

## SPECIES OF *MIROCULIS* FROM THE SERRANÍA DE CHIRIBIQUETE IN COLOMBIA

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### Abstract

*Miroculis (Miroculis) chiribiquete* new species is described from male and female imagos from streams in the region of Serranía de Chiribiquete National Park, Caquetá Department, Colombia. The new species is distinguished from other species of *Miroculis* by hyaline wings in both sexes, the presence of prominent basal hooks on the penes of the male and an expanded opening on sternum 7 of the female. The subgenus *Miroculis* s.s. is redefined to include all species with dorsally-directed, stalked eyes and 5–20 facets in the longest row of the dorsal portion. The female imagos and nymphs of *Miroculis (Miroculis) nebulosus*, a new subgeneric combination, are described for the first time, and the description of the male imago is expanded. *M. nebulosus* is a new record for Colombia. Ecological data and notes on swarming of *M. chiribiquete* new species are included.

Key words: Ephemeroptera; Leptophlebiidae; *Miroculis*; Colombia; Chiribiquete.

### Introduction

The genus *Miroculis* was established by Edmunds (1963) for the species *Miroculis rossi* Edmunds from Peru. Eleven more species were later described by Savage and Peters (2003) and Savage (1987b) from Brazil, Colombia and Venezuela. Additional records extend the genus into Argentina in the South (ED), Ecuador in the West (ED) and Trinidad in the North (Savage 1987a). The genus is distinguished by several apomorphies, most notably the tent-shaped costal projection of the hind wing and the long-spike like projection on the male foreclaw in the imago, and in the nymph by the combination of a long distal filament on the gill, ventral glossae and a thick row of pectinate setae on the maxilla (Savage and Peters 1983). Males of many species have stalked eyes, and Savage and Peters (1983) with later modifications by Savage (1987b), divided the genus into subgenera based on the male eyes: *Miroculis* s.s. (long stalks with length greater than width, 10 facets or less in longest row of dorsal portion), *Yaruma* (short wide stalks), *Ommaethus* (without stalks), and *Atroari* (without stalks or with short stalks and more than 11 facets in longest row of dorsal portion). Recent collections near the Parque Nacional Natural Serranía de Chiribiquete

in the Amazonian region of Colombia have added to our knowledge of *Miroculis* and revealed a new species that we describe here. Specimens of *Miroculis nebulosus* Savage were also collected, making possible the description of the female imago and nymph.

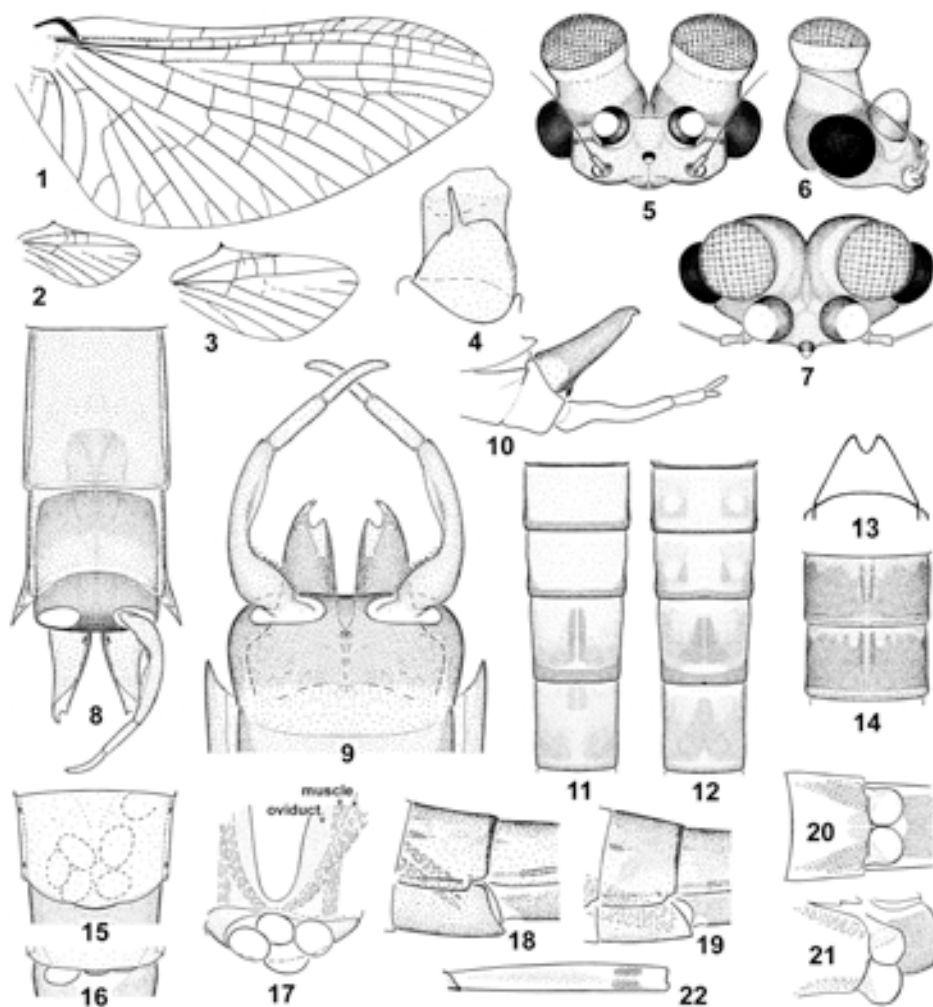
The Serranía del Chiribiquete is marked by sandstone ridges and a layer of igneous rock relating the region to the ancient Guyanan and Brazilian shields (Zloty and Pritchard 2001). The area receives 3 to 4 thousand mm rainfall each year (Goulding et al. 2003). The study stream of the junior author (AC-D), "La Piscina," is located on the right bank of the Mesay river southwest of the Puerto Abeja Biological Station at the southeastern border of Chiribiquete National Park. It is a small blackwater stream, approximately 2.5-m wide and at most 1.5-m deep, subject to wide variations in depth between dry and rainy season and to smaller oscillations from local rain. During the dry season, sandy river banks are visible. From July to December 2001 water temperature ranged between 20°C and 26°C. In July, 1996, three streams within 15–30 minutes walking distance south of Puerto Abeja were sampled by G. Pritchard and J. Zloty, their Stream #3 being equivalent to "La Piscina" (Zloty and Pritchard personal communication). Stream #1, closest to the station, was 1–2 m wide with dirty brown water, and Stream #2 (15 min walk uphill from #1) was very small with many pools (Zloty, pers. comm.), acidic (pH 5.3) and chemically thin (5.4 mg/l TDS) (Zloty and Pritchard 2001).

### ***Miroculis (Miroculis) chiribiquete* new species**

(Figs. 1–22)

*Male imago* (in alcohol). Length of body 5.7–6.4 mm, forewing 5.0–6.1 mm. Head brown, darker posteriorly and around base of eyes, pale between ocelli (Figs. 5 and 7). Antennal scape light brown, pedicel brown, flagellum pale. Dorsal portion of eyes on stalk, with 11–20 facets in longest row (16 on holotype) (Figs. 5–7). Pronotum light brown medially with blackish posterior margin, each lateral third lobed posteriorly and surrounded by blackish brown band; mesonotum brown, a little lighter dorsally in some specimens, with median longitudinal suture occasionally brown to pale, anteronotal transverse impression darker, scutellum blackish brown laterally in some specimens; prosternum brown, meso- and metasterna brown except lateral protuberances of furcasternum darker brown to blackish brown. Wings (Figs. 1–3): longitudinal veins light brown, C, Sc and R<sub>1</sub> of forewing and bases of C, Sc and R of hind wing a little darker, crossveins yellowish brown; bulla prominent on Sc and major branches of Rs; membrane of fore and hind wings pale tan to hyaline. Legs: ratios of segments of foreleg to tibia (tibia 2.2–2.9 mm): femur 0.52–0.59, tarsal segments 0.03–0.04, 0.29–0.32, 0.21–0.26, 0.14–0.19, 0.06–0.07; coxae and trochanters brown; femora of prothoracic legs light brown with blackish brown

band subapically and with lateral blackish streak on inner surface, tibiae lighter brown and



Figures 1–22. *Miroculis chiribiquete* new species. Figs. 1–12, male imago: 1–3, forewing, hind wing and hind wing enlarged; 4, foreclaw; 5, frontal view of head; 6–7, lateral and dorsal views of head (December 2001); 8, sternum 8–9 and genitalia (free); 9, genitalia (ventral, slide mounted); 10, genitalia (lateral); 11–12, terga 4–7 (December 2001). Figs. 13–21, female imago: 13, apex of sternum 9; 14, terga 5–6 (December 2001); 15–16, 20–21, sternum 7 variations (21, sublateral view of specimen in Fig. 20); 17, internal aspect of apex of sternum 7 showing broad opening with eggs; 18–19, abdominal segment 7, lateral, variations; 22, female mesothoracic

femur. (Figures prepared from material collected in July 1996 unless indicated; concave veins stippled in wing figures.)

tarsal segments fading to yellowish brown; meso- and metathoracic legs light brown to yellow-brown, femora with dark blackish mark on apical sixth of femur and medial blackish streak on inner surface as in Fig. 22, tibiae with subapical blackish band, tarsal segments pale with apical margins distinct; foreclaw as in Fig. 4. Abdomen: base color of all terga a translucent golden brown with posterior blackish bands on all terga or reduced on tergum 8; tergum 1 dark brown posteriorly to dark brown entirely, terga 2–3 lighter brown posteriorly to brown over most of terga, terga 1–3 with anteromedian dark line; terga 4–5 pale medially with darker posterolateral markings (Fig. 11), to terga 4–5 with small submedian markings (Fig. 12); tergum 6 with heavy median blackish brown longitudinal lines which may form a weak inverted "V"; tergum 7 similar but markings less distinct (Figs. 11 and 12); terga 8–9 brown; tergum 10 brown with median line and heavy posterior band; spiracles weakly indicated, tracheae hyaline to margined in dark gray; sterna translucent golden brown, sometimes with narrow posterior blackish bands, sternum 9 brown anteriorly, paler toward stylicher plate (Fig. 8). Genitalia (Figs. 8–10): length of stylicher plate about half width, dark brown to blackish brown apically; forceps and penes as in Figs. 8–10, basal segment of forceps brown, apical segments paler; penes brown with hook-like spines near base. Cerci approximately 3 times length of body, terminal filament a little shorter; all caudal filaments light brown, fading apically.

*Female imago* (in alcohol). Length of body 4.0–6.2 mm, forewing 4.3–6.4 mm. Markings of head, thorax, and legs as in male, with bands on femora (Fig. 22) and tibiae usually darker. Abdominal segments brownish with lateral tracheae black to indistinct, muscles to egg guide visible through integument on 6 and 7 (Figs. 18–19, 21); each tergum with narrow posterior blackish band; terga 1–6 with heavy blackish brown wash dorsally, wash paler laterally and anterolaterally (Figs. 14, 18–19), terga 7–9 with similar pattern but a lighter brown, tergum 10 a richer brown with median brown marking; submedian longitudinal black bars on terga 5–6, bars and wash heaviest on tergum 6 (Fig. 14), bars sometimes present but less distinct on terga 4 and 7; sterna 1–6 light brown, sternum 7 brown, sternum 8 darker brown, sternum 9 dark brown posteriorly. Sternum 7 with broad egg guide (genital extension) (Figs. 15–21); sternum 9 with apical cleft (Fig. 13). Caudal filaments broken off and missing.

*Material.* Holotype male imago: COLOMBIA: Caquetá: Colombian Amazonia, Stream #1, Trib. of Rio Mesay, approximately 1 km S of Puerto Abeja, NW of Araracuara, 2-VII-1996, G. Pritchard & J. Zloty. Allotype female imago, same data as holotype. Paratypes: 5 male and 5 female imagos, same data as holotype, 2-VII-1996 and 5-VII-1996; 6 male imagos, same data as holotype except Stream #3, 3-VII-1996; 3 male and 5 female imagos, Parque Nacional Natural de Chiribiquete, Quebrada La Piscina (0° 04' 16" N; 72° 26' 48" W), cuenca Rio Mesay, Estacion

Puerto Abeja, trampa de luz, 7-XII-2001, A Currea-Dereser. Holotype, allotype and one male paratype deposited at the Instituto Alexander von Humboldt, Villa de Leyva, Colombia; paratypes at Florida A&M University, Tallahassee; the Fundación Instituto Miguel Lillo, Tucumán, Argentina; and Museo de Entomología, Universidad del Valle, Cali, Colombia.

*Diagnosis.* *Miroculis (Miroculis) chiribiquete* n. sp. may be distinguished from all species of *Miroculis* by the combination of hyaline wings in both sexes and the following characters: in the male by 1) spines present at base of the penes (Figs. 8–10), and 2) eyes on stalks (length of stalk  $\geq$  than width) with 11–20 facets in the longest row (Figs. 5–7); and in the female by 1) sternum 7 with broad egg guide (genital extension) so some eggs extruding laterally (Figs. 15–19), 2) muscles to genital extension visible through integument on abdominal segments 6–7 (Figs. 18–19, 20–21), and 3) submedian longitudinal black bars heaviest on tergum 6 (Fig. 14).

*Discussion.* There is variation on markings of the leg. The apical bands on the femora of all legs are always present and distinct, but the inner medial markings and the bands at the apex of the tibiae are faded or absent and never conspicuously marked. The base of the male genital ducts is visible on sternum 8 in some of the specimens (Fig. 8). Although the site was studied for six months, only specimens from July and December can be located, representing the beginning and end of the study period for AC-D. Specimens from July are larger (wing length of males 5.5–6.1 mm, of females 6.0–6.4 mm) than specimens collected in the December dry season (wing length of males 5.0–5.1 mm, of females 4.3–5.2 mm) and color markings are generally darker and more extensive in December (Figs. 12 and 14), although color variations occur among specimens from both collecting dates. The number of facets in the dorsal portion of the eye is greater in July [stream #1: 16–18 (Fig. 5), stream #3 (La Piscina): 18–20] than in December [La Piscina: 11–12 (Figs. 6 and 7)]. Illustrations from earlier in the season at La Piscina show 15 facets (AC-D).

*Biology.* *Miroculis chiribiquete* n. sp. is the only species of the genus with hook-like spines at the base of the penes (Figs. 8–10). It is also the only species where female oviducts appear expanded or pulled (compared against *M. nebulosus* Savage, *M. fittkau* Savage and Peters and *M. sp. nr. mourei*). Detailed observations of mating behavior of *Miroculis sp. nr. mourei* have shown strong male/male competition for females and secondary swarm behavior as males approach mated females at the oviposition site (ED, unpublished data). In most examined females of *M. chiribiquete* n. sp., a few eggs remained in lateral positions, but in one specimen with no eggs, the oviducts were completely everted (Figs. 20 and 21). We suggest that the basal hooks on *M. chiribiquete* n. sp. are derived to pull female oviducts and prevent other males from fertilizing eggs.

Mating flights were observed every other day at La Piscina from 16 July to 10 December, 2001, and adults were present the entire season. However, peak activity

occurred during the last two weeks of August with a smaller peak in early November. The flight took place from 0800 to 1000 hours, with highest densities early in the swarm. The swarm was composed of 60 to 100 individuals, flying at 50 to 70 cm above the water. Males flew in large companies over the main part of the stream where water was swiftest. Observations by Zloty in early July were similar: "1–2 m above the water in the middle of the river, with swarms in excess of 100 individuals; on this occasion, swarming occurred in full sunlight starting about 1100 following morning rain." More specimens, mostly female, were found in the water near the sandy river banks, apparently close to the area of oviposition (AC-D) or concentrated on the surface in one small area near the bank (Zloty). Very few copulas were observed (5 or 6) during the whole period. More females than males were collected, but females were more accessible in funnel traps set in the sandy margins. Most males could only be collected at light. (Males collected by Zloty were collected with a long-handled net.)

*Subgenera of Miroculis.* Most species of *Miroculis* are described from short series from isolated localities, and the range of individual variation is unknown. *Miroculis chiribiquete* n. sp., described from a longer series from one locality, although from different collectors in different years, displays seasonal variation in coloration, size and the number of facets in the male eyes. For this reason, the number of facets can no longer be used to distinguish subgenera, and it is necessary to redefine the limits of the subgenus *Miroculis* to include all species with dorsally-directed, stalked eyes in the male (presently known to have 5–20 facets in the longest row of the dorsal portion). Except for the number of facets, this follows the key of Savage and Peters (1983). The species *Miroculis (Atroari) nebulosus* is transferred to the subgenus *Miroculis*. Couplet number 1 in the key to subgenera (Savage and Peter 1983) is modified to read as follows:

- 1       Upper portion of eyes on narrow, dorsally-directed stalks (Figs. 5–7, 26 and Figs. 44–46 in Savage and Peters 1983, Figs. 14 and 15 in Savage 1987b), 5–20 facets in longest row of dorsal portion, eyes separated on meson of head by a distance 0.5–1.5 width of an upper portion ..... *Miroculis (Miroculis)*
- 1'      Upper portion of eyes not on stalks (Figs. 49–54 in Savage and Peters 1983), or upper portion on short, wide stalks (Figs. 47 and 48 in Savage and Peters 1983) separated on meson of head by a distance 0.1–0.2 maximum width of an upper portion; 27–40 medium sized facets in longest row .....
- ..... other subgenera of *Miroculis* as keyed in Savage and Peters (1983)

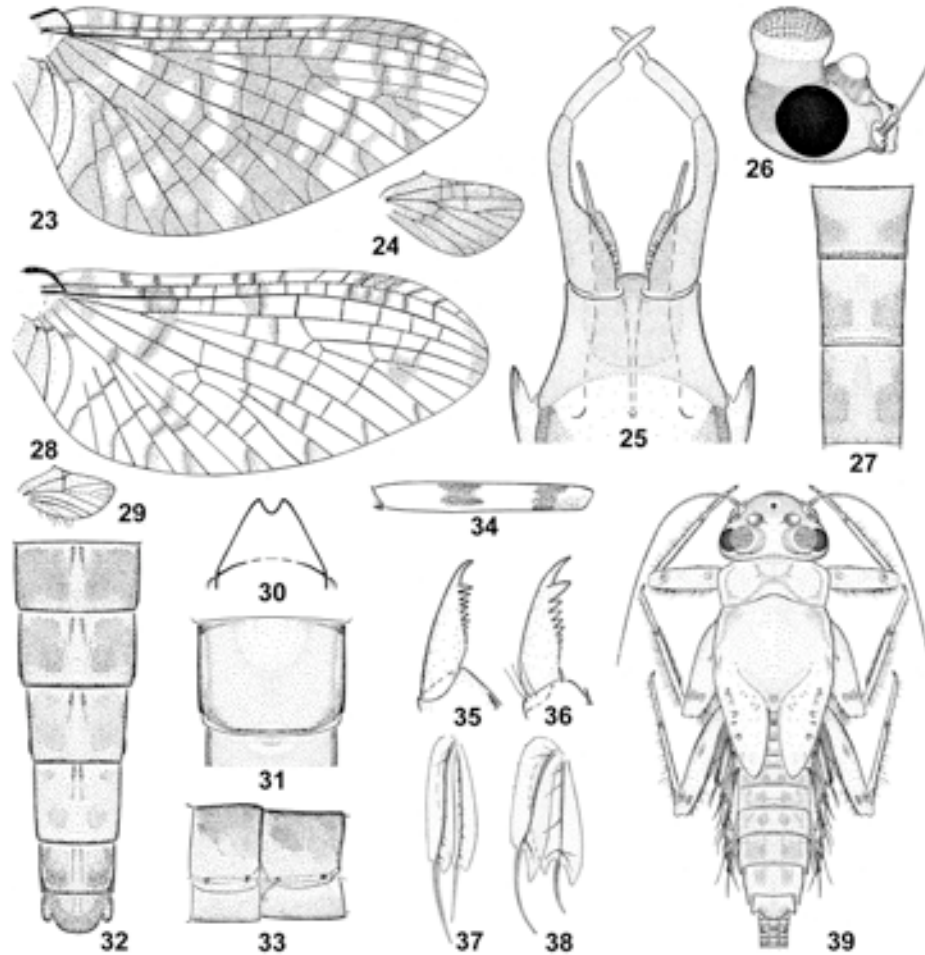
***Miroculis (Miroculis) nebulosus* Savage, 1987, new subgeneric combination**

(Figs. 23–39)

*Miroculis (Atroari) nebulosus* Savage, 1987b:104.

*Male imago* (in alcohol). As described by Savage (1987b), except body length of male to 6.4 mm, forewing length to 5.1 mm, foreleg length to 5.4 mm, wing color banding heavier and more distinct (Figs. 23 and 24), distance between dorsal portion of compound eyes equal to width of dorsal portion and dorsal portion almost circular (Fig. 26) without evident median projection. Abdomen: tergum 1 brown, terga 2–8 light brown, translucent, with sublateral darker marks as in Fig. 27, marks indistinct on terga 3–4; posterior dark brown bands on terga 2–5, variable on terga 6–8; terga 9–10 uniformly brown, but a little darker medially and posteriorly; spiracles black, tracheae outlined in gray; sterna light brown, same intensity as base color of terga. Genitalia (Fig. 25) as described by Savage (1987b) except apex of styliiger plate rounded.

*Female imago* (in alcohol). Body length 5.2 mm, forewing length 4.4 mm. Head with blackish brown wash, heaviest anteriorly, pale posterior to ocelli and between eyes. Antennal scape pale, pedicel blackish brown, flagellum light brown. Pronotum yellow-brown with blackish median carina and posterior band, each lateral third lobed posteriorly and surrounded by dark brown band with heavier black band medially; mesonotum brown; thoracic sterna brown except a little lighter medially. Wings (Figs. 28 and 29): longitudinal and cross veins brown, with small brownish band around most crossveins, bands heaviest anteriorly (Fig. 28), base and apex of wing also tinged with brown; hind wing veins brown in basal half, fading to hyaline apically, membrane with small brownish apical band (Fig. 29). Coxae brown, trochanters a darker brown, remainder of legs yellow-brown faded to pale on tarsal segments; heavy medial and apical blackish bands on femora of all legs, bands on forefemora heavier than illustrated for mesothoracic femur (Fig. 34), tibiae with a subapical black band. Abdominal terga a light brown with heavy blackish brown wash dorsally (Fig. 32), submedian longitudinal marks and blackish wash anterolaterally on terga 2–6 (Fig. 33), wash a little lighter on terga 7–8; terga 9 and 10 dark posteriorly (Fig. 32); all terga with narrow posterior blackish bands; spiracles black, tracheae margined with black (Fig. 33); sterna light brown, color darker posteriorly on sterna 7–9. Sternum 7 illustrated in Fig. 31 with eggs apparently extruded from single medial opening; sternum 9 with apical cleft typical for genus (Fig. 30). Caudal filaments broken off and missing (from male and nymph, probably with dark rings at base of annulations).



Figures 23–39. *Miroculis nebulosus* Savage. Figs. 23–27, male imago: 23–24, forewing and hind wing; 25, ventral view of genitalia; 26, lateral view of head; 27, terga 5–7. Figs. 28–34, female imago: 28–29, forewing and hind wing; 30, apex of sternum 9; 31, sternum 7; 32, terga 5–10; 33, lateral view of abdominal segments 5–6; 34, mesothoracic femur. Figs. 35–39, mature nymph: 35, foreclaw; 36, mesothoracic claw; 37–38, gill 4 (variations); 39, full nymph, male. (Concave veins stippled in wing figures.)

*Mature nymph* (in alcohol). Head brown with pale area between eyes in both sexes; mouthparts characteristic for genus (Savage and Peter 1983); antennae pale except



pedicel dark brown. Pronotum light yellowish brown, with adult markings visible as in Fig. 39; mesonotum light brown; developing wings in wing pads with numerous mottles; thoracic sterna pale yellowish, except prosternum with darker margins. Legs pale yellowish brown with heavy posterior blackish brown band on femora and tibiae and a second band just basal to middle of femora, this band heavier on inner surface of leg; prothoracic and mesothoracic claw illustrated in Figs. 35 and 36 (see discussion). In males, abdominal terga 1-10 with posterior blackish brown band; terga 1-2 brown medially; terga 3-4 pale medially with lateral brownish markings, terga 5-8 with heavier sublateral and lateral blackish brown marking, marks reduced on terga 9-10 (Fig. 39); sterna pale yellowish brown. In females, a uniform blackish brown wash over terga 1-10, but lighter medially on terga 8-10; sterna yellowish brown. Gills well developed, with additional tracheae forking from median trachea on some gills and outer lobe of dorsal portion as in Figs. 37 and 38; gill membrane light gray. Posterolateral spines on terga 3 or 4-9, progressively larger from terga 5 or 6-9. Caudal filaments with dark bands at annulations.

*Material.* 4 male imagos, 1 female imago, 4 nymphs. COLOMBIA: Caquetá: Colombian Amazonia, Stream #2 (0° 04' 44" N, 72° 26' 50" W), Trib. Rio Mesay, S of Puerto Abeja and upstream from Stream #1, 2-4-VII-1996, G. Pritchard & J. Zloty.

*Diagnosis.* The male is keyed in Savage (1987b). In the only key to females (Savage and Peters 1983), *M. nebulosus* is closest to *M. fittkai* from which it is distinguished by the heavy wing markings (Figs. 28 and 29), heavy medial and apical blackish bands on the femora (Fig. 34), and markings on abdominal tergum 6 which repeat those of preceding terga (Fig. 32). Nymphs will key to *M. colombiensis* Savage and Peters (or to *M. amazonicus* Savage and Peters) from which male nymphs can be distinguished by the developing male eye stalks (Fig. 39). Female nymphs may possibly be distinguished by the continuation of developing dark adult coloration on terga 8-9, but this and possible claw characters may be variable. Although not mentioned in Savage and Peters (1983), the paratype nymphs of *M. colombiensis* show the same developing wing coloration as illustrated for *M. nebulosus* (Fig. 39).

*Discussion.* *Miroculis nebulosus* was described from Cerra de la Neblina, Venezuela, by Savage (1987b) from male imagos. The presence of this species at Chiribiquete, Colombia, represents a range extension for the species and a new record for Colombia. There are only minor differences between these males and those described by Savage (1987b): the apex of the styliger plate is rounded instead of shallowly notched (Fig. 25) and the wing coloration is more intense (Figs. 23 and 24). The color pattern of the Chiribiquete males matches a variation described for *M. nebulosus* (Savage 1987b) where lateral bands and submedial bands appear to merge (Fig. 27). Eyes are within the variation described by Savage (1987b),

although more circular. In the male wing illustrated (Fig. 23), vein  $MP_2$  attaches to vein CuA, but this atypical condition is not found on the other wing of this specimen or on the other males.

The nymphal color pattern is that of imagos, as all nymphs examined were about to emerge. The broad gills with heavy branched tracheation resemble *M. colombiensis*; however, we examined the paratype male nymph of *M. colombiensis*, and its eyes do not show developing stalks and have at least 20 facets in the longest row (eye damaged when mouthparts were dissected, so precise number not known). The illustrated foreclaw (Fig. 35) shows an apical denticle only a little larger than the preceding denticle, but other specimens of *M. nebulosus* have an apical denticle much larger than the preceding denticles resembling that illustrated for the mesothoracic leg (Fig. 36). Paratypes of *M. colombiensis* also have a larger apical denticle on the mesothoracic leg. Because all specimens of both species are teneral adults, the denticle on the foreclaw may be worn in some specimens. Based on the present material, only the developing male eyes will clearly separate *M. nebulosus* from *M. colombiensis*.

*Biology.* The habitat (Stream #2) was very small with trickling water and many small pools filled with leaf litter. Nymphs were collected from rocks and leaf packs in the pools, and adults were collected from rocks at the margins.

### Acknowledgments

We sincerely thank J. Zloty (University of Calgary, Alberta, Canada) for specimens of *Miroculis chiribiquete* n. sp. and *M. nebulosus* and for information on the habitat. We also thank M. del C. Zuñiga (Universidad del Valle, Cali, Colombia) for specimens of *M. chiribiquete*. We especially thank H. M. Savage (Centers for Disease Control, Fort Collins, Colorado) for advice on the status of subgenera, helpful suggestions and review of the manuscript.

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