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# THE BLACK FLIES OF TAIWAN (DIPTERA: SIMULIIDAE)

By **Hiroyuki Takaoka**[1]

*Abstract:* Twenty-two species of black flies from Taiwan are discussed, comprising 8 new species and 14 named species, of which 5 are recorded from the area for the first time. Descriptions of all new species and redescriptions of 3 species are given; keys to all known stages are presented.

Though several faunistic investigations of the family Simuliidae in the Oriental Region have been made (Malay Peninsula by Edwards 1928; India by Puri 1932a, b, c, d, e, 1933a, b, c, d and by Datta 1973, 1974, 1975a, b, c; Java and Sumatra by Edwards 1934; the Philippines by Delfinado 1960, 1969, 1971; Sabah (Borneo) by Smart & Clifford 1968; and the Ryukyu Is by Takaoka 1976a, b, 1977), the Taiwanese fauna has had relatively little study. The only comprehensive study on the Simuliidae of Taiwan is that of Shiraki (1935), in which he described 9 species. All the species described were based on adult flies; pupae and larvae have remained unknown. It is essential for the modern taxonomy of this family to have immature stages associated with known adults.

The present paper contains the results of a preliminary survey on the aquatic immatures of Taiwanese black flies.

## MATERIALS

The material studied consisted of larvae, pupae and reared imagines of both sexes taken at various localities in Taiwan by the author in July 1976.

All types are deposited in the Bishop Museum, Hawaii, USA (BISHOP).

## TAXONOMY AND NOMENCLATURE

The taxonomic characters and their terminology used herein follow those of Crosskey (1969). Wing length represents the distance from arculus to wing tip.

As with previous authors who concerned themselves with the simuliid fauna of the Oriental Region, I hold the conservative classification for the present study. All species discussed belong to the genus *Simulium* Latreille, as defined by Smart (1945), and are further divided into 3 subgenera, as defined by Crosskey (1967, 1969), viz, *Eusimulium* Roubaud (8 spp.), *Gomphostilbia* Enderlein (2 spp.) and *Simulium* Latreille s. str. (12 spp.). Accordingly, *Eusimulium,* treated as a genus by Shiraki (1935), is here regarded as a subgenus; and, as the generic name *Odagmia* is applied in the restricted sense only to the *ornatum* group, *Odagmia karenkoensis* Shiraki, which is not a member of the *ornatum* group, is transferred to the subgenus *Simulium.*

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## ZOOGEOGRAPHY

The simuliid fauna of Taiwan is similar in character to that of some other parts of the Oriental Region (India, Malay Peninsula, Sabah, Java and Sumatra). The majority of the Taiwanese simuliids is assigned to 2 subgenera (*Eusimulium* and *Simulium*), in which most species groups (*E. vernum* group, *E. feuerborni* group, *E. ruficorne* group, *E. montium* group and *S. tuberosum* group) occur mainly in the Palaearctic Region and extend their distribution into the Oriental Region; other species groups (*S. striatum* group, *S. novolineatum* group and *S. nobile* group) are, for the most part, endemic to the Oriental Region.

The Taiwanese fauna shows less affinity than might be expected with the geographically closer Philippine fauna in lacking species of *Morops* and *Gomphostilbia* (except for 2 species of the latter), both of which are dominant elements of the Philippine fauna. *Morops* is an essentially Australasian endemic subgenus, and *Gomphostilbia* has its primary distribution in both the Oriental and the Australasian Regions. It is noteworthy that 1 species of *Morops* and 4 of *Gomphostilbia* have been reported from the Ryukyu Is north of Taiwan (Takaoka 1976a, b).

### Keys to the subgenera of Simuliidae of Taiwan

#### Females

1. Frons shiny, sparsely covered with dark hairs only; basal section of radius bare (except for *S. quinquestriatum*); claw simple or with minute subbasal tooth ..... **Simulium**
   Frons not shiny, covered densely with yellowish pubescence as well as sparse dark hairs; basal section of radius haired; claw with large or medium-sized basal tooth ..... 2
2. Katepisternum haired; tergites of abdominal segments 6, 7 and 8 semishiny ..... **Gomphostilbia**
   Katepisternum bare; tergites of abdominal segments 6, 7 and 8 not shiny ..... **Eusimulium**

#### Males

1. Scutum with iridescent pattern consisting of whitish gray or silvery pruinosities and contrasting black ground color; basal section of radius bare; abdominal segments 5, 6 and 7 (sometimes also segment 4 and sometimes only segments 6 and 7) dorsolaterally with whitish gray or silvery pruinosities; coxite short, nearly as long as wide ..... **Simulium**
   Scutum without such pattern; basal section of radius haired; abdominal segments 5, 6 and 7 without such colored pruinosities; coxite much longer than wide ..... 2
2. Upper eye with enlarged facets in about 13 transverse rows; katepisternum haired; abdominal segments 5, 6 and 7 dorsolaterally with shiny parts; median sclerite broad, membranous ..... **Gomphostilbia**
   Upper eye with moderate-sized facets in 16–19 transverse rows; katepisternum bare; abdominal segments dorsolaterally without shiny parts; median sclerite narrow club-shaped or forked apically ..... **Eusimulium**

#### Pupae

1. Head trichomes 3 pairs in number; abdominal segment 6 without dorsal spine-combs ..... **Simulium**
   Head trichomes 4 pairs in number; abdominal segment 6 with dorsal spine-combs (except for *S. aureohirtum*) ..... 2

2. Gill organ filamentous, with 8 filaments; last abdominal segment with 3 grapnel-shaped hooklets on each side ..... **Gomphostilbia**
   Gill organ inflated with 2 horns, or filamentous, with 4, 6 or 12 filaments; last abdominal segment without such grapnel-shaped hooklet, or with only 1 on each side ..... **Eusimulium**

## Larvae

1. Ventral papillae absent ..... **Simulium**
   Ventral papillae present ..... 2
2. Comb-teeth of mandible gradually decreasing in length posteriorly; hypostomium without lateral serration on each side; postgenal cleft deep or medium-sized, more than 2× as long as postgenal bridge; abdomen covered with black spinous setae dorsally and laterally ... **Gomphostilbia**
   Comb-teeth of mandible with 2nd tooth shorter than 1st and as long as, or slightly shorter than 3rd; hypostomium with lateral serrations on each side; postgenal cleft absent or shallow, shorter than postgenal bridge; abdomen bare or with minute colorless setae dorsally and laterally on posterior segments ..... **Eusimulium**

## Keys to the species of *Simulium* of Taiwan[2]

## Females

1. Basal section of radius haired ..... 2
   Basal section of radius bare ..... 10
2. Claw simple ..... **quinquestriatum**
   Claw with large or medium-sized basal tooth ..... 3
3. Katepisternum haired ..... **metatarsale**
   Katepisternum bare ..... 4
4. Postscutellum haired ..... **taipei**
   Postscutellum bare ..... 5
5. Basal tooth of claw about ½× as wide as, and less than ⅓× as long as claw proper .... **chowi, n. sp.**
   Basal tooth of claw nearly as wide as, and about ½× as long as claw proper ..... 6
6. Calcipala about ⅔× as wide as distal part of basitarsus and extending beyond basal ½ of 2nd tarsal segment ..... **chitoense, n. sp.**
   Calcipala about ½ as wide as distal part of basitarsus and short, only reaching basal ⅓ of 2nd tarsal segment ..... 7
7. Hind tibia and basitarsus nearly brownish ..... **taulingense, n. sp.**
   Hind tibia and basitarsus bicolored, yellow on basal ½ and black on distal ⅓ or more ..... 8
8. Antenna entirely yellow; hind tibia yellow on basal ½ and without subbasal dark ring; frons about 2× as long as its greatest width at vertex; back of head covered with numerous brown hairs ..... **geniculare**
   Antenna yellow with at least 1st flagellar segment darkened; hind tibia yellow on basal ½ and with subbasal dark ring; frons as long as or 1.5× as long as its greatest width at vertex; back of head with numerous yellowish white hairs ..... 9
9. Frons as long as its greatest breadth at vertex; antenna yellow with 1st flagellar segment brown ..... **aureohirtum**
   Frons about 1.5× as long as its greatest breadth at vertex; antenna yellow with basal 2 or 3 flagellar segments brown ..... **falcoe**
10. Claw with minute subbasal tooth ..... 11
    Claw simple, without subbasal tooth ..... 12
11. Scutum with blackish brown pubescence; hind femur black ..... **karenkoensis**
    Scutum with yellow pubescence; hind femur yellow with distal tip darkened .... **taiwanicum, n. sp.**

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2. Only known stages for each species are included in the keys.

12. Scutum with longitudinal stripes ..... 13
Scutum without stripes ..... 15
13. Hind tibia black except for yellow at extreme base; hind basitarsus entirely yellow ..... **ambiguum**
Hind tibia yellow on basal ⅔ and black on distal ⅓; hind basitarsus yellow on basal ½ or ⅔ .... 14
14. Hind tibia as long as hind basitarsus; hind femur yellow on basal ⅓ and black on distal ⅔ ... **katoi**
Hind tibia 1/5× longer than hind basitarsus; hind femur yellow on basal 1/5 and black on distal 4/5 ..... **sakishimaense**
15. Hind tibia entirely black or with extreme base yellow ..... 16
Hind tibia yellow at least on basal ½ ..... 17
16. Hind basitarsus yellow on basal 3/5 and black on distal 2/5 ..... **suzukii**
Hind basitarsus entirely yellow ..... **shirakii**
17. Scutum with copper-colored pubescence; hind basitarsus yellow on basal 3/5 ..... **rufibasis**
Scutum with yellowish white pubescence; hind basitarsus yellow on basal ½ ..... **arisanum**

## Males

1. Basal section of radius haired ..... 2
Basal section of radius bare ..... 6
2. Katepisternum haired ..... **metatarsale**
Katepisternum bare ..... 3
3. Hind basitarsus nearly parallel-sided, much narrower than hind tibia; mid and hind tibiae yellow on basal ½ and with broad subbasal brown ring ..... **aureohirtum**
Hind basitarsus swollen, spindle-shaped, as wide as or wider than hind tibia; mid and hind tibiae entirely brown ..... 4
4. First flagellar segment of antenna about 2.5× as long as 2nd flagellar segment; style tapering distally; paramere with 7 parameral hooks; median sclerite simple, not forked apically ..... **chitoense, n. sp.**
First flagellar segment of antenna less than 2× as long as 2nd flagellar segment; style not tapering distally; paramere with 1 long parameral hook; median sclerite forked apically ..... 5
5. First flagellar segment of antenna about 1.6× length of 2nd flagellar segment .. **yushangense, n. sp.**
First flagellar segment of antenna about 2× length of 2nd flagellar segment .... **taulingense, n. sp.**
6. Scutum largely silvery white pruinose with contrasting inverted V-shaped black band which is in certain angle of light disconnected anteromedially forming a pair of long black bands from anteromedial portion to posterolateral margin; abdomen with dorsolateral silvery white pruinosities on segments 2, 4, 5, 6 and 7 ..... **shirakii**
Scutum silvery white pruinose anteriorly, laterally and posteriorly but posterior transverse pruinosity never extending forwards beyond center of scutum, so that contrasting black area not appearing as an inverted V-shape; abdomen with dorsolateral silvery white pruinosities on segments 2, 5, 6 and 7, or on segment 2, 6 and 7 ..... 7
7. Scutum with golden yellow or bright copper-colored pubescence; silvery or whitish gray lateral bands on scutum broadly continuous to posterior band ..... 8
Scutum with dark brown or black pubescence; silvery or whitish gray lateral bands on scutum disconnected or narrowly connected with posterior band ..... 11
8. Hind femur brown to black except basal area minutely yellow ..... 9
Hind femur yellow except distal tip brown ..... 10
9. Mid tibia entirely black ..... **quinquestriatum**
Mid tibia yellow on basal ½ and brownish black on distal ½ ..... **sakishimaense**
10. Mid femur and tibia entirely yellow; hind tibia black with basal ⅓ yellow; style narrow, about ½× as wide as coxite ..... **ufengense, n. sp.**
Mid femur yellow with distal tip brown and mid tibia brownish black with medial large portion of outer surface paler; style broad, slightly narrower than coxite ..... **taiwanicum, n. sp.**
11. Fore femur yellow; hind basitarsus largely yellow ..... **ambiguum**
Fore femur brown to brownish black; hind basitarsus black with basal 2/5 or ½ yellow ..... 12

12. Abdomen with dorsolateral silvery white pruinosities on segments 2, 5, 6 and 7; basal protuberance of style with very stout spines ..... **suzukii**
Abdomen with dorsolateral silvery white pruinosities on segments 2, 6 and 7; those on segment 5, if present, very small and almost invisible; basal protuberance of style with moderately developed spines ..... 13
13. Mid basitarsus yellow on basal ⅔ and black on distal ⅓; hind basitarsus yellow on basal ½ and black on distal ½ ..... **puliense, n. sp.**
Mid basitarsus yellow on basal ⅓ and black on distal ⅔; hind basitarsus yellow on basal $^{2}/_{5}$ and black on distal $^{3}/_{5}$ ..... **rufibasis**

## Pupae

1. Gill organ of inflated form ..... 2
Gill organ of slender, filamentous form ..... 3
2. Gill organ composed of 2 inflated horns ..... **taulingense, n. sp.**
Gill organ composed of 3 inflated horns ..... **shirakii**
3. Gill organ with 4 filaments ..... **yushangense, n. sp.**
Gill organ with 6 or more filaments ..... 4
4. Gill organ with 6 filaments ..... 5
Gill organ with 8 or more filaments ..... 11
5. Filaments much longer than pupal body; lower 2 filaments arising from a long stalk ..... **chitoense, n. sp.**
Filaments shorter than pupal body; lower 2 filaments sessile or arising from a short stalk ..... 6
6. Cocoon with broad, anterodorsal projection ..... **aureohirtum**
Cocoon simple, slipper-shaped ..... 7
7. Last abdominal segment with a pair of terminal hooks ..... 8
Last abdominal segment without terminal hooks ..... 9
8. Filaments slightly decreasing in thickness from dorsal to ventral and arising from short stalk of almost similar length; integument of head with dorsal trichomes, less than ½× as long as anterior ones; cocoon tightly woven ..... **suzukii**
Filaments equal in thickness except ventral 2 filaments thinner than others; dorsal and ventral pairs of filaments arising from short stalk of almost same length, but middle pair sessile or arising from very short stalk; integument of head with trichomes of similar size; cocoon roughly woven, having small interspaces anteriorly ..... **taiwanicum, n. sp.**
9. Integument of head and thorax almost bare and with branched trichomes; 7th abdominal segment without dorsal spine-comb; outer filaments of dorsal and middle pairs thicker than others, which are similar in thickness ..... **ufengense, n. sp.**
Integument of head and thorax covered moderately with tubercles and simple trichomes; 7th abdominal segment with dorsal spine-comb; filaments otherwise ..... 10
10. Filaments decreasing in thickness from dorsal to ventral ..... **rufibasis**
Outer filament of dorsal pair thicker and longer than others, which are similar in thickness and length ..... **puliense, n. sp.**
11. Gill organ with 8 filaments ..... 12
Gill organ with 10 or more filaments ..... 13
12. Gill organ composed of 4 pairs of filaments; cocoon simple or with low anteroventral collar and lateral windows ..... **sakishimaense**
Gill organ composed of 3 groups arranged in 3 + 3 + 2 filaments from dorsal to ventral; cocoon without lateral windows ..... **metatarsale** or **tuenense, n. sp.**
13. Gill organ with 10 filaments; cocoon boot-shaped ..... **quinquestriatum**
Gill organ with 12 filaments; cocoon simple, slipper-shaped and with anterodorsal projection ..... **chowi, n. sp.**

## Larvae

1. Ventral papillae present ..... 2
   Ventral papillae absent ..... 8
2. Hypostomium with lateral serrations on each side ..... 3
   Hypostomium without lateral serrations on each side ..... 7
3. Postgenal cleft inapparent; if present, very minute ..... **chowi, n. sp.**
   Postgenal cleft shallow but well shaped ..... 4
4. Abdomen with reddish brown markings dorsally on posterior segments ..... **chitoense, n. sp.**
   Abdomen without colored marking dorsally on posterior segments ..... 5
5. Postgenal cleft slightly shorter than postgenal bridge; mandible without supernumerary serrations ..... **aureohirtum**
   Postgenal cleft about ½× as long as postgenal bridge; mandible with supernumerary serrations 6
6. Accessory sclerites of last abdominal segment distinct, well sclerotized and brown in color ..... **yushangense, n. sp.**
   Accessory sclerites weakly developed, indistinct and not colored ..... **taulingense, n. sp.**
7. Postgenal cleft rounded, about 2× as long as postgenal bridge; abdomen with colored markings; most of spinous setae on abdominal cuticle branched ..... **tuenense, n. sp.**
   Postgenal cleft deep, 3–5× as long as postgenal bridge; abdomen without any colored markings; most of spinous setae on abdominal cuticle simple ..... **metatarsale**
8. Postgenal cleft about 1.5× as long as postgenal bridge ..... **taiwanicum, n. sp.**
   Postgenal cleft deep, more than 4× as long as postgenal bridge ..... 9
9. Postgenal cleft large, mitre-shaped and as wide as or a little wider than long ..... 10
   Postgenal cleft narrow or moderately wide, arrowhead-shaped or triangular ..... 11
10. Abdominal cuticle bearing a pair of dorsal protuberances submedially on each segment and covered moderately with minute black spinous setae dorsally and laterally ..... **quinquestriatum**
    Abdominal cuticle without any protuberances or spinous setae ..... **sakishimaense**
11. Body with reddish brown broad transverse band on each thoracic and abdominal segment; postgenal cleft constricted basally and inner margins gently curved ..... **suzukii**
    Body without a colored band; postgenal cleft not constricted basally and inner margins straight or slightly angled medially ..... 12
12. Head spots on cephalic apotome uniformly darkened contrasting with less darkened ground; inner margin of postgenal cleft nearly straight ..... **puliense, n. sp.**
    Head spots on cephalic apotome faint, suffused with ground color; inner margins of postgenal cleft slightly angled medially ..... **rufibasis**

## Genus **Simulium** Latreille, 1802
## Subgenus **Eusimulium** Roubaud, 1906

### **Simulium (Eusimulium) yushangense** Takaoka, **new species**

FIG. 1, 7, 11, 17, 22, 26

♀. Unknown.

♂. General body color blackish. Body length 3.6–4.0 mm. *Head.* As wide as thorax. Posterior surface with long whitish yellow hairs. Upper eye consisting of about 17 transverse rows of large facets. Clypeus black, gray-pollinose, with whitish yellow hairs. Antenna composed of 2 + 9 segments, uniformly brownish black, 1st flagellar segment somewhat elongated, about 1.6× length of 2nd flagellomere. Maxillary palp with 5 segments in proportion of 3:3:10:8:19; sensory vesicle of 3rd segment small, globular, as long as wide and ½× width of its segment. *Thorax.* Scutum black, rather densely covered with short, recumbent, golden yellow pubescence and with longer, concolored hairs on prescutellar area. Scutellum brown, with long golden yellow hairs intermixed with short pubescence. Postscutellum black, bare. Pleural membrane and katepisternum bare. *Legs* dark brown to black with basal ¾ of all femora pale brown in the dissected

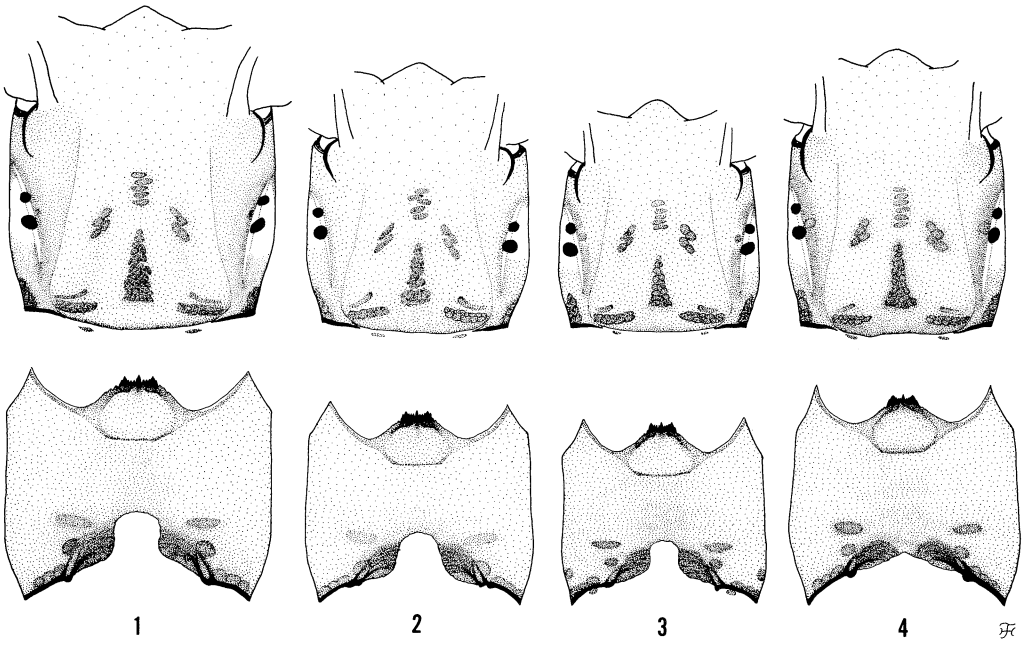


FIG. 1–4. Dorsal and ventral views of larval head capsules of *Simulium* (*Eusimulium*) spp.: 1, *yushangense*; 2, *taulingense*; 3, *chitoense*; 4, *chowi*.

specimens. Fore basitarsus slender, cylindrical. Hind basitarsus swollen, as wide as greatest width of hind tibia. *Wing.* Costa with 2 parallel rows of short spinules as well as brown and yellow hairs. Subcosta bare. Basal section of radius fully haired. $R_1$ with a single row of about 20 spinules interspersed with brown hairs. *Abdomen.* Basal scale brown with a fringe of yellow hairs. Dorsal surface of abdomen brownish, not shiny, with short pale yellow and brown pubescence. *Genitalia* (FIG. 26). Coxite subconical, about 2× as long as wide. Style boot-shaped, ¾× as long as coxite, with a medially directed apical margin; inner distal margin produced as a subtriangular lobe bearing a small apical spine. Ventral plate lamellate, somewhat tapering apically; apicolateral corners broadly rounded; posterior margin concave medially, with a low, hairy process projecting downwards; proximal margin slightly convex medially; basal arms short, directed forwards, heavily sclerotized. Median sclerite slender, heavily sclerotized, bifid apically. Each paramere broad, subrectangular in lateral view, sclerotized, with a long stout parameral hook. Dorsal plate broad, sclerotized, rounded apically, tapering basally and then expanding laterally.

*Pupa.* Body length (excluding gill filaments) about 4.0 mm. *Head and thorax.* Integument dark yellow, almost smooth except scattered small, cone-shaped tubercles on posterior ½ of thorax. Head with 4 pairs of long and simple trichomes, of which 1 is on ventroanterior margin and others on anterodorsal surface. Thorax with 5 pairs of long and simple trichomes anterodorsally and 1 shorter pair laterally. *Gill organ* (FIG. 17, 22) with 4 filaments arranged in pairs, longer than pupal body; all filaments slender, tapering distally, with numerous transverse ridges and covered densely with minute tubercles; dorsal-most filament 1.4–1.5× as long as, and somewhat thicker than other 3 filaments, which are subequal to one another in length and thickness. *Abdomen.* Terga 1 and 2 dark yellow, weakly tuberculate; tergum 1 with a single long seta on each side, tergum 2 with 6 short setae on each side, 1 of 6 setae much longer than others. Terga 3 and 4 each with 4 hooked spines directed forwards along posterior margin and 1 short seta medially on each side. Terga 5–8 each with spine-combs (several stout spines directed caudad and set in a transverse row behind anterior margin), comb-like groups of minute spines laterally and a pair of short setae situated

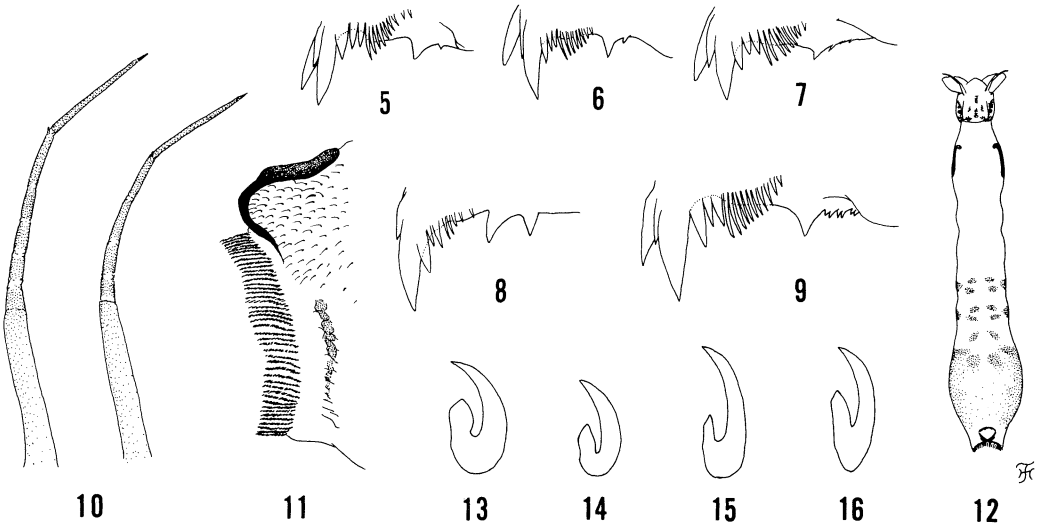


FIG. 5–16. 5–9. Tip of larval mandibles of *Simulium* (*Eusimulium*) spp.: 5, *chowi*; 6, *chitoense*; 7, *yushangense*; 8, *aureohirtum*; 9, *taulingense*. 10. Larval antennae of *S. chowi*. 11. Side view of last abdominal segment of *S. yushangense* larva. 12. Dorsal view of *S. chitoense* larva. 13–16. Claws of *Simulium* (*Eusimulium*) spp.: 13, *taulingense*; 14, *aureohirtum*; 15, *chowi*; 16, *chitoense*.

medially on each side. Tergum 9 dark yellow, with comb-like groups of minute spines in transverse rows, sparsely scattered, small cone-shaped tubercles and a pair of terminal hooks which are stout, conical in shape, gently curved dorsally. Sterna 4–8 each with comb-like groups of minute spines directed backwards and a few short, fine (or somewhat stout) setae on each side. Sternum 4 with a simple spinous hair on each side. Sternum 5 with a pair of bifid (or occasionally trifid) hooks situated close together on each side. Sterna 6 and 7 each with a pair of inner bifid (or occasionally trifid) and outer simple (sometimes bifid) hooks widely spaced. *Cocoon* (FIG. 17) slipper-shaped, tightly woven, extending ventrolaterally, with strong anterior margin and anterodorsal projection.

*Mature larva.* Body color yellowish brown. Body length 6.3–7.2 mm. Cephalic apotome (FIG. 1) yellow with positive head spots; 3 isolated spots under eye and 2 large ones behind eye moderately distinct. Antenna composed of 4 segments; ratio of each segment from base to apex 50:63:30:3. Cephalic fan with about 42 main rays. Mandible (FIG. 7) with a few, very minute supernumerary serrations; comb-teeth unequal in length and stoutness, 2nd tooth smallest and 3rd a bit shorter than 1st. Hypostomium with a row of 9 apical teeth; corner and median teeth moderately prominent; lateral serration moderately developed apically; 5 or 6 hypostomial setae lying parallel to lateral margin on each side. Postgenal cleft (FIG. 1) small, rounded, a little over ½× length of postgenal bridge. Thoracic cuticle bare. Abdominal cuticle sparsely covered with very minute setae dorsally and laterally on posterior segments, as well as colorless pubescence on each side of anal sclerite. Rectal gill lobes compound, each with 10–12 finger-like secondary lobules. Anal sclerite of X-form with anterior arms slightly shorter than posterior ones. Accessory sclerite (paired ventrolateral streaks just before posterior circlet) marked and moderately sclerotized. Posterior circlet with about 88 rows of about 14 hooks. Ventral papillae well developed.

Holotype ♂ (BISHOP 11,328), slide-mounted with associated pupal skin and cocoon, dissected from a pupa, TAIWAN: Ta U Lin, roadside between Tai Chun and Hua Lien, ca 2600 m, 16.VII.1976, H. Takaoka. 1 ♂ with associated pupal skin, 24 mature larvae, paratype, same data as holotype (BISHOP).

*Ecological notes.* One pupa and most of mature larvae were taken on decaying

leaves and another pupa and some larvae on stones in shaded cascading mountain stream (2–4 m wide). This species was collected together with *S. taulingense,* n. sp., *S. chowi,* n. sp. and *S. rufibasis.*

*Distribution.* Taiwan.

*Remarks.* This new species belongs to the *vernum* group, as defined by Crosskey & Davies (1972), and the male, pupa and mature larva are very similar to those of other members of the group. The combination of pupal gill with 4 filaments, of which the uppermost is much longer and thicker, and the accessory sclerite of the last abdominal segment of the larva serves to differentiate *S. yushangense* from other species in the *vernum* group.

### **Simulium (Eusimulium) taulingense** Takaoka, **new species**

FIG. 2, 9, 13, 21, 25, 27, 30

♀. General body color black. Body length 4.2 mm. *Head* narrower than thorax. Posterior surface with dense, yellowish hairs intermixed with brown hairs. Frons and clypeus brown, gray-pruinose, not shiny, with whitish yellow hairs and scattered brown hairs. Frons narrowed towards antennal base, ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 11:6:13. Antenna composed of 2 + 9 segments, uniformly blackish brown. Maxillary palp brown, with 5 segments in proportion of 3:3:11:9:18; 3rd segment relatively enlarged, about ½× as wide as its length; sensory vesicle elongate, almost 2× as long as wide and 0.64× as long as 3rd segment. Maxilla with about 12 strong teeth on each side. Mandible armed with about 40 small inner teeth and about 16 strong outer ones. Cibarium without any denticle. *Thorax.* Scutum blackish, not shiny, rather densely covered with golden yellow pubescence and with long, concolored hairs on prescutellar area. Scutellum brown, with golden yellow pubescence and long, upstanding hairs. Postscutellum brownish black, bare. Pleural membrane and katepisternum bare. *Legs* brown except basal ¾ of all femora and median large portion of all tibiae pale. Fore basitarsus slender, cylindrical. Hind basitarsus somewhat enlarged, but nearly parallel-sided. Calcipala and pedisulcus well developed. Each claw (FIG. 13) with large basal tooth. *Wing* as in *S. yushangense* except for subcosta haired. *Abdomen.* Basal scale brownish black with a fringe of pale brown hairs. Dorsal surface of abdomen brownish black, not shiny, with minute whitish yellow hairs as well as brown ones. *Genitalia* (FIG. 30). Anterior gonapophyses simple, nearly triangular; inner margin nearly straight, and narrowly sclerotized; posterior border thin and somewhat transparent. Stem of genital fork strongly sclerotized; arms very widely expanded, inner margin broadly concave and converging apically, anterolateral margin of expansion strongly sclerotized. Spermatheca almost globular in shape, strongly sclerotized and with incomplete hexagonal reticulate pattern. Paraproct short, not produced beneath cercus and with long setae. Cercus subtriangular when viewed from side and moderately setose.

♂. General body color blackish. Body length 4.6 mm. *Head* as wide as thorax. Posterior surface with long whitish yellow hairs intermixed with scattered brown hairs. Upper eye consisting of about 19 transverse rows of large facets. Clypeus black, gray-pollinose, with whitish yellow hairs. Antenna composed of 2 + 9 segments, uniformly brownish black; 1st flagellar segment somewhat elongated, 2× as long as 2nd flagellar segment. Maxillary palp with 5 segments in proportion of 3:3:12:9:23; sensory vesicle small and globular as in *S. yushangense. Thorax, wing, legs and abdomen* as in *S. yushangense. Genitalia* (FIG. 27). Ventral plate rectangular, slightly tapering apically; posterior margin nearly straight when viewed ventrally, but depressed dorsomedially; proximal margin slightly convex medially; basal arms short, nearly parallel-sided (occasionally tip of arm directed outwards as shown in FIG. 27) and heavily sclerotized. Otherwise, similar to that of *S. yushangense.*

*Pupa.* Body length (excluding gill organ) about 4.2 mm. Similar to that of *S. yushangense* except for the integument of thorax and gill organ. Integument of thorax covered moderately with cone-like tubercles. *Gill organ* (FIG. 21, 25) grayish brown in color, composed of 2 inflated horns, 1 directed dorsomedially and 1 forwards; large horn in the form of club with large globular expansion apically; surface of horns irregularly and lightly undulate and covered moderately with pale seta-like minute projections which are

confined to small horns and basal ½ of large one, and covered densely with cone-like minute tubercles. *Cocoon* (FIG. 21) simple, slipper-shaped, tightly woven, extending ventrolaterally and with strong anterior margin which is somewhat raised.

*Mature larva.* Body color yellowish brown. Body length 7.8–8.2 mm. Cephalic apotome (FIG. 2) somewhat darkened, with marked head spots; lateral surface of head capsule with 3 isolated spots under eye and 2 large spots behind eye. Antenna composed of 4 segments, ratio of each segment from base to apex 50:70:27:3. Cephalic fan with about 44 main rays. Mandible (FIG. 9) with supernumerary serrations as in *S. yushangense.* Hypostomium with a row of 9 apical teeth; corner and median teeth moderately prominent; lateral serration moderately developed apically; about 8 hypostomial setae lying parallel to lateral margin on each side. Postgenal cleft (FIG. 2) small, rounded, and slightly over ½× length of postgenal bridge. Thoracic cuticle bare. Abdominal cuticle uniformly covered with very minute, simple setae dorsally and laterally on posterior segments, as well as longer, simple pubescence on each side of anal sclerite. Rectal gill lobes compound, each with 12–16 finger-like secondary lobules. Anal sclerite X-formed, with posterior arms longer than anterior ones. Accessory sclerite present but weakly sclerotized and small, invisible in some specimens. Posterior circlet with about 110 rows of about 16 hooks. Ventral papillae well developed.

Holotype ♀ (BISHOP 11,329), slide-mounted with associated pupal skin and cocoon, dissected from a pupa, TAIWAN: Ta U Lin, roadside between Tai Chun and Hua Lien, ca 2600 m, 16.VII.1976, H. Takaoka. Allotype ♂ (BISHOP), 1 ♀, 1 ♂, 2 pupae, 10 mature larvae paratypes (BISHOP), same data as holotype.

*Ecological notes.* All 6 pupae and most of the mature larvae were taken on stones in a shaded, cascading, mountain stream, together with *S. yushangense, S. chowi,* n. sp. and *S. rufibasis.*

*Distribution.* Taiwan.

*Remarks.* Like *S. yushangense,* this species is assignable to the *vernum* group by general features of both sexes of adults and larvae, but in the pupal stage is immediately distinguishable by the inflated gill organ. It is noteworthy that *S. taulingense* is atypical for the *vernum* group and for the subgenus *Eusimulium* in having a unique inflated gill form (FIG. 21, 25) in place of the filamentous one.

### **Simulium (Eusimulium) chowi** Takaoka, **new species**

FIG. 4, 5, 10, 15, 18, 23, 31

♀. General color brownish. Body length 3.6 mm. *Head* narrower than thorax. Posterior surface, frons and clypeus dark brown, not shiny and with dense yellowish white hairs as well as sparse dark ones. Frons widely diverging upwards, the greatest width about ¼× that of head; ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 7:4:6. Antenna composed of 2 + 9 segments, uniformly dark brown. Maxillary palp blackish, with 5 segments in proportion of 6:5:12:12:20; 3rd segment somewhat enlarged when viewed from side; sensory vesicle elongate, about ½× length of 3rd segment. Maxilla with 9 strong inner teeth and 14 strong outer ones. Mandible with about 28 small inner teeth and no outer one. *Thorax.* Scutum brown, not shiny and rather densely covered with recumbent yellowish white pubescence as well as sparse erect brown hairs on prescutellar area. Scutellum brown, with several erect brown hairs as well as yellowish white fine hairs. Postscutellum brown, bare. Pleural membrane and katepisternum bare. *Legs* brown except basal 4/5 of all femora yellowish brown and median large portion of mid and hind tibiae and hind basitarsus grayish brown. Fore basitarsus slender, cylindrical. Hind basitarsus parallel sided. Calcipala and pedisulcus well developed. Each claw (FIG. 15) with sharp basal tooth which is about ⅓× length of claw and is narrower than claw. *Wing* as that of *S. taulingense. Abdomen.* Basal scale pale brown with a fringe of pale yellowish white hairs. Dorsal surface of abdomen dark brownish, not shiny, and with minute yellowish white hairs as well as scattered brown ones. *Genitalia* (FIG. 31). Anterior gonapophyses thin, produced posteriorly; inner margin narrowly sclerotized; posterior border

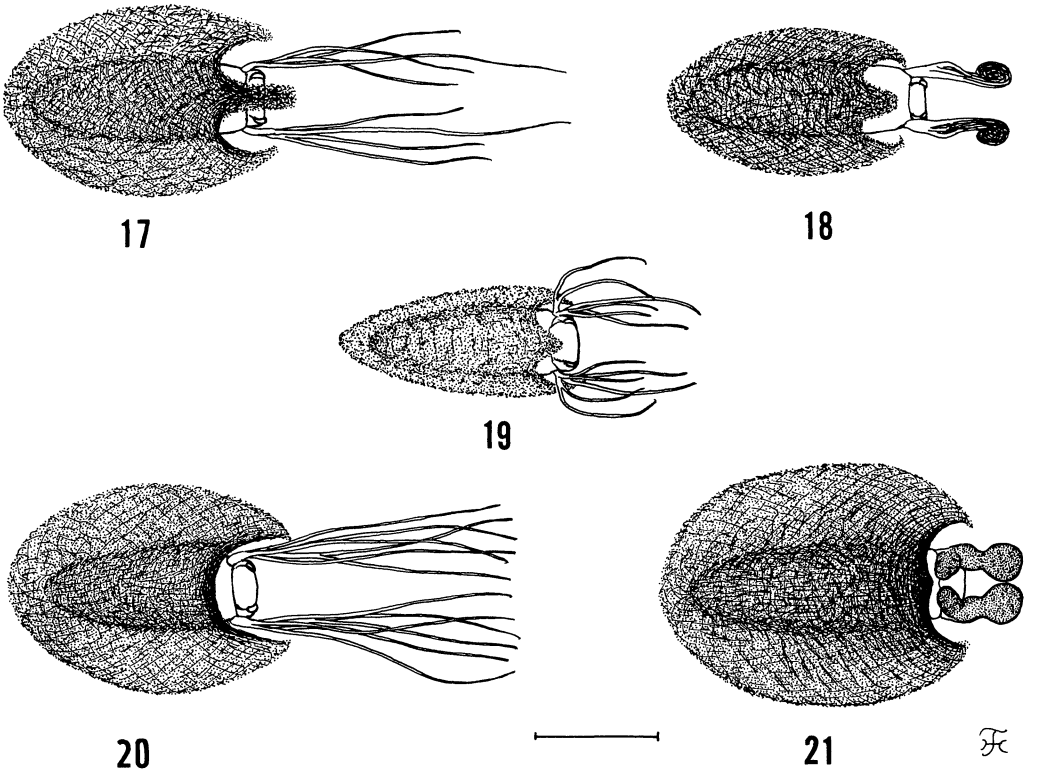


FIG. 17–21. Pupae and cocoons of *Simulium* (*Eusimulium*) spp.: 17, *yushangense*; 18, *chowi*; 19, *aureohirtum*; 20, *chitoense*; 21, *taulingense*. Scale: 2 mm.

rounded, thin and transparent. Stem of genital fork strongly sclerotized, with basal dilatation; arms moderately wide, each with stout, long projection directed forwards, as well as weakly sclerotized triangular one directed inwards. Spermatheca ovoid in shape, strongly sclerotized and with reticulate pattern. Paraproct short, not produced under cercus, moderately setose. Cercus short, about ½× as long as wide when viewed from side, and moderately setose.

♂. Unknown.

*Pupa.* Body length (excluding gill filaments) about 3.8 mm. *Head and thorax.* Integument yellowish brown, densely covered with tubercles. Trichomes of head and thorax simple and very minute. *Gill organ* (FIG. 18, 23) with 12 filaments arranged in groups of 2, 3, 3, 2, 2 from dorsal to ventral; all filaments tapering apically, coiled together and uniformly covered with conspicuous cone-shaped tubercles as well as very minute ones (these minute tubercles are omitted in FIG. 23). *Abdomen* yellowish brown. Terga 1–4 weakly sclerotized and tuberculate. Arrangement of setae, spines and hooks of both dorsal and ventral surfaces of abdomen similar to those of *S. yushangense,* except 1 of 6 short setae on each side of tergum 2 equal in length to the others but much more slender than the others, tergum 5 without spine-combs, and terminal segment with an anchor-like hooklet on each side.

*Mature larva.* Body color grayish yellow with posterior abdominal segments reddish brown dorsally and laterally. Body length 6.8–7.5 mm. Cephalic apotome (FIG. 4) yellowish brown with marked head spots; 3 isolated spots under eye and 2 large ones behind eye also distinct; posterior surface of cephalic apotome somewhat darkened just before posterior margin. Antenna composed of 4 segments in proportion of

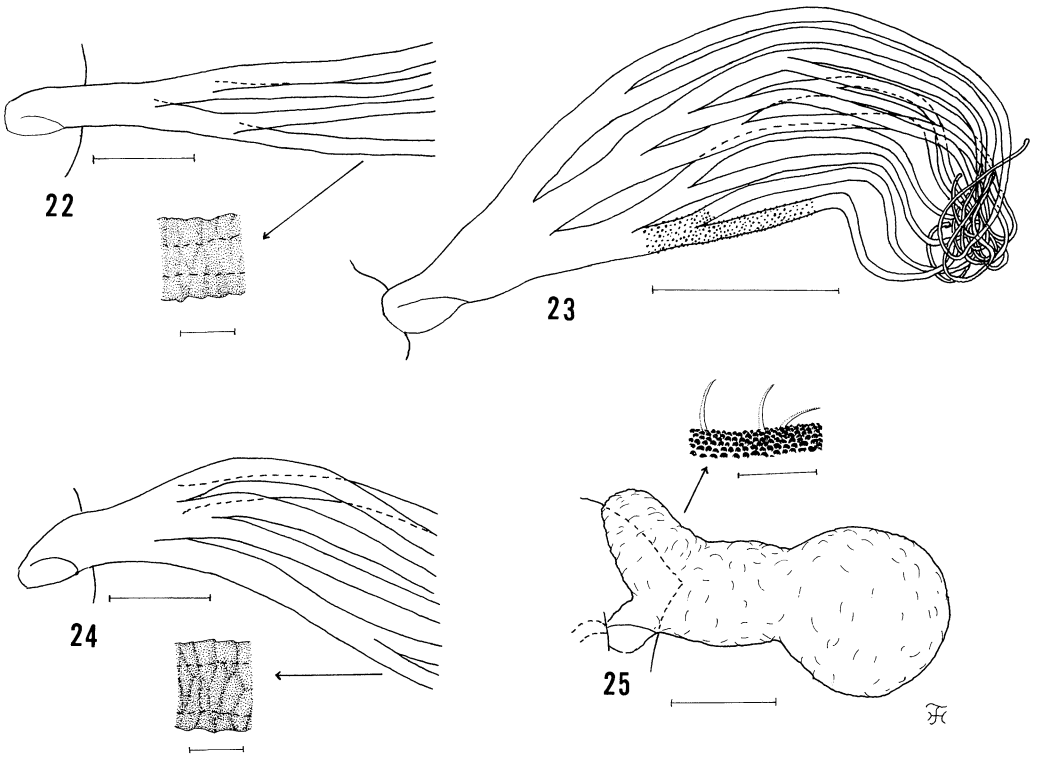


FIG. 22–25. Gill organs of *Simulium* (*Eusimulium*) spp.: 22, *yushangense*; 23, *chowi*; 24, *chitoense*; 25, *taulingense*. Scales for gills: 22, 24, 0.2 mm; 23, 25, 0.5 mm. Scales for enlargements: 22, 24, 0.03 mm; 25, 0.01 mm.

55:55:40:3; segment 2 with 3 or 4 pale annulets as shown in FIG. 10. Cephalic fan with about 36 main rays. Mandible (FIG. 5) without supernumerary serration, comb-teeth unequal in length, 1st tooth longer than others, 2nd and 3rd almost same in length. Hypostomium with a row of 9 apical teeth; corner and median teeth strongly developed; middle tooth of intermediate ones smallest; lateral serration weakly developed apically; 5 or 6 hypostomial setae lying slightly divergent posteriorly from lateral margin on each side. Postgenal cleft (FIG. 4) very minute. Thoracic cuticle bare. Abdominal cuticle bare except last segment hairy dorsally and laterally. Anal sclerite X-shaped, with posterior arms slightly longer than anterior ones. Accessory sclerite absent. Posterior circlet with about 90 rows of about 14 hooks. Ventral papillae well developed.

Holotype ♀ (BISHOP 11,330), slide-mounted with associated pupal skin and cocoon, TAIWAN: Ta U Lin, roadside between Tai Chun and Hua Lien, ca 2600 m, 16.VII.1976, H. Takaoka. 1 ♀, 6 mature larvae paratypes (BISHOP), same data as holotype.

*Ecological notes.* Two pupae and some mature larvae of this species were taken on stones, and some larvae on decaying leaves. The material was collected from a shaded, cascading mountain stream, together with *S. yushangense, S. taulingense* and *S. rufibasis.*

*Distribution.* Taiwan.

*Remarks.* According to the definition of Rubzov (1959–64), *S. chowi* belongs to the *montium* group, which contains several upland species (1200–3000 m). This new species seems closely related to *S. ghoomense* Datta, 1975, *S. nemorivagum* Datta, 1973 from India, *S. kobayashii* Okamoto, Yoshida, Sato & Shogaki, 1958 from Japan, and *S. kirgisorum* Rubzov, 1956 from USSR in having the same arrangement of 12 pupal filaments with conspicuous tubercles. This species is distinguished from *S. ghoomense* by the absence of a longitudinal groove on the frons, by having an elongate sensory vesicle which is about 3× as long as wide, an anterior gonapophysis produced posteriorly in the female, and by the well developed pupal terminal hooks. It differs from the other 3 species by the presence of a dorsomedian projection on the cocoon.

This new species is named in honor of Professor C. Y. Chow, Regional Adviser in Vector Biology and Control, WHO Western Pacific Regional Office, Manila, Philippines, for his valuable suggestions and information on the investigation of black flies in Taiwan.

**Simulium (Eusimulium) chitoense** Takaoka, **new species**

FIG. 3, 6, 12, 16, 20, 24, 29, 33

♀. General body color brown. Body length about 3.0 mm. Wing length about 3.2 mm. *Head* narrower than thorax. Posterior surface of head, frons and clypeus blackish brown, gray-pollinose, and densely covered with yellow pubescence as well as scattered long brown hairs. Frons about ⅓× as long as the greatest width of head; ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 10:6:15. Antenna composed of 2 + 9 segments, dark brown with scape, pedicel and base of 1st flagellar segment yellow. Maxillary palp with 5 segments in proportion of 4:4:11:8:12; 3rd segment enlarged, about ½× as wide as long; sensory vesicle elongate, almost 3× as long as wide, and about $^3/_5$× length of 3rd segment. Maxilla with about 9 strong inner teeth and about 14 strong outer ones. Mandible with about 20 small inner teeth and no outer one. Cibarium without any denticle. *Thorax.* Scutum blackish brown, densely clothed with recumbent yellow pubescence, and several erect brown hairs on prescutellar area; in certain angle of light, scutum gray-pruinose with 3 narrow longitudinal blackish brown stripes; median stripe about ½× as wide as submedian ones, which are slightly divergent posteriorly. Scutellum brown, with several erect brown hairs as well as yellow pubescence. Postscutellum blackish brown, gray-pruinose and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa and all trochanters yellow. Mid and hind coxae brown. Fore femur yellow basally, becoming dark distally and blackish brown on distal ¼. Mid and hind femora yellow with apical ¼ or $^1/_5$ blackish brown. All tibiae brownish black with median large portion pale brown and basal minute of mid and hind tibiae yellow. All tarsi brownish black with hind basitarsus pale brown. Fore basitarsus slender, cylindrical, about 8× as long as its greatest width. Hind basitarsus parallel-sided, somewhat elongate, a bit shorter than hind tibia. Calcipala well developed, extending to apical ⅓ of 2nd segment. Pedisulcus well developed. Each claw (FIG. 16) with large basal tooth which is about ½× as long as claw proper and bluntly ended. All femora and tibiae covered densely with yellow pubescence and sparsely with long black hairs. *Wing.* Costa with 2 parallel rows of black spinules as well as brown hairs, and a patch of yellow hairs near base. Subcosta hairy. Base of radius with a tuft of brown hairs. Basal section of radius fully haired. $R_1$ with a row of black spinules as well as hairs. *Abdomen.* Basal scale brown, with a fringe of long yellow hairs. Dorsal surface of abdomen brown on 2nd segment and brownish black on remaining segments, not shiny, and with dense yellow pubescence, becoming sparse distally, and replaced with black minute hairs on posterior segments; sides of segments 4–8 with long black hairs dorsolaterally. *Genitalia* (FIG. 33). Ventral surface of segment 7 with a large, weakly chitinized plate medially which has semicircular anterior margin and nearly straight posterior border and is uniformly setose. Anterior gonapophyses simple, subtriangular; inner margin gently curved and narrowly sclerotized; posterior border almost straight, thin and transparent. Stem of genital fork slender, strongly sclerotized; arms moderately wide, each with a stout projection directed

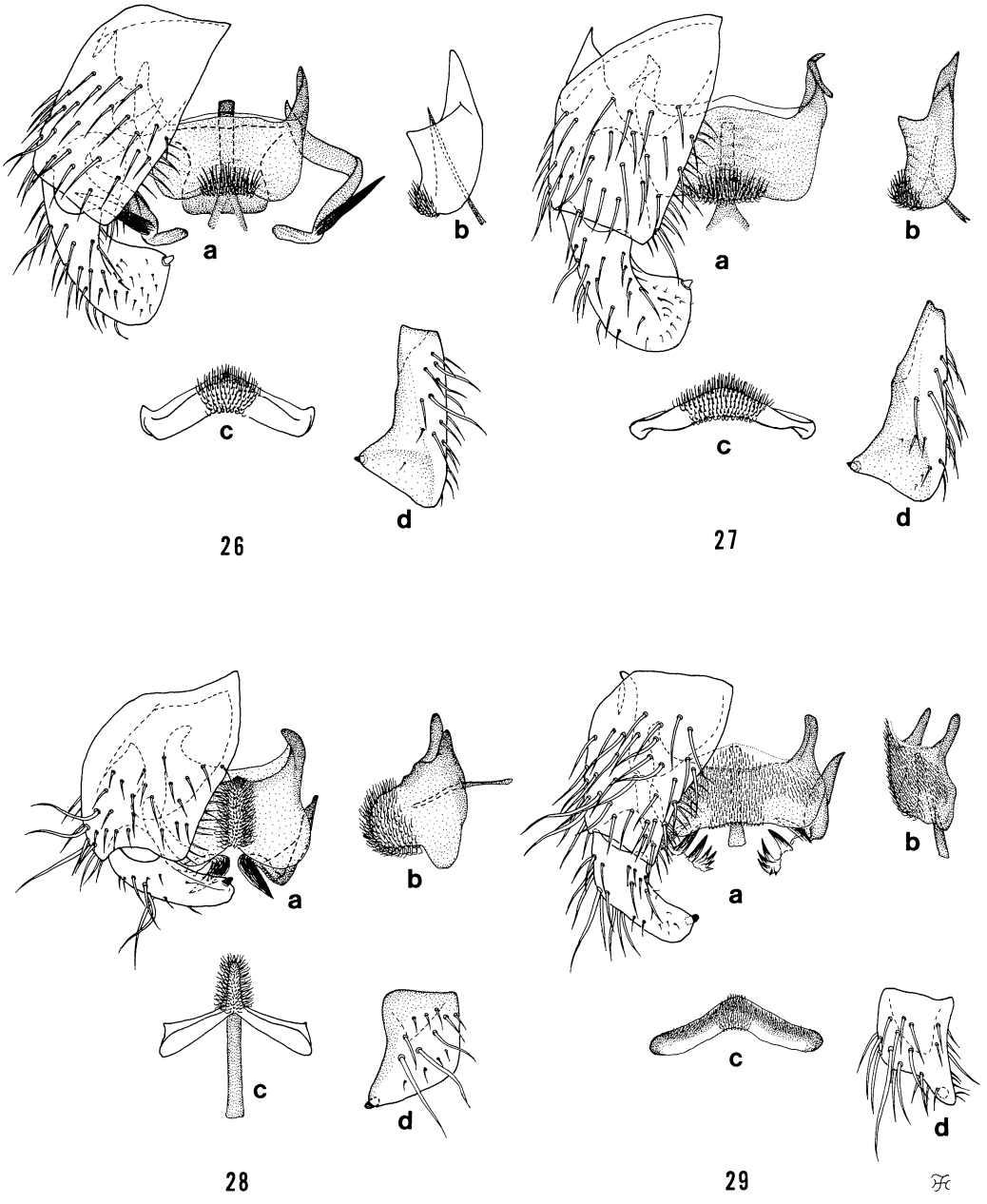


FIG. 26–29. ♂ genitalia of *Simulium* (*Eusimulium*) spp.: 26, *yushangense*; 27, *taulingense*; 28, *aureohirtum*; 29, *chitoense*. **a**, ventral view of coxite, style, ventral plate, parameres and median sclerite in situ; **b**, side view of ventral plate and median sclerite; **c**, end view of ventral plate; **d**, side view of style.

forwards and weakly sclerotized process directed inwards. Spermatheca ovoid in shape, strongly sclerotized and with distinct reticulate pattern. Paraproct not produced under cercus, moderately setose. Cercus subtriangular when viewed laterally, about 2× as long as wide and moderately setose.

♂. General body color blackish. Body length about 4.0 mm. Wing length about 3.0 mm. *Head* wider than thorax. Posterior surface with yellow pubescence as well as scattered black hairs. Upper eye consisting of about 16 transverse rows of large facets. Clypeus brownish black, gray-pruinose, and with yellow pubescence and black erect hairs. Antenna composed of 2 + 9 segments, blackish brown with scape, basal ⅔ of pedicel and basal ⅓ of 1st flagellar segment yellow; 1st flagellar segment considerably elongate, about 2.4× as long as wide, and about 2.5× length of 2nd flagellar segment. Maxillary palp blackish with 5 segments in proportion of 15:15:34:34:50; sensory vesicle small and globular in shape. *Thorax.* Scutum black, not shiny, somewhat gray-pruinose, and densely covered with golden yellow pubescence and with several erect black hairs on prescutellar area; in certain angle of light, scutum with 3 narrow longitudinal black stripes as in ♀. Scutellum brownish black with several erect brown hairs as well as golden pubescence. Postscutellum blackish brown, pruinose and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa and all trochanters dark yellow. Mid and hind coxae brown. All femora dark yellow to yellowish brown with apical ¼ or ⅕ blackish brown. All tibiae brownish to black, with median portion of mid and hind tibiae slightly paler. All tarsi brownish black with hind basitarsus brownish. Fore basitarsus slender, cylindrical and about 9.5× as long as its greatest width. Hind basitarsus enlarged, somewhat spindle-shaped, about 4.7× as long as its maximum width and almost equal to hind tibia in greatest breadth. *Wing* as in ♀ except subcosta bare (at times subcosta sparsely haired). *Abdomen.* Basal scale brown with a fringe of long yellow hairs and brown short ones. Dorsal surface of abdomen brownish black, not shiny, and with short black hairs. *Genitalia* (Fig. 29). Coxite subconical, about 1.5× as long as wide. Style small, much shorter than coxite, tapering distally, with a stout apical spine; when viewed ventrolaterally, style abruptly narrowed apically and twisted inwards. Ventral plate lamellate, much wider than long, covered with minute setae ventrally and posteriorly as shown in Fig. 29; posterior margin broadly concave; anterior border thin, gently produced forwards; basal arms short, slightly curved inwards and strongly sclerotized; lateral margin of ventral plate rounded medially. Paramere with about 7 parameral hooks decreasing in length distally.

*Pupa.* Body length (excluding gill filaments) about 4.0 mm. *Head and thorax* as in *S. yushangense* except integument moderately covered with cone-like tubercles, and anterodorsal head trichomes much shorter than anteroventral ones. *Gill organ* (Fig. 20, 24) with 6 filaments arranged in pairs and longer than pupal body; ventral pair of filaments with long stalk, other filaments sessile or with very short stalks; all filaments directed forwards close together, tapering distally and with numerous transverse ridges forming reticulate pattern and densely covered with minute tubercles, the larger ones on ridges and smaller ones on interspaces. *Abdomen* similar to that of *S. yushangense* except tergum 5 without spine-combs. *Cocoon* (Fig. 20) simple, slipper-shaped, tightly woven, extending ventrolaterally and with a thick anterior margin.

*Mature larva.* General body color grayish yellow with reddish brown markings dorsally on the abdominal segments, as shown in Fig. 12. Body length 7.0–8.4 mm. Cephalic apotome (Fig. 3) yellow with positive head spots; when viewed from side, 3 isolated spots under eye and 2 large spots behind eye prominent. Antenna composed of 4 segments in proportion of 50:48:33:3. Cephalic fan with about 30 main rays. Mandible (Fig. 6) without supernumerary serration. Hypostomium with a row of 9 apical teeth; corner and median teeth well developed; middle tooth of intermediate ones smallest; lateral serration moderately developed on apical ½; hypostomial setae about 4 in number slightly diverging posteriorly from lateral margin on each side. Postgenal cleft (Fig. 3) small, subquadrate and about ½× length of postgenal bridge. Thoracic cuticle bare. Abdominal cuticle bare except last abdominal segment hairy on each side of anal sclerite. Rectal gill lobes compound, each with about 12 finger-like secondary lobules. Anal sclerite X-shaped, with anterior arms a little shorter than posterior ones. Posterior circlet with about 70 rows of about 12 hooks. Ventral papillae well developed.

Holotype ♀ (Bishop 11,331), slide-mounted with associated pupal skin, TAIWAN: Shi To, ca 1000 m, 14.VII.1976, H. Takaoka. Allotype ♂ (Bishop), 2 ♀, 3 ♂, 4 larvae paratypes (Bishop), same data as holotype.

*Distribution.* Taiwan.

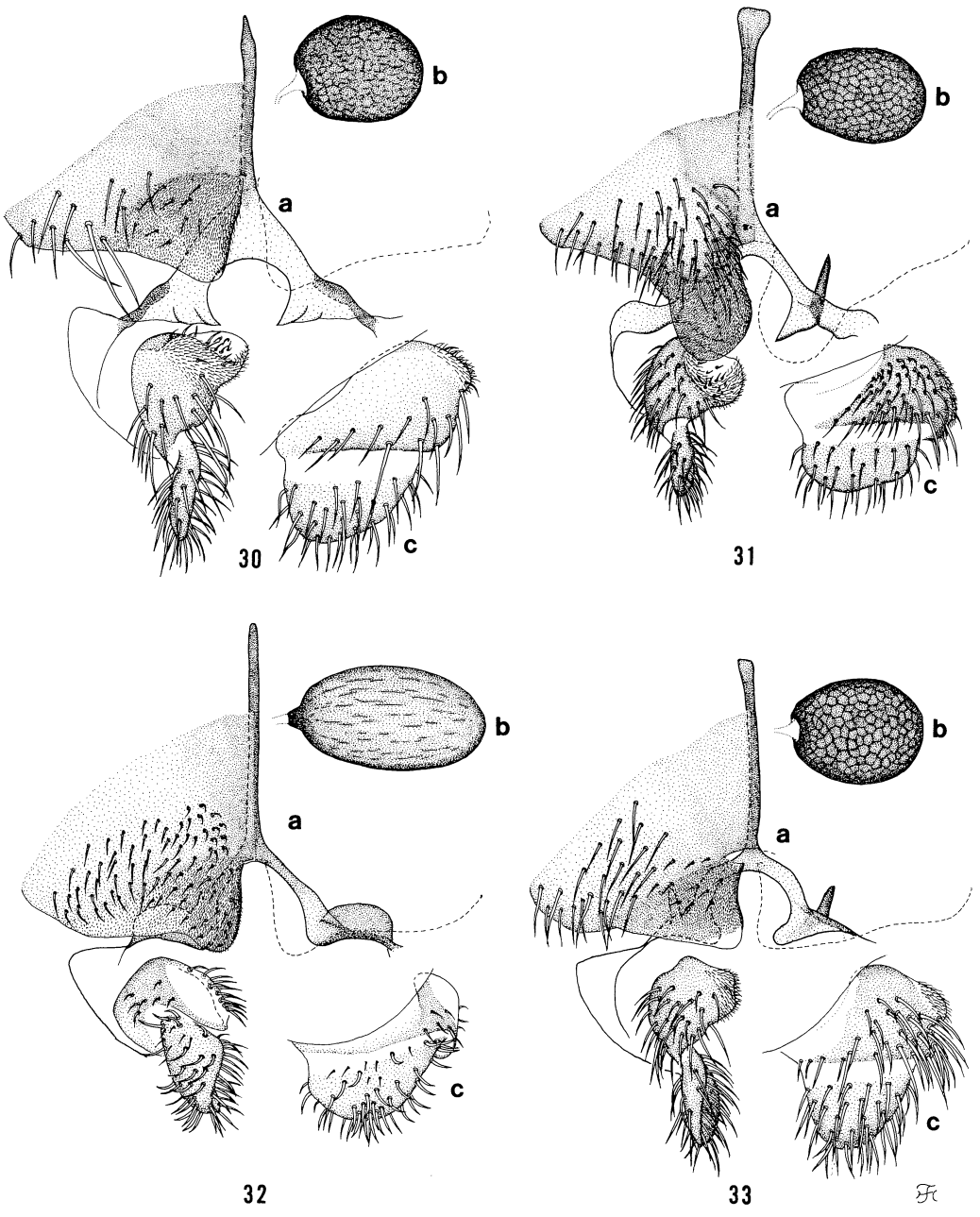


FIG. 30–33. ♀ genitalia of *Simulium* (*Eusimulium*) spp.: 30, *taulingense*; 31, *chowi*; 32, *aureohirtum*; 33, *chitoense*. **a**, ventral view of 8th sternite, anterior gonapophyses, genital fork, paraproct and cercus in situ; **b**, spermatheca; **c**, side view of paraproct and cercus.

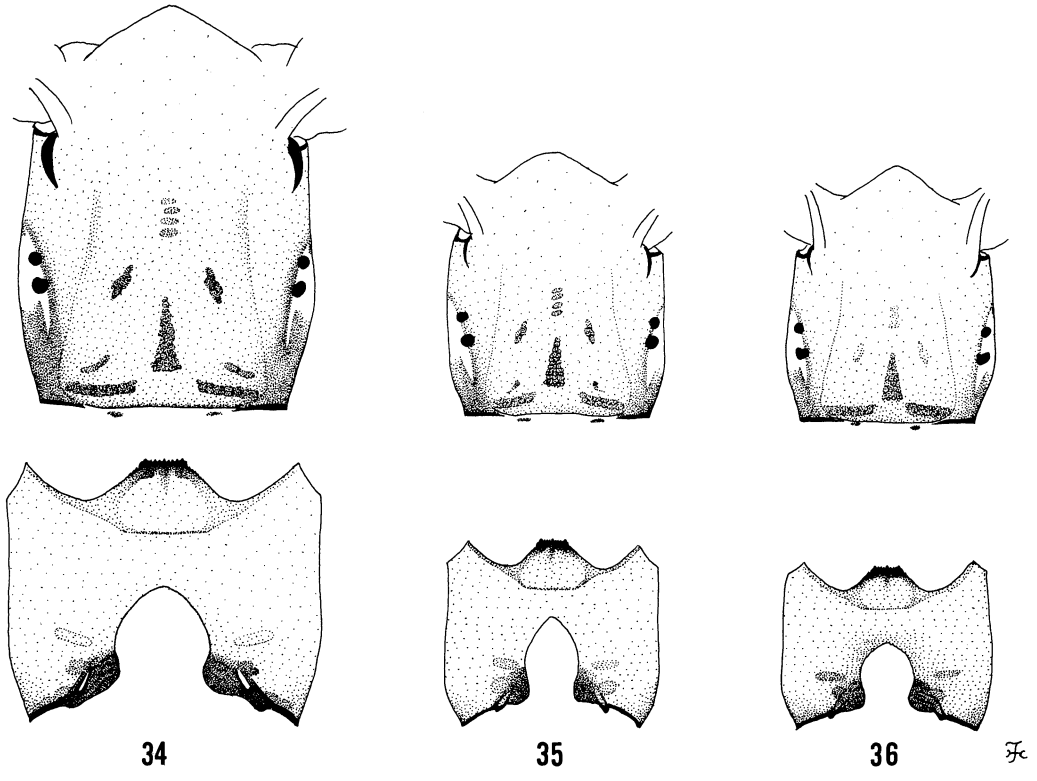


FIG. 34–36. Dorsal and ventral views of larval head capsules: 34, *S.* (*S.*) *taiwanicum*; 35, *S.* (*G.*) *metatarsale*; 36, *S.* (*G.*) *tuenense*.

*Ecological notes.* This species was taken as pupae and larvae on trailing grasses and decaying leaves in a small, shaded mountain stream (0.2–1.0 m wide). The material was collected together with *S. metatarsale, S. taiwanicum,* n. sp., *S. suzukii, S. rufibasis* and *S. sakishimaense.*

*Remarks. S. chitoense* seems to belong to the *feuerborni* group, as defined by Datta (1973), in the shape of genitalia of both sexes of adults, pupal gill organ with 6 filaments in pairs, of which ventral pair bears a long stalk, postgenal cleft small and subquadrate, and the presence of dorsal markings on the larval abdomen. The simple cocoon and the pattern of dorsal markings of the larval abdomen easily separate this species from *S. feuerborni* Edwards, 1934 from Java, *S. praelargum* Datta, 1973 from India, and *S. sasai* Rubzov, 1962 from Japan, all of which were assigned to this group by Datta (1973). The 2 other related species cited by Datta (1973), *S. senile* Brunetti, 1911 from West Himalayas and *S. fuscinervis* Edwards, 1933 from Sabah, were each described from a single male fly, and the female and the immature stages are not available for comparison. However, the male of *S. chitoense* differs from that of *S. senile* by the presence of a stout apical spine on the style and the coloration of the

hind basitarsus, and from *S. fuscinervis* by the width of the head compared with thorax and the number of parameral hooks (7 in *S. chitoense* and 10 in *S. fuscinervis*). This species also closely resembles *S. mie* Ogata & Sasa, 1954 and *S. morisonoi* Takaoka, 1973, both from Japan. The pupa and cocoon of both species are similar to those of *S. chitoense* and are difficult to differentiate. The main differences between *S. chitoense* and the 2 Japanese species are the length of the 1st flagellar segment of the male antenna and the dorsal markings on the larval abdomen. In the adults, there are slight differences in the shape of the ventral plate and of the genital fork. From Taiwan, Shiraki (1935) described *S. taipei* from a single female fly. The original description of the female conforms with that of this new species except for differences in the frons and postscutellum. The ratio of height to the greatest width of frons is 2:1 in *S. taipei* but 3:2 in *S. chitoense*. The postscutellum of *S. taipei* is furnished with hairs but that of *S. chitoense* is bare.

**Simulium (Eusimulium) aureohirtum** Brunetti FIG. 8, 14, 19, 28, 32

*Simulium aureohirtum* Brunetti, 1911: 283–88.
*Simulium (Eusimulium) aureohirtum*: Puri, 1933c: 1–9.—Ogata & Sasa, 1954: 325.—Ogata, Sasa & Suzuki, 1956: 73.—Takaoka, 1976a: 170–71.
*Simulium (Nevermannia) aureohirtum*: Ogata, 1956: 61–62.—Ogata, 1966: 129.
*Eusimulium aureohirtum*: Orii, Uemoto & Onishi, 1969: 1–13.

♀. Body length 2.8 mm. Wing length 2.1 mm. *Head* narrower than thorax. Posterior surface of head, frons and clypeus blackish brown, gray-pollinose and with dense yellowish white pubescence. Frons narrowed towards antennal base, about ¼× as wide as head; ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 8:5:8. Antenna composed of 2 + 9 segments, pale yellow to yellowish brown with 1st flagellar segment dark brown; all flagellar segments much shorter than wide except apical segment. Maxillary palp with 5 segments in proportion of 5:5:16:16:34; 3rd segment somewhat enlarged; sensory vesicle elliptical, about 0.38× as long as 3rd segment. Maxilla with 12 strong inner teeth and about 14 strong outer ones. Mandible with about 20 small inner teeth and about 10 small outer ones. Cibarium bare. *Thorax.* Scutum blackish brown, not shiny, grayish white-pruinose, and densely covered with yellowish white pubescence; in certain angle of light, scutum with 3 faint longitudinal stripes. Scutellum concolored with scutum and with long yellowish white hairs as well as concolored pubescence. Postscutellum blackish brown, grayish white-pruinose and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa pale yellow, mid and hind coxae brown. All trochanters pale yellow. Fore and mid femora pale yellow with distal $^1/_5$ dark brown. Hind femur pale yellow with distal ¼ dark brown. All tibiae yellow basally, gradually becoming brown on distal ½ and with broad, subbasal brown ring. All tarsi brown to brownish black except basal ½ of hind basitarsus yellow (its border not well defined). Fore basitarsus slender, cylindrical. Hind basitarsus not enlarged, parallel-sided. Calcipala and pedisulcus well developed. Each claw (FIG. 14) with large basal tooth which is almost as wide as claw proper. *Wing* as in that of *S. taulingense* ♀. *Abdomen.* Basal scale pale brown with fringe of yellowish white hairs. Dorsal surface of abdomen brown to brownish black, not shiny, and with dense yellowish white pubescence. *Genitalia* (FIG. 32). Anterior gonapophyses simple, roundly produced posteromedially; inner margin nearly straight and narrowly sclerotized; posterior border thin. Stem of genital fork slender and strongly sclerotized; each arm with broad expansion directed forwards. Spermatheca elongate, about 2× as long as wide, and with sclerotized neck. Paraproct very short, narrowed dorsally, slightly produced beneath cercus and with large pale portion ventrointernally. Cercus short, about ½× as long as wide, moderately setose.

♂. General body color blackish. Body length 2.8 mm. Wing length 2.0 mm. *Head* slightly wider than thorax. Posterior surface blackish brown with pale yellow hairs as well as brown ones. Clypeus brown, grayish white-pruinose, and with yellowish white hairs. Upper eye consisting of about 18 transverse rows

of large facets. Antenna composed of 2 + 9 segments, yellow to yellowish brown with 1st flagellar segment dark brown. Maxillary palp with 5 segments in proportion of 12:12:27:29:64; sensory vesicle small and globular in shape. *Thorax.* Scutum black, not shiny, with dense recumbent yellow pubescence; in certain angle of light, scutum with broad black median longitudinal stripe and obscure submedian black spot on each side. Scutellum brownish black, with long, upstanding brown hairs as well as whitish yellow pubescence. Postscutellum brownish black and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa yellow, mid and hind ones dark brown. Fore and mid trochanters dark yellow, hind one yellow. Fore femur yellowish brown with distal $^1/_5$ dark brown. Mid and hind femora yellow with distal $^1/_5$ blackish brown. Fore tibia blackish brown with median large portion pale brown. Mid and hind tibiae as those of ♀, but subbasal ring much broader. All tarsi blackish brown except basal ½ of hind basitarsus pale brown. Fore basitarsus slender, cylindrical. Hind basitarsus not enlarged, parallel-sided. Calcipala and pedisulcus well developed. *Wing* as that of *S. yushangense* ♂. *Abdomen.* Basal scale brown with a fringe of pale brown hairs. Dorsal surface of abdomen brown to brownish black, not shiny, and with whitish yellow pubescence. *Genitalia* (FIG. 28). Coxite large, subconical in shape. Style short, flattened, with an apical spine on inner edge. Ventral plate broad, plate-like, somewhat folded in the middle, and with a median keel-like process produced ventrally; process densely covered with long setae; basal arms short, curved inwards, and strongly sclerotized. Each paramere slender, well sclerotized, and with a long parameral hook. Median sclerite simple, rod-like, and moderately sclerotized.

*Pupa.* Body length (excluding gill filaments) about 2.6 mm. *Head and thorax* similar to those of *S. taulingense* except trichomes not curled apically. *Gill organ* (FIG. 19) with 6 filaments in pairs and shortly stalked; all filaments widely divergent and tapering distally; ventral pair of filaments somewhat longer and thicker than other filaments, and nearly as long as pupal body; surface of filaments with numerous transverse ridges forming reticulate pattern, and densely covered with minute tubercles. *Abdomen.* Arrangements of setae, spines and hooks of both dorsal and ventral surfaces resembling those of *S. yushangense* except terga 5 and 6 lacking spine-combs. *Cocoon* (FIG. 19) simple, slipper-shaped, closely woven, and with broad anterodorsal projection as in *S. chowi,* but anterior margin not thickened.

*Mature larva.* Grayish yellow in body color. Body length 5.8 mm. Cephalic apotome yellow with positive head spots; all spots very marked, except anterior-most spot of mediolateral and posterolateral series somewhat pale; median longitudinal spots suffused with dark ground; posterior margin of apotome somewhat darkened. Eye surrounded by dark ring; 3 isolated spots under eye and 2 large ones behind eye prominent. Antenna consisting of 4 segments in proportion of 15:16:11:1. Cephalic fan with about 34 main rays. Mandible (FIG. 8) with a pair of well developed mandibular serrations of almost similar size; comb-teeth unequal in length and stoutness, 1st tooth longest and stoutest, 3rd ½× length and stoutness of 1st, and 2nd slightly shorter than, and ½× as thick as, 3rd; serration behind comb-teeth several in number and decreasing in size posteriorly. Hypostomium with a row of 9 apical teeth; corner and median teeth strongly developed; median tooth of intermediate ones minute compared with neighboring teeth; lateral serration very well developed; hypostomial setae about 5 in number, slightly diverging posteriorly from lateral margin on each side. Postgenal cleft somewhat quadrate in shape, slightly shorter than postgenal bridge. Thoracic cuticle bare. Abdominal cuticle moderately covered with simple, minute setae dorsally and laterally on posterior segments, as well as somewhat longer setae on each side of anal sclerite. Rectal gill lobes compound, each with a few, short finger-like secondary lobules. Anal sclerite X-formed with anterior arms shorter than posterior ones. Posterior circlet with about 70 rows of about 12 hooks. Ventral papillae small, conical in shape, and situated laterally.

*Material examined.* 1 ♀, 1 pupa, 1 larva, TAIWAN: Sun Moon Lk, ca 1000 m, 9.VII.1976, H. Takaoka; 1 ♀, 5 ♂, Hua Lien, Chi Nan, 18.VII.1976, H. Takaoka.

*Ecological notes.* The 1 pupa and 1 larva of this species were taken on trailing grasses in a small ditch flowing through Aborigin village park on the Sun Moon Lake. Some pupae were taken also on trailing grasses in a slow-moving lowland stream (about 0.3 m wide) exposed to the sun. Two females of this species had mature eggs on emergence.

*Distribution.* Taiwan, Japan, Java, Sumatra and India.

*Remarks.* *S. aureohirtum* belongs to the *ruficorne* group defined by Crosskey (1969) and is widely distributed in the Oriental Region and parts of the Palaearctic Region. This is the first report from Taiwan.

This species was originally described from Umling, India (Brunetti 1911). Puri (1933c) redescribed all stages based on specimens from the type locality. The morphological features of the Taiwanese specimens conform to the redescription of *S. aureohirtum* given by Puri (1933c), except for minor differences in the comb-teeth of the mandible and the ratio of antennal segments in the larva.

**Simulium (Eusimulium) falcoe** (Shiraki), **new combination**

*Eusimulium falcoe* Shiraki, 1935: 13–15.

This species was originally described from 2 females collected among the feathers of *Falco tinnunculus japonicus* in Kappansan. According to the original description, *S. falcoe* is differentiated from *S. aureohirtum* by the frons, of which the height is about 1.5× the greatest width in *S. falcoe* while almost equal in *S. aureohirtum.* Otherwise, the females of both species are almost identical in many features, including coloration of the antenna and legs, which are characteristic. It is likely that this species is synonymous with *S. aureohirtum.*

**Simulium (Eusimulium) taipei** (Shiraki), **new combination**

*Eusimulium taipei* Shiraki, 1935: 15–18.

This species was described from a unique female collected while biting the author (Dr Shiraki) in his laboratory at Taihoku University. The original description agrees well with that of *S. chitoense,* except for the haired postscutellum, which suggests that *S. taipei* is not a member of the *feuerborni* group but belongs to the *aureum* group.

**Simulium (Eusimulium) geniculare** (Shiraki), **new combination**

*Eusimulium geniculare* Shiraki, 1935: 19–20.

*S. geniculare* seems somewhat related to *S. aureohirtum* in having short antennae, but the coloration of both the antenna and legs of the *S. geniculare* female is clearly different from that of the latter. According to Shiraki (1935), *S. geniculare* is a man-biting species, whereas *S. aureohirtum* was reported to be autogenous at least for the 1st batch of eggs and to feed probably on birds for subsequent ovarian development (Takaoka & Noda 1978). All other *Eusimulium* species dealt with herein do not have yellowish legs as does *S. geniculare.*

Subgenus **Gomphostilbia** Enderlein, 1921

**Simulium (Gomphostilbia) metatarsale** Brunetti FIG. 35, 37, 42, 52, 54, 55

*Simulium metatarsalis* Brunetti, 1911: 284.
*Simulium metatarsale*: Edwards, 1934: 119–129.
*Simulium (Gomphostilbia) metatarsale*: Crosskey, 1967: 38.—Datta, 1973: 382.

♀. Body length 2.4–2.6 mm. Wing length about 2.1 mm. *Head* narrower than thorax. Frons and clypeus black, whitish gray-pruinose and densely covered with whitish yellow pubescence interspersed with brown hairs. Frons very narrow, the greatest width about 1/4.5× that of head; ratio of the greatest breadth at vertex, the narrowest near antennal base and height of frons 4:2:5. Antenna composed of 2 + 9 segments, brown to brownish black except for scape, pedicel and basal ½ of 1st flagellar segment yellow. Maxillary palp with 5 segments in proportion of 14:16:25:28:50; 3rd segment of moderate size; sensory vesicle oblong, about 2× as long as wide and about 1/2.8× length of segment 3. Maxilla with about 11 inner teeth and about 12 outer ones. Mandible with about 28 inner teeth and lacking outer serration. Cibarium smooth. *Thorax.* Scutum brownish black, semishiny, thinly gray-pruinose and covered densely with whitish yellow pubescence; scutum with 3 longitudinal lines. Scutellum brown with erect long brown hairs as well as whitish yellow pubescence. Postscutellum brownish black, thinly gray-pruinose and bare. Pleural membrane bare. Katepisternum with brown hairs as well as whitish yellow fine hairs. *Legs.* Fore coxa yellow, mid and hind ones brown. All trochanters yellow. All femora brown to dark brown except for basal narrow part yellow. All tibiae yellow on basal ⅔ and brownish black on distal ⅓. Fore tarsi brownish black. Mid tarsi brownish black with basal ½ of basitarsus yellow, though its border not well defined. Hind tarsi brownish black with basal $^3/_5$ of basitarsus and basal ½ of 2nd segment yellow. Fore basitarsus not dilated, about 6.5× as long as its greatest width. Hind basitarsus nearly parallel-sided. Calcipala a little more than ½× as wide as basitarsus and extending to basal ½ of 2nd segment. Pedisulcus well developed at basal ¼ of 2nd tarsal segment. Each claw with large basal tooth as wide as and about ½× as long as claw proper. *Wing.* Costa with 2 parallel rows of spinules as well as hairs. Subcosta fully haired. Basal tuft of hairs at base of radius yellow. Basal portion of radius fully haired. $R_1$ with hairs intermixed with spinules. $R_2$ with hairs. *Abdomen.* Basal scale yellowish brown with a fringe of yellow hairs. Dorsal surface of abdominal segments dark brown except for basal ½ or more of segment 2 pale and with sparse brown hairs; 2nd segment with a pair of dorsolateral whitish pruinosities; tergites of segments 6, 7 and 8 subshiny. *Genitalia* (FIG. 53). Anterior gonapophyses simple; inner margin parallel-sided and narrowly sclerotized; posterior margin thin, transparent. Stem of genital fork slender, strongly sclerotized; arms with strongly sclerotized anterolateral ridge and weak lobe posteromedially. Spermatheca elliptical with numerous longitudinal lines. Paraproct of moderate size, narrowed dorsally and moderately setose. Cercus short, about ½× as long as wide, moderately setose and with rounded posterior margin.

♂. Body length 2.5–2.9 mm. Wing length about 2.0 mm. *Head* wider than thorax. Posterior surface black with dense yellow pubescence intermixed with sparse brown hairs along upper margin. Clypeus black gray-pollinose, with dense yellow pubescence and sparse brown hairs near lower margin. Upper eye consisting of about 13 transverse rows of large facets. Antenna composed of 2 + 9 segments, brown to dark brown except for scape, pedicel and base of 1st flagellar segment yellow; 1st flagellar segment somewhat elongated, a little less than 2× length of 2nd flagellar segment. Maxillary palp with 5 segments in proportion of 10:12:25:27:56; sensory vesicle small, nearly globular in shape. *Thorax.* Scutum brownish black, semishiny laterally and posteriorly and covered densely with recumbent whitish yellow pubescence. Scutellum brownish black with erect, long, brown hairs as well as whitish yellow pubescence. Postscutellum brownish black, thinly gray-pruinose and bare. *Legs.* Coxae, trochanters and femora as in ♀. Fore tibia yellow on basal ⅔, brownish black on distal ⅓ and somewhat dark along inner border. Mid and hind tibiae yellow on basal ⅓ or a little more and brownish black on remaining distal portion. Fore tarsi brownish black. Mid tarsi brownish black with basal ⅓ of basitarsus yellow, though its border not well defined. Hind tarsi brownish black except for basal $^2/_5$ or a little more of basitarsus and base of 2nd tarsal segment yellow. Fore basitarsus not dilated, about 7.6× as long as its greatest width. Hind basitarsus much enlarged, spindle-shaped, about 3.5× as long as its greatest width and as wide as or slightly wider than hind tibia. Calcipala about ⅓× as wide as maximum width of basitarsus and extending to basal ½ of 2nd segment. Pedisulcus well developed at basal ⅓ of 2nd tarsal segment. *Wing* as in ♀ except subcosta bare or very sparsely haired. *Abdomen.* Basal scale brown with a fringe of pale brown long hairs. Dorsal surface of abdominal segments brownish black except 2nd tergite pale brown and covered with brown hairs; tergites of segments 2, 5, 6 and 7 dorsolaterally with shiny pruinose patches. *Genitalia* (FIG. 55). Coxite large, much longer than wide. Style shorter than coxite, tapering towards tip and with apical spine. Ventral plate lamellate, subquadrate, with a row process projecting downwards along posterior margin; ventral and posterior surface covered with minute setae; basal arms directed forwards. Median sclerite broad, membranous. Parameres narrow with 3 long parameral hooks and numerous small ones.

*Pupa.* Body length (excluding gill filaments) about 2.8 mm. *Head and thorax.* Integument yellow, moderately covered with tubercles. Head trichomes 4 pairs in number, all long and simple. Thoracic trichomes 5 pairs in number, 3 dorsally and 2 laterally, all long and simple. *Gill organ* (FIG. 52) much longer than pupal body, with 8 filaments arranged in groups of 3, 3, 2; 2 filaments of lower pair longest and slightly thicker than other filaments; 3 filaments of middle group slightly shorter than lower 2 filaments but longer than upper triplets; 3 filaments of upper group usually arising from almost same level of short primary stalk, at times 2 of them bearing a very short secondary stalk; stalk of lower pair stoutest and always shorter than primary and secondary stalks of middle group put together; all filaments with numerous sharp transverse ridges forming reticulate pattern, and densely covered with minute tubercles, the somewhat larger ones on ridges and smaller ones in interspaces. *Abdomen* similar to that of *S. yushangense* except for the following features. Terga 1 and 2 yellow and without tubercles; tergum 5 without spine-combs; last segment ventrolaterally with 3 grapnel-shaped hooklets on each side; terminal hooks subtriangular, plate-like and with weakly serrated posterior margin (FIG. 42). *Cocoon* slipper-shaped, moderately woven, extending ventrolaterally, and occasionally with short, irregular anterodorsal projection.

*Mature larva.* Body color dark yellow. Body length 5.0–5.5 mm. Cephalic apotome (FIG. 35) pale yellow with faint positive spots; side of head with dark area behind eye. Antenna slightly longer than stem of cephalic fan, composed of 4 segments in proportion of 35:28:35:3. Cephalic fan with about 37 main rays. Mandible (FIG. 37) without supernumerary serration; comb-teeth decreasing in length posteriorly, 1st tooth stoutest. Hypostomium with a row of 9 apical teeth, corner and median teeth moderately developed, intermediate teeth small, of almost similar size; lateral serration absent; hypostomial setae 4 or 5 in number, lying subparallel to lateral margin on each side. Postgenal cleft (FIG. 35) spearhead-shaped, constricted basally, 3–5× as long as postgenal bridge. Thoracic cuticle almost bare. Abdominal cuticle moderately covered with minute, simple, black spinous setae dorsally and laterally, becoming sparse anteriorly, as well as colorless setae on each side of anal sclerite. Rectal gill lobes compound, each with about 10 finger-like secondary lobules. Anal sclerite X-formed, having base broadly sclerotized and with anterior arms as long as posterior ones. Posterior circlet with about 84 rows of about 12 hooks. Ventral papillae well developed, conical in shape.

*Material examined.* 21 ♀, 15 ♂, 10 pupae and 8 larvae, TAIWAN: Sun Moon Lk, roadside between Sun Mun Lk and Puli, about 2 km N of lake, 9.VII.1976, H. Takaoka; 10 ♀, 7 ♂, 5 pupae and 10 larvae, Sun Moon Lk, Aborigin village park, 9.VII.1976, H. Takaoka; 3 ♀, 2 ♂, 4 pupae and 10 larvae, Wu Lai, 4.VII.1976, H. Takaoka; 2 ♀, 1 ♂ and 5 larvae, Sui Li, 11.VII.1976, H. Takaoka; 18 ♀, 6 ♂, 8 pupae and 12 larvae, Shi Tou, 14.VII.1976, H. Takaoka; 5 ♀, 3 ♂, 3 pupae and 9 larvae, Hua Lien, Chi Nan, 18.VII.1976, H. Takaoka.

*Ecological notes.* This species was taken in abundance as pupae and larvae on trailing grasses and decaying leaves from slow-moving streams (0.3–1.0 m wide) exposed to the sun. The larvae and pupae of this species were found together with *S. aureohirtum, S. chitoense, S. suzukii, S. puliense,* n. sp., *S. rufibasis, S. taiwanicum, S. shirakii, S. sakishimaense* and *S. quinquestriatum.*

*Distribution.* Taiwan, India and Java.

*Remarks. S. metatarsale* was originally described from a single male collected from Kurseong, Eastern Himalayas (Brunetti 1911), and the female, pupa and larva of this species were later described by Edwards (1934) based on the East Javan specimens.

This species is closely related to *S. ogatai* Rubzov, 1962, *S. tokarense* Takaoka, 1973, *S. okinawense* Takaoka, 1976, all from Japan, and *S. tenuistylum* Datta, 1973 and *S. darjeelingense* Datta, 1973, both from India, especially in having the hind basitarsus swollen in the male. The difference between *S. metatarsale* and these species has been previously discussed (Datta 1973; Takaoka 1976b).

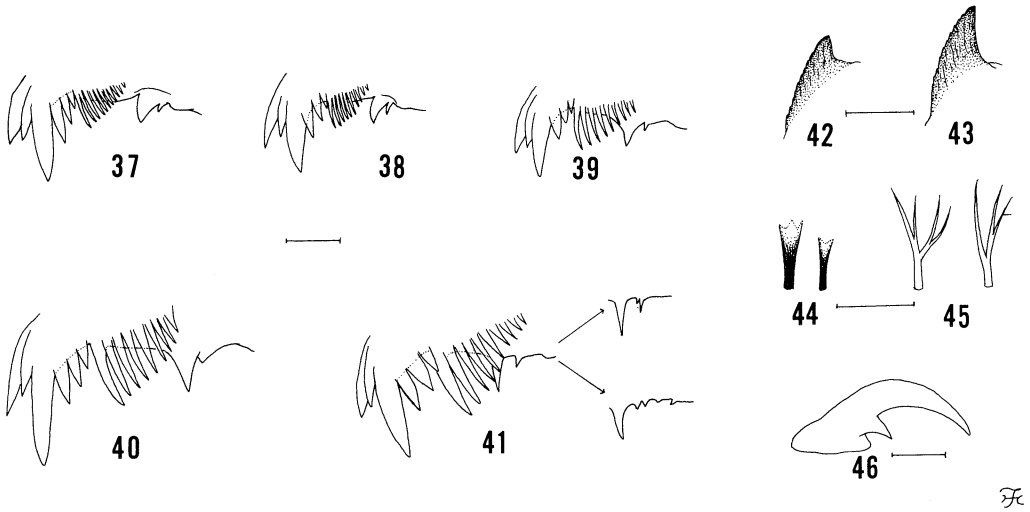


FIG. 37–46. 37–41. Tips of larval mandibles: 37, *S.* (*G.*) *metatarsale*; 38, *S.* (*G.*) *tuenense*; 39, *S.* (*S.*) *puliense*; 40, *S.* (*S.*) *taiwanicum*; 41, *S.* (*S.*) *quinquestriatum*. Scale: 0.02 mm. 42–43. Terminal hooks of pupal abdomen: 42, *S.* (*G.*) *metatarsale*; 43, *S.* (*G.*) *tuenense*. Scale: 0.02 mm. 44–45. Spine-like setae on larval abdominal cuticle: 44, *S.* (*S.*) *quinquestriatum*; 45, *S.* (*G.*) *tuenense*. Scale: 0.01 mm. 46. Claw of hind leg of *S.* (*S.*) *taiwanicum* ♀.

**Simulium (Gomphostilbia) tuenense** Takaoka, **new species** FIG. 36, 38, 43, 45

♀ and ♂ unknown.

*Pupa.* Only the following features were discerned through the transparent integument of mature larva. *Thorax*: integument covered densely with tubercles and with 5 pairs of trichomes, 3 dorsally and 2 laterally, all long, simple and with curled tip. *Gill organ* with 8 filaments arranged as in *S. metatarsale*. *Abdomen* similar to that of *S. metatarsale*.

*Mature larva.* Body length 4.3–4.5 mm. Body color pale yellow with distinct colored pattern on abdomen, entirely greenish gray on segments 1 and 2, same-colored dorsally and laterally on segments 7 and 8, and transverse, broad, reddish brown band dorsally on segments 5 and 6, each band usually broken submedially, forming a concolored median spot and lateral spots. Cephalic apotome (FIG. 36) pale yellow with faint spots, anterocentral and lateromedian spots indistinct; sides of head with large spots behind eye and 3 very faint isolated spots under eye. Antenna slightly longer than stem of cephalic fan, with 4 segments in proportion of 33:28:30:3. Cephalic fan with about 38 main rays. Mandible (FIG. 38) and hypostomium similar to those of *S. metatarsale*. Postgenal cleft (FIG. 36) rounded, slightly constricted basally, about 2× as long as postgenal bridge. Thoracic cuticle almost bare. Abdominal cuticle moderately covered with minute, branched (into 2–5) black spinous setae dorsally and laterally, becoming sparse anteriorly, as well as colorless setae on each side of anal sclerite. Rectal gills compound, each lobe with 5–8 finger-like secondary lobules. Anal sclerite as in *S. metatarsale* except anterior arms shorter than posterior ones. Posterior circlet with about 80 rows of about 12 hooks. Ventral papillae well developed, conical in shape.

Holotype mature larva (BISHOP 11,437), slide-mounted, TAIWAN: Sun Moon Lk, 9.VII.1976, H. Takaoka. Paratypes, 2 mature larvae (1 just before pupating), slide-mounted, same data as holotype.

*Ecological notes.* A small number of larvae of this species were taken on trailing grasses in a small, shaded brook (0.3–1.0 m wide) flowing down from Sun Moon Lake, near the lake. No other species was collected from the same place.

*Distribution.* Taiwan.

*Remarks.* The larvae of *S. tuenense* closely resembles that of *S. okinawense* Takaoka, 1976 from the Ryukyu Islands in the pattern of the body color and the postgenal cleft, but the pupa is distinguished from the latter by the arrangement of the gill filaments and the thoracic integument densely covered with tubercles. This species is also closely similar to *S. catleyi* Smart & Clifford, 1965 from New Britain and New Guinea, in the pupal gill organ and the size of postgenal cleft in the larvae. However, there seem to be slight differences in the shape of the postgenal cleft and the anal sclerite in the larvae.

## Subgenus **Simulium** Latreille, 1802 s. str.

### **Simulium (Simulium) taiwanicum** Takaoka, **new species**

FIG. 34, 40, 46, 51, 53, 58

♀. A large species with yellow legs. Body length 3.4–3.7 mm. Wing length about 3.2 mm. *Head* narrower than thorax. Posterior surface black, densely covered with black hairs. Frons black, shiny, thinly gray-pruinose and sparsely with black hairs along lateral and lower margins; frons about 1/4.6× as long as head width; ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 65:52:53. Clypeus black, thickly whitish gray-pruinose and covered moderately with black hairs intermixed with several yellow fine hairs. Antenna composed of 2 + 9 segments, black with scape, pedicel and base of 1st flagellar segment yellow to dark yellow. Maxillary palp with 5 segments in proportion of 20:20:41:46:105; 3rd segment not enlarged; sensory vesicle oblong, about 2.6× as long as wide, and about 1/2.5× length of 3rd segment. Maxilla with about 32 inner teeth and about 14 outer ones. Cibarium armed with about 40 minute tubercles. *Thorax.* Scutum black, semishiny, whitish gray-pruinose anteriorly and laterally, and densely covered with golden yellow pubescence interspersed with several erect black hairs on prescutellar area. Scutellum black with erect, long, black hairs as well as dense, golden yellow pubescence. Postscutellum black with gray-pruinosity and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa yellow, mid and hind ones black. All trochanters yellow to dark yellow. All femora yellow with distal tip brownish black. Fore tibia black except median large portion of outer surface white, and with large white sheen on whitish portion. Mid tibia yellow with distal tip brownish black. Hind tibia yellow with distal ⅓ brownish black. Mid and hind tibiae with whitish sheen largely on basal ½ or more of posterior surface. All tarsi black with basal $^3/_5$ or a little more of mid and hind basitarsi and basal ½ of hind 2nd tarsal segment yellow. Fore basitarsus dilated, about 5.2× as long as its greatest width, and with thick, dorsal hair crest. Hind basitarsus narrow, parallel-sided. Calcipala as long as wide, and its width about ½× that of hind basitarsus. Pedisulcus well developed at basal ⅓ of 2nd basal segment. Each claw (FIG. 46) with subbasal tooth. *Wing.* Costa with spinules and black hairs. Subcosta fully haired. Base of radius with a tuft of black hairs. Basal section of radius bare. $R_1$ with black spinules and black hairs. *Abdomen.* Basal scale dark yellow, with a fringe of long yellow hairs. Dorsal surface of abdomen brownish black except for 2nd segment dark yellow to brown, and with sparse black hairs; 2nd segment with a pair of dorsolateral whitish pruinosities; tergites of segments 6, 7 and 8 shiny. *Genitalia* (FIG. 53). Anterior gonapophyses large, with transparent bare tip and covered with numerous long hairs; inner margin widely concave, and narrowly sclerotized. Stem of genital fork long, strongly sclerotized; arms diverged laterally, each with strongly sclerotized anterolateral ridge and prominent projection directed forwards. Spermatheca ovoid in shape, with reticulate pattern and internal hairs. Paraproct of moderate size, with pale ventrolateral groove, and with numerous hairs. Cercus rounded posteriorly, short, about ½× as long as wide, densely setose.

♂. Body length 3.4–3.7 mm. Wing length about 2.9 mm. *Head* slightly wider than thorax. Posterior surface black with dense black hairs. Clypeus black, whitish gray-pruinose, with sparse black hairs. Upper eye consisting of about 22 transverse rows of large facets. Antenna composed of 2 + 9 segments, brownish black with base of 1st flagellar segment somewhat pale; 1st flagellar segment elongated, about 1.7× as long

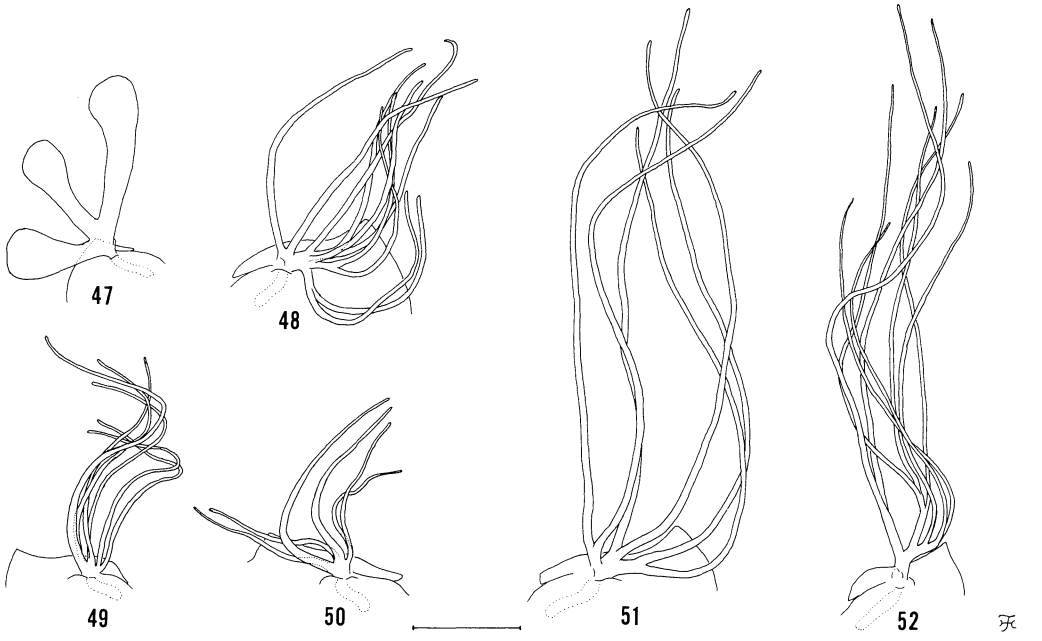


FIG. 47–52. Pupal gill organs: 47, *S.* (*S.*) *shirakii*; 48, *S.* (*S.*) *quinquestriatum*; 49, *S.* (*S.*) *puliense*; 50, *S.* (*S.*) *ufengense*; 51, *S.* (*S.*) *taiwanicum*; 52, *S.* (*G.*) *metatarsale*. Scale: 0.5 mm.

as next flagellar segment. Maxillary palp with 5 segments in proportion of 15:15:33:39:85; sensory vesicle small, elliptical in shape. *Thorax.* Scutum black, not shiny, covered densely with golden yellow pubescence interspersed with erect black hairs on prescutellar area; scutum with iridescent pattern, a pair of small silvery pruinosities on shoulders, a transverse silvery band along posterior margin and silvery bands along lateral margins; anterior spots widely separated in the middle and connected with posterior band by lateral bands. Scutellum brownish black with erect, long hairs as well as dense golden yellow pubescence. Postscutellum black, bare and with whitish gray-pruinosity. Pleural membrane and katepisternum bare. *Legs.* Fore coxa yellow, mid and hind ones brownish black. All trochanters brown. All femora yellow with distal tip brownish black. Fore tibia black with median large portion of outer surface pale yellow and with silvery sheen largely on pale portion. Mid tibia brown except for distal tip black but often appearing yellow on basal ⅔ or more by large silvery sheen on posterior surface and by dense covering of golden yellow hairs. Hind tibia black with minute silvery sheen at base. All tarsi black except basal ½ of mid and hind basitarsi yellow to dark yellow. Fore basitarsus dilated, about 5.8× as long as its greatest width, and with thick, dorsal hair crest. Hind basitarsus, swollen, spindle-shaped, slightly widened to distal $^2/_5$, and then slightly narrowed towards tip, and about 5× as long as its greatest width and a little narrower than hind tibia. Calcipala and pedisulcus well developed as in ♀. *Wing* as in ♀ except for subcosta bare. *Abdomen.* Basal scale brownish black with a fringe of black hairs. Dorsal surface of abdomen black and covered with brown hairs; tergites of segments 2, 5, 6 and 7 each with a pair of dorsolateral silvery pruinosities, those on segment 2 connected in the middle forming a broad, transverse silvery band. *Genitalia* (FIG. 58). Coxite quadrate in shape, nearly as long as wide. Style rather long, about 2.5× as long as its greatest width near base, of more or less the same width through its length and somewhat flattened dorsoventrally; distal end rounded and with apical spine directed inwards; style with subbasal, hairy protuberance produced dorsally. Ventral plate roughly Y-shaped, strongly sclerotized, having a ventrally produced median process or keel with toothed posterior margins in proximal ½; distal ½ process lip-like and sparsely setose on outer

surface; basal arms strongly sclerotized and slightly converged apically. Parameres broad basally, tapering towards parameral hooks, with numerous small parameral hooks. Median sclerite broad, plate-like, gradually broadened distally and with rounded tip.

*Pupa.* Body length (excluding gill filaments) about 3.8 mm. *Head and thorax.* Integument yellowish brown densely covered with tubercles. Head trichomes 3 pairs, all simple and medium-sized. Thoracic trichomes 4 pairs, 2 dorsally and 2 laterally, all long and simple. *Gill organ* (FIG. 51) much shorter than pupal body, with 6 filaments arranged in pairs; all filaments almost equal in length (about 2.5 mm) and thickness, tapering distally, with numerous sharp transverse ridges forming reticulate pattern, and densely covered with minute tubercles, the larger ones on ridges and smaller ones on interspaces. *Abdomen* similar to that of *S. yushangense* except 5th segment without dorsal spine-combs, and terminal hooks less developed. *Cocoon* simple, slipper-shaped, loosely woven, slightly extending ventrolaterally and with strong anterior margin.

*Mature larva.* Body color pale yellow. Body length 8.0–9.0 mm. Cephalic apotome (FIG. 34) yellow with distinct head spots; side of head with darkened area behind eye region and 1 isolated spot under eye. Antenna composed of 4 segments in proportion of 40:52:28:3, and slightly longer than stem of cephalic fan. Cephalic fan with about 52 main rays. Mandible (FIG. 40) without supernumerary serrations; comb-teeth equal in thickness and decreasing in length posteriorly. Hypostomium with a row of 9 apical teeth, corner and median teeth moderately developed, and intermediate teeth small, of similar size; lateral serration well developed on apical ½; hypostomial setae 7 or 8 in number diverging posteriorly from lateral margin on each side. Postgenal cleft (FIG. 34) rounded, medium-sized, about 1.5× as long as postgenal bridge. Thoracic cuticle bare. Abdominal cuticle bare except for colorless setae on each side of anal sclerite. Rectal gills compound, each lobe with about 10 finger-like secondary lobules. Anal sclerite X-formed with anterior arms much shorter than posterior ones. Posterior circlet with about 92 rows of about 16 hooks. Ventral papillae absent.

Holotype ♀ (BISHOP 11,438), slide-mounted, TAIWAN: Shi Tou, ca 1000 m, 14.VII.1976, H. Takaoka. Allotype ♂ (BISHOP), 10 ♀, 10 ♂, 5 pupae, 10 larvae paratypes (BISHOP), same data as holotype.

*Ecological notes.* The pupae and larvae of this species were taken in abundance from a small, shaded, mountain stream (0.2–1.0 m wide), on trailing grasses and decaying leaves. This species was found together with *S. chitoense, S. metatarsale, S. suzukii, S. rufibasis* and *S. sakishimaense.*

*Distribution.* Taiwan.

*Remarks.* *S. taiwanicum* very closely resembles *S. himalayense* Puri, 1932 from India but differs from it by the color of the female mid leg. This species is also similar to *S. aokii* Takahasi, 1941 from Japan. However, *S. taiwanicum* is easily differentiated by the shorter postgenal cleft and the numerous secondary lobules of the rectal gills in the larva, the yellow femora of the male, and the large number of tubercles on the base of female cibarium.

**Simulium (Simulium) ufengense** Takaoka, **new species** FIG. 50, 57

♀. Unknown.

♂. A large species with yellow legs. Body length 3.8 mm. Wing length 2.3 mm. *Head* slightly wider than thorax. Clypeus black, whitish gray-pruinose and covered sparsely with black hairs. Upper eye consisting of about 20 transverse rows of large facets. Antenna composed of 2 + 9 segments, yellow basally, becoming dark towards tip; 1st flagellar segment elongated, about 1.6× as long as 2nd flagellar segment. Maxillary palp with 5 segments in proportion of 14:14:29:38:74; sensory vesicle small, globular in shape. *Thorax, wing and abdomen* similar to those of *S. taiwanicum* ♂. *Legs.* Fore coxa yellow, mid and hind ones black. All trochanters yellow. All femora yellow with distal cap of hind femur brownish black. Fore tibia

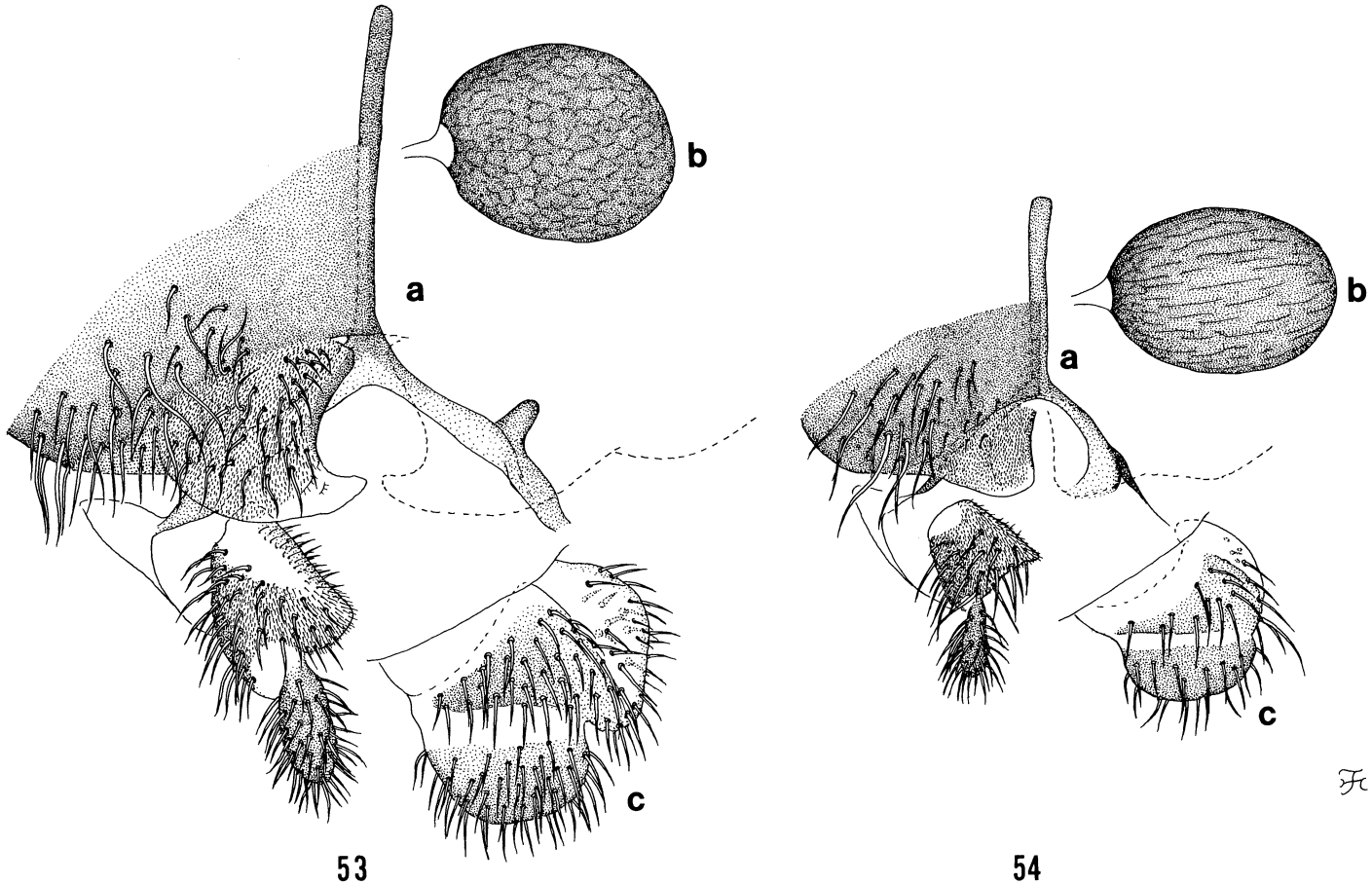


FIG. 53–54. ♀ genitalia: 53, *S.* (*S.*) *taiwanicum*; 54, *S.* (*G.*) *metatarsale*. **a**, 8th sternite, anterior gonapophyses, genital fork, paraproct and cercus in situ (ventral view); **b**, spermatheca; **c**, side view of paraproct and cercus.

dark yellow to brown except for inner margin and distal $^1/_5$ brownish black, and with silvery sheen on median large portion of outer surface. Mid tibia entirely yellow. Hind tibia brownish black, with basal ⅓ yellow, though its border obscured. Fore tarsi brownish black. Mid tarsi brownish black, with basal $^4/_5$ of basitarsus yellow to dark yellow, though its border not well defined. Hind tarsi brownish black except for basal ½ of basitarsus and basal ⅓ of 2nd tarsal segment yellow. Fore basitarsus dilated, about 6× as long as its greatest width, and with thick, dorsal hair crest. Hind basitarsus moderately expanded, about 4.2× as long as its greatest breadth at distal ⅓ and narrower than hind tibia. Calcipala distinct, nearly as long as wide and about ½× as wide as distal portion of basitarsus. Pedisulcus well developed at basal ⅓ of 2nd tarsal segment. *Genitalia* (FIG. 57). Coxite quadrate in shape, nearly as long as wide. Style rather long, about 3.7× as long as its greatest width near base, gradually narrowed towards distal ⅓ and then widened distally; apex rounded and without distinct apical spine though present is a small, spine-like hair indistinguishable from those nearby; style with basal horn-like protuberance produced dorsally, bearing 2 or 3 weakly developed spines apically. Ventral plate quadrate in shape, flat dorsoventrally, and with diverged basal arms; ventral surface of ventral plate sparsely haired centrally. Parameres broad basally, and each with several strong parameral hooks. Median sclerite long, gradually broadened towards tip.

*Pupa.* Body length (excluding gill filaments) about 3.5 mm. *Head.* Integument yellowish brown, bare and with 3 pairs of trichomes, anterior one long and simple, while dorsal ones long and branched into 2 or 3. *Thorax.* Integument yellowish brown, almost bare on anterior ½ and moderately with cone-shaped tubercles on posterior ½; trichomes 5 pairs in number, 3 dorsally and 2 laterally, all long and branched into 3 or 4. *Gill organ* (FIG. 50) with 6 filaments arranged in pairs; inner filaments of dorsal and middle pairs directed internally, while others directed forwards; outer filaments of dorsal and middle pairs a little thicker than other 4 filaments; all filaments almost sessile or very shortly stalked, equal in length (about 1.0 mm), tapering distally and with numerous transverse ridges and covered densely with minute tubercles of same size. *Abdomen* similar to that of *S. yushangense* except for dorsal spine-combs only on segment 8 and the absence of terminal hook. *Cocoon* simple, slipper-shaped, thickly and tightly woven and with strong anterior margin.

*Mature larva.* Unknown.

Holotype ♂ (BISHOP 11,439), slide-mounted with associated pupal skin, TAIWAN: Chao Chi, Wu Feng Cataract, 6.VII.1976, H. Takaoka; 1 ♂ paratype, Wu Lai, 20.VII.1976, H. Takaoka (BISHOP).

*Ecological notes.* Two pupae were taken on decaying leaves, 1 from a small, shallow, shaded river (about 6 m wide) near the basin of a waterfall in a lowland, together with a few pupae of *S. sakishimaense,* and the other from a swift-flowing, shaded, mountain stream, in company with *S. suzukii, S. metatarsale* and *S. sakishimaense.*

*Distribution.* Taiwan.

*Remarks. S. ufengense* is related to *S. novolineatum* Puri, 1932, *S. barraudi* Puri, 1932, *S. digitatum* Puri, 1932 and *S. dentatum* Puri, 1932, all from India, *S. fenestratum* Edwards, 1934 from Sumatra and *S. sakishimaense* Takaoka, 1977 from the Ryukyu Islands and Taiwan, in having the male style with a prominent, horn-like basal protuberance. However, this species is easily separated from other species by the shape of the ventral plate, the coloration of the legs and the number of the pupal gill filaments (6 instead of 8).

**Simulium (Simulium) puliense** Takaoka, **new species** FIG. 39, 49, 59

♀. Unknown.

♂. A small blackish species. Body length 2.2 mm. Wing length 1.2 mm. *Head* wider than thorax. Clypeus black, silvery-pruinose and sparsely covered with black hairs. Upper eye consisting of 21 transverse rows of large facets. Antenna composed of 2 + 9 segments, brownish black with minute base of 1st flagellar

segment somewhat pale; 1st flagellar segment elongated, about 1.7× as long as 2nd flagellar segment. Maxillary palp with 5 segments in proportion of 12:10:23:28:53; sensory vesicle small, globular in shape. *Thorax.* Scutum black, not shiny, covered uniformly with brown pubescence intermixed with long hairs on prescutellar area; scutum with iridescent pattern similar to that of *S. taiwanicum* but silvery pruinosities much more prominent, contrasting with black ground color and lateral bands very narrowly connected with posterior transverse band in front of wing base. Scutellum brownish black with erect, long, black hairs as well as short ones. Postscutellum black, gray-pruinose and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa yellow, mid and hind ones brownish black. All trochanters brown to brownish black with hind one dark yellow. All femora brownish black. Fore tibia brownish black with large silvery sheen on outer surface. Mid and hind tibiae brownish black with basal area minutely pale and with whitish sheen basally on outer surface. Fore tarsi entirely brownish black. Mid tarsi brownish black except for basal ⅔ and a little more of basitarsus and basal ⅓ of 2nd tarsal segment yellow. Hind tarsi brownish black with basal ½ of basitarsus and basal ⅓ of 2nd tarsal segment yellow. Fore basitarsus dilated, about 4× as long as its greatest width, and with thick, dorsal hair crest. Hind basitarsus moderately swollen, about 3.4× as long as its greatest breadth at distal ⅓, and slightly narrower than hind tibia. Calcipala distinct, as long as wide, and about 1/2.7× as wide as distal portion of basitarsus. Pedisulcus well developed at basal ⅓ of 2nd tarsal segment. Wing and abdomen similar to those of *S. taiwanicum* except segment 5 without a pair of silvery pruinosities. *Genitalia* (Fig. 56). Coxite short, quadrate in shape and nearly as long as wide. Style elongate, about 3.3× as long as its greatest width at basal ¼, gradually narrowed distally on basal ½ and then, more or less, parallel-sided on distal ½; distal end rounded and with subapical spine directed inwards; style with basal protuberance produced dorsomedially, bearing numerous spines of different sizes on its surface. Ventral plate with base rectangular in shape, slightly shorter than wide, having ventrally produced hairy process with toothed posterior margins on proximal ½; posterior margin, when viewed ventrally, widely concave; basal arms slightly diverged. Parameres large basally and each with numerous small parameral hooks. Median sclerite plate-like, gradually widened on basal ½ and then nearly parallel-sided and rounded at tip.

*Pupa.* Body length (excluding gill filaments) 2.5 mm. *Head and thorax.* Integument brown, moderately covered with rather large rounded tubercles. Head trichomes 3 pairs, 1 anteriorly, simple and medium-sized, and 2 dorsally, simple and short. Thoracic trichomes 4 pairs, 2 dorsally and 2 laterally, all simple and medium-sized. *Gill organ* (Fig. 49) with 6 filaments arranged in pairs; outer filament of dorsal pair slightly thicker than other 5 filaments (about 1.3×); all filaments directed forwards close together, almost sessile or very shortly stalked and subequal in length (about 1.5 mm); surface of all filaments with numerous transverse ridges and covered densely with minute tubercles of 2 slightly different sizes, the larger ones on ridges and smaller ones on interspaces. *Abdomen* similar to that of *S. yushangense* except for dorsal spine-combs only on segments 7, 8 and 9 and the absence of terminal hook. *Cocoon* simple, slipper-shaped, tightly woven, with moderately strong anterior margin and not extending ventrolaterally.

*Mature larva.* Only 1 shed larval skin associated with pupa was available. Cephalic apotome brown with positive, boldly marked head spots. Hypostomium with a row of 9 apical teeth, corner and median teeth moderately developed, intermediate ones small; lateral serration moderately developed on apical ½; hypostomial setae 5 in number diverging posteriorly from lateral margin on each side. Postgenal cleft deep, sharp-triangular in shape, about 4.2× as long as postgenal bridge; inner margin nearly straight. Anal sclerite X-formed with posterior arms much longer than anterior ones. Posterior circlet with about 76 rows of about 14 hooks.

Holotype ♂ (Bishop 11,440), slide-mounted with associated pupal skin, TAIWAN: Sun Moon Lk, roadside between Sun Moon Lk and Pu Li, about 2 km N of lake, 9.VII.1976, H. Takaoka. Paratype pupa (Bishop), slide-mounted with associated larval skin, same data as holotype.

*Ecological notes.* The 2 pupae were taken from a slow-moving lowland stream (about 0.3 m wide) exposed to the sun, on trailing grasses. This species was collected together with *S. metatarsale* and *S. shirakii.*

*Distribution.* Taiwan.

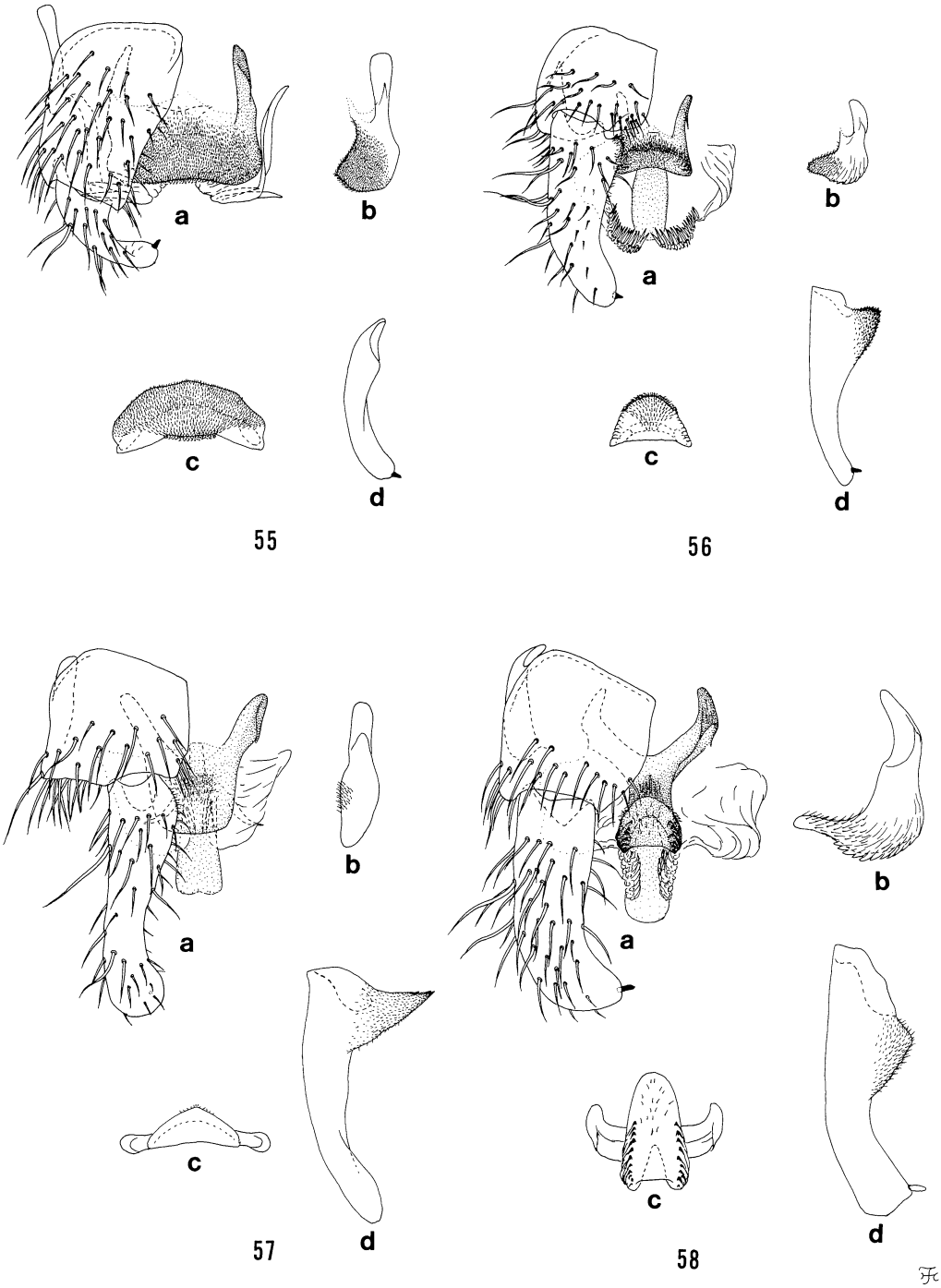


FIG. 55–58. ♂ genitalia: 55, *S.* (*G.*) *metatarsale*; 56, *S.* (*S.*) *puliense*; 57, *S.* (*S.*) *ufengense*; 58, *S.* (*S.*) *taiwanicum*. **a**, coxite, style, ventral plate, parameres and median sclerite in situ (ventral view); **b**, side view of ventral plate; **c**, end view of ventral plate; **d**, side view of style.

*Remarks.* *S. puliense* is assigned to the *tuberosum* group by the shape of genitalia and the pupal gill filaments. The male of this species closely resembles that of *S. rufibasis* Brunetti, a common species in the Oriental Region and the southern parts of the Palaearctic Region, but is distinguishable by the coloration of the mid and hind tarsal segments. The pupal gill filaments easily separate this species from *S. rufibasis,* as noted in the key.

This species may represent the male of *S. arisanum* Shiraki, 1935. Since *S. arisanum* is known only from the adult female, it is not possible to associate these with each other until further collections are made.

**Simulium (Simulium) rufibasis** Brunetti

*Simulium rufibasis* Brunetti, 1911: 282–88.—Rubzov, 1959–1964: 554–55.
*Simulium (Simulium) rufibasis*: Puri, 1932b: 899–903.—Ogata et al., 1956: 94–95.—Takaoka, 1977: 213–16.

This species belongs to the *tuberosum* group and is distinct from other members in the presence of paired submedian clusters of long hairs on the 7th sternite in the female and the arrangement of the pupal gill filaments.

*S. rufibasis* was originally described from Kurseong, Darjeeling, India. Detailed descriptions of all stages were given by Puri (1932b) and Takaoka (1977). The female, male, pupa and larva of the Taiwanese specimens were identical to specimens redescribed by Takaoka (1977). This is a new record for Taiwan.

*Material examined.* 1 ♀, 1 ♂, 6 larvae, TAIWAN: Shi Tou, ca 1000 m, 14.VII.1976, H. Takaoka; 2 ♀, 1 ♂, 4 pupae, 12 larvae, Ta U Lin, ca 2600 m, 16.VII.1976, H. Takaoka.

*Ecological notes.* The pupae and larvae were taken from swift-flowing mountain streams, on decaying leaves and trailing grasses. This species was collected together with *S. yushangense, S. taulingense, S. chowi, S. chitoense, S. metatarsale, S. taiwanicum, S. sakishimaense* and *S. suzukii.*

*Distribution.* India, Taiwan, Japan and Korea.

**Simulium (Simulium) suzukii** Rubzov

*Simulium suzukii* Rubzov, 1963: 525–26.
*Simulium ryukyuense* Ogata, 1966: 123–30.
*Simulium (Simulium) suzukii*: Orii et al., 1969: 1–13.—Takaoka, 1977: 209–13.

This small species is a member of the *tuberosum* group and is one of the commonest species in Japan and Korea. *S. suzukii* closely resembles *S. nitidithorax* Puri, 1932 from India and slightly differs from the latter in the shape of the female frons and the pupal gill filaments. The frons of *S. suzukii* is rather broad, nearly as long as or slightly shorter than greatest width at vertex [in the redescription by Takaoka (1977), the frons was erroneously stated to be about 1.2× as long as wide at vertex], while that of *S. nitidithorax* is, according to the original description, narrow and a little less

than 2× as long as its breadth at the middle. The gill filaments are shortly stalked in the present species but sessile in *S. nitidithorax.*

A detailed description of all stages of *S. suzukii* was made by Takaoka (1977). The Taiwanese material agrees well with Takaoka's description and illustrations. This is the first report of this species from Taiwan.

*Material examined.* 10 ♀, 10 ♂, 3 pupae, 25 larvae, TAIWAN: Wu Lai, 20.VII.1976, H. Takaoka; 1 ♀, 4 larvae, Sun Moon Lk, 9.VII.1976, H. Takaoka; 6 ♀, 4 ♂, 5 larvae, Shi Tou, 14.VII.1976, H. Takaoka.

*Ecological notes.* The pupae and larvae were taken on trailing grasses and decaying leaves or sticks. The material was abundantly collected from the swift-flowing, shaded, mountain streams (0.5–3.0 m wide) and rarely from a slow-moving, lowland stream (about 0.5 m wide) exposed to the sun. This species was found in association with *S. chitoense, S. metatarsale, S. taiwanicum, S. puliense, S. rufibasis, S. sakishimaense, S. shirakii* and *S. quinquestriatum.*

*Distribution.* Korea, Japan and Taiwan.

**Simulium (Simulium) sakishimaense** Takaoka

*Simulium (Simulium) sakishimaense* Takaoka, 1977: 197–201.

*S. sakishimaense* belongs to the *novolineatum* group in having the female scutum with 5 longitudinal lines, the anterior gonapophyses very short and widely separated from each other, the male style long and with prominent, horn-like, basal protuberance, the pupal gill organ with 8 filaments, the cocoon with lateral window and the large, rounded, larval postgenal cleft.

This species was described from the Sakishima Is in the Ryukyu Archipelago, about 200 km W of Taiwan (Takaoka 1977). The morphological features of the Taiwanese material agree well with the original description. This is the first record from Taiwan.

*Material examined.* 2 ♀, 2 ♂, 3 pupae, 8 larvae, TAIWAN: Wu Lai, 20.VII.1976, H. Takaoka; 1 ♀, Chao Chi, Wu Feng Cataract, 6.VII.1976, H. Takaoka; 1 ♀, 2 ♂, 3 larvae, Sun Moon Lk, 9.VII.1976, H. Takaoka; 1 ♀, 4 ♂, 10 larvae, Shi Tou, 14.VII.1976, H. Takaoka; 2 ♀, 2 ♂, Hua Lien, Chi Nan, 18.VII.1976, H. Takaoka.

*Ecological notes.* The pupae and larvae were taken on trailing grasses and decaying leaves or sticks, and occasionally on stones or polyethylene bags in the water. The material was found in various habitats, from a slow-moving stream (about 0.5 m wide) to swift-flowing streams or rivers (about 10 m wide). This species was collected together with *S. chitoense, S. metatarsale, S. taiwanicum, S. ufengense, S. suzukii, S. rufibasis, S. puliense, S. shirakii* and *S. quinquestriatum.*

*Distribution.* Ryukyu Is and Taiwan.

**Simulium (Simulium) quinquestriatum** (Shiraki) FIG. 41, 44, 48

*Stilboplax 5-striatum* Shiraki, 1935: 27–33.

*Simulium* (*Stilboplax*) *5-striatum*: Ogata & Sasa, 1954: 330–31.—Ogata et al., 1956: 77–78.—Orii et al., 1969: 1–13.

*Simulium* (*Simulium*) *quinquestriatum*: Anonym., 1974: 192.—Takaoka, 1977: 205–09.

♀. A large species with longitudinal black stripes on the scutum and haired basal portion of radius. Body length 3.0–3.2 mm. Wing length 2.3–2.5 mm. *Head.* Width narrower than that of thorax. Posterior surface of head black, gray-pruinose, with numerous black hairs. Frons black, thinly gray-pruinose, with several black hairs along lateral and lower margins; frons about 1/4.5× as long as head width; ratio of the greatest width at vertex, the narrowest near antennal base and height of frons 55:40:46 (in some specimens, frons as long as its greatest breadth at vertex). Clypeus black, thickly whitish gray-pruinose and covered moderately with black hairs. Antenna composed of 2 + 9 segments, brownish black with scape, pedicel and base of 1st flagellar segment yellowish brown (in some specimens, antenna yellowish brown basally, becoming dark distally). Maxillary palp with 5 segments in proportion of 18:18:36:37:80; sensory vesicle oblong, about 2× as long as wide, and about 1/2.2× length of 3rd segment; opening of sensory vesicle of 2 types in size and shape, in some specimens, small, nearly globular, ½× as wide as sensory vesicle, and in other specimens, enlarged, elliptical, almost as wide as, and ½× as long as sensory vesicle. Maxilla with about 14 inner teeth and about 13 outer teeth. Mandible with about 30 inner teeth and about 14 outer ones. Cibarium armed with minute, weak tubercles. *Thorax.* Scutum black, shiny, thickly whitish gray-pruinose and uniformly covered with recumbent, yellow pubescence interspersed with erect, brown hairs on prescutellar area; scutum when viewed from front with 5 broad, longitudinal black stripes, 1 medially, 2 submedially and remaining 2 laterally, all these stripes being united with a broad transverse black band on prescutellar region; when viewed from behind, scutum having reversed color, with 4 broad, longitudinal black stripes, 2 submedially and other 2 laterally, all these terminated before anterior and posterior margins; in certain angle of light, scutum entirely whitish gray-pruinose and black stripes disappear. Scutellum brownish black, thinly gray-pruinose, with erect, long black hairs as well as recumbent, yellow pubescence. Postscutellum black, gray-pruinose and bare. Pleural membrane and katepisternum bare. *Legs.* Fore coxa yellow, mid and hind coxae black. Fore trochanter yellow to yellowish brown, mid one black and hind one yellow. Fore femur yellowish brown to dark brown, gradually darkened distally. Mid and hind femora black with base of hind one pale. Fore tibia black with inconspicuous whitish gray sheen on outer surface. Mid and hind tibiae black with base pale yellow, and each with inconspicuous whitish gray sheen on posterior surface. Fore tarsi black. Mid tarsi brownish black with basal ¾ of basitarsus and basal ½ of 2nd segment whitish yellow. Hind tarsi black with basal $^3/_5$ of basitarsus and basal $^2/_5$ of 2nd segment whitish yellow. Fore basitarsus dilated, 5.0–5.8× as long as its greatest width and with thick, dorsal hair crest. Hind basitarsus parallel-sided. Calcipala a little longer than wide, reaching pedisulcus. Pedisulcus well developed at basal $^2/_5$ of 2nd tarsal segment. Each claw simple. *Wing* as in *S. taiwanicum* ♀ except basal section of radius fully haired. *Abdomen.* Basal scale brownish black, with a fringe of dark long hairs. Dorsal surface of abdomen black, with sparse black hairs; tergite of 2nd segment with a broad transverse silvery band; tergites of segments 6, 7 and 8 shiny. *Genitalia.* Sternite of 8th segment posteriorly with a deep quadrate notch in the middle. Anterior gonapophyses with ventrally produced lobe along inner margin and covered with numerous yellow short hairs; inner margin narrowly sclerotized, separated from each other. Stem of genital fork slender, strongly sclerotized; arms slender, each with well sclerotized ridge distally. Spermatheca globular in shape, well sclerotized, with inconspicuous reticulate pattern on surface and numerous internal hairs. Paraproct produced ventrally, about 2.5× as wide as long and about 2× width of cercus, and moderately setose; anterointernal margin well sclerotized. Cercus of moderate size, about ½× as long as wide, and moderately setose.

♂. Body length 3.0–3.5 mm. Wing length 2.1–2.5 mm. *Head* as wide as thorax (in some specimens, head slightly wider than thorax). Posterior surface black, with numerous black hairs. Clypeus black, whitish gray-pruinose, with sparse black hairs. Upper eye consisting of about 16 transverse rows of large facets. Antenna composed of 2 + 9 segments; 1st flagellar segment elongated, about 1.6× as long as 2nd flagellar segment; coloration variable as in ♀. Maxillary palp with 5 segments in proportion of 15:15:29:39:80; sensory vesicle small, globular in shape. *Thorax.* Scutum black, not shiny, covered uniformly with recumbent golden yellow pubescence (in some specimens, pubescence bright copper-colored) interspersed with

erect, long black hairs on prescutellar area; scutum with iridescent pattern similar to that of *S. taiwanicum* except for a pair of anterior whitish gray spots much larger and narrowly spaced in the middle. Scutellum black, thinly gray-pruinose, with erect, long black hairs as well as recumbent yellow pubescence. Postscutellum black, whitish gray-pruinose and bare. Pleural membrane and katepisternum bare. *Legs* similar to those of ♀ except for slight difference in the fore and hind basitarsus. Fore basitarsus dilated, about 6.0× as long as its greatest width. Hind basitarsus yellow on basal ½ or a little more, moderately expanded, spindle-shaped, about 3.6× as long as its greatest width, and slightly narrower than hind tibia (in some specimens, hind basitarsus expanded to lesser extent, nearly parallel-sided, 4.0–5.0× as long as wide, and much narrower than hind tibia). *Wing* similar to that of ♀ except subcosta and basal section of radius bare. *Abdomen* as in *S. taiwanicum* ♂. *Genitalia.* Coxite quadrate, nearly as long as wide. Style rather long, about 3× as long as its broadest near basal ¼, and about 5× as long as width of distal ½ portion which is, more or less, parallel-sided; distal end rounded and with apical spine directed inwards; style dorsally with subbasal protuberance furnished with several small spines on anterior surface of distal portion. Ventral plate broad, rounded, saddle-shaped, with prominent median process sharply narrowed down to a more or less rounded small distal tip; anteroventral surface moderately setose medially; basal arms short, strongly sclerotized and nearly parallel-sided. Parameres and median sclerite similar to those of *S. taiwanicum.*

*Pupa.* Body length (excluding gill filaments) 3.4–4.0 mm. *Head and thorax.* Integument brown, moderately covered with rather large rounded tubercles. Head trichomes 3 pairs in number, all long and simple (in some specimens, some or all of trichomes split into 2–4 branches). Thoracic trichomes 5 pairs in number, 3 dorsally and 2 laterally, all long and branched. *Gill organ* (FIG. 48) with 10 filaments arranged in groups of 2, 3, 3, 2; each group shortly stalked, and middle triplets with secondary stalk of variable length; all filaments spread out somewhat fan-like, subequal in length and thickness, and less than ½× as long as pupal body; surface of filaments with numerous transverse ridges forming reticulate pattern and densely covered with minute tubercles of 2 types, the somewhat larger ones on ridges and smaller ones on interspaces. *Abdomen* similar to that of *S. yushangense* except for dorsal spine-combs present only on segment 8 (in some specimens, a few smaller spine-combs also on segment 7 and/or 9), 4 of 6 dorsal setae on each side of 2nd segment much stouter than those of *S. yushangense,* and terminal hooks less developed. *Cocoon* boot-shaped, loosely and elaborately woven by thick strands anteriorly with numerous, small interspaces near opening; its opening directed upwards and a little forwards depending upon the collar of variable height.

*Mature larva.* Body color grayish brown. Body length 6.0–6.5 mm. Cephalic apotome usually dark brown along lateral sides and posterior margins, and somewhat paler medially, and with positive head spots; lateral spots sometimes submerged in the ground color. Antenna composed of 4 segments in proportion of 23:34:18:3 and slightly longer than stem of cephalic fan. Cephalic fan with about 44 main rays. Mandible (FIG. 41) occasionally with supernumerary serrations; comb-teeth similar to those of *S. taiwanicum.* Hypostomium with a row of 9 apical teeth, corner and median teeth moderately developed, intermediate teeth small, of similar size; lateral serration moderately developed on apical ½; hypostomial setae 4 or 5 in number, diverging posteriorly from lateral margin on each side. Postgenal cleft enlarged, rounded, reaching near posterior margin of hypostomium. Thoracic cuticle covered very sparsely with minute black spinous setae. Abdominal cuticle moderately covered with minute, chisel-shaped, black spinous setae (FIG. 44) interspersed with minute, simple black ones dorsally and laterally, becoming denser posteriorly, as well as minute, colorless, simple setae on each side of anal sclerite; dorsum of abdominal segments 1–8 each with a pair of prominent cone-like protuberances submedially. Rectal gills compound, each with 10–12 finger-like secondary lobules. Anal sclerite X-formed with anterior arms broadly sclerotized and a little more than ½× as long as posterior ones. Posterior circlet with about 104 rows of about 18 hooks. Ventral papillae absent.

*Material examined.* 30 ♀, 31 ♂, 10 pupae, 15 larvae, TAIWAN: Hua Lien, Chi Nan, 18.VII.1976, H. Takaoka; 2 ♀, 5 pupae, 6 larvae, Wu Lai, 20.VII.1976, H. Takaoka; 1 ♀, 1 ♂, 5 larvae, Sun Moon Lk, 9.VII.1976, H. Takaoka.

*Ecological notes.* The pupae and larvae of this species were taken abundantly from large rivers (5–12 m wide) exposed to the sun and rarely from small lowland streams

(0.3–1.0 m wide). The material was found on decaying leaves, trailing grasses and stones. This species was collected together with *S. metatarsale, S. suzukii, S. sakishimaense, S. ufengense* and *S. shirakii.*

*Distribution.* Taiwan, Japan and Korea.

*Remarks.* This species was originally described under the name *Stilboplax 5-striatum* from the female and male specimens from Taiwan (Shiraki 1935). The immature stages were unknown from the type locality but were described based on Japanese material (Orii et al. 1969; Takaoka 1977). The morphological features of the adults of the present material agree with the original description except for slight differences in the female frons and the male abdomen. According to the original description, the frons is about 1.5× as long as its greatest width, while in the present female specimens it is as long as, or a little shorter than its greatest breadth. The abdomen of the male has a pair of whitish gray spots dorsolaterally on segments 2, 5, 6 and 7 in the present material instead of segments 2, 4 and 5 as in the original description.

The pupae and larvae which are reported for the first time from Taiwan conform to those of the Japanese material described by Takaoka (1977). *S. quinquestriatum* is assigned to the *striatum* group in having the striped thorax, the ventrally produced anterior gonapophyses and the simple claws in the female, the saddle-shaped ventral plate in the male, the pupal gill organ with 10 filaments and the boot-shaped cocoon. Among the *striatum* group, this species closely resembles *S. grisescens* Brunetti, 1911 from India by having the haired basal section of radius and the dark colored legs. The female, male and pupa of the present species are practically identical to those of *S. grisescens,* and this species may be synonymous with *S. grisescens.* However, it is not possible to make a close comparison because the larval stage of *S. grisescens* is not known.

**Simulium (Simulium) shirakii** Kono & Takahasi

*Simulium minutum* Shiraki, 1935: 62–66.
*Simulium shirakii* Kono & Takahasi, 1940: 82.—Bentinck, 1955: 12.

*S. shirakii* is assigned to the *nobile* group by the V-shaped pattern on the male scutum and the characteristic features of genitalia of both sexes.

This species was originally described under the name *S. minutum* from adults from Taiwan (Shiraki 1935) and the replacement name, *S. shirakii* was later given by Kono & Takahasi (1940). The ♂ and ♀ genitalia of the type material were elaborately illustrated by Bentinck (1955).

In this study, only 1 reared male and 2 pupal skins are available. The morphological features of the male material conform to the original description and illustration. The pupa of this species is here described for the first time.

*Pupa.* Body length (excluding gill organ) 2.8 mm. *Head.* Integument dark yellow and bare. Trichomes 3 pairs in number, all medium-sized and simple (occasionally bifid). *Thorax.* Integument dark yellow,

almost bare on anterodorsal surface and moderately covered with small, cone-shaped tubercles on posterodorsal surface. Trichomes 5 pairs in number, all medium-sized and simple. *Gill organ* (FIG. 47) pale yellow, with 3 inflated horns in a vertical plane, increasing in length dorsal to ventral, each gradually swollen distally and with large rounded tip; surface of horns smooth and densely covered with minute tubercles. *Abdomen* similar to that of *S. yushangense* except for dorsal spine-combs present only on segments 8 and 9, and terminal hook absent.

*Material examined.* 1 ♂, TAIWAN: Sun Moon Lk, roadside between Sun Moon Lk and Pu Li, about 2 km N of lake, 9.VII.1976, H. Takaoka; 2 pupal skins, Hua Lien, Chi Nan, 18.VII.1976, H. Takaoka.

*Ecological notes.* The material was collected from small, slow-flowing lowland streams (0.3–0.5 m wide). The 1 pupa was taken on trailing grass in 1 stream with *S. metatarsale* and *S. puliense,* and the 2 pupal skins on slender sticks in another stream, together with *S. metatarsale, S. sakishimaense* and *S. quinquestriatum.*

*Distribution.* Taiwan.

**Simulium (Simulium) karenkoensis** Shiraki, **new combination**

*Odagmia karenkoensis* Shiraki, 1935: 42–45.

This species was described from a single female fly collected at Karenko, Taiwan. The female is characterized by the claws with small subbasal tooth and the blackish legs.

This species is related to *S. taiwanicum,* but is easily differentiated by the coloration of legs and the pubescence on scutum.

**Simulium (Simulium) arisanum** Shiraki

*Simulium arisanum* Shiraki, 1935: 80–82.

*S. arisanum* was originally described from female specimens collected on Mt Arisan (ca 2000 m), Taiwan. This species very closely resembles *S. rufibasis,* from which it differs by the coloration of legs and pubescence on scutum, as shown in the key.

**Simulium (Simulium) katoi** Shiraki

*Simulium katoi* Shiraki, 1935: 53–56.

This species was described from a single female fly collected at Taihoku, Taiwan. The female seems related to that of *S. sakishimaense* by having 5 longitudinal stripes on scutum, but is easily separated from the latter species by the relative length of hind basitarsus compared to hind tibia and the coloration of hind femur as noted in the key.

**Simulium (Simulium) ambiguum** Shiraki

*Simulium ambiguum* Shiraki, 1935: 71–73.

This species was described from adults of both sexes collected at Taihoku, Taiwan. The female resembles that of *S. sakishimaense* but differs by the coloration of the

pubescence on scutum and hind tibia and basitarsus, as mentioned in the key. The male seems similar to males of *S. suzukii, S. rufibasis* and *S. puliense,* from which it is easily separated by the coloration of legs, as noted in the key.

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## APPENDIX

### List of the species of Simuliidae of Taiwan

1. *Simulium* (*Eusimulium*) *yushangense* Takaoka, new species
2. *Simulium* (*Eusimulium*) *taulingense* Takaoka, new species
3. *Simulium* (*Eusimulium*) *chowi* Takaoka, new species
4. *Simulium* (*Eusimulium*) *chitoense* Takaoka, new species
5. *Simulium* (*Eusimulium*) *aureohirtum* Brunetti, 1911, new record
6. *Simulium* (*Eusimulium*) *falcoe* (Shiraki), 1935
7. *Simulium* (*Eusimulium*) *taipei* (Shiraki), 1935
8. *Simulium* (*Eusimulium*) *geniculare* (Shiraki), 1935
9. *Simulium* (*Gomphostilbia*) *metatarsale* Brunetti, 1911, new record
10. *Simulium* (*Gomphostilbia*) *tuenense* Takaoka, new species
11. *Simulium* (*Simulium*) *taiwanicum* Takaoka, new species
12. *Simulium* (*Simulium*) *ufengense* Takaoka, new species
13. *Simulium* (*Simulium*) *puliense* Takaoka, new species
14. *Simulium* (*Simulium*) *rufibasis* Brunetti, 1911, new record
15. *Simulium* (*Simulium*) *suzukii* Rubzov, 1963, new record
16. *Simulium* (*Simulium*) *sakishimaense* Takaoka, 1977, new record
17. *Simulium* (*Simulium*) *quinquestriatum* (Shiraki), 1935
18. *Simulium* (*Simulium*) *shirakii* Kono & Takahasi, 1940
19. *Simulium* (*Simulium*) *karenkoensis* (Shiraki), 1935
20. *Simulium* (*Simulium*) *arisanum* Shiraki, 1935
21. *Simulium* (*Simulium*) *katoi* Shiraki, 1935
22. *Simulium* (*Simulium*) *ambiguum* Shiraki, 1935

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