

Parasitic copepods of Carcharhinidae and Sphyridae (Elasmobranchia) from the Atlantic Ocean

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Seventy-four sharks of the families Carcharhinidae and Sphyridae, mainly from the central Atlantic Ocean, were examined. Fourteen species of Copepoda were found on them. *Prionace glauca* and *Sphyrna zygaena* are new hosts for the copepod *Pandarus floridanus*. *Kroyeria carchariaeglauci* is reported from the nasal cavities of *Prionace glauca* for the first time.

KEYWORDS: Parasitic copepods, sharks, Atlantic Ocean.

Introduction

The leading publications describing parasitic copepods of sharks by Hewitt (1967), Cressey (1967 a, b) concern hosts generally living outside the Atlantic Ocean, whereas Kabata (1979) wrote mainly about parasitic copepods of British fishes and Yamaguti (1963) about all the world's fishes, including those in the Atlantic. The papers by Benz (1980, 1981, 1983, 1986, 1987), Lewis (1966), Cressey (1967 a, b, 1970, 1972), Hewitt (1967, 1979), Rokicki and Borowicz (1987) deal with parasitic copepods mostly from common species of sharks. The fact that sometimes, as in Benz (1986), only the English names of the sharks are used hinders their identification, which is difficult enough anyway as many shark species display great morphological similarities. The considerable body size of these fish also prolongs the time required to examine a single specimen. All these facts taken together have led to a situation in which our knowledge of shark Copepoda is still unsatisfactory.

The increasing interest being shown in the parasitic Copepoda of sharks can be ascribed to the wish to improve our understanding of the migrations and biology of the hosts.

Materials and methods

Seventy-four sharks belonging to 7 species: *Prionace glauca* (Linnaeus, 1758); *Carcharhinus obscurus* (Le Sueur, 1818); *C. longimanus* (Poey, 1861); *C. plumbeus* (Nordo, 1827); *C. signatus* (Poey, 1868); *Sphyrna lewini* (Griffith and Smith, 1834); *S. zygaena* (Linnaeus, 1758) were examined (Table 1). Fourteen copepod species were collected from these hosts.

The parasitic copepods came from sharks caught mainly in the central Atlantic between September 1979 and October 1985. The sharks were caught for technological purposes by vessels of the Marine Fisheries Institute of Gdynia and were identified immediately after being taken on board.

Table 1. Quantitative comparison of copepod infestation of recorded sharks.

Host species	No. of sharks		No. of copepod species
	Examined	Infested	
<i>Prionace glauca</i>	35	34	10
<i>Carcharhinus obscurus</i>	14	3	3
<i>Carcharhinus longimanus</i>	7	0	0
<i>Carcharhinus plumbeus</i>	2	0	0
<i>Carcharhinus signatus</i>	1	1	2
<i>Sphyrna lewini</i>	5	5	4
<i>Sphyrna zygaena</i>	10	4	6
Total	74	47	—

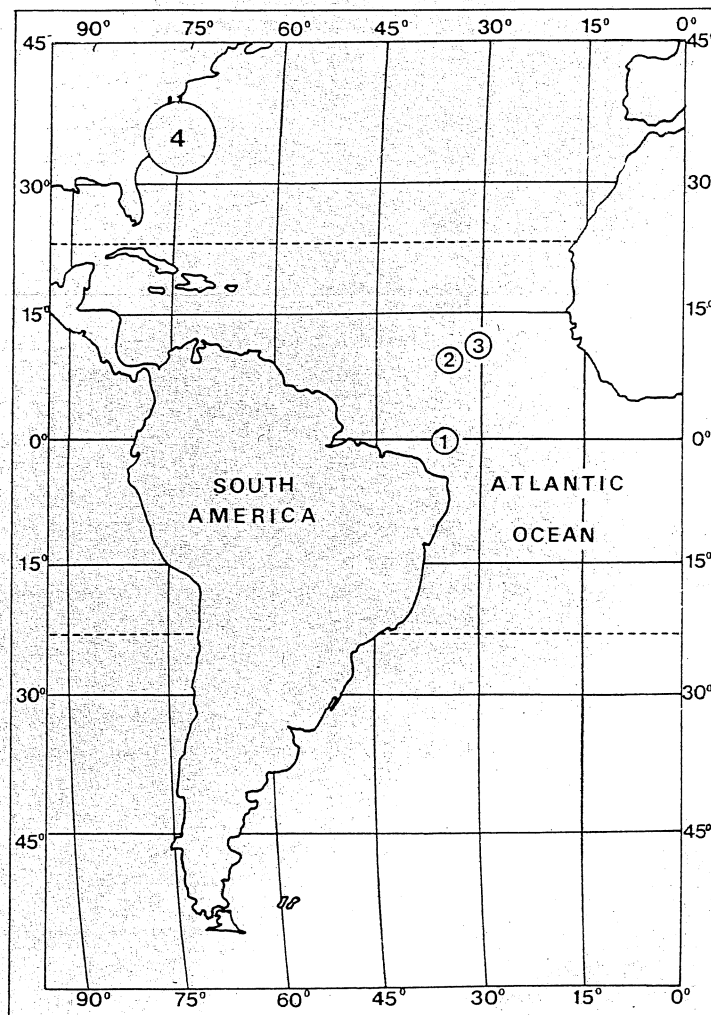


FIG. 1. Capture areas of sharks infested by Copepoda: 1 00°21'N-34°W; 2 09°41'-11°34'N and 34°04'-37°54'W; 3 12°28'-15°01'N and 29°20'-30°35'W; 4 33°08'-35°38'N and 73°51'-74°45'W.

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The locations where the sharks were caught are shown in Fig. 1. Copepods were collected on deck from 36 host individuals. The other sharks were preserved in refrigerators for a considerable time. After the sharks had been thawed on land, parasites were collected from the surface of the body and fins, from the buccal, nasal and gill cavities, and from the gills themselves. The regions around the anus and the sexual openings are also examined. In eight sharks the copepods were taken from the body and fin surfaces only. The parasites collected were preserved in 70% ethanol.

Results

Fourteen species of parasitic Copepoda (Table 2) were collected from sharks belonging to the families Carcharhinidae and Sphyridae. Forty-nine of the 74 sharks examined were infested with Copepoda (Table 1).

Pandarus satyrus Dana, 1852.

Host: *Prionace glauca*.

Location on the host: skin, especially that of the fins.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 8 sharks were infested with an intensity ranging from 1 to 23 parasites.

A cosmopolitan species, captured in areas 1, 2, 3 and 4 (see Fig. 1).

Pandarus cranchii Leech, 1819.

Hosts: *Prionace glauca*, *Carcharhinus obscurus*, *C. signatus* and *Sphyrna lewini*.

Location on the host: dorsal fin and gills.

Incidence and intensity of infestation: out of the 5 *Sphyrna lewini* examined, 4 sharks were infested with an intensity ranging from 1 to 4 parasites. Only 1 copepod was found on 35 examined *Prionace glauca*, yet the 1 *Carcharhinus signatus* examined was infested with 6 copepods. Out of the 14 *Carcharhinus obscurus* examined 1 parasite was found.

A cosmopolitan species, recorded from areas 1, 3 and 4 (see Fig. 1).

Pandarus smithii Rathbun, 1886

Hosts: *Prionace glauca*, *Carcharhinus obscurus*, *C. signatus*, *C. plumbeus*, *Sphyrna zygaena*.

Location on the host: skin, specially that of dorsal and pectoral fins.

Incidence and intensity of infestation: 35 *Prionace glauca* were examined, only 1 *P. smithii* parasite was found. Out of the 9 *Carcharhinus obscurus* examined, 1 copepod was found. Two were found on the single *Carcharhinus signatus* examined. Out of the 2 *C. plumbeus* examined 1 copepod was found. Out of the 10 *Sphyrna zygaena* examined 1 parasite was found.

Previously recorded from the Atlantic and the Indian Ocean. The present distribution was in areas 2, 3 and 4 (see Fig. 1).

Pandarus floridanus Cressey, 1967

Hosts: *Prionace glauca*, *Sphyrna zygaena*.

Location on the host: pectoral fin and near mandibula.

Incidence and intensity of infestation: out of the 35 *Prionace glauca* examined, *P. floridanus* was found on 2 sharks, with a single copepod, 1 with 3. Out of the 10 *Sphyrna zygaena* examined 1 parasite was found.

Previously recorded from the Atlantic and Indian Ocean. The present distribution was in areas 2 and 3 (see Fig. 1).

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and 9°41'–11°34'N
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Phyllothyreus cornutus (Milne-Edwards, 1840)

Hosts: *Prionace glauca*, *Carcharhinus plumbeus*, *Sphyrna zygaena*.

Location on the host: gills and skin.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 7 sharks were infested with intensities ranging from 1 to 5 copepods. Out of the 2 *Carcharhinus plumbeus* examined 1 parasite was found. Out of the 10 *Sphyrna zygaena* examined 1 copepod was found.

Previously recorded from the Indian and Pacific Oceans and the Mediterranean Sea. The present distribution was in areas 2, 3 and 4 (see Fig. 1).

Gangliopus pyriformis Gerstaecker, 1854

Host: *Prionace glauca*.

Location on the host: gills.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 6 sharks were infested with intensities ranging from 1 to 10 copepods per host.

Previously recorded from the Pacific, the North Atlantic and the Indian Oceans. Presently recorded from area 3 (see Fig. 1).

Pagina tunica Cressey, 1964

Host: *Sphyrna zygaena*.

Location on the host: fins.

Incidence and intensity of infestation: out of the 10 sharks examined, one parasite was found.

The species has been recorded from the Indian and Pacific Oceans. Presently recorded from area 2 (see Fig. 1).

Echthrogaleus coleoptratus (Guerin-Meneville, 1837)

Host: *Prionace glauca*.

Location on the host: fins.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 7 sharks were infested with intensities ranging from 2 to 8 copepods per host.

A cosmopolitan species, recorded from all areas sampled, i.e. 1, 2, 3 and 4 (see Fig. 1).

Nemesis robusta (Beneden, 1851)

Host: *Sphyrna zygaena*.

Location on the host: gills.

Incidence and intensity of infestation: out of the 10 *S. zygaena* examined 1 was infested by 5 copepods.

A cosmopolitan species, though presently recorded only from area 4 (see Fig. 1).

Nessipus borealis (Steenstrup and Lütken, 1861)

Hosts: *Prionace glauca* and *Sphyrna lewini*.

Location on the host: gills and fins.

Incidence and intensity of infestation: out of the 35 *Prionace glauca* examined, 15 sharks were infested with intensities ranging from 1 to 7 copepods per host. Out of the 5 *Sphyrna lewini* examined 2 sharks were infested, 1 with 1 and the other with 2 parasites.

Previously recorded from the Atlantic and Pacific Oceans. Presently recorded from areas 3 and 4 (see Fig. 1).

Kroyeria lineata van Beneden, 1853Host: *Prionace glauca*.

Location on the host: gills.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 22 sharks were infested with intensities ranging from 2 to 111 copepods per host.

Previously recorded from the Pacific and Atlantic Oceans and the Mediterranean Sea. Present recorded from area 3 (see Fig. 1).

Kroyeria carchariaeglauci Hesse, 1878Host: *Prionace glauca*.

Location on the host: nasal cavity.

Incidence and intensity of infestation: out of the 35 *P. glauca* examined, 5 sharks were infested with from 2 to 15 copepods.

Previously recorded from the west part of North Atlantic. Presently found in area 3 (see Fig. 1).

Alebion crassus Kroyer, 1863Hosts: *Sphyrna lewini* and *Carcharhinus obscurus*.

Location on the hosts: basis of dorsal fin.

Incidence and intensity of infestation: out of the 5 *Sphyrna lewini* examined, 4 sharks were infested with from 1 to 13 copepods. Out of the 14 *Carcharhinus obscurus* examined, 1 shark was infested with 12 copepods.

Previously recorded from the North Atlantic. Presently taken from area 4 (see Fig. 1).

Alebion carchariae Kroyer, 1863Hosts: *Sphyrna lewini* and *S. zygaena*.

Location on the host: basis of dorsal and caudal fins. Incidence and intensity of infestation: out of the 5 *S. lewini* examined, 1 shark was infested by 9 copepods. Out of the 10 *S. zygaena* examined, 1 had 12 parasites.

Previously recorded from the northern Atlantic and western part of Indian Ocean. Presently recorded from area 4 (see Fig. 1).

Discussion

A wide variety of parasitic copepods were found on the blue shark (*Prionace glauca*), probably because of the wide dispersal of this host species in all the oceans and some seas from the tropics to the temperature zone. In the present study, examination of 35 specimens of *Prionace glauca* yielded 10 species of copepods (Table 2). According to Benz (1986) *Prionace glauca* is host to 8 copepod species: *Pandarus satyrus*, *P. cranchii*, *P. smithii*, *Phyllothereus cornutus*, *Gangliopus pyriformis*, *Echthrogaleus coleoptratus*, *Kroyeria carchariaeglauci*, *Caligus productus* Dana, 1852 and to two others identifiable only to genus (*Eudactylina* sp. and *Kroyeria* sp.).

Benz's observations are only partially confirmed by our findings—only 7 species appear in both lists. At the same time we found 3 species (*Kroyeria lineata*, *Nessipus borealis* and *Pandarus floridanus*). The first of these could be the one that Benz described in general terms as *Kroyeria* sp. In our material *Kroyeria lineata* was common and occurred in large numbers, so perhaps its presence is linked with the place where the sharks were caught. The copepods collected for this paper came from the central Atlantic, whereas Benz's material came from the western North Atlantic.

Of the 35 examined specimens of *Prionace glauca*, 5 were infested with *Kroyeria carchariae* with an intensity of 2–5 specimens. These parasites were located in the nasal cavity. Benz (1986) describes them as 'copepods which live in the excurrent water channels between the gill filaments'.

Kabata (1979) lists 7 species of parasitic Copepoda on *Prionace glauca* from the waters around Great Britain. Three of them are the same as were found on sharks from the central Atlantic, 4 are different: *Anthosoma crassum* (Abildgaard, 1794), *Dinemoura producta* (Müller, 1785), *Nemesis robusta* (Beneden, 1851) and *Pandarus bicolor* Leach, 1816. Of interest is the fact that *Dinemoura producta*, said by many authors to be widespread, was not present in our material.

Tagging of *Prionace glauca* has shown that a large part of the population of these sharks migrated from the NE to the central Atlantic (Pelczarski, 1984). The occurrence of similar sets of Copepoda in both these areas would be confirmation of this investigation. However, Pelczarski's supposition that the western Atlantic population of *Prionace glauca* mixes with that from the eastern Atlantic, seen in the light of comparisons of the Copepoda parasitizing them, appears to be much smaller in extent. Planned tagging of sharks off European coasts may confirm this.

Lewis (1966) records the following species on *Prionace glauca*: *Pandarus satyrus*, *Phyllothyreus cornutus* and *Dinemoura latifolia* (Steenstrup and Lütken, 1861), while Hewitt (1967) found *Pandarus bicolor*, *Phyllothyreus cornutus* and *Echthrogaleus coleoptratus*. Of these species, we found only *Phyllothyreus cornutus* and *Echthrogaleus coleoptratus*.

Cressey (1967 a) reports 5 parasitic copepod species from *Prionace glauca*, namely *Pandarus satyrus*, *Phyllothyreus cornutus*, *Echthrogaleus coleoptratus*, *Dinemoura producta* and *Gangliopus pyriformis*. Our observations agree in part with Cressey's, but we did not find one of these species: *Dinemoura producta*.

Of the total number of around 15 copepod species recorded from *Prionace glauca*, *Pandarus satyrus* and *Phyllothyreus cornutus* exhibit the widest range. They occur on this host not only in the central and northern Atlantic but also in the Indian and Pacific Oceans. In the central Atlantic, *Prionace glauca* had the largest number of copepod species (10) encountered.

Benz (1981) noted the arrangement of large groups of *Pandarus satyrus* on the pectoral fins of *Prionace glauca*. The parasites aligned themselves in rows, forming a rhomboid group. Moreover, the genital segment of one specimen overlapped in tile fashion on the left or right side of the cephalothorax of the two specimens behind it. This characteristic arrangement was seen on some of the sharks examined in this study. Benz explains this arrangement as ensuring a stronger link between parasite and host. Such a tight formation may well protect individual specimens from the predatory fish *Remora remora*, although analyses of the stomach contents of this predator did not usually reveal the presence of *Pandarus satyrus* with which the shark's fins were infested. Benz makes further suggestions regarding this characteristic tight formation of copepods. These groups of parasites consisted almost exclusively of females; if males were present, they took up positions on the edges of the fins and were few in number. Such an arrangement may facilitate the assembly of females in a particular place (the pectoral fins).

Almost all of the specimens of *Pandarus satyrus* in the present material were female; only in one case were 2 males found in a group. Our own observations have confirmed Benz's suppositions. Our material was taken from frozen sharks and was frequently transported, yet the specimens of *Pandarus satyrus* remained attached to the shark's

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pectoral fins in compact groups, which would endorse Benz's suggestion that this is a way in which the parasite maintains strong links with its host.

Cressey (1968) considers *Pandarus satyrus* to be a cosmopolitan species, but one occurring exclusively on *Prionace glauca*, and that its reported presence on other hosts is due to incorrect identification of the parasite or even of the host. Our observations concur with this statement: we found *Pandarus satyrus* only on *Prionace glauca*. Cressey further suggests that it is probable that each *Pandarus* species is located in a different position on the shark's body. Benz (1986) believes this dependence is due to structural differences in the scales covering the shark's body. When collecting the parasites for this study it was noticed that copepods never occurred on the dorsal side of the head or trunk of the sharks. The scales covering these parts of the trunk are the largest on the whole body and lie very flat against the shark's body. Benz's suggestion, however, requires further investigation. Again, Benz (1986) considers *Pandarus satyrus* as specific to *Prionace glauca*, and disagrees with Lewis (1966), who lists other hosts for this species. In this study *Pandarus satyrus* was not found on *Sphyrna zygaena*, which would support Benz's observations.

The parts of the shark's bodies where the various parasitic copepod species were found are the same as those given in the literature, with the exception of *Kroyeria carchariaeglauca*. This species was found in the nasal cavity and gill of *Prionace glauca*, which is contrary to Benz's observations (1986); he collected them only from the gills of *Prionace glauca*.

The present study has confirmed the views of Cressey (1967 a) and Benz (1986) that *Gangliopus pyriformis* is specific to *Prionace glauca*.

Hewitt (1979) draws attention to the number of copepod species present on one host specimen. Usually there are 2 or 3 species of copepods on one shark. Hewitt mentions a case where 8 copepod species were found on a single specimen of *Carcharodon carcharias* caught near Wellington, New Zealand. We found 6 copepod species on each of 2 specimens of *Prionace glauca* from the central Atlantic. One of these sharks was infested with *Pandarus satyrus*, *P. floridanus*, *P. cranchii*, *Nessipus borealis*, *Kroyeria lineata* and *Gangliopus pyriformis*, and the other with *Pandarus satyrus*, *P. floridanus*, *Nessipus borealis*, *Kroyeria lineata*, *Phyllothyreus cornutus* and *Gangliopus pyriformis*. The species composition of parasites on these 2 sharks is very much the same. In both cases there were at least 2 *Pandarus* species, which concurs with Hewitt's statement (1967). He says that *Pandarus* species occur together on particular host species.

The number of male and female specimens of *Prionace glauca* examined was roughly the same, but there were no significant differences regarding numbers and species composition in the collection of parasites from both sexes. Previous authors have not mentioned the sex of the parasite-infested sharks, neither have they considered a possible sex-linked difference in the prevalence of copepod infestation.

Fourteen specimens of *Carcharhinus obscurus* were investigated in the present study and Copepoda were found on 3 of them: *Pandarus smithii*, *P. cranchii* and *Alebion crassus* (Kroyer, 1863). Benz (1986) and Lewis (1966) mention 2 copepod species for this host: *Pandarus cranchii* and *P. smithii* from the northeast Atlantic and off the Hawaiian Islands. Cressey (1967 a) found 6 copepod species on *Carcharhinus obscurus* from the Indian Ocean: *Alebion carcharie* Kroyer, (1863), *Nessipus orientalis*, *Pandarus smithii*, *P. cranchii*, *Kroyeria gracilis* Wilson, 1932, *Nemesis spinulosus* (Cressey, 1970). Of these species we found only *Pandarus smithii* and *P. cranchii*. *Alebion crassus* was not mentioned by Cressey (1967 a). The differences in copepod species composition on particular sharks may be due to the different fishing grounds where they were caught.

No parasites were found on seven specimens of *Carcharhinus longimanus*, but this could be attributable to only a small number of sharks of this species having been studied.

Four copepod species—*Pandarus cranchii*, *Nessipus borealis*, *Alebion crassus* and *A. carchariae* (Table 2)—were collected from 5 specimens of *Sphyrna lewini*. Benz (1986) reports 5 copepod species from this species of shark: *Alebion carchariae*, *A. crassus*, *Echthrogaleus coleoptratus*, *Pandarus smithii* and *P. zygaena* Brady, 1883. Cressey (1967 a) has recorded 5 species of copepods for this host altogether, but with the exception of *Alebion carchariae* they are different from those given by Benz: *Alebion elegans* (Capart, 1953), *Nessipus crypturus* Heller, 1865, *Kroyeria scutorum* and *Eudactylina pollex* Cressey, 1967. Lewis (1966) observed only 2 copepod species, *Pandarus cranchii* and *Kroyeria longicauda* Cressey, 1970, on *Sphyrna lewini*. The present study has partially upheld the observations of Benz, Cressey and Lewis, but we found also *Nessipus borealis*, which these authors do not mention in connection with *Sphyrna lewini*. The lack of the other parasites mentioned by them may be due to the small number of *Sphyrna lewini* specimens that we investigated (Table 1) and the different places from which hosts were caught. The material for the present study came from fishing grounds in the Atlantic Ocean (Fig. 1). Benz's specimens (1986) of *Sphyrna lewini* came from the same area. Two species of Copepoda (*Alebion carchariae* and *A. crassus*) are common to Benz's material (1986) and our own.

Ten specimens of *Sphyrna zygaena* were found to be hosts to a total of 6 copepod species: *Pandarus smithii*, *P. floridanus*, *Phyllothyreus cornutus*, *Pagina tunica* Cressey, 1964, *Nemesis robusta* and *Alebion carchariae*. Cressey (1967 a) gives 4 species—*Pandarus cranchii*, *P. smithii*, *P. zygaena* and *Nessipus orientalis* Heller, 1865.

Hewitt (1967) mentions *Perissopus dentatus*. The parasitic copepod *Kroyeria lineata* reported by Kabata (1979) was not present in our material. Lewis (1966) found *Pandarus smithii* on *Sphyrna zygaena*; our study confirms that observation. On the other hand, we did not find 2 other species given by Lewis: *Alebion echinatus* and *Nessipus crypturus*. *Sphyrna zygaena* thus appears to be host to many copepod species.

Cressey (1967 b) mentions 3 species of Copepoda from *Carcharhinus plumbeus* in the Indian Ocean. In the present study we did not find any of these species on any of the 2 sharks from the Atlantic which we examined (Table 1). Recorded *Carcharhinus plumbeus* yielded *Phyllothyreus cornutus* (see also Kabata, 1979) and *Pandarus smithii* (recorded also by Lewis, 1966 and Cressey, 1970). Benz (1986) reports *Pandarus sinuatus*, *P. smithii* and *Perissopus dentatus* on this host species in the North Atlantic.

Examination of 1 specimen of the shark *Carcharhinus signatus* revealed the presence of 2 copepod species: *Pandarus cranchii* and *P. smithii*; Benz (1986) reports 3 copepod species for this host: *Pandarus smithii*, *Alebion lobatus* and *Echthrogaleus coleoptratus*, as well as an unidentified *Opinia* sp.

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