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ABSTRACT: *Acanthogyrus* (*Acanthosentis*) *barmeshoori* n. sp. (Quadrigyridae) is described from the Persian tooth-carp, *Aphanius farsicus* Teimori, Esmaeili, and Reichenbacher, 2011 (Cyprinodontidae) in the Maharlu Lake basin, southern Iran. *Aphanius farsicus* is an endemic freshwater fish found in streams and springs that drain into Maharlu Lake, Shiraz, Iran. The new species is the smallest of all the 44 known species of the subgenus *Acanthosentis* Verma and Datta, 1929, measuring between 0.26 and 1.68 mm in length. It is further distinguished by having a short cylindrical proboscis with very long anterior hooks widely separated from very small hooks in 2 very close circles posteriorly (hook length ratio about 4:1). It is separated from 4 other species of *Acanthosentis* with similar proboscis armature but with less-extreme diversification of hook length. The new species is also distinguished in having anterior para-receptacle structures (PRS) and a similar posterior structure like those reported in only 1 other species of *Acanthosentis* from Japan. Proboscis receptacle is single walled with a large triangular cephalic ganglion. Testes are large, pre-equatorial, and Saefftigen's pouch is prominent. Fourteen to 25 circles of spines cover the anterior 50–70% of the trunk, but a few spines may be present at posterior end of trunk. This is the first species of *Acanthosentis* where SEM images, showing external morphological details, are provided. From a total of 357 fish specimens examined between July 2006 and June 2007, 173 specimens (48.5%) were infected with individuals of the new species. The prevalence of infection decreased with increasing fish size. The parasite was observed all year, with the highest abundance and intensity in May while the prevalence was highest in February. The prevalence of acanthocephalans decreased with increasing fish size. While most worms were recovered in fish within the length range of 18–29.9 mm, 1 of the longest parasites (1.68 mm long) was found in fish within the range of 30–33.9 mm long.

The Quadrigyridae Van Cleave, 1920 (Acanthocephala: Order Gyracanthocephala Van Cleave, 1936) includes 2 subfamilies, Quadrigyrinae Van Cleave, 1920 with 2 genera and Pallisentinae Van Cleave, 1928, with 6 genera, including *Acanthogyrus* Thapar, 1927. Golvan (1959) synonymized *Acanthosentis* with *Acanthogyrus* and reduced *Acanthosentis* to a subgenus based on the number of hooks on the proboscis. Accordingly, the nominal subgenus has 3 circles of 8 proboscis hooks each and *Acanthosentis* has 3 circles of 6 hooks each. This arrangement has been accepted by most systematists. Golvan (1994) returned *Acanthosentis* to full generic status but did not provide any justification. The subgeneric classification is retained here in agreement with Amin (1985, 2005) and Amin and Hendrix (1999). For further discussion on the taxonomy of the group, see Amin (2005).

The results reported here constitute the first record of *Acanthosentis* in Iran and extend its predominantly Asian distribution, especially in the Indian subcontinent, China, and Japan to the Middle East. Very few non-Asian species are also known in Africa (n = 6), Puerto Rico (1), and the Adriatic Sea off Yugoslavia (1) (see Amin [2005] for detailed distributional records and key to species).

Aphanius is the only native representative of the Cyprinodontidae (Teleostei, Cyprinodontiformes) in Iran, Europe, and the Persian Gulf area. Iran is central to *Aphanius* diversity, with 8 species recognized at present (Wildekamp, 1993; Coad, 1996, 2000a, 2000b, 2009; Hrbek et al., 2006) and their distribution area includes both brackish and freshwater water bodies (Wildekamp, 1993). The genus includes *Aphanius dispar* (Rüppell, 1828), *Aphanius mento* (Heckel, 1843), *Aphanius sophiae* (Heckel, 1849), *Aphanius ginaonis* (Holly, 1929), *Aphanius vladykovi* Coad, 1988, *Aphanius isfahanensis* Hrbek, Keivany and Coad, 2006, *Aphanius mesopotamicus* Coad, 2009, and *Aphanius farsicus* Teimori, Esmaeili, and Reichenbacher, 2011. In spite of the importance of these species for the biologic control of anopheline mosquito larvae in streams (Steven, 1913; Frenkel and Goren, 1999), little attention is paid to their parasitic infections, especially *A. farsicus*, a fish that is apparently able to feed on invertebrate intermediate hosts of acanthocephalans, judging by its harboring adults of the species described herein.

The objective of the present study is to describe the new species from the digestive tract of the Persian tooth-carp, *A. farsicus*, and to examine the parameters of the host–parasite associations in relation to seasonality, length, and weight of the *A. farsicus* population in Barm-e-Shoor, Maharlu Lake Basin, Shiraz, in southern Iran.

MATERIALS AND METHODS

The study was conducted in the Barm-e-Shoor Spring (29°27′951″N, 52°42′0.051″E) in Maharlu Lake Basin, southern Iran, between July 2006 and June 2007 (Fig. 1). *Aphanius farsicus* is endemic in this basin. The lake is located in the Shiraz Valley in Fars Province at an altitude of about 1,460 m (Fig. 1). This is a chloride lake and is fish-free. Only the inflowing streams and associated springs have fish. *Aphanius farsicus* is commonly found in springs and pools that drain into Maharlu Lake. The bottom of these springs is generally muddy and the water is clear and slow running. The physico-chemical parameters of the water in Barm-e-Shoor spring, measured monthly by routine methods during the survey, were as follows: water temperature, 1.0–23.4 C; pH, 6.47–7.8; salinity, 6.2–12 mg/L; dissolved oxygen, 2.7–5.8 mg/L; nitrite, 0.01–0.10 mg/L; and nitrate, 0.1–4.7 mg/L.

A total of 357 fish specimens was collected from the Barm-e-Shoor Spring from July 2006 to June 2007. Fish were caught with a dip net and immediately preserved in 5% formalin until examination. Fish were measured (total and standard length) and weighed. The fish were necropsied and examined for parasites using a stereoscope; recovered parasites were placed in small vials, separately, using a pipette. Specimens were stained in Mayer's acid carmine, destained in 4% hydrochloric acid

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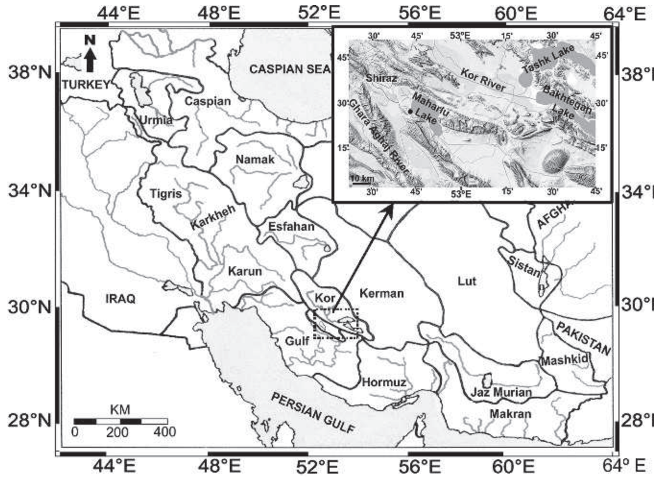


FIGURE 1. Map of Iran showing major basins, after Abdoli (2000), and the study area in dotted rectangular box in southern Iran; the location of Barm-e-Shoor spring (•), Maharlu Lake Basin, which is the type locality of *Acanthogyrus barmeshoori*. Source of map: Google Earth, modified.

in 70% ethanol, dehydrated in ascending concentrations of ethanol (24 hr each), and cleared in graduated concentrations of terpineol in 100% ethanol to 100% terpineol, then in 50% terpineol in 50% Canada balsam (24 hr each). Specimens were then transferred to, and whole-mounted in, Canada balsam (Amin, 2005).

For SEM studies a few specimens 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, followed by critical-point drying (Lee, 1992). Samples were mounted on SEM sample mounts, gold coated, and observed with a scanning electron microscope (XL30 ESEMFEG; FEI, Hillsboro, Oregon).

Original line drawings were made by O.M.A. Measurements were made using an ocular compound microscopy. All measurements are made in micrometers (μm) unless otherwise stated. Range values are followed by the mean in parentheses. Length measurements are given before the width; the latter refers to maximum width. Trunk length does not include the neck, proboscis, or bursa. Eggs refer only to fully developed eggs, which were usually removed from the body cavity.

Prevalence (%) was calculated as the number of infected fish divided by the total number of fish examined. Mean intensity is the total number of recovered parasites divided by the number of infected fish. Abundance is the total number of recovered parasites divided by the number of examined fish (infected and uninfected).

Type specimens were deposited at the Harold W. Manter Laboratory (HWML) collection at the University of Nebraska, Lincoln, U.S.A. Other specimens were deposited in the Parasitology Collection in Tehran University School of Public Health (TUSPH), Tehran, Iran, and in the Biology Collection of Shiraz University (BCSU), Shiraz, Iran.

RESULTS

The recognition of the acanthocephalan species reported herein is based on the examination of reference specimens and descriptions in the senior author's collection as well as on the key to species of *Acanthosentis* in Amin (2005).

A total of 357 fish specimens was collected of which 173 specimens (48.5%), including 83 males and 90 females, were infected (Tables I, II). Infected fish did not exhibit any external or internal pathology compared to uninfected fish.

Maximum number of infected fish was observed in May, April, and October when 141, 112, and 78 parasites were recovered, respectively. Maximum number of observed parasites in an individual fish was 18 in April. In December, infected fish did not have more than 1 parasite and only 4 of 30 examined fish were infected. The smallest acanthocephalan was 0.26 mm long in October while in May, recovered acanthocephalans reached a maximum length of up to 1.68 mm in one individual (Table II).

The parasite was found during all months with the highest abundance (4.7) and intensity (5.9) in May while the prevalence was highest in February (81.5%) (Table I). The prevalence values decreased with increasing fish size. Fish 18.0–29.9 mm in length possessed the greatest number of acanthocephalans (Table III).

While most worms were recovered in fish within the length range of 18.0–29.9 mm, one of the longest parasites (1.68 mm long) was found in a fish in the range of 30.0–33.9 mm long (Table IV).

DESCRIPTION

Acanthogyrus (Acanthosentis) barmeshoori n. sp.

(Figs. 2–14)

Diagnosis: With characters of *Acanthogyrus* and the subgenus *Acanthosentis* (Quadrigyridae). Small worms, body length 0.3–1.7 mm. Shared characters larger in females than in males. Trunk small, somewhat enlarged in middle of males and more anteriorly in females, gradually tapering at both ends (Figs. 2–4, 9, 10). Trunk in some gravid females strongly arched dorsally, with antero-dorsal hump over subventral proboscis and markedly attenuated posterior end bent ventrad (Fig. 8). Cuticular spines (Fig. 12), 10–14 long, smaller anteriorly, with discoid base and lobulate margins. Spines cover anterior 50–75% of trunk, occasionally reaching level of cement gland, in 14–25 circles of 10–20 spines on each side anteriorly. Spines become more widely spaced and somewhat fewer posteriorly, occasionally becoming absent ventro-posteriorly (Figs. 2–4, 9, 10). Few rows of spines may be present at posterior end of trunk (Figs. 2, 9, 14). Proboscis cylindrical posteriorly but rounded-hexagonal anteriorly with 3 circles of 6 hooks each (Figs. 2–5, 10, 11). Apical organ prominent, occasionally extending into neck (Figs. 2–5). Hooks in anterior circle in anterior proboscis long, widely spaced from posterior hooks; 2 anterior lateral hooks displaced posteriorly (Fig. 5). Anterior hook roots

TABLE I. Seasonal prevalence of *Acanthogyrus* (*Acanthosentis*) *barmeshoori* n. sp. Infections in *Aphanius farsicus* from Barm-e-Shoor, Maharlu Basin, Iran, 2006–2007.

Month	July	August	September	October	November	December	January	February	March	April	May	June
Examined fish (male and female)	30	30	30	30	30	30	30	27	30	30	30	30
Infected fish (male and female)	11	10	10	23	11	4	6	22	13	24	24	15
Infected males	5	3	6	12	2	1	3	13	7	10	12	9
Infected females	6	7	4	11	9	3	3	9	6	14	12	6
Parasites collected	31	15	17	78	28	4	10	39	26	112	141	33
Prevalence (%)	36.7	33.3	33.3	76.7	36.7	13.3	20.0	81.5	43.3	80.0	80.0	50.0
Abundance	1.0	0.5	0.6	2.6	0.9	0.1	0.3	1.4	0.9	3.7	4.7	1.1
Intensity	2.2	1.5	1.7	3.4	2.5	0.1	1.7	1.8	2.0	4.7	5.9	2.2

TABLE II. The seasonal relationship between fish length and weight and parasite length, 2006–2007.

Month	Parameter*	N	Minimum	Maximum	Mean	Standard deviation
July	TL	30	17.9	34.50	22.30	4.58
	SL	30	14.50	28.40	18.21	3.73
	W	30	0.11	0.84	0.25	0.19
	MPL	10	0.84	1.57	1.06	0.23
August	TL	30	17.40	23.90	19.76	1.64
	SL	30	13.90	20.20	16.25	1.56
	W	30	0.09	0.28	0.16	4.90
	MPL	9	0.30	1.12	0.66	0.27
September	TL	30	16.70	26.10	22.49	2.42
	SL	30	14.10	22.20	18.80	2.14
	W	30	0.11	0.36	0.23	7.63
	MPL	8	0.36	1.28	0.77	0.35
October	TL	30	18.40	23.80	20.85	1.29
	SL	30	14.80	19.80	17.23	1.18
	W	30	0.09	0.25	0.16	3.59
	MPL	22	0.26	0.75	0.36	0.10
November	TL	30	18.30	26.00	22.15	1.73
	SL	30	15.40	21.30	17.95	1.51
	W	30	0.11	0.34	0.19	5.52
	MPL	11	0.28	1.16	0.69	0.35
December	TL	30	14.10	25.00	20.97	2.68
	SL	30	11.20	20.70	16.91	2.31
	W	30	0.04	0.29	0.17	6.14
	MPL	3	0.40	0.68	0.51	0.15
January	TL	30	18.90	27.40	22.53	1.92
	SL	30	15.50	22.60	18.42	1.67
	W	30	0.08	0.38	0.19	6.47
	MPL	6	0.28	1.04	0.59	0.26
February	TL	30	19.20	31.20	24.14	3.04
	SL	30	15.30	25.10	19.47	2.58
	W	30	0.11	0.65	0.27	0.12
	MPL	21	0.32	1.30	0.57	0.25
March	TL	27	19.30	30.50	25.12	3.16
	SL	27	15.60	24.60	20.51	2.64
	W	27	0.11	0.52	0.29	0.12
	MPL	11	0.28	1.22	0.69	0.28
April	TL	30	21.90	35.00	27.20	3.04
	SL	30	18.00	28.50	22.40	2.65
	W	30	0.20	0.88	0.41	0.15
	MPL	24	0.44	1.63	0.79	0.30
May	TL	30	19.80	41.90	29.05	5.12
	SL	30	17.60	35.20	23.55	5.29
	W	30	0.16	1.33	0.53	0.30
	MPL	24	0.48	1.68	0.98	0.34
June	TL	30	16.20	32.10	24.62	4.61
	SL	30	13.20	27.60	20.24	3.99
	W	30	0.07	0.78	0.32	0.19
	MPL	14	0.40	1.60	0.95	0.35

* TL: fish total length; SL: fish standard length; W: fish weight (g); MPL: mean parasite length (mm). (Total no. of fish = 357, total counted parasites = 163.)

simple, about half as long as blades, with short anterior manubria. Hooks in posterior 2 circles in posterior proboscis closer together, with short, stubby roots. Basal hooks slightly smaller than middle hooks (Fig. 5). Proboscis receptacle single-walled, longer than proboscis and neck, with large triangular cephalic ganglion in posterior 50–70% of receptacle (Figs. 2–5). Para-receptacle structure (PRS) prominent in both sexes antero-ventrally and similar structure at posterior end of trunk (Figs. 2, 3, arrows). Lemnisci digitiform, subequal, with single nucleus in swollen area just posterior to level of proboscis receptacle (Figs. 3, 4), usually extending past anterior testis.

Male (based on 18 mature specimens): Trunk 0.26–1.06 (0.89) mm long by 0.17–0.32 (0.27) mm wide. Proboscis 52–72 (61) long by 48–65 (57) wide. Apical organ 50–67 (58) long by 15–25 (20) wide. Proboscis hooks 35–42 (38) long in anterior circle and 7–12 (9) in 2 posterior circles. Neck 17–25 (22) long by 55–65 (59) wide posteriorly. Proboscis receptacle 102–158 (131) long by 52–80 (66) wide. Shorter lemniscus 120–205 (160) long by 18–32 (23) wide; longer lemniscus 130–245 (180) long by 18–30 (25) wide. Posterior male reproductive structures (Fig. 2) extending into bursa. Testes pre-equatorial, ovoid, almost equal, contiguous, often overlapping. Anterior testis 117–250 (185) long by 115–225 (169) wide; posterior testis 115–240 (155) long by 125–225 (172) wide. Cement gland with 4–6 large giant nuclei, 60–200 (132) long by 57–125 (95) wide. Cement reservoir just posterior to cement gland, 40–102 (75) long by 23–73 (51) wide. Common sperm duct prominent, 120–170 (148) long by 50–100 (74) wide. Saefftigen's pouch prominent, 112–200 (154) long by 30–60 (90) wide (Fig. 2). Penis triangular with 2 internal lobes, 50 long by 30 wide at base. Bursa 54–109 (78) long by 71–102 (88) wide.

Female (based on 15 mostly gravid specimens): Trunk 0.41–1.7(1.11) mm long by 0.1–0.5 (0.3) mm wide. Proboscis 57–88 (73) long by 47–80 (60) wide. Apical organ 60–85 (77) long by 22–34 (27) wide. Proboscis hook length 35–46 (41) long in anterior circle, 8–15 (12) in 2 posterior circles. Proboscis receptacle 96–175 (144) long by 65–107 (84) wide. Shorter lemniscus 138–222 (170) long by 18–38 (28) wide; longer lemniscus 168–278 (220) long by 20–40 (31) wide. Reproductive system 284–357 (318) long. Vagina muscular, bulbous (Fig. 6); gonopore terminal (Figs. 3, 4). Egg fusiform, elongate, with bluntly pointed ends and no polar prolongation of fertilization membrane (Figs. 7, 13), 27–31 (29) long by 7–9 (8) in diameter.

Taxonomic summary

Type host: Aphanius farsicus Teimori, Esmaeili and Reichenbacher, 2011.

Type locality: Barm-e-Shoor Spring, Maharlu Lake Basin, southern Iran (29°27′951″N, 52°42′0.051″E).

Type material: HWML collection nos. 49750 (holotype male and paratypes on same slide) and 49751 (allotype female and paratypes on same slide). Voucher specimens at TUSPH and BCSU.

Etymology: The species is described after the name of the Barm-e-Shoor Spring, which is now an environmentally sensitive and threatened locality in the Maharlu Lake Basin.

Remarks

Using Amin's (2005) key to species of the subgenus *Acanthosentis*, and upon examining reference specimens and descriptions of species of the same subgenus in the senior author's collection, it was clearly evident that *A. barmeshoori* is a new species for 3 reasons. First, the small size of specimens of *A. barmeshoori* is unmatched, even by the smallest of the other 44 valid species of this subgenus, *Acanthogyrus* (*Acanthosentis*) *shuklai* Agrawal and Singh 1982, described from 1 male and 1 female from Gorakhpur, India. In A. *shuklai*, the male reproductive system is posterior, Saefftigen's pouch is lacking, the anterior and posterior proboscis hooks are not widely separated, and the eggs are much smaller than those of *A. barmeshoori*. Second, anterior PRS and the similar posterior structure (see Amin et al., 2007) have been demonstrated in *A. barmeshoori*. PRS has been found in only 1 other species of *Acanthosentis*, i.e., *Acanthogyrus* (*Acanthosentis*) *parareceptaclis* Amin, 2005 from a Lake Biwa fish in Japan. Specimens of the Japanese species, however, are larger, with fewer hypodermal giant nuclei (1–3 dorsal, 0–1 ventral), no extreme diversification in size of proboscis hooks that are not widely spaced, and with equatorial testes. Third, specimens of 4 other species of *Acanthosentis* also have long anterior hooks widely separated from the small and equal hooks of the middle and posterior circles. These can be separated from the new species as follows. In *Acanthogyrus* (*Acanthosentis*) *acanthuri* Cable and Quick, 1954 from Puerto Rica and Tobago, the trunk is considerably longer, elongate, and cylindrical, the proboscis and hooks are larger, the roots of the anterior hooks are without manubria, and the testes are elliptical and equatorial. In *Acanthogyrus* (*Acanthosentis*) *dattai* Podder 1938 from Bengal, the elongate cylindrical trunk, the proboscis, and the hooks are larger than in specimens of our new species, the whole trunk is covered with circles of spines, the roots of the anterior hooks are without

TABLE III. Prevalence (%) of *Acanthogyrus* (*Acanthosentis*) *barmeshoori* n. sp. in *A. farsicus* of different length classes, 2006–2007.

	Length classes (mm)*							
Month	14–17.9	18–21.9	22–25.9	26–29.9	30–33.9	34–37.9	38–41.9	All classes % prevalence
July	0	7 (23%)	2 (7%)	1 (3%)	1 (3%)	0	0	36%
August	0	8 (27%)	2 (7%)	0	0	0	0	33%
September	0	4 (13%)	4 (13%)	2 (7%)	0	0	0	33%
October	0	18 (60%)	5 (17%)	0	0	0	0	77%
November	0	3 (10%)	7 (23%)	1 (3%)	0	0	0	36%
December	0	1 (3%)	3 (10%)	0	0	0	0	13%
January	0	3 (10%)	3 (10%)	0	0	0	0	20%
February	0	6 (22%)	9 (33%)	6 (22%)	1 (3%)	0	0	80%
March	0	1 (3%)	3 (10%)	8 (27%)	1 (3%)	0	0	43%
April	0	1 (3%)	8 (27%)	11 (37%)	3 (10%)	1 (3%)	0	80%
May	0	1 (3%)	4 (13%)	10 (33%)	5 (17%)	2 (7%)	2 (7%)	80%
June	0	4 (13%)	3 (10%)	6 (20%)	2 (7)	0	0	50%

* Total number of recovered parasites (% prevalence).

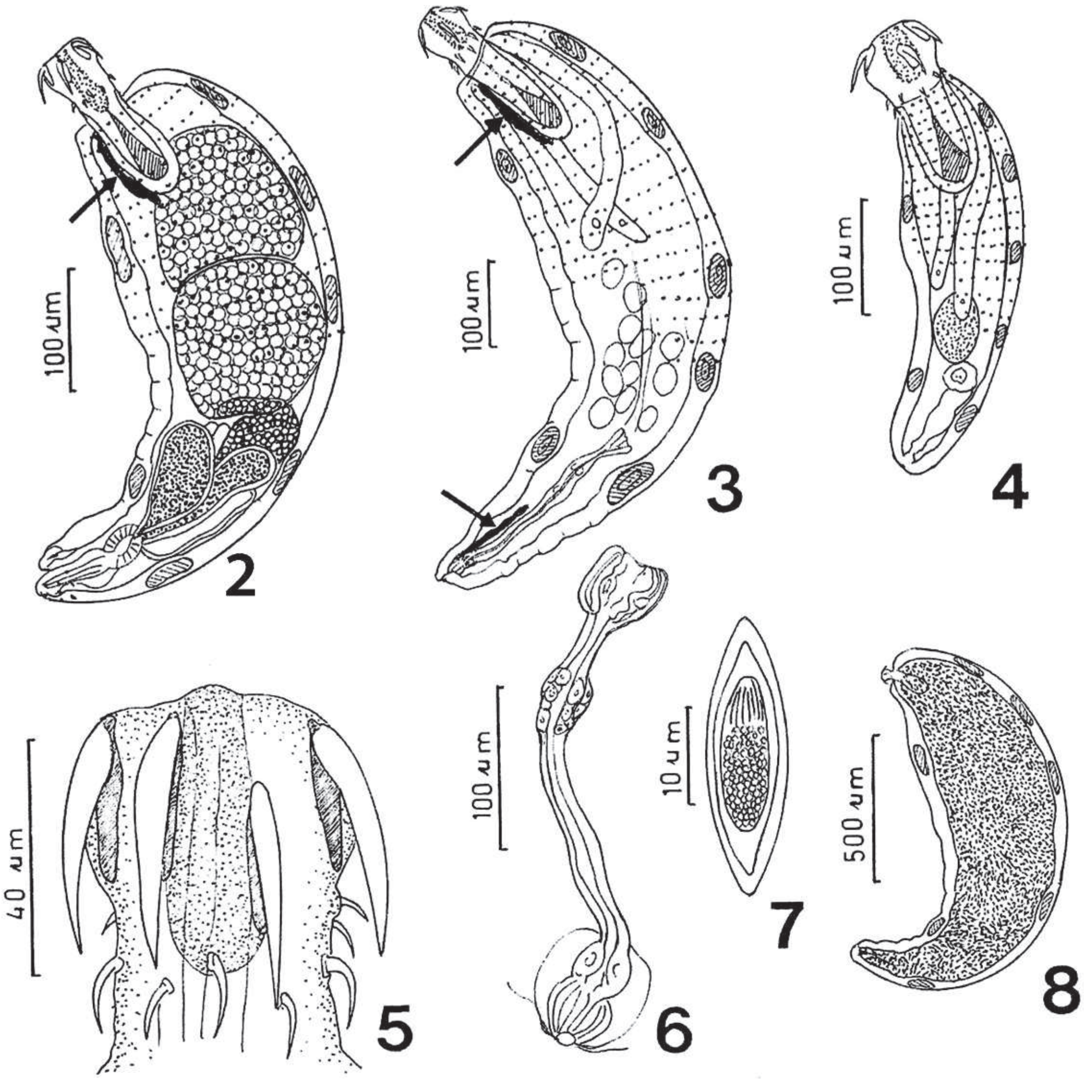
manubria, the lemnisci are barely longer than the proboscis receptacle, and the testes are post-equatorial. In *Quadrigyrus* (*Acanthosentis*) *periophthalmi* Wang, 1980 from Fujian, China, the trunk is larger than in our specimens and is almost all covered with circles of spines, except for the posterior-most end, and only with 1 dorsal and 1 ventral hypodermal giant nuclei; anterior proboscis hooks are only twice as long as those in the middle and posterior circles, and the testes are post-equatorial. In *Acanthogyrus* (*Acanthosentis*) *tilapiae* Baylis, 1947 from Nile fishes in Africa, the proboscis and the trunk, which is completely covered with spines, are markedly larger, the cephalic ganglion is smaller than in our specimens, and the testes are equatorial.

DISCUSSION

This is the first report of infection of *A. farsicus* with an acanthocephalan. This record is unique in that infected fish were collected from a spring that channels into a chemically inhospitable salt lake, Maharlu Lake, which does not harbor any fish. There is no permanent river in Maharlu Lake Basin and no other acanthocephalans are known in this geographical area (Fig. 1). Species of *Acanthosentis* have never been reported from Iran or any of the adjacent countries. The population of *A. barmeshoori* reported in this study appears to represent a relic species that has been isolated for a long period of time, probably corresponding with the isolation of its tooth-carp host. *Aphanius farsicus* is an endemic species confined to inflowing streams and springs of Maharlu Lake basin, an endorheic area where the northern part is mountainous and the southern part is plain and flat (Coad, 1996). Maharlu Lake was formed in post-Pleistocene by fault movement to northwest-southeast (Aghanabati, 2006). The main water sources for this lake are the freshwater rivers and streams that drain into the lake from northwest-southeast (Aghanabati, 2006). These spring-streams, and consequently the *Aphanius* individuals, may connect to each other during the rainy seasons. It is also suggested that they may be connected via the underground water networks in spite of the long isolation of these springs (Coad, 1996). Additionally, the presence of artificial channels for agriculture activities may create another way of connecting populations. However, Maharlu Lake, with high salinity (>200 ppt), is an impassable barrier to dispersal of *Aphanius* populations inhabiting the springs or streams in this basin (Coad, 1996).

TABLE IV. Length (mm) of *Acanthogyrus* (*Acanthosentis*) *barmeshoori* in *A. farsicus* of different length classes by season, 2006–2007.

	Fish length classes						
Month	14–17.9	18.0–21.9	22.0–25.9	26.0–29.9	30.0–33.9	34.0–37.9	38.0–41.9
July	0	0.84–1.15	0.90–1.57	1.32–1.32	0.99–0.99	0	0
August	0	0.30–1.12	0.76–0.76	0	0	0	0
September	0	0.56–1.12	0.36–0.92	0.58–1.28	0	0	0
October	0	0.27–0.48	0.26–0.75	0	0	0	0
November	0	0.32–1.16	0.28–1.16	1.04–1.04	0	0	0
December	0	0.40–0.40	0.44–0.68	0	0	0	0
January	0	0.40–0.68	0.28–1.04	0	0	0	0
February	0	0.32–0.58	0.32–0.96	0.46–1.30	0.46–0.46	0	0
March	0	0.56–0.56	0.56–0.78	0.28–1.22	0.87–0.87	0	0
April	0	0.60–0.60	0.44–1.52	0.48–1.04	0.44–0.96	1.63–1.63	0
May	0	0.48–.48	0.8–1.64	0.48–1.44	0.58–1.68	1.01–1.38	0.56–0.92
June	0	0.60–1.28	0.64–0.90	0.40–1.60	0.56–1.16	0	0

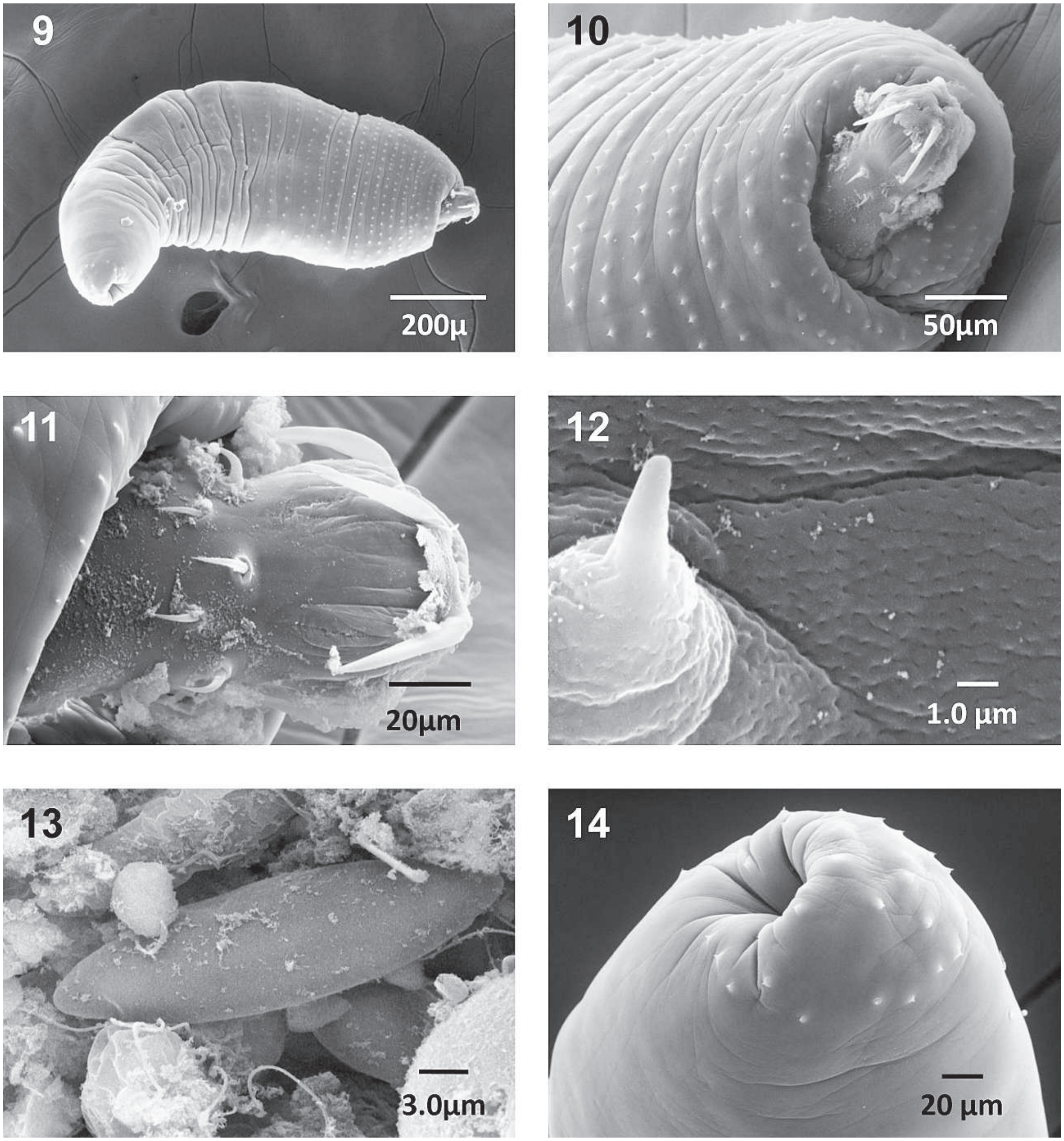


FIGURES 2–8. The morphology of paratype specimens of *Acanthogyrus* (*Acanthosentis*) *barmeshoori* n. sp. from the Persian tooth-carp *Aphanius farsicus* in Iran. (**2**) An adult male; note the para-receptacle structure (arrow). (**3**) An adult female in the ovarian ball stage; note the para-receptacle structures (arrows). (**4**) A juvenile female. (**5**) Proboscis, hooks, and roots with anterior manubria from a gravid female. (**6**) Female reproductive system. (**7**) Egg. (**8**) A gravid female with arched dorsum.

Actually, the present tooth-carp in inland waters may have risen a long time ago with the post-Pliocene uplift of the Zagros and Alborz Mountains rather than being the result of relatively recent inter-basin dispersal (Kosswig, 1967; Coad, 1996; Coad and Abdoli, 2000). When the Maharlu Lake completely dries out, as it did in 1968, some springs less than 17 km away directly across from the lake become recolonized from neighboring higher springs, thereby forcing the interconnection of springs on the lake bed (Cornwallis, 1968; Coad, 1996). It should be noted that the current studied locality is less than 1 km away from the dried lake margin. The main aquatic features of the Maharlu Basin and the unconnected nearby Kor River Basin are fishless chloride lakes of post-Pleistocene origin but with tributary streams and springs containing tooth-carps (Fig. 1). This geological situation created isolated springs which effectively block gene flow between upland and lowland populations and, consequently, speciation is a more likely phenomenon. Moreover, the present geographic distribution of the extant *Aphanius* species is directly linked to the climate change and paleo-geographic reorganization that occurred in the Paratethys and Mediterranean areas during the Miocene (Reichenbacher and Kowalke, 2009).

Meanwhile, the presence of fossil *Aphanius* (Priem, 1908) from the Miocene of northwestern Iran, at Orumiyeh Lake, indicates that tooth-carps like *Aphanius*, and likely their parasites, have a long history in Iran. Kosswig (1967) regards *Aphanius* species as relicts of the Tethys Sea from about 20 mya, as they are small fishes with low dispersal ability. It is generally agreed that a global ecological change, i.e., a gradual reduction of humidity or desertification, was under way during the Miocene (e.g., Cerling et al., 1997; Ward, 2009), which most probably caused their extinction and the speciation of *Aphanius* populations in the late Miocene.

In addition, high species diversity of fauna and flora in southern and central Iran appears to be related to a complex



FIGURES 9–14. SEM of paratypes of *Acanthogyrus* (*Acanthosentis*) *barmeshoori* n. sp. from *Aphanius farsicus*. (**9**) A paratype female. (**10**) Anterior end of the same specimen in Figure 10. (**11**) Proboscis of the same specimen in Figure 1. (**12**) A trunk spine showing epidermal micropores. (**13**) Egg. (**14**) Posterior end of a specimen showing posterior trunk spines.

geological history (Hrbek et al., 2002). The geological events causing rapid isolation of mountainous areas and subsequent fragmentation of populations gave rise to the evolution of new species (Sengör et al., 1988). Therefore, the individual geological histories of the endorheic basins, e.g., Maharlu, Kor, and of the Fars area (Zagros mountains), as detailed by Ramsey et al. (2008) and Kehl et al. (2009), may have affected speciation and thus contributed to the unusually high *Aphanius* species diversity in this region. Nevertheless, more studies on these basins in the central and southern regions of Iran can increase our knowledge of their geological history, which has never been reported from Iran before, and increase the chances of finding more acanthocephalans.

In this study the prevalence of infection varied from 13.3 to 81.5% (mean of 48.5%) during the year; higher prevalence was noted in February, April, May, and October. Prevalence decreased with increasing fish size, probably due to reduced consumption of infected copepods by older fish. Heavily infected fish appear to die early in winter, corresponding with low water temperatures and changes of water chemistry.

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