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REDESCRIPTION OF *SPHAERIROSTRIS PICAE* (ACANTHOCEPHALA: CENTRORHYNCHIDAE) FROM MAGPIE, *PICA PICA*, IN NORTHERN IRAN, WITH SPECIAL REFERENCE TO UNUSUAL RECEPTACLE STRUCTURES AND NOTES ON HISTOPATHOLOGY

Omar M. Amin, Richard A. Heckmann*, Ali Halajian†, and Ali Eslami‡
Institute of Parasitic Diseases, 11445 E. Via Linda, # 2-419, Scottsdale, Arizona 85259. *e-mail: omaramin@aol.com*

ABSTRACT: Adults of *Sphaerirostris picae* (Rudolphi, 1819) Golvan, 1956 are described from European magpie, *Pica pica* Linnaeus (Corvidae), collected in 2008 from wooded areas near the northern Iranian town of Tonekabon by the southern shores of the Caspian Sea. Other specimens also were collected from *Corvus cornix* Linnaeus, *Corvus corone* Linnaeus, and *Corvus frugilegus* Linnaeus (Corvidae) in the same location, as well as from some of these hosts in other locations. Our specimens had 31–38 proboscis hook rows on the ovoid anterior proboscis and 27–36 spine rows on the cylindrical- to cone-shaped posterior proboscis, each with 8–10 hooks and 2–5 spines per row, respectively. They are distinguished from those of all other species of the genus by having a unique prominent expansion of the dorsal inner receptacle wall, called the receptacle process (RP), anteriorly into the anterior proboscis and by the presence of longitudinal alveolar lobes throughout the receptacle and proboscis. The RP is described using histological sections. *Sphaerirostris picae* is further distinguished from 2 closely related species, namely, *Sphaerirostris lancea* (Westrumb, 1821) Golvan, 1956 and *Sphaerirostris pinguis* (Van Cleave, 1918) Golvan, 1956, by characteristics of proboscis armature, position of female gonopore, and other reproductive system and receptacle features. Histological sections revealed damage to host intestinal tissue.

The taxonomy of *Sphaerirostris* Golvan, 1956 has been in a state of confusion since Golvan (1956) established it as a subgenus of *Centrorhynchus* Lühe, 1911 and included 21 species, with several synonymies. Golvan (1994) listed 26 species of *Sphaerirtostris* after having deleted all the synonymies that he created earlier in 1956. Between 1956 and 1994, reports of many species primarily described proboscis armature and used it as the sole differentiating criterion for distinguishing the species from each other. Special emphasis was placed on the number of proboscis hook rows, e.g., see Petrochenko's (1958) and Hoklova's (1986) keys. This character proved to be most variable with its range overlapping among many species. *Sphaerirostris* is clearly a genus in need of serious taxonomic revision, which will undoubtedly lead to the creation of more synonymies. As it presently stands, it encompasses 20 species. The revision is planned for a later date.

Sphaerirostris picae (Rudolphi, 1819) Golvan, 1956, the type species, was recovered from the type host, the European magpie, *Pica pica* Linnaeus, a host from which other species of *Sphaerirostris* also have been reported previously. The parasite was found in a new locality in Iran and provided an opportunity to describe unique and unusual taxonomic features not reported previously, as well as to evaluate the usefulness of traditional taxonomic criteria.

MATERIALS AND METHODS

The reported material was collected by one of us (A.H.) from 4 corvid species—*P. pica*, *Corvus cornix* Linnaeus, *Corvus corone* Linnaeus, and *Corvus frugilegus* Linnaeus—in and around various villages and municipalities in the vicinity of Tonekabon City (36°48′31″N, 50°52′54″E), Tonekabon County, Mazandaran Province, northern Iran by the southern shore of the Caspian Sea. Sixty-three magpies were examined between January and December 2008, and 231 worms were collected from 41 infected hosts (Table I). Additional worms were collected in December for scanning electron microscopy (SEM), transmission electron microscopy, and histological studies. Birds were made available after having been captured by hunters, and the intestinal track was examined immediately for parasites. Worms were mostly found in the posterior end of the large intestine close to the cloacae and around the ceca. Only a few specimens were collected from the 3 species of *Corvus* noted above.

For taxonomic studies, 45 worms from *P. pica* were fixed in 70% ethanol after having been placed in water upon collection for a few hours to extend the proboscis. Worms were punctured with a fine needle and subsequently stained in Mayer's acid carmine overnight; destained in 4% HCl in 70% ethanol; dehydrated in ascending concentrations of ethanol (24 hr each); cleared in graduated (increasing) concentrations of terpineol in 100% ethanol to 100% terpineol, then 50% terpineol and 50% Canada balsam (24 hr each); and finally whole mounted in Canada balsam. Some thick specimens were sliced before mounting to improve visibility of internal structures. Of the 45 processed worms, 18 males and 19 females were measured. Measurements are in micrometers, unless otherwise stated. The range is followed by the mean (in parentheses). Length measurements are given before the width; the latter measurement refers to maximum width. Trunk length does not include the neck, proboscis, or bursa. Eggs refer only to fully developed mature eggs removed from the body cavity. RP refers to the unique prominent expansion of the dorsal inner receptacle wall anteriorly into the anterior proboscis. Voucher specimens from *P. pica* were deposited in the Harold W. Manter Laboratory Collection (HWML), Lincoln, Nebraska.

For histological sections, infected intestinal host tissues were fixed in 10% buffered formalin. After dehydration and blocking, standard methods (Bancroft and Gamble, 2001; Kienan, 2002) were used to section the paraffin-blocked samples. The tissue was cut at 4–6 µm and stained with hematoxylin and eosin (H&E) and Mallory's trichrome stain after mounting on glass slides (Galigher and Kazloff, 1971). An LSM laser (Carl Zeiss, Thornwood, New York) equipped compound light microscope was used to examine the prepared glass slides, with representative pictures taken at varying magnifications with a digital camera. For comparative purposes, host intestinal tissue without the parasite was processed in a similar manner. H&E is the standard stain for tissue, whereas Mallory's trichrome helps differentiate granular tissue typical of parasitic invasion.

For histological sections of parasites, an additional 10 specimens from *P. pica* were fixed in 10% formalin immediately after collection, embedded in paraffin, sectioned to a thickness of 6 µm, and stained with H&E for optical observations with a compound microscope at magnifications of ×100, ×400, and ×1,000. All specimens sectioned were mature males and females. Images were captured with a 35-mm camera.

For SEM studies, 20 specimens from *P. pica* previously fixed in 70% ethanol were placed in critical-point drying baskets and dehydrated using an ethanol series of 95% and 3 N 100% for at least 10 min per soak

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*Department of Integrative Biology, 401 WIDB, Brigham Young University, Provo, Utah 84602.
†Department of Parasitology, Veterinary Faculty, Islamic Azad University, Tehran Science and Research Branch, Tehran, Iran.
‡Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran.
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followed by critical point drying (Lee, 1992). Samples were then mounted on SEM sample mounts, gold coated, and observed with a scanning electron microscope (XL30 ESEMFEG; FEI, Hillsboro, Oregon). Digital images of the structures were obtained using digital imaging software attached to a computer.

For taxonomic comparisons and for verification of the presence or absence of the RP in other species of *Sphaerirostris*, the descriptions of all species currently considered valid were examined and specimens of 4 related species were obtained from the HWML and from the United States National Parasite Collection (USNPC), Beltsville, Maryland, as well as from Dr. Olga Lisitsyna's Collection (OLC) from Askania-Nova Black Sea Reserve, Ukraine (I.I. Schmalgausen Institute of Zoology, Kiev) and Dr. Zlatka Dimitrova's Collection (ZDC) from Stara Zagora, Bulgaria (Higher Institute of Zootechnics and Veterinary Medicine, Stara Zagora, Bulgaria). Specimens from the latter 2 collections were processed and whole mounted as noted above for comparative purposes. These specimens included males and females of *Sphaerirostris lancea* (Westrumb, 1821) Golvan, 1956 from China and Ukraine (HWML 34561 and OLC); *Sphaerirostris picae* (Rudolphi, 1819) Golvan, 1956, from Isreal (HWML 34870, a misidentification), Bulgaria (ZDC), and Ukraine (OLC); *Sphaerirostris pinguis* from China and Taiwan (HWML 34567 and 34570 and USNP 71366); *Sphaerirostris turdi* (Yamaguti, 1939) Golvan, 1956 from China and Taiwan (HWML 34564 and USNP 71335); and *Sphaerirostris wertheimae* Schmidt, 1975 from Isreal (HWML 34523 and USNP 73777, 73778).

RESULTS

Two hundred and thirty-one specimens were collected from 41 infected magpies in the region of Tonekabon City, northern Iran, by the southern coast of the Caspian Sea between May and December 2008. Male birds were relatively more frequently, but less heavily, infected than females. Birds seemed more heavily infected in July, with relatively moderate infections through the rest of the year (Table I). The magpie occurs in a broad range of habitats but tends to breed around farms and villages and in urban areas where there are trees, shrubs, and open spaces (Mullarney et al., 1999). It is omnivorous and opportunistic, feeding primarily on animal matter, especially insects (Trost, 1999). Cystacanths of the closely related *S. pinguis* were found in various species of mammals and snakes from Taiwan (Schmidt and Kuntz, 1969). Isopods also were found infected with larvae of another closely related species, *S. lancea*, in Uzbekestan (Sultanov et al., 1980).

REDESCRIPTION

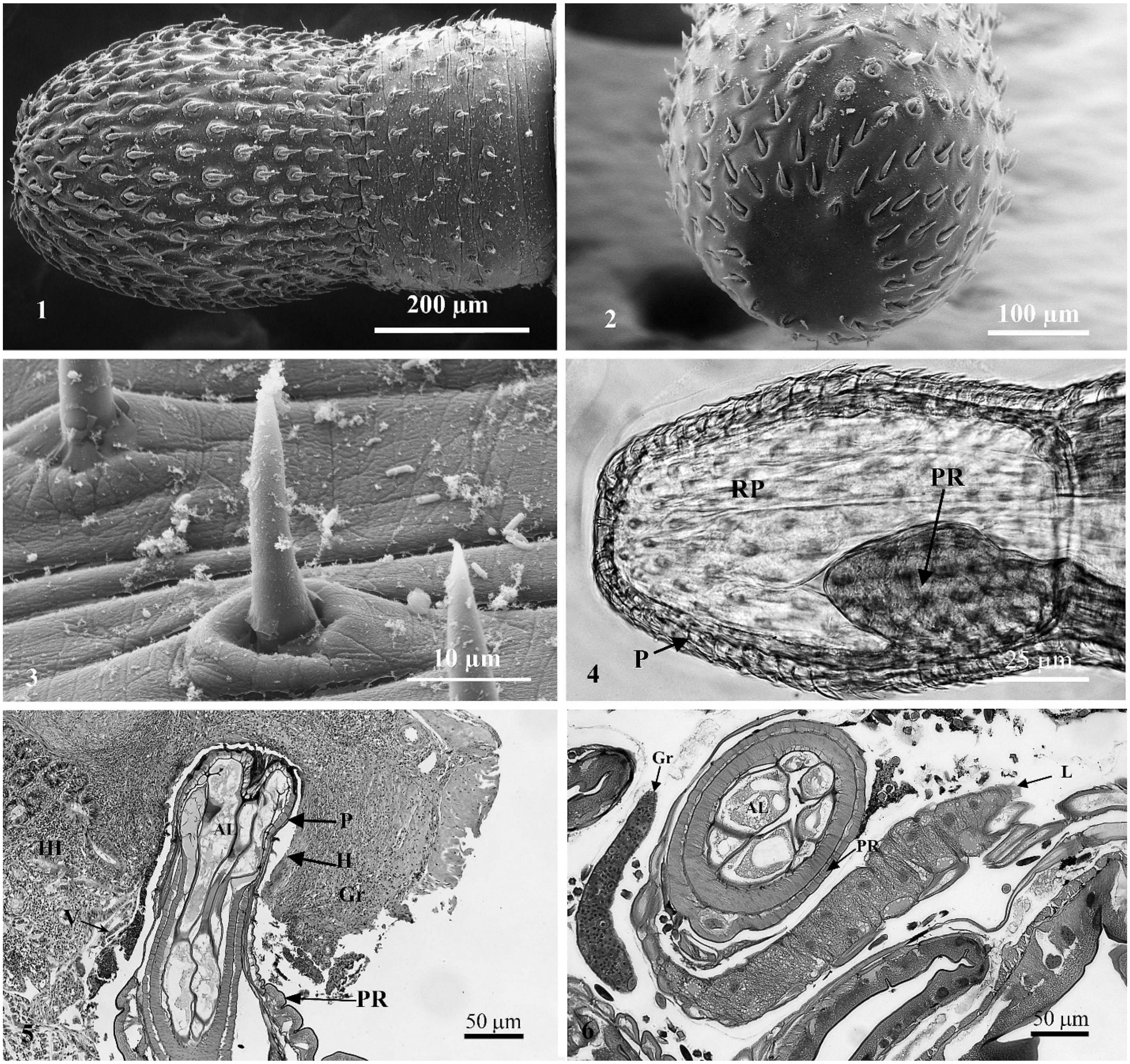
Sphaerirostris picae

(Figs. 1–13)

General: Trunk cylindrical, slender, spindle shaped, gradually tapering toward both ends, rounded posteriorly. Body wall with reticular lacunar system and many prominent nuclei throughout. Tegument with many similar micropores throughout (Fig. 14). Sexual dimorphism evident in shared structures. Proboscis bare and flat apically (Fig. 2), in 2 parts separated by constriction (Fig. 1) at anterior attachment of conically shaped double walled proboscis receptacle; cephalic ganglion at its middle. Anterior proboscis ovoid, markedly longer than wide with prominent RP (expansion of dorsal inner receptacle wall; Fig. 4) and 32–38 longitudinal rows of 8–10 (usually 9) hooks each. Proboscis and receptacle packed with longitudinal alveolar lobes (Figs. 5–8). Hook length increases from small apically to maximum of 55 in fifth position then gradually decreases posteriorly. Anterior hooks with simple posteriorly directed roots but posterior 3–4 (usually 3) hooks with anteriorly directed roots. Posterior proboscis cylindrical with more widely spaced armature, 27–36 longitudinal rows of 2–5 (usually 3 or 4) spines (spiniform hooks) each. When interpreted diagonally, spiral rows include 4–7 spines each. All spines with prominent anteriorly directed roots (manubria); anterior spines slightly longer than posterior spines. All hooks and spines emerge from elevated

TABLE I. Host and seasonal distribution of *Sphaerirostris picae* from *Pica pica* collected in and around Tonekabon City, northern Iran, in 2008. Inf = infected, Prev. = prevalence.

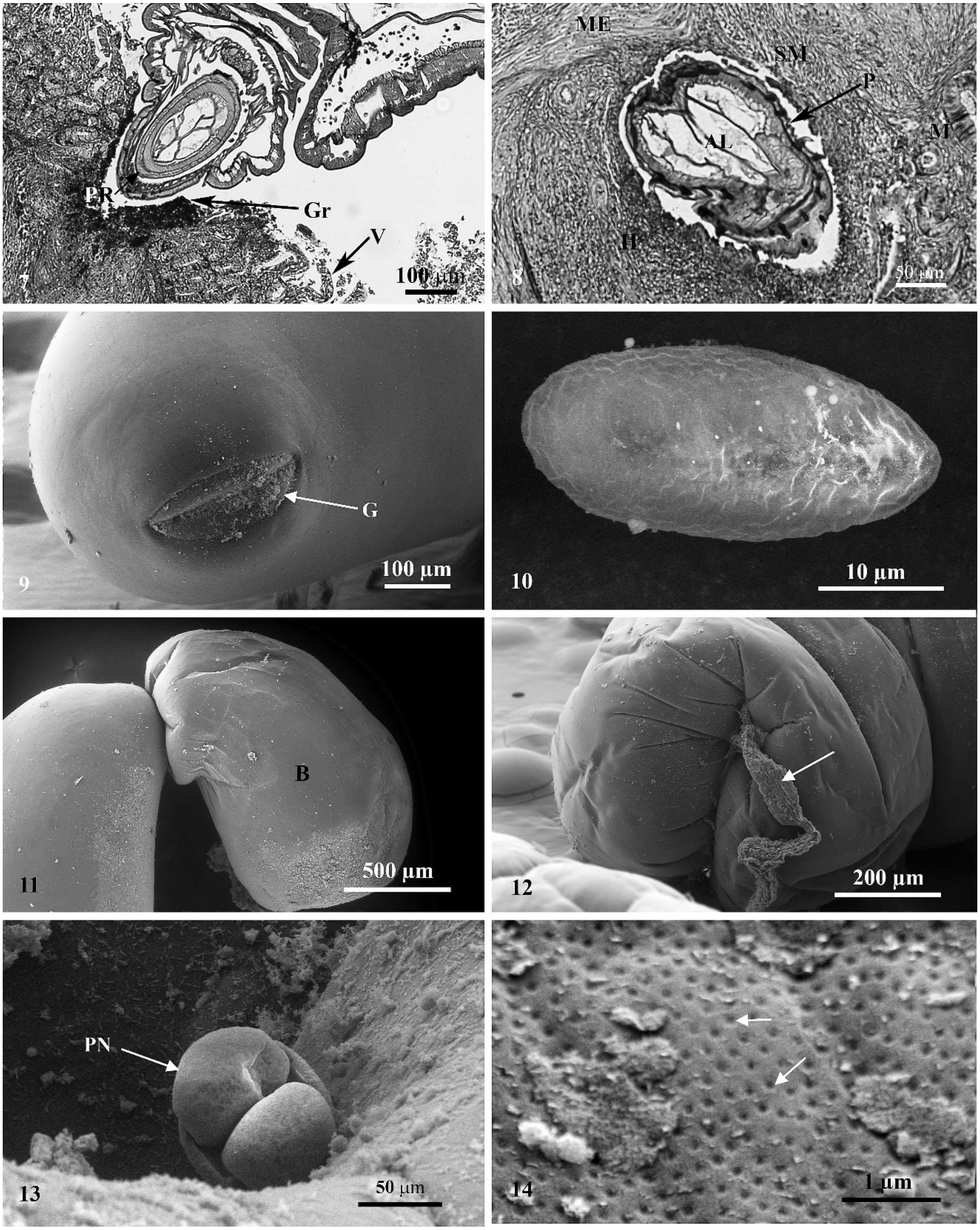
Mo	Male birds						Female birds						Total					
	Exam	Inf.	Prev., %	No. of worms	Range	Mean	Exam.	Inf.	Prev., %	No. of worms	Range	Mean	Exam.	Inf.	Prev., %	No. of worms	Range	Mean
January	1	0	—	0	—	—	0	—	—	0	—	—	1	0	—	0	—	—
February	0	—	—	0	—	—	1	0	—	0	—	—	1	0	—	0	—	—
May	2	2	100	5	2–3	2.5	0	—	—	—	—	—	2	2	100	5	2–3	2.5
June	9	6	67	44	3–11	4.9	4	2	50	19	8–11	4.7	13	8	62	63	3–11	4.8
July	2	1	50	14	14	7.0	3	3	100	45	12–18	15.0	5	4	80	59	12–8	11.8
September	6	4	67	16	2–9	2.7	6	1	17	2	2	0.33	12	5	42	18	2–9	1.5
October	4	4	100	17	1–8	4.2	10	8	80	34	1–12	3.4	14	12	86	51	1–12	3.6
November	8	5	62	12	1–5	1.5	4	3	75	12	3–6	3.0	12	8	67	24	1–6	2.0
December	1	1	100	6	6	6.0	2	1	50	5	5	2.5	3	2	67	11	5–6	3.7
Total	33	23	70	114	1–11	3.4	30	18	60	117	1–34	3.9	63	41	65	231	1–34	3.7



FIGURES 1–6. Scanning electron micrographs, histopathological sections, and light microscopical images of *Sphaerirostris picae* from *Pica pica* in Iran. (**1**) Proboscis of an adult male showing the constriction dividing the anterior proboscis with longitudinal rows of hooks and the posterior proboscis with spines. The constriction marks the point of the anterior attachment of the proboscis receptacle. (**2**) View of the anterior end of the same proboscis in Figure 1 showing the flat unarmed apical end. Note that the longitudinal rows of hooks also can be interpreted diagonally as spiral rows. (**3**) Spine from a male specimen emerging from a typical elevated rim from the proboscis surface. (**4**) Optical microscope image of the anterior proboscis (P) of an adult male showing the receptacle process (RP) at the anterior end of the proboscis receptacle (lower right). This image was enhanced using Acrobat Photoshop. (**5**) Histological section showing the insertion of the proboscis (P) with hooks (H) and the anterior trunk (AT) of a specimen into host intestine (HI) and host granular tissue with red blood cells (Gr). Note the alveolar lobes (AL) packing the proboscis and proboscis receptacle. This section did not pass through the RP. (**6**) Histological section showing a cross section of the proboscis receptacle (PR) and alveolar lobes (AL), as well as part of a lemniscus (L) and granular tissue with red blood cells (Gr).

round rims on proboscis surface (Fig. 3). Neck short. Lemnisci relatively longer than proboscis receptacle, more so in males than in females.

Male (based on 18 adult specimens with sperm): Trunk 5.12–13.00 (8.87) mm long by 1.20–2.10 (1.60) mm wide; width/length 17% (13–19%) in mature adults and 20% (16–24%) in immatures. Proboscis 665–801 (740) long in 2 parts; anterior proboscis 426–520 (492) long by 343–385 (363) wide, posterior proboscis 156–312 (246) long by 260–374 (342) wide. Total proboscis hooks 10–14 (12) per row. Anterior proboscis with 32–38 (33.5) hook rows each with 8–10 (9.1) hooks. Posterior proboscis with 27–36 (31.0) spine rows each with 2–4 (2.9) spines. Spines numbered 4–7 (5.2) when counted diagonally. Length of hooks from anterior 25–35 (32), 31–40 (37), 35–45 (41), 40–47 (44), 42–55 (47), 35–47 (42), 32–42 (37), 30–40 (36), 35–40 (37), 32–40 (35). Length of spines from anterior 32–40 (36), 32–40 (35), 30–40 (34), 31–45 (35). Proboscis receptacle 975–1,525 (1,135) long



FIGURES 7–14. Scanning electron micrographs and histological sections of *Sphaerirostris picae* from *Pica pica* in Iran. (**7**) Histological section showing the interface between the anterior end of a worm and compromised villus (V) and granular tissue with red blood cells (Gr). Note the alveolar lobes within the proboscis receptacle (PR). (**8**) Histological section showing the alveolar lobes (AL) in a proboscis deeply embedded in host (H) submucosa (SM) showing dense granular reaction. Note host mucosa (M) and muscularis externa (ME). (**9**) Posterior end of a female showing the subventral gonopore (G). (**10**) Egg teased out of the body cavity of a gravid female. (**11**) Bursa (B) of a male. Note the ventral position and lack of ornamentation or special features. (**12**) Terminal view of another bursa showing a hardened stream of semen (arrow). (**13**) View into the rim of a bursa

by 250–350 (285) wide anteriorly. Lemnisci 780–2,925 (1,717) long by 104–400 (208) wide. Reproductive system in posterior three fourths to four fifths of trunk with pre-equatorial vertically or diagonally contiguous ovoid or elliptic testes and fairly long cement glands. Anterior testis 700–1,800 (1241) long by 450–950 (646) long by 450–950 (639) wide, larger than posterior testis 650–1775 (1,080) long by 450–950 (639) wide. Cement glands 4, stagger in length anteriorly, but join posteriorly in 2 elongate plump cement reservoirs surrounding Saefftigen's pouch then extend posteriorly as cement gland ducts emptying into penis along with posterior extension of common sperm duct. Longest cement gland starts at mid-posterior testis and shortest cement glands begins near anterior third of longest gland. Longer cement gland 1,250–4,325 (2,822) long by 135–458 (230) wide; shorter cement gland 825–3,250 (1,885) long by 114–374 wide. Cement reservoir 832–1,900 (1,334) long by 135–425 (271) wide. Saefftigen's pouch of comparable length 780–1,825 (1,341) long by 260–625 (416) wide. Bursa near ventral side of posterior end of trunk with no specialized features (Fig. 11) within which hardened stream of semen (Fig. 12) or tip of penis (Fig. 13) can be seen.

Female (based on 19 adult specimens): Trunk 5.12–18.87 (12.62) mm long by 1.12–2.50 (1.99) mm wide; width/length 15% (11–19%) in gravid specimens and 19% (17–22%) in young specimens. Fully gravid adults (n = 12) 11.87–18.87 (15.12) mm long by 1.92–2.50 (2.22) mm wide; younger adults mostly with ovarian balls (n = 7) 5.12–10.00 (8.04) mm long by 1.12–1.90 (1.56) mm wide. Proboscis 728–874 (799) long in 2 parts; anterior proboscis 510–593 (550) long by 374–447 (416) wide, posterior proboscis 177–333 (249) long by 364–437 (399) wide. Total proboscis hooks 11–14 (12.2) per row. Anterior proboscis with 31–37 (34.6) hook rows each with 8–10 (9.0) hooks. Posterior proboscis with 32–35 (34.2) spine rows each with 2–5 (3.2) spines. Spines numbered 4–7 (5.3) when counted diagonally. Length of hooks from anterior 30–40 (34), 32–45 (39), 35–46 (43), 40–50 (45), 45–55 (48), 42–50 (47), 40–48 (42), 38–44 (40), 37–45, 32–37 (34). Length of spines from anterior 37–42 (39), 35–42 (38), 30–42 (37), 32–45 (37). Proboscis receptacle 988–1,625 (1,329) long by 260–354 (2,975) wide. Lemnisci 1,248–2,600 (1,696) long by 62–300 (153) wide. Reproductive system 1.52–2.50 (1.9) mm long; percentage of trunk length 15.0% (in larger specimens) to 22.5% (in younger specimens) (18.7% average for all specimens). Gonopore terminal in juveniles becoming subterminal with prominent lips (Fig. 9) in adults. Eggs plain, oblong to elliptical (Fig. 10), with concentric membranes 45–60 (53) long by 17–24 (22) wide.

Taxonomic summary

Type host: European magpie, *Pica pica* Linnaeus.

Other hosts from which specimens were examined: Corvus cornix Linnaeus, *Corvus corone* Linnaeus, *Corvus frugilegus* Linnaeus.

Site of infection: Intestine at cloacae and around ceca.

Present collection locality: Villages and municipalities in the vicinity of Tonekabon City (36°48′31″N, 50′52′54″E), Tonekabon County, Mazandaran Providence, northern Iran by the southern shores of the Caspian Sea.

Other localities: Europe (Armenia, Bulgaria, Hungary, Ukraine, Russia, France), Africa (Egypt, Morocco).

Voucher specimens from P. pica: HWML 49209 (accession P-2009-025).

Remarks

Golvan (1956) erected *Sphaerirostris* as a subgenus of *Centrorhynchus* Lühe, 1911 and included 21 species with polydendritic lacunar system and 3 or 4 tubular cement glands. Golvan (1994) listed 26 species by reversing the synomymies that he noted earlier (Golvan, 1956), without giving any explanation. Synonymies in this genus and keys (see Petrochenko, 1958 and Hoklova, 1986) are primarily based on proboscis armature, especially the number of longitudinal hook rows on the proboscis. More recent reports have demonstrated the wide range of intraspecific variability in this trait, showing definite overlap among a large number of species. For example, *S. lancea* (Westrumb, 1821) Skrjabin, 1913 sensu De Marvel, 1905, Skrjabin, 1913; Bykhovskaya, 1948, Golvan, 1956; Belopolskaya, 1983 has 26–32 proboscis hook rows, whereas *Sphaerirostris lanceoides* (Petrochenko, 1949) sensu Golvan, 1956; Petrochenko, 1958; Hoklova, 1971; Belopolskaya, 1983 possessed 36–42 longitudinal hook rows; the only noted distinguishing difference between the 2 species. Dimitrova et al. (1995, 1997) reported *S. lancea* with 40–42 and with 36–38 longitudinal hook rows and Florescu and Ienistea (1984) synomymized *S. lanceoides* with *S. lancea* based primarily on this character.

Similarly, *Sphaerirostris teres* (Westrumb, 1821) Golvan, 1956 (=*Echinorhynchus teres* Westrumb, 1821; *Echinorhynchus hepaticus* Molin, 1858 and 1861; *Echinonhynchus lobianchii* Monticelli, 1887) has been treated as a valid species since its description by many authors, including Meyer (1932–1933), Golvan (1956, 1994), Petrochenko (1958), Yamaguti (1963), Cordonnier and Ward (1968), Hoklova (1986), and Lisitsyna and Tkach (1994) until its synonymization with *S. picae* has been recognized by Dollfus and Golvan (1957), Dimitrova et al. (1995, 1997), and Amin et al. (this study). Westrumb (1821) originally designated *Echinorhynchus teres* as a new species and included *Echinorhynchus picae* Rudolphi, 1819 as its synonym. De Marval (1905), Meyer (1932–1933), and Petrochenko (1958) considered *S. picae* a synonym of *S. teres*. Golvan (1956, 1960) and Dollfus and Golvan (1957) established the validity of *S. picae* (Rudolphi, 1819) and regarded *S. teres* and *S. picae* Dollfus 1953 as its synonyms. However, Golvan (1994) listed *S. picae* and *S. teres*, as well as all his earlier synonymized species as distinct species, thus reversing his earlier decisions without giving any justification.

The relatedness of *S. lancea*, *S. lanceoides*, *S. pinguis*, and *S. terres* to *S. picae* and their confused taxonomic state needed to be explored as the need to revise the taxonomy of this group of acanthocephalans becomes apparent. Much of this confusion in the taxonomy of *S. picae*, among other species of the same genus, can be traced to intraspecific variability among various geographical populations and the choice of variable taxonomic criteria to distinguish between them. A comparison of selected key characteristics distinguishing these geographical populations is presented in Table II. Similar observations have lead to further synonymies leading to the recognition of 20 species in *Shaerirostris*. Eight of these species were not included in Glovan's (1956) list.

Sphaerirostris picae from Iran is distinguished from all other species by having in the anterior proboscis a structure unique to this genus, e.g., the RP. This structure was observed in all specimens examined and in sections that were fixed in 70% ethanol or in 10% formalin. It has never been reported in the descriptions of the same species by other authors, ex., Cordonier and Ward (1968), De Marval (1905), Dimitrova et al. (1995, 1997), Florscu and Ienistea (1984), and Hoklova (1985) from other geographical locations or in the descriptions of any other species of *Sphaerirostris*, including specimens of *S. lancea*, *S. pingius*, *S. turdi*, and *S. wertheimae* examined in this study. The RP was demonstrated in juvenile and adult male and female specimens of *S. picae* from *P. pica*, *C. corone*, and *C. frugilegus* in Iran, Bulgaria, and Ukraine. It is clearly a reliable taxonomic trait that is consistently present in worms at different developmental stages from different host species in different geographical regions. The RP definitively distinguishes *S. picae* from all other species of the genus and provides a validation for the use of such a structure in other genera when present. A similar structure assuming a digitiform anatomy was reported previously only once in the proboscis of *Plagiorhynchus* (*Prosthorhynchus*) *digiticephalus* Amin, Ha and Heckmann, 2008 (Polymorphidae: Plagiorhynchidae), whereas it represented the primary justification for the erection of the new species. Similarly, our *S. picae* material is distinguished from all other species of the genus by having the longitudinal alveolar lobes packing the proboscis and receptacle in adults and juveniles of both sexes. The function of the receptacle process and the alveolar lobes is not known at the present time.

In addition, our specimens of *P. picae* from Iran varied morphometrically from those described from other geographical locations (Table II) by having longer anterior proboscis, smaller cement glands, smaller eggs, and greater maximum number of spines per row on posterior proboscis. Our specimens also had markedly longer proboscis hooks than specimens

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showing the tip of a penis (PN). (**14**) High magnification of the integument at mid trunk showing the typical micropores (arrows) found throughout the integument of all other parts of the body.

TABLE II. Intraspecific variability in key taxonomic characteristics of both sexes of *Sphaerirostris picae* (=*S. teres*) from different geographical regions.

Character	Northern Iran This study *S. picae*	Bulgaria Dimitrova et al. (1997) *S. picae*	Hungary Dimitrova et al. (1995) *S. picae* females
Trunk	Fusiform	Fusiform	Fusiform
Anterior proboscis, L × W*	426–593 × 343–447	394–469 × 356–469	438–500 × 400–450
Posterior proboscis, L × W	187–333 × 260–437	123–281 × 388–444	80–260 × 360–513
Hook rows × hooks per row	32–38 × 8–10	28–34 × 7–9	34–36 × 8–9
Spine rows × spines per row	27–36 × 2–5	— × 3–4	— × 3–4
Longest hook, longest spine	55, 45	50, —	55, —
Neck	Short	Short	Short
Proboscis receptacle, L × W	975–1,625 × 250–354	1,080–1,300 × 220–310	—
Cement glands, length (no.)	825–4,325 (4)	3,090–5,700 (4)	—
Eggs, L × W	45–60 × 17–24	55–62 × 20–25	52–65 × 22–27
Female reproductive system	1,520–2,500	—	1,160
Female posterior end	Rounded	Rounded	Rounded
Gonopore	Subterminal	—	—

* L × W, length × width.

from Armenia, France, and Russia, and smaller proboscis receptacle than specimens from Ukraine, France, and Russia (Table II). The present description of the Iranian population of *S. picae* further provides new information on the characteristic features of this species by the SEM images provided for the first time.

Of the 20 recognized species of *Sphaerirostris*, 2 are most similar to *S. picae*. These are *S. lancea* and *S. pinguis*. The anterior proboscis of *S. lancea* is spheroid; about as long as wide. The number of proboscis hook rows varies between 30 and 42 (see status of *Sphaeroristris* above) but is not a very useful taxonomic characteristic in this genus; it was 30–32 in the specimens of *S. lancea* that we examined from China. In these specimens, the number of proboscis hooks per row was 10 or 11, somewhat smaller than in *S. picae*, but it was reported to vary between 10 and 14 (usually 12) by Golvan (1956), Petrochenko (1958), Belopolskaya (1983), and Dimitrova et al. (1995, 1997). More definitive distinguishing differences include a trunk that is relatively fusiform only anteriorly, with parallel sides posteriorly and pointed at posterior end, and smaller proboscis hooks reaching a maximum of 30–47 in *S. lancea* (Petrochenko, 1958; Dimitrove et al., 1995, 1997) than in *S. picae*. In *S. lancea*, the neck is much longer and the proboscis receptacle and lemnisci are markedly shorter (1.03–1.11 and 1.05 mm long, respectively) (Petrochenko, 1958; Dimitrova et al., 1997). In addition, *S. picae* is found only in Passeriformes, whereas *S. lancea* is only known from Charadriiformes.

Sphaerirostris pinguis characteristically has terminal female gonopore (figs. 1, 4 of Van Cleave, 1918) also observed in the material that we examined from China and Taiwan and markedly more proboscis hooks/spines per row (14–16) than *S. picae*. In Van Cleave (1918), fig. 2 shows a single row of 8 proboscis hooks, all with posteriorly directed roots, and 7 rootless spines. The *S. pinguis* male and female specimens that we examined had 8–9 hooks per row the posterior 3 or 4 of which had anteriorly directed roots and 5–6 spines per row all with anteriorly directed roots. The number of hook rows was 36–38, and the eggs were longer (72 × 22) than those of *S. picae*.

The significance of providing this new description of *S. picae* from a new geographical location in Iran is to describe the various new features that have never been reported and to give a comparison with other geographical populations of the same species and with related species that have been plagued with taxonomic problems.

The following 20 species recognized as valid, and their synonymies, are listed below.

1. *Sphaerirostris areolatus* (Rudolphi, 1819) Golvan, 1956 (=*Echinorhynchus areolatus* Rudolphi, 1819; *Echinorhynchus oriole* Rudolphi, 1819; *Echinorhynchus sigmoides* Westrumb, 1821).
2. *Sphaerirostris batrachus* (Das, 1952) n. comb. (=*Centrorhynchus batrachus* Das, 1952; *Centrorhynchus splendi* Gupta and Gupta, 1970; *Sphaerirostris splendi* Golvan, 1994).
3. *Sphaerirostris dollfusi* Golvan, 1994 (=*Centrorhynchus picae* sensu Dollfus, 1953).
4. *Sphaerirostris erraticus* (Chandler, 1925) Golvan, 1956 (=*Centrorhynchus erraticus* Chandler, 1925).
5. *Sphaerirostris globuli* (Nama and Rathore, 1984) Golvan, 1956 (=*Centrorhynchus globuli* Nama and Rathore).
6. *Sphaerirostris lancea* (Westrumb, 1821) Golvan, 1956 (=*Echinorhynchus lancea* Westrumb, 1821; *Centrorhynchus lanceoides* Petrochenko, 1949; *Sphaerirostris lanceoides* Golvan, 1956).
7. *Sphaerirostris lesiniformis* (Molin, 1859) Golvan, 1994 (=*Echinorhynchus lesiniformis* Molin, 1859).
8. *Sphaerirostris maryasis* (Datta, 1933) Golvan, 1956 (=*Centrorhynchus maryasis* Datta, 1933).
9. *Sphaerirostris opimus* (Travassos, 1919) Golvan, 1956 (=*Centrorhynchus opimus* Travassos, 1919).
10. *Sphaerirostris physocoracis* (Porta, 1913) Golvan, 1956 (=*Echinorhynchus physocoracis* Porta, 1913).
11. *Sphaerirostris picae* (Rudolphi, 1819) Golvan, 1956 (type species) (=*Echinorhynchus* picae Rudolphi, 1819; *Echinorhynchus lobianchii* Monticalli, 1887; *Echinorhynchus teres* Westrumb, 1821; *Sphaerirostris teres* Golvan, 1956).
12. *Sphaerirostris pinguis* (Van Cleave, 1918) Golvan, 1956 (=*Centrorhynchus pinguis* Van Cleave, 1918; *Centrorhynchus bipartitus* Solovieff, 1912; *Centrorhynchus corvi* Fukui, 1929; *Centrorhynchus leguminosus* Solovieff, 1912; *Centrorhynchus skrjabini* Petrochenko, 1949).
13. *Sphaerirostris reptans* (Bhalero, 1931) Golvan, 1956 (=*Centrorhynchus reptans* Bhalero, 1931).
14. *Sphaerirostris robustus* (Datta, 1928) Golvan, 1994 (=*Echinorhynchus robustus* Datta, 1928).
15. *Sphaerirostris saxicoloides* (Nama and Rathore, 1984) Golvan, 1994 (=*Centrorhynchus saxicoloides* Nama and Rathore, 1984).
16. *Sphaerirostris scanensis* (Lunström, 1941) Golvan, 1956 (=*Centrorhynchus scanensis* Lundström, 1941).
17. *Sphaerirostris serpenticola* (Linstow, 1908) Golvan, 1956 (*Echinorhynchus serpenticola* Linstow, 1908).
18. *Sphaerirostris tenuicaudatus* (Marotel, 1889) Amin, 1985 (=*Echinorhynchus tenuicaudatus* Marotel, 1889).
19. *Sphaerirostris turdi* (Yamaguti, 1939) Golvan, 1956 (=*Centrorhynchus turdi* Yamaguti, 1939.
20. *Sphaerirostris wertheimae* Schmidt, 1975.

Histopathology

Due to worm size and the length of the well-armed proboscis, the invasive action of this parasite on host tissue displayed classic tissue pathology represented in Figures 4–7. Hemorrhaging of nucleated red

TABLE II. Extended.

Ukraine	Ukraine	Armenia	France	Russia
Lisitsyna and Tkach (1994)	Lisitsyna (pers. comm.)	Petrochenko (1958)	Golvan (1956)	Hoklova (1986)
S. teres cystacanths	*S. picae*	*S. teres*	*S. teres*	*S. teres*
Fusiform	Fusiform	Fusiform	Fusiform	Fusiform
450–460 × 460–490	400–470 × 370–460	400–500 × 400	— × 350	390–500 × 396–400
190–470 × 490	—	200–300 × 400	— × 350	200–300 × 400
33–38 × 7–9	32–38 × 8–10	32–34 × 8	22–32 × 9	26–36 × 8–9
— × 3–4	—	— × 3–4	— × 3	— × 3–4
45–48, —	53, 38	36–38, —	36, —	47, —
Short	Short	Short	Short	Short
—	770–1,730 × 310–450	1,300–1,400 × 140–200	1,400–1,800 × 380–450	720–2,060 × 150–520
—	—	—	— (3)	2,000–7,000 (4)
—	55–62 × 24	61–65 × 26–28	55–73 × 23	32–65 × 18–26
—	—	—	2,000	—
Rounded	Rounded	Rounded	Rounded	Rounded
Terminal	Subterminal	—	—	—

blood cells is prominent around the proboscis with a typical granulocyte concentration (Figs. 5–8). Presence of a high granulocyte count (Figs. 6, 7) found in this tissue sample is consistent with acute damage. Note the loss of the columnar cells that typically line host villi around the everted proboscis (Figs. 5, 7) and the obstruction and blockage of the intestinal lumen. The proboscis of *S. picae* extends deep into the layers of the host intestine (Figs. 5, 8) residing near the bilayered muscularis externa (ME). The proboscis was surrounded by host tissue at this level and seemed to bend along the ME (Fig. 8). This acanthocephalan may actually migrate through the ME into the abdominal cavity of the host as has been evidenced by occasional separate observations upon dissection of birds.

DISCUSSION

The most prominent feature characterizing *S. picae* from all other species of *Sphaerirostris*, the RP, represents a unique structure of unknown utility, yet of significant taxonomic importance. The taxonomy of *Sphaeriristris* has been largely dependent on the use of proboscis armature, especially the number of proboscis hook rows, e.g., keys by Petrochenko (1958) and Hoklova (1986). This character has proven to be extremely variable and a good number of synonymies were made. Relegation to other genera is also noted, e.g., *Gorgorhynchoides orientalis* Wang, 1966 (=*Sphaerirostris orientalis* [Wang, 1966] Wang, 1986). It is likely that more synonymies may be made when demonstrable overlap in proboscis armature characters can be demonstrated, especially in new populations, and when other traits, e.g., receptacle, neck, and reproductive structures, especially the position of female gonopore and the shape of the female posterior trunk, are used. The 2 latter characters are often overlooked in the taxonomic literature. Considering the abovementioned information, it is clear that the taxonomy of *Sphaerirostris* and composition of its member species need a comprehensive revision. Such a revision would be more meaningful when specimens in private and institutional collections that remain unpublished, e.g., the Dimitrova and the Lisitsyna collections from Bulgaria and the Ukraine, among others, are accounted for. This needed revision, however, is beyond the scope of the present work.

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