ACTA ZOOLOGICA BULGARICA

Acta Zool. Bulg., 74 (2), June 2022: 305-315
Published online 08 April 2022
http://www.acta-zoologica-bulgarica.eu/2022/002594

Parasitology
Research Article

New Records of Hymenolepidid Cestodes (Cyclophyllidea: Hymenolepididae) from Ducks (Anseriformes: Anatidae) in Bulgaria

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Abstract: Three hymenolepidid species (Cyclophyllidea, Hymenolepididae) from anseriform birds are reported for the first time in Bulgaria (new geographical records). These are *Diorchis asiatica* Spasskii, 1963 from *Tadorna ferruginea* (Pallas) (new host record), *Echinocotyle minutissima* Singh, 1952 from *Spatula querquedula* (L.), and *Fimbriarioides tadornae* Maksimova, 1976 from *Tadorna tadorna* (L.). The species are redescribed and figured on the basis of newly-collected and voucher specimens from Bulgaria. The taxonomic status and the synonymy of *D. asiatica* are discussed. The authorship of *Diorchis diorchis* Burt & McLaughlin, 1975 is clarified and its position as a junior synonym of *D. asiatica* is justified.

Key words: Cestoda, *Diorchis asiatica*, *Echinocotyle minutissima*, *Fimbriarioides tadornae*, Anseriformes

Introduction

The avifauna of Bulgaria includes 40 species of the family Anatidae; these include mostly frequently recorded birds (some of them with the status of game waterfowl), several protected species and a few rare species known from the country based on a few records only (Nankinov et al. 1997, Michev et al. 2012). Despite this great variety of potential definitive hosts, the cestode diversity of waterfowl in Bulgaria remains insufficiently studied. More than a half of the waterfowl species recorded in Bulgaria have never been registered as hosts of helminth parasites, including cestodes (see Marinova et al. 2013). Until now, 50 hymenolepidid cestode species have been reported from anseriform birds at various localities in Bulgaria (Marinova et al. 2013, 2015, Marinova 2017, Marinova & Vasileva 2021).

Recently, more detailed studies on the cestode fauna in anseriform birds in Bulgaria have been carried out (Marinova et al. 2013, 2015, Marinova 2017, Marinova & Vasileva 2021). In the course of these faunistic examinations based on samples collected during the last 50 years, we found three hymenolepidid species registered for the first time in the helminth fauna of Bulgaria. The aim of this article is to present redescriptions of these species and to clarify their synonymy, geographical distribution and host ranges.

Materials and Methods

The present study was based on cestode specimens isolated from the small intestines of five ducks belonging to three species, i.e. *Spatula querquedula* (L.) (three specimens), *Tadorna ferruginea* (Pallas) (one specimen) and *T. tadorna* (L.) (one specimen). The samples included specimens from the Helminthological Collection of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (IBER–BAS) and newly-collected specimens from Radnevo (Stara Zagora

Region) collected by the senior author (MHM). The birds were collected from three localities. Cestodes were isolated from the intestines, relaxed in tap water, fixed in 4% hot formalin solution and preserved in 70% ethanol. They were stained with iron acetocarmine (Georgiev et al. 1986), dehydrated in ethanol series, cleared in clove oil and mounted in Canada balsam. One specimen was mounted in Berlese's medium to facilitate observations of the rostellar hooks. Details about the specimens studied, their hosts, localities and collection numbers are given in the text for each species. Observations, measurements and drawings were made using compound microscopes Leica DM 2500 and Olympus BX51, equipped with differential interference contrast and drawing tubes.

The metrical data are given as the range, with the mean and the number of measurements taken (n) in parentheses. The measurements are given in micrometres unless otherwise stated. The terminology of the types of the rostellar hooks is according to Skrjabin & Mathevossian (1945). Terminology describing the stages of maturation of proglottides follows Georgiev & Vaucher (2001). The identifications of birds have been based on Nankinov et al. (1997) and Michev et al. (2012). The nomenclature of birds follows Avibase (Lepage 2021).

Results

Genus *Diorchis* Clerc, 1903

***Diorchis asiatica* Spasskii, 1963**

Syns.: *D. danutae asiatica* Spasskii, 1963; *Diorchis diorchis* Burt & McLaughlin, 1975.

Specimens studied: from *Tadorna ferruginea,* MHM 106, 28.12.2009, Radnevo (Stara Zagora Region), about 5 fragments of strobila at various stage of development, stained and mounted in Canada balsam (2 slides). Scoleces not available in specimens studied.

Redescription (Figs. 1A–C; for measurements, see Table 1): Strobila with maximum width at level of last (mature hermaphroditic) proglottides. Scolex not available. Proglottides craspedote, wider than long. Genital pores unilateral, dextral, opening at middle of lateral proglottis margin. Genital atrium funnel-shaped (Fig. 1A). Strobila protandrous.

Testes two, oval, situated in median field. External seminal vesicle elongate, overlapping antiporal end of cirrus-sac dorsally; connecting with cirrus-sac by short isthmus (Fig. 1A). Cirrus-sac elongate, thin-walled, crossing midline of proglottis in mature hermaphroditic proglottides (Fig. 1A). Internal seminal vesicle large, elongate, occupying almost entire cirrus-sac when fully-developed. Evaginated cirrus cylindrical, armed with three types of spines; basal part slightly larger, armed with fine, triangular spines; middle part cylindrical, gradually tapering, unarmed; distal part slightly tapering, densely covered with longer, needle-shaped spines (Fig. 1C).

Ovary with two compact lobes, situated antiporally in median field of proglottis; ventral to testes and seminal receptacle (Fig. 1A). Vitellarium oval, ventral and posterior to ovary (Fig. 1A). Seminal receptacle sac-like, thin-walled, ventral to cirrus-sac (Fig. 1 A, B). Vagina consisting of two distinct parts, opening and passing ventrally and posteriorly to cirrus-sac; copulatory part tubular, with thick muscular walls, consisting of distinct radial musculature; surrounded by thin sleeve of glandular cells; conductive part of vagina tubular, thin-walled, slightly folded (Fig. 1A, B). Proglottides with developing uterus not available.

Remarks: The species was described on the basis of specimens from *Mareca falcata* (Georgi) in Tuva (Russia), recorded by Spasskaya (1961) as "*Diorchis danutae* Czaplinski, 1956". Spasskii (1963) compared the morphology of these specimens with the original description of *D. danutae* from Poland (Czapliński 1956) and identified the cestodes from Tuva as the new subspecies *D. danutae asiatica* Spasskii, 1963 based on the differences in the length of the rostellar hooks, the position of the copulatory part of the vagina and the peculiar cirrus armament. Spasskaya (1966) raised this subspecies to the species rank and considered both *D. asiatica* and *D. danutae* as valid species. A detailed comparative analysis of the morphology and the life cycles of *D. danutae* and *D. asiatica* was published by Czapliński & Szelenbaum-Cielecka (1986). These two species were clearly distinguished on the basis of the length of the strobila and the rostellar hooks, the shape and armament of the evaginated cirrus, and the shape and size of the oncospheres. Differences were also observed in their host-range. *D. asiatica* was considered a specific parasite of ducks of the tribe Anatini, while *D. danutae* was recorded mainly in diving ducks of the genera *Aythya* Boie and *Netta* Kaup (tribe Aythyini) as well as from *Oxyura* Bonaparte (tribe Oxyurini) (Czapliński & Szelenbaum-Cielecka 1986).

The validity of *D. asiatica* was rejected by Tolkacheva (1991). She re-examined the paratypes of *D. asiatica* and considered it as a junior synonym of "*Diorchis diorchis* Baer, 1962". During the present study, we analysed the taxonomic history

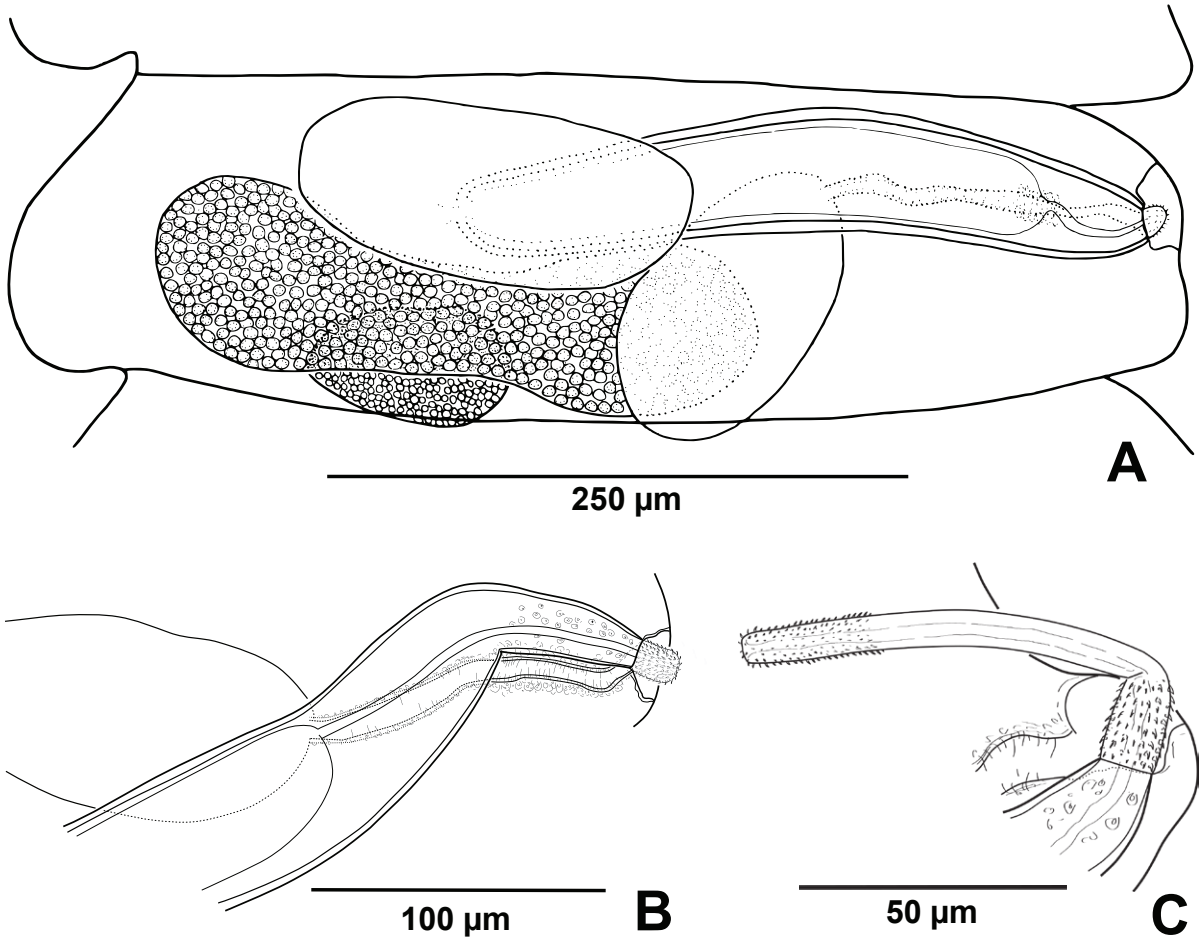

Fig. 1. *Diorchis asiatica* Spasskii, 1963, specimens from *Tadorna ferruginea* from Radnevo, Bulgaria. A. Hermaphroditic mature proglottis. B. Terminal genital ducts. C. Evaginated cirrus.

and the authorship of *D. diorchis*. Baer (1962) recorded specimens from *Mareca penelope* (L.) in Iceland as "*Diorchis diorchis* (Fuhrmann, 1913) Baer, 1962". However, *Hymenolepis diorchis* Fuhrmann, 1913 was originally described from *Somateria mollissima* (L.) in Iceland (Fuhrmann 1913). Subsequently, Burt & McLaughlin (1975) and Galkin et al. (2008) re-examined the type-series of *H. diorchis* and the materials of Baer (1962) from Iceland. Burt & McLaughlin (1975) found that the type-specimens of Fuhrmann (1913) from *Somateria mollissima* possessed three testes per proglottis and rostellar hooks with length 50–64 µm. They identified these specimens as belonging to the genus *Microsomacanthus* Lopez-Neyra, 1942, which was confirmed by Galkin et al. (2008). The specimens described by Baer (1962) from *M. penelope* in Iceland possessed two testes per proglottis and much shorter hooks with a different shape. They were considered as a distinct species of the genus *Diorchis* by Burt & McLaughlin (1975) proposing a new name for this material, i.e. "*Diorchis diorchis* Baer, 1962". However, the proposed authorship of this species did not follow the ICZN (see Article 50, ICZN 1999) since Baer (1962) has never recognised the specimens from *Mareca penelope* from Iceland as belonging to a new species. Therefore, the authorship of the new taxon should be *Diorchis diorchis* Burt & McLaughlin, 1975. The morphological similarity between *D. diorchis* and *D. asiatica* was mentioned by Burt & McLaughlin (1975). The present study also confirms their morphological (including metrical) similarities (see Table 1 for comparison between specimens from Tuva and those from Iceland). On this basis, we confirm the synonymy proposed by Tolkacheva (1991). Following the ICZN (Article 50, ICZN 1999), the name of the valid species is *D. asiatica* Spasskii, 1963 and *D. diorchis* Burt & McLaughlin, 1975 is its junior synonym.

The specimens from *T. ferruginea* from Bulgaria were fragmented and, unfortunately, scoleces were not preserved. Nevertheless, they possess the main diagnostic characters of *D. asiatica*, i.e. the antiporal position of the female gonads, the peculiar pattern of the cirrus armament and the

Table 1. Metrical data for *Diorchis asiatica* Spasskii, 1963. Legend: * – maximum length of the fragments of strobila, ** – diameter of testes.

Host		***Mareca falcata***	***Mareca penelope***	***Mareca strepera***	***Tadorna ferruginea***		
Locality		Tuva (Russia)	Iceland	Poland	Bulgaria		
Source		Spasskaya (1961)	Burt & McLaughlin (1975)	Czapliński & Szelenbaum-Cielecka (1986)	Present study		
		Range	Range	Range	Range	Mean	n
Strobila	Length (mm)	28	8–34	15.5–32	7–23*	–	2
	Width (mm)	0.74	0.4–0.7	0.52–0.82	0.52–0.65	–	2
Testes	Length	127–145	70–90**	23–55	77–107	88	10
	Width	100–120	–	24–80	55–68	60	10
External seminal vesicle	Length	135	200	–	128–200	170	10
	Width	80	65	–	75–120	93	10
Cirrus-sac	Length	475	201–336	300–380	280–333	305	10
	Width	46	23–38	20–38	51–55	54	10
Evaginated cirrus	Length	182	150	150–185	75–100	–	2
	Max. width	17	13	12–20	11–13	–	2
Ovary	Max. width	82–384	144–198	150–280	205–285	245	14
Vitellarium	Length	27–100	48–70	30–80	80–108	92	12
	Width	27–45	25–48	23–50	38–55	44	12
Seminal receptacle	Length	140	160–320	–	100–155	122	6
	Width	36	60–65	–	67–80	71	6
Copulatory vagina	Length	36	–	120–160	108–170	135	6
	Width	–	–	–	18–20	19	6

structure of the copulatory vagina (see Spasskaya 1961, Burt & McLaughlin 1975, Czapliński & Szelenbaum-Cielecka 1986). The metrical data also correspond well to the previous descriptions (Table 1). Therefore, we consider the specimens from the ruddy shelduck from Bulgaria as belonging to *D. asiatica*.

Diorchis asiatica is a species with Holarctic distribution, including Europe (Iceland, Finland, Poland and Bulgaria), Asia (Tuva and Western Siberia) and North America (Canada) (Spasskaya 1966, Burt & McLaughlin 1975, Hair & Holmes 1975, Czapliński & Szelenbaum-Cielecka 1986, Brglez et al. 1986, present study). The analysis of its host range has revealed that it is a euryixenous parasite (according to the classification of Combes 1995). It has been recorded so far in birds of the subfamily Anatinae, including species of the tribes Anatini (*Anas platyrhynchos* L., *Anas acuta* L. *Mareca strepera* (L.), *M. falcata, M. penelope* (L.), *Spatula querquedula*), and Aythyini (*Aythya fuligula* L. and *A. affinis* Eyton). The present finding of *D. asiatica* in *T. ferruginea* is the first host record of this cestode in the subfamily Tadorninae. The life cycle of *D. asiatica* is dixenic; the cysticercoids were reported in three species of ostracods, e.g. *Cypria ophtalmica* (Jurine, 1820), *Cyclocypris laevis* (O. F. Muller, 1776), and *Cypridopsis vidua* (O. F. Muller, 1776) (Czapliński & Szelenbaum-Cielecka 1986).

Genus *Echinocotyle* Blanchard, 1891

Echinocotyle minutissima Singh, 1952

Specimens studied: from *Spatula querquedula*, Krapets Village (Dobrich Region); IBER–BAS C0044.1.3-1.4, 14.04.1985, 3 mature specimens without scoleces, stained whole-mounts (1 slide); one specimen mounted in Berlese's medium; IBER–BAS C0044.1.7–1.8, 14.04.1987, 34 mature specimens, stained and mounted in Canada balsam (2 slides), IBER–BAS C0044.1.13–1.14, 06.03.1994, six specimens (two of them with scoleces), stained whole-mounts (2 slides).

Redescription (Figs. 2–3; for measurements, see Table 2): Strobila short, gradually widening posteriorly, with maximum width at level of gravid proglottides (Fig. 2A). Scolex with well-developed conical rostrum and very long, protrusible rhynchus; maximum width at level of suckers (Figs. 2A, B). Suckers elliptical, with

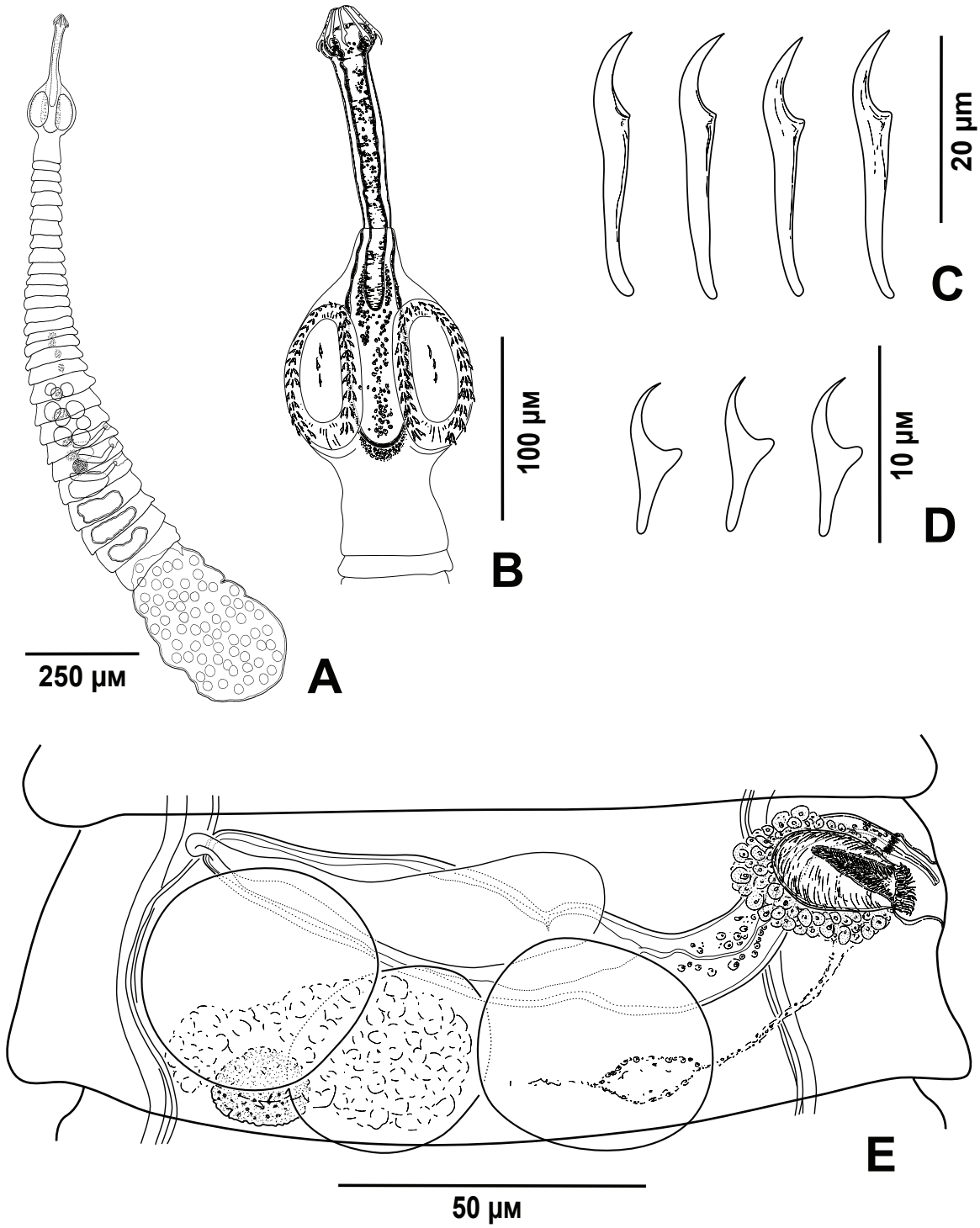

Fig. 2. *Echinocotyle minutissima* Singh, 1952, specimens from *Spatula querquedula* from Krapets, Bulgaria. A. General view of strobila. B. Scolex. C. Rostellar hooks. D. Hooklets of suckers. E. 'Male' mature proglottis.

weakly-developed musculature; lateral margins of suckers armed with numerous small, rosethorn-shaped hooklets, arranged in transverse rows of mainly 3, rarely 4 hooklets (Figs. 2B, D); often few hooklets (up to 4) forming irregular single row on bottom of suckers (Fig. 2B). Rhynchus very long, thin-walled, unarmed (Fig. 2B). Rostellum highly elongate, thin-walled, with muscular apical enlargement; intensely staining glandular cells present in its cavity (Fig. 2B). Rostellar sheath sac-like, with weakly-developed musculature of walls and staining glandular cells in its cavity; extending beyond posterior margins of suckers (Fig. 2B). Rostellum armed with single crown of ten hooks;

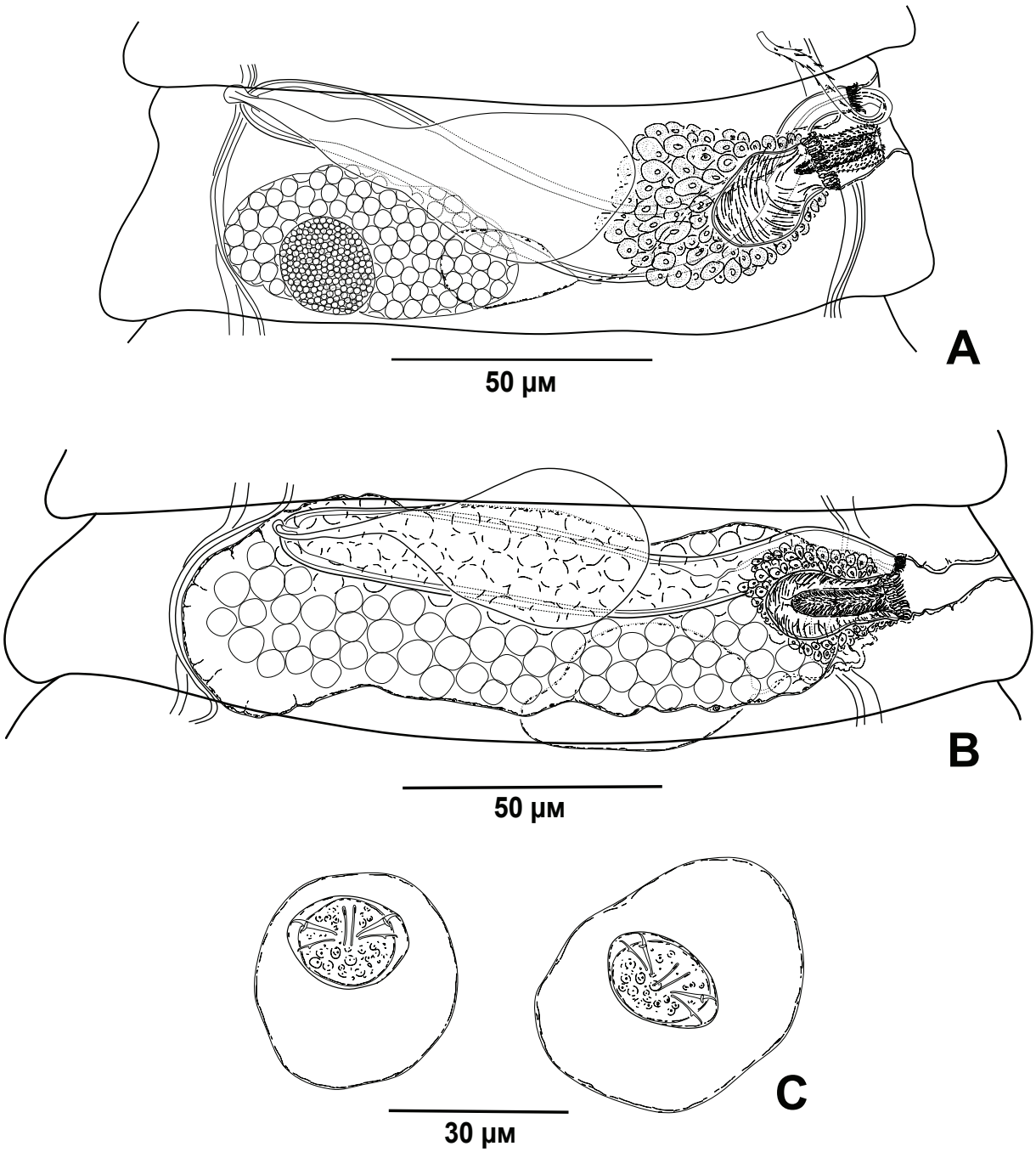

Fig. 3. *Echinocotyle minutissima* Singh, 1952, specimens from *Spatula querquedula* from Krapets, Bulgaria. A. Hermaphroditic mature proglottis. B. Pregravid proglottis. C. Eggs.

each hook with long, straight handle with slightly curved posterior end, well-developed sickle-like blade, much shorter than handle and rudimental guard (Fig. 2C); length of blade 8–9 (8, n = 20), distance between tip of guard and tip of handle 17–20 (19, n = 20). Neck well-differentiated from scolex; 30–53 (44, n = 3) long and 43–45 (44, n = 3) wide. Proglottides craspedote, less than 40 in number; immature and mature proglottides much wider than long; proglottides with developing uterus enlarged posteriorly, last gravid proglottides usually longer than wide (Fig. 2A). Genital pores unilateral, dextral, opening at anterior half of lateral proglottis margin. Genital atrium funnel-shaped, deep, thick-walled (Figs. 2E, 3A, B). Genital ducts dorsal to poral osmoregulatory canals. Osmoregulatory canals without transverse anastomoses; dorsal canals 2–3 (3, n = 10) wide; ventral canals 5–10 (7, n = 10) wide (Figs. 2E, 3A, B). Strobila with protandrous development.

Table 2. Metrical data for *Echinocotyle minutissima* Singh, 1952 from *Spatula querquedula.* Legend: * – measurements of accessory sac included both glandular and muscular parts.

Locality		**India**	**Ukraine**	**Krapets (Bulgaria)**		
Source		Singh (1952)	Kornyushin & Greben (2000)	Present study		
		Range	Range	Range	Mean	n
Strobila	Length (mm)	1–1.2	2.1–2.5	1–2	1.4	8
	Max. width (mm)	0.12–0.19	0.20	0.18 – 0.25	0.21	8
Proglottides	Number	15–20	–	23–33	28	8
Scolex	Length	194	225–240	163–245	198	5
	Max. width	103	110	83–108	97	5
Suckers	Length	86	85	75–85	79	20
	Width	30	40	28–45	36	20
Rostellum	Length	–	120–125	108–170	145	3
	Max. width	–	20	23–35	27	4
Rostellar sheath	Length	–	–	85–112	98	4
	Width	–	–	30–38	36	4
Rostellar hooks	Total length	24	27	25–29	27	20
Hooklets	Length	7–9	8	8–9	8	27
Testes	Diameter	18–25	10–18	30–43	36	20
External seminal vesicle	Length	–	–	40–50	48	10
	Width	37	–	23–35	31	10
Cirrus-sac	Length	110–120	126–130	106–135	120	20
	Width	16	17–21	13–18	14	20
Evaginated cirrus	Length	43–53	37–58	28–35	31	5
	Max. width	3	4	3	–	5
Accessory sac*	Length	34	33–38	30–40	37	12
	Width	19	18–20	25–38	33	12
Ovary	Max. width	53	60	50–90	67	20
Vitellarium	Diameter	25	21	20–38	28	10
Seminal receptacle	Length	–	–	30–47	35	10
	Width	40	–	17–30	24	10

Testes three, oval, compact; arranged in shallow triangle in median field, slightly disposed antiporally (Fig. 2E). External seminal vesicle elongate, voluminous, overlapping cirrus-sac dorsally (Figs. 2E, 3A, B). Cirrus-sac highly-elongate, cylindrical, thin-walled, slightly tapering porally; crossing midline of proglottis, often reaching antiporal osmoregulatory canals; poral end of cirrus-sac provided with basal crown of needle-shaped refractive spines (Figs. 2E, 3A, B). Internal seminal vesicle occupying almost 2/3 of cirrus-sac; intensely stained cells surrounding ejaculatory duct (Figs. 3A, B). Evaginated cirrus cylindrical, slender; basal part unarmed, middle and conically tapering distal part armed with small triangular spines (Fig. 3A). Accessory sac dorsal to cirrus-sac and vagina; consisting of bulb-shaped muscular part with cylindrically tapering poral end, provided with basal row of app. 30 hook-liked spines; cavity protrusible, armed with dense, needle-shaped spines (Figs. 2E, 3A, B); muscular part of accessory sac surrounded by thick sleeve of large, intensely stained glandular cells (Figs. 2E, 3A, B); measurements of muscular part 20–28 × 14–20 (24 × 17, n = 10).

Ovary elliptical, compact, disposed antiporally in median field of proglottis, ventral to testes (Fig. 3A). Vitellarium compact, oval, dorsal to ovary; disposed antiporally (Fig. 3A). Seminal receptacle sac-like, thin-walled, situated poral to ovary and ventral to cirrus-sac and uterus (Figs. 3A, B). Vagina hardly visible; tubular, thin walled, opening and passing ventral and posterior to male pore and accessory sac; copulatory part slightly enlarged, 15–20 (17, n = 6) long and 5–10 (8, n = 6) wide (Figs. 2E, 3A, B). Developing uterus sac-like, thin-walled, transversely elongated, ventral to accessory sac and male genital ducts; pregravid uterus occupying entire median field, not crossing

osmoregulatory canals (Fig. 3B); gravid uterus thin-walled, sac-like (Fig. 2A). Eggs oval, with thin outer envelope, measuring 32–40 × 24–35 (36 × 31, n = 10) (Fig. 3C). Embryophore lemon-shaped, 19–20 × 12–17 (19 × 15, n= 10). Oncosphere oval, thin-walled, 14–17 × 11–14 (15 × 13, n = 10); length of embryonic hooks 6–7 (7, n = 10).

Remarks: The species was described from *Querquedula circia* (L.) Elwes & Buckley (syn. of *Spatula querquedula*) in India (Singh 1952). According to the original description, the main diagnostic features of the species are the small size of the strobila, the rostellar hooks length of 24 μm, the cirrus-sac extending almost to the antiporal proglottis margin and the absence of hooklets in the middle of the suckers. The species has been recorded only once after the original description. Kornyushin & Greben (2000) redescribed *E. minutissima* from *S. querquedula* in Ukraine. Their redescription was in a good correspondence with the original data with one exception, i.e. the drawing of the scolex illustrated the presence of 1–2 hooklets on the bottom of the suckers (see fig. 2 of Kornyushin & Greben 2000). This observation corresponds with our results. The remaining morphological characters of the specimens from Bulgaria, including the metrical data (Table 2), are similar to the data of Singh (1952) and Kornyushin & Greben (2000) and confirm the identification of *E. minutissima*. The present study gives additional information on the morphology of the rostellar apparatus, the structure of the terminal genital ducts and the ripe eggs. The presence of a glandular sleeve surrounding the accessory sac as well as the specific basal armament of the accessory sac and the poral end of the cirrus-sac are described and illustrated for the first time here.

Echinocotyle minutissima is a species with Palaearctic-Oriental distribution. Until now, it has been recorded from India (Singh 1952), Ukraine (Kornyushin & Pronina 1983, Kornyushin & Greben 2000) and Bulgaria (present study; new geographical record). It appears to be an oioxenous species with a high-level of host specificity. Until now, it has been recorded from *Spatula querquedula* only.

Genus *Fimbriarioides* Fuhrmann, 1932

Fimbriarioides tadornae Maksimova, 1976

Specimens studied: from *Tadorna tadorna,* IBER–BAS C0041.2.2, 01.04.1986, Durankulak Village (Dobrich Region), a slide with 2 immature specimens (one with scolex), stained and mounted

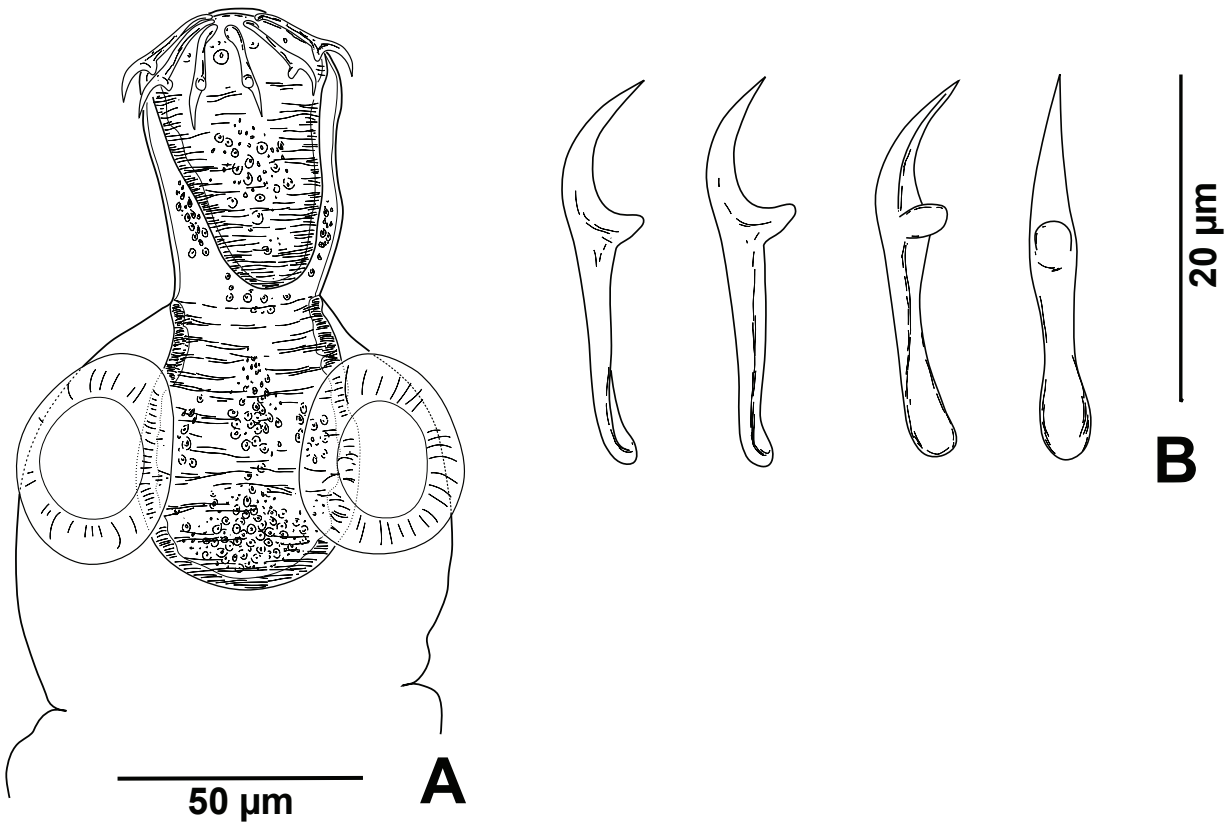

Fig. 4. *Fimbriarioides tadornae* Maksimova, 1976, specimens from *Tadorna tadorna* from Durankulak, Bulgaria. A. Scolex. B. Rostellar hooks.

Table 3. Metrical data for *Fimbriarioides tadornae* Maksimova, 1976 from *Tadorna tadorna.*

Locality		**Tengiz Lake (Kazakhstan)**	**Durankulak (Bulgaria)**		
Source		Maksimova (1976)	Present study		
		Range	Range	Mean	n
Strobila	Length (mm)	20	1.4–1.5	–	2
	Width (mm)	3.5	0.16–0.28	–	2
Scolex	Length	125	145	–	1
	Width	85	95	–	1
Suckers	Length	60	37–43	40	4
	Width	50	31–35	32	4
Pseudoscolex	Length (mm)	5.0	0.6–0.8	–	2
	Width (mm)	1.0	0.2	–	2
Rostellar sheath	Length	90	68	–	1
	Width	50	48	–	1
Rostellum	Length	80	55	–	1
	Width	50	36	–	1
Rostellar hooks	Length	28	23–24	24	3

in Canada balsam.

Redescription (Fig. 4; for measurements, see Table 3): Immature specimens with well-differentiated sickle-shaped pseudoscolex with distinct genital primordia. Strobila without external segmentation and distinct internal segmentation. Scolex oval, with short conical rostrum (Fig. 4A). Suckers oval, with weakly-developed musculature. Rhynchus thin-walled, with measurements 70 × 38 (n = 1). Rostellar sheath with thick walls, consisting of strong radial musculature; passing slightly beyond posterior margins of suckers; intensely staining cells present in its cavity. Rostellum thick-walled, muscular, with apical enlargement and intensely staining cells. Rostellar hooks 10, with almost diorchoid shape; each hook with long and straight handle with flattened, spatulate posterior end; blade sickle-shaped, much shorter than handle; guard short, thick (Fig. 4B). Measurements of hooks (not included in Table 3): length of blade 8 (n = 3), length of base 15 (n = 3), length of guard 2 (n = 3). Neck very thin and short. Strobila immature, with internal segmentation and visible primordia of male gonads.

Remarks: The original description of *Fimbriarioides tadornae* was based on both adult cestodes from *Tadorna tadorna* and cysticercoids developed experimentally in *Artemia salina* (L.) from Tengiz Lake, Kazakhstan (Maksimova 1976). The morphology of the scolex and the rostellar hooks of the specimens from Bulgaria correspond well to the metrical and morphological data of the original description, with a few exceptions (Table 3). The specimens from Bulgaria are very young and contracted, and this could explain the smaller size of the strobila and the smaller measurements of the pseudoscolex, rostellum and rostellar sheath. The rostellar hooks of the specimens from Bulgaria are also slightly smaller, i.e. 23–24 µm *vs* 28 µm in the adult specimens from Kazakhstan (as cited in the text of the original description). However, judging on the drawing presented on fig. 1b of Maksimova (1976), the length of the rostellar hook is 26 µm. The length of the rostellar hooks of the cysticercoids of *F. tadornae* from *Artemia parthenogenetica* Bowen & Sterling and *A. franciscana* Kellogg from Spain and France (Vasileva et al. 2009) varied between 24 and 27 µm. In addition, the shape of the rostellar hooks of both adults from Kazakhstan and Bulgaria, and the cysticercoids from *Artemia* spp. from Kazakhstan, Spain and France is the same. It is characterised by a spatulate end of the handle and a sickle-shaped blade. The small metrical differences are within the limits of intraspecific variation. On this basis, we identify our specimens as *F. tadornae*.

Fimbriarioides tadornae has Palaearctic distribution. Until now it has been recorded in Kazakhstan (Maksimova 1976), Ukraine [as *Fimbriarioides intermedia* (Fuhrmann, 1913), see Kornyushin (1969); re-identification proposed by Maksimova (1976)], Spain (Georgiev et al. 2007, Vasileva et al. 2009) and France (Vasileva et al. 2009). Three species of branchiopods were reported as intermediate hosts: *Artemia salina* from Lake Tengiz, Kazakhstan (Maksimova 1976), *A. parthenogenetica* from Odiel Saltpans and Bras del Port, Spain (Georgiev et al. 2007, Vasileva et al. 2009) and *A. franciscana* from the Ebro Delta in

Spain and from Aigues-Mortes in France (Vasileva et al. 2009).

Fimbriarioides tadornae is an oioxenic species with high host specificity. Up to now, the shelduck *Tadorna tadorna* has been reported as the only definitive host of this cestode species. The present observation is the first record of *F. tadornae* from Bulgaria.

Discussion

Our results present new data on the morphology as well as on the geographical and the host ranges of three hymenolepidid species from anatids. Until now, the cestode fauna of the Anseriformes in Bulgaria is represented by 53 species of the family Hymenolepididae (Marinova et al. 2013, 2015, Marinova 2017, Marinova & Vasileva 2021, present study). Most of the hymenolepidids of waterfowl are known as parasites with a wide host range (Spasskaya 1966, Schmidt 1986, Maksimova 1989). This was also confirmed by the studies on the hymenolepidids of the family Anatidae from Bulgaria. For example, 21 hymenolepidid species were recorded from *S. querquedula* in Bulgaria (Marinova 2013, present study). Most of them could be classified as euryxenous species. These are members of the genera *Cloacotaenia* Wolffhügel, 1938, *Microsomacanthus* Lopez-Neyra, 1942, *Retinometra* Spasskii, 1955, *Sobolevicanthus* Spasskii & Spasskaya, 1954 and *Diorchis*, which have been recorded in various host-species of waterfowl worldwide (Spasskii 1963, Spasskaya 1966, Maksimova 1989, Schmidt 1986). The only oioxenous species (specialised to infect a single host-species) is *E. minutissima*.

The shelducks of the genus *Tadorna* F. Boie have Palaearctic geographical distribution and are characterised by more specific hymenolepidid fauna. Kornyushin (1969) reported the presence of 14 hymenolepidid species in *T. tadorna* from the Ukrainian Black Sea coast and 9 of them could be classified as as euryxenous parasites. In comparison, the data about the hymenolepidids of the two species of shelducks in Bulgaria are scarce and we could expect that further studies may add more new geographical records of hymenolepidids in this group. In total, four species were recorded from *T. tadorna* in Bulgaria, including just one euryxenous species, *Diorchis elisae* (Skrjabin, 1914), two stenoxenous species, i.e. *Sobolevicanthus spasskii* Kornyushin, 1969 and *Monotestilepis tadornae* Gvozdev, Maksimova & Kornyushin, 1971, and only one oioxenous species, i.e. *Fimbriarioides tadornae*. The data about the hymenolepidid fauna of *Tadorna ferruginea* are even more incomplete, since the species has been considered "critically endangered" in Bulgarian Red Data Book (Golemanski et al. 2011). So far, only two hymenolepidid species have been recorded from *T. ferruginea* in Bulgaria, i.e. the euryxenous *Diorchis asiatica* and the oioxenous *Diorchis thracica* Marinova, Georgiev & Vasileva, 2015.

Spasskaya (1966) mentioned *T. ferruginea* as a host of 10 hymenolepidid species; almost all of them could be classified as euryxenous. However, several records of these species seem doubtful. E.g., these are records of *D. inflata* (Rudolphi, 1810) and *D. ransomi* Johri, 1939, which are typical parasites of Rallidae (Tolkacheva 1991) and their findings in shelducks need further confirmation.

Despite the more extensive faunistic and taxonomic studies on the waterfowl hymenolepidids in Bulgaria during the last ten years, this group of cestodes still needs further detailed revision based on both museum specimens and newly-collected samples. The clarification of previous records lacking morphological data is needed. In addition, these studies could be a valuable contribution to the taxonomy and the knowledge of the host specificity of the insufficiently studied species and genera of the family Hymenolepididae.

Acknowledgements: This study used facilities developed at the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, and the Thracian University of Stara Zagora in the frames of the projects CEBDER (National Science Fund of the Republic of Bulgaria, Grant DOO2-15/17.02.2009) and DiSSCo-BG (Upgrade of the Research Infrastructure 'Distributed System of Scientific Collections – Bulgaria', funded by the National Roadmap for Research Infrastructures of the Republic of Bulgaria). This investigation was completed with the financial support of the Bulgarian Ministry of Education and Science under the National Science Programme "Young Scientists and Postdoctoral Students" approved by DCM 577/17.08.2018 within the framework of the project.

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Received: 29.10.2021
Accepted: 03.04.2022