Original Article

Checklist and keys for the black flies (Diptera: Simuliidae) of Thailand

Hiroyuki TAKAOKA^{*, 1)}, Wichai SRISUKA²⁾ and Atiporn SAEUNG³⁾

* Corresponding author: takaoka@oita-u.ac.jp

¹⁾ Tropical Infectious Diseases Research and Education Centre (TIDREC), University of Malaya, 50603, Kuala Lumpur, Malaysia

²⁾ Entomology Section, Queen Sirikit Botanic Garden, P.O. Box 7, Maerim, Chiang Mai 50180, Thailand

³⁾ Department of Parasitology, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand

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Abstract: A checklist and keys for the 110 species of black flies (Diptera: Simuliidae) in Thailand are updated. The checklist includes *Simulium bishopi* Takaoka & Davies of the *Simulium melanopus* species-group, newly recorded from southern Thailand, and *S. chiangmaiense* Takaoka & Suzuki, previously treated as a junior synonym of *S. nakhonense* Takaoka & Suzuki. All species are classified in six subgenera (*Asiosimulium* Takaoka & Choochote, *Daviesellum* Takaoka & Adler, *Gomphostilbia* Enderlein, *Montisimulium* Rubtsov, *Nevermannia* Enderlein and *Simulium* Latreille) of the genus *Simulium* Latreille; and species in *Gomphostilbia*, *Nevermannia* and *Simulium* are placed in species-groups or subgroups. Keys to identify the species are provided for females, males, pupae and mature larvae under each subgenus.

Key words: taxonomy, aquatic insects, biodiversity, fauna

INTRODUCTION

The black fly fauna of Thailand was poorly studied, consisting of only two species, *Simulium nigrogilvum* Summers and *S. digrammicum* Edwards (Summers, 1911; Edwards, 1928), until Takaoka and Suzuki (1984) added 17 taxa consisting of seven new, five newly recorded and five unnamed species. The number of black fly species recorded in Thailand increased to 40 by the end of the twentieth century. The 21 additional species included seven new and 10 newly recorded species (Takaoka and Saito, 1996; Takaoka and Adler, 1997; Takaoka and Kuvangkadilok, 1999; Kuvangkadilok and Takaoka, 2000). The number of black fly species of Thailand has again doubled from 40 to 82 during the first decade of the twenty-first century (Jitklang and Kuvangkadilok, 2007; Jitklang *et al.*, 2008; Pramual and Tangkawanit, 2008; Takaoka, 2001; Takaoka and Choochote, 2004a–c, 2005a–j, 2006a–d, 2007; Takaoka *et al.*, 2009, 2010a–c; Takaoka and Srisuka, 2009, 2010a–d). The number continued to increase to 109 by 2019 (Takaoka and Srisuka, 2011, Takaoka *et al.*, 2012, 2013a, b, 2014a–c, 2017a–f, 2018a, c–g, i, 2019; Tangkawanit *et al.*, 2018; Thaijerern *et al.*, 2018). One newly recorded species is added in the current paper, bringing the total to 110 formally described species now known from Thailand.

All of these species are classified in six of the ten subgenera of the genus *Simulium* Latreille in the Oriental Region: five species in *Asiosimulium* Takaoka

& Choochote, two species in *Daviesellum* Takaoka & Adler, 34 species in *Gomphostilbia* Enderlein, six species in *Montisimulium* Rubtsov, 10 species in *Nevermannia* Enderlein and 53 species in *Simulium*. The species in three of these subgenera are further placed in species-groups: eight species-groups of *Gomphostilbia*, three species-groups of *Nevermannia* and 11 species-groups of *Simulium* (Adler, 2019; Takaoka, 2012, 2017b).

Chromosomal and molecular analyses revealed the cryptic diversity by disclosing two or more cytospecies, cytoforms or molecular lineages in Thai populations of the following 10 morphospecies: *S. angulistylum* Takaoka & Davies (Pramual and Kuvangkadilok, 2012), *S. asakoe* Takaoka & Davies, *S. sheilae* Takaoka & Davies (Jitklang *et al.*, 2008), *S. siamense* Takaoka & Suzuki (Kuvangkadilok *et al.*, 2008; Pramual and Wongpakam, 2011), *S. feuerborni* Edwards (Pramual *et al.*, 2015; Yacob *et al.*, 2017b), *S. malayense* Takaoka & Davies, *S. fenestratum* Edwards (Thaijerern *et al.*, 2018), *S. tani* Takaoka & Davies (Tangkawanit *et al.*, 2009), *S. tenebrosus* Takaoka, Srisuka & Saeung (Adler *et al.*, 2019) and *S. doipuiense* Takaoka & Choochote (Tangkawanit *et al.*, 2009; Adler *et al.*, 2016). Each of these 10 morphospecies is thus considered a species complex.

Furthermore, Thai populations of six other species were reexamined morphologically and genetically, and their taxonomic statuses were changed as follows: the species previously treated as *S. caudisclerum* Takaoka

& Davies in Thailand was recognized as a new species, *S. chomthongense* Takaoka, Srisuka & Choochote (Takaoka *et al.*, 2012); *S. decuplum* Takaoka & Davies was found to be composed of five new species (Takaoka *et al.*, 2018d); *S. gombakense* Takaoka & Davies was shown to consist of *S. gombakense* sensu stricto and three lineages of a new species complex, *S. paiense* Takaoka, Srisuka & Saeung (complex) (Takaoka *et al.*, 2018e); the species previously treated as *S. nobile* De Meijere in Thailand was recognized as a new species, *S. vanluni* Ya'cob, Takaoka & Sofian-Azirun (Low *et al.*, 2016; Ya'cob *et al.*, 2017a); the species previously treated as *S. parahiyangum* Takaoka & Sigit was described as a new species, *S. ngaoense* Takaoka, Srisuka & Saeung (Takaoka *et al.*, 2018a); and *S. rufibasis* Brunetti was recognized as a new species, *S. tenebrosum* Takaoka, Srisuka & Saeung (Takaoka *et al.*, 2018g).

Phylogenetic relationships of Thai black fly species, those of species in the subgenus *Gomphostilbia*, and those of three small subgenera (*Asiosimulium*, *Daviesellum* and *Wallacellum* Takaoka) were molecularly studied by Phayahasena *et al.* (2010), Pramual *et al.* (2011), and Otsuka *et al.* (2007), respectively.

Ecological studies of adults and immature stages of black flies in Thailand were carried out, revealing different seasonal and elevational patterns of species composition and abundance (Choochote *et al.*, 2005; Ishii *et al.*, 2008; Srisuka *et al.*, 2015, 2017).

Six species are known to bite humans: *S. asakoe*, *S. chamlongi* Takaoka & Suzuki, *S. doipuiense* (complex), *S. nigrogilvum* and *S. nodosum* Puri and *S. tenebrosum* (reported as *S. rufibasis*) (Choochote *et al.*, 2005; Pramual *et al.*, 2016). *Simulium asakoe*, *S. nigrogilvum* and *S. nodosum* were incriminated as natural vectors of three different kinds of filariae including one *Onchocerca* species (Fukuda *et al.*, 2003; Ishii *et al.*, 2008; Takaoka *et al.*, 2003).

For these chromosomal, phylogenetic, ecological

and parasite transmission studies, accurate identification of black fly species is prerequisite. However, no keys to identify the Thai black fly species have been available, since earlier keys were provided, first for 19 taxa (Takaoka and Suzuki, 1984) and subsequently for 55 species (Takaoka and Choochote, 2004b).

Our purpose is to provide an updated checklist of black fly species of Thailand and to construct keys for adult females, males, pupae and mature larvae. In a new checklist, *S. Chiangmaiense* Takaoka & Suzuki, synonymized with *S. nakhonense* Takaoka & Suzuki by Pangjanda and Pramual (2017), is treated as a valid species based on a genetic difference in the fast-evolving nuclear big zinc finger (BZF) gene sequences (Takaoka *et al.*, 2018c) and morphological differences in the arrangement and size of the pupal gill filaments (Takaoka *et al.*, 2018h). Eleven new and two newly recorded species reported from Thailand in 2018 and 2019 (Takaoka *et al.*, 2018a, c–g, i, 2019a, b; Tangkawanit *et al.*, 2018; Thaijerern *et al.*, 2018) are added to the checklist. In addition, *S. bishopi* Takaoka & Davies originally described from Peninsular Malaysia and placed in the *S. melanopus* species-group (Takaoka and Davies, 1995) is included as a new record from Thailand. A single female of this species was collected by a Malaise trap set at an elevation of 952 m in Namtok Yong National Park, Nakhon Si Thammarat Province, southern Thailand, 9-II-2009, by Paiboon.

Two species originally described from Peninsular Malaysia, *S. duolongum* Takaoka & Davies and *S. tahanense* Takaoka & Davies, which were reported from Thailand with their DNA sequences (Pramual *et al.*, 2011), are not included in the new list, because these two species from Thailand were shown to be different from those from Peninsular Malaysia by a DNA analysis (Takaoka *et al.*, 2018b). Identities of these two species reported from Thailand as *S. duolongum* and *S. tahanense* remain unclear.

I. A CHECKLIST OF 110 SPECIES OF BLACK FLIES IN THAILAND

A classification scheme in this new checklist follows the arrangement of Adler (2019) except that cytoforms and molecular forms are not included, and species in certain large species-groups are placed in subgroups following Takaoka (2012, 2017a, b).

Genus *Simulium* Latreille

Subgenus *Asiosimulium* Takaoka & Choochote

1. *Simulium furvum* Takaoka & Srisuka, 2013 [in Takaoka *et al.*, 2013a] Thailand
2. *Simulium oblongum* Takaoka & Choochote, 2005 Thailand
3. *Simulium phurueaense* Tangkawanit, Wongpakam & Pramual, 2018 Thailand
4. *Simulium saeungae* Takaoka & Srisuka, 2018 [in Takaoka *et al.*, 2018i] Thailand
5. *Simulium wanchaii* Takaoka & Choochote, 2006 Thailand

Subgenus *Daviesellum* Takaoka & Adler

6. *Simulium courtneyi* Takaoka & Adler, 1997 Thailand

7. *Simulium pahangense* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand
Sulchichnephia unidens Takaoka & Davies, 1995 [Syn.]
- Subgenus *Gomphostilbia* Enderlein
- Simulium asakoe species-group
8. *Simulium asakoe* Takaoka & Davies, 1995 (complex) Peninsular Malaysia, Hong Kong, Thailand, Vietnam
Simulium sp. C [in Takaoka and Suzuki, 1984]
9. *Simulium Chiangdaoense* Takaoka & Srisuka, 2009 Thailand
10. *Simulium udomi* Takaoka & Choochote, 2006 Thailand
- Simulium batoense species-group
- Simulium decuplum subgroup
11. *Simulium Chiangraiense* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018c] Thailand
12. *Simulium huaikaeoense* Takaoka, Srisuka & Low, 2018 [in Takaoka *et al.*, 2018c] Thailand
Simulium decuplum (not *sensu* Takaoka & Davies, 1995)
13. *Simulium khaokhoense* Takaoka, Srisuka & Low, 2018 [in Takaoka *et al.*, 2018c] Thailand
14. *Simulium maeklangense* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018c] Thailand
15. *Simulium pamiangense* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018c] Thailand
- Simulium duolongum subgroup
16. *Simulium siamense* Takaoka & Suzuki, 1984 (complex) Nepal, Thailand, Vietnam
- Simulium parahiangum subgroup
17. *Simulium dentistylum* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand
18. *Simulium ngaoense* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018a] Thailand, Vietnam
Simulium parahiangum (not *sensu* Takaoka & Sigit, 1991)
- Simulium sextuplum subgroup
19. *Simulium fukudae* Takaoka, Srisuka & Saeung, 2017 Thailand
- Simulium ceylonicum species-group
- Simulium sheilae subgroup
20. *Simulium curtatum* Jitklang, Kuvangkadilok, Baimai, Takaoka & Adler, 2008 Thailand
21. *Simulium inthanonense* Takaoka & Suzuki, 1984 China (Yunnan), Thailand, Vietnam
22. *Simulium sheilae* Takaoka & Davies, 1995 (complex) Malaysia (Peninsular, Sarawak, Sabah), Thailand
23. *Simulium trangense* Jitklang, Kuvangkadilok, Baimai, Takaoka & Adler, 2008 Peninsular Malaysia, Thailand
- Simulium darjeelingense species-group
24. *Simulium chayamaritae* Takaoka & Srisuka, 2010 Thailand
- Simulium epistum species-group
- Simulium zonatum subgroup
25. *Simulium adleri* Jitklang & Kuvangkadilok, 2008 [2007] Peninsular Malaysia, Thailand
26. *Simulium cheongi* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand, Indonesia (Kalimantan)
27. *Simulium datfaense* Takaoka & Otsuka, 2009 [in Takaoka *et al.*, 2009] Thailand
- Simulium atratum subgroup
28. *Simulium angulistylum* Takaoka & Davies, 1995 (complex) Peninsular Malaysia, Thailand
29. *Simulium isanense* Takaoka, Srisuka & Saeung, 2017 [in Takaoka *et al.*, 2017b] Thailand
30. *Simulium otsukai* Takaoka & Choochote, 2009 [in Takaoka *et al.*, 2009] Thailand
- Simulium gombakense species-group
31. *Simulium gombakense* Takaoka & Davies, 1995 Peninsular Malaysia, Myanmar, Thailand
32. *Simulium maleewongae* Takaoka, Srisuka & Saeung, 2017 Thailand
33. *Simulium paiense* Takaoka, Srisuka & Saeung, 2018 (complex) [in Takaoka *et al.*, 2018e] Thailand
34. *Simulium prayongi* Takaoka & Choochote, 2005 Thailand
35. *Simulium thuathienense* Takaoka & Sofian-Azirun, 2015 [in Takaoka *et al.*, 2015] Thailand, Vietnam
- Simulium varicorne species-group
- Simulium burtoni subgroup
36. *Simulium burtoni* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand
- Simulium chumpornense subgroup
37. *Simulium chumpornense* Takaoka & Kuvangkadilok, 2000
[in Kuvangkadilok and Takaoka, 2000] Thailand
38. *Simulium kuvangkadilokae* Pramual & Tangkawanit, 2008 Thailand
39. *Simulium piroonae* Takaoka & Srisuka, 2014 [in Takaoka *et al.*, 2014b] Thailand

Simulium novemarticulatum subgroup

40. *Simulium novemarticulatum* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand

Gomphostilbia species unplaced to group

41. *Simulium doisaketense* Jitklang, Kuvangkadilok, Baimai, Takaoka & Adler, 2008 Thailand

Subgenus *Montisimulium* Rubtsov

42. *Simulium angkaense* Takaoka & Choochote, 2005 Thailand
 43. *Simulium laoleense* Takaoka & Choochote, 2005 Thailand
 44. *Simulium merga* Takaoka & Choochote, 2005 Thailand
 45. *Simulium nanense* Takaoka & Srisuka, 2010 [in Takaoka *et al.*, 2010c] Thailand
 46. *Simulium phahompokense* Takaoka & Srisuka, 2010 Thailand
 47. *Simulium surachaii* Takaoka & Choochote, 2005 Thailand

Subgenus *Nevermannia* Enderlein

Simulium feuerborni species-group

48. *Simulium chiangklangense* Takaoka & Choochote, 2005 Thailand
 49. *Simulium fangense* Takaoka & Choochote, 2006 Thailand
 50. *Simulium feuerborni* Edwards, 1934 (complex) Indonesia (Bali, Java, Sumatra), Thailand
 Simulium sp. B (pupa) [in Takaoka and Suzuki, 1984]
 51. *Simulium fruticosum* Takaoka & Choochote, 2005 Thailand
 52. *Simulium maeaiense* Takaoka & Srisuka, 2011 Thailand, Vietnam
 53. *Simulium vessabutrae* Takaoka & Srisuka, 2010 Thailand
 54. *Simulium wichaii* Takaoka, 2010 [in Takaoka and Srisuka, 2010b] Thailand

Simulium ruficorne species-group

55. *Simulium aureohirtum* Brunetti, 1911 India, Bhutan, China, Guam, Indonesia
 (Flores, Java, Kalimantan, Lombok,
 Maluku, Sulawesi, Sumatra, Timor),
 Japan, Malaysia, Nepal, Pakistan, Philippines,
 Sri Lanka, Taiwan, Thailand, Vietnam

Simulium vernum species-group

56. *Simulium chomthongense* Takaoka, Srisuka & Choochote, 2012 [in Takaoka *et al.*, 2012] Thailand
 Simulium sp. A [in Takaoka and Suzuki, 1984]
 Simulium caudisclerum (not *sensu* Takaoka & Davies, 1995)
 57. *Simulium khunklangense* Takaoka & Srisuka, 2013 [in Takaoka *et al.*, 2013b] Thailand

Subgenus *Simulium* Latreille s. str.

Simulium christophersi species-group

58. *Simulium atipornae* Takaoka, Srisuka & Choochote, 2014 [in Takaoka *et al.*, 2014a] Thailand, Vietnam

Simulium crocinum species-group

59. *Simulium crocinum* Takaoka & Choochote, 2004 Thailand
 60. *Simulium mediocoloratum* Takaoka & Choochote, 2004 Thailand
 61. *Simulium rudnicki* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand
 62. *Simulium yongi* Takaoka & Davies, 1997 Peninsular Malaysia, Thailand

Simulium griseifrons species-group

63. *Simulium choochotei* Takaoka, 2002 [in Takaoka and Choochote, 2002] Thailand
 64. *Simulium digrammicum* Edwards, 1928 Peninsular Malaysia, Thailand
 65. *Simulium maenoi* Takaoka & Choochote, 2002 Thailand, Vietnam
 66. *Simulium phukaense* Takaoka & Choochote, 2005 Thailand
 67. *Simulium pukaengense* Takaoka & Choochote, 2005 Thailand
 68. *Simulium suchariti* Takaoka & Choochote, 2004 Thailand
 69. *Simulium thongsahuani* Takaoka & Choochote, 2010 [in Takaoka *et al.*, 2010b] Thailand
 70. *Simulium visuti* Takaoka & Choochote, 2006 Thailand

Simulium grossifilum species-group

71. *Simulium grossifilum* Takaoka & Davies, 1995 Peninsular Malaysia, Thailand, Vietnam
 72. *Simulium phayaoense* Takaoka & Choochote, 2005 Thailand

Simulium indicum species-group

73. *Simulium nigrogilvum* Summers, 1911 Thailand, Vietnam

74. *Simulium umphangense* Takaoka, Srisuka & Saeung, 2017 Thailand
75. *Simulium vanellum* Huang, Phasuk, Chanpaisaeng & Adler, 2010 Thailand
- Simulium malyschevi* species-group
76. *Simulium baimaii* Kuvangkadilok & Takaoka, 1999 [in Takaoka and Kuvangkadilok, 1999] Thailand
77. *Simulium lomkaoense* Takaoka & Srisuka, 2014 [in Takaoka *et al.*, 2014c] Thailand
78. *Simulium siripoomense* Takaoka & Saito, 1996 Thailand
- Simulium melanopus* species-group
79. *Simulium bishopi* Takaoka & Davies, 1995 Peninsular Malaysia, Indonesia (Sumatra),
Thailand (**New Record**)
- Simulium multistriatum* species-group
80. *Simulium bullatum* Takaoka & Choochote, 2005 Thailand
81. *Simulium chainarongi* Kuvangkadilok & Takaoka, 1999 [in Takaoka and Kuvangkadilok, 1999] ... Thailand
82. *Simulium chaliowae* Takaoka & Boonkemtong, 1999 [in Takaoka and Kuvangkadilok, 1999] Thailand
83. *Simulium chanyae* Takaoka & Choochote, 2007 Myanmar, Thailand
84. *Simulium daoense* Takaoka & Adler, 2017 [in Takaoka *et al.*, 2017a] Thailand, Vietnam
85. *Simulium fenestratum* Edwards, 1934 (complex) Indonesia (Sumatra), Laos, Thailand
Simulium sakishimaense (not *sensu* Takaoka, 1977)
86. *Simulium lampangense* Takaoka & Choochote, 2005 Thailand
87. *Simulium malayense* Takaoka & Davies, 1995 (complex) Peninsular Malaysia, Thailand, Vietnam
88. *Simulium takense* Takaoka & Choochote, 2005 Thailand
89. *Simulium triglobus* Takaoka & Kuvangkadilok, 1999 Thailand
90. *Simulium undecimum* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018f] Thailand
- Simulium nobile* species-group
91. *Simulium nodosum* Puri, 1933 India, China, Taiwan, Thailand, Vietnam
92. *Simulium vanluni* Ya'cob, Takaoka & Sofian-Azirun, 2017 [in Ya'cob *et al.*, 2017a] Peninsular Malaysia,
Simulium nobile (not *sensu* De Meijere, 1911) Thailand
- Simulium striatum* species-group
93. *Simulium Chiangmaiense* Takaoka & Suzuki, 1984 Myanmar, Thailand, Vietnam
94. *Simulium nakhonense* Takaoka & Suzuki, 1984 Myanmar, Thailand, Vietnam
95. *Simulium phraense* Takaoka, Srisuka & Saeung, 2018 [in Takaoka *et al.*, 2018c] Thailand
96. *Simulium quikestriatum* (Shiraki, 1935) Taiwan, China, Japan, Korea, Thailand, Vietnam
97. *Simulium thailandicum* Takaoka & Suzuki, 1984 China, Thailand, Vietnam
- Simulium tuberosum* species-group
- Simulium brevipar* subgroup
98. *Simulium brevipar* Takaoka & Davies, 1995 Peninsular Malaysia, Indonesia (Sumatra),
Thailand, Vietnam
99. *Simulium yuphae* Takaoka & Choochote, 2005 Thailand
Simulium brevipar (not *sensu* Takaoka & Davies, 1995)
- Simulium nitidithorax* subgroup
100. *Simulium tani* Takaoka & Davies, 1995 (complex) Peninsular Malaysia, Indonesia (Sumatra),
Simulium nitidithorax (not *sensu* Puri, 1932) Thailand, Taiwan, Vietnam
- Simulium rufibasis* subgroup
101. *Simulium doipuiense* Takaoka & Choochote, 2005 (complex) Thailand, Vietnam
Simulium sp. E [in Takaoka and Suzuki, 1984]
102. *Simulium manooni* Takaoka & Choochote, 2005 Thailand
103. *Simulium setsukoe* Takaoka & Choochote, 2004 Thailand
Simulium sp. D [in Takaoka and Suzuki, 1984]
104. *Simulium tenebrosus* Takaoka, Srisuka & Saeung, 2018 (complex) [in Takaoka *et al.*, 2018g] Thailand
Simulium rufibasis (not *sensu* Brunetti, 1911)
105. *Simulium weji* Takaoka, 2001 Thailand
- Simulium variegatum* species-group
106. *Simulium barnesi* Takaoka & Suzuki, 1984 India, Thailand
107. *Simulium chamlongi* Takaoka & Suzuki, 1984 Myanmar, China (Yunnan, Tibet), Vietnam
108. *Simulium kiewmaepanense* Takaoka, Srisuka & Saeung, 2017 Thailand
109. *Simulium luculentum* Takaoka, Srisuka & Saeung, 2019 Thailand
110. *Simulium srisukai* Takaoka & Saeung, 2017 [in Takaoka *et al.*, 2017e] Thailand

II. KEYS TO 110 SPECIES OF BLACK FLIES IN THAILAND

Terms for morphological features (Figs. 1 & 2) follow those of Takaoka (2003) and partially those of Adler *et al.* (2004). Detailed descriptions and illustrations of morphological characters of each species, if needed, refer to individual original papers listed in the references.

(1) Keys to six subgenera of the genus *Simulium* in Thailand

Adult females

1. Katepisternum haired *Gomphostilbia*
 Katepisternum bare 2
2. Cibarium with distinct group of spinous processes medially *Asiosimulium*
 Cibarium without such processes medially 3
3. Ovipositor valve tongue-shaped 4
 Ovipositor valve otherwise 5
4. Basal section of radius haired *Montisimulium*
 Basal section of radius bare *Daviesellum*
5. Claw with large basal tooth *Nevermannia*
 Claw simple or with small subbasal tooth *Simulium*

Adult males

1. Katepisternum haired *Gomphostilbia*
 Katepisternum bare 2
2. Coxite longer than style 3
 Coxite shorter than style 5
3. Paramere without hooks *Asiosimulium*
 Paramere with hooks 4
4. Paramere with 1 hook *Nevermannia* (*S. vernum* & *S. ruficorne* species-groups)
 Paramere with 3 or more hooks *Montisimulium* & *Nevermannia* (*S. feuerborni* species-group)
5. Coxite much longer than wide *Daviesellum*
 Coxite as long as or slightly shorter than wide *Simulium*

Pupae

1. Gill with 19–56 filaments *Asiosimulium*
 Gill with less than 15 filaments 2
2. Gill with 12–14 filaments. Gill filaments with numerous tiny black spots *Montisimulium*
 Gill with less than 12 filaments. Gill filaments without black spots 3
3. Dorsal surface of abdominal segment 2 with stout hooks, similar in size to those on abdominal segments 3 and 4. Dorsal surface of abdominal segment 5–9 without spine-combs *Daviesellum*
 Dorsal surface of abdominal segment 2 with spines in place of such distinct hooks, and much smaller than hooks on abdominal segments 3 and 4. Dorsal surface of at least abdominal segment 8 with spine-combs 4
4. Abdominal segment 9 with grapnel-like hooklets on each side *Gomphostilbia*
 Abdominal segment 9 without grapnel-like hooklets on each side 5
5. Gill with 2, 3, 8 or 10 filaments *Simulium*
 Gill with 4 or 6 filaments 6
6. Gill with 4 filaments *Nevermannia* (*S. vernum* species-group)
 Gill with 6 filaments 7
7. Gill filaments longer than pupal body *Nevermannia* (*S. feuerborni* species-group)
 Gill filaments shorter than pupal body 8
8. Cocoon with short anterodorsal projection *Nevermannia* (*S. ruficorne* species-group)
 Cocoon wall-pocket shaped without anterodorsal projection, shoe-shaped or boot-shaped *Simulium*

Mature larvae

1. Hypostoma wide, with 12 or 13 apical teeth *Daviesellum*
 Hypostoma of moderate width, with 9 apical teeth 2
2. Postgenal cleft vestigial, very small *Montisimulium*
 Postgenal cleft well defined, small to large 3
3. Ventral papillae present, medium to large 4
 Ventral papillae absent or small if any 5
4. Lateral margin of hypostoma serrated *Nevermannia*
 Lateral margin of hypostoma smooth *Gomphostilbia*

5. Histoblast of pupal gill with 19–56 filaments *Asiosimulium*
 Histoblast of pupal gill with 2–10 filaments *Simulium*

(2) Keys to five Thai species of the subgenus *Asiosimulium*

Adult females

1. Cercus much elongated, about twice as long as its basal width *S. oblongum* & *S. phurueaense*
 Cercus normal or somewhat elongated, less than 1.3 times as long as its basal width 2
 2. Abdominal segment 5 shiny dorsally *S. wanchaii*
 Abdominal segment 5 dull dorsally 3
 3. Spermatheca globular *S. saeungae*
 Spermatheca pear-shaped *S. furvum*

Adult males

1. Hind basitarsus slightly widened, 0.75 times as wide as hind tibia *S. oblongum* & *S. phurueaense*
 Hind basitarsus much widened, 0.94–0.96 times as wide as hind tibia 2
 2. Abdominal segments 5–7 each with pair of shiny dorsolateral patches 3
 Abdominal segments 5–7 without shiny patches *S. wanchaii*
 3. Antenna yellow except apical flagellomere light brown *S. saeungae*
 Antenna dark brown except scape, pedicel and base of first flagellomere yellow *S. furvum*

Pupae

1. Head and thoracic integument bare *S. saeungae*
 Head and thoracic integument with tubercles 2
 2. Gill with 31–33 filaments *S. oblongum* & *S. phurueaense*
 Gill with 19 or 22 filaments 3
 3. Gill with 19 filaments *S. wanchaii*
 Gill with 22 filaments *S. furvum*

Mature larvae

1. Postgenal cleft with pigmented sheath of subesophageal ganglion 2
 Postgenal cleft without pigmented sheath of subesophageal ganglion 3
 2. Histoblast of pupal gill with 22 filaments *S. furvum*
 Histoblast of pupal gill with 31–33 filaments *S. phurueaense*
 3. Labral fan with 30–33 primary rays *S. saeungae*
 Labral fan with 38–45 primary rays 4
 4. Labral fan with 38–40 primary rays. Mandible with supernumerary serrations *S. wanchaii*
 Labral fan with 43–45 primary rays. Mandible without supernumerary serrations *S. oblongum*

(3) Keys to two Thai species of the subgenus *Daviesellum*

Adult females

1. Arms of genital fork with moderate projection directed anteriorly *S. courtneyi*
 Arms of genital fork without such projection *S. pahangense*

Adult males

1. Ventral plate much longer than wide when viewed ventrally *S. courtneyi*
 Ventral plate much shorter than wide when viewed ventrally *S. pahangense*

Pupae

1. Frons densely covered with tubercles *S. courtneyi*
 Frons mostly bare except narrow portion near lower margin *S. pahangense*

Mature larvae

1. Postgenal cleft long, but its apex not reaching posterior margin of hypostoma *S. courtneyi*
 Postgenal cleft long, its apex reaching posterior margin of hypostoma *S. pahangense*

(4) Keys to 34 Thai species of the subgenus *Gomphostilbia*

Adult females*

1. Antenna with 7 or 8 flagellomeres 2
 Antenna with 9 flagellomeres 6
 2. Antenna with 7 flagellomeres *S. novemarticulatum*
 Antenna with 8 flagellomeres 3
 3. Tergite 5 shiny *S. burtoni*
 Tergite 5 not shiny 4

4. Mandible with 3–5 teeth on outer margin	<i>S. piroonae</i>
Mandible without teeth on outer margin	5
5. Hind tibia yellowish white on basal 2/3	<i>S. chumpornense</i>
Hind tibia yellowish white on basal 1/2	<i>S. kuvangkadilokae</i>
6. Posterior surface of hind tibia mostly darkened except basal tip	7
Posterior surface of hind tibia white or yellow on basal 2/5 or more	11
7. Sensory vesicle 0.5 or more times length of third palpomere of maxillary palp	8
Sensory vesicle 0.4 or less times length of third palpomere of maxillary palp	10
8. Fore basitarsus 7.5 times as long as its greatest width	<i>S. chayamaritae</i>
Fore basitarsus 5.3–6.8 times as long as its greatest width	9
9. Arms of genital fork with short projection directed anteriorly	<i>S. chiangraiense</i> , <i>S. huaikaeoense</i> , <i>S. khaokohense</i> , <i>S. maeklangense</i> & <i>S. pamiangense</i>
Arms of genital fork without such projection	<i>S. ngaoense</i>
10. Frons:head ratio 1.0:4.5	<i>S. siamense</i> (complex)
Frons:head ratio 1.0:5.4–6.4	<i>S. fukudae</i>
11. Hind tibia with dark subbasal spot	12
Hind tibia without dark subbasal spot	16
12. Sensory vesicle enlarged, 0.65 times as long as third palpomere of maxillary palp	<i>S. adleri</i>
Sensory vesicle of medium size, 0.3 times as long as third palpomere of maxillary palp	13
13. Abdominal segment 2 pale	<i>S. cheongi</i> & <i>S. datfaense</i>
Abdominal segment 2 darkened	14
14. Hind tibia whitish yellow on basal 1/2	<i>S. maleewongae</i>
Hind tibia whitish yellow on basal 2/3	15
15. Fore basitarsus 6.5 times as long as its greatest width	<i>S. angulistylum</i> (complex)
Fore basitarsus 7.3–7.4 times as long as its greatest width	<i>S. isanense</i>
16. Hair tuft on base of radius whitish	17
Hair tuft on base of radius dark	22
17. Sensory vesicle 0.3–0.4 times as long as third palpomere of maxillary palp	18
Sensory vesicle 0.6–0.8 times as long as third palpomere of maxillary palp	21
18. Sensory vesicle 0.4 times as long as third palpomere of maxillary palp	<i>S. thuathienense</i>
Sensory vesicle 0.3 times as long as third palpomere of maxillary palp	19
19. Hind tibia whitish on basal 1/2 or little more	<i>S. chiangdaoense</i>
Hind tibia whitish on basal 2/3	20
20. Plate folded from dorsal margin of cibarium 1/3 times as wide as cibarium	<i>S. udomi</i>
Plate folded from dorsal margin of cibarium 1/2 times as wide as cibarium	<i>S. asakoe</i> (complex)
21. Fore basitarsus 5.8–6.0 times as long as its greatest width	<i>S. gombakense</i>
Fore basitarsus 6.2–7.2 times as long as its greatest width	<i>S. paiense</i> (complex)
22. Frons:head ratio 1.0:5.7. Sensory vesicle enlarged, 0.68 times as long as third palpomere of maxillary palp	<i>S. sheilae</i> (complex)
Frons:head ratio 1.0:4.2–5.0. Sensory vesicle enlarged, 0.55–0.59 times as long as third palpomere of maxillary palp	23
23. Fore basitarsus 6.1 times as long as its greatest width	<i>S. inthanonense</i>
Fore basitarsus 5.0–5.2 times as long as its greatest width	<i>S. trangense</i>
Adult males**	
1. Antenna with 7 flagellomeres	<i>S. novemarticulatum</i>
Antenna with 8 or 9 flagellomeres	2
2. Antenna with 8 flagellomeres	3
Antenna with 9 flagellomeres	5
3. Ventral plate produced ventrally	<i>S. burtoni</i>
Ventral plate nearly flat	4
4. Upper-eye facets in 15 vertical columns and 15 horizontal rows	<i>S. chumpornense</i>
Upper-eye facets in 11 or 12 vertical columns and 12 or 13 horizontal rows	<i>S. kuvangkadilokae</i> & <i>S. piroonae</i>
5. Hind basitarsus enlarged	6
Hind basitarsus slender, much narrower than hind tibia	12
6. Fore coxae darkened	<i>S. chayamaritae</i>
Fore coxae yellow	7

7. Hair tuft of base of radius yellow	8
Hair tuft of base of radius darkened	9
8. Upper-eye facets in 13 horizontal rows	<i>S. asakoe</i> (complex)
Upper-eye facets in 15 or 16 horizontal rows	<i>S. chiangdaoense</i> & <i>S. udomi</i>
9. Upper-eye facets in 13 horizontal rows	10
Upper-eye facets in 16 or 17 horizontal rows	11
10. Basal 1/3 of hind basitarsus whitish yellow	<i>S. trangense</i>
Basal 1/3 of hind basitarsus somewhat darkened, its border not well defined	<i>S. sheilae</i> (complex)
11. Upper-eye facets in 13 vertical columns	<i>S. curtatum</i>
Upper-eye facets in 17 vertical columns	<i>S. inthanonense</i>
12. Mid and hind femora yellow except apical cap dark	<i>S. dentistylum</i>
Mid and hind femora almost dark except base pale	13
13. Hind tibia almost dark except base pale	14
Hind tibia whitish on basal 1/2 or more	19
14. Scutum with brassy pubescence; abdominal segments 2, 5, 6 and 7 each with dorsolateral pair of shiny whitish-pruinose patches	15
Scutum with yellow pubescence; abdominal segments 2, 6 and 7 each with dorsolateral pair of shiny whitish-pruinose patches	16
15. Paramere with fine setae on outer surface	<i>S. fukudae</i>
Paramere without fine setae on outer surface	<i>S. siamense</i> (complex)
16. Upper-eye facets in 13–15 vertical columns	<i>S. khaokhorensae</i> , <i>S. huaikaeoense</i> & <i>S. ngaoense</i>
Upper-eye facets in 16 or 17 vertical columns	17
17. Fore basitarsus 6.6 times as long as its greatest width	<i>S. pamiangense</i>
Fore basitarsus 7.6–8.6 times as long as its greatest width	18
18. Fore basitarsus 7.6–7.8 times as long as its greatest width	<i>S. chiangraiense</i>
Fore basitarsus 7.9–8.6 times as long as its greatest width	<i>S. maeklangense</i>
19. Style of same width from base to apical 1/3 when viewed ventrolaterally	20
Style gradually tapered when viewed ventrolaterally	21
20. Fore basitarsus 5.5 times as long as its greatest width	<i>S. angulistylum</i> (complex)
Fore basitarsus 7.7–7.9 times as long as its greatest width	<i>S. isanense</i> & <i>S. otsukai</i>
21. Ventral plate concave ventromedially when viewed posteriorly	<i>S. maleewongae</i> & <i>S. thuathienense</i>
Ventral plate rounded ventrally when viewed posteriorly	22
22. Upper-eye facets in 9 or 10 vertical columns and 10 or 11 horizontal rows	23
Upper-eye facets in 14 or 15 vertical columns and 14–16 horizontal rows	24
23. Sensory vesicle small, globular, 0.15 times as long as third palpomere of maxillary palp	<i>S. cheongi</i>
Sensory vesicle small, ellipsoidal, 0.25 times as long as third palpomere of maxillary palp	<i>S. adleri</i>
24. Fore basitarsus 6.8–7.1 times as long as its greatest width	
..... <i>S. gombakense</i> , <i>S. prayongi</i> & part of <i>S. paiense</i> (genoform B)	
Fore basitarsus 7.6–8.5 times as long as its greatest width	<i>S. paiense</i> (complex)
Pupae	
1. Gill of inflated structure	2
Gill filamentous	7
2. Gill with 12 slender filaments	<i>S. kuvangkadilokae</i>
Gill with 8 slender filaments	3
3. Gill with 4–6 finger-, thumb- or nipple-like projections	4
Gill without such finger-, thumb- or nipple-like projections	<i>S. maleewongae</i>
4. Terminal hooks cone-like	<i>S. thuathienense</i>
Terminal hooks plate-like with crenulated outer margins	5
5. Inflated structure of gill bifurcated when viewed laterally, with 4–6 thumb- or nipple-like projections	<i>S. prayongi</i>
Inflated structure of gill nearly straight when viewed laterally, with 6 finger- or thumb-like projections	6
6. Relative width of second constriction against that of first one 0.8–0.9	<i>S. gombakense</i>
Relative width of second constriction against that of first one 1.0–1.4	<i>S. paiense</i> (complex)
7. Gill with 6 filaments	8
Gill with 8 or 10 filaments	10
8. Cocoon without anterodorsal projection	<i>S. piroonae</i>

Cocoon with anterodorsal projection	9
9. Cocoon with elongate anterodorsal projection extending beyond anteroventral tips of cocoon ... <i>S. udomi</i>	
Cocoon with short anterodorsal projection not extending beyond anteroventral tips of cocoon	<i>S. fukudae</i>
10. Gill with 10 filaments	11
Gill with 8 filaments	12
11. Dorsal surface of abdominal segments 1 and 2 darkened	<i>S. chiangraiense</i> & <i>S. pamiangense</i>
Dorsal surface of abdominal segments 1 and 2 not darkened	<i>S. huaikaeoense</i> , <i>S. khaokhoense</i> & <i>S. maeklangense</i>
12. Frons and anterodorsal part of thorax bare	<i>S. adleri</i>
Frons and anterodorsal part of thorax with tubercles	13
13. Face with 2 trichomes on each side	<i>S. chayamaritae</i>
Face with 1 trichome on each side	14
14. Gill filaments arranged as 1+1+2+4 from dorsal to ventral	<i>S. otsukai</i>
Gill filaments arranged as 3+3+2 or 6+2 from dorsal to ventral	15
15. Gill filaments arranged in 2 groups, i.e. one dorsal (4 individual and 2 paired filaments) and one ventral (2 paired filaments)	<i>S. chumpornense</i>
Gill filaments arranged in 3 groups (3, 3 and 2 filaments from dorsal to ventral)	16
16. Gill filaments all shorter than pupal body (shorter than 1.6 mm), short-stalked	17
Gill filaments subequal to, or longer than, pupal body (longer than 1.9 mm), moderately-stalked	20
17. Antennal sheath smooth	18
Antennal sheath with tubercles	19
18. Dorsal surface of abdominal segments 1–5 not darkened	<i>S. angulistylum</i> (complex)
Dorsal surface of abdominal segments 1–5 darkened	<i>S. isanense</i>
19. Antennal sheath with 9 marked ridges each corresponding to flagellomeres 1–9, each ridge covered with several tubercles	<i>S. ngaoense</i>
Antennal sheath with 10 less marked ridges corresponding to pedicel and flagellomeres 1–9	<i>S. dentistylum</i>
20. Dorsal and middle triplets and ventral pair arising basally at same level	21
Dorsal and middle triplets sharing short stalk, which arises with stalk of ventral pair from short common basal stalk	24
21. Terminal hooks wide, plate-like, with crenulated outer margins	22
Terminal hooks triangular	23
22. Six filaments of two triplets abruptly tapered basally	<i>S. datfaense</i>
Six filaments of two triplets nearly of same thickness	<i>S. cheongi</i>
23. Dorsal surface of abdominal segment 9 with spine-combs; terminal hooks triangular, with base extending laterally when viewed posteriorly	<i>S. siamense</i> (complex)
Dorsal surface of abdominal segment 9 without spine-combs; terminal hooks cone-like, with base not extending laterally	<i>S. novemarticulatum</i>
24. Dorsal and middle triples consisting of 1 individual filament and 2 paired filaments with long stalk	<i>S. burtoni</i>
Dorsal and middle triplets consisting of 1 individual filament and 2 paired filaments with short or medium-long stalk	25
25. Cocoon with distinct anterodorsal projection	26
Cocoon with or without anterodorsal bulge, but without anterodorsal projection	27
26. Cocoon with elongate anterodorsal projection extending much beyond anteroventral tips of cocoon	<i>S. chiangdaoense</i>
Cocoon with short anterodorsal projection extending up to anteroventral tips of cocoon	<i>S. inthanonense</i>
27. Terminal hooks weakly undulate on outer margin	<i>S. sheilae</i> (complex)
Terminal hooks weakly serrate on outer margin	28
28. Dorsal surface of abdominal segments 1 and 2 darkened	<i>S. asakoe</i> (complex)
Dorsal surface of abdominal segments 1 and 2 not darkened	29
29. Angle formed by stalks of ventral pair and dorsal triplet more than 90 degrees when viewed laterally	<i>S. trangense</i>
Angle formed by stalks of ventral pair and dorsal triplet 90 degrees when viewed laterally	30
30. Anterodorsal margin of cocoon somewhat produced anteriorly	<i>S. doisaketense</i>

Anterodorsal margin of cocoon not produced anteriorly	<i>S. curtatum</i>
Mature larvae***	
1. Abdomen with protuberances dorsally	2
Abdomen without protuberances dorsally	6
2. Abdominal segments 1 and 2 each with 4 pairs of protuberances	<i>S. kuvangkadilokae</i>
Abdominal segments 1 and 2 each with 1–3 pairs of protuberances	3
3. Abdominal segments 1 and 2 each with 3 pairs of protuberances	<i>S. piroonae</i>
Abdominal segments 1 and 2 each with 1 or 2 pairs of protuberances	4
4. Thoracic segment 3 and abdominal segments 1–5 each with 1 pair of dorsolateral protuberances	<i>S. novemarticulatum</i>
Thoracic segment 3 and abdominal segments 1–5 each with 1 dorsal pair and 1 dorsolateral pair of protuberances	5
5. Postgenal cleft long, reaching posterior margin of hypostoma. Thorax and abdomen densely covered with dark spines of various sizes	<i>S. ngaoense</i>
Postgenal cleft long, but not reaching posterior margin of hypostoma. Thorax and abdomen sparsely or moderately covered with unpigmented or dark minute setae	<i>S. chumpornense</i>
6. Postgenal cleft long, approaching or completely reaching posterior margin of hypostoma	7
Postgenal cleft short or medium-long	17
7. Abdomen markedly constricted between segments 4 and 5 when viewed dorsally	<i>S. dentistylum</i>
Abdomen not constricted between segments 4 and 5 when viewed dorsally	8
8. Abdomen moderately covered with unbranched minute dark setae dorsally on segments 5–8	9
Abdomen moderately or densely covered with branched dark spinous setae or spinules dorsally on segments 5–8	10
9. Postgenal cleft reaching posterior margin of hypostoma	<i>S. sheilae</i> (complex)
Postgenal cleft approaching to posterior margin of hypostoma	<i>S. trangense</i>
10. Histoblast of gill with 6 filaments	<i>S. fukudae</i>
Histoblast of gill with 8 or 10 filaments	11
11. Thoracic cuticle moderately covered with minute dark spinules with 7–11 branches dorsally. Histoblast of pupal gill with 10 filaments	<i>S. chiangraiense</i> , <i>S. huaikaeoense</i> , <i>S. khaokhoense</i> , <i>S. maeklangense</i> & <i>S. pamiangense</i>
Thoracic cuticle almost bare or sparsely covered with minute spinules dorsally. Histoblast of pupal gill with 8 filaments	12
12. Minute dark spinous setae on abdominal segments 5–8 somewhat flat and stout basally, with short branches apically	<i>S. siamense</i> (complex)
Minute dark spinous setae on abdominal segments 5–8 slender and hair-like basally, with long branches	13
13. Labral fan with 26 primary rays	<i>S. chayamaritae</i>
Labral fan with 32–41 primary rays	14
14. Minute dark spinous setae on abdominal segments 5–8 with 5–12 (mostly 8–10) branches	<i>S. angulistylum</i> (complex)
Minute dark spinous setae on abdominal segments 5–8 with 0–5 branches	15
15. Posterior circlet with 94–98 rows of hooklets	<i>S. isanense</i>
Posterior circlet with less than 90 rows of hooklets	16
16. Posterior circlet with about 76 rows of hooklets	<i>S. burtoni</i>
Posterior circlet with about 86 rows of hooklet	<i>S. cheongi</i>
17. Histoblast of pupal gill inflated	18
Histoblast of pupal gill filamentous	20
18. Abdomen with reddish-brown markings on segments 1–8	<i>S. maleewongae</i>
Abdomen with ochreous or reddish-brown markings on segments 6–8	19
19. Abdominal segments 1–4 yellow	<i>S. thuathienense</i>
Abdominal segments 1–4 gray	<i>S. gombakense</i> & <i>S. paiense</i> (complex)
20. Histoblast of gill with 6 filaments	<i>S. udomi</i>
Histoblast of gill with 8 filaments	21
21. Postgenal cleft short, as long as or shorter than postgenal bridge	22
Postgenal cleft longer than postgenal bridge	23
22. Head capsule brownish	<i>S. adleri</i>
Head capsule yellowish	<i>S. inthanonense</i>

23. Abdominal segments 1–4 light grayish *S. asakoe* (complex)
 Abdominal segments 1–3 or 1–4 greenish 24
24. Abdominal segments 1–3 greenish *S. curtatum*
 Abdominal segments 1–4 greenish *S. doisaketense*
- * The female of *S. curtatum* runs to couplet 22 but cannot be further compared with those of *S. inthanonense* and *S. sheilae* due to brevity of the original description.
- * The females of *S. dentistylum*, *S. doisaketense*, *S. otsukai* and *S. prayongi* are unknown.
- ** The males of *S. datfaense* and *S. doisaketense* are unknown.
- ***The larvae of *S. chiangdaoense*, *S. datfaense*, *S. otsukai* and *S. prayongi* are unknown.

(5) Keys to six Thai species of the subgenus *Montisimulium*

Adult females

1. Claw with small subbasal tooth *S. phahompokense*
 Claw with medium-sized basal tooth 2
2. Claw tooth 0.28 times as long as claw *S. surachaii*
 Claw tooth 0.32–0.38 times as long as claw 3
3. Hind basitarsus 7.3 times as long as its greatest width *S. angkaense*
 Hind basitarsus 6.3–6.6 times as long as its greatest width 4
4. Sensory vesicle 0.43–0.50 times as long as third palpomere of maxillary palp *S. nanense*
 Sensory vesicle 0.6 times as long as third palpomere of maxillary palp 5
5. Fifth palpomere of maxillary palp 1.1 times length of third one *S. laoleense*
 Fifth palpomere of maxillary palp 1.9 times length of third one *S. merga*

Adult males*

1. Hind basitarsus 5.4–5.9 times as long as its greatest width *S. angkaense*
 Hind basitarsus 4.5–4.9 times as long as its greatest width 2
2. Hind basitarsus subequal in width to hind femur *S. merga*
 Hind basitarsus 0.8 or 0.9 times as wide as hind femur 3
3. Hind basitarsus 0.9 times as wide as hind femur *S. laoleense*
 Hind basitarsus 0.8 times as wide as hind femur *S. nanense*

Pupae**

1. Gill composed of 2 inflated tubal trunks with 14 slender filaments *S. merga*
 Gill composed of 12 or 14 slender filaments 2
2. Gill with 12 slender filaments *S. angkaense*
 Gill with 14 slender filaments 3
3. Outer group of 4 gill filaments arising at same level as dorsal and inner groups *S. laoleense*
 Outer group of 4 gill filaments arising more basally than dorsal and inner groups *S. nanense*

Mature larvae***

1. Antenna with hyaline bands on segment 2. Abdomen with reddish-brown markings dorsally on segments 5–9 *S. angkaense*
 Antenna without hyaline bands on segment 2. Abdomen without reddish-brown markings dorsally on segments 5–9 2
2. Eyebrow well defined, dark brown *S. merga*
 Eyebrow not well defined, only somewhat darkened at most near both ends 3
3. Labral fan with 28–32 primary rays *S. laoleense*
 Labral fan with 22 primary rays *S. nanense*

* The males of *S. phahompokense* and *S. surachaii* are unknown.

** The pupae of *S. phahompokense* and *S. surachaii* are unknown.

***The larvae of *S. phahompokense* and *S. surachaii* are unknown.

(6) Keys to ten Thai species of the subgenus *Nevermannia*

Adult females*

1. Antenna yellow with at least first flagellomere darkened. Hind tibia yellow on basal 1/2, dark on distal 1/2, and with subbasal dark ring *S. aureohirtum*
 Antenna almost all darkened or mostly so except few basal segments pale. Hind tibia brownish 2
2. Scutum with 3 dark longitudinal vittae 3
 Scutum without longitudinal vittae 6

3. Genital fork with strongly sclerotized horizontal bar at base of anterodorsal projection of each arm *S. maeaiense*
Genital fork without strongly sclerotized horizontal bar at base of anterodorsal projection of each arm ... 4
4. Mandible with 17 or 18 inner teeth *S. vessabutrae*
Mandible with 20–23 inner teeth 5
5. Frons: head ratio 1:5.4 *S. feuerborni* (complex)
Frons: head ratio 1:4.6–5.2 *S. chiangklangense*, *S. fangense* & *S. fruticosum*
6. Hind basitarsus 7.2 times as long as its greatest width *S. chomthongense*
Hind basitarsus 6.8–6.9 times as long as its greatest width *S. khunklangense*

Adult males**

1. Antenna yellow or yellowish brown with first flagellomere darkened. Hind basitarsus slender, parallel-sided, much narrower than hind tibia *S. aureohirtum*
Antenna almost all darkened. Hind basitarsus inflated, and nearly as wide as hind tibia 2
2. Paramere with 3–7 hooks 3
Paramere with 1 hook 7
3. Upper-eye facets in 21 vertical columns *S. fangense*
Upper-eye facets in 14–19 vertical columns 4
4. Upper-eye facets in 19 vertical columns *S. maeaiense*
Upper-eye facets in 14–17 vertical columns 5
5. Upper-eye facets in 17 vertical columns. Paramere with 9 hooks *S. vessabutrae*
Upper-eye facets in 14–16 vertical columns. Paramere with 3–8 hooks 6
6. Upper-eye facets in 16 vertical columns. Paramere with 3 or 4 hooks *S. feuerborni* (complex)
Upper-eye facets in 14 or 15 vertical columns. Paramere with 6–8 hooks *S. fruticosum* & *S. wichaii*
7. Upper-eye facets in 15 or 16 vertical columns *S. chomthongense*
Upper-eye facets in 18 vertical columns *S. khunklangense*

Pupae

1. Gill with 4 filaments 2
Gill with 6 filaments 3
2. Length ratio of common basal stalk of gill against interspiracular trunk 0.76–0.79 *S. chomthongense*
Length ratio of common basal stalk of gill against interspiracular trunk 0.50–0.65 *S. khunklangense*
3. All filaments divergent widely from base *S. aureohirtum*
All filaments extending forwards close together 4
4. Cocoon with anterodorsal projection 5
Cocoon without anterodorsal projection 7
5. Gill filaments arranged as 2+1+2+1 from inside to outside, lying horizontally *S. maeaiense*
Gill filaments arranged otherwise, not lying horizontally 6
6. Gill filaments arranged as 4+2 from dorsal to ventral *S. feuerborni* (complex)
Gill filaments arranged as 2+1+1+2 or 3+1+2 from dorsal to ventral *S. fangense*
7. Common basal stalk longer than interspiracular trunk *S. vessabutrae*
Common basal stalk much shorter than interspiracular trunk 8
8. Frons and thorax covered with dark brown rather large tubercles. Facial trichome short and slender, slightly longer than frontal ones. Gill filaments covered with rather large tubercles on ridges ... *S. wichaii*
Frons and thorax covered with light brown small tubercles. Facial trichome medium-long and somewhat stout, 2.5 times as long as frontal ones. Gill filaments covered with small tubercles on ridge 9
9. Stalk of ventral paired filaments medium-long to long *S. fruticosum*
Stalk of ventral paired filaments short *S. chiangklangense*

Mature larvae***

1. Abdomen with characteristic reddish-brown markings dorsally 2
Abdomen without colored markings dorsally 7
2. Thoracic segment 1 with tawny transverse band dorsally 3
Thoracic segment 1 without colored band dorsally 4
3. Ventral surface of head capsule darkened medially *S. feuerborni* (complex)
Ventral surface of head capsule not darkened medially *S. vessabutrae*
4. Labral fan with 16 primary rays *S. wichaii*
Labral fan with 23 or more primary rays 5
5. Postgenal cleft 0.3 times as long as postgenal bridge *S. maeaiense*
Postgenal cleft 0.5–0.6 times as long as postgenal bridge 6

6. Each lobe of rectal organ with 17–21 secondary lobules *S. fangense*
 Each lobe of rectal organ with 11 or 12 secondary lobules *S. fruticosum*
 7. Accessory sclerite present *S. chomthongense* & *S. khunklangense*
 Accessory sclerite absent *S. aureohirtum*

* The female of *S. wichaii* is unknown.

** The male of *S. chiangklangense* is unknown.

*** The larva of *S. chiangklangense* is unknown.

(7) Keys to 53 Thai species of the subgenus *Simulium* s. str

Adult females*

1. Claw with small subbasal tooth 2
 Claw without any tooth 15
2. Basal section of radius fully haired. Fore basitarsus with thick dorsal hair crest 3
 Basal section of radius bare. Fore basitarsus with moderate dorsal hair crest 5
3. Fore tibia entirely darkened *S. umphangense*
 Fore tibia yellow on basal 1/2 and darkened on apical 1/2 4
4. Mandible with 5 or 6 distinct outer teeth *S. nigrogilvum*
 Mandible with 6 vestigial outer teeth *S. vanellum*
5. Mid and hind femora mostly yellowish 6
 Mid and hind femora mostly brownish 8
6. Hind tibia mostly yellowish except apical cap darkened 7
 Hind tibia mostly darkened except base yellow *S. kiewmaepanense*
7. Mid tibia entirely yellowish *S. luculentum*
 Mid tibia yellowish except posterior surface mostly darkened *S. chamlongi*
8. Scutum densely covered with yellow hairs 9
 Scutum moderately covered with brassy hairs 11
9. Ovipositor valve with inner margin nearly straight *S. atipornae*
 Ovipositor valve with inner margin concave 10
10. Anteromedian surface of paraproct unpigmented *S. srisukai*
 Anteromedian surface of paraproct darkened *S. barnesi*
11. Antenna yellow or tawny with 2 apical flagellomeres blackish *S. vanluni*
 Antenna brownish black with scape, pedicel and base of first flagellomere yellow 12
12. Ovipositor valve elongated, tapered apically *S. bishopi*
 Ovipositor valve short, obliquely slanted posterolaterally 13
13. Abdominal segment 7 with branched hairs ventrally *S. siripoomense*
 Abdominal segment 7 with unbranched hairs ventrally 14
14. Subcosta haired *S. baimaii*
 Subcosta bare *S. lomkaoense*
15. Scutum with 5 distinct longitudinal vittae 16
 Scutum without dorsal vittae 36
16. Scutum with 1 median, 2 submedian and 2 lateral dark vittae when illuminated anteriorly and viewed dorsally 17
 Scutum with 1 median, 2 submedian and 2 sublateral dark vittae when illuminated anteriorly and viewed dorsally 27
17. Fore tibia medium to dark brown, without white area on outer surface. Hind tibia dark brown to brownish black with base yellow. Inner margin of ovipositor valve with ventrally produced round flap *S. nakhonense*, *S. chiangmaiense*, *S. phraense* & *S. quinquestriatum*
 Fore tibia with white shiny area on outer surface. Hind tibia whitish or yellowish on basal 2/3 or more, dark brown to brownish black on remainder. Inner margin of ovipositor valve without such flap 18
18. Basal section of radius fully haired 19
 Basal section of radius bare or partially haired 24
19. Ovipositor valve with elongate internal projection 20
 Ovipositor valve without such internal projection 21
20. Sensory vesicle 0.41 times as long as third palpomere of maxillary palp *S. grossiflum*
 Sensory vesicle 0.34 times as long as third palpomere of maxillary palp *S. phayaoense*
21. Ovipositor valve with 22 or 23 stout hairs, as long as or longer than those on sternite 8 *S. chochootei*
 Ovipositor valve with 12–16 hairs, much shorter than those on sternite 8 22

22. Paraproct with about 60 medium-long to long stout hairs, several of which are much longer than those on sternite 8 *S. visuti*
 Paraproct with 28–30 short to medium-long hairs, all of which are much shorter than those on sternite 8 23
23. Cibarium with minute spinous processes near base of medial projection *S. pukaengense*
 Cibarium without such spinous processes near base of medial projection *S. digrammicum*
24. Ovipositor valve narrowly darkened along inner margin *S. suchariti*
 Ovipositor valve unpigmented along inner margin 25
25. Cibarium with medial projection shorter than its basal width. Abdominal segment 2 entirely dark brown *S. phukaense*
 Cibarium with medial projection much longer than its basal width. Abdominal segment 2 pale yellow on anterior 1/2–3/4 26
26. Fore basitarsus 5.5 times as long as its greatest width *S. maenoi*
 Fore basitarsus 4.5 times as long as its greatest width *S. thongsahuani*
27. Mid femur entirely yellow. Spermathecae 3 in number *S. triglobus*
 Mid femur with darkened area. Spermatheca 1 in number 28
28. Hind femur yellowish almost entirely *S. chanyae*
 Hind femur darkened at least on more than apical 1/2 29
29. Paraproct in lateral view tapered ventrally 30
 Paraproct in lateral view rounded ventrally 31
30. Cibarium with minute spinous processes dorsomedially 32
 Cibarium without any processes dorsomedially *S. malayense* (complex)
31. Fore basitarsus 5.0 times as long as its greatest width *S. undecimum*
 Fore basitarsus 4.1 times as long as its greatest width *S. bullatum*
32. Ovipositor valve with 7–10 medium-long hairs *S. takenae*
 Ovipositor valve with 1–5 short to medium-long hairs 33
33. Basal section of radius with few hairs near apical end *S. chaliowae* & *S. fenestratum* (complex)
 Basal section of radius entirely bare 34
34. Fore basitarsus 5.5–5.9 times as long as its greatest width *S. daoense*
 Fore basitarsus 4.7–4.9 times as long as its greatest width 35
35. Sensory vesicle 0.35 times as long as third palpomere of maxillary palp *S. chainarongi*
 Sensory vesicle 0.44 times as long as third palpomere of maxillary palp *S. lampangense*
36. Mid tarsomeres 2 and 3 entirely yellow *S. nodosum*
 Mid tarsomeres 2 and 3 light brown to brownish black 37
37. Mid femur entirely yellow 38
 Mid femur almost dark brown 40
38. Mid tibia yellowish white with apical cap light to medium brown *S. mediocoloratum*
 Mid tibia entirely yellowish 39
39. Dorsal surface of anterior 1/2 of abdominal segment 2 medium brown *S. crocinum*
 Dorsal surface of anterior 1/2 of abdominal segment 2 white or whitish yellow *S. rudnicki*
40. Abdominal segment 7 with pair of clustered hairs ventrally 41
 Abdominal segment 7 without such clustered hairs ventrally 45
41. Pair of clustered hairs on abdominal segment 7 short, subequal in length to those on surrounding area *S. setsukoae*
 Pair of clustered hairs on abdominal segment 7 much longer than those on surrounding area 42
42. Mid tibia light brown with base somewhat yellow *S. weji*
 Mid tibia white on basal 2/5 or more, medium brown on rest 43
43. Hind basitarsus yellow on basal 1/2, dark brown on rest *S. tenebrosum* (complex)
 Hind basitarsus yellowish on basal 3/5, dark brown on rest 44
44. Hind tibia yellowish white except apical 2/5 medium to dark brown *S. doipuiense* (complex)
 Hind tibia brownish black except little more than basal 2/5 yellowish white *S. manooni*
45. Hind basitarsus white on little more than basal 1/2, and brownish black on rest. Scutum covered with yellowish hairs as well as dark ones *S. yongi*
 Hind basitarsus white on basal 3/5 or more, and brownish black on rest. Scutum covered with dark brown hairs only 46
46. Sensory vesicle enlarged, 0.6–0.7 times as long as third palpomere of maxillary palp *S. tani* (complex)

Sensory vesicle medium-sized, 0.3 times as long as third palpomere of maxillary palp	
.....	<i>S. brevipar</i> & <i>S. yuphae</i>
Adult males**	
1. Basal section of radius fully haired	2
Basal section of radius bare or with few hairs apically	7
2. Abdomen with pair of shiny whitish pruinose spots dorsally or dorsolaterally on segments 2, 5, 6 and 7	3
Abdomen with pair of shiny white pruinose spots dorsally or dorsolaterally on segments 2, 6 and 7	4
3. Upper-eye facets in 17 vertical columns. Hind basitarsus nearly parallel-sided	<i>S. choochotei</i>
Upper-eye facets in 20 vertical columns. Hind basitarsus spindle-shaped	<i>S. visuti</i>
4. Fore basitarsus with thick dorsal hair crest. Hind basitarsus nearly parallel-sided	5
Fore basitarsus with moderate dorsal hair crest. Hind basitarsus spindle-shaped	6
5. Upper-eye facets in 20 vertical columns	<i>S. nigrogilvum</i>
Upper-eye facets in 17 vertical columns	<i>S. vanellum</i>
6. Upper-eye facets in 19 vertical columns. Ventral plate rectangular, nearly parallel-sided when viewed ventrally	<i>S. pukaengense</i>
Upper-eye facets in 21 or 22 vertical columns. Ventral plate gradually narrowed posteriorly when viewed ventrally	<i>S. digrammicum</i>
7. Scutum broadly silvery pruinose with transverse, inverted-V shaped, black band	8
Scutum otherwise	9
8. Ventral plate with narrow body, parallel-sided when viewed ventrally	<i>S. vanluni</i>
Ventral plate with wide body, widened medially when viewed ventrally	<i>S. nodosum</i>
9. Mid femur and tibia almost yellow	10
Mid femur and tibia otherwise	11
10. Hind tibia brownish black except base narrowly yellow	<i>S. rudnicki</i>
Hind tibia dark brown to brownish black except base widely yellow	<i>S. crocinum</i>
11. Mid tibia mostly dark (including posterior surface)	12
Mid tibia whitish or yellowish (at least on posterior surface) on basal 2/5 or more and dark brown on rest	29
12. Fore tibia medium brown, with white shiny area on outer surface	13
Fore tibia medium to dark brown, without white area on outer surface	27
13. Hind basitarsus white or whitish yellow on basal 1/2 or less and dark brown to brownish black on rest	14
Hind basitarsus white or whitish yellow on more than basal 1/2 and light to dark brown on rest	24
14. Hind basitarsus somewhat enlarged, 4.0–5.0 times as long as its greatest width, and much narrower than greatest width of hind tibia	15
Hind basitarsus much enlarged, 3.2–3.5 times as long as its greatest width, and subequal to, or slightly wider than, greatest width of hind tibia	18
15. Abdomen with dorsolateral pair of silvery spots on segments 2, 6 and 7	<i>S. atipornae</i>
Abdomen with dorsolateral pair of silvery spots on segments 2, 5, 6 and 7	16
16. Upper-eye facets in 19 vertical columns	<i>S. chamlongi</i>
Upper-eye facets in 22–26 vertical columns	17
17. Upper-eye facets in 22 or 23 vertical columns	<i>S. luculentum</i>
Upper-eye facets in 24–26 vertical columns	<i>S. srisukai</i>
18. Abdomen with dorsolateral pair of silvery spots on segments, 2, 4, 5, 6 and 7	<i>S. bishopi</i>
Abdomen with dorsolateral pair of silvery spots on segments, 2, 5, 6 and 7, or 2, 6 and 7	19
19. Abdomen with dorsolateral pair of silvery spots on segments 2, 5, 6 and 7	<i>S. tani</i> (complex)
Abdomen with dorsolateral pair of silvery spots on segments 2, 6 and 7	20
20. Upper-eye facets in 20 vertical columns	<i>S. setsukoae</i>
Upper-eye facets in 15–18 vertical columns	21
21. Hind basitarsus spindle-shaped	<i>S. manooni</i>
Hind basitarsus wedge-shaped	22
22. Style with well produced basal projection closely covered with spines	<i>S. brevipar</i> & <i>S. yuphae</i>
Style with basal area somewhat produced, sparsely covered with several spines	23
23. Fore basitarsus 7.2–8.2 times as long as its greatest width	<i>S. tenebrosum</i> (complex)
Fore basitarsus 5.9–6.1 times as long as its greatest width	<i>S. doipuiense</i> (complex)
24. Hind basitarsus enlarged, whitish yellow on basal 3/5 or little less and dark brown on rest	25

Hind basitarsus narrow (similar to that of female), parallel-sided, white except apical 1/6 light brown ...	26
25. Hind basitarsus spindle-shaped	<i>S. lomkaoense</i>
Hind basitarsus wedge-shaped	<i>S. weji</i>
26. Hind tibia entirely brownish black	<i>S. siripoomense</i>
Hind tibia brownish black except base narrowly yellow	<i>S. baimaii</i>
27. Abdomen with dorsolateral pair of silvery spots on segments 2, 6 and 7	<i>S. phukaense</i>
Abdomen with dorsolateral pair of silvery spots on segments 2, 5, 6 and 7	28
28. Hind basitarsus whitish yellow on basal 1/2, brownish black on rest	<i>S. quinquestriatum</i>
Hind basitarsus whitish yellow on basal 3/5 and brownish black on apical 2/5	<i>S. Chiangmaiense, S. nakhonense, S. phraense & S. thailandicum</i>
29. Hind basitarsus whitish on basal 1/2 or little more and brownish black on rest. Body of ventral plate wider than long	30
Hind basitarsus entirely light to dark brown, or so with basal 2/5–1/3 whitish yellow or dark yellow. Body of ventral plate longer than wide	33
30. Scutum covered with dark brown recumbent hairs only	<i>S. yongi</i>
Scutum covered with golden-yellow recumbent hairs interspersed with brown hairs anteriorly	31
31. Ventral plate with body nearly quadrate, shorter than arms	<i>S. mediocoloratum</i>
Ventral plate with body rectangular, longer than arms	32
32. Abdomen with dorsolateral pair of silvery spots on segments 2, 5, 6 and 7	<i>S. grossifilum</i>
Abdomen with dorsolateral pair of silvery spots on segments 2, 6 and 7	<i>S. phayaoense</i>
33. Hind basitarsus entirely light to dark brown	34
Hind basitarsus brownish black with basal 1/3–2/5 whitish yellow or dark yellow	36
34. Ventral plate in ventral view subquadrate, and with distinct teeth on posterior surface	<i>S. chaliowae</i>
Ventral plate in ventral view gradually narrowed posteriorly, and without teeth on posterior surface ...	35
35. Fore basitarsus 6.8 times as long as its greatest width	<i>S. maenoi</i>
Fore basitarsus 5.4 times as long as its greatest width	<i>S. thongsahuani</i>
36. Upper-eye facets in 20 or 21 vertical columns and 20 or 21 horizontal rows	37
Upper-eye facets in 15–18 vertical columns and 16–19 horizontal rows	40
37. Ventral plate without setae	<i>S. undecimum</i>
Ventral plate with setae	38
38. Ventral plate without teeth	<i>S. suchariti</i>
Ventral plate with teeth	39
39. Ventral plate in ventral view rounded posteriorly	<i>S. chainarongi</i>
Ventral plate in ventral view with posterior margin concave	<i>S. takense</i>
40. Upper-eye facets in 15 vertical columns and 16 horizontal rows. Ventral plate with 2 vertical rows of teeth nearly parallel-sided on posterior surface	<i>S. malayense</i> (complex)
Upper-eye facets in 17 or 18 vertical columns and 17–19 horizontal rows. Ventral plate with teeth irregularly situated on posterior surface	41
41. Sensory vesicle 0.3–0.4 times as long as third palpomere of maxillary palp	<i>S. daoense</i>
Sensory vesicle 0.2 times as long as third palpomere of maxillary palp	42
42. Basal projection of style with 1 spine	<i>S. fenestratum</i> (complex)
Basal projection of style with several spines	43
43. Mid tibia whitish except apical cap darkened	<i>S. chanyae</i>
Mid tibia whitish on basal 2/5, then gradually darkened toward apex	<i>S. lampangense</i>
Pupae***	
1. Gill with 2 or 3 inflated tubes	2
Gill with 6–10 filaments	4
2. Gill with 2 inflated tubes	3
Gill with 3 inflated tubes with rounded apex	<i>S. nodosum</i>
3. Gill with long inflated common basal stalk	<i>S. baimaii</i>
Gill with short common basal stalk	<i>S. lomkaoense</i>
4. Gill with 6 filaments	5
Gill with 8–10 filaments	35
5. Gill with 6 inflated tubal filaments with minute spines	6
Gill with 6 thread-like filaments (with basal portions somewhat inflated or not) without minute spines ...	7
6. Terminal hooks present	<i>S. grossifilum</i>
Terminal hooks absent	<i>S. phayaoense</i>

7. Cocoon wall-pocket shaped	8
Cocoon shoe shaped or boot shaped	27
8. Cocoon with lateral windows anteriorly	9
Cocoon without lateral window	15
9. Gill filaments subequal in length and thickness to one another	10
Gill filaments decreasing in thickness from dorsal to ventral	13
10. Gill filaments short-stalked. Spine-combs on abdominal segments 7 and 8 or 7–9	11
Gill filaments almost sessile. Spine-combs present only on abdominal segment 8	12
11. Spine-combs on abdominal segments 7 and 8	<i>S. atipornae</i>
Spine-combs on abdominal segments 7–9	<i>S. siripoomense</i>
12. Small raised area near base of gill with tubercles	<i>S. mediocoloratum</i>
Small raised area near base of gill bare	<i>S. rudnicki</i>
13. Cocoon with small lateral windows. Terminal hooks present	<i>S. maenoi</i>
Cocoon with moderate lateral windows. Terminal hooks absent	14
14. Integument of head densely covered with tubercles	<i>S. suchariti</i>
Integument of head bare	<i>S. crocinum</i>
15. Integument of head and thorax bare (except posterior 1/2 of thorax with minute tubercles)	16
Integument of head and thorax moderately or densely covered with tubercles	18
16. Cocoon very thin, transparent, and its anterior margin often not well defined. Inner filament of ventral pair narrowed basally. Spine-combs dorsally on abdominal segment 8. Terminal hooks absent ...	<i>S. yongi</i>
Cocoon thickly woven, not transparent, and its anterior margin well defined. Inner filament of ventral pair not narrowed basally. Spine-combs dorsally on abdominal segments 7–9. Terminal hooks present	17
17. Upper filament of dorsal pair more than twice as thick as interspiracular trunk	<i>S. srisukai</i>
Upper filament of dorsal pair less than twice as thick as interspiracular trunk	<i>S. chamlongi</i>
18. Frontal trichomes each with 8–12 slender branches	<i>S. thongsuhani</i>
Frontal trichomes unbranched	19
19. Gill with short common basal stalk	20
Gill without common basal stalk	23
20. Terminal hooks present	21
Terminal hooks absent	22
21. Basal portion of upper filament of dorsal pair nearly as thick as interspiracular trunk ...	<i>S. kiewmaepanense</i>
Basal portion of upper filament of dorsal pair 1.6–1.8 times as thick as interspiracular trunk	<i>S. luculentum</i>
22. Frons densely covered with tubercles	<i>S. tenebrosum</i> (complex)
Frons moderately covered with tubercles	<i>S. doipuiense</i> (complex)
23. Thoracic integument with pit-like organ at base of gill	24
Thoracic integument without pit-like organ at base of gill	25
24. Lower filament of ventral pair directed forward	<i>S. brevipar</i>
Lower filament of ventral pair directed downwardly and posteriorly	<i>S. yuphae</i>
25. Abdominal segment 7 without spine-combs dorsally	<i>S. weji</i>
Abdominal segment 7 with spine-combs dorsally	26
26. Inner filament of ventral pair much thinner than outer filament. Terminal hooks present	<i>S. tani</i> (complex)
Two filaments of ventral pair subequal in thickness. Terminal hooks absent	<i>S. manooni</i> & <i>S. setsukoe</i>
27. Cocoon loosely woven, with many small open spaces	28
Cocoon tightly woven	29
28. Gill filaments somewhat inflated, larger in diameter than interspiracular trunk. Terminal hooks large, longer than their basal width	<i>S. choochotei</i>
Gill filaments not so inflated, smaller in diameter than interspiracular trunk. Terminal hooks of moderate size, shorter than their basal width	<i>S. visuti</i>
29. Cocoon with anterolateral flap and small anterolateral window on each side	<i>S. digrammicum</i>
Cocoon without such flap and window	30
30. Gill filaments decreasing in length and thickness from dorsal to ventral. Facial and frontal trichomes branched	31

Gill filaments subequal in length and thickness to one another. Facial and frontal trichomes unbranched	32
31. Gill filaments light yellowish-white to yellowish-brown. Terminal hooks present	<i>S. pukaengense</i>
Gill filaments dark brown. Terminal hooks absent	<i>S. phukaense</i>
32. Abdominal segment 8 with spine-combs dorsally	33
Abdominal segment 8 without spine-combs dorsally	34
33. Frons bare	<i>S. bishopi</i>
Frons sparsely or moderately covered with tubercles	<i>S. vanluni</i>
34. Two filaments of ventral pair thicker than interspiracular trunk	<i>S. nigrogilvum</i>
Two filaments of ventral pair thinner than interspiracular trunk	<i>S. vanellum</i>
35. Gill with 8 filaments	36
Gill with 10 filaments	46
36. Cocoon wall-pocket shaped	37
Cocoon shoe shaped	42
37. Cocoon without lateral windows	38
Cocoon with lateral windows	39
38. Gill filaments widely divergent, angle between stalks of dorsal and ventral pairs 180 degrees	<i>S. chanyae</i>
Gill filaments moderately divergent, angle between stalks of dorsal and ventral pairs 90 degrees	<i>S. malayense</i> (complex)
39. Gill with large unpigmented basal fenestra	<i>S. bullatum</i>
Gill without large basal fenestra	40
40. Gill filaments widely divergent, angle between stalks of dorsal and ventral pairs more than 90 degrees	<i>S. lampangense</i>
Gill filaments moderately divergent, angle between stalks of dorsal and ventral pairs 90 degrees or less	41
41. Spine-combs only on dorsal surface of abdominal segment 8	<i>S. daoense</i>
Spine-combs on dorsal surface of abdominal segments 7 and 8	<i>S. fenestratum</i> (complex) & <i>S. undecimum</i>
42. Cocoon roughly woven anteriorly, leaving some large open spaces in anterior collar and many small open spaces near anterior margin	43
Cocoon without open spaces	44
43. All gill filaments subequal in thickness to one another	<i>S. triglobus</i>
Two filaments of ventral pair much thinner than others	<i>S. chiangmaiense</i>
44. At least 2 gill filaments directed posteriorly. Terminal hooks present	<i>S. takense</i>
Gill filaments not directed posteriorly. Terminal hooks absent	45
45. Basal portion of upper filament of dorsal pair about 1.4 times as thick as lower filament of ventral pair	<i>S. chaliowae</i>
Basal portion of upper filament of dorsal pair about twice as thick as lower filament of ventral pair	<i>S. chainarongi</i>
46. Gill filaments arranged as 2+3+3+2 from dorsal to ventral. All gill filaments subequal in thickness to one another	<i>S. quinquestriatum</i>
Gill filaments arranged as 2+2+2+2+2 or 2+1+2+1+2+2 from dorsal to ventral. Four or five dorsal filaments slightly to markedly thicker than others	47
47. Gill filaments lacking ridges and furrows	<i>S. phraense</i>
Gill filaments with ridges and furrows	48
48. Head integument with round tubercles	<i>S. nakhonense</i>
Head integument with angular tubercles	<i>S. thailandicum</i>
Mature larvae****	
1. Histoblast of pupal gill with 2 filaments	2
Histoblast of pupal gill with 3, 6, 8 or 10 filaments	3
2. Histoblast of pupal gill with filaments arising from short stalk	<i>S. baimaii</i>
Histoblast of pupal gill with filaments lacking stalk	<i>S. lomkaoense</i>
3. Histoblast of pupal gill with 3 filaments	<i>S. nodosum</i>
Histoblast of pupal gill with 6–10 filaments	4
4. Histoblast of pupal gill with 6 filaments	5
Histoblast of pupal gill with 8 or 10 filaments	32
5. Last abdominal segment with accessory sclerite ventrally	6

Last abdominal segment without accessory sclerite ventrally	7
6. Mandible with supernumerary serration	<i>S. nigrogilvum</i>
Mandible without supernumerary serration	<i>S. vanellum</i>
7. Abdominal segments 1–5 (or up to 8) each with 1 or more pairs of protuberances dorsally or dorsolaterally	8
Abdominal segments lacking protuberances	9
8. Abdominal segments 1–8 each with 1–6 pairs of protuberances dorsally and dorsolaterally	<i>S. siripoomense</i>
Abdominal segments 1–5 each with pair of protuberances dorsally	<i>S. vanluni</i>
9. Abdomen with its greatest width on segment 8	10
Abdomen with its greatest width on segment 6 or 7	13
10. Cephalic apotome mostly pale yellow. Body length 6.5–8.0 mm	<i>S. yongi</i>
Cephalic apotome mostly light to medium brown. Body length 8.1–11.2 mm	11
11. Posterior circllet with about 210 rows of hooklets	<i>S. choochotei</i>
Posterior circllet with less than 160 rows of hooklets	12
12. Posterior circllet with 144–160 rows of hooklets	<i>S. rudnicki</i>
Posterior circllet with 136–138 rows of hooklets	<i>S. visuti</i>
13. Postgenal cleft widely rounded apically	14
Postgenal cleft nearly pointed apically	22
14. Body longer than 7.0 mm	15
Body shorter than 7.0 mm	16
15. Posterior circllet with 87–93 rows of hooklets	<i>S. srisukai</i>
Posterior circllet with about 120 rows of hooklets	<i>S. suchariti</i>
16. Postgenal cleft moderately widened medially, its greatest width much larger than width at base	17
Postgenal cleft not widened or slightly so medially, its greatest width subequal to, or slightly larger than, width at base	18
17. Body length 5.2–5.6 mm. Each lobe of rectal organ with 6–10 secondary lobules	<i>S. chamlongi</i>
Body length 5.9–6.3 mm. Each lobe of rectal organ with 11–16 secondary lobules	<i>S. luculentum</i>
18. Each lobe of rectal organ with 19–28 secondary lobules	<i>S. pukaengense</i>
Each lobe of rectal organ with 7–17 secondary lobules	19
19. Labral fan with 30–36 primary rays	<i>S. maenoi</i>
Labral fan with 38–50 primary rays	20
20. Labral fan with 38–40 primary rays	<i>S. digrammicum</i>
Labral fan with 46–50 primary rays	21
21. Posterior circllet with 140–143 rows of hooklets	<i>S. thongsahuani</i>
Posterior circllet with about 104 rows of hooklets	<i>S. bishopi</i>
22. Body length 5.8–8.0 mm	23
Body length shorter than 5.6 mm	27
23. Histoblast of pupal gill with inflated filaments	24
Histoblast of pupal gill with slender filaments	25
24. Postgenal cleft 2.4–2.8 times as long as postgenal bridge. Posterior circllet with 84–98 rows of hooklets	<i>S. phayaoense</i>
Postgenal cleft 1.8–2.0 times as long as postgenal bridge. Posterior circllet with about 120 rows of hooklets	<i>S. grossifilum</i>
25. Sheath of subesophageal ganglion unpigmented	<i>S. atipornae</i>
Sheath of subesophageal ganglion pigmented	26
26. Eyebrow distinct	<i>S. mediocoloratum</i>
Eyebrow indistinct	<i>S. crocinum</i>
27. Body color reddish brown	<i>S. tani</i> (complex)
Body color otherwise	28
28. Anterior 1/2 of cephalic apotome broadly dark medially	<i>S. weji</i>
Anterior 1/2 of cephalic apotome entirely pale	29
29. Eye-spot region surrounded by darkened area	<i>S. brevipar</i> & <i>S. yuphae</i>
Eye-spot region not surrounded by darkened area	30
30. Eyebrow well defined	<i>S. manooni</i>
Eyebrow weakly defined or indistinct	31
31. Eyebrow indistinct	<i>S. doipuiense</i> (complex)

Fig. 1. Morphological features and their terms of adults of black flies. A, female head (front view); B, thorax (lateral view); C, female legs (fore, mid and hind legs from left); D, Wing; E, male genitalia (ventral view); F, female terminalia (ventral view). (Reproduced from Takaoka, 2003).

Eyebrow weakly defined	<i>S. tenebrosum</i> (complex)
32. Histoblast of pupal gill with 8 filaments	33
Histoblast of pupal gill with 10 filaments	42
33. Histoblast of pupal gill with enlarged basal fenestra	<i>S. bullatum</i>
Histoblast of pupal gill with small basal fenestra	34
34. Abdomen with protuberances dorsally	35
Abdomen without protuberances dorsally	39
35. Abdominal segments 1–8 each with pair of protuberances dorsally	<i>S. Chiangmaiense</i>
Abdominal segments 1–6 or 2–7 each with pair of protuberances dorsally	36
36. Each lobe of rectal organ with 15–20 secondary lobules	<i>S. fenestratum</i> (morphoform A)
Each lobe of rectal organ with less than 15 secondary lobules	37
37. Head spots positive	<i>S. chainarongi</i>
Head spots indistinct	38
38. Abdominal segments 3–7 each with pair of protuberances dorsally	<i>S. lampangense</i>

Fig. 2. Morphological features and their terms of the pupa and larva of black flies. A, pupa in cocoon; B, head integument of pupa spread flattened (front view); C & D, pupal abdomens (C, dorsal view; D, ventral view); E, mature larva (lateral view); F & G, head capsules of larva (F, dorsal view; G, ventral view); H, hypostoma; I, posterior tip of larval abdomen (posterodorsal view); (Reproduced from Takaoka, 2003).

- Abdominal segments 2–6 each with pair of protuberances dorsally *S. chaliowae*
39. Each lobe of rectal organ with 15–22 secondary lobules *S. daoense* & *S. fenestratum* (morphoform B)
- Each lobe of rectal organ with less than 15 secondary lobules 40
40. Labral fan with 56–60 primary rays *S. triglobus*
- Labral fan with 40–45 primary rays 41
41. Each lobe of rectal organ with 8–10 secondary lobules *S. malayense* (complex)
- Each lobe of rectal organ with 13 or 14 secondary lobules *S. undecimum*
42. Histoblast of pupal gill with 10 filaments arranged as 2+3+3+2 from dorsal to ventral *S. quinquestriatum*
- Histoblast of pupal gill with 10 filaments arranged as 2+2+2+2+2 or 2+1+2+1+2+2 from dorsal to ventral 43
43. Histoblast of pupal gill with 10 filaments arranged as 2+1+2+1+2+2 from dorsal to ventral. Filaments without ridges and furrows *S. phraense*

Histoblast of pupal gill with 10 filaments arranged as 2+2+2+2+2 from dorsal to ventral. Filaments with ridges and furrows *S. nakhonense*

* The female of *S. thailandicum* is unknown.

** The males of *S. barnesi*, *S. bullatum*, *S. triglobus*, *S. kiewmaepanense* and *S. umphangense* are unknown.

*** The pupae of *S. barnesi* and *S. umphangense* are unknown.

**** The larvae of *S. barnesi*, *S. chanyae*, *S. kiewmaepanense*, *S. phukaense*, *S. setsukoeae*, *S. takense*, *S. thailandicum* and *S. umphangense* are unknown. Morphoform A and morphoform B of *S. fenestratum* herein designated are based on Takaoka *et al.* (2000) and Thaijarern *et al.* (2018), in which two types of larvae are noted in populations of *S. fenestratum* from Sumatra and Thailand: one with protuberances on the dorsum of the abdomen, and the other without protuberances. Whether the difference between these two morphoforms is intraspecific should be confirmed.

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REFERENCES

- Adler, P. H. 2019. World Blackflies (Diptera: Simuliidae): A Comprehensive Revision of the Taxonomic and Geographical Inventory [2019]. 139 pp., <http://entweb.clemson.edu/biomia/pdfs/blackflyinventory.pdf> [accessed on March 20, 2019]
- Adler, P. H., Currie, D. C. and Wood, D. M. 2004. The Black Flies (Simuliidae) of North America. xv+941 pp., Cornell University Press, Ithaca, New York, USA.
- Adler, P. H., Srisuka, W., Saeung, A., Low, V. L. and Takaoka, H. 2019. High-elevation chromosomal diversity of black flies (Diptera: Simuliidae) in Thailand. *Insect Systematics Diversity*, 3(3): 1–10.
- Adler, P. H., Takaoka, H., Sofian-Azirun, M., Low, V. L., Ya'cob, Z., Chen, C. D., Lau, K. W. and Pham, X. D. 2016. Vietnam, a hotspot for chromosomal diversity and cryptic species in black flies (Diptera: Simuliidae). *PLoS ONE*, 11: e0163881.
- Choochote, W., Takaoka, H., Fukuda, M., Otsuka, Y., Aoki, C. and Eshima, N. 2005. Seasonal abundance and daily flying activity of black flies (Diptera: Simuliidae) attracted to human baits in Doi Inthanon National Park, northern Thailand. *Med. Entomol. Zool.*, 56: 335–348.
- Edwards, F. W. 1928. Diptera Nematocera from the federated Malay States Museums. *J. Federated Malay State Museum*, 14: 1–139.
- Fukuda, M., Choochote, W., Bain, O., Aoki, C. and Takaoka, H. 2003. Natural infections with filarial larvae in two species of black flies (Diptera: Simuliidae) in northern Thailand. *Jpn. J. Trop. Med. Hyg.*, 31: 99–102.
- Ishii, Y., Choochote, W., Bain, O., Fukuda, M., Otsuka, Y. and Takaoka, H. 2008. Seasonal and diurnal biting activities and zoonotic filarial infections of two *Simulium* species (Diptera: Simuliidae) in northern Thailand. *Parasite*, 15: 121–129.
- Jitklang, S. and Kuvangkadilok, C. 2007. A new species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) from southern Thailand, with description of its polytene chromosomes. *Stud. Dipterologica*, 14: 1–7.
- Jitklang, S., Kuvangkadilok, C., Baimai, V., Takaoka, H. and Adler, P. H. 2008. Cytogenetics and morphotaxonomy of the *Simulium* (*Gomphostilbia*) *ceylonicum* species group (Diptera: Simuliidae) in Thailand. *Zootaxa*, 1917: 1–28.
- Kuvangkadilok, C., Lualon, U. and Baimai, V. 2008. Cytotaxonomy of *Simulium siamense* Takaoka & Suzuki (Diptera: Simuliidae) in Thailand. *Genome*, 51: 972–987.
- Kuvangkadilok, C. and Takaoka, H. 2000. Taxonomic notes on Simuliidae (Diptera) from Thailand: Description of a new species and new distributional records of nine known species. *Jpn. J. Trop. Med. Hyg.*, 28: 167–175.
- Low, V. L., Takaoka, H., Pramual, P., Adler, P. H., Ya'cob, Z., Chen, C. D., Yotopranoto, S., Zaid, A., Hadi, U. K. and Sofian-Azirun, M. 2016. Three taxa in one: Cryptic diversity in the blackfly *Simulium nobile* (Diptera: Simuliidae) in South East Asia. *J. Med. Entomol.*, 53: 972–976.
- Otsuka, Y., Aoki, C., Choochote, W., De Las Llagas, L. and Takaoka, H. 2007. Phylogenetic analysis of three subgenera: *Asiosimulium*, *Daviesellum* and *Wallacellum*, of the genus *Simulium* s. l. endemic in the Oriental Region. *Med. Entomol. Zool.*, 58: 329–333.
- Pangjanda, S. and Pramual, P. 2017. Tests of conspecificity for closely related black fly (Diptera: Simuliidae) species of the *Simulium striatum* group in Thailand. *Zootaxa*, 4231: 421–430.
- Phayuhasena, S., Colgan, D. J., Kuvangkadilok, C., Pramual, P. and Baimai, V. 2010. Phylogenetic relationships among the black fly species (Diptera: Simuliidae) of Thailand based on multiple gene sequences. *Genetica*, 138: 633–648.
- Pramual, P. and Kuvangkadilok, C. 2012. Integrated cytogenetic, ecological, and DNA barcode study reveals cryptic diversity in *Simulium* (*Gomphostilbia*) *angulistylum* (Diptera: Simuliidae). *Genome*, 55: 1–12.
- Pramual, P. and Tangkawanit, U. 2008. A new species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) from Northeastern Thailand. *Med. Entomol. Zool.*, 59: 297–303.
- Pramual, P., Thaijarern, J., Sofian-Azirun, M., Ya'cob, Z., Hadi, U. K. and Takaoka, H. 2015. Cytogenetic and molecular evidence of additional cryptic diversity in high elevation black fly *Simulium feuerborni* (Diptera: Simuliidae) populations in Southeast Asia. *J. Med. Entomol.*, 52: 829–836.
- Pramual, P., Thaijarern, J. and Wongpakam, K. 2016. DNA barcoding of human-biting black flies (Diptera: Simuliidae) in Thailand. *Acta Trop.*, 164: 33–40.
- Pramual, P. and Wongpakam, K. 2011. Cytogenetics of *Simulium siamense* Takaoka and Suzuki, 1984 (Diptera: Simuliidae) in northern Thailand. *Aquat. Insects*, 33: 171–184.
- Pramual, P., Wongpakam, K. and Adler, P. H. 2011. Cryptic biodiversity and phylogenetic relationships revealed by DNA barcoding of Oriental black flies in the subgenus *Gomphostilbia* (Diptera: Simuliidae). *Genome*, 54: 1–9.
- Srisuka, W., Takaoka, H., Otsuka, Y., Fukuda, M., Thongsahuan, S., Choochote, W. and Saeung, A. 2015. Seasonal biodiversity of black flies (Diptera: Simuliidae) and evaluation of ecological

- factors influencing species distribution at Doi Pha Hom Pok National Park, Thailand. *Acta Trop.*, 149: 212–219.
- Srisuka, W., Takaoka, H., Otsuka, Y., Fukuda, M., Thongsahuan, S., Taai, K., Choochote, W. and Saeung, A. 2017. Biodiversity, seasonal abundance and distribution of black flies (Diptera: Simuliidae) in six different regions in Thailand. *Parasit. Vectors*, 10: 574.
- Summers, S. L. M. 1911. Notes from the Entomological Department of the London School of Tropical Medicine. No. II. Description of a new species of *Simulium* from the Siamese hills. *Ann. Mag. Nat. Hist.*, 8: 586–588.
- Takaoka, H. 2001. *Simulium* (*Simulium*) *weji* sp. nov. (Diptera: Simuliidae) from Thailand. *Jpn J. Trop. Med. Hyg.*, 29: 349–354.
- Takaoka, H. 2003. The Black Flies (Diptera: Simuliidae) of Sulawesi, Maluku and Irian Jaya. xxii + 581 pp., Kyushu University Press, Fukuoka, Japan.
- Takaoka, H. 2012. Morphotaxonomic revision of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) in the Oriental Region. *Zootaxa*, 3577: 1–42.
- Takaoka, H. 2017a. Speciation, faunal affinities and geographical dispersal of black flies (Diptera: Simuliidae) in the Oriental Region. *Acta Trop.*, 166: 234–240.
- Takaoka, H. 2017b. Morphotaxonomic revision of species-groups of *Simulium* (*Simulium*) (Diptera: Simuliidae) in the Oriental Region. *Zootaxa*, 4353: 425–446.
- Takaoka, H. and Adler, P. H. 1997. A new subgenus, *Simulium* (*Daviesellum*), and a new species, *S. (D.) courtneyi*, (Diptera: Simuliidae) from Thailand and Peninsular Malaysia. *Jpn J. Trop. Med. Hyg.*, 25: 17–27.
- Takaoka, H. and Choochote, W. 2002. Taxonomic notes on the *griseifrons* species-group in *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand: Descriptions of two new species and description of the male, pupa and larva of *S. (S.) digrammicum* Edwards. *Jpn J. Trop. Med. Hyg.*, 30: 115–132.
- Takaoka, H. and Choochote, W. 2004a. Two new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand. *Trop. Med. Health*, 32: 31–36.
- Takaoka, H. and Choochote, W. 2004b. A list of and keys to black flies (Diptera: Simuliidae) in Thailand. *Trop. Med. Health*, 32: 189–197.
- Takaoka, H. and Choochote, W. 2004c. Taxonomic notes on the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in Northern Thailand. *Trop. Med. Health*, 32: 311–327.
- Takaoka, H. and Choochote, W. 2005a. Two new species of *Simulium* (*Montisimulium*) (Diptera: Simuliidae) from Northern Thailand. *Med. Entomol. Zool.*, 56: 21–31.
- Takaoka, H. and Choochote, W. 2005b. A new subgenus and a new species of *Simulium* s. l. (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 56: 33–41.
- Takaoka, H. and Choochote, W. 2005c. A new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 56: 43–47.
- Takaoka, H. and Choochote, W. 2005d. Two new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 56: 99–110.
- Takaoka, H. and Choochote, W. 2005e. Two new species of *Simulium* Latreille (Diptera: Simuliidae) from northwestern Thailand. *Med. Entomol. Zool.*, 56: 123–133.
- Takaoka, H. and Choochote, W. 2005f. A new species of *Simulium* (*Simulium*) from northern Thailand (Diptera: Simuliidae). *Trop. Med. Health*, 33: 95–101.
- Takaoka, H. and Choochote, W. 2005g. Two new species of the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in northern Thailand. *Med. Entomol. Zool.*, 56: 219–235.
- Takaoka, H. and Choochote, W. 2005h. Two new species of *Simulium* (*Nevermannia*) (Diptera: Simuliidae) from northern Thailand. *Trop. Med. Health*, 33: 133–141.
- Takaoka, H. and Choochote, W. 2005i. Two new species of black flies (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 56: 319–334.
- Takaoka, H. and Choochote, W. 2005j. Discovery of two more new species of *Simulium* (*Montisimulium*) (Diptera: Simuliidae) in Doi Inthanon National Park, Chiang Mai, Thailand. *Trop. Med. Health*, 33: 209–215.
- Takaoka, H. and Choochote, W. 2006a. A new species of the subgenus *Simulium* (*Asiosimulium*) (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 57: 45–48.
- Takaoka, H. and Choochote, W. 2006b. A new species of *Simulium* (*Nevermannia*) from northern Thailand (Diptera: Simuliidae). *Med. Entomol. Zool.*, 57: 83–92.
- Takaoka, H. and Choochote, W. 2006c. A new species of the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in northern Thailand. *Med. Entomol. Zool.*, 57: 115–124.
- Takaoka, H. and Choochote, W. 2006d. A new species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 57: 229–233.
- Takaoka, H. and Choochote, W. 2007. A new species of the *multistriatum* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) from Northern Thailand. *Trop. Med. Health*, 35: 19–22.
- Takaoka, H., Choochote, W., Aoki, C., Fukuda, M. and Bain, O. 2003. Black flies (Diptera: Simuliidae) attracted to humans and water buffalos and natural infections with filarial larvae, probably *Onchocerca* sp., in northern Thailand. *Parasite*, 10: 3–8.
- Takaoka, H. and Davies, D. M. 1995. The Black Flies (Diptera: Simuliidae) of West Malaysia. viii + 175 pp., Kyushu University Press, Fukuoka, Japan.
- Takaoka, H. and Kuvangkadilok, C. 1999. Four new species of black flies (Diptera: Simuliidae) from Thailand. *Jpn J. Trop. Med. Hyg.*, 27: 497–509.
- Takaoka, H., Low, V. L., Srisuka, W., Ya'cob, Z. and Saeung, A. 2018a. Morphological and molecular evidence for multiple taxa in *Simulium parahiyangum* (Diptera: Simuliidae), a geographic generalist black fly in Southeast Asia. *J. Med. Entomol.*, 55: 1453–1463.
- Takaoka, H., Low, V. L., Tan, T. K., Ya'cob, Z., Sofian-Azirun, M., Chen, C. D., Lau, K. W. and Pham X. D. 2018b. A new black fly species of the *Simulium* (*Gomphostilbia*) *duolongum* subgroup (Diptera: Simuliidae) from Vietnam, and molecular comparisons with related species using the COI barcoding gene. *J. Med. Entomol.* (published on-line: doi: 10.1093/jme/tjy222)
- Takaoka, H., Otsuka, Y., Choochote, W., Aoki, C., Hayakawa, H. and Thongsahuan, S. 2010a. Descriptions of the male, pupa and larva of *Simulium* (*Gomphostilbia*) *novemarticulatum* (Diptera: Simuliidae) from Peninsular Malaysia and Thailand. *Med. Entomol. Zool.*, 61: 59–67.
- Takaoka, H., Otsuka, Y., Choochote, W. and Thongsahuan, S. 2009. Two new and one newly recorded species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) from southern Thailand. *Med. Entomol. Zool.*, 60: 259–268.
- Takaoka, H., Otsuka, Y., Choochote, W. and Thongsahuan, S. 2010b. A new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from southern Thailand. *Med. Entomol. Zool.*, 61: 17–29.
- Takaoka, H. and Saito, K. 1996. A new species and new records of black flies (Diptera: Simuliidae) from Thailand. *Jpn J. Trop. Med. Hyg.*, 24: 163–169.
- Takaoka, H., Sofian-Azirun, M., Ya'cob, Z., Chen, C. D., Lau, K. W. and Pham, X. D. 2015. The black flies (Diptera: Simuliidae) from Thua Thien Hue and Lam Dong Provinces, Vietnam. *Zootaxa*, 3961: 1–96.
- Takaoka, H., Sofian-Azirun, M., Ya'cob, Z., Chen, C. D., Lau, K. W.,

- Low, V. L., Pham, X. D. and Adler, P. H. 2017a. The black flies (Diptera: Simuliidae) of Vietnam. *Zootaxa*, 4261: 1–165.
- Takaoka, H. and Srisuka, W. 2009. *Simulium (Gomphostilbia) chiangdaoense* sp. nov. (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 60: 269–276.
- Takaoka, H. and Srisuka, W. 2010a. *Simulium (Nevermannia) vessabutrae*, a new black fly species (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 61: 97–104.
- Takaoka, H. and Srisuka, W. 2010b. Description of a new species of *Simulium (Montisimulium)* (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 61: 261–264.
- Takaoka, H. and Srisuka, W. 2010c. *Simulium (Gomphostilbia) chayamaritae*, a new species of black fly (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 61: 265–271.
- Takaoka, H. and Srisuka, W. 2010d. *Simulium (Nevermannia) wichaii*, a new species of black fly (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 61: 273–279.
- Takaoka, H. and Srisuka, W. 2011. A new species of *Simulium (Nevermannia)* (Diptera: Simuliidae) from Thailand, with keys to members of the *Simulium feuerborni* species-group in Thailand. *ZooKeys*, 89: 57–70.
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2017b. A new black fly species of the *Simulium (Gomphostilbia) epistum* species-group (Diptera: Simuliidae) from Thailand. *Acta Trop.*, 176: 373–379.
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2018c. A new species of the *Simulium (Simulium) striatum* species-group (Diptera: Simuliidae) from Thailand, and its differentiation from two related species based on a fast-evolving nuclear gene. *J. Med. Entomol.*, 55: 561–568.
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2018d. Five new species of the *Simulium decuplum* subgroup of the *Simulium (Gomphostilbia) batoense* species-group (Diptera: Simuliidae) from Thailand. *Acta Trop.*, 182: 271–284.
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2018e. A new species and a new record of the *Simulium (Gomphostilbia) gombakense* species-group (Diptera: Simuliidae) from Thailand. *Acta Trop.*, 185: 156–166.
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2018f. A new species of the *Simulium (Simulium) multistriatum* species-group (Diptera: Simuliidae) from Thailand and its phylogenetic relationships with related species. *J. Med. Entomol.*, (Published on line: doi: 10.1093/jme/tjy178).
- Takaoka, H., Srisuka, W., Low, V. L. and Saeung, A. 2018g. Morphological and molecular analyses of *Simulium rufibasis* Brunetti (Diptera: Simuliidae) in Thailand. *J. Med. Entomol.*, (Published on line: doi: 10.1093/jme/tjy180).
- Takaoka, H., Srisuka, W., Maleewang, W. and Saeung, A. 2018h. New record of 13 species of black flies (Diptera: Simuliidae) from Myanmar. *Acta Trop.*, 178: 281–289.
- Takaoka, H., Srisuka, W., Otsuka, Y. and Choochote, W. 2014a. A new species and species-group of *Simulium (Simulium)* (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 51: 725–732.
- Takaoka, H., Srisuka, W. and Saeung, A. 2017c. *Simulium maleewongae*, a new species of *Simulium (Gomphostilbia)* (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 54: 91–99.
- Takaoka, H., Srisuka, W. and Saeung, A. 2017d. A new human-biting black fly species of *Simulium (Simulium)* (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 54: 945–948.
- Takaoka, H., Srisuka, W. and Saeung, A. 2017e. Two new species of the *Simulium (Simulium) variegatum* species-group of black flies (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 54: 1213–1223.
- Takaoka, H., Srisuka, W. and Saeung, A. 2017f. A new black fly species of *Simulium (Gomphostilbia)* from Thailand. *J. Med. Entomol.*, 54: 1552–1559.
- Takaoka, H., Srisuka, W. and Saeung, A. 2018i. A new species of *Simulium (Asiosimulium)* (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 55: 569–574.
- Takaoka, H., Srisuka, W. and Saeung, A. 2019. A new species of the *Simulium variegatum* species-group (Diptera: Simuliidae) from Thailand. *Acta Trop.*, 191: 155–161.
- Takaoka, H., Srisuka, W., Saeung, A. and Choochote, W. 2013a. *Simulium (Asiosimulium) furvum*, a new species of black fly (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 50: 493–500.
- Takaoka, H., Srisuka, W., Saeung, A. and Choochote, W. 2014b. A new species of *Simulium (Gomphostilbia)* (Diptera: Simuliidae) from Thailand, with keys to 11 species of the *Simulium varicorne* species-group. *J. Med. Entomol.*, 51: 314–322.
- Takaoka, H., Srisuka, W., Saeung, A. and Otsuka, Y. 2014c. *Simulium (Simulium) lomkaoense*, a new species of black fly (Diptera: Simuliidae) from Thailand. *J. Med. Entomol.*, 51: 1109–1115.
- Takaoka, H., Srisuka, W., Saeung, A., Otsuka, Y., Aoki, C. and Choochote, W. 2010c. Taxonomic notes on *Simulium (Montisimulium) laoleense* and a close related new species (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 61: 363–374.
- Takaoka, H., Srisuka, W., Saeung, A., Otsuka, Y. and Choochote, W. 2012. *Simulium (Nevermannia) chomthongense*, a new species of black fly (Diptera: Simuliidae) from Chiang Mai, Thailand. *Trop. Biomed.*, 29: 381–390.
- Takaoka, H., Srisuka, W., Saeung, A., Otsuka, Y. and Choochote, W. 2013b. *Simulium (Nevermannia) khunklangense*, a new species of black fly (Diptera: Simuliidae) from Chiang Mai, Thailand. *Zootaxa*, 3694: 280–288.
- Takaoka, H. and Suzuki, H. 1984. The blackflies (Diptera: Simuliidae) from Thailand. *Jpn. J. Sanit. Zool.*, 35: 7–45.
- Takaoka, H., Yunus, M., Hadi, U. K., Sigit, S. H. and Miyagi, I. 2000. Preliminary report of faunistic surveys on black flies (Diptera: Simuliidae) in Sumatra, Indonesia. *Jpn J. Trop. Med. Hyg.*, 28: 157–166.
- Tangkawanit, U., Kuvangkadilok, C., Baimai, V. and Adler, P. H. 2009. Cytosystematics of the *Simulium tani* group (Diptera: Simuliidae) in Thailand. *Zool. J. Linn. Soc.*, 155: 289–315.
- Tangkawanit, U., Wongpakam, K. and Pramual, P. 2018. A new black fly (Diptera: Simuliidae) species of the subgenus *Asiosimulium* Takaoka & Choochote from Thailand. *Zootaxa*, 4388: 111–122.
- Thaijarern, J., Adler, P. H. and Pramual, P. 2018. Limited differentiation among black flies in the *Simulium multistriatum* species group (Diptera: Simuliidae) in Thailand: Cryptic species, homosequential species, and homosequential cryptic species. *Zool. J. Linn. Soc.*, 184: 1024–1054.
- Yacob, Z., Takaoka, H., Low, V. L. and Sofian-Azirun, M. 2017a. First description of a new cryptic species, *Simulium vanluni* from Peninsular Malaysia: An integrated morph-taxonomical and genetic approach for naming cryptic species in the Family Simuliidae. *Acta Trop.*, 165: 31–39.
- Yacob, Z., Takaoka, H., Low, V. L. and Sofian-Azirun, M. 2017b. Uncovering the mask of the *Simulium feuerborni* complex (Diptera: Simuliidae): description of *Simulium pairoti* sp. nov. from Malaysia based on integrative taxonomic evidence. *Acta Trop.*, 169: 133–141.