

## New Species of *Falcaustra* (Nematoda: Kathlaniidae) and Other Helminths in *Megophrys stejnegeri* (Anura: Megophryidae) from Samar Island, Philippines

CHARLES R. BURSEY,<sup>1,5</sup> STEPHEN R. GOLDBERG,<sup>2</sup> CAMERON D. SILER,<sup>3</sup> AND RAFE M. BROWN<sup>4</sup>

<sup>1</sup> Department of Biology, Pennsylvania State University, Shenango Campus, Sharon, Pennsylvania 16146, U.S.A.

<sup>2</sup> Department of Biology, Whittier College, Whittier, California 90608, U.S.A.

<sup>3</sup> University of Oklahoma, Sam Noble Oklahoma Museum of Natural History, Norman, Oklahoma 73072, U.S.A.

<sup>4</sup> Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, Kansas 66045, U.S.A.

**ABSTRACT:** *Falcaustra samarensis* n. sp. (Ascaridida, Kathlaniidae) from the intestines of *Megophrys stejnegeri* Taylor 1920 (Anura, Megophryidae) is described and illustrated. *Falcaustra samarensis* n. sp. represents the one hundred fourth species assigned to the genus and the thirty-seventh Oriental species. It is distinguished from other Oriental species by the pattern of caudal papillae (8 precloacal, 2 adcloacal, 10 postcloacal, and 1 median), length of spicules (2,050–3,300 µm) and presence of 1 pseudosucker. *Megophrys stejnegeri* was also found to harbor 2 additional species of Nematoda, adults of *Aplectana ranae* and *Batrachostromylus longispiculus*. *Megophrys stejnegeri* represents a new host record for each of these helminth species.

**KEY WORDS:** *Aplectana ranae*, *Batrachostromylus longispiculus*, *Falcaustra samarensis* n. sp., Nematoda, Megophryidae, Mindanao horned frog.

The genus *Falcaustra* was established by Lane (1915) when he redescribed *Oxysoma falatum* Linstow, 1906, a nematode from the intestine of the Indian Black Turtle, *Melanochelys* (= *Nicoria*) *trijuga* and discovered *Oxysoma* to be preoccupied. Species of *Falcaustra* occur in the digestive tracts of fish, amphibians, and reptiles. Of the 103 nominal species (see Bursey et al., 2014), 36 are known from the Oriental Region (Table 1). The genus *Batrachostromylus* was established by Yuen (1963) for a nematode from the intestine of a Malayan horned frog, *Megophrys nasuta*. There is a single species assigned to the *Batrachostromylus*, *Batrachostromylus longispiculus* Yuen, 1963, which is known from 2 hosts (Baker, 1983). The genus *Aplectana* was established by Railliet and Henry (1916) in their review of oxyurid nematodes where they proposed *Aplecta* with *Ascaris acuminata* Schrank, 1788, as type species, but they later found *Aplecta* to be preoccupied and substituted *Aplectana* as the replacement name (Railliet, 1916). Baker (1980) revised the genus and provided redescriptions of 10 species and comments for 37 additional species; however, *Aplectana ranae* was not red-described. Species of *Aplectana* occur in the intestines of amphibians and reptiles. Of the 52 nominal species (see Bursey et al., 2018), 4 are known from the Oriental Region.

*Megophrys stejnegeri* Taylor, 1920 (Mindanao horned frog) is a common endemic anuran species found throughout much of the Mindanao Pleistocene Aggregate Island Complex, a biogeographic sub-province of the Philippines, composed of Basilan, Biliran, Bohol, Dinagat, Leyte, Mindanao, Samar, and Siargao Islands (Brown and Diesmos, 2009). Individuals of this species inhabit leaf litter of primary and secondary rainforests at varying elevations (Sanguilla et al., 2016; Vidal et al., 2018). On Samar, the species has been recorded from 160 m (southern Samar Municipality of Balangiga) to 760 m (central Samar Municipality of San Jose de Buan; RMB, personal observations). The species is fairly resistant to disturbance and can be found on the edge of agricultural fields (Warguez et al., 2013; Sanguilla et al., 2016). The International Union for Conservation of Nature (IUCN SSC, 2018) assessment of *M. stejnegeri* has recently been revised from Vulnerable (VU) to Least Concern (LC). Individuals are medium-sized terrestrial frogs (males, 38–55 mm; females, 40–76 mm) (Alcala and Brown, 1998) and all members of the genus, sensu stricto (Chen et al., 2016), have pointed epithelial projections extending from the lateral edges of the palprebra, commonly referred to as “horns” (Alcala and Brown, 1998).

The purpose of this paper is to describe a new species of *Falcaustra* from the large intestines of *M. stejnegeri* and to provide an initial helminth list for this host species.

<sup>5</sup> Corresponding author (e-mail: cxb13@psu.edu).

**Table 1.** Selected characteristics of male individuals of species of *Falcaustra* from the Oriental biogeographical region.\*

<i>Falcaustra</i> sp.	Type host	Body length	Spicule length (mm)	Papillae pattern†	Pseudosucker
<i>F. annandalei</i> (Baylis and Daubney, 1922) Chabaud and Golvan, 1957 = <i>Zanclophorus annandalei</i> Baylis and Daubney, 1922	turtle	15.5–15.9	2.20–2.30	12-0-8+1	1
<i>F. barbi</i> Baylis and Daubney, 1922 = <i>Spironoura kalasiensis</i> Karve and Naik, 1951 = <i>Spironoura sudanensis</i> Khalil, 1962	fish	15.2–16.5	1.13	6-0-14+1	1
<i>F. bengalensis</i> Manna and Mahapatra, 1989	turtle	12.7–13.5	0.45–0.51	8-0-38	absent
<i>F. brevicaudatum</i> (Khan and Yaseen, 1969) Soota, 1983 = <i>Kathlania brevicaudatum</i> Khan and Yaseen, 1969	fish	10.2–11.5	unequal 0.50 + 1.77	10-2-8	1
<i>F. chauhani</i> (Soota, 1975) Petter, 1979 = <i>Spironoura chauhani</i> Soota, 1975	fish	7.7–10.8	0.41–0.44	6-6-8+1	absent
<i>F. chiloscyllii</i> (Thwaite, 1927) Soota, 1983 = <i>Kathlania chiloscyllii</i> Thwaite, 1927	fish	8.3–10.0	2.0–2.6	12-0-10	1
<i>F. desilvai</i> Bursey, Goldberg and Bauer, 2009	lizard	6.3–8.0	0.96–1.05	12-2-10+1	absent
<i>F. dubia</i> Yuen, 1963	frog	13.5–14.0	1.54–1.69	6-2-12+1	1
<i>F. duyagi</i> (Tubanqui and Villaamil, 1933) Freitas and Lent, 1941 = <i>Spironoura duyagi</i> Tubangui and Villaamil, 1933	turtle	11.5–13.0	0.75–0.90	10-0-10+1	2–3
<i>F. falcata</i> (Linstow, 1906) Lane, 1915 = <i>Oxysoma falcata</i> Linstow, 1906 = <i>Oxysoma kachugae</i> Steward, 1914 = <i>Spironoura brevispiculata</i> Baylis, 1935	turtle	13.0–14.0	0.35–0.45	4-2-14+1	absent
<i>F. fernandoi</i> (Sathananthan, 1972) Baker, 1987 = <i>Spironoura fernandoi</i> Sathananthan, 1972	turtle	7.0	1.70–1.80	6-6-8+1	absent
<i>F. greineri</i> Bursey and Kinsella, 2003	turtle	14.0–17.5	1.07–1.33	6-0-14+1	absent
<i>F. heosemydis</i> Bursey, Goldberg and Miller, 2004	turtle	13.2–14.7	0.79–0.89	10-0-12+1	absent
<i>F. kalasiensis</i> (Karve and Naik, 1951) Vassiliades and Troncy, 1973 = <i>Spironoura kalasiensis</i> Karve and Naik, 1951	fish	11.4–11.7	0.45–0.55	6-0-4+1	1
<i>F. kaverii</i> (Karve and Naik, 1951) Vassiliades and Troncy, 1973 = <i>Spironoura kaverii</i> Karve and Naik, 1951	fish	13.7–15.5	2.00–2.23	6-0-14+1	1
<i>F. kempii</i> (Baylis and Daubney, 1922) Chabaud and Golvan, 1957 = <i>Zanclophorus kempii</i> Baylis and Daubney, 1922	turtle	10.9–12.8	2.90	10-0-8+1	1
<i>F. khadrai</i> (Karve, 1941) Chabaud and Golvan, 1957 = <i>Spironoura khadrai</i> Karve, 1941	fish	1.2–14.3	0.35–0.38	10-0-10+1	absent
<i>F. kinsellai</i> Bursey and Freeman 2005	turtle	9.6–10.2	0.43–0.45	6-6-10+1	1
<i>F. kutcheri</i> Bursey, Platt, and Rainwater, 2000	turtle	13.0	0.38	8-2-10+1	absent
<i>F. leptcephala</i> Baylis and Daubney, 1922	fish	19.0	1.00	6-4-10+1	absent
<i>F. malaysiaia</i> Bursey, Goldberg, and Grismer, 2014	lizard	8.3–8.9	1.31–1.37	6-2-12+1	1
<i>F. manouriacola</i> Bursey and Rivera, 2009	turtle	18.0–25.5	4.67–4.80	10-2-8	1



Table 1. Continued.

<i>Falcaustra</i> sp.	Type host	Body length	Spicule length (mm)	Papillae pattern†	Pseudosucker
<i>F. nilgiriensis</i> (Soota and Chaturvedi, 1971) Petter, 1979 = <i>Spironoura nilgiriensis</i> Soota and Chaturvedi, 1971	fish	7.5–9.6	0.24–0.35	6-0-14+1	absent
<i>F. onama</i> (Karve, 1927) Freitas and Lent, 1941 = <i>Spironoura onama</i> Karve, 1927	turtle	8.3–8.5	0.81	6-4-10+1	1
<i>F. pahangi</i> Yuen, 1963	toad	11.0	3.98	10-0-12+1	1
<i>F. pillaii</i> (Sathananthan, 1972) Baker, 1987 = <i>Spironoura pillaii</i> Sathananthan, 1972	turtle	9.0–10.4	1.33	6-6-10+1	absent
<i>F. purchoni</i> Yuen, 1963	toad	10.0–11.0	1.07–1.15	8-0-10+1	1
<i>F. purvisi</i> (Baylis, 1933) Chabaud and Golvan, 1957 = <i>Zanclaphorus purvisi</i> Baylis, 1933	turtle	21.0–24.0	2.40–3.60	6-6-8	1
<i>F. rangoonica</i> (Chatterji, 1936) Freitas and Lent, 1941 = <i>Spironoura rangoonica</i> Chatterji, 1936	turtle	8.8–10.2	0.35–0.50	6-4-10+1	1
<i>F. roberti</i> (Chou and Lowe, 1984) Burse and Kinsella, 2003 = <i>Spironoura roberti</i> Chou and Lowe, 1984	turtle	6.10–11.0	0.55–0.60	10-0-10	2
<i>F. samarensis</i> n. sp.	frog	10.6–19.8	2.05–3.33	8-2-10+1	1
<i>F. siamensis</i> Baylis, 1920	turtle	15.9	0.86	6-2-12+2	3–4
<i>F. stewarti</i> Baylis and Daubney, 1922	turtle	17.0–20.4	0.50–0.56	6-0-30/34+1	absent
<i>F. stromateii</i> (Bilquees and Khanum, 1971) Soota, 1983 = <i>Kathlania stromateii</i> Bilquees and Khanum, 1971	fish	7.3	Unequal 0.33 + 1.0	10-2-10	1
<i>F. testudinis</i> Baylis and Daubney, 1922	turtle	10.2–10.4	0.80	6-4-12+1	absent
<i>F. tintlwini</i> Burse and Platt, 2018	turtle	15.0–22.0	0.43–0.56	6-0-12	absent
<i>F. trilokiae</i> (Singh, 1958) Chabaud, 1978 = <i>Velariocephalus trilokiae</i> Singh, 1958	frog	6.9–9.6	0.25–0.29	4-0-6+1	absent

\*Holt et al. (2013).

†Precloacal-adcloacal-postcloacal+median.

## MATERIALS AND METHODS

Eight specimens of *Megophrys stejneri* Taylor, 1920 (mean snout-vent length = 47.4 mm ± 7.8 SD, range = 39–63 mm) were borrowed from the herpetology collection of the Sam Noble Oklahoma Museum of Natural History (OMNH). The frogs were hand collected by Jason B. Fernandez, CDS, and RMB during an expedition to northern and eastern Samar Island, Philippines, in 2014 (7 from San Jose de Buan [12.05284°N, 125.04754°E] 2–6 July 2014, OMNH 45141, 45144, 45148, 45155–45158; 1 from the Municipality of Taft [12.03429°N, 125.03429°E] 6 July 2014, OMNH 45159). Following collection and examination, specimens were euthanized with aqueous chloroform, and each voucher was fixed in 10% buffered formalin, before eventually being transferred to 70% ethanol for long-term storage.

The body cavity was opened by a longitudinal lateral incision, and the gastrointestinal tract was removed by cutting across the esophagus and rectum. The esophagus, stomach, small intestine, large intestine, and coelom of each frog were examined separately for helminths. Only nematodes were found, and each nematode, fixed in situ, was removed and placed in lactophenol, allowed to clear, then examined under a light microscope (Leica, ATC 2000). Drawings were made with the aid of a microprojector. Measurements are given in micrometers, unless otherwise stated, with mean ± 1 SD and range in parentheses.

## RESULTS

Seven (88%) of the 8 frogs harbored a total of 66 nematodes: 4 (50%) hosts harbored 1 nematode species, 3 (38%) harbored 2 species. Thus, there were

1.25 ± 0.25 ( $x \pm 1$  standard error [SE]) (range 1–2) helminth species per infected frog and 8.25 ± 1.98 (1–15) helminth individuals per infected frog. Three species of Nematoda were found: 3 individuals were assigned to *Aplectana* Railliet and Henry, 1916, based upon the presence of simple papillae in the male and parallel uteri directed anteriorly in the female; 1 individual was assigned to *Batrachostromylus* Yuen, 1963, based upon the absence of a cephalic vesicle and presence of a conspicuously swollen anterior end of the esophagus as well as a strongyle-like ovejector; 62 individuals were assigned to *Falcaustra* Lane 1915 based upon the structure of the esophagus. Based upon the descriptions and illustrations published by Walton (1931) and Baker (1980), the 3 individuals were identified as *A. ranae*. Based upon the descriptions and illustrations published by Yuen (1963) and Baker (1983) the single individual was identified as *B. longispiculus*. The 62 individuals assigned to *Falcaustra* were unlike any known species and determined to be a new species. Prevalence, mean intensity, and range by helminth species are given in Table 2. Selected nematode specimens were deposited in the Harold W. Manter Laboratory (HWML), University of Nebraska, Lincoln, USA. Description of the new species follows.

## DESCRIPTION

### *Falcaustra samarensis* n. sp. (Figs. 1–10)

*General*: Family Kathlaniidae Lane, 1915. Nematodes with cylindrical body tapering posteriorly, truncate anteriorly. Cuticle with fine, regular, transverse striations. Mouth bounded by 3 lips, each with a pair of sessile papillae at anterior margin. Amphids flat, 1 on each ventrolateral lip. Esophagus with subspheroid isthmus, valved bulb. Excretory pore anterior to level of isthmus. Tail conical in both sexes.

*Male* (holotype, 9 paratypes): Length 14.9 ± 2.6 mm (10.6–19.8 mm); width at level of esophageal-intestinal junction 363 ± 52 (281–434). Mouth bounded by 3 lips each approximately 77 wide, 25 long. Esophagus 2,520 ± 361 (1,709–2,882) in length consisting of corpus with short anterior muscular portion 149 ± 15 (115–166) in length and long posterior glandular portion 2,015 ± 307 (1,326–2,295) in length by 87 ± 11 (77–102) wide throughout; isthmus 161 ± 19 (128–179) in length by 125 ± 20 (89–153) wide; and valved bulb 195 ± 34 (140–255) in length by 199 ± 26 (153–230) wide. Nerve ring 416 ± 19 (382–438) and excretory pore 1,711 ± 133 (1,581–1,938) from anterior end, respectively. One pseudosucker approx-

imately 300 in length by 30 deep, approximately 15 pairs of muscles terminating on rim of pseudosucker. Posterior lip of pseudosucker approximately 2,300 from tip of tail. Approximately 30 pairs of oblique ventral muscles in a single field beginning near posterior lip of pseudosucker and terminating slightly anterior to cloaca. Conical tail 251 ± 30 (204–293) in length, 10 pairs of caudal papillae (4 pairs precloacal, 1 pair adcloacal, 5 pairs postcloacal; of the postcloacal papillae, 3 pairs ventral in position, 2 pairs lateral in position), single median papilla immediately anterior to cloacal meatus. Phasmids midway between lateral postcloacal papillae. Spicules similar in shape, 2,757 ± 392 (2,050–3,330) in length, alate, distal end pointed, curved through 180°, proximal end not expanded. Gubernaculum 114 ± 11 (102–128) in length, blunt distal tip.

*Female* (allotype, 9 paratypes): Length 17.0 ± 2.0 mm (14.7–19.3 mm), width at level of vulva 449 ± 81 (363–663). Mouth bounded by 3 lips, each approximately 88 wide, 25 long. Esophagus 2,643 ± 160 (2,372–2,882) in length consisting of anterior muscular portion 175 ± 9 (166–191) in length, posterior glandular portion 2,069 ± 136 (1,836–2,295) in length by 109 ± 11 (102–128) wide throughout; isthmus 185 ± 20 (153–204) in length by 134 ± 15 (115–153) wide; valved bulb 214 ± 17 (191–230) in length by 216 ± 18 (179–230) wide. Nerve ring 422 ± 24 (383–472) and excretory pore 1,872 ± 66 (1,785–1,989) from anterior end. Vulva transverse slit, 3,783 ± 431 (3,260–4,480) from posterior end; vagina approximately 625 in length directed anteriodorsally, giving rise to 2 divergent uteri. Eggs oval, 66 ± 2 (61–70) in length by 42 ± 2 (39–43) wide, thick shelled, unembryonated. Rectum separated from intestine by well-developed valve; thick cuticular lining present. Tail conical, 430 ± 29 (383–459) in length terminating in a short spike approximately 75 in length.

## Taxonomic summary

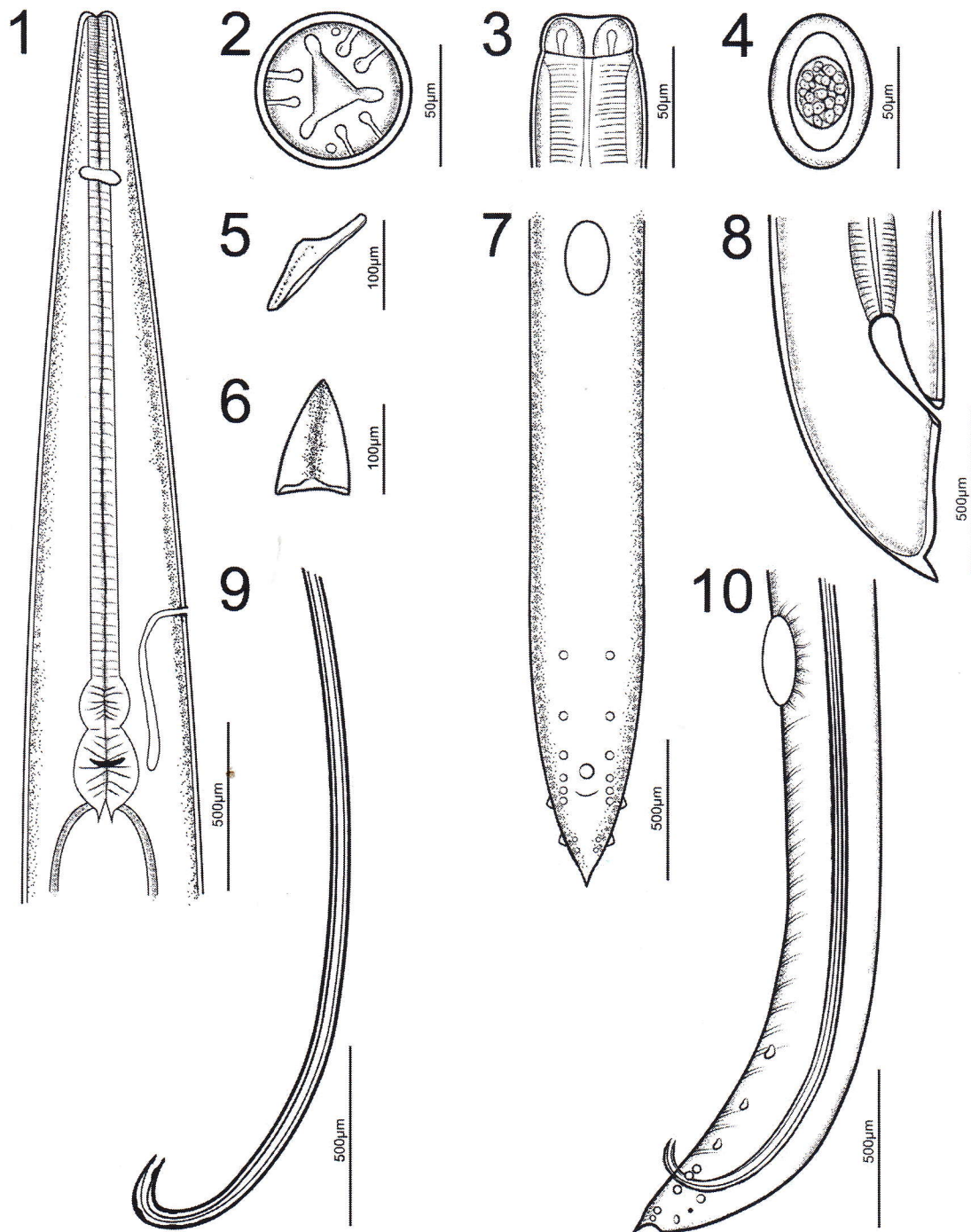
*Type host*: *Megophrys stejneri* Taylor, 1920, Megophryidae, Mindanao horned frog; symbiotype OMNH 45155: collection date, 6 July 2014.

*Type locality*: Philippines; Samar Island, Western Samar Province, Municipality of San Jose de Buan, 12.05613°N, 125.04754°E. Elevation 209 m.

*Site of infection*: Large intestine.

*Type specimens*: Holotype male, HWML 110623; Allotype female, HWML 110624; Paratype ( $n = 18$ ), HWML 110625.





**Figures 1–10.** *Falcaustra samarensis* n. sp. 1. Female, anterior end, lateral view. 2. Female, en face view. 3. Female, anterior end, dorsal view. 4. Egg. 5. Gubernaculum, lateral view. 6. Gubernaculum, dorsal view. 7. Male, papillae arrangement, ventral view. 8. Female, posterior end, lateral view. 9. Spicules. 10. Male, posterior end, lateral view.

**Table 2.** Site of infection, number of helminths, prevalence, intensity, and range of infection for 3 helminth species from *Megophrys stejnegeri*.

Helminth	Site of infection	<i>n</i>	Prevalence (%)	Intensity (mean ± SE)	Range	HWML accession no.
<i>Aplectana ranae</i>	small intestine	3	2/8 (25%)	4.0 ± 4.5	1–2	110626
<i>Batrachostrogylus longispiculus</i>	stomach	1	1/8 (13%)	1.5 ± 0.5	0	110627
<i>Falcaustra samarensis</i> n. sp.	intestines	62	7/8 (88%)	8.9 ± 2.1	1–15	110623–110625

*Etymology:* The new species is named in reference to Samar Island of the Mindanao faunal region.

### Remarks

The structure of the esophagus of *F. samarensis* n. sp. allows its assignment to Kathlaniidae Lane, 1914. Chabaud (1978) characterized *Falcaustra* as having a generally spherical isthmus immediately anterior to the esophageal bulb. Lane (1915) described the posterior portion of the esophagus to be hourglass shaped, while Chitwood and Chitwood (1974) stated that the isthmus in kathlaniid nematodes is subspheroid. This character is evident in *F. samarensis*.

Species of *Falcaustra* are distinguished on the basis of male characteristics: number and arrangement of caudal papillae, length of spicules, and presence or absence of a pseudosucker. Of the 36 species previously reported from the Oriental Region (Table 1), 17 possess a pseudosucker, namely, *Falcaustra annandalei*, *Falcaustra barbi*, *Falcaustra brevicaudatum*, *Falcaustra chiloscyllyi*, *Falcaustra dubia*, *Falcaustra kalasienensis*, *Falcaustra kaverii*, *Falcaustra kempi*, *Falcaustra kinsellai*, *Falcaustra malaysiaia*, *Falcaustra manouriacola*, *Falcaustra onama*, *Falcaustra pahangi*, *Falcaustra purchoni*, *Falcaustra purvisi*, *Falcaustra ragoonica*, *Falcaustra stromateii*. Of these, only *F. dubia* is known from a frog host, *Limnonectes macrodon*. *Falcaustra samarensis* n. sp. is easily separated from the above species: *F. brevicaudatum* and *F. stromateii* have unequal spicules; *F. manouriacola* and *F. pahangi* have spicules greater than 3.75 mm. *Falcaustra annandalei*, *F. chiloscyllyi*, *F. kaverii*, *F. kempi*, *F. purvisi*, and *F. samarensis* n. sp. have spicules greater than 2 mm in length. The remaining species in the above list possess spicules less than 2 mm in length. *Falcaustra samarensis* n. sp. is separated from the 5 species having spicules greater than 2 mm by papillae arrangement: *F. annandalei* (12-0-8+1); *F. chiloscyllyi* (12-0-10); *F. kaverii* (6-0-16+1); *F. kempi* (10-0-8+1); *F. purvisi* (6-6-8); *F. samarensis* n. sp. (8-2-10+1).

### DISCUSSION

Eighty-three species have been assigned to the genus *Megophrys* (Frost, 2019). However, parasitological studies of species assigned to the genus are severely limited. *Aplectana ranae* was originally described as *Oxysomatium ranae* from *Rana magna* (currently *Limnonectes macrocephalus*) collected on Luzon Island, Philippines, by Walton (1931) but reassigned to *Aplectana* by Baker (1980), who did not redescribe the species because of lack of male individuals. *Platymantis dorsalis* collected on Luzon Island has also been reported to harbor *A. ranae* (Goldberg and Bursey, 2019). *Megophrys stejnegeri* represents the third host reported for this nematode.

*Batrachostrogylus longispiculus* was originally described from specimens taken from *M. nasuta* collected in Malaysia (Yuen, 1963) and was also reported from *Megophrys montana* collected in Selangor, Malaysia (Baker, 1983). It should be noted that *M. montana* is currently restricted to Java (Frost, 2019); thus this report of *B. longispiculus* must belong to some related named or unnamed megophryid species. However, *M. stejnegeri* represents the third host reported for this nematode.

Other reports of helminths from species of *Megophrys* include *Seuratascares numidica* in *Megophrys nasicornis* (Sprent, 1985a); (however, *M. nasicornis* is a “nomen nudum” and we suggest *M. nasuta* may have been the host observed); *Orneoascaris sandoshami* in *M. nasuta* (Yuen, 1963; Sprent, 1985b) and in an undetermined species of *Megophrys* (Yuen, 1963); and *Aplectana macintoshii* from *Megophrys hasseltii* (Yuen, 1965). It should be noted that *M. hasseltii* has been reassigned to *Leptobracium* (see Frost, 2019) and the species *Leptobracium hasseltii* has been restricted to Java Island, Indonesia (Brown et al. 2009). More recently, Imkongwapang and Tandon (2010) described the monogenean *Neoriojatrema mokokchungensis* from *Xenophrys glandulosa* (currently *Megophrys glandulosa*) collected in Nagaland, India. Later, Imkongwapang et al. (2014) reported



*X. glandulosa* to harbor the nematode *Rhabdias ranae* and the acanthocephalan *Acanthocephalus bufonis* and listed 2 helminths for *Xenophrys wuliangshanensis* (currently *Megophrys wuliangshanensis*): *Pleurogenoides gastroporus* and *R. ranae*.

Given the current data, it would appear that species of *Megophrys* harbor a depauperate helminth fauna, as such, we emphasize the crucial importance of comprehensive herpetofaunal and parasite surveys (see Brown et al. 2013) of other riparian anurans in order to determine the distribution and host infection intensity among Philippine anurans.

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