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Endohelminthes of *Scorpaena porcus* Linnaeus, 1758 (Pisces: Scorpaenidae) in the southwestern part of the Crimean Black Sea shelf

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ABSTRACT: *Scorpaena porcus* Linnaeus, 1758 (black scorpionfish) is one of the most common coastal fish in the Black Sea. As scorpionfish is not a commercial fish in the Crimean part of the Black Sea shelf, its helminth fauna has previously attracted minor research interest, with no more than 70 fish specimens studied over about 80 years. In this study, we examined a total of 951 *S. porcus* specimens collected in the southwestern part of Crimean Black Sea shelf in 1994–2022. The rich endohelminth fauna was revealed: we found 16 species (four trematodes, three cestodes, seven nematodes, two acanthocephalans) but didn't find five helminth species previously known from this host in the region. One trematode (*Proctoeces maculatus*), larvae of three nematode species (*H. aduncum* l. III, *Cosmocephalus obvelatus* l. III, *Contracaecum rudolphii* l. III) and adult nematodes of three other species (*Dichelyne* (*Cucullanellus*) *minutus, Cucullanus* sp., *Spinictectis tamari*) as well as two acanthocephalans (*Telosentis exiguus, Acanthocephaloides propinquus*) and one cestode species (*Progrillotia dasyatidis* l.) were recorded from *S. porcus* in the study area for the first time. Taking into account the earlier findings, the recorded endohelminth fauna of the scorpionfish in this area of the Black Sea includes 21 species. The black scorpionfish was revealed to be an accidental host for trematodes *Proctoeces maculatus* and *Lecithochirium musculus*, cestodes *Scolex pleuronectis* l., nematodes *Cucullanus* sp., *S. tamari*, *C. obvelatus* l. III, *D.* (*C.*) *minutus,* for acanthocephalans *T. exiguus* and *A. propinquus.* Six helminth species (*T. exiguous*, *Philometra* sp., *Cucullanus* sp., *D.* (*C.*) *minutus*, *S. tamari*, *A. capitellatum*) were not found to reach maturity in the scorpionfish. The "core" part of *S. porcus* helminth fauna in the studied region consists of seven species: *Helicometra fasciata sensu lato* and *Galactosomum lacteum* mtc., *Bothriocephalus scorpii sensu lato* and *P. dasyatidis* l., *Ascarophis pontica*, *H. aduncum*, *C. rudolphii* l. III. The helminth fauna of the scorpionfish is dominated by the trematode *H. fasciata* and the nematode *A. pontica*; this has not changed over the almost 80-year period of research. We revealed long-term trends towards a decrease in number for trematodes *H. fasciata sensu lato*, *G. lacteum* mtc*., L. musculus*, cestodes *B. scorpii sensu lato* and *S. pleuronectis* l., nematodes *A. pontica* and *H. aduncum*. The main share of *S. porcus* endohelminth fauna in the studied area of the Black Sea are boreal-Atlantic marine stenohaline species, principally real generalists; they are transmitted exclusively through benthic food chains. *S. porcus* is an ecological dead end for the autogenic digenean *Metadena pauli* and allogenic nematode *C. obvelatus* l. III.

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KEY WORDS**:** helminthes, *Scorpaena porcus*, Crimean shelf, Black Sea.

Эндогельминты *Scorpaena porcus* Linnaeus, 1758 (Pisces: Scorpaenidae) в юго-западной части крымского участка шельфа Чёрного моря

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РЕЗЮМЕ: *Scorpaena porcus* Linnaeus, 1758 (скорпена) — одна из наиболее обычных рыб прибрежной зоны Чёрного моря. Так как в крымской части шельфа Черного моря скорпена не является промысловой рыбой, ее гельминтофауне ранее уделялось мало внимания и почти за 80 лет паразитологами было изучено не более 70 экз. этих рыб. Всего мы исследовали 951 экз. *S. porcus*, выловленных в 1994–2022 гг. в юго-западной части крымского шельфа Черного моря. Выявлена богатая гельминтофауна: нами обнаружено 16 видов эндогельминтов (четыре вида трематод, три — цестод, семь — нематод, два — скребня), но не найдено пять видов гельминтов, ранее известных у этого хозяина в данном районе моря. Впервые у *S. porcus* в районе наших исследований мы отметили один вид трематод (*Proctoeces maculatus*), личинки нематод трех видов (*H. aduncum* l. III, *Cosmocephalus obvelatus* l. III, *Contracaecum rudolphii* l. III) и взрослых нематод трех других видов (*Dichelyne* (*Cucullanellus*) *minutus*, *Cucullanus* sp., *Spinictectis tamari*), а также два вида скребней (*Telosentis exiguus*, *Acanthocephaloides propinquus*) и один вид цестод (*Progrillotia dasyatidis* l.). С учетом ранее полученных данных, фауна эндогельминтов скорпены в этом районе моря включает в общей сложности 21 вид. Установлено, что скорпена является случайным хозяином для трематод *Proctoeces maculatus* и *Lecithochirium musculus*, личинок цестод комплекса *Scolex pleuronectis*, нематод *Cucullanus* sp., *S. tamari*, *C. obvelatus* l. III, *D.* (*C.*) *minutus*, скребней *T. exiguus* и *A. propinquus.* Шесть видов гельминтов (скребень *T. exiguus*, нематоды *Philometra* sp., *Cucullanus* sp., *D.* (*C.*) *minutus*, *S. tamari*, трематода *A. capitellatum*) не продуцируют яйца в организме скорпен. «Ядро» гельминтофауны *S. porcus* в указанном районе Черного моря составляют семь видов: *Helicometra fasciata sensu lato* и *Galactosomum lacteum* mtc., *Bothriocephalus scorpii* sensu lato и *P. dasyatidis* l., *Ascarophis pontica*, *H. aduncum*, *C. rudolphii* l. III; доминирующими видами в гельминтофауне скорпены являются трематода *H. fasciata* и нематода *A. pontica* и такое положение вещей не изменяется в течение почти 80 лет. Мы выявили тенденции к долговременному снижению численности парагемипопуляций трематод *H. fasciata sensu lato*, *G. lacteum* mtc., *L. musculus*, цестод *B. scorpii sensu lato* и *S. pleuronectis* l., нематод *A. pontica* и *H. aduncum.* Основную долю эндогельминтофауны *S. porcus* в исследованном районе Черного моря составляют бореально-атлантические морские стеногалинные виды, преимущественно широкоспецифичные к хозяевам; они передаются исключительно по донным пищевым цепям. *S. porcus* является экологическим тупиком для автогенной трематоды *Metadena pauli* и аллогенной нематоды *C. obvelatus* l. III.

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КЛЮЧЕВЫЕ СЛОВА: гельминты, *Scorpaena porcus*, шельф Крыма, Черное море.

Introduction

The black scorpionfish, *Scorpaena porcus* Linnaeus 1758, is one of the most common fishes inhabiting coastal ecosystems of the Black Sea (Svetovidov, 1964; Vasil'eva, 2007). In the Crimean part of the Black Sea shelf, scorpionfish reside year-round at depths up to 40 m and dominate in number (Gordina, 1976; Pashkov *et al*., 1999), however, they are not an object of commercial fishing in this area of the Black Sea shelf and are only important as bycatch and for amateur fishing (Pashkov *et al*., 1999).

The first data on the helminth fauna of black scorpion fish in the Black Sea date back to the end of the 19th century (Ulyanin, 1872). Later, due to insignificant commercial value of this fish, there were only episodic studies on its helminths fauna (Osmanov, 1940; Nikolaeva, 1970; Nikolaeva, Solonchenko, 1970; Mange, 1993; Korniychuk, 1999, 2000; Kornyychuk, Gaevskaya, 1999). From the end of the 19th century and until 1990, no more than 70 specimens had been examined by helminthologists in this area of the sea.

The present investigation focuses solely on the issue of *S. porcus* endohelminth fauna in the south-western part of the Crimean Black Sea shelf and on its long-term changes.

Material and methods

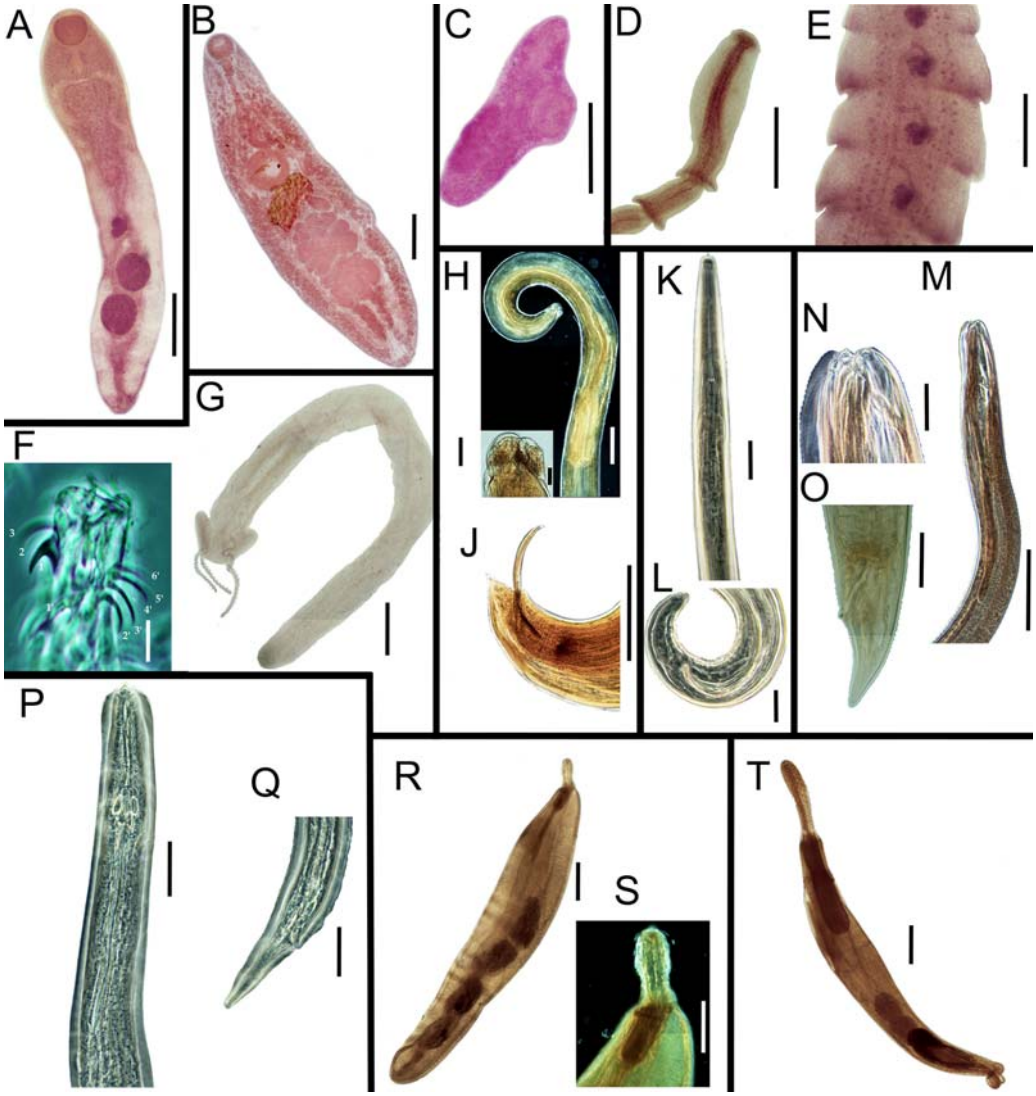
We studied 951 specimens of *S. porcus* caught during 1994–2022 with fixed seines, nets and bait in the bays of Sevastopol: Apollonova (44°36′58″N 33°32′29″E), Severnaya (44°37′30″N 33°32′05″E), Aleksandrovskaya (44°37′01″N 33°30′49″E), Martynova (44°37′00″N 33°30′30″E), Karantinnaya (44° 36′45″N 33°29′59″E), Matjushenko (44°37′41″N 33°31′23″E), Pesochnaya (44°36′36″N 33°28′59″E), Streletskaya (44°36′17″N 33°28′08″E), Kamyshovaya (44°35′04″N 33°25′24″E), Kazachya (44°34′ 30″N 33°24′45″E), Golubaya (44°33′20″N 33°24′ 33″E) and adjacent coast shelf regions — Uchkuevka (44°39′00″N 33°32′25″E), Cape Aya (44°25′36″N 33°39′12″E) and Batiliman (44°25′13″N 33°41′1″E) (Fig. 1).

The fish were subjected to a partial helminthological dissection according to standard methods

Fig. 1. Sampling sites in the Sevastopol region of the Black Sea shelf: 1 — Apollonova Bay; 2 — Severnaya Bay; 3 — Aleksandrovskaya Bay; 4 — Martynova Bay; 5 — Karantinnaya Bay; 6 — Matjushenko Bay; 7 — Uchkuevka; 8 — Pesochnaya Bay; 9 — Streletskaya Bay; 10 — Kamyshovaya Bay; 11 — Kazachya Bay; 12 — Golubaya Bay; 13 — Balaklava; 14 — Cape Aya; 15 — Batiliman.
Рис. 1. Места отбора проб в Севастопольском районе шельфа Черного моря: 1 — бухта Аполлонова; 2 — Северная бухта; 3 — Александровская бухта; 4 — Мартынова бухта; 5 — Карантинная бухта; 6 — бухта Матюшенко; 7 — Учкуевка; 8 — Песочная бухта; 9 — Стрелецкая бухта; 10 — Камышовая бухта; 11 — Казачья бухта; 12 — Голубая бухта; 13 — Балаклава; 14 — мыс Айя; 15 — Батилиман.

(Bykhovskaya-Pavlovskaya, 1985; Klimpel *et al*., 2019), immediately after the catch. Trematodes and cestodes recovered were initially fixed in 4% formalin and after preserved in 70% ethanol; for light microscopy they were prepared as whole mounts as follows: the worms were stained in aceto-carmine, differentiated in tap water, destained in 70% acid-ethanol, dehydrated in a graded series of ethanol, cleared in clove oil and mounted in Canada balsam (Bykhovskaya-Pavlovskaya, 1985; Georgiev *et al*., 1986). Nematodes and acanthocephalans were clarified in Amann's lactophenol (Bykhovskaya-Pavlovskaya, 1985; Moravec, 1994) on temporary slides. Helminth species were identified using an Olympus

Fig. 2. Endohelminth species identified in *Scorpaena porcus* from the Sevastopol region of the Crimean Black Sea shelf. A — *Galactosomum lacteum* mtc.; B — *Helicometra fasciata* (marita); C — *Proctoeces maculatus* (non-gravid marita); D–E — *Bothriocephalus scorpii sensu lato*; F–G — *Progrillotia dasyatidis* l.; H–J — *Hysterothylacium aduncum*; K–L — *Ascarophis pontica*; M–O — *Contracaecum rudolphii* l. III;



P–Q — *Cosmocephalus obvelatus* l. III; R–S — *Acanthocephaloides propinquus*; T — *Telosentis exiguus*. D — scolex; E — immature proglottids; F — metabasal tentacular armature, internal surface of tentacle with profiles of hooks 1(1') to 6(6') from the principal rows; G — larva; H, K, M, P — male anterior end; I, N — head; J, L, O, Q — male posterior end; R — whole worms; S — anterior end. Scale bars: A–E, G, H, J, R, T — 300 µm; M, O, P, Q — 50 µm; I, K, L, N, S — 30 µm; F — 10 µm.

Рис. 2. Виды эндогельминтов, идентифицированные у *Scorpaena porcus* из Севастопольского района крымского шельфа Черного моря. A — *Galactosomum lacteum* mtc.; B — *Helicometra fasciata* (marita); C — *Proctoeces maculatus* (незрелая marita); D–E — *Bothriocephalus scorpii sensu lato*; F–G — *Progrillotia dasyatidis* l.; H–J — *Hysterothylacium aduncum*; K–L — *Ascarophis pontica*; M–O — *Contracaecum rudolphi* l. III; P–Q — *Cosmocephalus obvelatus* l. III; R–S — *Acanthocephaloides propinquus*; T — *Telosentis exiguus*.

D — сколекс; E — неполовозрелая проглоттида; F — метабазальное вооружение хоботка, внутренняя поверхность хоботка с профилями крючков с 1(1') по 6(6') от основных рядов; G — личинка; H, K, M, P — передний конец самца; I, N — голова; J, L, O, Q — задний конец самца; R — целый червь; S — передний конец. Масштаб: A–E, G, H, J, R, T — 300 мкм; M, O, P, Q — 50 мкм; I, K, L, N, S — 30 мкм; F — 10 мкм.

CX-41 microscope with a digital camera CAM-SC50 and CellSens Standard v. 1.18 software.

Sixty seven vouchers were deposited in the A.O. Kovalevsky Institute of Biology of the Southern Seas Russian Academy of Sciences (IBSS RAS) Collection of Marine Parasites (CMP) in the frame of this work: *Helicometra fasciata* (slides 1369.Tr.39.v2-15; 1389.Tr.39.v16-25); *Galactosomum lacteum* mtc. (1392.Tr.43.v1-10); *Proctoeces maculatus* (1391.Tr.44.v1); *Bothriocephalus scorpii sensu lato* (69.C.2j.p1; 71.C.2j.p3; 72.C.2j.p4-6; 73.C.2j.p7); *Progrillotia dasyatidis* larvae (138.C.is.v7-8; 1380.C.is.v9-11; 1381.C.is.v12-13); *Ascarophis pontica* (939.N.2x.v1-3; 1386.N.2x.v4-5; 1387.N.2x.v6); *Hysterothylacium aduncum* (1384.N.2r.v1); *Cosmocephalus obvelatus* l. III (1383.N.2S.v10); *Contracaecum rudolphii* l. III (1388.N.2p.v8); *Telosentis exiguus* (1382.A.28.v86), *Acanthocephaloides propinquus* (925.A.1t.v104-107; 926.A.1t.v108; 927.A.1t.v109; 1377.A.1t.v167-168; 1378.A.1t.v169) Abbreviation l. III referrers to the third stage larvae of nematodes; mtc. — to the metacercarial stage of trematodes.

Prevalence (P), range (min-max), mean intensity (MI) and abundance (A) were calculated as well as standard errors (SE) of mean intensity and abundance (Bush *et al*., 1997) for the samples pooled over the entire period of the study (Table 1).

We classified all the helminths recorded from the black scorpionfish in the region of investigation on the basis of published (Gaevskaya *et al*., 1975; Gaevskaya, Korniychuk, 2003; Moravec, 1994; Palm, 2004; Marques *et al*., 2005; Simkova, 2006) data:

– according to the types of life cycles: into groups of allogenous (AL) (use fish as intermediate or paratenic hosts, the definitive hosts are birds and mammals) and autogenous (AU) (sexually mature helminths parasitize in fish) species;

– according to the salinity tolerance: into marine (M), freshwater and brackish water (B), steno- (S) and euryhaline (E);

– according to the host specificity (for each of the life cycle stages and only for helminths identified to the species level): into strict specialists (SS) infecting a single host species; intermediate specialists (IS) infecting two or more host species of the same genus; intermediate generalists (IG) infecting two or more noncongeneric but closely related hosts; generalists (G) infecting different hosts belonging to one subfamily; real generalists (RG) infecting different host species from different subfamilies.

Results

We found sixteen endohelminth species (Fig. 2) in the black scorpion specimens we studied: four Trematoda species (three of them were maritae and one — at the metacercarial stage), three Cestoda (two of them parasitize *S. porcus* at the larval stage), seven Nematoda (one species represented by both adults and larvae as well as larvae of two species and adults of four species) and two Acanthocephala (Table 1).

Adult worms belonging to eleven species were found to parasitize the scorpionfish gut: *Helicometra fasciata* Rudolphi 1819, *Lecithochirium musculus* (Looss, 1907) Nasir et Diaz, 1971, *Proctoeces maculatus* (Looss, 1901) Odhner, 1911, *Bothriocephalus scorpii* (Müller, 1776) Cooper, 1917 *sensu lato*, *Dycheline* (*Cuculanellus*) *minutus* (Rudolphi, 1819), *Hysterothylacium aduncum* (Rudolphi, 1802) Deardorff et Overstreet, 1981, *Spinictectis tamari* Naidenova, 1966, *Cucullanus* sp., *Telosentis exiguus* (von Linstow, 1901) Van Cleave, 1923, *Acanthocephaloides propinquus* (Dujardin, 1845) Meyer, 1933; *Ascarophis pontica* Nikolaeva, 1970 in host gut were found as adults as at larvae IV stage. As for *Cucullanus* sp., *D.* (*Cuculanellus*) *minutus*, *S. tamari*, *T. exiguus*, the specimens we found didn't have eggs in uterus.

Metacercaria of the trematode *Galactosomum lacteum* (Jägerskiöld, 1896) Looss, 1899 were found in the fish brain but sometimes on its skin and fins. *Progrillotia dasyatidis* Beveridge, Neifar et Euzet, 2004 plerocercoids occurred in the gall bladder and sometimes in the gut, *Scolex pleuronectis* pleurocercoids we recorded in the gut.

Larvae III stages of three nematode species, *H. aduncum, Cosmocephalus obvelatus* (Creplin, 1825) Seurat, 1919 and *Contracoecum rudolphii* Hartwich, 1964, parasitized mesentery of *S. porcus*.

One trematode species, larvae of three species and adult nematodes of three other species as well as acanthocephalans (two species) are being recorded from *S. porcus* in the study area for the first time (Table 1).

Taking into account earlier records, the total number of endohelminth species known from the black scorpionfish in this area of the Black Sea reaches 21; nevertheless, we didn't find five endohelminth species previously known from this host in Sevastopol region (Table 1).

Three species of endohelminths parasitizing the black scorpionfish (*G. lacteum* met., *C. obvelatus* l. III and *C. rudolphii* l. III) complete

Table 1. Endohelminths of *Scorpaena porcus* from the Sevastopol part of the Crimean Black Sea shelf.
Таблица 1. Эндогельминты *Scorpaena porcus* из Севастопольского района крымского шельфа Черного моря.

Helminth species	**Species status***	**Previous records**	**Our data**		
			MI ±SE / min–max‡	**P**	**A±SE**
Trematoda					
Helicometra fasciata sensu lato	MS, AU, RG	Osmanov, 1940 (as *H. pulchella*); Nikolaeva, Solonchenko, 1970; Kornyychuk, 1999, 2000; Korniychuk, Gaevskaya, 1999	4.1±0.4/ 1–69	28	1.13± 0.1
Galactosomum lacteum	MS, AL, RG	Osmanov, 1940; Nikolaeva, Solonchenko, 1970	3±0.3 / 1–11	5.2	0.13± 0.02
Lecithochirium musculus	MS, AU, RG	Nikolaeva, Solonchenko, 1970 (as *Brachyphallus musculus*)	1.3±0.3/ 1–2	0.3	0.002± 0.002
Proctoeces maculatus†	MS, AU, IG	–	2	0.1	0.002± 0.002
Anisocoelium capitellatum	MS, AU, SS	Nikolaeva, Solonchenko, 1970	–	–	–
Metadena pauli mtc.	MS, AU, RG	Nikolaeva, Solonchenko, 1970 (as *Achoerus pauli*)	–	–	–
Gaevskaja-trema perezi	MS, AU, IG	Mange, 1993	–	–	–
Aponurus tschugunovi	MS, AU, RG	Nikolaeva, Solonchenko, 1970	–	–	–
Cestoda					
Bothriocepha-lus scorpii sensu lato	MS, AU, SS	Ulyanin, 1872; Osmanov, 1940; Nikolaeva, Solonchenko, 1970	1.1±0.06/ 1–2	3	0.03± 0.01
Progrillotia dasyatidis l.†	ME, AU, RG	–	3±0,9/ 1–25	3	0.1± 0.03
Scolex pleuronectis l.	ME, AU. RG	Nikolaeva, Solonchenko, 1970	1.4±0.03/ 1–3	0.7	0.01± 0.004
Nematoda					
Philometra sp. (adult+larvae)	ME, AU	Nikolaeva, Solonchenko, 1970	–	–	–
Ascarophis pontica	MS, AU, SS	Nikolaeva, 1970; Nikolaeva, Solonchenko, 1970	10±1.4 / 1–84	12	1.2± 0.2
Hysterothylaciu m aduncum	ME, AU, RG	Nikolaeva, Solonchenko, 1970	4±0.7 / 1–20	3.4	0.12± 0.03
H. aduncum l. III †		–	3±0.6 / 1–13	3	0.08± 0.02
Cosmocephalus obvelatus l. III †	ME, AL, RG	–	3±2 / 1–5	0.2	0.01± 0.01

Table 1 (continued).
Таблица 1 (окончание).

Helminth species	Species status*	Previous records	Our data		
			MI ±SE / min–max‡	P	A±SE
Nematoda					
Contracaecum rudolphi l. III †	ME, AL, RG	–	8±2 / 1–100	7.6	0.6± 0.2
Cucullanus sp.†	ME, AU	–	1.5±0.5 / 1–2	0.2	0.003± 0.002
Dichelyne (*Cucullanellus*) *minutus*†	B, AU, RG	–	2	0.1	0.002± 0.002
Spinictectis tamari†	MS, AU, RG	–	1	0.1	0.001± 0.001
Acanthocephala					
Telosentis exiguus †	ME, AU, RG	–	1	0.1	0.001± 0.001
Acantho-cephaloides propinquus †	ME, AU, RG	–	1.4±0.2 / 1–2	1.1	0.02± 0.01

* — for abbreviations (MS, ME, B, AU, AL, SS, RG) see "Material and Methods";
‡ — for abbreviations (MI, P, A) see "Material and Methods";
† — first record in the region investigated.

their development in aquatic and semi-aquatic birds, while the vast majority (86%) of scorpionfish helminths are autogenous (Table 1).

Two most abundant species were the digenean *H. fasciata* and the nematode *A. pontica*; the nematode *C. rudolphii* l. III were slightly less numerous (Table 1, Fig. 3).

Discussion

The endohelminth fauna of the black scorpionfish had revealed by our predecessors (Ulyanin, 1892; Osmanov, 1940; Nikolaeva, Solonchenko, 1970) seemed to be relatively rich: seven species of trematodes, three species of cestodes and three species nematodes (see Table 1). Nevertheless, several endohelminth species were known as single findings (*M. pauli* mtc., *A. tschugunovi* and *G. perezi*) and we believe scorpionfish to be their accidental hosts; we also consider that single records of juvenile *A. capitellatum* marita and immature nematode *Philometra* spp. (Nikolaeva, Solonchenko, 1970) implies that *S. porcus* is not a true, but an abortive host for these two helminths.

Judging by our quantitative data (see Table 1), the black scorpionfish is an accidental host also for trematodes *P. maculatus* and *L. musculus*, for *Scolex pleuronectis* cestode larvae and nematodes *Cucullanus* sp., *S. tamari*, *C. obvelatus* l. III, *D.* (*C.*) *minutus*, as well as for acanthocephalans *T. exiguus* and *A. propinquus*.

S. porcus in the region of our investigation is, most likely, an abortive host also for acanthocephalans *T. exiguus*, nematodes *Cucullanus* sp., *D.* (*C.*) *minutus* and *S. tamari* as all of the endohelminthes mentioned above we found only as premature adults.

Thus, it is likely that the *S. porcus* endohelminth fauna in the studied region of the Black Sea consists, in fact, of seven species: *H. fasciata* and *G. lacteum* mtc., *B. scorpii sensu lato* and *P. dasyatidis* l., *A. pontica*, *H. aduncum*, *C. rudolphii* l. III.

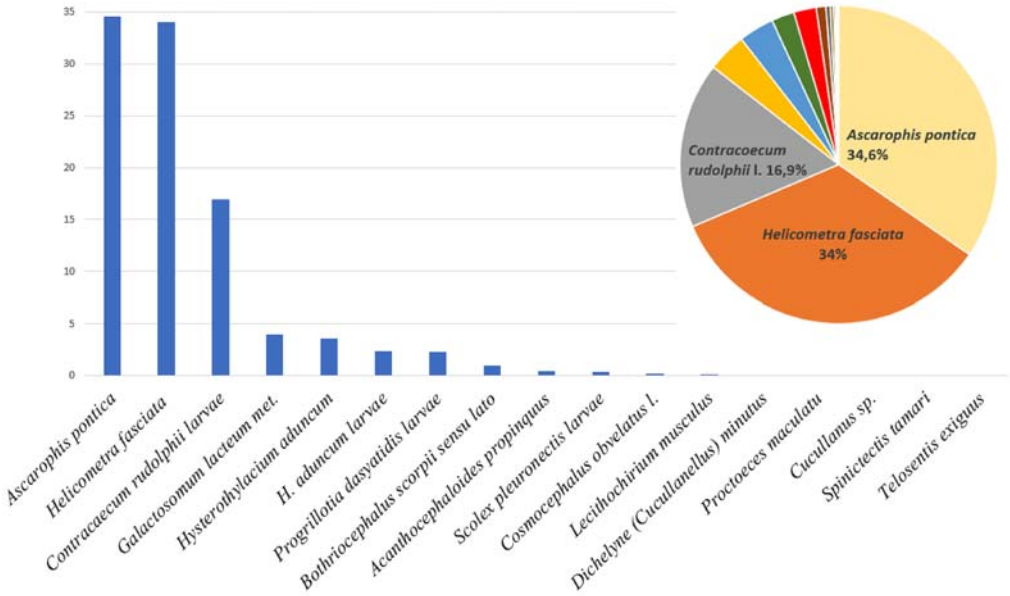


Fig. 3. The curve of helminths dominance/diversity (by the number of specimens) in *Scorpaena porcus* from the Sevastopol region of the Crimean Black Sea shelf in 1994–2022.
Рис. 3. Кривая доминирования-разнообразия гельминтов (по количеству особей) *Scorpaena porcus* из Севастопольского района крымского шельфа Черного моря в 1994–2022 гг.

Of them, the digenean *H. fasciata* and the nematode *A. pontica* dominated the component communities of the black scorpionfish endohelminths during period of our investigations, while the nematode *C. rudolphii* l. III we believe to be a subdominant species (Table 1, Fig. 2); so, we refer to these three endohelminth species as "core species" of *S. porcus* endohelminth fauna in the southwestern region of the Black Sea shelf.

Being a boreal-Atlantic and typical marine fish, *S. porcus* turned out to be infected mainly with boreal-Atlantic endohelminths with a minor share of Black Sea endemics and cosmopolitan species; the helminths found are almost exclusively stenohaline but the nematodes *H. aduncum, C. obvelatus* l. III and *C. rudolphii* l. III can also circulate in brackish waters (see Table 1).

Only the nematode *A. pontica* and the cestode *B. scorpii sensu lato* are strictly specific to the Black Sea *S. porcus* (Gaevskaya, Korniychuk, 2003). Except for *P. maculatus*, *G. perezi* and *A. capitellatum* (as *S. porcus* is their accidental or abortive host), the scorpionfish endohelminths are real generalists demonstrating the so-called biocenotic (Rhode, 1982) specificity to demersal and demersal-pelagic Black Sea fishes (Gaevskaya *et al.,* 1975; Gaevskaya, Korniychuk, 2003). The nematode *H. aduncum* seems to be an exception as its adult and larval stages are known mainly from the pelagic fish, however, a special "benthic" subsystem is present in its life cycle in the Black Sea, too (Gaevskaya *et al.*, 2010), with a black scorpionfish as its part.

The *S. porcus* involvement in the life cycles of endohelminths transmitted only in benthic food chains is quite understandable: the black scorpionfish is a benthic ambush nocturnal predator preying only on moving objects and ignoring immobile ones (Svetovidov, 1964). Benthic and demersal pelagic fish and crustaceans prevail among its food objects (the most common are large Decapoda — crabs and shrimps) as well as polychaetae and other invertebrates (Svetovidov, 1964; Vasil'eva, 2007).

S. porcus are armed with poisonous spiny rays on dorsal fins and gill covers (Svetovidov, 1964). It narrows the range of fish predators and

determines the role of scorpionfish as an ecological dead end in the parasite systems of, for example, trematodes *M. pauli* infecting this fish at metacercarial stage. On the other hand, taking also into account the cannibalism described among *S. porcus* and predation of older age scorpionfishes (Svetovidov, 1964), one can assume that mature forms of autogenous trematodes, cestodes, nematodes and acanthocephalans can be transmitted from scorpionfish of younger age groups to the older ones. Besides, the Black Sea common stingray *Dasyatis pastinaca* Linnaeus, 1758 was mentioned to feed on the black scorpionfish (Smirnov, 1986) which means *S. porcus* is true paratenic host for cestodes *P. dasyatidis* and *S. pleuronectis* l.

Allogeneic endohelminthes of *S. porcus*, nematode *C. rudolphii* and trematode *G. lacteum*, are known from the Black Sea cormorants (Smogorzhevskaya, 1978). Taking into account that the great cormorants *Phalacrocorax carbo* (Linnaeus, 1758) are known to feed on not very large (total length up to 15–22 cm) *S. porcus* (Giragosov, 2020), one could believe scorpionfish to be a true intermediate host for these parasites. Nevertheless, as adult nematodes *C. obvelatus* are known from Laridae, Stercoraridae, Gaviidae water birds not mentioned to feed on scorpionfish, thus *S. porcus* is a dead-end host in the life cycle of this nematode.

We evaluated, comparing our and published quantitative data, trends in long-term changes of "core species" helminth population abundance.

Judging by the data of V.M. Nikolaeva and A.I. Solonchenko (1970) who studied helminths of 43 *S. porcus* specimens from the same region, that time the "core" of the endohelminth fauna consisted of two species, the nematode *A. pontica* (P = 60%) and the trematode *H. fasciata* (P = 56%), while *L. musculus* (44%) and *H. aduncum* (40%), as well as *G. lacteum* mtc. (28%) could be considered subdominant.

One can easily note a downward trend in abundance of *A. pontica* nematodes in scorpionfish: 50 years ago, infection rates for were five times higher than today (P= 60% in 1970s vs 12% now).

Undoubtedly, *H. fasciata* is a core species of the *S. porcus* helminth fauna in the Black Sea; however, over the past 50 years, the prevalence of its infection with this trematode has significantly decreased — from 53–56% (Osmanov, 1940; Nikolaeva, Solonchenko, 1970) to the current value of P=28% (see Table 1). The prevalence of scorpionfish infection with the metacercariae of *G. lacteum* decreased to 5.2% while *L. musculus* maritae might disappeared.

The *S. pleuronectis* plerocercoids were quite numerous 50 years ago (they were found in 48% of scorpionfish, according to Nikolaeva, Solonchenko, 1970) but we now found them in less than 1% of *S. porcus* (see Table 1).

As for *B. scorpii*, we believe the decrease of its population occurred even earlier: 27% of scorpionfish were infected with this cestode in the 1930s (Osmanov, 1940), but the prevalence dropped to 4% by the late 1960s (Nikolaeva, Solonchenko, 1970) and remains at this level now (see Table 1).

S. porcus infection with the sexually mature nematodes *H. aduncum* has also significantly decreased over the entire observation period: in the 1960s they were found in about 40% of this fish (Nikolaeva, Solonchenko, 1970), and we revealed the decline in prevalence up to 3.4%.

On the contrary, the nematodes *C. rudolphii* l. III not previously recorded in the scorpionfish helminth fauna, are relatively numerous (P = 7.6%) now (see Table 2).

Conclusions

We recorded 16 species of endohelminths in the *Scorpaena porcus* inhabiting the southwestern area of the Crimean shelf of the Black Sea but didn't find five helminth species previously known from this host in the region. Taking into account the earlier findings, the fauna of endohelminths of the scorpionfish in this area includes 21 species.

The trematode *Proctoeces maculatus*, larvae of nematodes *Hysterothylacium aduncum* l. III, *Cosmocephalus obvelatus* l. III, *Contracaecum rudolphii* l. III and adult nematodes *Dichelyne* (*Cucullanellus*) *minutus*, *Cucullanus* sp., *Spinictectis tamari*) as well as acanthocephalans *Telosentis exiguus*, *Acanthocephaloides propinquus* and cestode *Progrillotia dasyatidis* l. are being recorded from *S. porcus* in the study area for the first time.

The black sea scorpionfish revealed to be an accidental host for the trematodes *P. maculatus* and *Lecithochirium musculus*, cestodes *Scolex*

pleuronectis l., nematodes *Cucullanus* sp., *S. tamari*, *C. obvelatus* l. III, *D.* (*C.*) *minutus*, for acanthocephalans *T. exiguus* and *A. propinquus*.

S. porcus is an abortive host for acanthocephalans *T. exiguus*, nematodes *Philometra* sp., *Cucullanus* sp., *D.* (*C.*) *minutus*, *S. tamari*, trematode *A. capitellatum*.

The "core" part of *S. porcus* endohelminth fauna in the studied region of the Black Sea consists of seven species: *H. fasciata*, *G. lacteum* mtc., *B. scorpii sensu lato*, *P. dasyatidis* l., *A. pontica*, *H. aduncum*, and *C. rudolphii* l. III. During the research period, the endohelminth fauna of the scorpionfish was dominated by the trematode *H. fasciata* and the nematode *A. pontica*; this dominance has persisted over the almost 80-year period of research.

We revealed the long-term trends towards a decrease in the number for trematodes *H. fasciata*, *G. lacteum* mtc., *L. musculus*, cestodes *B. scorpii sensu lato* and *S. pleuronectis* l., nematodes *A. pontica* and *H. aduncum* hosted by the black sea scorpionfish inhabiting southwestern part of the Crimean Black Sea shelf zone.

The main share of *S. porcus* endohelminth fauna in the studied area of the Black Sea are boreal-Atlantic marine stenohaline species, principally real generalists; they are transmitted exclusively through the benthic food chains.

S. porcus is an ecological dead end for the autogenic digenean *Metadena pauli* and the allogenic nematode *Cosmocephalus obvelatus*.

Compliance with ethical standards

CONFLICTS OF INTEREST: The authors declare no conflicts of interest.

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