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A new species of planthopper in the genus *Cobacella* (Hemiptera: Auchenorrhyncha: Derbidae) from oil palm (*Elaeis guineensis*) in Costa Rica

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Abstract

Recent survey work in Costa Rica has revealed a high diversity of planthoppers in the family Derbidae on palms (Arecaceae). During an expedition to Costa Rica in 2021, specimens were collected from African oil palm (*Elaeis guineensis*) along the pacific coast and determined to represent a new species of derbid in the genus *Cobacella*. Herein, the novel taxon, *Cobacella palmensis* **sp. n.**, is described and compared with the two other species in the genus. Supplemental molecular data for the cytochrome *c* oxidase subunit I (COI) barcoding region, 18S rRNA gene and D9-D10 expansion region of the 28S rRNA gene are provided to test the placement of the novel taxon relative to available otiocerine planthoppers. We also present a preliminary key to the species of *Cobacella* and review all available specimen records of the genus.

Key words: taxonomy, phylogeny, biodiversity, systematics, survey, Otiocerini

Resumen

Durante un reciente trabajo de investigación en Costa Rica se encontró una gran diversidad de chicharritas de la familia Derbidae en palmeras (Arecaceae). Durante un muestreo en el 2021 por la costa Pacífica del país, se recolectaron especímenes que se encontraban en palmeras aceiteras africanas (*Elaeis guineensis*) y se determinó que pertenecían a una nueva especie de dérbido del género *Cobacella*. En este documento, se describe el nuevo taxón *Cobacella palmensis* **sp. n.** y se compara con las otras dos especies del mismo género. Se proporcionan datos moleculares complementarios para la región del código de barras de la subunidad I (COI) del gen del citocromo c oxidasa, el gen 18S ARNr y la región de expansión D9-D10 del gen 28S ARNr para corroborar la ubicación del nuevo taxón en relación con los individuos disponibles pertenecientes a la subfamilia Otiocerinae. También se presenta una clave preliminar para las especies de *Cobacella* y se revisan todos los registros disponibles de especímenes pertenecientes a este género.

Palabras Clave: taxonomía, filogenia, biodiversidad, sistemática, encuesta, Otiocerini

Introduction

Cobacella Fennah 1952 (Otiocerinae: Otiocerini) currently consists of two species, *C. rubescens* (Fowler 1900) from Mexico (the type species, from Veracruz and Tabasco states) and *C. sexguttata* Fennah 1952 from Trinidad (Fowler 1900, Fennah 1952). *Cobacella* was described as a segregate out of *Otiocerus* Kirby 1821, where it was

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doubtfully placed by Fowler (1900). Among features used to differentiate the genera were the antennae and wing venation—the antennae of *Cobacella* are shorter than *Otiocerus* and lack the subantennal appendage, and the fork of RP from Sc+RA in the forewing (Sc+R in Fennah 1952) is in the basal 1/5th of the wing in *Cobacella* and near midlength in *Otiocerus*.

The tribe Otiocerini includes about 40 genera worldwide (some doubtfully placed), with 11 of these New World (Fennah 1952, Emeljanov 1996, Szwedo 2005, Bourgoin 2023). Szwedo (2005) reviewed tribal features and provided an updated key to world genera. Among New World taxa, the Otiocerini are relatively easily recognized as fragile forms with wings greatly exceeding the abdomen (more than 2.5x as long as broad), usually held parallel to the body (or somewhat laterad), head greatly compressed and distinctly projecting, clavus open (composite vein Pcu+1A reaching CuP and sometimes beyond), and hind tarsomere with more than 4 apical teeth. The genera of New World Otiocerini are imperfectly known. *Labicerus* Erichson 1848 (from Guyana, as British Guiana) has not been recorded since its original description and has been omitted from keys to genus (e.g., Fennah 1952, Szwedo 2005). Our understanding of the genera *Platocerella* Fennah 1952 and *Heronax* Kirkaldy 1906, subgenus *Homometria* Fennah 1952, are based primarily on the descriptions in Fennah (1952).

Cobacella can be diagnosed by the shape of the head (head in lateral view projecting 'moderately' beyond eyes, and apex forming a subconical curve), antennae (elongated but not reaching apex of the head), and some details of the wing venation (location of origin of MP relative to Sc+R; MP forked from Sc+R in the proximal quarter in *Cobacella*). The closest New World taxon in the key provided by Fennah (1952) is the genus *Anotia* Kirby 1821 but differs from *Cobacella* by having an angulate head apex with antennae surpassing the head apex. Additionally, Fennah (1952) noted that in the field, *Anotia* generally holds its wings slightly upward and outward while at rest whereas *C. sexguttata* was noted as holding the wings laterocaudally with apices nearly touching substrate (e.g., iNaturalist observation #151547369).

Recent survey efforts in Costa Rica have documented many new species of planthoppers on palms (Bahder *et al.* 2019, Bahder *et al*. 2020, Barrantes-Barrantes *et al.* 2021, Zumbado-Echavarria *et al.* 2022a). Most taxa discovered have belonged to the Cixiidae and Derbidae, and recently an achilid (Zumbado-Echavarria *et al.* 2022b). Both palms in disturbed habitats (primarily coconut palms—*Cocos nucifera* L.) and native/naturally occurring palms in pristine habitats have been surveyed due to renewed interest in phytoplasma vector efforts. In July of 2021 during an expedition along the southern Pacific coast of Costa Rica, a derbid planthopper was collected while sweeping African oil palm (*Elaeis guineensis* Jacq.) and subsequently determined to be a new species of *Cobacella*.

The new species is herein described with accompanying molecular data for the barcoding region (5' half) of cytochrome *c* oxidase subunit I (COI) gene and the 18S rRNA gene to further support the generic status of *Cobacella* relative to *Anotia* and other available taxa. All available specimen records of the genus are also reviewed. Finally, a key is presented to the species of *Cobacella.*

Materials and methods

Locality and specimen collection. Individuals of the novel taxon were swept from African oil palms in a production plot near an empty lot (Fig. 1) (9.533661, -84.377233) with the permission of the owner and were immediately transferred to 95% ethanol. Specimens were collected (permit no. SINAC-ACOSA-D-R-060-2021) and exported under permit number CUSBSE-659-2021 to the U.S.A. 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 of the new species, are deposited at the University of Florida—Fort Lauderdale Research and Education Center (FLREC) in Davie, FL, U.S.A and the Florida State Collection of Arthropods (FSCA) in Gainesville, FL, U.S.A. The new species was compared with images of a syntype of *Cobacella rubescens* and a specimen consistent with *Cobacella sexguttata* identified by Broomfield (both from the Natural History Museum, London; BMNH), and an undetermined *Cobacella* female at the University of Delaware Insect Research Collection (UDCC). Verifiable distribution records from iNaturalist (https://www.inaturalist.org) were noted in addition to published records in the species checklist.

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.

FIGURE 1. Locality and habitat of *Cobacella palmensis* **sp. n.**.

Dissections and DNA extraction. The male terminalia that was dissected for morphological examination also served as the source of tissue for DNA extraction. The terminal end of the abdomens was removed and placed directly 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, 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 were then used for morphological characterization and photography.

TABLE 1. Primers used to amplify loci used for assessment of *Cobacella palmensis* **sp. n.** and corresponding annealing temperatures and extension times.

Primer Name	Gene	Sequence (5'→3')	Annealing	Extension	Reference
LCO1490	COI	GGTCAACAAATCATAAAGATATTG	40˚C	1 min. 30 sec.	Folmer *et al.*
HCO2198		TCAGGGTGACCAAAAAAATCA			1994
18SACDN_F1	18S	AGAGGGAGCCTGAGAAACG	60˚C	1 min. 45 sec.	Bahder *et al.*
18SACDN_R1		GGGCAGGGACGTAATCAAC			2023
V	28S	GTAGCCAAATGCCTCGTCA	55˚C	1 min. 30 sec.	Cryan *et al.*
X		CACAATGATAGGAAGAGCC			2000

PCR parameters, Ssequence data, and analysis. Primers to amplify COI, 18S and 28S 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 were as follows: 2 min initial denaturation at 95°C, followed by 35 cycles of 30-sec denaturation at 95°C, 30-sec annealing, extension at 72°C, followed by a 5 min extension at 72°C. Annealing temperatures and extension times for corresponding primers/loci are presented in Table 1. PCR product was run on a 2% agarose gel stained with GelRed (Biotium) amplicons of the appropriate size and were purified using the Exo-SAP-IT™ PCR Product Cleanup Reagent (ThermoFisher Scientific, Waltham, Massachusetts, USA). The 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), and aligned using Clustal*W* as part of the package MEGA7 (Kumar *et al.* 2016). Maximum Likelihood trees were generated using the Bootstrap

method at 1,000 replicates based on the Tamura-Nei model for COI, 18S, and 28S loci separately as well as one based on concatenated data forming a consensus tree based on COI, 18S and 28S with MEGA7 (Kumar *et al.* 2016).

Taxon sampling. For molecular comparisons, specimens of *Shellenius ballii* (McAtee 1923), *S. schellenbergii* (Kirby 1821), and *S. serratus* Bahder & Bartlett 2023 were used. Other Otiocerinae (Otiocerini) used to construct phylogenies included *Anotia firebugia* Bahder & Bartlett, 2020, an undescribed species of *Anotia* from Costa Rica , and *Sayiana sayi* (Ball 1902). In addition, *Patara vanduzei* Ball, 1902, *P. cooki* Bahder & Bartlett, 202 (Otiocerinae: Patarini), *Mula resonans* Ball, 1928 (Otiocerinae: Sikaianini), and *Agoo xavieri* Bahder & Bartlett, 2019 (Derbinae: Cenchreini) were included to root the tree. All GenBank accession numbers are included in Table 2.

TABLE 2. Representative Otiocerinae used for morphological and molecular comparisons with *Agoo xavieri* as subfamily outgroup (Derbinae).

	Locus		
Species	COI	18S	28S (D9 to D10)
Cobacella palmensis **sp. n.**	ORO44883	ORO41765	ORO50628
Agoo xavieri	MK443068	MK443073	ORO50638
Anotia firebugia	MT084365	MT945942	ORO50636
Mula resonans	OQ473376	OQ519977	ORO50635
Patara vanduzei	OQ473377	OQ519977	ORO50633
Patara cooki	MW332651	MW333024	ORO50634
Sayiana sayi	ORO44884	ORO41766	ORO50632
Shellenius ballii	OQ473378	OQ519976	ORO50631
Shellenius schellenbergii	OQ473379	OQ519975	ORO50630
Shellenius serratus	OQ473380	OQ519974	ORO50629

Systematics

Family Derbidae Spinola 1839

Subfamily Otiocerinae Muir 1917

Tribe Otiocerini Muir 1917

Genus *Cobacella* Fennah, 1952

Type species: *Otiocerus rubescens* Fowler 1900 by original designation

Species composition

Cobacella rubescens (Fowler 1900)—Mexico (Veracruz, Tabasco)
Cobacella sexguttata (Fennah 1952)—Trinidad; Brazil (Amazonas)
Cobacella palmensis **sp. n.—**Costa Rica

Amended diagnosis. (modified from Fennah 1952). Elongate, fragile forms, ~5–9 mm in body length (incl. wings), often pale with varying degrees of reddish wash (wing veins often reddish) and posterior margin of mesonotum with row of 6 fuscous spots (sometimes obsolete). Head strongly compressed and projected in front of eyes (for a distance about equal to width of eyes in longest dimension); leading margin of head rounded in lateral view. Vertex about twice as long as broad at base; posterior margin excavate, lateral margins converging distally; disc strongly depressed, lateral carinae bearing pustules. Antennae elongate but not reaching anterior margin of head, scape wider than long, pedicle elongate, subantennal process absent. Pronotum short medially,

strongly declinate in lateral view, in dorsal view anteriorly sharply convex, posteriorly deeply angularly concave; medially carinate. Mesonotum large, about as broad as long, weakly tricarinate; posterior margin of mesoscutellum transverse, ecarinate. Forewing elongate and broadly spatulate, widest about in distal three-fifths (composite vein Sc+R+M very short), fork of CuA about on level with fusion of Pcu and A1 in clavus, clavus open, composite vein Pcu+A1 joining with CuP and CuA before reaching wing margin. Apex of forewing broadly rounded, apical cells at least twice as long as broad. Male terminalia in lateral view with pygofer narrow, irregularly quadrate, anterior and caudal margins sinuate, medioventral process absent. Gonostyli elongate, exceeding anal tube, medially cupped, in ventral view medial margins sinuate (lacking median processes). Aedeagal shaft tubular, weakly upcurved bearing varied apical or subapical sclerotized processes and membranous retrorse endosoma bearing varied sclerotized processes. Anal segment short, apical angles shortly produced lateroventrad.

Remarks. Among New World Otiocerini, *Cobacella* can be recognized by the superficial characteristics of being midsized and usually with a reddish wash, mesothorax bearing 6 fuscous spots along caudal margin (sometimes absent), head roundly produced (forward projecting, not upward), subantennal processes absent and forewings relatively broad. Fennah (1952) noted that in life they hold their wings slightly spread with the apices nearly touching the substrate (as opposed to upward and slightly spread in *Anotia*). The lack of a subantennal process distinguishes this genus from *Apache* Kirkaldy, 1901, *Otiocerus* Kirby, 1821, *Shellenius* Ball, 1928, and *Kubilaya* Koçak & Kemal, 2010 (see Fennah 1952, fig. 37A and Fennah 1945, figs 39, 40 as *Iquitosa* Fennah, 1945) and *Labicerus* Erichson, 1848 (noted as present in the description Erichson, 1848). The rounded, forward-projecting head of *Cobacella* distinguishes it from *Anotia*, *Sayiana* Ball, 1928, *Kubilaya* and *Heronax* (*Homometria*), which are subconical and upward projecting, and from *Platocerella* Fennah 1952 and *Platonax* Metcalf, 1938 which are not as strongly projecting as *Cobacella*.

Cobacella is an infrequently encountered genus and is poorly represented in institutional collections and on citizen science forums (4 putative records on iNaturalist). It appears that the species of *Cobacella* may possess sexual dimorphism (possibly differences in the projection of the head), intraspecific color variation, and may have some or all of the fuscous spots of the mesothorax obsolete. The lack of specimens in series and uncertainty in the association of males and females has made it difficult to assess intraspecific species variability.

Cobacella rubescens (Fowler) was described (as *Otiocerus* (?) *rubescens*) based on 2 syntype specimens from Mexico (Figs 9B, C, 10)*Cobacella sexguttata* was described based on a male holotype and female paratype from Trinidad. See 'Other material examined' for specifics.

Plant associations. No plant associations are reported for *Cobacella rubescens*. The holotype of *C. sexguttata* was collected "resting on leaves of wild tobacco, *Acnistus arborescens*" (Solanaceae; Fennah 1952). The new species was collected in association with African oil palm, *Elaeis guineensis* Jacq. (Arecaceae).

Etymology. The genus name is feminine in gender and appears to be formed from *Cobax* + *-ella* (diminutive suffix); *Cobax* is a derbid genus name, possibly originating from the Hungarian word '*kovács*' (blacksmith) (Dmitriev 2002).

Key to species of *Cobacella*

1. Apices of forewings shaded fuscous, contrasting with hyaline middle portion offorewing; Trinidad, Brazil. . . . . *C. sexguttata*
- Apices of forewings concolorous with remainder of wing, not contrastingly colored, hyaline or fuscous shaded; Mesoamerica 2
2. Forewings with membrane uniformly shaded fuscous; Costa Rica . . . . . *C. palmensis* **sp. n.**
- Forewings with membrane hyaline; Mexico . . . . . *C. rubescens*

Cobacella palmensis Bahder & Bartlett sp. n.

(Figures 2–6)

Type locality. Costa Rica, Puntarenas Province, Costa Rica.

Diagnosis. Description. *Color*. General body color yellow, darker in males, paler ventrad (Fig. 2). Head in lateral view dark orange, yellow around eyes and antennae, antennae concolorous with body. Mesonotum with six black spots, three each side of midline, anterior-most rounded adjacent to tegulae, second pair crescent-shaped at lateral extreme of scutum,third pair circular, near caudal extreme of lateral carinae (Fig. 2). Wings fuscous with red

veins, darker in males (Fig. 2). Legs pale yellow, with variable reddish wash, especially proximad, male with reddist tarsi. Dorsum of abdomen brown.

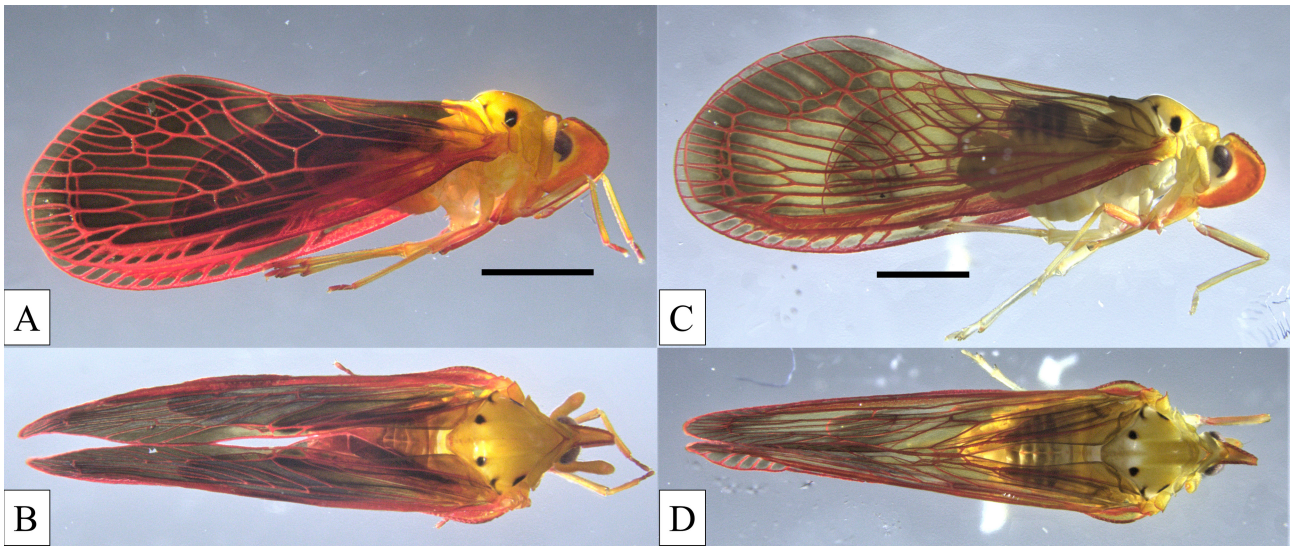

FIGURE 2. Adult habitus of *Cobacella palmensis* **sp. n.**; (A) adult male lateral view, (B) adult male dorsal view, (C) adult female lateral view, and (D) adult female dorsal view.

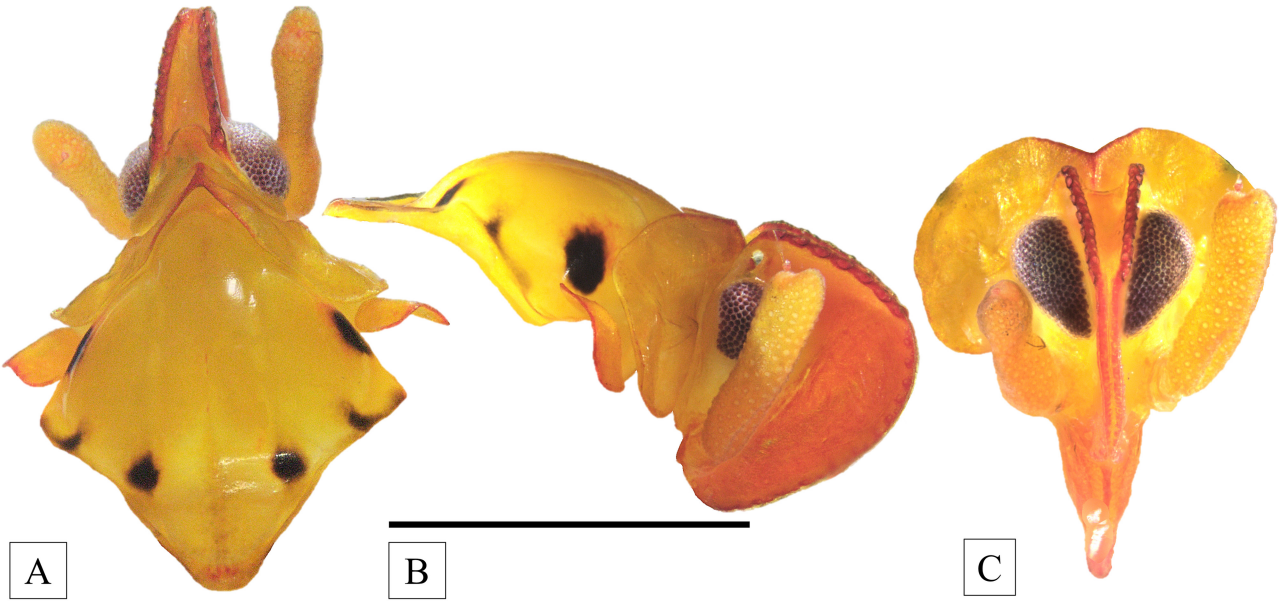

FIGURE 3. Adult male of *Cobacella palmensis* **sp. n.**; (A) head, pronotum, and mesonotum in dorsal view, (B) lateral view, and (C) head and pronotum in frontal view; scale bar = 1 mm.

Structure. Body length (including wings) males: 7.0 mm (n = 1) and females: 7.8 mm (n=2). Head. Strongly compressed, projecting beyond eyes for distance about equal to greatest width of eye, in lateral view, head rounded, vertex declinate smoothly rounded at fastigium.Vertex in dorsal view narrowly triangular, approximately twice as long as wide at base, disc strongly concave, posterior margin strongly concave, lateral margins converging anteriorly (nearly meeting at apex), strongly carinate and thickened bearing row of pits (Fig. 3A), continued in reduced form on lateral margins of frons (Fig. 3B). In frontal view, frons greatly compressed, lateral margins strongly carinate, closely approximate (Fig. 3C). Antennae cylindrical and tubular, scape ring-like, pedicle approximately four times as long as wide (Fig. 3). Eyes roughly oval, emarginated above antennae, lateral ocelli faintly indicated anterior to antennae.

Thorax. Prothorax steeply inclined in lateral view (Fig. 3B), narrow in dorsal view, strongly convex at anterior margin, strongly concave at posterior margin, expanding slightly at lateral margins (Fig. 3B); tricarinate, median carina strong, lateral carinae weak, arising from median carina near midlength, becoming obsolete laterad (Fig.

3A,B). Mesonotum large, scutum convex in lateral view with concave inflection at leading margin of scutellum, in dorsal view posterior margin of mesoscutellum truncate; in dorsal view with tricarinate, median carina extending from anterior margin to posterior margin, inner lateral carinae sinuate, curved distad at anterior margin (Fig. 3A), lateral margin of mesothorax carinate, arising near midpoint, forming posterior lip of the mesothorax (Fig. 3B). Spinulation of hind tibiae 5-5-4.

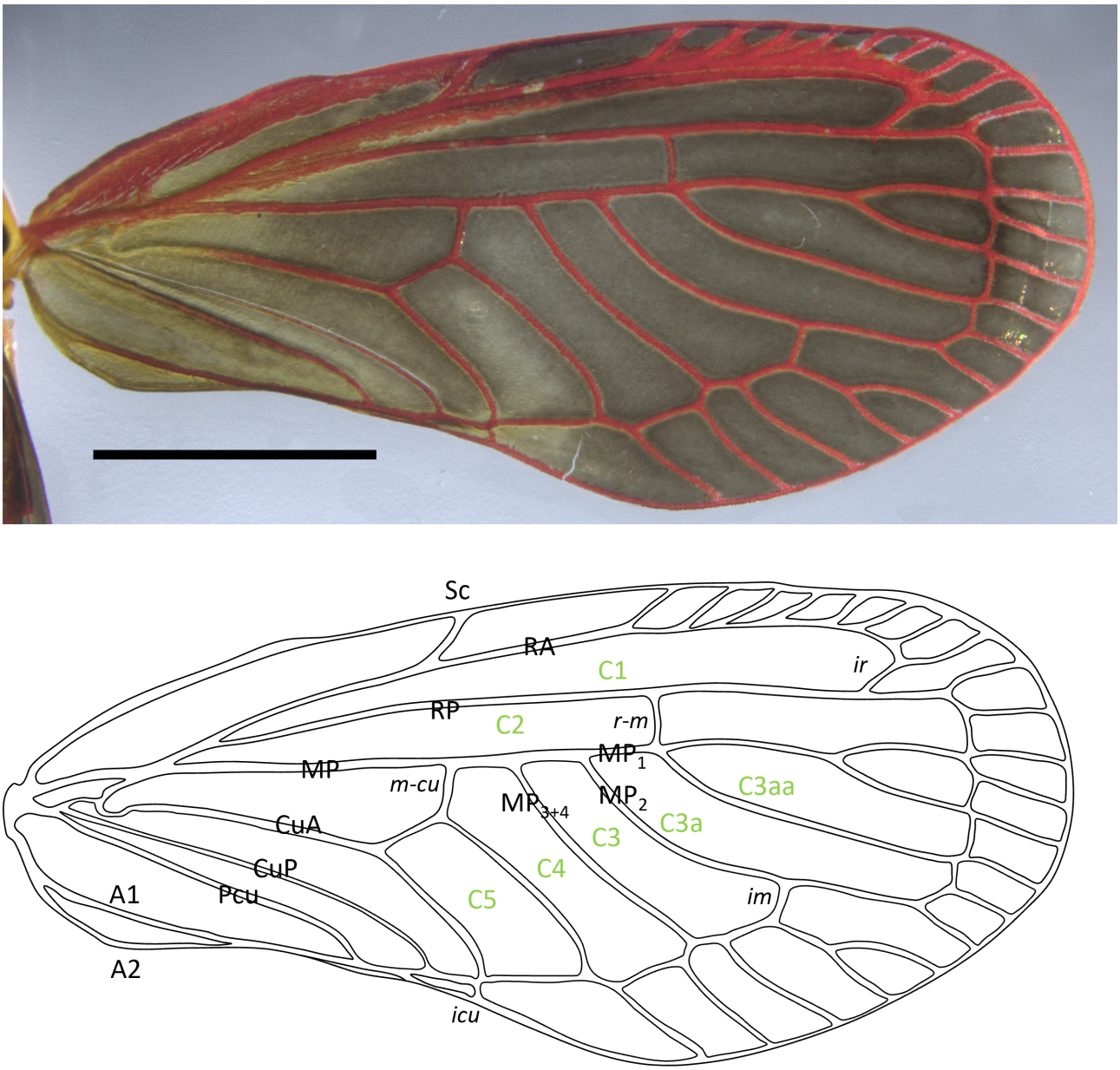

FIGURE 4. Adult male forewing of *Cobacella palmensis* **sp. n.**; black = vein, italics = crossvein, green = cell.

Forewings broad and spatulate, narrowest basally, widest near midlength, costal margin weakly convex, broadly rounded, trailing margin broadly convex except for concave expansion in jugal region. Clavus open, composite vein Pcu+A1 projecting anteriorly to encompass CuP and branches of CuA before arched to wing margin past midlength; 22 vein branches reaching wing margin between ScP and A1+Pcu+Cu inclusive; marginal cells longer than wide. MP branching from ScP+R in base of wing just beyond basal cell, with fork of RP from Sc+RA shortly beyond fork of MP; ScP reaching wing margin just before wing midlength. Branching pattern RA 8-branched, RP 2-branched, MP 10-branched, CuA 2-branched (anastomosed to form closed procubital cell (Emeljanov 1996).

Terminalia. Pygofer in lateral view narrow, irregular, strongly narrowed at dorsal margin, strongly sinuate on anterior margins, posterior margin bearing large rounded lobe in dorsal half, (Fig. 5A); medioventral process absent (Fig. 5B). Gonostyli in lateral view spatulate, medially cupped, irregularly sinuate on dorsal and ventral margins,

inner dorsal margin with elongate process with sclerotized hooked apex (Figs 5A–C); in ventral view, gonostyli narrow basally, expanding greatly at midpoint, truncate at apex with slight invagination near inner margin (Fig. 5B). Aedeagal shaft tubular, simple, slightly upcurved, spinose flange on dorsal margin near midpoint (A1) and process arising subapically on left, dorso-lateral margin (A2), angled dorsad, curving slightly ventrad, nearly reaching apex of flagellum, reaching anterior margin of A1 (Fig. 6), and serrulations on right lateral margin, from midlength to near apex (Fig. 6A, 6D). Flagellum bilaterally asymmetrical, two large processes on left lateral side along dorsal margin (F1 & F2), process F1 on outer lateral margin, generally uniform in width, apex slightly constricted, inner and outer margins sinuate, apex curved slightly mesad; F2 more constricted at apex and curved mesad, F1 and F2 curved ventrad, approximately equal length (Fig. 6A & 6B). Anal tube in lateral view slender, dorsal margin straight, ventral margin sinuate, apex angled ventrad, almost reaching apex of gonostyli (Fig. 6A); in dorsal view, apex appears strongly forked and pointed (Fig. 6B).

TABLE 3. Biometric data for *Cobacella palmensis* **sp. n.** (in mm)

Character	Male (*n*=1)	Female (*n*=2)
Body length with wings	7.01	7.81
Body length without wings	3.59	3.98
Forewing length	4.48	4.96
Vertex length	0.35	0.39
Vertex width—basal	0.26	0.29
Vertex width—distal	0.10	0.11
Pronotum length—midline	0.08	0.09
Mesonotum length—midline	1.29	1.43
Mesonotum width	1.24	1.37
Frons length	0.57	0.63
Frons width—dorsal	0.09	0.10
Frons width—frontoclypeal	0.24	0.27
Frons width—narrowest	0.01	0.01
Frons width—widest	0.24	0.27
Clypeus length	0.23	0.26

Plant associations. African oil palm, *Elaeis guineensis* Jacq. (Arecaceae).

Distribution. Puntarenas Province, Costa Rica.

Etymology. The specific epithet is in reference to the town where specimens were collected "La Palma", formed by the trucation of the town name as "*palm*-" with the suffex "-*ensis*", meaning from a place or location. The specific name is intended as feminine to agree with the genus, although the spelling would be the same in either feminine or masculine form.

Material examined. Holotype male "Costa Rica, Puntarenas Pr. / Finca La Palma / 6.VI.2021, sweeping palms / Coll.: B.W.Bahder // Holotype / *Cobacella palmensis* ♂ /" (FLREC); Paratypes same as holotype (2 females, FLREC).

Sequence Data. For the barcoding region of COI, a 584 bp product was generated, for the 18S gene, a 1,305 bp sequence was generated, and for the D9-D10 region of the 28S gene, a 776 bp sequence was generated. The phylogeny generated based on the available data and taxa showed low bootstrap support for most clades for COI, except for the genus *Patara*, which had moderate support (83) (Fig. 7A). However, the phylogeny based on 18S showed strong bootstrap support (97) for *C. palmensis* **sp. n.** resolving adjacent to *Sayiana sayi* (Fig. 7B). The phylogeny generated based on 28S showed moderate support (69) for placement of *C. palmensis* **sp. n.** adjacent to *Anotia*, however strong bootstrap support (100) for *Anotia* as a distinct clade from *Cobacella* (Fig. 7C). Both the 18S and 28S derived phylogenies showed strong bootstrap support (100 and 99 respectively) for a clade comprised of *Anotia*, *Cobacella*, and *Sayiana*. The consensus tree based on all three loci also shows strong bootstrap support (87) for the placement of *C. palmensis* **sp. n.** adjacent to *Sayiana sayi* and also showed strong support (100) for the clade comprised of *Anotia*, *Cobacella*, and *Sayiana* (Fig. 7D).

Based on the pairwise comparison for the 18S gene, the average intrageneric variability is 1.8% (±0.2) while the average intergeneric variability is 11.7% (±0.5) (Table 4). *Cobacella palmensis* **sp. n.** differs on average by 12.3%

(±1.3) from all other genera included in this analysis with the lowest level of variation occurring when compared to *Sayiana sayi* where it differs by 5.3% and the highest level of variance (excluding cenchreine outgroup) occurring with*S. ballii* and *P. vanduzei*, varying by 14.9% (Table 4). Based on the pairwise comparison for 28S, the average intrageneric variability is 3.9% (±0.1) whereas the average intergeneric variability is 16% (±0.7) (Table 5). Based on 28S, *C. palmensis* **sp. n.** differs on average by 15.3% (±0.2) from the other genera analyzed, with the lowest level of variability observed with *Sayiana sayi* (7.7%) and the highest level of variability observed with *Mula resonans* (23.2%) (Table 5).

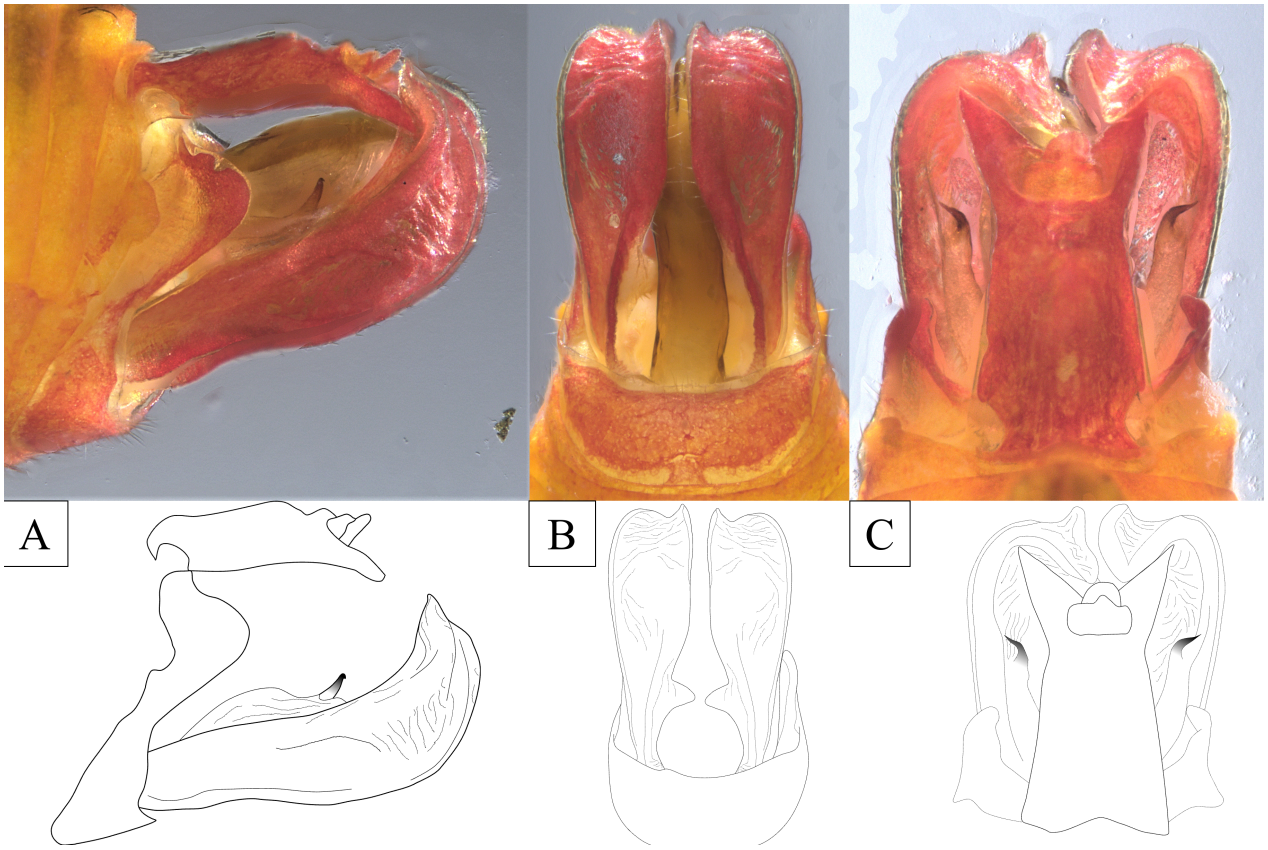

FIGURE 5. Male *Cobacella palmensis* **sp. n.** terminalia; (A) lateral view, (B) ventral view, and (C) dorsal view.

Remarks. The placement of *C. palmensis* **sp. n.** in *Cobacella* is supported by morphological characters observed and compared to both *C. rubescens* and *C. sexguttata*. However, a paucity of specimens from institutional collections, and limited observations on citizen science forums like iNaturalist, make it difficult to ascertain the extent of intraspecific variation or sexual dimorphism within species. In this manuscript we are annotating all the specimens or observations of which we are aware.

Cobacella palmensis **sp. n.** differs from *C. sexguttata* in both the structure of aedeagus and wing coloration. Fennah (1952: 163, figs 34H, 34I) illustrated the aedeagus of *C. sexguttata,* which he described as "… asymmetrical, sinuately tubular; flagellum with a single spinose process at its base, and a flattened plate acute at tip on left· on right two sclerties distally acute, supporting membranous portion". Fennah's (1952) illustrations are imprecise, but it is evident that the aedeagus of *C. sexguttata* is more strongly asymmetrical, lacks the spinose flange on dorsal margin (found in *C. palmensis* **sp. n.**, A1 in Fig. 6) near midpoint, and has a different arragements of sclerotized spines of the flagellum. With respect to wing coloration,*C. sexguttata* has a more fuscous patch at the apex of the forewing with basal portion less fuscous while *C. palmensis* **sp. n.** has a uniform tint to the forewing.

Concerning *C. rubescens*, it appears that the wing membrane is uniformly fuscous in *C. palmensis* **sp. n.** and more clearly hyaline in *C. rubescens.* In addition, *C. palmensis* **sp. n.** differs from *C. rubescens* in the size and shape of black spots on the mesothorax.–Unfortunately, the male terminalia of *C. rubescens* has not been described and the syntypes are female.

TABLE 4. Pairwise comparison based on the 18S rRNA locus to demonstrate intra (orange) and inter (blue) generic variability by percent nucleotide difference (bottom left) and standard error (top right).

		1	2	3	4	5	6	7	8	9	10	11
1	*Cobacella palmensis* **sp. n.**		0.008	0.008	0.007	0.011	0.011	0.011	0.011	0.010	0.010	0.011
2	*Anotia firebugia*	0.071		0.004	0.008	0.010	0.010	0.010	0.010	0.010	0.010	0.011
3	*Anotia* sp.	0.075	0.018		0.008	0.010	0.011	0.011	0.011	0.010	0.010	0.011
4	*Sayiana sayi*	0.053	0.068	0.074		0.011	0.011	0.011	0.011	0.011	0.011	0.011
5	*Mula resonans*	0.137	0.134	0.135	0.138		0.010	0.010	0.010	0.010	0.010	0.010
6	*Shellenius serratus*	0.147	0.138	0.136	0.141	0.133		0.005	0.004	0.006	0.006	0.008
7	*Shellenius schellenbergii*	0.148	0.137	0.138	0.142	0.132	0.022		0.005	0.007	0.007	0.009
8	*Shellenius ballii*	0.149	0.140	0.138	0.146	0.132	0.013	0.026		0.006	0.006	0.008
9	*Patara vanduzei*	0.149	0.143	0.140	0.148	0.129	0.051	0.058	0.053		0.003	0.007
10	*Patara cooki*	0.148	0.140	0.137	0.149	0.131	0.048	0.055	0.051	0.012		0.007
11	*Agoo xavieri*	0.155	0.146	0.147	0.161	0.140	0.080	0.090	0.079	0.068	0.062	

TABLE 5. Pairwise comparison based on the 28S rRNA locus (D9-D10 region) to demonstrate intra (orange) and inter (blue) generic variability by percent nucleotide difference (bottom left) and standard error (top right).

		1	2	3	4	5	6	7	8	9	10	11
1	*Cobacella palmensis* **sp. n.**		0.010	0.010	0.011	0.016	0.014	0.014	0.014	0.014	0.014	0.014
2	*Sayiana sayi*	0.077		0.010	0.010	0.015	0.013	0.014	0.013	0.014	0.014	0.013
3	*Anotia firebugia*	0.090	0.096		0.004	0.016	0.014	0.014	0.014	0.015	0.014	0.014
4	*Anotia* sp.	0.101	0.104	0.016		0.016	0.014	0.014	0.014	0.015	0.014	0.015
5	*Mula resonans*	0.232	0.228	0.216	0.225		0.015	0.015	0.015	0.015	0.015	0.015
6	*Shellenius ballii*	0.167	0.160	0.183	0.178	0.220		0.009	0.006	0.010	0.010	0.010
7	*Shellenius schellenbergii*	0.172	0.173	0.185	0.180	0.217	0.072		0.009	0.011	0.011	0.011
8	*Shellenius serratus*	0.167	0.163	0.179	0.178	0.213	0.024	0.064		0.011	0.010	0.009
9	*Patara vanduzei*	0.176	0.175	0.194	0.194	0.229	0.090	0.107	0.086		0.005	0.011
10	*Patara cooki*	0.179	0.176	0.192	0.191	0.225	0.087	0.105	0.086	0.018		0.011
11	*Agoo xavieri*	0.173	0.169	0.192	0.192	0.220	0.080	0.090	0.071	0.101	0.093	

Aside from type material, the only other available specimen of *Cobacella* is a pallid female from La Selva research station in Costa Rica (Fig. 11) with the mesothoracic spots reduced to one on each side. This specimen likely represents an additional species. On iNaturalist there are four additional records of *Cobacella*. Two are from Puntarenas, Costa Rica (#151547369, 146292818) that appear to represent *C. palmensis* **sp. n.**, one from San José, Costa Rica (#88345785) that may be *C. rubescens,* and one from São Paulo State, Brazil (#146995673) that we are reluctant to speculate on because it is geographically distant from the other observations.

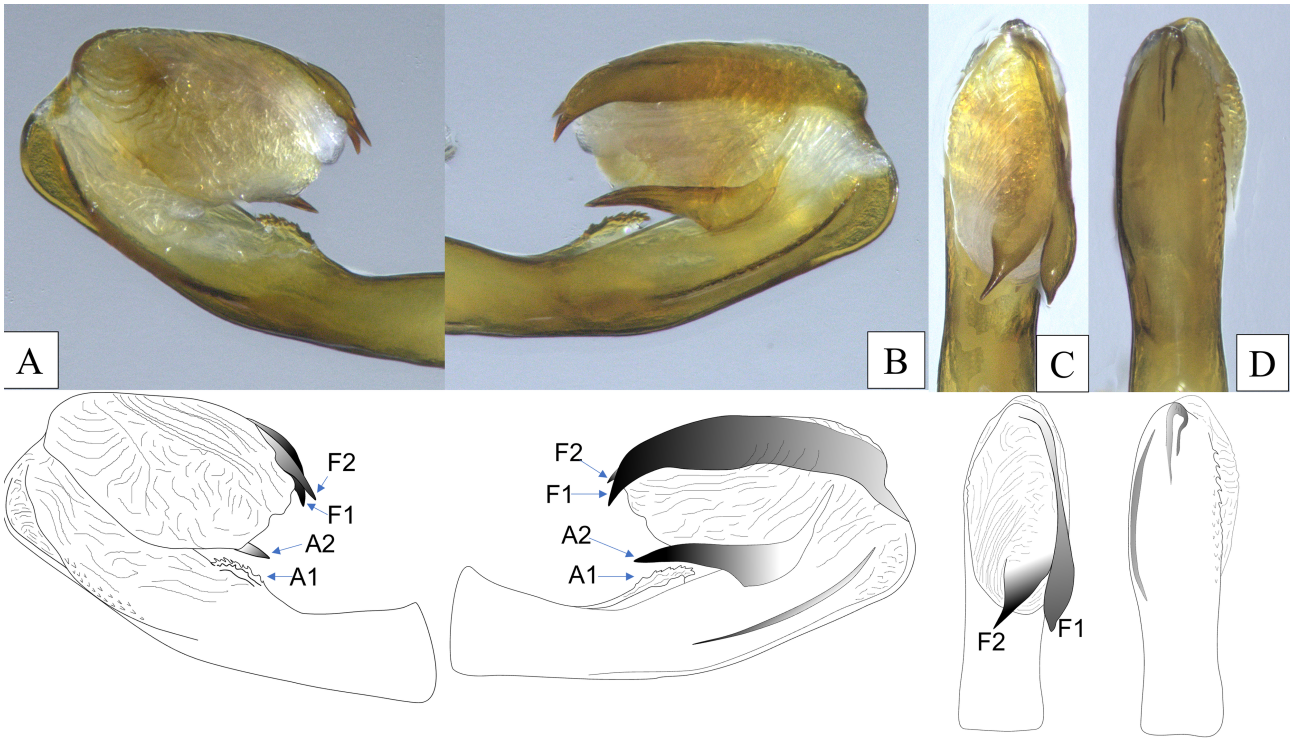

FIGURE 6. Aedeagus of *Cobacella palmensis* **sp. n.**; (A) right lateral view, (B) left lateral view, (C) dorsal view, and (D) ventral view.

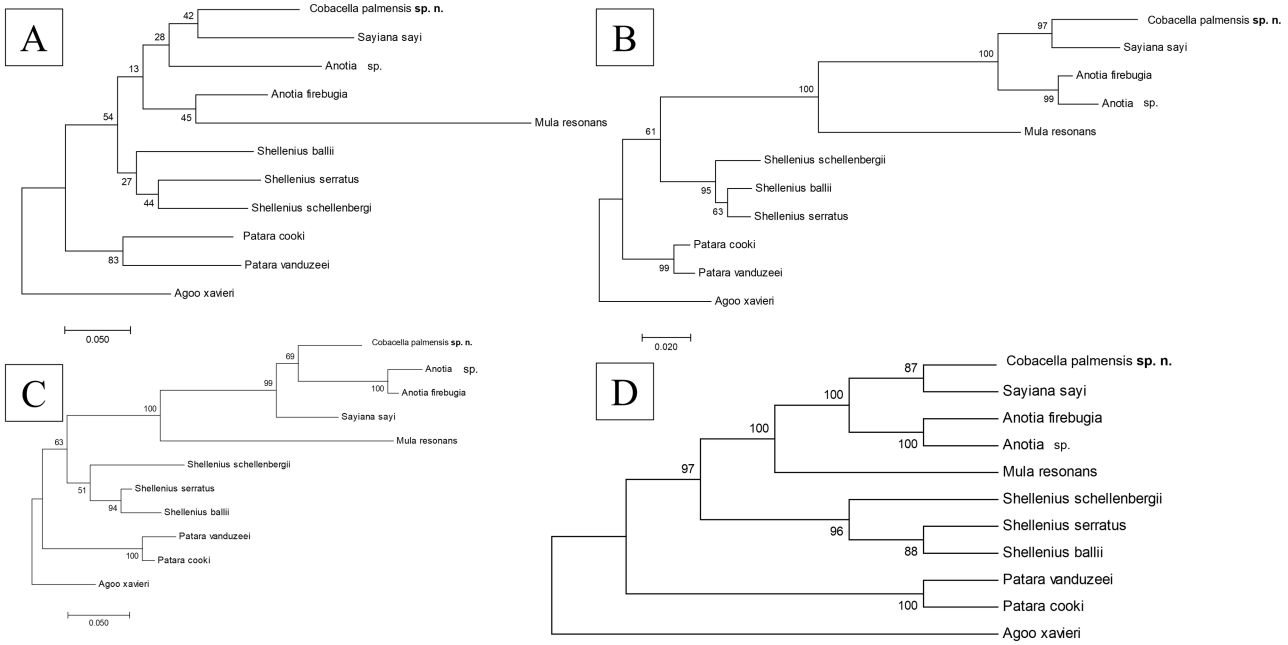

FIGURE 7. Maximum Likelihood trees (1,000 replicates) showing the relationship of *Cobacella palmensis* **sp. n.** relative to other available species of Otiocerinae; (A) COI, (B)18S, (C) 28S and (D) consensus tree based on concatenated COI and 18S sequence data, scale bar = percent nucleotide difference.

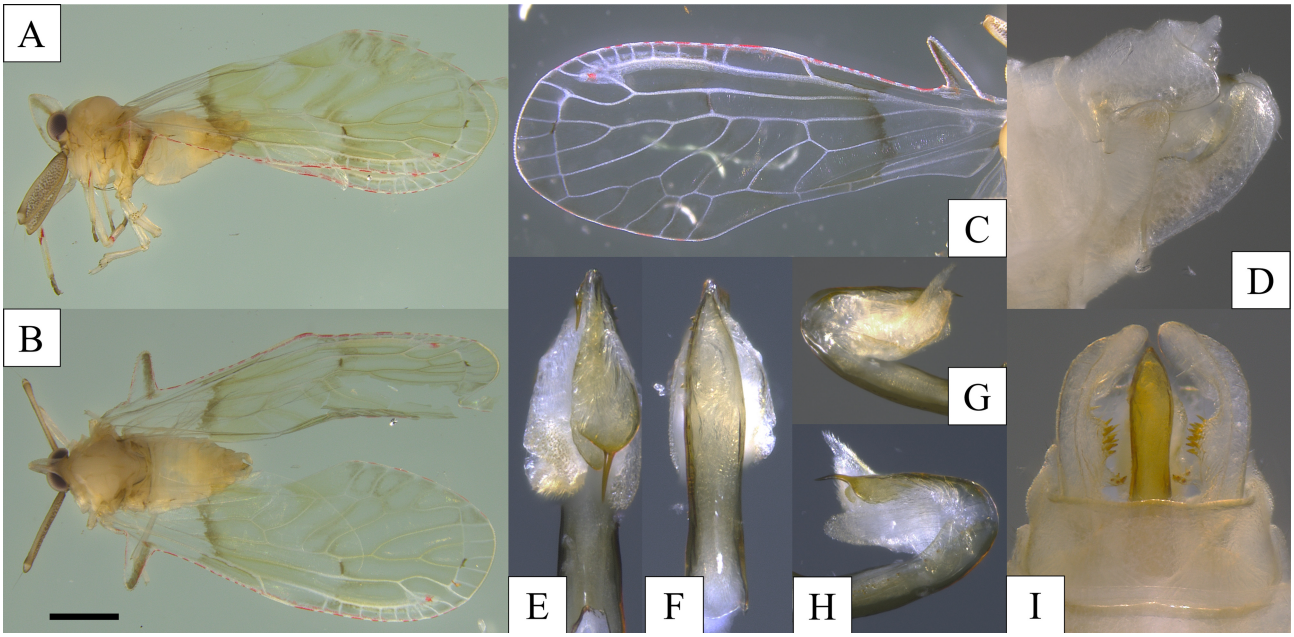

FIGURE 8. Adult male of *Sayiana sayi*; (A) habitus lateral view, (B) habitus dorsal view, (C) forewing, (D) terminalia in lateral view, (E) aedeagus dorsal view, (F) aedeagus ventral view, (G) aedeagus right lateral, (H) aedeagus left lateral view and (I) terminalia ventral view; scale = 1 mm.

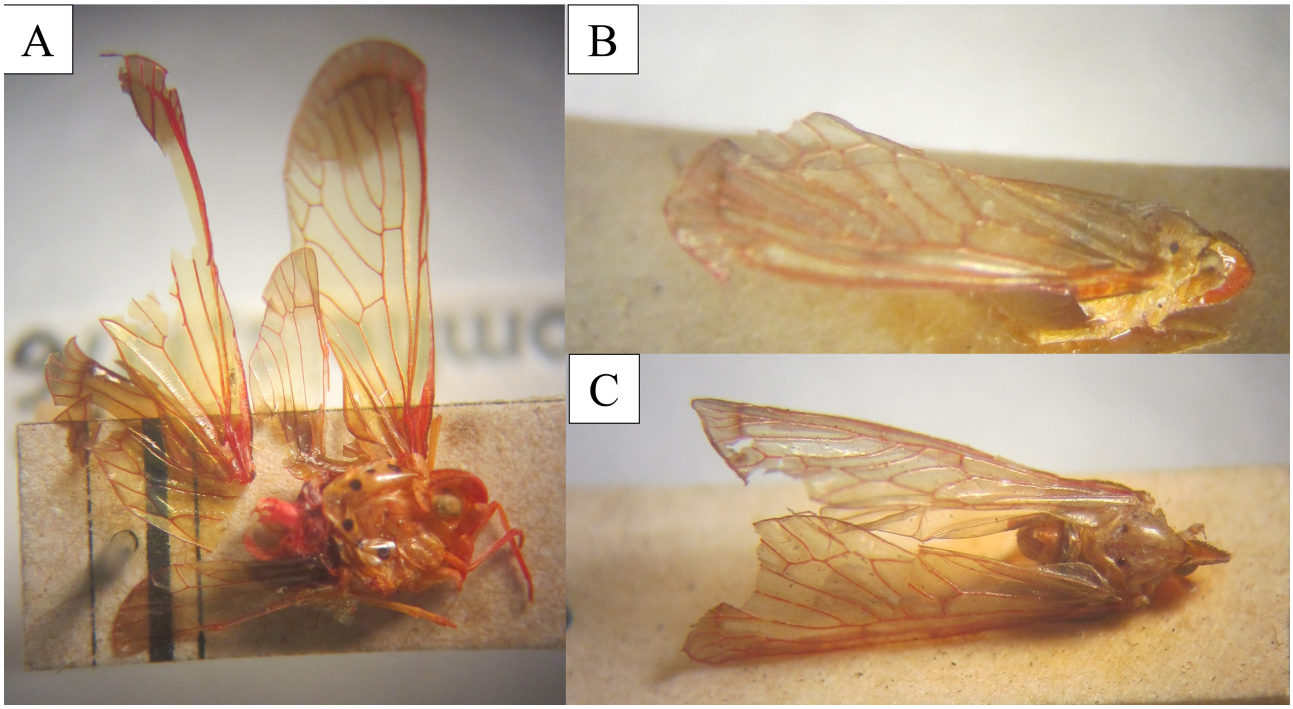

FIGURE 9. Habitus of *Cobacella* specimens from the Natural History Museum, London (BMNH); (A) *Cobacella sexguttata* Fennah (Amazonas, Brazil, Det. P.S. Broomfield), (B–C) *Cobacella rubescens* (Fowler), syntype female (B) lateral and (C) dorsal view.

Other material examined. *Cobacella rubescens* (BMNH, female syntypes, Figs 9B, C) Teapa, Mexico, H.H. Smith; (NHMW , female, Fig. 10) "[Dominik] Bilimek / Mexico / 1871 / Orizaba // Juni [Duch for June] // rubescens / det. Fowler // Otiocerus ? rubescens Fowler / Type" (in Mus. Vind. Caes. = in Museo Vindobonense Caesarei = Imperial Museum Vienna).

Cobacella sexguttata (BMNH, male); Amazonas, Fonteboa, Broomfield (det: Broomfield); and male holotype and female paratype (BMNH, in alcohol) "Cobaccella / sexguttata / Fenn. Type / 1949 / Trinidad B.W.I." reported as La Reunion, Carapo, 14.ix.1949, R. G. Fennah.

Cobacella sp. (UDCC, female): Costa Rica, Heredia nr Puerto Viejo, La Selva Biol Sta. (at station) 179ft, N10 25', W84 00, 24 Feb. 2004, light, CR Bartlett, J. Cryan & J. Urban.

iNaturalist records: Costa Rica (observations #146292818, 151547369, 88345785); Brazil (São Paulo) (observation #146995673).

FIGURE 10. Habitus of *Cobacella rubescens* syntype female from Orizaba, Veracruz, Mexico (image credit Harald Bruckner, Hemiptera Image Collection, Natural History Museum Vienna); (A) lateral view, (B) dorsal view (C) ventral view, and (C) labels.

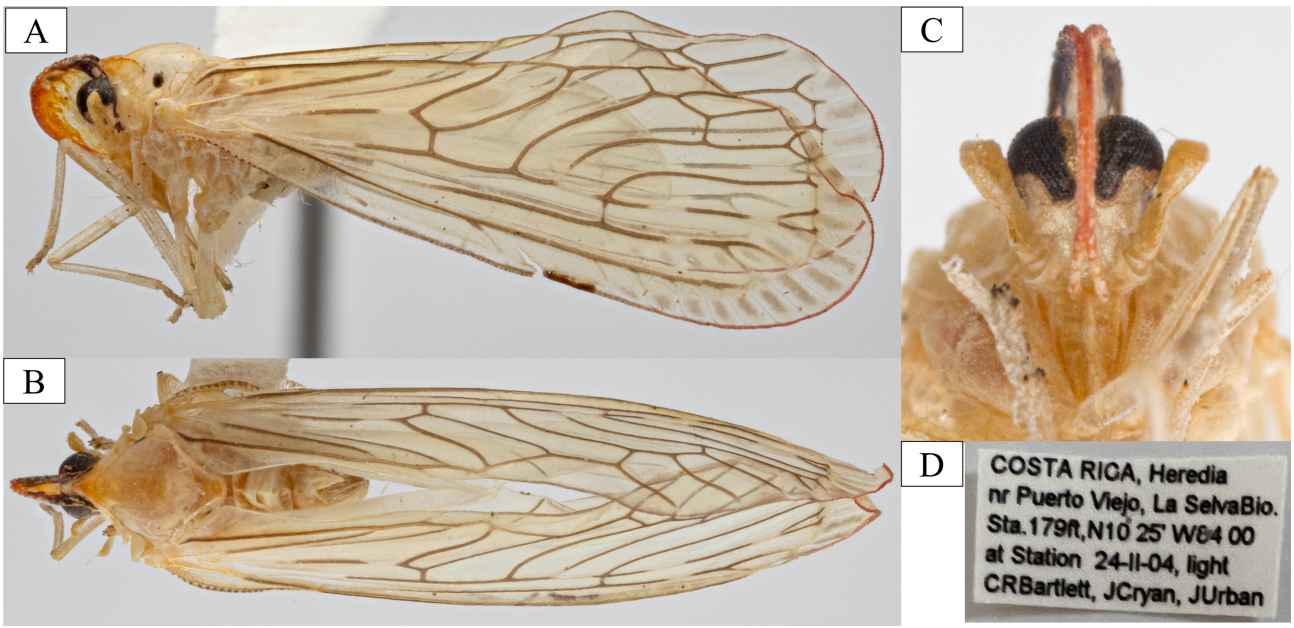

FIGURE 11. Habitus of a female *Cobacella* specimen from La Selva, Costa Rica (University of Delaware Insect Research Collection, UDCC), (A) lateral habitus view, (B) dorsal habitus view, (C) ventrofrontal view, and (D) label.

Discussion

The status of *Cobacella* as a distinct genus is supported by the molecular data presented for the available taxa. The level of variability observed between *C. palmensis* **sp. n.** and other genera is consistent with genus-level differences observed for both 18S and 28S.

Of particular interest is the evident close relationship of *Cobacella* to *Sayiana* based on the data in this study. Fennah (1952) compares *Cobacella* to *Anotia* and highlights the relative position of the wings to the body asa useful distinction between the two genera, with *Cobacella* holding wings laterocaudally (an observation that was confirmed in *C. palmensis* **sp. n.** in the field) whereas *Anotia* generally outwards and upwards. *Sayiana sayi* appears to carry its wings like *Cobacella* (e.g., see iNaturalist observation 41682560), although how the other three *Sayiana* species hold their wings has not been recorded.

The genus *Sayiana* was originally described as a segregate from *Anotia*, differing most notably in the development of the costal flange being large and triangular in *Sayiana* (Ball 1928; viz. Fig. 8C) that is lacking or present only as a low, rounded lobe in *Anotia* (Ball also claimed differences in the shape of the antennal pedicle and the wing venation). In this study, there is very strong molecular evidence that *Sayiana sayi* is closer *C. palmensis* **sp. n.** than to *Anotia*, and more distantly related to *Shellenius*, based on the available taxa.

The discovery of another new species of derbid on palms in Costa Rica provides more support for the close relationship between palms and derbids. The habitat where *C. palmensis* **sp. n.** was collected is characteristic of many unique derbids found in the neotropics; medium-sized palms with an abundance of leaf litter/green waste present in large piles throughout the habitat. Derbids are presumed fungal feeders as nymphs (e.g., Howard et al. 2001) and the association of adults on palms near rotting plant material appears to support this association. Maintaining survey efforts are needed for continued documentation of novel taxa associated with palms as well as to collect nymphs to assess habitat and dietary requirements of this life stage.

Cobacella remains a relatively poorly known taxon (both taxonomically and biologically) with few observations from any source. Aside from *Cobacella,* several other Neotropical Otiocerini (e.g., *Kubilaya*, *Labicerus*, *Heronax* (*Homometria*), *Platonax*, and *Platocerella*) remain obscure and would benefit from a recharacterization using modern techniques.

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