Digestive tract parasites in rhynchoteuthion squid paralarvae, particularly in *Illex argentinus* (Cephalopoda: Ommastrephidae)

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Cephalopods play an important role in the transfer of parasites through the food web. They are second and third intermediate hosts for larval stages of digeneans, cestodes, and nematodes. The final hosts are usually fishes, sea birds, and marine mammals (Hochberg, 1990). Nevertheless, the interactions of cephalopods and their parasites are still poorly understood, and almost nothing is know about parasitism in cephalopod paralarvae and early juveniles (Vecchione, 1987). Information on parasitism in the early stages of cephalopod life cycles can provide a better understanding of host-parasite relationships as well as the environment and conditions in which infection first occurs.

Ommastrephid paralarvae are among the smallest cephalopods at hatching and are termed "rhynchoteuthion" because their tentacles are fused into a proboscis-like structure. Three distinct morphological types of rhynchoteuthion paralarvae (types "A," "B," and "C") are found commonly off southern Brazil (Haimovici et al., 1995). "Type C" is *Illex argentinus* (Castellanos, 1960) and "type A" probably is *Ommastrephes bartramii* (Lesueur, 1821). *Illex argentinus* is distributed in the southwestern Atlantic Ocean from 22° to 54°S (Roper et al., 1984), and it currently supports the largest squid fishery in the world. This species is an important link in the trophic relations of the pelagic ecosystem of this region and constitutes a major element of the diet of several commercial fishes, such as *Thunnus obesus*, *Merluccius hubbsi*, *Xiphias gladius*, and *Polyprion americanus* (Santos, 1992; Ivanovic and Brunetti, 1994).

The digestive tract contents of *Illex argentinus* and the other rhynchoteuthion types were examined by Vidal and Haimovici (1998). During examination of the digestive tracts, observations on parasitism were made. In this note we report the parasites (protistans and metazoans) found in the digestive tract of rhynchoteuthion paralarvae, mainly *Illex argentinus*.

Material and methods

Ommastrephid paralarvae were collected in four surveys carried out between Cape of Santa Marta Grande (28°30'S) and Chuí (34°20'S), Brazil, during the spring of 1987, summer of 1990, autumn of 1991, and winter of 1988. Paired bongo nets, with 60-cm mouth diameter and 0.33-mm mesh were used in oblique tows between the surface and depths of approximately 300 m. This gear was towed at a speed of 2 kn and deployed for 5–15 min. Afterwards, paralarvae were fixed and preserved in formalin.

Digestive tracts were examined from paralarvae of 72 *I. argentinus* (1.0–8.0 mm of mantle length (ML)), 12 "type A" (1.0–5.8 mm ML) and 4 "type B" (2.0–4.0 mm ML). Paralarvae were stained with alcian blue and then cleared with trypsin, following the method of Vecchione (1991). This method makes the paralarvae semitransparent and the parasites in the gut easier to see. The stomach, caecum, and intestine of all paralarvae were examined for parasites with a light microscope at a magnification of 400×. The esophagus was not examined. Five *I. argentinus* juveniles (16.0–38.0 mm ML) and 14 paralarvae (1.6–9.7 mm ML) of *I. argentinus* with no previous clearing and staining treatment were also examined. The prevalence and the mean intensity of infestation (number of a particular parasite per infected individuals) were calculated according to Margolis et al. (1982).

Results

Parasites were not found in the 14 untreated paralarvae. The opaque walls of the internal organs made the visualization of parasites difficult. A single copepod parasite was found in one of the five untreated juveniles.

Four types of parasites were observed in paralarvae and juvenile *I. argentinus*: coccidians (Apicomplexa: Sporozoea: Eucoccidiida), didymozoid–metacercariae (Platyhelminthes: Trematoda: Digenea),

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Table 1

Results of examinations of rhynchoteuthion paralarvae from four surveys conducted between the spring of 1987 and autumn of 1991. + = presence; 0 = absence.

	Spring 1987		Summer 1990	Autumn 1991		Winter 1988
	Illex argentinus	"Type B"	"Type A"	*Illex argentinus*	"Type B"	*Illex argentinus*
Paralarvae mantle length (mm)	1.0–8.0	2.8	1.0–5.8	1.3–5.5	2.0–4.0	1.0–7.8
Digestive tracts examined	41	1	12	19	3	12
Parasites:						
Nematode	+	0	0	0	0	0
Aggregata sp. (coccidian)	0	0	0	0	0	+
Didymozoids						
Monilicaecum sp.	+	0	+	+	0	+
Prevalence (%)	7.3		72.0	10.5		8.3
Mean intensity of infestation	2.3		3.5	1.5		1.0

a nematode (Nematoda) and a copepod (Arthropoda: Crustacea: Siphonostomatoida). About 50 coccidians (*Aggregata* sp.) were found distributed along the caecum wall of a 7.8-mm-ML paralarva collected in winter. Because the paralarva was preserved in glycerin for several months, taxonomic details of the parasites were not very clear. Cyst capsules (sporocystes) varied in size from 11 to 17 µm. However, the detailed structures inside the capsules were obscure and no certainty could be attained about the presence of sporozooites; hence this protozoan was assigned to the genus *Aggregata*. The observed parasites may have been in a very early stage of development and if the capsules actually represent sporocystes they were unusual because only 1 or 2 were present inside an amorphous oocyst mass (Hochberg[1]). These parasites are deposited at the Santa Barbara Museum of Natural History.

Six *I. argentinus* paralarvae (2.2–6.7 mm ML) from autumn, winter, and spring surveys contained 1–3 didymozoid metacercariae, probably type *Monilicaecum*. The body dimensions of the parasites ranged from 140 to 200 µm and because of their size and the absence of testicular anlagen, they appeared to be recently hatched. A single trematode attached to the caecum wall was found in the smallest paralarva. Three parasites were found in the largest paralarva, two attached to the stomach wall and one near the buccal mass. In the other paralarvae, the parasites were found attached to the caecum wall. Data on prevalence and mean intensity of infestation of different paralarval types and surveys of didymozoids are presented in Table 1. We found a single (nematode attached to the caecum wall of a 7.0-mm-ML rhynchoteuthion from the spring sample. The copepod parasite was located on the caecum wall of a 38.0-mm-ML juvenile obtained in spring. The copepod was identified as an adult male of *Metacaligus uruguayensis* (Siphonostomatoida: Caligidae) (Ho and Bashirullah, 1977). *Illex argentinus* is a newly recorded host for *M. uruguayensis*.

In the summer of 1990, didymozoid metacercariae were found in "type A" rhynchoteuthions from 2.0 to 5.0 mm ML. Prevalence was 72% and the mean intensity of infestation was 3.5 (Table 1). All were attached to the caecum or stomach walls, except for three parasites attached to the inner wall of the mantle and two others to the caecum wall of a single paralarva (3.6 mm ML).

Parasites were not found in "type B" rhynchoteuthions. However, only four paralarvae of this type were examined.

Discussion

Illex argentinus first acquire didymozoid metacercariae as small rhynchoteuthions. Hatchlings typically are found off southern Brazil at the outer shelf and slope in tropical and subtropical waters (Vidal and Haimovici, 1997). The infestation may be related to the fact that paralarvae are distributed mainly in tropical waters, where cystophorous cercariae may be abundant and not necessarily because the paralarvae are eating infected intermediate hosts. Crustacean prey were not found in the digestive tracts of rhynchoteuthions smaller than 3.7 mm ML (Vidal and Haimovici, 1998). However, paralarvae

[1] Hochberg, F. G. 1997. Santa Barbara Museum of Natural History, 2559 Puesta del Sol Road, Santa Barbara, CA 93105. Personal commun.

larger than this size could also be infested by consuming infected second-intermediate hosts, such as copepods and other crustaceans.

Infestation in the smaller rhynchoteuthions may occur when free cystophorous cercariae are released into the plankton and passively enter the mantle cavity during respiration (Gaevskaya, 1976) or when the cercariae attach to mucus that covers the mantle and head of rhynchoteuthions. They may also be ingested directly, in the same way that crustaceans are infested. If this is true, ommastrephid paralarvae may act as second intermediate hosts for some didymozoids. The presence of didymozoid metacercariae in the digestive tracts of rhynchoteuthions as small as 2.0 mm ML shows that the infection occurs well before that previously recorded by Gaevskaya and Nigmatullin (1983). Additionally, the size of the didymozoid metacercariae type *Monilicaecum* (140–200 µm) found on rhynchoteuthion paralarvae is strong evidence that they are in an early developmental stage in relation to those found on adult *I. argentinus* from southern Brazil (400–800 µm) (Santos, 1992). Our results are in accordance with the suggestion of Hochberg (1990) that didymozoids can grow inside the squid host. Hochberg (1990) also reported that a peak of infestation by didymozoids occurs in squids from 10 to 25 cm in ML. Nevertheless, infection decreases in adult individuals (Gaevskaya and Nigmatullin, 1977, 1983) owing to the fact that the didymozoids die after they reach a maximum size in a specific host (Hochberg, 1990). Larger squids may be reinfected by didymozoid metacercariae when they feed on infested fish prey (Hochberg, 1990). Our results indicate that more paralarvae should be examined in the future. If it is correct to assume that recently hatched didymozoid metacercariae usually infest early paralarvae, information on size and developmental stage of both host and parasites would help to understand their relationship better.

Didymozoid metacercariae were found in *I. argentinus* rhynchoteuthions from autumn to spring and in "type A" rhynchoteuthions during the summer. This morphotype had a higher prevalence and infestation of didymozoids than those of *I. argentinus*. They were collected in the summer of 1990, when tropical waters dominate the study area (Vidal and Haimovici, 1997). Thus, these larval trematodes are present off southern Brazil throughout the year. This finding is in agreement with the occurrence of the high prevalence and intensities of didymozoid metacercariae in juvenile and immature *I. argentinus* from the same area year around (Santos, 1992).

Only the sexual stages of *Aggregata* occur in cephalopods, whereas asexual stages infect the digestive tracts of crustaceans (Hochberg, 1990). *Aggregata* appears to be host-specific only in cephalopods, not in crustaceans, and is a common parasite of *Sepia* and *Octopus* (Hochberg, 1990). Our study is the first to report its presence in *I. argentinus*. This coccidian has not been found in adults of *I. argentinus* collected off southern Brazil (Santos, 1992) or Argentina (Nigmatullin and Shukhgalter, 1990; Sardella et al., 1990). *Martialia hyadesi*, a southern Atlantic oceanic species, and *Todaropsis eblanae* and *Todarodes sagittatus* in waters off Spain are the other ommastrephid squids in which *Aggregata* have been reported (Gaevskaya et al. 1986, Pascual et al. 1996). It is important to stress that infections by *Aggregata* can only be established after paralarvae begin to feed on crustaceans infected with the asexual stages of the parasite. The infected paralarva observed in this study was 7.8 mm ML; however, crustacean prey, mainly copepods, have been found in the gut of *I. argentinus* paralarvae larger than 3.7 mm ML (Vidal and Haimovici, 1998).

Metacaligus uruguayensis was originally described from the gill cavity of *Trichiurus lepturus* from Venezuela (Ho and Bashirullah, 1977). This genus previously has not been reported from cephalopods (see review by Hochberg, 1990). Associations between copepods and cephalopods appear to be primarily commensal and not truly parasitic (Hochberg, 1990). In southern Brazil, small and large adult *T. lepturus* (70–1000 mm TL) occasionally prey on juvenile and adult *I. argentinus* (22–200 mm ML) (Martins, 1992); however, additional information is required to determine whether *I. argentinus* serves as a final or only an accidental host for this copepod.

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