

**NOTES ON *RHAGOVELIA* MAYR (HEMIPTERA: VELIIDAE)
FROM SINGAPORE, WITH DESCRIPTION OF A NEW SPECIES**

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ABSTRACT. A recent study of riffle bugs in Singapore's nature reserves documented three species of *Rhagovelia* in forest streams, i.e. *R. sumatrensis* Lundblad, *R. rudischuhi* Zettel, and a new species, *R. singaporensis*, which is described and illustrated herein. *Rhagovelia sondaica* Polhemus and Polhemus, a species formerly collected in Singapore, was not rediscovered during the present survey, while previous records of *R. femorata* from Singapore are interpreted to have been based on misidentifications. A key is provided to the species of *Rhagovelia* found in Singapore.

INTRODUCTION

Riffle bugs in the genus *Rhagovelia* are commonly encountered on the forest streams of Singapore and Malaysia. Since all the species present in the area are small in size, generally dark in coloration, and appear superficially similar, their correct identification has been problematic. Fernando & Cheng (1974) reported only *R. femorata* from West Malaysia, while Polhemus & Polhemus (1988) and Polhemus (1990) revised the Southeast Asian fauna and recorded three species from the region: *R. sumatrensis* Lundblad, *R. femorata* Dover and *R. sondaica* Polhemus & Polhemus. These three species were also reported from Ulu Kinchin, Pahang in Peninsular Malaysia by Kovac & Yang (1989). A fourth species, *R. rudischuhi* Zettel, was subsequently described from Perak, in Peninsular Malaysia, by Zettel (1993).

Murphy (1990) reported two *Rhagovelia* species, *R. sumatrensis* and *R. femorata*, from Singapore. Our recent studies have found that *R. sumatrensis* and *R. rudischuhi* are common on the island, and that in addition a new species, *R. singaporensis*, is also present. By contrast, *R. sondaica* has not been collected in Singapore since 1964, and based on our current taxonomic interpretation *R. femorata* is not believed to occur there.

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MATERIAL AND METHODS.

The material that formed the primary basis for this report was collected from streams in the Bukit Timah Nature Reserve and the Central Catchment Area during the Nature Reserves Survey carried out from 1992 to 1994. Material previously collected in Singapore by D. H. Murphy, C. H. Fernando, L. Cheng and others were also examined. All the material examined is deposited in the Zoological Reference Collection (ZRC) of the National University of Singapore, paratypes of new species have been distributed to the Bishop Museum, Honolulu, Hawaii, USA, and the J. T. Polhemus collection, Englewood, Colorado, USA. All measurements in the following descriptions are given in millimeters.

KEY TO THE SPECIES OF *RHAGOVELIA* REPORTED FROM SINGAPORE

1. Anterior margin of pronotum black, bearing an orange brown transverse band centrally, surrounded by black margins, length of this band along midline less than 1/3 length of pronotum 2
 Anterior margin of pronotum with a broad orange band, extending laterally to propleura and prosternum, length of this band along midline about 2/3 length of pronotum; male hind femur with 2-6 small basal teeth, followed by one long middle spine, then 5-9 small teeth distally; female hind femur with 1-2 basal, 1 middle and 3-6 distal teeth.
 *R. rudischuhii* Zettel
2. Mid-coxa entirely black; posterior margin of pronotum concave; male hind femur with 10-12 basal teeth, followed by one large curved spine beyond middle, then 4-6 small distal teeth; female hind femur with 7-9 basal, 1 middle and 3-5 distal teeth *R. femorata* Dover
 Mid-coxa white or slightly embrowned; posterior margin of pronotum either concave or straight 3
3. Male mid-femur with 3-4 slender, sharp spines ventrally on basal half; mid-coxa slightly brownish; posterior margin of pronotum straight; male hind femur with 14-18 basal teeth reaching to base of femur, followed distally by 7-9 distal teeth after the long curved middle spine; female hind femur with 3-6 basal, 1 middle and 5-6 distal teeth; hind trochanter with 4-6 black denticles *R. sumatrensis* Lundblad
 Male mid-femur lacking sharp spines ventrally on basal half; mid-coxa white; posterior margin of pronotum slightly straight or concave; male hind femur with less than 10 basal teeth, these teeth not reaching base of hind femur; hind trochanter with only 2-3 black denticles or none 4
4. Hind trochanter lacking black denticles; male hind femur with a single row of teeth, beginning with 4-7 small basal teeth, followed by one long and curved spine beyond middle, then 2-5 distal teeth; female hind femur armed with 0-2 distal teeth. Posterior margin of pronotum concave *R. sondaica* Polhemus & Polhemus
 Hind trochanter with 2-3 black denticles; male hind femur with two rows of teeth, anterior row beginning with 1-6 very small basal teeth, followed by 2-5 small distal teeth, posterior row without basal teeth, bearing 1 large curved spine at middle followed by 6-10 smaller teeth decreasing in size distally; female hind femur armed with only a single row of teeth, bearing 0-2 basal teeth, 1 middle, and 4-9 distal teeth. Posterior margin of pronotum straight *R. singaporensis*, new species

***Rhagovelia rudischuhi* Zettel, 1993**
(Fig. 7)

Material examined.— 2 males, 2 females, Sungai Seletar, Mandai Road; coll. C. H. Fernando & L. Cheng, 24.xi.1961 & 9.iv.1964 (formerly identified as *R. femorata*). — 6 males, 5 females, stream at MacRitchie Forest, near Rifle Range Road; coll. D. H. Murphy, iii.1981. — 5 males, 13 females, stream at Jungle Fall Valley, Bukit Timah Hill; coll. C. M. Yang, H. K. Lua & K. L. Yeo, 13.xii.1990 & 7.x.1992. — 22 males, 19 females, forest streams to Upper Peirce Reservoir; coll. D. H. Murphy & C. M. Yang, iii & xi.1991. — numerous other samples collected from different streams in the Central Catchment Area and Bukit Timah Hill between 1992 and 1994.

Remarks.— *Rhagovelia rudischuhi* is easily separated from other Singapore species by the broad orange band across the anterior portion of the pronotum, and by the structure of the male paramere (fig. 7). The body colour may vary from being mostly dark brown except for the venter and anterior pronotal band, to mostly orange brown, with the latter form having more than half of the body covered with such coloration, including the following structures: the entire venter, the connexiva, and an orange median longitudinal band extending across the mesonotum to the basal abdominal segments. The populations in the Central Catchment Area tend to exhibit a greater degree of orange brown coloration, while the darker form is predominant on Bukit Timah Hill.

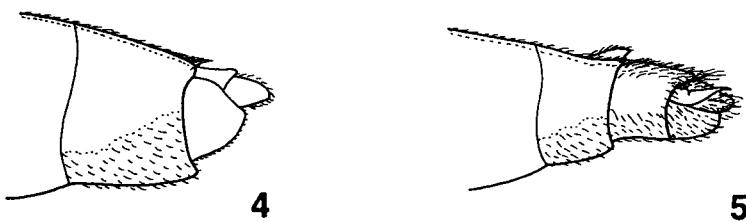
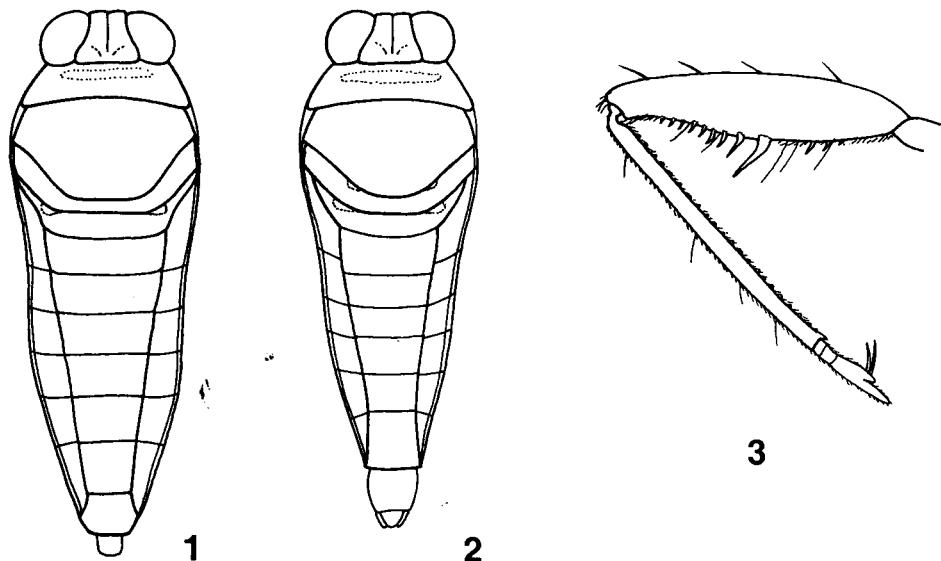
This is the most common *Rhagovelia* in Singapore, and is widespread in the Central Catchment Area. It is found on riffles of both slow and fast flowing streams, especially on headwaters of forest streams, and on the very slow moving waters of forest swamps. It also co-occurs with *R. sumatrensis* on more sandy and fast flowing streams.

Rhagovelia rudischuhi was first described by Zettel (1993) from specimens collected at Taipeh, Perak, in Peninsular Malaysia. The senior author has also collected this species from Johore, and Pulau Batam (Indonesia).

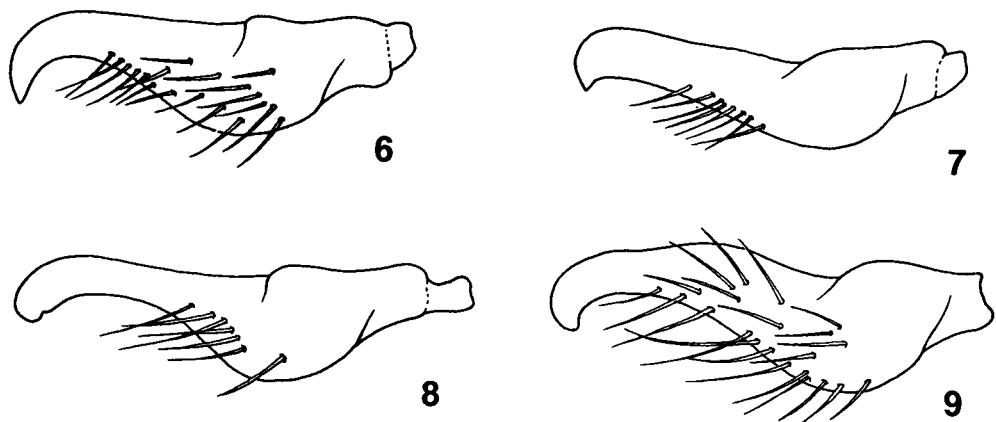
***Rhagovelia sumatrensis* Lundblad, 1922**
(Fig. 9)

Material examined.— 2 males, 2 females, stream at Jungle Fall Valley, Bukit Timah Hill; coll. C. M. Yang, H. K. Lua & K. L. Yeo, viii & xii.1990. — numerous samples also collected from Central Catchment Area and Bukit Timah Hill between 1990 and 1994.

Remarks.— *Rhagovelia sumatrensis* may be easily recognized by the presence of short, sharp spines ventrally on the basal portion of the male middle femur, and by the structure of the male paramere (fig. 9). This species is found in flowing streams with slow to moderately fast current, being most common on sandy-bottomed streams. It is widespread, occurring from North India to South China, Indochina, Peninsular Malaysia and Indonesia (Polhemus & Polhemus, 1988), and belongs to a species group with additional representatives in Africa and on the Indian Ocean islands.



Figs. 1-5. *Rhagovelia singaporenensis*, new species. 1. Wingless female, dorsal habitus, legs omitted. 2. Wingless male, dorsal habitus, legs omitted. 3. Male left hind leg, dorsal view. 4. Female terminal abdomen, left lateral view. 5. Male terminal abdomen, left lateral view.



Figs. 6-9. Male right parameres of *Rhagovelia* species known to occur in Singapore. 6. *Rhagovelia singaporenensis*, new species. 7. *Rhagovelia rudischuhi* Zettel. 8. *Rhagovelia sondaica* Polhemus & Polhemus. 9. *Rhagovelia sumatrensis* Lundblad.

***Rhagovelia sondaica* Polhemus & Polhemus, 1988**
(Fig. 8)

Material examined.— 2 males, 6 females, Sungai Seletar, Mandai Road; coll. C. H. Fernando & L. Cheng, 9 & 16.iv.1964 (originally labelled as *R. femorata*).

Remarks.— This species is a member of the *R. sarawakensis* group as defined by Polhemus and Polhemus (1988), and may be recognized by its dark coloration, pale mid-coxae, and relatively elongate male paramere (fig. 8).

The above specimens labelled were originally identified as *R. femorata*, but are actually *R. sondaica*, and represent the only record of this species from Singapore. The recent survey did not find any *R. sondaica* in the Singapore reserves, although it is widespread in Peninsular Malaysia, Borneo and Java (Polhemus & Polhemus, 1988). The specimens from Lower Peirce Forest listed by Yang & Lua (1992) as this species in fact represent *R. rudischuhi*.

***Rhagovelia femorata* Dover, 1928**

Remarks.— *Rhagovelia femorata* was not found during this survey, and we consider the presence of this species in Singapore as doubtful. The Zoological Reference Collection has three jars of specimens labelled as *R. femorata*, collected from Sungai Seletar, Mandai Road, by C. H. Fernando and L. Cheng on 24 November 1961, and 9 and 16 April 1964. After re-examination, it is noted that they are not *R. femorata* but instead represent *R. rudischuhi* and *R. sondaica*. Material reported by Murphy (1990) as *Rhagovelia femorata*, collected from the outflow stream at the Nee Soon swamp on 3 January 1986, actually represents a series of *R. singaporensis*, new species.

***Rhagovelia singaporensis*, new species**
(Figs. 1 - 6)

Material examined.— Holotype - apterous male (ZRC 6.17084), outflow stream from Nee Soon swamp forest; coll. C. M. Yang, 13.viii.1990.

Paratypes - 8 males, 6 females, 1 macropterous female, same data as holotype. — 10 males, 6 females 1 macropterous female, same locality as holotype; coll. C. M. Yang & K. L. Yeo, 20.ii.1992. — 5 males, 5 females, same locality as holotype; coll. K. L. Yeo, 12.v.1994. — 4 males, 14 females, outflow stream from Nee Soon swamp forest; coll. D. H. Murphy, 3.i.1986. — 10 males, 5 females, stream at Rifle Range Road, flowing to MacRitchie Reservoir; coll. H. K. Lua, 25.iv.1994. — 25 males, 18 females, 1 macropterous female, stream near Chestnut Drive Water Treatment Plant; coll. C. M. Yang & H. K. Lua, 9 & 23.vi.1994.

Description.— Holotype, apterous male: Length 2.75 mm, width 0.92 mm; body shape as in fig. 2. Ground colour black; pronotum with small transverse orange brown spot centrally behind head; coxae, trochanters, basal 2/3 of fore femur, ventral 1/2 and dorsal 1/3 of hind femur, and basal 1/2 of first antennal segment leucine to white. Head length 0.26, bearing short setae intermixed with a few scattered longer setae; antennae with all segments slender and unmodified, covered with short setae, plus several long, stout setae dorsally on segments I and II; length of antennal segments I-VI: 0.66:0.28 :0.42: 0.41. Pronotum shorter than the length of an eye, posterior margin straight, covered with short setae intermixed with a few scattered longer setae laterally; length of pronotum : mesonotum : metanotum respectively:

0.26: 0.22 : 0.50 : 0.08. Abdomen covered with short setae intermixed with a few scattered longer setae, these longer setae denser on posterior part of abdominal tergite VII and genital segment. Abdominal sternites carinate on midline; tergite VII and genital segment shining. Length of abdominal tergites I- VII: 0.14 : 0.17 : 0.17 : 0.18 : 0.22 : 0.32; genital segment length 0.32; posterior width (0.28) of tergite VII same as anterior and slightly shorter than its length. Proctiger with basal half lightly sclerotized, bearing well developed, rounded lateral lobes; distal cone heavily sclerotized, setiferous, bearing slightly developed, rounded lateral lobes basally; paramere elongate, symmetrical, curved at tip, shape and setiferation as in fig. 6.

Legs covered with short setae, intermixed with a few long, stout, black setae along dorsal margins of femora and tibiæ; ventral surface of fore femur with two parallel longitudinal rows of long slender black setae; fore tibia with moderately long pale setae along anterior and posterior margins; hind femur with scattered long, slender setae along ventral margin amid spines. Fore femur slightly flattened ventrally; fore tibia simple, not expanded distally; coxae and trochanters of mid- and hind legs armed with a few black denticles; hind trochanter bearing 2-3 black denticles; hind femur armed with 2 rows of teeth; anterior row basally with 3 (left) and 6 (right) small teeth before middle, then 2 small teeth distally; posterior row with a large curved spine beyond middle, followed by 7-8 smaller teeth decreasing in size distally (fig. 3); ventral face of posterior tibia armed along entire length with short stout teeth (fig. 3). Proportions of legs as follows: fore femur : tibia: tarsal I : tarsal II : tarsal III: 0.55 : 0.78 : 0.02(I-III); mid-femur : tibia: tarsal I : tarsal II : tarsal III: 1.31 : 0.94 : 0.06 : 0.34 : 0.54; hind femur : tibia: tarsal I : tarsal II : tarsal III: 1.06 : 1.02 : 0.03 : 0.03 : 0.20.

Apterous female: Length 2.81 mm., width 0.98 mm; body shape as in fig. 1. Coloration, setation and general structure similar to holotype with following exceptions: length of head : pronotum : mesonotum : metanotum: 0.23 : 0.19 : 0.50 : 0.10. Length of antennal segments I-IV: 0.66 : 0.30 : 0.39 : 0.38. Length of abdominal segments I-VIII: 0.14 : 0.18 : 0.19 : 0.21 : 0.21 : 0.25 : 0.27 : 0.22; length of genital segment 0.12; abdominal segments slightly carinate medially along longitudinal midline; tergites VII, VIII and genital segment shining. Hind trochanter unarmed; hind femur bearing only one row of teeth, beginning with one basal tooth before the large curved middle spine, followed by 8 distal teeth distally; hind tibia not armed with stout teeth ventrally; posterior projections of connexiva not reaching to middle of tergite VIII.

Macropterous female: Length 3.03 mm., width 1.57 mm. Similar to apterous form in general structure and coloration except pronotum broader centrally. Wings extending beyond tip of abdomen, bearing 3 closed cells reaching slightly beyond mid-wing.

Other paratypes examined: Length - males, 2.58-2.78 mm. (mean = 2.70); females 2.78-2.99 mm. (mean = 2.85). Coloration similar to holotype, but some specimens with broader leucine markings on dorsum of hind femur; basal teeth of hind femur ranging from 1 to 6; number of distal teeth in posterior row 6-10, in anterior row 2-5, these rows occasionally becoming indistinct; female with only one row of posterior teeth on hind femur, containing 0-2 basal teeth, then a long curved spine, followed by 4-9 distal teeth.

Remarks.- On the basis of its forewing venation *Rhagovelia singaporensis* new species is a member of the *R. sarawakensis* group as defined by Polhemus & Polhemus (1988), and is similar to *R. sondaica* in general size and coloration. It differs from the latter by having two rows of teeth on the hind femur, black denticles on the hind trochanter, and fewer long

setae on the body; the long setae on the genital segment are also shorter and not so dense. The posterior margin of the pronotum is almost straight, rather than concave, and the episternum near the coxa is white, rather than black as in *R. sondaica*. The male parameres of the two species are also diagnostic, that of *R. sondaica* being distally elongate with a rounded tip, while that of *R. singaporense* is strongly curved and comes to a pointed tip (compare figs. 6 and 8).

This species is found on slow flowing forest streams, or on outflow streams from forest, usually in partial shade. It is not unusual to find this species occurring sympatrically with *R. sumatrensis*.

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