Parasitic copepods of the narrownose smooth-hound shark *Mustelus schmitti* (Chondrichthyes: Triakidae) from Argentina

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Abstract. The parasitic copepod fauna of 182 specimens of *Mustelus schmitti* Springer from the coast of Mar del Plata, Argentina was investigated. Three species of parasitic copepods were identified: *Nessipus orientalis* Heller, 1865 from the buccal cavity, *Perissopus oblongus* (Wilson, 1908) from the edge of pectoral, pelvic, dorsal, anal and caudal fins and in claspers, and *Lernaeopoda galei* Krøyer, 1837 from the base of the pectoral fins. *N. orientalis* was most common being present the entire year, while *P. oblongus* and *L. galei* occurred seasonally with low prevalence and mean intensity. There were differences in the site of infection by these copepods and variations in the relationship between prevalence and mean intensity and host size and seasonality. These parameters were unrelated to host sex. Our data suggest that the structure of this parasite community is a result of a complex of biotic and abiotic factors, such as temperature, spawning and breeding preferences of the host, and overlapping in the distribution of different shark species. This is the first report of *N. orientalis* in Argentinean waters.

The narrownose smooth-hound shark *Mustelus schmitti* Springer (Chondrichthyes: Triakidae) is a common fish in Argentinean waters and the shark species most frequently caught by commercial fisheries (Cousseau 1986). The geographic distribution of this species extends from Rio de Janeiro (Brazil) to 43º30'S, in waters between 22 and 121 m deep (Menni 1985, 1986) where temperatures range between 8-11.7ºC and 5.5-11ºC (surface and bottom, respectively). Previous studies on the parasite fauna of this shark include systematic and ecological aspects of endoparasitic helminths (Ostrowski de Núñez 1973, Ivanov 1996, 1997) and ectoparasitic monogeneans (Suriano 1977). Previous records of parasitic copepods from *M. schmitti* are those by Brian (1944), i.e., *Lernaeopoda mustelicola* Leigh-Sharpe, 1919 and *Achtheinus dentatus* Wilson, 1911 in Argentina and by Thomsen (1949) (*Nessipus ornatus* Thomsen, 1949) in Uruguay.

The aim of the present paper is to clarify the identity of parasitic copepods from *M. schmitti* and analyse some aspects of their ecology.

MATERIALS AND METHODS

A total of 182 specimens of *M. schmitti* were examined from catches of commercial trawlers at the port of Mar del Plata (38°08'S, 57°32'W) in 1993. All sharks were measured and sexed, parasitic copepods removed, fixed in 70% alcohol, and their locations recorded. In the laboratory, the appendages were dissected, cleared in lactic acid and examined with a light microscope. Measurements in the descriptions include the mean followed in parentheses by the range. All measurements are in millimetres. Copepod parasites have been deposited at the Museo de Ciencias Naturales de La Plata, Departamento de Zoología Invertebrados (Parasitología) (MLP), Argentina; the Institute of Parasitology, Academy of Sciences of the Czech Republic (IPCAS), České Budějovice, and the United States National Parasite Collection (USNPC) in Beltsville, Maryland, USA.

Prevalence and mean intensity of infection were calculated in association with host size and sex. The relationship between prevalence and host size was analyzed by Spearman's rank correlation coefficient (Siegel 1990), and the relationship between prevalence and host sex by the Wilcoxon's signed-rank test (both tests performed using Statistical Graphic System, version 6.0). A probability level of 0.05 was considered significant in both cases. The ecological terminology of Margolis et al. (1982) was followed throughout.

RESULTS

Parasite identification

Three species of parasitic copepods were identified as follows:

Nessipus orientalis Heller, 1865 (Copepoda: Pandaridae)

Site of infection: buccal cavity.

Material deposited: MLP No. copepo 22, IPCAS No. Cr-6, USNPC No. 88532.

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Dimensions of specimens (based on 14 females): total length (uropods included) 5.10 (4.35-5.39); cephalothorax length 1.80 (1.50-1.96); cephalothorax width 2.20 (2.10-2.48); egg sac length 7.90 (6.60-8.80).

Remarks. Thomsen (1949) described *Nessipus ornatus* based on specimens from *Mustelus schmitti* in the coast of Uruguay. More recently, Cressey (1967) synonymised *N. ornatus* with *Nessipus orientalis* Heller, 1865. Specimens obtained in this study could be clearly identified as *N. orientalis* by the fourth thoracic segment with alate plates and the presence of long setae on the endopod of leg 4. This is the first record of *N. orientalis* in Argentinean waters.

Perissopus oblongus (Wilson, 1908) (Copepoda: Pandaridae)

Site of infection: edges of pelvic, pectoral, dorsal, anal and caudal fins and in claspers.

Material deposited: MLP No. copepo 21, IPCAS No. Cr-5, USNPC No. 88531.

Dimensions of specimens (based on 12 females): total length 6.39 (5.61-7.26); cephalothorax length 2.02 (1.70-2.27); cephalothorax width 2.20 (2.10-2.35); genital segment length 3.44 (2.90-4.03); egg sac length 15.4 (11.00-20.10).

Remarks. Brian (1944) reported *Achtheinus dentatus* Wilson, 1911 in Argentina. Later, Cressey (1967) discussed the validity of the genus *Achtheinus* Wilson, 1908 and grouped all the species described within this genus under *Perissopus oblongus* (Wilson, 1908), incorrectly named *P. oblongatus*. In addition, he considered *Achtheinus galeorhini* Yamaguti, 1936 the most accurate description of *P. oblongus*.

The specimens studied herein agree with the description of *Perissopus oblongus* sensu Yamaguti (1936) by the shape of female body and genital segment, and shape and armature of thoracic legs 1 to 4. Recently, Oldewage (1992) described the female and added the first description of the male of this species. However, his description of the female of *P. oblongus* differs from Yamaguti's and our specimens by the genital segment not posteriorly invaginated, and by a differential segmentation and armature of thoracic legs.

Oldewage (1992) stated that these morphological differences could be considered intraspecific variations, and that further work on this genus will possibly confirm Cressey's (1967) suggestion that there are in fact only two valid species of *Perissopus*: *P. oblongus* and *P. dentatus*.

Cressey (1967) suggested that further studies could re-establish some of the species he included as synonyms of *P. oblongus*. The similarities between the specimens here studied and those described by Yamaguti (1936) indicate that a detailed analysis of *P. oblongus* (Wilson, 1908) and *P. galeorhini* (Yamaguti, 1936) could granted real status to both species. However, in this paper, Cressey's criteria of synonyms are followed.

Lernaeopoda galei Krøyer, 1837 (Copepoda: Lernaeopodidae)

Site of infection: base of pectoral fins.

Material deposited: USNPC No. 88533

Dimensions of specimens (based on 6 females): total length (uropods included) 8.40 (8.14-9.00); cephalothorax length 1.87 (1.76-1.98); uropod length 1.74 (1.70-2.20); egg sac length 2.21 (2.10-2.52); second maxilla length 3.35 (2.90-3.92).

Remarks. Kabata (1979) stated that among the species described of *Lernaeopoda* only two can be accepted without hesitations as members of the genus, *Lernaeopoda bidiscalis* Kane, 1892 and *Lernaeopoda galei* Krøyer, 1837.

Brian (1944) described *Lernaeopoda mustelicola* from *Mustelus asterias* Cloquet in Argentina. Kabata (1979, 1992) considered this species a *species inquirenda* and suggested that the specimens described by Brian (1944) should be referred to *Lernaeopoda galei*. The morphology of specimens found in *M. schmitti* could be identified as *L. galei* according to Kabata (1979, 1992) by the presence of a trunk longer than broad, dorsal shield of cephalothorax without distinctive colour and tips of second maxillae not greatly expanded.

There remains some question as to the correct identity of the host species for *P. oblongus* and *L. galei* reported by Brian (1944). He listed *Mustelus asterias* as the host for *L. mustelicola* (actually, *L. galei*) and *M. asterias*, *Galeus canis* Müller et Henle and *Heptanchias pectorosus* Garman as hosts for *P. oblongus* (syn. *Achtheinus dentatus*), all taken off Mar del Plata, Argentina. Since Compagno (1984) and Heemstra (1997) did not include the Argentinean Sea within the area of distribution of *M. asterias*, we assume this host record probably referred to *M. schmitti*. Furthermore, *Galeus canis* should be referred to *Galeorhinus vitaminicus* De Buen *sensu* Menni et al. (1984). Finally, Menni et al. (1984) synonymised *Heptanchias pectorosus* with *Notorhyncus pectorosus* (Garman), followed by Compagno (1984) who considered *N. pectorosus* a synonym of *N. cepedianus* (Peron), arguing that differences between the two species were intraspecific variations. In this paper we confirm the presence of *P. oblongus* and *L. galei* on *M. schmitti*. It would be ideal to examine individuals of *G. vitaminicus* and *N. cepedianus* to corroborate the presence of *P. oblongus* on these hosts.

Aspects on parasite biology

There were differences in the sites of infection preferred by the parasitic copepods. Variations in the

Table 1. Comparison of infection of *Nessipus orientalis*, *Perissopus oblongus* and *Lernaeopoda galei* on *Mustelus schmitti* by host age (size). Abbreviations: n – number of fish examined, P – prevalence, I – mean intensity, rs – Spearman's rank correlation coefficient, * – significant at 0.05 level.

Host size		*N. orientalis*		*P. oblongus*		*L. galei*	
(cm)	n	P(%)	I	P(%)	I	P(%)	I
43-50	25	36.0	3.0	8.0	2.0	-	-
51-55	55	40.0	3.6	3.6	2.0	3.6	1.0
56-60	56	19.6	4.1	-	-	3.6	1.0
61-65	26	15.4	2.5	3.9	1.0	7.7	1.0
66-70	8	12.5	2.0	-	-	-	-
71-80	12	-	-	-	-	-	-
Total	182	25.8	3.5	2.7	1.8	3.3	1.0
rs		-0.94*	-0.77	-0.69	-0.80	-0.18	-0.29

Table 2. Seasonal variation in the prevalence (P) and mean intensity (I) of *Nessipus orientalis*, *Perissopus oblongus* and *Lernaeopoda galei* in *Mustelus schmitti*. × – mean; SD – standard deviation, n – number of fish examined.

	Host size (cm)		*N. orientalis*		*P. oblongus*		*L. galei*	
	× (SD)	n	P(%)	I	P(%)	I	P(%)	I
Summer	59.3 (7.2)	59	11.9	4.1	3.4	1.5	8.5	1.0
Autumn	56.2 (6.1)	59	52.5	3.5	-	-	-	-
Winter	52.9 (3.9)	36	11.1	3.3	-	-	-	-
Spring	61.1 (8.8)	28	17.9	2.2	10.7	2.0	3.6	1.0

relationship between their prevalence and mean intensity with host size and seasonality were also observed.

Nessipus orientalis, found in the buccal cavity, had the highest prevalence and mean intensity (Table 1) of the three species and was present during all seasons, being more abundant in autumn (Table 2). Our data suggest that there is a negative relationship between host size (age) and intensity and prevalence of infection, although only the correlation between prevalence and host size was statistically significant. A Wilcoxon's signed-rank test analysis showed no significant relationship between the parasite intensity, prevalence, and host sex (Table 3).

Perissopus oblongus attaches to the edges of fins and claspers. This species was found only in warmer seasons (spring and summer) (Table 2). The prevalence and intensity of infection were low (Table 1), and correlation between these parameters and host size and sex were not significant (Table 3).

Lernaeopoda galei was found at the base of the pectoral fins. As for *P. oblongus*, this species was observed only in warmer seasons (spring and summer), with low prevalence and intensity of infection (Tables 1 and 2). Correlation between these parameters and host size and sex were not significant (Table 3).

There were also seasonal fluctuations in the mean and standard deviation of host size (Table 2). These variations could presumably be due to a mix of individuals of different sizes in shallow waters during spring and summer, and an abundance of small individuals in winter and autumn.

DISCUSSION

As was previously noted by Kabata (1979, 1992) in other species of *Mustelus* Linck, the community of parasitic copepods on *M. schmitti* is comprised of representatives of the family Pandaridae and Lernaeopodidae. In this community, one species was present during the entire year (*N. orientalis*), while *P. oblongus* and *L. galei* had a limited seasonal occurrence marked by low prevalence and by low mean intensity. These qualitative and quantitative fluctuations in parasite community are distinctive of a low-order and non-saturated community, which is characteristic of metazoan ectoparasites from marine fishes (Rohde et al. 1995).

Such fluctuations did not allow recognition of well-defined patterns of relationship between hosts and parasites. Only the most stable species in the community (*N. orientalis*) had a significant negative correlation between prevalence and host size, suggesting a preference for juvenile sharks.

Interspecific interactions among parasites were not observed since the species have well-defined patterns of spatial distribution on the host thereby avoiding competitive interactions at the sites of attachment. This observation is in agreement with the generalization made by Rohde et al. (1995) that interspecific interactions are likely to be rare in communities of metazoan ecto-parasites of marine fishes.

There is little information on the biology of parasitic copepods. Seasonal variations in parasitic copepod populations previously reported involve a variety of biotic and abiotic factors (Rawson 1977, Bortone et al. 1978, van den Broek 1979, Voorhees and Schwartz 1979, Etchegoin 1988, Etchegoin and Sardella 1990, de Meeüs et al. 1995). Fluctuations in temperature, salinity in coastal and estuarine areas, and changes in the population structure of hosts due to trophic and reproductive migrations have been mentioned as factors determining parasite loads and localization of the host. Particularly, Kabata (1981) studied the influence of temperature on reproduction of parasitic copepods, e.g. higher temperatures stimulated the maturation of eggs and development of egg sacs in females.

The occurrence of *P. oblongus* and *L. galei* during spring and summer in *M. schmitti* may be a result of an increased reproductive rate of these species during the warmer seasons. This pattern is not clear for the third species *N. orientalis*, with higher prevalence and intensity of infection in autumn.

Studies on the biology of *M. schmitti* indicate that the spawning and breeding areas are in shallow waters

Table 3. Comparison of infection of *Nessipus orientalis*, *Perissopus oblongus* and *Lernaeopoda galei* in *Mustelus schmitti* and host sex. Abbreviations: P – prevalence, I – mean intensity, Z – Wilcoxon's test.

	N. orientalis				*P. oblongus*				*L. galei*			
	Female		Male		Female		Male		Female		Male	
	P(%)	I	P(%)	I	P(%)	I	P(%)	I	P(%)	I	P(%)	I
	26.6	3.9	25.0	3.0	3.3	1.3	2.2	2.5	2.2	1.0	4.3	1.0
Z	0	0.40	0	0.40	0.62	0.36	0.62	0.36	0.63	0.53	0.63	0.53

(Cousseau 1986, Díaz de Astarloa et al. 1997). In fact, during the spawning season in spring (November-December) (Menni 1986) adult females of *M. schmitti* can be found near shore (Cousseau, pers. comm.), resulting in a mix of juvenile and adult sharks in this area. The concentration of potential hosts could increase the chances of parasite contacts with host individuals and result in increased rates of infection by less common parasite species in spring and summer.

Furthermore, *P. oblongus* was reported from two additional shark species (*G. vitaminicus* and *N. cepedianus*) that are common in commercial catches taken off Mar del Plata (Menni et al. 1986). The presence of different host species for *P. oblongus* in the same area likely explains the observed increase in prevalence and mean intensity of these parasites on *M. schmitti*. The sporadic occurrence and low prevalence and intensity of *L. galei* could be related to host preference and the presence of other potential host species in the area. Occasional infections of *M. schmitti* may be due to increased contact among hosts during warmer seasons.

Nessipus orientalis is the only species that is known from *M. schmitti* in Argentina and Uruguay that is present the entire year with a defined pattern of distribution in this shark population. A greater host specificity could be suggested for this parasite in comparison with *P. oblongus* and *L. galei*. In any event, the presence of both small and large sharks during spawning and breeding seasons and variations in abiotic factors, especially temperature in spring and summer, could increase the possibility of infection with *N. orientalis*. Such increment could be observed in autumn. Otherwise, the low prevalence and mean intensity of infection of *N. orientalis* in cold months might be related to seasonal mortality of the parasites. Seasonal mortality in parasitic copepods was observed in *Neobrachiella insidiosa* f. *pacifica* Kabata, 1979 (Lernaeopodidae) from the pacific hake *Merluccius productus* (Sankurathri et al. 1983).

Studies on population dynamics of *P. oblongus* and *L. galei* in other hosts (e.g., *G. vitaminicus* and *N. cepedianus*) are necessary to appreciate the processes which are affecting the community structure of copepods parasitic on *M. schmitti*. Nevertheless, our data suggest that the structure of this parasite community is influenced by a complex of biotic and abiotic factors, such as temperature, spawning and breeding preferences of the host, and overlapping in the distribution of different shark species.

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