Simulium (*Psilopelmia*) *ochraceum* Walker complex

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This species is the primary vector of river blindness in Central America, where it is very common. However, it has a relatively low biting density in Ecuador and in Brazil. On the contrary, it is a biting nuisance in Galapagos Islands.

Simulium ochraceum Walker, 1861: 332. NEOTYPE f#, MEXICO: Chiapas State, Huixtla, Morelos, 30.vi.1985 (*A.L. Millest*) (BMNH) [Neotype designation (Cytotype A) by Shelley *et al.* 2002b: 164.]

Simulium bipunctatum Malloch, 1912: 650. HOLOTYPE f#, PERU: Rio Charape, 13.ix.1911 (*C. H. T. Townsend*) (USNM, cat. no. 15305) [Examined.] [Synonymised with *S. dinellii* Joan by Knab, 1913: 155; revalidated by Coscarón, 1985: 320.] [Synonymy with *S. ochraceum* by Shelley *et al.* 2002b: 164.]

Simulium antillarum Jennings, 1915: 200. LECTOTYPE m#, VIRGIN ISLANDS: St Croix Island, 1.5 miles west of West End, Frederiksted, 24.xi.1913 (*A.H. Jennings*) (USNM, cat. no. 19997). [Lectotype designation by Stone, 1969: 313).] [Synonymy of *S. antillarum* with *S. bipunctatum* by Shelley *et al*., 1989a: 92; synonymy with *S. ochraceum* by Shelley *et al.* 2002b: 164.]

Simulium scutellatum Lane and Porto, 1940: 192 [In Porto, 1940: 383]. HOLOTYPE f# (man-biting), COLOMBIA: Restrepo; 6.i.1935, (*S.F.A.*) (MZUSP). [Synonymy by Py-Daniel & Moreira Sampaio, 1995: 117.] [Examined.]

Simulium wolcotti Fox, 1953: 138. HOLOTYPE m#, PUERTO RICO: Henry Barracks, near Cayey, 1950 (*I. Fox*) (STMPR). [Synonymy with *S. antillarum* Jennings by Stone, 1969: 313; synonymy with *S. bipunctatum* by Shelley *et al*., 1989a: 92; synonymy with *S. ochraceum* by Shelley *et al.* 2002b: 164.]

Simulium pseudoantillarum Ramírez Pérez & Vulcano, 1973: 379. SYNTYPES 1f#, 1m#, VENEZUELA: Monagas State, San Antonio de Maturin, [No collection date.] (*Ramírez Pérez & Vulcano*) (DERM, now MEPG). [Synonymy with *S. antillarum* by Shelley *et al*., 1989a: 93; synonymy with *S. ochraceum* by Shelley *et al.* 2002b: 164.]

FEMALE. General body colour orange. Dimensions show only ranges compiled from specimens collected in Belize, Brazil, Ecuador and Mexico. Complete data are given in Shelley *et al*. (1997, 2002b). Body length (pinned) 2.1 mm, (specimens preserved in alcohol) 1.8-3.4 mm. Wing length 1.7-2.7 mm, wing width 0.7-1.2mm

Head – dichoptic with red eyes, nudiocular area well developed (Fig. Ps6). Frons, clypeus and occiput black with silver pruinosity. Mouthparts black. Antennae orange with distal third to half dark brown. Cibarium with anterior margin sclerotised, central trough armed with several irregular rows of small teeth, 1+1 groups of teeth forming a protuberance on each side of trough that continue to the sclerotised, well developed cornuae (Fig. Ps19).

Thorax – orange with lateral margins yellowish. With light source anterior (Fig. Ps37) 1+1 yellowish bands running parallel to anterior scutal margin from a sub-median position to the lateral margins in anterior eighth of scutum. Scutum with pair of sub-median silvery white, comma-shaped marks in anterior third of scutum commencing behind ends of yellow bands. [These marks vary in length being shorter in populations from Guatemala and Mexico, but longer in Brazil, Ecuador and the Caribbean Islands – see Shelley *et al*., 2002b.] With light source posterior comma-shaped marks absent (Fig. Ps38). Paranotal folds orange/brown in fresh specimens, often becoming dark brown to black in preserved material. Scutum with numerous adpressed black setae lying singly. Pleural region varying from light orange to mid brown with faint silver pruinosity. Scutellum orange with

erect, black bristles on posterior margin; postnotum orange [This varies, being orange in specimens from Colombia, Dominican Republic, Jamaica, Montserrat, Panama, Puerto Rico, Venezuela and most Ecuador specimens, but brown, and sometimes black from Mexico.] Subcostal wing vein with line of 5-10 setae in middle section, basal section of Radius with one (rarely two irregular) rows of setae. Costal base tuft dark brown. Leg coloration and proportions as in Fig. Ps58. Fore leg coxae, trochanters and femora of all legs orange to light brown; coxae of mid and hind legs light brown on anterior half, dark brown on posterior half; tibiae and tarsi of all legs dark brown. Mid and hind leg femora and tibiae with darker distal articulations. Leg colour varies in specimens from other countries as detailed in Shelley *et al.* (2002b). In specimens from Mexico, Guatemala and Panama legs are dark brown, and in some cases with darker distal articulations on the tibiae and femora. Specimens from Dominican Republic, Ecuador, Jamaica, Puerto Rico, Montserrat and Venezuela are similar to those from Brazil. Exceptionally, legs are dark brown and In Colombia both colour patterns may be found in the same locality. Claws curved with large basal tooth. Halteres yellow with light brown stems.
Abdomen – tergites from yellowish orange to brown depending on age of specimen and whether it has blood fed; older blood fed specimens tend to become dark brown. Tergites I-IV usually mottled light brown and yellow, but can be yellowish orange particularly in reared material, occasionally mid brown; tergite V matt grey; tergites VI-IX dull mottled mid and light brown, but sometimes completely shiny brown or black. Tergal plates well developed and generally light brown, sometimes dark brown. Sternites and genitalia orange to light brown becoming dark brown in preserved specimens. Eighth sternite usually lightly sclerotised with 20-24 setae on each side; gonopophyses sub-triangular and rounded apically, membranous with microtrichiae more obvious basally, internal margins sclerotised and this extends over a large area of structure (Fig. Ps71). Cerci hemispherical, heavily sclerotised; paraproct sub-rectangular and lightly sclerotised on base of sub-triangular ventral extension that is same length as cercus (Fig. Ps84). Genital fork slender generally with terminal knob and well developed, triangular anterior processes (Fig. Ps97). Spermatheca, oval, sclerotised, with surface covered in regular rounded depressions and spicules of inner surface randomly arranged; area of insertion of spermathecal duct membranous and between a third and a quarter as wide as maximum width of spermatheca.

MALE. General body colour orange. Dimensions show only ranges compiled from specimens collected in Belize, Brazil, Ecuador and Mexico. Complete data are given in Shelley *et al*. (1997, 2002b). Body length (pinned) 1.7 mm; specimens preserved in alcohol) 2.0-3.2 mm; wing length 1.8-2.6 mm; wing width 0 8-1.2 mm.

Head – holoptic with red eyes. Clypeus black with silver pruinosity. Rest of head coloration as in female.
Thorax – coloration and hairing of scutum, pleural region, scutellum and postnotum as in female (Figs. Ps109, Ps110). Subcostal wing vein bare or with variable number of setae (1-7) in central portion, basal section of Radius with single row of setae. Leg and haltere coloration as in female.
Abdomen – tergites I-IV mottled orange and light brown; tergites V-IX and genitalia light to dark brown; basal tuft of light orange hairs. Silver ornamentation as follows: tergites VI and VII with a pair of sub-median silver pruinose patches, anterior margin of tergite II and all of tergite IX faintly pruinose. Sternites I-IV light orange, V-IX dark brown; sternal plates well developed only on segments V-VIII. Genitalia orange to dark brown. Gonocoxite wider than long; gonostyle same length as gonocoxite, curved and conical with apical spine (Fig. Ps125). Ventral plate (Fig. Ps134) sub-rectangular with no median development of anterior margin, but slightly pointed apically, basal arms developed, sclerotised and close together; hairs long and covering most of ventral plate. Median sclerite (Fig. Ps134) slightly longer than wide with apical incision. Paramere as in Fig. Ps143 with few well developed, mainly apical spines and several smaller spines.

PUPA. Dimensions show only ranges compiled from specimens collected in Belize, Brazil, Ecuador

and Mexico. Cocoon length dorsally 2.1-3.2, ventrally 2.8-4.2 mm, pupa length 1.7-3.3 mm, gill length 1.4-3.2 mm.

Cocoon- slipper-shaped, dark brown; rim of aperture dark brown, reinforced and usually without median protuberance, composed of thick threads producing an open weave, particularly laterally at point of adhesion to substrate.
Gill - light brown with eight forwardly directed slender filaments arranged irregularly in vertical plane (Fig. Ps152). Main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments. Filaments arise basally on all primary branches; filaments slender with crenated margins and rounded distally, their surfaces covered with fine spicules.
Head - with 2+2 frontal and 1+1 facial bifid or trifid well developed trichomes; surface of frontoclypeus with sparsely distributed, rounded tubercles.
Thorax - with 5 + 5 trichomes on anterior border, each with 2-5 branches, 1 + 1 postero-dorsal and 1 + I ventral unbranched trichomes. Surface of thorax with few rounded tubercles, concentrated dorsally [In Ecuador more densely distributed in this region].
Abdomen - tergites II-IV with 4 + 4 simple hooks, more weakly developed on segment II, VI-IX with spine combs on anterior margins, tergite IX with 1 + 1 strong, unbranched spines; sternite IV in female with 2 + 2 simple hooks, in male reduced to fine setae, sternites V-VII with 2 + 2 simple to bifid hooks; I + 1 patches of spine combs on postero-lateral borders of sternites IV-VIII.

TAXONOMIC DISCUSSION

This has been comprehensively dealt with in Shelley *et al*. (1989a, 1997 [as *S. bipunctatum*], 2002b).

In 1983 Hirai & Uemoto showed that *S. ochraceum* is a species complex in Central America consisting of three cytotypes, A, B and C. Preliminary studies showed that *S. ochraceum s.l.* can be distinguished from other species using both isozyme and molecular techniques (Agatsuma *et al*., 1986, 1993; Tang *et al*., 1996), and the latter needs to be used more fully for defining the complex.

Coscarón & Coscarón-Arias (2007) accepted the synonyms of *S. ochraceum* in Shelley *et al*. (2002b), but maintained *S. antillarum* as a distinct species from *S. ochraceum s.l.* because of differences in several morphological characters. In the female they distinguished these two species by the length of the sub-median white cunae in the female. It is unclear how they reached this conclusion because they recorded a variation in which the sub-median silvery stripes reach the posterior scutal border in *S. ochraceum,* but did not accept the less pronounced variation in this character described by Shelley *et al*. (2002b). This variation was one of the main characters used by Shelley *et al*. (2002b) in their synonymy of *S. antillarum* and *S. bipunctatum* with *S. ochraceum*. Coscarón & Coscarón-Arias (2007) also referred to differences in the cibarium that were not observed in our studies of types of *S. ochraceum*, *S. antillarum* and *S. bipunctatum*. In the male different widths in the male gonostyle were used for separating *S. antillarum* from *S. ochraceum*, but this character varies depending on the position of the gonostyle on the slide preparation. They provided figures illustrating differences in the ventral plates, but we were unable to detect differences in this structure from specimens from Guatemala and Brazil (where we previously referred to the species as *S. bipunctatum*). They also recorded the tubercle density varying from absent or very scarce on the frontoclypeus and thorax of the pupa and in coloration of the larval apotome in *S. ochraceum*. They regarded *S. pseudoantillarum* as a synonym of *S. antillarum*, which they suggested is a species complex. Furthermore they suggested that *S. scutellatum* is a possible synonym of *S. ochraceum*, but this synonymy was previously made by Py-Daniel & Moreira Sampaio (1995) and supported by Hernandez *et al.* (2007).

Simulium ochraceum [as *S. antillarum*] was placed in the subgenus *Lanea* by Vargas & Diaz Najera (1951a or b), but these authors later (1953a) synonymised *Lanea* with *Psilopelmia*. Coscarón & Coscarón-Arias (2007) included *S. ochraceum* in their *dinellii* species group within the subgenus

Ectemnaspis, whereas Crosskey & Howard (2004) placed it in *Psilopelmia*. Descriptions of all life stages may be found in Coscarón (1991), Shelley *et al*. (1989a, 1997 [as *S. bipunctatum*], 2002b [except larva]).

DISTRIBUTION

In Brazil *S. ochraceum s.l.* is found in the states of Rio de Janeiro and Amazonas (Shelley *et al*, 1997, as *S.* bipunctatum). It also occurs in the following countries: Belize, Brazil, Colombia, Costa Rica, Cuba, The Dominican Republic, Ecuador [including Galapagos Islands], French Guiana, Guatemala, Jamaica, Mexico, Montserrat, Panama, Peru, Puerto Rico, St. Croix and Trinidad (Coscarón, 1987; Crosskey, 1999; Crosskey & Howard, 1997; Hamada & Fouque, 2001; Shelley *et al*., 1989a [as *S. bipunctatum*). Millest (1989) found all three cytotypes in Mexico, each associated with a different onchocerciasis focus: cytotype A in the South Chiapas focus, cytotype B in the Oaxaca focus and cytotype C in the North Chiapas focus. Only cytotypes A and C have been found in Guatemala and cytotype A predominates in the main Yepocapa onchocerciasis focus (Procunier, 1989).

BIOLOGY AND MEDICAL IMPORTANCE

Simulium ochraceum s.l. will bite man to varying degrees in different localities, but can be entirely zoophilic (Shelley, 1988a; Shelley *et al*., 1989a [as *S. bipunctatum*], 2002b) and also bites a variety of animals: horses, mules, donkeys, cattle, sheep, goats, pigs, dogs, foxes, cats, and tayras (weasels), chickens, turkeys, ducks and pigeons (Dalmat, 1955). It is markedly anthropophilic in the Upper Amazon region of Brazil along the R. Vaupes, but only occasionally bites man (possibly due to small fly populations rather than zoophilic tendencies) farther north in the Amazonia onchocerciasis focus of Brazil and Venezuela. In parts of Guadeloupe and the Galapagos Islands of Ecuador it can be a biting nuisance (Dr C. Causton – www.darwinfoundation.org.). This species is the primary vector of human onchocerciasis in Guatemala and Mexico and may be responsible for sporadic transmission of the disease in the onchocerciasis foci of mainland Ecuador (see Shelley 1988a, 1991, 1994 for overviews). *Simulium ochraceum s.l.* typically breeds in shaded, slow or fast flowing streams up to an altitude of 1200 m throughout the year, but has been recorded in larger rivers (up to 20 m wide) in Brazil. The biology of *S. ochraceum s.l.* has been studied in Guatemala (Dalmat, 1955), particularly with reference to transmission and control of onchocerciasis through vector larviciding (Tada, 1983, 1985, 1987). Little is known about its habits in terms of cytotype. From Millest's work (1989) larvae of different cytotype were collected from different types of stream in terms of size, temperature and pH. It is also apparent from this work that all three cytotypes transmit *O. volvulus.*