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A new species of planthopper in the genus *Tico* (Hemiptera: Auchenorrhyncha: Derbidae) on palms from lowland tropical rainforest in Costa Rica

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Abstract

Recently, the genus *Tico* Bahder & Bartlett was described as part of ongoing research focused on planthopper diversity on palms in Costa Rica to accommodate two new species and the transfer of one species from *Cenchrea* Westwood. Herein, a new species of *Tico* is described from palms and *Heliconia* spp. at the La Selva Biological Station in Costa Rica. Placement of the novel taxon is supported by molecular analysis of the cytochrome *c* oxidase subunit I (COI) gene and 18S rRNA gene.

Key words: Derbidae, Costa Rica, planthopper, new species, Cenchreini

Resumen

Como resultado de una investigación en curso enfocada en la diversidad de chicharritas en palmeras de Costa Rica, recientemente se describió el género *Tico* Bahder & Bartlett para acomodar dos nuevas especies y la transferencia de una especie de *Cenchrea* Westwood. En el presente documento se describe una nueva especie de *Tico* encontrada en palmeras y *Heliconia* spp. en la Estación Biológica La Selva en Costa Rica. La clasificación del nuevo taxón está respaldada por el análisis molecular del gen de la subunidad I (COI) del citocromo *c* oxidasa y del gen 18S ARNr.

Palabras clave: Derbidae, Costa Rica, chicharrita, especies nueva, Cenchreini

Introduction

Tico Bahder & Bartlett is a recently described genus of three species: *T. emmettcarri* Bahder & Bartlett, *T. pseudosororius* Bahder & Bartlett, and *T. sororius* (Fennah) (Bahder *et al*. 2021a). This genus is similar to *Cenchrea* Westwood, but differences in DNA sequence data and morphology of the terminalia, compared to *Cenchrea dorsalis* Westwood (the type species of *Cenchrea*), led to the placement of these species into a new genus. The general features of *Tico* are that they are small cenchreines (~3 mm), with moderately compressed frons (lacking a median

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carina) and foliately keeled lateral carinae bearing sensory pustules; vertex with an apical transverse carina; pronotum (from lateral view) anteriorly declinate, forewing with the ScP branch preceding apex of clavus (resulting in a long marginal cell); and the ventral margin of the pygofer opening, lacking a median projection. However, *Tico* is also characterized as being "pale … with variably marked, clear wings (Bahder *et al*. 2021a: 371), a characterization that is contraindicated by the new species considered here.

Both *T. emmettcarri* and *T. pseudosororius* were discovered during survey work aimed at understanding planthopper diversity on palms but were collected on *Asplundia* (Cyclanthaceae), which had been mistaken for a palm in the field. During the same survey, another small planthopper was collected from palm seedlings in primary growth, lowland tropical rainforest. Upon closer examination, the specimens were found to represent a new species of *Tico,* despite being a dark species with deeply colored wings.

Herein, the novel taxon is described with accompanying molecular data for the cytochrome *c* oxidase subunit I (COI) gene and 18S rRNA gene to test the generic placement of the new species. An updated key is provided for members of the genus *Tico*.

Materials and methods

Locality and Specimen Collection. Individuals of the novel taxon were collected by sweeping palm seedlings along trails at La Selva Biological Station, Heredia Province, Costa Rica (10.431269, -84.005961). Specimens were aspirated and transferred to 95% ethanol in the field while still alive. Specimens were collected under permit no. SINAC-ACTo-GASPPNI-016-2018, exported under permit number DGVS-256-2018 to the U.S.A. and imported under permit number P526-170201-001. All specimens collected were measured, photographed, and dissected using a Leica M205 C stereoscope. Images of specimens and all features photographed were generated using the LAS Core Software v4.12. Voucher specimens, including primary types, are stored at the University of Florida—Fort Lauderdale Research and Education Center (FLREC) in Davie, and the Florida State Collection of Arthropods (FSCA) in Gainesville, FL, U.S.A.

Morphological terminology and identification. Morphological terminology generally follows that of Bartlett *et al*. (2014), except forewing venation following Bourgoin *et al*. (2015) and with male terminalia nomenclature modified after Bourgoin (1988) and Bourgoin & Huang (1990). New taxa are intended to be attributed to Bahder & Bartlett.

Dissections and DNA Extraction. The terminalia that was dissected also served as the source of tissue for DNA extraction. The terminal end of the abdomen was removed and placed into a solution of tissue lysis buffer (buffer ATL) and proteinase K (180 µl ATL and 20 µl proteinase K) from the DNeasy® Blood and Tissue Kit (Qiagen). The abdomen was left to lyse for 24 hours at 56°C. Following lysis, the eluate was transferred to a new 1.5 ml microcentrifuge tube and DNA extraction proceeded as per the manufacturer's instructions. The terminalia were then immersed in 200 µl of buffer ATL and 200 µl of buffer AL from the same kit and placed at 95°C for 24 hours to remove fat, wax, and residual tissue. The cleared genitalia was then used for morphological characterization and photography.

PCR Parameters, Sequence Data, and Analysis. Primers to amplify COI and 18S loci are presented in Table 1. PCR reactions contained 5x GoTaq Flexi Buffer, 25 mM $MgCl_2$, 10 mM dNTP's, 10 mM of each primer, 10% PVP-40, and 2.5U GoTaq Flexi DNA Polymerase, 2 µl DNA template, and sterile dH_20 to a final volume of 25 µL. Thermal cycling conditions for COI were as follows: 2 min initial denaturation at 95°C, followed by 35 cycles of 30-sec denaturation at 95°C, 30-sec annealing at 40°C, 1 min 30-sec extension at 72°C, followed by a 5 min extension at 72°C. Thermal cycling conditions for 18S were as follows: 2 min initial denaturation at 95°C, followed by 35 cycles of 30-sec denaturation at 95°C, 30-sec annealing at 50°C, 2 min extension at 72°C, followed by a 5 min extension at 72°C. PCR products of the appropriate size were purified using the Exo-SAP-IT™ PCR Product Cleanup Reagent (ThermoFisher Scientific, Waltham, Massachusetts, USA). Purified PCR product was quantified using a NanoDropLite spectrophotometer (ThermoFisher Scientific, Waltham, Massachusetts, USA) and sent for sequencing at Eurofins Scientific (Louisville, KY, USA). Contiguous files were assembled using DNA Baser (Version 4.36) (Heracle BioSoft SRL, Pitesti, Romania), aligned using Clustal*W* as part of the package MEGA7 (Kumar *et al.* 2016). A matrix of pairwise differences using the number of differences among COI and 18S was calculated with MEGA7 (Kumar *et al.* 2016). The bootstrap method was used for variance estimation at 1,000 replicates and

using the p-distance model. Maximum Likelihood trees were generated using the Bootstrap method at 1,000 replicates based on the Tamura-Nei model for both the COI and 18S loci separately as well as one based on concatenated data forming a consensus tree between COI and 18S.

TABLE 1. Primers used to obtained molecular data for selected loci of novel taxon.

Primer Name	Gene	Direction	Sequence (5'→3')	Reference
LCO1490	COI	Forward	GGTCAACAAATCATAAAGATATTG	Folmer *et al.* 1994
HCO2198	COI	Reverse	ACTTCTGGATGACCAAAAAATCAA	Folmer *et al.* 1994
18S Fulfwd1	18S	Forward	GGATAACTGTGGTAATTCTAG	Urban & Cryan 2007
18SR	18S	Reverse	GTCCGAAGACCTCACTAAA	Bahder *et al.* 2019

Taxon sampling. The generic placement of the novel taxon was assessed based on 18S and COI data available for Cenchreini (Table 2). For constructing phylogenies, eight species of *Omolicna* Fennah, four species of *Agoo* Bahder & Bartlett, two species of *Tico* Bahder & Bartlett, *Anchimothon dubia* (Caldwell), *Oropuna halo* Bahder & Bartlett (in Bahder *et al*. 2021b), *Herpis soros* Bahder & Bartlett (in Bahder *et al*. 2021c), *Cenchrea dorsalis*, and *Neocenchrea heidemanni* (Ball) were used for both COI and 18S data. *Anotia firebugia* Bahder & Bartlett (Otiocerini; Barrantes *et al*., 2020) was used as an outgroup to polarize the Cenchreini. For pairwise comparisons, only genera with multiple species available were included (*Agoo*, *Omolicna*, and *Tico*) to assess intra- and intergeneric levels of variability based on three randomly selected taxa from each genus.

TABLE 2. Representative Cenchreini used for morphological and molecular comparisons.

			GenBank Accession No.	
Species	**Source**	**Locality**	**COI**	**18S**
Agoo beani	FLREC	Jamaica	MT413388	MT415403
Agoo dahliana	FLREC	Costa Rica	MN496467	MH472754
Agoo luzdenia	FLREC	Costa Rica	MT085818	MN999709
Agoo xavieri	FLREC[1]	Costa Rica	MK443068	MK443073
Omolicna brunnea	FLREC	Costa Rica	MK443070	MK443071
Omolicna mariajosae	FLREC	Costa Rica	MT422534	MT424915
Omolicna cubana	FLREC	Jamaica	MT413386	MT415404
Omolicna joi	FLREC	U.S.A., FL	KF472312	MN472753
Omolicna latens	FLREC	Costa Rica	MN496472	MN472757
Omolicna puertana	UPR[3]	U.S.A., PR	MN496468	MN472751
Omolicna tarco	FLREC	Jamaica	MT422533	MT424914
Omolicna triata	FLREC	Costa Rica	MK443069	MK443072
Oropuna halo	FLREC	Costa Rica	MZ836006	MZ828126
Cenchrea dorsalis	UD	St. Vincent	MT413387	MN472756
Anchimothon dubia	FLREC	Costa Rica	MN496470	MN474755
Herpis soros	FLREC	Costa Rica	MT085817	MT415406
Neocenchrea heidemanni	UD	U.S.A., DE	MN496473	MT415406

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TABLE 3. Pairwise comparison for the COI gene based on 1,000 bootstrap replications using the p-distance method; numbers on bottom left=percent difference, numbers in upper right=standard error, blue cells=intrageneric variability, orange cells=intergeneric variability.

		1	2	3	4	5	6	7	8	9
1	*Tico sierra* **sp. n.**		0.014	0.015	0.017	0.017	0.019	0.017	0.017	0.018
2	*Tico emmettcarri*	0.130		0.016	0.017	0.017	0.018	0.017	0.017	0.019
3	*Tico pseudosororius*	0.137	0.143		0.018	0.018	0.018	0.018	0.017	0.018
4	*Agoo xavieri*	0.196	0.185	0.189		0.016	0.017	0.019	0.017	0.019
5	*Agoo dahliana*	0.178	0.189	0.183	0.148		0.017	0.019	0.018	0.019
6	*Agoo luzdenia*	0.213	0.187	0.178	0.167	0.174		0.018	0.018	0.019
7	*Omolicna brunnea*	0.176	0.180	0.191	0.224	0.215	0.202		0.016	0.017
8	*Omolicna cubana*	0.187	0.180	0.196	0.202	0.198	0.193	0.152		0.017
9	*Omolicna joi*	0.202	0.217	0.213	0.252	0.230	0.237	0.163	0.178	

TABLE 4. Pairwise comparison for the 18S gene based on 1,000 bootstrap replications using the p-distance method; numbers on bottom left=percent difference, numbers in upper right=standard error, blue cells=intrageneric variability, orange cells=intergeneric variability.

		1	2	3	4	5	6	7	8	9
1	*Tico sierra* **sp. n.**		0.003	0.004	0.007	0.007	0.007	0.009	0.009	0.009
2	*Tico emmettcarri*	0.010		0.003	0.007	0.007	0.007	0.009	0.009	0.009
3	*Tico pseudosororius*	0.016	0.011		0.007	0.007	0.007	0.008	0.009	0.009
4	*Agoo xavieri*	0.066	0.064	0.066		0.003	0.003	0.008	0.008	0.008
5	*Agoo dahliana*	0.068	0.064	0.067	0.011		0.003	0.008	0.008	0.008
6	*Agoo luzdenia*	0.064	0.061	0.064	0.011	0.012		0.008	0.008	0.008
7	*Omolicna brunnea*	0.104	0.104	0.102	0.102	0.103	0.105		0.002	0.002
8	*Omolicna cubana*	0.105	0.105	0.106	0.103	0.104	0.106	0.007		0.003
9	*Omolicna joi*	0.106	0.106	0.106	0.102	0.104	0.106	0.007	0.009	

Systematics

Family Derbidae Spinola 1839

Subfamily Derbinae Spinola 1839

Tribe Cenchreini Muir 1913

Genus *Tico* Bahder & Bartlett 2021a

Type species: *Tico emmettcarri* Bahder & Bartlett 2021a, by original designation.

Amended Diagnosis. Small (~2.5–3.0 mm), cenchreine derbids. Frons moderately compressed (length at midline about 4x dorsal width), median carina absent, lateral carinae foliately keeled, bearing a row of sensory pustules. Vertex roughly triangular or trapezoidal, widest posteriorly, disc concave, lateral margins keeled (bearing pustules), with transverse carinae near fastigium. Forewing with ScP branch preceding apex of clavus (resulting in a long marginal cell; this cell short in *Cenchrea dorsalis*). Pygofer opening with distinct lateral expansions (not processes, viz. *Cenchrea* in Fennah 1952 figs 10A, E), medioventral margin of opening without lobe. Gonostyli long and spatulate, apex rounded, with a medially directed dorsal lobe near midlength. Aedeagus nearly bilaterally symmetrical, lacking projections on shaft, except apically, terminating in retrorse endosoma and complex array of processes. Anal tube elongate, in lateral view ventral margin weakly concave, apex inflected downward, apex truncate; in dorsal view broadly spatulate.

Distribution. Costa Rica, Trinidad, Venezuela (Fennah 1952, Bahder *et al*. 2021a).
Plant associations. *Asplundia* sp. (Cyclanthaceae).

FIGURE 1. Habitat where specimens of the novel taxon were collected.

Key to the species of *Tico*

1. Body brownish orange to fuscous (Fig. 2), forewings dark, reddish, legs pale . . . . . *T. sierra* **sp. n.**
1. Body pale (body yellowish-white; Bahder *et al*. 2021a, figs 4, 12), wings clear except for varied fuscous to black markings . 2
2. Forewing with a black spot at base (in clavus) and 4 large blacks spots distally along trailing margin (dorsal portion of wing when in repose; Bahder *et al*. 2021a fig. 14, Fennah 1952 fig 11G); head with dark marking anterior to eyes (Bahder *et al*. 2021a fig. 13C) 3
-. Forewing without a black spot in clavus or series of 4 dark spots along trailing margin, markings limited to well-separated single spots (including one in costal cell, one near fork of CuA, and one in cell C3, proximad of an intramedial crossvein; head in front of eyes pale . . . . . *T. emmettcarri*
3. Ventral processes of first gonapophysis of ovipositor not twisted (Fennah 1952 fig 11H), apex of the dorsal process angled dorsad, bifid; pregenital plate pyramid-shaped (Fennah 1952 fig 11K) . . . . . .*T. sororius*
-. Ventral processes of first gonapophysis twisted into near-helix (Bahder *et al*. 2021a, fig. 19B), apex of the dorsal process not bifid, hooked anteriorly; pregenital plate spade-shaped (Bahder *et al*. 2021a, fig. 19A) . . . . . *T. pseudosororius*

Tico sierra Bahder & Bartlett sp. n.

(Figures 2–6)

Type locality. Costa Rica, Heredia, La Selva Biological Station.

Diagnosis. Distinguished from congeners by the red-tinted fuscous coloration over most of body and wings (but venter and legs pale). Pygofer with lateral margins of opening posteriorly expanded. Aedeagal shaft with dorsal process and pair of ventral serrated flanges. Gonostyli with sclerotized process on inner margin (near midlength) and pair of processes on dorsal margin (proximal process short and sclerotized, distal elongate, arched anteriorly). Anal tube with ventrodistal portion narrow and elongate (not broadened).

Description. *Color*. General body brownish-orange (thorax) to fuscous (abdominal terga) with red tint (Fig. 2); ventral portion of thorax (including legs) and abdomen ivory, clypeus fuscous dorsad, fading to testaceous yellow ventrad after midlength (Fig. 3). Antennae whitish (tinged pink around flagellum). Nota of pro- and mesothorax (in dorsal view) orangish tan, margined with red; paranota (lateral view) paler ventrally. Forewings fuscous with red veins, more strongly tinted red on leading and apical margins, clear patches along wing margin at apex of RA, $RP_{2,}$ and between MP_4 and CuA (Fig. 4).

FIGURE 2. Adult male habitus *Tico sierra* **sp. n.**; A) body lateral view and B) body dorsal view, scale = 1 mm.

Structure. Body length (without wings) 1.51–1.52 mm (males), 1.60–1.62 mm (females) (Table 5). Head. In lateral view rounded (with slight hump marking transverse suture at fastigium) (Fig. 3A). In dorsal view, vertex trapezoidal, posterior margin truncately concave, lateral margins converging to weakly convex, transverse carina, vertex slightly more than 2X as wide on posterior margin as long at midlength; lateral carinae foliately keeled bearing single row of pits, disc strongly concave relative to keeled lateral carinae (Fig. 3B). In frontal view, transverse carina at fastigium distinct; lateral margins of frons foliately keeled, nearly parallel, converging slightly below eyes, expanding to frontoclypeal suture, a single row of pits running length of lateral margins, median carina absent (Fig. 3C). Frontoclypeal suture weakly arched (concave ventrally). Lateral ocelli distinct below eyes. Antennae short, posterior to eyes, scape very short, pedicel ovoid, bearing numerous sensillae and an elongate flagellum with bulbous base.

Thorax. Pronotum (dorsal view, Fig. 3B) at midline about ¾ length of vertex, anterior margin following contour of head, medially truncate behind vertex; posterior margin moderately concave; distinctly tricarinate (lateral carinae laterally arched, reaching hind margin or nearly so); in lateral view (Fig. 3A), posterior margin of pronotum raised, anteriorly declining; paradiscal regions broadly foliate, forming cup-like fossa surrounding antennae posteriorly

(Fig. 3A, a tribal feature), in frontal view, foliations broadly exceeding antennae, appearing rounded (Fig. 3C). Forewing (Fig. 4) with apex of clavus near forewing midlength, fused vein Pcu+A1 reaching wing margin distantly proximad to CuP apex. Fork of R somewhat preceding claval apex, fork of CuA proximad of R fork (cell C5 longer than C1); composite vein M+R+ScP forming elongate stem from basal cell before branching of MP from ScP+R. Branching pattern: RA 1-branched, RP 2-branched (RP_{1+2} and RP_{3+4}), MP 4-branched (a forked MP_1 plus MP_2 and MP_{3+4}; given in error as MP_1, MP_2, MP_3, and MP_4 in Bahder *et al*. 2021a fig. 6), CuA 2 branched (forming cells C5 and C5' by icua crossvein and icu forming marginal C6 cell).

TABLE 5. Biometric data for type material of *Tico sierra* **sp. n.**

	Male		Female	
Character	Range	Average ± SE	Range	Average ± SE
Body length, with wings	2.51–2.52	2.52±0.01	2.56–2.58	2.57±0.02
Body length, no wings	1.50–1.51	1.51±0.01	1.60–1.61	1.61±0.01
Forewing length	2.20–2.21	2.20±0.01	2.26–2.27	2.26±0.01
Vertex length	0.11–0.12	0.12±0.01	0.12–0.12	0.12±0.00
Vertex width, basal margin	0.22–0.22	0.22±0.00	0.22–0.22	0.22±0.00
Vertex width, distal margin	0.95–0.95	0.95±0.00	0.95–0.95	0.95±0.00
Pronotum length, midline	0.10–0.10	0.10±0.00	0.10–0.10	0.10±0.00
Mesonotum length, midline	0.41–0.41	0.41±0.00	0.41–0.42	0.42±0.01
Mesonotum width	0.53–0.54	0.53±0.01	0.54–0.54	0.54±0.00
Frons width, dorsal margin	0.95–0.95	0.95±0.00	0.95–0.95	0.95±0.00
Frons width, clypeal suture	0.17–0.17	0.17±0.17	0.17–0.17	0.17±0.00
Frons width, widest	0.17–0.17	0.17±0.17	0.17–0.17	0.17±0.00
Frons width, narrowest	0.09–0.09	0.09±0.00	0.09–0.09	0.09±0.00
Frons length, midline	0.34–0.34	0.34±0.00	0.35–0.35	0.35±0.00
Clypeus length	0.23–0.23	0.23±0.23	0.23–0.23	0.23±0.23

Terminalia. Pygofer in lateral view irregularly sinuate on anterior and posterior margins, wide dorsally, broadening near midlength, then narrowing to form large rounded projections on posterior margin (i.e., forming lateral projections of pygofer opening); a rounded tooth just on reclining face of posterior margin; lateral face of pygofer having appearance of a diagonal fold on medial portion (a similar structure evident in *Tico emmettcarri*, but less evident in *T. pseudosororius*, Bahder *et al*. 2021a, figs. 7A and 15A respectively), and appearing weakly sclerotized. In ventral view, medioventral process of pygofer opening absent (slightly invaginated at ventral midline, Fig. 5B). Gonostyli in lateral view with angular projection at base, sinuate on ventral margin, distal end curving dorsad to semitruncate apex with slight invagination, dorsal margin with large, irregular process comprised of a smaller, sclerotized nodule at anterior end and longer, slender, pale process curved cephalad (Fig. 6A); in ventral view, expanded at base, constricting to narrowest point at 1/3 length, expanding to widest region at 2/3 length, narrowing to pointed apices curving mesad (Fig. 5B); inner face with sclerotized, crescent-shaped process near midlength (Fig. 6B). Aedeagus approximately bilaterally symmetrical, without processes along shaft (except subapically), shaft bearing rows of irregular serrations on weak flange ventrally and on middorsal projection (Figs 7A, 7B); apex with two pairs of elongate dorsal subapical processes, outer pair (A1 & A2) longer, twisted and robust, inner pair (A3 & A4) shorter, more slender, and not twisted; endosoma complex, with four pairs of processes, first (E1 & E2) dorsalmost, wide, flattened, auriform, and shortest of endosomal processes; second (E3 & E4) moderately long (exceeding A1 & A2) and angled dorsomediad, third (E5 & E6) about equal in length to E3 & E4, situated on lateral margin of endosoma, curved dorsoventrad; fourth (E7 & E8) longest, ventral-most, nearly reaching base of aedeagus (Fig. 7). Anal tube, in lateral view, expanding distally, roughly triangular, elongate, reaching gonostyli apices, ventral margin weakly convex, distally projected, apex truncate (Fig. 5A), in dorsal view spatulate (expanded distally), apex truncate (Fig. 5C).

Plant associations. Palm seedlings (Arecaceae); also swept off *Heliconia* L. (Heliconiaceae).

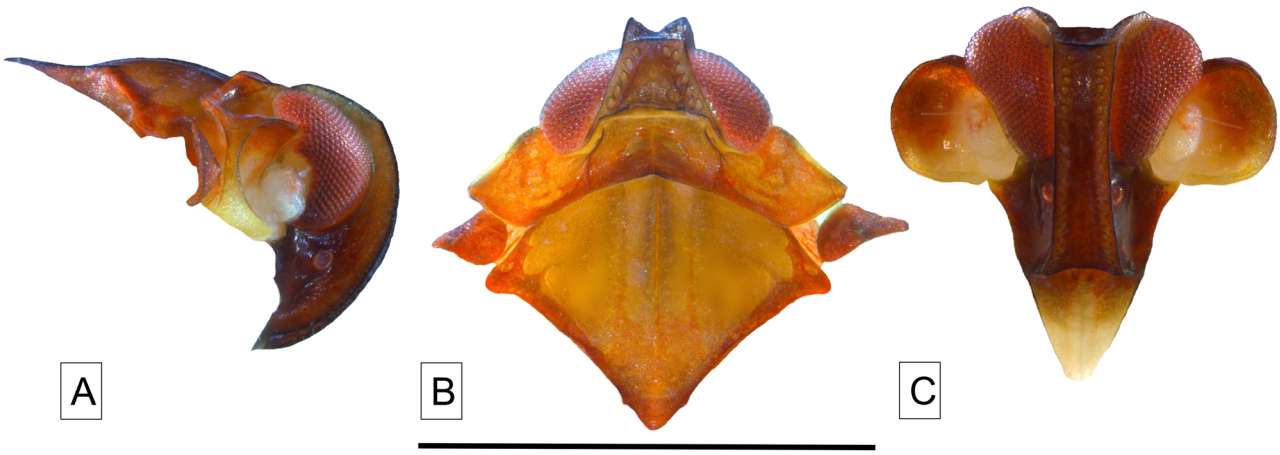

FIGURE 3. Adult male *Tico sierra* **sp. n.**; A) head, pronotum, and mesonotum right lateral view, B) head, pronotum, and mesonotum dorsal view, and C) head and paranotal fovea frontal view, scale = 1 mm.

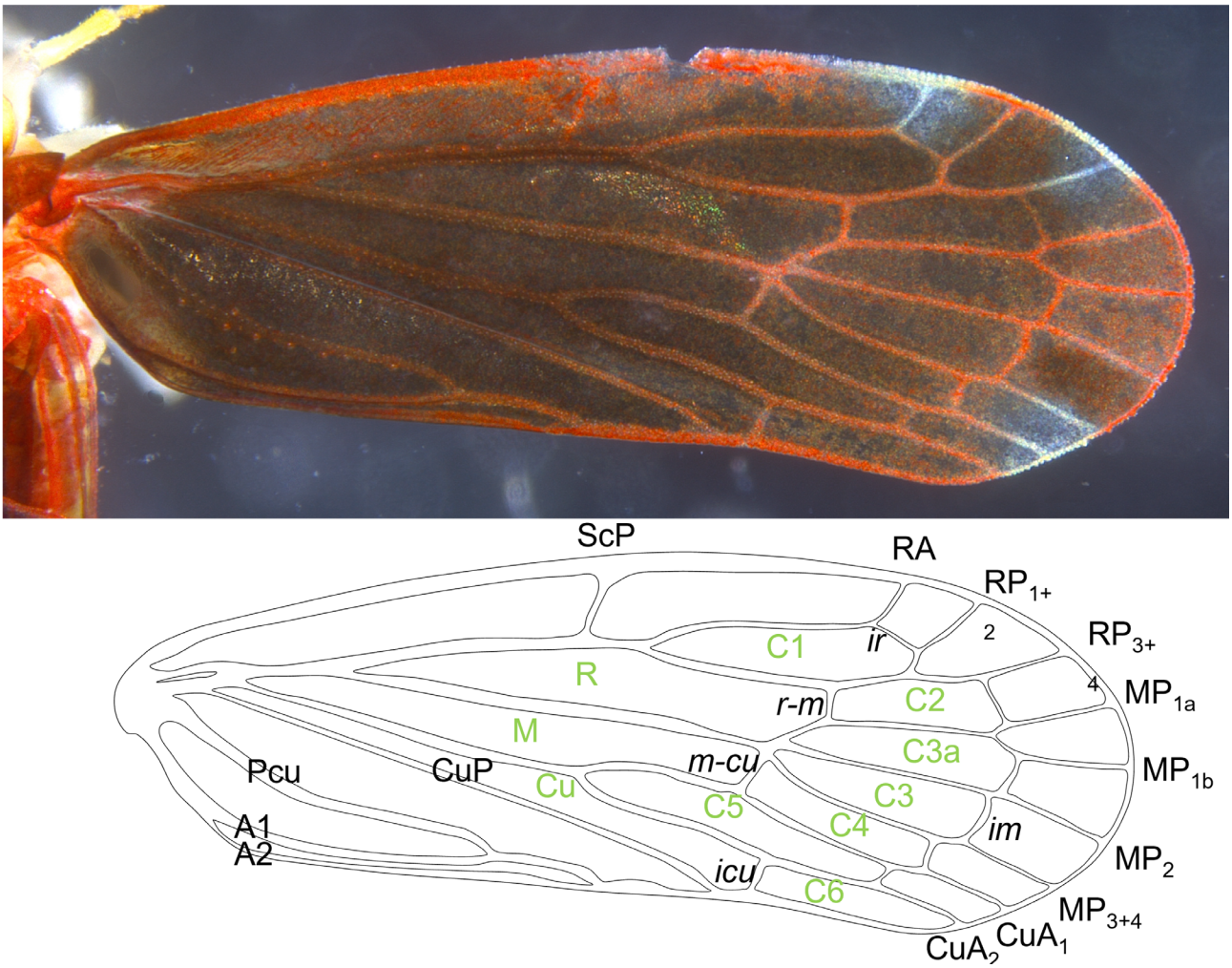

FIGURE 4. Male *Tico sierra* **sp. n.** wing venation; black = vein, italics = crossvein, green = cell.

Distribution. Costa Rica (Heredia).

Etymology. The specific name refers to the serrations on the aedeagus, a feature not observed in other *Tico* with the term '*sierra*' Spanish for a saw. The specific name is intended as indeclinable.

Material examined. Holotype male "Costa Rica, Heredia / La Selva Biological Station / 15.V.2018 / Coll.: B.W. Bahder, sweeping palms / Holotype *Tico sierra* ♂" (FLREC); paratypes same as holotype (3 males, 2 females, FLREC and FSCA).

Sequence Data and Analysis. For the COI gene, a 632 bp product was generated (GenBank Accession No. OK575934) for *Tico sierra* **sp. n.** The phylogenetic analysis (Fig. 8A) demonstrated moderate bootstrap support (79) for the genus *Tico* with *T. sierra* **sp. n.** resolving adjacent to *T. emmettcarri* with that clade sister to *T. pseudosororius*. The mean variability within *Tico*, *Agoo*, and *Omolicna* is 13.7% (±0.3), 16.3% (±0.8), and 16.4% (±0.8), respectively while the mean variation among genera is 20% (±0.0).

For the 18S gene, a 1,329 bp product was generated (GenBank Accession No. OK577947) for *Tico sierra* **sp. n.** The phylogenetic analysis (Fig. 8B) demonstrated strong bootstrap support (99) for the genus *Tico* with the arrangement of *Tico* species the same as for COI.

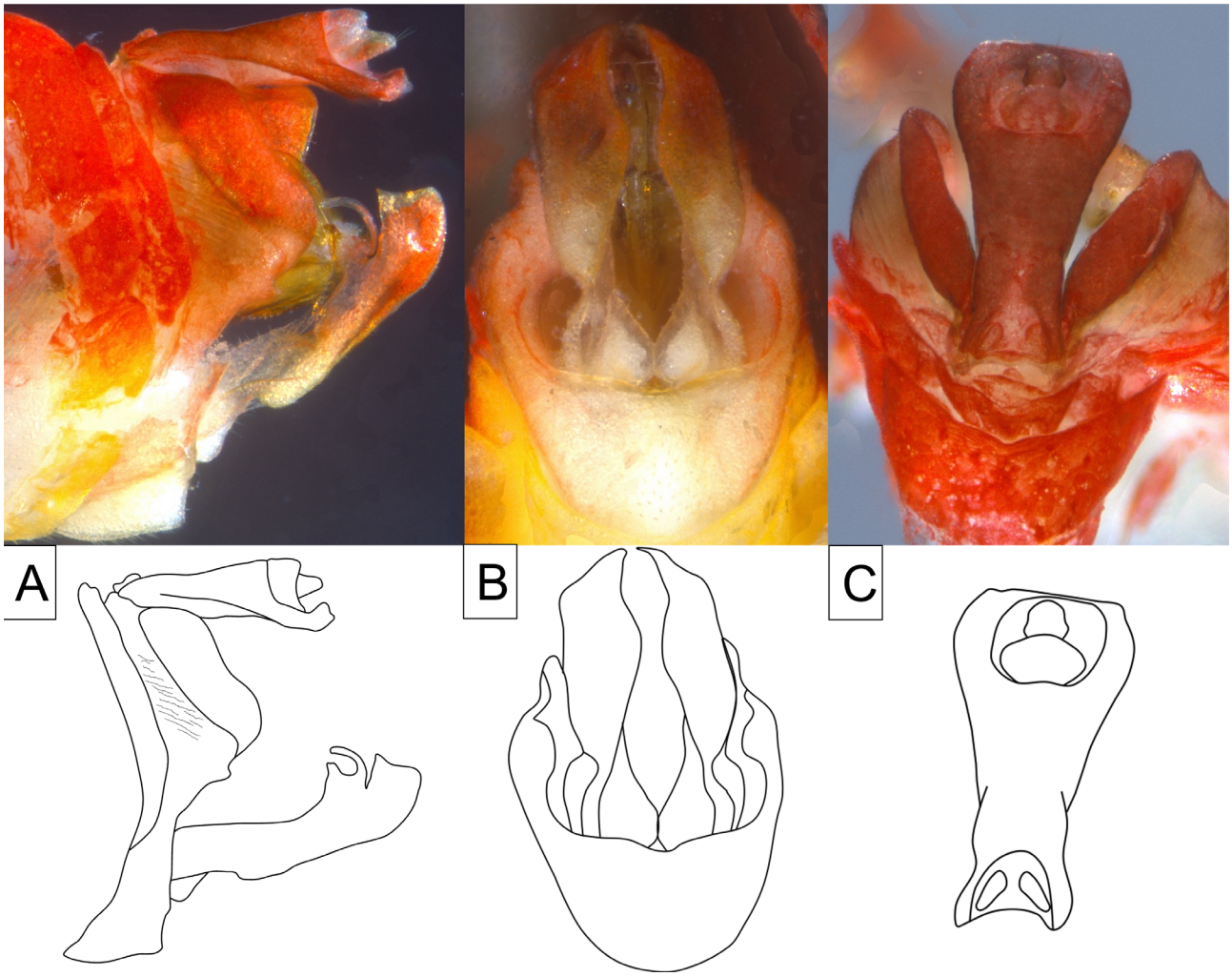

FIGURE 5. Male *Tico sierra* **sp. n.** terminalia; A) left lateral view, B) ventral view, and C) dorsal view.

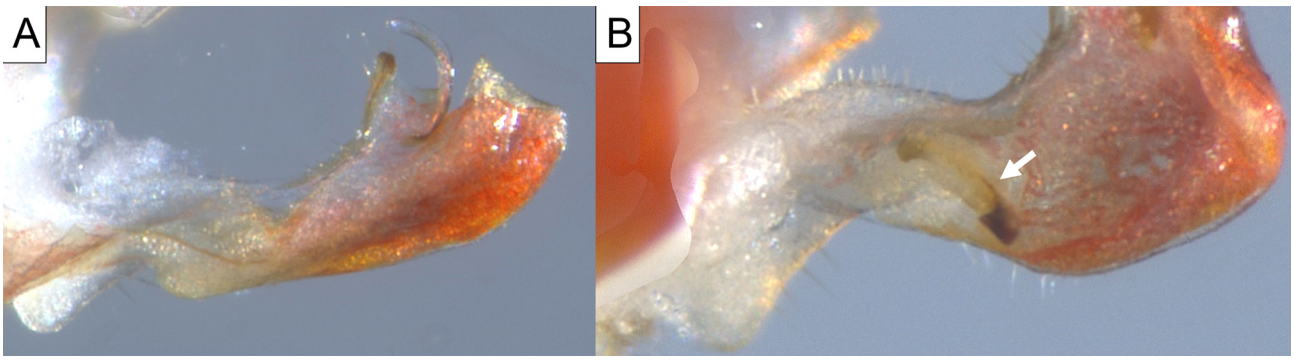

FIGURE 6. Male *Tico sierra* **sp. n.** gonostylus; A) outer lateral view and B) inner margin showing sclerotized process.

The consensus tree (Fig. 8C) supports placement of the novel taxon in the genus *Tico*. The mean variability within *Tico*, *Agoo*, and *Omolicna* is 1.2% (±0.2), 1.1% (±0.0), and 0.7% (±0.1), respectively while the mean variation among genera is 9.1% (±0.4). The combined tree supports *Tico* as monophyletic, with the arrangement of species the same as presented for the individual genes.

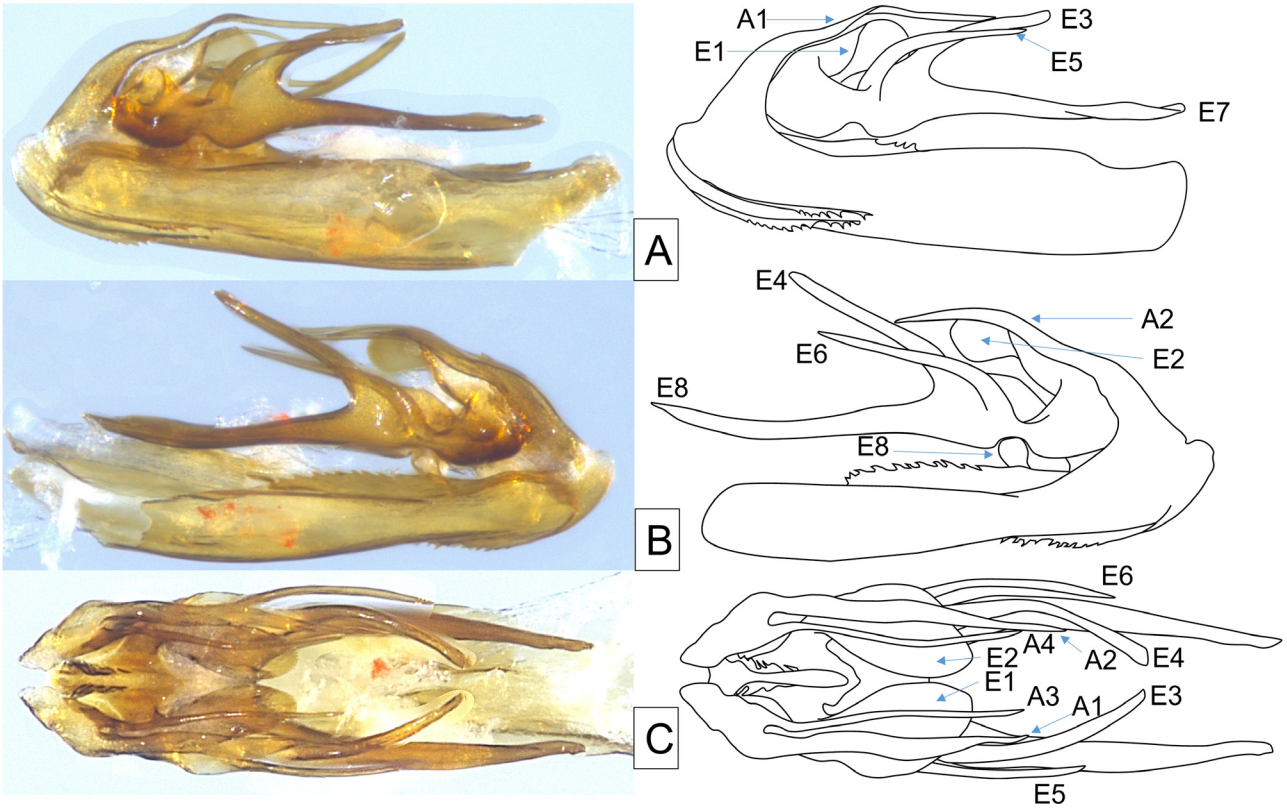

FIGURE 7. Aedeagus of *Tico sierra* **sp. n.**: A) right lateral view, B) left lateral view, and C) dorsal view; A = aedeagal process, E = endosomal process.

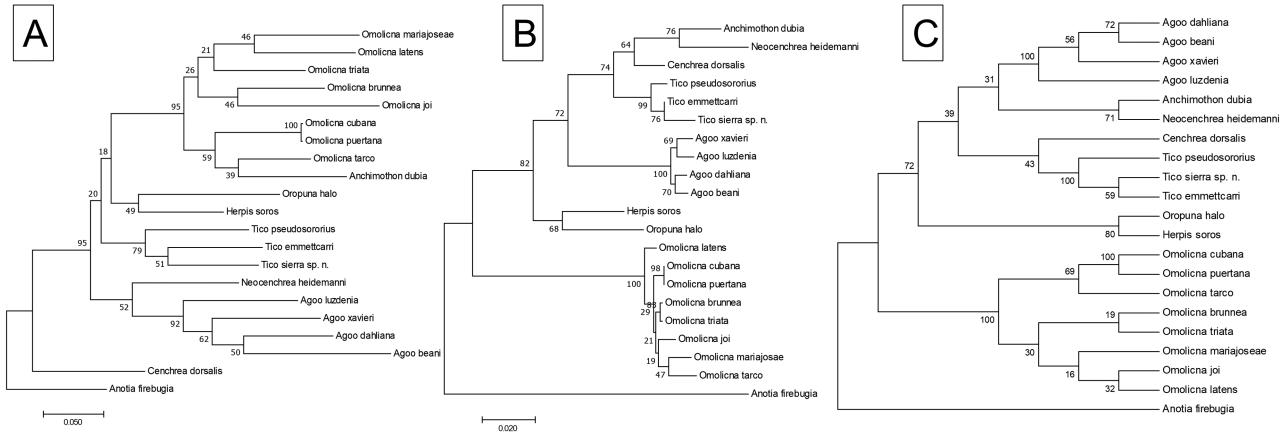

FIGURE 8. Maximum Likelihood phylogenetic tree based on 1,000 replicates: A) COI gene, B) 18S gene, and C) consensus of concatenated COI and 18S sequences.

Remarks. Both molecular and morphological evidence supports the placement of the novel taxon in *Tico*, however, the coloration of this species sets it apart from its congeners. The three previously described species (*Tico emmettcarri*, *T. pseudosororius,* and *T. sororius*) are all pale with predominately clear wings bearing varied markings; whereas *Tico sierra* **sp. n.** is a dark species (except ventrally) with deeply red-infuscate forewings. In addition, the presence of serrations along the dorsal and ventral margin of the aedeagus is unique. Aside from color, the structure of the head, forewing venation, and male terminalia are all fundamentally comparable to the three previously described species.

For both COI and 18S, the amount of variability that *Tico sierra* **sp. n.** exhibits relative to *T. emmettcarri* and *T. pseudosororius* is consistent with intrageneric variability assessed in this study for *Agoo* and *Omolicna*. Additionally, photographs of this species were taken from various species of *Heliconia* at the same location the type material was collected. The collection of *T. emmettcarri* and *T. pseudosororius* from a non-palm host and the association of *Tico sierra* **sp. n.** with both palms and non-palm monocots may indicate that members of *Tico* are not strict palm feeders.

Discussion

Tico sierra **sp. n.** is unlike other *Tico* in that it has a generally dark body and wings, although the pale venter and legs may suggest that the species is derived from paler ancestors. Available molecular data (COI, 18S) suggest that *Tico* is monophyletic (Fig. 8), as are *Omolicna* and *Agoo*, and may be sister to *Cenchrea*, but the relationships among the genera are not consistent between the individual genes and the combined data with weak support values along the spine, suggesting that additional data and taxonomic sampling are needed. The missing New World genera are *Persis* Stål (which includes 3 subgenera), the monobasic *Cenanges* Fennah, and five included genera are represented by single species.

While *Tico sierra* **sp. n.** was found associated with palm seedlings, the genus as a whole appears to be associated with broad-leaf monocots. Of the described species, only *T. sierra* **sp. n.** appears to be associated with palms (Arecaceae), but this species was also found on *Heliconia* (Heliconiaceae), with *T. emmettcarri,* and *T. pseudosororius* associated with *Asplundia* (Cyclanthaceae), all broad-leaf monocots. While the main target of the current survey work is to document palm-associated planthoppers, especially those in the Cenchreini and Oecleini (Cixiidae), this focus will underestimate planthopper diversity in the Caribbean basin because of the targeted nature of the sampling.

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References

Bahder, B.W., Bartlett, C.R., Barrantes, E.A.B, Echavarria, M.A.Z., Humphries, A.R., Helmick, E.E., Ascunce, M.S. & Goss, E.M. (2019) A new species of *Omolicna* (Hemiptera: Auchenorrhyncha: Fulgoroidea: Derbidae) from coconut palm in Costa Rica and new country records for *Omolicna brunnea* and *Omolicna triata*. *Zootaxa*, 4577 (3), 501–514. https://doi.org/10.11646/zootaxa.4577.3.5

Bahder, B.W., Echavarria, M.A.Z., Barrantes, E.A.B., Helmick, E.E. & Bartlett, C.R. (2021a) A new genus and two new species of planthopper in the tribe Cenchreini (Hemiptera: Auchenorrhyncha: Derbidae) from lowland tropical rainforest in Costa Rica. *Zootaxa*, 4908 (3), 369–392. https://doi.org/10.11646/zootaxa.4908.3.3

Bahder, B.W., Echavarria, M.A.Z., Barrantes, E.A.B., Helmick, E.E. & Bartlett, C.R. (2021b) A new species of planthopper from Costa Rica in the genus *Oropuna* from palms in lowland tropical rainforest. *Zootaxa*, 5081 (1), 116–130. https://doi.org/10.11646/zootaxa.5081.1.4

Bahder, B.W., Echavarria, M.A.Z., Barrantes, E.A.B., Helmick, E.E. & Bartlett, C.R. (2021c). A new species of planthopper in genus *Herpis* (Hemiptera: Derbidae) from lowland tropical rainforest in Costa Rica. *Zootaxa*, 5032 (1), 121–135. https://doi.org/10.11646/zootaxa.5032.1.7

Barrantes, E.A., Echavarria, M.A.Z., Bartlett, C.R., Helmick, E.E., Cummins, P.P., Ascunce, M.S. & Bahder, B.W. (2020) A new species of planthopper in the genus *Anotia* Kirby (Hemiptera: Auchenorrhyncha: Derbidae) from coconut palm in Costa Rica. *Zootaxa*, 4763 (1), 50–60. https://doi.org/10.11646/zootaxa.4763.1.4

Bartlett, C.R., O'Brien, L.B. & Wilson, S.W. (2014) A review of the planthoppers (Hemiptera: Fulgoroidea) of the United States.

Memoirs of the American Entomological Society, 50, 1–287.
Bourgoin, T. (1988) A new interpretation of the homologies of the Hemiptera male genitalia illustrated by the Tettigometridae (Hemiptera, Fulgoromorpha). *In*: Vidano, C. & Arzone, A. (Eds.), *Proceedings of the 6th Auchenorrhyncha Meeting, Turin, Italy, 7–11 September 1987*. Consiglio Nazionale delle Ricerche, IPRA Rome, pp. 113–120.
Bourgoin, T, & Huang, J. (1990) Morphologie comparée des genitalia mâles des Trypetimorphini et remarques phylogénétiques (Hemiptera: Fulgoromorpha: Tropiduchidae). *Annales de la Société Entomologique de France*, Nouvelle Serie, 26, 555–564.
https://doi.org/10.1002/jmor.1052070205
Bourgoin, T., Wang, R.R., Asche, M., Hoch, H., Soulier-Perkins, A., Stroinski, A., Yap, S. & Szwedo, J. (2015) From micropterism to hyperpterism: recognition strategy and standardized homology-driven terminology of the forewing venation patterns in planthoppers (Hemiptera: Fulgoromorpha). *Zoomorphology*, 134 (1), 63–77.
https://doi.org/10.1007/s00435-014-0243-6
Fennah, R.G. (1952) On the generic classification of Derbidae (Homoptera: Fulgoroidea) with descriptions of new Neotropical species. *Transactions of the Royal Entomological Society of London*, 103 (4), 109–170.
https://doi.org/10.1111/j.1365-2311.1952.tb01063.x
Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3 (5), 294–299.
Kumar, S., Stecher, G. & Tamura, K. (2016) MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution*, 33, 1870–1874.
https://doi.org/10.1093/molbev/msw054
Muir, F.A.G. (1913) On some new species of leafhoppers. Part II. Derbidae. *Bulletin of the Hawaiian Sugar Planters' Association Experiment Station. Division of Entomology, Honolulu*, 12, 28–92.
Spinola, M. (1839) Essai sur les Folgorelles, sous-tribu des Cicadaires, ordre des Rhyngotes. *Annales de la Société Entomologique de France*, 8, 133–337.
Urban, J.M. & Cryan, J.R. (2007) Evolution of the planthoppers (Insecta: Hemiptera: Fulgoroidea). *Molecular Phylogenetics and Evolution*, 42 (2), 556–572.
https://doi.org/10.1016/j.ympev.2006.08.009