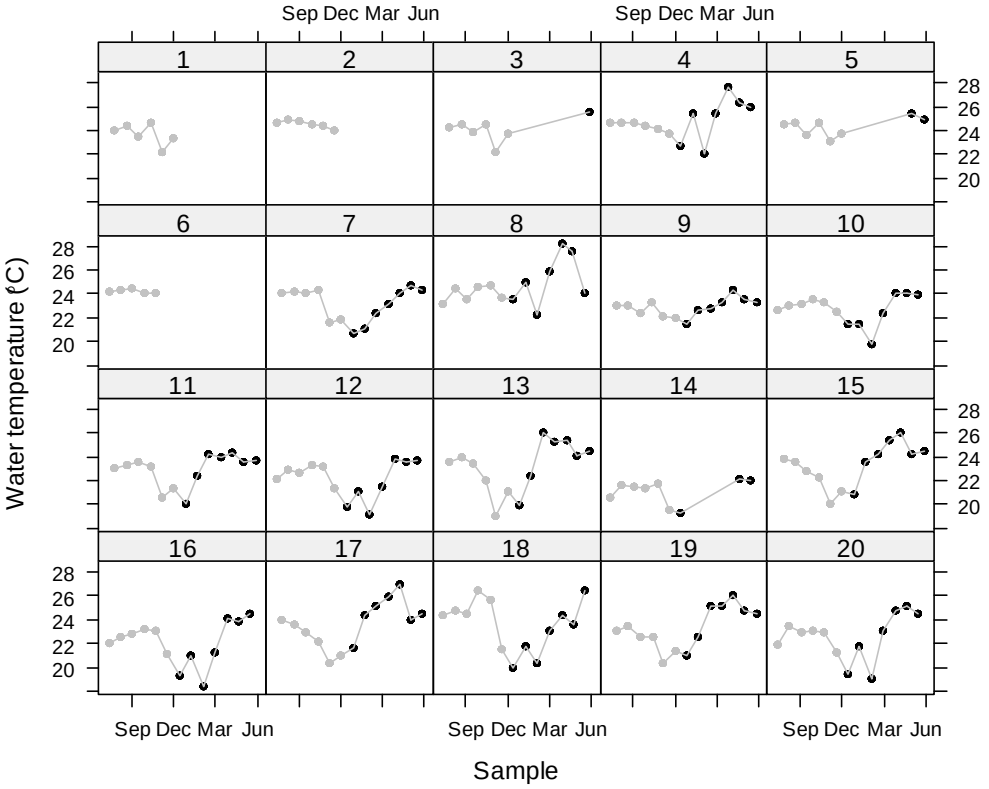

Figure 7 Water temperature of 20 collection sites at Khao National Park. Gray = 2000, Black = 2001

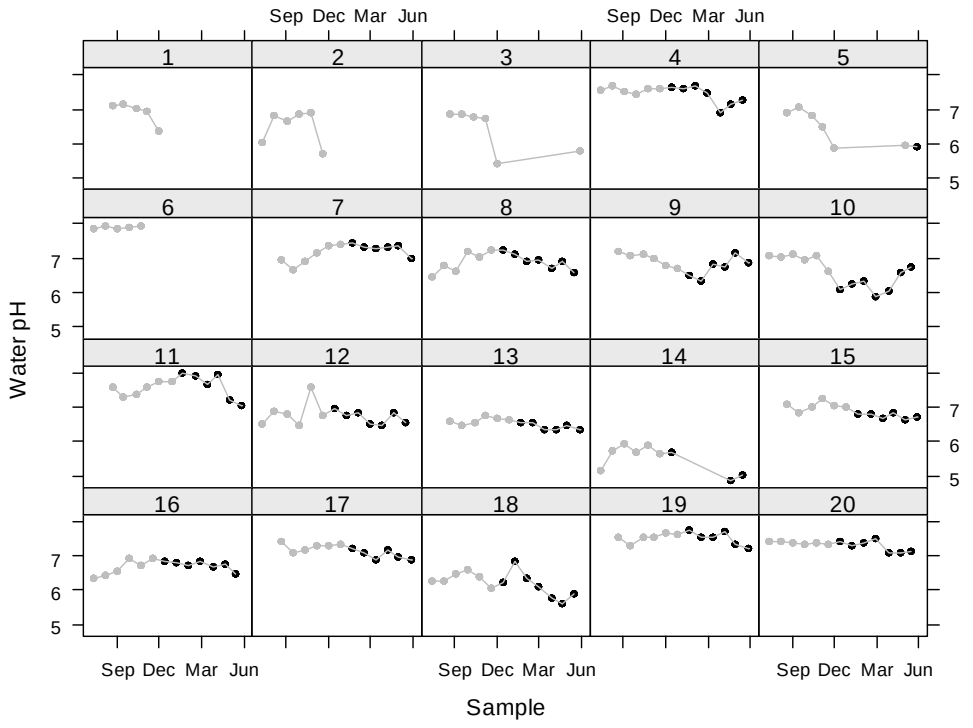

Figure 8 pH of 20 collection sites at Khao National Park. Gray = 2000, Black = 2001

Table 5 Measured physical variables correlation matrix (* = $p < 0.05$)

	Current velocity maximum	Current velocity minimum	Depth maximum	Depth minimum	Width maximum	Width minimum
Current velocity maximum	1.00					
Current velocity minimum	0.88*	1.00				
Depth maximum	0.42	0.56*	1.00			
Depth minimum	0.37	0.37	0.59*	1.00		
Width maximum	0.56*	0.69*	0.63*	0.35	1.00	
Width minimum	0.55*	0.65*	0.70*	0.38	0.58*	1.00

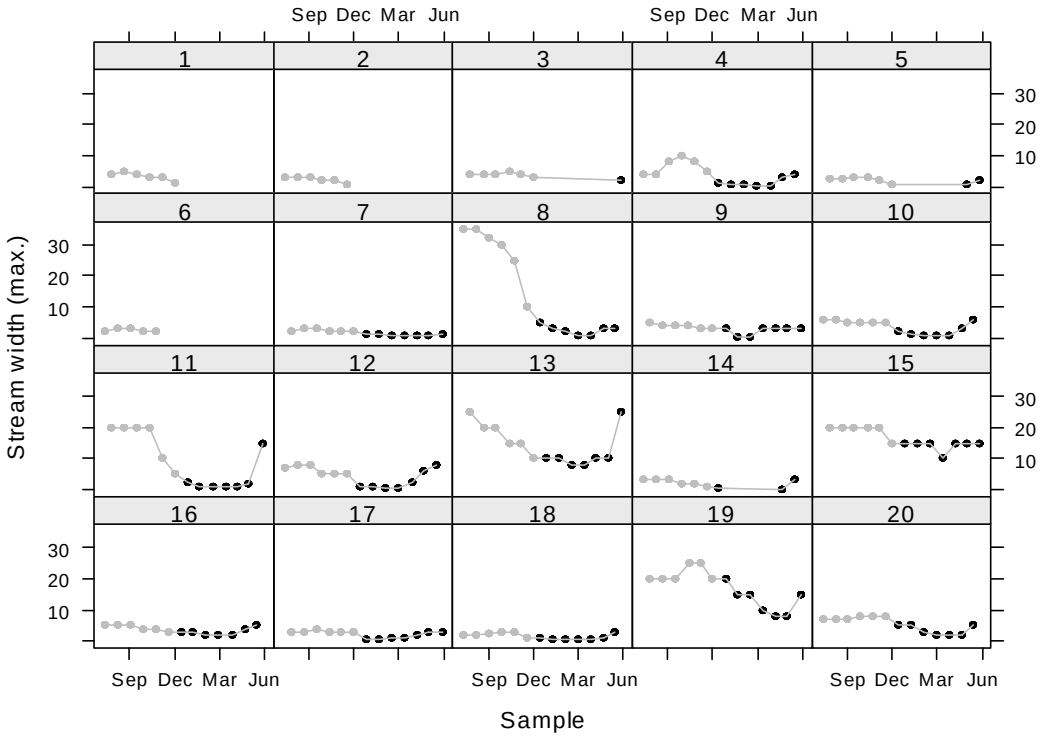

Figure 9 Stream width (max.) of 20 collection sites at Khao National Park. Grey = 2000, Black = 2001

2. Simuliid taxonomy and description

2.1 Summary and checklist of Simuliidae of Khao Yai National Park

Twenty-two species of black flies were collected during a 2000-2001 survey of 20 streams at Khao Yai National Park, Thailand. These 22 consist of 16 formally described species, including one newly recorded from Thailand (*Simulium novemarticulatum*), and 6 undescribed species (*S.* sp. A, *S.* sp. nr. *sheilae*, *S.* sp. B, *S.* sp. C, *S.* sp. D, and *S.* sp. E). Species belong to the subgenera *Gomphostilbia* Enderlein (12 spp.), *Nevermannia* Enderlein (1 sp.) and *Simulium* Latreille s.str. (9 spp.) of the genus *Simulium* Latreille s.l. The following analysis was based mostly on morphological characters of mature larvae and pupae.

Checklist of black flies of Khao Yai National Park

Genus *Simulium* Latreille s.l.

Subgenus *Gomphostilbia* Enderlein

(A) *batoense* species-group

1. *Simulium angulistylum* Takaoka and Davies, 1995
2. *Simulium decuplum* Takaoka and Davies, 1995
3. *Simulium dentistylum* Takaoka and Davies, 1995
4. *Simulium gombakense* Takaoka and Davies, 1995
5. *Simulium siamense* Takaoka and Suzuki, 1984
6. *Simulium* sp. A

(B) *ceylonicum* species-group

7. *Simulium asakoae* Takaoka and Davies, 1995
8. *Simulium sheilae* Takaoka and Davies, 1995
9. *Simulium* sp. nr. *sheilae* Takaoka and Davies, 1995

(C) *varicorne* species-group

10. *Simulium novemarticulatum* Takaoka and Davies, 1995

(D) ungrouped species

11. *Simulium* sp. B

12. *Simulium* sp. C

Subgenus *Nevermannia* Enderlein

(A) *feuerborni* species-group

13. *Simulium feuerborni* Edwards, 1934

Subgenus *Simulium* Latreille s. str.

(A) *griseifrons* species-group

14. *Simulium grossifilum* Takaoka and Davies, 1995

15. *Simulium rudnicki* Takaoka and Davies, 1995

(B) *multistriatum* species-group

16. *Simulium chainarongi* Kuvangkadilok and Takaoka, 1999

17. *Simulium fenestratun* Edwards, 1934

(C) *striatum* species-group

18. *Simulium nakhonense* Takaoka and Suzuki, 1984

19. *Simulium quinquestriatum* (Shiraki, 1935)

(D) *tuberosum* species-group

20. *Simulium tani* Takaoka and Davies, 1995

(E) ungrouped species

21. *Simulium* sp. D

22. *Simulium* sp. E

2.2 Keys to the species of Simuliidae of Khao Yai National Park

Only one genus, *Simulium* Latreille was found in this study. This genus is distinguished from other genera by the following character: adult antenna with 7-9 flagellomeres; anterior wing veins with spinules as well as hairs, radial sector not forked; hind basitarsus with well-developed calcipala, and second segment of hind tarsus with distinct pedisulcus; hypogynial valves short, not longer than wide; pupa with cocoon wall-pocket-, shoe-, or boot-shaped; larva with hypostomal teeth rather low, median tooth not trifid, and anal sclerite with posterior arms subequal to, or longer than, anterior ones (Davies and Györkös, 1987; Takaoka and Davies, 1995; Takaoka and Davies, 1996).

Keys to subgenera of Simuliidae were given by Takaoka and Davies (1995, 1996) and Takaoka and Choochote (2004b).

Mature larvae

1. Last abdominal segment without ventral papillae or with small ventrolateral tubercles……..……...2

1'. Last abdominal segment with a pair of ventral papillae……...10

2(1). Abdominal segments I-VI (or up to VIII) each with a pair of protuberances dorsally or dorsolaterally…….……...3

2'. Abdominal segments without any protuberances……...……...5

3(2). Abdominal segments I-VI each with a pair of protuberances dorsolaterally……*chainarongi*

3'. Abdominal segments I-VIII each with a pair of protuberances dorsally ……4

4(3'). Gill histoblast with coiled filaments, somewhat inflated filaments at base (Figure 61B), arranged in groups of 2+2+ 2+2+2 from dorsal to ventral in pharate pupal gill…….……..*nakhonense*

4'. Gill histoblast with coiled filaments, not inflated filaments at base (Figure 65B), arranged in groups of 2+3+3+2 from dorsal to ventral in pharate pupal gill…….……..….*quinquestriatum*

5(2'). Pharate pupal gill with 6 filaments……..……..6

5'. Pharate pupal gill with 8 or more filaments …….…….8

6(5). Pharate pupal gill with 6 inflated tubular filaments…....….*grossifilum*

6'. Pharate pupal gill with 6 thread-like filaments……..……7

7(6'). Body color reddish brown; cephalic apotome pale yellow……..…..*tani*

7'. Body color dark grey; cephalic apotome dark brown .……...*rudnicki*

8(5'). Postgenal cleft moderately widened medially, its greatest width much larger than the wide at base (Figure 57D); pharate pupal gill with 8 filaments……..……..……*fenestratum*

8'. Postgenal cleft very long; pharate pupal gill with 19 or 27-34 filaments…….9

9(8'). Pharate pupal gill with 19 filaments; mandibular serrations composed of 1 well developed and 1 small teeth and with supernumerary serrations on each side (Figure 73F)……...…….sp. D

9'. Pharate pupal gill with 27-34 filaments; mandibular serrations composed of 1 well developed and 1 small teeth and without supernumerary serrations on each side (Figure 75F)……..…….sp. E

10(1'). Postgenal cleft shorter than postgenal bridge (Figure 48D); lateral serrations of hypostomium well developed; abdomen with characteristic reddish brown markings dorsally (Figure 48A) ..……..…….....*feuerborni*

10'. Postgenal cleft variable length, subequal or longer than postgenal bridge; lateral serrations of hypostomium weakly developed or absent; abdomen without such colored marking dorsally.…….…...11

11(10'). Postgenal cleft subequal to postgenal bridge (Figure 30C)…….*asakoae*

11'. Postgenal cleft longer than postgenal bridge……...…….12

12(11'). Abdominal segments I-V each with a pair of small dorsolateral protuberances…….…...13

12'. Abdominal segments I-V each without any protuberances…...……...14

13(12). Thoracic segment III and abdominal segments I-IV each with a pair of small dorsolateral protuberances; thoracic cuticle bare dorsally …….…..……..….*novemarticulatum*

13'. Thoracic segment III without protuberances and abdominal segments II-V each with a pair of small dorsolateral protuberances; thoracic cuticle sparsely covered thick, dark, unbranched and 2 or 3 branched setae dorsally……..……...……..….sp. B

14(12'). Abdomen distinctly constricted between segments IV and V, with a cluster of dark setae on the frontolateral surface of segment V (Figure 18D)..……..……...*dentistylum*

14'. Abdomen not constricted between segments IV and V, without a cluster of dark seate on the frontolateral surface of segment V……...15

15(14'). Abdominal cuticle almost bare dorsally……...16

15'. Abdominal cuticle sparsely to densely covered with unbranched or branched dark setae dorsally on segments V-VIII……...17

16(15). Gill histoblast with broad, somewhat inflated structure, filaments not coiled (Figure 20B); cephalic apotome pale with positive head spots…...……...*gombakense*

16'. Gill histoblast with short basal common stalk and stalk of upper triplet, filaments coiled (Figure 47B); cephalic apotome brownish yellow with distinct positive head spots (Figure 47C)...…….....sp. C

17(15'). Thoracic cuticle sparsely or moderately covered with branched dark setae dorsally…….……...18

17'. Thoracic cuticle bare……...…….19

18(17). Pharate pupal gill with 8 filaments……...…….*siamense*

18'. Pharate pupal gill with 10 filaments…….*decuplum*

19(17'). Minute dark setae on abdominal segments V-VIII somewhat flat and stout basally, scalelike setae with 3-6 branches (Figure 26D).…….sp. A

19'. Minute dark setae on abdominal segments V-VIII slender and hair-like basally, with long branches apically..……...……...…….20

20(19'). Gill histoblast with very short-stalked, three pairs of coiled filaments (Figure 10G); abdomen densely covered with minute seate branching into 5-12 slender hairs dorsally on segments V-VIII (Figure 10D) ……...……..……...*angulistylum*

20'. Gill histoblast with short basal common stalk and stalk of upper triplet, coiled filaments (Figures 30I, 34G, 38I), abdomen sparsely or densely covered with minute unbranched setae and branching into 2-6 slender hairs dorsally on segments V-VIII..…….21

21(20'). Postgenal cleft 3X as long as postgenal bridge (Figures 30G, 38C); abdomen sparsely covered with minute unbranched setae and branching into 2 or 3 slender hairs dorsally on segments V-VIII (Figures 30E, 38E)…….……...….*asakoae* and sp. nr. *sheilae*

21'. Postgenal cleft nearly approaching posterior margin of hypostomium; abdomen sparsely or densely covered with minute unbranched setae and branching into 2-6 slender hairs dorsally on segments V-VIII.....22

22(21'). Abdominal cuticle sparsely covered with minute unbranched setae and branching into 2 or 3 slender hairs dorsally on segments V-VIII (Figure 38E)…...……...…..……..…….sp. nr. *sheilae*

22'. Abdominal cuticle densely covered with minute setae branching into 2-6 slender hairs dorsally on segments V-VIII (Figure 34D).…….*sheilae*

Pupae

1. Each gill of inflated form……..…….2

1'. Each gill filamentous……...……...3

2(1). Gill markedly inflated at base, with 2 triplet groups of finger-like projection and 8 slender filaments (Figure 21B); dorsal spine-combs present on abdominal segments VI-VIII……..……*gombakense*

2'. Gill with 6 inflated filaments (Figure 52D); dorsal spine-combs present on abdominal segments VIII-IX.……*grossifilum*

3(1'). Gill with 6 filaments…….……..……4

3'. Gill with 8 or more filaments……...…….…….6

4(3). All filaments extending forward close together, 4 dorsal filaments and 2 ventral filaments, latter with rather long stalk (Figure 49B); cocoon wall-pocket-shaped with anterodorsal projection (Figure 49A) ..……..….*feuerborni*

4'. Gill filaments arranged in pairs; cocoon wall-pocket-shaped without anterodorsal projection…...……...…….5

5(4'). Gill filaments almost sessile (Figure 55B); dorsal spine-combs present only on abdominal segment VIII; cocoon with an anterolateral window on each side (Figure 55A)……...……..…..…...….*rudnicki*

5'. Gill filaments short-stalked (Figure 70F); dorsal spine-combs present on abdominal segments VII-IX; cocoon without lateral windows….*tani*

6(3'). Gill with 8 filaments……...7

6'. Gill with 10 or more filaments……...……..16

7(6). Gill filaments arranged in pairs……...……...8

7'. Gill filaments otherwise……...……..9

8(7). Cocoon wall-pocket-shaped with an anterolateral window on each side (Figure 58B)…….…..…*fenestratum*

8'. Cocoon shoe-shaped without lateral windows……...…...*chainarongi*

9(7'). Gill filaments arranged in groups of 2+1+3+2 from dorsal to ventral (Figure 19B); antennal sheath with tubercles……....*dentistylum*

9'. Gill filaments arranged in groups of 3+3+2 from dorsal to ventral; antennal sheath smooth……...…….……10

10(9'). Gill filaments all shorter than pupal body, short-stalked (Figure 11E)……..*angulistylum*

10'. Gill filaments subequal to, or longer than pupal body, moderately-stalked……...11

11(10'). Dorsal and middle triplet groups and ventral pair group arising, basally at the same level……..……..……...12

11'. Dorsal and middle triplet groups sharing a short stalk, which arises with a stalk of ventral pair group, from short common basal stalk…..13

12(11). Dorsal spine-combs present on abdominal segments VI-IX.…*siamense*

12'. Dorsal spine-combs present on abdominal segments VI-VIII…… ……..*novemarticulatum*

13(11'). Dorsal and middle triplet groups composed of 1 individual filament and 2 paired filaments with long stalk (Figure 27E)…...…….....…sp. A

13'. Dorsal and middle triplet groups composed of 1 individual filament and 2 paired filaments with a short or medium stalk……..…….14

14(13'). Terminal hooks plate-like (Figure 39B)…… sp. nr. *sheilae*

14'. Terminal hooks irregular triangle-shape……...……...15

15(14'). Terminal hooks distinct large (Figure 35B), weakly undulate on outer margin ……..……...…*sheilae*

15'. Terminal hooks moderate (Figure 31B), weakly serrate on outer margin…….……..……..…...…..…*asakoae*

16(6'). Gill with 10 filaments……...……17

16'. Gill with 19 or 27-34 filaments……...…….19

17(16). Cocoon simple wall-pocket-shaped; gill filaments arranged in groups of 4 (or 3+1)+4+2 from dorsal to ventral (Figure 15E)……....*decuplum*

17'. Cocoon shoe-shaped; gill filaments otherwise……...……..18

18(17'). Gill filaments arranged in groups of 2+3+3+2 from dorsal to ventral (Figure 66F); all filaments subequal in thickness to one another; cocoon shoe-shaped with high neck (Figure 66B)…….*quinquestriatum*

18'. Gill filaments arranged in pairs, upper 5 or 6 filaments inflated at base while others slender (Figure 62F); cocoon shoe-shaped with low neck (Figure 62B)..……..…..*nakhonense*

19(16'). Gill with 19 filaments (Figure 74C)..……...…….....sp. D

19'. Gill with 27-34 filaments (Figure 76B)..……...……...sp. E

2.3 Descriptions of species and ecology of the aquatic stages

In this study, morphological features were identified and formed the basis for taxonomic keys based on mature larvae and pupae. However, confirmation of identification of some species required adult stages. Characters used in larval taxonomy included the shape of the body, the general ground-color of the head capsule, the shape and relative size of the postgenal cleft, mandibles, hypostomium and gill histoblast. Characters of pupal taxonomy included the number and the branching configuration of gill filaments, the shape and texture of the cocoon, the surface texture of head integument in the pupal exuviae, the form and disposition of abdominal spines and hooks, and the size and shape of terminal hooks. Adult taxonomic characters included features of genitalia, antenna, maxillary palp, claws, and the shape and color pattern of legs. Photographic images of morphological characters were obtained directly from specimens used in the construction of keys.

Subgenus *Gomphostilbia* Enderlein

(A) *batoense* species-group

1. *Simulium* (*Gomphostilbia*) *angulistylum* Takaoka and Davies, 1995

(Figures 10, 11, 12, 13)

Simulium (*Gomphostilbia*) *angulistylum* Takaoka and Davies, 1995: 42-46 (female, male, pupa, and mature larva).

Description.

Larva (Figure 10). See Takaoka and Davies (1995).

Pupa (Figure 11). See Takaoka and Davies (1995).

Female (Figure 12). See Takaoka and Davies (1995).

Male (Figure 13). See Takaoka and Davies (1995).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 2.3 km. above S gate, 14°14’N 101°23’E; Creek 3.0 km. above S gate, 14°14’N 101° 23’E; Creek 3.2 km. above S gate, 14°14’N 101°23’E; Than Rattana Waterfall, 14° 14’N 101°23’E; Creek 5.3 km. above S gate, 14°15’N 101°23’E; Creek 6.0 km. above

S gate, 14°15'N 101°23'E; Creek under wood bridge at Haew Narok Waterfall, 14° 17'N 101°23'E; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101° 23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Creek 29 km. above S gate at Khao Kheow, 14°22'N 101°24'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14° 25'N 101°24'E; Creek 1.3 km. up Haew Suwat Waterfall Rd., 14°24'N 101°22'E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26'N 101°25'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14°25'N 101°25'E.

Ecological notes. This species occurred in all seasons. Pupae and larvae were collected from fallen leaves, trailing grasses, leaves and roots, rocks and sticks, in streams of various width (0.15-35 m.) and flow velocity (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded in natural forest. Half of inhabited streams were ephemeral, lacking flowing water for 1-8 months during the survey. When the water level in streams was low and dried up, this species was absent. Altitudes, water temperatures, and pH for collection sites ranged from 188-952 m, 18.4-26.4 °C, and 5.04-7.95, respectively. This species was found with *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, *S.* (*G.*) *gombakense*, *S.* (*G.*) *novemarticulatum*, *S.* (*G.*) sp. B, *S.* (*G.*) sp. C, *S.* (*N.*) *feuerborni*, *S.* (*S.*) *grossifilum*, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, *S.* (*S.*) *tani*, *S.* (*S.*) sp. D, and *S.* (*S.*) sp. E.

Remarks. This species was originally described based on the female, male, pupa, and mature larva from West Malaysia (Takaoka and Davies, 1995). The pupal gill has eight short, slender filaments arranged in groups of 3 + 3 + 2 from dorsal to ventral. Larva can be identified by the presence of delicate setae with 5-12 (mostly 8-10) branches on abdominal segments V-VIII.

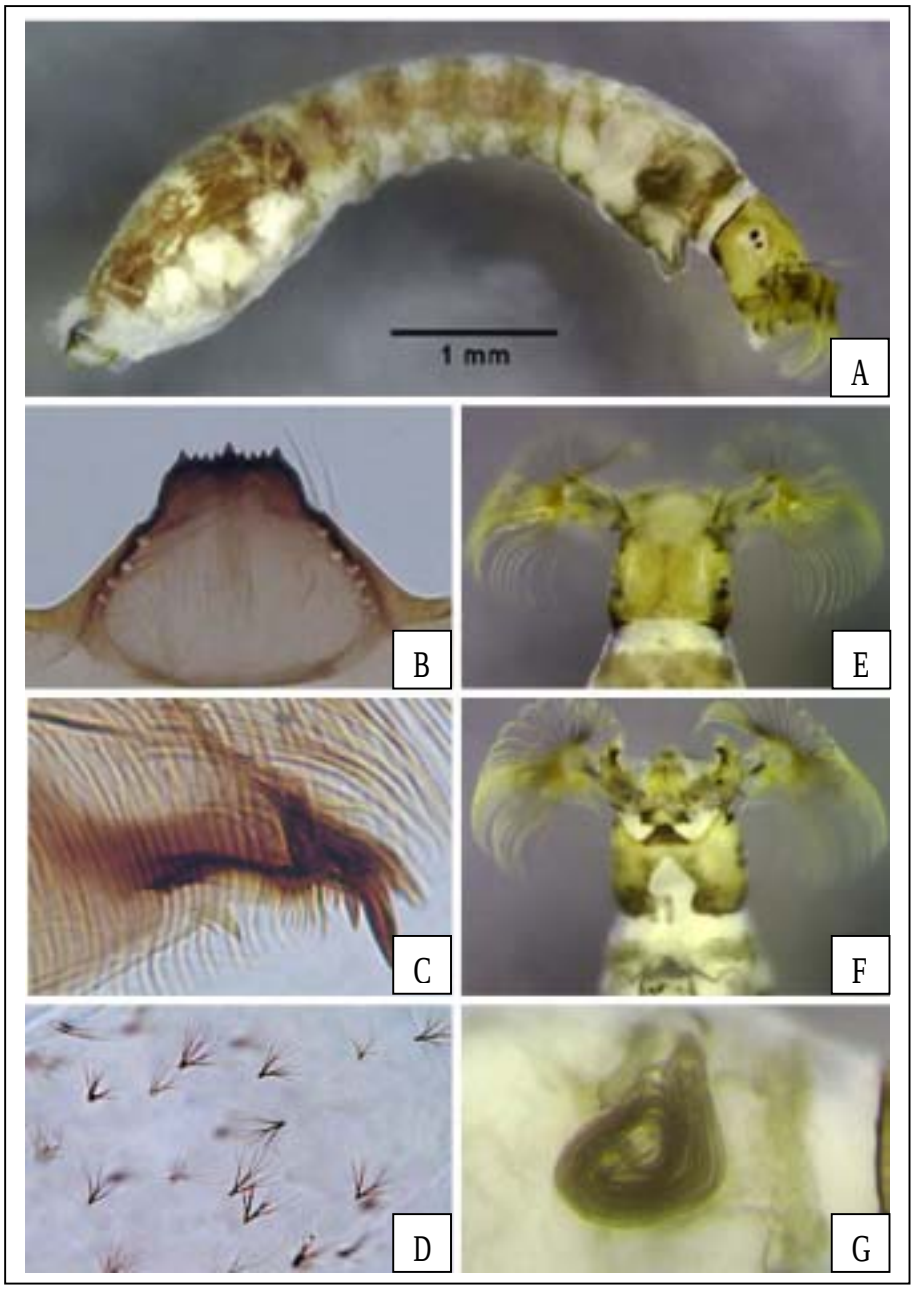

Figure 10 Larval structures of *Simulium angulistylum*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

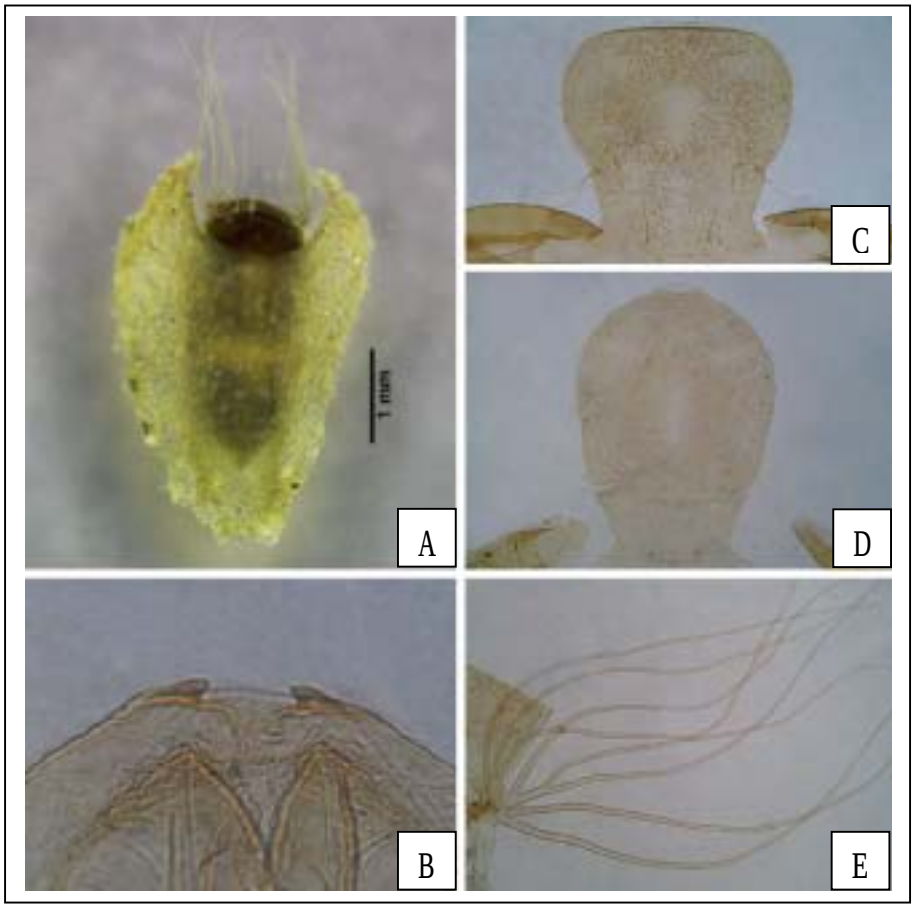

Figure 11 Pupal structures of *Simulium angulistylum*. A, dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

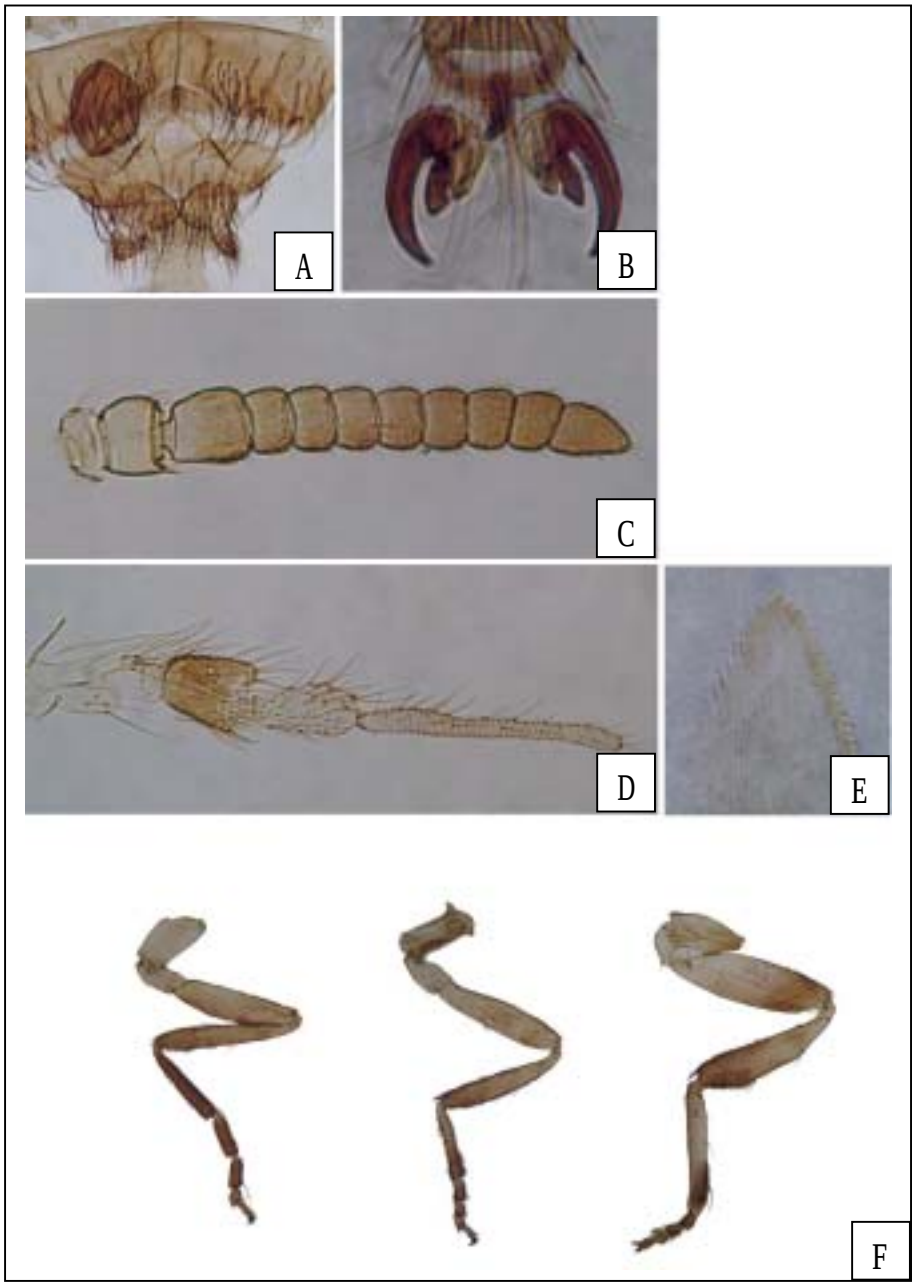

Figure 12 Adult structures of *Simulium angulistylum* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

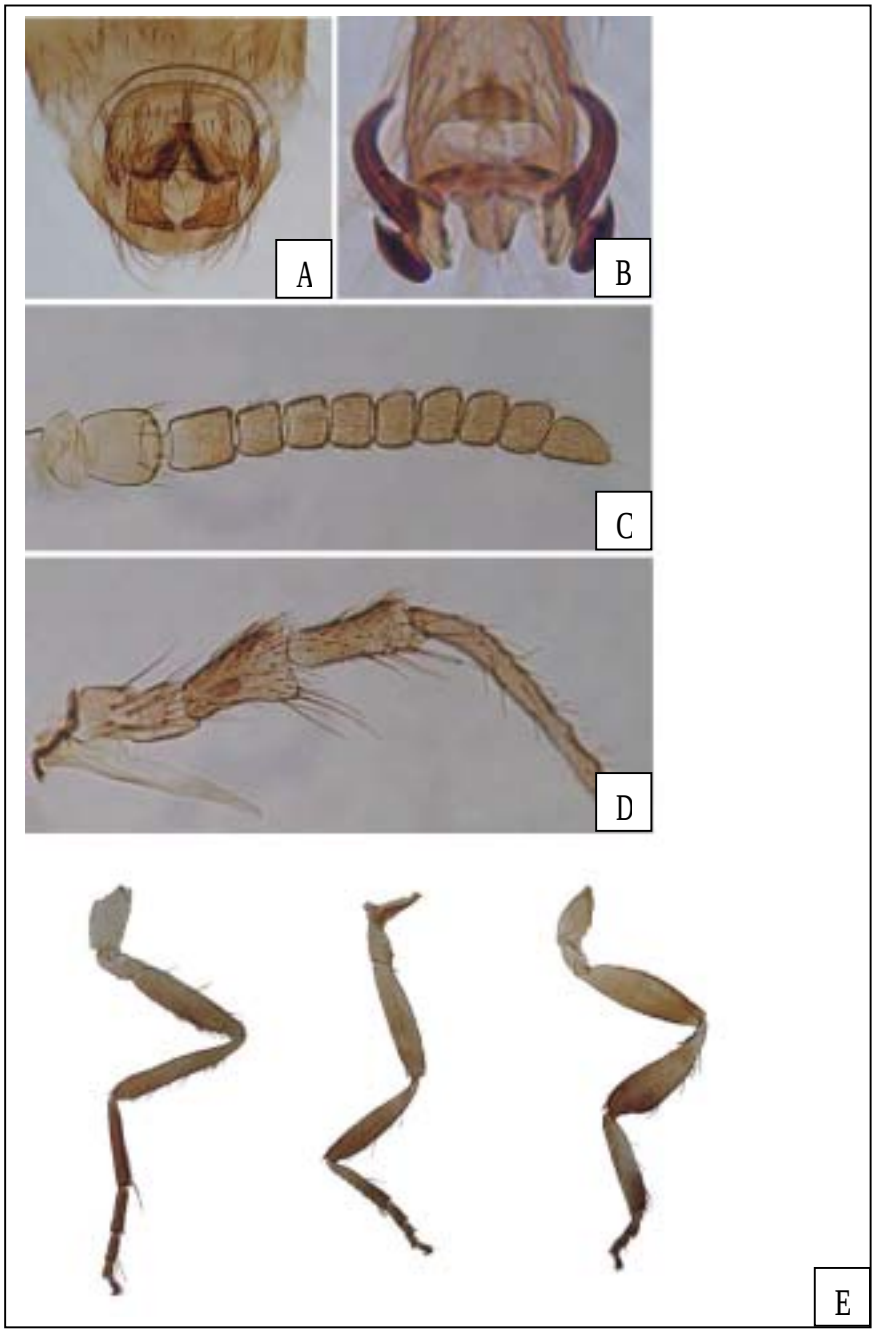

Figure 13 Adult structures of *Simulium angulistylum* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

2. *Simulium* (*Gomphostilbia*) *decuplum* Takaoka and Davies, 1995

(Figures 14, 15, 16, 17)

Simulium (*Gomphostilbia*) *decuplum* Takaoka and Davies, 1995: 46-50 (female, pupa, and mature larva).

Description.

Larva (Figure 14). See Takaoka and Davies (1995).

Pupa (Figure 15). See Takaoka and Davies (1995).

Female (Figure 16). See Takaoka and Davies (1995).

Male (Figure 17). No description.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 3.0 km. above S gate, 14°14'N 101°23'E; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14° 19'N 101°21'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14°25'N 101° 25'E.

Ecological notes. This species was most abundant in the cold season (November 2000-January 2001). Pupae and larvae were collected from fallen leaves, trailing grasses and leaves in small to large streams (0.15-20 m width) with slow to fast flowing water (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 199-751 m, 18.4-24.5 °C, and 6.01-7.75, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, *S.* (*G.*) *novemarticulatum*, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, and *S.* (*S.*) *tani*.

Remarks. *Simulium* (*G.*) *decuplum* was described from the female, pupa and mature larva from West Malaysia (Takaoka and Davies, 1995). The pupa is recognized by 10 gill filaments are slender, short, and arranged in groups of 4 (or 3+1) + 4 + 2 from dorsal to ventral. The larva has a deep postgenal cleft almost reaching the posterior border of the hypostoma and abdominal cuticle bearing dark setae with 10-14 branches.

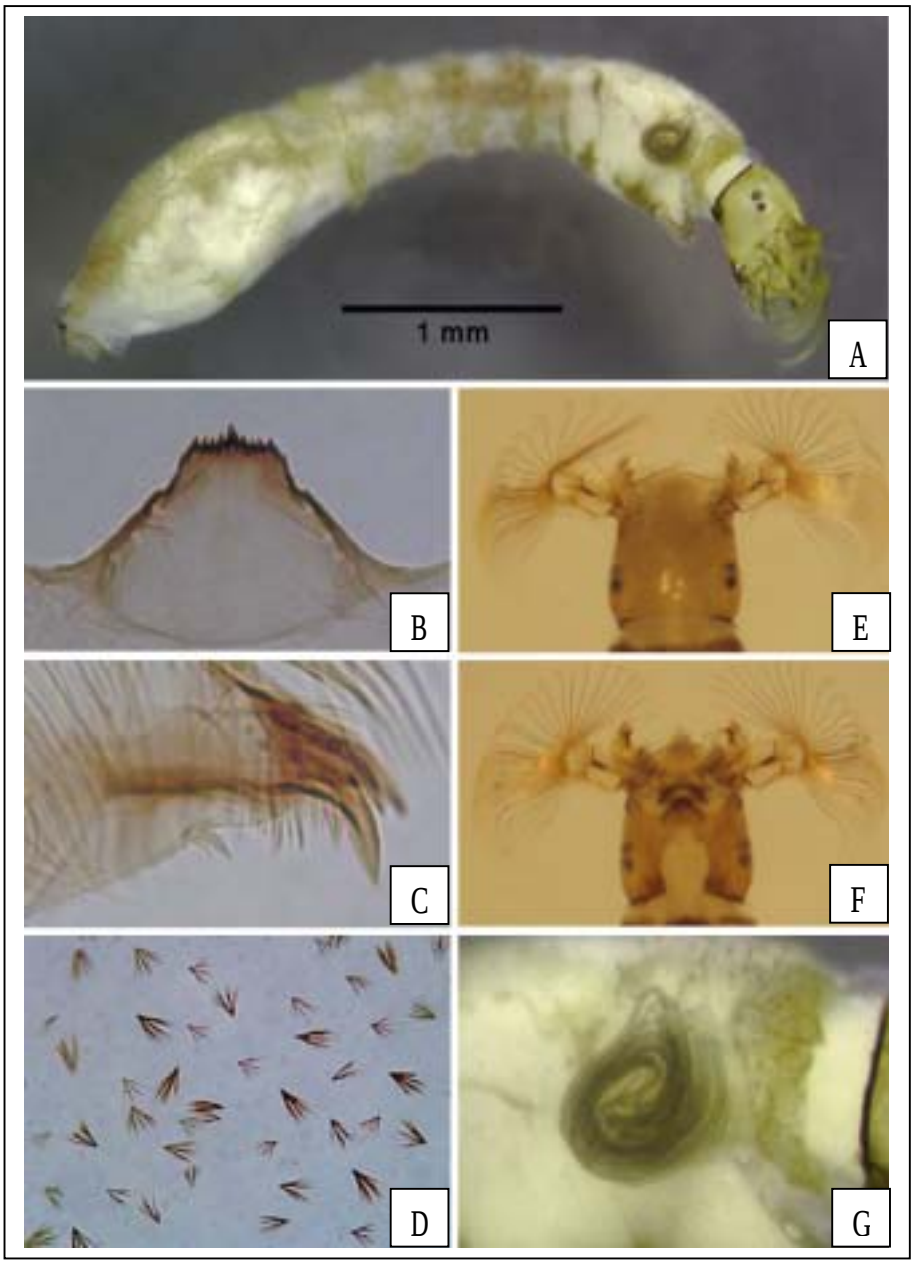

Figure 14 Larval structures of *Simulium decuplum*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

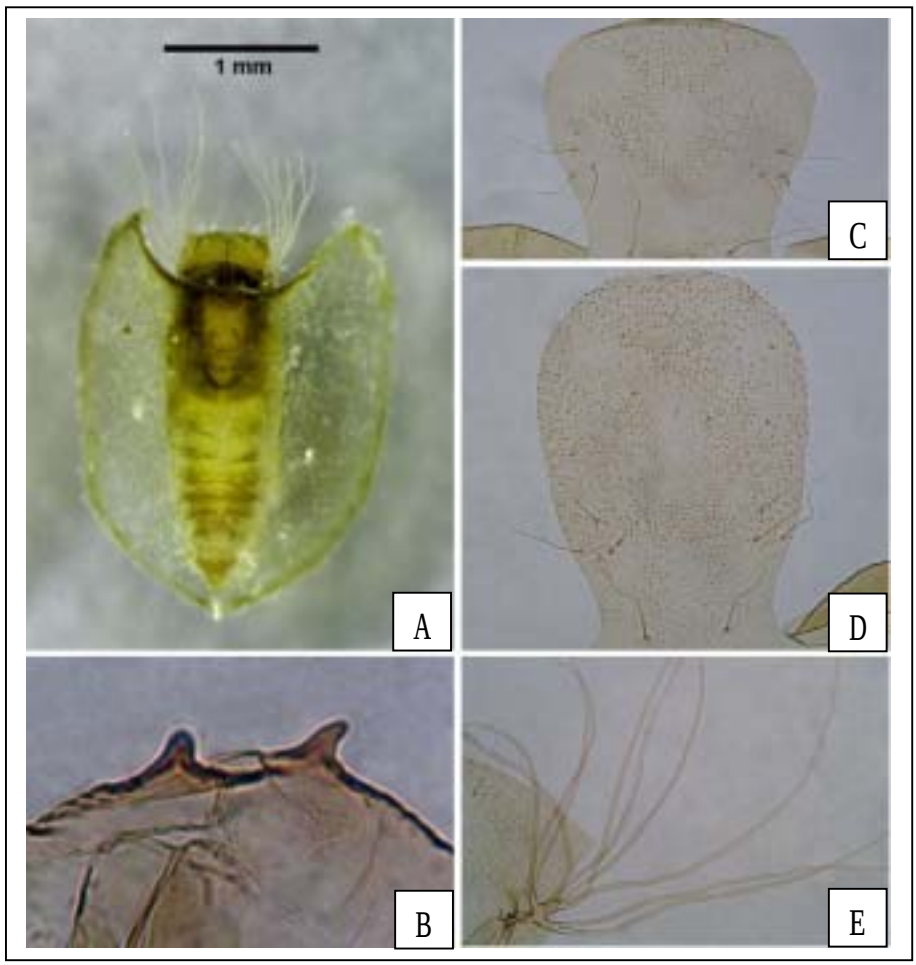

Figure 15 Pupal structures of *Simulium decuplum*. A, dorsal view; B, terminal hooks; C, D: head integument in front view, C, female, D, male, E, gill filaments

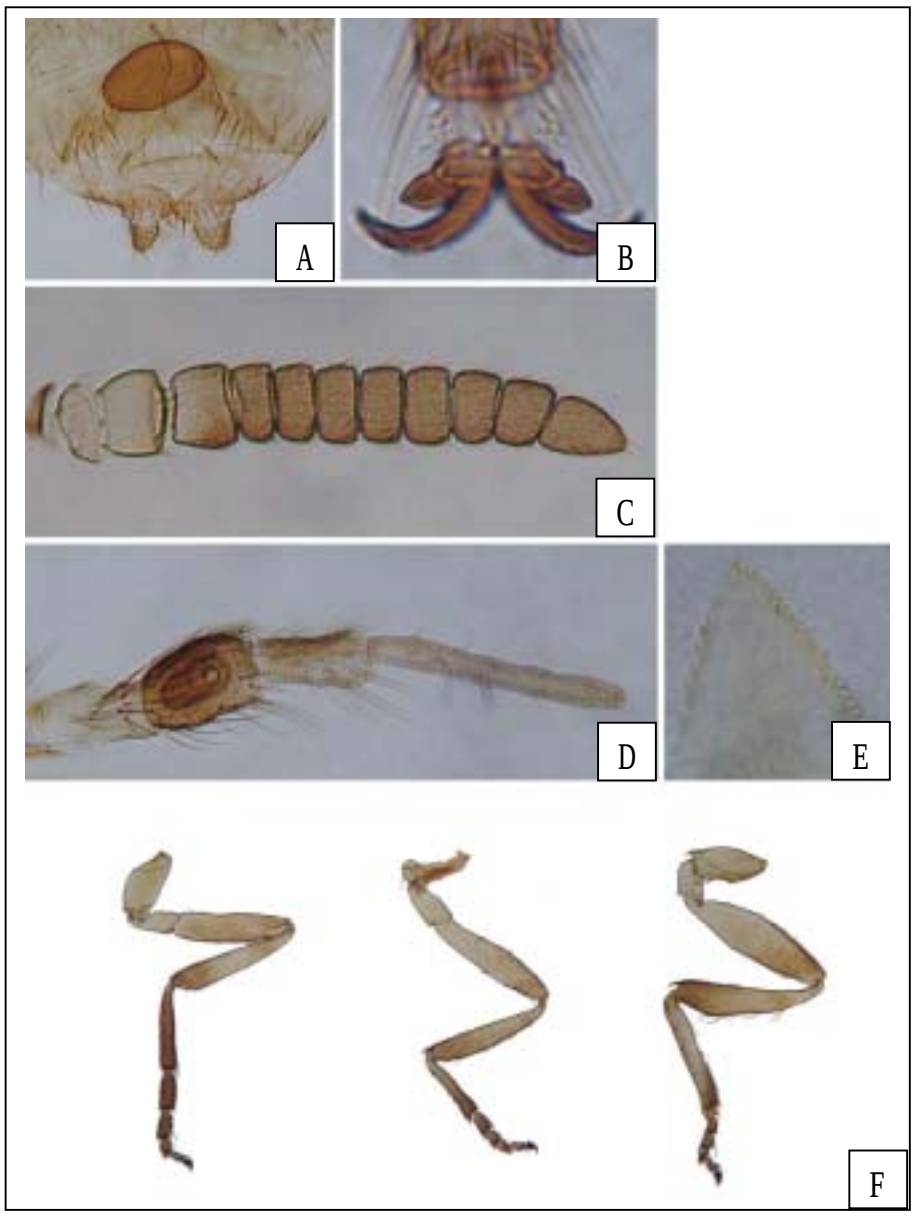

Figure 16 Adult structures of *Simulium decuplum* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

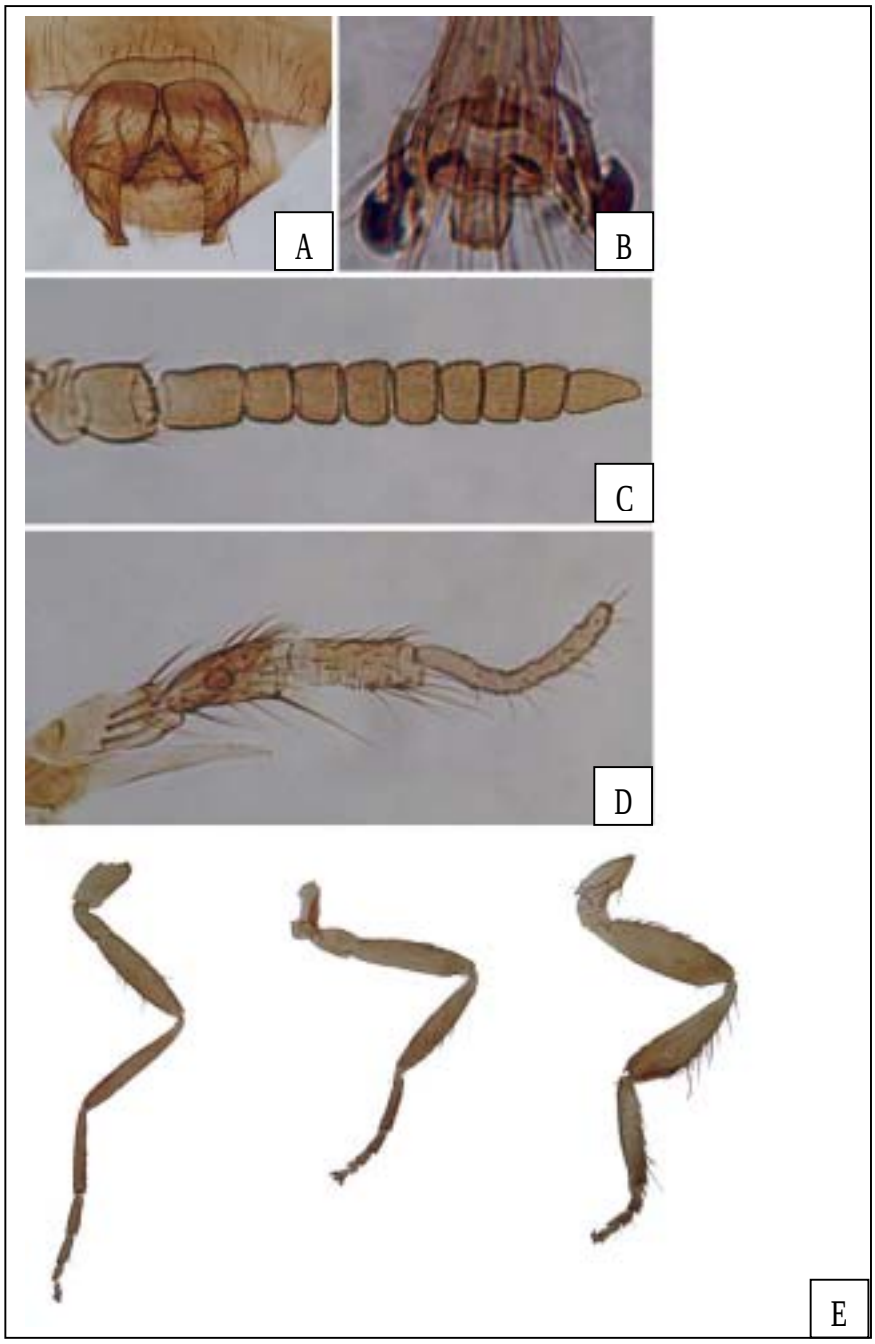

Figure 17 Adult structures of *Simulium decuplum* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

3. *Simulium* (*Gomphostilbia*) *dentistylum* Takaoka and Davies, 1995

(Figures 18, 19)

Simulium dentistylum Takaoka and Davies, 1995: 51-55 (male, pupa, and mature larva).

Description.

Larva (Figure 18). See Takaoka and Davies (1995).

Pupa (Figure 19). See Takaoka and Davies (1995).

Female. Unknown.

Male. See Takaoka and Davies (1995).

Collection site. Thailand. Nakhon Ratchasima, Khao Yai National Park; Tad Tapoo creek, 14°24'N 101°22'E.

Ecological notes. This species was found in the cold season (November 2000-February 2001). Pupae and larvae were collected from fallen leaves and trailing roots at only site 16, a small shaded stream (1-4 m width) with slow to moderately flowing water (0.1-0.8 m s^{-1}) in natural forest. Altitude at this site is 744 m. Water temperatures and pH for collection sites ranged from 19.3-23.1 °C, and 6.72-6.85, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *ceylonicum* species-group, *S.* (*S.*) *fenestratum*, and *S.* (*S.*) *tani*.

Remarks. This species was described based on male, pupa, and mature larval specimens from West Malaysia (Takaoka and Davies, 1995). Pupa is recognized by the eight short, slender gill filaments are arranged in groups of 2 + 1 + 3 + 2 from dorsal to ventral. The larva is characterized by a deep postgenal cleft; a marked constriction between abdominal segments IV and V; and both flat, scalelike setae and dark, unbranched or bifurcated setae on the cuticle of abdominal segment V.

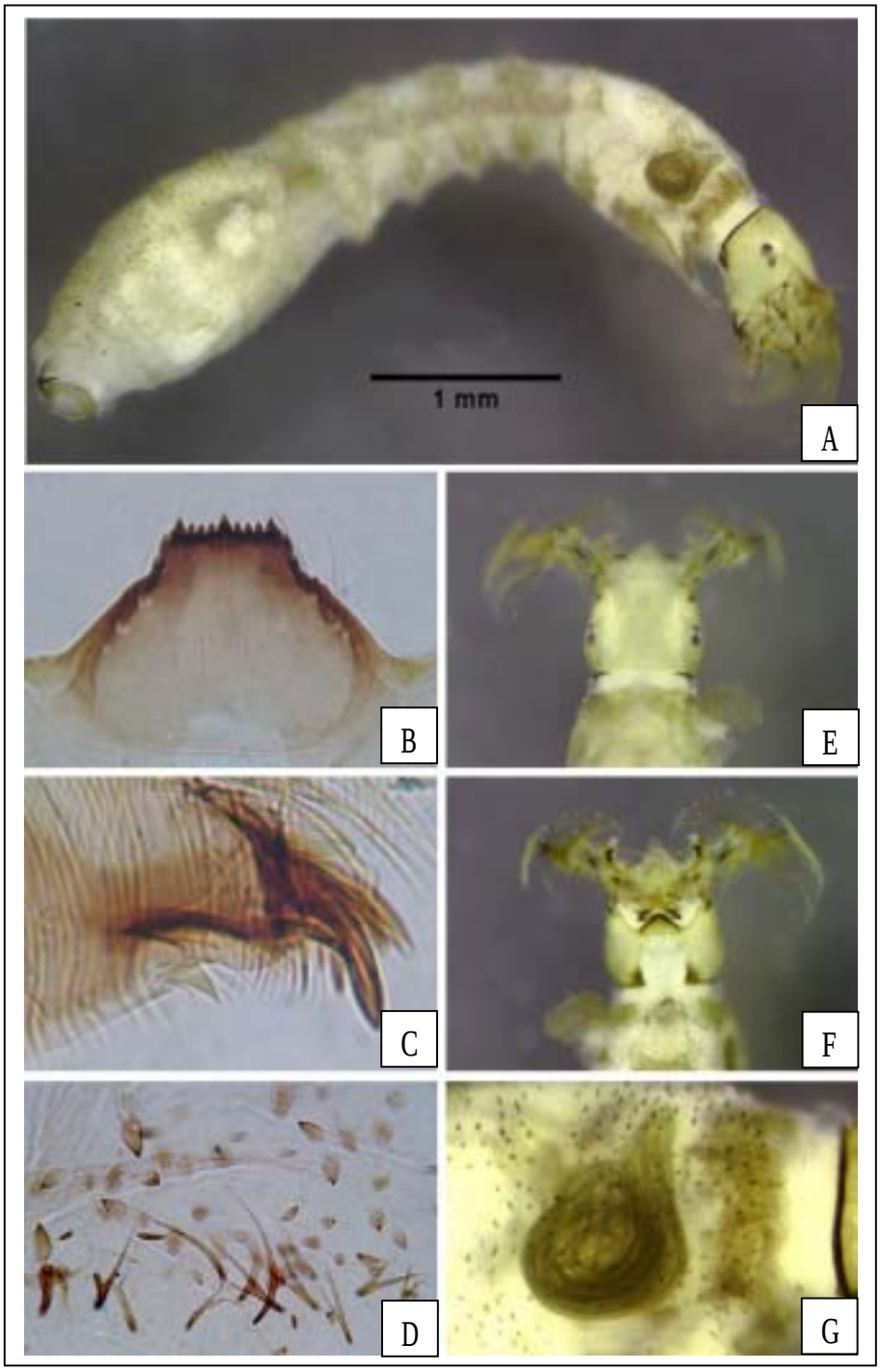

Figure 18 Larval structures of *Simulium dentistylum*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

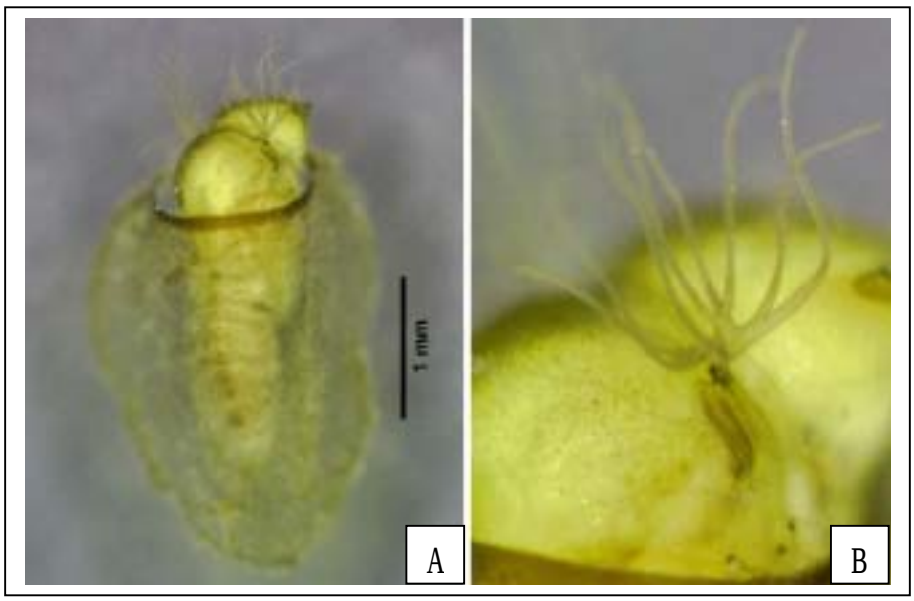

Figure 19 Pupal structures of *Simulium dentistylum*. A, dorsal view; B, gill filaments

4. *Simulium* (*Gomphostilbia*) *gombakense* Takaoka and Davies, 1995

(Figures 20, 21)

Simulium (*Gomphostilbia*) *gombakense* Takaoka and Davies, 1995: 82-84 (mature larva).

Simulium (*Gomphostilbia*) *gombakense*: Takaoka, 2000 (male and pupa).

Description.

Larva (Figure 20). See Takaoka and Davies (1995).

Pupa (Figure 21). See Takaoka (2000).

Female. Unknown.

Male. See Takaoka (2000).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 6.0 km. above S gate, 14°15'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E.

Ecological notes. Larvae were collected from fallen leaves and rocks. Only one pupa was found on a fallen leaf. This species occurred in small to medium-sized streams (0.15-5 m width) with slow to moderately flowing water (0.1-0.7 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 297-654 m, 23.0-25.0 °C, and 7.10-7.90, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *asakoae*, *ceylonicum* species-group, *S.* (*G.*) sp. C, *S.* (*S.*) *fenestratum* and *S.* (*S.*) *tani.*

Remarks. *Simulium* (*G.*) *gombakense* was described from pharate pupae and mature larvae from West Malaysia (Takaoka and Davies, 1995). The male and pupa were later described by Takaoka (2000). The pupal gill is much inflated with six fingerlike projections and eight slender filaments. The postgenal cleft of the larva is longer than the postgenal bridge and the abdominal cuticle is almost bare except the last segment, which has short, colorless, unbranched setae on each side of the anal sclerite.

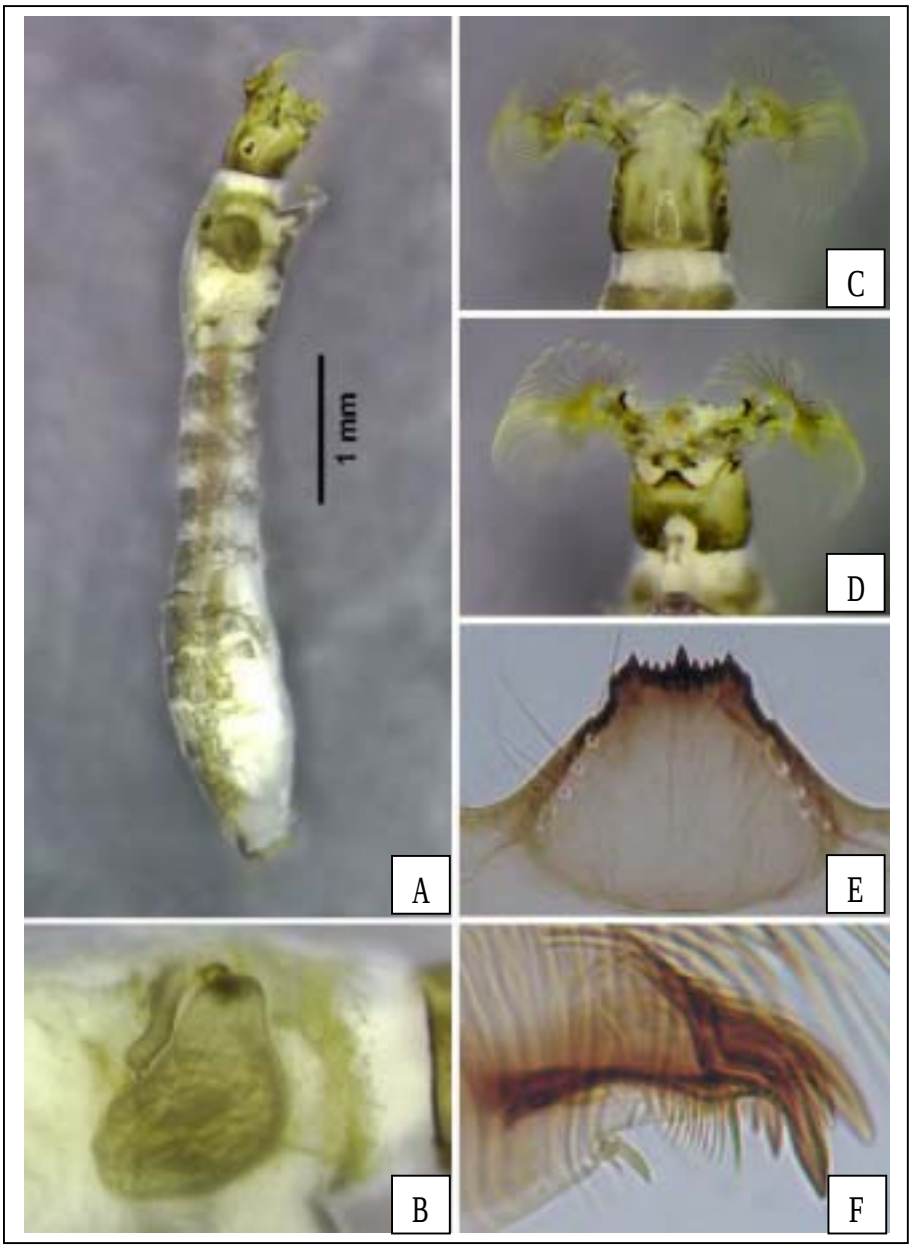

Figure 20 Larval structures of *Simulium gombakense*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

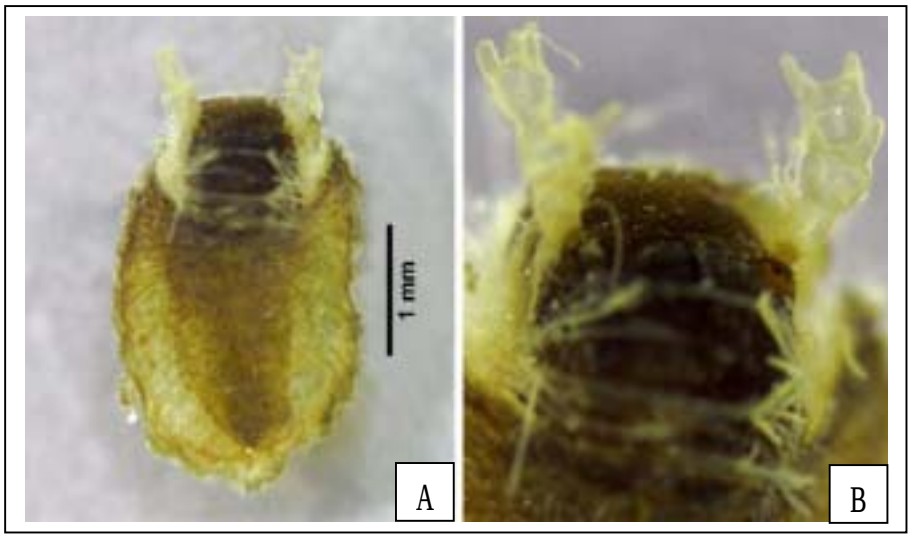

Figure 21 Pupal structures of *Simulium gombakense*. A, dorsal view; B, gill filaments

5. *Simulium* (*Gomphostilbia*) *siamense* Takaoka and Suzuki, 1984

(Figures 22, 23, 24, 25)

Simulium (*Gomphostilbia*) *siamense* Takaoka and Suzuki, 1984: 14-18 (female, male, pupa, and mature larva).

Description.

Larva (Figure 22). Takaoka and Suzuki (1984).

Pupa (Figure 23). Takaoka and Suzuki (1984).

Female (Figure 24). Takaoka and Suzuki (1984).

Male (Figure 25). Takaoka and Suzuki (1984).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Than Rattana Waterfall, 14°14'N 101°23'E; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14° 19'N 101°21'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E; Creek 1.3 km. up Haew Suwat Waterfall Rd., 14°24'N 101°22'E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26'N 101°25'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14°25'N 101°25'E.

Ecological notes. Larvae were found in all seasons and collected from bedrock, fallen leaves, trailing grasses, leaves and roots, rocks, and plastic tubes in streams of various width (0.2-35 m) and flow velocity (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 233-751 m, 18.4-28.2 °C, and 5.88-7.70, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, *S.* (*G.*) *novemarticulatum*, *S.*

(*G.*) sp. B, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, and *S.* (*S.*) *tani*.

Remarks. *Simulium* (*G.*) *siamense* was described from specimens collected in Mae Hong Son, Thailand (Takaoka and Suzuki 1984). The present specimens differ slightly from those in the original description by having minute black setae on the larval thorax. The eight-filamented pupal gill is arranged in groups of 3 + 3 + 2 from dorsal to ventral. The larva can be identified by the presence of dark setae with 6-8 branches on abdominal segments V-VIII.

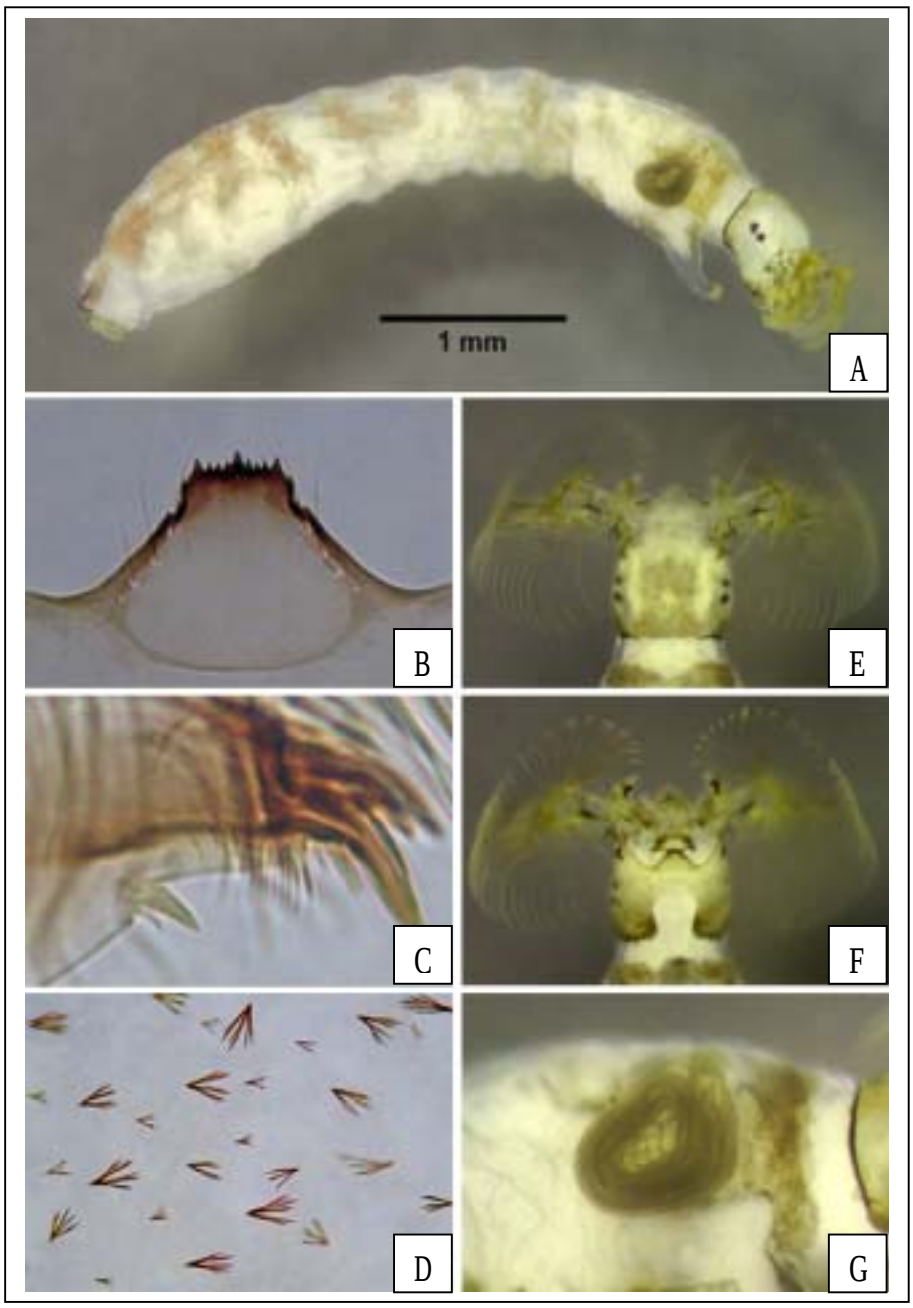

Figure 22 Larval structures of *Simulium siamense*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

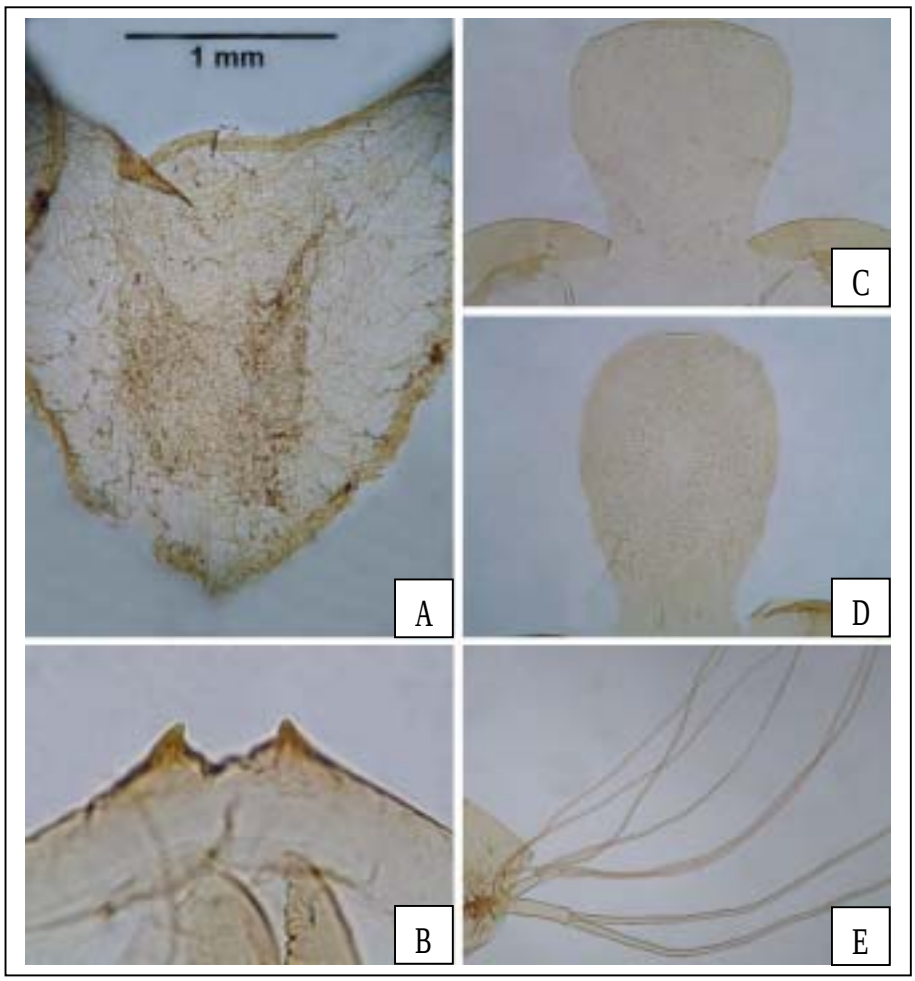

Figure 23 Pupal structures of *Simulium siamense*. A, cocoon in dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

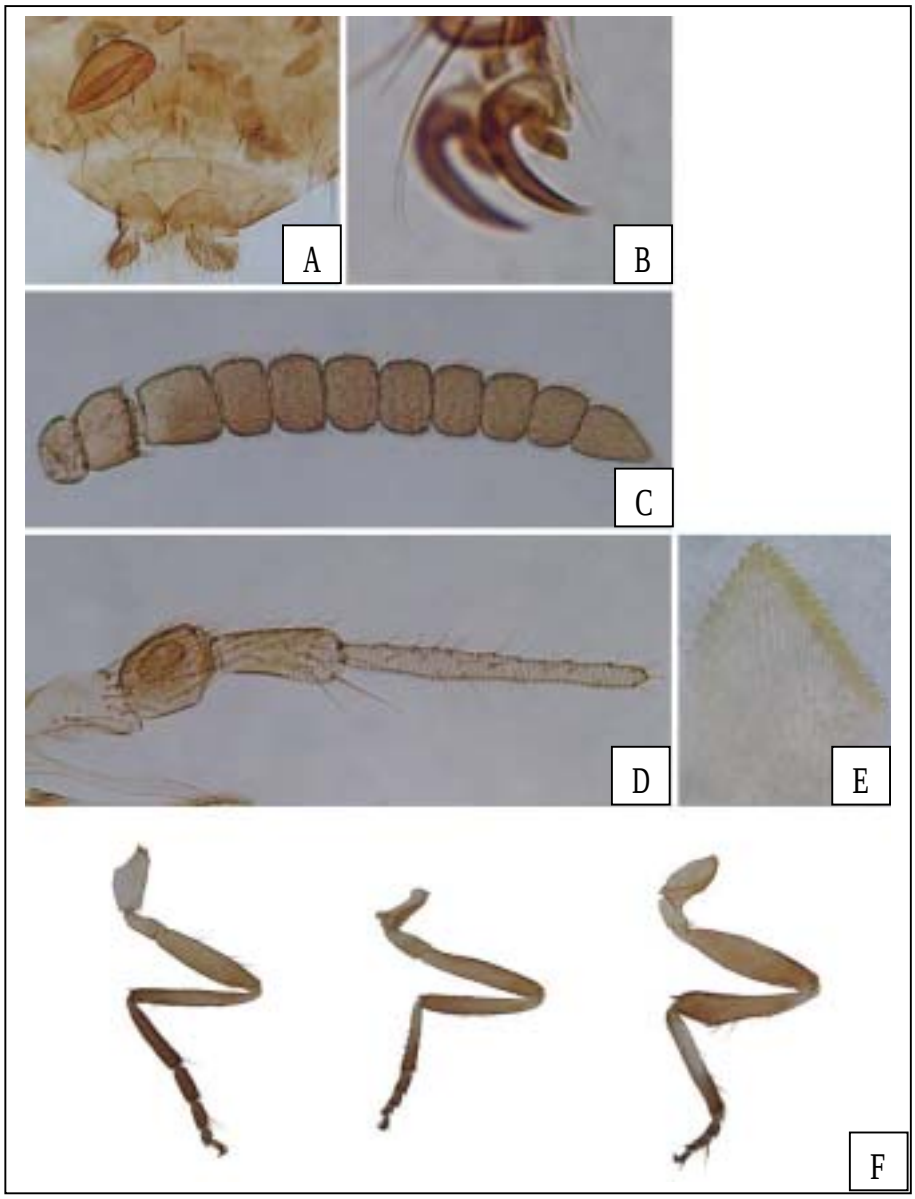

Figure 24 Adult structures of *Simulium siamense* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

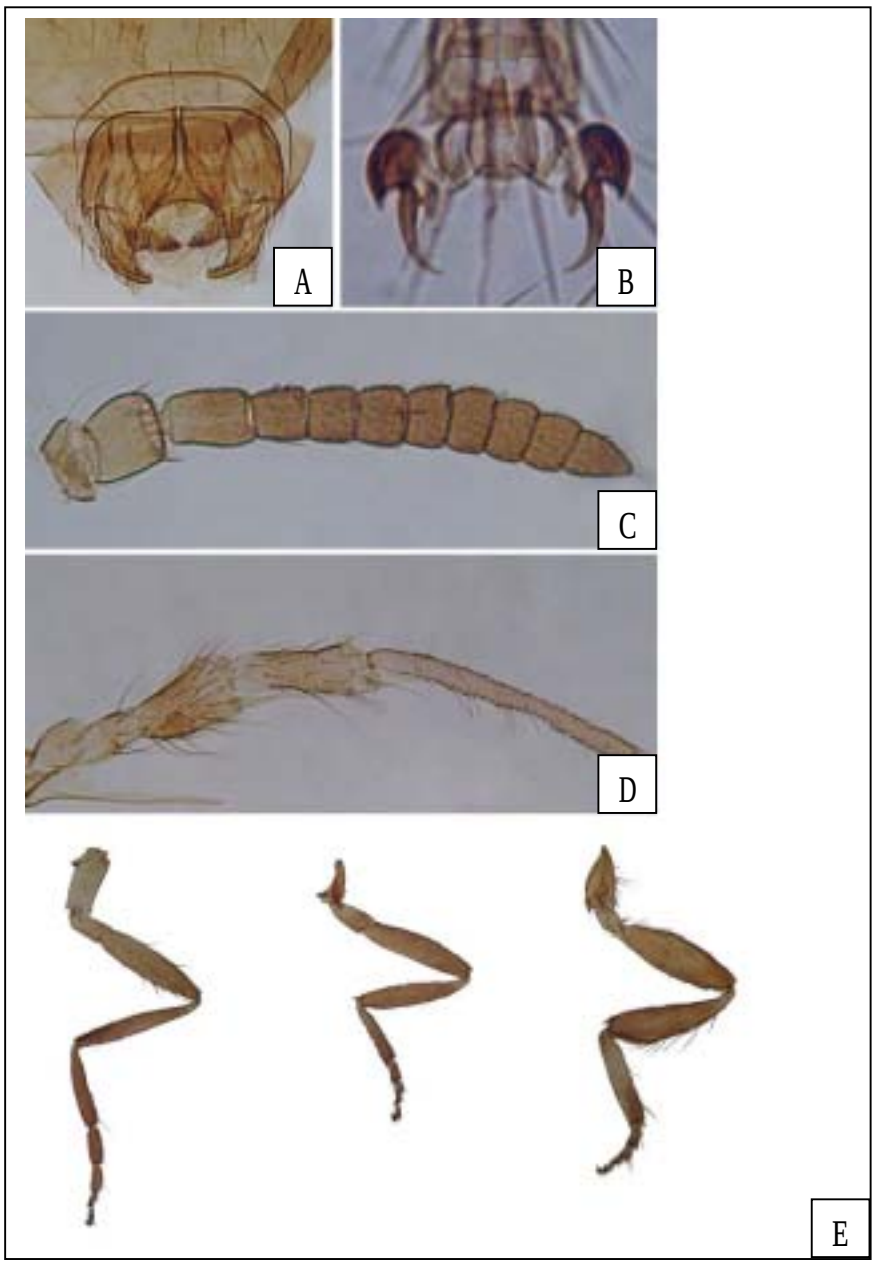

Figure 25 Adult structures of *Simulium siamense* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

4. *Simulium* (*Gomphostilbia*) sp. A

(Figures 26, 27, 28, 29)

Description.

Mature larva (Figure 26A). Body length 3.8-4.5 mm (mean = 4.1 mm, n = 4). Body greyish yellow with transverse reddish brown markings on each abdominal segment. Head capsule yellow with faint positive head spots (Figure 26E). Labral fan with 44-46 main rays (n = 2). Postgenal cleft (Figure 26F) deep, 4.7-7x as long as postgenal bridge. Hypostomium (Figure 26B) with a row of 9 apical teeth; median tooth and each corner tooth longer than others; lateral margin smooth; hypostomal bristles 4 in number lying subparallel to lateral margin on each side. Mandible (Figure 26C) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle bare. Abdominal cuticle bare on segments I-III, densely covered with minute, dark, scalelike setae with 3-6 branches dorsally on segments IV-VIII (Figure 26D). Ventral papillae well developed. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 10-12 hooks in 65-70 rows (n = 2). Gill histoblast (Figure 26G) with short basal common stalk; upper triplet with short stalk, composed of 1 individual and 2 paired, coiled filaments.

Pupa (Figure 27A). Body length 2.2-2.8 mm (mean = 2.5 mm, n = 6). Gill (Figure 27E) with 8 filaments arranged in groups of 3+3+2 from dorsal to ventral; stalk of lower paired filaments long but much shorter than combined length of primary and secondary stalks of upper and middle triplet and their common stalk; all filaments subequal in thickness; lower pair of filaments longer than other 6 filament of upper and middle triplets, as long as or a little longer than pupal body. Head integument (Figures 27C, D) trichomes 4 pairs, all long and simple with abundant, irregularly distributed, rounded granules. Thoracic trichomes simple. Tergite I and II pale yellow; tergites III and IV each with 4 hooklike setae directed forward per side; tergites VI-IX each with well developed spine comb; tergite IX (Figure 27B) with a pair of terminal hooks. Sternite IV with 1 distinct simple hook; sternite V with a pair of bifid hooks per side; sternite VI and VII each with a pair of inner bifid and outer simple hooks per side; sternite IX with a few grapnel-shaped hooks on each side.

Cocoon simple, wall-pocket-shaped, moderately woven, somewhat extended ventrolaterally, often somewhat produced anterodorsally forming short bulge.

Female (Figure 28). No description.

Male (Figure 29). No description.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek under wood bridge at Haew Narok Waterfall. Nakhon Ratchasima; Tad Tapoo creek, 14° 24'N 101°22'E; Creek 1.3 km. up Haew Suwat Waterfall Rd., 14°24'N 101°22'E.

Ecological notes. This species occurred during November 2000 to January 2001 and June 2001. Pupa and larvae were collected from fallen leaves in small shaded streams (0.5-3 m width) with slow to moderately flowing water (0.10-0.8 m s^{-1}). Altitudes, water temperatures, and pH for collection sites ranged from 404-744 m, 19.3-24.3 °C, and 6.07-7.41, respectively. This was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, and *S.* (*S.*) *tani*.

Remarks. The arrangement of gill filaments of this species is similar to that of *S. varicorne* from West Malaysia (Takaoka and Davies 1995), but the adults differ by having antennae with 11 flagellomeres. The dorsal and middle groups of the gill, each with three filaments, share a short stalk, and the ventral group of two filaments arises from an independent stalk. The larva has minute, dark, scalelike setae with 3-6 branches on abdominal segments IV-VIII. The larva is characterized by a deep postgenal cleft, 4.7-7.0 times as long as the postgenal bridge.

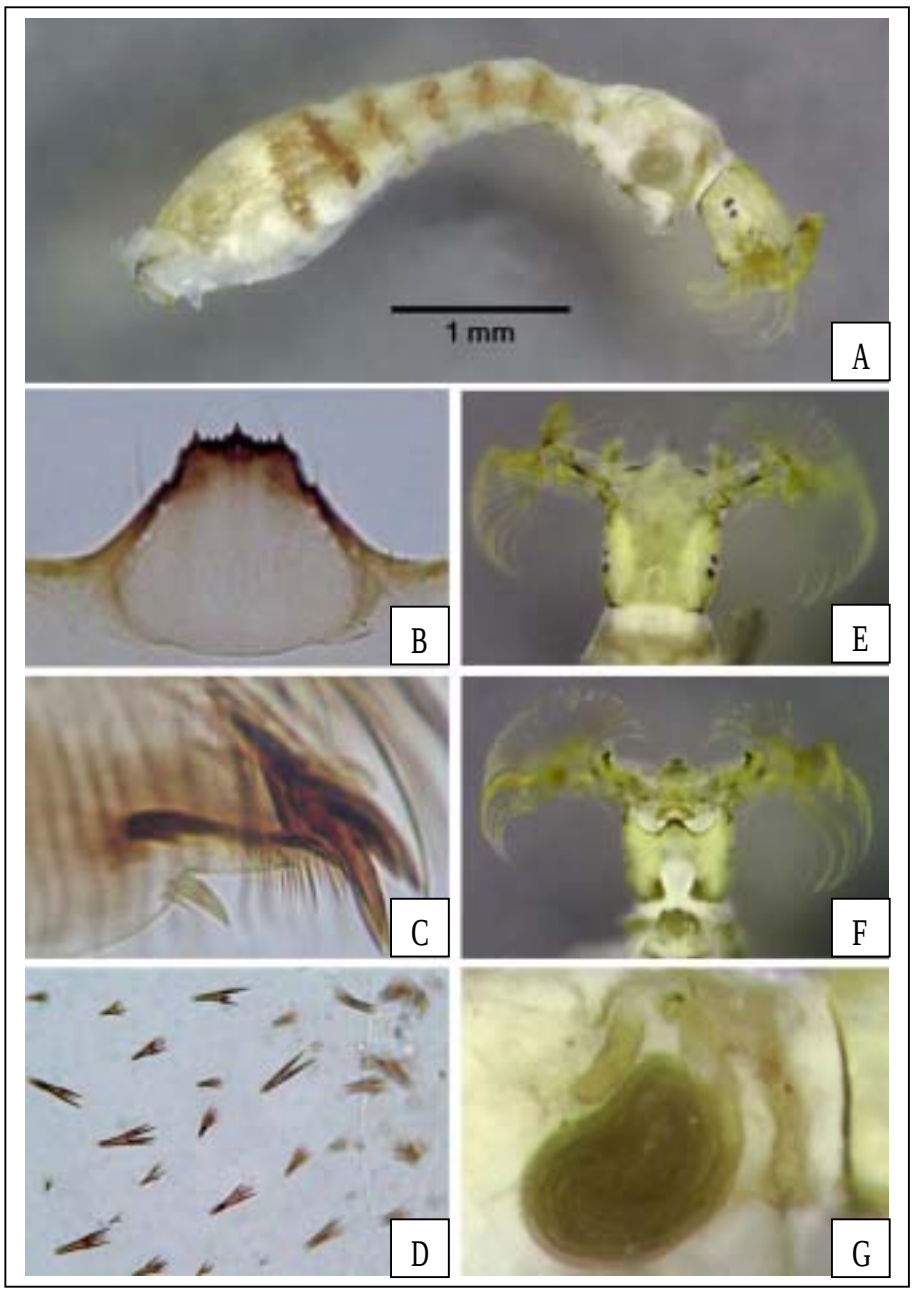

Figure 26 Larval structures of *Simulium* sp. A. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

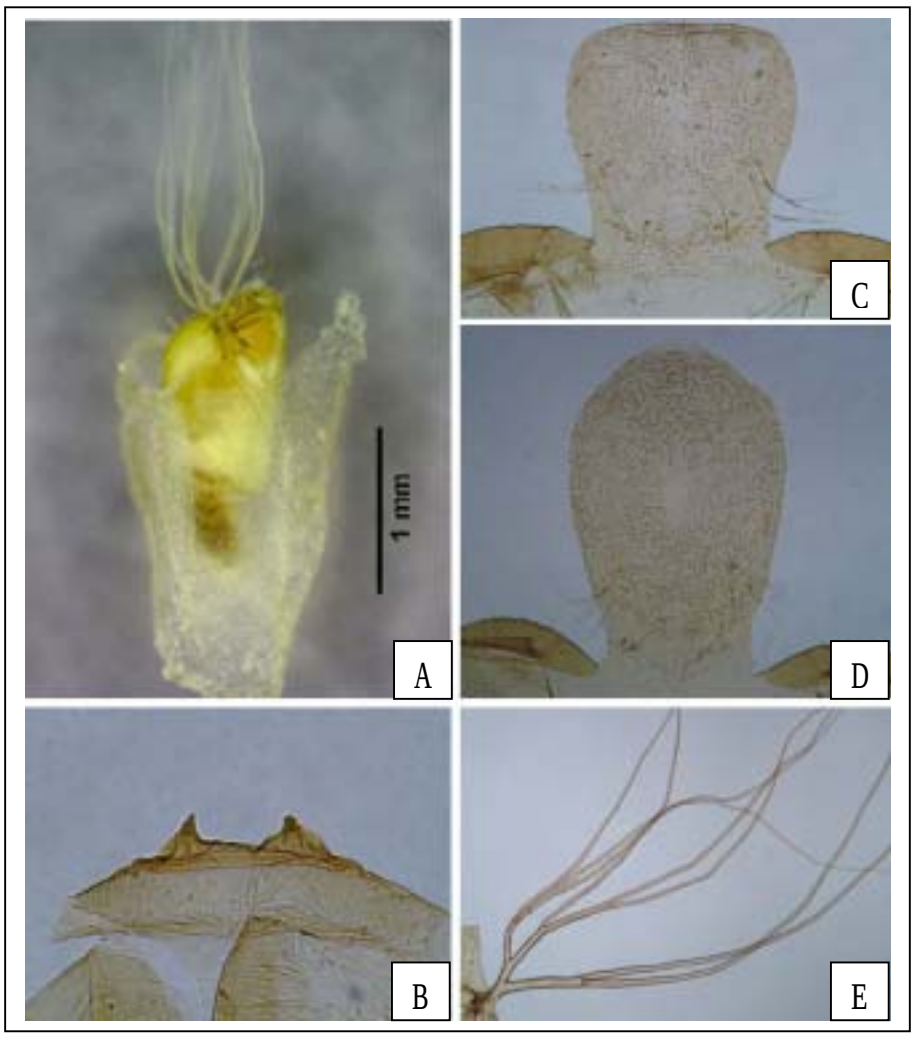

Figure 27 Pupal structures of *Simulium* sp. A. A, dorsal view; B, terminal hooks; C, D: head integument in front view, C, female, D, male, E, gill filaments

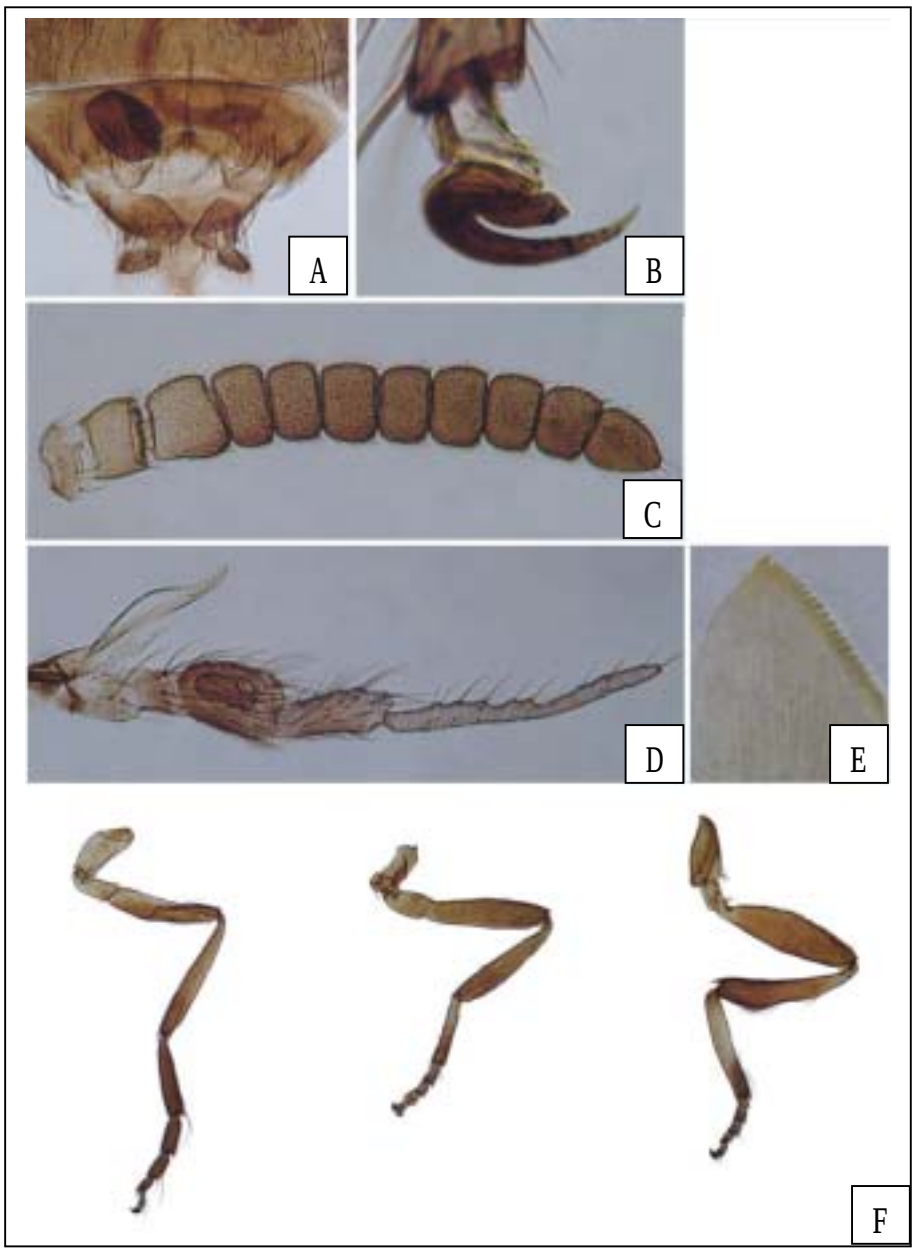

Figure 28 Adult structures of *Simulium* sp. A female. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

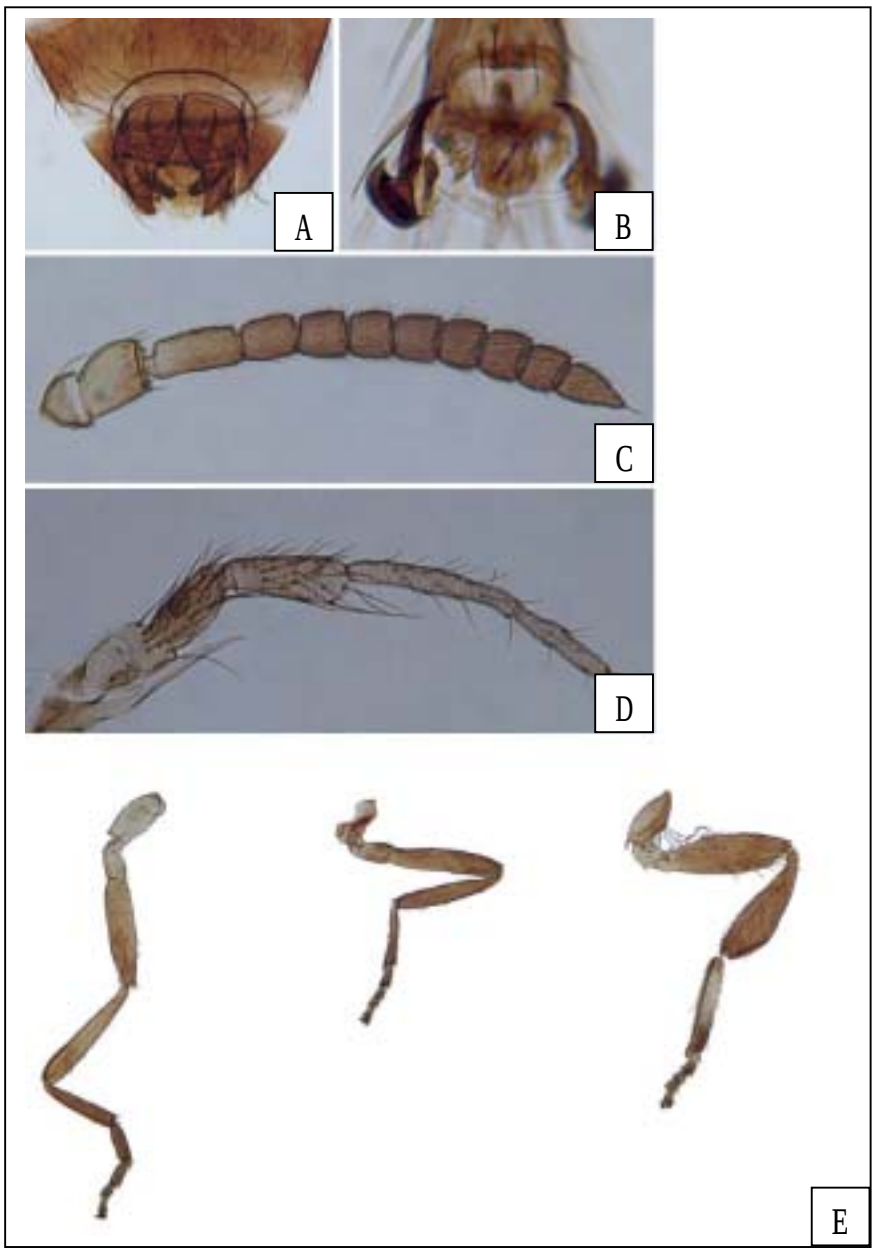

Figure 29 Adult structures of *Simulium* sp. A male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(B) *ceylonicum* species-group

7. *Simulium* (*Gomphostilbia*) *asakoae* Takaoka and Davies, 1995

(Figures 30, 31, 32, 33)

Simulium (*Gomphostilbia*) *asakoae* Takaoka and Davies, 1995: 55-60 (female, male, pupa, and mature larva).

Simulium (*Gomphostilbia*) sp. C Takaoka and Suzuki, 1984: 21-22 (male).

Description.

Larva (Figure 30). See Takaoka and Davies (1995).

Pupa (Figure 31). See Takaoka and Davies (1995).

Female (Figure 32). See Takaoka and Davies (1995).

Male (Figure 33). See Takaoka and Davies (1995).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 6.0 km. above S gate, 14°15'N 101°23'E; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E; . Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Creek 29 km. above S gate at Khao Kheow, 14°22'N 101°24'E; Tad Tapoo creek, 14°24'N 101° 22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14°25'N 101°25'E.

Ecological notes. Larvae were found in all seasons and collected from fallen leaves, rocks, and trailing roots in streams (0.3-6 m width) with slow to fast flowing water (0.1-0.9 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 297-952 m, 19.1-25.0 °C, and 5.88-7.63, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, *S.* (*G.*) *gombakense*, *S.* (*G.*) sp. A, *S.* (*N.*) *feuerborni*, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, and *S.* (*S.*) *tani*.

Remarks. This species was described from West Malaysia (Takaoka and Davies 1995). Takaoka and Saito (1996) noted that the male was reported as *S.* sp. C from Thailand by Takaoka and Suzuki (1984). The present larval specimens from Khao Yai National Park differ from Malaysian specimens in the type of the setae on the abdomen and the shape of the postgenal cleft. The arrangement of pupal gill filaments most closely resembles that of *S. sheilae*. However, adults of *S. asakoae* are distinguished from those of *S. sheilae* by the mostly white hind tibia and basitarsus, and larvae are recognized by the sparse, minute, dark, delicate, unbranched (rarely with 2 or 3 branches) abdominal setae.

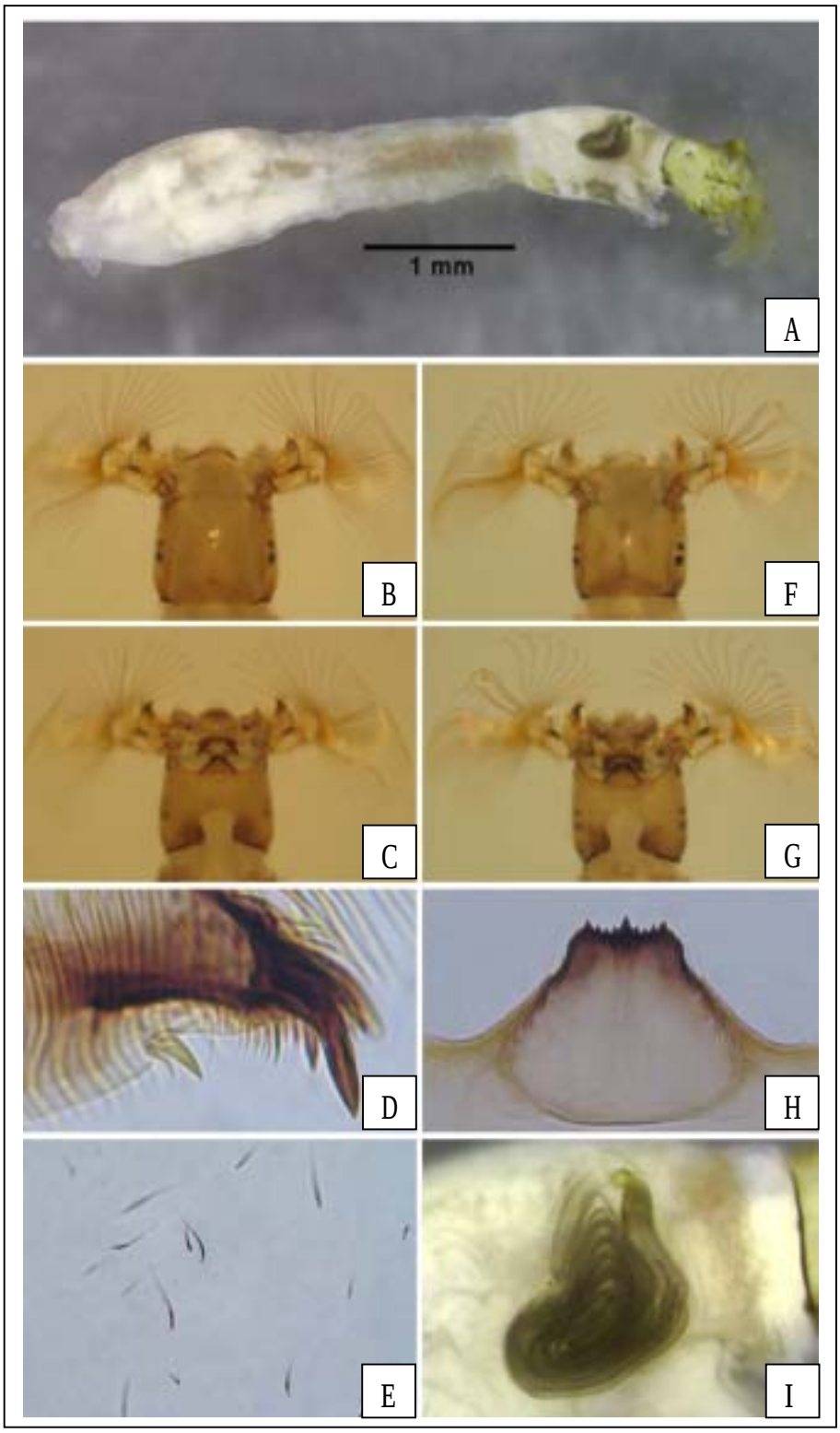

Figure 30 Larval structures of *Simulium asakoae*. A, lateral view of mature larva; B, C and F, G: head capsule, B, F, dorsal view; C, G, ventral view; D, apical tip of mandible; E, setae on abdomen; H, hypostomium; I, gill histoblast

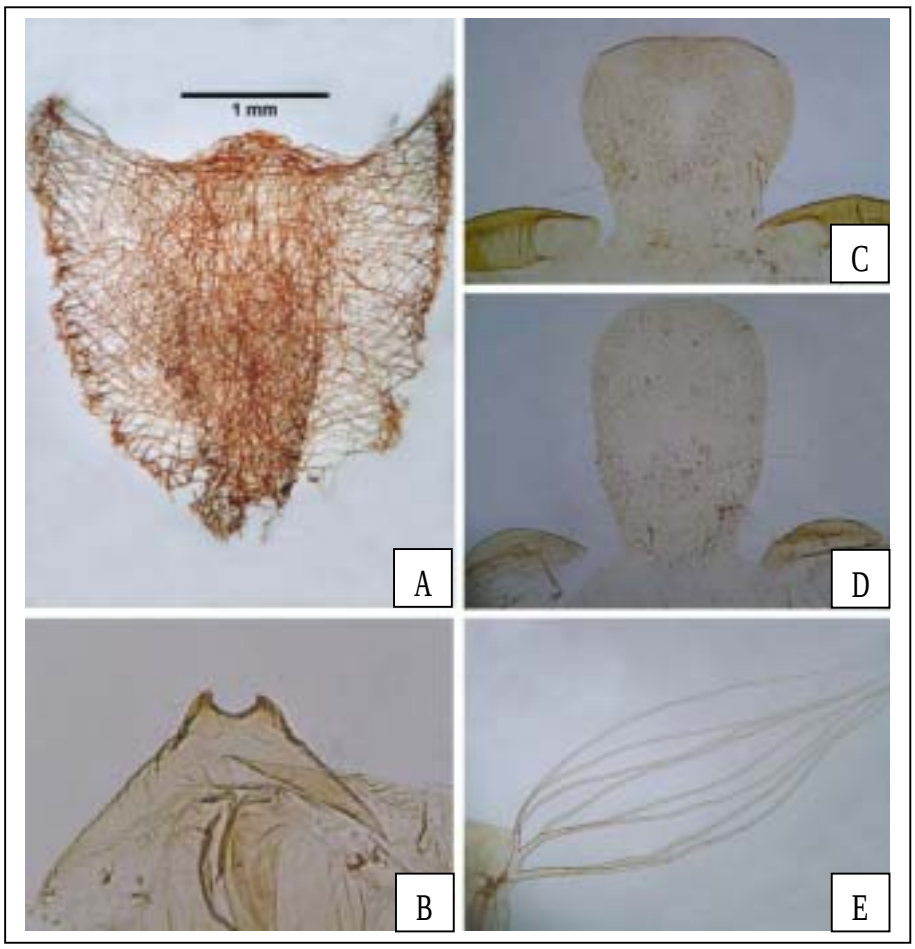

Figure 31 Pupal structures of *Simulium asakoae*. A, cocoon in dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

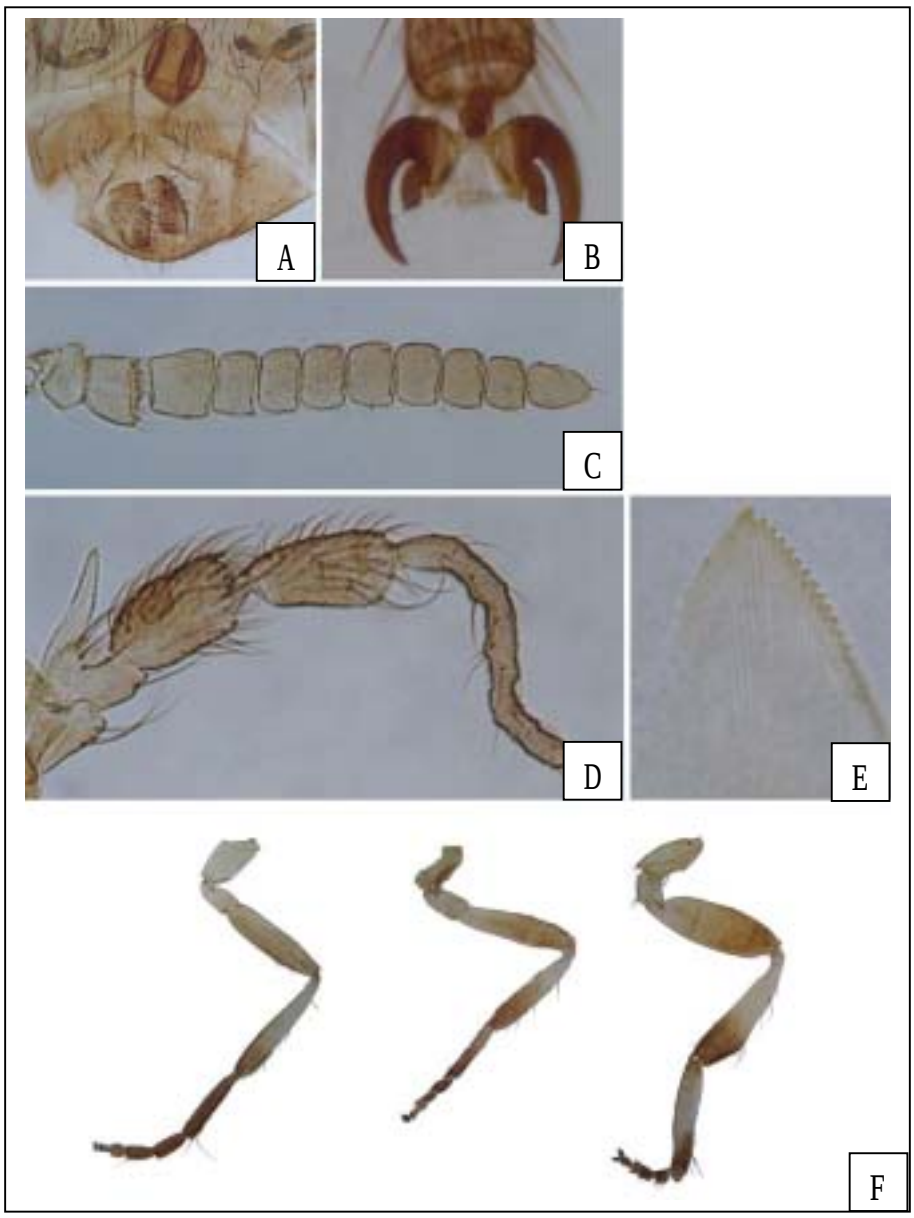

Figure 32 Adult structures of *Simulium asakoae* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

Figure 33 Adult structures of *Simulium asakoae* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

8. *Simulium* (*Gomphostilbia*) *sheilae* Takaoka and Davies, 1995

(Figures 34, 35, 36, 37)

Simulium (*Gomphostilbia*) *sheilae* Takaoka and Davies, 1995: 60-65 (female, male, pupa, and mature larva).

Description.

Larva (Figure 34). See Takaoka and Davies (1995).

Pupa (Figure 35). See Takaoka and Davies (1995).

Female (Figure 36). See Takaoka and Davies (1995).

Male (Figure 37). See Takaoka and Davies (1995).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Pa Krajai Waterfal, 14°21'N 101°20'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 1.3 km. up Haew Suwat Waterfall Rd., 14°24'N 101°22'E.

Ecological notes. This was the most abundant species in the cold season (November and December 2000). Larvae were collected from fallen leaves, rocks, trailing leaves, and sticks in small streams (0.09-3 m width) with slow to fast flowing water (0.05-1.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 404-744 m, 19.3-26.4 °C, and 5.59-7.38, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *ceylonicum* species-group, and *S.* (*S.*) *tani*.

Remarks. The female, male, pupa, and mature larva of *S.* (*G.*) *sheilae* were reported from West Malaysia (Takaoka and Davies 1995). The eight pupal gill filaments are arranged in groups of 3 + 3 + 2 from dorsal to ventral. The larva is characterized by a deep postgenal cleft, which almost reaches the posterior margin of the hypostoma, and dark, delicate setae with 2-6 branches on abdominal segments V-VIII.

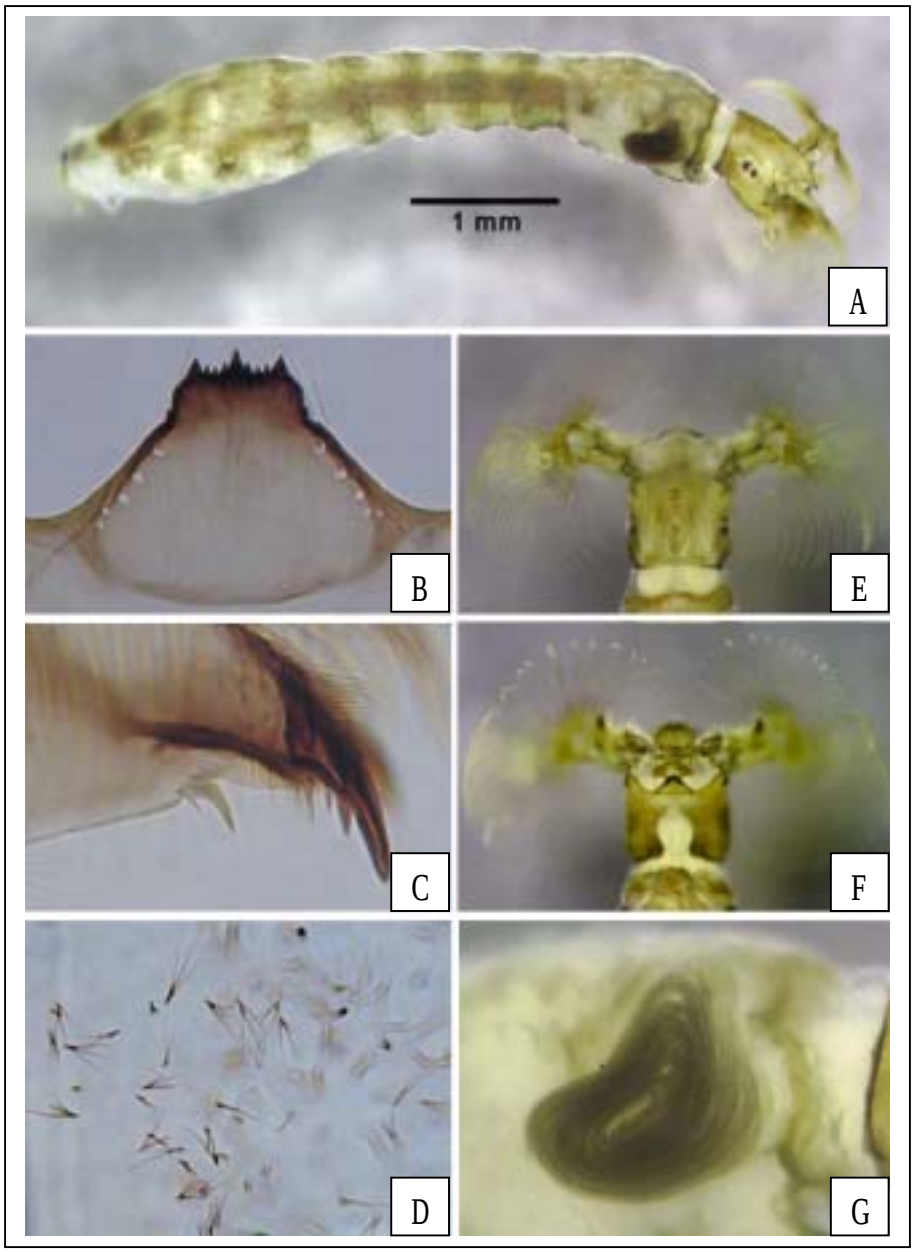

Figure 34 Larval structures of *Simulium sheilae*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

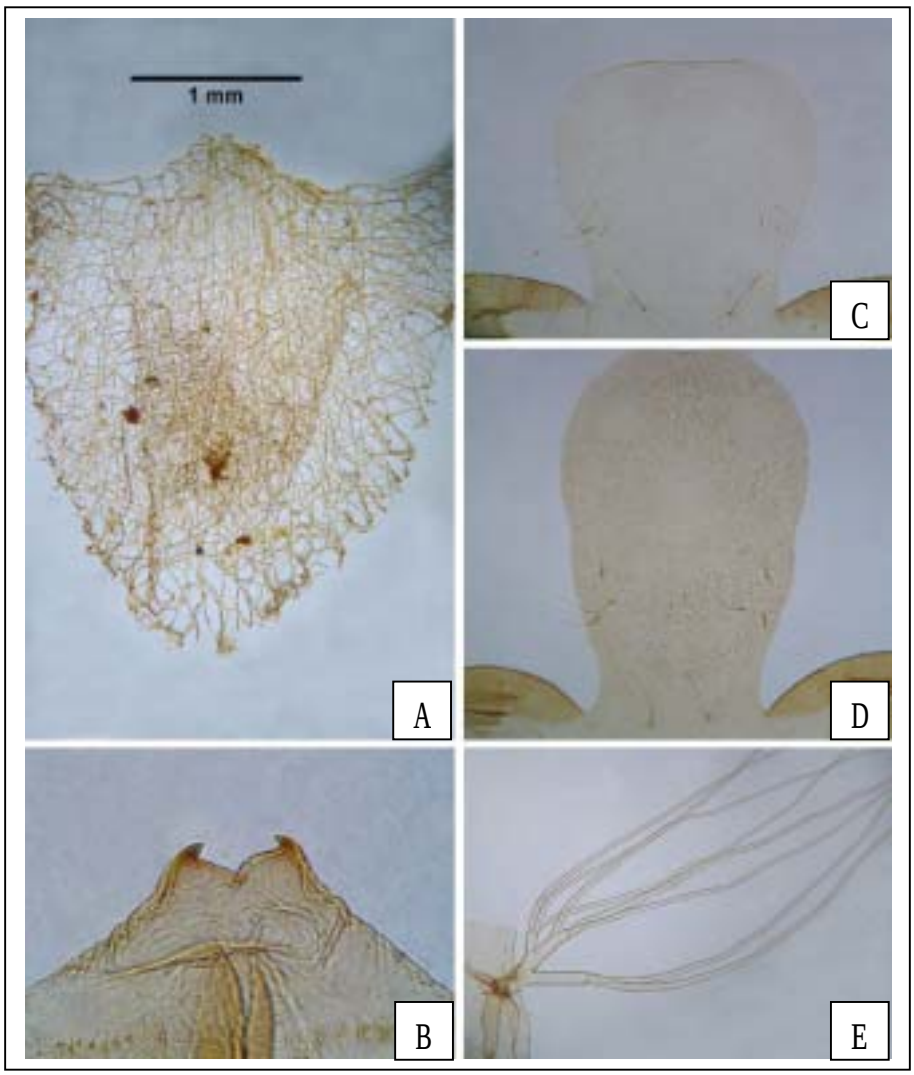

Figure 35 Pupal structures of *Simulium sheilae*. A, cocoon in dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

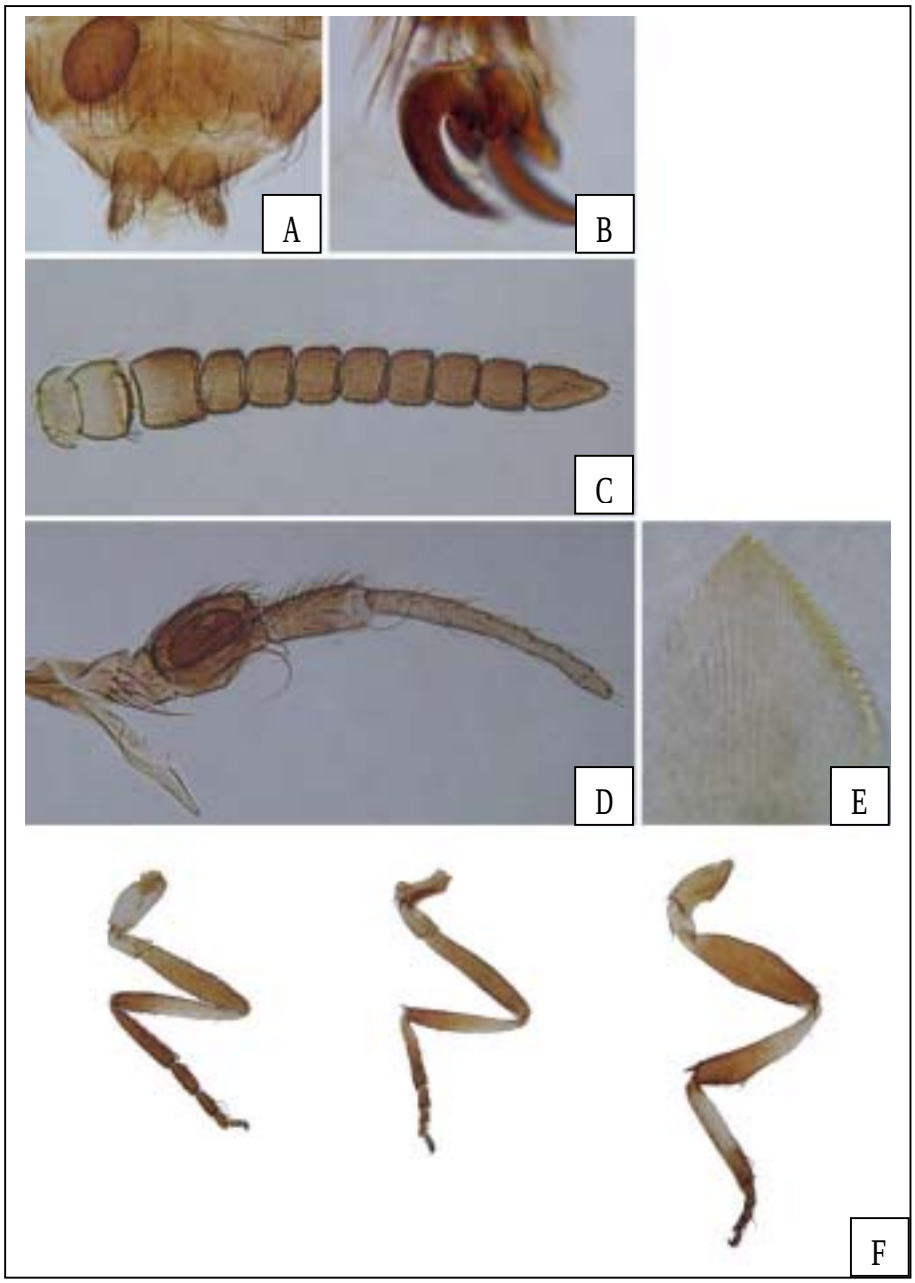

Figure 36 Adult structures of *Simulium sheilae* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

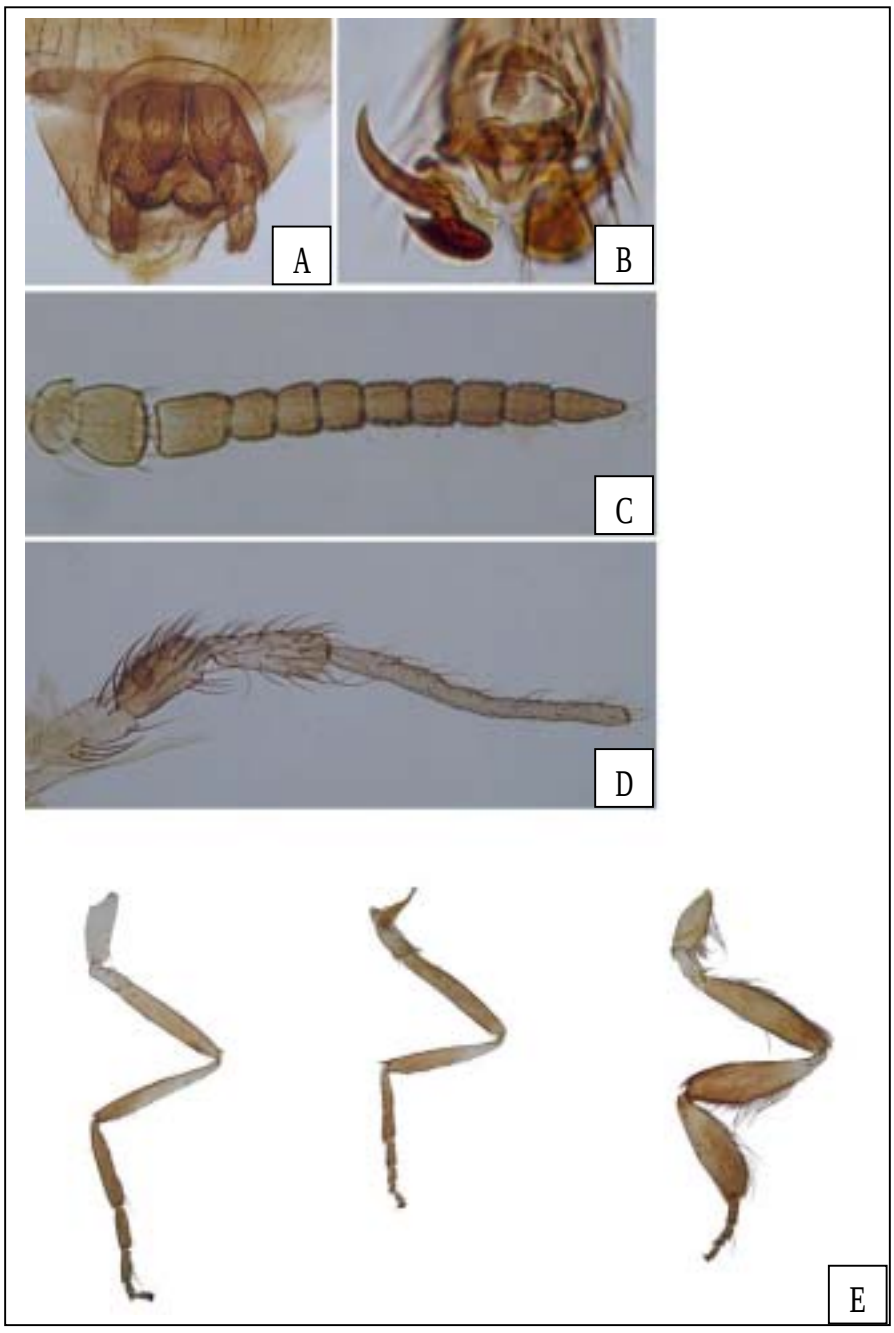

Figure 37 Adult structures of *Simulium sheilae* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

9. *Simulium* (*Gomphostilbia*) sp. nr. *sheilae* Takaoka and Davies, 1995

(Figures 38, 39, 40, 41)

Description.

Mature larva (Figure 38A). Body length 5.0-5.3 mm (mean = 5.1 mm, n = 4). Body greyish yellow with transverse reddish brown markings on each abdominal segment. Head capsule yellow with faint positive head spots (Figures 38B, F). Labral fan with 44-47 main rays (n = 3). Postgenal cleft (Figures 38C, G) of variable length, 3X as long as postgenal bridge or very deep, nearly approaching posterior margin of hypostomium. Hypostomium (Figure 38H) with a row of 9 apical teeth; median tooth and each corner tooth longer than others; lateral margin smooth; hypostomal bristles 4 in number lying subparallel to lateral margin on each side. Mandible (Figure 38D) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle bare. Abdominal cuticle bare on segments I-III, sparsely or moderately covered with minute, dark, delicate setae, unbranched and 2 or 3 branches dorsally on segments V-VIII (Figure 38E). Ventral papillae well developed. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 10-12 hooks in 66-75 rows (n = 4). Gill histoblast (Figure 38I) with short basal common stalk; upper triplet with short stalk, composed of 1 individual filament and 2 paired filaments, coiled filaments.

Pupa. Body length (pupal exuvia) 3.0-3.5 mm (mean = 3.2 mm, n = 8). Gill (Figure 39E) with 8 filaments arranged in groups of 3+3+2 from dorsal to ventral; upper and middle triplets sharing short common stalk; upper triplet with stalk of variable length (subequal to or longer, or rare shorter than secondary stalk), composed of 1 individual filament and 2 paired filaments with short stalk or at the same level; middle triplet with stalk of moderate length, composed of 1 individual filament and 2 paired filaments with secondary stalk of short length or at the same level; lower paired filaments with stalk of moderate length, subequal or much shorter than primary and secondary stalk of middle triplet put together, all filaments subequal in length and thickness, as long as, or a little longer than pupal body. Head integument (Figure 39C, D) trichomes 4 pairs, all long and simple with abundant, irregularly distributed,

rounded granules. Thoracic trichomes simple. Tergite I and II pale yellow; tergites III and IV each with 4 hooklike setae directed forward per side; tergites VI-IX each with well developed spine comp; tergite IX (Figure 39B) with a pair of terminal hooks. Sternite IV with 1 distinct simple hook per side; sternite V with a pair of bifid hooks per side; sternite VI and VII each with a pair of inner bifid and outer simple hooks per side; sternite IX with a few grapnel-shaped hooks on each side. Cocoon (Figure 39A) simple, wall-pocket-shaped, moderately woven, somewhat extended ventrolaterally, often somewhat produced anterodorsally forming short bulge.

Female (Figure 40). No description.

Male (Figure 41). No description.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Creek 29 km. above S gate at Khao Kheow, 14°22'N 101°24'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E.

Ecological notes. Larvae of this species were collected from fallen leaves, stones, and bedrock. They was found in small to medium streams (0.5-6 m width) with slow to fast flowing water (0.1-1.5 m s^{-1}), and ranging from exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 404-952 m, 18.4-24.3 °C, and 5.20-7.43, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *ceylonicum* species-group, and *S.* (*S.*) *tani*.

Remarks. This species belongs to the *S. ceylonicum* group on the basis of an enlarged basitarsus in the male. The male is similar to that of *S. sheilae* in the coloration of the hind tibia and basitarsus, which are mostly dark, leaving a pale portion at the base. The eight pupal gill filaments are similar to those of *S. sheilae*.

However, this species differs from *S. sheilae* by having plate-like terminal hooks in the pupa and minute setae on the larval abdomen. Most larval specimens of *S.* sp. nr. *sheilae* had sparse, minute, delicate setae with 2 or 3 branches (rarely simple) on the dorsal surface of the posterior abdominal segments; however, some specimens had mostly unbranched setae and were, therefore, similar to larvae of *S. asakoae*. The postgenal cleft is variable in length; moderately deep, about 3 times as long as the postgenal bridge and a deep postgenal cleft, nearly approaching posterior margin of hypostomium. The polytene chromosomes provide resolution of these species.

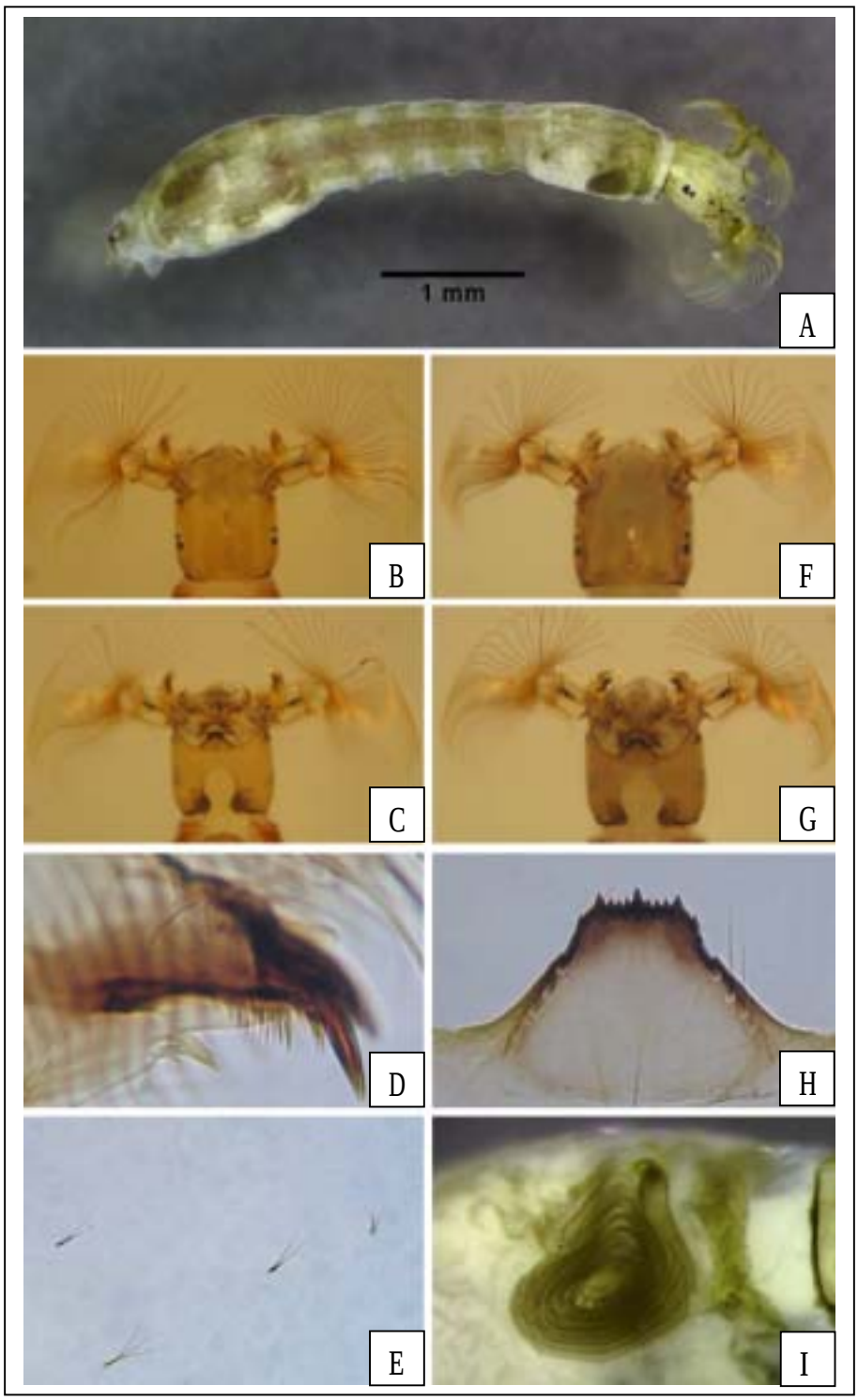

Figure 38 Larval structures of *Simulium* sp. nr. *sheilae*. A, lateral view of mature larva; B, C and F, G: head capsule; B, F, dorsal view; C, G, ventral view; D, apical tip of mandible; E, setae on abdomen; H, hypostomium; I, gill histoblast

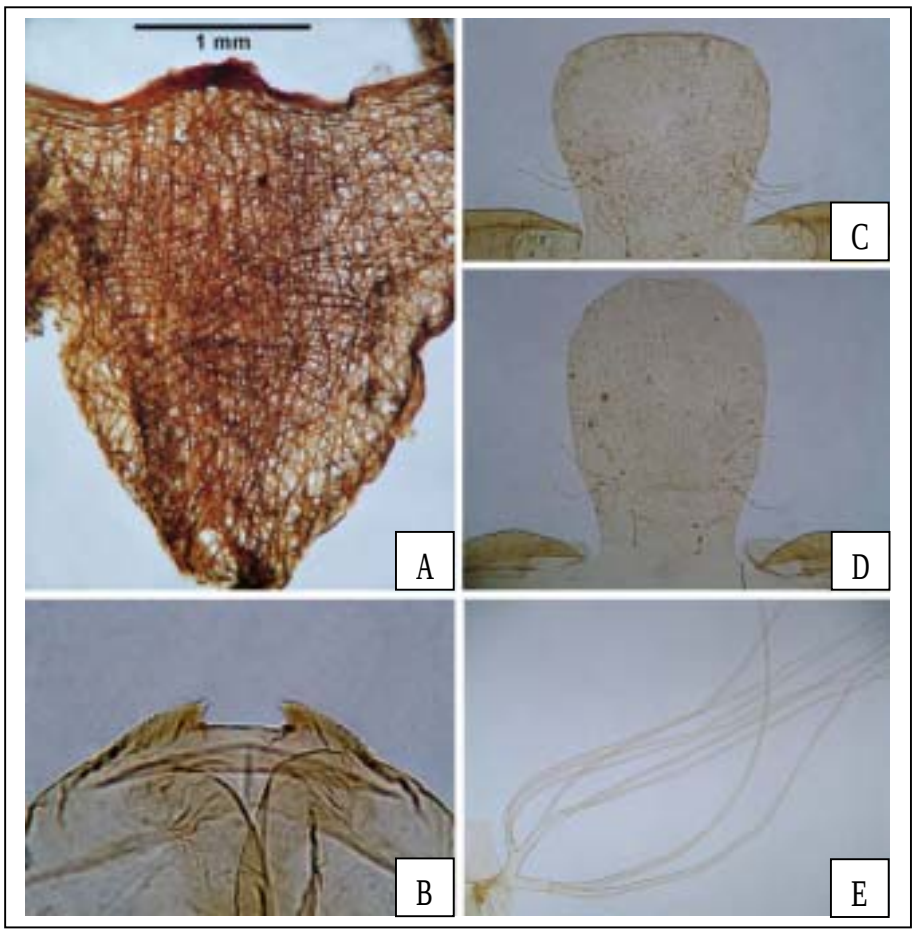

Figure 39 Pupal structures of *Simulium* sp. nr. *sheilae*. A, cocoon in dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

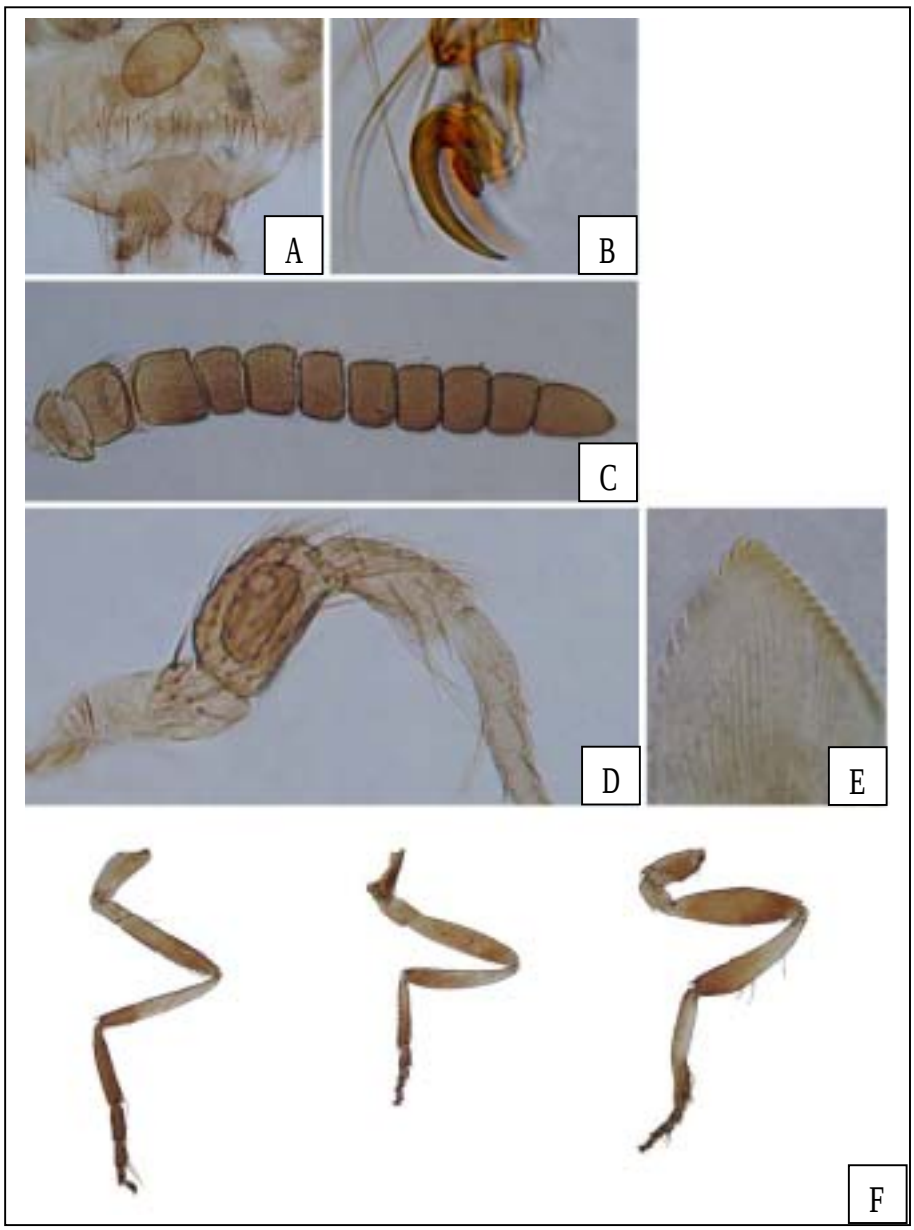

Figure 40 Adult structures of *Simulium* sp. nr. *sheilae* female. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

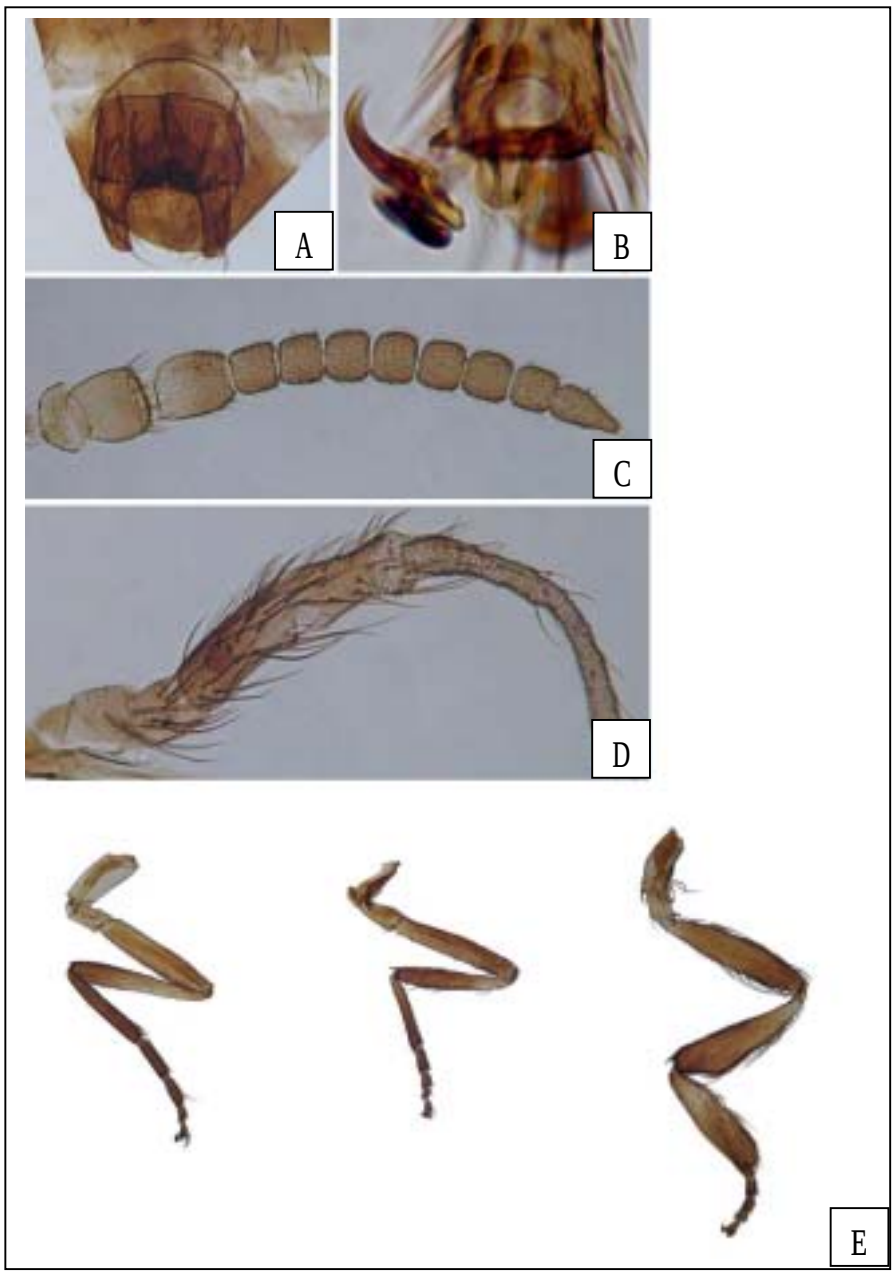

Figure 41 Adult structures of *Simulium* sp. nr. *sheilae* male. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(C) *varicorne* species-group

10. *Simulium* (*Gomphostilbia*) *novemarticulatum* Takaoka and Davies, 1995

(Figures 42, 43, 44, 45)

Simulium (*Gomphostilbia*) *novemarticulatum* Takaoka and Davies, 1995: 77-79 (female).

Description.

Mature larva (Figure 42A). Body length 3.8-4.2 mm (mean = 4.0 mm, n = 5). Body pale greyish. Head capsule whitish yellow with faint positive head spots (Figure 42E). Labral fan with with 29-31 main rays (n = 3). Postgenal cleft (Figure 42F) deep, widely reaching posterior margin of hypostomium, constricted basally. Hypostomium (Figure 42B) with a row of 9 apical teeth; median tooth and each corner tooth longer than others; lateral margin weakly serration apically; hypostomal bristles 4 in number lying subparallel to lateral margin on each side. Mandible (Figure 42C) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle bare with a dorsolateral pair of small protuberance on segment III. Abdominal cuticle with a dorsolateral pair of small protuberances each on segments I-IV, sparsely covered by two types of setae on the abdominal cuticle; thick, dark setae with 2 or 3 branches and minute, dark, delicate setae with 2-4 branches (Figure 42D). Ventral papillae well developed. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 12 hooks in 68-70 rows (n = 3). Gill histoblast (Figure 42G) with short basal common stalk; upper triplet with short stalk; middle triplet with moderate stalk, coiled filaments.

Pupa. Body length (pupal exuvia) 2.5-3.5 mm (mean = 3.0 mm, n = 8). Gill (Figure 43E) with 8 filaments arranged in groups of 3+3+2 from dorsal to ventral; common stalk short, divided into 3 subsequent stalks; upper and middle groups each composed of 1 individual and 2 paired filaments; upper triplets with short stalk; middle triplet with moderate stalk, always longer than that of upper group; lower paired filaments with longer than primary and secondary stalks of middle triplet put together; lower pair of filaments as long as or a little longer than pupal body and longer and thicker than other 6 filaments of upper and middle triplet. Head

integument (Figures 43C, D) trichomes 4 pairs, all long and simple with abundant, irregularly distributed, rounded granules. Thoracic trichomes simple. Tergite I and II pale yellow; tergites III and IV each with 4 hooklike setae directed forward per side; tergites VI-VIII each with well developed spine comp; tergite IX (Figure 43B) with a pair of terminal hooks. Sternite IV with 1 distinct simple hook per side; sternite V with a pair of bifid hooks per side; sternite VI and VII each with a pair of inner bifid and outer simple hooks per side; sternite IX with a few grapnel-shaped hooks on each side. Cocoon (Figure 43A) simple, wall-pocket-shaped, tightly woven, with anterior border thickly woven, somewhat extended ventrolaterally, often somewhat produced anterodorsally forming weakly bulge.

Female (Figure 44). Takaoka and Davies (1995).

Male (Figure 45). No description.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Ratchasima, Khao Yai National Park; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E.

Ecological notes. Larvae of *S.* (*G.*) *novemarticulatum* were found in the rainy season (June-July and September 2000). The larvae were collected from fallen leaves and trailing leaves in small to large streams (3-35 m width) with moderately to fast flowing water (0.3-1.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 404-744 m, 23.1-24.6 °C, and 6.63-7.19, respectively. This species was found with *S.* (*G.*) *angulistylum, S.* (*G.*) *decuplum, S.* (*G.*) *siamense, S.* (*S.*) *nakhonense* and *S.* (*S.*) *quinquestriatum*. This is the first record of this species from Thailand.

Remarks. The original description of this species was based on female specimens collected from Malaysia (Takaoka and Davies 1995). Through association of larvae, pupae, and reared females from the same stream in Khao Yai National Park, confirmation of the first known collection of the former two life stages. The antenna of the adult is composed of 9 articles, whereas the antenna of *S. siamense* has 11

flagellomeres. The arrangement of pupal gill filaments of this species is similar to that of *S. siamense*. The eight pupal gill filaments of this species are arranged in groups of 3+3+2 from dorsal to ventral. However, the stalk of the lower pair is variable in length. The larva is distinguished from that of *S. siamense* by its deep postgenal cleft, with the apex reaching the posterior margin of the hypostoma, and by two types of setae on the abdominal cuticle; thick, dark, setae with 2 or 3 branches and minute, dark, delicate setae with 2-4 branches.

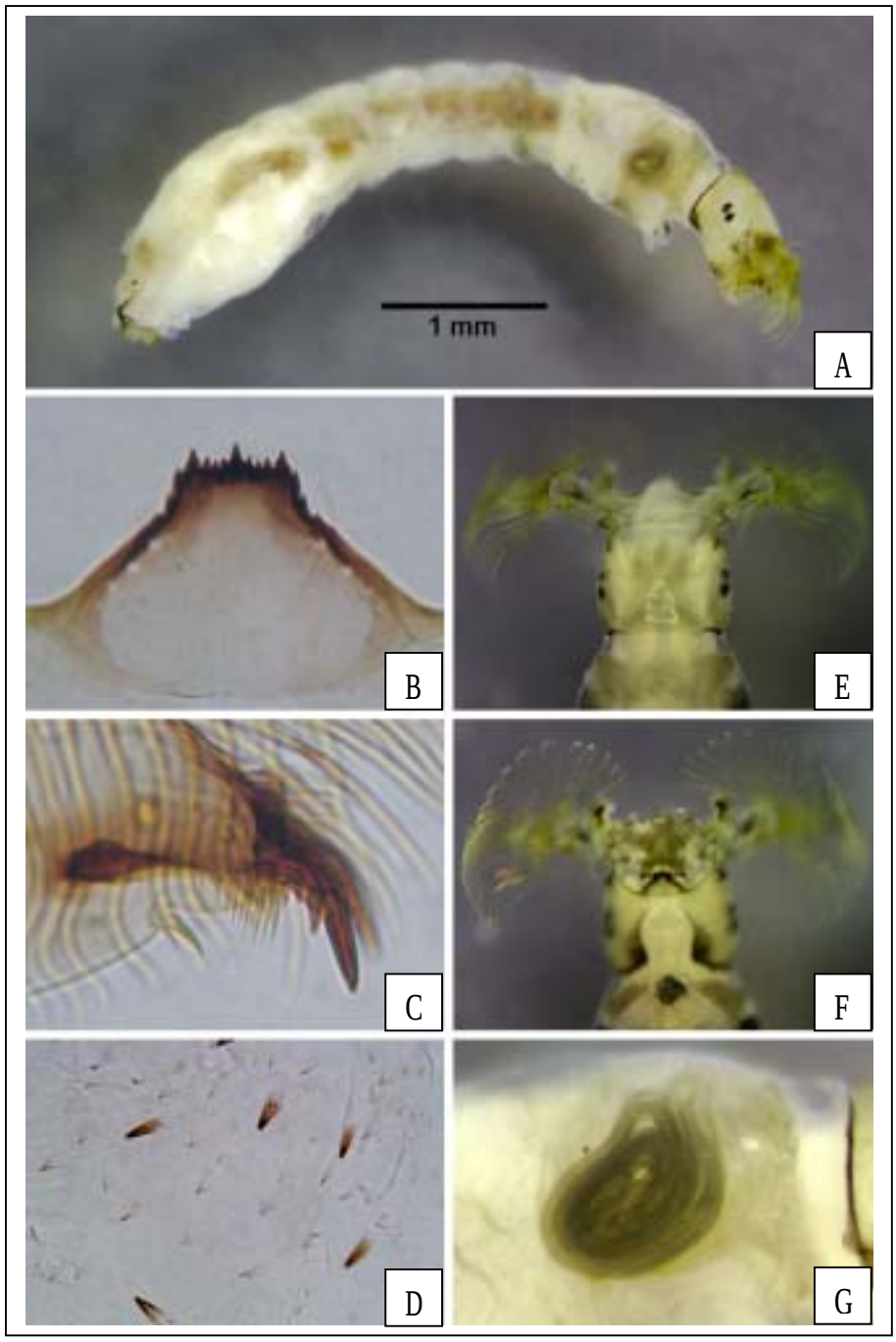

Figure 42 Larval structures of *Simulium novemarticulatum*. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

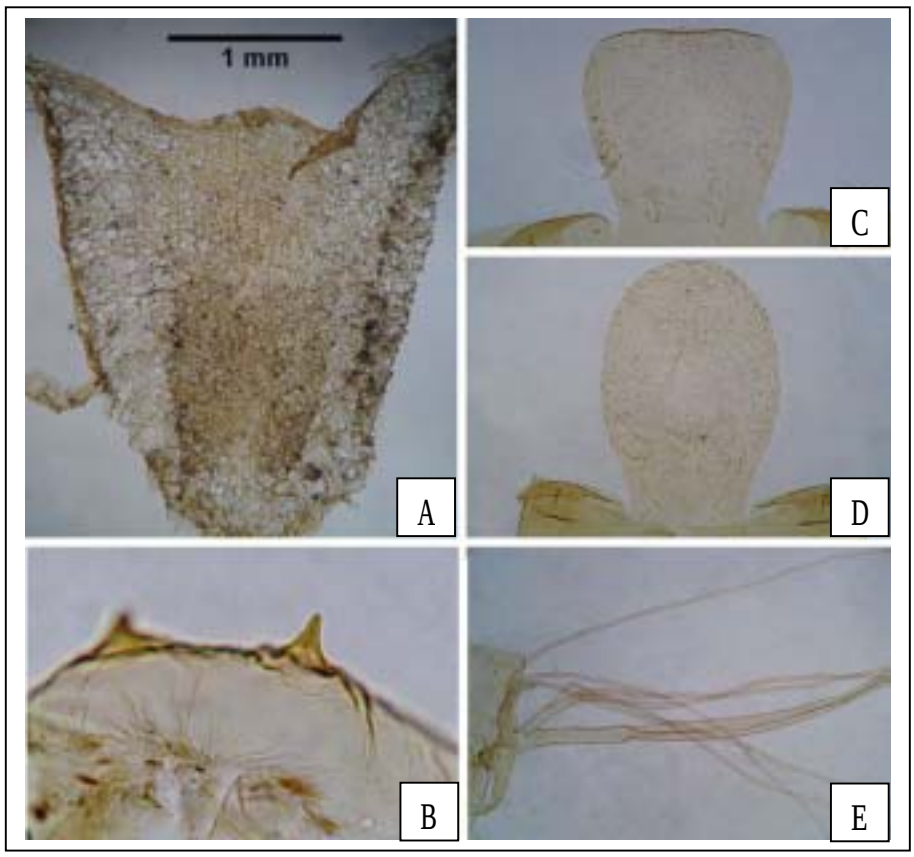

Figure 43 Pupal structures of *Simulium novemarticulatum*. A, cocoon in dorsal view; B, terminal hooks; C, D: head integument in front view; C, female; D, male; E, gill filaments

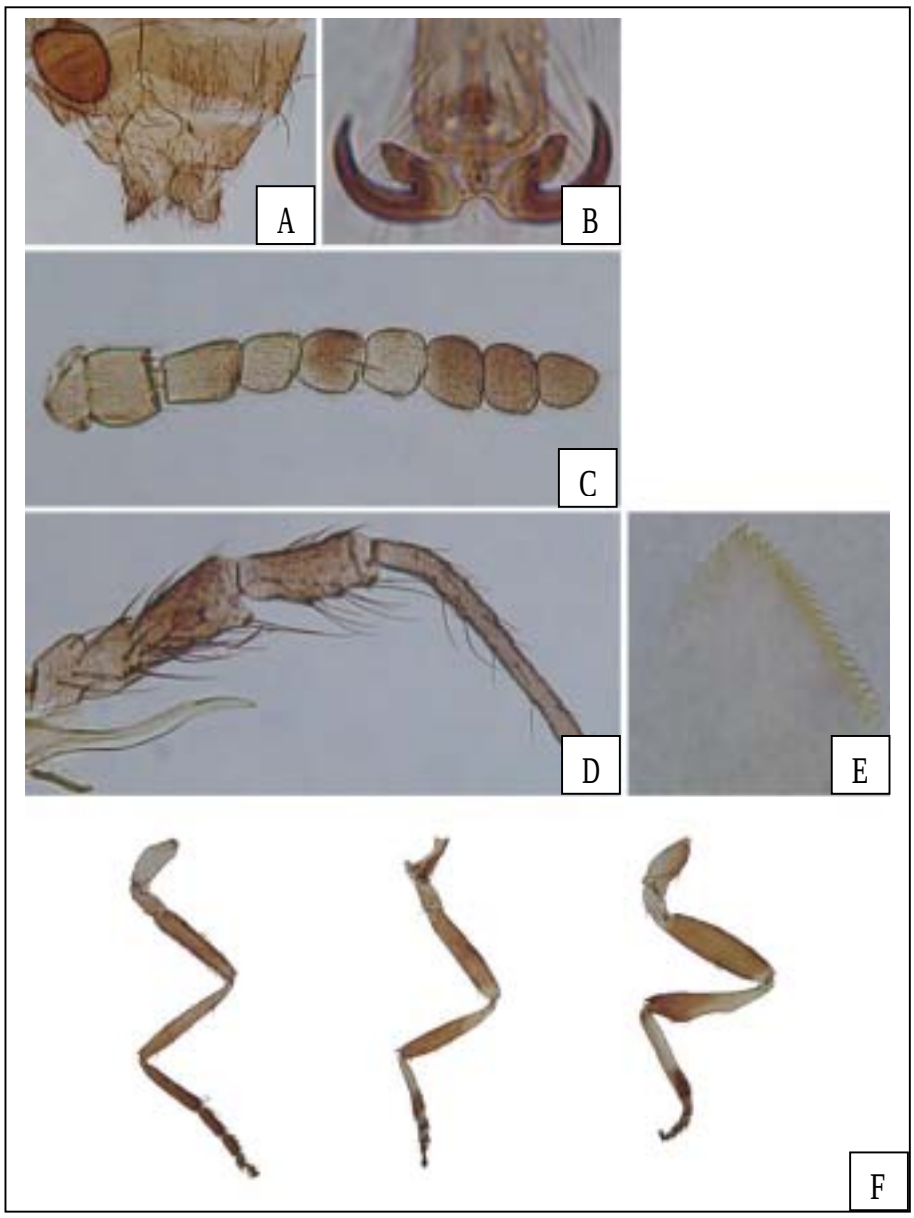

Figure 44 Adult structures of *Simulium novemarticulatum* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

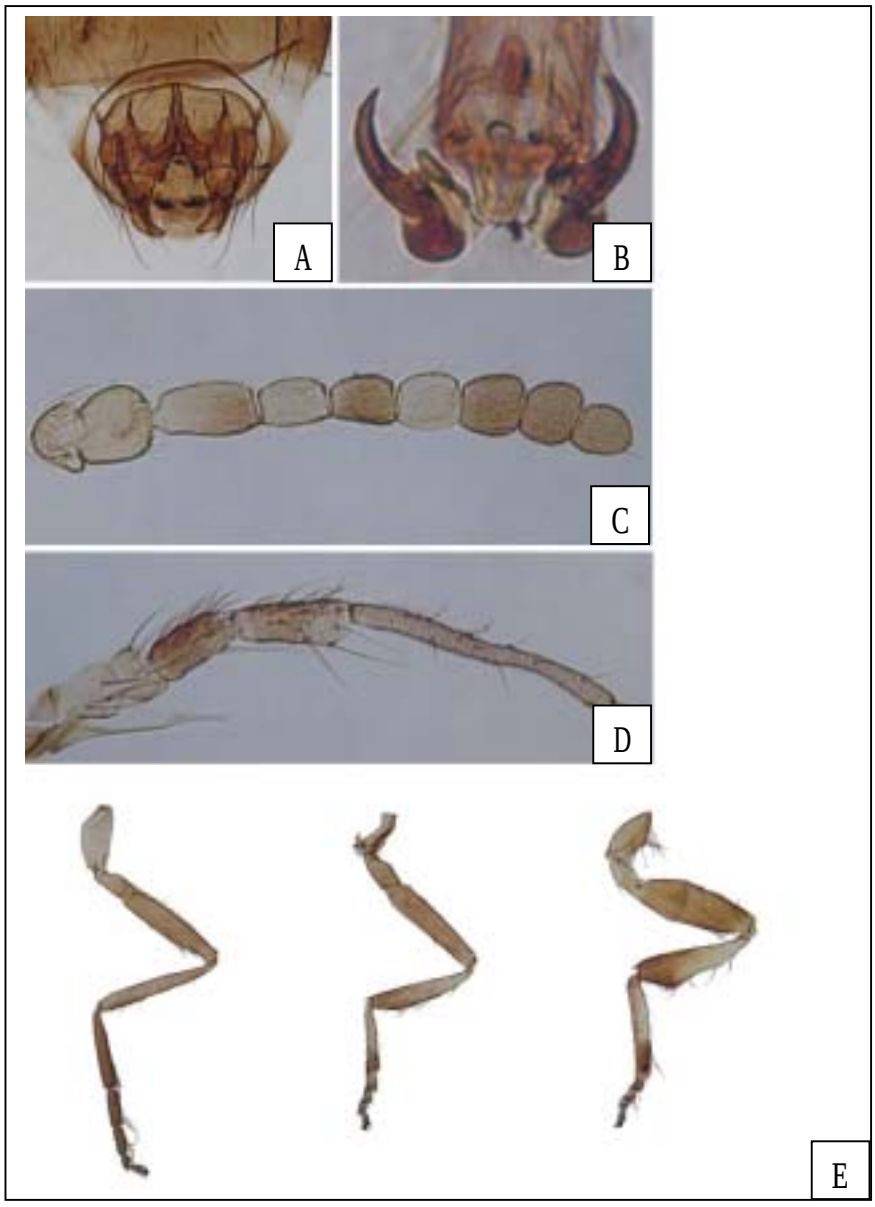

Figure 45 Adult structures of *Simulium novemarticulatum* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(D) ungrouped species

11. *Simulium* (*Gomphostilbia*) sp. B

(Figure 46)

Description.

Mature larva (Figure 46A). Body length 3.5-3.6 mm (mean = 3.5 mm, n = 3). Body pale yellow with transverse reddish brown markings on each abdominal segment. Head capsule yellow with faint positive head spots (Figure 46E). Labral fan with with 37-39 main rays (n = 2). Postgenal cleft (Figure 46F) very deep, its apex almost reaching posterior margin of hypostomium, constricted basally. Hypostomium (Figure 46B) with a row of 9 apical teeth; median tooth and each corner tooth longer than others; lateral margin smooth; hypostomal bristles 3 or 4 in number lying subparallel to lateral margin on each side. Mandible (Figure 46C) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle sparely covered with thick, dark, unbranched and 2-3 branched setae. Abdominal cuticle sparely covered with unbranched, thick, dark setae on segments I-IV, covered with thick, dark, unbranched and 2-3 branched setae moderately on segments V and VI, densely on segments VII-VIII dorsally and dorsolaterally (Figure 46D); segments II-V each with a dorsolateral pair of small protuberances. Ventral papillae well developed. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 60-66 hooks in 10-12 rows (n = 2). Gill histoblast (Figure 46G) with short basal common stalk; upper triplet with short stalk, composed of 1 individual and 2 paired, coiled filaments.

Pupa. Unknown.

Female. Unknown.

Male. Unknown.

Collection sites. Thailand. Nakhon Ratchasima, Khao Yai National Park; Pa Kluai Mai Waterfall, 14°25’N 101°24’E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26’N 101°25’E.

Ecological notes. Two larvae were found in October 2000 and June 2001. They were collected from fallen leaves in exposed streams (3-20 m width) with moderately to fast flowing water (0.6-1.9 m s^{-1}). Altitudes, water temperatures, and pH for collection sites ranged from 633-695 m, 22.3-24.5 °C, and 7.00-7.20, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *siamense*, *S.* (*S.*) *quinquestriatum*, and *S.* (*S.*) *tani*.

Remarks. The number and arrangement of gill filaments are similar to those of *S.* sp. A. However the larva can be distinguished from that of *S.* sp. A by the deep postgenal cleft, almost reaching the posterior border of the hypostoma, and a thick covering of unbranched and 2-3 branched setae on the abdomen.

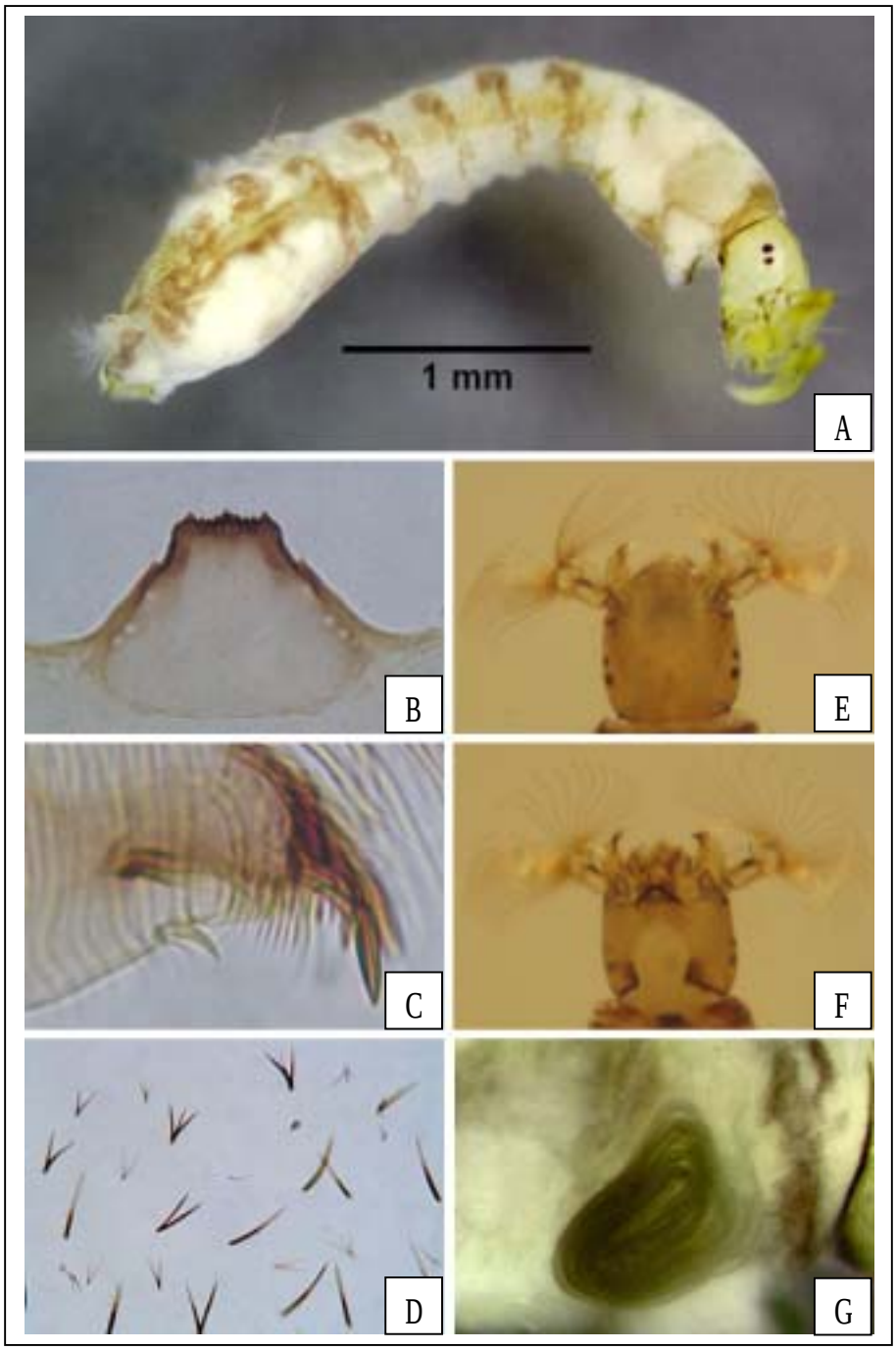

Figure 46 Larval structures of *Simulium* sp B. A, lateral view of mature larva; B, hypostomium; C, apical tip of mandible; D, setae on abdomen; E, F: head capsule; E, dorsal view; F, ventral view; G, gill histoblast

12. *Simulium* (*Gomphostilbia*) sp. C

(Figure 47)

Description.

Mature larva (Figure 47A). Body length 5.0-5.2 mm (mean = 5.0 mm, n = 5). Body dark gray (or somewhat reddish brown specially on the dorsal abdominal segments 4-9. Head capsule brownish yellow with positive head spots (Figure 47C). Labral fan with with 35-36 main rays (n = 3). Postgenal cleft (Figure 47D) moderately developed, 2-2.75X as long as postgenal bridge. Hypostomium (Figure 47E) with a row of 9 apical teeth; median tooth and each corner tooth longer than others; lateral margin smooth; hypostomal bristles 4 in number lying subparallel to lateral margin on each side. Mandible (Figure 47F) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle bare. Abdominal cuticle bare. Ventral papillae well developed. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 11-14 hooks in 72-80 rows (n = 2). Gill histoblast (Figure 47B) with short basal common stalk; upper triplet with short stalk, composed of 1 individual filament and 2 paired filaments, coiled filaments.

Pupa. Unknown.

Female. Unknown.

Male. Unknown.

Collection sites. Thailand. Nakhon Nayok, Khao Yai National Park; Pa Krajai Waterfal, 14°21’N 101°20’E.

Ecological notes. Larvae were found in March and April 2001 and collected from fallen leaves. They were at site 11, exposed stream (0.15-1 m width) with slow to fast flowing water (0.1-1.0 m s^{-1}) in natural forest. Altitude at this site is 654 m. Water temperatures, and pH for collection sites ranged from 24.2-24.3 °C, and 7.90-7.93, respectively. This species was found with *S.* (*G.*) *angulistylum*, *ceylonicum*-species group, *S.* (*G.*) *gombakense*, *S.* (*S.*) *grossifilum*, *S.* (*S.*) *fenestratum*, and *S.* (*S.*) *tani*.

Remarks. The number and arrangement of pupal gill filaments of this species are similar to those of *S. asakoae*, *S. sheilae*, and *S.* sp. nr. *sheilae*. However, the larva differs by having the thoracic and abdominal segments nearly bare of setae.

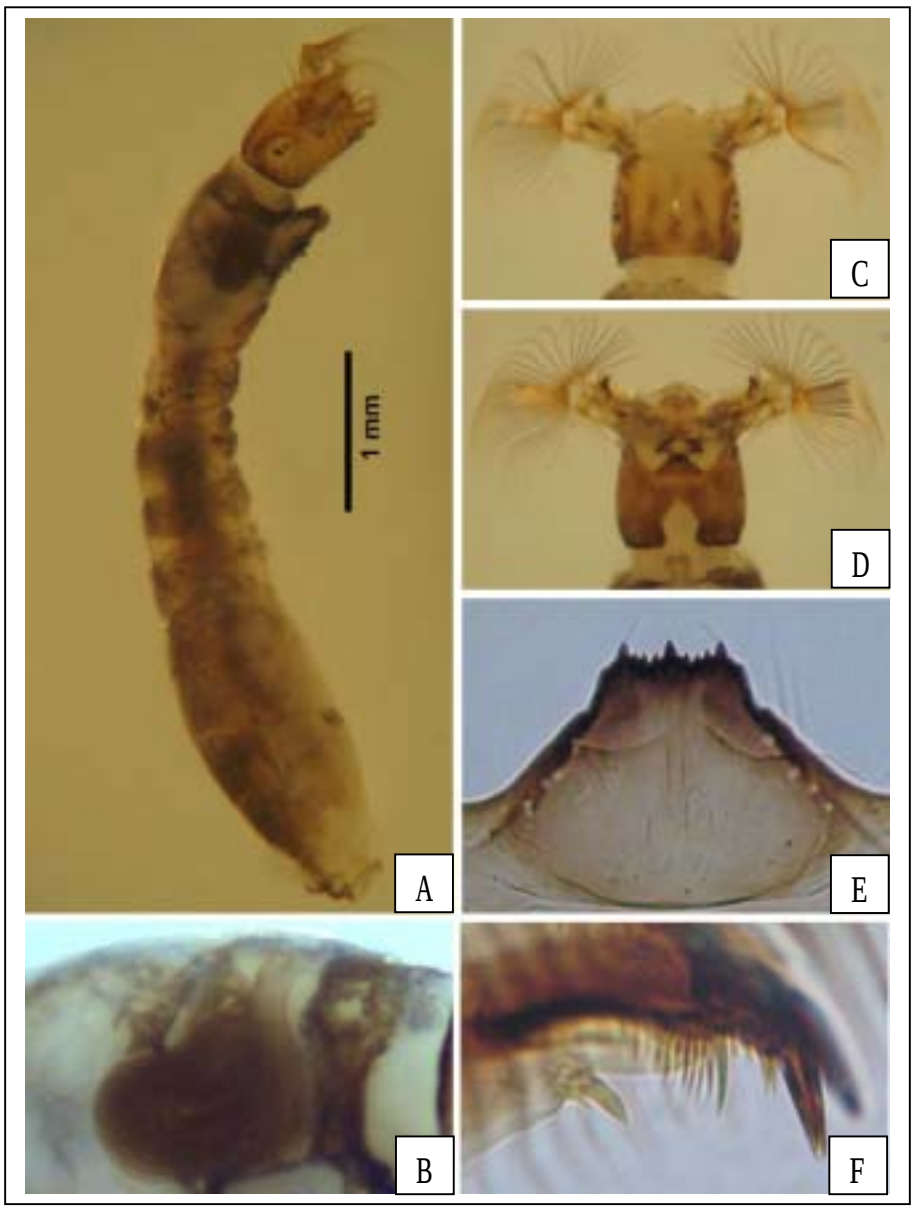

Figure 47 Larval structures of *Simulium* sp. C. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

Subgenus *Nevermannia* Enderlein

(A) *feuerborni* species-group

13. *Simulium* (*Nevermannia*) *feuerborni* Edwards, 1934

(Figures 48, 49, 50,51)

Simulium (*Nevermannia*) *feuerborni* Edwards, 1934: 129-132 (male, pupa, and mature larva).

Simulium (*Nevermannia*) *feuerborni*: Takaoka and Davies, 1996: 10-13 (female, male, pupa, and mature larva).

Description.

Larva (Figure 48). See Takaoka and Davies (1996).

Pupa (Figure 49). See Takaoka and Davies (1996).

Female (Figure 50). See Takaoka and Davies (1996).

Male (Figure 51). See Takaoka and Davies (1996).

Collection sites. Thailand. Nakhon Ratchasima, Khao Yai National Park; Creek 29 km. above S gate at Khao Kheow, 14°22'N 101°24'E.

Ecological notes. This species was found only during October and November 2000. Pupae and larvae were collected from fallen leaves and rocks at only site 14, a small shaded stream (0.5-2 m width) with slow to moderately flowing stream (0.1-0.4 m s^{-1}). Altitude at this site is 952 m. Water temperatures, and pH for collections ranged from 19.5-21.7 °C, and 5.64-5.88, respectively. This species was found with *S.* (*G.*) *angulistylum* and *S.* (*G.*) *asakoae.*

Remarks. The male, pupa, and mature larva were reported from East Java and Bali (Edwards, 1934). Takaoka and Davies (1996) provided a description of the female and revised descriptions of the male, pupa and mature larva. The pupal gill has 6 filaments per side, all filaments extending forwards close together; lower 2 filaments with long stalk. The cocoon has an anterodorsal projection. The larval body is most distinctive by characteristic reddish brown markings dorsally and the short postgenal cleft.

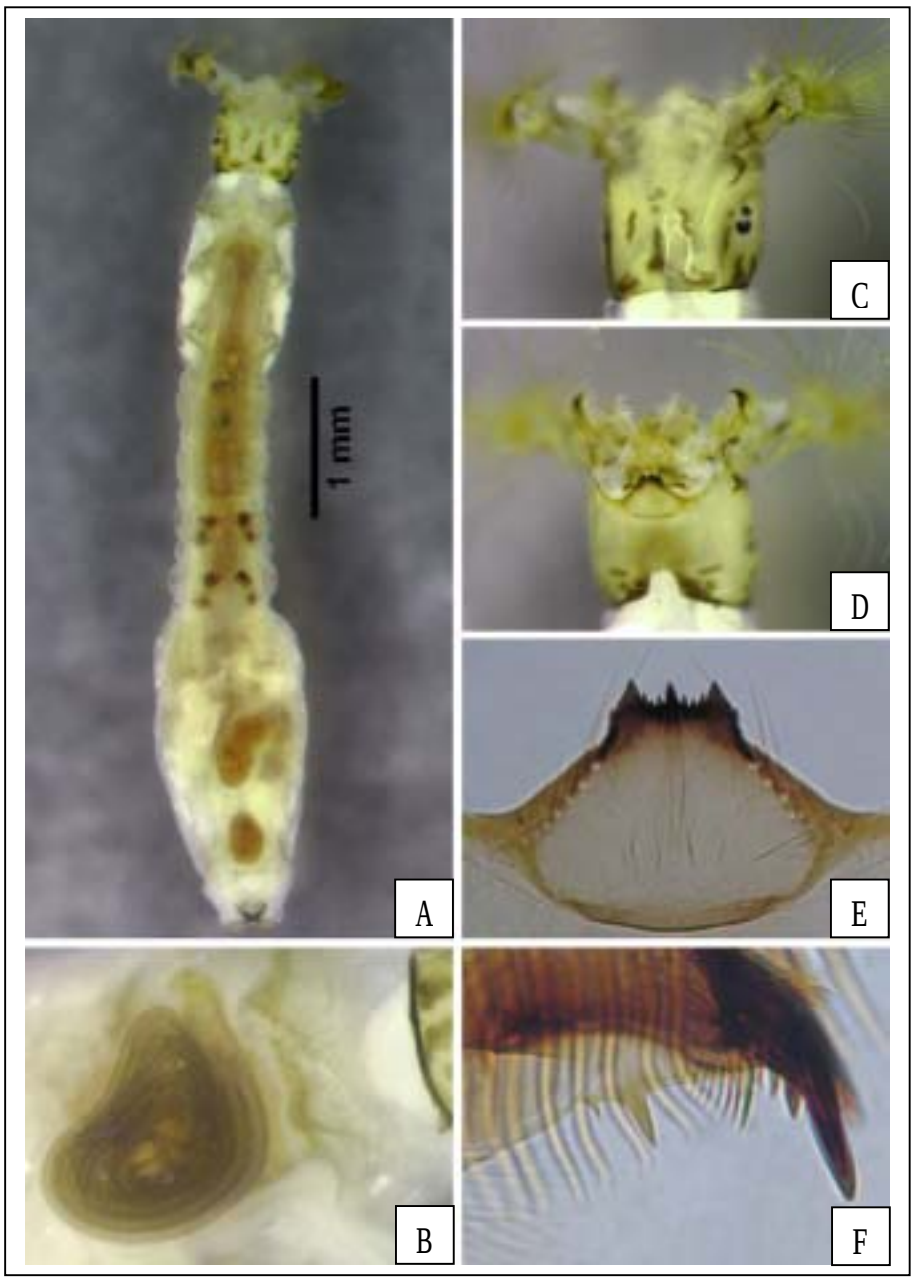

Figure 48 Larval structures of *Simulium feuerborni*. A, dorsal view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

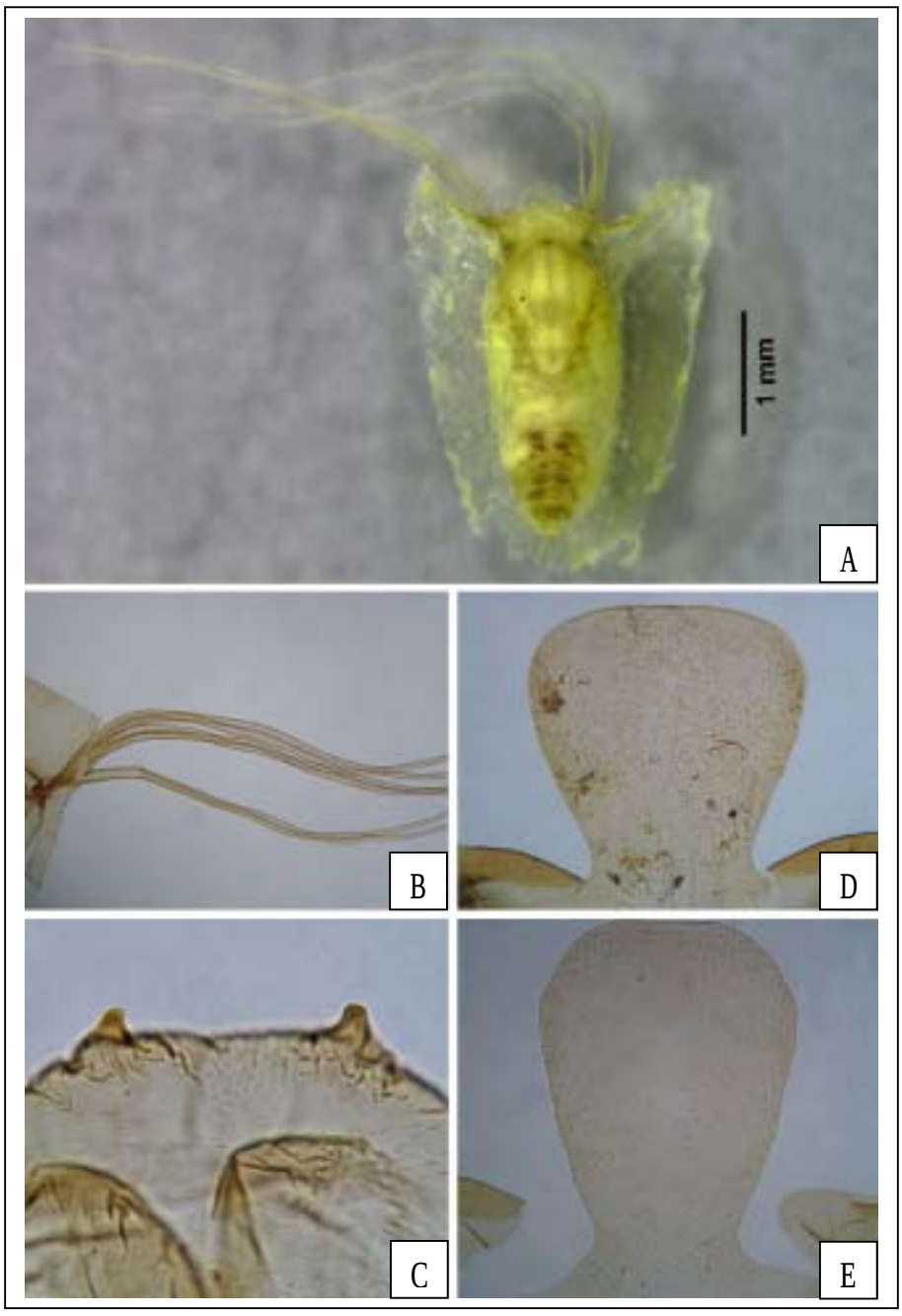

Figure 49 Pupal structures of *Simulium feueborni*. A, dorsal view; B, gill filaments; C, terminal hooks; D, E: head integument in front view: D, female; E, male

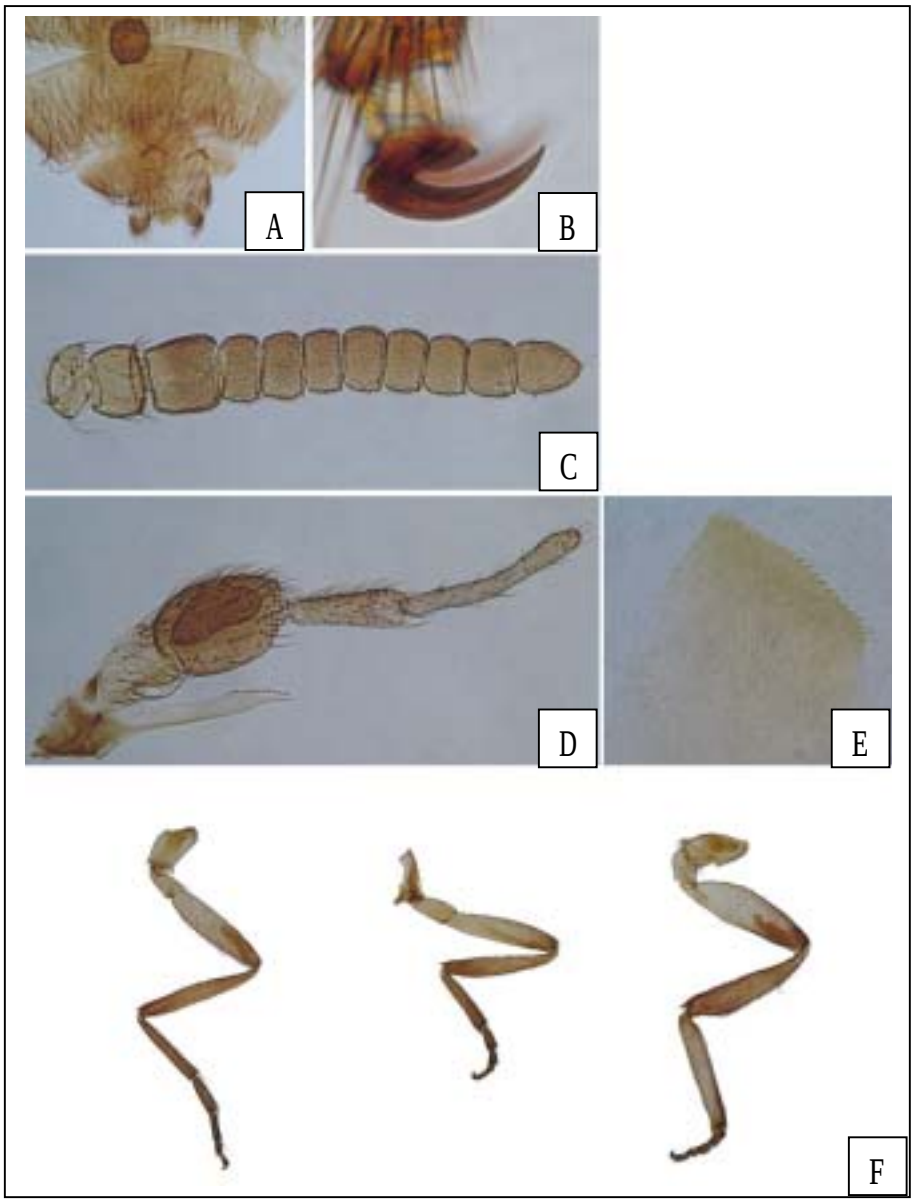

Figure 50 Adult structures of *Simulium feuerborni* female. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

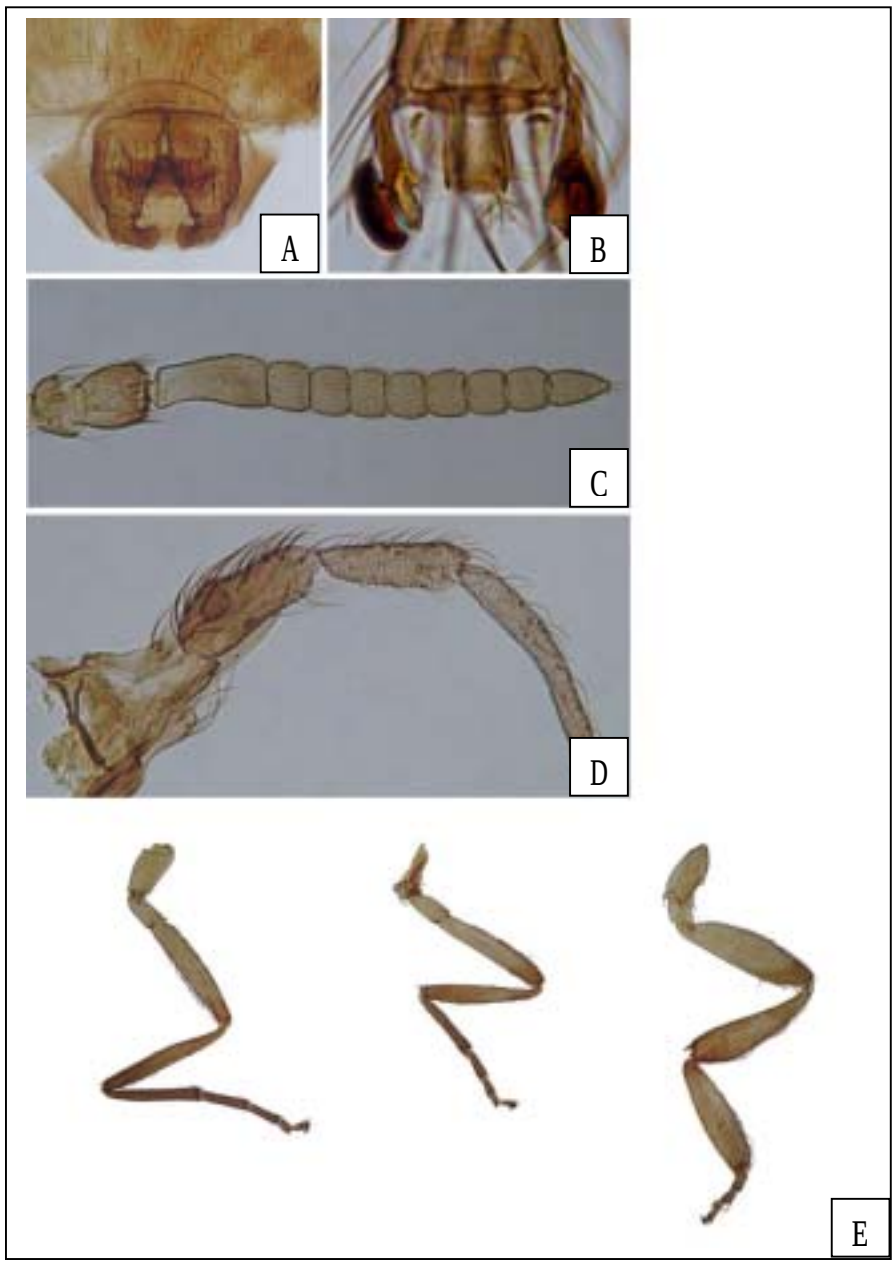

Figure 51 Adult structures of *Simulium feuerborni* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

Subgenus *Simulium* Latreille s. str.

(A) *griseifrons* species-group

14. *Simulium* (*Simulium*) *grossifilum* Takaoka and Davies, 1995

(Figures 52, 53)

Simulium (*Simulium*) *grossifilum* Takaoka and Davies, 1995: 105-110 (female, male, pupa, and mature larva).

Description.

Larva. See Takaoka and Davies (1995).

Pupa (Figure 52). See Takaoka and Davies (1995).

Female. See Takaoka and Davies (1995).

Male (Figure 53). See Takaoka and Davies (1995).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 6.0 km. above S gate, 14°15'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Pa Krajai Waterfal, 14°21'N 101°20'E.

Ecological notes. Only pupae of this species were found in two samples collected in July 2000 and April 2001. The pupae were collected from fallen leaves and rocks in small streams (0.5-2 m width) with slow to fast flowing water (0.2-1.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 297-654 m, 24.2-24.3 °C, and 7.93, respectively. This species was found with *S.* (*G.*) *angulistylum*, *ceylonicum*-species group, *S.* (*G.*) sp. C, *S.* (*S.*) *nakhonense* and *S.* (*S.*) *tani*.

Remarks. This species was originally described from specimens collected from West Malaysia (Takaoka and Davies, 1995). The pupa is very distinctive by having 6 inflated tubular gill filaments and a cocoon with large dorsolateral window anteriorly on each side. The larva has a medium postgenal cleft, pointed apically, nearly as long as wide and abdominal segments lacking a pair of small dorsal protuberances.

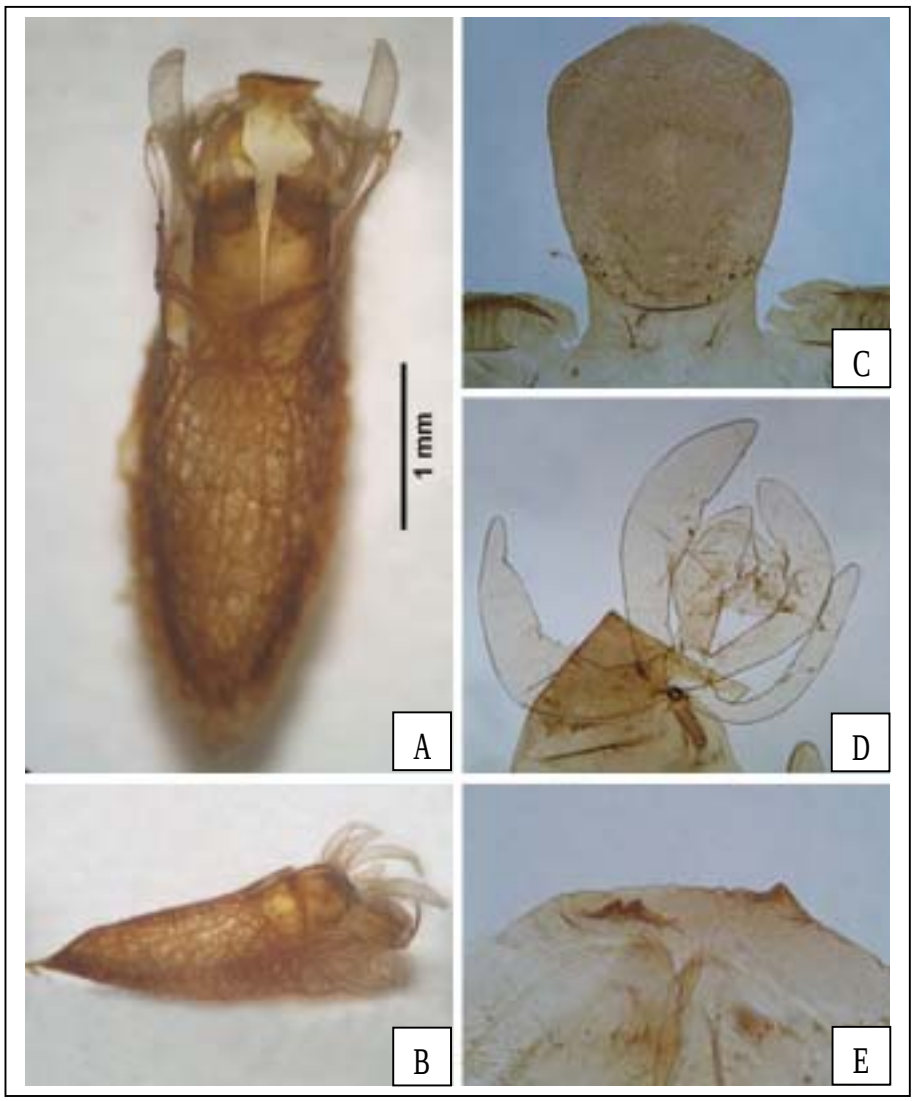

Figure 52 Pupal structures of *Simulium grossifilum*. A, B: cocoon and pupal exuviae; A, dorsal view; B, lateral view; C, head integument of male in front view; D, gill filaments; E, terminal hooks

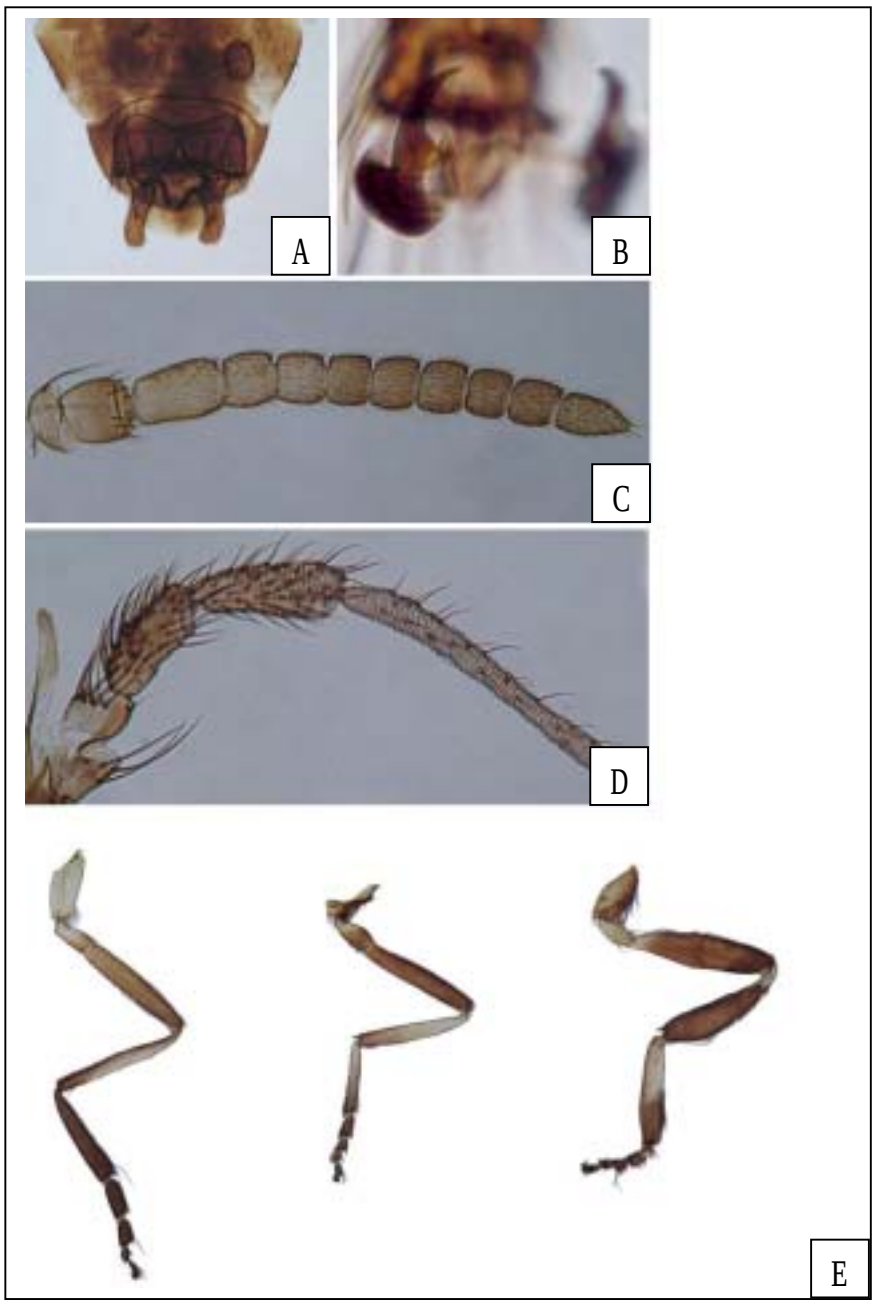

Figure 53 Adult structures of *Simulium grossifilum* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

15. *Simulium* (*Simulium*) *rudnicki* Takaoka and Davies, 1995

(Figures 54, 55)

Simulium (*Simulium*) *rudnicki* Takaoka and Davies, 1995: 155-157 (female).

Simulium (*Simulium*) *rudnicki*:Takaoka and Choochote, 2004: 311-314 (male, pupa, and mature larva).

Description.

Larva (Figure 54). See Takaoka and Choochote, (2004).

Pupa (Figure 55). See Takaoka and Choochote, (2004).

Female. See Takaoka and Davies (1995).

Male. See Takaoka and Choochote, (2004).

Collection sites. Thailand. Nakhon Nayok, Khao Yai National Park; Pa Tabak creek, 14°19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E.

Ecological notes. One larva was found in January 2001 and collected from bedrock. One pupa was found in February 2001 and collected from fallen leaf. They were in small exposed to shaded streams (0.15-2.5 m width) with slow to fast flowing water (0.1-2.0 m s^{-1}) in natural forest. Altitudes, water temperatures, and pH for the collection sites ranged from 505-654 m, 20.0-22.4 °C, and 7.75-7.98, respectively. This species was found with *ceylonicum*-species group, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *quinquestriatum* and *S.* (*S.*) *tani*

Remarks. *Simulium* (*S.*) *rudnicki* was originally described based on a female from West Malaysia (Takaoka and Davies, 1995). The male, pupa, and mature larva were described from Thailand by Takaoka and Choochote, (2004c). The pupal gill has 6 filaments arranged in sessile pairs and a cocoon with an anterolateral window on each side. The larva has a medium postgenal cleft, pointed apically, head capsule with mostly dark brown and abdominal segments lacking a pair of small dorsal protuberances.

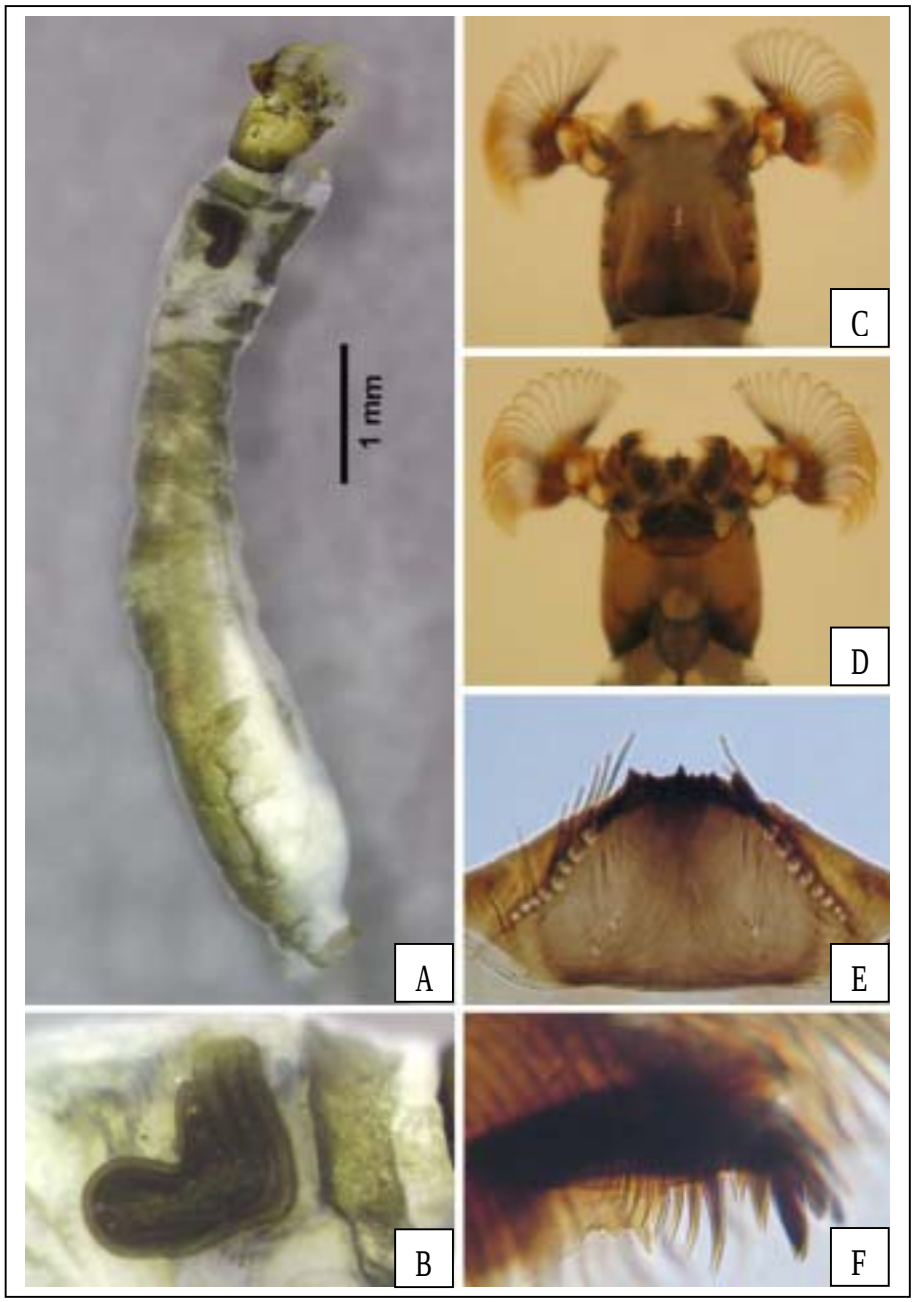

Figure 54 Larval structures of *Simulium rudnicki*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

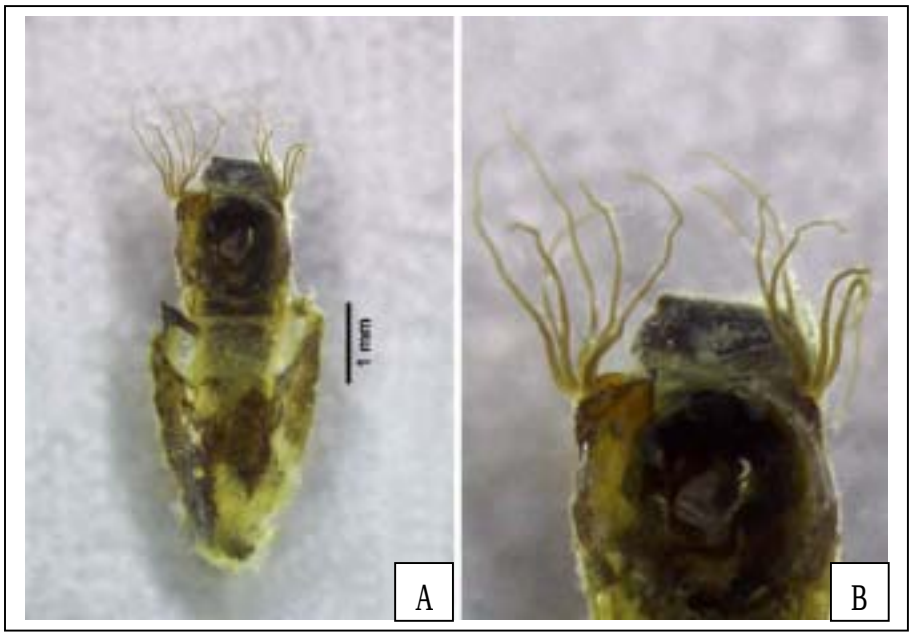

Figure 55 Pupal structures of *Simulium rudnicki*. A, dorsal view; B, gill filaments

(B) *multistriatum* species-group

16. *Simulium* (*Simulium*) *chainarongi* Kuvangkadilok and Takaoka, 1999

(Figure 56)

Simulium (*Simulium*) *chainarongi* Kuvangkadilok and Takaoka, 1999: 501-504 (female, male, pupa, and mature larva).

Description.

Larva (Figure 56). See Takaoka and Kuvangkadilok (1999).

Pupa. See Takaoka and Kuvangkadilok (1999).

Female. See Takaoka and Kuvangkadilok (1999).

Male. See Takaoka and Kuvangkadilok (1999).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 5.3 km. above S gate, 14°15'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E.

Ecological notes. Only larvae were found from bedrock, fallen leaves, trailing grasses, leaves, and sticks in streams (0.15-20 m width) with slow to fast flowing water (0.2-1.5 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 256-751 m, 20.0-24.5 °C, and 6.59-7.76, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *siamense*, *S.* (*G.*) *asakoae*, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, *S.* (*S.*) *tani*, and *S.* (*S.*) *rudnicki*.

Remarks. *Simulium* (*S.*) *chainarongi* was originally described from female, male, pupal, and mature larval specimens collected in Thailand (Takaoka and Kuvangkadilok, 1999). The eight short slender pupal gill filaments are arranged in pairs, with the dorsalmost filament twice as thick in the basal portion as the

lowermost. The cocoon of this species is distinguished by the shoe-shape with an anterior collar. The larva has a pair of small dorsal protuberances on the abdominal segments 1-6.

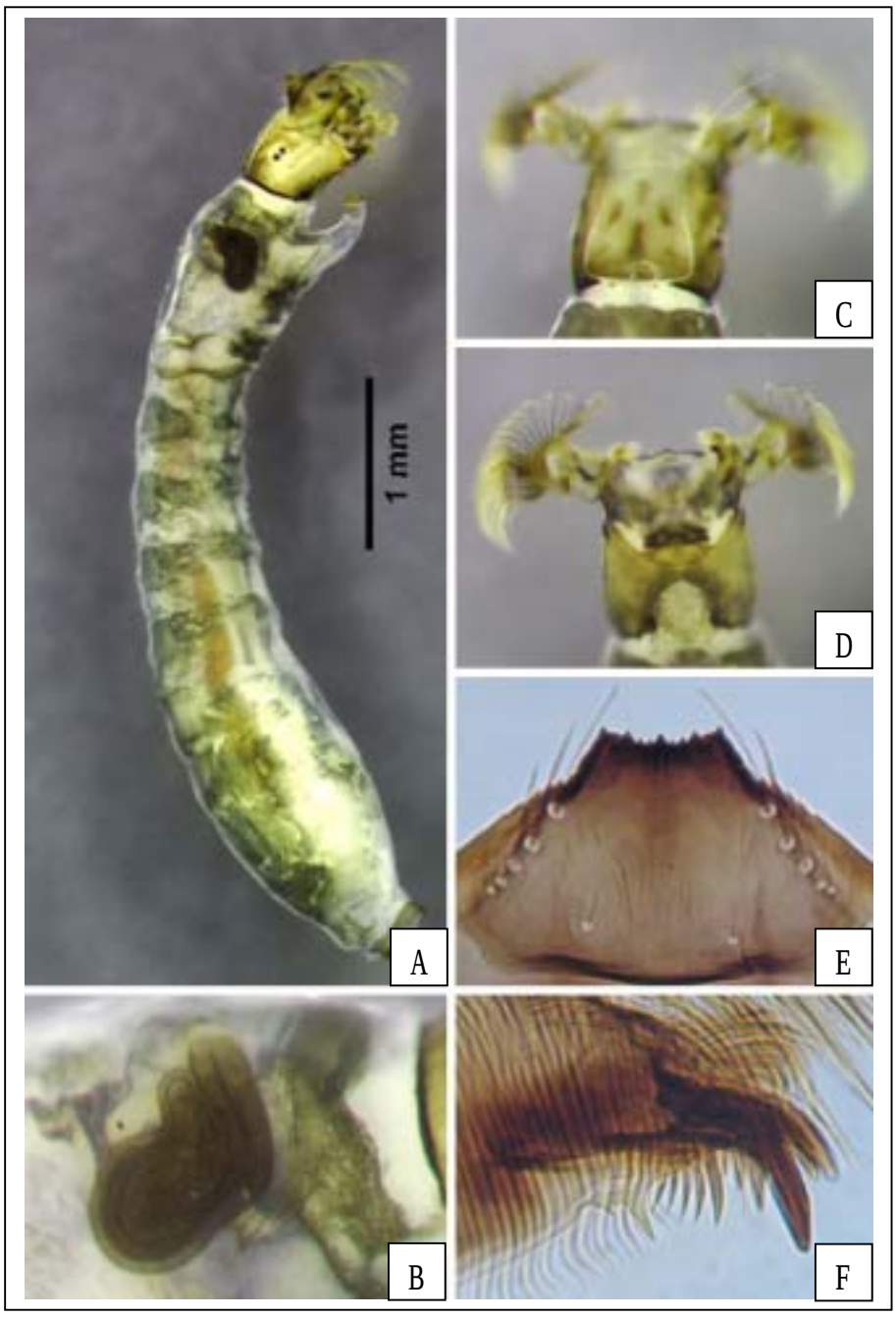

Figure 56 Larval structures of *Simulium chainarongi*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

17. *Simulium* (*Simulium*) *fenestratun* Edwards, 1934

(Figures 57, 58, 59, 60)

Simulium (*Simulium*) *fenestratun* Edwards, 1934: 110-111 (female, male, pupa, and mature larva).

Simulium (*Simulium*) *sakishimaense* (*nec* Takaoka, 1977): Takaoka & Suzuki, 1984: 39-40.

Description. See Edwards (1934).

Larva (Figure 57). See Edwards (1934).

Pupa (Figure 58). See Edwards (1934).

Female (Figure 59). See Edwards (1934).

Male (Figure 60). See Edwards (1934).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 2.3 km. above S gate, 14°14'N 101°23'E; Than Rattana Waterfall, 14°14'N 101°23'E; Creek 5.3 km. above S gate, 14°15'N 101°23'E; Creek 6.0 km. above S gate, 14°15'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14°19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Tad Tapoo creek, 14°24'N 101° 22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E.

Ecological notes. This species was recorded in all seasons but was not found in April and May 2001. Pupae and larvae were collected from bedrock, fallen leaves, rocks, trailing grasses, leaves and roots, and sticks in streams (0.15-25 m width) with slow to fast flowing water (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 188-751 m, 20.0-25.5 °C, and 6.19-7.90, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) *asakoae*, *S.* (*G.*) sp. nr. *sheilae*, *ceylonicum* species-group, *S.* (*G.*) *gombakense*, *S.* (*G.*) sp. C, *S.*

(*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, *S.* (*S.*) *tani*, *S.* (*S.*) *rudnicki* and *S.* (*S.*) sp. E.

Remarks. This species was originally described from Java and Sumatra (Edwards, 1934). The eight short slender pupal gill filaments are arranged in pairs, three pairs with short stalks and the lower pair sessile. This species is distinguished by the shoe-shape cocoon with an anterolateral window on each side. The larva does not have a pair of small dorsal protuberances on the abdomen.

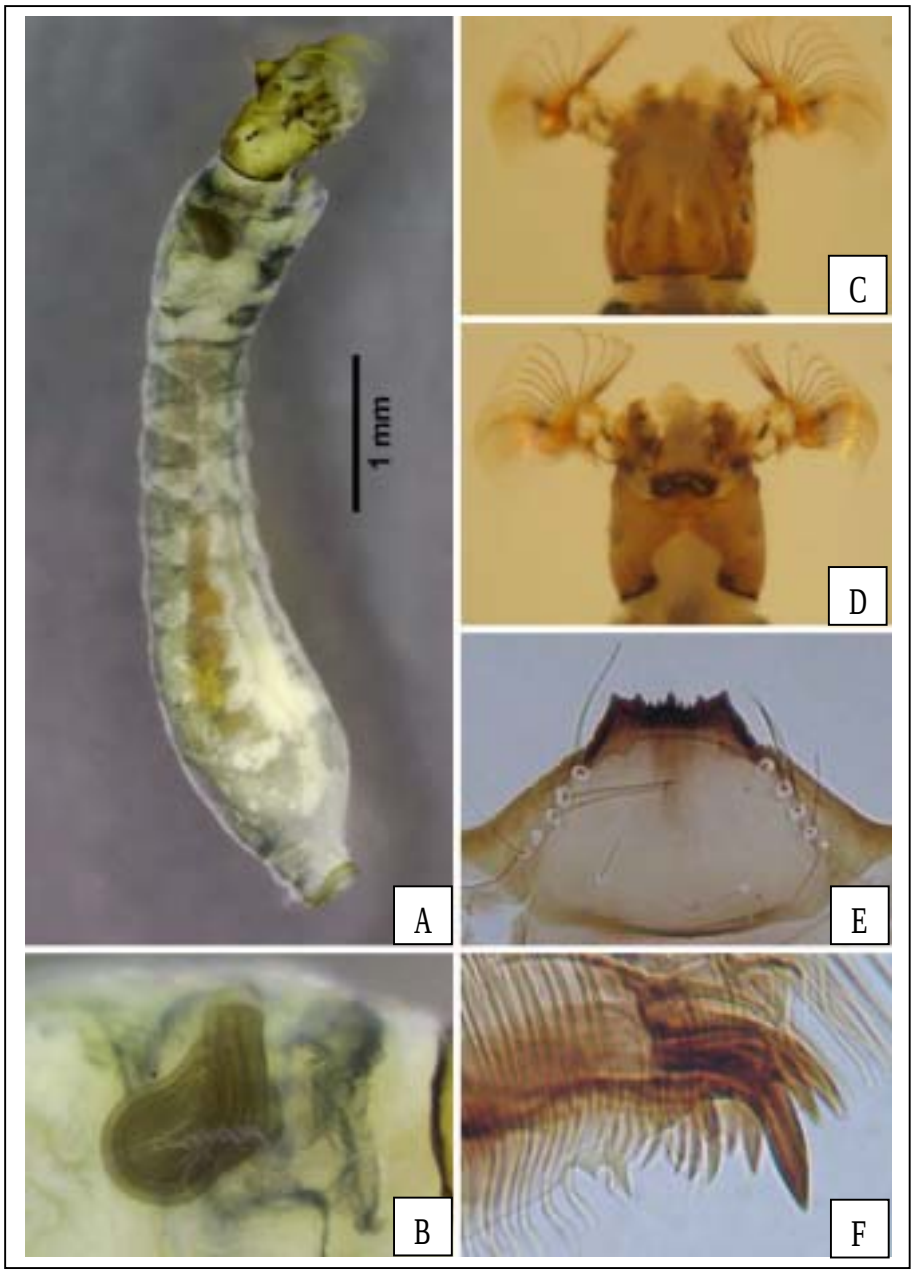

Figure 57 Larval structures of *Simulium fenestratum*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

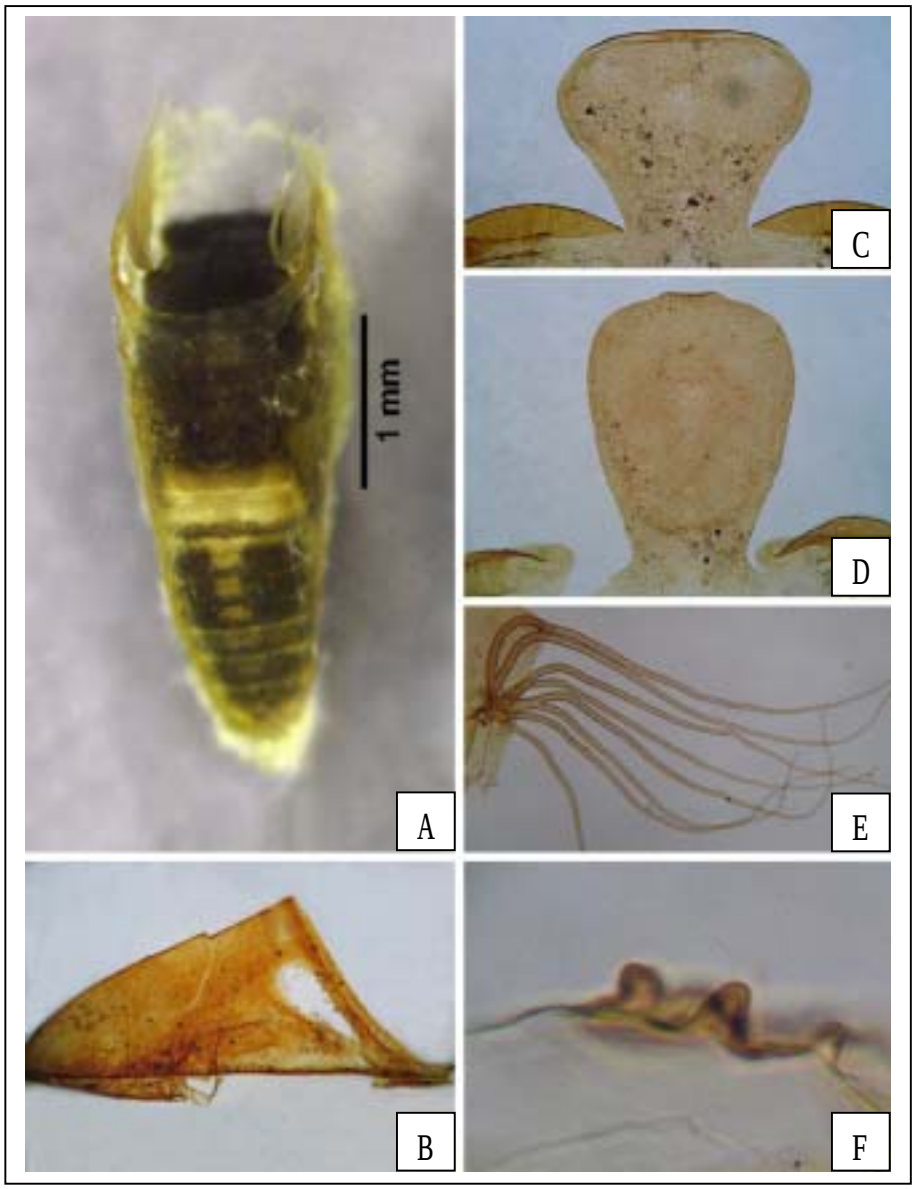

Figure 58 Pupal structures of *Simulium fenestratum*. A, dorsal view; B, cocoon in lateral view; C, D: head integument in front view; C, female; D, male; E, gill filaments; F, terminal hooks

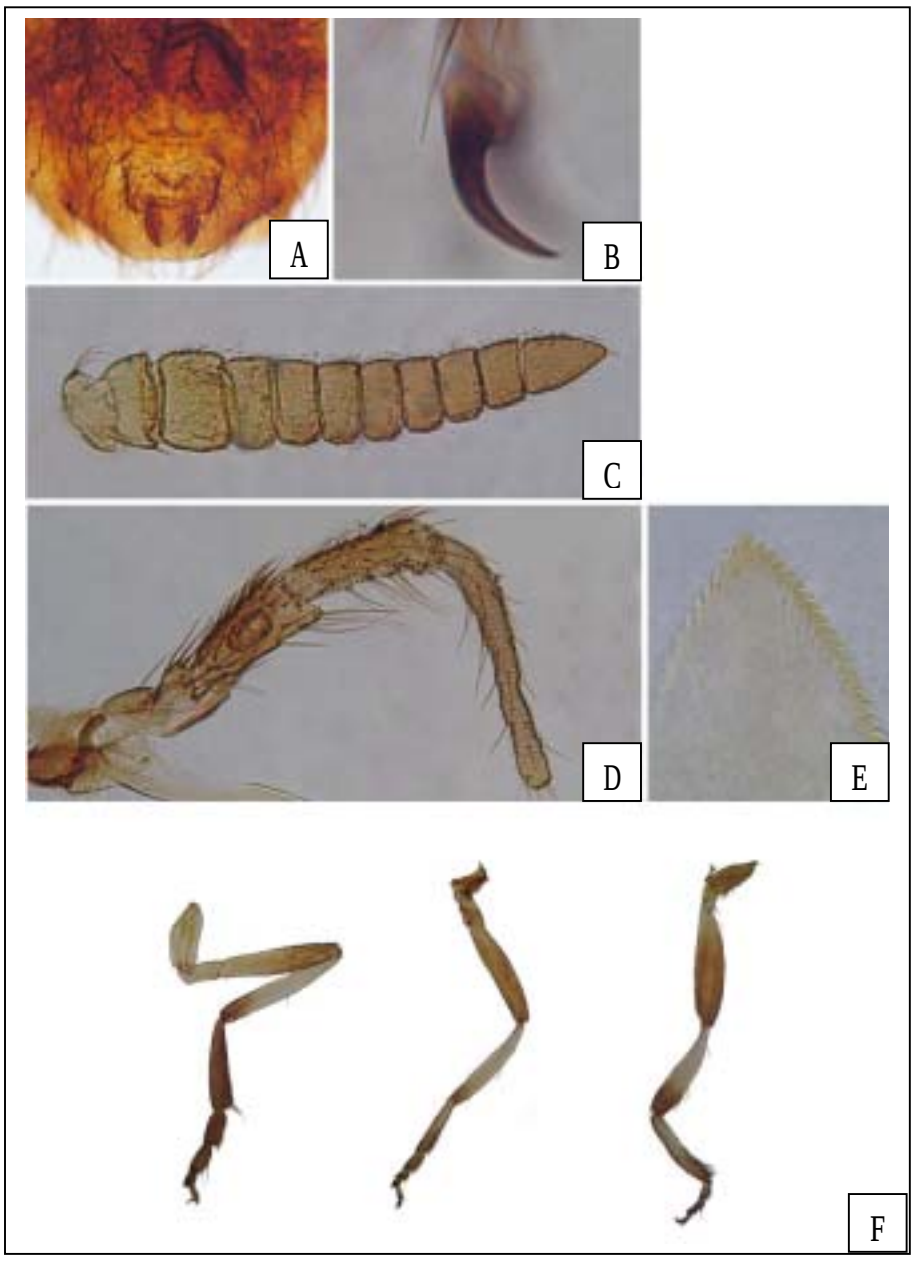

Figure 59 Adult structures of *Simulium fenestratum* female. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

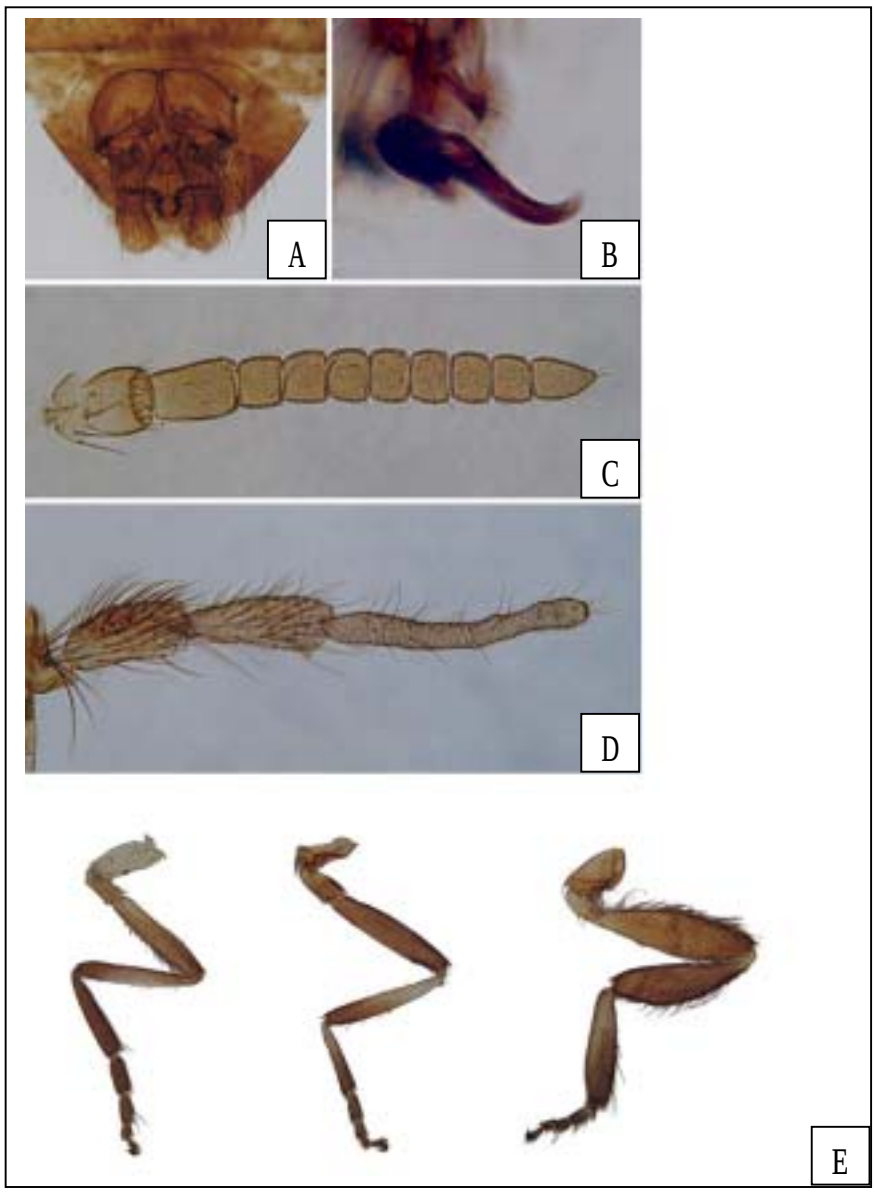

Figure 60 Adult structures of *Simulium fenestratum* male. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(C) *striatum* species-group

18. *Simulium* (*Simulium*) *nakhonense* Takaoka and Suzuki, 1984

(Figures 61, 62, 63, 64)

Simulium (*Simulium*) *nakhonense* Takaoka and Suzuki, 1984: 33-37 (female, male, pupa, and mature larva).

Description.

Larva (Figure 61). Takaoka and Suzuki (1984).

Pupa (Figure 62). Takaoka and Suzuki (1984).

Female (Figure 63). Takaoka and Suzuki (1984).

Male (Figure 64). Takaoka and Suzuki (1984).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Than Rattana Waterfall, 14°14'N 101°23'E; Creek 6.0 km. above S gate, 14°15'N 101° 23'E; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Pa Krajai Waterfal, 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26'N 101°25'E.

Ecological notes. This species was recorded in all seasons but was not found in May 2001. Pupae and larvae were collected from bedrock, fallen leaves, rocks, trailing grasses, leaves and roots, and aquatic plant in streams (0.15-35 m width) with slow to fast flowing water (0.2-1.9 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 233-751 m, 19.0-26.1 °C, and 6.19-7.70, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *siamense*, *ceylonicum* species-group, *S.* (*G.*) *novemarticulatum*, *S.* (*S.*) *grossifilum*, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *quinquestriatum*, and *S.* (*S.*) *tani*.

Remarks. *Simulium* (*S.*) *nakhonense* was originally described based on female, male, pupal, and mature larval specimens from Thailand (Takaoka and Suzuki, 1984). The pupal gill with 10 filaments are arranged in pairs, upper 5 or 6 filaments inflated at base while others slender. This species is distinguished by the shoe-shape cocoon with low neck. The larva has a pair of small dorsal protuberances on the abdominal segments 1-8.

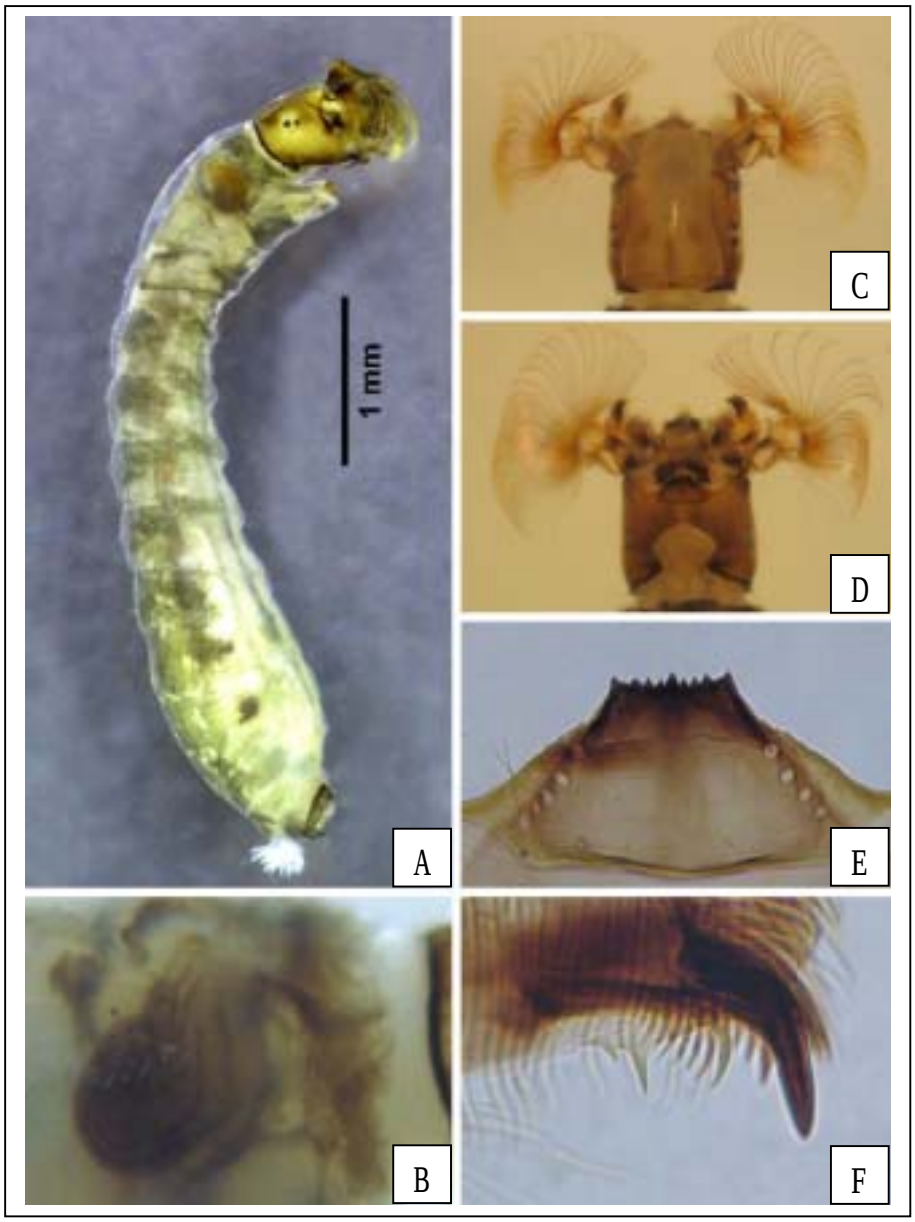

Figure 61 Larval structures of *Simulium nakhonense*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

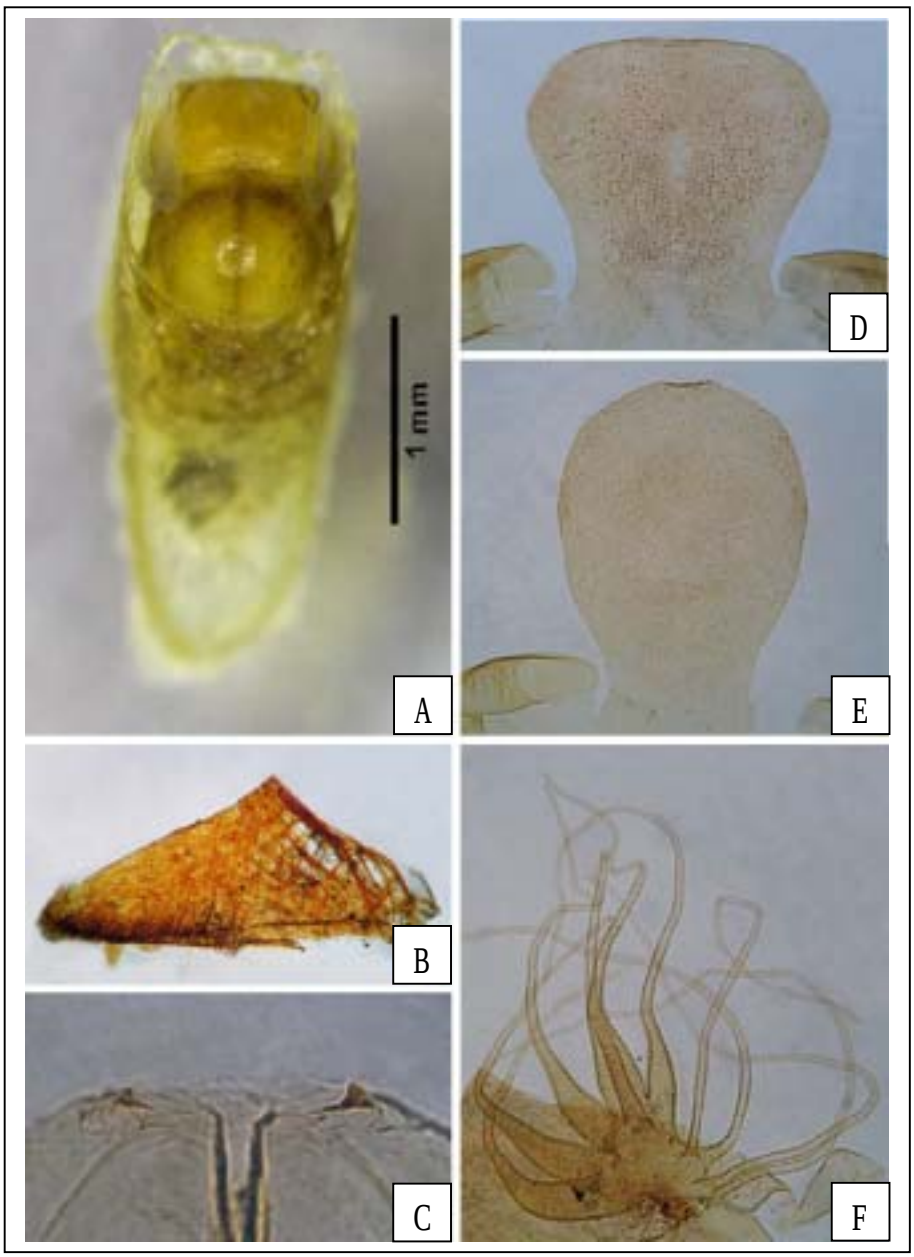

Figure 62 Pupal structures of *Simulium nakhonense*. A, dorsal view; B, cocoon in lateral view; C, terminal hooks; D, E: head integument in front view: D, female; E, male; F, gill filaments

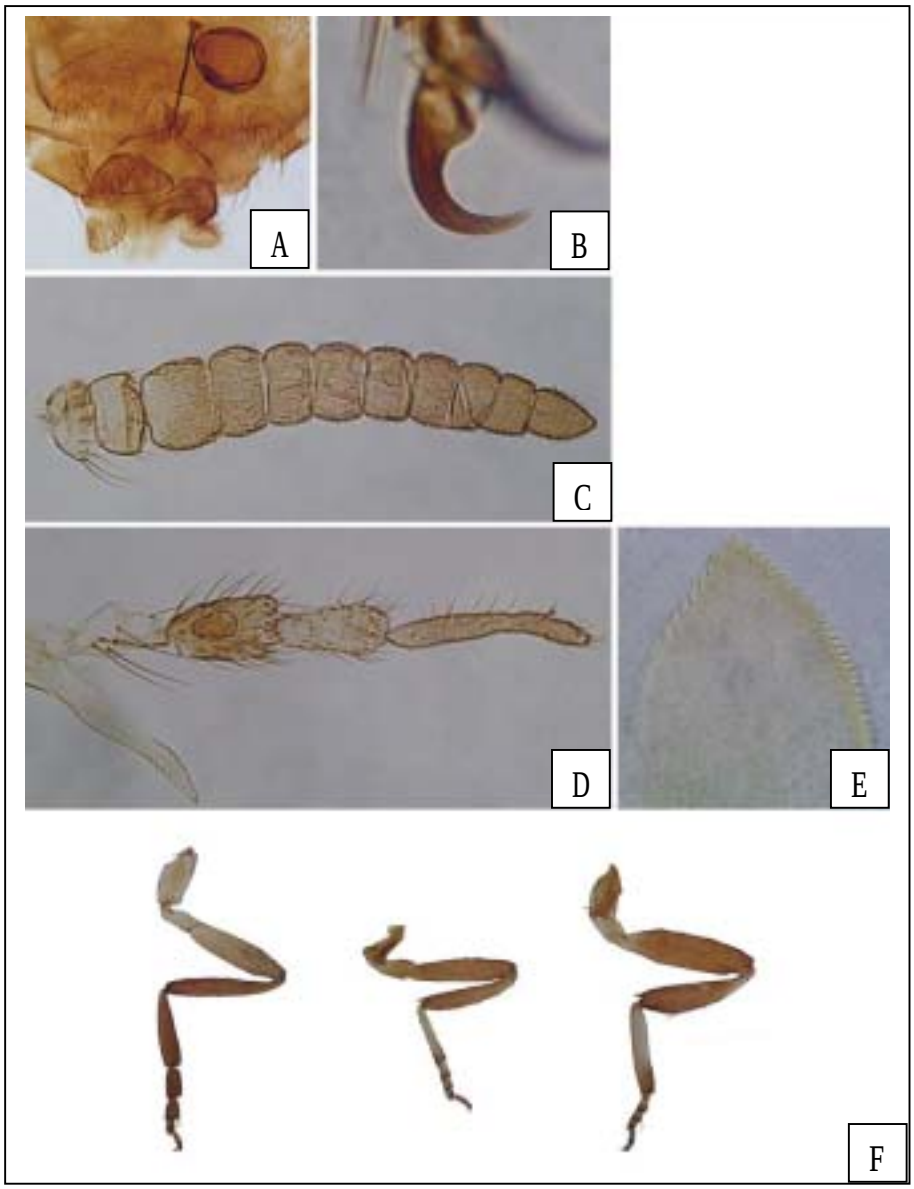

Figure 63 Adult structures of *Simulium nakhonense* female. A, genitalia in ventral view; B, claw; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

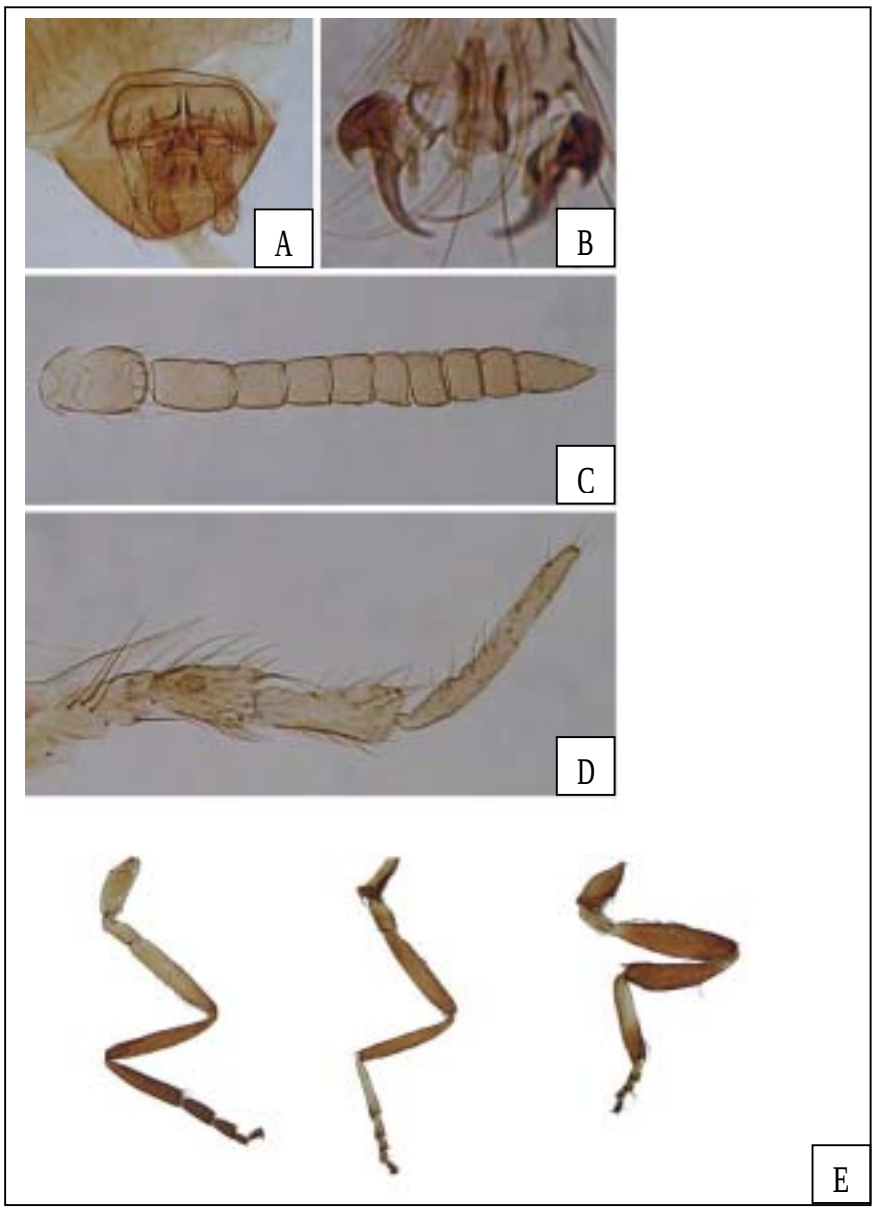

Figure 64 Adult structures of *Simulium nakhonense* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

19. *Simulium* (*Simulium*) *quinquestriatum* (Shiraki, 1935)

(Figures 65, 66, 67, 68)

Stilboplax 5-striatum Shiraki, 1935: 27-33 (female and male).

Simulium (*Simulium*) *quinquestriatum*: Takaoka, 1979: 396-399 (female, male, pupa, and mature larva).

Description.

Larva (Figure 65). See Takaoka (1979).

Pupa (Figure 66). See Takaoka (1979).

Female (Figure 67). See Takaoka (1979).

Male (Figure 68). See Takaoka (1979).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Than Rattana Waterfall, 14°14'N 101°23'E; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14° 19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26'N 101°25'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14° 25'N 101°25'E.

Ecological notes. This species was found in all seasons. Pupae and larvae were collected from bedrock, aquatic plant, fallen leaves, rocks, trailing grasses and leaves, sticks, and plastic tube in streams (0.15-35 m width) with slow to fast flowing water (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 233-751 m, 19.0-26.1 °C, and 6.19-7.98, respectively. This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *siamense*, *ceylonicum* species-group, *S.* (*G.*) *novemarticulatum*, *S.* (*G.*) sp. B, *S.* (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *tani*, and *S.* (*S.*) *rudnicki*.

Remarks. *Simulium* (*S.*) *quinquestriatum* was originally described based on female and male specimens under the name *Stilboplax 5-striatum* collected from Taiwan (Shiraki, 1935). The revised description of all life stages was given by Takaoka (1979). The pupal gill with 10 slender filaments are slender, arranged in groups of 2+3+3+2 from dorsal to ventral, all filaments subequal in thickness. This species is distinguished by the shoe-shape cocoon with high neck. The larva has a pair of small dorsal protuberances on the abdominal segments 1-8. The present larva specimens differ from the original description by the thoracic and abdominal cuticle bare.

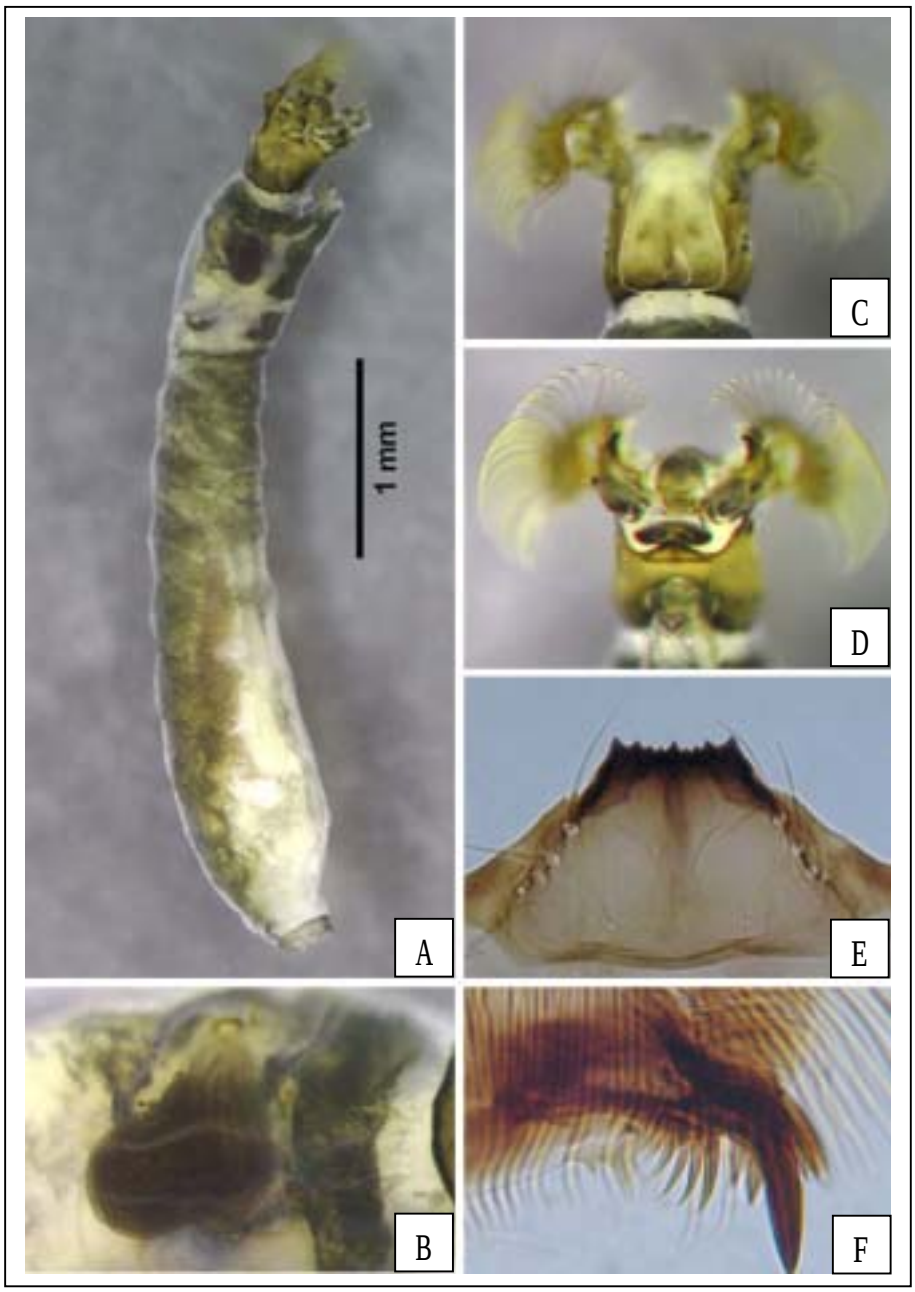

Figure 65 Larval structures of *Simulium quinquestriatum*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

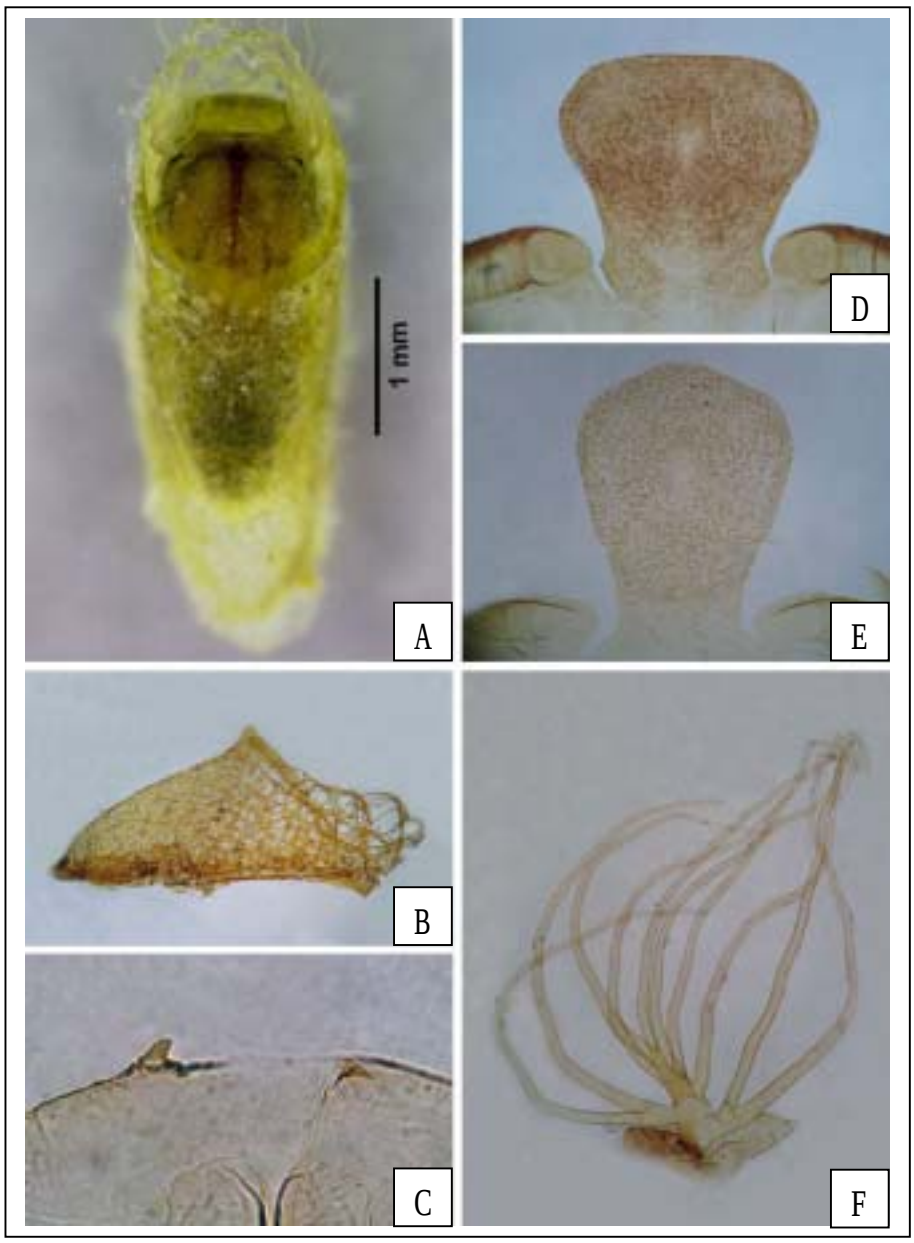

Figure 66 Pupal structures of *Simulium quinquestriatum*. A, dorsal view; B, cocoon in lateral view; C, terminal hooks; D,E: head integument in front view; D, female; E, male; F, gill filaments

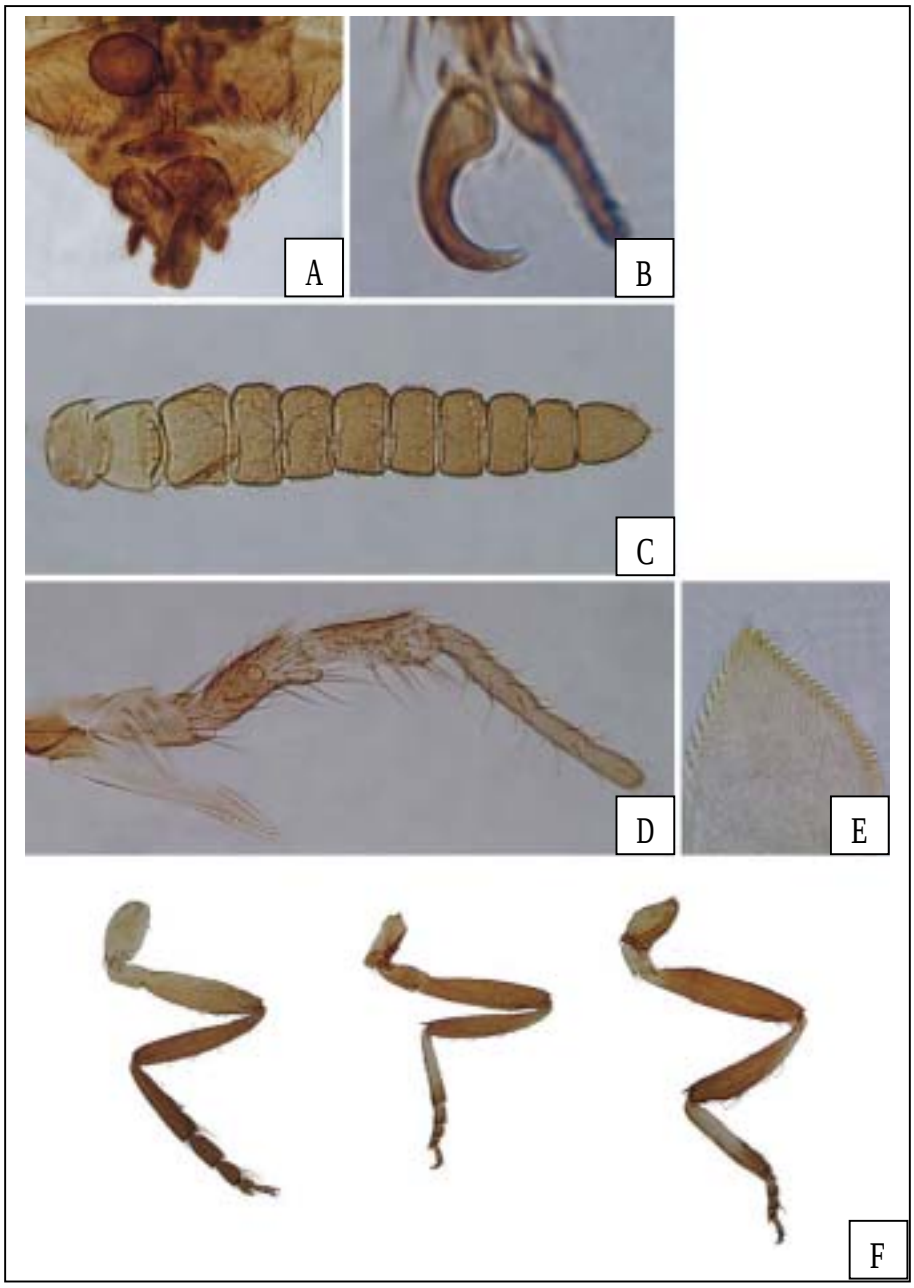

Figure 67 Adult structures of *Simulium quinquestriatum* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

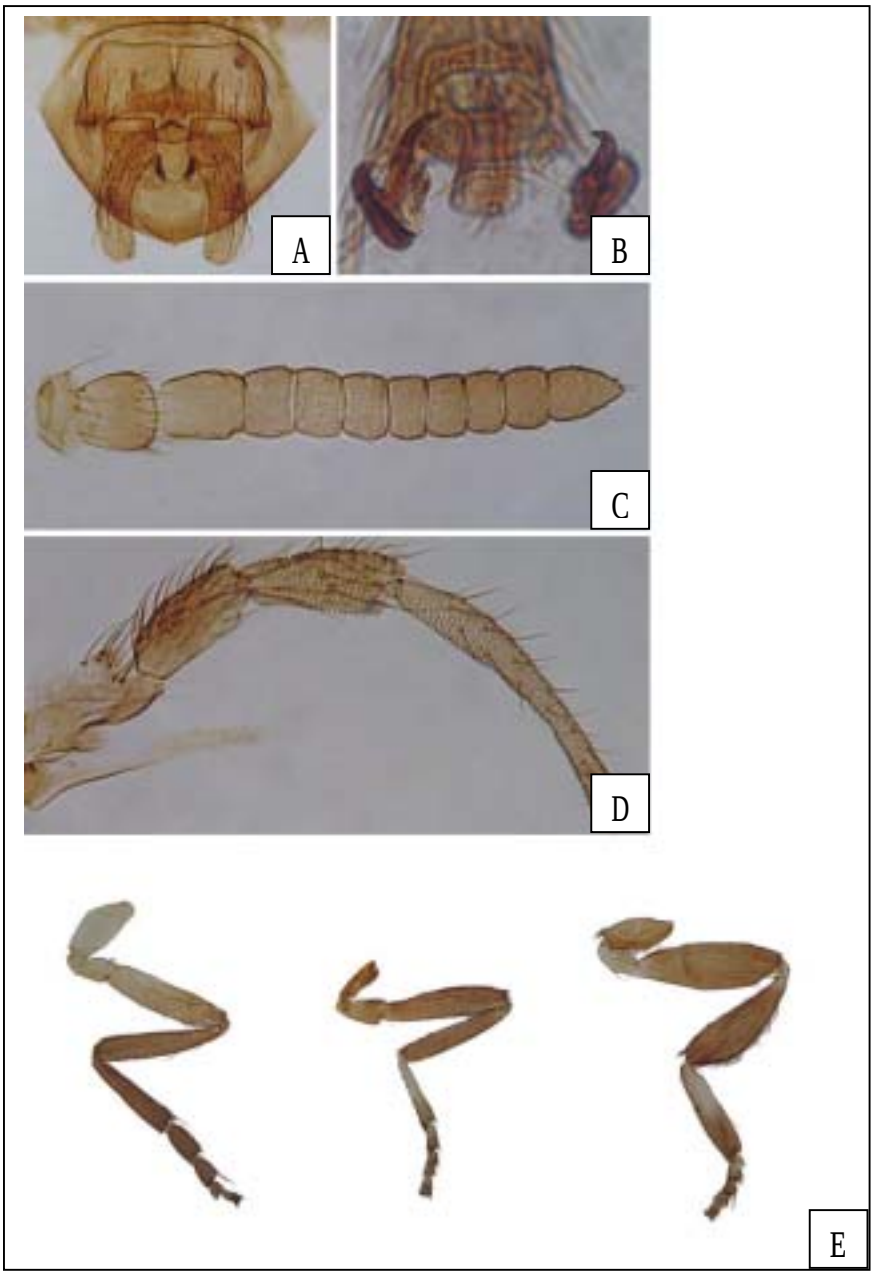

Figure 68 Adult structures of *Simulium quinquestriatum* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(D) *tuberosum* species-group

20. *Simulium* (*Simulium*) *tani* Takaoka and Davies, 1995

(Figures 69, 70, 71, 72)

Simulium (*Simulium*) *tani* Takaoka and Davies, 1995: 137-141 (female, male, pupa, and mature larva).

Simulium (*Simulium*) *nitidithorax* (*nec* Puri, 1932): Takaoka and Suzuki, 1984: 40-41 (mature larva).

Description.

Larva (Figure 69). See Takaoka and Davies (1995).

Pupa (Figure 70). See Takaoka and Davies (1995).

Female (Figure 71). See Takaoka and Davies (1995).

Male (Figure 72). See Takaoka and Davies (1995).

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 3.2 km. above S gate, 14°14'N 101°23'E; Creek under wood bridge at Haew Narok Waterfall, 14°17'N 101°23'E; Creek under concrete bridge at Haew Narok Waterfall, 14°17'N 101°23'E. Nakhon Nayok, Khao Yai National Park; Creek under 1st concrete bridge before Khao Kheow Rd., 14°20'N 101°21'E; Pa Tabak creek, 14° 19'N 101°21'E; Pa Krajai Waterfal, 14°21'N 101°20'E; Creek under 2nd concrete bridge before Khao Kheow Rd., 14°21'N 101°20'E. Nakhon Ratchasima, Khao Yai National Park; Huai Lam Takrong at Wang Jumpee, 14°26'N 101°22'E; Pa Kluai Mai Waterfall, 14°25'N 101°24'E; Tad Tapoo creek, 14°24'N 101°22'E; Creek 5.8 km. up Haew Suwat Waterfall Rd., 14°25'N 101°24'E; Huai Lam Takrong below at Haew Suwat Waterfall, 14°26'N 101°25'E; Tributary of Huai Lam Takrong at Haew Suwat Waterfall, 14°25'N 101°25'E.

Ecological notes. This species was found in all seasons. Pupae and larvae were collected from bedrock, fallen leaves, rocks, trailing grasses, leaves and roots, and sticks in streams (0.15-25 m width) with slow to fast flowing water (0.1-2.0 m s^{-1}), and ranging from fully exposed to shaded. Altitudes, water temperatures, and pH for collection sites ranged from 200-751 m, 19.0-25.7 °C, and 6.19-7.98, respectively.

This species was found with *S.* (*G.*) *angulistylum*, *S.* (*G.*) *decuplum*, *S.* (*G.*) *dentistylum*, *S.* (*G.*) *siamense*, *S.* (*G.*) sp. A, *S.* (*G.*) *asakoae*, *S.* (*G.*) *sheilae*, *S.* (*G.*) sp. nr. *sheilae*, *S.* (*G.*) *gombakense*, *S.* (*G.*) sp. B, *S.* (*G.*) sp. C, *S.* (*S.*) *grossifilum*, S. (*S.*) *fenestratum*, *S.* (*S.*) *chainarongi*, *S.* (*S.*) *nakhonense*, *S.* (*S.*) *quinquestriatum*, and *S.* (*S.*) *rudnicki*.

Remarks. This species was originally described from West Malaysia (Takaoka and Davies, 1995). The mature larva was previously reported from Thailand as *S.* (*S.*) *nitidithorax*, which Puri originally described from India (Takaoka and Suzuki, 1984). The gill with 6 short-stalked filaments are arranged in pairs. This species is distinguished by the simple wall-pocket-shape cocoon. The larva with a deep postgenal cleft, is longer than wide. The body color is reddish brown and abdominal segments lacking a pair of small dorsal protuberances. It is noted that the present larva specimens slightly differ from the Malaysian ones by having 4 or 5 hypostomal bristles diverging posteriorly from lateral border on each side.

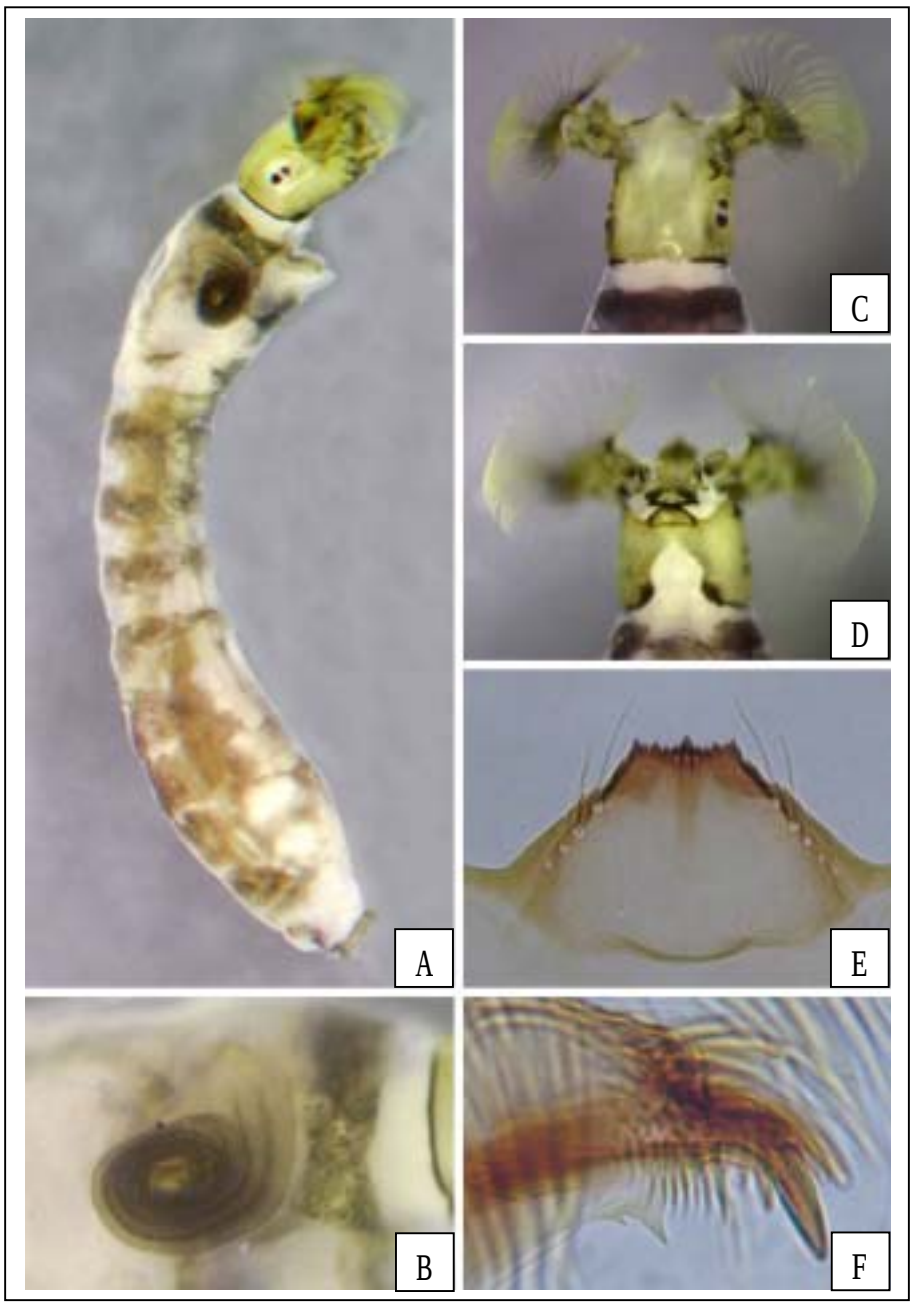

Figure 69 Larval structures of *Simulium tani*. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

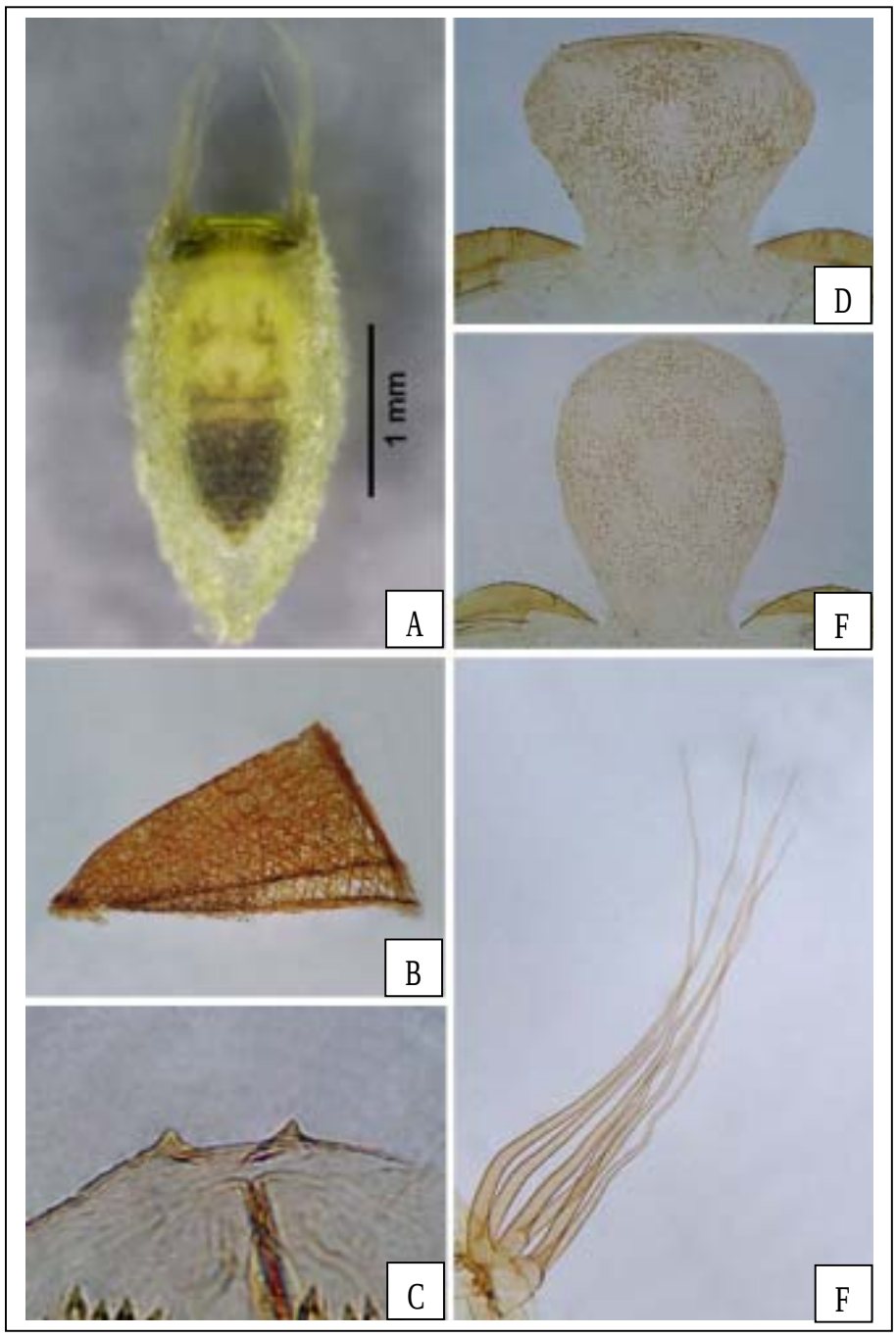

Figure 70 Pupal structures of *Simulium tani*. A, dorsal view; B, cocoon in lateral view; C, terminal hooks; D,E: head integument in front view; D, female; E, male; F, gill filaments

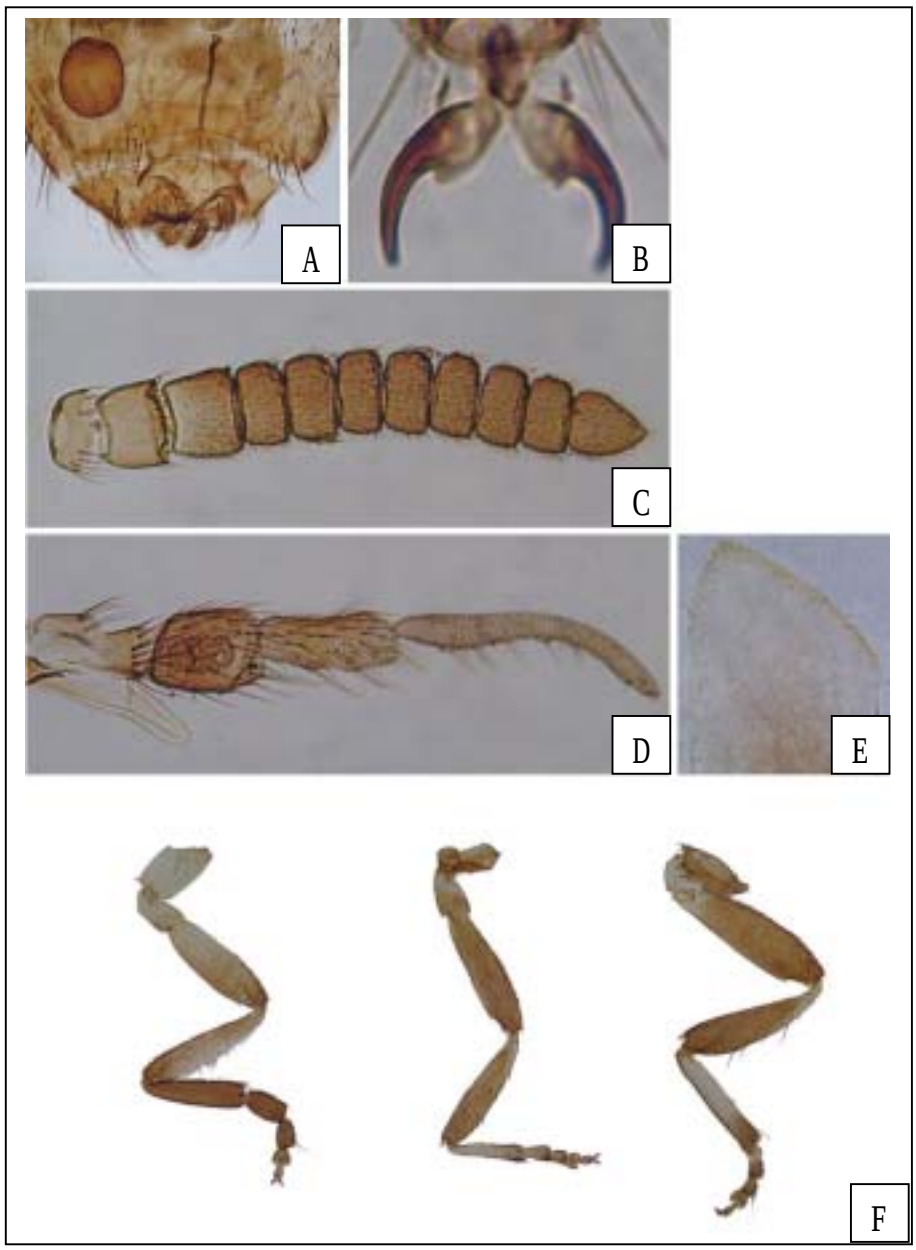

Figure 71 Adult structures of *Simulium tani* female. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, mandible; F, legs (fore, mid and hind legs from left)

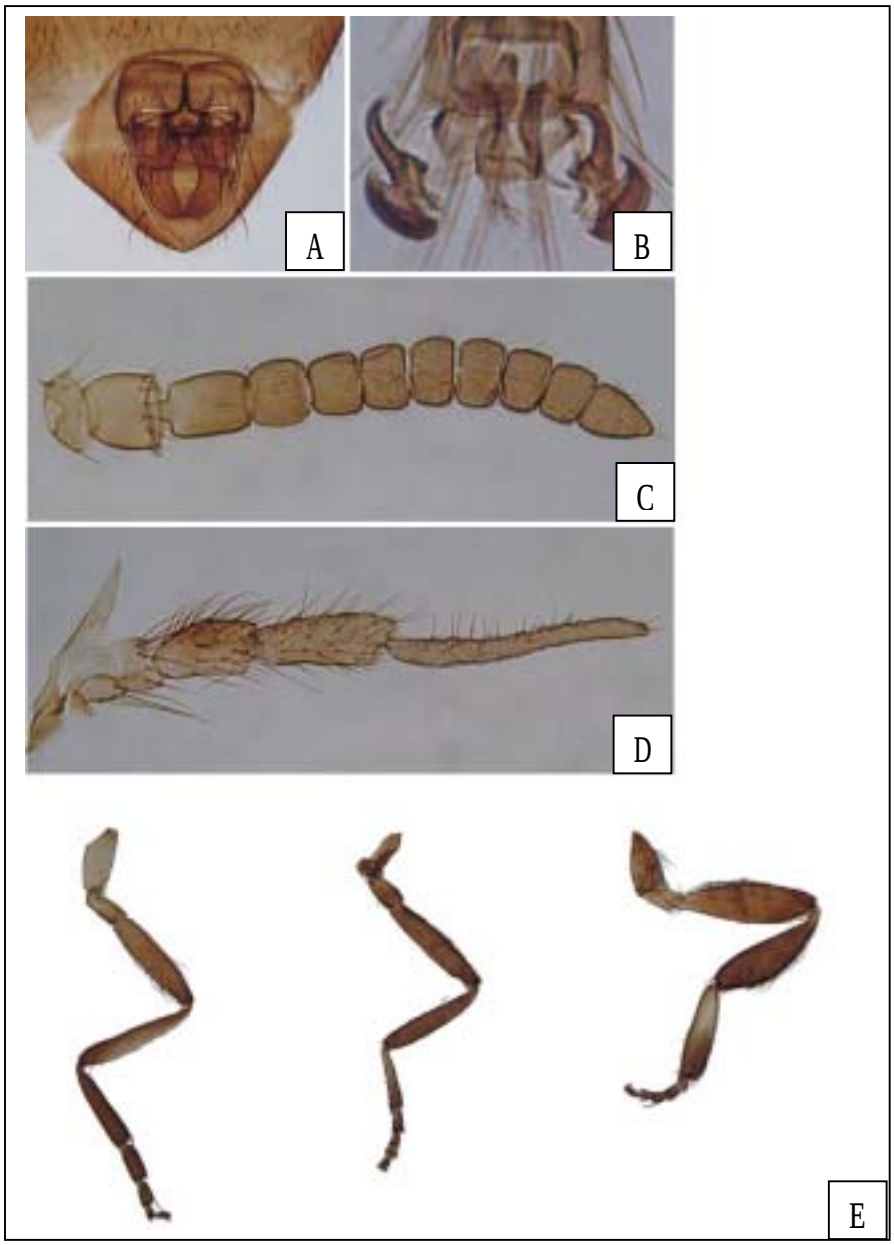

Figure 72 Adult structures of *Simulium tani* male. A, genitalia in ventral view; B, claws; C, antenna; D, maxillary palp; E, legs (fore, mid and hind legs from left)

(E) ungrouped species

21. *Simulium* sp. D

(Figures 73, 74)

Description.

Mature larva (Figure 73A). Body length 6.3-6.5 mm (n = 2). Body dark purple. Head capsule pale with dark along posterior margins, and with positive head spots (Figure 73C). Labral fan with with 31-32 main rays (n = 3). Postgenal cleft (Figure 73D) deep, subtriangular, its apex approaching posterior margin of hypostomium leaving very narrow bridge. Hypostomium (Figure 73E) with a row of 9 apical teeth; median tooth longer than each corner tooth; 3 intermediate teeth on each side shorter and smaller than corner teeth; lateral margin serrate apically; hypostomal bristles 5 or 6 in number lying subparallel to lateral margin on each side. Mandible (Figure 73F) with supernumerary serrations, as well as usual 2 mandibular serrations; comb-teeth decreasing in size from 1st to 3rd. Thoracic cuticle bare. Abdominal cuticle bare. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 12-14 hooks in 76-77 rows (n = 2). Gill histoblast (Figure 73B) with about three groups of coiled filaments.

Pupa. Body length 3.5 mm (n = 1). Gill (Figure 74C) with 19 filaments arranged in various groups. Cocoon (Figures 74A, B) simple, wall-pocket-shaped, tightly woven without open spaces in webs, not extending ventrolaterally.

Female. Unknown.

Male. Unknown.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 6.0 km. above S gate, 14°15’N 101°23’E. Nakhon Nayok, Khao Yai National Park; Pa Tabak creek, 14°19’N 101°21’E.

Ecological notes. This species was found in May 2000 and 2004 and collected from rocks and bedrock in shaded streams with moderately to fast flowing water (0.37-1.1 m s^{-1}). Altitudes, water temperature, and pH for collection sites ranged from 297-505 m, 24.2°C, and 8.09, respectively. This species was found with *S.* (*G.*) *angulistylum.*

Remarks. The pupal gill of this species is a very distinctive, with 19 filaments. In addition, the pupa is recognized by the simple, wall-pocket-shaped cocoon. The larva has a deep bullet-shaped postgenal cleft and abdominal segments lacking a pair of small dorsal protuberances.

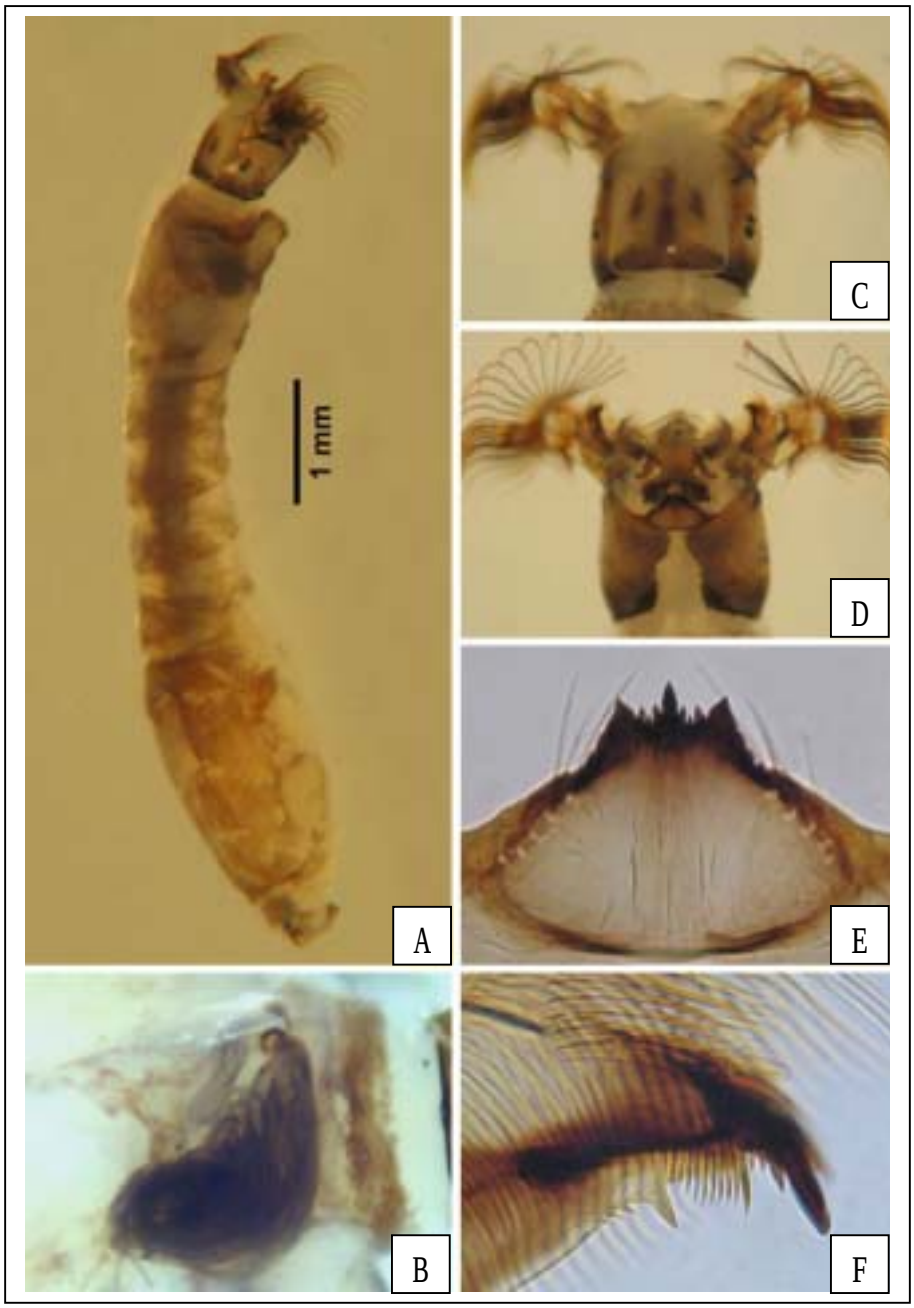

Figure 73 Larval structures of *Simulium* sp. D. A, lateral view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

Figure 74 Pupal structures of *Simulium* sp. D. A, dorsal view; B, lateral view; C, gill filaments

22. *Simulium* sp. E

(Figures 75, 76)

Description.

Mature larva (Figure 75A). Body length 6.6-7.3 mm (mean = 6.5 mm, n = 3). Body dark gray. Head capsule brownish with dark along posterior margins, and with positive head spots (Figure 75C). Labral fan with with 38-45 main rays (n = 4). Postgenal cleft (Figure 75D) deep, triangular, its apex approaching posterior margin of hypostomium leaving very narrow bridge. Hypostomium (Figure 75E) with a row of 9 apical teeth; median tooth longer than each corner tooth; 3 intermediate teeth on each side shorter and smaller than corner teeth; lateral margin serrate apically; hypostomal bristles 5-7 in number lying subparallel to lateral margin on each side. Mandible (Figure 75F) with comb-teeth decreasing in size from 1st to 3rd; mandibular serrations composed of 1 large and 1 small teeth, without supernumerary serrations. Thoracic cuticle bare. Abdominal cuticle bare. Rectal organ with three simple lobes. Anal sclerite of usual X-form. Posterior circlet bearing 12-13 hooks in 76-81 rows (n = 4). Gill histoblast (Figure 75B) with about three groups of coiled filaments.

Pupa. Body length 3.5 mm (n = 2). Gill (Figure 76B) with 27-34 filaments (in pharate larvae with 27-32 filaments) arranged in various groups. Cocoon (Figure 76A) simple, wall-pocket-shaped, tightly woven without open spaces in webs, not extending ventrolaterally, anterior margin somewhat thickly woven.

Female. Unknown.

Male. Unknown.

Collection sites. Thailand. Prachinburi, Khao Yai National Park; Creek 2.3 km. above S gate, 14°14’N 101°23’E; Creek 3.0 km. above S gate, 14°14’N 101° 23’E.

Ecological notes. They were found in May to June 2000 and July 2001 and collected from fallen leaves and on rocks in small shaded streams (1.0-3 m width) with moderately flowing water (0.3-0.6 m s^{-1}). Altitudes, water temperatures, and pH for collection sites ranged from 188-199 m, 24.7-25.5 °C, and 5.62-7.16, respectively. This species was found with *S.* (*G.*) *angulistylum* and *S.* (*S.*) *fenestratum.*

Remarks. The pupa of this species is distinguished by a gill with 27-32 filaments and a simple, wall-pocket-shaped cocoon. The larva has deep triangular postgenal cleft and abdominal segments lacking a pair of small dorsal protuberances.

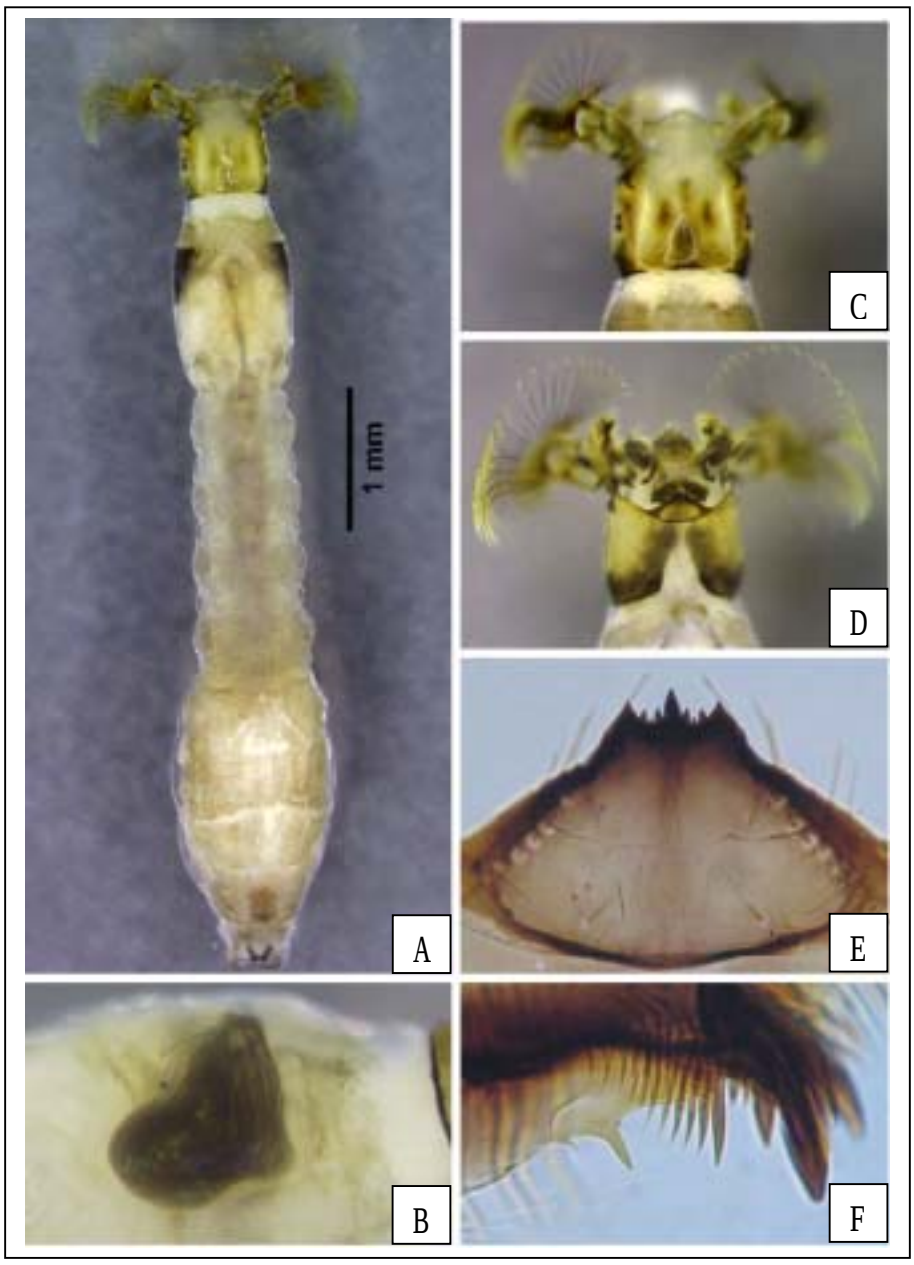

Figure 75 Larval structures of *Simulium* sp. E. A, dorsal view of mature larva; B, gill histoblast; C, D: head capsule; C, dorsal view; D, ventral view; E, hypostomium; F, apical tip of mandible

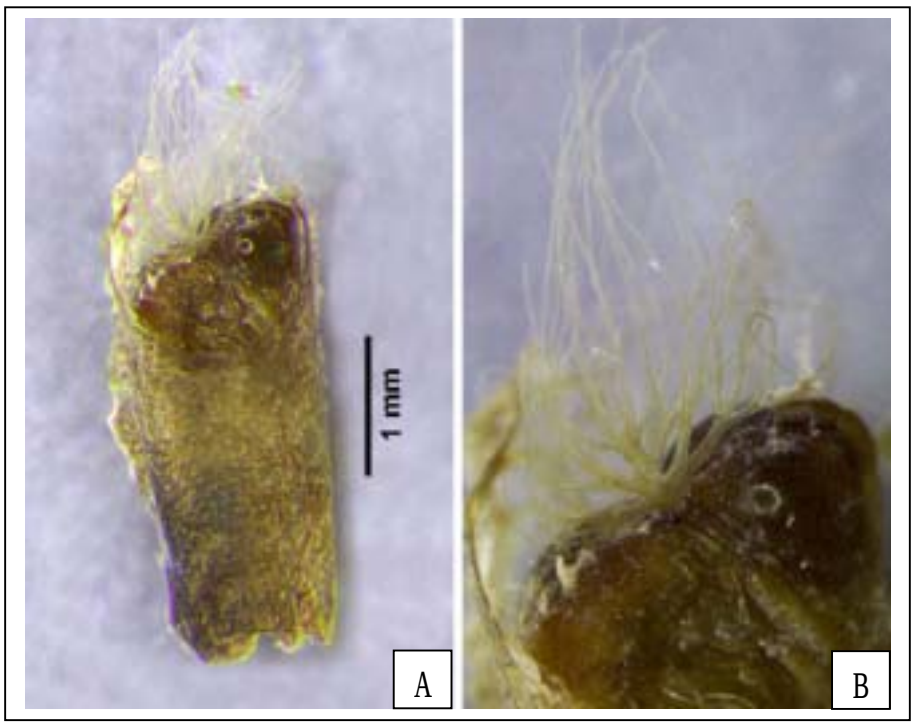

Figure 76 Pupal structures of *Simulium* sp. E. A, dorsal view; B, gill filaments

3. Morphological characters of polytene chromosomes

In the present study, 215 of 755 *Gomphostilbia* larvae were analyzed for major chromosomal landmarks. All 12 species of *Gomphostilbia* in Khao Yai National Park had a chromosome number of $n = 3$, standard arm associations, tightly paired homologues, the nucleolar organizer in chromosome I (typically in the base of IS), and the "trapezoid" landmark in the basal in IIS. The cytotaxonomy of each species is briefly described below. Diagnostic chromosomal and morphological data are summarized in Table 6.

The following 12 species of *Gomphostilbia* from Khao Yai National Park consist of 8 formally described species, including one newly recorded from Thailand (*Simulium novemarticulatum*), and 4 undescribed species (*Simulium* sp. A, *Simulium* sp. nr. *sheilae*, *Simulium* sp. B, and *Simulium* sp. C). The three species in the *S. ceylonicum* species group (i.e., *S. asakoae*, *S. sheilae*, and *S.* sp. nr. *sheilae*) are morphologically similar; the chromosomes, therefore, provide an essential diagnostic aid. *Simulium novemarticulatum* is a member of the *S. varicorne* species group, and the remaining eight species are members of the *S. batoense* species group.

Simulium angulistylum

(Figures 77, 88A)

The polytene chromosomes of this species were figured by Kuvangkadilok *et al*. (2003), although chromosomes II and III were reversed.

In the present study, 15 of 62 larvae were analyzed for major landmarks. Figure 77 shows the six chromosome arms. The centromere regions of chromosomes I and II are slightly expanded, but the centromere region of chromosome III is not expanded. In the IIS arm, the bulge is central and the ring of Balbiani subterminal (Figure 88A). The IIIS end was splayed and the blister subterminal.

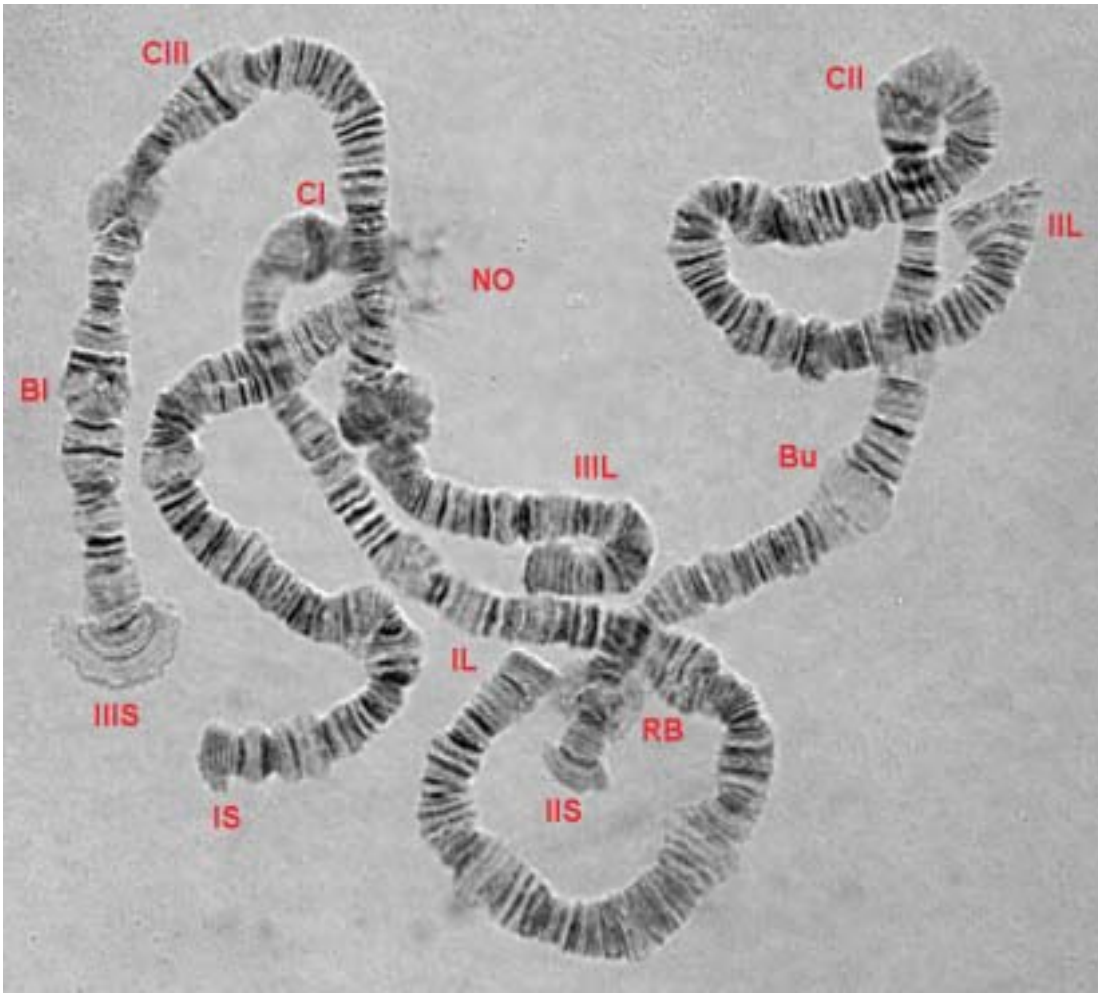

Figure 77 The karyotype of larval polytene chromosomes of *Simulium angulistylum*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

Simulium decuplum

(Figures 78, 88B)

The chromosomes of this species were first described by Kuvangkadilok *et al*. (2003).

In the present study, 13 of 40 larvae were analyzed for major landmarks. Figure 78 shows the six chromosome arms. The centromere regions are not expanded. The IIS arm has the ring of Balbiani near the bulge and closer to the centromere than to the end of the chromosome (Figure 88B). IIIS was characterized by being slightly widened with the blister subterminal.

Simulium dentistylum

(Figures 79, 88C)

Two of three larvae were analyzed for major landmarks. However, the pictures of the karyotype did not show well spread chromosome arms I and III.

Arm associations were standard (Figure 79). None of the centromere regions are expanded. The bulge is near the ring of Balbiani in the middle of the IIS arm (Figure 88C). IIIS was recognized by the end widened and blister subterminal.

Simulium gombakense

(Figures 80, 88D)

Four of five larvae were analyzed for major landmarks. Figure 80 shows the six chromosome arms. The centromere regions are not expanded. In the IIS arm, the ring of Balbiani and the bulge are subterminal (Figure 88D). The end of IIIS was splayed and was recognized by the blister subterminally.

Simulium siamense

(Figures 81, 88E)

The chromosomes of this species were described by Kuvangkadilok *et al*. (2003).

Sixteen of 52 larvae were analyzed for major landmarks. Figure 81 shows the six chromosome arms. None of the centromere regions are expanded. The IIS arm has the ring of Balbiani near the subterminal bulge (Figure 88E). The IIIS end was slightly widened and the blister subterminal.

Simulium sp. A

(Figure 88F)

The chromosomal quality of the slide preparations for this species was poor.

Two of 12 larvae were analyzed for major landmarks. The IIS arm has the bulge near the subterminal ring of Balbiani (Figure 88F).

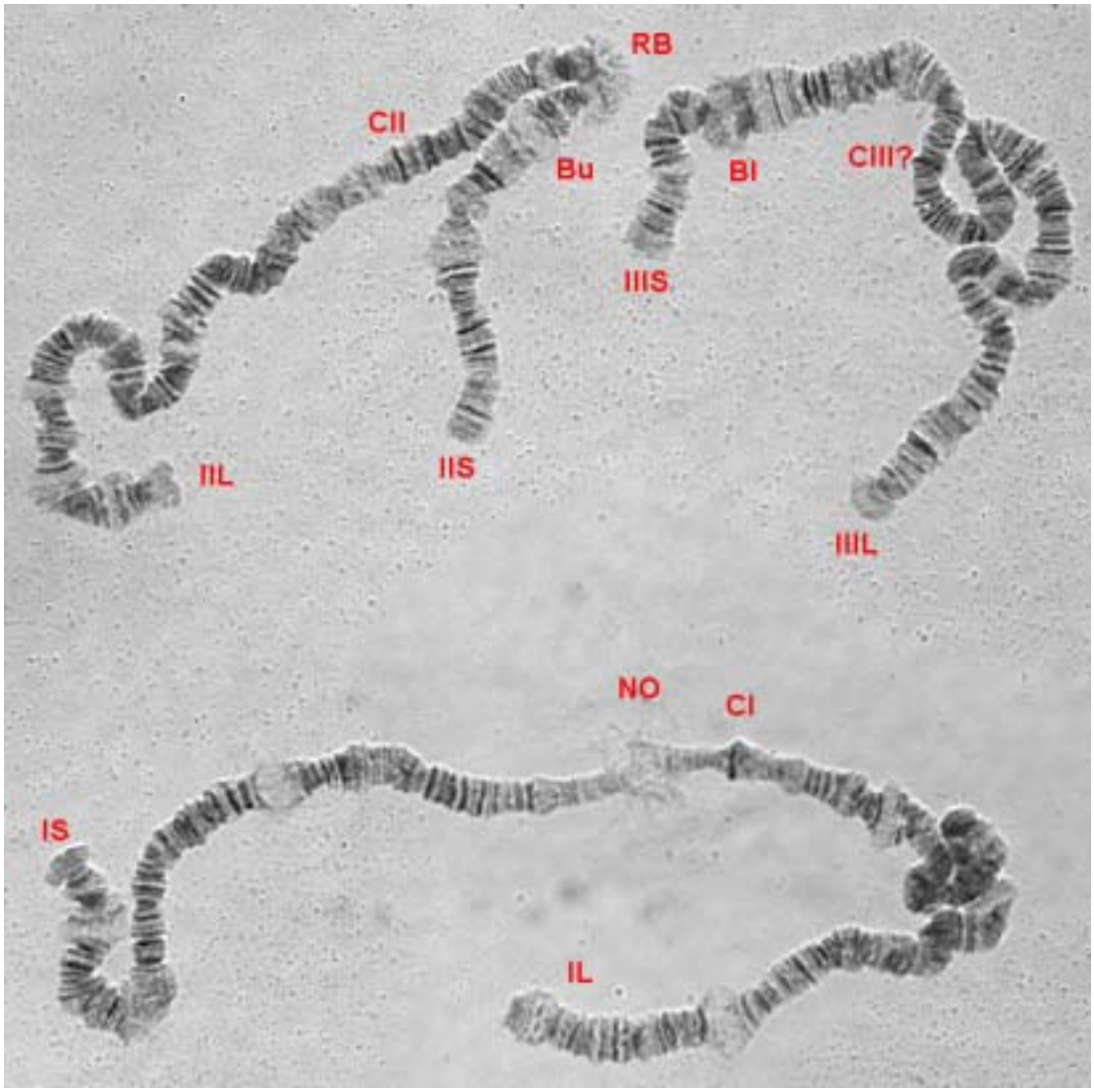

Figure 78 The karyotype of larval polytene chromosomes of *Simulium decuplum*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

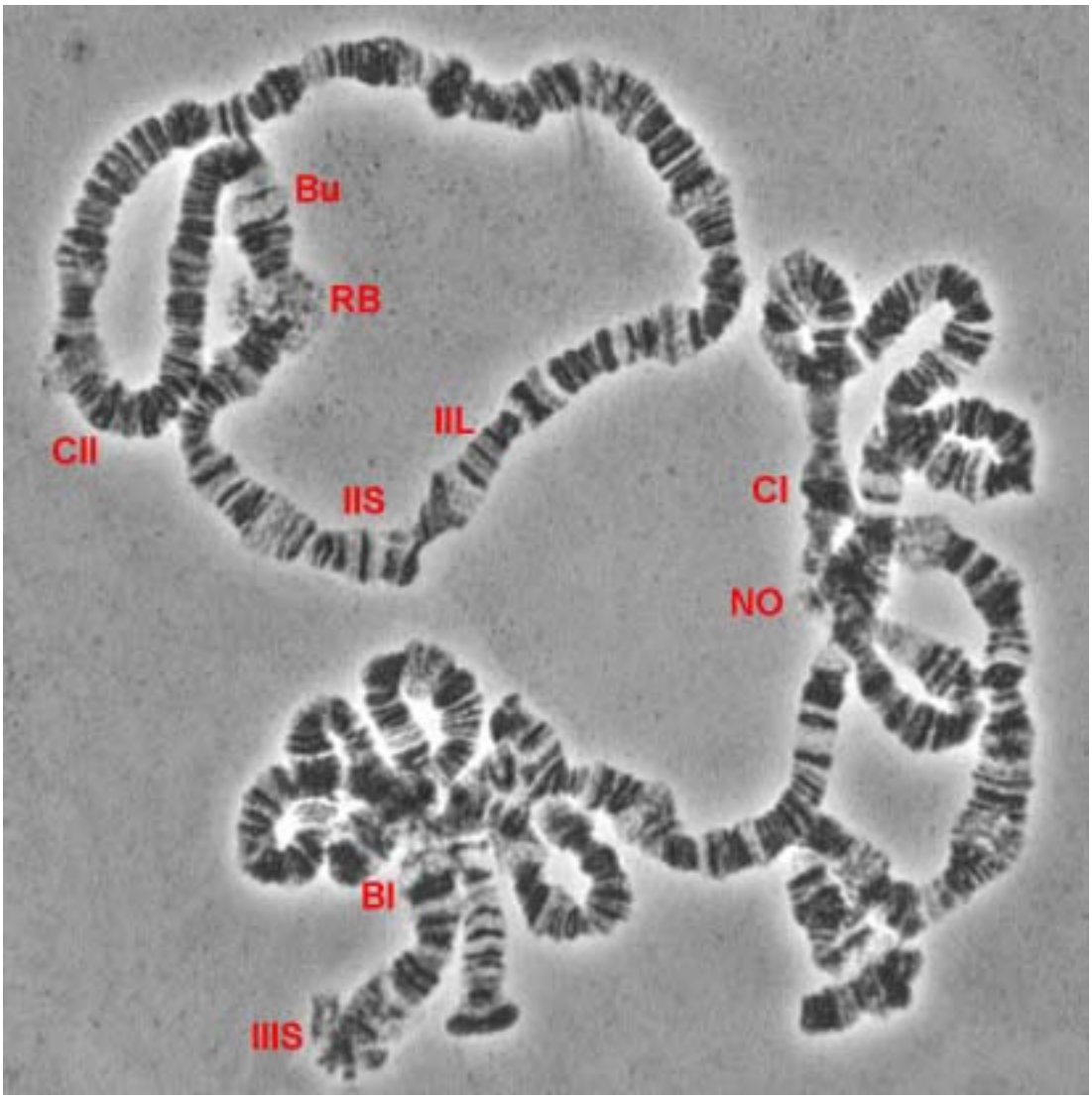

Figure 79 The karyotype of larval polytene chromosomes of *Simulium dentistylum*. I, II, and III, chromosomes; S and L, short and long arms, respectively; C, centromere; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

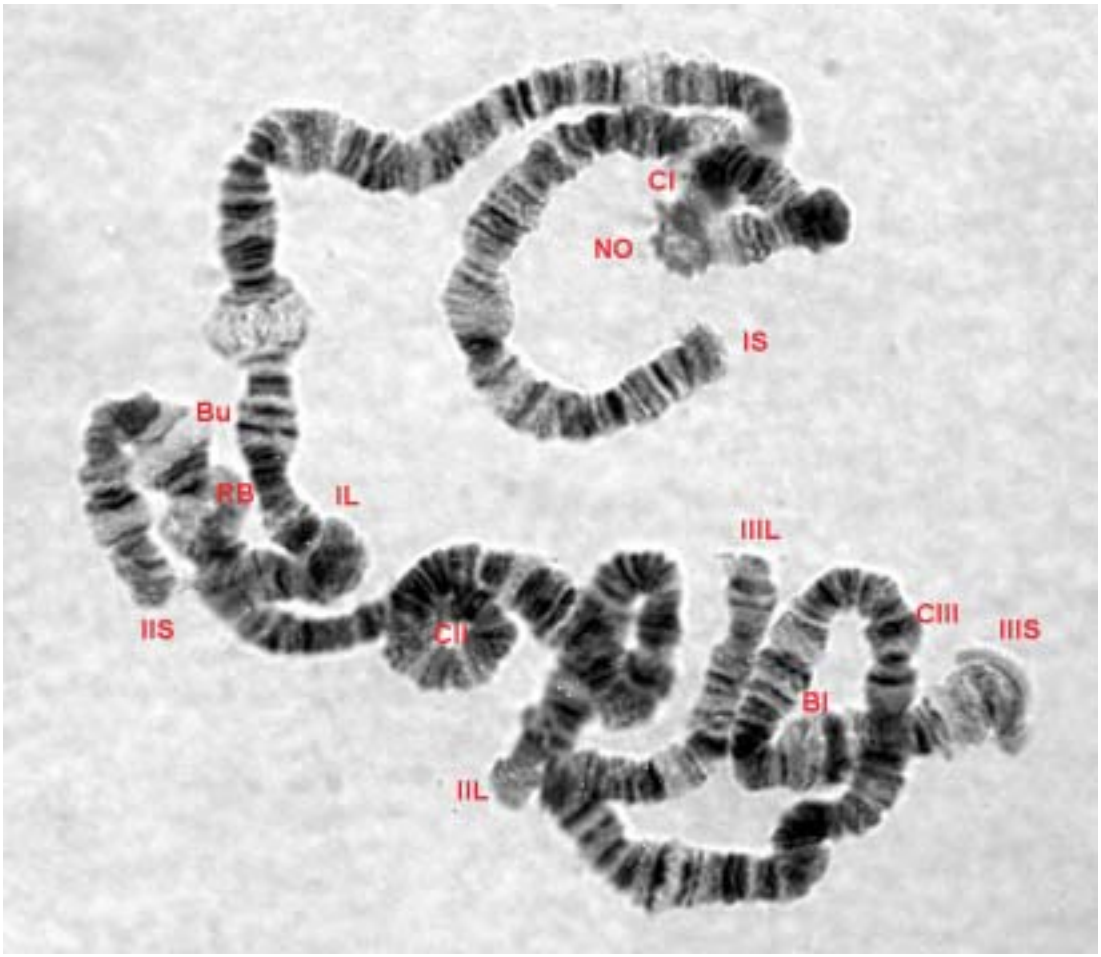

Figure 80 The karyotype of larval polytene chromosomes of *Simulium gombakense*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

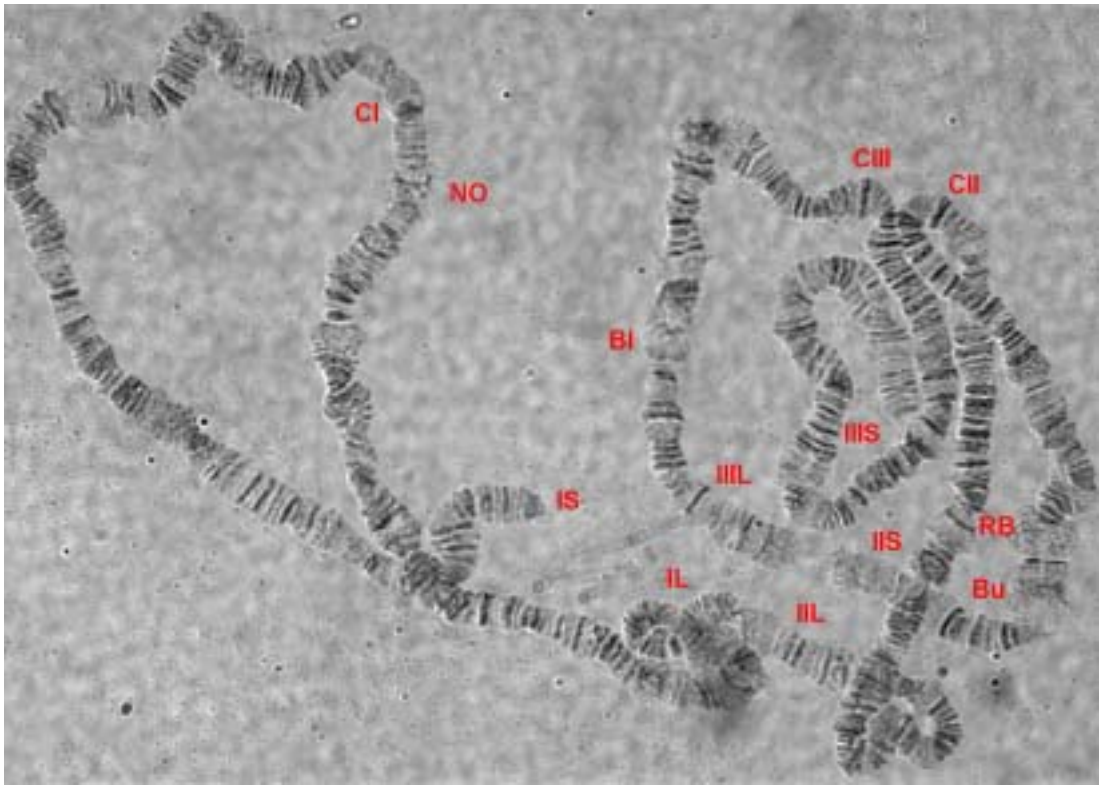

Figure 81 The karyotype of larval polytene chromosomes of *Simulium siamense*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

Simulium asakoae

(Figure 82, 88G)

The chromosomes of this species were described by Kuvangkadilok *et al*. (2003).

A total of 67 larvae of *S. asakoae* were analyzed for major landmarks. Figure 82 shows the six chromosome arms. The centromere regions are not notably expanded. The IIS arm has the bulge near the ring of Balbiani, which is subterminal (Figure 88G). The IIIS end was widened and the blister subterminal.

Simulium sheilae

(Figure 83, 88H)

Five of 35 larvae were analyzed for major landmarks. However, the pictures of the karyotype were not clear to interpret each of chromosomes I and III. Arm associations were standard (Figure 83). The centromere region of chromosome I is not expanded. In the IIS arm, the ring of Balbiani is basal and the bulge subterminal (Figure 88H).

Simulium sp. nr. *sheilae*

(Figure 84, 88I)

For this species, 79 larvae were analyzed for major landmarks. Figure 84 shows the six chromosome arms. The centromere region of chromosome I is expanded, whereas the centromere regions of chromosomes II and III are not. The IIS arm has the bulge and ring of Balbiani in the same locations as in *S. sheliae* (Figure 88I). The end of IIIS was slightly widened and the blister subterminal.

Simulium novemarticulatum

(Figures 85, 88J)

Three of 77 larvae were analyzed for major landmarks. However, the pictures of the karyotype were difficult to see some landmarks on the chromosome arms. Figure 85 shows the six chromosome arms. The IIS arm has the ring of Balbiani near the subterminal bulge (Figure 88J). The IIIS end was slightly widened.

***Simulium* sp. B**

(Figures 86, 88K)

All 3 larvae were analyzed for the major landmarks. Figure 86 shows the six chromosome arms. The centromere regions are not expanded. The IIS arm has the ring of Balbiani located basally and the bulge somewhat centrally (Figure 88K). The end of IIIS was widened and the blister subterminal.

***Simulium* sp. C**

(Figures 87, 88L)

Six of 7 larvae were analyzed for the major landmarks. However, the pictures of the karyotype were not clear to identify the arms of chromosome I. Figure 87 shows the six chromosome arms. The centromere bands were faint and the centromere regions were not expanded. In the IIS arm, the ring of Balbiani and bulge were subterminal (Figure 88L). The IIIS end was widened and the blister subterminal.

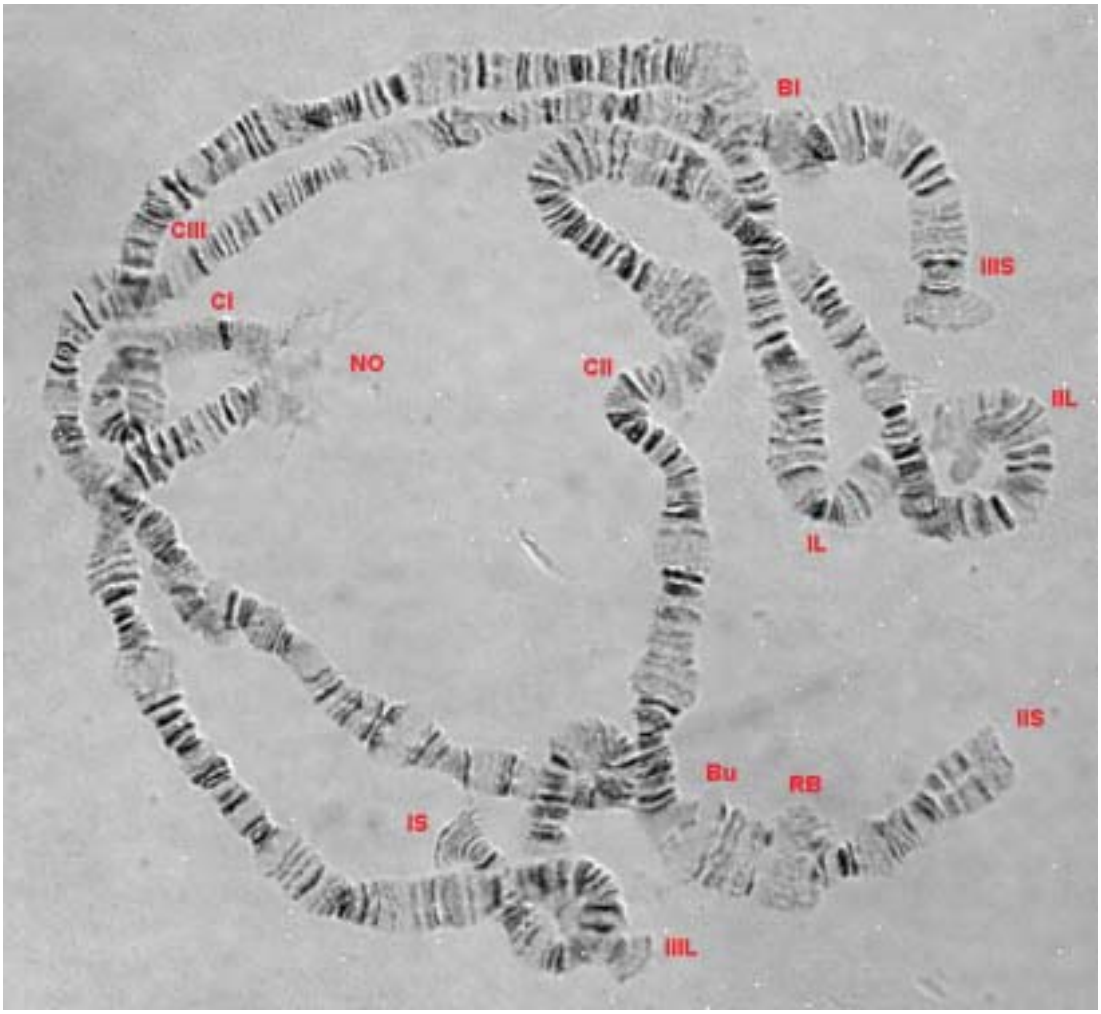

Figure 82 The karyotype of larval polytene chromosomes of *Simulium asakoae*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

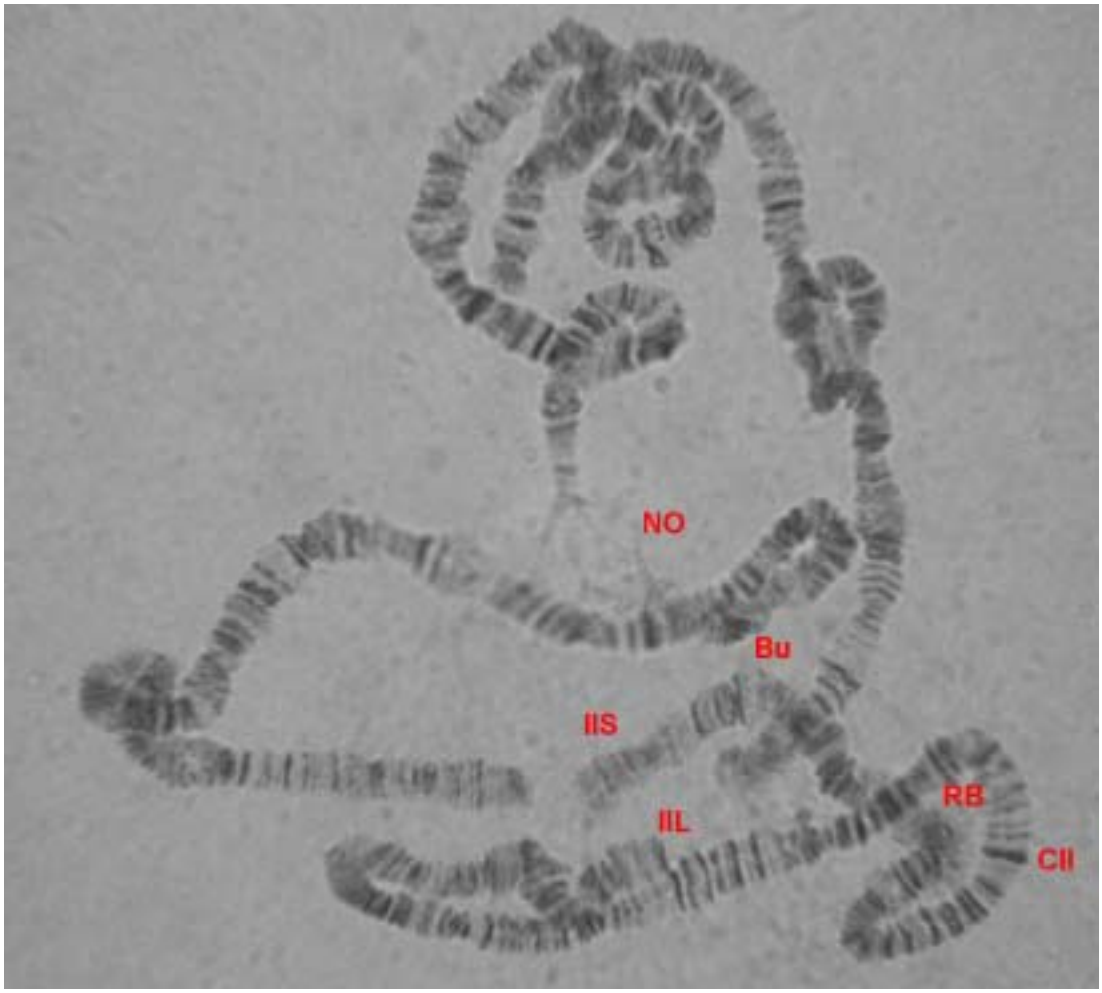

Figure 83 The karyotype of larval polytene chromosomes of *Simulium sheilae*. II, chromosome; S and L, short and long arms, respectively; C, centromere; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

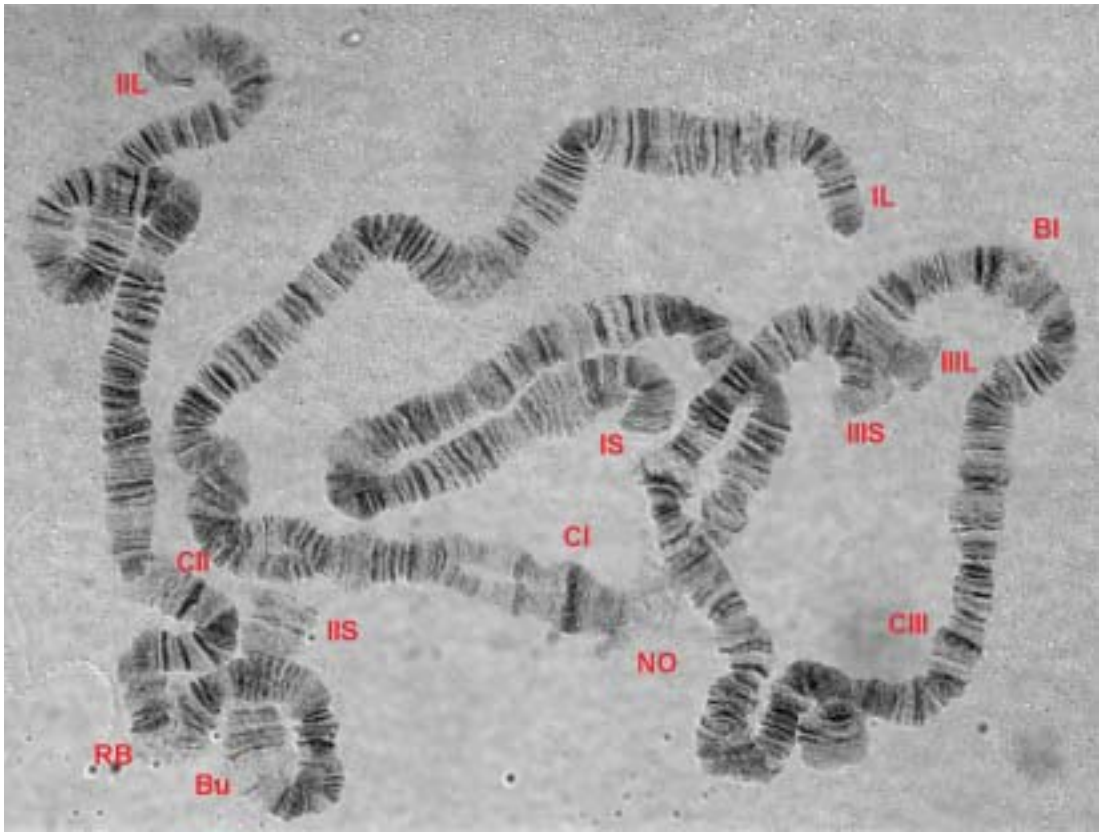

Figure 84 The karyotype of larval polytene chromosomes of *Simulium* sp. nr. *sheilae*. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

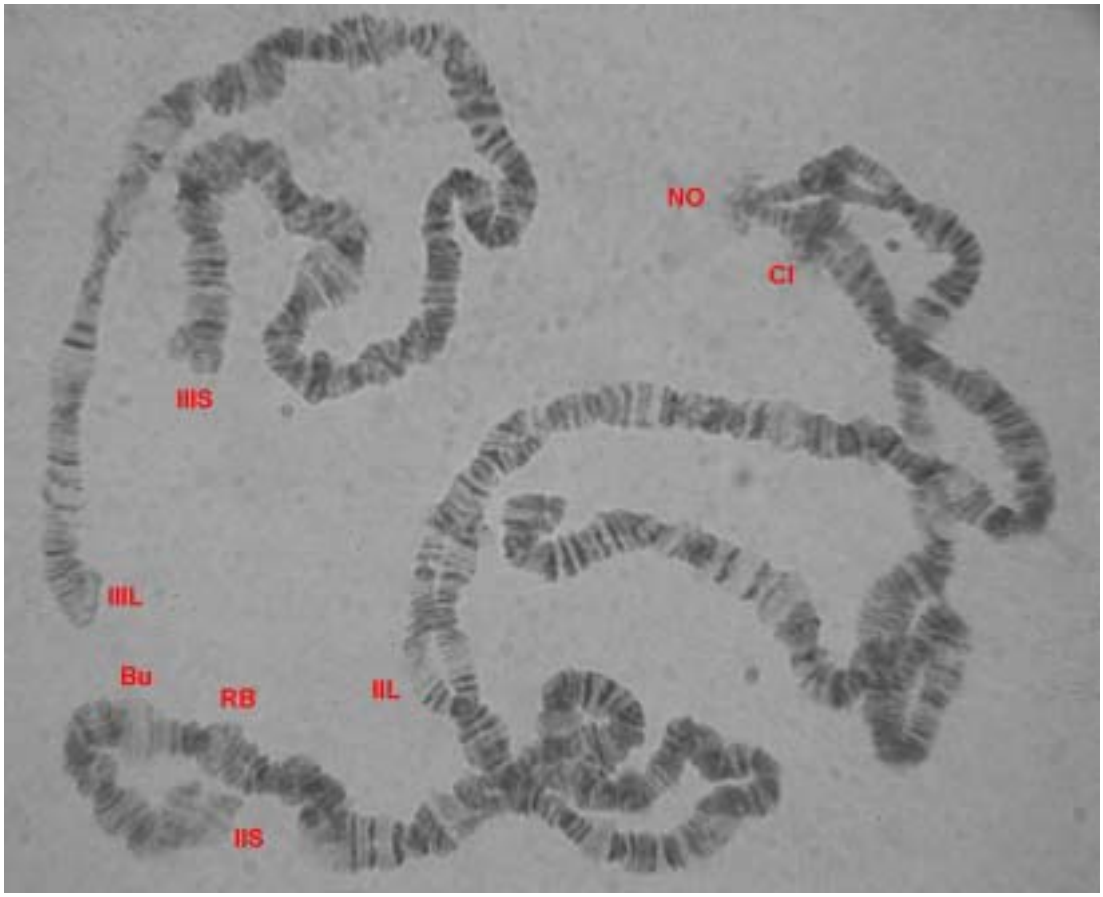

Figure 85 The karyotype of larval polytene chromosomes of *Simulium novemarticulatum*. I, II, and III, chromosomes; S and L, short and long arms, respectively; C, centromere; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

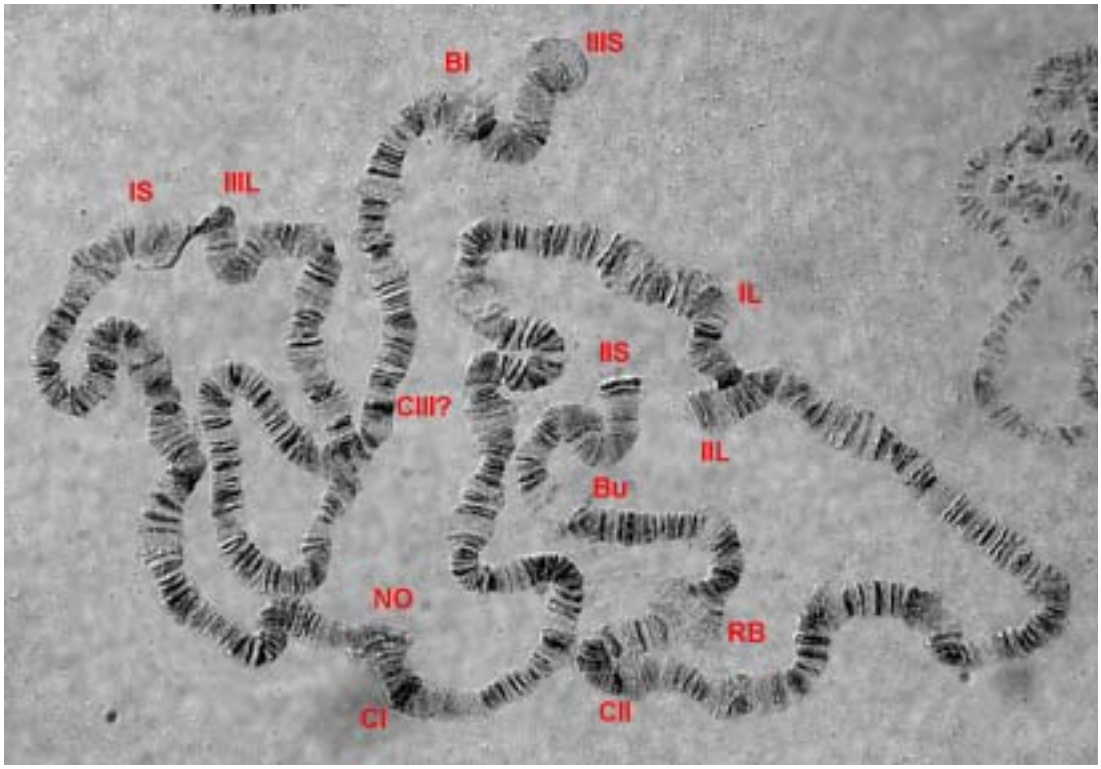

Figure 86 The karyotype of larval polytene chromosomes of *Simulium* sp. B. CI, CII, and CIII, centromeres of chromosomes I, II, and III; S and L, short and long arms, respectively; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

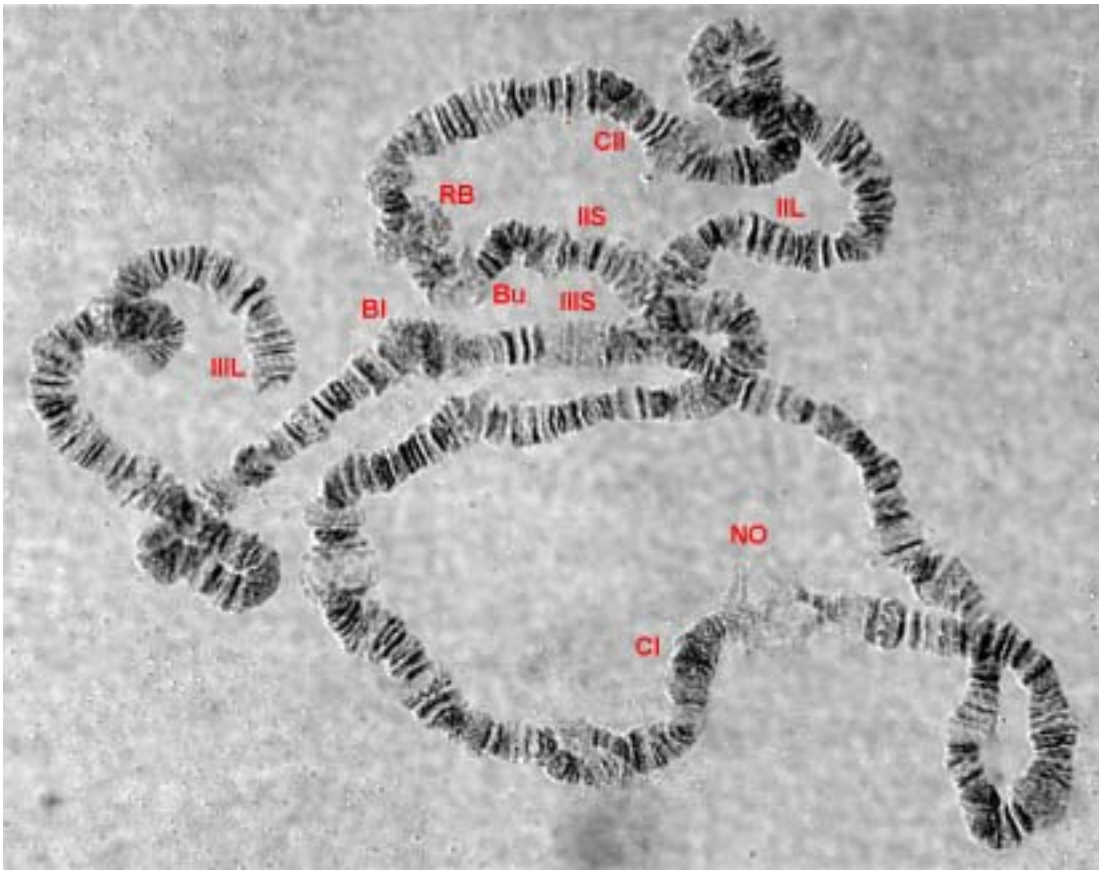

Figure 87 The karyotype of larval polytene chromosomes of *Simulium* sp. C. I, II, and III, chromosomes; S and L, short and long arms, respectively; C, centromere; Bl, blister; Bu, bulge; NO, nucleolar organizer; RB, ring of Balbiani

Table 6. Summary of larval characters for 12 *Simulium* species in the subgenus *Gomphostilbia*

Species	IIS arm	Abdominal setae	Gill filaments	Depth of postgenal clef
1.*Simulium angulistylum*	Bulge central and ring of Balbiani subterminal	Delicate, with 5-12 (mostly 8-10) branches	3 + 3 + 2	Deep; apex nearly reaching posterior margin of hypostoma
2.*Simulium decuplum*	Ring of Balbiani near bulge and closer to centromere than to end of chromosome	Dark, with 10-14 branches	4 + 4 + 2	Deep; apex nearly reaching posterior margin of hypostoma
3.*Simulium dentistylum*	Bulge near ring of Balbiani in middle of IIS arm	Two types: flat scalelike; and dark, unbranched or bifurcated	2 + 1 + 3 + 2	Deep; broadly reaching posterior margin of hypostoma
4. *Simulium gombakense*	Ring of Balbiani and bulge subterminal	Bare	Inflated with 6 fingerlike projections and 8 slender filaments	Moderately deep; 3.0-3.5× as long as postgenal bridge
5.*Simulium siamense*	Ring of Balbiani near subterminal bulge	Dark, with 6-8 branches	3 + 3 + 2	Deep; apex nearly reaching posterior margin of hypostoma
6.*Simulium* sp. A	Bulge near subterminal ring of Balbiani	Thick, dark, with 3-6 branches	3 + 3 + 2	Deep; 4.7-7.0× as long as postgenal bridge
7.*Simulium asakoae*	Bulge near subterminal ring of Balbiani	Sparse, dark, delicate, unbranched (rarely 2 or 3 branched)	3 + 3 + 2	Shallow to moderately deep; 1-3× as long as postgenal bridge

Table 6 (Continued)

Species	IIS arm	Abdominal setae	Gill filaments	Depth of postgenal clef
8.*Simulium sheilae*	Ring of Balbiani basal and bulge subterminal	Dark, delicate, with 2-6 branches	3 + 3 + 2	Deep; apex nearly reaching posterior margin of hypostoma
9.*Simulium* sp. nr. *sheilae*	Bulge and ring of Balbiani in same locations as in *S. sheilae*	Similar to *S. asakoae*	3 + 3 + 2	Moderately deep to deep; 3× as long as postgenal bridge or apex nearly reaching posterior margin of hypostoma
10.*Simulium novemarticulatum*	Ring of Balbiani near subterminal bulge	Two types: thick, dark, with 2 or 3 branches and minute, dark, delicate, with 2-4 branches	3 + 3 + 2	Deep; broadly reaching posterior margin of hypostoma
11.*Simulium* sp. B	Ring of Balbiani basal and bulge somewhat central	Unbranched and 2- and 3-branched	3 + 3 + 2	Deep; apex nearly reaching posterior margin of hypostoma
12.*Simulium* sp. C	Ring of Balbiani and bulge subterminal	Bare	3 + 3 + 2	Moderately deep; 2.00-2.75× as long as postgenal bridge