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The springtail catchers of the genus *Neurigona* (Insecta, Diptera, Dolichopodidae) in the primary forest of Bukit Timah Nature Reserve, Singapore

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ABSTRACT. Three species of *Neurigona* Rondani, 1856, are recorded from the primary forest of Bukit Timah Nature Reserve in the centre of the city of Singapore. *Neurigona squamifera* Parent, 1935, originally described from Peninsular Malaysia, is a species common in Bukit Timah. *Neurigona temasek* sp. nov., the most common species, and *Neurigona timahensis* sp. nov., a very rare species, are described as new for science. Gross morphology images are provided as well as illustrations of the male terminalia. A key is given to the five species hitherto known from Singapore.

Keywords. Invertebrate conservation, *Neurigona*, new species

Introduction

The famous old-growth or primary forest of Bukit Timah in the middle of the city of Singapore was already known to Alfred Russel Wallace (1869). He stayed there several times with the Catholic Missionaries at St. Joseph's in Upper Bukit Timah. He wrote: "In about two months I obtained no less than 700 species of beetles, a large proportion of which were quite new. … Almost all these were collected in one patch of jungle, not more than a square mile in extent, and in all my subsequent travels in the East I rarely if ever met with so productive a spot." The future will show if the Dipteran fauna will prove to be as rich as for the Coleoptera since our surveys of the flies in what is now Bukit Timah Nature Reserve has only recently begun.

The comprehensive biodiversity survey of the 163 ha Bukit Timah Nature Reserve (BTNR) has been introduced by Chan & Davison (2019). In the present paper we report on the long-legged flies belonging to the genus *Neurigona* Rondani. These large yellow flies on their very long legs can be easily observed on the base of tree trunks in the forest. The trunks they choose to rest on should have a diameter of at least 20 cm and they generally roost, hunt and display on the basal metre of trunk above the ground. Sometimes they hold a small fly between their labia and often their prey

consists of springtails (Insecta: Collembola). Hence their vernacular name, springtail catchers. Ample images of this feeding habit are available on the internet.

There are 25 Oriental species of *Neurigona* known so far (Yang et al., 2006) and up to now we have recorded five species from the island of Singapore. The three species found in Bukit Timah Nature Reserve occur in inland forest while the other two species, *Neurigona angulata* de Meijere, 1916 and *N. pectinata* Becker, 1922 are unique to mangrove. Nevertheless, more species are expected to occur in Singapore. Females could be associated to the equivalent males using the Next Generation Sequencing (NGS) 313bp barcodes as described by Meier et al. (2016), Wang et al. (2018) and Ramos et al. (2018).

Materials and methods

Neurigona were collected with Malaise traps but also individually by hand capture on tree trunks. Some of the recent material was NGS barcoded (Meier et al., 2016; Wong et al., 2014). To do so, a piece of a hind leg was removed and a direct Polymerase Chain Reaction (PCR) was done. The voucher specimens are conserved in 70% ethanol in the collections of the Lee Kong Chian Natural History Museum (ZRC), Singapore. The ZRC number given to the individuals is the inventory number, enabling individual recognition of the barcoded specimens.

Abbreviations used in this paper for morphological descriptions are: ad: anterodorsal; av: anteroventral; pd: posterodorsal; pv: posteroventral.

Taxonomy

Family Neurigoninae
Genus *Neurigona* Rondani, 1856

Neurigona squamifera Parent, 1935

Neurigona squamifera Parent, Ann. Mag. Nat. Hist. 15: 207 (1935), Fig. 23–25. Type locality: Malaysia (precise locality not given). (Fig. 1–2)

Extended diagnosis. ***Male*** body length: 6 mm; wing: 4.4 mm. ***Antenna*** yellow. Third antennal segment as long as it is wide. Palpus yellow with yellow bristling. ***Thorax*** yellow. Prescutellar depression faintly brown (quite variable in intensity, but never dark brown). Scutellum brown, border yellow. Ventral border of postnotum brown. Acrostichals biseriate throughout. Dorsocentrals short and multiseriate in basal half followed by a row of 6 uniseriate dorsocentrals, becoming longer towards scutellum. ***Legs*** yellow, but fore tarsus with apical 3 tarsomeres entirely black, hind femur ventrally darkened. Fore coxa with pale hairs on basal half, black hairs on apical half; 3 strong black bristles at side and 6 at tip. Tarsomeres 4 and 5 dorsally with a

Fig. 1. *Neurigona squamifera*. **A.** Parent gross morphology of male. **B.** Parent gross morphology of female A from *ZRCBDP0005487*; B from *ZRCBDP0007646*. (Photos: K.Q. Chin;).

comb of black squamiform bristles; longest at base of tarsomere 4 and decreasing in length towards tip of tarsomere 5. ***Wing*** brownish tinged; anterior third darker brown than the posterior part. Vein M with a strong rectangular bent. Squama yellow with a brown border bearing long yellow setae. Haltere with knob anteriorly dusky yellow, otherwise almost white. ***Abdomen***. First segment completely yellow. Base, tip and sides of tergite 2 and 3 yellow, rest brown to black. Tergite 4 with only a narrow yellow band at base and tip, side brown. Tergite 5 dorsally yellowish white, a small brown patch at side. Ventrally with a long brown appendage as long as genital capsule (Fig. 1A, 2). Genital capsule black, cercus white.

Female body length: 5.8 mm; wing: 5 mm. Resembling the male apart from the terminalia and lacking the flags on the fore leg.

Distribution. Malaysia, Singapore. *Neurigona squamifera* is quite common in inland forests. Unknown from mangroves.

Remarks. An extended diagnosis is given here for this previously described species since we have indications that a sister species with similar flagged front legs occurs in Southeast Asia and this extended diagnosis might help in recognising this species.

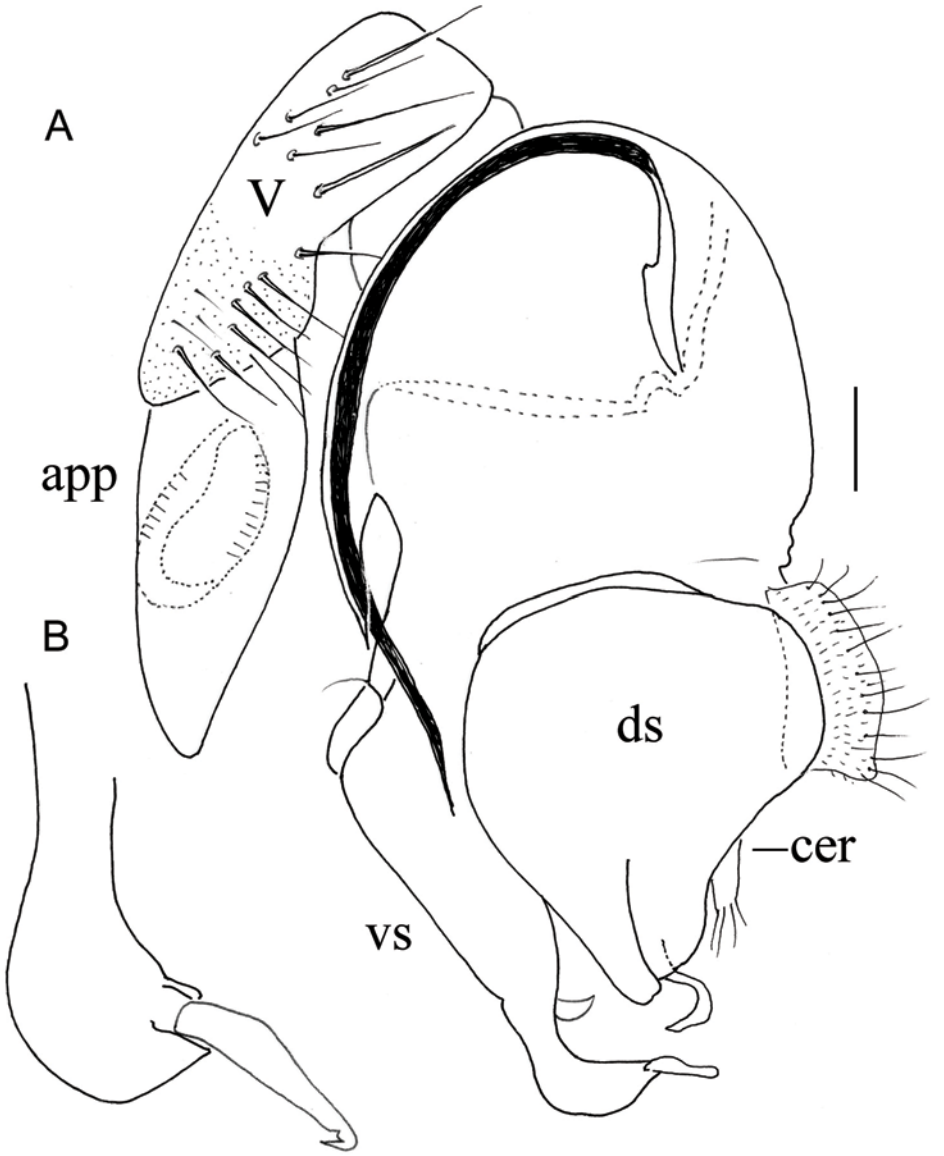

Fig. 2. *Neurigona squamifera* Parent male terminalia. **A.** Epandrium and fifth abdominal segment; **B.** Tip of ventral surstylus. app: ventral appendage of fifth abdominal segment; cer: cercus; ds: dorsal surstylus; vs: ventral surstylus. Scale 0.1 mm.

Material examined. SINGAPORE: 1 male, Bukit Timah (Taban valley, on tree trunk), 11 March 2005 (Si414, leg. Patrick Grootaert); 1 male, Nee Soon, 16 March 2005 (Mal 1, Si460, leg. Patrick Grootaert); 1 male, 1 female, Nee Soon, 14 October 2005 (Mal 4, Si1308, leg. Patrick Grootaert); 2 males, Sime forest, 1 April 2005 (Mal 1, Si614, leg. Patrick Grootaert); 1 male,

Sime forest, 16 September 2005 (Mal 1, Si1069, leg. Patrick Grootaert); 1 male, Sime forest, 22 July 2005 (Mal 2, Si1077, leg. Patrick Grootaert).

NGS barcode: male, ckq_DOL_ZRCBDP00005323_Neurigona_squamifera_M_Nee Soon, done by Ms Kai Qing Chin
cttatcttctggaattgcacacggtggagcatctgttgatttagcaatttttctcttcatttagctggaatttcatcaattttaggagctgta
aattttattacaacagtaattaatatacgatccccagggattacattagaccgaataccttttatttgtttgatctgtagttattacagctat
tctccttcttttgtctcttcctgttttagcaggagctattactatactttaacagatcgtaatttaaatacatcatttttgacccggctggag
gaggagacccaattttatatcaacatttattc

There are 16 NGS barcodes of *Neurigona squamifera* available. The genetic variability is up to 3.1 %.

***Neurigona temasek* sp. nov.** (Fig. 3–4)

Extended diagnosis. ***Male*** body length: 5 mm; wing: 4.4 mm. ***Antenna*** yellowish. Third antennal segment a little longer than high. Arista with basal segment yellowish, base of apical aristal segment pale becoming black towards tip. Palpus white, but base posteriorly pale brownish, covered with white hairs. ***Thorax*** yellow, with a brown prescutellar patch. Acrostichals biseriate. Dorsocentrals short multiseriate in basal half, 5 longer uniseriate dorsocentrals in apical half. ***Legs*** yellow, except hind femur ventrally brown. Fore coxa with minute pale anterior bristles on basal half, minute black on apical third. Only hind coxa with a strong black exterior bristle. ***Wing*** brown with anterior apical quarter darkened and an elongate contrastingly clear patch below the third vein (R_{4+5}). ***Abdominal segment*** 5 in male with ventral appendages as long as genital capsule is high, covering the base of the terminalia (Fig. 3A, 4).

Female body length: 6.3 mm; wing: 4.7 mm. Resembling male but palpus with minute black bristles on tip; prescutellar depression with a dusky yellowish spot, not brown; hind femur entirely yellow and wing uniformly brownish tinged.

Distribution. Singapore: Bukit Timah, Nee Soon, Sime forest.

Etymology. The name Temasek is the old name of Singapore: meaning city by the sea. The name is used as a noun.

Material examined. Holotype male: SINGAPORE: Bukit Timah, 30 August 2016 (Mal BT08, 1°21’16.8”N 103°46’55.2”E, ZRCBDP0068434 with NGS barcode, leg. Maosheng Foo).
Paratypes: SINGAPORE: 1 male, 4 females, Bukit Timah, 11 March 2005 (Si413, hand capture, leg. Isabella Van de Velde); 8 males, 4 females, Nee Soon, 5 April 2005 (Mal 2, Si648, leg. Patrick Grootaert, sequenced by Lim et al. 2009); 1 male, Sime forest, 22 July 2005 (Mal 2, Si1078, leg. Patrick Grootaert); 10 males, 3 females, Sime forest, 14 October 2005 (Mal 3, Si1313, leg. Patrick Grootaert).

NGS barcode: male, ckq_DOL_ZRCBDP00005621, Reg. 29181, Nee Soon (NS1), 18 April 2012, leg. Patrick Grootaert, done by Ms Kai Qing Chin.

Fig. 3. *Neurigona temasek sp. nov.* **A.** Gross morphology of male. **B.** Gross morphology of female. A from *ZRCBDP0007627*; B from *ZRCBDP0005305*. (Photos: A, K.Q. Chin; B, M.S. Foo)

tttatcttctggcatcgcccatggaggagcatccgttgatttagcaatttttctcttcatttagctggaatttcatcaattttaggagccgta
aattttattacaacagtaattaatatgcggtccccaggaattacgctagatcgaataccctttatttgtttgatctgtagttattacagctat
tcttcttcttctatctctccctgttttagcaggagctatcactatactttaacagatcgtaacttaaatacatcatttttgaccctgccggag
gaggagacccaattttataccaacatttattt

There are 567 more NGS barcodes available of the new species from Bukit Timah and Nee Soon. The genetic variability is maximum 0.3%.

***Neurigona timahensis* sp. nov. (**Fig. 5–6)

Extended diagnosis. ***Male*** body length: 4.8 mm; wing: 4.1 mm. ***Ocellar bristles*** as long as verticals but thicker. Postoculars white. Antenna with basal 2 segments white, third segment yellow, arista black. Third antennal segment as long as high, with truncate tip. Arista 3 times as long as the 3 antennal segments together. Palpus brown elongate. ***Thorax*** yellow; pleura yellowish white. Acrostichals biseriate. Anterior dorsocentrals minute, multiseriate on basal half; posterior 5 dc strong. ***Legs*** yellow, with all coxae yellowish white. Only hind femur ventrally brown, darkest in basal half. ***Fore coxa*** anteriorly with minute black bristles, only apex bordered with long black bristles. Fore femur and tibia lacking distinct bristles. Mid and hind femora also lacking distinct

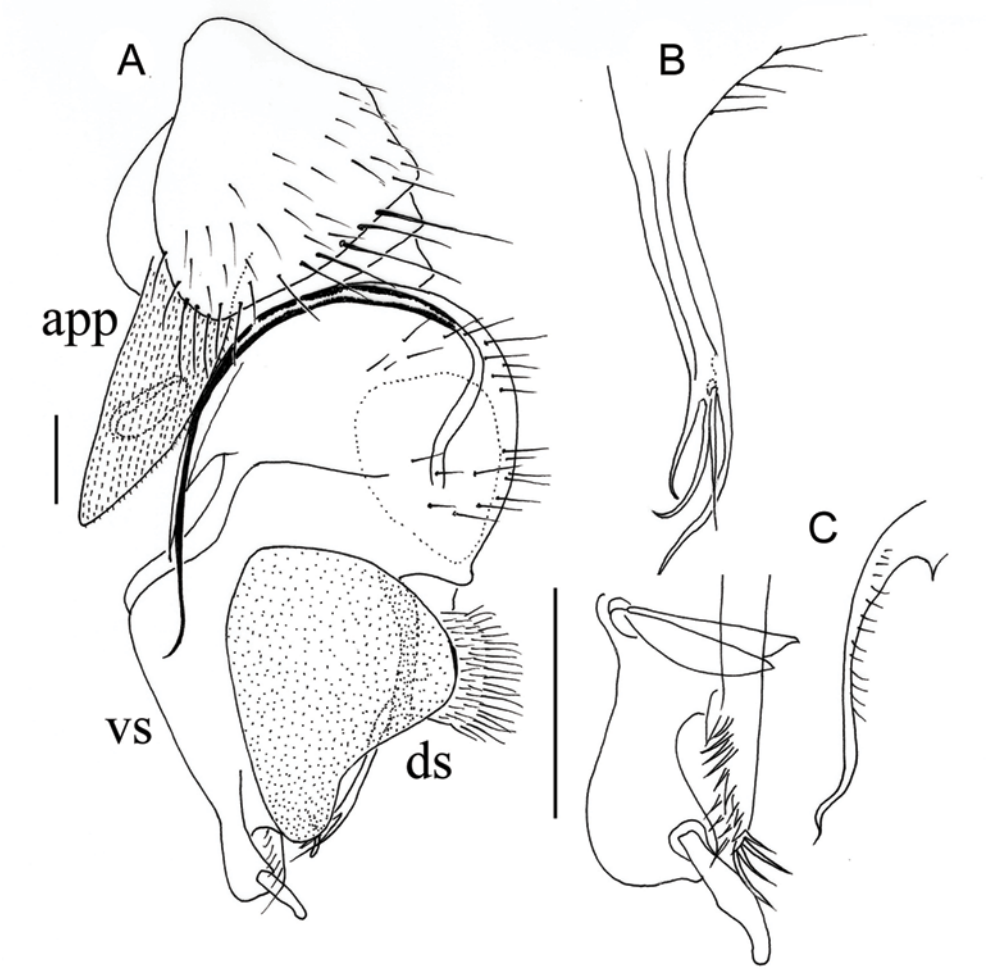

Fig. 4. *Neurigona temasek sp. nov.* male terminalia. **A.** Epandrium and fifth abdominal segment; **B.** Tip of cercus; **C.** Tip of ventral surstylus and tip of postgonite. app: ventral appendage of fifth abdominal segment; ds: dorsal surstylus; vs: ventral surstylus. Scale 0.1 mm.

bristles. Mid tibia with 4 short ad, 2 pd, 1 stronger av near middle. Hind tibia with 3 short ad, 3 longer pd, a crown of short apicals. ***Wing*** brownish tinged (Fig. 7). Squama and haltere yellowish. ***Abdomen*** with first tergite yellow with long black marginal bristles. tergite 2 with basal ¾ black, tergite 3 with base and and tip yellow, centrally black. Only tip of tergite 4 brown. Tergite 5 and 6 entirely brown. Hypopygium black (Fig. 5A, 6). Ventral appendages on segment 5 short, half as long as tergite 5 is high.

Female body length: 5 mm; wing: 4.4 mm. Resembling male except for the terminalia (Fig. 5B).

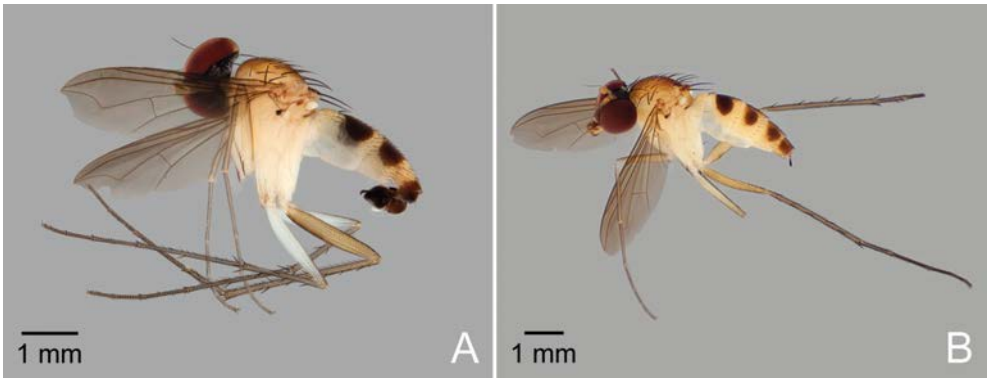

Fig. 5. *Neurigona timahensis sp. nov.* **A.** Gross morphology of male. **B.** Gross morphology of female. A from *ZRCBDP0007579*; B from *ZRCBDP0006219*. (Photos: K.Q. Chin)

Distribution. Only known from Singapore, where it is recorded from Bukit Timah and Nee Soon. Uncommon.

Etymology. The name refers to the site of Bukit Timah.

Remarks. This species has a very simple morphology lacking male secondary sexual characters.

Material examined. Holotype male: SINGAPORE: Bukit Timah, 30 August 2016, BT08 (1°21'16.8"N 103°46'55.2"E, Malaise trap, ZRCBDP0068443 with NGS barcode, leg. Maosheng Foo).
Paratypes: SINGAPORE: male Bukit Timah, 14 December 2016 (ZRCBDP0072372 with NGS barcode, leg. Maosheng Foo); 4 males, 8 females, Nee Soon, (ZRCBDP0007592; all with NGS barcodes).

ZRCBDP0068443_BTNR_BT08_30Aug2016 male Holotype
a a a t a a a t g t t g a t a t a a a a t t g g g t c t c c t c c t c c t g c t g g g t c a a a a a a t g a t g t a t t
t a a a t t a c g g t c t g t t a a a a g t a t a g t a a t a g c a c c a g c t a a a a c a g g t a a t g a t a a a a g
a a g a a g a a t a g c t g t a a t a a c t a c a g a t c a t a c a a a t a a a g g t a t t c g a t c t a a t g t a a t
t c c t g g a g a t c g c a t a t t a a t t a c t g t t g t a a t a a a a t t t a c a g c t c c t a a a a t t g a g g a
a a t t c c a g c t a a a t g a a g a g a a a a a a t t g c t a a a t c a a c a g a t g c c c c t c c g t g g g c a a t
t c c a g a t g a t a a t

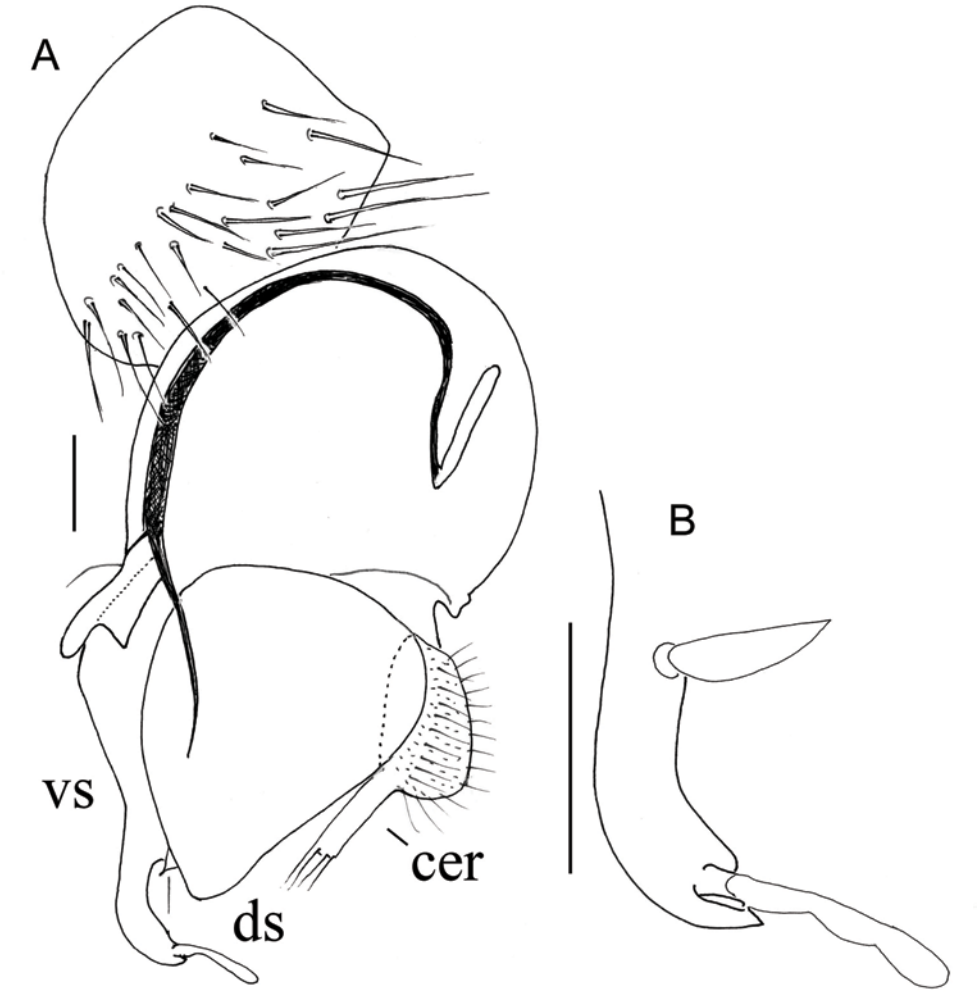

Fig. 6. *Neurigona timahensis sp. nov.* male terminalia. **A.** Epandrium and fifth abdominal segment; **B.** Tip of ventral surstylus. cer: cercus; ds: dorsal surstylus; vs: ventral surstylus. Scale 0.1 mm.

Key to the male *Neurigona* from Singapore

1a. Acrostichals multiseriate (mangrove) ..... *N. angulata*
1b. Acrostichals biseriate only 2

2a. Fore tarsus with black squamiform bristles on tarsomeres 4 and 5 (Fig. 1A) .... *N. squamifera*
2b. Fore tarsus without black squamiform bristles 3

3a. Wing with apical quarter and anterior border darkened, a contrastingly hyaline elongated streak below vein R_{4+5} (Fig. 3A) ..... *N. temasek*
3b. Wing if slightly darkened without a hyaline streak below vein R_{4+5} 4

4a. Mid leg with tibia and tarsomere 1 anteroventrally with a row of very short pale erect hairs (mangrove only) ..... *N. pectinata*
4b. Mid tibia and tarsomere 1 lacking a row of pale short erect anteroventral hairs ... . *N. timahensis*

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