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Machadonannus brailovskyi n. sp., a new species of Schizopteridae (Hemiptera: Heteroptera) from the Afrotropical Region

Machadonannus brailovskyi n. sp., una nueva especie de Schizopteridae (Hemiptera: Heteroptera) de la región Afrotropical

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ABSTRACT

Compared to the faunas of the Neotropical and Australian regions, the biodiversity of Afrotropical Dipsocoromorpha (Hemiptera: Heteroptera) is either relatively small or poorly documented. Only 37 species of Dipsocoromorpha, or minute litter bugs, have so far been reported from that biogeographic region. Recent residue sorting efforts of trap samples from Africa recovered >800 specimens of Schizopteridae. Most specimens belong to the genera *Hypselosoma* Reuter, 1884, *Pinochius* Carayon, 1949, *Kokeshia* Miyamoto, 1960, and *Dundonannus* Wygodzinsky, 1950, and closely related undescribed genera. We here focus on an apparently rarely collected genus, *Machadonannus* Wygodzinsky, 1950, that has remained monotypic so far, with the type species only known from Angola, and describe a new species, *Machadonannus brailovskyi* n. sp., from the Central African Republic. Habitus images are provided, as are light microscopical, macrophotographic, and confocal microscopical documentation of morphological features.
Keywords: Heteroptera, Dipsocoromorpha, Afrotropical region, species discovery, taxonomy, morphology.

RESUMEN

En comparación con la fauna del Neotrópico y Australia, la biodiversidad de Dipsocoromorpha Afrotropical es relativamente pequeña o poco documentada. Sólo 37 especies de Dipsocoromorpha han sido reportadas en ese continente. Recientes esfuerzos de clasificación de residuos de muestras provenientes de trampas de África, permitieron recuperar >800 especímenes adicionales de Schizopteridae. La mayoría de dichos especímenes pertenecen a los principales géneros *Hypselosoma* Reuter, 1884, *Pinochius* Carayon, 1949, *Kokeshia* Miyamoto, 1960, y *Dundonannus* Wygodzinsky, 1950, así como géneros relacionados no descritos previamente. Centrándonos en el género monotípico raramente colectado, *Machadonannus* Wygodzinsky, 1950, actualmente sólo reportado para Angola; al mismo tiempo describimos una nueva especie, *Machadonannus brailovskyi* n. sp., de la República Centroafricana. Se proporcionan imágenes de habitus, así como la microscopía óptica, macrofotografía y microscopía confocal de las características morfológicas.
Palabras clave: Heteroptera, Dipsocoromorpha, región Afrotropical, descubrimiento de especies, taxonomía, morfología.

Recent biodiversity discovery and documentation of Dipsocoromorpha, the minute litter bugs, has focused on the Australian, Oriental, and Neotropical regions and has left the African fauna poorly understood (Štys 1985; Rédei 2008; Hill 2013, 2014; Makhan 2013; Weirauch and Frankenberg 2015; Knyshov *et al.* 2016; Leon and Weirauch 2016a; Leon and Weirauch 2016b). Only 37 species have been described from the Afrotropical region including Madagascar, 13 of which belong to the Ceratocombidae, three to the Dipsocoridae, two to the Hypsipterygidae, and 19 to the Schizopteridae (Reuter 1894, Poppius 1910; Carayon 1949; Wygodzinsky 1950, 1953, 1958, 1959; Drake 1961; Southwood 1961; Štys 1970, 1977, 1983; Péricart and Matocq 2003). Based on recent revisionary studies on Australian and Neotropical taxa this number can be expected to be a dramatic underestimate of actual species diversity. Peter Wygodzinsky contributed the largest number of species descriptions, the majority of which were published in two monographs focusing on material from Angola (Wygodzinsky 1950, 1953). Pavel Štys subsequently discovered and described significant higher-level systematic diversity among African Dipsocoromorpha (Štys 1970, 1977, 1983). Species from 11 African countries including Madagascar were described in the above references. Only a single species of Dipsocoromorpha each is currently documented for seven of these countries (Algeria, Cameroon, Democratic Republic of Congo, Egypt, Togo, and Uganda), while multiple species are known from Angola (17 ssp.), Ghana (3 spp.), Madagascar (5 spp.), South Africa (2 spp.), and the Sudan (4 spp.).

The Heteropteran Systematics Lab at the University of California, Riverside and collaborators are documenting the biodiversity of Dipsocoromorpha with emphasis on Schizopteridae as part of a US National Science Foundation "Advancing Revisionary Taxonomy and Systematics" (ARTS) program project. While most of the sorting efforts and the bulk of revisionary work have focused on the New World fauna, the project has also databased 866 specimens of African Schizopteridae. Of these, 846 are non-type specimens that are not included in the above publications. Specimens are deposited in 12 institutions in Africa, Europe and North America, with 5 institutions contributing the majority of the material (California Academy of Sciences [CAS], Field Museum of Natural History [FMNH], Muséum d'Histoire Naturelle Geneva [MHNG], IZIKO Museum [SAMC], and Entomology Research Museum, University of California, Riverside [UCR]). The three currently recognized schizopterid subfamilies are represented, with 17% of specimens belonging to the Hypselosomatinae, 29% to the Ogeriinae, and 38% to the Schizopterinae, while 16% are at this time placed as incertae sedis. A total of 186 non-type specimens were recorded from Madagascar alone, representing described and undescribed species of *Hypselosoma* Reuter, 1884, *Pinochius* Carayon, 1949, *Kokeshia* Miyamoto, 1960, and *Dundonannus* Wygodzinsky, 1950, in addition to specimens that require further examination to determine if they can be placed in existing or represent undescribed genera. Non-type specimens from continental Africa comprise described and undescribed species of *Dundonannus* Wygodzinsky, 1950, or closely related, undescribed genera (~40% of specimens), *Ogeria* Distant, 1913 (so far not reported from Africa) or related genera, as well as *Kokeshia* and *Pinochius*. About 37% of the specimens have not yet been classified to genus, and may represent additional undescribed genera. Specimens were mostly collected using Berlese extraction (40%), yellow pan traps (25%), or general collecting (i.e. sweeping of vegetation; 20%), while Malaise traps and light traps collected less than 5% of specimens. Specimens of *Vilhenannus* Wygodzinsky, 1950, and *Machadonannus* Wygodzinsky, 1950, account for less than 5% of the surveyed schizopterid specimens from continental Africa, suggesting that these species are either rare or that the collecting methods used were ineffective for these taxa.

We here describe a new species of Schizopteridae in the genus *Machadonannus* based on three male specimens retrieved from sweep sample residues at the IZIKO Museum (Capetown) that originate from Parc National de Dzanga-Ndoki in the Central African Republic. *Machadonannus* was proposed as a monotypic genus for *M. ocellatus* Wygodzinsky, 1950, a species which was described based on seven specimens from Angola along with the putatively closely related genus *Vilhenannus* that comprises two species (Wygodzinsky 1950). Wygodzinsky (1950) emphasized the unique wing venation and other wing features, male genitalia, and modifications of the male pre-genital abdomen that set apart these two genera from all currently described genera of Schizopteridae in Africa and elsewhere. The new species examined here shares features with *M. ocellatus* that Wygodzinsky (1950) considered to be diagnostic at the genus level and we therefore place this new species in the genus *Machadonannus*. Clarifying the phylogenetic position of *Machadonannus* (and *Vilhenannus*) within the Schizopteridae and Schizopterinae is beyond the scope of this project. Nevertheless, the digital images and confocal micrographs in this study should be useful for future integrated morphological and molecular phylogenetic analyses across Schizopteridae.

MATERIAL AND METHODS

Material and databasing. Three ethanol-preserved specimens of *Machadonannus* were loaned from the IZIKO Museum (Cape Town, South Africa) and are deposited in that collection. The slide-mounted male holotype of *M. ocellatus* (deposited in The Natural History Museum, London; BMNH) and a point-mounted female paratype (AMNH) were examined and imaged for comparison.

Databasing and map. All specimens examined during this study were associated with matrix-code labels with unique prefix and eight-digit number combinations and databased in the PBI instance of the Arthropod Easy Capture database served from the American Museum of Natural History (AMNH) https://research.amnh.org/pbi/locality/. We georeferenced localities using Google Earth for specimens studied by Wygodzinsky (1950). To generate a map for all known specimens of *Machadonannus* and *Vilhenannus*, coordinates for individual species were downloaded from the PBI database, mapped in SimpleMappr http://www.simplemappr.net/ using ecoregions according to Olson et al. (2001) and the map edited in Adobe Photoshop CS3.

Dissections, compound, and confocal microscopy. One male specimen (UCR_ENT 00125913) was cleared while extracting DNA using a Qiagen DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany). The head plus prothorax, meso- and metathorax, right hemelytron and hindwing, and abdomen were disassembled and mounted in glycerine on microscope slides in preparation for compound and confocal microscopy. Compound microscopical images of specimen UCR_ENT 00125913 were generated using a GT Vision imaging system on a Zeiss Axioskop 2 compound microscope (Oberkochen, Germany) using Archimed V5.4.1. (Microvision) and images assembled in Zerene Stacker V1.02 (Zeren Systems, Richland, WA), those of specimens at the AMNH using a Leica MZ 16 and LAS V 2.5.0 and of specimens at the BMNH using a Leica MZ 125 with Canon EOS 550D and Helicon Focus (Kharkiv, Ukraine). The abdomen of UCR_ENT 00125913 was imaged using a Leica SP5 Inverted confocal microscope, exciting with 488nm and 543nm lasers and collecting with detectors in diapasons of 500-535nm (green in figures) and 555-700nm (red in figures). Confocal images were rendered in Imaris V7.6.4. (Bitplane, Zurich) and edited and assembled into a plate using CorelDraw X3 V13.

Digital habitus imaging. Specimen UCR_ENT 00125908 was mounted in a watch glass on the surface of a small droplet of KYJelly and submerged in ethanol. Dorsal, lateral, and ventral habitus images were taken using a Leica DFC 450 C Microsystems setup (Leica, Wetzlar, Germany) with Planapo 1.0x and 2.0x objectives and the Leica Application Suite (LAS) V4.3. The LAS software or Zerene Stacker were used to assemble composite images. Images were edited in Photoshop CS4 and image plates assembled in Corel Draw X3 V13.

Slide-mounting. The dissected specimen UCR_ENT 00125913 and specimen UCR_ENT 00125909 that was already partially disassembled when retrieved from the residue sample were permanently slide-mounted following protocols outlined in Noyes (1982), Platner *et al.* (1999) and Huber (2015).

Measurements. Measurements were generated using the measure tool in LAS for the intact specimen UCR_ENT 00125908.

Terminology. Morphological terminology follows a combination of sources, most importantly Wygodzinsky (1950), Emsley (1969), Rédei *et al.* (2012) and Knyshov *et al.* (2016).

Abbreviations for morphological structures used in the figures. 1AN– first anal vein; 2AN– second anal vein; ac– anal cell; am– anteriormost cell, enclosed by C+Sc and R+M; abp– basal process of anophore; ap– anophoric process; apc– canal in basal half of anophoric process; apg– groove on apical part of anophoric process; apc– apical cell formed by C +Sc, R, and M; at– anal tube; bc– basal cell; bp– basal plates; C– costa; Cu– cubitus; lp– left paramere;

ms– mesosternum; mssp– mesosternal spine; oc– ocellar pigment spot; pastIV– parasternite IV; pstV– process of sternite V; ptVII–spiracle-bearing process of tergite VII; py– pygophore; rp– right paramere; sen– group of sensilla on left paramere; sII-VII– segments II-VII; spV-spVIII– spiracles V to VIII; stV– sternite V; stVI– sternite VI; stVII– sternite VII; tar1-3– tarsomeres 1 to 3; tc– trapezoidal cell; tV-tVIII– tergites V to VIII; v– vesica.

RESULTS

Taxonomy

Machadonannus Wygodzinsky, 1950

Figs 1–5

Machadonannus Wygodzinsky, 1950: 14

Type species by original designation: *Machadonannus ocellatus* Wygodzinsky, 1950

Revised diagnosis: Recognized among Schizopteridae by the overall pale coloration with dark mark on basal cell (Figs. 1, 2A, 2E), posterior border of the pronotal collar with dentation (Fig. 2C), presence of a simple, not bifurcate appendage on the metasternum (Fig. 2D), hemelytron with very long anteriormost cell (cell enclosed by C+Sc and R+M; Fig. 2E), base of R+M dentate (Fig. 4B), 1AN ending near (Fig. 2E) or at Cu (Fig. 4B), male pregenital abdomen with a hook-shaped or coiled process on sternite V (Fig. 3B), strongly sclerotized small processes laterally on tergite VII (Fig. 3C), a long and slender right paramere with widened base and pointed tip (Fig. 3E) and a long, longitudinally grooved, and curved anophoric process (Fig. 3C). *Machadonannus* shares with *Vilhenannus* the long anteriormost cell, dentate base of R+M and the above genitalic features as well as modifications of the pre-genital abdomen, but is separated by the remaining thoracic characters listed above.

Redescription: Male: total length 1.5–1.7 mm; macropterous; body shape elongate elliptical (Fig. 1). Coloration: uniformly stramineous, basal cell with dark roundish mark and surrounding area paler than rest of body (Figs 1, 4B, D). Vestiture: inconspicuous. Structure: head in frontal view triangular (Fig. 4); eyes about 1/3 as wide as synthlipsis (Figs 1, 4), ocelli represented by tiny red pigmented spots distant from and mesad to eye (Fig. 4A); labium reaching to about base of mesocoxa, 3-segmented (Fig. 6A,B), with segment 1 short and wide, segments 2 and 3 very slender and long (Figs 2B, 4); antenna not reaching apex of anteriormost cell (Fig. 1). Thorax with pronotal collar present and with posteriorly pointing denticles (Fig. 2C); scutellum triangular with short spine (Fig. 2A); metathoracic scent gland evaporatoria not visible; mesosternal spine simple and rounded, (Fig. 2D), metasternal process (not shown) short; tarsal formula 3-3-3 (Fig. 2G), claws slender, with bristle-like processes, parempodia slightly widened towards apex, dorsal arolia absent from all pairs of legs (Fig. 2G; fig. 20 in Wygodzinsky [1950]); coxal pads very small. Fore wing (Fig. 7): anteriormost cell extending along ~2/3 of length of wing, apical cell enclosed by C +Sc, R, and M elongate elliptical, 3 times or more than 4 times as long as wide, proximal portion of R +M with denticles (Fig. 4B), basal cell elongated pentagonal, trapezoidal cell 1.5 to 2 times longer than wide, discal cell absent, 1AN ending near (Fig. 2E) or at Cu (Fig. 4B), clavus with distinct AN1 and AN2; hindwing large with two incisions (Fig. 2F and Wygodzinsky [1950]: fig 13). Pregenital abdomen highly asymmetrical, segments IV to VII strongly modified, spiracles present on segments VI–VIII only (Fig. 3; Wygodzinsky [1950]: figs 21, 22), tergites II to VIII partially sclerotized, sternites II to VII sclerotized, segment IV with transverse triangular parasternite on right side, process on sternite V hook-shaped (Fig. 3B, C) or coiled (Wygodzinsky [1950]: figs 21), sternite VI with heavily sclerotized area laterally on right side, tergite VII wider on left and tapering to right side that carries group of heavily sclerotized small processes (Fig. 3C, inset), tergite VIII transverse elliptical, spiracles VI and VII on sternites, left spiracle VIII on tergite, right spiracle VIII on process arising from tergite VIII. Genitalia (Fig. 3A–C, E, F): with pygophore extending dorsally on left side, aedeagus with basal plates consisting of several sclerites (Fig. 3F), vesica slender with less than one (Wygodzinsky [1950]: figs 22) or 1.25 coils, a long and slender right paramere with widened base and pointed tip (Fig. 3E), apical portion short triangular and distinctly widened and rounded subapical portion (Fig. 3E) or slender with elongated tip with notch (Wygodzinsky [1950]: figs 27), left paramere trapezoidal (Wygodzinsky [1950]: figs 28) or with left side elongated into tapering process (Fig. 3E), with group of sensilla on dorsal surface (Fig. 3E), base of anophoric process with intertwining sclerites and short basal process, anophoric process curved, long, and stout, tapering towards apex, with internal canal opening into groove at midpoint of process (Fig. 3C; Wygodzinsky [1950]: figs 25), anal tube conspicuous (Fig. 3E).

Female: as in Fig. 4C, D and as described by Wygodzinsky (1950).

Distribution and ecology: Species of *Machadonannus* are only known from tropical Africa. Macropterous males and submacropterous females examined by Wygodzinsky (1950) were collected in soil and plant detritus in riparian forest close to Dundo (Angola), while the macropterous males in the current study were swept from vegetation in the Parc National de Dzanga-Ndoki (Central African Republic). This indicates that species of *Machadonannus* may not be as strictly associated with leaf litter as indicated by Wygodzinsky (1950).

Discussion: Wygodzinsky (1950) suggested that *Dundonannus* may be more closely related to the Neotropical genus *Nannocoris* Reuter, 1884, than to the remaining African genera described in the same paper, a claim that remains to be tested. *Machadonannus* was not included in the molecular analysis of Dipsocoromorpha published by Weirauch and Štys (2014). An unpublished, preliminary dataset that includes species of *Machadonannus*, *Vilhenannus*, *Dundonannus*, and an undescribed taxon near *Semangananus* Štys, 1974 from Thailand, in addition to a comprehensive generic sample of Schizopteridae from all biogeographic regions, suggests that the above mentioned taxa form a highly supported clade within the Schizopterinae, but they are not closely related to *Nannocoris*. Future systematic research on this putative genus group should also better document the largely unexplored diversity of *Dundonannus* and evaluate generic boundaries in the context of phylogenetic analyses derived from comprehensive taxon sampling and molecular as well as morphological data.

Key to the species of *Machadonannus* (based on males)

1. Hemelytron with trapezoidal cell ~1.5 times as long as wide and apical cell ~3 times as long as wide (Fig. 4B), the process of sternite V slender and coiled with expanded tip, and right paramere with slender, elongated tip with notch (Wygodzinsky [1950]: figs 23, 27) .... *Machadonannus ocellatus*

- Hemelytron with trapezoidal cell ~2 times as long as wide and apical cell >4 times as long as wide (Fig. 2E), the process of sternite V stout, hook-shaped, tapering at apex (Fig. 3C), and right paramere with short triangular apical portion and distinctly widened and rounded subapical portion (Fig. 3E) .... *Machadonannus brailovskyi*, n. sp.

Machadonannus brailovskyi, **sp. n.**
Figs 1–3, 5
http://zoobank.org/DD1B7F35-8902-4761-8C98-91E867AC168A

Diagnosis: Recognized by the elongate wing with the trapezoidal cell about twice as long as wide and the cell formed by R and M tapering apically (Fig. 2E), the process of sternite V stout, hook-shaped, tapering at apex, the apical portion almost in one plane, not coiled (Fig. 3C, D), right paramere with short triangular apical portion and distinctly widened and rounded subapical portion (Fig. 3E), and left paramere with left side elongated into a tapering process (Fig. 3E).

Description: Male: Total length ~1.7 mm; as in diagnosis, generic description, and Figs 1–3.

Female: Unknown.

Etymology: Named in honour of Dr. Harry Urad Brailovsky Alperowitz, who has contributed so much to the systematics of Heteroptera. Noun in apposition.

Material examined: Holotype: CENTRAL AFRICAN REPUBLIC: Sangha-Mbaere: Parc National de Dzanga-Ndoki, Mabea Bai, 21.4 km 53° NE Bayanga, 3.0335°N 16.4095°E, S. van Noort, 5 May 2001 (UCR_ENT 00125908) (SAMC). Paratypes: same data as holotype (UCR_ENT 00125909, UCR_ENT 00125913) (SAMC).

Distribution: Known from the type locality in rainforest in the southwestern part of the Central African Republic.

Collecting method: Sweeping vegetation.

Discussion: This new species is very similar to *M. ocellatus* in general habitus, overall morphology of the pregenital abdomen and genitalia, and coloration. The shape of the sternite V process clearly differentiates the two species, together with other diagnostic features derived from the genitalia and wing venation.

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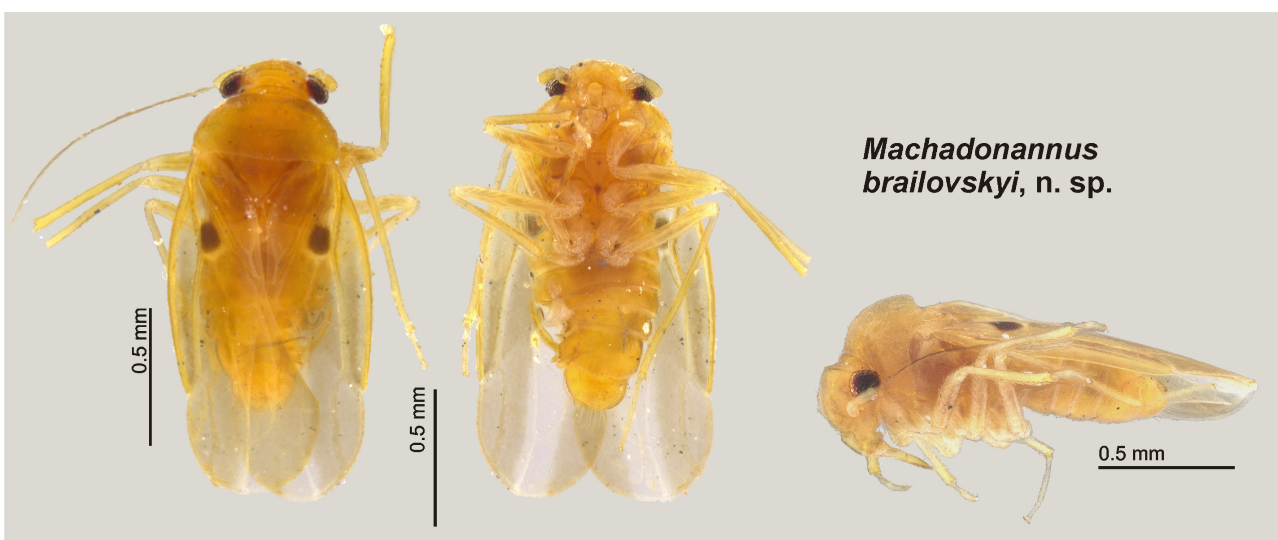

Figure 1. Habitus of the male holotype of *Machadonannus brailovskyi* n. sp., in dorsal, ventral, and lateral views.

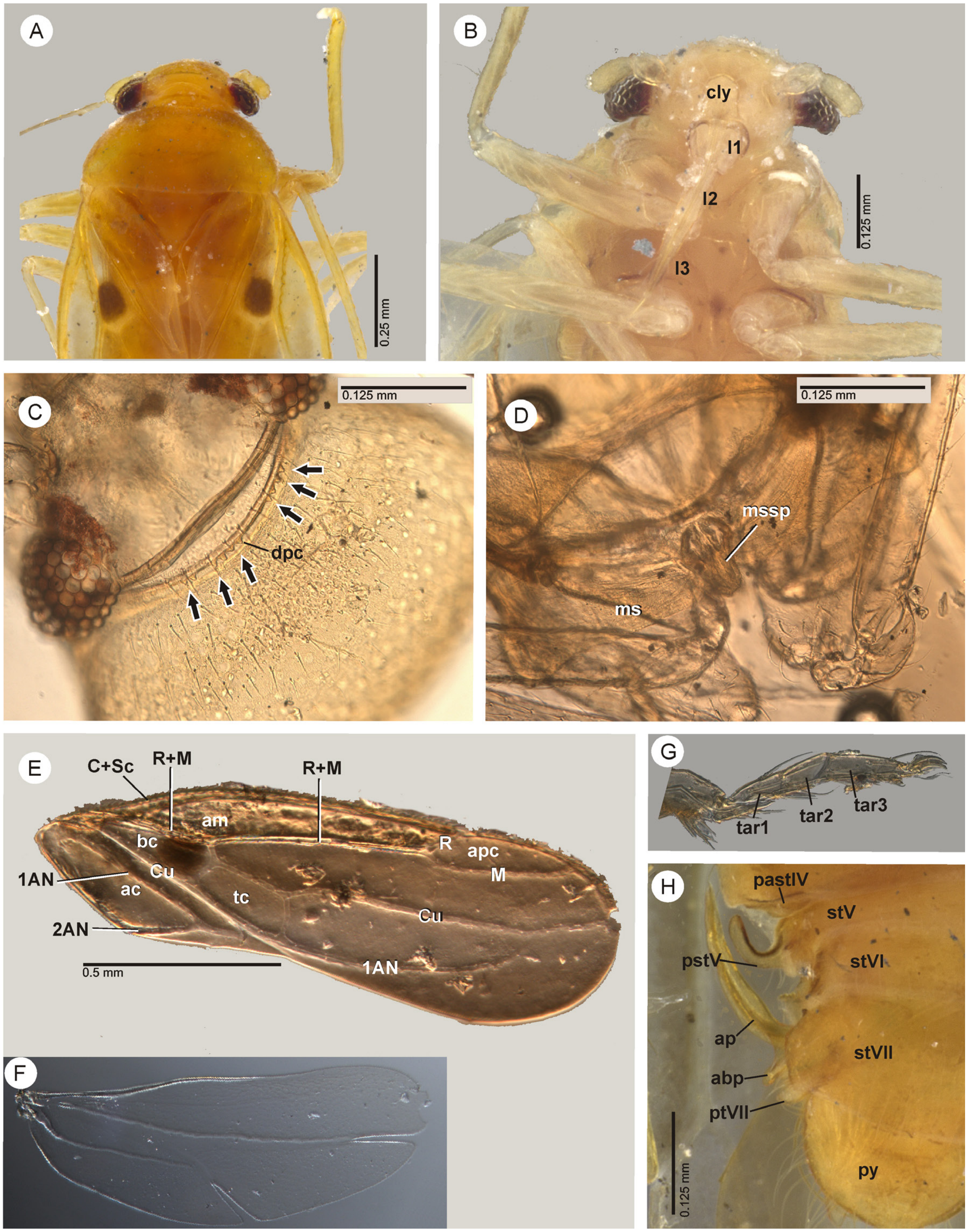

Figure 2. Morphological details of *Machadonannus brailovskyi* n. sp., documented using a Leica imaging system (A, B, H) and Zeiss Axioskop compound microscope (C–G). A, head and thorax, dorsal view; B, head and thorax, ventral view; C, head and pronotum, dorsal view; D, meso- and metathorax, ventral view; E, hemelytron; F, hind wing; G; midtarsus, lateral view; H, right side of abdomen, ventral view.

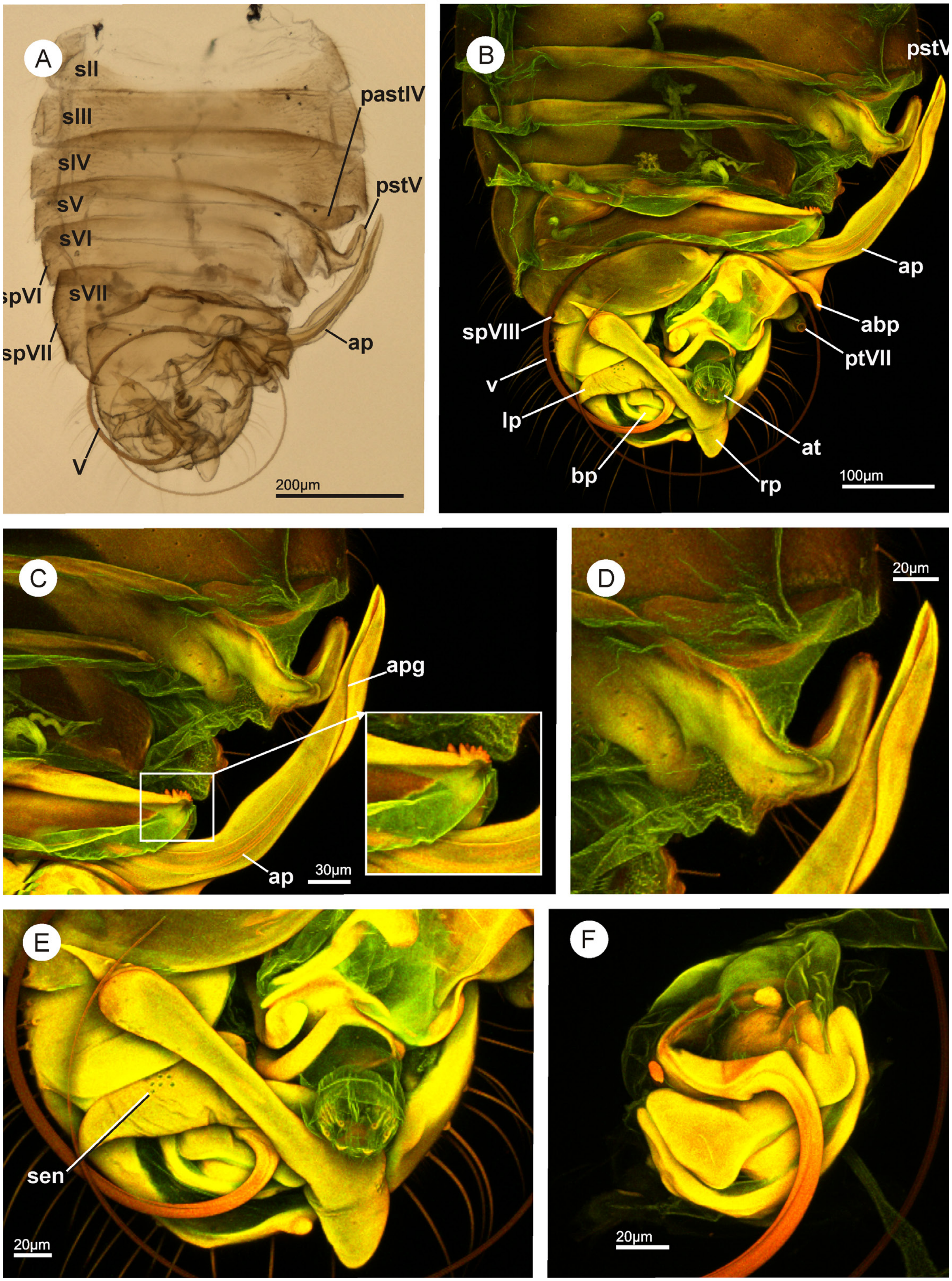

Figure 3. Pregenital abdomen and genitalia of *Machadonannus brailovskyi* n. sp., documented using a Zeiss Axioskop compound microscope (A) and Leica confocal microscope (B–F). A,B, abdomen, dorsal view; C, right side of segments V to IX, inset documenting group of heavily sclerotized small processes on sternite VII; D, process of sternite V and apical part of anophoric process; E, pygophore with right and left paramere, aedeagus, anophore, and base of anophoric process; F, basal plates of aedeagus and base of vesica.

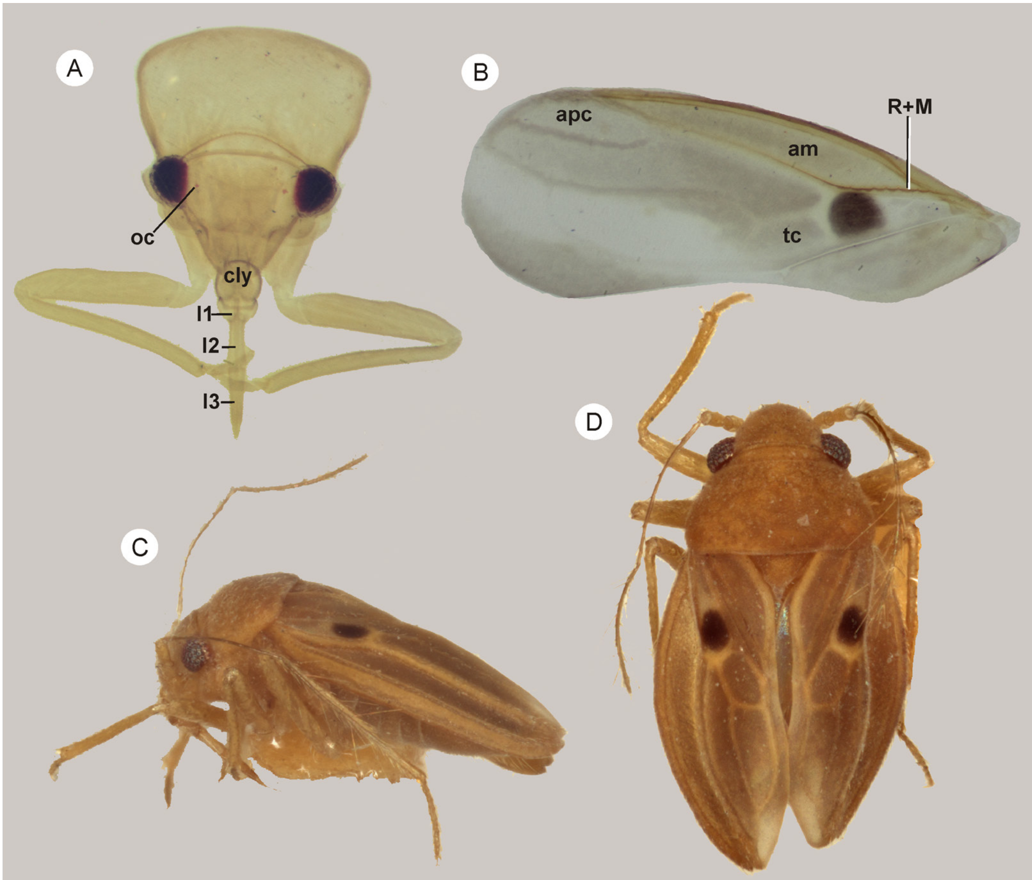

Figure 4. *Machadonannus ocellatus* Wygodzinsky, 1950, slide-mounted male holotype (A, B) and point-mounted female paratype (C, D). A, head and thorax, dorsal/frontal view; B, hemelytron; C, habitus, lateral view; D, habitus, dorsal view.

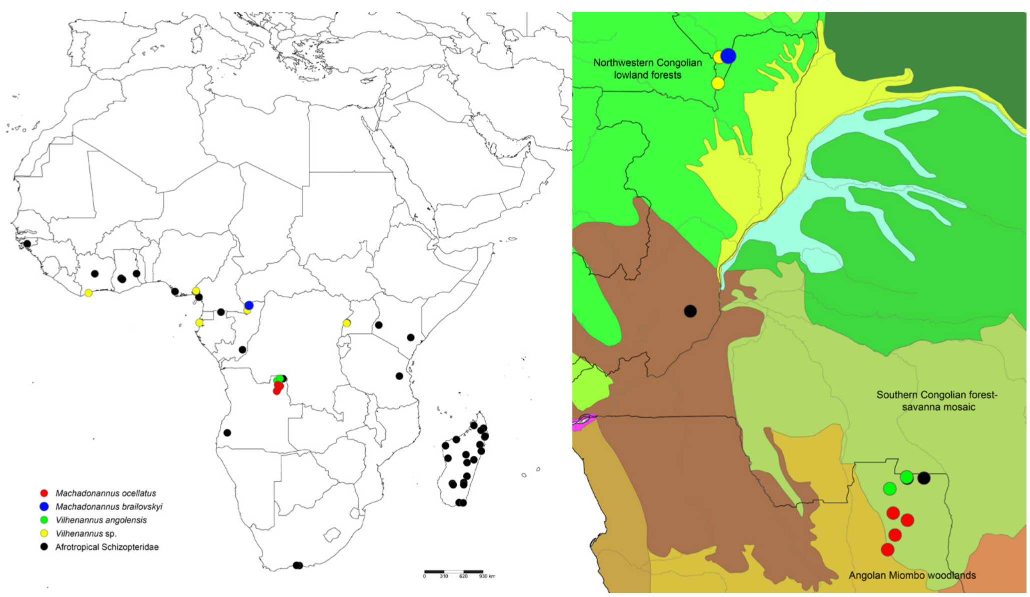

Figure 5. Map documenting distribution of *Machadonannus* spp., *Vilhenannus* spp., and other Afrotropical Schizopteridae that have been sorted and databased as part of the Dipsocoromorpha ARTS project. A, overview; B, *Machadonannus* and *Vilhenannus* localities on map showing ecoregions.