

ORIGINAL ARTICLE

Taxonomic revision of the genus *Chaquihua* Demoulin (Ameletopsidae: Ephemeroptera) with notes on its biology and distribution

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Abstract

A taxonomic revision of the genus *Chaquihua* is presented confronting new material with the literature descriptions of the genus. The nymph and male imago are described here for the first time and the existing descriptions of other developmental stages are complemented. Association of larvae and winged stages is now confirmed by rearing. The synonymy of the extant species is proposed. Notes on the biology and distribution of the genus are also included.

Resumen

Se presenta una revisión del género *Chaquihua* contrastando material nuevo con las descripciones del género en la literatura. Se describe por primera vez la ninfa e imago macho y se complementan las descripciones de los otros estados de desarrollo. Todos los estados quedan asociados mediante crianzas. Se propone la sinonimia de las especies existentes. Además se incluyen notas acerca de la biología y distribución del género.

Keywords: *Chaquihua*, Ephemeroptera, taxonomy, Neotropical, distribution

Introduction

The amphinotic family Ameletopsidae comprises the New Zealand genus *Ameletopsis* (one species), the Australian *Mirawara* (three species), and the two Neotropical representatives *Chiloporter* (one species, Mercado & Elliott, 2005), and *Chaquihua* (two species). The genus *Chaquihua* was erected by Demoulin (1955) for his new species *Ch. penai* described from two specimens, a male subimago (holotype) from Río Chaquihua and a female imago from Enco, both Chilean localities. The other species included in this genus was described by Navás (1930) from a winged specimen from Angol, Chile, which he named *Euthyplocia bullocki*. The species was later relocated in the genus *Chaquihua* by Edmunds et al. (1976) mentioning only that “*E. bullocki* Navas, described from Chile, is actually a species of the siphonurid genus *Chaquihua*”. Even though no reasons were given to support this relocation, ample and obvious reasons exist, as

we shall point out in our discussion. Therefore, the species *Ch. bullocki* (Navás, 1930) is included in this revision. This name was also included in a catalogue by Hubbard (1982) and later maintained by Camousseight (2001).

It is the object of this work to present a revision of the genus *Chaquihua* with a view to establishing the specific variability along its distributional area. First descriptions of the nymph, of which only the mandible is known through the drawing in Edmunds (1975), and male imago are given. Earlier descriptions of other stages are complemented. Remarks on the variability of the more relevant characters are also included.

Materials and methods

Specimens were collected from numerous rivers and streams between VII and XI regions, in Chile. Collections were made in spring and summer 1999 to 2004. This material is labelled with the

prefixes “N” for nymph and “A” for the winged stages.

Nymphs were collected using a dipnet with a mesh of 500 μm . Emerging stages were captured by means of a semi-submerged driftnet anchored to the stream bed from early afternoon until the following morning. Flying insects were captured by the watercourses with an aerial net.

Some of the nymphs collected were reared to adult in their native watercourses or at our laboratory. Specimens in all stages of development were preserved in 70% ethanol. Part of this material has been deposited in the Museo Nacional de Historia Natural de Chile (MNHN), the remaining material is deposited in the macrozoobenthos collection of the BENTHOS Laboratory of Aquatic Entomology, Valdivia, Chile.

Microscopic preparations were made of mouthparts, legs and rear abdomen of specimens from different localities. Some nymphal and adult parts were clarified in KOH and mounted in Euparal.

Material examined

Chile: 2 male nymphs, 1 female nymph, Río Cauquenes, Los Ruiles ($35^{\circ}52'30''\text{S}$; $72^{\circ}22'30''\text{W}$) VII Región, N° Coll. N-1814a, N-1814b; 2 male nymphs, 2 female nymphs, 1 female imago, 1 male subimago (reared), $37^{\circ}48'48''\text{S}$ – $72^{\circ}50'29''\text{W}$ Río Picoiquén, Angol, N-2139, A-1398, A-1399; 3 male nymphs, 2 male subimagines, 3 female imagines, Río Cruces ($39^{\circ}24'37''\text{S}$; $72^{\circ}16'12''\text{W}$), IX Región, N° Coll. N-1201, A-1201 (captured and reared), A-1000; 2 female nymphs, Arroyo Pishuinco, Valdivia, X Región, N° Coll. N-2016; 1 female nymph, Río Contaco, Osorno, X Región, N° Coll. N-017; 1 female nymph, Río Contaco, Osorno, X Región, N° Coll. WDS-A-1521 (leg. W. Shepard); 8 male nymphs, 13 female nymphs, 5 male imagines, 3 female imagines; unnamed stream ($40^{\circ}40'56''\text{S}$; $72^{\circ}01'13''\text{W}$), Ruta Internacional Puyehue, Osorno, X Región, altitude 1022 m. N° Coll. N-2017 deposited in the MNHN, N-2018, A-1389, A-1390 reared; 1 female nymph, Río Gol-Gol 1, Osorno, X Región, N° Coll. N-0969; 2 female nymphs, 1 male imago, 2 female imagines, Río Gato 2, Llanquihue, X Región, N° Coll. N-2019, A-1391 (reared), A-1392 (reared); 1 female nymph, 3 male imagines, 1 female imago, Río Chaquihua, Llanquihue, X Región, N° Coll. N-0676, A-312, A-320; 1 male nymph, 1 female nymph, Río Puntra, Isla Chiloé, X Región, N° Coll. N-0698a, N-0698b; 2 female nymphs, 4 female subimagines, 1 female imago, Río Butalcura, Isla Chiloé, X Región, N° Coll. N-2020, A-0039, A-1393; 1 female nymph, Río Maldito, tributary to Río Mañihuales, Aysén, XI Región, N° Coll. N-2021; 1 female nymph, Río

Murta ($46^{\circ}26'30''\text{S}$; $72^{\circ}43'30''\text{W}$) Coyhaique, XI Región, N° Coll. N-0908.

Results

Genus *Chaquihua* Demoulin, 1955

Nymph. Body dorsoventrally depressed, head prognathous, maxillary and labial palpi filiform and multisegmented, seven pairs of subrectangular gills with pigmented and abundant ramifications, caudal filaments feathered.

Adults. Male imagines with translucent wings and body except at both ends of the abdomen where a slight pink colouration is present. Female imagos with translucent wings and orange-red body, abdomen with characteristic dorsal maculation consisting of a longitudinal middle line and posterior margin of each segment dark red. Both sexes with abundant unpigmented wing venation as in Figure 2a, stigmatic area with abundant anastomosis, cubital area with at least five sigmoidal and three long, free intercalary veins; females with one of the last two sigmoidal veins forked. In life, the subimagines of both sexes are bright yellow all over with characteristic dorsal maculation in the abdomen (Figure 2b). Tarsal claws different within a pair. Abdominal segment IX with posterolateral projections. Male genitalia as in Figure 2c. Long cerci and terminal filament very short.

Chaquihua bullocki (Navás, 1930)

Euthyplocia bullocki Navás, 1930, pp. 320–330, Figure 75 (female), type is lost (Camousseight, 2001).

Chaquihua bullocki Edmunds et al., 1976

Chaquihua penai Demoulin, 1955, pp. 11–14, Figure 3 (male subimago, female imago), type at the Institut Royal des Sciences Naturelle, Belgium
NEW SYNONYMY.

Larvae (Figure 1). Body dorsoventrally depressed, 18–20 mm in length without the caudal filaments. Legs slim, caudal filaments “feather-like” (up to 7 mm in length), characteristic body maculation. Head rounded, prognathous, with large non-protuberant eyes, each one occupying approximately 1/5 of the corresponding hemi-head. Antennae filiform with 25 segments per antennal flagellum, even though it is difficult to establish whether this character is constant, as these structures are fragile and in some specimens they appear to have been severed. Mouthparts of the carnivorous type: labrum wide, internal margin with a shallow cleft covered with setae, dorsal surface coarse, particularly inside the cleft.

Mandibles (Figure 2f) with a trifid canine (incisor) at the apex, the larger one with a serration on the

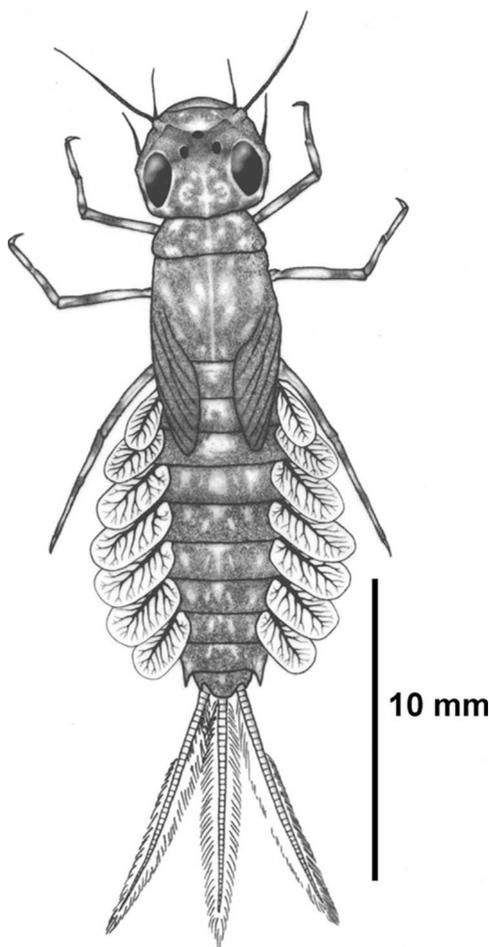


Figure 1. Nymph of *Chaquihua bullocki*.

inner margin along $2/3$ of its basal portion. The inner incisor is bifid, transversally oriented and very close to the molar area, its dorsal tooth with a row of dorsal denticles along $3/4$ of its basal portion. Molar area rectangular with a long tooth-like anterior projection with long setae on the inferior margin.

Maxillae (Figure 2g) wide, triangular in shape, with five teeth at the apex, all incurved, the inner one half as long as the longest and $2/3$ the length of the others. Maxillary palps filiform, with 16 segments.

Labium (Figure 2d) with glossa subrectangular but rounded contours. Paraglossa segmented, anterior external margins with setae. Labial palps filiform, with 17 segments. Submentum with lamellar lateral expansions, as in *Chiloporter* (Mercado & Elliott, 2005) but with anterior apexes pointed.

All abdominal segments with posterolateral projections progressively larger towards the rear end. Ventral view of last segment with distal margin rounded and “V” shaped cleft, the cleft is narrower amongst the males. *Chaquihua* presents seven pairs of profusely tracheated and well-pigmented subrectangular gills (Figure 2e), the anterior margin is slightly pigmented and thicker as a reinforcement. Terminal filament slightly shorter than cerci, with

setae approximately $2\frac{1}{2}$ times as long as cerci diameter. Inner margin of cerci with setae similar in length to those in terminal filament. The outer margins of the cerci lack setae in the proximal $1/3$ length.

Legs slim and subequal in length, the last and longest pair being almost $3/4$ as long as the abdomen. Maximum width of femur almost $1/5$ its length. Internal margin of all tibiae and tarsi with short spines. Claws slightly curved, without denticles and $1/4$ to $1/3$ as long as the corresponding tarsus.

Male imago. Body length 12.1–15.2 mm; cerci 20 mm; terminal filament 4 mm; Forewing length 16.8 mm, width 6.2 mm; hindwing length 6.8 mm, width 3.5mm. Colouration in life translucent except both ends of the abdomen with slight pink to ochre pigmentation. Wings and wing venation translucent, stigmatic area slightly opaque.

Head. Eyes large but inner margins do not meet. Three white ocelli, each with a thick dark band at the base. Antennae short, flagellum similar in length to eye diameter. Brown-reddish pigmented zone between occipital suture, compound eye and coronal suture.

Thorax. Colour in alcohol ochre-white, anterior portion of mesonotal suture darkened, metathorax with dark symmetrical maculae. Wings hyaline and translucent. Forewing (Figure 2a) with abundant anastomosis in the stigmatic area, sigmoidal veins variable in number but no less than five, with intercalary veins between them. Hindwing (Figure 2a') with pointed costal projection. Leg I as long as body without the cerci, length of tarsus $9/8$ of femur and tibia combined, tarsal formula: 2, 1 = 3, 4, 5; leg II slightly longer than $1/2$ of leg I, tarsus length subequal to tibia and tibia subequal to femur, tarsal segment 1 partially fused with tibia, distal end of tibia and first 4 tarsal segments with a pair of small spines; tarsal formula 1 = 2, 3, 5, 4; leg III as leg II. Claws of all three pairs of legs double and different within a pair, one flattened with rounded contours, the other as a sharp hook.

Abdomen. Colour in life translucent white with a wide dorsal pink band on the first and last three segments. Posterior margins of segments V, VI and VII and sometimes VIII, with a thin dark brown dorsal band. The above is a vestige of characteristic subimaginal maculation. Segment X with posterolateral projections. Styliiger plate wide, with a small open “V” shaped cleft; trisegmented forceps with basal segment long and curved (Figure 2c), twice as long as styliiger plate, with an inside prominence at the first third. Segments II and III of forceps combined subequal in length to $1/4$ of first segment,

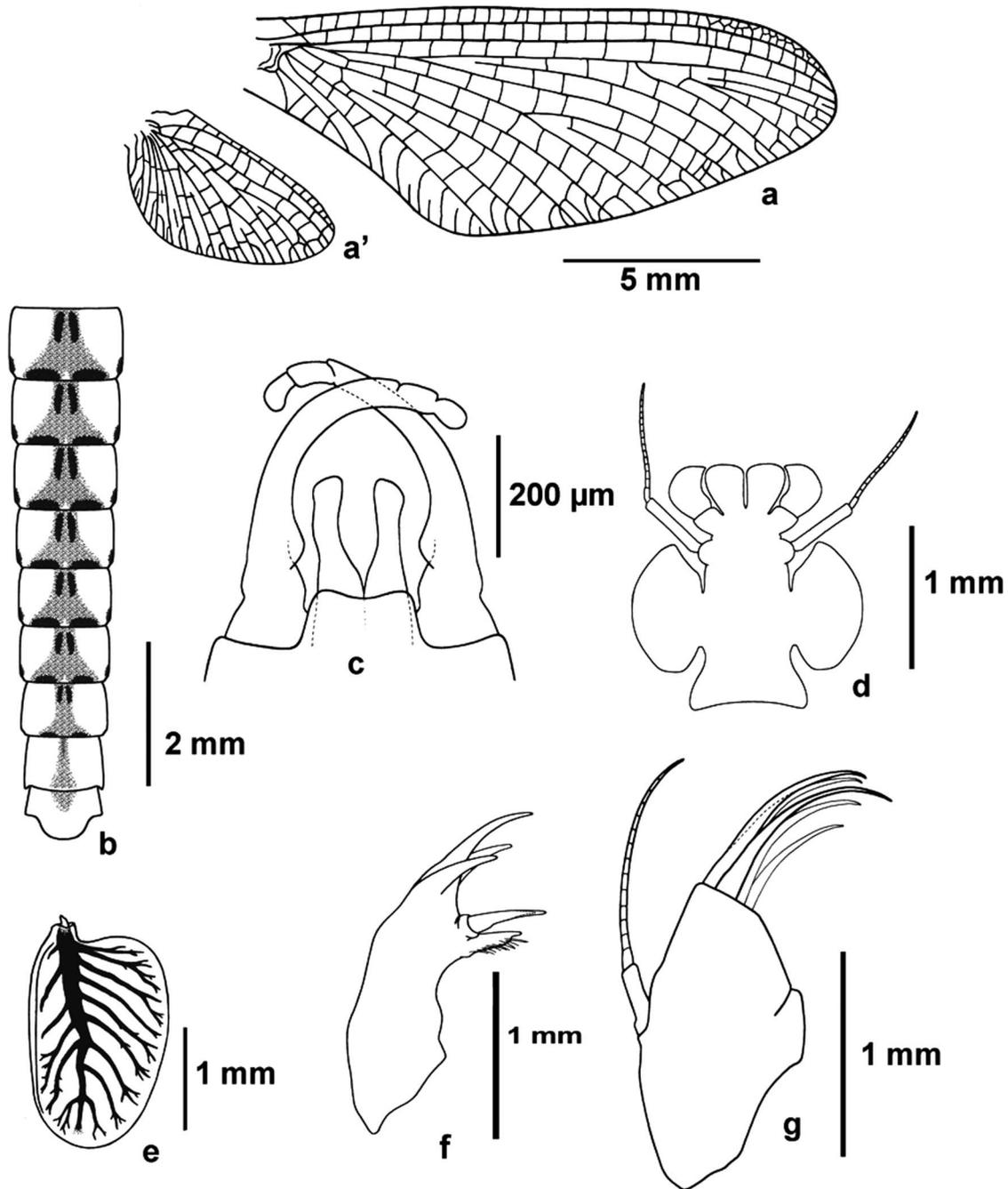


Figure 2. *Chaquihua bullocki*. (a) Fore wing and a' hind wing: male imago, (redrawn from Demoulin, 1955); (b) abdominal maculation, dorsal view, subimagines; (c) male imago, genitalia, ventral view; (d) nymph, labium, ventral view; (e) nymph, gill IV; (f) nymph, right mandible; (g) nymph, right maxilla.

third segment $\frac{3}{4}$ as long as segment II and with numerous minute globular structures along the inner face; penes lobes elongated and tubular, fused along the basal $\frac{1}{3}$ of its length, small spines on the inside where the lobes diverge.

Male subimago. Demoulin's (1955) description of this stage is mostly consistent with our material, therefore we will mention here only new observations and discrepancies with this author.

Body length 10.1–12.5 mm, cerci not included. Colouration in life citric-yellow all over, with characteristic dorsal maculation pattern as in Figure 2b. In alcohol the insect turns milky-white but keeps its dorsal maculation.

Head. Same as imago.

Thorax. Same as imago, except leg I is $\frac{1}{3}$ the body length (without the cerci), tibia is $\frac{4}{5}$ and tarsus $\frac{6}{5}$

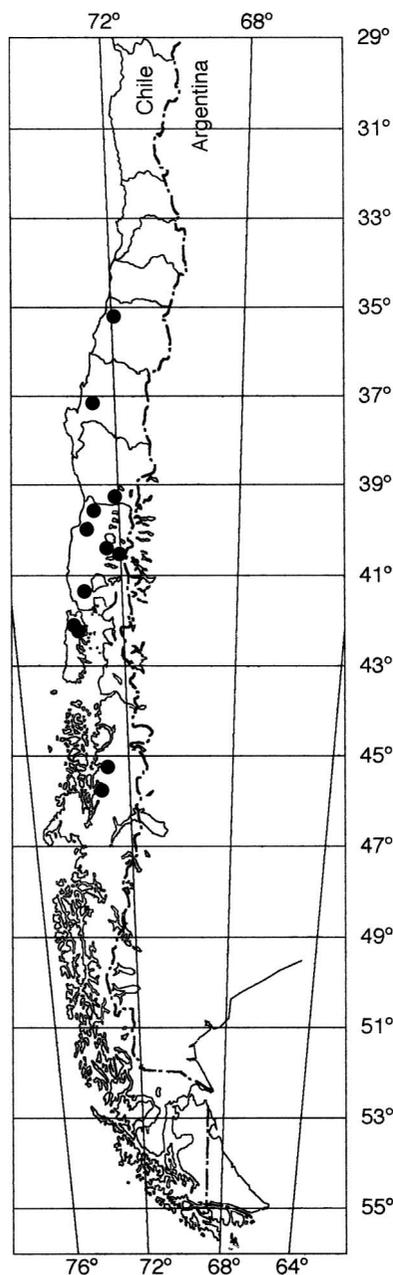


Figure 3. Geographical distribution of *Chaquihua bullocki*.

the femur length, tarsal formula: 2, 1, 3 = 4, 5; leg II with tibia partially fused to tarsal segment I and 4/5 the length of leg I, tarsal formula: 1 = 2, 3 = 5, 4; leg III as leg II.

Abdomen. Same as imago, except the “V” shaped cleft on the styliger plate is more pronounced, reaching into half the segment length, just as observed by Demoulin (1955).

Female imago. Body length 12.0–18.1 mm cerci not included; forewing length 20.2 mm, width 8 mm; hindwing length 7 mm; cerci 21.8 mm, caudal filum 5.2 mm. Demoulin’s (1955) description of colouration is consistent with our material.

Head. Eyes smaller than in males. Colour and antennae same as males.

Thorax. General colouration reddish with pigmented areas as in males but more intense. Inner side of all three pairs of coxa reddish, as observed by Demoulin (1955), coxa II is light brown. Wings hyaline and translucent. Forewing with bulla in Sc y R₂, venation with light ochre pigmentation. Unlike the males, the females have in the cubital area one forked sigmoidal vein (either 5 or 6), plus the normal 5 or 6 sigmoidal and 3 intercalary; this character is quite stable and was present in both wings. The previously unknown leg I is 2/3 as long as the body (cerci excluded), tibia is slightly less than 4/5 and tarsus 6/5 the femur length, tarsal formula: 2, 1, 3, 4, 5, tarsus I partially fused with tibia; leg II is 19/20 the length of leg I, with tibia 9/10 and tarsus 4/5 the femur length, tarsal formula: 1 = 2, 5, 3, 4; leg III subequal to leg II, with segments proportions as in leg II, tarsal formula: 1, 2, 5, 3, 4. Claws same as males.

Abdomen. Our material is completely consistent with Demoulin’s (1955) description. Subanal plaque with elongated and rounded posterior margin, with a short median incision. Abdomen wine coloured, with a large longitudinal median brown band, attenuated over the last three segments. Posterior margin of tergites I–V (VI) dark brown. Lateral margins of tergites less pigmented and underlined with reddish pigment. Ventral face reddish, with a small black macula centred on the posterior margin of sternites I–VI. A pair of anterior oblique clear maculae flanking the nervous chain on sternites I–IX.

Female subimago. The “citrinus” colouration indicated by Navás (1930) for *Euthyplocia bullocki* corresponds to this developmental stage of *Chaquihua bullocki*. This pigmentation is lost in the imaginal stage as the wings become translucent and a copper-like colouration predominates on the female body.

Body length 12.7–14.3 mm cerci not included. Cerci as long as body, terminal filum short, slightly more than 1/4 the cerci length.

Head. As in female imago.

Thorax. Body maculae and wing venation as in female imago. Leg I slightly longer than body (cerci excluded), tibia 8/9 the femur length and tarsus 7/6 the femur length, tarsal formula: 2, 1, 3, 5, 4, tarsus 1 partially fused with tibia; leg II subequal to leg I, tibia 3/4 and tarsus slightly more than 1/4 the femur length, tarsal formula: 1 = 2, 3 = 5, 4; tarsus 1 partially fused to tibia; leg III same as leg II.

Abdomen. General colouration citric-yellow, same dorsal maculation as male subimago (Figure 2b).

Diagnosis. The nymphs of *Chaquihua* present the following group of characters: body dorsoventrally depressed; head prognathous and slightly wider than thorax; paraglossa two segmented; submentum with lateral expansions of rounded contours except for pointed anterior apex (Figure 2d); antennal flagellum may develop as much as 25 segments, maxillary palp 16 and labial palp 17; seven pairs of subrectangular abdominal gills (Figure 2e), with well-developed pigmented tracheae; outer margin of cerci without setae on the proximal 1/3; caudal filament almost as long as cerci, with setae on both sides.

The winged stages of the genus present the following character assemblage: abundant anastomosis on the stigmatic area and wing venation of the forewing as well as costal projections of hindwing as in Figures 2a and 2a'. Claws different within a pair. Abdominal maculation as in Figure 2b in the subimaginal stages. Male genitalia as in Figure 2c. Terminal filament very short.

The most remarkable differences with the nymphs of *Chiloporter eatoni*, the only other neotropical member of the family Ameletopsidae, lie in the gills, which in *Chiloporter* are double with a discoidal dorsal portion and a fibrillous ventral one, the head is not as wide, the antennae and maxillary palpi are longer, and the anterior margin of the lateral expansions of the labrum is acute (Figure 2d), whereas in *Chiloporter* it is rounded.

The differences with the imagines of *Chiloporter eatoni* are the dorsal maculation of the abdomen, the general colouration, and the very short terminal filament of *Chaquihua*.

Biology. *Chaquihua* is a member of the Ameletopsidae family, whose nymphs are carnivorous and present similar mouth structures, such as chitinized masticatory and shredding parts with prominent incisors on their maxillae and mandibles, multisegmented filiform labial and maxillary palpi. Just as all the other members of the family, *Chaquihua* has spines on the inner surface of its legs, possibly connected with predatory activities. The mandibles of *Chaquihua* were mentioned by Edmunds (1975), as carnivory adapted.

Amongst the stomach contents we found remains of larvae of Ephemeroptera, mostly Leptophlebiidae but also some Baetidae. Similar stomach contents have been found in nymphs of other members of the family (Phillips, 1930, p. 333 in Needham et al., 1935).

The nymph of *Chaquihua* has been found in rithronic reaches of small to medium sized rivers and streams, invariably where native riparian vegetation has been preserved. Unlike *Chiloporter* (Mercado & Elliott, 2005), the other Chilean representative of

the family, *Chaquihua*, has never been collected in appreciably polluted waters. The nymphs are very specific in their instream habitat preferences, although sometimes found elsewhere, small groups of nymphs characteristically gather in the undercut banks of pools, occupying a restricted segment where water flows appreciably but not swiftly. The above, coupled with the predatory role of the nymphs, accounts for their relatively low density and numbers. Just like *Chiloporter* (Mercado & Elliott, 2005), the nymph of *Chaquihua* has mixed locomotion capabilities; we have observed it crawling on the bottom of our aquariums although it is capable of short bursts of fast swimming.

Hatching of subimagines has been observed from October to early March but mostly occurs in December and early January. Typically isolated individuals hatch in the evenings, starting around 5 pm. The nuptial flight of *Chaquihua* takes place in broad daylight, starting around 4:30 pm and may last until sunset. Swarms are not numerous (some 15 individuals) and the males adhere to the usual up and down pattern, with active flight in both phases.

The winged stages of *Chaquihua* present dramatic changes in colouration related to the developmental stage and sex of the individuals. The subimagines of both sexes are opaque yellow-green all over except for characteristic dorsal maculation pattern (Figure 2b). Amongst the imagines colouration reflects sexual dimorphism: while some of the yellow pigment is retained in their wings and bodies by the newly hatched imagines of both sexes, eventually the females develop an intense copper-like body colour while the males become almost completely colourless. The imaginal wings of both sexes become completely translucent after a day or two. It should be noted that the subimaginal colour blends perfectly with the spring foliage while little more than the sparkle of the sun in the wings can be seen of the imaginal nuptial flight.

Geographic distribution (Figure 3). Our new records extend the previously known distributional area of *Chaquihua* in Chile as far as the Río Cauquenes (35°52'30"S; 72°22'30"W), VII región, to the north and as far as the Río Murta (46°26'30"S; 72°43'30"W), XI región, to the south. *Chaquihua* can be found in Andean watercourses at altitudes up to 1022 m, and also in the Chilean coastal ranges, only metres away from the sea.

Discussion

Reasons for the relocation of the species Euthyplocia bullocki Navás in the genus Chaquihua Demoulin

Since the type is missing we will propose the relocation based on the analysis of the available

literature and new material collected and reared by the authors in the type locality.

While describing the species *E. bullocki*, based on a winged female, Navás (1930) remarked first that it is “*Simil hecubae*” and then noted some characteristics concerning mostly the specimen’s colouration. The predominant citric colour is noted for the body, legs and wings. Also mentioned is the “charred looking” longitudinal band that runs dorsally along the abdomen, as well as the dark pigmentation of the posterior margin in each segment, the darkened middle zone of the pronotum and metanotum, and the mesonotum with darker anterior and posterior middle zones. Actually, the adults of the family Euthyplociidae present dark greyish colourations, the adults of *Euthyplocia hecuba* in particular, are violet-grey (Domínguez et al., 1994).

Navás (1930) indicated that the forewing of *E. bullocki* is 18 mm long and 5.5 mm wide, that it is slightly more than 1/4 its length; according to Figure 6, lam. XXIV, in Domínguez et al. (1994), the forewing width of *E. hecuba* is almost 1/2 its length, otherwise Edmunds et al. (1976) mentioned that the forewings of the members of the genus *Euthyplocia* are 20–38 mm long. Regarding the posterior margin of the forewing Navás (1930) stated that it is nearly straight with 7–8 veins in the axillar zone (sigmoidal veins), but in *Euthyplocia* the posterior margin is angular and with a minimum of 10 sigmoidal veins (Edmunds et al., 1976; Domínguez et al., 1994).

From the biogeographical point of view, the family Euthyplociidae has a pantropical distribution (Edmunds et al., 1976), the genus *Euthyplocia* ranging from Central America to northern Argentina (Salta, 24°46'60"S) (Domínguez et al., 2002). The specimen Navás (1930) described was captured at Angol (37°47'60"S), IX región, in Southern Chile. According to the new biogeographic scheme proposed by Morrone (2001) the distribution of the genus *Euthyplocia* is Neotropical comprising the Caribbean, Amazonian and part of the Chaqueña subregions, while the insect Navás described came from the subantarctic subregion of the Andean Region.

All the above arguments concur to justify the removal of *Euthyplocia bullocki* Navás from that genus. On the other hand, Demoulin (1955) mentioned that *Chaquihua* presents on the posterior margins of the abdominal segments, in dorsal view, dark bands plus a longitudinal band the colour of terracotta which tends to fade in the last segments. Also, and as previously mentioned, the general citric colouration pointed out by Navás (1930) is characteristic of the subimagines of the genus *Chaquihua*. Therefore, the characters described by Navás (1930), mostly related to colours and maculation, permit its relocation in the genus *Chaquihua*, as they are

completely coincident with the unique and distinctive colouration and maculation patterns known of only one species cited for that particular area in Chile, which is a species of the genus *Chaquihua*.

Synonymy of the species of the genus Chaquihua

Based on the available literature, the synonymy can be effected by comparing the winged stages of the females of *Chaquihua*. Demoulin (1955) described a female imago and Navás (1930) described a winged female whose characteristics are completely consistent with all our *Chaquihua penai* subimaginal material.

Navás (1930) also mentioned and drew a group of sigmoidal veins (7–8) in the cubital area of the forewing of his specimen. This character is not described in the same way by Demoulin (1955), nor have we found it amongst our material. Since the type material is unavailable, we collected and reared nymphs from the type locality (Angol); all this material turned out perfectly consistent with Demoulin’s (1955) description. Since, amongst the Chilean Ephemeroptera, no other species remotely resembles the description by Navás (1930), we have concluded that Navás (1930) is in error as he may easily have counted some of the intercalary veins amongst the sigmoidals. In *Chaquihua* these intercalary veins are sometimes so long that they nearly reach the CuA. Also, veins in that area are tenuous and venation is difficult to elucidate.

For of all the above reasons we propose the synonymy of the species of the genus *Chaquihua*, the name *Chaquihua bullocki* prevailing by nominal priority.

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