Description of a new species *Topomyia (Topomyia) sarawakensis* (Diptera: Culicidae) from Lanjak-Entimau Wildlife Sanctuary, Sarawak, Malaysia

Ichiro Miyagi*, 1), 2), Takako Toma1), 2), Takao Okazawa3) and Siew Fui Wong4)

* Corresponding author: topmiyagii@gmail.com

1) University Museum (Fujukan), University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa 903–0213, Japan
2) Laboratory of Mosquito Systematics of Southeast Asia and Pacific, c/o Ocean Health Corporation, 4–21–11 Iso, Urasoe, Okinawa 901–2132, Japan
3) Department of Parasitology, Graduate School of Medical Science, Kanazawa University, Takaramachi, Kanazawa, Ishikawa 920–8640, Japan
4) Sarawak Museum Department, 93566, Kuching, Sarawak, Malaysia

(Received: 31 March 2021; Accepted: 25 May 2021)

Abstract: A new mosquito species, *Topomyia (Topomyia) sarawakensis* Miyagi, Toma and Okazawa is described from Sarawak, Malaysia. The adult male and female, pupa, and fourth-instar larva are described in detail. Illustrations of the male genitalia, pupa, and fourth-instar larva of the species are also provided. The larvae of this species breed in the water accumulation of the phytotelmata (leaf axils) of ginger plants (*Boesenbergia* sp.), *Pandanus* sp., and taro plants (*Alocasia* and *Colocasia*) in mountain forests.

Key words: *Topomyia sarawakensis*, new species, Culicidae, description, Sarawak, Malaysia

INTRODUCTION

*Topomyia* Leicester, 1908 is the Oriental genus of mosquito, with most species occurring in Southeast Asia. Recently, Harbach and Culverwell (2014) proposed a third subgenus, *Miyagiella* Harbach, for *Topomyia discors* Harbach from Sabah, Malaysia. The genus includes currently 66 species in three subgenera: subgenus *Topomyia* Leicester, 1908 (43 species), *Suaymyia* Thurman, 1959 (22 species) and *Miyagiella*, 2014 (1 species). Three subgenera are distinguished by combination of the following characteristics (Harbach and Culverwell, 2014; Walter Reed Biosystematics Unit, 2020): (1) foretarsomere 2 is longer than tarsomere 3 in both *Suaymyia* and *Miyagiella*, but shorter in *Topomyia*; (2) gonocoxite is covered with conspicuous scales among setae, gonostylar claw is present, and aedeagus is elongate in *Suaymyia* and *Topomyia*, whereas gonocoxite is covered with few inconspicuous scales, the claw is absent, and aedeagus is bulbous in *Miyagiella*; and (3) dorsal lobe of claspette is present in *Topomyia*, but absent in *Suaymyia* and *Miyagiella*.

After the pioneer works by Leicester (1908) and Edwards (1922), extensive surveys for this genus throughout Peninsular Malaysia, Sarawak, and Sabah were carried out by Ramalingam (1975, 1983, 1987), Ramalingam and Banu (1987), Ramalingam and Ramakrishna (1988), Miyagi and Toma (2005, 2007, 2008, 2010a, b), and Miyagi et al. (1989a, b, 1990, 2006, 2007, 2009, 2011, 2012, 2013, 2014, 2017, 2021). The species of the genus *Topomyia* generally show a high degree of endemism. The immature stages of *Topomyia* mosquitoes are found exclusively in phytotelmata, small water bodies in living or dead terrestrial plants. Phytotelmata are often overlooked because they are small, hidden, and inconspicuous (Mogi, 2000). Moreover, the adults are non-blood sucking and not significant from the perspective of disease transmission. Therefore, much taxonomic work on the genus remains to be conducted.

Since 2005, in connection with the project, *Study on taxonomy and bionomics of two winged flies, Diptera in Sarawak*, a survey was conducted with the coordination and cooperation of the Sarawak Museum in Kuching. Extensive mosquito larval collections were created in the secondary forests of different localities. Numerous immature mosquitoes were collected from the leaf axils of various types of phytotelmata plants in the Lanjak-Entimau Wildlife Sanctuary (LEWS) in 2011 and 2012.

In the course of sorting and classifying these specimens, we found an interesting species of the subgenus *Topomyia*. After careful examination of the specimens and comparison with descriptions of the described species of the subgenus from Malaysia and
Indonesia (Edwards, 1922; Brug, 1931; Thruman, 1959; Miyagi et al., 1989b, 1990, 2012, 2014, 2017; Ramalingam and Banu, 1987; Ramalingam and Ramakrishna, 1988), we concluded that these specimens were from an undescribed species with characteristic male genitalia. In this paper, we describe *Topomyia (Topomyia) sarawakensis* Miyagi, Toma, and Okazawa as a new species, with illustrations of the male genitalia, pupae, and fourth-instar larvae.

**Materials and Methods**

**Collection locations.** The Lanjak-Entimau Wildlife Sanctuary (LEWS) is located in the south-western part of Sarawak at 1°19’N to 1°51’N 111°53’E to 112°28’E. The LEWS is contiguous with Batang Ai National Park in Sarawak in the south, and Betung-Kerihun National Park in West Kalimantan, Indonesia in the south-east.

**Specimen preservation and preparation.** The morphology of the male genitalia is by far the most reliable character for specific recognition in the genus. Accurate identification of the species by only female, larva, and pupa is not possible currently. Therefore, individual rearing is absolutely essential to identification of species and to establish correlations between the immatures and adult, and between the two sexes of the adults.

More than 100 field-collected *Topomyia* larvae were reared individually in small containers with water from the breeding leaf axils. The specimens were isolated, and labeled with the individual numbers (ID) indicated in bold fonts. As soon as possible after pupation and emergence, larval and pupal exuviae were preserved in 80% ethyl alcohol. Soon after emergence, the adult was transferred to a clean vial, which was provided with a moist cotton pad. After 24 hours, the adult was mounted on a micropin. Slide mount was also made for male genitalia and given genitalia number (G) indicated in bold fonts. The young larvae collected from the same leaf axils were mass reared to the adult stage. Some of the fourth-instar larvae were preserved in 80% ethyl alcohol. Whole larva, larval and pupal exuviae, and male genitalia preserved in the ethyl alcohol, were mounted in euparal as a permanent mounting medium (Belkin, 1962).

**Terminology.** The terminology and abbreviations used for adult, pupae, larvae, and male genitalia mostly follow Harbach and Knight (1980, 1981) and Harbach and Peyton (1993), except dorsomesal lobe (DML) of the male genitalia (Miyagi et al., 2021). The siphon index is the ratio of length to width at the midpoint of the siphon (Belkin, 1962). The trumpet and paddle indices are the ratio of the length to width at the midpoint of the trumpet and at the widest point of the paddle, respectively. In order to compare the general appearance of male genitalia in the dorsal aspect, an angle of the outer apical corner of the gonocoxite is shown as the Gc angle. The angle was measured on a point intersect lines a (vertical line of outer lateral Gc) with b (horizontal line of apical Gc) as shown in Fig. 1D (Miyagi et al., 2014). The methods and enumeration of seta branching in this paper follow Miyagi et al. (2012, 2017).

**Type deposition.** The holotype and some paratype specimens have been deposited at the National Museum of Nature and Science, Tsukuba, Japan (NMNS); some paratype specimens have been deposited at Sarawak Museum, Kuching (SM), Malaysia and University Museum (Fujukan), University of the Ryukyus.

*Topomyia (Topomyia) sarawakensis* Miyagi, Toma and Okazawa sp. nov

**Male.** Wing, 3.0 mm. Proboscis, 1.70–2.0 mm. Forefemur, 1.93–2.26 mm. **Head.** Occiput and side of head with broad, flat velvety black spatulate scales sheening light green at certain angles; dorsocentral part of anterior vertex with triangular silvery scale patch, posterior with spatulate dark scales and without erect scales; postgena with indistinct silvery scale patch. Intercocular and ocellar setae present. Clypeus quadrilateral in shape, integument brown without scales. Maxillary palpus brown, about 0.18 times as long as the proboscis. Proboscis entirely dark dorsally, slender, elongate, and slightly swollen at tip. Ventral white line extending from base to basal half of proboscis, line conspicuous at base. Pedicel of antenna dark brown without scales; antenna as long as proboscis. **Thorax.** Integument of scutum black, covered sparsely with dark piliform scales; silver central line starting at anterior promontory and extending caudally to prescutellar; scutal fossa, dorsocentral, prescutellar, and supraalar setae well developed. Scutellum brown; median scutellar lobe with a patch of silver scales and 2 or 3 conspicuous setae; lateral lobes without silver scales and with 2 or 3 conspicuous setae. Antepronotum with conspicuous silver spatulate scales and with a row of 6–8 prominent setae on anterior side (or margin). Postpronotum covered sparsely with spatulate silver scales on lobe; single prominent seta present at middle of posterior border. 4 fine prespiracular setae present. Postspiracular with spatulate silvery scales and without setae. Paratergite bare. Silver scales forming large patch to cover postspiracular and subspiracular areas and most of mesokatepisternum and mesaneupimeron.

**Legs.** All coxae with several setae and with a patch of silver scales; trochanters covered with silver scales. Dorsal part of all legs covered with small dark brown scales and spicules, and ventral part with a white scale line extending from base of femora to tips of tarsi, somewhat unclear in fore and midlegs; tarsomeres of fore and midlegs with an unclear ventral line, especially in the apical 2 tarsomeres; all tarsomeres
Fig. 1. _Topomyia (Topomyia) sarawakensis_ sp. nov., male genitalia, larval siphon and phytotelma plants—A and D, dorsal aspect of genitalia (prerotation sense); B, apical part of tibia (Ti-III) and basal part of 1st tarsus of hindleg (Ta-III); C, siphon with numerous pectens; E, _Boesenbergia_ sp.; F, Taro plant; G, _Pandanus_ sp. with inserted a pipet into the leaf axil. DML, dorsomesal lobe; Gc, gonocoxite; Gs, gonostylus; Cl, claspette; IX-TL, tergum IX; Gc angle see text. Scales in mm.
of hindlegs with an obvious ventral line; tarsomere II in foreleg slightly shorter than tarsomere III; apical tarsomere V in all legs, usually (not always) elbowed, directed posteriorly. A group of several short spicules on apical part of tibia (Ti-III) of hind legs (Fig. 1B).

Ungues on all legs small, simple, and equal. **Wings.** Brown-scaled. Cell R2 about 3.2 times the length of its stem (R2/3). Alula with a row of fine, hair-like scales; upper calypter bare. **Halter.** Capitellum and pedicel covered with dark brown scales, scabellum.
light brown without scales. **Abdomen.** Terga I–IX dark scaled with indications of pale-scaled lateral margins; conspicuous setae on only tergum I dorsally and laterally; integuments of sterna II–VII apparently pale with sparse pale scales; sternum VIII entirely dark scaled. **Male genitalia** (Fig. 1A, D). Gonocoxite (Gc) narrow at base and broadest basal 0.65, about 1.6 as long as maximum width; Gc angle 85°–90°; apical margin of Gc usually with 5–10 strong single setae and central two setae of them single, long, curved, usually situated close to each other; approx. 30 strong single setae along lateral margin. Dorsoesmal lobe (DML) with numerous curled setae, some of them reaching to or over distal margin of Gc. Basal lobe of claspette (CL) with 1–3 prominent setae and many fine setae; basal rod-like stem long, slightly curved with elongated spine and curved fine filament on apex; stem 1.8 times longer than spine. Gonostylus (Gs) expanded from base to middle with many fine setae on dorsal clench fist, slender to apex; apical claw simple with 3 fine setae. Tergum IX (IX-TL) broad, with two lobes close to each other; each lobe with 2 fine lateral setae and one stout blunt seta medially inserted.

**Female.** Wing, 3.0 mm. Proboscis, 1.8 mm. Forefemur, 2.16 mm. Resembles male except for following characteristics. Whitish scale line on ventral proboscis absent. Tarsomere II in foreleg slightly longer than tarsomere III; apical tarsomere V in all legs usually straight; antenna shorter than forefemur. Cell R1 approx. 4 times the length of its stem (R1.<sub>+</sub>).

**Abdomen.** Terga I–VIII densely covered with flat, dark brown scales. Lateral margin of all terga without strip of pale scales. Sterna I–VII covered uniformly by flat silver colored scales.

**Pupa** (Fig. 2A, B, C). Abdomen (I–VIII), ca. 3.10 mm. Trumpet length, ca. 0.31 mm. Paddle length, ca. 0.48 mm. Chaetotaxy of cephalothorax and abdominal segments shown in Fig. 2 and Table 1.

**Cephalothorax.** Lightly pigmented in median keel (MK). Trumpet (T), brownish yellow with distinct sculpturing; index, ca. 3.60. Metathoracic wing (MtW) lightly pigmented. **Abdomen.** Lightly pigmented, microtrichia present indistinctly on segments VII and VIII (10×40). Paddle (Pa) tapering with well-developed marginal setae, paddle index, ca. 2.22. Genital lobe (GL) lightly pigmented, extending to ca. 0.82 of paddle length in male, and short, extending to ca. 0.35 in female.

**Fourth-instar larva** (Figs. 1C, 3A–D). Head length, ca. 0.64 mm; width, ca. 0.76 mm. Siphon length, ca. 0.71 mm; width, ca. 0.12 mm; index ca. 6.4. Chaetotaxy of head, thorax, and abdominal segments shown in Fig. 3 and Table 2. **Head.** Integument smooth, pale yellow in color. Maxilla (Mx) shown in Fig. 3, a prominent collection of brush (MxB) with lanceolate setae and a row of several conspicuous spicules (LR: laciniarastrum); maxillary horn absent, apical teeth (AT) small; seta 4 single, extending over tip of MxB; seta 6 well developed and single. Dorsomentum (Dm) with a prominent middle tooth with 9 or 10 small regular teeth on either side. Seta 1-C single, placed at 0.74 of head, thorax, and abdominal segments shown in Fig. 3 and Table 2. **Thorax.** Setae 5–7, 9, 10, and 12-Prothorax (P) long, aciculate. Setae 5, 6, 9, 10 and 12-Mesothorax (M) long, aciculate. Seta 7-M long, without aciculate. Setae 9, 10 and 12-Metathorax (T) long, aciculate; seta 13-T numerous, markedly longer than setae 0, 1 and 13-P; 13-T usually 7 branched.

**Abdomen.** Setae 6-I–VI, 7-I, II, and 3-VII long, aciculate. Setae 1-I–VIII with more numerous branches and more developed and stellate toward III–

| Table 1. Numbers of branches for pupae of Topomyia (Topomyia) sarawakensis n. sp. |
|---|---|---|---|---|---|---|---|---|
| Seta no. | Cephalothorax | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|
| 0 | - | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 2 | M | 1–7 | 1–12 | 2–10 | 1–5 | 1–4 | 1 | - |
| 2 | 2–5 | 1 | 1, 2 | 1, 2 | 1, 2 | 1, 2 | 1 | 1 | - |
| 3 | 2–4 | 1 | 1 | 1 | 2, 3 | 1–4 | 1, 2 | 1 | - |
| 4 | 2–5 | 1–3 | 2–6 | 2–4 | 2–4 | 3–7 | 3–5 | 1 | 1, 2 |
| 5 | 3–7 | 2–9 | 1–4 | 1–5 | 1, 2 | 1 | 1 | 1 | - |
| 6 | 1–4 | 1, 2 | 1 | 1–4 | 1–3 | 1–3 | 1 | 1, 2 | - |
| 7 | 2, 3 | 1, 2 | 1–3 | 1–5 | 3–6 | 1–6 | 1 | 1 | - |
| 8 | 1–4 | - | - | 2–4 | 1, 2 | 1–3 | 2–6 | 2–6 | - |
| 9 | 1–3 | 1 | 1 | 1 | 1 | 1 | 1 | 22–28* | 19–26* |
| 10 | 1–5 | - | - | 1, 2 | 1, 2 | 1–3 | 1–3 | 1–3 | - |
| 11 | 1 | - | 1, 2 | 1 | 1–3 | 1, 2 | 1–4 | 1, 2 | - |
| 12 | 1–3 | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | - |

M: dendritic with many branches. *aciculate. Obsolete and missing setae are shown with a hyphen (-). Specimens examined: 5 pupal exuviae from Bloh Station, LEWS, Sarawak, East Malaysia.
Fig. 3. *Topomyia (Topomyia) sarawakensis* sp. nov., fourth-instar larva in dorsal and ventral aspects—A, thorax and abdominal segments I–VI; B, head (C); C, maxilla (Mx) in dorsal and ventral aspects; D, abdominal segments VII, VIII and X, and siphon. Dm, dorsomentum; 1-A, antennal seta 1; CS, comb scale; Pt, pecten; S, siphon; 1–S, siphonal seta; 1a-S, ventral (posterior) setae of siphon; 2a-S, dorsal (anterior) setae of siphon; Sa, saddle; AT, apical teeth; MxB, maxillary brush; MxBo, maxillary body; MPlp, maxillary palpus; LR, laciniastrum. Scales in mm.
Abdominal segments branches. dorsal tufts (2a-S) usually 5 tufts in pairs with 2–5 tufts, each with 2–4 branches, last 2 tufts small; sub-9 or more teeth together at base (Fig. 3D), variable 5 to yellow pigmentation, smooth integument, slender, scales pointed with a fringe at base. scales (CS) 15–20 in irregular double rows, individual papillae. usually 7 branched; 3-X very long, single; 4-X usually 4 branched, aciculate; 2-X long, aciculated. Pale ca. 10 small spines on distal margin; anal papilla long with tapering and rounded ending. Seta 1-X long, 2–4 branched, aciculate; 2-X long, usually 7 branched; 3-X very long, single; 4-X usually 7 branched, as long as or a little shorter than annal papillae.

**Type specimens. Holotype.** ♀ (20110304-15), individual number, ID (313) mounted on pin with P and L (fourth-instar larva) and P (pupa) exuviae and genitalia (G-128) mounted on 2 slides. The larva was collected from leaf axils of ginger, Boesenbergia sp., at Head Quarter of Bloh Station in LEWS, March 4, 2011, by I. Miyagi, and reared to adults in the laboratory. **Paratypes.** Bloh Station, LEWS. 5♂♂♂ (20110228-12), ID (228, 233, 257, 302 and 321) mounted on pins with P, L and male genitalia (G-99, G-101, G-110, G-133 and G-150) mounted on 10 slides. 2♂♂♂ (20110228-12), ID (87 and 212) with L, P and (G-3 and G-91) on 4 slides, and adult pin lost. 1 whole fourth-instar larva (20110301-3) on slide. 1 whole fourth-instar larva (20110303-6) on slide. 1♂ (20110303-2), ID (264) with adult, P and L (G-114) on 2 slides. 1♂ (20110303-4), ID (355) on pin with P, L and (G-160) on 2 slides. 2♂♂♂ (20110304-15), ID (244 and 291) on pins with P, L and (G-105, and G-125) on 4 slides. 1♂♂♂ (20110304-15), ID (247) on pin with P and L on slide. 1♂♂♂ (20110304-15), ID (451) with P and L on slide, and adult pin lost. 6 whole fourth-instar larvae (20110304-15) on 6 slides. 1♂♂♂ (20110305-4), ID (186) with P and L (G-76) on 2 slides, and adult pin lost. 1♂♂♂ (20110306-1), ID (315) on pin with P and L (G-129) on 2 slides. 3♀♀♀, 20110306-1, ID (100, 165 and 194) on pins with P and L on 3 slides. 10 whole fourth-instar larvae (20110306-1) on 10 slides. 1♂♂♂ (20110306-4), ID (377) with adult, P, L and (G-165) on 2 slides. 3♂♂♂ (20110907-2), ID (220, 229 and 272) on pins with P, L and (G-101, G-106 and G-124) on 3 slides. 3♂♂♂ (20110907-2), ID (3, 13 and 86) on pins with P and (G-3, G-6 and G-52) on 3 slides. 1♂♂♂ (20110907-2), ID (42) on pin with (G-43) on slide without P and L. 1♂♂♂ (20110910-6), ID (222) on pin with P and (G-102) on slide. Segerak Station, LEWS. 1♂♂♂ (20120628-6), ID (158) with (G-80) on slide without adult, P and L. 2♂♂♂ (20120629-3), ID (62 and 117) with (G-15 and G-63) on 2 slides, without adult, P and L. Paratype specimens were collected at Bloh Station from February 28 to March 6, and from September 7 to 10, 2011, and June 28 and 29, 2012 at Segerak Station by Miyagi.

**Specimens examined.** 1 whole fourth-instar larva (20110306-1) on slide, and 8 whole fourth-instar larvae (20110910-5) on 3 slides. 3 whole fourth-instar larvae (20110910-6) on slide. Specimens examined were collected at Bloh Station from February 28 to March 6, and from September 7 to 10, 2011 by Miyagi.

**Etymology.** The species name, sarawakensis refers to the place name Sarawak where this species was found.

**Taxonomic discussions.** Topomyia sarawakensis appears to be very similar to To. sabahensis Ramalingam and Ramakrishna, 1988, from Sabah,
Malaysia, To. aliy usopi Miyagi and Toma, 2014, from Sarawak, Malaysia, To. gracilis Brug, 1931, from Sumatra, Indonesia. They have common characters and are distinguishable from other species of the subgenus from Borneo (Sarawak and Sabah). Tergum IX is broad and has two lobes close to each other, each lobe has a flat, broad and pointed spatulate seta, and usually has two small setae laterally. Gonocoxite is narrow at base, and broadest at distal end without any apical lobe. Claspette stem is usually without seta from base to apex and is longer than elongate apical spine. They are easily differentiated by the diagnostic characteristics of the male genitalia in the following key:

1. Dorsomesal lobe (DML) with a tuft of prominent setae, their tips reaching at or over apical margin of gonocoxite (Gc) ........................................... 2
   — DML with fine setae, without prominent setae . . . . 4
2. Tuft of DML setae with sinuously matted tip, reaching to apex of Gc ........................................... 3
   — DML setae without such setae ............ To. pilosa
3. Gc with one prominent inner curved seta on apical filament; Gs swollen apically like oval in shape .......................... To. sabahensis

4. Elongate apical spine of claspette (Cl) narrow, pointed filament; Gs not swollen apically . . . To. aliy usopi
   — Apical spine of Cl somewhat stout, not pointed filament; Gs not swollen apically . . . To. sarawakensis

**Bionomics.** Topomyia sarawakensis is found in the secondary forests (less than 1,000 m high), throughout the Lanjak-Entimau Wildlife Sanctuary and Borneo high, Kuching. The immature mosquitoes are not predacious and can be collected from the leaf axils of ginger plants (Boesenbergia sp.) (Poulsen, 2006), Pandanus sp., and taro plants (Alocasia and Colocasia) (Fig 1E, F, G) with To. aliy usopi and To. gracilis.

**Distribution.** Malaysia (Sarawak).

**Acknowledgements.**

We thank the Sarawak Forestry Department for granting permission for sampling of two-winged flies (Diptera) in the Lanjak-Entimau Wildlife Sanctuary and also Dr. Leh, M. U. (Sarawak Museum) for supporting our collaborative research on various aspects. We wish to express deep gratitude to Dr. Yong, H. S. (University of Malaya) for critiquing the original manuscript of this paper. We also thank Dr. Poulsen, A. D. for identifying phytotelmata plants which are habitats of the present new species To. sarawakensis.

**References.**

Belkin, J. N. 1962. The Mosquitoes of the South Pacific (Diptera). 2 vols. 608 and 412 pp., University of California Press, Berkeley and Los Angeles.

Brug, S. L. 1931. Culiciden der Deutschen Limnologischen Sunda-Expedition. Arch. Hydrobiol. Suppl., 9: 1–42 (illus.).

Edwards, F. W. 1922. A synopsis of adult Oriental Culicidae (including Megarhinine and Sabethine) mosquitoes. Part II. Indian J. Med. Res., 10: 430–475.

Harbach, R. E. and Culverwell, C. L. 2014. A new subgenus and species of Topomyia (Diptera; Culicidae: Sabethini) based on a remarkable male mosquito from Sabah, Malaysia. Zootaxa, 3794: 575–580.

Harbach, R. E. and Knight, K. L. 1980. Taxonomists’ glossary of mosquito anatomy. 415 pp., Plexus Publishing, Incorporation, Marlton, New Jersey.

Harbach, R. E. and Knight, K. L. 1981. Corrections and additions of Taxonomists’ glossary of mosquito anatomy. Mosq. Syst., 13: 201–217.

Harbach, R. E. and Peyton, E. L. 1993. Morphology and evolution of the larval maxilla and its importance in the classification of the Sabethini (Diptera: Culicidae). Mosq. Syst., 25: 1–16.

Leicester, G. F. 1908. The Culicidae of Malaya. Studies of Medical Research Federated Malay States, 3: 18–261.

Miyagi, I., Okazawa, T., Higa, Y. and Leh, M. U. 2009. Culicidae and Corethrellidae (Diptera) collected in Sarawak, Malaysia from 2005 to 2008. Sarawak Museum Journal, 66: 313–341.

Miyagi, I., Okazawa, T., Higa, Y., Wong, S. F., Leh, M. U. and Yong, H. S. 2013. A redescription of Topomyia trifida Edwards (Diptera: Culicidae) from Sarawak, Malaysia. J. Sci. Tech. Trop., 9: 103–111.

Miyagi, I. and Toma, T. 2005. Topomyia rothcharlesi, a new species of the subgenus Suaymyia (Diptera: Culicidae) from Gombak, Peninsular Malaysia. Med. Entomol. Zool., 56: 275–282.

Miyagi, I. and Toma, T. 2007. A new mosquito of the genus Topomyia (Diptera: Culicidae) from a Nepenthes pitcher plant in a Bario highland of Sarawak, Malaysia. Med. Entomol. Zool., 58: 164–174.

Miyagi, I. and Toma, T. 2008. Description of a new species Topomyia (Suaymyia) ichcharlesi (Diptera: Culicidae) from Sarawak, Malaysia. Med. Entomol. Zool., 59: 163–170.

Miyagi, I. and Toma, T. 2010a. Descriptions of Topomyia aureicsps Brug and Topomyia pseudoaureicsps, n. sp. from Sarawak, Malaysia (Diptera: Culicidae). Med. Entomol. Zool., 61: 27–38.

Miyagi, I. and Toma, T. 2010b. Topomyia (Suaymyia) kelabitensis (Diptera: Culicidae), a new species from Sarawak, Malaysia. Med. Entomol. Zool., 61: 353–361.

Miyagi, I., Toma, T. and Okazawa, T. 2006. Redescription of Topomyia argentoeventralis Leicester, 1908 (Diptera, Culicidae) from Malaysia. Med. Entomol. Zool., 57: 347–354.

Miyagi, I., Toma, T., Okazawa, T., Leh, C. and Azirun, M. S. 2007. A redescription of Topomyia decorabilis Leicester, 1908 (Diptera, Culicidae) from Malaysia and Indonesia. Med. Entomol. Zool., 58: 251–259.

Miyagi, I., Toma, T., Okazawa, T. and Leh, M. U. 2011. Description of pupa and larva of the Malaysian mosquito Topomyia (Topomyia) rubithoracis Leicester (Diptera, Culicidae). Med. Entomol. Zool., 62: 93–99.

Miyagi, I., Toma, T., Okazawa, T. and Wong, S. F. 2021. Description of a new species of the Topomyia (Diptera: Culicidae) from Mount Murud, Sarawak, Malaysia. Med. Entomol. Zool., 72: 59–65.

Miyagi, I., Toma, T., Okazawa, T., Wong, S. F. and Leh, M. U. 2017. Redescription of the immature stages and male genitalia of...
Topomyia (Topomyia) gracilis Leicester, 1908 (Diptera: Culicidae) from Malaysia and Indonesia. Med. Entomol. Zool., 68: 11–18.

Miyagi, I., Toma, T., Okazawa, T., Wong, S. F., Leh, M. U. and Yong, H. S. 2012. Three new phytotelma mosquitoes of the genus Topomyia (Diptera: Culicidae) from Katibas, Lanjak-Entimau, Sarawak, Malaysia. J. Sci. Tech. Trop., 8: 97–117.

Miyagi, I., Toma, T., Okazawa, T., Wong, S. F., Leh, M. U. and Yong, H. S. 2014. Description of a new species of Topomyia (Topomyia) aliyusopi (Diptera: Culicidae) from Kelabit highland, Sarawak, Malaysia. J. Sci. Tech. Trop., 10: 27–38.

Miyagi, I., Toma, T., Ramakrishna, K. and Ramalingam, S. 1989a. Studies on the genus Topomyia: 3. Redescription of spathulirostris and transfer to the subgenus Suaymyia. Mosq. Syst., 21: 40–49.

Miyagi, I., Toma, T. and Ramalingam, S. 1989b. Topomyia (Topomyia) hardini, a new species from Sarawak Malaysia (Diptera: Culicidae). Trop. Biomed., 6: 91–98.

Miyagi, I., Toma, T. and Ramalingam, S. 1990. Topomyia (Topomyia) yongi, a new species of mosquito from Peninsular Malaysia (Diptera: Culicidae). Mosq. Syst., 22: 185–191.

Mogi, M. 2000. Phytotelmata: cryptic mosquito habitats. In: Mosquitoes and mosquito-borne diseases F. S. P. (ed. Ng, F. S. P. and Yong, H. S.), pp. 255–272, Academy of Sciences Malaysia, Kuala Lumpur.

Poulson, A. D. 2006. A Pocket Guide: Gingers of Sarawak. 102 pp., Natural History Publications (Borneo), Kota Kinabalu.

Ramalingam, S. 1975. A new species of Topomyia from Peninsular Malaysia (Diptera: Culicidae). Mosq. Syst., 7: 185–192.

Ramalingam, S. 1983. Topomyia haughtoni Feng, a new record in Malaysia and a redescription of the adult and immature stages. Mosq. Syst., 15: 33–40.

Ramalingam, S. 1987. Description of a new species of Topomyia from peninsular Malaysia (Diptera: Culicidae). Mosq. Syst., 19: 245–250.

Ramalingam, S. and Banu, Q. 1987. Studies on the genus Topomyia: 2. Description of a new species from Sabah, Malaysia (Diptera: Culicidae). Trop. Biomed., 4: 119–124.

Ramalingam, S. and Ramakrishna, K. 1988. Studies of the genus Topomyia 1. A new species from Sabah, Malaysia. Mosq. Syst., 20: 33–40.

Thruman, E. B. 1959. A contribution to a Revision of the Culicidae of Northern Thailand. Bull. A-100, 182 pp., University Maryland Agricultural Experiment Station, Maryland.

Walter Reed Biosystematics Unit. 2020. Systematic Catalog of Culicidae. Water Reed Biosystematics Unit [accessed December 21, 2020]. http://www.mosquitocatalog.org/