

Helminths and Helminth Communities of the Caucasian Dwarf Goby *Knipowitschia caucasica* (Berg) (Actinopterygii: Gobionellidae) from Lake Atanasovsko, Bulgaria

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Abstract: During a helminthological survey carried out during the spring, summer and autumn of 2012–2013, a total of 186 specimens of the Caucasian dwarf goby *Knipowitschia caucasica* (Berg) from Lake Atanasovsko, Bulgaria, were examined. Of these, 171 specimens were infected, with a prevalence (P) of 91.94%, mean intensity (MI) of 35.80 and mean abundance (MA) of 32.91. Four helminth species were recorded: the trematodes *Aphalloides coelomicola* Dollfus, Chabaud & Golvan, 1957 in the body cavity (P 59.14%, MI 8.64, MA 5.11) and *Paratimonia gobii* Prévot & Bartoli, 1967 from the intestine (P 58.60%, MI 35.82, MA 20.98), the monogenean *Gyrodactylus bubyri* Osmanov, 1965 from the skin, fins and gills (P 50.54%, MI 13.46, MA 6.80) and the nematode *Contraecaecum* sp. (third-stage larvae) from the body cavity (P 1.61%, MI 1.00, MA 0.01). Based on their total prevalence values, *A. coelomicola*, *P. gobii* and *G. bubyri* are recognised as common species and *Contraecaecum* sp. is considered a rare species at the component community level. The helminth component communities and infracommunities studied are characterised by a smaller species richness than those recorded in the same host species from two other (brackish) localities in the Black Sea basin.

Key words: Helminth parasites, *Knipowitschia caucasica*, Black Sea, Bulgaria

Introduction

The Caucasian dwarf goby *Knipowitschia caucasica* (Berg) is a euryhaline fish species inhabiting shallow coastal marine waters, lakes, lagoons and estuaries along the coasts of the Caspian Sea, Sea of Azov, Black Sea and Aegean Sea (KOTTELAT & FREYHOF 2007). It was unintentionally introduced (1954–1956) from the Caspian Sea into the Aral Sea (OSMANOV 1965, 1971) but those populations are currently considered extinct (KOTTELAT & FREYHOF 2007). From a parasitological point of view, this fish has been relatively little investigated. OSMANOV (1965, 1971), in Uzbekistani waters of the Aral Sea, recorded two helminth species from *K. caucasica*, i.e. the monogenean *Gyrodactylus bubyri* Osmanov, 1965 and larvae of the nematode *Contraecaecum squali* (von Linstow, 1907) (later recognised as a

synonym of *C. microcephalum* (Rudolphi, 1809), see MORAVEC 1994). From the Caspian Sea, data about three species were published, i.e. the cestode *Proteocephalus percae* (Müller, 1780), and metacercariae of the trematodes *Diplostomum spathaceum* (Rudolphi, 1819) and *Holostephanus cobitidis* Opravilova, 1968 (see SEMENOVA et al. 2007). From the Black Sea Basin, NAYDENOVA (1974) reported six trematode, one cestode and one nematode species from *K. caucasica* in the Sea of Azov. KRASNOVYD et al. (2012) recovered 11 helminth species, of which seven were trematodes, two nematodes and two acanthocephalans from this host in the Sukhyi Estuary (Sukhyi Liman) on the Black Sea coast of the Ukraine. According to GAEVSKAYA (2012), the parasite fauna harboured by *Knipowitschia* spp. in

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the Black Sea basin is poor. Recently, VANHOVE et al. (2014) reported *G. bubyri* on the same host species from the Struma (Strymon) River, Greece, extending the known geographical range of this parasite to European waters. After the recent expansion of the non-native geographical range of this fish species in Central Europe and Anatolia, there are records of helminth parasites from *K. caucasica* from Lake Tisza, Hungary (ANTAL et al. 2015) and Lake Egirdir, Turkey (DILER & YILDIRIM 2003). In Bulgaria, MARGARITOV (1960) reported metacestodes of *Ligula colymbi* Zeder, 1803 (Cestoda) in the body cavity of *K. caucasica* from Lake Burgas (Lake Vaya) close to the Bulgarian Black Sea coast. Recently, STOYANOV et al. (2015, 2016) recorded the trematode *Aphalloides coelomicola* Dollfus, Chabaud & Golvan, 1957 and the monogenean *Gyrodactylus bubyri* from this goby in Lake Atanasovsko and published results on their taxonomy. So far, there are no published data on helminth communities of this fish species.

The aim of the present study is to characterise the species composition and the structure of the helminth communities harboured by the Caucasian dwarf goby *Knipowitschia caucasica* in Lake Atanasovsko, Bulgaria.

Materials and Methods

During May, July and September, 2012–2013, we examined 186 specimens of *K. caucasica* (Table 1) from the northern part of Lake Atanasovsko (42°34'55"N, 27°28'12"E). This part of the lake has been declared a managed reserve and a Ramsar site (VASSILEV et al. 2013). It is involved in salt production and consists of numerous ponds, ranging from freshwater to hyperhaline (IVANOV et al. 1964, VASSILEV et al. 2013). The fish specimens were caught in brackish ponds using seines or landing nets and kept alive in containers filled with aerated water taken from the habitat. Subsequently, each fish was dissected under a stereomicroscope within the following 24 hours. The isolated helminths were placed in saline for approximately 10 min, then fixed in hot saline and preserved in 70% ethanol. Trematodes were stained in iron acetocarmine, dehydrated in an ethanol series, cleared in dimethyl phthalate and mounted in Canada balsam. Monogeneans were mounted in glycerine-jelly on slides (after GUSSEV 1983) and measured as proposed by SHINN et al. (2004) (for further details, see STOYANOV et al. 2016). Nematodes were studied as temporary mounts in glycerine.

The metrical data are presented as the range, followed by the mean and the number of measurements taken (n) in parentheses. The standard deviation

is given only when $n \geq 30$. All measurements are in micrometres.

The infection parameters and related terminology are as defined by BUSH et al. (1997). The prevalence criteria 10% and 50% were adopted for identification of rare, intermediate and common species (CHAPMAN et al. 2015). The significance of seasonal dynamics (mean intensity, mean abundance and species richness) was assessed by applying the Kruskal-Wallis H test. Parameters describing helminth communities were calculated following MAGURRAN (1988): for component communities, these were Shannon's Diversity Index (H') and Simpson's Dominance Index; for infracommunities, we calculated the number of helminth species per fish, the number of helminth individuals per fish (both as the mean \pm standard error, range and median) as well as values of Shannon's Diversity Index (H') and Simpson's Dominance Index.

Results

Systematic survey of helminth species

During the course of the present study, we identified four helminth species in 171 of 186 fish specimens studied: two trematode species (*Aphalloides coelomicola* Dollfus, Chabaud & Golvan, 1957 and *Paratimonia gobii* Prévot & Bartoli, 1967), the monogenean *Gyrodactylus bubyri* Osmanov, 1965 and the nematode (unidentified at the species level) *Contracaecum* sp. (third-stage larva). We present below short descriptions and illustrations based on specimens from Lake Atanasovsko as information supporting our identification and complementing data on the variation of the helminth species found.

Class Trematoda

Family Cryptogonimidae Ward, 1917

Aphalloides coelomicola Dollfus, Chabaud & Golvan, 1957

Site of infection: body cavity.

Remark: A redescription of this species, based on material collected during the course of this survey, was published by STOYANOV et al. (2015).

Family Monorchidae Odhner, 1911

Paratimonia gobii Prévot & Bartoli, 1967

Site of infection: intestine.

Description (based on 20 mature specimens; Figs. 1–3; for metrical data, see Table 2): Body fusiform, with both anterior and posterior extremities rounded; maximum width at level of ventral sucker (Fig. 1). Tegument entirely spinous (Fig. 3A–C). Eyespots two, dark-brown, forming compact (sometimes dispersed) granulated masses, dorsal, at

Table 1. Host sample size (n), prevalence (P%), intensity (I), mean intensity \pm standard error (MI \pm SE) and mean abundance \pm standard error (MA \pm SE) of seasonal samples of helminth parasites from *Knipowitschia caucasica* (Berg) in Lake Atanasovsko, Bulgaria. Significant differences (Kruskal-Wallis H test) in bold; level of confidence $p \leq 0.05$.

Helminth species	Infection parameters	May 2012, n=31	July 2012, n=31	September 2012, n=31	May 2013, n=31	July 2013, n=31	September 2013, n=31	K-W (H)*	p-values	Total n=186
<i>Aphallioides coelomicola</i>	P%	83.87	38.71	38.71	93.55	38.71	61.29	–	–	59.14
	I (Range)	1–31	1–22	1–30	1–54	1–12	1–18	–	–	1–54
	MI \pm SE	6.42 \pm 1.46	4.08 \pm 1.78	3.75 \pm 2.40	20.28 \pm 2.61	3.83 \pm 0.89	2.89 \pm 0.89	49.88333	0.0000	8.64 \pm 1.07
	MA \pm SE	5.39 \pm 1.29	1.58 \pm 0.76	1.45 \pm 0.96	18.97 \pm 2.60	1.48 \pm 0.48	1.77 \pm 0.60	75.18145	0.0000	5.11 \pm 0.71
<i>Paratimonnia gobii</i>	P%	77.42	58.06	77.42	96.77	9.68	32.26	–	–	58.60
	I (Range)	1–114	1–136	1–32	1–226	1–3	1–35	–	–	1–226
	MI \pm SE	27.83 \pm 6.40	26.28 \pm 7.85	11.95 \pm 2.24	77.60 \pm 10.26	2.33 \pm 0.67	14.10 \pm 3.65	37.32175	0.0000	35.82 \pm 4.26
	MA \pm SE	21.55 \pm 5.37	15.26 \pm 5.08	9.25 \pm 1.95	75.09 \pm 10.23	0.23 \pm 0.14	4.55 \pm 1.66	84.73852	0.0000	20.98 \pm 2.81
<i>Gyrodactylus bubyri</i>	P%	29.03	25.81	51.61	48.39	100.00	48.39	–	–	50.54
	I (Range)	1–33	1–13	1–46	1–17	3–89	1–20	–	–	1–89
	MI \pm SE	6.11 \pm 3.41	4.50 \pm 1.67	6.38 \pm 2.74	5.47 \pm 1.45	30.09 \pm 3.49	3.80 \pm 1.43	47.78833	0.0000	13.46 \pm 1.79
	MA \pm SE	1.77 \pm 1.07	1.16 \pm 0.54	3.29 \pm 1.51	2.64 \pm 0.85	30.09 \pm 3.49	1.84 \pm 0.76	83.28360	0.0000	6.80 \pm 1.03
<i>Contracaecum</i> sp. (third-stage larvae)	P%	3.23	–	3.23	–	–	3.23	–	–	1.61
	I (Range)	1	–	1	–	–	1	–	–	1
	MI \pm SE	1 \pm 0.00	–	1 \pm 0.00	–	–	1 \pm 0.00	0.000000	1.000	1 \pm 0.00
	MA \pm SE	0.03 \pm 0.03	–	0.03 \pm 0.03	–	–	0.03 \pm 0.03	3.032787	0.6949	0.01 \pm 0.00
Total	P%	96.77	80.65	90.32	100.00	100.00	83.87	–	–	91.94
	I (Range)	1–114	1–136	1–46	1–226	1–89	1–35	–	–	1–226
	MI \pm SE	29.70 \pm 6.95	22.32 \pm 5.91	15.53 \pm 2.99	96.71 \pm 11.69	31.81 \pm 3.41	9.77 \pm 2.26	68.70496	0.0000	35.80 \pm 3.53
	MA \pm SE	28.74 \pm 6.79	18.00 \pm 5.01	14.03 \pm 2.83	96.71 \pm 11.69	31.81 \pm 3.41	8.19 \pm 2.00	77.97427	0.0000	32.91 \pm 3.32



Fig. 1. *Paratimonia gobii* Prévot & Bartoli, 1967. Body, general view. Scale bar: 100 μ m.

level of pharynx, rarely at level of ventral sucker or slightly posterior to it. Ratio of body length to body width 2.3–3.7 : 1 (3.2 : 1; 20). Ratio of forebody length to body length 0.34–0.42 : 1 (0.38 : 1; 20). Oral sucker round to slightly oval, subterminal. Ventral sucker oval, situated in anterior quarter of body. Oral sucker and ventral sucker approximately equal in size, with ratio of oral sucker width to ventral sucker width 0.8–1.1 : 1 (1 : 1; 20). Prepharynx curved, thick-walled. Pharynx oval, muscular. Oesophagus curved, longer than prepharynx (Table 2). Intestinal bifurcation slightly anterior to ventral sucker. Caeca straight, long, narrow, extend to level of testes, terminate blindly. Testes two, elongate-oval, oblique, in posterior part of hindbody. Cirrus-sac thick-walled, dorsal to ventral sucker, enclosing

seminal vesicle, pars prostatica and cirrus (Fig. 2A). Seminal vesicle oval, connected to cirrus via narrow duct. Withdrawn cirrus thick-walled; its distal region covered by spines and proximal region smooth (Fig. 2A). Cirrus spines conical. Genital atrium small, thick-walled, without spines, opens via transversely-elongate genital pore situated medially and just anterior to ventral sucker. Ovary trilobed (Fig. 3D), sometimes consisting of more (up to seven) lobes, dextral, pretesticular, in hindbody. Uterus well developed, coiled, extends from posterior extremity of body to level of ventral sucker, filled with numerous eggs, ends in form of terminal organ. Terminal organ bipartite, thick-walled, muscular, dorsal to ventral sucker; tubular distal region covered by spines; proximal region vesicular and unarmed (Fig. 2A). Spines of terminal organ conical (Fig. 2A). Vitellarium consisting of two compact masses connected to one another, situated anteriorly to ovary or at its level, sometimes slightly overlapping anterior margin of anterior testis. Excretory vesicle saccular, relatively thick-walled, with folded inner surface, at posterior extremity of body, opens terminally via short duct and excretory pore. Eggs ovoid, yellowish-brown, operculate (Figs. 2B–C, 3E–F), some of them often deformed (Fig. 2D).

Remarks: The morphology of the specimens studied corresponds to the diagnosis of the genus *Paratimonia* Prévot & Bartoli, 1967 (see PRÉVOT & BARTOLI 1967, MADHAVI 2008), i.e. with two oblique testes, uterus extending well in post-testicular space, and vitellarium consisting of two compact masses connected with one another and situated anterior to or at level of ovary. The generic affiliation is also supported by the occurrence in gobionellid gobies (PRÉVOT & BARTOLI 1967, MAILLARD 1975, NAYDENOVA 1970b, 1974, KVACH 2004, 2005, 2010, KRASNOVYD et al. 2012). In addition, the present material possesses overlapping ranges of variation with those in the previous descriptions of *P. gobii* (Table 2). The life cycle of *P. gobii* includes the bivalve *Abra segmentum* (Récluz) [syn. *A. ovata* (Philippi)] acting as both first and second intermediate host, and gobies as definitive host (MAILLARD 1975).

P. gobii is the only species of this genus in European waters. Two subspecies have been recognised, i.e. the nominotypical *Paratimonia gobii gobii* Prévot & Bartoli, 1967, originally described as a parasite of the common goby *Pomatoschistus microps* (Krøyer) in the Mediterranean Sea off Marseille, France (PRÉVOT & BARTOLI 1967), and *P. gobii pontica* Naydenova, 1970 (originally named as “forme pontica”) from the marbled goby *Pomatoschistus marmoratus* (Risso) in the Sea of Azov (NAYDENOVA

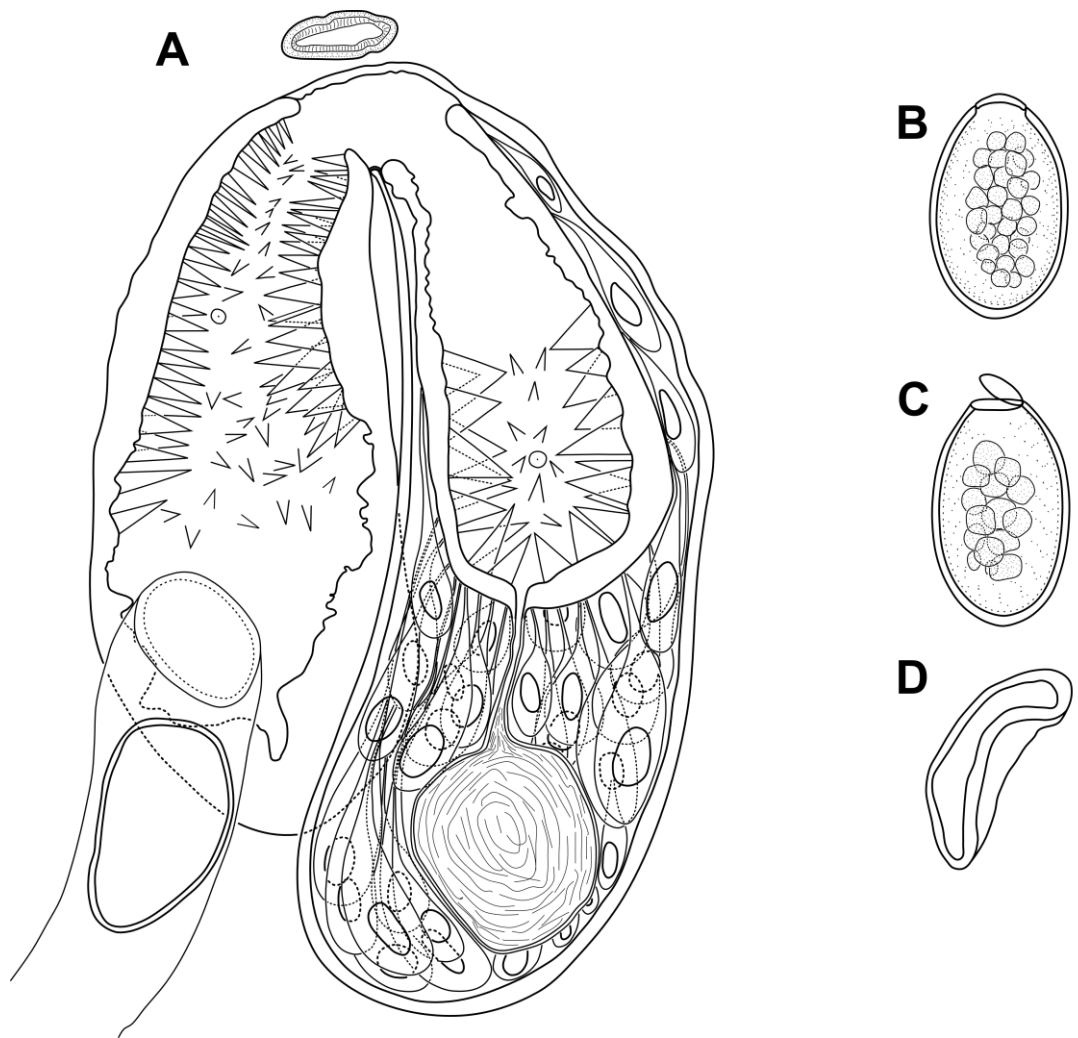


Fig. 2. *Paratimonia gobii* Prévot & Bartoli, 1967. A. Genital pore and terminal parts of genitalia: terminal organ (left) and cirrus-sac containing seminal vesicle, spined cirrus and pars prostatica (right). B, C. Operculate eggs. D. Deformed egg. Scale bar: 20 μm .

1970b). Recently, *P. gobii* has also been recorded as a parasite in *Knipowitschia caucasica* in the Sukhyi Liman near Odessa, a Black Sea coastal lake (KRASNOVYD et al. 2012). NAYDENOVA (1970b) distinguished *P. gobii pontica* from the Mediterranean *P. gobii gobii* by its smaller body size, larger eggs, entire ovary and strongly-developed vitellarium. These differences are believed to be a result of the peculiar environmental conditions in the Sea of Azov, leading to the geographical isolation of this parasite population (NAYDENOVA 1970b, 1974, MAILLARD 1975).

The presence of characters such as tegument entirely covered by spines vs tegument covered to mid-body by spines, lobed ovary vs entire ovary, and vitellarium consisting of two or several compact masses vs vitellarium in form of single compact mass makes our specimens closer to the original description of *P. gobii* (see Figs. 5, 8 and 9 of PRÉVOT & BARTOLI 1967) and distinguishes them from “*P.*

gobii pontica” (see Figs. 6a and 15a of NAYDENOVA 1970b, 1974). Compared to the original description from France, the present specimens possess only a few minor metrical differences, such as: smaller body length, average prepharynx length, anterior testis length, shorter distance between oral and ventral suckers, shorter posterior testis and shorter cirrus-sac (Table 2); we recognise these differences as an intraspecific variation. In addition, the present material possesses operculate eggs (Figs. 2B–C, 3E–F) vs unoperculate eggs reported in the previous descriptions (PRÉVOT & BARTOLI 1967, NAYDENOVA 1970b). Our observations reveal that the operculum is not distinct in all the eggs *in utero* but obvious in many of them. Although metrical differences between our material and “*P. gobii pontica*” have not been recorded (Table 2), based mainly on the above-mentioned qualitative characters, we consider the present specimens closer to the original description than to the description of

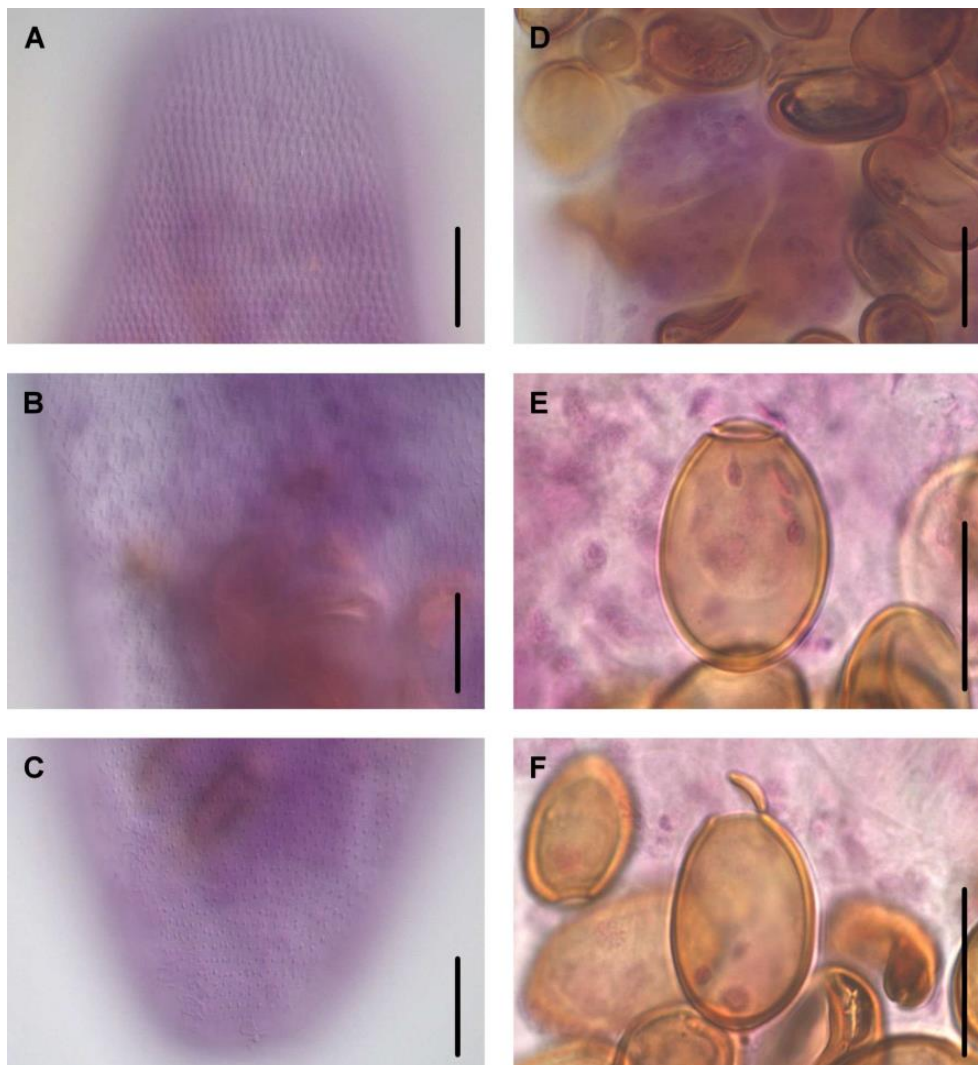


Fig. 3. *Paratimonia gobii* Prévot & Bartoli, 1967. A–C. Spines on body surface. A. Anterior end of body. B. Middle part of body. C. Posterior end of body. D. Ovary. E, F. Operculate eggs. Scale bars: 20 µm.

“*P. gobii pontica*” presented by NAYDENOVA (1970b). According to Dr Y. Kvach (personal communication), the specimens used for the original description of “*P. gobii pontica*” have been fixed between slides by adding ethanol to living flattened specimens, which can explain the differences in the shape and size of ovary and vitellarium as well as the partial loss of tegumental spines. Therefore, the recognition of subspecies within *P. gobii* could be due to the methods of fixation and its confirmation requires further studies.

The present study is the first record of *Paratimonia gobii* Prévot & Bartoli, 1967 for the Bulgarian fauna.

Class Monogenea

Family Gyrodactylidae Cobbold, 1864

***Gyrodactylus bubyri* Osmanov, 1965**

Site of infection: Skin, fins and gills.

Remarks: A redescription and molecular identification of the species, based on material collected during the course of this study, were published by STOYANOV et al. (2016).

Class Secernentea

Family Anisakidae Railliet & Henry, 1912

***Contracaecum* sp., third-stage larvae**

Site of infection: body cavity.

Description (based on two third-stage larvae; Fig. 4; for metrical data, see Table 3): Body fusiform, yellowish-brown. Cephalic extremity tapering, with weakly developed larval lips and tiny ventral conical larval tooth situated between larval lips (Fig. 4A). Cuticle at body extremities conspicuously thicker than remaining body cuticle, with more distinct external transverse striation; no cuticular spines. Excretory pore opens at base of larval lips. Oesophagus with long muscular part and small

Table 2. Metrical data of *Paratimonia gobii* Prévot & Bartoli, 1967 from different hosts and localities in Europe.

Species	<i>Paratimonia gobii gobii</i>			<i>P. gobii pontica</i>
	<i>Pomatoschistus microps</i>		<i>Knipowitschia caucasica</i>	<i>Pomatoschistus marmoratus</i>
Host				
Locality	Gulf of Marseille (France)	Costal marshes in Languedoc (France)	Lake Atanasovsko (Bulgaria)	Sea of Azov
Source	PRÉVOT & BARTOLI (1967)	MAILLARD (1975)	Present study	NAYDENOVA (1970b)
Character	Range (Mean)	Range (Mean)	Range (Mean ± SD; n)	Range
BL	670–1,500 (1,000)	800–1,500 (900)	338–568 (473.9; 20)	420–690
BW	174–340 (235)	180–250 (210)	95–184 (151.1; 20)	120–150
OSL	60–95 (80)	70–130 (95)	54–75 (62.6; 20)	56–87
OSW	–	–	55–80 (67.0; 20)	56–71
VSL	66–96 (83)	70–170 (100)	50–79 (64.0; 20)	56–93
VSW	–	–	45–87 (69.7; 20)	56–71
OSDVS	–	120–200 (160)	29–73 (50.9; 20)	–
VSDAB	–	–	92–142 (116.0; 20)	–
PL	27	–	8–16 (11.9; 16)	–
PW	–	–	8–18 (11.8; 16)	–
PHL	30–42 (35)	30–36 (34)	20–30 (25.2; 20)	–
PHW	24–35 (33)	–	25–33 (28.4; 20)	–
OL	–	–	12–35 (23.3; 19)	–
OW	–	–	7–23 (12.3; 19)	–
OVL	–	100–120 (110)	53–100 (75.0; 12)	–
OVW	–	–	30–78 (55.2; 12)	–
TOPL	–	–	40–75 (48.0; 14)	–
TOPW	–	–	24–46 (31.1; 14)	–
TODL	–	–	20–60 (33.4; 13)	–
TODW	–	–	20–77 (36.0; 13)	–
TOSL	6	–	5–10 (6.7±1.0; 40)	–
TOSW	–	–	2–4 (2.6±0.7; 40)	–
ATL	180–425 (254)	130–290 (220)	77–158 (108.5; 17)	93–102
ATW	50–100 (77)	50–70 (60)	20–53 (37.7; 17)	53–56
PTL	160–300 (213)	270–320 (290)	65–175 (113.8; 20)	93–102
PTW	55–125 (85)	50–100 (80)	20–56 (42.5; 20)	53–56
CSL	110–225 (175)	170–250 (220)	100–160 (122.1; 9)	–
CSW	36–66 (52)	–	40–70 (57.7; 9)	–
CL	–	–	30–75 (53.1; 20)	–
CW	–	–	17–37 (26.7; 20)	–
CSpL	5	–	5–7 (5.5±0.7; 40)	–
CSpW	–	–	3–6 (4.3±0.7; 40)	–
SVL	–	–	22–47 (38.6; 11)	–
SVW	–	–	27–60 (36.7; 11)	–
EVL	–	–	22–43 (33.0; 9)	–
EVW	–	–	13–25 (19.4; 9)	–
EGL	17–25 (23)	24–29 (25)	20–30 (25.4±2.6; 200)	28–31
EGW	11–16 (13)	–	10–20 (14.3±2.5; 200)	16–24

Abbreviations: ATL, anterior testis length; ATW, anterior testis width; BL, body length; BW, body width; CL, cirrus length; CSL, cirrus-sac length; CSW, cirrus-sac width; CSpL, cirrus spines length; CSpW, cirrus spines width; CW, cirrus width; EGL, egg length; EGW, egg width; EVL, excretory vesicle length; EVW, excretory vesicle width; OL, oesophagus length; OSDVS, oral sucker, distance from ventral sucker; OSL, oral sucker length; OSW, oral sucker width; OVL, ovary length; OVW, ovary width; OW, oesophagus width; PHL, pharynx length; PHW, pharynx width; PL, prepharynx length; PTL, posterior testis length; PTW, posterior testis width; PW, prepharynx width; SVL, seminal vesicle length; SVW, seminal vesicle width; TODL, terminal organ distal region length; TODW, terminal organ distal region width; TOPL, terminal organ proximal region length; TOPW, terminal organ proximal region width; TOSL, terminal organ spines length; TOSW, terminal organ spines width; VSDAB, ventral sucker, distance from anterior extremity of body; VSL, ventral sucker length; VSW, ventral sucker width.

glandular ventriculus at proximal end. Ventriculus irregular in shape, with posteriorly directed, short, claviform ventricular appendix (Fig. 4B); ventricular appendix significantly shorter than oesophagus and intestinal caecum (Table 3). Intestine brownish, thick-walled, with narrow lumen. Anterior intestinal caecum elongate-conical, with rounded tip, extending to level slightly posterior to nerve ring, almost half length of oesophagus (Table 3). Rectum tubular, short (Fig. 4C). Genital primordium indistinct. Tail rounded due to thickening of cuticle (Fig. 4C).

Remarks: The morphology of the present specimens is in agreement with the diagnosis of the genus *Contracaecum* Railliet & Henry, 1912 (see MORAVEC 1994): cuticle without spines, oesophagus with ventriculus at proximal end, posterior ventricular appendix and anterior intestinal caecum present, excretory pore opens just posterior to lips. Currently, it is considered that the identification of *Contracaecum* larvae at the species level based on morphological characters is not possible (MORAVEC 1994, MORAVEC et al. 2016). MORAVEC (1994) reviewed larvae of *Contracaecum* spp. from fishes in Europe. A recent description of larvae of this genus was provided by STOYANOV et al. (2017) based on specimens from *Lepomis gibbosus* (L.) in Lake Atanasovsko. Comparing metrical data from larvae of *Contracaecum* spp. in European fishes (Table 3), we can conclude that the above-described specimens differ from all known forms described from Europe. In addition, our specimens have a ratio of intestinal caecum to ventricular appendix length greater than in larvae of *C. rudolphii* Hartwich, 1964, *C. microcephalum* (Rudolphi, 1809) and *Contracaecum* sp. from *Lepomis gibbosus* in Lake Atanasovsko Wetlands (Table 3). The ratio of ventricular appendix to oesophagus length in our specimens is smaller than in larvae of *C. micropapillatum* (Stossich, 1890) and *Contracaecum* sp. in *L. gibbosus* from the Lake Atanasovsko Wetlands (Table 3). The two samples of *Contracaecum* spp. from fishes in the Lake Atanasovsko Wetlands can also be distinguished on the basis of the ratio of intestinal caecum to oesophagus length, which is greater in the specimens from *L. gibbosus* than in those from *K. caucasica* (present study) as well as in the absolute values of all measurements (Table 3). In addition, the nematodes from the Caucasian dwarf gobies are characterised with a rounded tail, whereas those from *L. gibbosus* have a conical tail with a bluntly-pointed tip (STOYANOV et al. 2017).

Eleven species of *Contracaecum* have been recorded as parasites of fish-eating birds and marine

mammals (definitive hosts), fishes (second intermediate or paratenic hosts) and copepods (first intermediate hosts) in Europe (MORAVEC 1994, STOYANOV et al. 2017). GVOZDEV et al. (1983) summarised data on nematode parasites in avian hosts from the Black Sea region and reported eight species of this genus; further two congeneric species have been described from *Pelecanus crispus* Bruch in Northern Greece (MATTIUCCI et al. 2010). Nevertheless, it is clear that the species identification of the above-described larvae requires further studies.

OSMANOV (1971) recorded *Contracaecum squalii* (von Linstow, 1907) from *K. caucasica* in the Aral Sea off the coast of Uzbekistan; this species is currently recognised as being a synonym of *C. microcephalum* (see MORAVEC 1994). No larvae of *Contracaecum* spp. have been reported from *K. caucasica* in the Black Sea basin by previous authors (NAYDENOVA 1970b, 1974, GAEVSKAYA et al. 1975, GAEVSKAYA 2012, KRASNOVYD et al. 2012).

Helminth communities

Of 186 Caucasian dwarf gobies studied, 171 were infected with helminth parasites. The component helminth community in *Knipowitschia caucasica* from Lake Atanasovsko consisted of four species (Tables 1 and 4). Based on all six seasonal samples collected during 2012–2013, three of the helminth species could be classified as common (*Aphalloides coelomicola*, *Paratimonia gobii* and *Gyrodactylus bubyri*). None of the helminth species could be referred to as intermediate. The category of rare parasites could be applied to *Contracaecum* sp. (larvae) only.

Of the four species of parasites, three were persistent in all six seasonal samples; larvae of *Contracaecum* sp. were detected only in three samples, always with a low prevalence and abundance (Table 1). The number of common species varied from one to two across seasons. *Aphalloides coelomicola* was a common species in three seasonal samples, reaching a maximum prevalence during May of both 2012 and 2013; in the remaining three seasonal samples, it was an intermediate species. *Paratimonia gobii* was a common species in all of the seasonal samples taken between May 2012 and May 2013, followed by a rapid decrease in its prevalence during July 2013 (reaching the level of a rare species) and a slight increase in September 2013 (Table 1). *Gyrodactylus bubyri* was common in September 2012 and July 2013, and an intermediate species in the remaining four seasonal samples. Interestingly, its absolute maximum during July 2013 (prevalence 100%) coincided with the absolute minimum of *P. gobii* and one of the three

Table 3. Metrical data of *Contracaecum* spp. (third-stage larvae) harboured by various fishes from Europe.

Species	<i>C. microcephalum</i>	<i>C. micropapillatum</i>	<i>C. osculatum</i>	<i>C. ovale</i>	<i>C. rudolphii</i>	<i>Contracaecum</i> sp.	<i>Contracaecum</i> sp.
Host	Various fishes	Various fishes	Various marine and freshwater fishes	Various fishes	Various fishes	<i>Lepomis gibbosus</i>	<i>Knipowitschia caucasica</i>
Locality	Europe	Europe	Europe	Europe	Europe	Lake Atanasovsko, Bulgaria	Lake Atanasovsko, Bulgaria
Source	MORAVEC (1994)						
Character	Range	Range ^a	Range	Range	Range	Range (Mean; n)	Range (Mean; n)
BTL	1,310–2,000 ^a or 3,600–7,800 ^a	430–6,000	3,810–22,000	3,800–4,100	780–910 or 15,000–24,000 ^b	2,632–3,681 (3,157; 2)	19,000–26,591 (22,796; 2)
BMW	56–70 ^a or 150–240 ^a	10–40	150–530	210–250	900–2,100	105–165 (135; 2)	870–1,050 (960; 2)
BWA	–	–	–	–	–	43–63 (53; 2)	202–826 (514; 2)
OL	210–230 ^a or 400–480 ^a	110–600	550–1,710	600	–	278–415 (347; 2)	4,750
OW	–	–	–	–	–	13–25 (19; 2)	100
VL	16–17 ^a	–	–	40–50	20–30	16–25 (21; 2)	150
VW	10–20 ^a	–	–	30–40	10–30	17–18 (18; 2)	100
VAL	190–240 ^a or 420–500 ^a	80–570	540–1,580	680–800	150–200 or 500–650 ^b	225–410 (318; 2)	700
VAW	–	–	–	–	–	21–41 (31; 2)	150
NR	116–120 ^a	50–60	–	–	140–150	125–160 (143; 2)	270–380 (325; 2)
ICL	6–43 ^a or 210–270 ^a	10–500	290–890	350–400	1,450–2,250	128–185 (157; 2)	2,780
ICW	–	–	–	–	–	26–44 (35; 2)	332
TL	50–90 ^a	50–150	90–210	–	–	95–105 (100; 2)	121–292 (207; 2)
Ratios							
VAL/OL	–	1 : 1.0–1.3	–	–	–	1 : 1.01–1.23 (1 : 1.12; 2)	1 : 6.78 (n = 1)
ICL/VAL	1 : 3–4 ^b	–	–	–	3 : 1	1 : 1.75–2.21 (1 : 1.98; 2)	3.97 : 1 (n = 1)
ICL/OL	–	–	–	–	–	1 : 2.17–2.24 (1 : 2.20; 2)	1 : 1.71 (n = 1)

^aWhen naturally infected fish – larvae larger; ^bFrom experimentally infected fish; ^bIn a more advanced larva.

Abbreviations: BMW, body maximum width; BTL, body total length; BWA, body width at anus; ICL, intestinal caecum length; ICW, intestinal caecum maximum width; NR, nerve ring, distance from anterior extremity; OL, oesophagus length; OW, oesophagus maximum width; TL, tail length; VAL, ventricular appendix length; VAW, ventricular appendix maximum width; VL, ventriculus length; VW, ventriculus width.

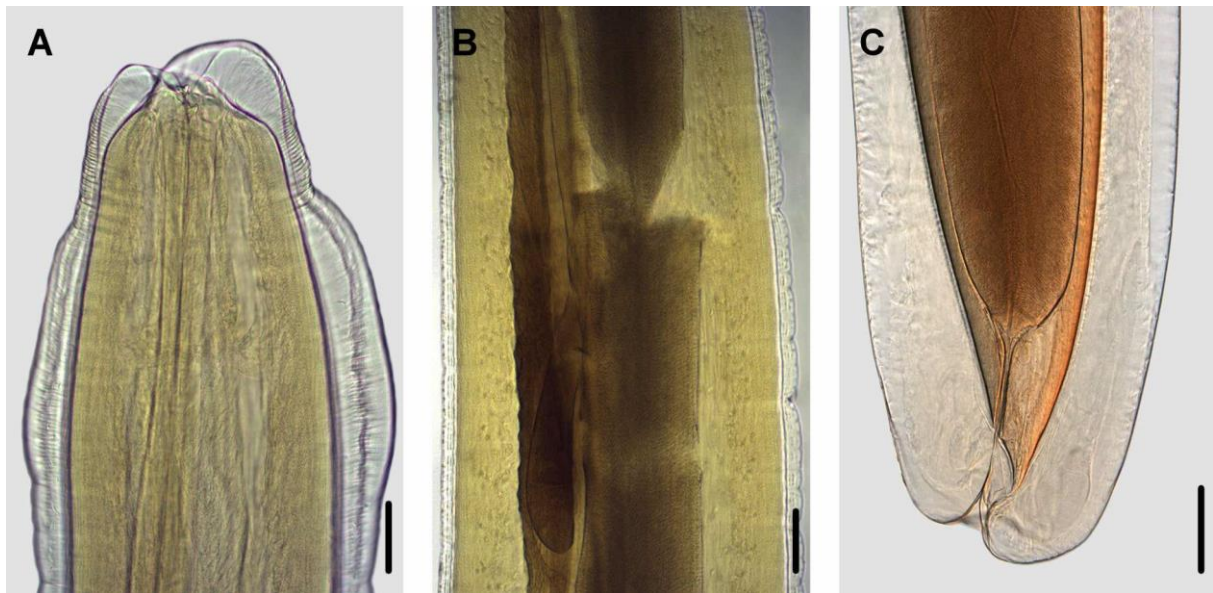


Fig. 4. *Contracaecum* sp., third-stage larva. A. Body, anterior end. B. Body, oesophago-intestinal junction and posterior ventricular appendix. C. Body, posterior end. Scale bars: A – 100 μ m; B, C – 200 μ m.

minimum prevalence values of *A. coelomicola* (Table 1). The three helminth species classified as common exhibited significant differences relative to their mean intensity and mean abundance, with maximum values for *A. coelomicola* and *P. gobii* during May 2013 and an outbreak of *G. bubyri* in July 2013 (Table 1). The Shannon's Diversity Index calculated on the basis of all samples was 0.91, varying in seasonal samples between 0.23 (July 2013) and 1.01 (September 2013). The value of the Simpson's Dominance Index was 0.47 based on all the samples, ranging 0.41–0.90 in the seasonal samples (Table 4).

At the infracommunity level, the mean number of helminth species per examined fish specimen (species richness of infracommunities) varied between 1.23 in July 2012 and 2.39 in May 2013 (Table 4); the differences in the species richness were significant (Kruskal – Wallis $H = 37.51626$, $p = 0.0000$). The majority of infracommunities consisted of one or two species, as demonstrated by the median value of their species richness. Based on all samples, the mean number of helminth species per fish specimen was 1.70, with a range of variation of 0–4. The mean number of parasite specimens per fish (i.e. total mean abundance, see Table 1) was between 8.19 and 96.71 in seasonal samples and the differences between them were significant (Table 1). Shannon's Diversity Index of infracommunities varied between 0.16 (July 2013) and 0.51 (May 2013) in seasonal samples. Simpson's Dominance Index exhibited constantly high values (Table 4).

Discussion

Our study revealed four helminth species in the Caucasian dwarf goby *Knipowitschia caucasica* from Lake Atanasovsko: two trematode, one monogenean and one larval nematode species. This is a small proportion of the 30 species (17 trematodes, one monogenean, five cestodes, five nematodes and two acanthocephalans, see Table 5) reported from this host species in previous studies (MARGARITOV 1960, OSMANOV 1965, 1971, NAYDENOVA 1970a, b, 1974, GAEVSKAYA et al. 1975, DILER & YILDIRIM 2003, SEMENOVA et al. 2007, KRASNOVYD et al. 2012, VANHOVE et al. 2014, ANTAL et al. 2015).

The recorded trematodes, *Aphalloides coelomicola* and *Paratimonia gobii*, are considered stenoxenous parasites occurring in gobionellid gobies of the genera *Pomatoschistus* Gill, 1863 and *Knipowitschia* Iljin, 1927 (DOLLFUS et al. 1957, PRÉVOT & BARTOLI 1967, NAYDENOVA 1970a, b, 1974, GAEVSKAYA et al. 1975, KVACH 2010, GAEVSKAYA 2012, KRASNOVYD et al. 2012, STOYANOV et al. 2015, KVACH et al. 2017). Until recently, the genus *Aphalloides* Dollfus, Chabaud & Golvan, 1957 was believed to consist of two species occurring in European coastal areas, i.e. the type-species *A. coelomicola* described from the French Mediterranean coast (DOLLFUS et al. 1957) and subsequently recorded from the same region (BAYSSADE-DUFOUR & MAILLARD 1982, PAMPOULIE et al. 1999, 2000, 2004, PAMPOULIE & MORAND 2002), the Black Sea basin (NAYDENOVA 1970a, b, 1974, KVACH 2004, 2005, 2010, KRASNOVYD et al. 2012, STOYANOV et al. 2015) and the North Sea off

Table 4. Parameters of the helminth communities in *Knipowitschia caucasica* (Berg) from different localities in the Black Sea basin.

Localities	Ukraine		Bulgaria					Total
	Sea of Azov in 1964–1967 (1974)	Sukhyi Liman Spring, summer and autumn in 2008–2010 (2012)	May 2012	July 2012	September 2012	May 2013	July 2013	
Source	NAYDENOVA (1974)	KRASNOVYD et al. (2012)	Present study					
Fish specimens studied	14	23	31	31	31	31	31	31
Helminth species number	8	11	4	3	4	3	3	4
Component communities								
Shannon's Diversity Index (H')	–	–	0.71	0.53	0.86	0.61	0.23	1.01
Simpson's Dominance Index	–	–	0.60	0.73	0.50	0.64	0.90	0.41
Dominant structure								
Common species number	1	1	2	1	2	2	1	1
Intermediate species number	4	5	1	2	1	1	1	2
Rare species number	3	5	1	0	1	0	1	1
Infracommunities								
Mean number of species per fish ± SE	–	–	1.94±0.16	1.23±0.14	1.71±0.14	2.39±0.10	1.48±0.11	1.45±0.17
Median	–	–	2	1	2	2	1	1
Range	–	–	0–4	0–3	0–3	1–3	1–3	0–3
Mean number of individuals per fish ± SE	–	–	28.74±6.79	18.00±5.01	14.03±2.83	96.71±11.69	31.81±3.41	8.19±2.00
Median	–	–	12	12	7	93	30	3
Range	–	–	0–140	0–136	0–61	8–264	6–89	0–50
Shannon's Diversity Index (H')								
Mean ± SE	–	–	0.40±0.06	0.20±0.05	0.42±0.06	0.51±0.04	0.16±0.04	0.32±0.07
Median	–	–	0.41	0.00	0.52	0.52	0.00	0.18
Simpson's Dominance Index								
Mean ± SE	–	–	0.76±0.04	0.88±0.03	0.73±0.04	0.69±0.03	0.91±0.03	0.80±0.04
Median	–	–	0.75	1.00	0.67	0.66	1.00	0.92
								0.80

Table 5. Helminth parasites from Caucasian dwarf goby *Knipowitschia caucasica* recorded from its native (N) and non-indigenous (NI) geographical range.

No	Parasite species	Locality	Range	Source
	Trematoda			
	Bucephalidae			
1	<i>Bucephalus polymorphus</i> von Baer, 1827, met.	Lake Egirdir (Turkey)	NI	DILER & YILDIRIM (2003)
	Diplostomidae			
2	<i>Diplostomum spathaceum</i> (Rudolphi, 1819), met.	Caspian Sea (Russia)	N	SEMENOVA et al. (2007)
	Cyathocotylidae			
3	<i>Holostephanus cobitidis</i> Opravilova, 1968, met.	Caspian Sea (Russia)	N	SEMENOVA et al. (2007)
	Strigeidae			
4	<i>Apatemon gracilis</i> (Rudolphi, 1819), met.	Lake Tisza (Hungary)	NI	ANTAL et al. (2015)
	Hemiuridae			
5	<i>Lecithaster maeoticus</i> Naydenova, 1970	Sea of Azov	N	NAYDENOVA (1970b, 1974)
	Derogenidae			
6	<i>Magnibursatus skrjabini</i> (Vlasenko, 1931)	Sea of Azov	N	NAYDENOVA (1974)
	Echinochasmidae			
7	<i>Echinochasmus</i> sp., met.	Lake Tisza (Hungary)	NI	ANTAL et al. (2015)
	Opecoelidae			
8	<i>Nicolla skrjabini</i> (Iwanitzky, 1928)	Lake Tisza (Hungary)	NI	ANTAL et al. (2015)
	Cryptogonimidae			
9	<i>Acanthostomum</i> sp., met.	Sea of Azov	N	NAYDENOVA (1970b, 1974)
10	<i>Aphalloides coelomicola</i> Dollfus, Chabaud & Golvan, 1957	Sea of Azov	N	NAYDENOVA (1970a, b, 1974)
		Odessa Region	N	KRASNOVYD et al. (2012)
		Lake Atanasovsko	N	STOYANOV et al. (2015)
11	<i>Timoniella imbutiforme</i> (Molin, 1859), met.	Odessa Region	N	KRASNOVYD et al. (2012)
	Heterophyidae			
12	<i>Cryptocotyle concava</i> (Creplin, 1825), met.	Sea of Azov	N	NAYDENOVA (1970b, 1974)
		Odessa Region	N	KRASNOVYD et al. (2012)
13	<i>Cryptocotyle lingua</i> (Creplin, 1825), met.	Odessa Region	N	KRASNOVYD et al. (2012)
14	<i>Pygidiopsis genata</i> Looss, 1907, met.	Odessa Region	N	KRASNOVYD et al. (2012)
	Monorchidae			
15	<i>Paratimonia gobii</i> Prévot & Bartoli, 1967	Odessa Region	N	KRASNOVYD et al. (2012)
		Lake Atanasovsko	N	Present study
16	Monorchidae gen. sp., met.	Sea of Azov	N	NAYDENOVA (1974)
	Lissorchiidae			
17	<i>Asymphylogora pontica</i> (Chernyshenko, 1949)	Odessa Region	N	KRASNOVYD et al. (2012)
	Monogenea			
	Gyrodactylidae			
18	<i>Gyrodactylus bubyri</i> Osmanov, 1965	Aral Sea (Uzbekistan)	NI	OSMANOV (1965, 1971)
		River Strymon (Greece)	N	VANHOVE et al. (2014)
		Lake Atanasovsko	N	STOYANOV et al. (2016)
	Cestoda			
	Diphyllobothriidae			
19	<i>Ligula colymbi</i> Zeder, 1803, larvae	Lake Burgas (Bulgaria)	N	MARGARITOV (1960)
20	<i>Ligula pavlovskii</i> Dubinina, 1959, larvae	Black Sea basin	N	GAEVSKAYA et al. (1975)
	Proteocephalidae			
21	<i>Proteocephalus percae</i> (Müller, 1780)	Caspian Sea (Russia)	N	SEMENOVA et al. (2007)
22	<i>Proteocephalus</i> sp., larvae	Lake Tisza (Hungary)	NI	ANTAL et al. (2015)
	Tetraphyllidea <i>incertae sedis</i>			
23	<i>Scolex pleuronectis</i> Müller, 1788, larvae	Sea of Azov	N	NAYDENOVA (1970b, 1974)

Table 5. Continued.

No	Parasite species	Locality	Range	Source
	Nematoda			
	Anisakidae			
24	<i>Contracaecum microcephalum</i> (Rudolphi, 1809), larvae	Aral Sea (Uzbekistan)	NI	OSMANOV (1971)
25	<i>Contracaecum</i> sp., larvae	Lake Atanasovsko	N	Present study
	Cucullanidae			
26	<i>Dichelyne minutus</i> (Rudolphi, 1819)	Sea of Azov	N	NAYDENOVA (1970b, 1974)
		Odessa Region	N	KRASNOVYD et al. (2012)
	Camallanidae			
27	<i>Camallanus truncatus</i> (Rudolphi, 1814)	Lake Tisza (Hungary)	NI	ANTAL et al. (2015)
	Acuariidae			
28	<i>Agamospirura</i> sp., larvae	Odessa Region	N	KRASNOVYD et al. (2012)
	Acanthocephala			
	Arhythmacanthidae			
29	<i>Acanthocephaloides irregularis</i> Amin et al., 2011	Odessa Region	N	KRASNOVYD et al. (2012)
	Illiosentidae			
30	<i>Telosentis exiguus</i> (von Linstow, 1901)	Odessa Region	N	KRASNOVYD et al. (2012)

Belgium (VAES 1978), and *A. timmi* Reimer, 1970 from the Baltic Sea (REIMER 1970, REIMER et al. 1996, ZANDER et al. 1999, 2000, ZANDER 2003, 2004, 2005a, b, KVACH & WINKLER 2011) and the estuary of the River Glomma in the region of Oslofjord (BAKKE 1980). A recent revision of the genus (KVACH et al. 2017) showed that *A. timmi* should be recognised as a junior synonym of *A. coelomicola*. Therefore, all the above-listed records are referred to *A. coelomicola*.

The second trematode species, *Paratimonia gobii*, was originally described as an intestinal parasite of the common goby *Pomatoschistus microps* (Krøyer) from the Gulf of Marseille on the Mediterranean coast of France (PRÉVOT & BARTOLI 1967). Subsequently, it has also been recorded from other sand gobies, i.e. *Pomatoschistus marmoratus* (Risso) and *Knipowitschia caucasica*, in the Black Sea basin (NAYDENOVA 1970b, 1974, KVACH 2004, 2005, 2010, KRASNOVYD et al. 2012, present study). Further studies are needed to confirm the recognition of the subspecies proposed by NAYDENOVA (1970b) within the type-species.

The monogenean recorded from *K. caucasica* in Lake Atanasovsko, *Gyrodactylus bubyri*, was believed to represent an oioxenous parasite of this host (OSMANOV 1965, 1971, DMITRIEVA & SKIDAN 2005, VANHOVE et al. 2014). A recent study (STOYANOV et al. 2016) has proposed that *G. micropsi* Gläser, 1974 from *Potamoschistus microps* in the Baltic and the North Seas is its junior synonym (for details, see STOYANOV et al. 2016). Therefore, *G. bubyri* is also a stenoxenous parasite occurring in gobionellid gobies

of the genera *Pomatoschistus* and *Knipowitschia*. Its geographical range includes the Aral Sea (now probably extinct there), the Black Sea basin, the River Struma (Strymon) in Greece (Aegean basin), the North Sea and the Baltic Sea (STOYANOV et al. 2016).

Although, the recorded third-stage larvae of *Contracaecum* sp. are not identified at the species level, we can speculate that they are parasitic as adults in fish-eating birds, which are frequent in the studied habitat. In total, 317 bird species have been recorded from Lake Atanasovsko (VASSILEV et al. 2013). DIMITROV et al. (2005) reported various concentrations of 39 fish-eating bird species of the families Gaviidae, Podicipedidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Ciconiidae, Threskiornithidae, Anatidae and Laridae from Lake Atanasovsko, which explain the presence of *Contracaecum* spp. in fishes from the Lake Atanasovsko Wetlands (see also STOYANOV et al. 2017).

In summary, the studied population of *K. caucasica* from Lake Atanasovsko harbours four helminth species. Of these, three are considered stenoxenous (parasitic in gobionellid gobies in European waters). The specificity of the fourth species, *Contracaecum* sp., cannot be evaluated due to its identification to the generic level only and the unknown ranges of its fish second intermediate hosts. This is the first record of a nematode of the genus *Contracaecum* in this host species from the Black Sea basin.

Previous information on the component helminth communities in *K. caucasica* is scarce. NAYDENOVA (1974) reported data based on the exam-

ination of 14 specimens from the Sea of Azov. She recorded eight helminth species. The only species in common between her study and ours is *A. coelomicola*, which was recorded in the Sea of Azov with prevalence 35.7% and mean intensity 4.0 (range 1-10); these infection values were lower than in the population studied by us. The other helminths recorded by NAYDENOVA (1974) include five trematode species: metacercariae of three species (Monorchidae gen. sp., *Acanthostomum* sp. and *Cryptocotyle concava* (Creplin, 1825), the former two with unknown ranges of second intermediate hosts and the latter being an euryxenous parasite of marine fishes) and two trematodes occurring as adults (*Lecithaster maeoticus* Naydenova, 1970, a stenoxenous parasite of gobionellid gobies, and *Magnibursatus skrjabini* (Vlasenko, 1931), a euryxenous intestinal parasite of a wide range of marine fishes, mostly gobies). NAYDENOVA (1974) also recorded "*Scolex pleuronectis* Müller, 1788", a collective name for cestode larvae in marine fishes (see KHALIL et al. 1994), and the cucullanid nematode *Dichelyne minutus* (Rudolphi, 1819), a euryxenous parasite occurring in diverse benthic fishes. Therefore, at least six of the species recorded by NAYDENOVA (1974) have a wider range of hosts and are not specific to gobionellid gobies. Of the species she recorded, one is common, four are intermediate and three are rare (Table 4).

Another study summarized data on the structure of the component helminth community on the basis of the examination of 23 individuals of *K. caucasica* from Sukhyi Liman on the Ukrainian Black Sea coast (KRASNOVYD et al. 2012). In total, 11 helminth species were recorded. The most prevalent parasites recorded by us, the trematodes *A. coelomicola* and *P. gobii*, were also the most prevalent in the population of *K. caucasica* in Sukhyi Liman. The remaining nine helminths included seven trematode species (six and one occurring as metacercariae and adults, respectively), two nematode species (one adult and one third-stage larva) and two acanthocephalan species. Except for the two mentioned trematode species, which are stenoxenous for the gobionellid gobies, the remaining parasites are either euryxenous or the assessment of their specificity is not possible due to their identification only to the generic or the family level. Based on their prevalence, these species can be classified as one common (*P. gobii*), five intermediate and five rare (Table 4). The two species with the highest prevalence in our study, *A. coelomicola* and *P. gobii*, were recognised as core species of the component helminth community in another gobionellid species in the Black Sea basin, *Pomatoschistus marmoratus* (see KVACH 2010).

The studies by NAYDENOVA (1974) and KRASNOVYD et al. (2012) demonstrated much more speciose helminth communities than occur in Lake Atanasovsko. A possible explanation for this is the presence of several species of gobies in both the Sea of Azov and Sukhyi Liman, which support more diverse parasite assemblages, and only one goby species in Lake Atanasovsko (STEFANOV 2006). In addition, the brackish habitats examined by NAYDENOVA (1974) and KRASNOVYD et al. (2012) obviously support more diverse invertebrates, which can act as intermediate hosts of helminth parasites, than the hyperhaline Lake Atanasovsko.

At the infracommunity level, both the mean number of helminth species per fish and the mean number of helminth individuals per fish exhibited substantial variation, reaching their maximum values in May 2013 (Table 4). These peaks in their dynamics coincided with the maximum value for the diversity of infracommunities. A possible explanation for the peaks in the diversity and the abundance of the infracommunities in *K. caucasica* is the peculiar life cycle of these gobies, which live for less than two years (MILLER 1986). According to NAYDENOVA (1970a), the three gobionellid gobies in the Black Sea basin mate between the spring months and August, and there is a mass mortality of females and the majority of males after spawning. Therefore, the peaks in the diversity and abundance of infracommunities coincide with the presence of oldest surviving fishes in the studied fish population.

We were not able to compare the diversity indices for the component communities and the infracommunities because of the lack of earlier data. However, our data can be used in future studies of the same host species.

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