

New Data on the Morphology and the Host Range of Five Species of the Genus *Diorchis* Clerc, 1903 (Cestoda: Hymenolepididae) Recorded from Anseriform Birds in Bulgaria

Margarita H. Marinova^{1,2}

¹Faculty of Agriculture, Thracian University, Student Campus, 6000 Stara Zagora, Bulgaria; E-mail: mmarinova_@abv.bg

²Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin Street, 1113 Sofia, Bulgaria.

Abstract: As a result of examination of 12 individuals of seven species of waterfowl (Anseriformes, Anatidae) from Bulgaria, five species of the genus *Diorchis* Clerc, 1903 (Cyclophyllidea, Hymenolepididae) are recorded, i.e. *Diorchis elisae* (Skrjabin, 1914) from *Anser anser*; *Anas platyrhynchos* and *A. querquedula*; *D. longiovum* Schiller, 1953 and *D. spinata* Mayhew, 1929 from *Anas crecca*; *D. parvogenitalis* Mathevossian in Skrjabin and Mathevossian, 1945 from *Aythya ferina* and *A. nyroca*; *D. stefanskii* Czaplinski, 1956 from *Anas penelope*. The species are redescribed and figured on the basis of specimens from Bulgaria in order to complement knowledge of their morphology. The synonymies of *D. nyrocae* Yamaguti, 1935 with *D. elisae* and of *D. nyrocae* with *D. microcirrosa* Mayhew, 1929, as proposed by previous authors, are considered unjustified. The previous records and the host ranges of the species are analysed in the view of the present results. The main taxonomic characters at generic and species levels are discussed. Four new host records for Bulgaria are reported: *Anser anser* for *D. elisae*, *Anas crecca* for *D. spinata*, *Aythya ferina* and *A. nyroca* for *D. parvogenitalis*.

Key words: Cestoda, Hymenolepididae, *Diorchis*, Anseriformes, Anatidae, Bulgaria

Introduction

The cestode fauna of the waterfowl has been a subject of intensive studies during the last two centuries. Previous taxonomic and faunistic studies have revealed that cestodes from Anatidae are characterised by high host specificity, particularly cestodes of the family Hymenolepididae (SCHULTZ 1940; CZAPLIŃSKI 1956; SPASSKII 1963; SPASSKAYA 1966; MAKSIMOVA 1989; TOLKACHEVA 1991). The genus *Diorchis* Clerc, 1903 presently incorporates more than 70 species described from aquatic birds of the families Anatidae and Rallidae, occasionally Charadriiformes, from all over the world (for reviews, see SPASSKII 1963; SPASSKAYA 1966; SCHMIDT 1986; TOLKACHEVA 1991). Nine species of the genus *Diorchis* have been recorded in anseriform birds from various regions in Bulgaria (VASILEV 1962; KAMBUROV & VASILEV 1972; VASILEV 1973; KORNUSHIN *et al.* 1984; MARINOVA *et al.* 2013, 2015). Unfortunately, most of the records of *Diorchis* spp. from Bulgaria have not been accompanied by

any data on the morphology of the species, which makes their identification questionable in view of the present standards in cestode taxonomy.

During faunistic studies on cestodes from aquatic birds in Bulgaria, I identified five species of *Diorchis* in various Anatidae. The aim of this article is to present redescrptions of the species found and to summarise data on the species composition and the host range of cestodes of the genus *Diorchis* parasitising birds of the family Anatidae in Bulgaria.

Material and Methods

The present study was based on cestode specimens isolated from the small intestines of 12 anseriform birds belonging to three genera and seven species (the number of specimens is presented in the parentheses): *Anas querquedula* L. (1), *A. platyrhynchos* L. (1), *A. crecca* L. (3), *A. penelope* L. (1), *Anser anser* (L.) (1), *Aythya nyroca* (Güldenstädt) (2) and *Aythya*

ferina (L.) (3). The material included both specimens from the Helminthological Collection of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (IBER-BAS) (Coll. Nos. BBG) and newly collected specimens from Stara Zagora Region (Coll. Nos. MHM). The birds were collected from five localities during the last 50 years. 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. Some scoleces and whole specimens were mounted in Berlese's medium to facilitate observations of rostellar hooks and armament of suckers and the evaginated cirrus. Details about the studied specimens, their hosts, localities and collection numbers are given for each species.

The metrical data are given as the range, the mean in parentheses and the number of measurements taken (n). The measurements are given in micrometres unless otherwise stated. The following measurements of rostellar hooks were taken: total length of the hook, length of blade (measured from its base to the tip), length of base (the distance between the tip of the handle and the tip of the guard) and distance between the tip of the blade and the tip of the guard. 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 identification of birds was based on the books by NANKINOV *et al.* (1997) and MICHEV *et al.* (2012). The nomenclature of the birds follows HOWARD & MOORE (1980). The new hosts records of the *Diorchis* spp. found in Bulgaria are marked with an asterisk.

Results

Diorchis elisae (Skrjabin, 1914) Spasskii and Freze, 1961

Specimens studied: from **Anser anser*, BBG 6490, 25.10.1978, Burgas; one immature specimen, stained and mounted in Canada balsam (1 slide); from *Anas platyrhynchos*, BBG 15864, 26.01.1993, Krapets Village (Dobrich Region); a scolex mounted in Berlese's medium; from *Anas querquedula*, BBG 10103, 14.04.1985, Krapets Village (Dobrich Region); a gravid specimen, mounted on two slides; scolex mounted in Berlese's medium, strobila stained and mounted in Canada balsam.

Redescription (based on specimens of *A. querquedula*, Figs. 1D-H; for measurements see Table 1).

Strobila slender, gradually enlarging posteriorly, with maximum width at level of gravid proglottides. Scolex almost oval. Suckers round, armed; their edges densely covered with 4-5 rows of slightly bigger spines than these on bottoms of suckers. Morphology of rostellar sheath and rostellum not seen from single scolex mounted in Berlese's medium. Rostellar hooks diorchoid; each hook with short, triangular blade, distinct triangular guard, slightly shorter than blade; handle much longer than blade and guard, almost straight with slightly curved end (Fig. 1D); total length of hooks 24–25 (n = 2), length of blade 4 (n = 2), length of base 20–21 (n = 2), distance between blade-tip and guard-tip 4–5 (n = 2). Proglottides craspedote, wider than long at all stages of development (Figs. 1E–G). Genital pores unilateral, dextral, open at middle of lateral proglottis margin. Genital atrium cylindrical. Dorsal and ventral osmoregulatory canals without transverse anastomoses. Terminal genital ducts dorsal to poral osmoregulatory canals.

Strobila with protandrous development. Testes two, oval, compact, median (Fig. 1E). External seminal vesicle oval, connected with cirrus sac by distinct isthmus (Figs. 1E, F). Cirrus sac elongate, thin-walled, slightly tapering in its poral portion, usually crossing poral osmoregulatory canals dorsally, in 'male' mature proglottis often reaching midline of proglottis; in mature hermaphroditic and gravid proglottides, cirrus sac never reaching midline of proglottis (Figs. 1E-G). Internal seminal vesicle, large, elongate, filling up almost 2/3 of cirrus sac. Evaginated cirrus almost spindle-shaped, with short, cylindrical basal part, slightly widening at middle part; distal part conically tapering; basal part of cirrus densely armed with triangular spines, getting smaller in distal direction; distal third of fully-evaginated cirrus unarmed (Figs. 1E, H).

Ovary median, with three compact lobes (Fig. 1F). Vitellarium median, elliptical, dorsal and posterior to ovary (Fig. 1F). Seminal receptacle elongate, sac-like, thin-walled, ventral to cirrus sac and dorsal to ovary and vitellarium (Fig. 1F). Vagina with two distinct parts; copulatory part funnel-shaped, thick-walled, opening and passing ventrally to cirrus sac; conductive part long, thin-walled (Fig. 1H).

Uterus sac-like, thin-walled, extending beyond longitudinal osmoregulatory canals, passing dorsally to poral osmoregulatory canals and ventrally to antiporal canals (Fig. 1G). Eggs elongate, with thin, folded outer envelope; embryophore elongate, thick-walled, with well-developed lateral filaments; oncosphere elliptical or lemon-shaped, with elongate polar ends (Fig. 1I).

Observations on a specimen from *Anser anser* (Figs. 1A, B):

Scolex almost oval, 263 (n = 1) long, maximum width 248 (n = 1) at level of suckers (Fig. 1A). Suckers oval, with strong musculature, densely armed with spines, slightly larger at margins of suckers, bottoms covered with very fine spines; diameter of suckers 85-113 × 68-83 (n = 4). Rostellum retractile, 130 × 50 (n = 1), thick-walled, with anterior muscular enlargement; intensely staining glandular cells and longitudinal retractor muscles present in its cavity

(Fig. 1A). Rostellar sheath thick-walled, 170 × 88 (n = 1), passing beyond posterior margins of suckers; intensely staining glandular cells present within it. Rhynchus short, unarmed. Rostellum armed with single crown of ten hooks; each hook with very long handle and short blade and guard (Fig. 1B). Measurements of hooks: total length 24-25 (n = 3), length of blade 4 (n = 3), length of base 21 (n = 3), distance between blade-tip and guard-tip 4 (n = 3).

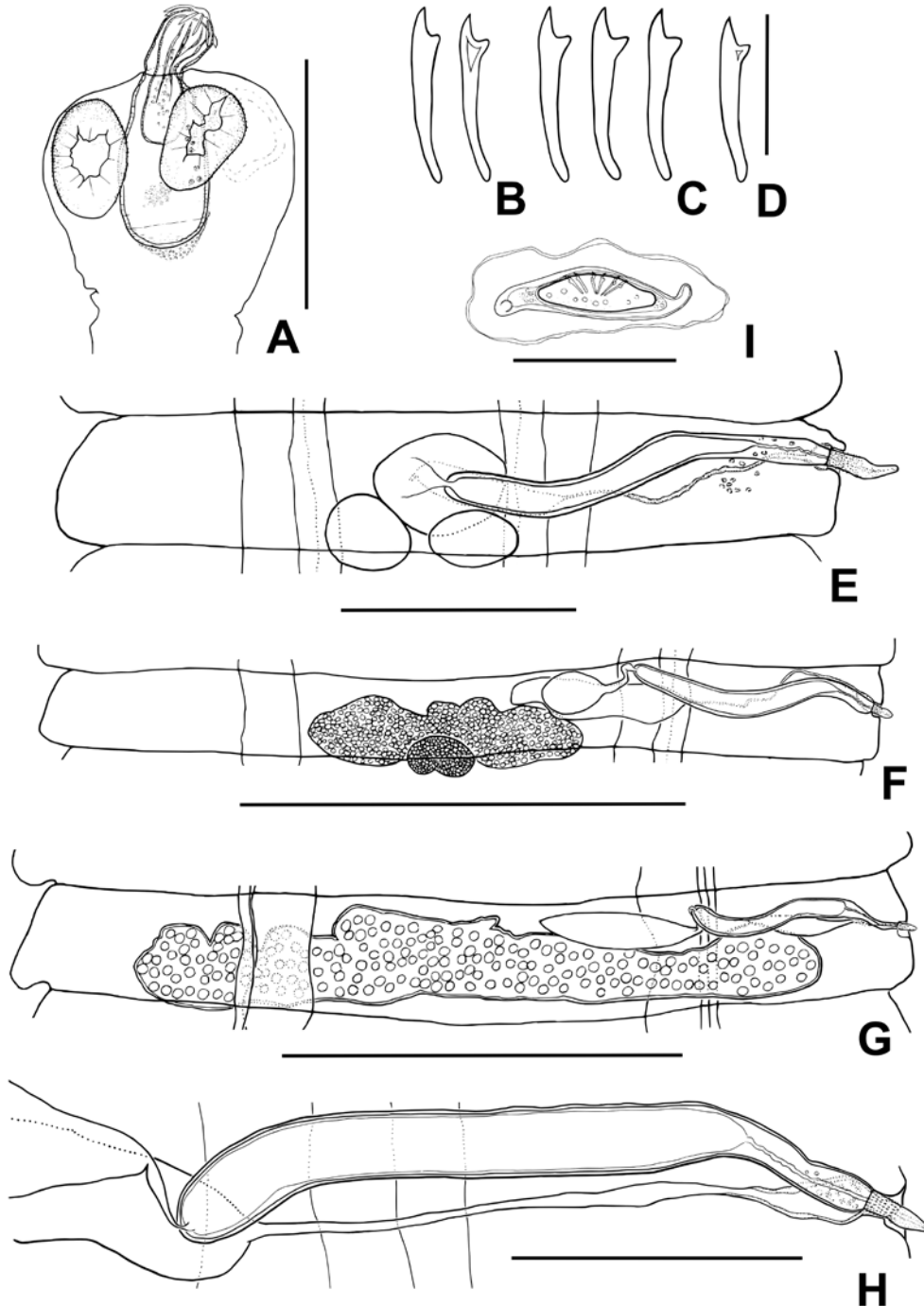


Fig. 1. *Diorchis elisae* (Skrjabin, 1914) Spassky & Freze, 1961, specimens from *Anser anser* (A, B), *Anas platyrhynchos* (C) and *A. querquedula* (D-H) from Bulgaria. A. Scolex. B-D. Rostellar hooks. E. 'Male' mature proglottis. F. Hermaphroditic proglottis. G. Pregravid proglottis. H. Genital ducts. I. Egg. Scale bars: A, 250 μm; B-D, 20 μm; E, 200 μm; F, G, 500 μm; H, 100 μm; I, 50 μm

Table 1. Metrical data for *Diorchis elisae* (Skrjabin, 1914) Spassky & Freze, 1961. Abbreviations: * – measurements of scolex mounted in Berlese's medium; ** – only metrical data from *Anas querquedula* were used

Host		<i>Anas querquedula</i>	<i>Anas querquedula</i>		<i>Anas querquedula</i>		
Locality		Kazakhstan	Russia		Krapets (Bulgaria)		
Source		MAKSIMOVA (1989)	TOLKACHEVA (1991)**		Present study		
		Range	Range	Mean	Range	Mean	n
Strobila:	Length (mm)	150-170	-	-	90	-	1
	Width (mm)	1.5-1.7	-	-	1.2	-	1
Scolex:	Length	175-320	150-300	218	390*	-	1
	Width	240-340	170-370	236	400*	-	1
Suckers:	Length	142	80-138	107	125-130*	126*	4
	Width	84	50-94	71	80-90*	86*	4
Rostellar hooks:	Length	24-27	25-28	26	24-25	-	2
Testes:	Diameter	68-90	38-110	73	40-55	48	12
External seminal vesicle:	Length	75-96	30-150	75	88-145	122	18
	Width	-	28-102	57	58-83	67	18
Cirrus sac:	Length	268-353	120-340	230	245-283	263	12
	Width	34-51	-	-	25	25	12
Evaginated cirrus:	Length	30-46	43-45	-	25-36	29	10
	Width	12	7-15	-	7-9	8	10
Ovary:	Max. width	235-270	50-560	246	215-340	279	20
Vitellarium:	Length	67-85	13-150	67	35-93	74	16
	Width	43-65	6-72	34	18-53	37	16
Seminal receptacle:	Length	-	72-234	143	108-230	178	14
	Width	-	38-90	61	25-63	43	14
Copulatory vagina:	Length	-	20-35	25	20	-	1
	Width	-	12-15	-	10	-	1
Eggs:	Length	40-45	68-78	-	55-70	64	3

Observations on a specimen from *A. platyrhynchos*:

The morphology of the rostellar hooks is presented in Fig. 1C. Measurements of hooks: total length 25-26 (n = 3), length of blade 4-5 (n = 3), length of base 20-21 (n = 3), distance between guard-tip and blade-tip 5 (n = 3).

Remarks

The species was described as *Aploparaksis elisae* from *Aythya nyroca* in Southern Kazakhstan (SKRJABIN 1914). Subsequently, SPASSKII & FREZE (1961) transferred it to the genus *Diorchis*. During the last century *D. elisae* became one of the most frequently reported species of *Diorchis* from anseriform birds in the Palaearctic (SPASSKII 1963; SPASSKAYA 1966; BRGLEZ 1981; MAKSIMOVA 1989; TOLKACHEVA 1991).

The shape and the measurements of the rostellar hooks of this species are reliable diagnostic characters and judging by them, the above-described specimens from *Anas querquedula*, *A. platyrhynchos* and *Anser anser* in Bulgaria belong to *D. elisae*. The strobilar morphology of Bulgarian specimens also corresponds well to the previous descriptions,

including in its metrical data (Table 1). The present results give new information about the topology of the female gonads, i.e. the dorsal position of the vitellarium in relation to the ovary, and the position of the uterus, which is passing ventrally to the antiporal osmoregulatory canals.

Several *Diorchis* spp. possessing similar rostellar hooks with length c. 25-27 µm have been considered as synonyms of *D. elisae*. One of them is *D. nyrocae* Yamaguti, 1935, which has been described from *Aythya marila* (L.) in Japan (YAMAGUTI 1935). Initially, SPASSKII & FREZE (1961) and SPASSKII (1963) mentioned the similarity between *D. elisae* and *D. nyrocae* but did not propose their synonymy due to the lack of sufficiently detailed description of *D. nyrocae*. SPASSKAYA (1966) proposed the synonymy of these two species. In contrast, BAER (1962) and McLAUGHLIN, BURT (1979) considered *D. nyrocae* as a synonym of *D. microcirrosa* Mayhew, 1929 from *Anas discors* L. in North Dakota, USA. Until now, there are no redescrptions of the type specimens of neither *D. nyrocae* or *D. microcirrosa*. Moreover, YAMAGUTI (1940) complemented the description of *D. nyrocae* with additional data based on specimens from *Tadorna tadorna* in Japan, adding details on the

genital system and ripe eggs. According to YAMAGUTI (1940), the eggs of these specimens have oval shape, with measurements $30\text{-}45 \times 23\text{-}35 \mu\text{m}$ and have no any polar filaments. For example, the eggs of *D. elisae* are $55\text{-}70 \mu\text{m}$ long, with long polar filaments. In addition, *D. nyrocae* possesses smaller testes, ovary and vitellarium as compared to the size of gonads in *D. elisae* (see YAMAGUTI 1940, Table 1). Another similar species, *D. microcirrosa* characterised by larger hooks than these of *D. elisae* ($29\text{-}32 \mu\text{m}$ vs $24\text{-}28 \mu\text{m}$, respectively: see MAYHEW 1929) and much smaller evaginated cirrus, $12\text{-}15 \mu\text{m}$ long versus $25\text{-}36 \mu\text{m}$ in *D. elisae*. On this basis, I consider the synonymy of *D. nyrocae* with *D. elisae* proposed by SPASSKAYA (1966) as well as the synonymy of *D. nyrocae* and *D. microcirrosa* proposed by BAER (1962) and McLAUGHLIN & BURT (1979) as unjustified, pending further re-examination of the type-specimens of *D. nyrocae* and *D. microcirrosa*.

Diorchis elisae was previously recorded in Bulgaria from *Anas querquedula* and *Anas platyrhynchos* (KAMBUROV & VASILEV 1972), *Anas platyrhynchos* f. dom. (VASILEV 1973) and *Tadorna tadorna* (KORNYUSHIN *et al.* 1984). *Anser anser* is a new host record of this cestode species in Bulgaria.

***Diorchis longiovum* Schiller, 1953**

Specimens studied: from *Anas crecca*, BBG 6493, 25.10.1978, 6519, 26.10.1978, Dolno Ezerovo Village (Burgas Region); two mature specimens and about eight fragments of strobila in various stage of development, stained whole-mounts (2 slides).

Redescription (Fig. 2; for measurements see Table 2):

Strobila long, maximum width at level of pregravid proglottides. Scolex with conically protruded rostrum and maximum width at level of posterior margins of suckers (Fig. 2A). Suckers muscular, with small dense spines, slightly larger at margins. Rostellar sheath thick-walled, extending beyond posterior margins of suckers; intensely staining glandular cells present at bottom of its cavity; measurements 230×85 ($n = 1$). Rostellum retractile, elongate, with apical muscular pad and intensely stained glandular cells in its cavity. Rostellum armed with single crown of ten diorchoid hooks; each hook with well-developed sickle-shaped blade, distinct, short guard and straight handle with slightly curved end, much longer than blade (Fig. 2B). Scolex gradually tapering and passing into long neck. Proglottides craspedote, wider than long at all stages of development (Figs. 2C-E). Genital pores unilateral, dextral, open at middle of lateral proglottis margin. Genital atrium deep, funnel-shaped, thick-walled, surrounded by intensely-staining cells (Fig. 2F). Dorsal and ventral osmoregulatory canals

without transverse anastomoses; diameter of dorsal canals $8\text{-}13$ (11 , $n = 14$); diameter of ventral canals $50\text{-}80$ (65 , $n = 6$). Terminal genital ducts passing dorsally to poral osmoregulatory canals (Figs. 2C-F).

Strobilar development protandrous. Testes two, oval, compact, median (Fig. 2C). External seminal vesicle oval, dorsal to antiporal end of cirrus sac, connected with it by short isthmus; measurements $113\text{-}155 \times 88\text{-}100$ (132×99 , $n = 16$; Figs. 2C-E). Cirrus sac elongate, cigarette-shaped, thin-walled, usually crossing midline of proglottis; in 'male' mature proglottis almost reaching antiporal osmoregulatory canals (Figs. 2C-E). Internal seminal vesicle large, elongate, fills up almost entire cirrus sac. Evaginated cirrus cylindrical, gradually tapering distally; basal part armed with fine, needle-shaped spines, sparsely arranged in longitudinal rows; middle and distal third of fully-evaginated cirrus pipette-like, unarmed (Fig. 2F).

Ovary median, with three compact, rounded lobes, with maximum width $400\text{-}450$ (434 , $n = 16$; Fig. 2D). Vitellarium elliptical, median, posterior and dorsal to ovary; $100\text{-}138 \times 60\text{-}120$ (111×75 , $n = 12$; Fig. 2D). Seminal receptacle sac-like, thin-walled, ventral to cirrus sac and dorsal to ovary and vitellarium; $170\text{-}263 \times 63\text{-}100$ (227×75 , $n = 12$; Figs. 2C-E). Vagina with two well-distinguished parts, opening and passing ventrally and posteriorly to cirrus sac (Fig. 2F). Copulatory part spindle-shaped, thick-walled, with radial musculature surrounding vaginal orifice and a thin sleeve of intensely stained cells; length $35\text{-}63$ (54 , $n = 12$), maximum width $9\text{-}15$ (12 , $n = 12$). Conductive part tubular, thin-walled, with a few transverse constrictions. Uterus sac-like, thin-walled, extending beyond longitudinal osmoregulatory canals, passing dorsally to poral osmoregulatory canals and ventrally to antiporal canals (Fig. 2E). Fully developed uterus and eggs not available in the studied material.

Remarks

This species was described from *Anas crecca* from Alaska, USA (SCHILLER 1953). The morphology of the specimens from Bulgaria corresponds well to the previous descriptions (SCHILLER 1953; CZAPLIŃSKI 1988), including the metrical data (Table 2). The present study gives new metrical data on the rostellar sheath, external seminal vesicle, seminal receptacle, female gonads and copulatory vagina. *Diorchis longiovum* has been recorded from the same host species in Bulgaria but without any morphological information (KORNYUSHIN *et al.* 1984).

***Diorchis parvogenitalis* Mathevossian in Skrjabin et Mathevossian, 1945**

Specimens studied: from **Aythya ferina*,

MHM 592, 07.10.1962, Elchovo (Yambol Region), 30 mature specimens, stained whole-mounts (13 slides) and three scoleces in Berlese's medium; BBG 15844, 15859, 01.1993, Krapets Village (Dobrich Region), 14 mature specimens, stained whole-mounts (16 slides); two scoleces mounted in Berlese's medium; from **A. nyroca*, BBG 14543, 14544, 04.06.1990, Krapets Village, 12 mature

specimens and two fragments of strobila, stained whole-mounts (6 slides), three scoleces mounted in Berlese's medium.

Redescription (based on specimens from *A. ferina* from Elchovo; Figs 3A, B, E, F, H; for measurements, see Table 3):

Strobila long, slender, gradually enlarging posteriorly. Scolex with short conically protruded

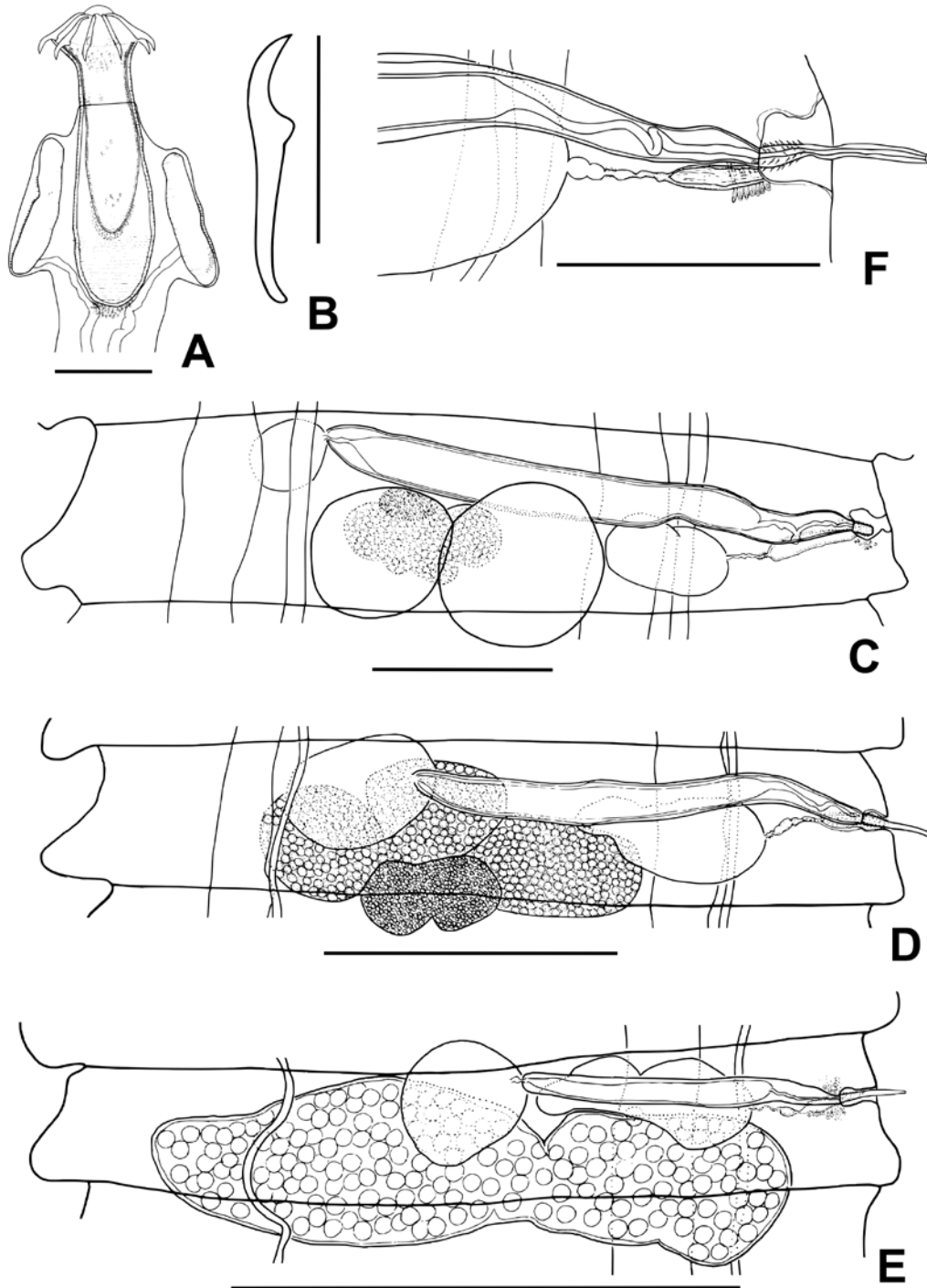


Fig. 2. *Diorchis longiovum* Schiller, 1953, specimens from *Anas crecca* from Dolno Ezerovo. A. Scolex. B. Rostellar hooks. C. 'Male' mature proglottis. D. Hermaphroditic proglottis. E. Pregravid proglottis. F. Genital ducts with evaginated cirrus. Scale bars: A, C, F, 100 µm; B, 50 µm; D, 250 µm; E, 500 µm

Table 2. Metrical data for *Diorchis longiovum* Schiller, 1953 from *Anas crecca*

Locality	Source	Alaska (USA)	Alaska (USA)	Dolno Ezerovo (Bulgaria)		
		SCHILLER (1953)	CZAPLIŃSKI (1988)	Present study		
		Range	Range	Range	Mean	n
Strobila:	Length (mm)	85-100	85	25-52	-	2
	Width (mm)	1.2	1.1	0.86-0.92	-	2
Scolex:	Length	308	224	315	-	1
	Width	224	206	218	-	1
Suckers:	Length	135	138-140	150-153	150	3
	Width	90	93-102	95	-	1
Rostellum:	Length	279	200	223	-	1
	Width	72	72	65	-	1
Rostellar hooks:	Length	57	58	62	-	2
Testes:	Length	126	100-132	80-128	103	18
	Width	-	-	75-113	92	18
Cirrus sac:	Length	530	350-450	340-425	394	16
	Width	39	30-45	35-48	39	16
Evaginated cirrus:	Length	-	110-132	61-75	68	10
	Width	-	7-8	6-8	7	10

rostrum; maximum width at level of posterior margins of suckers (Fig. 3A). Suckers oval, with strong musculature, armed with small spines, slightly larger on margins of suckers. Rostellum elongate, thick-walled, with well developed apical muscular pad. Rostellar sheath thick-walled, passing beyond posterior margins of suckers; 210-435 × 85-200 (315 × 131, n = 3). Rhynchus well developed, unarmed. Rostellum armed with single crown of ten diorchoid hooks (Fig. 3B); each hook with well-developed blade, distinct, short guard and straight handle with slightly curved end, much longer than blade; length of blade 11-12 (12, n = 8), length of base 25-27 (26, n = 8), distance between blade tip and guard tip 11-12 (12, n = 8). Neck long. Proglottides craspedote, much wider than long at all stages of development (Figs. 3E, F). Genital pores unilateral, dextral, median. Genital atrium thin-walled, cylindrical or funnel-shaped (Fig. 3H). Dorsal and ventral osmoregulatory canals without transverse anastomoses; diameter of ventral osmoregulatory canals 48-63 (52, n = 12), dorsal 13-15 (14, n = 12). Terminal genital ducts passing dorsally to poral osmoregulatory canals (Figs. 3E, F, H).

Strobilar development protandrous. Testes oval, compact, median (Fig. 3E). External seminal vesicle oval or elliptical, connected with cirrus sac by short isthmus (Fig. 3F). Cirrus sac elongate, cigarette-shaped, thin-walled, usually crossing poral osmoregulatory canals dorsally, never reaching midline of proglottis (Figs. 3E, F, H). Internal seminal vesicle elongate, fills up to 2/3 of cirrus sac. Evaginated cirrus short, conically tapering distally; basal part armed with fine spines, distal end of fully evaginated cirrus unarmed (Fig. 3H).

Ovary with three compact, oval lobes, median (Fig. 3F). Vitellarium oval, submedian, dorsal to

ovary (Fig. 3F). Seminal receptacle elongate, sac-like, thin-walled, ventral to cirrus sac and external seminal vesicle; 175-245 × 25-34 (218 × 29, n = 6) (Figs. 3E, F, H). Copulatory part of vagina with firm walls and characteristic shape; orifice funnel-shaped passing into firm, bulb-like enlargement (Fig. 3H). Conductive part of vagina tubular, thin-walled, convoluted; vagina opening and passing ventral to cirrus sac. Proglottides with developing uterus not available in specimens studied.

Observations on specimens from *A. ferina* from Krapets Village (Figs. 3C, G):

Total length of rostellar hooks (Fig. 3C) 36-38 (37, n = 3), length of blade 11-12 (11, n = 3), length of base 25-26 (26, n = 3), distance between blade-tip and guard-tip 11 (n = 3). Diameter of osmoregulatory canals: ventral 43-98 (69, n = 10), dorsal 18-23 (20, n = 10). Developing uterus sac-like, thin-walled, extending beyond longitudinal osmoregulatory canals, passing dorsally to poral osmoregulatory canals and ventrally to antiporal canals (Fig. 3G). Proglottides with fully-developed uterus and ripe eggs not available in the studied material.

Observation on specimens from *A. nyroca* from Krapets Village (Fig. 3D):

Total length of rostellar hooks 36 (n = 2), length of blade 10-11 (n = 2), length of base 26 (n = 2), distance between blade-tip and guard-tip 11 (n = 3). Diameter of osmoregulatory canals: ventral 25-35 (27, n = 12), dorsal 8-10 (9, n = 12).

Remarks

The species has been described from *Aythya ferina* (type-host), *A. fuligula* and *Anas crecca* from

Table 3. Metrical data for *D. parvogenitalis* Mathevossian in Skrjabin & Mathevossian, 1945

Host		<i>Aythya ferina</i> , <i>A. fuligula</i> , <i>Anas crecca</i>	<i>Aythya ferina</i> , <i>A. fuligula</i> , <i>A. nyroca</i>	<i>Aythya ferina</i>		
Locality		Azerbaijan, Russia	Poland	Elchovo (Bulgaria)		
Source		SKRJABIN & MATHEVOSSIAN (1945)	CZAPLIŃSKI & SZELENBAUM (1974)	Present study		
		Range	Range	Range	Mean	n
Strobila:	Length (mm)	130-230	120-476	25-40	33.3	3
	Width (mm)	1-1.5	0.8-1.68	0.4-0.5	0.43	3
Scolex:	Length	220-400	-	250-430	311	14
	Width	160-330	-	230-335	285	14
Suckers:	Length	110-170	-	138-163	154	5
	Width	67	-	98-120	113	3
Rostellum:	Length	-	-	140	-	1
	Width	36-67	-	65	-	1
Rostellar hooks:	Length	38-40	33-40	36-38	37	8
Testes:	Length	27-31	20-36	38-45	41	9
	Width	-	16-30	33-40	36	9
External seminal vesicle:	Length	112	-	95-125	111	17
	Width	49	-	38-48	42	17
Cirrus sac:	Length	150	170-230	223-245	236	10
	Width	-	-	23-25	24	10
Evaginated cirrus:	Length	-	-	12-16	14	12
	Max. width	-	4-5	5	5	12
Ovary:	Max. width	58-67	-	115-143	127	9
Vitellarium:	Length	45	-	30-50	39	7
	Width	-	-	28-40	33	7
Copulatory vagina:	Length	-	16-20	8-9	8	10
	Width	-	5-7	5-5	5	10

Azerbaijan (type locality) and Omsk Region, West Siberia, Russia (SKRJABIN & MATHEVOSSIAN 1945). Due to the similarity of the shape and the size of the rostellar hooks of *D. ransomi* Johri, 1939 and *D. parvogenitalis*, the validity of the latter species has been considered weakly supported (SPASSKII & BOBOVA 1962; SPASSKII 1963; SPASSKAYA 1966). CZAPLIŃSKI & SZELENBAUM (1974) proposed a detailed morphological comparison of *D. ransomi* and *D. parvogenitalis* and rejected their synonymy. The validity of *D. parvogenitalis* has been additionally confirmed by TOLKACHEVA (1991) who reexamined the holotype from *A. ferina* in Azerbaijan.

Up to now, *D. parvogenitalis* has been recorded from *Anas querquedula* in Bulgaria (KORNYUSHIN *et al.* 1984). The present study adds two new host records: *Aythya ferina* and *A. nyroca*. The analysis of the host range of *D. parvogenitalis* revealed that *D. parvogenitalis* is a typical parasite of Aythyinae and Anatinae (CZAPLIŃSKI & SZELENBAUM 1974; TOLKACHEVA 1991).

Diorchis spinata Mayhew, 1929

Specimens studied: from **Anas crecca*, BBG 6522, 26.10.1978, Burgas, one 'male' mature specimen, stained whole-mount (1 slide).

Redescription (Fig. 4A-D, for measurements, see Table 4):

Strobila slender, enlarging posteriorly, maximum width at level of last 'male' mature proglottides. Scolex with conically protruded rostrum and maximum width at level of posterior margins of suckers (Fig. 4A). Suckers oval, muscular, armed with fine spines, slightly larger at margins. Rostellum elongate, thin-walled, with well-expressed apical enlargement. Rhynchus long, unarmed. Rostellar sheath thick-walled, with intensely staining glandular cells in its cavity. Rostellum armed with single crown of ten diorchoid hooks; each hook with sickle-shaped blade, short guard and straight handle, much longer than blade (Fig. 4B); total length of hooks 58 (n = 2), length of blade 20-21 (n = 2), length of base 36-39 (n = 2), distance between blade-tip and guard-tip 20-22 (n = 2). Scolex gradually tapering and passing into long neck. Proglottides craspedote, wider than long. Genital pores unilateral, dextral, submedian. Genital atrium funnel-shaped, thick-walled, surrounded by intensely stained cells (Fig. 4D). Dorsal and ventral osmoregulatory canals without transverse anastomoses; diameter of dorsal canals 4-7 (5, n = 18), diameter of ventral canals 19-32 (24, n = 16).

Table 4. Metrical data for *Diorchis spinata* Mayhew, 1929. Abbreviations: * – single not fully matured specimen available from Bulgaria

Host		<i>Anas strepera</i>	<i>Anas strepera</i>	<i>Anas crecca</i>		
Locality		Poland	USA	Burgas (Bulgaria)		
Source		CZAPLIŃSKI (1956)	GREBEN (2007)	Present study		
		Range	Range	Range	Mean	n
Strobila:	Length (mm)	82-85	62.4	10 *	-	1
	Width (mm)	1.2-1.6	1.2	0.4 *	-	1
Scolex:	Length	170-190	290-380	315	-	1
	Width	250-280	365-400	218	-	1
Suckers:	Length	125-140	182-225	128-128	128	3
	Width	80-90	80-145	63-83	70	3
Rostellum:	Length	-	120	195	-	1
	Width	-	85-90	78	-	1
Rostellar sheath:	Length	-	280	175	-	1
	Width	-	220	73	-	1
Rostellar hooks:	Length	48-53	55-60	58	-	2
Testes:	Length	90-120	75-110	88-140	102	12
	Width	-	60-80	60-80	71	12
Cirrus sac	Length	-	520-620	162-200	176	4
	Width	-	40-52	23-28	26	4
External seminal vesicle:	Length	-	70-95	40-52	49	8
	Width	-	45-55	35-50	39	8
Evaginated cirrus:	Length	200	188-235	10	-	1
	Max. width	18-22	25-27	9	-	1
Seminal receptacle:	Length	-	55-110	52-38	69	3
	Width	-	45-75	32-38	34	3
Copulatory vagina:	Length	-	125-165	23-50	33	13
	Width	-	38-55	9-13	12	13

Terminal genital ducts passing dorsally to poral osmoregulatory canals (Fig. 4D).

Strobila with protandrous development. Testes two, oval, compact, large, situated in median field of proglottis, slightly overlapping osmoregulatory canals (Fig. 4C). External seminal vesicle oval, connecting with cirrus sac by very short isthmus (Fig. 4C). Cirrus sac highly elongate, cigarette-shaped, thin-walled; in 'male' mature proglottides, cirrus sac crossing midline of proglottis, passing dorsally of poral osmoregulatory canals, sometimes reaching antiporal osmoregulatory canals passing ventrally to them (Fig. 4D). Internal seminal vesicle elongate, fills up more than 2/3 of cirrus sac. Partly evaginated cirrus short, conical, covered with scarce coarse spines (Fig. 4D); fully evaginated cirri not available in the studied material.

Hermaphroditic mature proglottides not available. Seminal receptacle sac-like, voluminous, thin-walled, ventral to cirrus sac (Fig. 4D). Vagina with two well-distinguished parts, opening and passing ventrally and posteriorly to cirrus sac (Fig. 4D). Copulatory vagina with funnel-shaped orifice, enlarging into voluminous, thick-walled refractive part. Conductive vagina tubular, thin-walled, sometimes forming small enlargement at its middle

part (Fig. 4D). Uterine proglottides not available in the studied specimen.

Remarks

Diorchis spinata was described from *Anas strepera* in USA (MAYHEW 1929) and subsequently recorded from various hosts of the Anatidae in the Palaearctic (CZAPLIŃSKI 1956; SPASSKII 1963; SPASSKAYA 1966; TOLKACHEVA 1991). A similar species, *D. tshanensis* Krotov, 1949 was described from *Anas strepera* in Western Siberia (KROTOV 1949). TOLKACHEVA (1991) re-examined the syntypes of this species and considered *D. tshanensis* as a junior synonym of *D. spinata*. GREBEN (2007) proposed a re-validation of *D. tshanensis* and differentiated it from *D. spinata* by the slightly different shape of the evaginated cirrus and the shape and length of the copulatory vagina. GREBEN (2007) considered all records of *D. spinata* from anatids from Eurasia as belonging to *D. tshanensis*, including those which did not provide any morphological data. In my opinion, the proposed characters could not be considered as reliable distinguishing criteria between these two species. A new re-examination of the type-specimens could solve the questioned validity of *D. tshanensis*. Therefore, in the present study, I follow

the synonymy proposed by TOLKACHEVA (1991).

Despite that the only specimen from Bulgaria is not fully mature, it possesses the main diagnostic characters of *D. spinata*, i.e. the peculiar shape and length of the rostellar hooks, the presence of a highly elongated cirrus sac, the refractive copulatory vagina (CZAPLIŃSKI 1956; GREBEN 2007). Until now, *D. spinata* has been recorded in Bulgaria from *Anas platyrhynchos f. dom.* only (VASILEV 1973). The

present results add *Anas crecca* as a new host record in this country.

***Diorchis stefanskii* Czaplinski, 1956**

Specimens studied: From *Anas penelope*, MHM 1, 26.10.2007, Zagore Village (Stara Zagora Region); three immature specimens and a fragment of strobila, stained whole-mounts (2 slides).

Redescription (Figs. 4E-G):

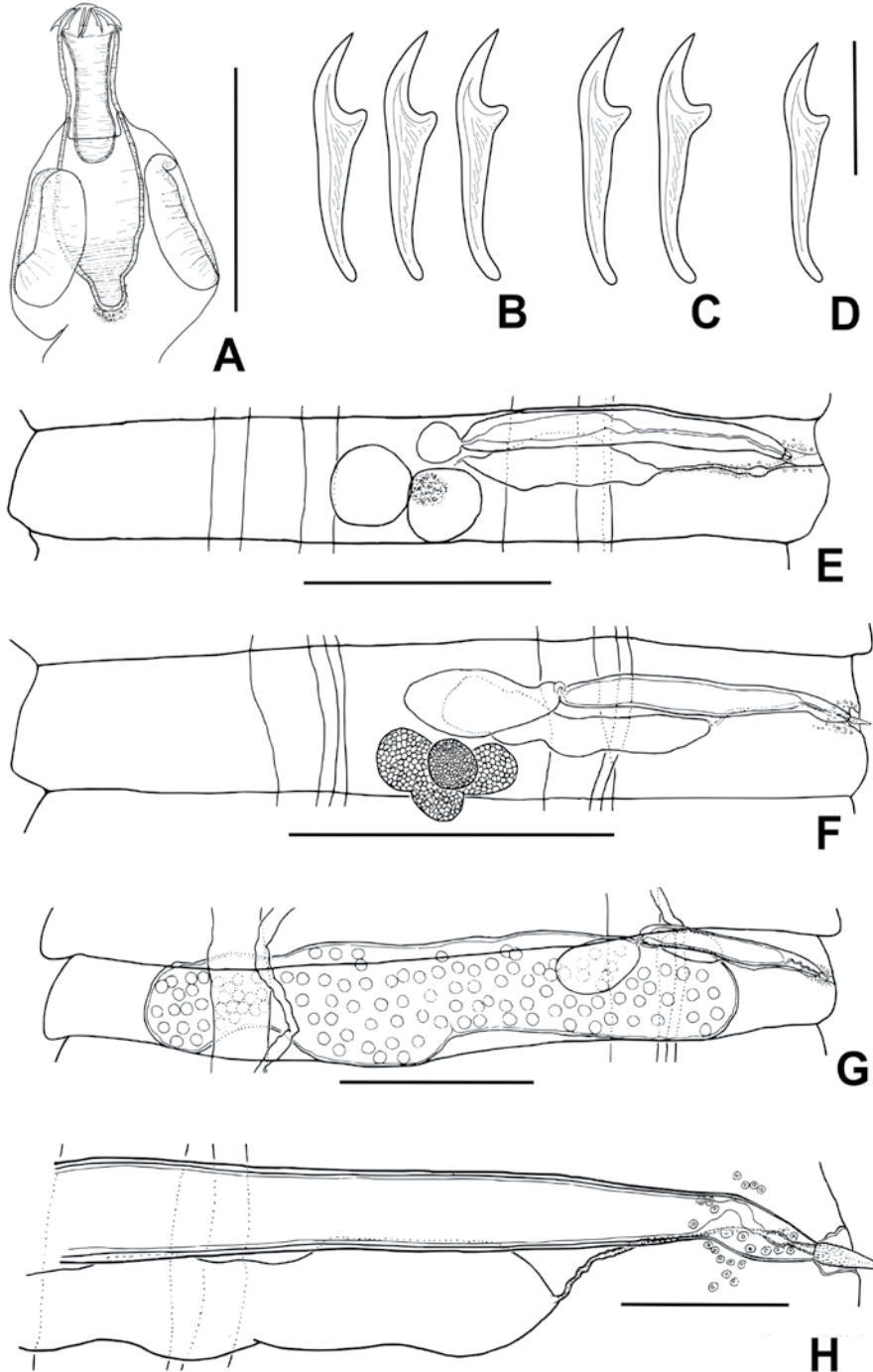


Fig. 3. *Diorchis parvogenitalis* Mathevossian in Skrjabin & Mathevossian, 1945, specimens from *Aythya ferina* from Elchovo (A, B, E, F, H), and *A. ferina* (C, G) and *A. nyroca* (D) from Krapets. A. Scolex. B-D. Rostellar hooks. E. ‘Male’ mature proglottis. F. Hermaphroditic proglottis. G. Pregravid proglottis. H. Genital ducts. Scale bars: A, F, G, 250 µm; B-D, 20 µm; E, 100 µm; H, 50 µm

Strobila slender. Scolex with well-developed conically protruded anterior part, with maximum width at level of posterior margins of suckers (Fig. 4E). Suckers oval, with strong musculature, densely covered with small spines. Rostellum elongate, with thick muscular walls and well-developed apical muscular enlargement. Rostellar sheath thick-walled, passing beyond posterior margins of suckers; intensely staining glandular masses presented in its cavity. Rhynchus unarmed. Rostellum armed with

single crown of ten diorchoid hooks; each hook with long blade, distinct guard much shorter than blade and long, straight handle with slightly curved posterior end (Fig. 4F). Measurements of hooks: length of blade 23-24 (24, n = 4), length of base 42-47 (45, n = 4), distance between blade-tip and guard-tip 21-26 (24, n = 4). Neck very short, minimal width 153- 225 (n = 2). Proglottides craspedote, wider than long. Genital pores unilateral, dextral, submedian. Genital atrium cylindrical, surrounded

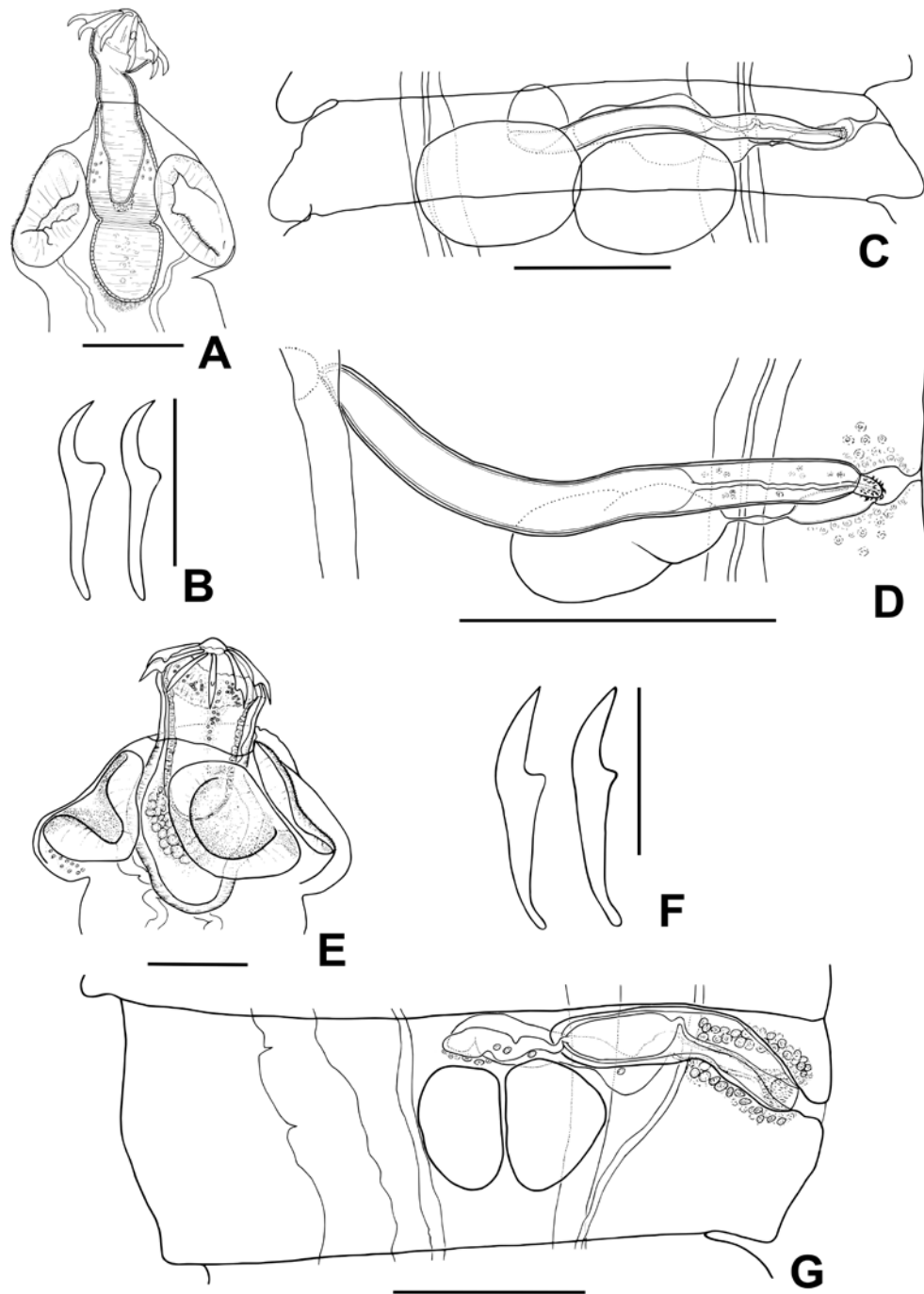


Fig. 4. *Diorchis spinata* Mayhew, 1929, specimens from *Anas crecca* from Burgas (A-D) and *Diorchis stefanskii* Czaplinski, 1956 from *Anas penelope* from Zagore (E-G). A, E. Scolex. B, F. Rostellar hooks. C, G. 'Male' mature proglottis. D. Genital ducts. Scale bars: A, C-E, G, 100 µm; B, F, 50 µm

Table 5. Metrical data for *Diorchis stefanskii* Czaplinski, 1956. Abbreviations: * – list of host-species not mentioned; ** – a single whole immature specimen available from Bulgaria

Host		<i>Anas platyrhynchos</i> , <i>A. strepera</i> , <i>Anser anser</i> , <i>Nyroca rufa</i>	Anatidae *		Anas penelope		
Locality		Poland	Russia		Zagore (Bulgaria)		
Source		CZAPLIŃSKI (1956)	TOLKACHEVA (1991)		Present study		
		Range	Range	Mean	Range	Mean	n
Strobila:	Length (mm)	188-279	147-149	-	18 **	-	1
	Width (mm)	1.35-1.71	0.77-2.20	1.08	1.45 **	-	1
Scolex:	Length	280-358	230-420	310	180-285	228	3
	Width	260-380	220-410	290	252-319	276	3
Suckers:	Length	160-179	130-210	170	141-170	156	7
	Width	115-130	50-140	100	54-98	77	7
Rostellum:	Length	-	110-250	140	154-164	161	2
	Width	126	90-120	108	72-121	97	2
Rostellar sheath:	Length	-	200-400	280	180-213	197	2
	Width	-	70-170	120	136-146	141	2
Rostellar hooks:	Length	66.4-74.1 (70)	65-78	73	71-73	72	4
Testes:	Length	38-60	24-102	64	28-46	36	11
	Width	-	30-72	53	18-28	25	11
Dorsal OC:	Diameter	8-13	3-18	-	10-15	11	6
Ventral OC:	Diameter	60-80	18-96	-	18-62	39	11

by intensely staining cells (Fig. 4G). Dorsal and ventral osmoregulatory canals without transverse anastomoses. Terminal genital ducts passing dorsally to poral osmoregulatory canals (Fig. 4G).

Strobilar development protandrous. Testes two, compact, median (Fig. 4G). External seminal vesicle elliptical, connecting with cirrus sac by distinct isthmus (Fig. 4G). Cirrus sac thick-walled; in 'male' mature proglottides cirrus sac crossing poral osmoregulatory canals dorsally, never reaching midline of proglottis (Fig. 4G). Internal seminal vesicle elongate, occupying almost half of cirrus sac. Invaginated cirrus armed with small spines (Fig. 4G); proglottides with evaginated cirri not available. Cirrus sac, short, thick-walled; in 'male' mature proglottides cirrus sac crossing poral osmoregulatory canals dorsally, never reaching midline of proglottis (Fig. 4G). Internal seminal vesicle elongate, occupying almost half of cirrus sac. Invaginated cirrus armed with small spines (Fig. 4G); proglottides with evaginated cirri not available.

Developing seminal receptacle sac-like, thin-walled, ventral to cirrus sac (Fig. 4G). Copulatory vagina thick-walled, funnel-shaped, surrounded by sleeve of intensely stained cells, passing ventrally and usually laterally to cirrus sac (Fig. 4G). Conductive part of vagina tubular, thin-walled, passing ventrally to cirrus sac. Mature hermaphroditic proglottides with developed ovary, vitellarium and uterus not available in the studied material.

Remarks

Diorchis stefanskii is described from four hosts of Anatidae in Poland: *Anas platyrhynchos*, *A. strepera*, *Anser anser* and *Aythya nyroca* (CZAPLIŃSKI 1956). The author did not mention the type-host. The specimens from Bulgaria are not fully-developed and the characters of the female genital system could not be described and compared. Nevertheless, the length and the shape of the rostellar hooks, the presence of a short cirrus sac which never extends to the midline of the proglottis, and the short, conical invaginated cirrus correspond to the main diagnostic characters of *D. stefanskii* (see CZAPLIŃSKI 1956; MAKSIMOVA 1989; TOLKACHEVA 1991).

Diorchis stefanskii is a widespread parasite of waterfowl of the family Anatidae with Holarctic distribution (SCHMIDT 1986; McLAUGHLIN 1990; TOLKACHEVA 1991). The species has been reported previously from ten waterfowl species in Bulgaria but without any morphological data supporting the identification of the material (VASILEV 1962, 1973; KAMBUROV & VASILEV 1972; KORNYUSHIN *et al.* 1984; MARINOVA *et al.* 2013).

Discussion

The present study and the review of the previous records have revealed that nine *Diorchis* spp. are recorded from Anatidae in Bulgaria (MARINOVA *et al.* 2013). The present results add four new host records for Bulgaria: *A. anser* for *D. elisae*, *A. crecca* for *D.*

spinata, *A. ferina* and *A. nyroca* for *D. parvogenitalis*. The present observations add new data about the morphology of five species relative to the topology of their genital organs, armament of cirrus, structure of the copulatory vagina and position of the uterus. The current observations on the morphology of *D. elisae*, *D. longiovum*, *D. parvogenitalis*, *D. spinata* and *D. stefanskii* from Bulgaria, and the previous descriptions of *Diorchis* spp. give grounds for some conclusions concerning the diagnostic characters at both generic and species level.

Three of the five species redescribed from Bulgaria possess a peculiar position of the uterus in relation to the osmoregulatory canals. The uterus in *D. elisae*, *D. longiovum* and *D. parvogenitalis* crosses the osmoregulatory canals passing dorsally to the poral canals and ventrally to the antiporal canals (Figs. 1G, 2E, 3G). The remaining two species, *D. spinata* and *D. stefanskii*, lack uterine proglottides in the studied specimens but this feature has previously been observed and illustrated in these two species by CZAPLIŃSKI (1956). In addition, the same position of the uterus has been observed also in *D. americana* Ransom, 1909 (see McLAUGHLIN & BURT 1976), *D. flavescens* (Kreff, 1873) (see CZAPLIŃSKI & AESCHLIMANN 1987), *D. inflata* (Rudolphi, 1819) (see CZAPLIŃSKI 1956), *D. ovofurcata* Czaplinski, 1972 (see CZAPLIŃSKI 1972), *D. ransomi* Johri, 1939 (see CZAPLIŃSKI & SZELENBAUM, 1974) and *D. thracica* Marinova, Georgiev & Vasileva, 2015 (see MARINOVA *et al.* 2015). It is interesting that the position of the cirrus sac and the external seminal vesicle in some species is similar to the position of the uterus, i.e. when the cirrus sac is very long, it is crossing the poral osmoregulatory canals dorsally and passing ventrally to the antiporal canals. This has been observed in *D. inflata* (see CZAPLIŃSKI 1956), *D. longiovum* (see CZAPLIŃSKI 1956; present study), *D. spinata* (see CZAPLIŃSKI 1956; present study), *D. pelagicus* Hoberg, 1982 (see HOBERG 1982) and *D. flavescens* (see CZAPLIŃSKI & AESCHLIMANN 1987). The peculiar position of the uterus and the cirrus sac has not been observed so far in other genera of the family Hymenolepididae from birds (CZAPLIŃSKI IN CZAPLIŃSKI & VAUCHER 1994). Further studies on these characters in the remaining *Diorchis* spp. are needed in order to test if they have diagnostic value at the generic level.

At species level, the present study confirmed the diagnostic importance of the length and the shape of the rostellar hooks, the length, the shape and the armament of the evaginated cirrus and the structure of the copulatory vagina. The present results revealed a wide range in the size of the cirrus-sac recorded for some of the species (see Table 3 for *D. parvogenitalis* and Table 4 for *D. spinata*). It is difficult to judge whether this is due to the different stage of development of the proglottides or the

contraction of strobila. However, despite the wide range of the length, the position of the cirrus sac in relation to the osmoregulatory canals and the midline of the proglottis exhibited intraspecific consistency. The plasticity of the cirrus-sac in some *Diorchis* spp. has been revealed previously (McLAUGHLIN & BURT 1976) and the present results could also confirm that the absolute size of the cirrus sac can hardly be considered as a diagnostic criterion. The position of the cirrus sac in relation to the midline of the proglottis could be recognised as more reliable taxonomic character at species level. In addition, I also consider as important distinguishing character the position of the vitellarium in relation to the ovary. Judging on the previous descriptions, most of *Diorchis* spp. are characterised with a vitellarium situated ventrally to the ovary (CZAPLIŃSKI 1956, SPASSKII 1963, SPASSKAYA 1966, TOLKACHEVA 1991). However, the present study revealed a dorsal position of vitellarium in relation to the ovary in *D. elisae*, *D. longiovum* and *D. parvogenitalis*. In addition, the dorsal position of vitellarium has been also illustrated in *D. flavescens* (see CZAPLIŃSKI & AESCHLIMANN 1987). In my opinion, this character has been probably underestimated in the previous descriptions. In addition, the shape of the eggs and the absence of lateral filaments of the embryonic envelopes could be also used as a diagnostic character at the species level. So far, five *Diorchis* spp. were known as having ovoid eggs, i.e. *D. asiatica* (see CZAPLIŃSKI & SZELENBAUM-CIELECKA 1986), *D. parvogenitalis* (see CZAPLIŃSKI & SZELENBAUM 1974), *D. nitidohamulus* Hovorka & Macko, 1972 (see HOVORKA & MACKO 1972), *D. stefanskii* (see CZAPLIŃSKI 1956) and *D. pelagicus* (see HOBERG 1982).

Most of *Diorchis* spp. are known as parasites with a wide host range within Anseriformes. The present data confirmed the narrower host specificity of some species, i.e. *D. parvogenitalis* was confirmed as a specific parasite of Aythyinae and Anatinae and *D. longiovum* has been recorded mainly in *Anas crecca*.

The life cycles of *Diorchis* spp. are aquatic and include crustaceans (mainly Ostracoda and Copepoda) as their intermediate hosts (for review see SPASSKAYA 1966; TOLKACHEVA 1991). The presence of diverse wetlands in Bulgaria used by waterfowl as nesting or migratory habitats, in addition to the rich fauna of the potential intermediate hosts, offer a favourable environment for the maintenance of the parasites.

Acknowledgements: I am grateful to Dr G. Vasileva and Prof. B. B. Georgiev (Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences) for providing materials from the Helminthological Collection of IBER-BAS, and for the useful comments during the preparation of the manuscript. This work was funded by the Projects 4E/2008, 4E/2012 and 5E/2015 of the Thracian University, funded by the National Science Fund. 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).

References

- BAER, J. G. 1962. Cestoda. – In: The zoology of Iceland, II, 12. Ejnar Munksgaard, Copenhagen & Reykjavik. 1-63.
- BRLGLEZ, J. 1981. Zajedavci pri pticah v Sloveniji. Cestoda Nematoda Acanthocephala. – *Zbornik Biotehniške Fakultete Univerze v Ljubljani Veterinarstvo, Supplement 5*: 1-410.
- CZAPLIŃSKI, B. 1956. Hymenolepididae Fuhrmann, 1907 (Cestoda), parasites of some domestic and wild Anseriformes in Poland. – *Acta Parasitologica Polonica*, **4**: 175-357.
- CZAPLIŃSKI, B. 1972. *Diorchis ovofurcata* sp. n. from *Aythya fuligula* and *A. nyroca* in Poland. – *Acta Parasitologica Polonica*, **20**: 63-72.
- CZAPLIŃSKI, B. 1988. Redescription of *Diorchis longiovum* SCHILLER, 1953 with remarks on the genus *Schillerius* Yamaguti, 1959 (Cestoda, Hymenolepididae). – *Acta Parasitologica Polonica*, **33** (2): 115-122.
- CZAPLIŃSKI, B. & AESCHLIMANN, A. 1987. Hymenolepididae (Cestoda) parasites des oiseaux d'Australie. II Morphologie et distribution géographique de *Diorchis thomasorum* n. novum, syn. *Diorchis flavescens* sensu Johnston, 1912, nec *Taenia flavescens* Kreffl, 1873. – *Acta Parasitologica Polonica*, **32**: 39-52.
- CZAPLIŃSKI, B. & SZELENBAUM, D. 1974. Morphological and biological differences between *Diorchis ransomi* JOHRI, 1939 and *Diorchis parvogenitalis* SKRJABIN et MATHEVOSSIAN, 1945 (Cestoda, Hymenolepididae). – *Acta Parasitologica Polonica*, **22**: 113-132.
- CZAPLIŃSKI, B. & SZELENBAUM-CIELECKA, D. 1986. Morphological and biological studies on *Diorchis danutae* Czaplinski, 1956 and *D. asiatica* Spassky, 1963 (Cestoda, Hymenolepididae). *Acta Parasitologica Polonica*, **30** (15): 127-142.
- CZAPLIŃSKI, B. & VAUCHER, C. 1994. Family Hymenolepididae Ariola, 1899. – In: KHALIL L. F., A. JONES, R.A. BRAY (Eds.) Keys to the cestode parasites of vertebrates. CAB International, Wallingford, 595-663 pp.
- GEORGIEV, B. B. & VAUCHER, C. 2001. Revision of the genus *Parvirostrum* Fuhrmann, 1908 (Cestoda: Cyclophyllidae: Paruterinidae). – *Systematic Parasitology*, **50**: 13-29.
- GEORGIEV, B. B., BISERKOV, V. & GENOV, T. 1986. In toto staining method for cestodes with iron acetocarmine. – *Helminthologia*, **23**: 279-281.
- GREBEN, O. B. 2007. Redescription of *Diorchis spinata* and *D. tshanensis* (Cestoda, Hymenolepididae), parasites of ducks of Holarctic. – *Vestnik Zoologii*, **41**: 99-111 (In Russian).
- HOBERG, E. P. 1982. *Diorchis pelagicus* sp.nov. (Cestoda: Hymenolepididae) from the Whiskered Auklet, *Aethia pygmaea*, and the Crested Auklet, *A. cristatella*, in the Western Aleutian Islands, Alaska. – *Canadian Journal of Zoology*, **60**: 2198-2202.
- HOVORKA, J. & MACKO, J. K. 1972. *Diorchis nitidohamulus* sp. n. (Cestoda) aus dem Wirt *Aythya fuligula*. – *Biológia, Bratislava*, **27**: 97-103.
- HOWARD, R. & MOORE, A. 1980. A complete checklist of the birds in the world. Oxford (Oxford University Press). 701 p.
- KAMBUROV, P. & VASILEV, I. 1972. Helminth fauna of waterfowl in Bulgaria. – *Izvestiya na Tsentralnata Khelminologichna Laboratoriya*, **15**: 109-133. (In Bulgarian).
- KORNYUSHIN, V. V., GENOV, T., JANCHEV, J., & VASILEV, I. 1984. Cestode fauna of wild birds in Bulgaria. – In: VASILEV, I. (ed.) Fauna, taxonomy and ecology of helminths of birds. Sofia (Publishing House of the Bulgarian Academy of Sciences), 149-171. (In Bulgarian, English summary).
- KROTOV, A. I. 1949. Hymenolepidids of Anserinae of the SSSR. – *Trudy Gel'mintologicheskoy Laboratorii Akademii Nauk SSSR*, **2**: 99-110. (In Russian).
- MAKSIMOVA, A. P. 1989. Hymenolepidid cestodes of the waterfowl of Kazakhstan. Nauka, Alma Ata, 223 p. (In Russian).
- MARINOVA, M. H., GEORGIEV, B. B. & VASILEVA, G. P. 2013. A checklist of cestodes (Platyhelminthes: Cestoda) of waterfowl (Aves: Anseriformes) in Bulgaria. – *Acta Zoologica Bulgarica*, **65** (4): 537-546.
- MARINOVA, M. H., GEORGIEV, B. B. & VASILEVA, G. P. 2015. Description of *Diorchis thracica* n. sp. (Cestoda, Hymenolepididae) from the ruddy shelduck *Tadorna ferruginea* (Pallas) (Anseriformes, Anatidae) in Bulgaria. – *Systematic Parasitology*, **91**: 261-271.
- MAYHEW, R. 1929. The genus *Diorchis* with description on four new species from North America. – *Journal of Parasitology*, **15**: 251-258.
- MCLAUGHLIN, J. D. 1990. Cestodes of waterfowl (Anseriformes). – In: KENNEDY M. J., Ed. Synopsis of the parasites of vertebrates of Canada. Animal Health Division, Alberta Agriculture, Edmonton, 1-21 pp.
- MCLAUGHLIN, J. D. & BURT, M. D. B. 1976. A contribution to the genus *Diorchis* Clerc (Cestoda: Hymenolepididae): a redescription of *Diorchis americana* Ransom, 1909 from *Fulica atra* (Gm). – *Canadian Journal of Zoology*, **54**: 1754-1759.
- MCLAUGHLIN, J. D. & BURT, M. D. B. 1979. Studies on the hymenolepidid cestodes of waterfowl from New Brunswick, Canada. – *Canadian Journal of Zoology*, **57**: 34-79.
- MICHEV, T., SIMEONOV, D. & PROFIROV, L. 2012. Birds of the Balkan Peninsula. Ekotan, Sofia, 300 p. (In Bulgarian).
- NANKINOV, D. N., SIMEONOV, S., MICHEV, T. & IVANOV, B. 1997. Fauna of Bulgaria. Volume 26. Aves. Part II. Academic Publishing House "Prof. M. Drinov" and Pensoft Publishers, Sofia, 427 p. (In Bulgarian).
- SCHILLER, E. L. 1953. Studies on the Helminth Fauna of Alaska. XIV. Some cestode parasites of the aleutian teal (*Anas crecca* L.) with the description of *Diorchis longiovum* n. sp. – *Proceedings of the Helminthological Society of Washington*, **20** (1): 7-12.
- SCHMIDT, G. D. 1986. *CRC handbook of tapeworm identification*. CRC Press, Boca Raton, Florida, 675 p.
- SCHULTZ, R. L. 1940. The Genus *Diorchis* Clerc, 1903. – *The American Midland Naturalist*, **23** (2): 382-389.
- SKRJABIN, K. J. 1914. Vogelcestoden aus Russisch Turkestan. – *Zoologische Jahrbücher, Abteilung für Systematik, Geographie und Biologie*, **37**: 411-492. (in German).
- SKRJABIN, K. I. & MATHEVOSSIAN, E. M. 1945. Tapeworms – Hymenolepididae of domestic and game birds. Selkhozgiz, Moscow, 488 p. (In Russian).
- SPASSKAYA, L. P. 1966. Cestodes of birds of the USSR. Hymenolepididae. Nauka, Moscow, 698 p. (In Russian).
- SPASSKII, A. A. 1963. Hymenolepididae – Tapeworms of wild and domestic birds. Part I. – In: SKRJABIN, K. I. (Ed.) Principles of cestodology. Vol. 2. Izdatel'stvo Akademii Nauk SSSR, Moscow, 418 p. (In Russian).
- SPASSKII, A. A. & BOBOVA, L. P. 1962. Hymenolepididae from aquatic birds in Kamchatka. – *Trudy Gel'mintologicheskoy Laboratorii AN SSSR*, **12**: 172-200. (In Russian).
- SPASSKII, A. A. & FREZE, V. I. 1961. A review of *Aploparaksis* CLERC, 1903 (Cestoda: Hymenolepididae). – *Československá Parasitologie*, **8**: 385-389.
- TOLKACHEVA, L. M. 1991. Cestodes of the USSR Fauna: Genus *Diorchis*. Nauka, Moscow, 180 p. (In Russian).
- VASILEV, I. 1962. Helminth fauna of the domestic goose (*Anser anser* dom.) in Bulgaria. – *Izvestiya na Tsentralnata Khelminologichna Laboratoriya*, **7**: 11-17. (In Bulgarian).
- VASILEV, I. 1973. Contribution to the knowledge of the helminth fauna of the domestic ducks in Bulgaria. II. – *Izvestiya na Tsentralnata Khelminologichna Laboratoriya*, **16**: 13-23. (In Bulgarian).
- YAMAGUTI, S. 1935. Studies on the Helminth Fauna of Japan. Part 6. Cestodes of birds, I. – *Japanese Journal of Zoology*, **6** (2): 183-232.
- YAMAGUTI, S. 1940. Studies on the helminth fauna of Japan. Part 30. Cestodes of birds, II. – *Japanese Journal of Medical Sciences. VI. Bacteriology and Parasitology*, **1** (4): 175-211.

Received: 06.07.2016

Accepted: 12.09.2016