Zootaxa 2349: 1–20 (2010)
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

Two new nematode species of the genus *Cosmocephalus* Molin, 1858 (Spirurida: Acuariidae), with an amended generic diagnosis and an identification key to *Cosmocephalus* spp.

YASEN MUTAFCHIEV[1], ALI HALAJIAN[2], BOYKO B. GEORGIEV[1,3]

[1]*Central Laboratory of General Ecology, Bulgarian Academy of Sciences, 2 Gagarin Street, 1113 Sofia, Bulgaria*
[2]*Veterinary Faculty, Islamic Azad University, Tehran Science and Research Branch, Tehran, Iran*
[3]*Corresponding author. E-mail: bbg@ecolab.bas.bg*

Abstract

Cosmocephalus podicipis **n. sp.** is described from *Podiceps cristatus* from the vicinity of Ramsar, Iran (type host and type locality) and from *Podiceps nigricollis* from the Bulgarian Black Sea coast. *Cosmocephalus pelecani* **n. sp.** is described from *Pelecanus conspicillatus* from Mansfield, Victoria, Australia. Comparative materials of three other species of *Cosmocephalus* were examined and described. These are *C. obvelatus* (based on specimens from *Larus argentatus* from Bulgaria), *C. jaenschi* (based on a paratype from *Phalacrocorax carbo* from Australia) and *C. capellae* (based on a male nematode from *Tringa totanus* from Bulgaria, a new geographical record). *Cosmocephalus faridi* from *Pelecanus onocrotalus* from Egypt, which has been considered by previous authors as a synonym of *C. obvelatus*, is validated. Results of SEM observations are presented for *C. podicipis* and *C. obvelatus*. In all the species examined, the presence of a single ventral ridge was recorded in males anterior to the caudal bursa. The generic diagnosis is amended to include more comprehensive information on the morphology of the studied species. Currently, the genus *Cosmocephalus* includes 7 species. *Cosmocephalus imperialis* is recognised as a *species inquirenda*. *Cosmocephalus argentinensis* is proposed as a junior synonym of *C. obvelatus*. An identification key to the species of *Cosmocephalus* is presented.

Key words: taxonomy, morphology, *Cosmocephalus podicipis* **n. sp.**, *C. pelecani* **n. sp.**, *C. obvelatus*, *C. capellae*, *C. jaenschi*, *C. faridi*

Introduction

The genus *Cosmocephalus* Molin, 1858 was erected (as monotypic) for *C. diesingi* Molin, 1858. During the next 150 years, thirteen nominal species have been placed in this genus (Molin, 1858, 1859, 1860; Seurat 1919; Yorke & Maplestone 1926; Morishita 1930; Khalil 1931; Yamaguti 1935; Johnston & Mawson 1941, 1952; Rao 1951; Rodrigues & Vicente 1963, cited after Bowie 1981; Boero & Led 1970), all parasitic in the oesophagus or stomach of aquatic birds. Anderson & Wong (1981) redescribed *C. obvelatus* (Creplin, 1825) and believed that it as well as *C. imperialis* Morishita, 1930, *C. capellae* Yamaguti, 1935 and *C. jaenschi* Johnston & Mawson, 1941 were the only valid species. They did not mention *C. argentinensis* Boero & Led, 1970; the latter was recently considered as *species inquirenda* (Diaz *et al*. 2001). Studies on nematode parasites from *Podiceps cristatus* (L.) in Iran and *Podiceps nigricollis* Brehm in Bulgaria revealed the occurrence of an undescribed species of *Cosmocephalus*. In the course of the examination of comparative material, we found another new species parasitic in Australian pelicans. Furthermore, the morphological study of three known species of the same genus provided new data on them and allowed the preparation of more detailed descriptions than those available in the literature.

The aim of the present article is to describe two new species of the genus *Cosmocephalus*. In addition, we

Accepted by G.P.-P. de Leon: 27 Nov. 2009; published: 2 Feb. 2010

present new morphological information on several known species and provide an identification key to *Cosmocephalus* spp.

Materials and methods

Specimens from the Helminthological Collections of the South Australian Museum, Adelaide (AHC), the Central Laboratory of General Ecology, Bulgarian Academy of Sciences (CLGE-BAS) and one of the present authors (AH) were studied. Details of the collection data and number of specimens are given in the text for each species.

The nematodes were preserved in 70% ethanol. For light-microscopy, specimens were cleared and examined as temporary mounts in glycerine. Specimens used for SEM observations were transferred from 70% ethanol to 40% ethanol (10 min), rinsed in 0.1 M cacodylate buffer, post-fixed in 1% OsO_4 for 2 h and dehydrated in an ethanol series. The female specimen of *C. podicipis* was coated with gold in fine coater JEOL JFS 1200 and examined using a JEOL JSM 5510 microscope at 10 kV. The specimens of *C. obvelatus* were coated with gold-palladium in a Polaron SC7640 sputter coater and examined using a LEO VP 1540 microscope at 10 kV.

Metrical data are given as the range, with the mean and the number of measurements taken (n) in parentheses. Measurements are in micrometres except where otherwise stated.

The following indices were used: cordon length/body length = $I_{CL/BL}$; length of muscular oesophagus/ length of glandular oesophagus = $I_{mOE/gOE}$; length of oesophagus/body length = $I_{OE/BL}$; length of caudal alae/ body length = $I_{CA/BL}$; length of left spicule/length of right spicule = $I_{LSP/RSP}$; distance from vulva to posterior end/body length = $I_{V/BL}$.

The type-specimens have been deposited in the helminthological collections of the: Natural History Museum, London (BMNH); Museum für Naturkunde der Humboldt Univesität zu Berlin (ZMB); and the Central Laboratory of General Ecology, Bulgarian Academy of Sciences, Sofia(CLGE-BAS).

Results

Descriptions of the new species

Cosmocephalus podicipis n. sp.

Type host: Great Crested Grebe, *Podiceps cristatus* (L.) (Podicipediformes, Podicipedidae).

Other host: Black-necked Grebe, *Podiceps nigricollis* Brehm.

Type locality: vicinity of the town of Ramsar (36°55'N, 50°40'E), Mazandaran Province, Iran.

Other locality: Durankulak Lake (43°40´N, 28°33´E), Dobrich Region, Bulgarian Black Sea coast.

Site: Oesophagus.

Intensity of infection: 1 male and 4 females in *P. cristatus* collected on 18 February 2008 and 7 males and 3 females in *P. cristatus* collected on 5 January 2009 from Iran; 1 male in *P. nigricollis* collected on 9 October 1989 from Bulgaria.

Type-material: From *P. cristatus*: Holotype: ZMB Vermes Entozoa 7459 (male). Paratypes: ZMB Vermes Entozoa 7460 (1 male and 1 female); BMNH 2009.11.6.1–2 (1 male and 1 female); AHC 45437 (1 male and 1 female); CLGE-BAS N000.461 (1 male); in the collection of AH (3 males and 3 females).

From *P. nigricollis*: Paratype: (1 male) CLGE-BAS N000.661.

Voucher: CLGE-BAS N001.067 (1 male and 1 female), SEM stub.

Etymology: The name of the new species reflects the generic name of its definitive host species.

Description (Figs 1A–G; 2A–G; 3A–F)

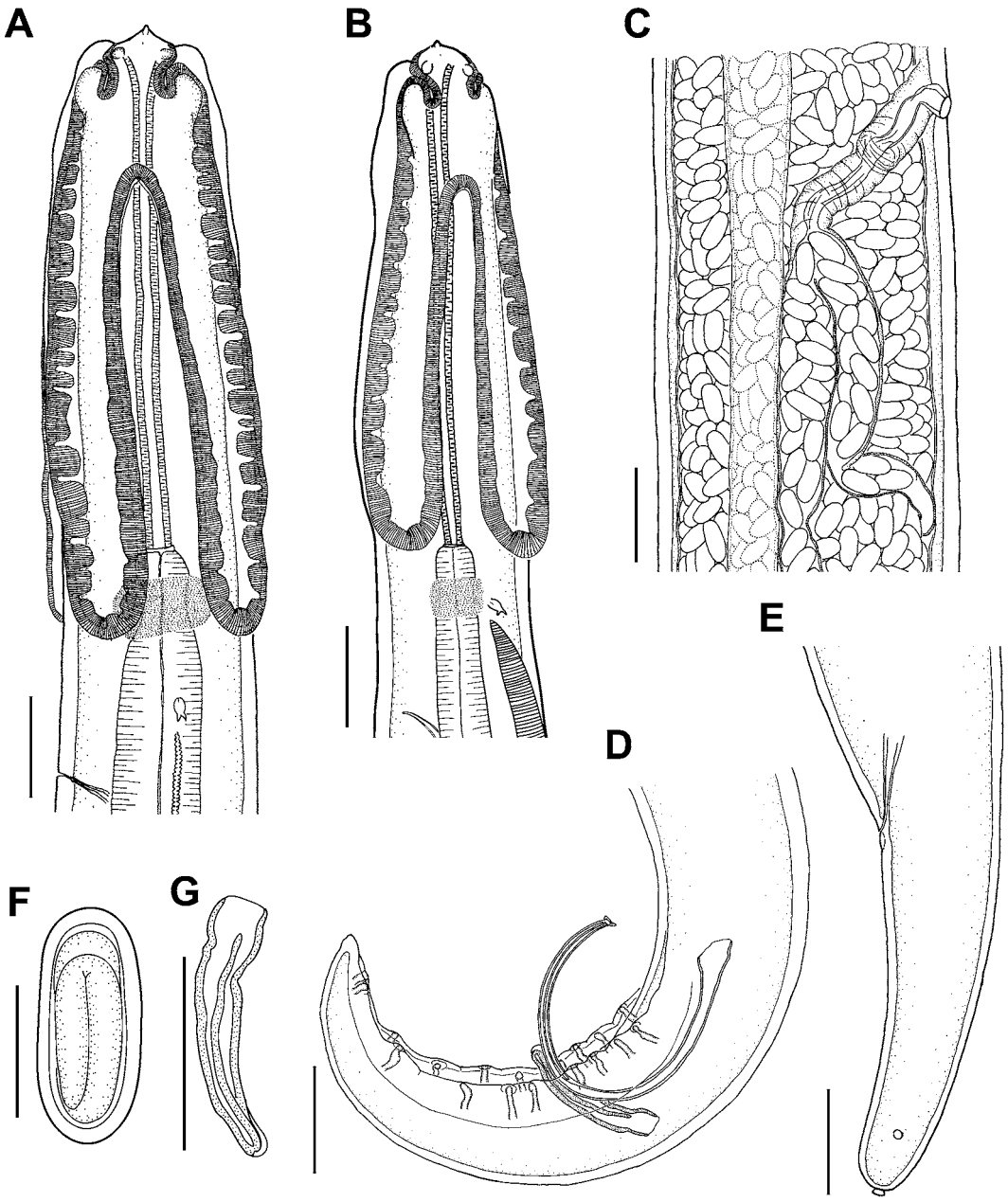

FIGURE 1 A–G. *Cosmocephalus podicipis* **n. sp.** A. Anterior end, female, lateral view; B. Anterior end, male, lateral view; C. Vagina, lateral view; D. Posterior end, male, lateral view; E. Caudal end, female, lateral view; F. Egg; G. Right spicule, dextral view. Scale bars: A–E, G = 100 μm; F = 25 μm.

General. Medium-sized acuariids. Anterior end with two triangular pseudolabia, each bearing single amphid and pair of prominent papillae (Fig. 2B, C). Pair of swellings situated dorsally and ventrally between bases of pseudolabia (Fig. 2B, C). Cordons arise dorsally and ventrally between pseudolabia; each cordon forming loop adjacent to its base and then continuing its course along longitudinal body axis; at level of posterior end of buccal cavity, cordons recurrent in anterior direction and reach level of anterior quarter of buccal cavity where they anastomose laterally (Figs 1A, B; 2A). Cordons consisting of a single row of cuticular plates (each plate c. 1.5 μm long) and longitudinal cuticular ridge along outer rims of plates; deep, almost closed longitudinal groove between plates and longitudinal ridge. Plates of descending cordon arm of unequal width, thus forming scalloped appearance (Figs 1A, B; 2E). Deirids 18–30 long, bicuspid, situated

behind cordons (Fig. 2A, D, F). Postdeirids, c. 5 long, with bifurcate tip (Fig. 2G). Lateral alae well-developed, extending from level just posterior of deirids to level about middle of body (Fig. 2D). Buccal cavity elongate (Fig. 1A, B). Excretory pore situated posteriorly to deirids (Figs 1A, B; 2D). Nerve ring surrounding anterior portion of muscular oesophagus. Phasmids subterminal (Fig. 3B, D).

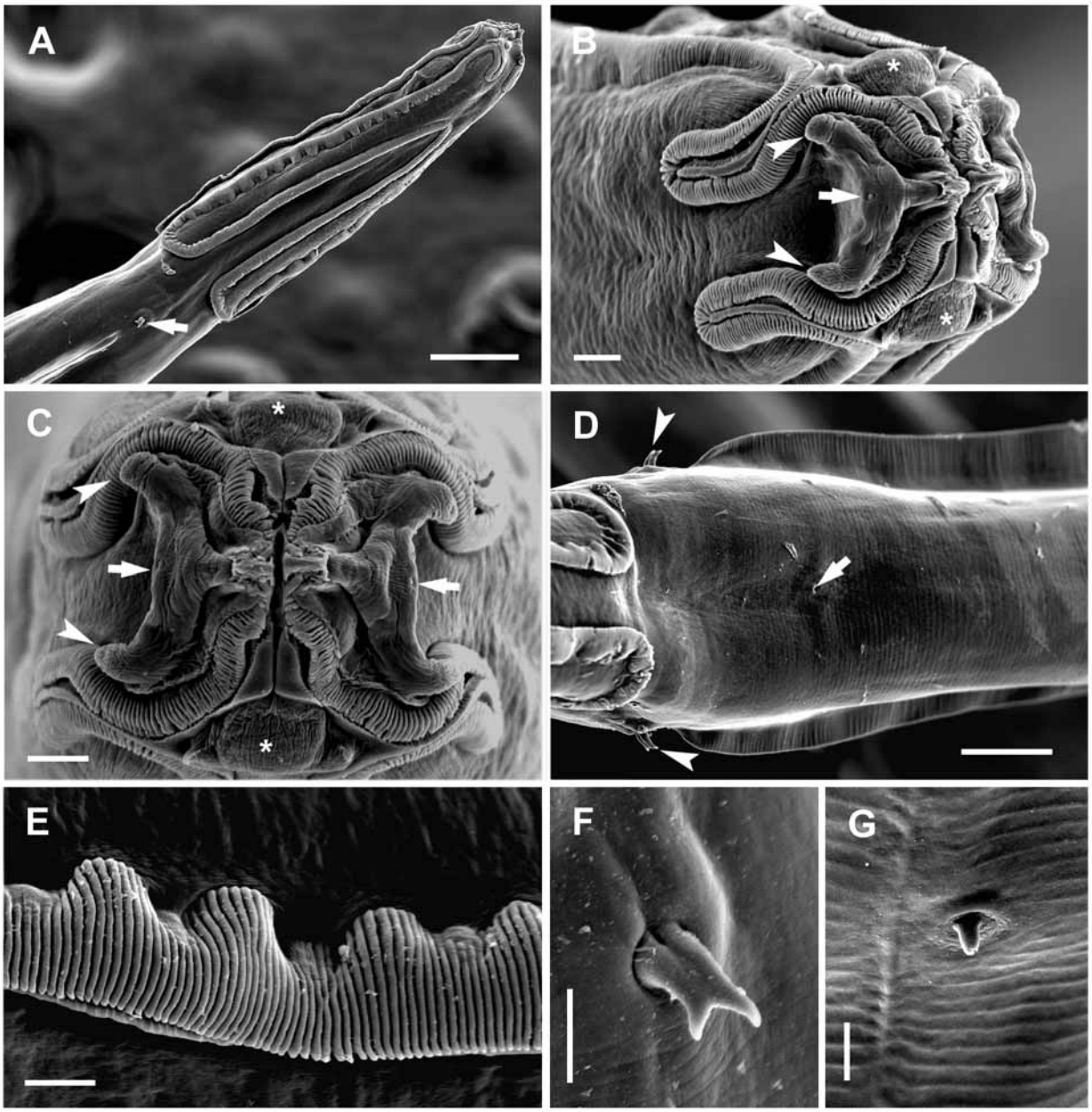

FIGURE 2 A–G. *Cosmocephalus podicipis* **n. sp.**, female, SEM. A. Anterior end, lateral view; note deirid (arrow); B. Pseudolabium, lateral view; note cephalic papillae (arrowheads), amphid (arrow), cuticular swellings dorsally and ventrally at the bases of the pseudolabia (asterisks); C. Anterior end, apical view; note cephalic papillae (arrowheads), amphids (arrows), cuticular swellings dorsally and ventrally at the bases of the pseudolabia (asterisks); D. Lateral alae; note deirids (arrowheads) and excretory pore (arrow); E. Cuticular plates, detail from the middle part of the descending arm of a cordon; F. Deirid; G. Postdeirid. Scale bars: A = 100 μm; B, C, E–G = 10 μm; D = 50 μm.

Male (from *P. cristatus* from Iran, n=8 except otherwise stated). Body length 8.1–13.2 mm (10.6 mm). Maximum body width 224–275 (249), about mid-body; width 98–127 (111) at level of cloaca. Tail 228–373 (309) long. Cordons 376–527 (437) long, recurrent in anterior direction to 107–143 (121) from anterior body end, 21–25 wide. Deirids and excretory pore at 416–573 (488) and 483–631 (555), respectively, from anterior

end of body. Left postdeirid and right postdeirid at 6.1–8.9 mm (7.4 mm, n=6) and 5.6–7.9 mm (6.8 mm, n=6), respectively, from anterior body end. Buccal cavity 358–527 (442) long and 14–16 wide. Muscular oesophagus 665–1,032 (881) long and 48–81 (66) wide. Glandular oesophagus 2,682–3,872 (3,305) long and 107–143 (123) wide. Nerve ring at 380–573 (476) from anterior body end. Cuticle 16–19 thick. Distance between cuticular striations 4–5 μm. Lateral alae extending to 5.3–8.8 mm (6.8 mm) from anterior body end, maximum width 47–50. Caudal alae 607–921 (745) long (Fig. 3C). Single ventral cuticular ridge extending between level at 1,356–2,613 (1,895) from posterior body end and beginning of caudal alae (Fig. 3E). Single median sessile precloacal papilla present. Nine pairs of pedunculate caudal papillae, 4 precloacal and 5 postcloacal (Figs 1D; 3D, E). Anterior four pairs of postcloacal pedunculate papillae with almost equal distance between them; fifth pair situated near posterior extremity of tail. Sixth pair of postcloacal papillae sessile, smaller, situated between bases of last pedunculate papillae. Left spicule 400–446 (423) long, 10–12 wide, with small projection on its distal end (Fig. 3F). Right spicule 125–150 (143) long, 23–28 (25) wide (Fig. 1G). $I_{CL/BL}$ 0.038–0.046 (0.042); $I_{mOE/gOE}$ 0.237–0.304 (0.268); $I_{OE/BL}$ 0.358–0.432 (0.397); $I_{CA/BL}$ 0.061–0.078 (0.068); $I_{LSP/RSP}$ 2.770–3.360 (2.977).

Female (from *P. cristatus* from Iran, n=7 except otherwise stated). Body length 10.9–17.8 mm (15.5 mm). Maximum body width 254–435 (358), width 86–143 (116) at anus and 237–435 (349) at vulva. Tail 250–335 (307) long. Cordons extending to 514–814 (635) from anterior end, recurrent in anterior direction to 104–157 (133) from anterior body end, 34–54 (43) wide. Deirids and excretory pore at 545–814 (676) and 612–917 (769), respectively, from anterior body end. Left postdeirid and right postdeirid at 6.4–9.5 mm (8.3 mm, n=4) and 6.1–8.7 mm (7.5 mm, n=4), respectively, from anterior body end. Buccal cavity 478–699 (574) long and 20–25 (23) wide. Muscular oesophagus 745–1,220 (957) long and 57–90 (73) wide. Glandular oesophagus 3,084–4,200 (3,575) long and 131–175 (154) wide. Nerve ring at 507–734 (606) from anterior body end. Cuticle 15–22 thick. Distance between striations 5–7 μm. Lateral alae extending to level of vulva, 54–65 wide. Vulva at 5.6–8.9 mm (7.7 mm) from anterior body end (Fig. 3A). Reproductive system didelphic. *Vagina vera* short, posteriorly directed, separated from *vagina uterina* by well-developed circular musculature (Fig. 1C). *Vagina uterina* longer, with muscular walls. Posterior extremity of tail with nipple-like projection (Figs 1E; 3B). Eggs elongate-oval, 41–45 × 19–20 (43 × 20, n=20), containing first stage larva (Fig. 1F). $I_{CL/BL}$ 0.036–0.047 (0.040); $I_{mOE/gOE}$ 0.191–0.301 (0.239); $I_{OE/BL}$ 0.271–369 (0.309); $I_{V/BL}$ 0.480–0.515 (0.496).

Remarks. Several studies have reported species of the genus *Cosmocephalus* as parasites of grebes (*Podiceps* spp.): *C. obvelatus* from *Podiceps* sp. from the Sea of Azov and Azerbaijan (Gushanskaya 1950) and from *Aechmophorus occidentalis* (Lawrence) in Canada (Gallimore 1964, cited after Storer 2000); *Cosmocephalus* sp. from *Podiceps grisegena* (Boddaert) from West Siberia (Spasskaya 1949); and *C. obvelatus magnus* Vasil'kova, 1926 from *Podiceps cristatus* in Turkmenistan (Kibakin 1965). None of these records was accompanied by descriptions or illustrations.

The specimens from *P. cristatus* from Iran and those from *P. nigricollis* from Bulgaria exhibit very similar morphology, including their metrical data (Table 1). They obviously belong to the same species, which we name *C. podicipis* **n. sp.** They can be distinguished from their congeners (see below for a survey of *Cosmocephalus* spp.) on the basis of the following comparisons:

C. podicipis can be differentiated from *C. obvelatus* by its longer cordons in both males and females (Table 1). The relative length of the cordons (as a proportion of the body length) of the new species is also greater than that in *C. obvelatus*, i.e. $I_{CL/BL}$ is 0.038–0.046 *vs* 0.029–0.036 in males and 0.036–0.047 *vs* 0.026–0.035 in females. The cordons of the new species are narrower than those in *C. obvelatus* (Fig. 2A and Fig. 6A). *C. podicipis* has shorter spicules (Table 1). The females of *C. podicipis* are characterised by a longer tail and smaller body width at the level of the anus (Fig. 1E and Fig. 5E). The eggs of *C. podicipis* are markedly more elongate (Fig. 1F and Fig. 5G).

The new species differs from *C. imperialis* [as described by Morishita (1930), see Table 1] by the longer body of males and the shorter spicules. The females of *C. podicipis* are narrower and their eggs are larger than those of *C. imperialis*.

TABLE 1. Metrical data of *Cosmocephalus* spp. from various hosts and localities.

Source	Anderson & Wong (1981)	Boero & Led (1970)	Present study	Morishita (1930)	Khalil (1931)	Yamaguti (1935)	Present study	Johnston & Mawson (1941)	Present study	Present study	Present study	Present study
Species	*C. obvelatus*	*C. argentinensis* (= *C. obvelatus*)	*C. obvelatus*	*C. imperialis*	*C. faridi*	*C. capellae*	*C. capellae*	*C. jaenchi*	*C. jaenschi*	*C. pelecani*	*C. podicipis*	*C. podicipis*
Host	*Larus delawarensis*	*Spheniscus magellanicus*	*Larus argentatus*	*Uria aalge*	*Pelecanus onocrotalus*	*Gallinago gallinago*	*Tringa totanus*	*Phalacrocorax carbo*	*Phalacrocorax carbo*	*Pelecanus conspicillatus*	*Podiceps cristatus*	*Podiceps nigricollis*
Locality	Canada	Argentina	Bulgaria	South Sakhalin	Egypt	Japan	Bulgaria	Australia	Australia	Australia	Iran	Bulgaria
Male	**n=10**	**-**	**n=10**	**-**	**n=1**	**n=1**	**n=1**	**n=2**	**n=1**	**n=3**	**n=8**	**n=1**
Body length (mm)	9.9-14.3	-	9.8-11.2	6.3-7.5	7.6	5.1	5.5	10.5	11.0	11.9-12.3	8.1-13.2	8.4
Maximum body width	200-350	-	255-286	290	-	170	179	-	228	115-116	224-275	214
Tail, length	400-500	-	290-369	-	270	240	220	290	293	294-302**	228-373	224
Buccal cavity, length	380-510	-	340-411	430	-	250*	237	390	389	411-434	358-527	317
Muscular oesophagus, length	1,000-1,300	-	848-940	800-900	-	470-500*	451	900	929	952-1,135	665-1,032	711
Glandular oesophagus, length	3,600-4,300	-	2,927-3,640	3,100-3,200	-	1,620-1,850*	2,418	3,700	3,770	4,003-4,265	2,682-3,872	2,603
Cordons, length	-	-	322-376	450-470	400	260-300*	241	390	371	415-469	376-527	316
Cordons, wide	-	-	27-32	26-29	-	-	11	-	38	30-36	21-25	24
Left spicule, length	590-700	-	487-548	580-660	540	350	389	610	672	658-665	400-446	390
Right spicule, length	180-220	-	142-167	180-280	160	123	138	150	159	151-155	125-150	130
Female	**n=10**	**n=1**	**n=9**	**-**	**n=1**	**n=1**	**-**	**-**	**-**	**n=2**	**n=7**	**-**
Body length (mm)	15.8-22.3	20.0	14.8-18.2	16.0-18.0	5.7	5.0	-	-	-	14.8-15.8	10.9-17.8	-
Maximum body width	320-500	400	402-456	470-500	-	220	-	-		385-493	254-435	-
Tail, length	220-380	250	197-291	250-300	180	100	-	-	-	233-237	250-335	-
Buccal cavity, length	570-730	620	456-519	400-430	-	250*	-	-	-	482-539	478-699	-
Muscular oesophagus, length	1,200-1,500	1,150	1,055-1,284	1,000-1,100	-	470-500*	-	-	-	939*	745-1,220	-
Glandular oesophagus, length	4,100-5,100	-	3,922-4,375	3,300-3,700	-	1,620-1,850*	-	-	-	4,149-4,706	3,084-4,200	-
Cordons, length	-	-	452-532	540-650	300	260-300*	-	-	-	516-539	514-814	-
Cordons, wide	-	-	54-77	45-54	-	-	-	-	-	52-54	34-54	-
Vulva from anterior end, distance (mm)	7.4-10.4	8.6	7.8-9.8	-	-	-	-	-	-	7.1-8.0	5.6-8.9	-
Eggs	-	36 × 24	35-39 × 20-22 (n=20)	35-36 ×17	-	39-42 × 24-21	-	-	-	36-39 × 22-24 (n=20)	41-45 × 19-21 (n=20)	-

*n = 1
**n = 2

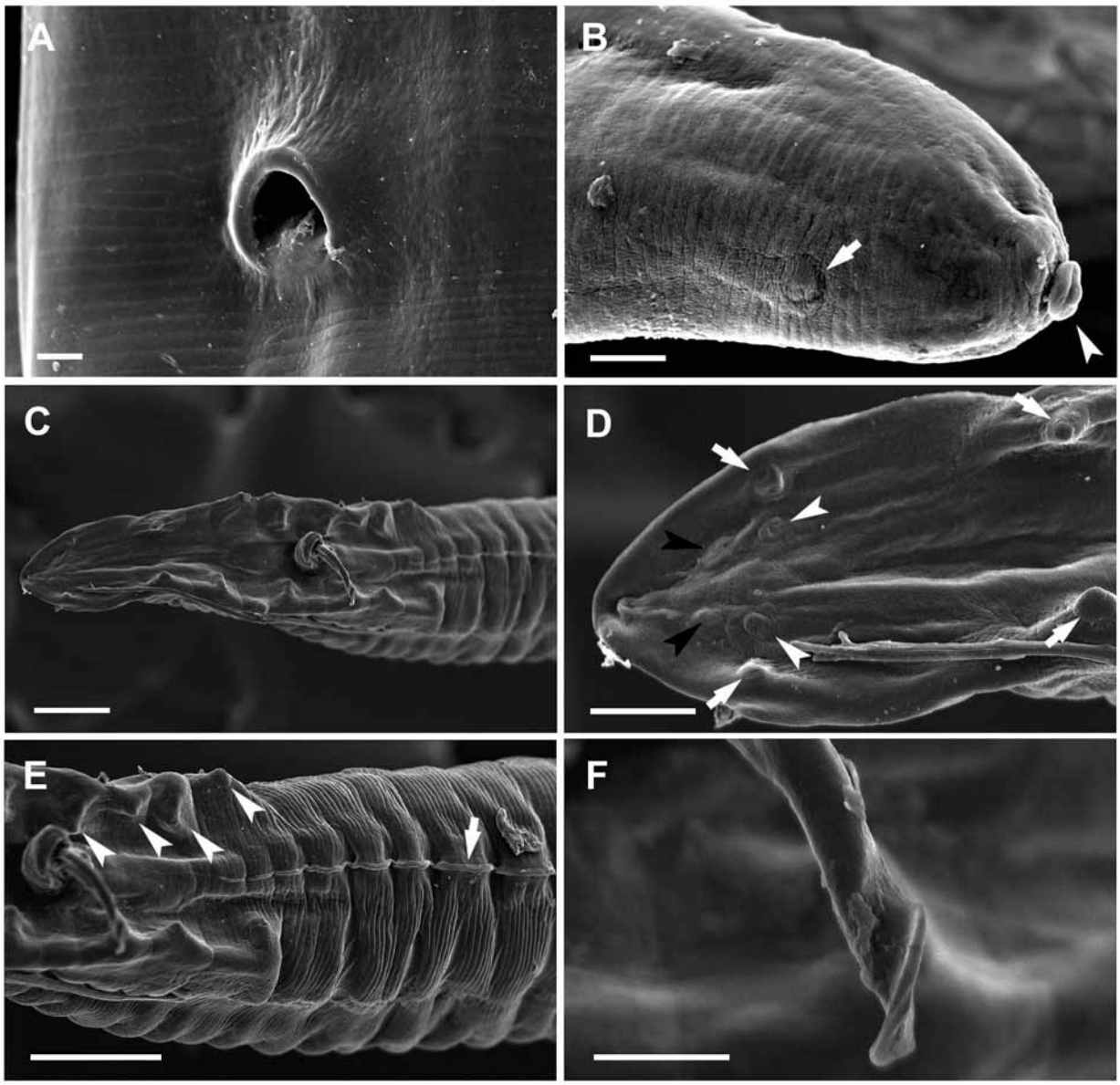

FIGURE 3 A–F. *Cosmocephalus podicipis* **n. sp.** A. Vulva; B. Posterior end, female; note nipple-like projection (arrowhead) and, phasmid (arrow); C. Posterior end, male, ventral view. D. Posterior end of male; ventral view; note sessile papillae (white arrowheads), pedunculate papillae (arrows) and phasmids (black arrowheads). E. Precloacal region of tail, ventral view; note papillae (arrowheads) and ventral cuticular ridge (arrow). F. Distal end of left spicule. Scale bars: A, B, F = 10 μm; C, E = 50 μm; D = 20 μm.

The males of *C. podicipis* can be distinguished from those of *C. faridi* [as described by Khalil (1931), see Table 1] by their longer body and shorter spicules. Furthermore, the cordons of *C. faridi* are characterised by their elongate loops reaching to one third of the total length of the cordons (Khalil 1931).

The new species is differentiated from *C. capellae* [as described by Yamaguti (1935)] by its longer body length in males (Table 1). In addition, *C. capellae* has tricuspid deirids while those of *C. podicipis* are bicuspid.

The male specimens of *C. podicipis* differ from those of *C. jaenschi* (compared with data obtained in the present study, Table 1) by their shorter left spicules. *C. podicipis* has bicuspid deirids, in contrast with the tricuspid deirids of *C. jaenschi*. In addition, *C. jaenschi* has a prominent appendage at the distal end of the left spicule (Fig. 7B), absent in *C. podicipis*.

***Cosmocephalus pelecani* n. sp.**

Type-host: Australian Pelican, *Pelecanus conspicillatus* Temminck, 1824 (Pelecaniformes, Pelecanidae).

Type-locality: Mansfield, Victoria, Australia (collected on 9 July 1972).

Site: Stomach.

Intensity of infection: 5 specimens (3 males and 2 females).

Type-material: Holotype: AHC 45436 (male); Paratypes: AHC 11466 (2 males and 2 females).

Etymology: The name of the new species reflects the generic name of the host species.

Description (Fig. 4A–G)

General. Medium-sized acuariids. Anterior end with two triangular pseudolabia, each bearing single amphid and pair of prominent papillae. Pair of swellings situated dorsally and ventrally at bases of pseudolabia. Cordons arise dorsally and ventrally between pseudolabia; each cordon forming loop adjacent to its base and then continuing its course along longitudinal body axis; at level of posterior end of buccal cavity, cordons recurrent in anterior direction and reach level of anterior quarter of buccal cavity where they anastomose laterally (Figs 4A, B). Cordons consisting of a single row of cuticular plates (each plate c. 2 μm long) and longitudinal cuticular ridge along outer rims of plates; deep, almost closed longitudinal groove between plates and longitudinal ridge. Plates of descending cordon arm of unequal width, thus forming wide portions with notches between them. Deirids 14–20 long, bicuspid. Lateral alae absent. Buccal cavity elongate. Excretory pore situated posteriorly to deirids. Nerve ring surrounding narrow anterior portion of muscular oesophagus. Phasmids subterminal.

Male (n=3 except otherwise stated). Body length 11.9–12.3 mm (12.0 mm). Maximum body width 115–116, about mid-body; width 107–116 (112) at level of cloaca. Tail 294–302 (298, n=2) long. Cordons 415–469 (442) long, recurrent in anterior direction to 116–132 (123) from anterior body end, 30–36 wide. Deirids and excretory pore at 482–561 (520) and 595–693 (640), respectively, from anterior body end. Buccal cavity 411–434 (419) long and 18–20 wide. Muscular oesophagus 952–1,135 (1,040) long and 50–56 (53) wide. Glandular oesophagus 4,003–4,265 (4,141) long and 116–143 (123) wide. Nerve ring at 453–516 (479) from anterior body end. Cuticle 18–20 thick. Distance between cuticular striations 4–5 μm. Caudal alae 597–660 (n=2) long. Single ventral cuticular ridge extending between level at 2,520–2,573 (n=2) from posterior body end to beginning of caudal alae. Single median sessile precloacal papilla present. Nine pairs of pedunculate caudal papillae, 4 precloacal and 5 postcloacal (Fig. 4F). Anterior four pairs of pedunculate postcloacal papillae with almost equal distance between them; fifth pair near posterior extremity of tail. Sixth pair of postcloacal papillae sessile, smaller, situated between bases of last pedunculate papillae. Left spicule 658–665 (n=2) long, 11–13 wide, with prominent projection on its distal end. Right spicule 151–155 (n=2) long, 30–36 (n=2) wide (Fig. 4E). $I_{CL/BL}$ 0.035–0.038 (0.037); $I_{mOE/gOE}$ 0.238–0.273 (0.251); $I_{OE/BL}$ 0.417–0.445 (0.431); $I_{CA/BL}$ 0.050–0.056 (n=2); $I_{LSP/RSP}$ 4.290–4.358 (n=2).

Female (n=2 except otherwise stated). Body length 14.5–15.8 mm. Maximum body width 385–493, about mid-body; width 129–130 at anus and 385–460 at vulva. Tail 233–237 long. Cordons extending to 516–539 from anterior body end, recurrent in anterior direction to 125–129 from anterior body end, 52–54 wide. Deirids and excretory pore at 584–596 and 688–791, respectively, from anterior body end. Buccal cavity 482–539 long and 24–28 wide. Muscular oesophagus 939 (n=1) long and 72 (n=1) wide. Glandular oesophagus 4,149–4,706 long and 112–125 wide. Nerve ring at 505–612 from anterior body end. Cuticle 14–18 thick. Distance between striations 6–7 μm. Vulva at 7.1–8.0 mm from anterior body end. Reproductive system didelphic. *Vagina vera* short, posteriorly directed, separated from *vagina uterina* by well-developed circular musculature (Fig. 4C). *Vagina uterina* longer, with muscular walls. Posterior extremity of tail with nipple-like projection (Fig. 4G). Eggs oval, 36–39 × 22–24 (37 × 23, n=20), containing first stage larva (Fig. 4D). $I_{CL/BL}$ 0.034–0.036; $I_{mOE/gOE}$ 0.200 (n=1); $I_{OE/BL}$ 0.357 (n=1); $I_{V/BL}$ 0.491–0.509.

Remarks. The presence of lateral alae has been described in *C. obvelatus* (see Anderson & Wong 1981; present study), *C. capellae* (see Yamaguti 1935; present study), *C. jaenschi* (present study) and *C. podicipis*

(present study). It was not mentioned in the original description of *C. imperialis* but was shown in the accompanying illustration (Morishita 1930). *C. pelacani* can be distinguished from all these species by the absence of lateral alae.

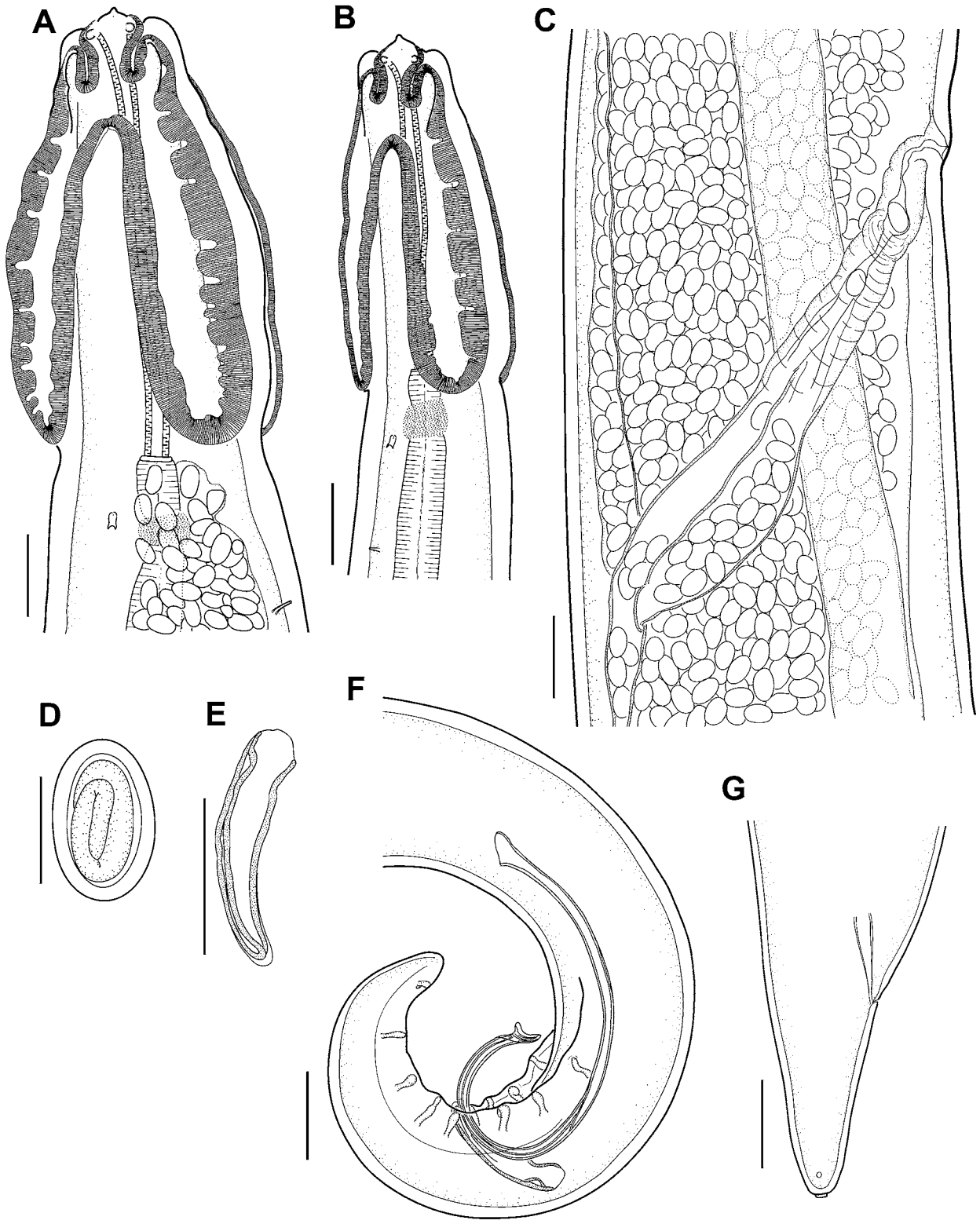

FIGURE 4 A–G. *Cosmocephalus pelecani* **n. sp.** A. Anterior end, female, lateral view; B. Anterior end, male, lateral view; C. Vagina, lateral view; D. Egg; E. Right spicule, dextral view; F. Posterior end, male, lateral view; G. Caudal end, female, lateral view. Scale bars: A–C, E–G = 100 μm; D = 25 μm.

Cosmocephalus pelecani is similar to *C. obvelatus* in its morphometrical characters (Table 1). In addition to the absence of lateral alae, *C. pelecani* can be differentiated by its more prominent appendage of the distal end of the left spicule than that in *C. obvelatus* (Fig. 4F and Fig. 5F).

The new species can be differentiated from *C. capellae* by the longer body of males and the longer spicules (Table 1). *C. pelecani* has longer and markedly wider cordons. Moreover, *C. capellae* exhibits tricuspid deirids (compared to bicuspid deirids in *C. pelecani*).

The absence of lateral alae and the bicuspid deirids of *C. pelecani* differentiate it from *C. jaenschi*; the latter has lateral alae and tricuspid deirids. *C. jaenschi* also has a prominent appendage on the distal apex of the left spicule, much bigger than in the new species (Fig. 7B and Fig. 4F).

The new species has longer males but a shorter right spicule than those of *C. imperialis* (Table 1).

Cosmocephalus pelecani is characterised by cordons consisting of plates of unequal width, forming a descending arm of wide series of plates separated by notches; in addition, the cordon loop is short. In contrast, *C. faridi* has no scalloped cordons and a very elongate loop (Khalil 1931). The males of *C. pelecani* can also be distinguished from those of *C. faridi* by their longer body and longer left spicule (Table 1).

Compared to *C. podicipis*, the males of *C. pelecani* have a longer left spicule (Table 1) and a greater spicule ratio, i.e. $I_{LSP/RSP}$ (4.290–4.358 *vs* 2.770–3.360). The eggs of *C. podicipis* are more elongate than those of *C. pelecani* (Fig. 1F and Fig. 4D).

Observations on comparative materials

Cosmocephalus obvelatus (Creplin, 1825) Seurat, 1919

Material studied: 12 males and 9 females; host: *Larus argentatus* Pontoppidan (Charadriiformes, Laridae); collected from Durankulak Lake, Bulgarian Black Sea coast (30 September 1990); site of infection: oesophagus.

Vouchers: ZMB Vermes Entozoa 7461 (3 males and 2 females); CLGE-BAS N000.011 (7 males and 5 females); CLGE-BAS N001.068 (2 males), SEM stub; CLGE-BAS N001.069 (2 females), SEM stub.

Description (Figs 5A–H; 6A–I)

General. Medium-sized acuariids. Anterior end with two triangular pseudolabia, each bearing single amphid and pair of prominent papillae (Fig. 6C). Pair of swellings situated dorsally and ventrally at bases of pseudolabia. Few pores situated posteriorly to apex of pseudolabium (Fig. 6D). Cordons arise dorsally and ventrally between pseudolabia (Figs 5A, B; 6A, B); each cordon forming loop adjacent to its base and then continuing its course along longitudinal body axis; at level of posterior end of buccal cavity, cordons recurrent in anterior direction and reach level of anterior quarter of buccal cavity where they anastomose laterally (Fig. 5A, B). Cordons consisting of a single row of cuticular plates (each plate c. 2 µm long) and longitudinal cuticular ridge along outer rims of plates; deep longitudinal groove between plates and longitudinal ridge. Plates of both descending and ascending cordon arms of unequal width, thus forming scalloped appearance. Deirids 13–20 long, bicuspid (Fig. 6E). Postdeirids c. 5 long, bifurcate (Fig. 6F). Lateral alae well-developed, extending from level just posterior of deirids to level about middle of body (Fig. 6A, B). Buccal cavity elongate. Excretory pore posterior to deirids (Fig. 5A, B). Nerve ring surrounding anterior portion of muscular oesophagus. Phasmids subterminal (Fig. 6I).

Male (from *L. argentatus*, n=10 except otherwise stated). Body length 9.8–11.3 mm (10.5 mm). Maximum body width 255–286 (271), about mid-body; width 98–136 (124) at level of cloaca. Tail 290–369 (325) long. Cordons 322–376 (350) long, recurrent in anterior direction to 97–170 (117) from anterior body end. Deirids and excretory pore at 384–434 (407) and 487–550 (506), respectively, from anterior body end. Left postdeirid and right postdeirid at 7.0–8.1 mm (7.5 mm, n=7) and 6.1–7.1 mm (6.5 mm, n=7), respectively, from anterior body end. Buccal cavity 219–246 (231) long and 12–14 wide. Muscular oesophagus 848–940 (903) long and 61–72 (65) wide. Glandular oesophagus 2,927–3,640 (3,187) long and 104–120 (113) wide.

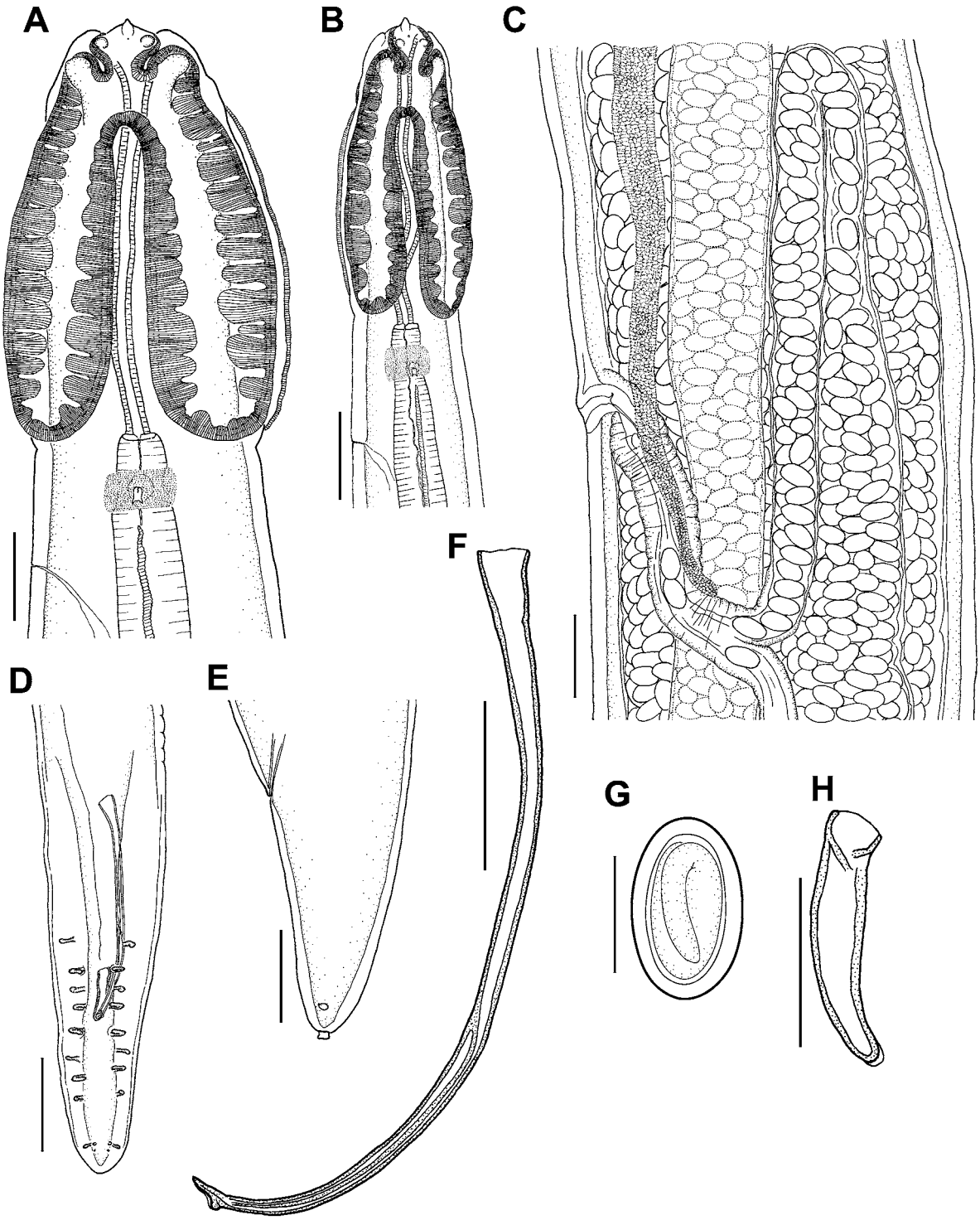

FIGURE 5 A–H. *Cosmocephalus obvelatus*. A. Anterior end, female, lateral view; B. Anterior end, male, lateral view; C. Vagina, lateral view; D. Caudal end, female, ventral view; E. Posterior end, female, lateral view; F. Left spicule, sinistral view; G. Egg; H. Right spicule, dextral view. Scale bars: A–C, E, F, H = 100 μm; D = 200 μm; G = 25 μm.

Nerve ring at 376–434 (407) from anterior body end. Cuticle 14–16 thick. Distance between cuticular striations 5–6 μm. Lateral alae extending to 6.4–7.1 mm (6.7 mm) from anterior body end, maximum width 44–50. Caudal alae 561–1,062 (839) long. Single ventral cuticular ridge extending between level at 2,036–2,775 (2,243) from posterior end and caudal alae (Fig. 6G). Single median sessile precloacal papilla present. Nine pairs of pedunculate caudal papillae, 4 precloacal and 5 postcloacal; postcloacal pairs with almost equal distance between them, fifth pair at posterior part of tail (Figs 5D; 6G, H). Sixth pair of postcloacal papillae

sessile, smaller, situated between bases of last pedunculate papillae. Left spicule 487–548 (515) long and 9–10 wide, with projection on its distal end (Fig. 5F). Right spicule 142–167 (156) long and 24–26 (25) wide (Fig. 5H). $I_{CL/BL}$ 0.029–0.036 (0.034); $I_{mOE/gOE}$ 0.246–0.317 (0.285); $I_{OE/BL}$ 0.370–0.421 (0.391); $I_{CA/BL}$ 0.056–0.095 (0.080); $I_{LSP/RSP}$ 3.109–3.859 (3.333).

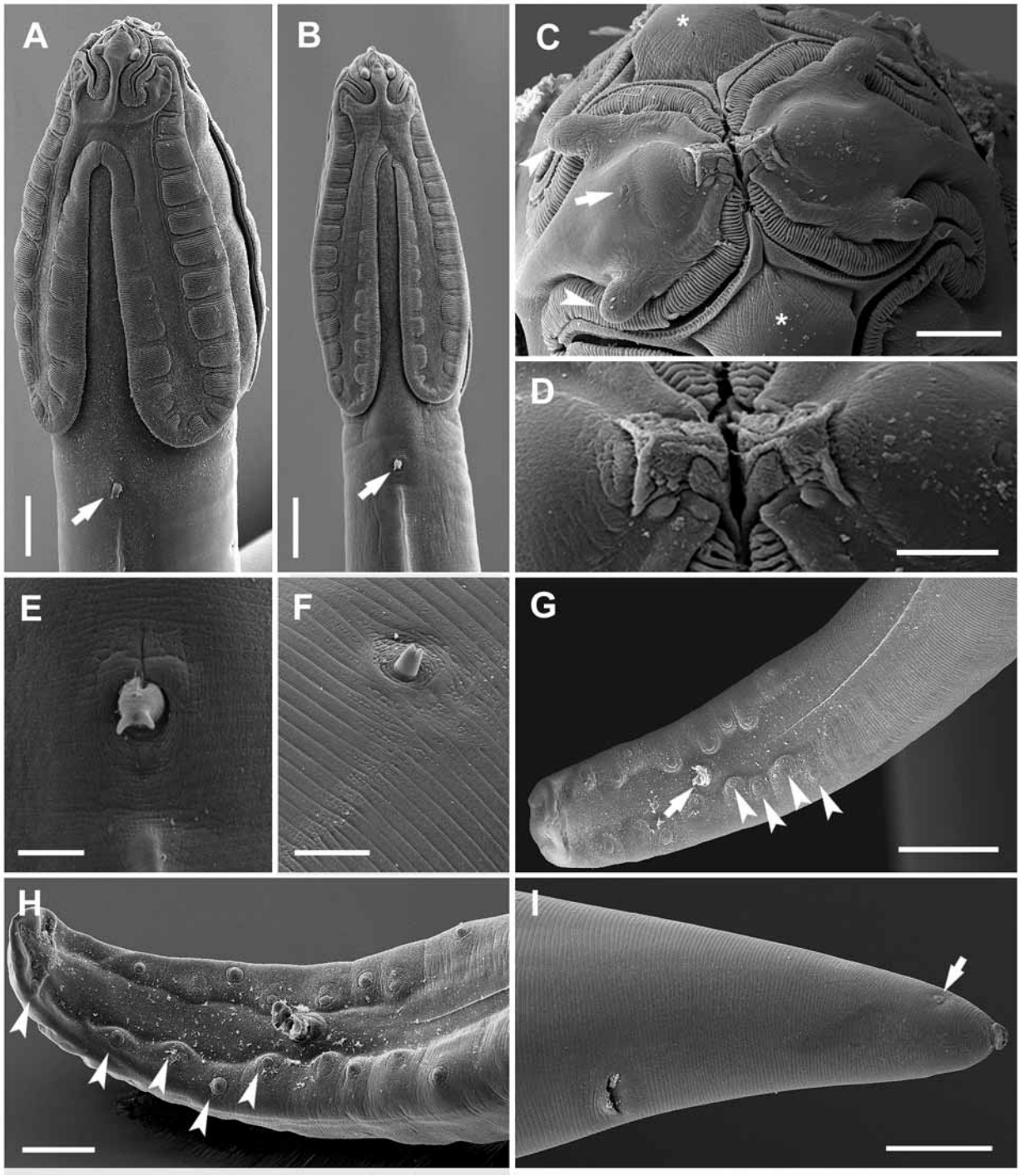

FIGURE 6 A–I. *Cosmocephalus obvelatus*, SEM. A. Anterior end, female, lateral view; note deirid (arrow); B. Anterior end, male, lateral view; note deirid (arrow); C. Pseudolabia, apical view; note cephalic papillae (arrowheads), amphid (arrow), cuticular swellings dorsally and ventrally at the bases of the pseudolabia (asterisks); D. Anterior end, apical view; note small pores; E. Deirid; F. Postdeirid. G. Posterior end, male, ventral view; note ventral cuticular ridge, precloacal papillae (arrowheads) and cloaca (arrow). H. Caudal alae, note postcloacal papillae (arrowheads). I. Posterior end, female, lateral view; note phasmid (arrow) and nipple-like projection. Scale bars: A, B, H, I = 50 μm; G = 100 μm; C, F = 20 μm; D, E = 10 μm.

Female (from *L. argentatus*, n=9 except otherwise stated). Body length 14.8–18.2 mm (16.6 mm). Maximum body width 402–456 (436), about mid-body; width 132–174 (150) at anus and 384–456 (414) at vulva. Cordons extending to 452–532 (490), recurrent in anterior direction to 97–122 (111) from anterior body end. Deirids and excretory pore at 474–590 (542) and 595–697 (639), respectively, from anterior body end. Left postdeirid and right postdeirid at 9.2–11.7 mm (10.6 mm) and 7.5–10.6 mm (9.3 mm) from anterior body end. Buccal cavity 456–519 (485) long, 14–17 (16) wide. Muscular oesophagus 1,055–1,284 (1,135) long, 70–89 (79) wide. Glandular oesophagus 3,922–4,375 (4,114) long, 147–182 (162) wide. Nerve ring at 469–550 (515) from anterior body end. Cuticle 14–16 thick. Distance between striations 6–7 μm. Lateral alae extending to level of vulva, 43–48 wide. Vulva at 7.8–9.8 mm (9.0 mm) from anterior body end. Reproductive system didelphic. *Vagina vera* short, posteriorly directed, separated from *vagina uterina* by well-developed circular musculature (Fig. 5C). *Vagina uterina* longer, with muscular walls. Posterior extremity of tail with button-like projection (Figs 5E; 6I). Eggs oval, 35–39 × 20–22 (37 × 21, n =20), containing first stage larva (Fig. 5G). $I_{CL/BL}$ 0.026–0.035 (0.030); $I_{mOE/gOE}$ 0.255–0.301 (0.276); $I_{OE/BL}$ 0.299–0.342 (0.316); $I_{V/BL}$ 0.520–0.570 (0.543).

Remarks. Anderson & Wong (1981) redescribed *Cosmocephalus obvelatus* and listed *C. diesingi* Molin, 1858, *Cosmocephalus obvelatus magnus* Vasil'kova, 1926, *C. firlottei* Rao, 1951, *C. tanakai* Rodrigues & Vicente, 1963 and *C. faridi* Khalil, 1931 as its junior synonyms. We consider that the synonymy of *C. faridi* (described from *Pelecanus onocrotalus* from Egypt) with *C. obvelatus* is not well-founded (see below). *C. obvelatus* is parasitic in a wide range of aquatic birds (see below) and its distribution is cosmopolitan (summarised from Anderson & Wong 1981; Baruš *et al*. 1978; Azuma *et al*. 1988; Smogorzhevskaya 1990; Diaz *et al*. 2001).

The nematodes from Bulgaria identified here as *C. obvelatus* correspond with the known range of morphological variation of this species as presented in previous studies (e.g. Cram 1927; Rao 1951; Bowie 1981; Smogorzhevskaya 1990; Diaz *et al*. 2001). However, our specimens exhibit shorter spicules and tails compared with the material from *Larus delawarensis* from Canada (Table 1) described by Anderson & Wong (1981). An explanation of the differences in these characters requires further study.

Our SEM observations are in agreement with results published by previous authors (Baruš & Majumdar 1975; Bowie 1981; Diaz *et al*. 2001; Frantová 2002). In addition to them, we describe the presence of a single ventral cuticular ridge situated anteriorly to the cloaca in male specimens (Fig. 6G, H). This structure was not mentioned in the previous descriptions of *C. obvelatus* but was documented in the illustrations of two articles (Diaz *et al*. 2001; Frantová 2002).

We consider *Cosmocephalus argentinensis* Boero & Led, 1970 as a synonym of *C. obvelatus*. The former species was described on the basis of a single female nematode collected from *Spheniscus magellanicus* (Forster) (Spheniscidae) from La Plata Zoo, Argentina (Boero & Led, 1970). Its description, including the metrical data (Table 1), coincides with that of females of *C. obvelatus*. Recent studies have demonstrated high prevalence and intensities of infection of *C. obvelatus* in the same host species (Diaz *et al*. 2001; Pazos *et al*. 2003). Diaz *et al*. (2001) considered *C. argentinensis* as a *species inquirenda*.

Cosmocephalus jaenschi Johnston & Mawson, 1941

Material studied: One male specimen (paratype, labelled 'cotype'), AHC 21265, mounted in glycerine jelly, one slide; host: *Phalacrocorax carbo* L. (Pelecaniformes, Phalacrocoracidae); locality: Tailem Bend, South Australia.

Redescription (Fig. 7A, B)

Body length 11.0 mm. Maximum body width 228, about mid-body; width 97 at level of cloaca. Tail 293 long. Anterior end with two triangular pseudolabia, each bearing single amphid and pair of prominent papillae. Pair of swellings situated dorsally and ventrally at bases of pseudolabia. Cordons arise dorsally and ventrally between pseudolabia, extending in longitudinal direction to 371 from anterior body end, recurrent and

anastomosing laterally at 102 from anterior body end (Fig. 7A). Each cordon consisting of a single row of cuticular plates (each c. 1.5 μm long) and longitudinal cuticular ridge along outer rims of plates; cuticular plates and longitudinal ridge delimiting deep, almost closed longitudinal groove. Maximum width of cordons 38. Deirids 18 long, tricuspid, at 453 from anterior body end. Excretory pore at 537 from anterior body end. Lateral alae well-developed, 17 wide, extending from level posterior of deirids to level about middle of body. Buccal cavity 389 long and 20 wide. Muscular oesophagus 929 long and 54 wide. Glandular oesophagus 3,770 long and 179 wide. Nerve ring at 421 from anterior body end. Cuticle 11–13 thick. Distance between cuticular striations 3–4 μm. Caudal alae 753 long. Single ventral cuticular ridge extending between level at 1,870 from posterior body end and beginning of caudal alae. Single median sessile precloacal papilla present. Nine pairs of pedunculate caudal papillae, 4 precloacal and 5 postcloacal (Fig. 7B). Anterior 3 pairs of postcloacal papillae with almost same distance between them; fourth pair at some distance from them; fifth pair at posterior end of tail. Sixth pair of postcloacal papillae sessile, smaller, situated between bases of last pedunculate papillae. Left spicule 672 long and 12 wide, with prominent projection on its distal end. Right spicule 159 long and 31 wide. Phasmids subterminal. $I_{CL/BL}$ 0.034; $I_{mOE/gOE}$ 0.249; $I_{OE/BL}$ 0.425; $I_{CA/BL}$ 0.068; $I_{LSP/RSP}$ 4.226.

Remarks. *Cosmocephalus jaenschi* was described on the basis of two male specimens obtained from *Phalacrocorax carbo* from Tailem Bend, Australia (Johnston & Mawson 1941). Johnston & Mawson (1942) described a single female specimen collected from *Pelecanus conspicillatus* as belonging to *C. jaenschi*. They mentioned that the two males from *P. carbo* had tricuspid deirids; in contrast, the female identified as the same species had bicuspid deirids. This questions the identification of the female specimen described by Johnston & Mawson (1942) and we consider that the morphology of female of this species remains unknown.

Johnston & Mawson (1941) did not mention the presence of lateral alae. Our study revealed the existence of lateral alae in the type material.

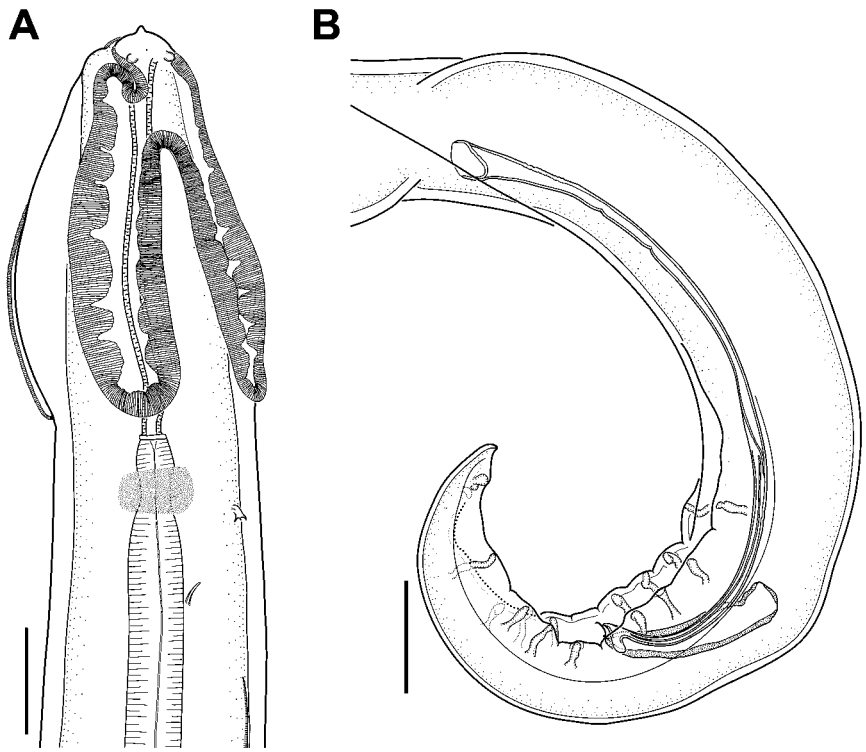

FIGURE 7 A, B. *Cosmocephalus jaenschi*, paratype, male. A. Anterior end, lateral view; B. Posterior end, lateral view. Scale bars: A, B = 100 μm.

***Cosmocephalus capellae* Yamaguti, 1935**

Material studied: One male specimen, CLGE-BAS N000.461; host: *Tringa totanus* L. (Charadriiformes, Scolopacidae); collected from Durankulak Lake, Bulgarian Black Sea coast (2 April 1986); site of infection: oesophagus.

Description (Fig. 8A–D)

Body length 5.5 mm. Maximum body width 179, about mid-body; width 86 at level of cloaca. Tail 220 long. Anterior end with two triangular pseudolabia, each bearing single amphid and pair of prominent papillae. Pair of swellings situated dorsally and ventrally at bases of pseudolabia (Fig. 8A). Cordons arise dorsally and ventrally between pseudolabia, extending in longitudinal direction to 241 from anterior body end, recurrent and anastomosing laterally at 74 from anterior body end (Fig. 8A). Cordons with slightly-expressed scalloped appearance of descending arm; maximum width of cordons 11 µm; cuticular plates delicate (each c. 1 µm long); cuticular ridge passing along outer rim of cuticular plates. Deep, almost closed longitudinal groove situated between plates and cuticular ridge. Deirids 12 long, at 270 from anterior body end, tricuspid. Excretory pore at 351 from anterior body end. Left postdeirid and right postdeirid at 3.3 mm and 3.5 mm, respectively, from anterior body end. Lateral alae well-developed, extending from level posterior of deirids to level about middle of body, 18 wide. Buccal cavity 237 long and 11 wide. Muscular oesophagus 451 long and 38 wide. Glandular oesophagus 2,418 long and 90 wide. Nerve ring at 261 from anterior body end. Cuticle 7 thick. Distance between cuticular striations 2–3 µm. Caudal alae 354 long. Single ventral cuticular ridge extending between level at 1,158 from posterior body end to caudal alae. Single median sessile precloacal papilla present. Nine pairs of pedunculate caudal papillae, 4 precloacal and 5 postcloacal (Fig. 8B). Anterior four pairs of postcloacal papillae with almost equal distance between them; fifth pair situated in posterior part of tail. Sixth pair of postcloacal papillae sessile, smaller, situated between bases of last pedunculate papillae. Left spicule 389 long, 12 wide, with prominent projection on its distal end (Fig. 8D). Right spicule 138 long, 28 wide (Fig. 8C). Phasmids subterminal. $I_{CL/BL}$ 0.044; $I_{mOE/gOE}$ 0.187; $I_{OE/BL}$ 0.519; $I_{CA/BL}$ 0.064; $I_{LSP/RSP}$ 2.819.

Remarks. *Cosmocephalus capellae* has been reported as a parasite of Scolopacidae, Charadriidae (Charadriiformes) and Anatidae (Anseriformes) from Europe (Iceland, Ukraine), Asia (Armenia, Uzbekistan, Kirghizia, Western Siberia, Japan) and North America (USA, Canada) (data summarised from Threlfall 1970; Smogorzhevskaya 1990; Wong & Anderson 1993). According to Smogorzhevskaya (1990), *C. capellae* has to be regarded as a specific parasite of Charadriidae and Scolopacidae; she believed that the two records of this species from ducks (*Anas querquedula* L. and *A. clypeata* L.) were accidental.

The nematode described by von Linstow (1877) as *Cosmocephalus obvelatus* (= *Filaria obvelata*) from *Tringa erythropus* (Pallas) (=*Totanus fuscus*) morphologically corresponds with *C. capellae*. Smogorzhevskaya (1990) presented a detailed description of *C. capellae*; however, there is a difference between the length of the left spicule as given in the text (710 µm) and the length as shown in the relevant illustration (about 420 µm).

The specimen from Bulgaria corresponds to the original description (Yamaguti 1935) (see Table 1). This is the first record of *C. capellae* from Bulgaria.

Discussion

Anderson & Wong (1981) considered four species valid within the genus *Cosmocephalus*: *C. obvelatus, C. imperialis, C. capellae* and *C. jaenschi*. They listed *C. diesingi* Molin, 1858, *C. faridi* Khalil, 1931, *C. firlottei* Rao, 1951 and *C. tanakai* Rodrigues & Vicente, 1963 as junior synonyms of *C. obvelatus*. This concept was followed by Smogorzhevskaya (1990) and Diaz *et al*. (2001).

We agree with the synonymy proposed by Anderson & Wong (1981), with the only exception being *C. faridi*. In our opinion, the latter species has to be considered valid. Its unique character among congeners is the highly-elongate loop of the cordon, reaching up to one third of the cordon length.

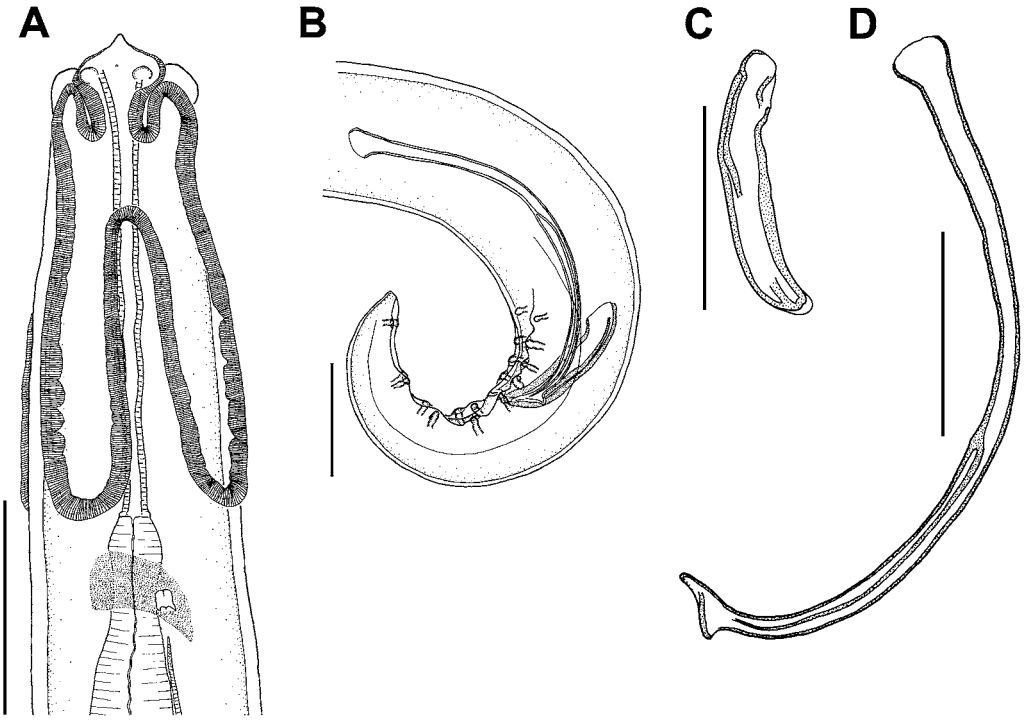

FIGURE 8 A–D. *Cosmocephalus capellae*, male. A. Anterior end, lateral view; B. Posterior end, lateral view; C. Right spicule, dextral view; D. Left spicule, sinistral view. Scale bars: A–D = 100 μm.

Currently, the genus *Cosmocephalus* includes the following species:

1. *C. obvelatus* (Creplin, 1825) Seurat, 1919. Synonyms *C. diesingi* Molin, 1858 (type species of the genus *Cosmocephalus*), *C. obvelatus magnus* Vasil'kova, 1926, *C. papillosus* Molin, 1859, *C. alatus* Molin, 1860, *C. firlottei* Rao, 1951, *C. tanakai* Rodrigues & Vicente, 1963, *C. argentinensis* Boero & Led, 1970, new synonymy. Hosts: Spheniscidae (Sphenisciformes), Laridae, Alcidae, Sternidae, Stercorariidae, Scolopacidae, Rhynchopidae (Charadriiformes), Anatidae (Anseriformes), Phalacrocoracidae, Pelecanidae (Pelecaniformes), Procellariidae (Procellariiformes), Podicipedidae (Podicipediformes), Gaviidae (Gaviiformes), Ardeidae, Threskiornithidae (Ciconiiformes). This species has a cosmopolitan distribution (data summarised on the basis of the works by Baruš *et al*. 1978; Anderson & Wong 1981; Azuma *et al*. 1988; Smogorzhevskaya 1990; Diaz *et al*. 2001).

The synonymy presented follows Seurat (1919) and Anderson & Wong (1981); the new synonymy of *C. argentinensis* and *C. obvelatus* is discussed above.

2. *C. imperialis* Morishita, 1930 from *Uria aalge* (Pontoppidan) (= *Uria troile*) (Alcidae, Charadriiformes) on Sakhalin Island, Russia.

3. *C. faridi* Khalil, 1931 from *Pelecanus onocrotalus* (Pelecanidae) in Egypt. This species is known from its original description only (Khalil 1931).

4. *C. capellae* Yamaguti, 1935 from Scolopacidae, Charadriidae (Charadriiformes) and Anatidae (Anseriformes) from Europe, Asia and North America (Threlfall 1970; Smogorzhevskaya 1990; Wong & Anderson 1993).

5. *C. jaenschi* Johnston & Mawson, 1941 from Phalacrocoracidae (Pelecanidae) in Australia (Johnston & Mawson 1941). As discussed above, the record (accompanied with a description of a female specimen) from Pelecanidae from Australia (Johnston & Mawson 1942) is related to another species, probably *C. pelecani* **n. sp.** The subsequent records were from *Phalacrocorax* spp. from Tasmania and New Zealand (Johnston & Mawson 1944, 1945). The record from Sternidae (Charadriiformes) in Australia (Mawson 1969) has not been accompanied by descriptions or illustrations and requires additional confirmation.

6. *C. podicipis* **n. sp.** from grebes (*Podiceps* spp.) in the Palaearctic (present study).

7. *C. pelecani* **n. sp.** from *Pelecanus conspicillatus* from Australia (present study).

Two other species were originally described as members of the genus *Cosmocephalus*. These are *Synhimantus australiensis* (Johnston & Mawson, 1952) Yamaguti 1961 from *Hydromys chrysogaster* (Geoffroy) (Mammalia: Rodentia: Muridae) in Australia and *Synhimantus asturis* (Yorke & Maplestone, 1926) Anderson & Wong, 1981 from "*Astur tachina* (Falconidae), Brazil" (Anderson & Wong 1981) or "*Astur tachino*, Natal" (Yamaguti 1961), which is probably *Accipiter tachiro* (Daudin, 1800) (Accipitridae), with the nominotypical subspecies *Accipiter tachiro tachiro* occurring from Mozambique and Angola to Cape Province (Howard & Moore 1980). The structure of their cordons differs from those of the genus *Cosmocephalus* by the lack of anterior loops; therefore, we follow Yamaguti (1961) and Anderson & Wong (1981), respectively, in considering these two species outside the genus *Cosmocephalus*. Beveridge & Barker (1975) also confirmed the allocation of *S. australiensis* in the genus *Synhimantus*.

The previous studies on *Cosmocephalus* spp. did not mention the single ventral cuticular ridge situated anterior to the cloaca of the males. This ventral cuticular ridge was documented by SEM micrographs of the posterior end of the males of *C. obvelatus* in the papers by Diaz *et al*. (2001) in their Fig. 6 and Frantová (2002) in her Fig. 8D. We observed this character in the males of all the species studied by us, i.e. in *C. obvelatus, C. capellae, C. jaenschi, C. podicipis* and *C. pelecani*. Therefore, we consider that this structure has to be included in the generic diagnosis. We interpret this structure as homologous to the *area rugosa* described in other acuariid genera, e.g. *Voguracuaria* Wong & Anderson, 1993 (see Wong & Anderson 1993), *Pectinospirura* Wehr, 1933 (see Wang 1976; Wong & Anderson 1982; Zhang 1990; Cremonte & Navone 1999), *Skrjabinoclava* Sobolev, 1943 (see Wong & Anderson 1987), *Xenocordon* Mawson, 1982 (see Mawson 1982) and *Dispharynx* Railliet, Henry & Sisoff, 1912 (see Mawson 1982; Zhang *et al*. 2004). Similar structures were described in members of the genus *Skrjabinocerca* Shikhobalova 1930 as the *crista media ventralis* (Shikhobalova 1930), a "single row of cuticular folds" (Wong & Anderson 1993; Diaz *et al*. 2005) and a "ventral preanal cuticular crest" (Bartlett *et al*. 1989).

On the basis of our observations, we propose the following amended diagnosis of the genus *Cosmocephalus* (after Smogorzhevskaya 1990, with modifications):

Medium-sized acuariids. Cuticle transversely striated, thicker in anterior part of body. Anterior end with two triangular pseudolabia, each with weekly-developed apex. Each pseudolabium bearing single amphid and pair of prominent papillae. Cordons arise dorsally and ventrally between pseudolabia; each cordon forming loop near bases of pseudolabia, then extending in posterior direction to level between buccal cavity and anterior part of muscular oesophagus, recurrent in anterior direction and anastomosing laterally. Each cordon consisting of single inner row of cuticular plates and longitudinal cuticular ridge passing along outer rims of plates; row of plates and cuticular ridge delimiting longitudinal canal. Pair of cuticular swellings situated dorsally and ventrally between bases of cordons. Deirids medium-sized, with two or three small cusps, posterior to cordons. Excretory pore posterior to deirids. Lateral alae typically present (absent in *C. pelecani*). Buccal cavity long. Glandular oesophagus at least three times longer than muscular oesophagus. Nerve ring surrounding anterior end of muscular oesophagus. Males with nine pairs pedunculate caudal papillae, four precloacal and five postcloacal; one pair sessile papillae at bases of last pair of predunculate papillae. Left spicule long and slender. Right spicule short and robust. Single ventral cuticular ridge present, situated anteriorly to cloaca. Females with vulva at about middle of body length. *Vagina vera* short, *vagina uterina* longer. Uterus didelphic. Tail apex with projection. Parasitic in oesophagus, rarely in stomach of aquatic birds. Cosmopolitan. Type species: *C. diesingi* Molin, 1858, a junior synonym of *C. obvelatus* (Creplin, 1825).

On the basis of the present observations and the critical analysis of the previous publications, we propose the following key for identification of the species of the genus *Cosmocephalus*. We consider that the differences between *C. obvelatus* and *C. imperialis* are not reliable. The variability of the latter species is poorly studied. When more material from Pacific alcids is available, it might be that it is a junior synonym of *C. obvelatus*. Currently, we consider it as a *species inquirenda*.

Key to the species of *Cosmocephalus*

1a. Anterior loops of cordons reach between one quarter and one third of the length of cordons..... *C. faridi*
1b. Anterior loops of cordons markedly shorter, do not exceed one quarter of the length of cordons..... 2
2a. Lateral alae absent ..... *C. pelecani*
2b. Lateral alae present 3
3a. Deirids bicuspid 4
3b. Deirids tricuspid..... 6
4a. Cordons with both descending and ascending arms scalloped 5
4b. Cordons with descending arm scalloped, ascending arm not scalloped..... *C. podicipis*
5a. Cordons shorter than 450 µm in males and than 550 µm in females, rarely longer; distal end of left spicule with sub-terminal projection ..... *C. obvelatus*
5b. Cordons 450–470 µm long in males and 540–650 µm long in females; tip of left spicule pointed, without projection ..... *C. imperialis*
6a. Cordons with well-expressed scalloped structure; inner row of plates 38 µm wide in males; left spicule more than 600 µm long ..... *C. jaenschi*
6b. Cordons not scalloped, width 25 in female and 20 in males; left spicule less than 400 µm long ..... *C. capellae*

Acknowledgements

Dr J. Mansoori (Tonekabon Islamic Azad University, Iran) kindly helped one of the present authors (AH) with identification of the host species. We are grateful to Dr L. Chisholm and Dr I. Whittington (South Australian Museum, Adelaide, Australia) for lending specimens. Dr J.M. Kinsella (HelmWest Laboratory, Missoula, Montana, USA) and Dr S.R. Martorelli (Centro de Estudios Parasitológicos y Vectores, La Plata, Argentina) helped with some important literature. SEM observations were carried out using facilities of the Museum für Naturkunde der Humboldt-Universität zu Berlin, Germany, in the course of a research visit of the senior author granted by Synthesys DE-TAF-3124 (EC FP6) and kindly hosted by Dr B. Neuhaus. Dr C.O. Coleman of the same museum kindly trained the senior author in digital inking. The open access fee for the present publication is covered by the EC-funded project WETLANET (FP7, Programme *Capacities*). Studies included in the present article were also funded by the National Science Fund of the Republic of Bulgaria, Grant DO/02-271/18.12.08.

References

Anderson, R.C. & Wong, P.L. (1981) Redescription of *Cosmocephalus obvelatus* (Creplin, 1825) (Nematoda: Acuarioidea) of *Larus delawarensis* Ord. (Laridae). *Canadian Journal of Zoology*, 59, 1897–1902.

Azuma, H., Okamoto, M., Ohbayashi, M., Nishine, Y. & Mukai, T. (1988) *Cosmocephalus obvelatus* (Creplin, 1825) (Nematoda: Acuariidae) collected from the esophagus of rockhopper penguin, *Eudyptes crestatus*. *Japanese Journal of Veterinary Research*, 36, 73–77.

Bartlett, C.M., Anderson, R.C. & Wong, P.L. (1989) Development of *Skrjabinocerca prima* (Nematoda: Acuarioidea) in *Hyalella azteca* (Amphipoda) and *Recurvirostra americana* (Aves: Charadriiformes), with comments on its precocity. *Canadian Journal of Zoology*, 67, 2883–2892.

Baruš, V. & Majumdar, G. (1975) Scanning electron microscopic studies on the cordon structures of seven acuariid genera (Nematoda: Acuariidae). *Folia Parasitologica*, 22, 125–131.

Baruš, V., Sergeeva, T.P., Sonin, M.D. & Ryzhikov, K.M. (1978) *Helminths of Fish-Eating Birds of the Palaearctic Region. I.* Academia, Moscow-Prague, 319 pp.

Beveridge, I. & Barker, I.K. (1975) Acuariid, capillariid and hymenolepidid parasites of the dasyurid marsupial *Antechinus stuartii* Macleay, 1841, from southeastern Australia. *Journal of Helminthology*, 49, 211–227.

Boero, J.J. & Led, J.E. (1970) El parasitismo de la fauna autóctona. VI. Los parásitos de la avifauna argentina. V. *Jornadas de Veterinaria, Facultad de Ciencias Veterinarias, La Plata*, 2, 65–71.

Bowie, J.Y. (1981) Redescription of *Cosmocephalus tanakai* Rodrigues & Vicente (Nematoda: Acuariidae), a parasite of the southern blackbacked gull in New Zealand. *New Zealand Journal of Zoology*, 8, 249–253.

Cram, E.B. (1927) Bird parasites of the nematode suborder Strongylata, Ascaridata, and Spirurata. *US National Museum*

Bulletin, 140, 1–465.
Cremonte, F. & Navone, G.T. (1999) Co-occurrence of *Pectinospirura argentata* Wehr, 1933, *Skrjabinoclava andersoni* n. sp. and larvae (Nematoda: Acuariidae) in the proventriculus of *Larus dominicanus* Lichtenstein (Aves: Laridae), with notes on their attachment. *Systematic Parasitology*, 42, 203–211.
Diaz, J.I., Navone, G.T. & Cremonte, F. (2001) New host and distribution records of *Cosmocephalus obvelatus* (Creplin, 1825) (Nematoda: Acuariidae), with morphometric comparison. *Comparative Parasitology*, 68, 277–282.
Diaz, J.I., Cremonte, F., Navone, G.T. & Laurenti, S. (2005) Adults and larvae of *Skrjabinocerca canutus* n. sp. (Nematoda: Acuariidae) from *Calidris canutus rufa* (Aves: Scolopacidae) on the southern Southwest Atlantic coast of South America. *Systematic Parasitology*, 60, 113–123.
Frantová, D. (2002) On the morphology and surface ultrastructure of some parasitic nematodes (Nematoda) of birds (Aves). *Acta Societatis Zoologicae Bohemicae*, 66, 85–97.
Gushanskaya, L.I. (1950) [Study of Spirurata from water birds on the USSR]. *Trudy Gel'mintologicheskoy Laboratorii Akademii Nauk SSSR*, 4, 55–63 (in Russian).
Johnston, T.H. & Mawson, P.M. (1941) Additional nematodes from Australian birds. *Transactions of the Royal Society of South Australia*, 65, 254–262.
Johnston, T.H. & Mawson, P.M. (1942) Remarks on some parasitic nematodes. *Records of the South Australian Museum*, 7, 183–186.
Johnston, T.H. & Mawson, P.M. (1944) Remarks on some parasitic nematodes from Australia and New Zealand. *Transactions of the Royal Society of South Australia*, 68, 60–66.
Johnston, T.H. & Mawson, P.M. (1945) Parasitic nematodes. *BANZ Antarctic Research Expedition, Reports, Series B*, 5, 73–159.
Johnston, T.H. & Mawson, P.M. (1952) Some nematodes from Australian birds and mammals. *Transactions of the Royal Society of South Australia*, 75, 30–37.
Howard, R. & Moore, A. (1980) *A Complete Checklist of the Birds of the World*. Oxford University Press, Oxford, 701 pp.
Khalil, M.B. (1931) On two new species of nematodes from *Pelecanus onocrotalus. Annals of Tropical Medicine and Parasitology*, 25, 455–460.
Kibakin, B.B (1965) [Helminth parasites of birds in Gasan-Kuli Reserve]. *Materialy k nauchnoy konferencii Vsesoyuznogo obshtestva gel'mintologov*, 1, 108–111 (in Russian).
Mawson, P.M. (1969) Some nematodes from Australian gulls and terns. *Journal of the Fisheries Research Board of Canada*, 26, 1103–1111.
Mawson, P.M. (1982) Some Acuariinae (Nematoda) from Australian birds. *Transactions of the Royal Society of South Australia*, 106, 19–30.
Molin, R. (1858) Prospectus helminthum, quae in prodromo faunae helminthologicae Venetiae continentur. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe*, 30, 127–158.
Molin, R. (1859) Cephalocotylea e Nematoidea. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe*, 38, 7–38.
Molin, R. (1860) Ternta specie di Nematoidi. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch- Naturwissenschaftliche Classe*, 40, 331–358.
Morishita, K. (1930) Two nematode parasites of the guillemot. *Japanese Journal of Zoology*, 3, 61–72.
Pazos, G.E., Laurenti, S. & Díaz, J.I. (2003) Helmintofauna del pingüino de Magallanes (*Spheniscus magellanicus*) en Península Valdes, Provincia del Chubut. Resultados preliminares. *Historia Natural* (*Segunda Serie*), 2, 85–94.
Rao, N.S.K. (1951) *Cosmocephalus firlottei* n. sp. (family Acuariidae) from the sea gull (*Larus argentatus*). *Canadian Journal of Zoology*, 29, 173–177.
Seurat, L.G. (1919) Dispharages (Nématodes) de l'Afrique mineure. *Novitates Zoologicae*, 26, 179–189.
Shikhobalova, N. (1930) On a new genus of the nematoda fam. Acuariidae Seurat, 1913. *Journal of Parasitology*, 16, 220–223.
Smogorzhevskaya, L.A. (1990) [Nematodes. Part 3. Acuarioidea.] *In*: Sharpilo, V.P. (Ed.), *Fauna Ukrainy. Vol. 32*. Naukova Dumka, Kiev, 188 pp. (in Russian).
Spasskaya, L.P. (1949) [Nematodes parasites in birds from Western Siberia collected during the 257th helminthological expedition of the Soviet Union]. *Trudy Gel'mintologicheskoy Laboratorii Akademii Nauk SSSR*, 11, 128–142 (in Russian).
Storer, R.W. (2000) The metazoan parasite fauna of grebes (Aves: Podicipediformes) and its relationship to the birds' biology. *Miscellaneous Publications of the Museum of Zoology, University of Michigan*, 188, 1–90.
Threlfall, W. (1970) A preliminary check list of the helminth parasites of the Common Snipe, *Capella gallinago* (Linnaeus). *American Midland Naturalist*, 84, 13–19.
von Linstow, O. (1877) Enthelminthologica. *Archiv für Naturgeschichte*, 43, 173–198.
Wang, P. (1976) Note on some new nematodes of the suborder Spirurata from Fujian, China. *Acta Zoologica Sinica*, 22,

393–402 (in Chinese).
Wong, P.C. & Anderson, R.C. (1982) Redescription of *Pectinospirura argentata* Wehr, 1933 (Nematoda: Acuarioidea) from *Larus delawarensis* Ord (Laridae). *Canadian Journal of Zoology*, 60, 1940–1944.
Wong, P.C. & Anderson, R.C. (1987) New and described species of *Skrjabinoclava* Sobolev, 1943 (Nematoda: Acuarioidea) of the proventriculus of nearctic waders (Aves: Charadriiformes) with a review of the genus and a key to species. *Canadian Journal of Zoology*, 65, 2760–2779.
Wong, P.L. & Anderson, R.C. (1993) New and described species of nematodes from shorebirds (Charadriiformes) collected in spring in Iceland. *Systematic Parasitology*, 25, 187–202.
Yamaguti, S. (1935) Studies on the helminth fauna of Japan. Part. 12. Avian nematodes, I. *Japanese Journal of Zoology*, 6, 403–431.
Yamaguti, S. (1961) *Systema Helminthum. Volume 3. The Nematodes of Vertebrates. Part 1*. Interscience Publishers, New York and London, 679 pp.
Yorke, W., & Maplestone, P.A. (1926) *The Nematode Parasites of Vertebrates*. J. & A. Churchill, London, 536 pp.
Zhang, L. (1990) Three new species of Acuarioidea from birds from Fujian, China. *Sichuan Journal of Zoology*, 9, 1–4 (in Chinese).
Zhang, L., Brooks, D.R. & Causey, D. (2004) Two species of *Synhimantus* (*Dispharynx*) Railliet, Henry and Sisoff, 1912 (Nematoda: Acuarioidea: Acuariidae), in passerine birds from the Area de Conservacion Guanacaste, Costa Rica. *Journal of Parasitology*, 90, 1133–1138.