



New Annotated Records of Helminth Parasites with Light Microscopy II. Acanthocephala (Polymorphida)

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Research Article

Volume 6 Issue 6

Received Date: October 31, 2023

Published Date: December 05, 2023

DOI: 10.23880/izab-16000530

Abstract

We give an account of 8 species of polymorphid acanthocephalans in 3 families collected from 14 various host species in different geographical locations. Each species account is annotated and morphologically presented using light microscopy showing characteristic diagnostic features. None of these accounts has been previously published. All geographical records and many host associations are new. This treatment includes *Centrorhynchus spinosus* (Kaiser, 1893) adults from *Strix aluco* Linn. in Iran and cystacanths from *Osteopilus septentrionalis* (Duméril & Bibron) in Florida; *Sphaerirostris lancea* (Westrumb, 1821) from *Vanellus vanellus* (Linn.) in Ukraine; *Sphaerirostris picae* (Rudolphi, 1819) Golvan, 1956 from various hosts in Ukraine, Iran, Bulgaria and Egypt (Centrorhynchidae); *Plagiorhynchus (Prosthorhynchus) cylindraceus* (Goeze, 1782) Schmidt & Kuntz, 1966 from *Turdus merula* Linn. in Iran and *Sturnus vulgaris* Linn. in Wisconsin; *Plagiorhynchus (Prosthorhynchus) nicobarensis* Soota & Kansal, 1970 from *S. vulgaris* in Iran (Plagiorhynchidae); *Andracantha gravida* (Algret, 1941) Schmidt, 1975 from *Gavia immer* (Brunnich) in Florida; *Arhythmorhynchus brevis* Van Cleave, 1916 from *Casmerodius albus* (Linn.) in Florida, and *Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932 (= *Polymorphus ardeae* Belopolskaya, 1958) from *Ardea cinerea* Linn. in Macedonia and from *Nycticorax violaceus* (Linn.) in Florida.

Keywords: Acanthocephala; Polymorphida; Wildlife; Descriptions; Distribution; Light Microscopy

Introduction

We have collected thousands of parasitic organisms from vertebrates over the years as part of an overall research program from North America and elsewhere in the world. Other collections were gifted to us for diagnosis or for joint research efforts. Significant collections were published. A few others were just saved and put aside after having been processed as whole mounts as reference material for future examination. We have started this series of investigations

by exploring a small group of digeneans, cestodes, and nematodes that have not been previously studied or published by Amin and Rubtsova [1]. The polymorphid acanthocephalans are the subject matter of this study.

We have studied morphometrically, geographically, and historically adults and cystacanths of *Centrorhynchus spinosus* (Kaiser, 1893) from birds and amphibians, respectively, and described males from Iran. We have similarly studied *Sphaerirostris lancea* (Westrumb, 1821) and described

males and females from Ukraine as well as 4 populations of another centrarchid acanthocephalan, *S. picae* (Rudolphi, 1819), from Ukraine, Iran, Bulgaria, and Egypt to evaluate its intraspecific variability. Our few specimens of *Plagiorhynchus cylindraceus* (Goeze, 1782) from the US and from Iran are compared with those from South Africa, Russia, Ukraine, and Taiwan. *Plagiorhynchus (Prosthorhynchus) nicobarensis* Soota and Kansal, 1970 was studied from a new population in Iran that varied from its original Indian specimens and our material of *Andracantha grandidi* (Algret, 1941) Schmidt, 1975 showed marked variations from those described from Cuba and Florida. Our specimens of *Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932 were originally described as *Polymorphus ardeae* Belopolskaya, 1958 from *Ardea cinerea* Linn. in Macedonia and we have also described more specimens from *Nycticorax violaceus* (Linn.) in Florida. The ecological implications of this taxonomic treatment are inescapable. The new host records in added geographical locations often unrelated to those of original descriptions reflect adaptations to a wider range of host specializations in different environments.

Materials and Methods

The specimens reported in this presentation were collected using routine methods for the examination of relevant hosts. For microscopical examination, specimens were placed in water overnight or until fully extended then fixed in 70% ethanol. Acanthocephalans were punctured with a fine needle and subsequently stained in Mayer's acid carmine, de-stained in 4% hydrochloric acid in 70% ethanol, dehydrated in ascending concentrations of ethanol (24 hr each), and cleared in 100% xylene then in 50% Canada balsam and 50% xylene (24 hr each). Whole worms were then mounted in Canada balsam. Optical microscope images were acquired using a BH2 light Olympus microscope (Olympus Optical Co., Osachi-shibamiya, Okaya, Nagano, Japan) attached to an AmScope 1000 video camera (United Scope LLC, dba AmScope, Irvine, California), linked to an ASUS laptop

equipped with HDMI high-definition multimedia interface system (Taiwan-USA, Fremont, California). Measurements are in micrometers unless otherwise noted; the range is followed by the mean values between parentheses when appropriate. Width measurements represent maximum width.

Results

Eight species of acanthocephalans reported from vertebrate hosts in 14 different geographical regions of the world are listed in Table 1 along with their hosts and localities from where they were collected. Morphological notes along with light microscopy images of major diagnostic features are included. Collectors' information when known and dates are also included.

Centrorhynchus spinosus (Kaiser, 1893) Van Cleave, 1924

Polymorphida (Centrorhynchidae) (Figures 1, 2)

Van Cleave [2] (p. 513) corrected the record of *C. spinosus* in his following statement "Echinorhynchus spinosus was originally described by Kaiser from an unrecorded host from Florida." The present writer (Van Cleave) [3], misinterpreting Kaiser's description, described and renamed the same species *Centrorhynchus spinosus* (based on one female). Several birds, all from Florida, have been listed as hosts for this species." The acanthocephalan has been since found in Russia [4] and Van Cleave [2] also described females from the "Galapagos hawk". We have 2 males and one fragmented gravid female collected from *Strix aluco* Linn. by Dr. Ali Halajian in Iran representing new records. All internal structures of the female were obscured by eggs. This appears to be a host-specific parasite found in only very few hosts including the great grey owl *Strix nebulosa* Forster in Russia [4].

Parasite	Host	Distribution
Centrorhynchidae		
<i>Centrorhynchus spinosus</i> (Kaiser, 1893) Van Cleave, 1924	<i>Strix aluco</i> , Linn, tawny owl	Iran
<i>Centrorhynchus spinosus</i> (Kaiser, 1893) Van Cleave, 1924 cystacanth	<i>Osteopilus septentrionalis</i> (Duméril & Bibron), Cuban tree frog	Tampa, Florida
<i>Sphaerirostris lancea</i> (Westrumb, 1821)	<i>Vanellus vanellus</i> (Linn.), Northern lapwing	Ukraine
<i>Sphaerirostris picae</i> (Rudolphi, 1819) Golvan, 1956	<i>Pica pica</i> (Linn.), Eurasian magpie and <i>Corvus</i> sp., crows & ravens	Ukraine

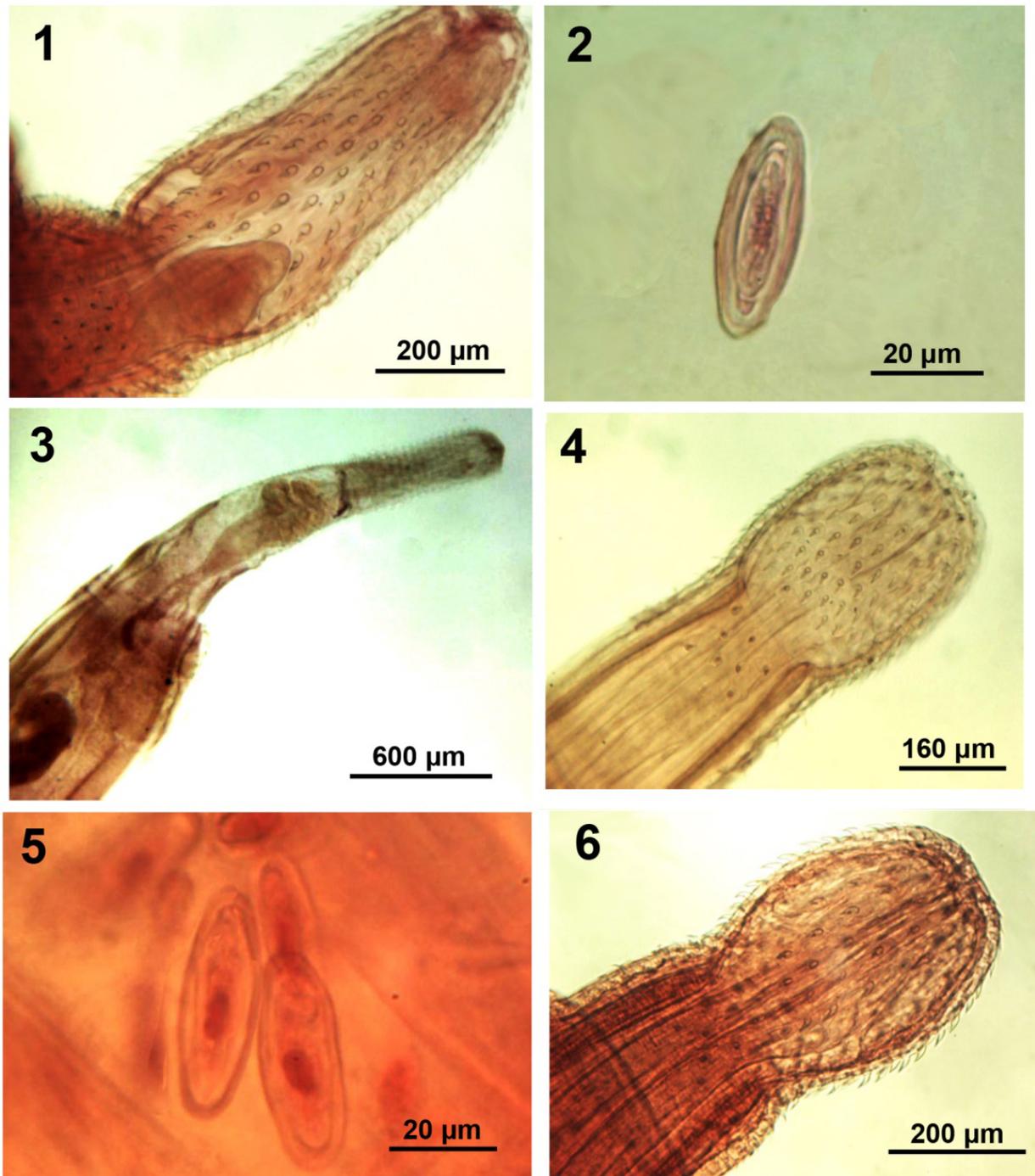
<i>Sphaerirostris picae</i> (Rudolphi, 1819) Golvan, 1956	<i>Pica pica</i> (Linn.), Eurasian magpie	Bulgaria
<i>Sphaerirostris picae</i> (Rudolphi, 1819) Golvan, 1956	<i>Corvus corone</i> Linn., Carrion crow & <i>Corvus frugilegus</i> Linn., Rook	Iran
<i>Sphaerirostris picae</i> (Rudolphi, 1819) Golvan, 1956	<i>Corvus corone</i> Linn., Carrion crow	Nile Delta, Egypt
Plagiorhynchidae		
<i>Plagiorhynchus (Prosthorhynchus) cylindraceus</i> (Goeze, 1782) Schmidt & Kuntz, 1966	<i>Turdus merula</i> Linn., blackbird	Iran
<i>Plagiorhynchus (Prosthorhynchus) cylindraceus</i> (Goeze, 1782) Schmidt & Kuntz, 1966	<i>Sturnus vulgaris</i> Linn., common starling	Kenosha, Wisconsin
<i>Plagiorhynchus (Prosthorhynchus) nicobarensis</i> Soota & Kansal, 1970	<i>Sturnus vulgaris</i> Linn., common starling	Iran
Polymorphidae		
<i>Andracantha gravis</i> (Algre, 1941) Schmidt, 1975	<i>Gavia immer</i> (Brunnich), common loon	Franklin Co., Florida
<i>Arhythmorhynchus brevis</i> Van Cleave, 1916	<i>Casmerodius albus</i> (Linn.), great egret	Florida
<i>Southwellina hispida</i> (Van Cleave, 1925) Witenberg, 1932	<i>Ardea cinerea</i> Linn., grey heron	Nestos River Delta, East Macedonia
<i>Southwellina hispida</i> (Van Cleave, 1925) Witenberg, 1932	<i>Nycticorax violaceus</i> (Linn.), yellow- crowned night heron	Snell Island, Florida

Table 1: Acanthocephala (Polymorphida) reported from wildlife in this paper and their hosts and geographical distribution.

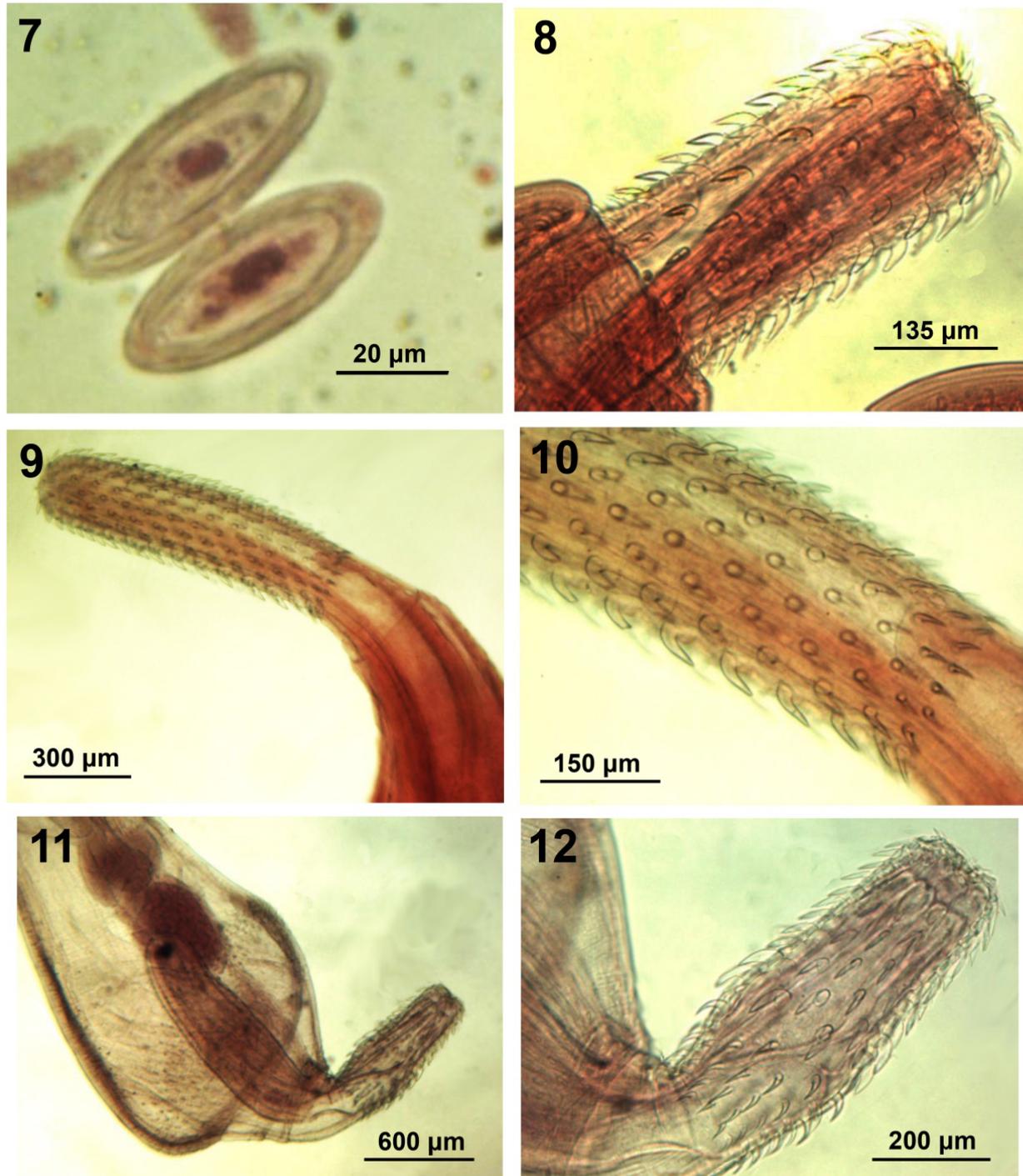
Available measurements of females especially those by Van Cleave [2,5,6] were confused giving trunk length of 20.00-60.00 mm, proboscis length of 0.65-1.00-1.30 mm, 30-34 proboscis hook rows of 22-24 hooks each measuring 38-48-60 long anteriorly and 50 posteriorly. Van Cleave [5] gave a count of 24 hooks per row but reported in 1924 9-12 rooted hooks anteriorly and 14-16 spine-like hooks posteriorly. He [6] (p. 296) emphasized "the great variability in the size of the proboscis hooks and thorns....that were even continuous in the same females." The determination of *C. spinosus* from India by Pujatti [7] was apparently in error as recognized by Golvan [8]. Similarly, Schmidt and Neiland [9] also recognized erroneous identifications of three Old World parasites of hawks that have the same number and arrangement of hooks as *C. spinosus*. Yamaguti (1963, p.126) referred to 30.00-45.00 mm long males and Nickol's [10] description of *C. spinosus* summarized previous taxonomic treatments and is used here as a reference point for comparison. Richardson and Nickol [11] provided a useful key to species of *Centrorhynchus* in North America which identifies *C. spinosus* with 8-11 anterior hooks in each longitudinal row and with trunk lacking anterior conspicuous inflation which agrees with our specimens. Similarly, Khokhlova [12] discussed the

status of *C. spinosus* in the USSR and provided a key of the 15 known species of *Centrorhynchus* there.

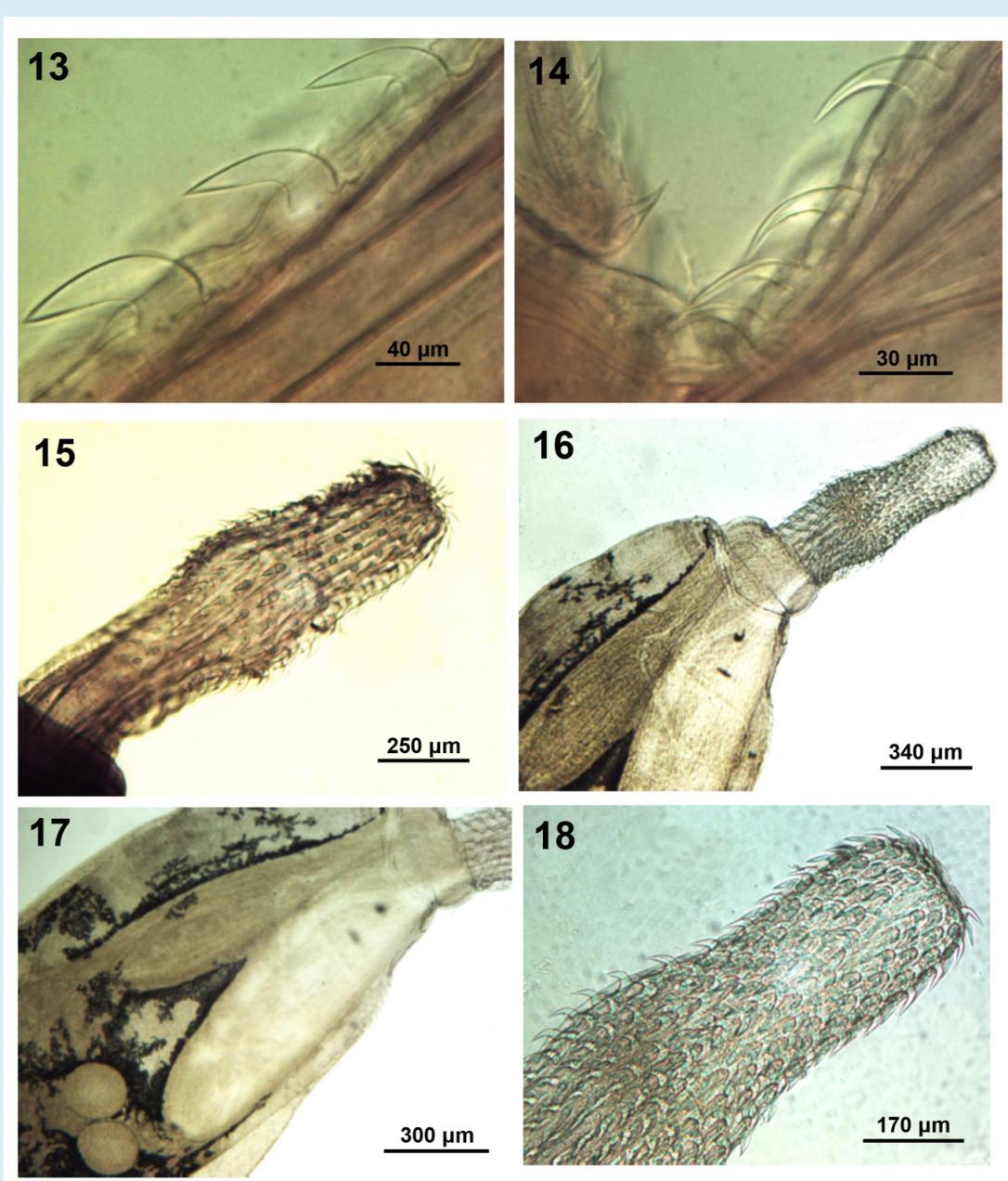
First Description of Male *Centrorhynchus spinosus* from *Strix aluco* in Iran: Based on two mature adults; one is fragmented. Trunk long, cylindroid, slightly inflated anteriorly, 23.37 mm long by 0.92 wide anteriorly. Proboscis (Fig. 1) 0.95-1.09 long. Anterior proboscis 525-650 long by 333-354 wide with 9-14 rooted hooks per row measuring maximum of 52-75 anteriorly and becoming most robust at middle and transitional posteriorly. Posterior proboscis 315-425 long by 364-385 wide with 8-9 curved spiniform hooks per row measuring maximum of 45-48 anteriorly. Internal anatomy of proboscis shows receptacle process (Fig. 1). Proboscis receptacle double walled, 1.30-1.37 mm long by 0.27 mm wide with cephalic ganglion near middle. Lemnisci longer than receptacle, 2.17 mm long by 0.16 mm wide. Testes close but not contiguous, 0.62-1.07 mm long by 0.40-0.50 mm wide, pre-equatorial, 4.50 mm from anterior trunk. Four tubular cement glands 11.25 mm long by 0.42 mm wide anteriorly. Saeftigen's pouch 2.80 mm long. Eggs oblong with concentric shells and some polar prolongation of fertilization membrane (Fig. 2).



Figures 1-6: Morphology of polymorphid acanthocephalans from wildlife. 1, 2. Proboscis and egg of an adult *Centrorhynchus spinosus* from *Strix aluco* in Iran. Note the receptacle process (Fig. 1) 3. Anterior portion of a cystacanth of *Centrorhynchus spinosus* from *Osteopilus septentrionalis* in Florida. 4, 5. Proboscis and eggs of *Sphaerirostris lancea* from *Vanellus vanellus* in Ukraine. 6. Proboscis of *Sphaerirostris picae* from *Pica pica* in Bulgaria.



Figures 7-12: Morphology of polymorphid acanthocephalans from wildlife. 7. Eggs of *Sphaerostris picae*. 8. Partially invaginated proboscis of *Sphaerostris picae*. 9, 10. Proboscis of *Plagiorhynchus (Prosthorhynchus) nicobarensis* from *Sturnus vulgaris* in Iran. Note the basal hooks in perfect circle (Fig. 10). 11, 12. Anterior portion and proboscis of *Andracantha gravidata* male from *Gavia immer* in Florida.



Figures 13-18: Morphology of polymorphid acanthocephalans from wildlife. 13, 14. Middle and posterior hooks and anterior trunk spines of the male specimen. 15. Proboscis of *Arhythmorhynchus brevis* from *Casmerodius albus* in Florida. 16-18. Anterior parts of a male *Southwellina hispida* from *Ardea cineria* in Macedonia showing the comparable shape and size of the lemnisci and the receptacle as well as the anterior half of the proboscis. Note the small round testes (Fig. 17).

- **Specimens:** Deposited at the Harold W. Manter Laboratory (HWML) Parasitology Collection no. 217063, Lincoln, Nebraska.
- **Remarks:** Compared to specimens described by above quoted observers, our specimens were only very mildly inflated at anterior trunk and at middle of proboscis and had a fewer spiniform hooks per row (8-9) in posterior proboscis. The number of the anterior rooted hooks was

considerably more stable than that of the more variable posterior spiniform hooks. However, 8-10 spiniform hooks per row were counted in Khokholova's [12] (Fig. 83b) specimens from Russia, the Volga region, Western Siberia, Azerbaijan, Kazakhstan, and Turkmenistan, even though she reported 10-15 such hooks per row. In addition, the testis appeared more rounded and separated in the Russian specimens of Khokhlova [12]

(Fig. 82c, p. 168). The proboscis of specimens from Louisiana [10] was extremely wide at middle; unlike our specimens or the Russian material. The eggs in our gravid female specimen were fusiform, 52-58 long by 20-25 in diameter, with blunt tips, concentric rings and minor polar prolongation (Fig. 2). Except for minor differences in measurements and the distant rounded testes, our specimens from Iran were morphologically most similar to those reported by Khokhlova [12] from Russia to Turkmenistan. Lisitsyna [13] reported Ukrainian specimens with a total of 23 hooks including transitional ones, and 8-10 spiniform hooks (Fig. 39a), testes very close to each other as in our specimens, but the lemnisci were very thick finger-like. In our specimens, the anatomy of the proboscis (Fig. 1) shows the receptacle process previously demonstrated in *Sphaerirostris picae* (Rudolphi, 1819) Golvan, 1956 by Amin, et al. [14].

***Centrorhynchus spinosus* (Kaiser, 1893) Van Cleave, 1924 cystacanth**

Polymorphida (Centrorhynchidae) (Figure 3)

We obtained 2 cystacanths of *C. spinosus* collected from a Cuban tree frog *Osteopilus septentrionalis* (Duméril & Bibron) in Tampa, Florida where the species was originally described. Nicole found the worms in the "small intestine area" of the body cavity in July, 2008, making the tree frog a paratenic host; a new record. Other species of frogs have been listed as paratenic hosts of various species of *Centrorhynchus* [15]. The proboscis armature of the two specimens fit that of the description of adults given above and keyed out to *C. spinosus* using the key of Richardson and Nickol [11] allowing for variations due to the different developmental stage.

The cystacanths (Fig. 3) had a bluntly pointed encased ovoid-shaped trunk, 1.42-1.47 mm long by 0.57-0.62 mm wide. Proboscis 1.06 mm long with 25-26 rows of 26 hooks each, divided by a mild constriction into 2 parts. Anterior proboscis 603-624 long by 218-260 wide, slightly inflated with 13 rooted hooks per row measuring 45-50 subapically; most robust hook just posterior to inflation. Posterior proboscis gradually widening basally, with 12-13 curved spiniform hooks per row measuring 35-37 posteriorly. Receptacle twisted and primordia of lemnisci visible.

- **Specimens:** Deposited at the Harold W. Manter Laboratory (HWML) Parasitology Collection no. 217064, Lincoln, Nebraska.

***Sphaerirostris lancea* (Westrumb, 1821) Golvan, 1956**

Polymorphida (Centrorhynchidae) (Figures 4, 5)

Golvan [8] created *Sphaerirostris* as a subgenus of *Centrorhynchus* Lühe, 1911 with 21 species and several

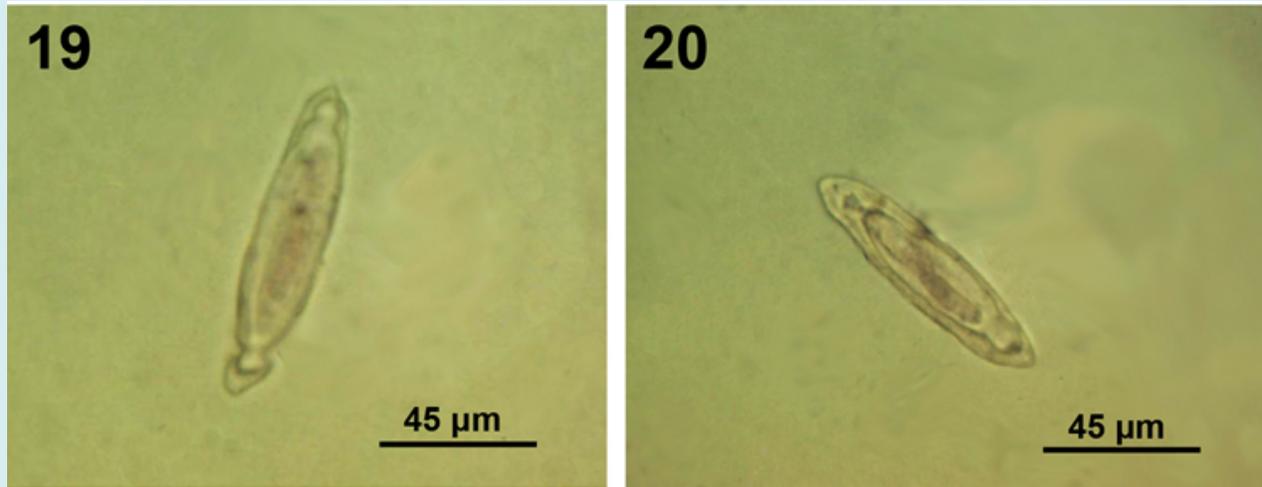
synonymies later increased to 26 species [16]. Twenty valid species are currently recognized [14]. Proboscis armature was a primary criterion distinguishing species apart. *Sphaerirostris lancea* is known from birds in the families Scolopacidae, Turdidae, Charadriidae, Burhinidae, Recurvirostridae, Cuculidae in the Palearctic as well as in China, Taiwan, Egypt, and the USA [13,17]. Lisitsyna provided us with 6 specimens (2 large females and 4 smaller males) from the lapwing *Vanellus vanellus* (Linn.) collected in Ukraine in 1988 [12]. Lisitsyna [13] provided detailed descriptions of *S. lancea* from Ukraine and Petrochenko [17] described it under *Centrorhynchus* from Russian Turkistan after Skryabin [18]. The brief description by Khokhlova [12] and her figure no. 86 are directly based on those provided by Petrochenko [17].

- **General description:** Trunk ovoid anteriorly and cylindrical posteriorly. The length proportion of the anterior ovoid to the posterior cylindrical trunk was 1:1.3-1.5 in our largest gravid females. This proportion was 2.3:1 in the specimens from Ukraine (Lisitsyna, [13]) (Fig. 1a) and the specimens from Russia (Petrochenko [17], Fig. 108). In our younger male specimens, the proportion was closer to 1:1. Cylindrical posterior trunk appearing to grow at a faster rate than the anterior trunk in maturing females. Proboscis in two parts; spheroid anteriorly and cylindrical posteriorly (Fig. 4). Anterior 7-8 hooks on anterior proboscis largest with prominent roots directed posteriorly followed by a transitional hook. Last 3 hooks smaller, slenderer with miniature anteriorly directed roots. Proboscis receptacle double-walled with spherical cephalic ganglion slightly posterior to its middle. Two slender, finger-like equal lemnisci not reaching anterior testis, attached posteriorly with filaments to body wall.
- **Males:** Based on 4 mature specimens with sperm. Trunk 5.87-11.00 mm long with anterior ovoid trunk 3.75-6.75 (5.40) mm long by 1.12-1.87 (1.56) mm wide and posterior cylindrical trunk 2.12-4.37 (3.49) mm long by 0.42-0.82 (0.64) mm wide. Total proboscis 600-700 (640) long by 300-350 (330) wide anteriorly, with 11-13 hooks per row. Proboscis receptacle 0.82-0.92 (0.88) long by 0.25-0.27 (0.26) wide. Lemnisci 1.50-1.57 mm long by 0.13 mm thick in one 11.00 mm long male. Testes in anterior trunk, ovoid, nearly contiguous. Anterior testis 0.82-1.05 (0.94) mm long by 0.42-0.50 (0.47) mm wide. Posterior testis 0.67-1.25 (1.00) mm long by 0.45-0.50 (0.46) mm wide. Cement glands unequal, beginning at level of posterior testis, 2.10-4.25 (3.42) mm long by 0.12-0.17 (0.14) mm wide. Saeftigen's pouch 0.75-1.30 (1.07) mm long by 0.25-0.50 (0.37) mm wide anteriorly.
- **Females:** Based on 2 large gravid specimens. Trunk 16.12-17.5 mm long with anterior ovoid trunk being 7.12-7.50 mm long by 2.35-2.40 mm wide and posterior

cylindrical trunk being 9.00-10.00 mm long by 1.15-1.37 mm wide. Total proboscis 603-832 long by 416 wide anteriorly, with 11-12 hooks per row. Proboscis receptacle 0.86-1.04 mm long by 0.28 wide. Genital pore subterminal and eggs ellipsoidal with concentric membranes (Fig. 5), 42-48 long by 17-22 wide.

- **Specimens:** Deposited at the Harold W. Manter Laboratory (HWML) Parasitology Collection no. 217065.
- **Remarks:** All measurements fell within the range

recorded by Petrochenko [17] and Lisitsyna [13] except that the eggs were somewhat immature and smaller. In the specimens from Ukraine, the eggs appeared oblong with rounded ends (Lisitsyna [13], Fig. 4), the lemnisci were thick, the testes were round and distant, and the cement glands began at the level of anterior testis (Lisitsyna [13], Fig. 41a). In the specimens from Russia, the testes were ovoid and contiguous [17,18], like ours.



Figures 19, 20: Morphology of polymorphid acanthocephalans from wildlife. Two eggs of *Southwelliona hispida* from *Nycticorax violaceus* in Florida showing the rounded polar prolongation of the fertilization membrane characteristic of this species.

Sphaerostris picae (Rudolphi, 1819) Golvan, 1956

Polymorphida (Centrorhynchidae) (Figures 6, 7)

Petrochenko [17] did not recognize Golvan's [8] *Sphaerostris* and did not include *S. picae* among his keyed out 51 species of *Centrorhynchus*. Khokhlova [12] did not include *S. picae* among her keyed out 11 species of *Sphaerostris* and Yamaguti [4] recognized *S. picae* under *Centrorhynchus* and Lisitsyna [13] provided a detailed description of *S. picae* among 5 species of *Sphaerostris* from Ukraine that she keyed out. Amin, et al. [14] recognized 20 valid species of *Sphaerostris*, redescribed *S. picae* from *Pica pica* (Linn.) in Iran, discussed its seasonal distribution, and compared its

intraspecific variability in populations from Iran, Bulgaria, Hungary, Ukraine, Armenia, France, and Russia. Amin, et al. [14] also described a special receptacle process at the anterior end of the proboscis extending into the proboscis. A similar structure was previously described in *Corynosoma hamanni* (Linstow, 1892) by [19, 20]. Radwan, et al. [21] studied the epidemiology of *S. picae* in Egypt.

In the present study, we evaluate the intraspecific variability in 4 additional populations of *S. picae* from Ukraine (provided by Olga Lisitsyna), Bulgaria (by Zlatka Dimitrova), Iran (by Ali Halajian), and Egypt (by Nahla Radwan) (Table 2) to compare with that in eight other populations reported earlier in Amin et al. [14].

Population	Males				Females			
	Ukraine	Iran	Bulgaria	Egypt	Ukraine	Iran	Bulgaria	Egypt
Host	<i>Pica pica</i> , <i>Corvus sp.</i>	<i>Corvus corone</i> , <i>C. frugilegus</i>	<i>Pica pica</i>	<i>Corvus corone</i>	<i>Pica pica</i> , <i>Corvus sp.</i>	<i>Corvus corone</i> , <i>C. frugilegus</i>	<i>Pica pica</i>	<i>Corvus corone</i>
Sample size	2	2	1	2	14	3	1	5

Trunk length (mm)	10.58-12.50*	9.00-10.75	9.75	11.87	11.00-15.00	11.62-13.00	12.50	9.50-14.75
Trunk width (mm)	2.00-3.00	1.50-2.10	1.82	2.15	0.92-3.17	1.12-2.50		1.75-2.58
Ant. proboscis length X width	390-500 X 375-420	426-550 X 343-400	425 X 350	500 X 400	475-550 X 375-425	500-575 X 325-447	500 X 400	500-575 X 425-475
Post. proboscis length X width	300 X 450	158-312 X 260-374	200 X 350	300 X 375	175-250 X 300-400	150-333 X 325-437	175 X 350	2.75-4.25 X 425-450
Hook rows	30-34	32-38	34	32-34	34-38	31-37	34	32-34
Spiniform hook rows	30-32	27-36	32	32-34	32-36	32-35	32	32-34
Hooks/row	8	8-10	10	9-10	9	8-10	8	9-10
Spiniform hooks/row	4	2-4	2-3	3-4	2-4	2-5	3	3-4
Largest hook L	57	55	43**	50	52	58	50	50
Largest spiniform hook L	42	40	32	38	52	47	42	43
Proboscis receptacle length X width (mm)	1.17-1.62 X 0.35-0.47	1.12-1.52 X 0.25-0.37	1.00 X 0.30	1.20 X 0.38	1.06-1.73 X 0.36-0.45	1.30-1.62 X 0.26-0.35	1.15 X 0.37	1.12-1.37 X 0.37-0.40
Lemnisci length (mm)	2.37-2.40	0.78-2.92	2	2.5	2.27	1.25-2.60	2.57	1.75-2.72
Ant. testis length X width (mm)	1.20-1.30 X 0.52-0.75	1.37-1.80 X 0.67-0.95	1.17 X 0.67	1.25-1.62 X 0.62-0.75	XXX	XXX	XXX	XXX
Post. testis L X W	1.12-1.25 X 0.95-1.12	0.90-1.77 X 0.67-0.95	1.12 X 0.70	1.25-1.62 X 0.65-0.70	XXX	XXX	XXX	XXX
Cement gland L (mm)	5.50-5.72	2.70-4.32	4.5	6.50-7.00	XXX	XXX	XXX	XXX
Cement reservoir length X width (mm)	1.00 X 0.37	0.83-1.90 X 0.52-0.75	—	—	XXX	XXX	XXX	XXX
Female reproductive syst. length (mm)	XXX	XXX	XXX	XXX	1.87-2.08	1.52-2.50	—	1.87-2.24
Egg length X diameter	XXX	XXX	XXX	XXX	52-65 X 17-23	52-65 X 17-24	42-55 X 18-24	

*All measurements are in micrometers except where otherwise noted.

**Extreme measurements are bolded.

Table 2: Intraspecific variability among populations of *Sphaerostris picae* from various hosts in Ukraine, Iran, Bulgaria and Egypt.

- **General Description:** Based on specimens from all new 4 populations. Trunk fusiform, spheroid. Anterior proboscis with flat apical end and cylindrical-conical posterior proboscis with more widely spaced spiniform hooks and fewer hook rows (Fig. 6). No significant sexual differentiation in proboscis armature. Anterior hooks strong, 5th hook usually largest, with prominent roots followed posteriorly with transitional then smaller posterior hooks with anteriorly directed roots. Receptacle double-walled with oval cephalic ganglion near its center, lemnisci longer than receptacle and not reaching anterior testis.
- **Males:** Testes pre-equatorial, occasionally overlap. Four cement glands staggering anteriorly at level of posterior testis and joining posteriorly in 2 cement reservoirs. Subterminal gonopore.
- **Females:** Vagina with 2 sphincters, genital opening terminal in juveniles but subterminal in mature adults, and eggs oval with external sculpturing and concentric shells (Fig. 7).
- **Specimens:** Deposited at the Lincoln, Nebraska Harold W. Manter Laboratory (HWML) Parasitology Collections nos. 217066, 217067, 217068, 217069 from Ukraine, Bulgaria, Iran, & Egypt, respectively.
- **Remarks:** Table 2 provides a taxonomic comparison among the 4 populations of *S. picae* studied here. Specimens of the four populations appear similar with measurements falling within the same range of intraspecific variations, with minor exceptions marked by bolded font. Amin, et al. [14] noted that “confusion in the taxonomy of *S. picae* can be traced to intraspecific variability among various geographical populations and the choice of variable taxonomic criteria to distinguish between them.” A similar study was performed in 8 populations of another species of Acanthocephala, *Mediorhynchus papillosus* Van Cleave, 1916 from 11 host species in Europe, Taiwan, and the USA by Amin and Dailey [22] who noted that “Distinctiveness of geographical populations appears to be related to geographical restrictions, intermediate and definitive host specificity and distribution, and host feeding behavior.”

***Plagiorhynchus (Prosthorhynchus) cylindraceus* (Goeze, 1782) Schmidt & Kuntz, 1966**

Polymorphida (Plagiorhynchidae) (Figure 8)

Schmidt and Kuntz [23] synonymized *Prosthorhynchus* Kostylew, 1915 with *Plagiorhynchus* Lühe, 1911 and reduced the two genera to subgenera of the genus *Plagiorhynchus* s. lat. We have 3 semi-contracted adult females of (*P.*) (*P.*) *cylindraceus* that we have not previously reported. Two specimens collected from a common blackbird *Turdus merula* Linn. in Iran by Dr. Ali Halajian in 2011, and one specimen from

a starling *Sturnus vulgaris* Rafinesque in Kenosha, Wisconsin by Bob Sewell in autumn, 1974. Available measurements include only proboscis size 1.07-1.14 mm long by 0.27 mm wide, largest proboscis hooks 83-94 long, number of hooks per row 13-14, and receptacle size 1.99-2.00 mm long by 0.32-0.36 mm wide.

- **Remarks:** The shape of the cylindrical proboscis and hooks (Fig. 8), and the above measurements are compatible with those described for *P. (P.) cylindraceus* from South Africa [24] or its synonyms *Plagiorhynchus formosus* (Van Cleave, 1918) Travassos, 1926 from North America and *Plagiorhynchus taiwanensis* Schmidt and Kuntz, 1966 from Taiwan or from Ukraine) [13], and Russia [12]. The contorted shape and limited measurements available in our 3 specimens from Iran and Wisconsin do not avail further detailed morphometric comparisons with specimens from other populations. Only Amin, et al. [24] provided detailed comparisons between *P. (P.) cylindraceus* and its synonyms *P. (P.) formosus*, and *P. (P.) taiwanensis*.
- **Specimens:** Deposited at the Lincoln, Nebraska Harold W. Manter Laboratory (HWML) Parasitology Collections nos. 217070, 217071 from Iran and Wisconsin, respectively.

***Plagiorhynchus (Prosthorhynchus) nicobarensis* (Soota & Kansal, 1970) Zafar & Farooqui, 1981**

Polymorphida (Plagiorhynchidae) (Figures 9, 10)

This acanthocephalan was originally described from 3 females collected from the ground thrush *Zoothera citrina* (Latham) at the Car Nicobar, India by Soota and Kansal [25] (Table 3). Ten years later, Zafar and Farooqui [26] redescribed it from an unknown number of males collected from warblers on mainland India. We are describing *P. (P.) nicobarensis* for the first time from the common starling in Iran; new host and locality records, and comparing its morphometrics with those in the original descriptions (Table 3).

- **Description of our Iranian Specimens:** Trunk elongated-fusiform. Proboscis cylindrical with hooks in parallel longitudinal rows with strong posteriorly directed roots except basal rootless spiniform hooks (Figs. 9, 10). Anterior hooks except apical largest. Basal hooks in perfect ring. Receptacle double-walled with cephalic ganglion near middle, lemnisci long, subequal, reaching posterior testis. Testes oval, contiguous, pre-equatorial, anterior testis occasionally totally overlapping proboscis receptacle. Cement glands 4, tubular, in 2 pairs. Saeftigen's pouch prominent, pyriform, thick walled, overlapping posterior end of cement glands. Female reproductive system long, with subterminal gonopore, one sphincter and long straight

uterine bell. Eggs elliptical with concentric shells.

Laboratory (HWML) Parasitology Collection no. 217072, Lincoln, Nebraska.

- **Specimens:** Deposited at the Harold W. Manter

Specimens	Original descriptions		Our material	
	Car Nicobar Island, Bay of Bengal	Aligarh, North Indian mainland	Iran	Iran
Reference	Soota & Kansal (1972)	Zafar & Farooqui (1981)	This paper	This paper
Host	<i>Zoothera citrina</i> (Latham), ground thrush	<i>Turdoides caudatus</i> (Dumont), common babbler	<i>Sturnus vulgaris</i> Linn., common starling	<i>Sturnus vulgaris</i> Linn. common starling
Worm sex	Females	Males	Females	Males
Sample size	3	"Few"	7	6
Trunk L X W (mm)	7.00-8.50 X 1.10-1.50*	8.00-10.00 X 1.50-2.50	7.00-11.00 X 0.82-1.40	5.50-6.57 X 0.70-1.22
Proboscis L X W (mm)	1.10 X 0.30	0.85 X 0.20	0.97-1.25 X 0.27-0.32	0.92-1.12 X 0.25-0.32
Hook rows	14-16**	18-20	18-20	19-20
Hooks/row	14-15	16	14-15	14-15
Largest hook	---	75 anteriorly	73-85 anteriorly	70-82
Smallest basal hooks	Rootless	Ca. 40	57-62	55-62
Receptacle L X W (mm)	1.62 X 0.30	1.65 X ---	1.67-2.20 X 0.30-0.42	1.50-2.37 X 0.32-0.40
Lemnisci L X W (mm)	Equal 2.00 X 0.10	Subequal 2.65 & 2.75 X --	2.55-3.12 X 0.13 2.70-3.50 X 0.13	2.40-3.17 X 0.06 2.57-3.22 X 0.15
Ant. testis length X width (mm)	XXX	1.27 X 0.65	XXX	0.55-0.90 X 0.37-0.67
Post. testis length X width (mm)	XXX	1.10 X 0.75	XXX	0.52-0.80 X 0.37-0.55
Cement gland L (mm)	XXX	3.65	XXX	1.72-2.85
Saeftigen's pouch length X width (mm)	XXX	1.50 X ---	XXX	0.57-1.12 X 0.23-0.34
Bursa length	XXX	300-360	XXX	---
Female reproductive syst. length (mm)	---	XXX	1.46	XXX
Egg length X width	70 X 35	XXX	58-63 X 25-30	XXX

*All measurements in micrometers unless otherwise noted.

** Extreme measurements are bolded.

Table 3: Comparative morphometries between specimens in the original description of *Plagiorhynchus (Prosthorhynchus) nicobarensis* from India and our specimens from Iran.

The morphology and organization of the Iranian specimens was similar to that of specimens in the original

descriptions but showed variations. The measurements of all structures were comparable (Table 3). However, males

from Iran had relatively smaller trunk and reproductive structures and females had slightly smaller eggs. Males from Aligarh had smaller basal hooks and females from Nicobar were reported with fewer proboscis hook rows. In general, Indian specimens had somewhat smaller receptacle. The above variations are considered to be of intraspecific nature in the various geographical populations. Updates to the key to species of *Plagiorhynchus* (*Prosthorhynchus*) in Amin, et al. [24] will need to take the above variations into account.

The 3 definitive hosts (Table 3) are omnivorous and insectivorous [27,28] and their invertebrate diet must include intermediate hosts commonly infected with larval acanthocephalans in India and Iran. For instance, invertebrates like the isopod *Aramadillidium vulgare* Latreille are naturally infected with plagiorhynchid acanthocephalans like *P. cylindraceus* that commonly infect starlings [29,30].

***Andracantha gravida* (Algret, 1941) Schmidt, 1975**

Polymorphida (Polymorphidae) (Figures 11-14)

Schmidt [31] erected the genus *Andracantha* for 3 species of *Corynosoma* Lühe 1904 with two fields of trunk spines and genital spines that he redescribed. *Andracantha gravida* was originally described as *Corynosoma gravida* by Alegret [32] from the double crested cormorant *Phalacrocorax auratus floridanus* (Audubon) in Cuba. The description and measurements of the Cuban material fell within the range of those described by Schmidt [31] (with proboscis length correction) also from the brown pelican *Pelecanus occidentalis carolinensis* Gmelin from Florida and Louisiana.

We currently possess one adult male specimen (Fig. 11) collected by DJF from a common loon *Gavia immer* (Brunnich) in Franklin County, Florida on 28 June, 1983. This is a new host record for *A. gravida*. Our male specimen is similar to those described by Schmidt [31] but with some distinct variations. Our specimen was smaller, 2.62 mm long by 1.05 wide but with similar measurements of proboscis (675 by 250) (Fig. 12), receptacle (1.02 mm by 0.27 mm wide), cement glands (280 by 146), largest dorsal hook (73 by 31 wide at base), largest ventral hook (83 by 31 wide at base) (Fig. 13). Posterior hooks smallest compared to largest anterior trunk spines (Fig. 14). Equal length of anterior, trunk and genital spines (30-33) but somewhat smaller testes (400 by 275) (Fig. 11). The distribution of anterior and trunk spines was similar to Schmidt's [31] specimens but our male specimen had only 1 genital spine as opposed to 18 marked in Schmidt's [31] (Fig. 2).

- **Specimens:** Deposited at the Harold W. Manter Laboratory (HWML) Parasitology Collection no. 217073, Lincoln, Nebraska.

***Arhythmorhynchus brevis* Van Cleave, 1916**

Polymorphida (Polymorphidae) (Figure 7)

Schmidt [33] recognized two types of acanthocephalans in the former assemblage of *Arhythmorhynchus* Lühe, 1911. "In one, the posterior trunk is very long and slender and the anterior trunk has one field of spines ...(with) two or four cement glands. These are *Arhythmorhynchus*. In the second form, the anterior trunk has two fields of trunk spines in at least one sex, the posterior trunk is much shorter, and there are four cement glands. This group.... represents *Southwellina*" (Schmidt [33], p. 300). This species was originally described as *A. brevis* based on already prepared museum specimens by Van Cleave [5]. Travassos [34] assigned the species to genus *Polymorphus* and Meyer [35] accepted this generic assignment. Van Cleave [36] re-examined the status of the species from additional collections and re-assigned it back to *Arhythmorhynchus* based on his "belief that ... the species is in agreement with the accepted concepts of the genus *Arhythmorhynchus*" and that Meyer's [35] relegation "apparently" based on his interpretation of the proboscis as "either weakly ovoidal or possibly approaching cylindrical form" was in error (Fig. 15). He did not refer to the reason for the re-assignment by Travassos [34]. For more on the turbulent nomenclature history of *A. brevis*, see Amin [37].

MGS gave us two whole-mounted darkly stained specimens, a male and a female that were collected from a great egret *Casmerodius albus* (Linn.) in Florida. Exact date and locality were not noted but other collections from the same source were from Franklin County in June, 1983. Measurements of our specimens are in Table 4 compared to those from the descriptions of Van Cleave [5,36].

- **Specimens:** Deposited at the Harold W. Manter Laboratory (HWML) Parasitology Collection no. 217074, Lincoln, Nebraska.
- **Remarks:** Van Cleave's [5,36] accounts were incomplete, not including measurements of lemnisci, receptacle, testes, cement glands, or cement gland ducts. Van Cleave did not count the number of cement glands but he (Van Cleave [36], Fig. 1) showed what appears to be 2 glands which is in agreement with Schmidt [33] of 2 or four glands in *Arhythmorhynchus*. However, our specimen appears to have more than 2 glands. Van Cleave's [36] (Fig. 1) also appears to show a lemniscus reaching to anterior end of posterior testis as it does in our male specimen. We could not delineate the whole female reproductive system (nor did Van Cleave) but the gonopore was between subterminal to near terminal with a simple vagina adjoining an unremarkable sphincter. Van Cleave (2016) described eggs with rounded swellings at the polar ends of "middle" membrane. Our female specimen had only large elongate ovarian balls.

Specimens	Our material		Material from Van Cleave (1916, 1945) in Japan	
Locality	Florida, USA		Our specimens from Maryland, Minnesota, Illinois	
Host	<i>Casmerodius albus</i> (Linn.), great egret		<i>Botaurus lentiginosus</i> (Rackett), American bittern <i>Pandion haliaetus carolinensis</i> (Linn.), osprey <i>Ardia herodias herodias</i> Linn., great blue heron <i>Nycticorax nycticorax</i> (Linn.), black crowned night heron	
Worm sex	Female	Male	Females	Males
Sample size	1	1	7	6
Trunk L X W (mm)	9.07 X 1.25 (ant.) & 0.62 (post.)	6.12 X 1.15 (ant.) & 0.55 (post.)	6.0-12.0 X 3.0 (ant.) & ca. 1.5 (post.)	5.0-6.0 X 1.0-1.5 (ant.) & 0.5-0.75 (post.)
Ant. trunk spine L	12-17	10-14	12	12
Proboscis L X W at center	738 X 302	634 X 239	665 X 340	665 X 340
Hook rows	15	15	13-16	13-16
Hooks/row	19	19	18	18
Largest hook	52 X 25 wide at base	42 X 15 wide at base	Slightly larger ventrally, 41-47 X ---	
Posterior 7 hooks	Spiniform, rootless	Spiniform, rootless	Only 5 rootless posterior spiniform hooks (Figs. 2 & 3)	
Smallest basal hooks	45 X 13 wide at base	42 X 10 at base	47 long	47 long
Receptacle L X W (mm)	1.67 X 0.26	1.17 X 0.22	---	---
Lemnisci L X W (mm)	1.92 X 0.31	1.70 X 0.25 Reaching post. testis	---	Reaching post. testis (Fig. 1)
Ant. testis length X width	XXX	600 X 275	XXX	---
Post. testis length X width (mm)	XXX	525 X 300	XXX	---
No. cement glands	XXX	2 or more	XXX	2 (Fig. 1)
Cement gland length X width (mm)	XXX	2.57 X 0.12	XXX	---
Cement gland ducts length X width	XXX	884 X 93	XXX	0.57-1.12 X 0.23-0.34
Egg length X width	Ovarian balls	XXX	76-100 X 24-30	XXX

*All measurements in micrometers unless otherwise noted.

** Extreme measurements are bolded.

Table 4: Comparative morphometrics between specimens in the original description of *Arhythmorhynchus brevis* from Japan and our specimens from Florida.

***Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932**

Polymorphida (Polymorphidae) (Figures 16-20)

Schmidt [33] resurrected the genus *Southwellina* Witenberg, 1932 and redefined it. Van Cleave [38] described *S. hispida* as *Arhythmorhynchus hispidus* from 4-5 mm long

immatures in Illinois, USA and Fukui [39] redescribed it under the same name from 6 males and 13 females that infected *Nycticorax n. nycticorax* Linn. in Japan.

One of the synonyms of *S. hispida* is *Polymorphus ardeae* Belopolskaia [40] seven specimens of which were sent to us in February, 2008 for evaluation. Konstantinos Oyrelidis and

Basil Ragias from Kavala, Greece sent 6 whole mounted males and 1 female collected from *Ardea cinerea* Linn. collected at the lagoons Vassova and Eratino of the River Nestos Delta in East Macedonia, Greece. They, among others [41] posted a report on these specimens as *P. ardeae*, the name under which their specimens were sent to us in 2008. Despite this universally accepted synonymy, it should be noted that, irrespective of measurements, these two synonyms differ markedly in proboscis shape (ovoid in *P. ardeae* but expanded medially in *S. hispidia*) as well as the morphology of hook roots especially the posterior hooks having long anterior manubria in *S. hispidia* (Amin, et al. [42], Fig. 2) and being without roots posteriorly and anteriorly in *P. ardeae* (see Belopolskaia [40], Fig. 1).

Only 2 male specimens from Macedonia, Greece were informative, one partially. The other specimens were totally corrupted with processing plaques. The anteriorly swollen trunk of our male specimens measured 3.37-8.75 mm long by 1.25-2.25 mm wide. Anterior trunk spines 22 long. Spindle-shaped proboscis 775-875 long by 325-350 wide at middle swelling (Figs. 16,18) with 24 rows of 14-16 hooks each. Largest hook 50-57 long by 17-20 wide at base. Posterior hooks with prominent and straight anterior manubria. Receptacle 1.50-1.52 mm long by 0.42-0.45 mm wide. Lemnisci inflated, superficially similar to receptacle in shape (Figs. 16,17) and about as long, 1.50 long by 0.28-0.32 wide. Testes round, almost equal, post-equatorial, oblique to nearly side by side (Fig. 17), anterior testis 235 by 235, posterior testis 225 by 225. Bursa round, 550-650 long by 550-675 in diameter.

Comparatively, our specimens from Macedonia were somewhat smaller than those described by Fukui [39] from Japan in size of trunk and testes. Fukui [39], however, described the testes in his specimens as tandem or very slightly oblique (his Fig. 34) and the lemnisci were club-shaped and very long, about 2-3 times as large as the receptacle (his Fig. 27b). The receptacle and lemnisci in our specimens were about equally long (Fig. 17). The proboscis and receptacle were larger in our specimens and the armature was comparable. Van Cleave [38] described the species from 5 juveniles in Japan that are best described in detail by Amin, et al. [42] who described juveniles from California.

Our single gravid female specimen from Florida provided by DJF from the yellow-crowned night heron *Nycticorax violaceus* (Linn.) was larger in all common measurements (10.25 mm long by 3.25 wide) than the male specimens with anterior trunk spines 30 long, proboscis 936 long by 350 at middle swelling with 16 hooks per row, largest hook 63 long by 27 wide at base. The gravid female specimen from Florida was slightly smaller than the female from Macedonia but provided measurements of eggs of 80-95 by 22-28 that

had the rounded polar prolongation of the fertilization membrane characteristic of this species (Figs. 19, 20). Other measurements and counts were comparable to those in Van Cleave [38] and Fukui [39].

- **Specimens:** Deposited at the Lincoln, Nebraska Harold W. Manter Laboratory (HWML) Parasitology Collections nos. 217075 and 217076 from Macedonia and Florida, respectively.

Acknowledgments

This project was partially supported by an ongoing institutional grant from the Parasitology Center, Inc., Scottsdale, Arizona, USA. We are immensely grateful to the many collaborators and former students who contributed the study materials that made the execution of this work possible. Students' involvements were part of joint research projects mostly under independent study programs at the University of Wisconsin-Parkside, Kenosha Wisconsin. Collaborators simply shared research material as part of joint research understandings. We also gratefully recognize the help of Dr. Gabor Racz., Collection Manager, Harold W. Manter Laboratory of Parasitology, University of Nebraska-Lincoln for kindly accessing and cataloging our specimens.

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