

Prevalence, geographical distribution and host specificity of parasitic copepode *Lophoura szidati* Stadler, 1978 (Copepoda: Sphyrriidae) on grenadiers (*Macrourus* spp.) in the Antarctic

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ABSTRACT: A total of 5948 specimens of *Macrourus whitsoni* Regan, 1913, 142 *M. holotrachys* Günther, 1878 and also three *M. caml* McMillan, Iwamoto, Stewart et Smith, 2012 from Antarctic deep waters were examined for the presence of a mesoparasite, *Lophoura szidati* Stadler, 1978. All specimens were collected during four Antarctic summers (December–March) in seasons 2010–2013 and 2014–2015 as by-catch during fishing for Antarctic toothfish *Dissostichus mawsoni* Norman, 1937 at a depth from 586 to 2300 m in the Pacific, Indian and Atlantic sectors of the Antarctic. Considering that seasonal variability in the prevalence of parasites may be caused by differences in selectivity and efficiency of fishing gears, it can be concluded that upon circumpolar distribution of *L. szidati* its mean prevalence on *M. whitsoni* reaches 10–12% and higher in the Pacific sector of the Antarctic. *M. caml* is recorded as a host of *L. szidati* for the first time.

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KEY WORDS: *Lophoura szidati*, *Macrourus whitsoni*, Antarctic.

Встречаемость, географическое распространение и гостальность *Lophoura szidati* Stadler, 1978 (Copepoda: Sphyrriidae) на макрурусах в Антарктике

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РЕЗЮМЕ: Проанализировано 5948 особей *Macrourus whitsoni* Regan, 1913, 142 особи *M. holotrachys* Günther, 1878 и три особи *M. caml* McMillan, Iwamoto, Stewart et Smith, 2012 из Антарктических вод на предмет зараженности мезопаразитом *Lophoura szidati* Stadler, 1978. Все особи были пойманы в течение четырех промысловых сезонов (декабрь–март) с 2010 по 2013 г. и в 2014–2015 гг. при промысле Антарктического клыкча *Dissostichus mawsoni* Norman, 1937 на глубине от 586 до 2300 м в тихоокеанском, атлантическом и индоокеанском секторах Антарктики. Учитывая

межсезонную вариабельность экстенсивности заражения и возможное влияние селективности и уловистости примеряемых орудий лова, можно заключить, что при циркумполярном распространении *L. szidati* экстенсивность заражения этим паразитом *M. whitsoni* в среднем по Антарктике достигает 10–12% и несколько выше в тихоокеанском секторе. *M. caml* описан как хозяин *L. szidati* впервые.

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КЛЮЧЕВЫЕ СЛОВА: *Lophoura szidati*, *Macrourus whitsoni*, Антарктика.

Introduction

Due to remoteness and hindered accessibility of the most part of Antarctic waters, knowledge about deep-water fish parasites is scarce. Most studies in the Southern Ocean deal with taxonomy of fish parasites, and there are a few new studies on distribution and host-specificity of known species (Walter et al., 2002, Klimpel et al., 2010, Brown et al., 2013, Sokolov, Gordeev, 2013, 2015). *L. szidati* is one of the most common mesoparasites of *Macrourus* spp. previously recorded in the Atlantic sector of the Antarctic and sub-Antarctic (Stadler, 1978, Walter et al., 2002). Surprisingly, these two papers seem to be the only papers on *L. szidati*. Overall, 19 species of *Lophoura* are known, but only *L. szidati* is found in the Antarctic (Walter, Boxshall, 2015). Its site of infection is located near the base of the dorsal fin, with the outgrowth of the copepod neck reaching the body cavity throughout the body musculature. Life cycle of *L. szidati* is not known.

Macrourus spp. are very widespread deep-water fishes that inhabit depths from 400 to 3185 m (Cohen et al., 1990; Gon and Heemstra, 1990) and form one of the most important part of the bottom ecosystem's food chain. Along with other species *M. whitsoni* is one of the most common fish in the Antarctic. Its distribution is circumpolar and includes areas of continental slope and ocean depths. Up to 2012 only three species of grenadiers were known in the Antarctic — *Macrourus whitsoni* Regan, 1913, *M. holotrachys* Günther, 1876 and *M. carinatus*

Günther, 1878 in sub-Antarctic (Gon, Heemstra, 1990; Miller, 1993; Smith et al., 2011). But in 2012 the fourth species, *M. caml* McMillan, Iwamoto, Stewart et Smith, 2012 was described based on morphological and molecular data. Its distribution is widespread in the Southern Ocean including the Ross Sea, Balleny and Scott Islands slope, Cosmonaut Sea, south of South Georgia, at 350–2080 m (McMillan et al., 2012).

The present study was carried out to consolidate data on infestation of the Antarctic *Macrourus* species by *L. szidati* collected during the four fishing seasons 2010–2013, 2014–2015 and, taking into account reference data, to summarize the existing knowledge about distribution, local variations of infestation prevalence and host-specificity of this species.

Materials and methods

All examined specimens of Whitson's grenadier (*Macrourus whitsoni*) were collected in the Antarctic in seasons 2010–2013 and 2014–2015 (February–March) during commercial and research fishing for toothfish *Dissostichus* sp. at a depth from 586 to 2300 m using bottom longline system of autoline and trot-line type [see Petrov et al. (2014) for the detailed descriptions of the fishing gear]. The total of 5948 specimens of *M. whitsoni* (TL 26–90 cm; anus length 10–31 cm; weight 130–3780 g) were examined. Locations of catch and quantitative characteristics of hauls are given in Tab. 1 and shown in Fig. 1. Prevalence of infestation (percentage of infested specimens), mean intensity

Table *Macrourus whitsoni* localities of catch, sample size and indices of infestation by copepod *Lophoura szidati* in the Antarctic.Таблица 1. Места вылова и размер выборки *Macrourus whitsoni*, индексы зараженности копеподой *Lophoura szidati* в Антарктике.

Locality			Season	Number	Mean Intensity (Intensity)	Prevalence (%)
Pacific sector	northern Ross sea	65°S 178°W	2010–2011	4	1.00 (1)	25.0
			2011–2012	15	1.00 (1)	20.0
			2014–2015	134	1.00 (1)	18.7
	Ross Sea slope	70–75°S 170°E — 174°W	2011–2012	701	1.28 (1–5)	12.3
			2012–2013	1721	1.17 (1–4)	13.4
			2014–2015	1431	1.26 (1–5)	10.1
	Amundsen Sea	69°S 126°W; 71–73°S 118– 121°W	2012–2013	110	1.24(1–3)	15.5
2014–2015			390	1.15(1–2)	8.7	
Indian sector	d'Urville Sea	64–65°S 130– 135°E; 64– 65°S 139°E	2010–2011	177	1.11(1–3)	10.7
	Mawson Sea	64–65°S; 110–115°E	2010–2011	48	1.75(1–3)	8.3
	Cooperation Sea	66°S 70–75°E	2010–2011	18	1.00(1)	11.1
Atlantic sector	Weddell Sea	73–74°S 29– 32°W	2012–2013	1181	1.09(1–3)	12.0
	Bouvet Island area	53–54°S 3– 4°E	2010–2011	18	1.00(1)	11.1

(the ratio of the number of parasites to the number of infested hosts) and extreme values of intensity were used as parasitological indices.

Three examined specimens of *Macrourus caml* (TL 42–45 cm; anus length 14–15 cm; weight 340–490 g) were caught in January 2015 in the following coordinates — 75°56'S; 170°49'W (Ross Sea) at a depth of 965 m. Species identification was done using McMillan et al. (2012). 142 specimens of *M. holotrachys* (TL 41–82 cm; anus length 15–29 cm; weight 300–2640 g) were caught in the Scotia Sea (53°S; 50°W) in March 2013 at a depth of 925–1536 m. Examination of infestation by *L. szidati* is very convenient due to large size of this mesoparasite

and abundance of *Macrourus* sp. in by-catch during longline fishing for toothfish in all areas of the Antarctic. Examination does not require full dissection, and visual inspection with partial dissection is usually enough for evaluation of infestation prevalence and intensity.

Results

Mean prevalence on *Macrourus whitsoni* is pretty stable among seasons and samples and reached 10–12%. Only one of three examined specimens of *M. caml* were infested. As on *M. whitsoni* the site of infection was near the base of the dorsal fin, with the outgrowth of the

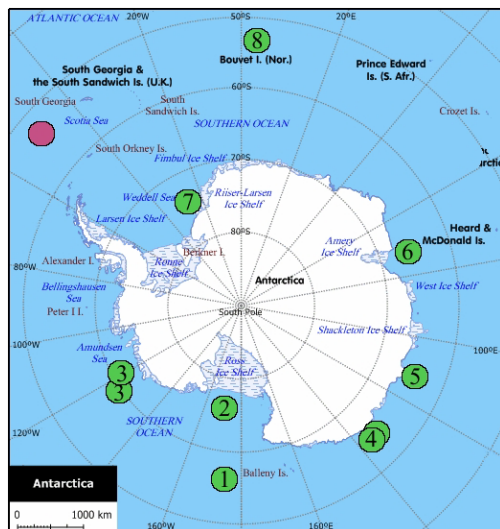


Figure 1. Map of the locations where the material was collected. The numbers indicating locations correspond to those in Table 1. Unnumbered circle shows the location where *Macrourus holotrachys* was caught in season 2012/13 in the Scotia Sea.

Рисунок 1. Карта сбора материала. Номера локаций соответствуют номерам в Таблице 1. Место вылова *Macrourus holotrachys* в сезоне 2012–2013 гг. в море Скоша отмечено нумерованным кружком.

copepod neck reaching the body cavity throughout the body musculature. None of the examined specimens of *Macrourus holotrachys* was infested (Table 1).

Seasonal prevalence of *M. whitsoni* at the separately located seamounts at northern Ross Sea is higher than at the near-continental area. At the same time mean prevalence in the Pacific sector could be about half higher than in the other sectors of Antarctic. Most specimens of Whitson's grenadier carried only one individual of *L. szidati*, meanwhile the maximal intensity was found at the Ross Sea slope where number of them reaches five. In the cases of multiple infestation parasites could be located both on one spot and at the different sides of the body. Most parasites were found on small and middle size fishes (TL 16–48 cm) while large specimens found only a few cases of infestation. Pathogenicity is expressed in often inflamma-

tion around the site of a parasite insertion into the host tissue and in damage to the muscle tissue, the wall of the body cavity and liver at the site of its joint intergrowths with copepod's holdfast.

Correlation between depth and prevalence or intensity was insignificant with no clear trend [correlation coefficient $r(p) = 0.6102 (0.0267)$]. The deepest place where infected *M. whitsoni* was caught is at the Mawson Sea (2300 m).

Discussion

Antarctic ecosystem is very famous for its homogenies when some species are endemic for the Antarctic and at the same time are found in all sectors, like *Euphasia superba* (Sala et al., 2002; Siegel et al., 2013), *Dissostichus mawsoni* (Mugue et al., 2014), *Pleuragramma antarcticum*, *Bathydraco scotiae*, *Gerlachea australis* (Miller, 1993; Shust, 1998). Despite circumpolar distribution (Fig. 1) of *L. szidati* in the Antarctic, which covers not only margins of shelf and continental slope but separately located seamounts in proximity to sub-Antarctic, our results show that in the Pacific sector its frequency of occurrence could be up to 50% higher than in other sectors of the Antarctic. More likely it is related with size of its host's biomass in the Ross Sea. Data on the larval stages are not available. We assume that the Ross Sea circulation current, described in the area between continental shelf and the Pacific-Antarctic Ridge (Rintoul, 2001), allows the infestation as the larvae remain within this current system. On one hand it also can explain higher maximal intensity (see Table 1) in the Ross Sea, — when most larvae are distributed within some boundaries a single host has higher chances to be infested. On the other hand, it may be caused by larger sample at the Ross Sea where a total of 3853 specimens were examined from slope when in other sectors there were substantially fewer specimens.

In Walter et al. (2002) there are data on infestation of *M. whitsoni* in the eastern Weddell Sea shelf ($n=65$, prevalence — 9%, intensity — 1, mean int. 1) and near the South Shetland Islands ($n=321$, prev. — 7%, int. — 1–2, mean

int. — 1) which seems to be the last published information about the *L. szidati*. With a much smaller sampling these data harmonize with the data obtained by us.

The level of host specificity in copepods ranges through a continuum from high, with the parasite species occurring on only a single host species, to low, with the parasite species occurring on a wide range of phylogenetically unrelated hosts (Boxshall, 1998). The author also noted that in the deep sea where densities of potential hosts are relatively low and the presumed probabilities of the infective stage of the parasite encountering a suitable host are also low, parasites should be less host specific than in shallower waters where host densities are higher, on the assumption that any host is better than no host (Boxshall, 1998). There are no new records that *L. szidati* has lower host specificity than its congener species and parasitize on representatives of other deep-water fish genera in the Antarctic other than *Macrourus*. Other representatives of fam. Sphyrriidae like *Sphyrion lumpi* show much lower level of host specificity parasitizing on at least 19 fish species (Boxshall, 1998). *Antimora rostrata* Günther, 1878 (Gadiformes: Moridae) is recorded as a host for *Lophoura tetraphylla* Ho, 1985 at Northwest Atlantic Ocean (Hogans, 1986) and inhabit Antarctic waters but no specimens examined in our study were infested by *L. szidati*.

It is hard to evaluate the influence of fishing gear features on sampling and ultimately on the calculated indices of infestation. Bottom longline has very high level of selectivity (Petrov et al., 2014) and in Antarctic conditions only limited number of species could be caught using it and furthermore by-catch species make up no more than 5–10% by weight. On one hand, in comparison with trawl, the trawl allows better survey of the fish fauna of a particular location both in terms of species diversity and size composition. On the other hand, longline fishing allows examination of specimens of quite variable sizes. Disadvantage in using longline fishing as a source of specimens in the Antarctic also lies in the fact that fishing at depths less than 550 m is prohibited by the Conservation Mea-

asures of the Commission for the Conservation of Marine Living Resources (CCAMLR) in order to preserve the Antarctic fauna. But most of these depths fall on shelf where deep-water fishes like *Macrourus* spp. are never caught, so for the present study longline works fine.

Macrourus holotrachys, which was the first recorded host of *L. szidati* (Stadler, 1978) from South Orkney Islands and South Sandwich Islands surprisingly showed no infestation. Unfortunately, there are no published data on the prevalence of *L. szidati* infestation on *M. holotrachys* for comparison. *M. caml* is recorded as a host for the first time. Despite the absence of data from the Kerguelen Islands, Prince Edward Islands and Crozet Islands slopes, it seems that the same as most endemics of the Antarctic geographical distribution of *L. szidati* is limited by the Antarctic Convergence. Depth distribution is related with host's features, maximal recorded depth — 2300 m.

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