

A new species of the *Simulium* (*Simulium*) *crocinum* species-group (Diptera: Simuliidae) from Vietnam

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Abstract. A new black fly species, *Simulium yukawai*, is described on the basis of one female and its pupal exuviae from Vietnam. This new species is placed in the *S. crocinum* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae). It is characterized in the female by the paraproct covered with 48–50 distinct hairs on its ventral and lateral surfaces, and in the pupa by the frons and most of the thorax bare, gill with six dark filaments in three pairs closely arising from the base, of which the two outer filaments of the dorsal and middle pairs are much longer than other filaments, abdomen with distinct spine-combs on the dorsal surface of segments 7–9, and cocoon wall-pocket shaped, with a large anterolateral window on each side. Taxonomic notes are given to separate this new species from related species. This species is the fourth member of the *S. crocinum* species-group known from Vietnam.

INTRODUCTION

The *Simulium crocinum* species-group is one of 33 species-groups of the subgenus *Simulium* Latreille, the largest of the 37 subgenera of the genus *Simulium* Latreille (Diptera: Simuliidae) (Adler & Crosskey, 2018). The diagnostic characters of the female are the antenna with pit-like cavities with sensilla on flagellomeres 1–8; cibarium without a median process; claw simple; and ovipositor valve broad, triangular and thick, with bare and transparent portions along the inner and posterior margins (Takaoka, 2017). This group consists of 22 species, of which 18 are distributed in the Oriental Region (seven in south China; three in Vietnam, three in Taiwan, two in Thailand, two in Peninsular Malaysia and Thailand, and one in Nepal), three in the Palaearctic Region (two in Hubei and one in Sichuan, China) and one in both

regions (Guizhou and Hubei Provinces, China) (Adler & Crosskey, 2018; Takaoka & Huang, 2018).

In a survey of black flies in Sapa, Lao Cai Province, northern Vietnam, in 2014, numerous new species were discovered and described (Takaoka *et al.*, 2017). Subsequent study of the Sapa material revealed an additional undescribed species of the *S. crocinum* species-group. This species is here described as new based on one female and its associated pupal exuviae and cocoon. Morphological differences are provided to separate this new species from other members of the *S. crocinum* species-group including *S. laocaiense* Takaoka & Lau, *S. turgidum* Takaoka & Pham, and *S. vietnamense* Takaoka, Sofian-Azirun & Chen, all recorded from Vietnam (Takaoka *et al.*, 2014, 2017).

The methods of collection, description and illustration, and terms for morphological features follow those of Takaoka (2003) and partially those of Adler *et al.* (2004).

***Simulium (Simulium) yukawai* Takaoka & Pham sp. nov.**

Female. Body length 3.5 mm. **Head.** Slightly narrower than thorax. Frons dark brown, shiny, with several dark stout hairs along lateral margins; frontal ratio 1.3:1.0:1.1; frons:head ratio 1.0:4.0. Fronto-ocular area well developed, short, directed laterally, and pointed apically. Clypeus dark brown, white pruinose when illuminated at certain angles, moderately covered with dark-brown medium-long hairs. Labrum 0.56 times length of clypeus. Antenna composed of scape, pedicel and nine flagellomeres; scape, pedicel and first flagellomere yellow, rest medium to dark brown; first to eighth flagellomeres each with pit-like depressions with many sensilla on inner and outer sides. Maxillary palp with five palpomeres, light to medium brown; proportional lengths of third, fourth, and fifth palpomeres 1.0:1.0:2.6; third palpomere (Fig. 1A) with medium-sized ellipsoidal sensory vesicle (0.32 times length of third segment) having medium-sized opening. Maxillary lacinia with 12 or 13 inner and 14 or 15 outer teeth. Mandible with 26 or 27 inner and 11 or 12 outer teeth. Cibarium (Fig. 1B) with 66 tiny processes near posterodorsal margin. **Thorax.** Scutum brownish black except anterolateral calli dark brown, shiny and gray pruinose except one medial and two sub-medial longitudinal vittae not shiny and non-pruinose when illuminated anterodorsally and viewed dorsally (pruinose and non-pruinose pattern reversed when illuminated posteriorly and viewed dorsally), and moderately covered with yellow recumbent short hairs interspersed with dark similar short hairs near anterior margin and several dark-brown long upright hairs on prescutellar area. Scutellum light brown, covered with dark-brown upright long hairs and yellow short hairs. Postnotum brownish black, bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, bare, and slightly shiny when illuminated at certain angles. **Legs.** Foreleg:

coxa whitish yellow; trochanter yellow with ventral surface light brown; femur yellow with apical cap light brown; tibia whitish except apical cap dark brown; tarsus brownish black to black, with moderate dorsal hair crest; basitarsus moderately dilated, 5.9 times as long as its greatest width. Midleg: coxa dark brown; trochanter yellow with ventral surface light brown; femur yellow with apical cap light brown; tibia white to yellowish white except apical cap medium brown and outer surface of apical half narrowly light brown; tarsus dark brown except basal half or little more of basitarsus yellow (though its border not well defined). Hind leg: coxa dark brown; trochanter yellow; femur yellow except apical cap medium brown; tibia white to whitish yellow except apical cap medium brown; tarsus medium brown except basal half or little more of basitarsus and basal half of second tarsomere yellow; basitarsus (Fig. 1C) nearly parallel-sided, 5.2 times as long as wide, and 0.8 and 0.7 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 1C) moderately developed, slightly shorter than its basal width, and 0.44 times as wide as greatest width of basitarsus; pedisulcus (Fig. 1C) well developed. Claw simple, without basal or subbasal tooth. **Wing.** Length 2.5 mm. Costa with dark spinules and hairs; subcosta haired except near apex bare; basal section of radius bare; R₁ with dark spinules and hairs; R₂ with dark hairs; hair tuft on base of radius dark brown; basal cell absent. **Halter.** White except basal portion darkened. **Abdomen.** Basal scale medium brown, with fringe of light-brown hairs. Dorsal surface of abdomen medium to dark brown except basal half of segment 2 yellow; tergite 2 shiny and white pruinose when illuminated at certain angles and tergites 6–9 shiny. **Terminalia.** Sternite 8 (Fig. 1D) with 19 dark-brown medium-long to long stout hairs and six or seven yellow short hairs on each lateral surface. Ovipositor valve (Fig. 1D) triangular, somewhat thick except areas along inner and posterior margins thin and transparent, somewhat rounded ventrally, densely covered with microsetae (except transparent portions along inner and posterior margins bare) interspersed with 16 or 17 yellow short

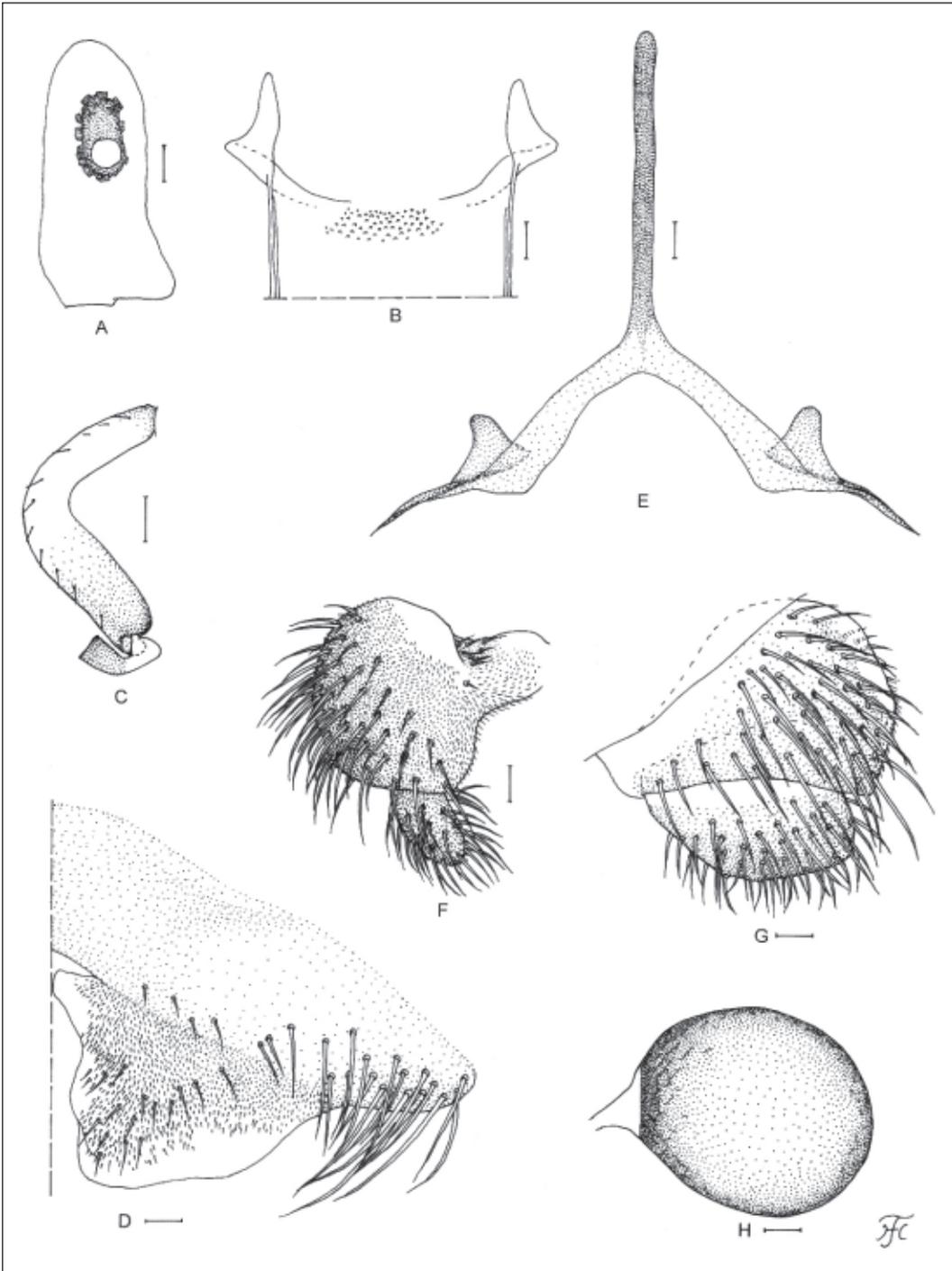


Figure 1. Female of *Simulium yukawai* sp. nov. (A) Third segment of maxillary palp with sensory vesicle (right side, front view). (B) Cibarium (front view). (C) Hind basitarsus and second tarsomere (left side; outer view). (D) Sternite 8 and ovipositor valve (left side only; ventral view). (E) Genital fork (ventral view). (F) & (G) Paraprocts and cerci (F, ventral view; G, lateral view). (H) Spermatheca. Scale bars: 0.1 mm for C; 0.02 mm for A, B and D-H.

hairs; inner margins sinuous, moderately separated from each other. Genital fork (Fig. 1E) of inverted-Y form, with narrow well sclerotized stem; arms of moderate width, each with heavily sclerotized lateral portion, with short triangular projection directed anterodorsally. Paraproct in ventral view (Fig. 1F) nearly ovoid, with 48–50 short to medium-long hairs on lateral and ventral surfaces, and with anteromedial surface somewhat darkened, with nine or ten short stout sensilla; paraproct in lateral view (Fig. 1G) 0.75 times as long as wide, and somewhat protruding ventrally beyond ventral margin of cercus. Cercus in lateral view (Fig. 1G) short, rectangular, about half as long as wide, with numerous short to medium-long hairs. Spermatheca (Fig. 1H) nearly ovoid, 1.2 times as long as greatest width, darkened except duct and small portion of junction with duct not pigmented, with faintly defined reticulate surface patterns near base; internal setae present; accessory ducts unpigmented, subequal in thickness to each other, and slightly thicker than major duct.

Pupa. Body length (excluding gill filaments) 3.5 mm. **Head.** Integument ochreous and bare: frons with two trifid or quadrifid medium-long trichomes (Fig. 2A) on each side; face with one bifid or trifid medium-long trichome (Fig. 2B) on each side. **Thorax.** Integument ochreous except anterior portion near anterior margin, anterolateral and lateral portions above and posterior to bases of gills, narrow portion on mediolongitudinal line, and posterodorsal portion medium brown, with small round protuberance anterior to base of gill on each anterolateral corner (2H), and bare except small portion near base of gill and small round protuberance on each side densely covered with tubercles (Fig. 2H) (most tubercles with tiny secondary projections), and posterior half of dorsal surface sparsely or moderately covered with small tubercles; thorax with three anterodorsal trichomes with four to seven branches (Fig. 2C), two anterolateral trichomes (anterior one with three branches, posterior one with five branches) (Fig. 2D), one bifid mediolateral trichome (Fig. 2E), and three ventrolateral trichomes (one unbranched, one bifid, and one

trifid) (Fig. 2F) on each side; all trichomes medium-long except one of ventrolateral trichomes short. Gill (Fig. 2G) with six slender short thread-like filaments in pairs closely arising from base; basal fenestra of medium size; ventral pair short stalked and dorsal and middle pairs almost sessile; all filaments dark grayish (though outer filaments of dorsal and middle pairs much darker); when measured from base of gill to apical tip of filaments, outer filament of dorsal pair longest (2.0 mm), outer filament of middle pair second longest (1.8 mm), other filaments much shorter: inner filament of dorsal pair (1.4 mm long), inner filament of middle pair (apical tip lost but probably 1.3 mm long), outer filament of ventral pair (1.2 mm long) and inner filament of ventral pair (1.15 mm long); outer filaments of dorsal and middle pairs subequal in thickness, 1.2 times as thick as inner filaments of same pairs, and 1.4 times as thick as two filaments of ventral pair; all filaments nearly parallel-sided basally (except inner filament of ventral pair slightly widened from base for short distance), then gradually tapered toward apex; cuticular surface with well-defined annular ridges and furrows throughout their length except apical portions less distinct, covered with microtubercles. **Abdomen.** Dorsally, entire surface of segment 1, anterior half of segment 2 and narrow portion along anterior margin of segment 3 light brown; other segments unpigmented; segment 1 smooth (without tubercles), with one unbranched slender medium-long seta (Fig. 2I) on each side; segment 2 smooth, with one unbranched slender short seta, five unbranched short setae, of which four are stout and darkened (Fig. 2J), on each side; segments 3 and 4 each with four unbranched hooked spines and one unbranched short seta on each side; segments 8 and 9 each with spine-combs in transverse row on each side (though spine-combs on segment 9 fewer and smaller than those on segment 8); segment 7 with one spine (Fig. 2K) equal in size to spine-combs on segment 8 only on right side; segments 5–9 each with comb-like groups of micro-spines; segment 9 without terminal hooks. Ventrally, all segments unpigmented; segment 4 with one unbranched hook and few short setae

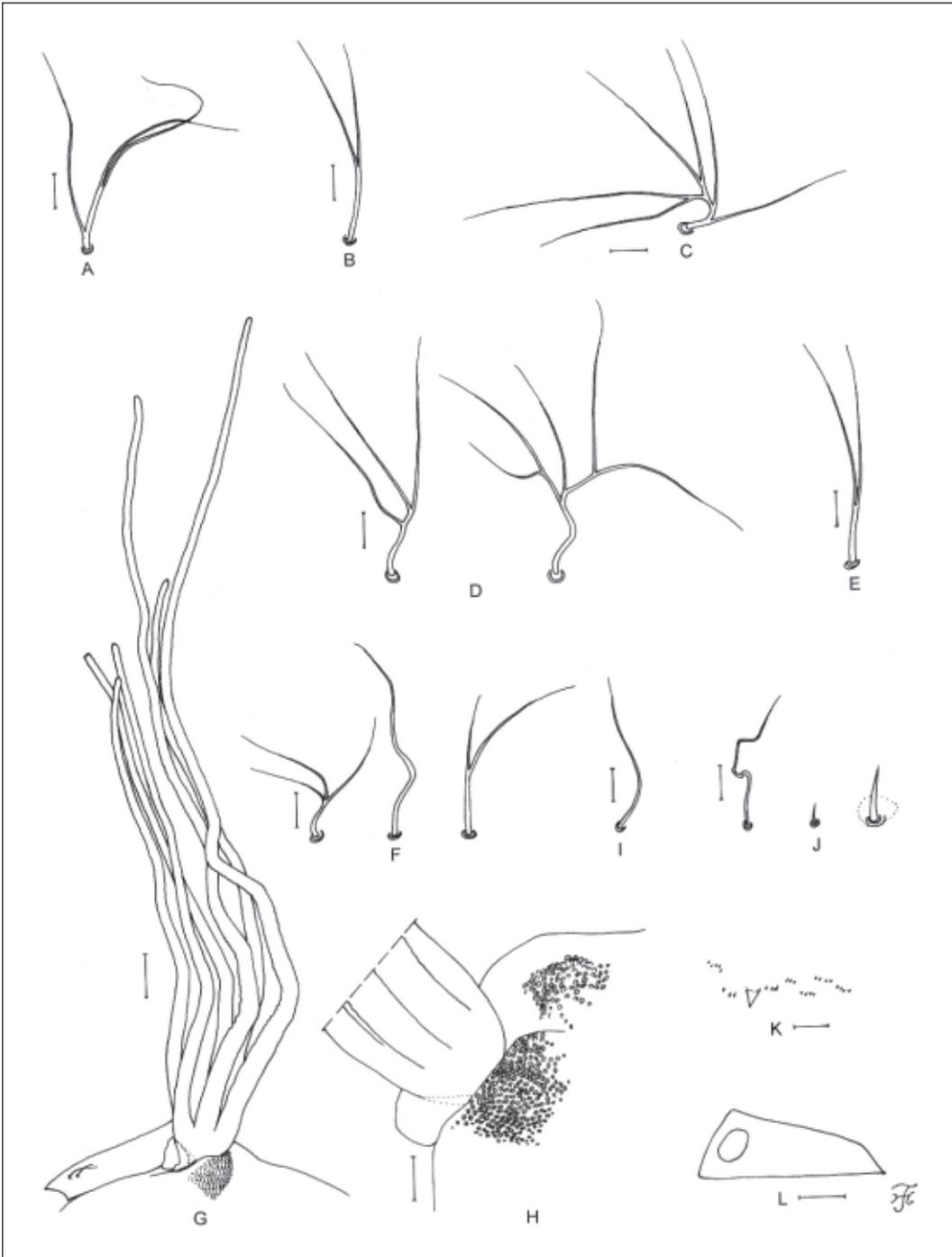


Figure 2. Pupa of *Simulium yukawai* sp. nov. (A) Frontal trichome. (B) Facial trichome. (C) – (F) Thoracic trichomes (C, mediodorsal; D, anterolateral; E, mediolateral; F, ventrolateral). (G) Gill filaments (left side; outer view). (H) Anterolateral corner of thorax showing tubercles. (I) Hair-like seta on dorsum of abdominal segment 1. (J) Hair-like seta, short slender minute seta and short stout seta on dorsum of abdominal segment 2. (K) Stout spine and comb-like groups of microspines on dorsum of abdominal segment 7. (L) Cocoon (lateral view). Scale bars: 1.0 mm for L; 0.1 mm for G; 0.05 mm for H; 0.02 mm for A–F and I–K.

on each side; segment 5 with pair of unbranched or bifid hooks submedially and few unbranched short setae on each side; segments 6 and 7 each with pair of bifid inner and unbranched outer hooks widely spaced and few unbranched short setae on each side; segments 4–8 each with comb-like groups of micro-spines. **Cocoon** (Fig. 2L). Wall-pocket-shaped, thickly woven, with open space anterolaterally on each side, ochreous, not extended ventrolaterally; individual threads invisible; 3.0 mm long by 2.1 mm wide.

Male and Mature larva. Unknown.

Type material. HOLOTYPE: Female (with its associated pupal exuviae and cocoon) dissected from a pupa collected from a small stream (22°21'43.110"N/103°47'19.221"E), Sapa, Lao Cai Province, northern Vietnam, 20-XII-2014, by H. Takaoka. Type specimens are deposited at the Tropical Infectious Diseases Research and Education Centre, University of Malaya, Kuala Lumpur, Malaysia.

Biological notes. The pupa of this new species was collected from a dead tree leaf in the current of a small stream (width 0.5 m, bottom rocky, water temperature 11.0°C, exposed to sun, elevation 1,750 m) moderately flowing in a secondary forest. Associated species were *Simulium* (*Montisimulium*) *nigrofilum* Takaoka & Sofian-Azirun, *S. (Nevermannia) tayense* Takaoka & Ya'cob, *S. (Simulium) laocaiense*, *S. (S.) sapaense* Takaoka & Low and *S. (S.) turgidum*.

Distribution. Vietnam.

Etymology. The species name *yukawai* is in honor of Dr. Junichi Yukawa, eminent entomologist and Professor Emeritus of Kyushu University, Fukuoka, Japan, who kindly taught HT how to describe new species of black flies in 1971.

Remarks. *Simulium yukawai* sp. nov. is assigned to the *S. crocinum* species-group of the subgenus *Simulium*, defined by Takaoka (2017), based on the female cibarium without a median process (Fig. 1B), claw simple, ovipositor valve triangular and thick, with bare and transparent portions along the inner and posterior margins (Fig. 1D); and the pupal gill with six filaments (Fig.

2G) and pupal abdomen without terminal hooks.

This new species is characterized in the female by having all femora yellow with the apical caps light brown, and the paraproct covered with 48–50 distinct hairs on its ventral and lateral surfaces (Fig. 1G), and in the pupa by the frons and most of the thorax bare (Fig. 2H), gill with six dark slender filaments in three pairs closely arising from the base, of which the two outer filaments of the dorsal and middle pairs are much longer than the other four filaments (Fig. 2G), abdomen with distinct spine-combs on the dorsal surface of segments 7–9, and cocoon with a large anterolateral window (Fig. 2L) on each side.

This new species is distinguished from all three other species of the *S. crocinum* species-group recorded from Vietnam, *S. laocaiense*, *S. turgidum* and *S. vietnamense*, by the female fore and mid femora yellow except the apical caps darkened (entirely yellowish in the three known species); and also from *S. laocaiense* by the cocoon with a large anterolateral window on each side (no window in *S. laocaiense*) and from *S. turgidum* by the pupal gill filaments slender (inflated in *S. turgidum*). The pupa of *S. vietnamense* is unknown.

The female of this new species is similar to that of *S. serenum* Huang & Takaoka from Taiwan (Huang & Takaoka, 2009) and *S. tumidifilum* Luo, Yang & Chen from China (Luo *et al.*, 2010) in many features including the leg color. However, it is distinguished from *S. serenum* by the frons:head ratio (1:4 vs 1:3.4) and the ratio of the labrum against the clypeus (0.56 vs 0.66), and from *S. tumidifilum* by the genital fork with a distinct projection on each arm (without a projection in *S. tumidifilum*). The females of the other 17 species in the *S. crocinum* species-group have the mid femur entirely yellow and/or the hind tibia darkened at least on the apical half of the outer surface.

By sharing a combination of two pupal characters – 1) the frons and most of the thorax bare, and 2) the cocoon with a large anterolateral window on each side – this new species is similar to the following four

species: *S. crocinum* Takaoka & Choochote from Thailand, *S. mediocoloratum* Takaoka & Choochote from Thailand, *S. rudnicki* Takaoka & Davies from Peninsular Malaysia and Thailand, and *S. tumidifilum* from China (Takaoka & Choochote, 2004; Takaoka & Davies, 1995; Luo *et al.*, 2010), although it is distinguished from all four species by the slender gill filaments closely arising basally (Fig. 2G) (gill filaments divergent basally in the former three species and inflated in the last species). The pupae of the remaining 15 species in the *S. crocinum* species-group have the frons and thorax covered with tubercles and/or the cocoon wall-pocket or shoe-shaped, without a large window on each side, thus differing from this new species.

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