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THE SPECIES OF *ASIOPHLUGIS* GOROCHOV, 1998 IN SINGAPORE (ORTHOPTERA: TETTIGONIIDAE: MECONEMATINAE)

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INTRODUCTION

This paper reports the genus *Asiophlugis* Gorochov, 1998 in Singapore. *Asiophlugis* is a member of the subfamily Meconematinae Burmeister, 1838 (Orthoptera: Tettigoniidae). From orthopteran surveys in and around the Bukit Timah Nature Reserve (BTNR) and the Central Catchment Nature Reserve (CCNR), three species of the *Asiophlugis* were recorded. *Asiophlugis thaumasia* (Hebard, 1922), combinatio nova, also known as the missing marvellous katydid (Davison et al., 2008), was rediscovered. A single male was previously collected and described in Singapore in 1922 (Hebard, 1922). This species was not reported since then and was listed in the Singapore Red Data Book as critically endangered or presumed nationally extinct (Davison et al., 2008).

Asiophlugis thaumasia was originally placed within the genus *Phlugis* Stal, 1861 which comprises of species mainly from South and Central America and a few from the Indo-Malayan region (Kevan & Jin, 1993). *Asiophlugis thaumasia* was questionably included in *Asiophlugis* owing to incomplete knowledge because of lack of specimens (Gorochov 1998; Gorochov & Tan, 2011). However, recent collections of new specimens allowed for the review of this species and enabled the description of the female for the first time.

Based on D. H. Murphy's orthopteran collections in the 1970s, a more common but different species of *Asiophlugis* was collected instead: *Asiophlugis temasek* Gorochov & Tan, 2011, which was only described recently (Gorochov & Tan, 2011). This paper also reports another species, *Asiophlugis rete* Gorochov, 1998, which was recorded for the first time for Singapore near the BTNR. These findings show that there is a dearth of knowledge on the *Asiophlugis* species in Singapore. In this paper, a provisional key to the Singaporean species of *Asiophlugis* is composed and the biology is briefly discussed. The national status and conservation needs of *Asiophlugis* are also examined.

MATERIAL AND METHODS

Materials examined were based on: (1) night surveys in and around the BTNR and CCNR conducted by TMK and collaborators from Oct.2010 – Jul.2011; and (2) voucher specimens in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore. Newly collected materials were deposited as voucher specimens in the ZRC.

Drawings were made using a stereozoom microscope with a camera lucida. Photographs of freshly euthanized specimens were taken using a digital SLR camera with compact-macro lens. Measurements were done with a 0.05 mm vernier caliper. For the habitat photographs, the following abbreviation is used: BL = body length (from tip of fastigium to abdominal apex) of freshly euthanized specimens.

SPECIMEN DETAILS

***Asiophlugis thaumasia* (Hebard, 1922) comb. n.**
Phlugis thaumasia Hebard, 1922: 263.
Material examined. — 1 male, ZRC.ORT.132, CCNR, along Nee Soon pipeline, coll. M. K. Tan, R. W. J. Ngiam & M. R. B. Ismail, 25 Nov.2010 (Fig. 1a); 1 female, ZRC.ORT.212, Dairy Farm Nature Park, along Dairy Farm Pass, coll. M. K. Tan, 19 Jan.2011 (Fig. 1b); 1 male, ZRC.ORT.227, Lower Peirce Reservoir Park, along boardwalk, coll. M. K. Tan, 16 Mar.2011.

Fig. 1. *Asiophlugis thaumasia*. (a) Male (ZRC.ORT.132, BL = 13.3 mm) collected along the Nee Soon Pipeline on 25 Nov.2010. (b) Female (ZRC.ORT.212, BL = 15.2 mm) collected along Dairy Farm Pass on 19 Jan.2011.

***Description and discussion.* —** Male: Stridulatory file on upper side of left tegmen as shown in Fig. 4a; not covered by pronotum. Cercus at base with strongly curved (hook-like) small process, apex of process brownish (Fig. 4c); genitalia membranous. The diagnostic characters make it clear that this species belong to the genus *Asiophlugis*. An extensive description of the male is given by Hebard (1922).

Female: Habitus as shown in Fig. 1b. Colouration and structure of body parts (excepting sexual ones) as in that of males. Last abdominal tergite with hind margin without median triangular notch; epiproct small; cerci simple, thin and long; subgenital plate longer than broad, swollen and sparsely setose on the lateral sides of the middle part, hind margin rounded and with minute notch (Fig. 4b); ovipositor with basal half expanded; distal half strongly curved upwards and slightly longer than basal half (Fig. 4d).

***Asiophlugis rete* Gorochov, 1998**
Material examined. — 1 male, ZRC.ORT.213, Dairy Farm Nature Park, along Wallace Trail, coll. M. K. Tan, 27 Jan.2011 (Fig. 2).

***Asiophlugis temasek* Gorochov & Tan, 2011**
Material examined. — 1 male, ZRC.ORT.107, MacRitchie Reservoir catchment area, along Venus Trail, coll. M. K. Tan & M. R. B. Ismail, 8 Oct.2010; 1 male, ZRC.ORT.108, MacRitchie Reservoir catchment area, along MacRitchie Nature Trail, 1 Nov.2010, coll. M. K. Tan (Fig. 3a); ZRC.ORT.109, 1 male, BTNR, along main road (Hindhede Drive), 13 Nov.2010, coll. M. K. Tan; 1 male, 1 female, ZRC.ORT.152, BTNR, Dairy Farm Loop, coll. M. K. Tan & M. R. B. Ismail, 10 Dec.2010. (Fig. 3b).

PROVISIONAL KEY TO THE *ASIOPHLUGIS* SPECIES OF SINGAPORE

The tentative key covers primarily males. The female of *Asiophlugis rete* is not known in Singapore to date. For full descriptions of *Asiophlugis rete* and *Asiophlugis temasek*, refer to Gorochov (1998) and Gorochov & Tan (2011).

1. Elevation of the hind lobe of the pronotum indistinct (Fig. 4g). Katydid macropterous, wings reaching the abdominal apex; hind wings longer than the tegmina. Male cercus elongated and slightly sigmoid, tapering into a sharply rounded apex (Fig. 4e, f). ..... *Asiophlugis thaumasia*
1. Elevation of the hind lobe of the pronotum more distinct. Katydid brachypterous or semi-brachypterous, wings not reaching the abdominal apex; hind wings shorter than the tegmina. Male cercus shorter and not as above. ... 2

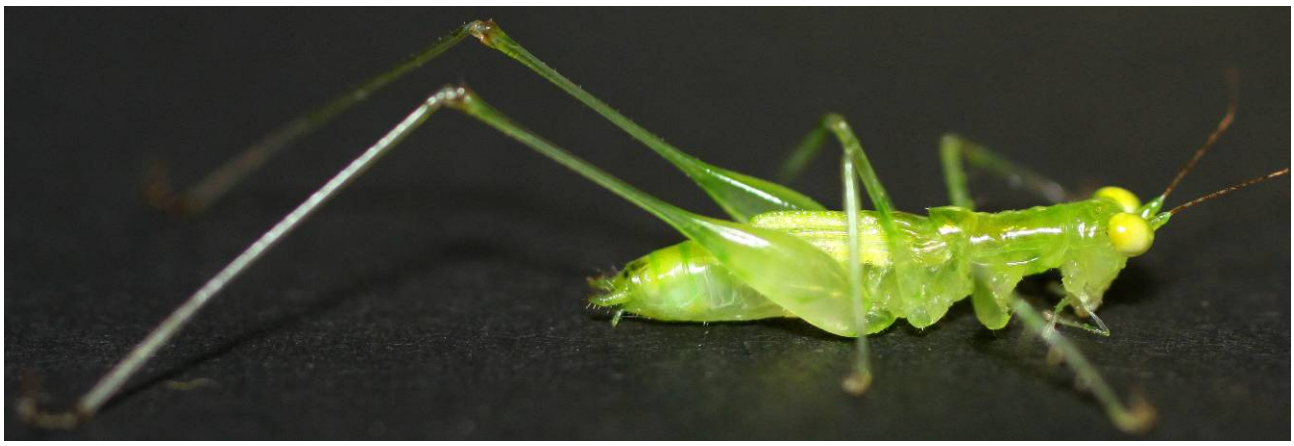

Fig. 2. *Asiophlugis rete* male (ZRC.ORT.213, BL = 12.7 mm) collected along the Wallace Trail on 27 Jan.2011.

Fig. 3. *Asiophlugis temasek*. (a) Male (ZRC.ORT.108, BL = 12.1 mm) collected along MacRitchie Nature Trail on 1 Nov.2010. (b) Female (ZRC.ORT.152, BL = 12.5 mm) collected along Dairy Farm Loop on 10 Dec.2010.

2. Elevation of the hind lobe of the pronotum slight (Fig. 4j). Katydid semi-brachypterous, the tegmina extending to the apex of 7th abdominal tergite. Male cercus gently curved inwards; distal half slightly curved upwards; apex truncated, not setose (Fig. 4h, i). ..... *Asiophlugis rete*

2. Elevation of the hind lobe of the pronotum pronounced (Fig. 4m). Katydid brachypterous, the tegmina extending to the posterior of the 4th abdominal tergite. Male cercus strongly sinuate; distal half curved downwards; apex rounded, setose (Fig. 4k, l). ..... *Asiophlugis temasek*

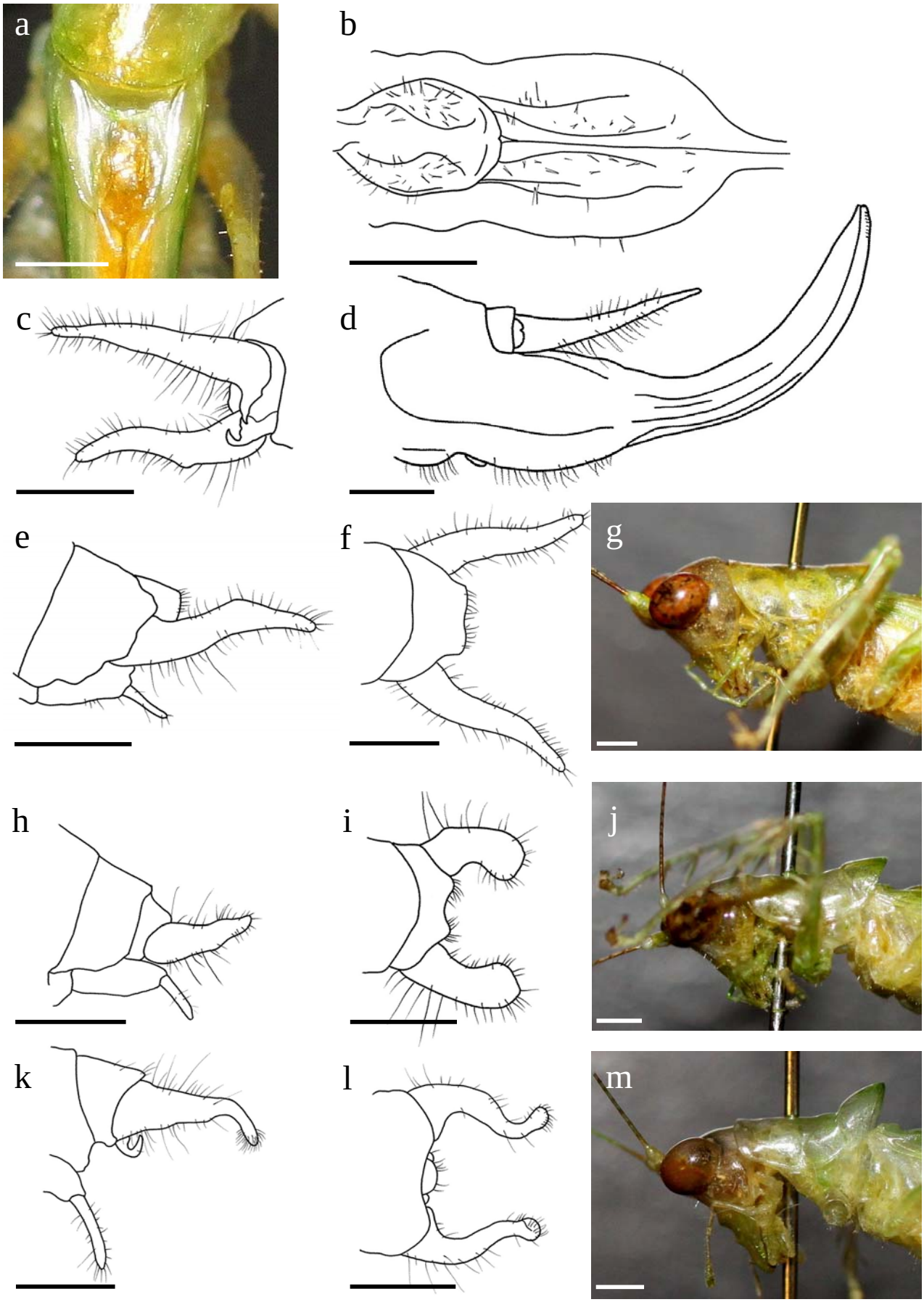

Fig. 4. *Asiophlugis thaumasia* (a–g); *Asiophlugis rete* (h–j); *Asiophlugis temasek* (k–m). a: male stridulum dorsal view; b: female abdominal apex ventral view; c: male abdominal apex ventro-lateral view; d: female abdominal apex profile view; e, h, k: male abdominal apex profile views; f, i, l: male abdominal apex dorsal views; g, j, m: head and pronotum profile view. Scale bar = 1 mm.

DISCUSSION

***Biology of the* Asiophlugis.** — Little is known about the biology of *Asiophlugis* species in Singapore. These katydids are true forest species, hence they are elusive. Individuals of *Asiophlugis* are almost always sighted on the leaves of short trees (Fig. 5). Species of Meconematinae are known to be predatory katydids (Rentz, 1996; Eades et al., undated) but were also observed to be opportunistic feeders (Fig. 6). Long mobile spurs on the fore tibiae allow *Asiophlugis* to hunt but it is unclear how they hunt. Acoustic analysis of *Asiophlugis* is still in its early stages, with only one species ever recorded, but this may have potential for more discoveries (Helfert & Sanger, 1998). During the surveys, male songs of *Asiophlugis* were not heard nor recorded. This may be due to its high frequency beyond the human hearing range (Helfert & Sanger, 1998).

Asiophlugis thaumasia*, a rediscovery.* — During the survey, three adult specimens were collected. Sightings of more adults were also recorded (Appendix, Table 1). There were also earlier encounters by Cheong Loong Fah (pers. comm.). It can be postulated that there may have been more casual sightings previously, but these records could not be confirmed owing to inadequate information available. The national status of *Asiophlugis thaumasia* as "critically endangered or presumed nationally extinct" was based on the collections of D. H. Murphy, mainly from the 1960s to 1970s, during which this species was not encountered. However, evidence from recent surveys suggests that this endemic katydid is still extant in Singapore. It is of concern that the localities of some observations were not within the limits of the nature reserve, which implies that the distribution of *Asiophlugis thaumasia* extends to areas threatened by development and other human disturbance. More worryingly, this species was hitherto not encountered during the survey in the BTNR where it was first collected.

Asiophlugis rete*, a new record for Singapore.* — In Singapore, a single adult male was observed and collected from the secondary forest patch along the Wallace Trail, Dairy Farm Nature Park. This species was described from the primary forest in Pahang, Peninsular Malaysia (Gorochov, 1998) and was not previously recorded for Singapore. Voucher specimens were also absent in the ZRC. It should be emphasized that the site of collection (along Wallace Trail from 1.36195N, 103.77745E to 1.36195N, 103.77795E) is merely permanent park land rather than within the nature reserve's boundaries. This indicates that the population of *Asiophlugis rete* is susceptible to local extinction should the area be re-gazetted in the future. Without further observations, it is not possible to ascertain the status of *Asiophlugis rete* in Singapore.

Asiophlugis temasek*, a recently described species.* — The subspecies *Asiophlugis temasek temasek* was mentioned in the 2nd edition of the Singapore Red Data Book as the common relative of *Asiophlugis thaumasia* (Davison et al., 2008). This species may be fairly commonly encountered at night throughout and around the BTNR and CCNR. During the survey, as many as 11 adults (five collected and six sighted) were encountered within three months (Appendix, Table 2). Additionally, many male and female adults were collected by D. H. Murphy in the BTNR forest and the forest adjacent to Sime Road (CCNR) from 1972–1985, all of which were deposited in the ZRC. On 19 May 2011, five male and four female adults were observed on different leaves of a single tree along Hindhede Drive. It is therefore evident that *Asiophlugis temasek* is not seriously threatened in Singapore. However, this species was not described until recently by Gorochov & Tan (2011). Until it is discovered elsewhere, *Asiophlugis temasek temasek* is considered endemic to Singapore and thus significant to the biodiversity of Singapore.

***Conservation needs of* Asiophlugis.** — The current knowledge of the Singaporean species of *Asiophlugis* is insufficient for designating the national status of individual species. Nonetheless, these katydids are still vulnerable to damage and loss of habitats (Davison et al., 2008). Observations so far suggest that the *Asiophlugis* species are adapted to primary and young and old secondary forests, both within and outside the boundaries of the nature reserve. However, forests will be encroached upon as Singapore continues to urbanise. Moreover, more trails within the BTNR and CCNR were also opened to the public (Chua, 2002). These may expose *Asiophlugis* species to human pressure, thus threatening their survival. This is especially significant in Singapore where the populations of *Asiophlugis* species may be highly localised in small forested patches (Cheong Loong Fah, in litt.).

CONCLUSIONS

The rediscovery of *Asiophlugis thaumasia* (previously presumed nationally extinct), and records of *Asiophlugis temasek* (only recently described) and *Asiophlugis rete* (a new record for Singapore) from new localities highlight the importance of continual surveys of the biodiversity of Singapore, particular in poorly studied taxa. However, our knowledge of the local *Asiophlugis* and other Orthoptera species is still poor. To protect these 'marvellous' katydids in Singapore, much work remains to be done with regards to the distribution of *Asiophlugis* within Singapore and their ecological needs, before their conservation may be achieved.

Fig. 5. An adult male *Asiophlugi temasek* (BL = ca. 11 mm) on a leaf blade along Sime Track on 12 Dec.2010. (Photograph by: Ngiam Wen Jiang Robin).

Fig. 6. A female adult *Asiophlugis temasek* (ZRC.ORT.152, BL = 12.5 mm) feeding on the wing of a termite along Dairy Farm Loop on 10 Dec.2010. (Photograph by: Mirza Rifiq bin Ismail).

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APPENDIX

Table 1. Sightings of adult *Asiophlugis thaumasia* between 2004–2011. (M = male, F = female)

Date	Time (hours)	Qty	Sex	Locality	Observer
23 Jul.2004	0933	1	M	Sime Forest, MacRitchie Reservoir Catchment Area	L. F. Cheong
10 Feb.2011	ca. 2000	1	F	Dairy Farm Pass, Dairy Farm Nature Park	M. K. Tan
22 Feb.2011	ca. 2045	1	M	Mandai Track 15, Central Catchment Area	M. K. Tan
9 Apr.2011	2020	1	M	Venus Trail, MacRitchie Reservoir Catchment Area	M. K. Tan

Table 2. Sightings of adult *Asiophlugis temasek* between Oct.2010–Dec.2010. (M = male, F = female)

Date	Qty	Sex	Locality	Observer(s)
26 Nov.2010	1	M	Sime Track, MacRitchie Reservoir Catchment Area	M. K. Tan, M. R. B. Ismail, T. M. Leong
3 Dec.2010	1	M	Wallace Trail, Dairy Farm Nature Park	M. K. Tan
3 Dec.2010	1	F	Wallace Trail, Dairy Farm Nature Park	M. K. Tan
12 Dec.2010	1	M	Sime Track, MacRitchie Reservoir Catchment Area	M. K. Tan, R. W. J. Ngiam
26 Dec.2010	2	M	Hindhede Way, BTNR	M. K. Tan