

## Revision of *Ngirhaphium* (Insecta: Diptera: Dolichopodidae), with the description of two new species from Singapore's mangroves

Patrick Grootaert<sup>1\*</sup> & Jayanthi Puniamoorthy<sup>2</sup>

**Abstract.** The type-species of *Ngirhaphium* Evenhuis & Grootaert, *N. murphyi* is re-described. Two new species are described from mangroves in Singapore: *N. sivasothii*, new species, and *N. caeruleum*, new species. A key to the three known species of the genus is given and male genitalia are illustrated. COI barcodes are provided for the three species, as well as data on distribution and phenology. Genetic distances of at least 10% suggest that the species have been genetically separated for a long time.

**Key words.** Dolichopodidae, new species *Ngirhaphium*, mangroves, Oriental region.

### INTRODUCTION

The genus *Ngirhaphium* was described by Evenhuis & Grootaert in 2002 as a monotypic genus from mangroves in Singapore. It was placed in the subfamily Rhaphiinae because of its obvious resemblance to *Rhaphium* Meigen, 1803. A molecular phylogenetic study by Lim et al. (2010) based on six genes could not place the genus significantly among other dolichopodid subfamilies. Moreover Germann et al. (2011), who sequenced nine species of Rhaphiinae, could neither place it as it occupies an unresolved position in their Bayesian tree and contributes to an insufficiently supported (ML: <50%) clade with Rhaphiinae as well as Acalcinae on the Maximum Likelihood tree. More taxa sampling of Rhaphiinae as well as using more nuclear genes to solve the phylogenetic position of *Ngirhaphium*.

Recent surveys of mangrove entomofauna in Singapore revealed the presence of two new species which are described here. In fact, insects of this genus are commonly found in Singapore's mangroves forest. Although theoretically it should occur in mangrove forests all along the South-China Sea, it is surprisingly still only known from Singapore. *Ngirhaphium* is quite a large dolichopodid that has been observed perching on vegetation bordering the mudflats towards the sea. It was also observed along creeks inside mangrove forests, but is less common there.

In the present paper we re-describe the type species *N. murphyi* mainly to point out the differences with the two

new sister-species. A key is provided as well as distribution and phenology data.

### MATERIAL AND METHODS

**Specimen collection and imaging.** The present study is based on various surveys of Dolichopodidae in Singapore (see Grootaert & Shamshev, 2012 for a detailed overview). In 2005–2006, mangroves of Sungei Buloh and Chek Jawa (Pulau Ubin) were sampled for a whole year with Malaise traps. Another important effort took place during the SMIP project (Singapore Mangrove Insect project) sponsored by National Parks in 2009. Then, 11 mangrove sites were sampled in one month (5 May–12 June 2009) with at least two Malaise traps per site, with the exception of Pulau Semakau and Lim Chu Kang, with 5 and 3 traps, respectively. A long-term survey was initiated on March 2012 to study the phenology of mangrove species (MIP) over two years. Most new records used in the present study come from the sampling conducted during the first year of the MIP survey. Samples were collected from Sungei Buloh (2 stations: SB1, SB2), Pulau Ubin (Chek Jawa, 3 stations: PU1, PU2, PU3), and Pulau Semakau (replanted mangroves: 3 stations: SMN1, SMN2, SMN3; original mangroves: 3 stations: SMO1, SMO2, SMO3). All material from the MIP survey were collected by the second author (JP) and her team of students.

High resolution photos were taken by JP with the Visionary Digital™ BK Plus Lab System.

Holotypes of the new species as well as most paratypes are stored in 70% ethanol in the collections of the Raffles Museum for Biodiversity Research, Singapore (ZRC: Zoological Reference Collection). Voucher paratypes are also preserved in the Royal Belgian Institute of Natural Sciences, Brussels (RBINS). For each record, a register number is given (register number in database linked to collection data such as locality, date, collector, and habitat). In addition, each species record is given an inventory number (e.g., Si200

<sup>1</sup>Department of Entomology, Royal Belgian Institute of Natural Sciences, Vautierstreet 29, B-1000 Brussels, Belgium; Email: Patrick.Grootaert@naturalsciences.be (\*corresponding author)

<sup>2</sup>Evolutionary Biology Laboratory, Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Singapore 117543; Email: jayanthi.puniamoorthy@gmail.com

or Ma0179), which indicates where the specimens can be found in the wet collection (Si stands for Singapore general collection while Ma for mangrove collection).

**Abbreviations used in text and on figures.** acr: acrostichal bristles; ad: anterodorsal; ae: aedeagus; av: anteroventral; c: cercus; dc: dorsocentral bristles; pd: posterodorsal; ds: dorsal surstylus; pv: posteroventral; hy: hypandrium; Tp: posterior cross vein (dm-Cu); vs: ventral surstylus.

**Genetic analysis.** DNA was extracted using the Qiagen DNEasy Kit. *COI* amplification was done using LCO1490 and HCO2198 primers as recommended by Lim et al. (2010). Polymerase Chain Reaction (PCR) conditions were as follows: Initial denaturation at 95°C (3 min); 40 cycles of 94°C (1 min), 48°C (1 min), and 72°C (1.5 min); Final extension at 72°C (5min). PCR products were purified using Biolibe's SureClean. Cycle sequencing reactions, done at 50°C with Big Dye, were cleaned using Agencourt's CleanSeq. Sequencing was done using the ABI 3130 by Applied Biosystems. Chromatograms were then analysed with Sequencher 4.6 and aligned with the online version of the multiple sequence alignment software MAAFT (Katoh & Standley, 2013). Molecular species limits were determined through clustering at various thresholds in TaxonDNA (version 1.7.8) (Meier et al., 2006). Two specimens of *N. murphyi*, five of *N. sivasothii* and three of *N. caeruleum* were sequenced. COI barcodes are available in GenBank.

## TAXONOMY

### FAMILY DOLICHOPODIDAE

#### SUBFAMILY RHAPHIINAE

#### Genus *Ngirhaphium* Evenhuis & Grootaert, 2002

*Ngirhaphium* Evenhuis & Grootaert, 2002, Raffles Bulletin of Zoology, 50: 310.

Type species by original designation: *Ngirhaphium murphyi* Evenhuis & Grootaert, 2002.

**Diagnosis.** Medium-sized species with a metallic green or blue ground-colour. Antenna very long in males, a little shorter in females. Arista apical, basal aristal segment long; length apical aristal segment specific. Rostrum in male small with well-developed labellae. Rostrum very large in female. Face wide, clypeus only a narrow strap in male; very long in females, pointed. Vertex excavated (cf. Sciapodinae) and ocellar tubercle much raised above frons. The ocellar bristles are very long and with a thick socket on ocellar triangle.

Thorax with biserial acr; dc multiserial in front of suture, further uniserial ending in 2 long prescutellars. A pair of long scutellars. A group of short upper propleurals and 2 longer lower propleurals.

Fore legs much shorter than mid and hind legs. No exterior bristle on mid and hind coxae. Hind coxae bare. Femora without conspicuous bristling. All tibiae with strong bristles.

Fore leg in male with tarsomere 4 with an asymmetrical apical dorsal protuberance (absent in female); terminal segment with a pair of normal claws and a thickened claw-like structure beneath the posterior claw. Female with the claws as usual, but the terminal segment bears a long dorsal protuberance. Mid and hind legs with tarsal segments 1–4 with an apical comb of short spinules.

Wing with tip of vein  $M_{1+2}$  sharply bent upward just before reaching the wing border and ending near tip of vein  $R_{4+5}$ .

**Differential diagnosis.** The genus resembles *Rhaphium*, especially the species *R. longicorne* (Fallén). Both genera have short fore tarsi. *Rhaphium* has the fore tarsomeres 4 and 5 normally shaped, has no apical comb of spinules on the tarsal segments 1–4 of the mid and hind legs. Vein  $M_{1+2}$  can converge a little to  $R_{4+5}$  in *Rhaphium*, but in *Ngirhaphium* the vein  $M_{1+2}$  bends up sharply before the tip of the wing and eventually ends close to  $R_{4+5}$  in the wing tip.

#### Key to males of *Ngirhaphium* from Singapore:

1. Mesonotum and tergites shining metallic blue. Large species (7–8 mm) with apical aristal segment filiform and much longer than basal aristal segment ..... *N. caeruleum*, new species
- Mesonotum and tergites shining metallic green. Medium-sized species (4.5–7.3 mm) with apical aristal segment shorter or about half as long as apical aristal segment ..... 2
2. Wing membrane not infusate. Apical aristal segment about half as long as basal aristal segment. Cerci fused and tips are protruding from tips of surstyli (Figs. 4, 5) ..... *N. murphyi* Evenhuis & Grootaert
- Wing membrane infusate brown or black with longitudinal veins and Tp dark seamed. Apical aristal segment broad at base and tapering toward apex, nearly as long as basal aristal segment in male, sometimes a little longer in female. Tip of dorsal surstylus truncate, very wide and darkened (Figs. 9, 10) ..... *N. sivasothii*, new species

#### *Ngirhaphium murphyi* Evenhuis & Grootaert, 2002 (Figs. 1–3, 4, 5, 18)

*N. murphyi* Evenhuis & Grootaert, 2002, Raffles Bulletin of Zoology, 50: 310: Type locality: Singapore: Kranji mangrove.

**Material examined.** Holotype male, 7 males, 4 females paratypes from Singapore: Kranji mangrove, 16 October 1984, on vegetation, D.H. Murphy (in ZRC, 1 male, 1 female in RBINS); 1 female, Mandai mangrove, 17 October 1978, D.H. Murphy (ZRC); 3 females, Lim Chu Kang mangrove, mud flats at low tide, perching on shoots and roots of mangrove trees, 13 October 2000, N.L. Evenhuis (BPBM).

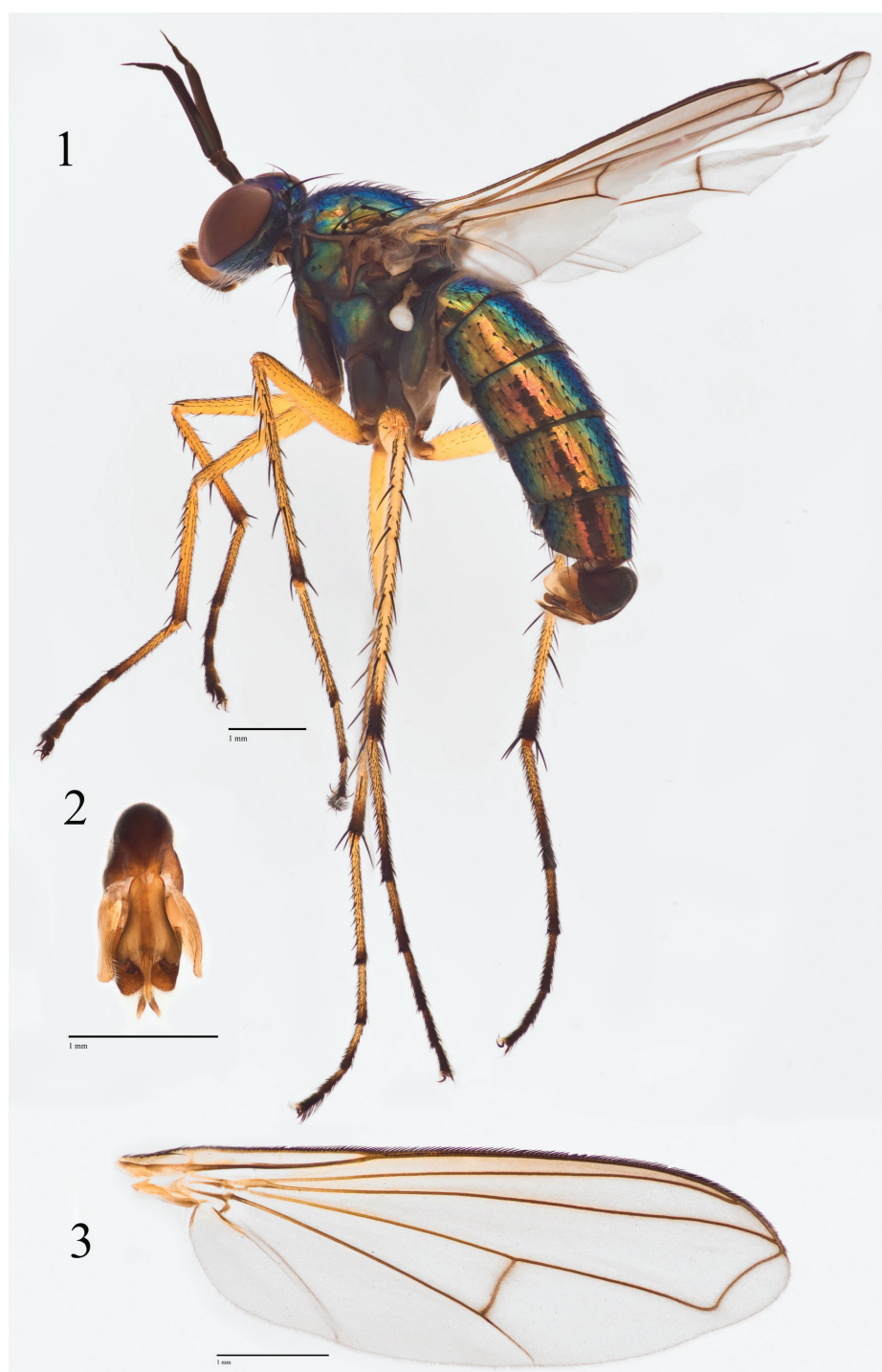
**New records MIP. Pulau Ubin:** 1 female, PU2, 23 June 2012, (reg. 29307, Ma1681). **Semakau:** 1 male, SMN2, 13 December 2012, (reg. 29626, Ma2292). **Sungei Buloh:** 2 males, SB1, 14 November 2012, (reg. 29569, Ma2250); 2 males, SB1, 18 November 2012, (reg. 29595, Ma2262); 1 male, SB1, 27 March 2013, (reg. 29820, Ma3807); 3 males, SB2, 14 November 2012, (reg. 29570, Ma2254).

**Other records. Sungei Buloh:** 1 male, 1 female, 22 April 2005, (reg. 25078, Si758, coll. P.G.); 1 female, 11 May.2005, (reg. 25159, Si805; coll. P.G.); 1 male, 16 September 2005, (reg. 25355, Si1168; coll. P.G.); 1 male, 28 September 2005, (reg. 25431, Si1167; coll. P.G.); 1 female, 28 October 2005, (reg. 25407, Si1169; coll. P.G.).

**Diagnosis.** A medium-sized species, generally with clear wing. Mesonotum and tergites shining metallic green. Apical arisal segment nearly half as long as basal arisal segment. Male with cerci longer than surstyli and thus the tip is visible outside the surstyli.

**Re-description.** Male: Body length: 5.7–6.7 mm.; wing length: 5.3–6 mm.

Head: Frons shining metallic green, sunken between the eyes, wide in front becoming even wider behind; ocellar callus small, globular and raised above the frons. Face wide, as wide as front of frons, parallel-sided, silvery grey dusted with a very narrow clypeus (hardly a tenth of the length of the face). Eyes pass beyond the border of the face; eyes densely set with silvery hairs. Palpus strap-shaped, brownish at base, yellowish at tip and bearing long, black hairs. Rostrum in male very small in comparison to the huge female rostrum;



Figs. 1–3. Male *Ngirhaphium murphyi*, Evenhuis & Grootaert (Sungei Buloh, Singapore): 1, Habitus; 2, Genital capsule removed; 3, Wing.



brown with long black hairs. Postcranium dark metallic green, with a fine greyish dusting. Two long diverging ocellars; 2 slightly shorter, converging verticals; A pair of strong postverticals well separated from the postoculars. Upper postoculars strong, uniseriate, black; lower postoculars white, becoming longer below and multiseriate.

Antenna: Antenna very long, completely black (Fig. 1). First segment (scape) long, bare; second segment (pedicel) narrow, apically densely set with bristles. Third segment (postpedicel) very long strap-shaped, laterally flattened, but with a narrow dorsal flat area (so somewhat triangular in cross-section). Arista apical with a long basal segment, apical segment about half as long as basal. Ratio of first, second, third segment, and basal and apical arista segments: 0.37 : 0.07 : 1.1 : 0.3 : 0.15 (mm).

Thorax: Thorax and scutellum with a shining dark metallic green ground-colour, covered with a fine grey dusting. A shining stripe on each acr-row. Pleura grey dusted. All hairs and bristles black. Acr biseriate, the rows more widely separated in front, while closer together behind. Presutural dc multiseriate; 6 post-sutural dc: 4 short and 2 long prescutellars. A pair of strong scutellars. A long humeral with a shorter bristle in front; a very strong posthumeral, 2 strong notopleurals, 1 postsutural, 1 supraalar, 1 postalar. 4 short upper and 2 very long black lower propleural bristles.

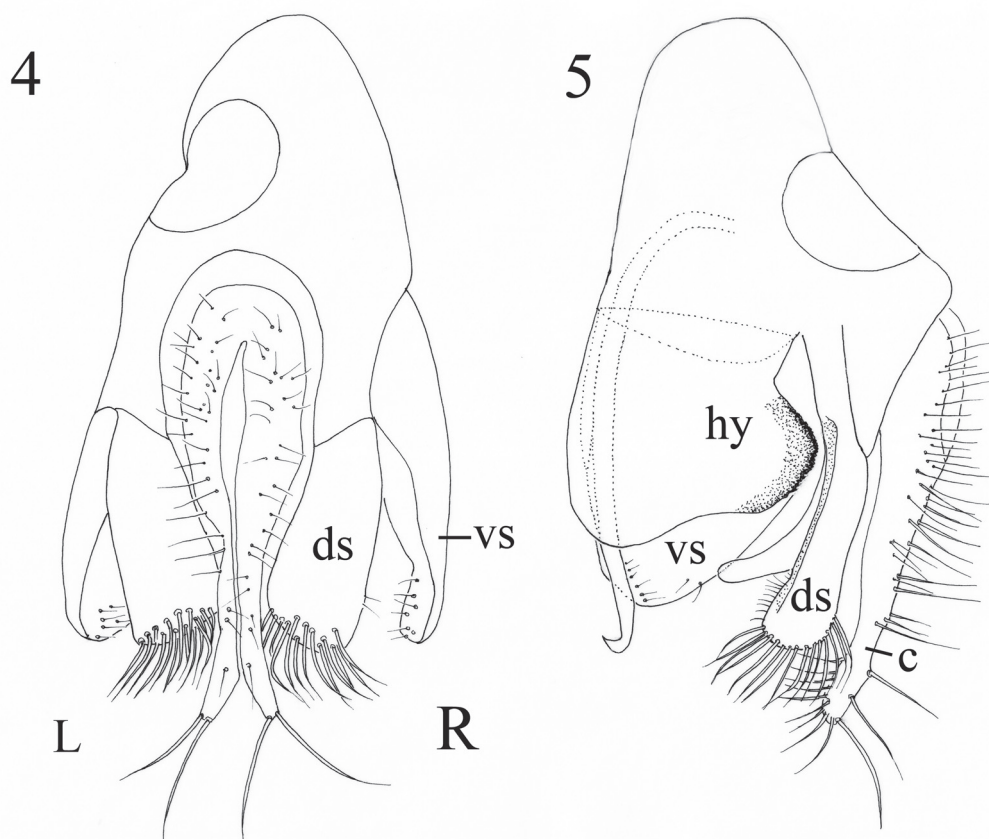
Legs (Fig. 1): yellow, all bristles black. All coxae greenish black in ground-colour, covered with a fine greyish dusting.

Tip of mid and hind tibiae annulated black at tip. Tip of all tarsal segments a little browned and terminal segments completely black.

Fore leg: Shorter than mid and hind leg. Fore femur a little swollen in basal half; a row of fine pv in apical half; a row of short ventral bristles, distinct only in apical half. Fore tibia with 4 strong ad and 4 strong pd. All tarsal segments densely set with long hairs. Fourth tarsal segment with a dorsal, asymmetrical forked protrusion, extending over the terminal segment (outer branch of the fork pointed; 1/3 length of inner fork). Terminal segment with a pair of long normal claws and a thicker third claw-like structure beneath the posterior claw. 2 well developed pulvilli and an empodium. Segments 1–4 ventrally at tip with a pair of long hairs. Length of tibia and tarsal segments (mm): 1.85 : 1.03 : 0.37 : 0.29 : 0.22 : 0.15.

Mid leg: Coxa with short bristles anteriorly; no exterior bristle. Mid femur a little stronger than fore femur; ventrally with inconspicuous bristles; a strong anterior preapical. Tibia with a 5 pd, 4 d and 5 longer pd and a crown of long apicals. Segments 1–4 ventrally at tip with a pair of short spinules as well as a comb of black bristles. Length of tibia and tarsal segments (in mm): 2.9 : 1.6 : 0.74 : 0.60 : 0.4 : 0.3.

Hind leg: Coxa bare. Hind femur stronger than mid femur, as wide as fore femur; ventrally with inconspicuous bristles; a strong anterior preapical. Tibia with 5 long av, 4 ad, 5 pd and crown of long apicals. Segments 1–4 ventrally at



Figs. 4–5. *Ngirhaphium murphyi*, Evenhuis & Grootaert: 4, Dorsal view of genital capsule; 5, Lateral view of genital capsule with left ventral surstylus removed, hypandrium at the front, right ventral surstylus at the back.

tip with a pair short spinules as well as a comb of black bristles. Length of tibia and tarsal segments (mm): 4.01 : 1.6 : 0.9 : 0.7 : 0.4 : 0.37.

Wings: hyaline (Fig. 3), anteriorly between costa and  $R_{2+3}$  with a yellowish tinge. Veins dark brown.  $M_{1+2}$  sharply bent upwards and ending in costa closely near tip of  $R_{4+5}$ .  $Tp$  straight, about as long as apical part of  $M_{3+4}$ . Anal vein well developed. Halter pale yellow. Squama yellowish, with yellow cilia.

Abdomen: 5 externally visible segments; shining dark metallic reddish-green; tips and sides of terga with a silvery dusting. Tergites densely set with quite long, black bristles; hind-marginal bristles hardly longer than the other bristles. Hypopygium (Figs. 2, 4, 5) sessile with long strap-shaped cerci. Apex of cerci hidden underneath sternite 4. Cercus yellowish brown with long yellowish bristles. Cercus longer than dorsal surstylus. Apex of cercus slender with a pair of long bristles (Fig. 4). Dorsal surstylus rectangular, not fused with ventral surstylus. Apex of dorsal surstylus densely set with long yellowish hairs. Apex of ventral surstylus on inside with short hairs. Hypandrium dorsally with a large black protuberance.

Female: Body length: 7–7.3 mm; wing length: 6.9–7.1 mm.

Antennae: Slightly shorter than in male. Ratio of first, second, third segment, and basal and apical arisal segments (mm): 0.29 : 0.07 : 0.7 : 0.3 : 0.22. Clypeus very large, protruding over rostrum; tip pointed. Rostrum huge (Fig. 18): in side view nearly as long as an eye. Palpus long, strap-shaped, completely brownish black.

Legs: Shape and bristling of legs similar to that of male except otherwise mentioned.

Fore leg: Fore tibia with a crown of very long apical bristles. Fourth segment as usual, without protuberance as in male. Terminal tarsal segment with a dorsal protuberance and with the usual claws and pulvilli. Ratio of tibia and tarsal segments (mm): 1.85 : 1.2 : 0.37 : 0.3 : 0.26 : 0.26.

Mid leg: ratio of tibia and tarsal segments (mm): 2.9 : 1.6 : 0.7 : 0.52 : 0.37 : 0.29.

Hind leg: ratio of tibia and tarsal segments (mm): 4.2 : 1.7 : 0.7 : 0.67 : 0.37 : 0.37.

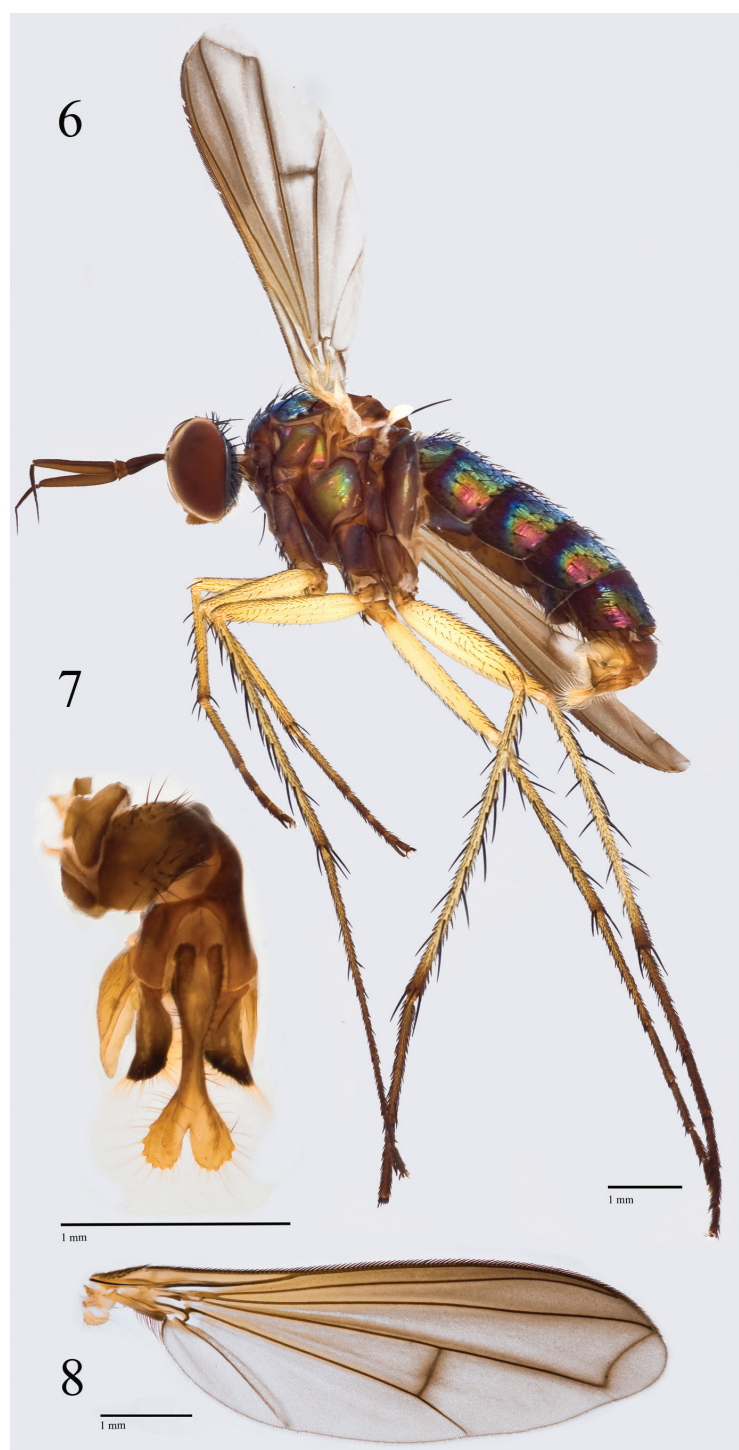
*Ngirhaphium sivasothii*, new species  
(Figs. 6–8, 9, 10, 17)

**Material examined.** Holotype male, Singapore, Semakau Island (type locality), SMN3, Malaise trap in mangrove, 27 September 2012 (reg. 29483, coll. J. Puniamoorthy & P. Grootaert; Ma1306 in coll. ZRC). Paratypes: Singapore: **Pulau Ubin**: 2 females, PU2, 20 April 2012, (reg. 29189, Ma0616); 1 male, PU2, 20 May 2012, (reg. 29242, Ma0648); 1 female, PU2, 16 June 2012, (reg. 29294, Ma1660); 1 female, PU2, 23 June 2012, (reg. 29307, Ma1682); 1 female, PU2, 30 June 2012, (reg. 29320, Ma1701); 1 male, 1 female, PU2, 14 July 2012, (reg. 29346, Ma1749); 1 female, PU2, 21 July 2012, (reg.

29359, Ma1759); 2 females, PU2, 28 July 2012, (reg. 29372, Ma1770); 1 female, PU2, 18 August 2012, (reg. 29411, Ma1881); 1 female, PU2, 25 August 2012, (reg. 29424, Ma1892); 1 male, PU2, 1 September 2012, (reg. 29437, Ma1782); 1 female, PU2, 22 September 2012, (reg. 29476, Ma1794); 1 male, PU2, 13 October 2012, (reg. 29515, Ma3179); 2 females, PU2, 23 February 2013, (reg. 29762, Ma3265); 2 females, PU2, 23 February 2013, (reg. 29762, Ma3864); 1 female, PU3, 7 April 2012, (reg. 29165, Ma1931); 1 male, 1 female, PU3, 21 July 2012, (reg. 29360, Ma1849); 1 female, PU4, 16 March 2013, (reg. 29805, Ma3872); **Semakau**: 1 male, SMN1, 3 April 2012, (reg. 29159, Ma0095); 3 males, 3 females, SMN1, 12 April 2012, (reg. 29166, Ma0262); 3 males, 1 female, SMN1, 19 April 2012, (reg. 29183, Ma0318); 1 male, SMN1, 26 April 2012, (reg. 29196, Ma0294); 5 females, SMN1, 3 May 2012, (reg. 29209, Ma0279); 2 males, 1 female, SMN1, 3 May 2012, (reg. 29222, Ma0288); 1 male, SMN1, 17 May 2012, (reg. 29235, Ma0299); 2 males, SMN1, 24 May 2012, (reg. 29248, Ma0304); 1 female, SMN1, 5 July 2012, (reg. 29326, Ma1082); 2 males, SMN1, 19 July 2012, (reg. 29352, Ma1091); 1 female, SMN1, 10 August 2012, (reg. 29391, Ma1242); 1 male, 1 female, SMN1, 6 September 2012, (reg. 29443, Ma1401); 1 female, SMN1, 13 September 2012, (reg. 29456, Ma1410); 1 male, 2 females, SMN1, 27 September 2012, (reg. 29482, Ma1415); 2 males, 2 females, SMN1, 18 October 2012, (reg. 29521, Ma2099); 4 males, 8 females, SMN1, 25 October 2012, (reg. 29534, Ma2123); 3 males, 3 females, SMN1, 1 November 2012, (reg. 29547, Ma2271); 4 males, 3 females, SMN1, 8 November 2012, (reg. 29560, Ma2264); 6 males, 11 female, SMN1, 15 November 2012, (reg. 29573, Ma2277); 3 males, 3 females, SMN1, 29 November 2012, (reg. 29599, Ma2257); 2 males, 7 females, SMN1, 6 December 2012, (reg. 29612, Ma2290); 5 males, 3 females, SMN1, 13 December 2012, (reg. 29625, Ma2286); 6 males, 9 females, SMN1, 27 December 2012, (reg. 29651, Ma2289); 8 males, 24 females, SMN1, 10 January 2013, (reg. 29677, Ma2303); 3 males, 4 females, SMN1, 17 January 2013, (reg. 29690, Ma2301); 12 males, 17 females, SMN1, 24 January 2013, (reg. 29703, Ma3273); 13 males, 19 females, SMN1, 7 February 2013, (reg. 29729, Ma3277); 1 male, SMN1, 7 February 2013, (reg. 29729, Ma3913); 4 males, 8 females, SMN1, 14 February 2013, (reg. 29742, Ma3286); 14 males, 19 females, SMN1, 21 February 2013, (reg. 29755, Ma3247); 22 males, 13 females, SMN1, 28 February 2013, (reg. 29768, Ma3210); 4 males, 16 females, SMN1, 7 March 2013, (reg. 29782, Ma3414); 8 males, 12 females, SMN1, 14 March 2013, (reg. 29796, Ma3289); 1 female, SMN1, 14 March 2013, (reg. 29796, Ma3433); 11 male, 9 females, SMN1, 21 March 2013, (reg. 29810, Ma3878); 12 males, 18 females, SMN1, 28 March 2013, (reg. 29824, Ma3298); 3 females, SMN2, 12 April 2012, (reg. 29167, Ma0325); 1 male, 2 females, SMN2, 19 April 2012, (reg. 29184, Ma0336); 2 females, SMN2, 03 May 2012, (reg. 29210, Ma0357); 2 females, SMN2, 10 May 2012, (reg. 29223, Ma0369); 2 females, SMN2, 30 May 2012, (reg. 29262, Ma0392); 1 male, 1 female, SMN2, 7 June 2012, (reg. 29275, Ma1021); 1 male, SMN2, 14 June 2012, (reg. 29288, Ma1033); 1 female, SMN2, 5 July 2012, (reg. 29327, Ma1103); SMN2, 16 August 2012, (reg. 29405, Ma1259); 1 male, 3 females, SMN2, 23 August 2012, (reg. 29418, Ma1268); 2 males, 2 females, SMN2, 30 August 2012, (reg. 29431, Ma1279); 2 males, 2 females, SMN2, 6 September 2012, (reg. 29444, Ma1420); 2 males, 3 females, SMN2, 13 September 2012, (reg. 29457, Ma1293); 3 males, 3 females, SMN2, 20 September 2012, (reg. 29470, Ma1319); 3 males, 3 females, SMN2, 27 September 2012, (reg. 29489, Ma1306); 4 males, 4 females, SMN2, 4 October 2012, (reg. 29496, Ma2628); 1 male, 1 female, SMN2, 18 October 2012, (reg. 29522, Ma2641); 1 male, SMN2, 25 October 2012, (reg. 29535, Ma2649); 1 male, SMN2, 15 November 2012, (reg. 29574, Ma2249); 2 females, SMN2, 22 November 2012, (reg. 29587, Ma2267); 1 male, SMN2, 29 November 2012, (reg. 29600, Ma2260); 3 males, SMN2, 3 January 2013, (reg. 29665, Ma2299); 6 males, 2 females, SMN2, 10 January 2013, (reg. 29678, Ma2297); 1 male, SMN2, 14 February 2013, (reg. 29743, Ma3480); 1 male, 3 females, SMN2, 21 February 2013, (reg. 29756, Ma3254); 1 male, 1 female,

SMN2, 28 February 2013, (reg. 29769, Ma3215); 1 male, 2 females, SMN2, 28 March 2013, (reg. 29825, Ma3509); 1 male, SMN3, 12 April 2012, (reg. 29168, Ma0180); 3 males, 1 female, SMN3, 19 April 2012, (reg. 29185, Ma0126); 1 male, 5 females, SMN3, 26 April 2012, (reg. 29198, Ma0159); 2 males, 1 female, SMN3, 3 May 2012, (reg. 29211, Ma0103); 1 male, 4 females, SMN3, 10 May 2012, (reg. 29224, Ma0143); 1 male, 4 females, SMN3, 17 May 2012, (reg. 29237, Ma0201); 2 males, SMN3, 24 May 2012, (reg. 29250, Ma0218); 1 male, 1 female, SMN3, 31 May 2012, (reg. 29263, Ma0238); 4 females, SMN3, 7 June 2012, (reg. 29276, Ma0252); 2 females, SMN3, 14 June 2012, (reg. 29289, Ma1054); 1 male, 1 female, SMN3, 21 June 2012, (reg. 29302, Ma1066); 1 female, SMN3, 28 June 2012, (reg. 29315, Ma1074); 1 male, SMN3, 5 July 2012, (reg. 29328, Ma1110); 1 male, 1 female, SMN3, 12

July 2012, (reg. 29341, Ma1115); 1 male, 2 females, SMN3, 26 July 2012, (reg. 29367, Ma1128); 1 female, SMN3, 2 August 2012, (reg. 29380, Ma1328); 2 males, 1 female, SMN3, 10 August 2012, (reg. 29393, Ma1332); 1 female, SMN3, 16 August 2012, (reg. 29406, Ma1338); 1 female, SMN3, 23 August 2012, (reg. 29419, Ma1343); 1 male, 1 female, SMN3, 13 September 2012, (reg. 29458, Ma1361); 2 males, 1 female, SMN3, 20 September 2012, (reg. 29971, Ma1374); 2 males, 2 females, SMN3, 27 September 2012, (reg. 29484, Ma1386); 1 male, SMN3, 4 October 2012, (reg. 29497, Ma2693); 4 females, SMN3, 18 October 2012, (reg. 29523, Ma2709); 2 females, SMN3, 8 November 2012, (reg. 29562, Ma2268); 1 male, SMN3, 15 November 2012, (reg. 29575, Ma2251); 4 females, SMN3, 22 November 2012, (reg. 29588, Ma2274); 2 females, SMN3, 29 November 2012, (reg. 29601, Ma2263); 2 females, SMN3, 6 December

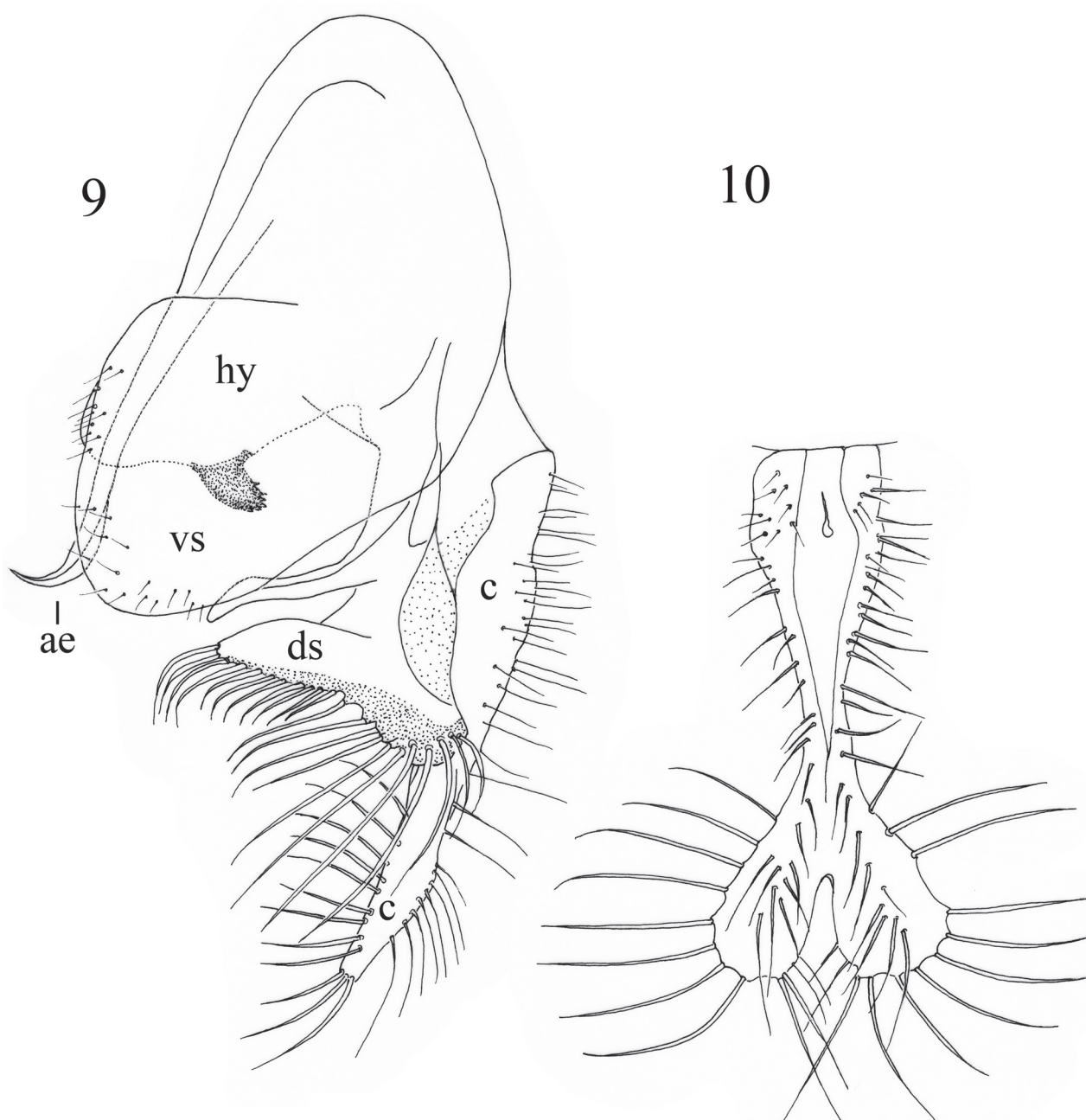


Figs. 6–8. Male *Ngirhaphium sivasothii*, new species (Semakau, Singapore): 6, Habitus; 7, Genital capsule removed; 8, Wing.



2012, (reg. 29614, Ma2293); 3 females, SMN3, 13 December 2012, (reg. 29627, Ma2295); 2 males, 4 females, SMN3, 20 December 2012, (reg. 29640, Ma2294); 2 females, SMN3, 27 December 2012, (reg. 29653, Ma2296); 2 males, 3 females, SMN3, 3 January 2013, (reg. 29666, Ma2298); 4 males, 5 females, SMN3, 10 January 2013, (reg. 29679, Ma2310); 3 males, 8 females, SMN3, 17 January 2013, (reg. 29692, Ma2312); 6 males, 3 females, SMN3, 24 January 2013, (reg. 29705, Ma2308); 1 female, SMN3, 31 January 2013, (reg. 29721, Ma2314); 1 male, 1 female, SMN3, 31 January 2013, (reg. 29718, Ma2400); 3 males, 6 females, SMN3, 7 February 2013, (reg. 29731, Ma3532); 5 males, 7 females, SMN3, 14 February 2013, (reg. 29744, Ma3544); 3 males, 5 females, SMN3, 21 February 2013, (reg. 29752, Ma2309); 4 males, 7 females, SMN3, 28 February 2013, (reg. 29770, Ma3218); 4 males, 7 females, SMN3, 28 February 2013, (reg. 29770, Ma3546); 2 males, 4 females, SMN3, 7 March 2013, (reg. 29784, Ma3557); 5 males, 6 females, SMN3, 14 March 2013, (reg. 29798, Ma3574); 3 males, 6 females, SMN3, 21 March 2013, (reg. 29812, Ma3586); 1 male, 1 female, SMN3, 28 March 2013,

(reg. 29826, Ma3596); 4 males, 2 females, SMO1, 3 April 2012, (reg. 29161, Ma0017); 5 males, 4 females, SMO1, 12 April 2012, (reg. 29169, Ma0403); 1 male, 1 female, SMO1, 12 April 2012, (reg. 29199, Ma0412); 3 males, 3 females, SMO1, 19 April 2012, (reg. 29186, Ma0420); 2 males, 1 female, SMO1, 3 May 2012, (reg. 29212, Ma0421); 1 female, SMO1, 10 May 2012, (reg. 29225, Ma0427); 2 males, SMO1, 24 May 2012, (reg. 29251, Ma0429); 3 males, SMO1, 31 May 2012, (reg. 29264, Ma0432); 1 male, 1 female, SMO1, 7 June 2012, (reg. 29277, Ma1131); 1 male, 1 female, SMO1, 14 June 2012, (reg. 29290, Ma1133); 2 females, SMO1, 21 June 2012, (reg. 29303, Ma1135); 8 males, 4 females, SMO1, 12 July 2012, (reg. 29342, Ma1139); 8 males, 4 females, SMO1, 19 July 2012, (reg. 29355, Ma1148); 8 males, 7 females, SMO1, 26 July 2012, (reg. 29358, Ma1157); 6 males, 1 female, SMO1, 2 August 2012, (reg. 29381, Ma1204); 12 males, 4 females, SMO1, 10 August 2012, (reg. 29394, Ma1215); 14 females, SMO1, 16 August 2012, (reg. 29407, Ma1217); 5 males, 5 females, SMO1, 23 August 2012, (reg. 29420, Ma1223); 6 males, 4 females, SMO1, 30 August 2012, (reg. 29433,



Figs. 9–10. *Ngirhaphium sivasothii*, new species (Semakau, Singapore): 9, Lateral view of genital capsule with left ventral surstylus at the front; 10, Dorsal view of cerci.

Ma1227); 1 male, 1 female, SMO1, 6 September 2012, (reg. 29446, Ma1439); 8 males, 5 females, SMO1, 13 September 2012, (reg. 29459, Ma1446); 5 males, 2 females, SMO1, 20 September 2012, (reg. 29472, Ma1450); 8 males, 2 females, SMO1, 27 September 2012, (reg. 29485, Ma1456); 2 males, 3 females, SMO1, 4 October 2012, (reg. 29498, Ma2804); 8 males, 5 females, SMO1, 11 October 2012, (reg. 29511, Ma2792); 2 males, SMO1, 18 October 2012, (reg. 29524, Ma2820); 3 males, 1 female, SMO1, 25 October 2012, (reg. 29537, Ma2801); 1 female, SMO1, 1 November 2012, (reg. 29550, Ma2757); 2 males, 1 female, SMO1, 8 November 2012, (reg. 29563, Ma2248); 1 male, SMO1, 15 November 2012, (reg. 29576, Ma2266); 1 male, SMO1, 22 November 2012, (reg. 29589, Ma2270); 2 males, SMO1, 29 November 2012, (reg. 29602, Ma2261); 5 females, SMO1, 6 December 2012, (reg. 29615, Ma2284); 1 male, 1 female, SMO1, 13 December 2012, (reg. 29628, Ma2285); 1 female, SMO1, 10 January 2013, (reg. 29680, Ma2305); 1 female, SMO1, 14 February 2013, (reg. 29745, Ma3608); 1 male, SMO1, 7 March 2013, (reg. 29785, Ma3609); 11 male, 16 females, SMO1, 14 March 2013, (reg. 29799, Ma3610); 3 males, 4 females, SMO1, 21 March 2013, (reg. 29813, Ma3624); 3 males, 2 females, SMO1, 28 March 2013, (reg. 29827, Ma3635); 1 female, SMO2, 2 August 2012, (reg. 29382, Ma1232); 1 female, SMO2, 20 December 2012, (reg. 29642, Ma2283); 1 male, SMO3, 3 May 2012, (reg. 29214, Ma0470); 3 males, 2 females, SMO3, 27 September 2012, (reg. 29487, Ma1459); 7 males, 15 females, SMO3, 4 October 2012, (reg. 29500, Ma2826); 4 males, 6 females, SMO3, 11 October 2012, (reg. 29513, Ma2842); 2 males, 13 females, SMO3, 18 October 2012, (reg. 29526, Ma2853); 3 males, 5 females, SMO3, 25 October 2012, (reg. 29539, Ma2864); 3 males, 7 females, SMO3, 1 November 2012, (reg. 29552, Ma2259); 4 females, SMO3, 8 November 2012, (reg. 29565, Ma2252); 5 males, 12 females, SMO3, 15 November 2012, (reg. 29578, Ma2278); 1 male, 1 female, SMO3, 22 November 2012, (reg. 29591, Ma2255); 2 males, 4 females, SMO3, 29 November 2012, (reg. 29604, Ma2276); 1 male, 2 females, SMO3, 6 December 2012, (reg. 29617, Ma2281); 1 male, SMO3, 13 December 2012, (reg. 29630, Ma2282); 1 male, 1 female, SMO3, 20 December 2012, (reg. 29643, Ma2279); 1 male, 3 females, SMO3, 27 December 2012, (reg. 29656, Ma2280); 1 male, SMO3, 10 January 2013, (reg. 29682, Ma2306); 1 female, SMO3, 17 January 2013, (reg. 29695, Ma2307); 1 male, 5 females, SMO3, 24 January 2013, (reg. 29708, Ma2423); 3 males, 4 females, SMO3, 7 March 2013, (reg. 29787, Ma3658); 1 female, SMO3, 14 March 2013, (reg. 29801, Ma3678); 2 males, 1 female, SMO3, 21 March 2013, (reg. 29815, Ma3696); 2 females, SMO3, 28 March 2013, (reg. 29829, Ma3718); **Sungei Buloh**: 1 female, SB1, 4 April 2012, (reg. 29155, Ma0775); 1 female, SB1, 1 August 2012, (reg. 29374, Ma1925); 1 female, SB1, 24 October 2012, (reg. 29530, Ma2445); 1 male, 1 female, SB1, 13 March 2013, (reg. 29792, Ma3755); 1 male, SB1, 27 March 2013, (reg. 29820, Ma3806); 1 female, SB2, 12 September 2012, (reg. 29453, Ma1922).

**Other records (non-MIP).** **Sungei Buloh**: 2 females, 11 May 2005, (reg. 25160, Si861; coll. P.G.); 1 female, 18 May 2005, (reg. 25161, Si1222; coll. P.G.); 1 female, 28 October 2005, (reg. 25406, Si1218; coll. P.G.); 1 female, 9 November 2005, (reg. 25418, Si1170; coll. P.G.); 1 male, 23 December 2005, (reg. 25471, Si1561; coll. P.G.); **Pulau Ubin, Chek Jawa**: 1 male, 11 October 2005, (reg. 25380, Si1087; coll. P.G.); 1 male, 26 October 2005, (reg. 25399, Si1130; coll. P.G.); 1 male, 30 December 2005, (reg. 25475, Si1442; coll. P.G.).

**Diagnosis.** A medium-sized species generally with dark infusate wing with longitudinal veins and Tp brownish seamed. Mesonotum and tergites shining metallic green. Apical arisal segment shorter, but nearly as long as basal

segment. Male with dorsal surstylus half as long as cerci, with a rectangular bent.

**Etymology.** The species is dedicated to N. Sivasothi from the National University of Singapore, our friendly and dedicated colleague specialised in mangroves and otters.

**Description.** Male: Body length: 5.7 mm; wing length: 5.5 mm.

**Head:** Frons shining metallic green (not dusted), sunken between the eyes, wide in front becoming wider behind; ocellar callus small, raised above frons. Face wide, as wide as front of frons, parallel-sided, silvery dusted with a very narrow clypeus (hardly a tenth of length of face). Eyes pass beyond the border of the face; eyes densely set with silvery hairs. Two very long ocellars, directed backward and diverging. Vertical bristles long, half as long as ocellars, rather antieriad on frons at level of ocellar callus, but close to eye border, long, black, directed forward and tips crossing. A pair of long black postverticals directed backward and crossing. Postoculars strong black in a single row; postcranium greenish in ground-colour but grey dusted, below with long fine yellowish white hairs. Palpus long strap-shaped, yellowish with few short black hairs, no bristles. Rostrum in male very small in comparison to the huge rostrum in female; labella brown with long black hairs.

**Antenna:** Antenna very long, completely black. First segment long, 3 times as long as second segment; second segment short, apically with a crown of short black bristles. Third segment very long strap-shaped, laterally flattened, about 6 times as long as width at base. Arista apical, apical segment a little shorter than basal segment, thickened and gradually tapering towards tip. Ratio scape, pedicel, postpedicel, basal arisal segment, apical arisal segment (mm): 0.36 : 0.11 : 0.91 : 0.35 : 0.32.

**Thorax:** Thorax and scutellum with a shining dark metallic green ground-colour, covered with a fine grey dusting. A black stripe outside each acr-row. All hairs and bristles black. Pleura more densely grey dusted than mesonotum. Acr biseriate, about 7 pairs, the rows widening a little behind. Presutural dc multiseriate; 6 post-sutural dc: 4 short and 2 long prescutellars. A pair of strong scutellars. A long humeral with a shorter bristle in front; a very strong posthumeral, 2 strong notopleurals, 1 postsutural, 1 supraalar, 1 very strong postalar. All propleural bristles black, 4 short upper and 2 longer black lower propleural bristles (lower one twice as long as upper).

**Legs (Fig. 6):** Yellow, all bristles black. All coxae greenish black in ground-colour, covered with a fine greyish dusting. All trochanters pale brown. Tip of mid and hind tibiae darkened at tip. All tarsi brownish yellow, becoming darker towards tip. Terminal segments completely black.

**Fore leg:** Shorter than mid and hind leg. Coxa with short black bristles. Fore femur a little swollen in basal half; a row of fine pv in apical half; a row of short ventral bristles, distinct only



in apical half. A short preapical posterior pointing downward and a stronger anterior preapical pointing forward. Fore tibia with 4 strong ad, 4 strong pd and a crown of 4 apicals. All tarsal segments densely set with black hairs and short black bristles. Fourth tarsal segment with a dorsal, asymmetrical forked protrusion, extending over the terminal tarsomere; outer branch of fork shorter than inner one, tips truncated. Terminal segment with a pair of long normal claws and a thicker claw-like structure beneath the posterior claw. 2 well developed pulvilli and an empodium. Length of tibia and tarsal segments (mm): 1.56 : 1.2 : 0.36 : 0.31 : 0.15 : 0.13.

Mid leg: Coxa with short bristles anteriorly; no exterior bristle. Mid femur as wide as fore femur; ventrally with inconspicuous bristles; a strong anterior preapical and 2 tiny posterior preapicals. Tibia with a 5 ad, 6 pd (might be considered as dorsal) and 5 longer av and a crown of long apicals. Tarsal segments 1–4 ventrally at tip with a pair short spinules as well as a comb of shorter black bristles. Length of tibia and tarsal segments (mm): 2.6 : 1.69 : 0.78 : 0.52 : 0.21 : 0.1.

Hind leg: Coxa bare. Hind femur stronger than mid femur, as wide as fore femur; ventrally almost bare; a strong anterior preapical, no posterior preapical. Tibia stronger bristled than mid tibia with 6 long av, 7 ad, 7 pd and crown of long apicals. Segments 1–4 ventrally at tip with a pair of short spinules as well as a comb of black bristles. Length of tibia and tarsal segments (mm): 3.51 : 1.45 : 0.83 : 0.65 : 0.4 : 0.34.

Wing: hyaline, faintly tinged brownish, but anteriorly between costa and  $R_{4+5}$  with a yellowish to brownish tinge. Membrane along veins  $R_{4+5}$ ,  $M_{1+2}$ ,  $M_{3+4}$  and  $Tp$  sometimes brown to black seamed. Veins dark brown.  $M_{1+2}$  sharply bent upwards and ending in costa closely near tip of  $R_{4+5}$ .  $Tp$  straight, about as long as apical part of  $M_{3+4}$ . Anal vein well developed. Halter with white knob. Squama white with long white cilia.

Abdomen: Shining dark metallic green; tips and sides of tergites with a greyish dusting. Sternites greyish dusted. Tergites densely set with quite long, black bristles; hind-marginal bristles a little longer than the other bristles. Only tergite 5 with very long marginal bristles. Sternites with very short hairs except for the longer marginals on sternite 4. Hypopygium sessile with tip of cerci hidden in sternite 4 (note that on Fig. 6 the hypopygium is removed from the sessile position). Cerci much longer than dorsal surstylus. Both cerci fused before apex. Tip of cercus (Fig. 10) much dilated, bordered with long yellow bristles. Tip of dorsal surstylus much enlarged, transverse on cercus, darkened, its border set with long yellowish bristles, longest on dorsal half. Ventral and dorsal surstylus not fused. Hypandrium dorsally with a narrow hook-shaped black protuberance.

Female: Body length: 4.5–5.1 mm; wing length: 5.7–6.4 mm.

Antennae: Antennae as long as in male. Ratio of first, second, third segment and basal and apical arisal segments (in mm): 0.42 : 0.14 : 0.84 : 0.32 : 0.35. Clypeus very large, nearly as long as upper part of face, protruding over rostrum; tip

pointed. Rostrum large: in lateral view about half as long as an eye. Palpus long, strap-shaped, brownish at base, yellowish at tip.

Legs: Shape and bristling of legs similar to that of male except otherwise mentioned.

Fore leg: Fourth tarsomere as usual, without protuberance like in male. Terminal tarsal segment with a dorsal apical protuberance and with the usual claws and pulvilli. Ratio of tibia and tarsal segments in mm: 1.82 : 1.3 : 0.52 : 0.52 : 0.41 : 0.26.

Mid leg: Ratio of tibia and tarsal segments (mm): 3.12 : 1.6 : 0.7 : 0.52 : 0.34 : 0.39.

Hind leg: Ratio of tibia and tarsal segments (mm): 4.2 : 1.6 : 0.9 : 0.67 : 0.39 : 0.34.

Abdomen. Tergites 1–5 and sternites 1–5 sclerotised, shining metallic green. Tergites 6–8 membranous (pale greyish) except for basal border. Sternites 6, 7 weakly sclerotised, brownish. Sternite 8 not sclerotised covered with thorn-like hairs. Segment 9 with a complex sclerotisation, densely pale haired. No acanthae present.

### *Ngirhaphium caeruleum*, new species

(Figs. 11, 12, 13–16, 19)

**Material examined.** Holotype male, Singapore: Semakau, SMN2, 27 September 2012 (reg. 29483, Ma1307).

Paratypes: Singapore: **Semakau**: 3 males, SMN1, 3 April 2012, (reg. 29159, Ma0089); 2 males, 1 female, SMN1, 12 April 2012, (reg. 29166, Ma0263); 2 males, 1 female, SMN1, 19 April 2012, (reg. 29183, Ma0317); 1 female, SMN1, 3 May 2012, (reg. 29222, Ma0287); 1 male, SMN1, 17 May 2012, (reg. 29235, Ma0298); 1 male, SMN1, 28 June 2012, (reg. 29313, Ma1016); 1 male, SMN1, 12 July 2012, (reg. 29339, Ma1087); 2 females, SMN1, 26 July 2012, (reg. 29365, Ma1096); 1 male, 1 female, SMN1, 6 September 2012, (reg. 29443, Ma1402); 1 male, SMN1, 13 September 2012, (reg. 29456, Ma1411); 1 female, SMN1, 27 September 2012, (reg. 29482, Ma1416); 1 female, SMN1, 4 October 2012, (reg. 29495, Ma2097); 1 male, SMN1, 18 October 2012, (reg. 29521, Ma2100); 5 males, 1 female, SMN1, 25 October 2012, (reg. 29534, Ma2122); 1 male, 1 female, SMN1, 1 November 2012, (reg. 29547, Ma2272); 3 males, SMN1, 8 November 2012, (reg. 29560, Ma2265); 2 males, 1 female, SMN1, 29 November 2012, (reg. 29599, Ma2258); 1 female, SMN1, 6 December 2012, (reg. 29612, Ma2291); 1 male, 1 female, SMN1, 13 December 2012, (reg. 29625, Ma2287); 1 male, 1 female, SMN1, 27 December 2012, (reg. 29651, Ma2288); 4 males, 3 females, SMN1, 10 January 2013, (reg. 29677, Ma2304); 2 females, SMN1, 17 January 2013, (reg. 29690, Ma2302); 1 female, SMN1, 24 January 2013, (reg. 29703, Ma3274); 1 male, 6 females, SMN1, 7 February 2013, (reg. 29729, Ma3278); 1 male, 2 females, SMN1, 14 February 2013, (reg. 29742, Ma3287); 2 males, 2 females, SMN1, 21 February 2013, (reg. 29755, Ma3246); 1 female, SMN1, 28 February 2013, (reg. 29768, Ma3393); 2 males, SMN1, 7 March 2013, (reg. 29782, Ma3413); 2 males, SMN1, 14 March 2013, (reg. 29796, Ma3290); 1 male, SMN1, 21 March 2013, (reg. 29810, Ma3879); 1 male, SMN2, 12 April 2012, (reg. 29167, Ma0324); 1 female, SMN2, 30 May 2012, (reg. 29262, Ma0393); 1 male, SMN2, 23 August 2012, (reg. 29418, Ma1267); 1 male, 3 females, SMN2, 30 August 2012, (reg. 29431, Ma1280); 2 males, 2 females, SMN2, 6 September 2012, (reg. 29444, Ma1421); 2 males, SMN2, 27 September 2012, (reg. 29489,

Ma1307); 2 males, SMN2, 25 October 2012, (reg. 29535, Ma2650); 1 female, SMN2, 3 January 2013, (reg. 29665, Ma2300); 1 male, SMN2, 14 February 2013, (reg. 29743, Ma3481); 1 female, SMN2, 28 February 2013, (reg. 29769, Ma3216); 1 male, SMN3, 12 April 2012, (reg. 29168, Ma0179); 2 males, SMN3, 26 April 2012, (reg. 29198, Ma0158); 2 males, SMN3, 3 May 2012, (reg. 29211, Ma0104); 1 male, SMN3, 10 May 2012, (reg. 29224, Ma0142); 1 female, SMN3, 24 May 2012, (reg. 29250, Ma0219); 2 males, 1 female, SMN3, 13 September 2012, (reg. 29458, Ma1360); 1 male, SMN3, 4 October 2012, (reg. 29497, Ma2694); 1 female, SMN3, 18 October 2012, (reg. 29523, Ma2708); 1 female, SMN3, 8 November 2012, (reg. 29562, Ma2269); 1 male, SMN3, 22 November 2012, (reg. 29588, Ma2273); 1 female, SMN3, 10 January 2013, (reg. 29679, Ma2311); 1 female, SMN3, 17 January 2013, (reg. 29692, Ma2313); 1 male, SMN3, 14 February 2013, (reg. 29744, Ma3545); 1 male, SMN3,

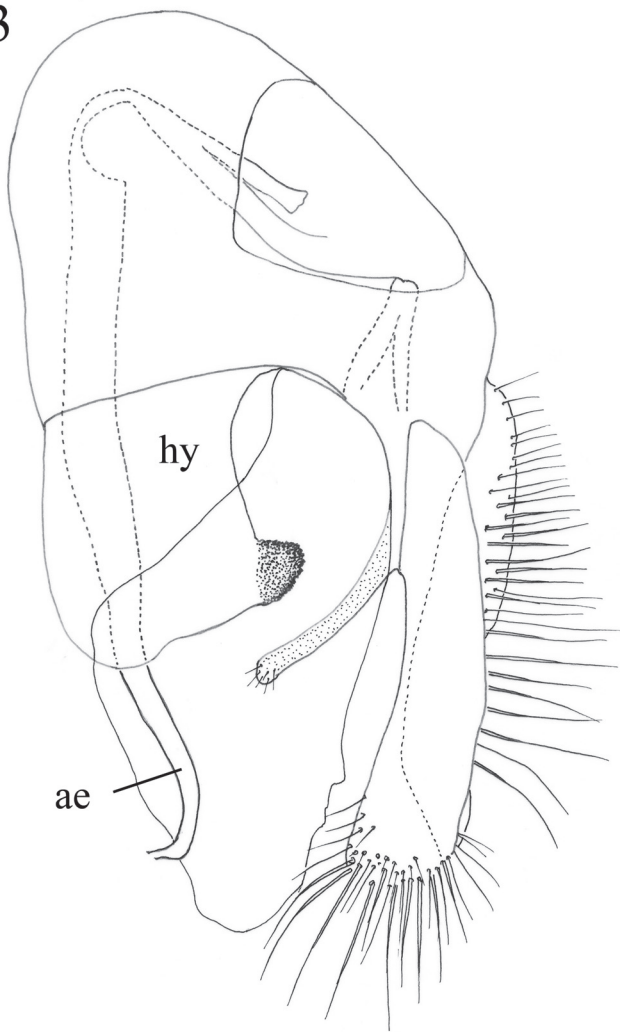
21 March 2013, (reg. 29812, Ma3587); 1 female, SMO1, 12 July 2012, (reg. 29342, Ma1140); 1 male, 1 female, SMO1, 10 August 2012, (reg. 29394, Ma1216); 1 male, SMO1, 11 October 2012, (reg. 29511, Ma2793); 1 female, SMO3, 27 September 2012, (reg. 29487, Ma1460); 1 male, SMO3, 18 October 2012, (reg. 29526, Ma2854); 1 female, SMO3, 22 November 2012, (reg. 29591, Ma2256); 1 female, SMO3, 29 November 2012, (reg. 29604, Ma2275); 1 female, SMO3, 14 March 2013, (reg. 29801, Ma3679); 1 male, 1 female, SMO3, 21 March 2013, (reg. 29815, Ma3695).

**Diagnosis.** A larger species with mesonotum and tergites shining metallic blue. Apical arisal segment thin (filiform) and longer than basal arisal segment. Male with dorsal and ventral surstylus at right side fused; separated at left

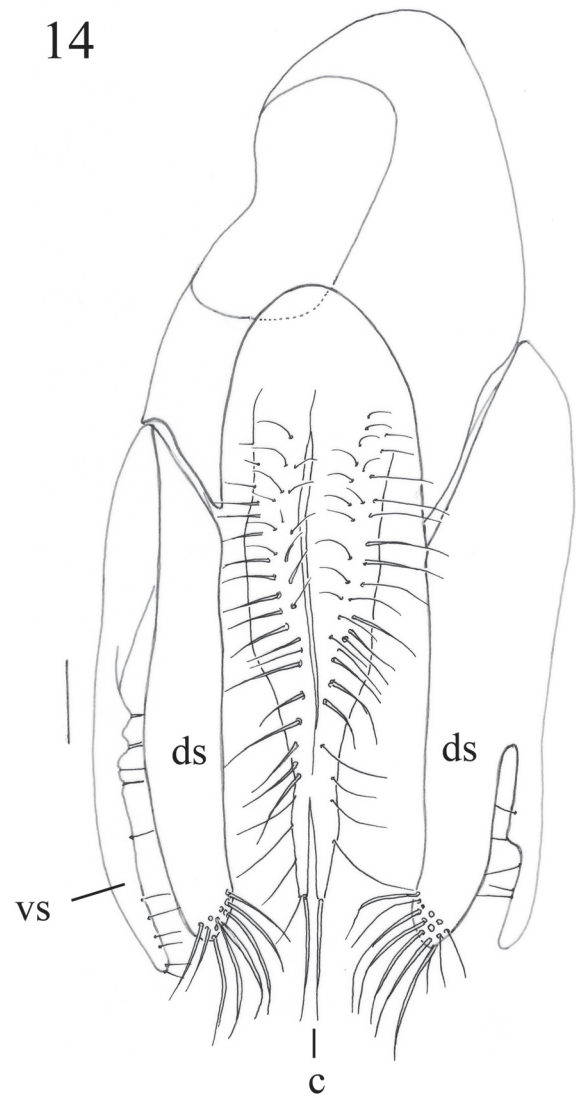


Figs. 11–12. Male *Ngirhaphium caeruleum*, new species (Semakau, Singapore): 11, Habitus with genital capsule removed. 12, Dorsal view of genital capsule.

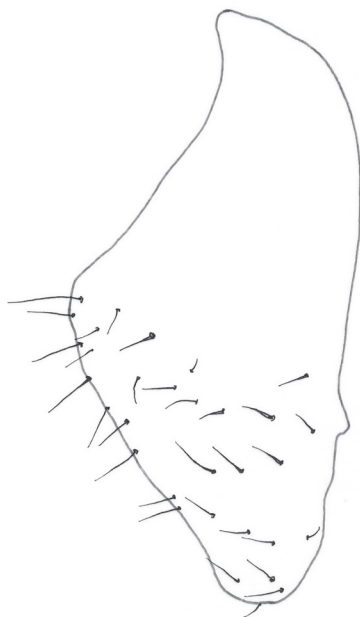
13



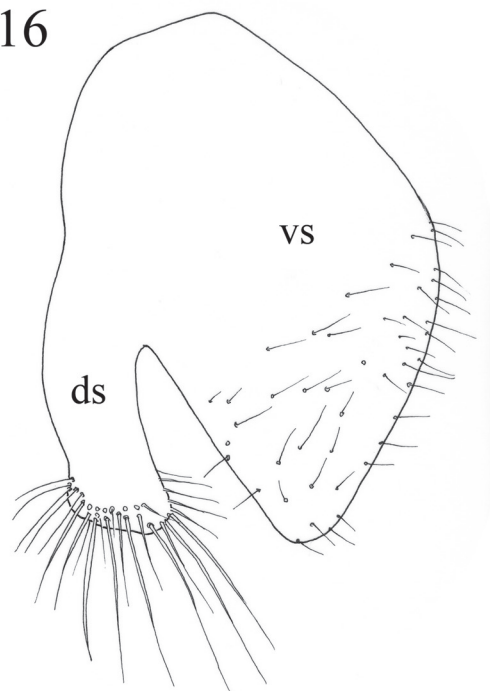
14



15



16



Figs. 13–16. *Ngirhaphium caeruleum*, new species (Semakau, Singapore): 13, Lateral view of genital capsule with left ventral surstylus removed; 14, Dorsal view of genital capsule; 15, Lateral, inner view of left ventral surstylus; 16, Fused right dorsal and ventral surstylus.



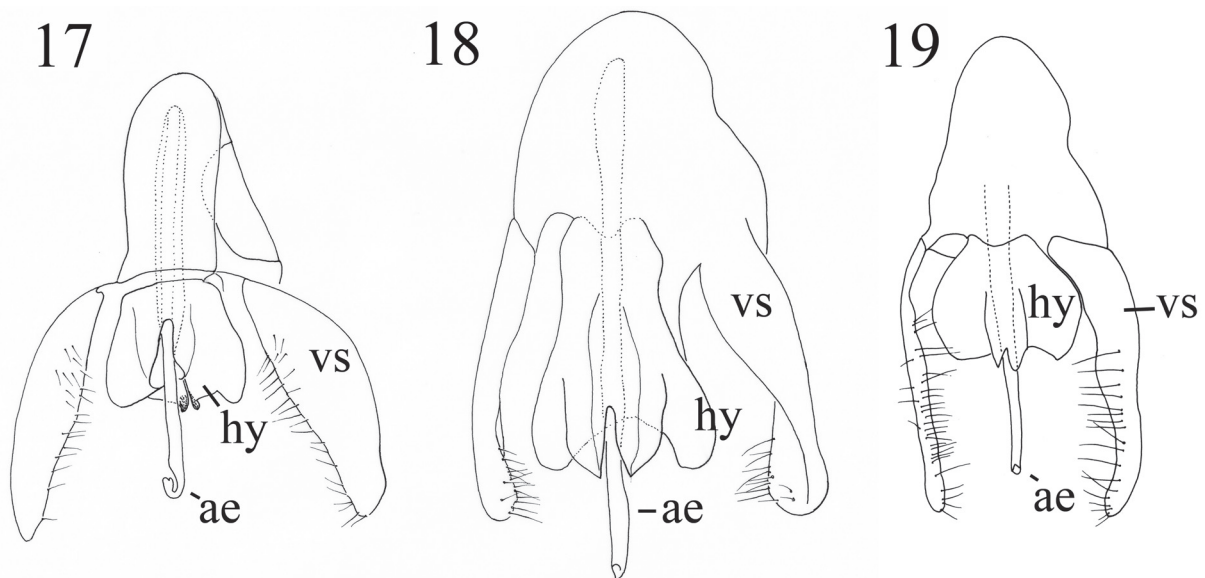
side. Cerci long, but shorter than surstyli so that they are concealed between the surstyli.

**Etymology.** The name *caeruleum* (adjective) means blue in Latin and it refers to the dark blue metallic ground-colour of thorax and abdomen.

**Description.** Male: Body length: 7 mm; wing length: 5.6 mm (holotype).

Head: Frons shining dark metallic blue (not dusted), sunken between the eyes, wide in front becoming wider behind; ocellar callus small, raised above frons. Face wide, as wide as front of frons, parallel-sided, silvery dusted with a very narrow clypeus (hardly a tenth of length of face). Eyes

pass beyond the border of the face; eyes densely set with silvery hairs. Two very long ocellars, directed backward and diverging. Vertical bristles long, half as long as ocellars, rather anteriad on frons at level of ocellar callus, but close to eye border, long, black, directed forward and tips crossing. A pair of long black postverticals directed backward and crossing. Postoculars in upper half strong black in a single row; in lower half white longer and fine; postcranium greenish in ground-colour but grey dusted, below with long fine yellowish white hairs. Palpus long strap-shaped, yellowish with few short black hairs, no bristles. Rostrum in male very small in comparison to the huge rostrum in female; labella brown with long black hairs. Antenna very long, completely black. First segment long, 2.5 times as long as second segment; second segment short, apically with a crown of short black bristles.



Figs. 17–19. Ventral view of male genital capsule: 17, *Ngirhaphium sivasothii*, new species; 18, *N. murphyi*; 19, *N. caeruleum*, new species.

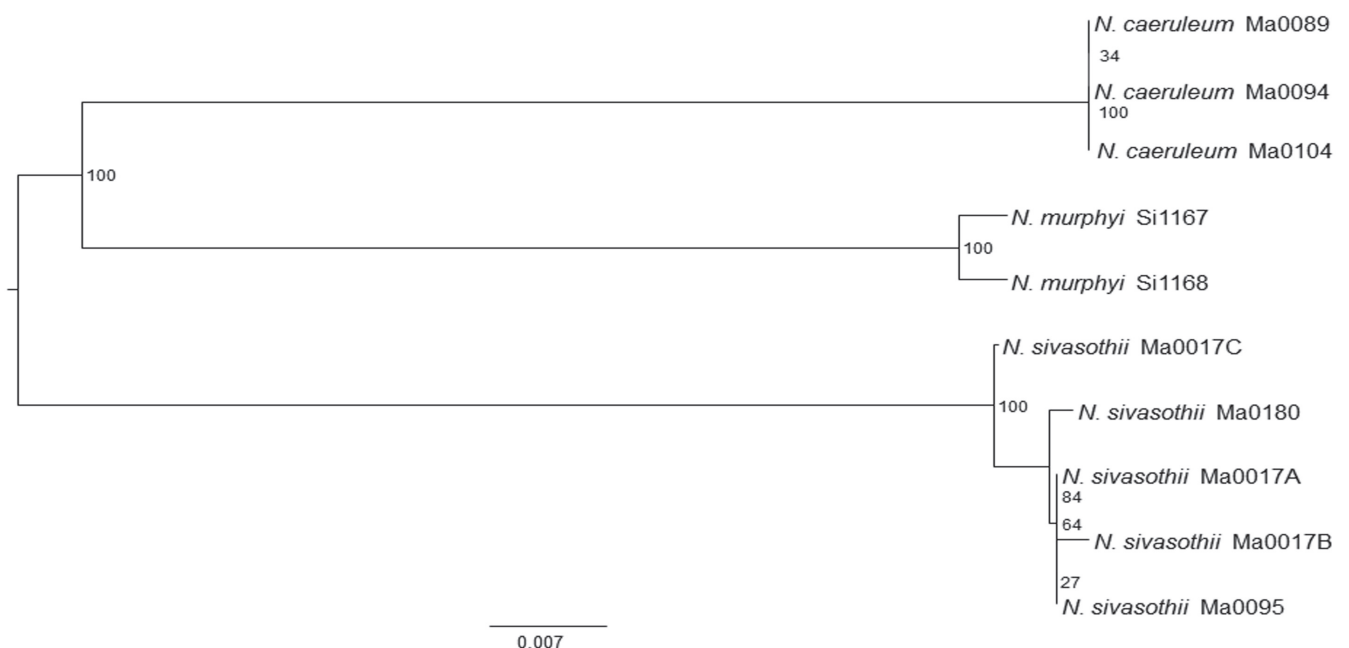


Fig. 20. Neighbour-joining cladogram of *Ngirhaphium*.

Third segment very long strap-shaped, laterally flattened, about 6 times as long as wide at base. Arista apical, apical segment much longer than basal segment, almost filiform towards tip. Ratio scape, pedicel, postpedicel, basal arista segment, apical arista segment (mm): 0.35 : 0.14 : 0.98 : 0.28 : 0.38.

Thorax: Thorax and scutellum with a shining dark metallic bluish ground-colour, covered with a fine grey dusting. A black stripe outside each acr-row. All hairs and bristles black. Pleura more densely grey dusted than mesonotum. Acr biseriate, about 7 pairs, the rows widening a little behind. Presutural dc multiseriate; 6 post-sutural dc: 4 short and 2 long prescutellars. A pair of strong scutellars. A long humeral with a shorter bristle in front; a very strong posthumeral, 2 strong notopleurals, 1 postsutural, 1 supraalar, 1 very strong postalar. All propleural bristles black, 4 short upper and 2 longer black lower propleural bristles (lower one twice as long as upper).

Legs (Fig. 11): Yellow, all bristles black. All coxae greenish black in ground-colour, covered with a fine greyish dusting. All trochanters pale brown. Tip of mid and hind tibiae darkened at tip. All tarsi brownish yellow, becoming darker towards tip. Terminal segments completely black.

Fore leg: Shorter than mid and hind leg. Coxa with short black bristles. Fore femur a little swollen in basal half;

ventrally flat, with a row of fine pv in apical half; and av in apical half (could be considered as ventrals). A row of 3 short posterior preapicals and a stronger anterior preapical pointing forward. Fore tibia with 5 strong ad, 4 strong pd and a crown of 4 apicals. All tarsal segments densely set with black hairs and short black bristles. Fourth tarsal segment with a dorsal, asymmetrical forked protrusion, extending over the terminal tarsomere; outer branch of fork half as long as inner branch, tips pointed. Terminal segment with a pair of long normal claws and a thicker claw-like structure beneath the posterior claw. 2 well developed pulvilli and an empodium. Length of tibia and tarsal segments (mm): 1.82 : 1.17 : 0.42 : 0.31 : 0.21 : 0.23.

Mid leg: Coxa with short bristles anteriorly; no exterior bristle. Mid femur a little wider as fore femur; ventrally with inconspicuous bristles; a strong anterior preapical and 2 tiny posterior preapicals. Tibia with a 5 ad, 5 pd (might be considered as dorsal) and 5 longer av and a crown of long apicals. Tarsal segments 1–4 ventrally at tip with a pair short spinules as well as an apical comb of shorter black bristles. Length of tibia and tarsal segments (mm): 2.86 : 1.82 : 0.78 : 0.65 : 0.4 : 0.4.

Hind leg: Coxa bare. Hind femur stronger than mid femur, as wide as fore femur; ventrally almost bare; a strong anterior preapical, no posterior preapical. Tibia stronger bristled than mid tibia with 6 long av, 7 ad, 7 pd and crown of long apicals.

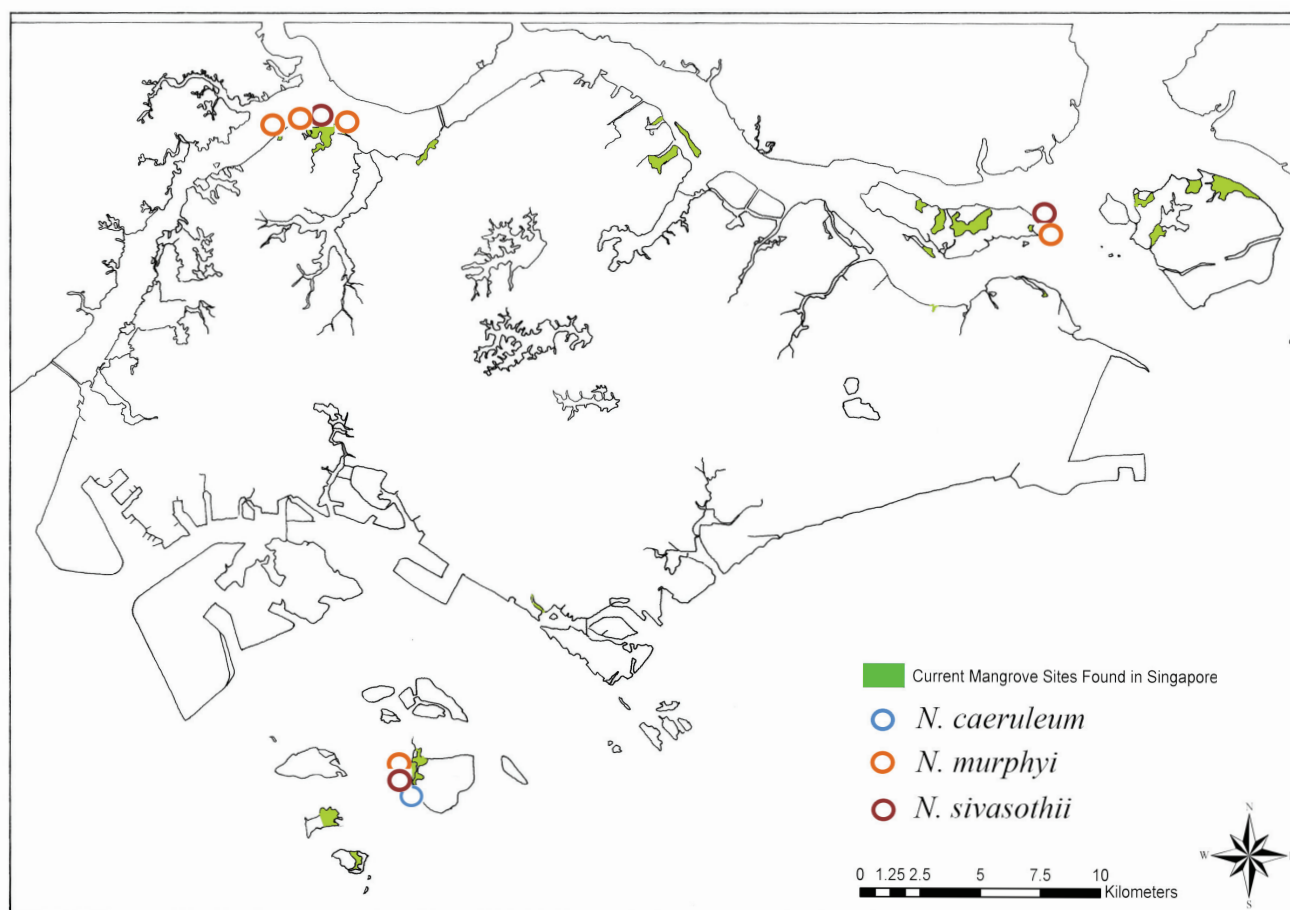


Fig. 21. Actual known distribution of *Ngirhaphium* in Singapore.

Table 1. Genetic distances of *Ngirhaphium* species.

Species	<i>N. murphyi</i>	<i>N. sivasothii</i> new species
<i>N. murphyi</i>	—	—
<i>N. sivasothii</i> new species	11.6 to 12.4%	—
<i>N. caeruleum</i> new species	11 to 11.1%	12.3 to 13.0%

Segments 1–4 ventrally at tip with a pair short spinules as well as a comb of black bristles. Length of tibia and tarsal segments (mm): 3.9 : 1.69 : 0.9 : 0.52 : 0.26: 0.26.

Wing: hyaline, faintly tinged brownish, but anteriorly between costa and  $R_{4+5}$  with a yellowish tinge. Membrane along veins  $R_{4+5}$ ,  $M_{1+2}$ ,  $M_{3+4}$  and  $Tp$  sometimes brown to black seamed. Veins dark brown.  $M_{1+2}$  sharply bent upwards and ending in costa closely near tip of  $R_{4+5}$ .  $Tp$  straight, a little longer than apical part of  $M_{3+4}$ . Anal vein well developed. Halter with white knob. Squama white with long white cilia.

Abdomen: Shining dark metallic bluish; tips and sides of tergites with a greyish dusting. Sternites greyish dusted. Tergites densely set with quite long, black bristles; hind-marginal bristles a little longer than the other bristles. Only tergite 5 with very long marginal bristles. Sternites with very short hairs except for the longer marginals on sternite 4. Hypopygium yellowish brown (Fig. 11) sessile with tip of cerci hidden in sternite 4. Cercus shorter than dorsal surstylus

(i.e., not surpassing the tips of the surstyli). Apex of cercus slender with a long bristle. Tip of dorsal surstylus set (Fig. 13) with a bundle of yellow bristles. Ventral surstylus at right side fused with dorsal surstylus (Fig. 16); ventral and dorsal surstylus separated at left side. Hypandrium with a large black dorsal protuberance (Fig. 13).

Female: Body length: 8.4 mm; wing length: 6.3 mm.

Body: Body more robust than in male.

Antennae: Antennae about as long as in male, but third antennal segment not as wide. Second arisal segment filiform: length variable from a little longer than basal arisal segment to 1.5 times as long. Ratio of first, second, third segment and basal and apical arisal segments (mm): 0.42 : 0.14 : 0.84 : 0.32 : 0.38. Clypeus very large, as long as upper part of face, protruding over rostrum; tip pointed. Rostrum large: in lateral view nearly as long as height of eye. Palpus long, strap-shaped, brownish at base, paler at tip.

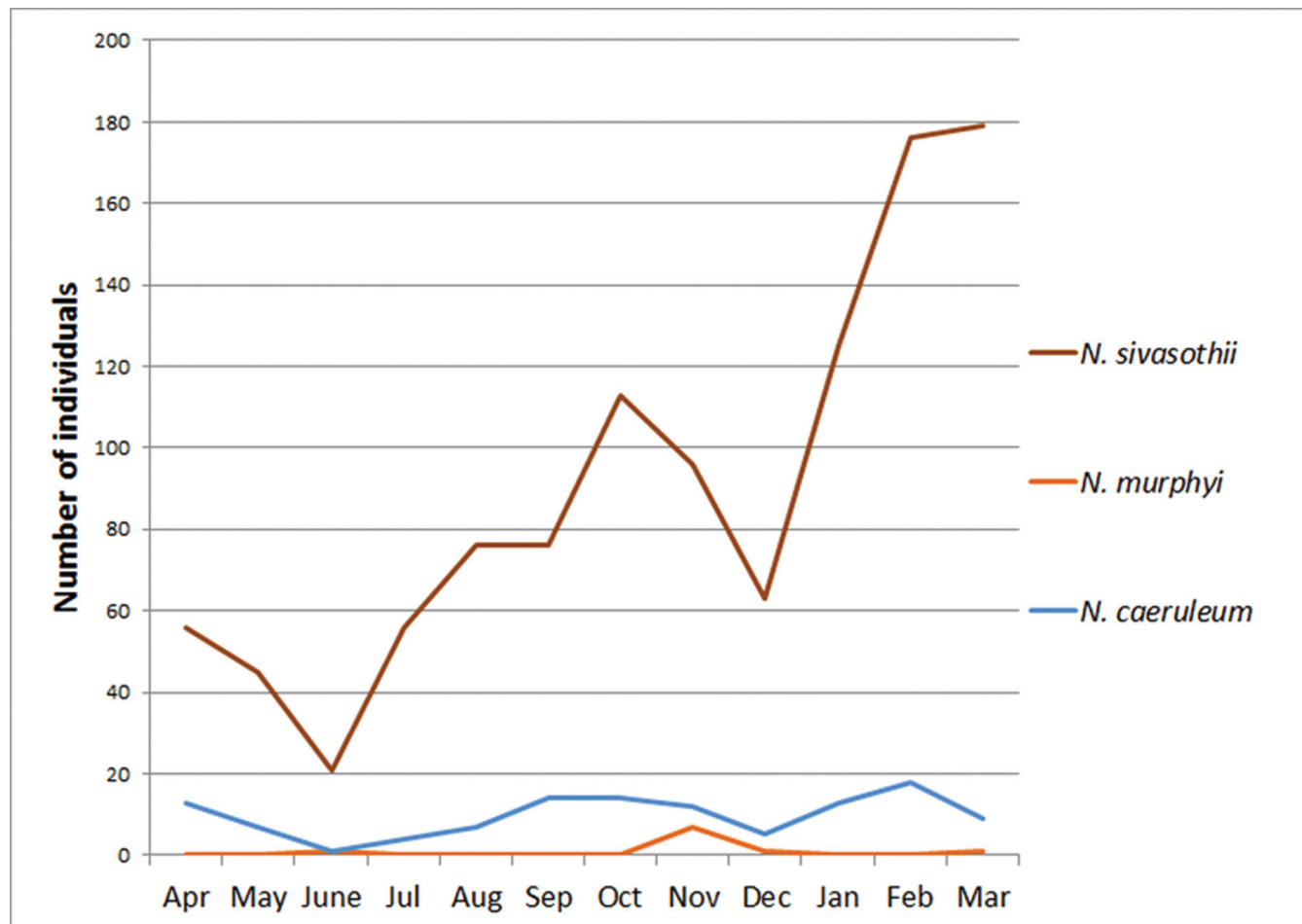


Fig. 22. Phenology of *Ngirhaphium* as recorded during the Mangrove Insect Project (records from April 2012 till March 2013).



Legs: Shape and bristling of legs similar to that of male.

Fore leg: Fourth tarsomere as usual, without protuberance like in male. Terminal tarsal segment with a dorsal apical protuberance and with the usual claws and pulvilli. Ratio of tibia and tarsal segments (mm): 1.82 : 1.3 : 0.52 : 0.52 : 0.42 : 0.26.

Mid leg: Ratio of tibia and tarsal segments (mm): 3.12 : 1.56 : 0.65 : 0.52 : 0.39 : 0.36.

Hind leg: Ratio of tibia and tarsal segments (mm): 3.64 : 1.56 : 0.9 : 0.78 : 0.42 : 0.36.

## DISCUSSION

**Genetic distance.** Specimens within each species showed little intraspecific variation (less than 0.6%). Genetic distances between species are given in Table 1 below.

**Ecology.** Species of the genus *Ngirhaphium* live along the seaward front of the mangrove, perching on vegetation at high tide and hunt on the sun exposed mud flats at low tide. They are rarely found inside the mangrove forest. Nothing is known about their larvae.

*N. murphyi* is a rather rare species recorded from Sungei Buloh, Lim Chu Kang, Mandai, and Chek Jawa on Pulau Ubin. Only a single male was recorded from Pulau Semakau. Maybe it prefers lower salinity since most records are from the northern part of Singapore. *N. sivasothii* is the most common species and has been recorded in almost all mangrove forests in Singapore. It is also most abundant on Pulau Semakau. *N. caeruleum* is only recorded from Pulau Semakau where it is most abundant in the replanted mangrove forest fragments.

**Phenology.** Figure 22 shows the activity of *Ngirhaphium* as recorded during the Mangrove Insect Project (records from April 2012 till March 2013). Activity of *Ngirhaphium* is lowest in June at the beginning of the dry season, before increasing in July and August, which are the driest months. Although a slight dip in activity was recorded at the beginning of the rain season in December, the wet season months of January and February recorded the highest activity.

## ACKNOWLEDGEMENTS

The authors thank Rudolf Meier, head of the Evolutionary Biology Laboratory DBS, and Peter Ng, director of the Raffles Museum for Biodiversity Research at NUS for encouraging the present research and providing logistics. The authorities of National Parks are thanked for issuing the research permits to collect in the nature reserves granting the Singapore Mangrove Insect Programme (SMIP) in 2010 and the long term mangrove survey that started in 2011: 'Mangrove insects as indicators of habitat quality'. Special thanks go to Lena Chan, Director of the National Biodiversity Centre at NParks and her staff. Jonas Mortelmans helped with the barcoding of the species, as well as Zoltán Nagy and Gontran Sonet from the Joint Experimental Molecular Unit (JEMU) in Brussels.

## LITERATURE CITED

- Evenhuis N & Grootaert P (2002) Annotated checklist of the Dolichopodidae (Diptera) of Singapore, with new records and descriptions of new species. *Raffles Bulletin of Zoology*, 50: 301–316.
- Germann C, Pollet M, Wimmer C & Bernasconi MV (2011) Molecular data sheds light on the classification of long-legged flies (Diptera: Dolichopodidae). *Invertebrate Systematics*, 25: 303–321.
- Grootaert P & Shamshev IV (2012) The fast-running flies (Diptera, Hybotidae, Tachydromiinae) of Singapore and adjacent regions. *European Journal of Taxonomy*, 5: 1–162.
- Katoh K & Standley DM (2013) MAFFT multiple sequence alignment software version 7: improvements in performance and usability. *Molecular Biology and Evolution*, 30: 772–780.
- Lim GS, Hwang WS, Kutty S, Meier R & Grootaert P (2010) Mitochondrial and nuclear markers of Oriental species support the monophyly of Dolichopodidae and suggest a rapid origin of the subfamilies (Diptera: Empidoidea). *Systematic Entomology*, 35: 59–70.
- Meier R, Shiyang K, Vaydya G & Ng PKL (2006) DNA barcoding and taxonomy in Diptera: a tale of high intraspecific variability and low identification success. *Systematic Biology*, 55: 715–728.