta*. Again, however, other decapods sharing the same habitat (even under the same rock) as *H. oregonensis*, such as *H. nudus*, *P. crassipes*, *P. cinctipes*, and *P. eriomerus* were never found to be infected. A second possible explanation for this infection pattern could be different food preferences of the decapods under question. However, this explanation seems less plausible. Perhaps further information on this point will become available when the definitive hosts are collected and their habits revealed.

There was no sign of physical damage to any of the infected crustaceans investigated here. However, detailed data of the effect on the crustaceans were not taken. Only Poinar and Kuris (in press) presented results indicating that *Ascarophis* infections decrease the rate of growth and possibly increase the mortality among older, larger individuals of *H. oregonensis*. It is possible that heavily infected decapods, in general, are more susceptible to predation by potential vertebrate hosts.

Acknowledgments

The authors thank Armand M. Kuris and John Cornell of the Bodega Bay Marine Laboratory for calling their attention to *Ascarophis* infections in decapod crustaceans they were studying and to Dennis Sullivan for help in collecting infected specimens. Grateful appreciation also is given to Dr. Annie J. Petter, Museum National d'Histoire Naturelle, Paris, for confirming the identifications of *Ascarophis*.

Literature Cited

Feigenbaum, D. L. 1973. Parasites of the commercial shrimp, *Penaeus vannamei* Boone and *Penaeus brasiliensis* Latreille. M.S. thesis, The University of Miami, Coral Gables, Florida, 84 p.

Petter, A. J. 1970. Quelques spirurides de poissons de la région nantaise. Ann. Parasit. Hum. Comp. 45: 31–46.

Poinar, Jr., George O. 1969. Arthropod immunity to worms. *In* "Immunity to Parasitic Animals," Vol. 1, p. 173 (G. Jackson, R. Herman, and I. Singer, eds.). Appleton-Century-Crofts, New York.

———, **and Roberta Hess.** (In press.) Cellular responses in decapod crustaceans to *Ascarophis* spp. (Spirurida: Nematoda). Comparative Pathobiol.

———, **and Armand M. Kuris.** (In press.) Juvenile *Ascarpohis* (Spirurida: Nematoda) parasitizing intertidal decapod crustacea in California with notes on prevalence and effects on host growth and survival. J. Invertebr. Pathol.

Tsimbalyuk, E. M., V. V. Kulikov, and A. K. Tsimbalyuk. 1970. A contribution to the biology of *Ascarophis pacificus* (Nematoda, Ascarophididae). Zool. Zh. 49: 1874–1875 (in Russian).

Uspenskaya, A. V. 1953. Life cycle of nematodes of the genus *Ascarophis* van Beneden (Nematodes-Spirurata). Zool. Zh. 32: 828–832 (in Russian).

Uzmann, J. R. 1967. Juvenile *Ascarophis* (Nematoda: Spiruroidea) in the American lobster, *Homarus americanus*. J. Parasit. 53: 218.

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Figure 3. Ventral view of the anterior portion of *Ascarophis* species A from *C. californiensis*.

Figure 4. Lateral view of the tail of *Ascarophis* species A from *C. californiensis*. Mag. same as Fig. 3.

Figure 5. *En face* view of *Ascarophis* species A from *C. californiensis*. Mag. same as Fig. 3.

Figure 6. Lateral view of the anterior portion of *Ascarophis* species B from *C. californiensis*. Mag. same as Fig. 3.

Figure 7. Lateral view of the tail of *Ascarophis* species B from *C. californiensis*. Mag. same as Fig. 3.

Figure 8. *En face* view of *Ascarophis* species B from *C. californiensis*.

Figure 9. Ventral view of the anterior portion of *Ascarophis* from *Pagurus* spp. Mag. same as Fig. 3.

Figure 10. Lateral view of the tail of *Ascarophis* from *Pagurus* spp. Mag. same as Fig. 3.

Figure 11. *En face* view of *Ascarophis* from *Pagurus* spp.