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Life History of an Assassin Bug, *Sirthenea flavipes* (Stål, 1855): Laboratory Rearing and Field Observations*

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Abstract A female adult of *Sirthenea flavipes* (Stål, 1855) collected in June 2022 from Izumo City, Shimane Prefecture, Japan, laid over 30 eggs under laboratory conditions. The eggs hatched after approximately two weeks in the laboratory. The first-instar nymphs hatched in early July and reached the fifth (last) instar in mid-August. The *S. flavipes* nymphs preyed on the nymphs of mole crickets (*Gryllotalpa orientalis* Burmeister, 1839). Each nymph instar could be determined based on size, wing bud shape, and head coloration. Early instars of *S. flavipes* appeared in the field from July, concomitantly with the appearance of early instars of mole cricket nymphs; mature fifth-instar nymphs of *S. flavipes* were observed in the field in late August; and the emergence of adult *S. flavipes* was confirmed in the laboratory in early September. Thirty *S. flavipes* nymphs were collected between July 13 and September 15, 2022. *Sirthenea flavipes* overwinters as adults, but not as nymphs. The *S. flavipes* nymphs were similar in body coloration and body size (more specifically, the second- and third-instar nymphs) to those of the toxic *Paederus fuscipes* Curtis, 1826, suggesting a possible case of mimicry.

Key words：biotope, Hemiptera, Reduviidae, wetlands, *Paederus fuscipes*

Introduction

Sirthenea flavipes (Stål, 1855) is distributed in Japan (Honshu, Shikoku, Kyushu, Nansei Islands), Taiwan, and the Oriental Region, is 18−20 mm long, inhabits wet ground, and often flies toward lights (Yasunaga *et al*., 1993). The body color of the adult is yellow, with black coloration on the posterior edge of the prothorax, scutellum, and forewings (Yasunaga *et al*., 1993). In contrast, the nymphs are reddish orange, and their head, scutellum, and wing buds are black (Ishikawa *et al*., 2012). The genus *Sirthenea*, including *S. flavipes*, is a known predator of mole crickets. Hudson (1987) examined nymphs and adults of a New World species, *Sirthenea carinata* (Fabricius, 1798), obtained from the field and laboratory-rearing, and reported the existence of five nymph instars and that the first three instars prefer crickets, while the fourth and fifth-instars and adults prey on mole crickets. To our knowledge, there are no literature records of *S. flavipes* feeding in Japan; however, images of adult *S. flavipes* feeding on mole crickets (*Gryllotalpa orientalis* Burmeister, 1839) have been posted on the Internet. In addition, the similarity of the dorsal pattern of *S. flavipes* to that of a bombardier beetle, *Pheropsophus occipitalis jessoensis* Morawitz, 1862 and the fact that both species

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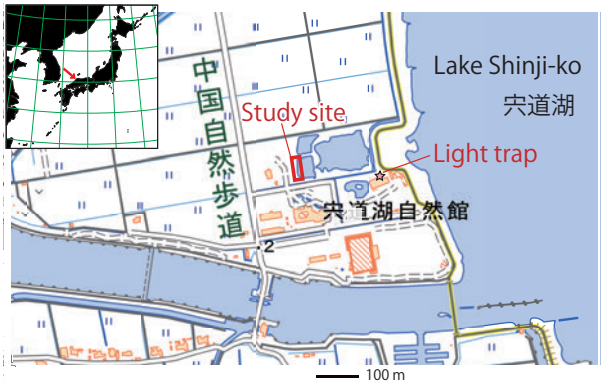

Fig. 1. Study site and location of the light trap at the Hoshizaki Institute for Wildlife Protection, Izumo. Modified from a GSI map (https://maps.gsi.go.jp).

prey on mole crickets have led to increased interest in the biology of this species.

Adults of *S. flavipes* are often seen flying toward lights, while nymphs are rarely observed. Thus, both adults and nymphs are expected to be underground rather than aboveground in nature. The present author observed mole crickets and *S. flavipes* at a waterside of an artificial wetland in Izumo City, Shimane Prefecture, Japan, in April 2022, and thus investigated the habitat of *S. flavipes* in captivity and in the field. Little information is available in the literature on the ecology of *S. flavipes* from Japan. The information obtained from this study is therefore summarized in the present paper and the estimated life history of *S. flavipes* is reported.

Methods and materials

1. Field observation

The study was conducted near the water's edge of an artificial wetland in Sono-cho, Izumo City, Shimane Prefecture, Japan (35.4481° N, 132.8641° E; alt. 0.5 m; Fig. 1). The water level in the wetland (Fig. 2a–d) was regulated and maintained at maximum level (20–30 cm deep) from mid-April to late August. The aquatic plants *Phragmites australis* and *Zizania latifolia* grew near the water's edge. Insect surveys were conducted 34 times from April 11 to September 22, 2022 by digging in the riparian mud and soil for 30–40 minutes using a hoe (Fig. 2e–k). The collected nymphs were preserved in 70 % ethanol and some were used for laboratory rearing.

2. Light trap

Hoshizaki Institute for Wildlife Protection is adjacent to the artificial wetland. White and black fluorescent lights outside of the Institute were turned on at night, and two buckets with funnels were installed to capture flying insects (35.447991° N, 132.866115° E; alt. 0.5 m; Fig. 1). This was performed from June 27 to October 8, 2021 and June 20 to September 29, 2022, except on days of inclement weather or because of other factors.

3. Laboratory rearing

One adult female from soil (June 20, 2022) and one adult female from a light trap (June 22, 2022) were collected and placed in 500-ml cylindrical containers (translucent) with moistened paper (Kimwipes, Nippon Paper Crecia Co., Ltd.) for rearing (Fig. 3a). Mole crickets obtained from the study site were used as food (Fig. 2f, i). The females were kept in the laboratory, with no

Fig. 2. Study site in 2022. a–d, artificial wetland in Sono-cho, Izumo City (a, April 11; b, June 6; c, July 31; d, September 15); e, riparian mud; f, mature nymphs and adults of mole crickets (April 18); g, female adult of *Sirthenea flavipes*; h, soft mud of water's edge (July 13); i, first nymphs of mole crickets collected from soft mud (July 1); j, third nymph (August 11); k, fifth nymph on water surface (August 19).

temperature or light/dark control. Room temperature was recorded with a data logger. Eggs found on the moistened paper were placed in the same cylindrical container and observed.

Hatched nymphs were reared in groups in a 500-ml plastic container (129 × 99 × 60 mm, L × W × H; translucent) set with moistened paper (Fig. 3b). Some nymphs were reared on the small cricket, *Pteronemobius ohmachii* (Shiraki, 1930). As live crickets were not preyed on, fresh dead crickets were used.

4. Photographs

Photographs of the immature stages of *S. flavipes* were taken using a Canon EOS 90D (Canon Inc., Tokyo, Japan) with a macro lens (MP-E 65 mm; Canon Inc.) at equal magnification. Photographs and movies in the field were taken using an iPhone SE (Apple Inc., Cupertino, CA, USA) and edited using iMovie version 10.3 (Apple, Inc.).

5. Measurements

The body parts of *S. flavipes* were measured. The width of the head (between the two ends of the compound eye) and the maximum width of the prothorax were measured from images taken at equal magnification with a macro lens and Canon EOS 90D.

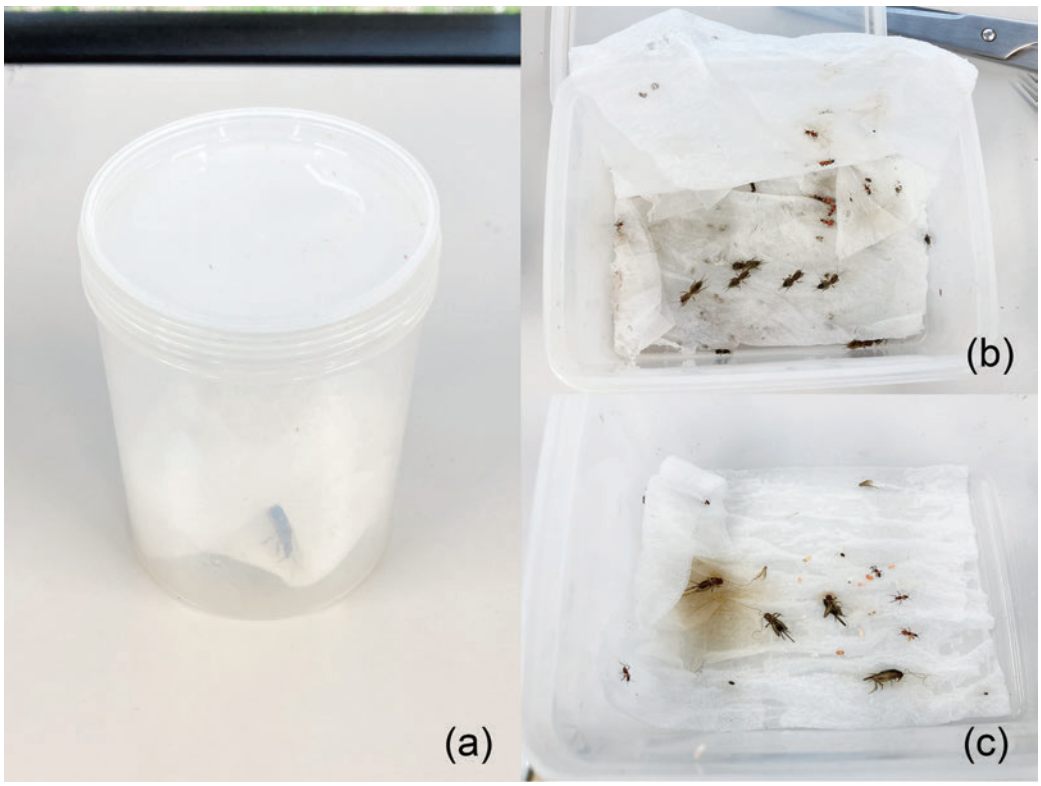

Fig. 3. Containers used for laboratory rearing. a, 500-ml cylindrical containers with moistened paper for the rearing of adults and eggs; b, c, 500-ml plastic container with moistened paper for the rearing of nymphs (b, with live mole crickets; c, with small dead crickets).

Results and discussion

1. Field observation

Female adults of *S. flavipes* were collected from mud and soil on May 19 and June 20, 2022 (Fig. 2g). Thirty nymphs were collected between July 13 and September 22, 2022 (Table 1). The nymphs were found in soft mud and soil at the waterside (Fig. 2h, j). Early instars of nymphs were found in very shallow mud, especially at the water's edge. Early instars of mole crickets were also found on the same dates. The fifth-instar nymph collected on August 26 hatched on September 5, and fifth-instar nymphs collected on September 4 hatched on September 10 (Fig. 5e). The abdomens of mature fifth-instar nymphs were significantly swollen. Nymphs were able to move quickly over the water surface (Fig. 2k).

Overwintered adults and nymphs of mole crickets were found from April to July (Fig. 2f); early instars of mole crickets appeared in riparian soft mud from July 1, 2022 (Fig. 2i).

Other organisms found at the water's edge at the study site included *Procambarus clarkii* (Girard, 1852), *Hydroglyphus japonicus* (Sharp, 1873), *Paederus fuscipes* Curtis, 1826, *Ochthera circularis* Cresson, 1926, *Fejervarya kawamurai* Djong, Matsui, Kuramoto, Nishioka et Sumida, 2011, *Pelophylax nigromaculatus* (Hallowell, 1861), among others.

Table 1. Number of *Sirthenea flavipes* collected from the study site in 2022

Month	Apr					May			Jun			Jul								Aug									Sep				
Day	11	15	18	20	27	18	19	30	6	15	20	1	7	10	13	21	22	25	27	31	1	4	8	11	12	19	23	26	29	4	7	9	15	22
1st															2							1							1					
2nd															2			3												1	1		1	
3rd															2			2					2	1			1							
4th																							1			1	1	1	1					
5th																										1		1		1	2			1
Adult							1				1																							

2. Light trap

A total of 15 and 20 *S. flavipes* adults were captured in 2021 and 2022, respectively; in 2021 they did not fly before mid-August, but in 2022 they flew intermittently from June through September. The flight of adults toward lights is highly influenced by weather and widely varies each year; individuals flying after late August are considered to be new adults because of their bright coloration.

Records. 1 ex., Aug. 23, 2021; 1 ex., Sep. 8, 2021; 2 exs., Sep. 11, 2021; 1 ex., Sep. 12, 2021; 1 ex., Sep. 16, 2021; 1 ex., Sep. 27, 2021; 4 exs., Sep. 28, 2021; 2 exs., Sep. 29, 2021; 1 ex., Sep. 30, 2021; 1 ex., Jun. 22, 2022; 1 ex., Jul. 16, 2022; 1 ex., Aug. 1, 2022; 1 ex., Aug. 2, 2022; 2 exs., Aug. 5, 2022; 3 exs., Aug. 8, 2022; 1 ex., Aug. 13, 2022; 1 ex., Aug. 19, 2022; 2 exs., Sep. 5, 2022; 1 ex., Sep. 10, 2022; 2 exs., Sep. 12, 2022; 2 exs., Sep. 14, 2022; 2exs., Sep. 18, 2022; 1ex., Sep. 23, 2022; 2 exs., Sep. 25, 2022; 1 ex., Sep. 29, 2022.

3. Laboratory rearing

One female collected from the study site on June 20, 2022, was reared and began laying eggs on June 22. Eggs were laid sporadically on moistened paper in the container. The first egg hatched on

July 4 (Fig. 4a–h). The female laid at least 30 eggs. In addition, a female collected by light trap on June 22 also laid eggs.

Fifteen laboratory-hatched first-instar nymphs (Fig. 4i, j) were reared in groups in a 500-ml plastic container and fed with early instars of mole cricket nymphs (body size: 5–6 mm), and predation was observed. The nymphs that attacked and fed on living mole crickets showed marked abdominal

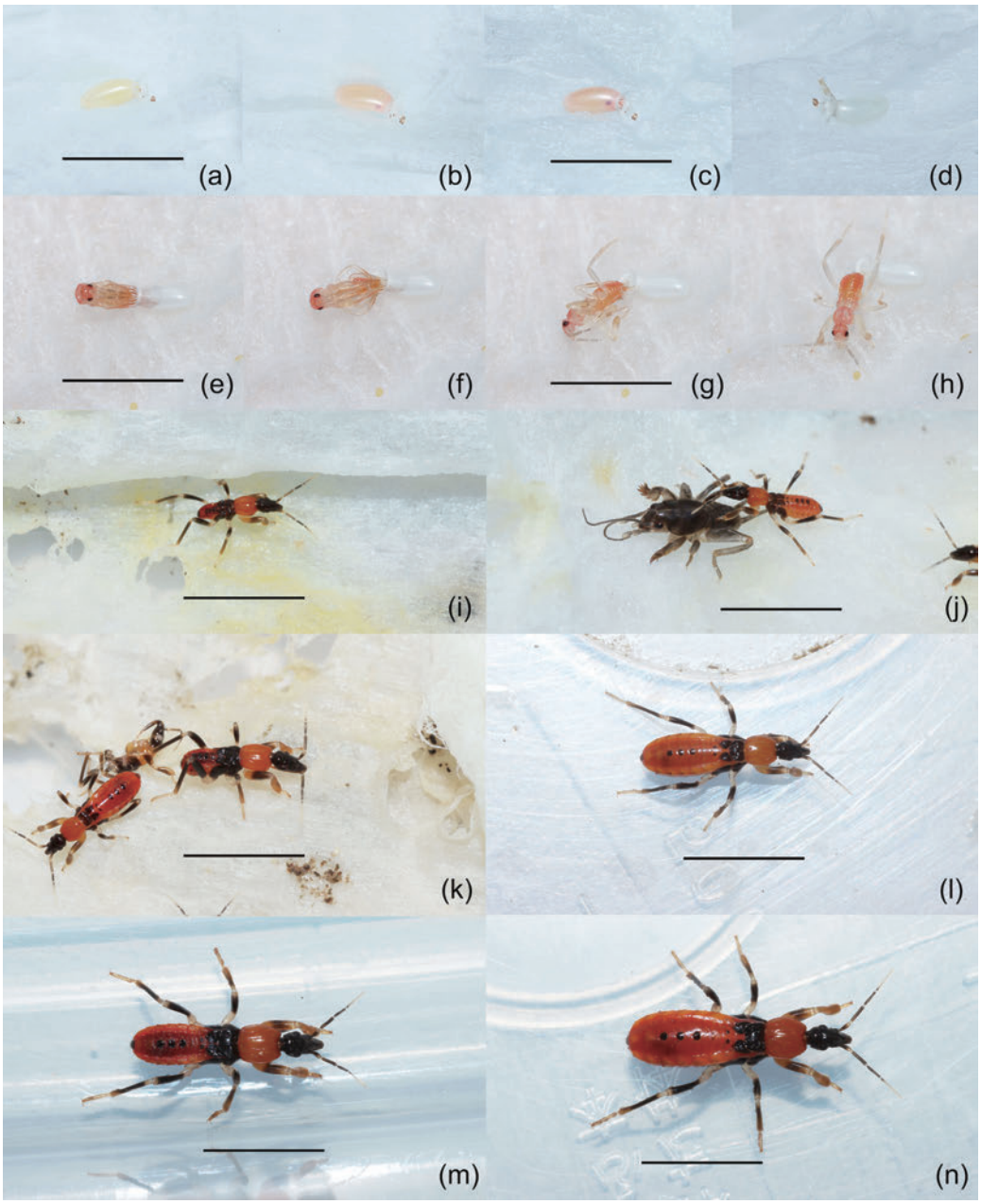

Fig. 4. Eggs and nymphs of *Sirthenea flavipes*. a–d, egg (a, June 26; b, June 30; c, July 1; d, July 4); e–h, hatching nymph; I, j, first-instar nymph; k, l, second-instar nymph; m, n, third-instar nymph. Scale bars = 5.0 mm.

swelling. Second-, third-, and fourth-instar nymphs of *S. flavipes* first emerged on July 16 (Fig. 4k, l), July 20 (Fig. 4m, n), and July 27 (Fig. 5a, b), respectively. On August 7–8, the mature fourth-instar nymphs began attacking one other, and eight third-instar nymphs and two fourth-instar nymphs died. The remaining three fourth-instar nymphs were kept separately. One fourth-instar nymph died on August 23. One fifth-instar nymph (Fig. 5c, d) emerged on August 18. The remaining two fifth-instar nymphs died on August 31 and September 12, respectively, and did not hatch.

Eight nymphs were reared in another 500-ml plastic container with small crickets. They did not prey on live crickets, but only sucked dead crickets (Fig. 5f). Only two grew to third-instar nymphs, and died before reaching the fourth-instar.

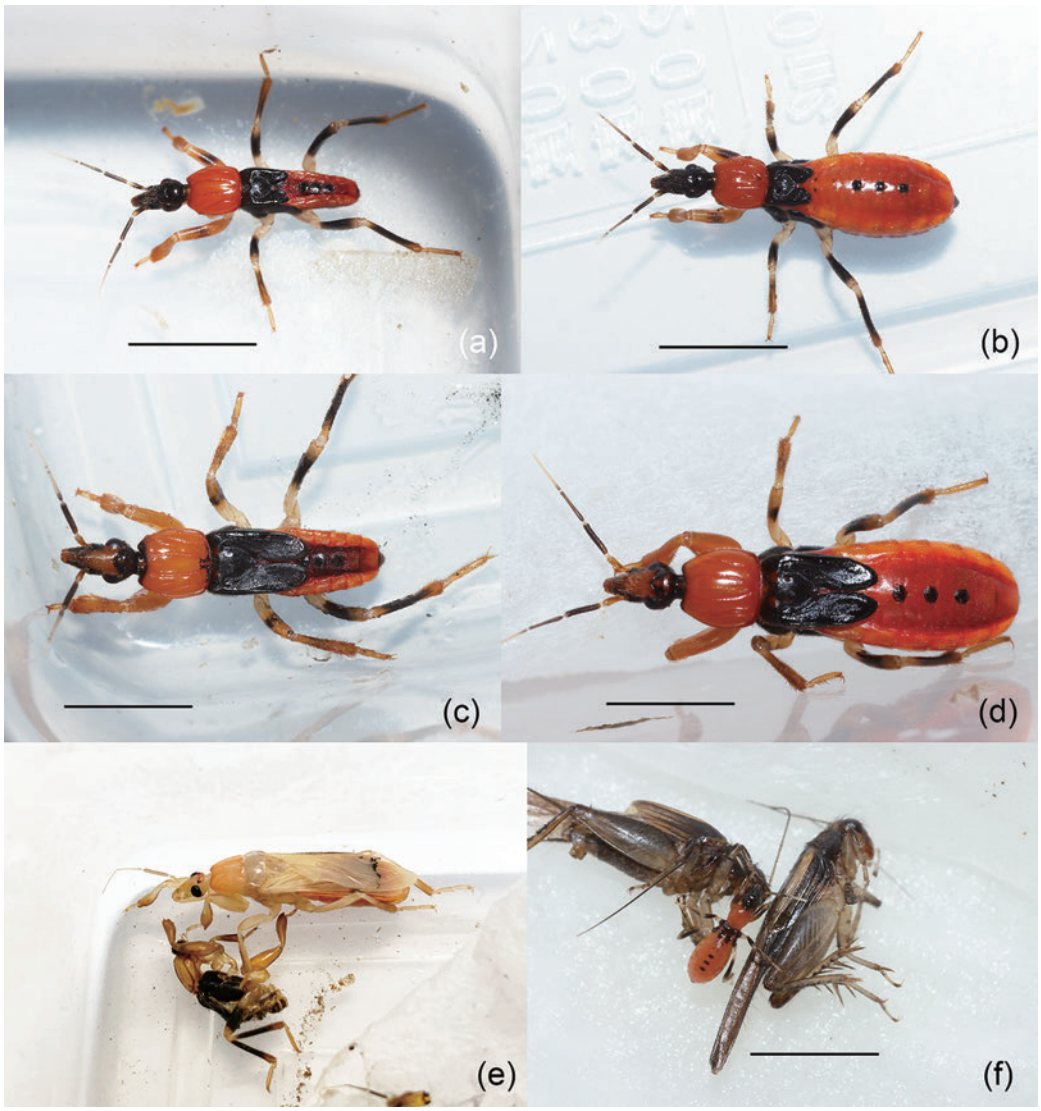

Fig. 5. Nymphs of *Sirthenea flavipes*. a, b, fourth-instar nymph; c, d, fifth-instar nymph; e, newly emerged adult; f, second-instar nymph feeding on small dead crickets. Scale bars = 5.0 mm (except for 5e).

4. Size and morphological changes of nymphs

Nymph body was reddish orange and differed from that of adults; the thorax and abdomen did not change from the first to fifth instars, but the head changed to reddish orange in the fifth instar (Fig. 6). In the fourth instar, the wing buds of the forewings elongated and became almost as long as the thorax (Fig. 6d), and in the fifth instar, the wing buds of the forewings further elongated and became distinctly longer than the thorax (Fig. 6e).

Measurements of nymphs are shown in Table 2 and Fig. 7. The measurement of 11 first-instar, four second-instar, 12 third-instar, seven fourth-instar, and six fifth-instar nymphs confirmed that the instars can be distinguished based on the head width and prothorax width.

Key to instars of *S. flavipes:*

1a. Posterior edge of the prothorax developed and black colored. Forewing covering abdomen … adult

1b Posterior edge of the prothorax not developed and orange colored. Forewing not covering abdomen … 2 (nymphs)

2a Head orange colored. Wing buds of the forewings longer than prothorax … fifth instar

2b Head entirely black … 3

3a Wing buds of the forewings as long as prothorax … fourth instar

3b Wing buds of the forewings without growth … 4

4a Maximum width of prothorax greater than 1.5 mm and less than 2.0 mm … third instar

4b Maximum width of prothorax less than 1.5 mm … 5

5a Maximum width of pronotum greater than 1.2 mm and less than 1.5 mm … second instar

5b Maximum width of pronotum less than 1.1 mm … first instar

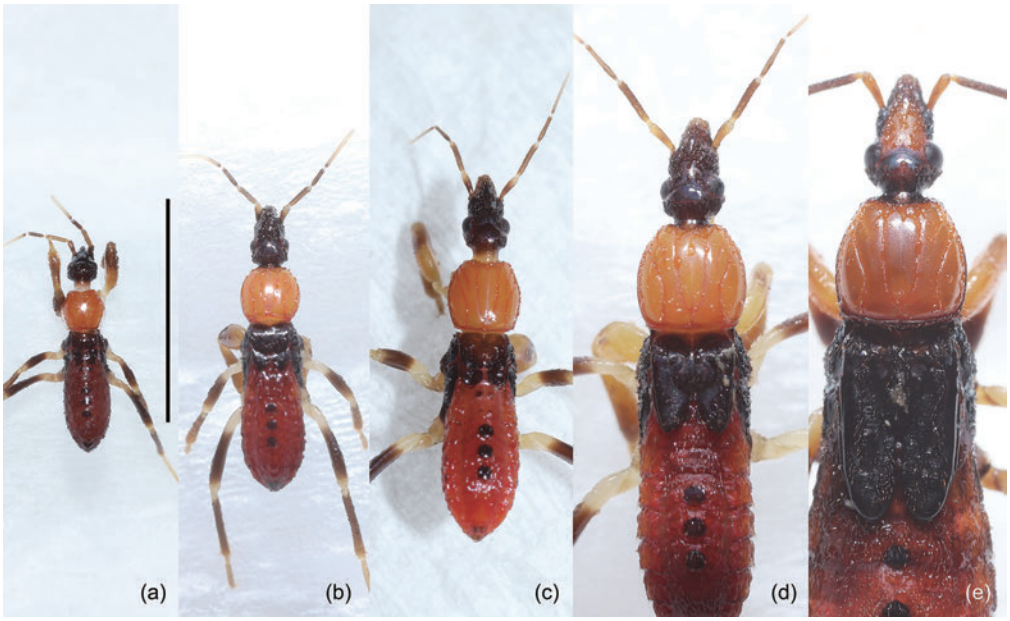

Fig. 6. Nymphs of *Sirthenea flavipes*. a, first instar; b, second instar; c, third instar; d, fourth instar; e, fifth instar. Scale bar = 5.0 mm.

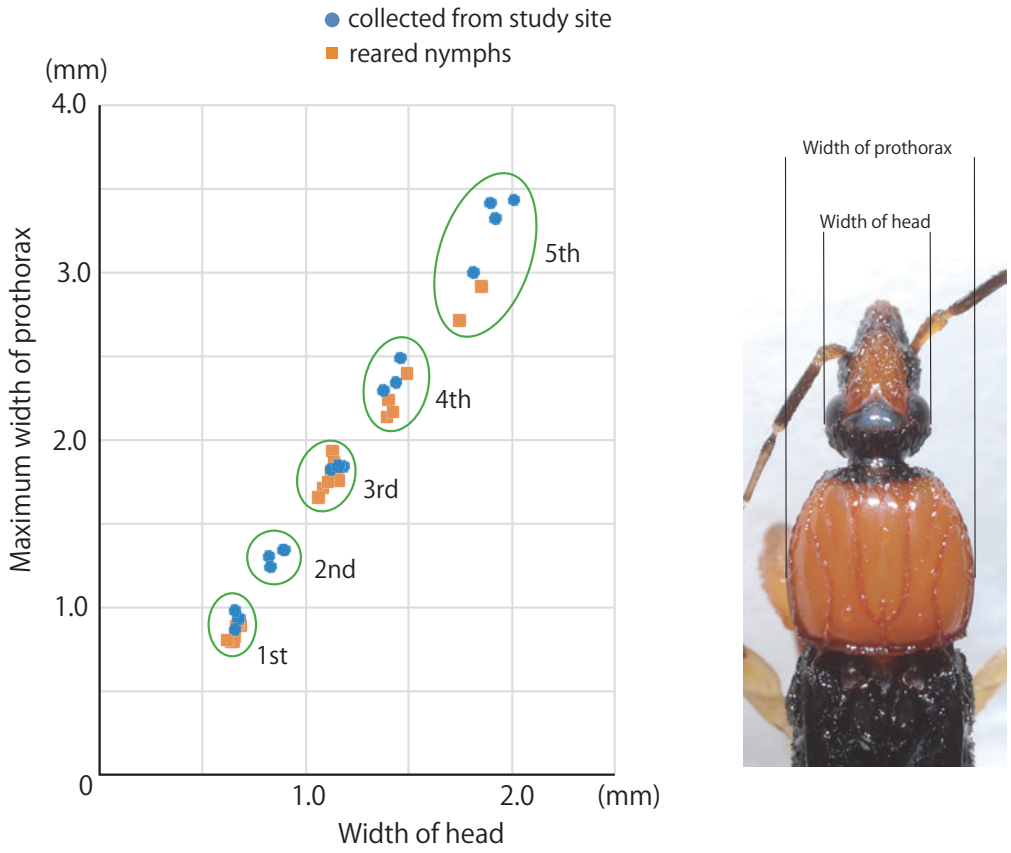

Fig. 7. Scatterplot of the head width versus the prothorax width of nymphs

Table 2. Size of nymphs of *Sirthenea flavipes*

Instars of nymph	1st	2nd	3rd	4th	5th
Width of head	0.62–0.69	0.83–0.90	1.07–1.18	1.38–1.49	1.75–2.01
(mean) mm	0.66	0.86	1.14	1.43	1.88
Width of prothorax	0.79–0.98	1.24–1.34	1.65–1.93	2.13–2.48	2.71–3.43
(mean) mm	0.87	1.30	1.80	2.29	3.13
N of specimens	11	4	12	7	6

5. Life history

The comparison of the life history of *S. flavipes* with that of the mole crickets is shown in Fig. 8. The emergence period of new adults was considered to be when brightly colored adults flew toward the lights, and the last-instar nymphs were considered to have hatched in the field after August. These new adults overwintered without reproducing. As the adults live underground, monitoring their activity in the field was difficult; nevertheless, their activity was resumed in May at the latest. The egg-laying season was from June to August, and the eggs may have been laid sporadically in crevices in the soil, such as mole crickets' tunnels. Eggs hatched after approximately two weeks. In the study site, early instars of mole crickets were abundant in the soft mud at the water's edge

in July and August, and first- to third-instar nymphs of *S. flavipes* were seen at the same time, suggesting that they come to the water's edge to prey on early instars of mole crickets. The fifth-instar nymphs of *S. flavipes* matured in late August, and new adults emerged in September or later. It is unclear how long the nymphs' emergence period lasts after September, but the absence of nymphs from April to May suggests that the nymphs do not overwinter as nymphs.

At the study site, approximately half of the mole crickets observed in April and May were nymphs, suggesting that most nymphs that hatched the previous year were wintering before reaching old age. Although the egg-laying season for mole crickets is considered to be from May onward (Akino *et al*., 1956), first-instar nymphs were not seen at the study site until July, and the egg-laying season was later, from June onward, which may be related to the large number of overwintering nymphs (Fig. 8).

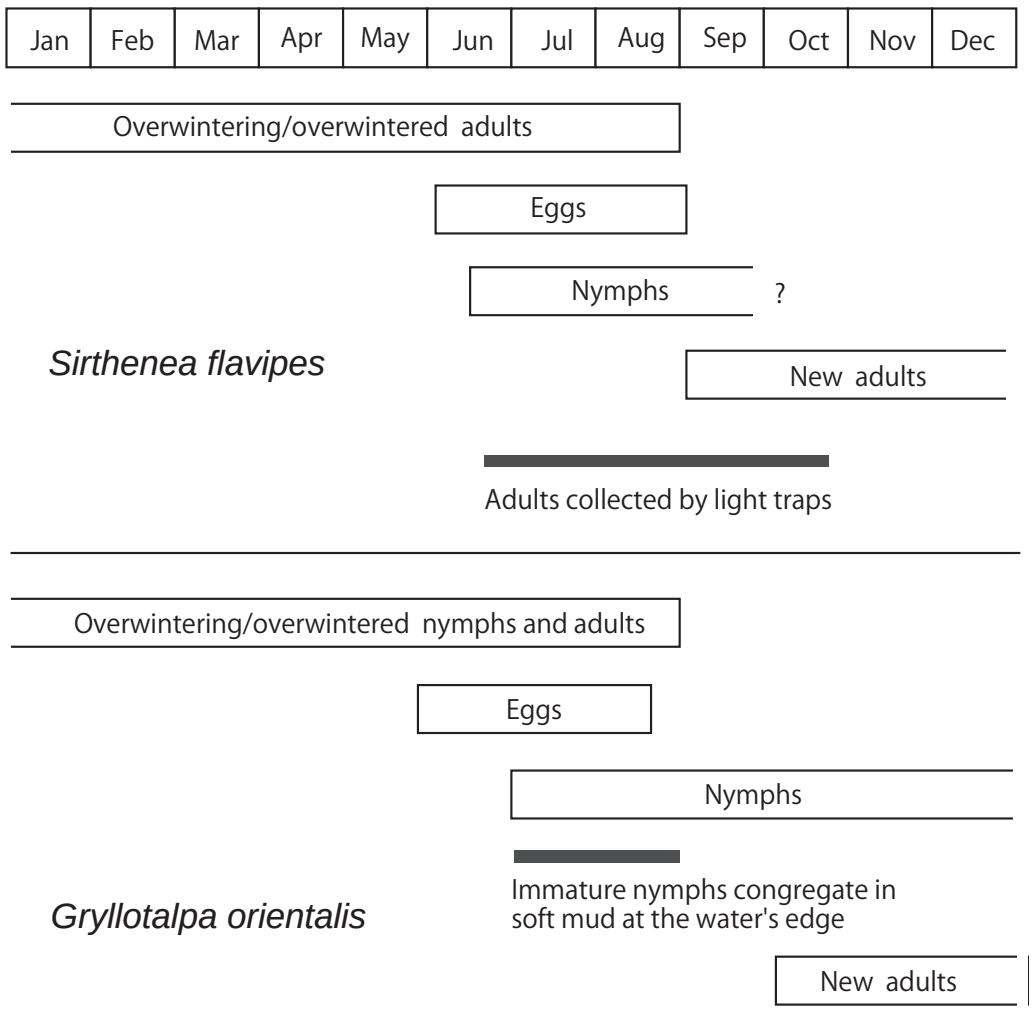

Fig. 8. Estimated life histories of *Sirthenea flavipes* and *Gryllotalpa orientalis* in Izumo City, Shimane Prefecture, Japan

Fig. 9. Adult of *Paederus fuscipes*

6. Nymph behavior and possible mimicry

Early instars of *S. flavipes* nymphs are often found in the same very shallow mud at the water's edge as early instars of mole crickets during the daytime. Therefore, they were often found with only a little digging in the mud. *Sirthenea flavipes* nymphs that appeared on the surface walked quickly or walked on the surface of the water, and often hid in mud crevices on the landward side.

Sirthenea flavipes nymphs are reddish orange with black markings on the head, mesothorax, dorsal surface of the abdomen, antennae, and legs. This coloration is similar to that of *Paederus fuscipes* (Staphylinidae; rove beetles: Fig. 9), which is 6.5–7.5 mm in length (Kurosa, 1958), approximately the same size as second-instar nymphs of *S. flavipes* with a full-grown abdomen or third-instar nymphs with an undersized abdomen. At the study site, the beetles were frequently observed roaming the ground near the water during April and May; *Paederus fuscipes* is a toxic organism with pederin in its body (Kurosa, 1958; Borroni *et al*., 1991). The similarity in coloration as well as the shared size and habitat suggests that *S. flavipes* nymphs may mimic *P. fuscipes*. The effect of mimicry on predators remains to be determined.

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I would like to thank Shinji Sugiura for the discussion on the ecology of *Sirthenea flavipes*.

References

Akino, K., M. Sasaki and D. Okamoto (1956) Studies on mole-crickets attacking rice seeds directly sown without transplanting between rows of wheat and barley. *Chugoku Nogyou Shikenjyo Houkoku, Bunsatsu A, Futu-nouji-kankei*, (4): 91–110. (in Japanese with English abstract)

Borroni, G., V. Brazzelli, R. Rosso and M. Pavan (1991) *Paederus fuscipes* dermatitis. A histopathological study. *The American Journal of Dermatopathology*, **13**(5): 467–474.

Hudson, W. G. (1987) Ontogeny of prey selection in *Sirthenea carinata*: generalist juveniles become specialist adults. *Entomophaga*, **32**(4): 399–406.

Ishikawa, T., M. Takai and T. Yasunaga (2012) *A field guide to Japanese bugs III*. Zenkoku Noson Kyoiku Kyokai, Tokyo. (in Japanese with English title)

Kurosa, K. (1958) Studies on the life history of *Pederus fuscipes* Curtis (Staphylinidae) (Studies on poisonous beetle, III). *Japanese Journal of Sanitary Zoology,* **9**(4): 245–276. (in Japanese with English abstract)

Yasunaga, T., M. Takai, I. Yamashita, M. Kawamura and T. Kawasawa (1993) *A field guide to*

Japanese bugs: Terrestrial Heteropterans. Zenkoku Noson Kyoiku Kyokai, Tokyo. (in Japanese with English title)

野外および室内観察に基づくキイロサシガメの生活史の解明

林　成多

島根県出雲市で6月に土中から採集したキイロサシガメ *Sirthenea flavipes* (Stal, 1855)を飼育した結果，1頭のメスは卵を30個以上産んだ．室内飼育で卵は2週間程度で孵化した．7月上旬に孵化した幼虫は8月中旬に終齢になった．キイロサシガメの幼虫はケラ *Gryllotalpa orientalis* Burmeister, 1839の幼虫を捕食した．齢数は5である．幼虫の齢は，サイズや翅芽の形，頭部の色彩で判別することができる．野外でも7月より若齢幼虫が出現したが，同時にケラの若齢幼虫が観察された．8月下旬には，腹部が顕著に膨らんだ，老熟した5齢幼虫が野外で確認され，9月上旬に羽化が飼育下で確認された．幼虫では越冬せず，成虫のみで越冬していると推定される．また，本種の幼虫は，体色が似ているだけでなく，2–3齢幼虫の体サイズもアオバアリガタハネカクシ *Paederus fuscipes* Curtis, 1826に近く，同じ環境に生息することから，有毒生物であるこのハネカクシに擬態している可能性を指摘した．

キーワード：ビオトープ，半翅目，カメムシ目，サシガメ科，湿地，アオバアリガタハネカクシ