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Trabalho de Conclusão de Curso apresentado à Universidade Federal de Lavras, como parte das exigências do Curso de Ciências Biológicas, para a obtenção do título de Bacharel.

Prof. Dr. Rodrigo Lopes Ferreira

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CINCO NOVAS ESPÉCEIES DE *PHALANGOPSIS* SERVILLE, 1831 (ORTHOPTERA: PHALANGOPSIDAE) DE CAVERNAS BRASILEIRAS NA FLORESTA AMAZÔNICA.

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Five new species of *Phalangopsis* Serville, 1831 (Orthoptera: Phalangopsidae) from Brazilian caves in the Amazon Forest.

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Abstract

The current work presents the description of five new cricket species for the genus *Phalangopsis* Serville, 1831 found in Brazilian caves in the Amazonas, Mato Grosso and Pará States, northern Brazil. The morphology of the phallic complex was used as the main criterion for distinguishing the species. In addition, we present data on the natural history and ecology of the new species as well as hypothesis about the variations of tegmina size in relation to the subterranean lifestyle for the genus. Finally, we provide a pictorial key based on adult males for the *Phalangopsis* species.

Key words: Ensifera, Cave, Insect, Taxonomy

Resumo

No presente trabalho são descritas cinco novas espécies para o gênero *Phalangopsis* Serville, 1831 encontradas em cavernas brasileiras presentes nos estados do Amazonas, Mato Grosso and Pará, norte do Brasil. A morfologia do complexo fálico foi utilizada como o principal critério de distinção das espécies. Além disso, discutimos a história natural, ecologia e hipóteses sobre variação de tamanho da tégmina em relação ao modo de vida subterrâneo para o gênero. Por fim, disponibilizamos uma chave pictórica baseada em espécimes machos adultos paras as espécies conhecidas do gênero.

Palavras chaves: Ensifera, Caverna, Inseto, Taxonomia

Introduction

Phalangopsis Serville, 1831 is one of the least known genera in the family Phalangopsidae Blanchard, 1845, with few records from South America. These crickets present sporadic registers for equatorial forests and inter-tropical regions, as Brazil (Serville, 1831; Saussure, 1874; Costa-Lima & Costa-Leite, 1953; Mews & Sperber, 2008; Cigliano *et al.* 2020), French Guiana (Desutter-Grandcolas, 1992) and Suriname (Saussure, 1878). Furthermore, species from this genus can be found in several Brazilian subterranean environments (Jaffé *et al.* 2016; Guimarães *et al.* 2019; Cigliano *et al.* 2020).

Phalangopsis Serville, 1831 species usually illustrate a spider-like form, very elongated palpi, tarsomeres and legs (Serville, 1831; Mews & Sperber, 2008), and

functional stridulatory apparatus (Serville, 1831; Mews & Sperber, 2008) that can be lacking in some species (Desutter-Grandcolas, 1992; Mews & Sperber, 2008). These crickets have nocturnal habits and are preferably found between cracks in logs and rocks, in the litter and in subterranean environments (Desutter, 1990; Desutter-Grandcolas, 1992; Desutter, 1993; Desutter, 1998; Mews & Sperber, 2008). These crickets have high mobility (Desutter-Grandcolas, 1992) and can act as seed dispersers in neotropical forests (Santana *et al.* 2016). The male adult genitalia (according to the nomenclature of Desutter-Grandcolas, 2003) dorsally project pseudepiphallic median lobes, reduced endophallic apodeme and pseudepiphallic dorsal branch project internally, with the presence of median lobes being one of the possible putative synapomorphies of the group (Mews & Sperber, 2008; Gorochov, 2014).

Although twelve species have been described for the genus since its creation, only six are currently considered valid according the database Orthoptera Species File Online (Cigliano *et al.* 2020). Such species are *Phalangopsis longipes* Serville, 1831 (from French Guiana and Suriname); *Phalangopsis gaudichaudi* Saussure, 1874 (from Brazil); *Phalangopsis flavilongipes* Desutter-Grandcolas, 1992 (from French Guiana); *Phalangopsis carvalhoi* (Costa-Lima & Costa-Leite, 1953) (from Brazil); *Phalangopsis arenita* Mews & Sperber, 2008 (from Brazil) and *Phalangopsis bauxitica* Mews & Sperber, 2008 (from Brazil).

The first species described, thus establishing the genus, were *Phalangopsis annulipes* Serville, 1831 (from Cuba, Guadalupe, Peru and Haiti); *Phalangopsis fuscicornis* Serville, 1831 (from Brazil) and *Phalangopsis longipes* Serville, 1831 (from French Guiana and Suriname) (Saussure, 1874; Serville, 1831, Cigliano *et al.* 2020). However, *P. annulipes* and *P. fuscicornis* were synonymized with the genus *Amphiacusta* by Saussure (1874). Hence, only the type-species of the genus, *Phalangopsis longipes* Serville, 1831, with registry to the Amazon Forest in French Guiana (Desutter-Grandcolas, 1992) and Suriname (Serville, 1839) was kept in the genus.

Phalangopsis annulata Biliimek, 1867 was described for the Cacahuamilpa Caves, Guerrero, Mexico, being later synonymized for genus *Arachnomimus* Saussure, 1897 by Kirby (1906). *Phalangopsis aureopubescens* was initially described for the genus *Arachnomimus* Saussure, 1897 by Wiendl (1970) based on two females found at Lençóis Paulistas, southeastern São Paulo state (Brazil). However, Braun (2009) *apud* (Cigliano *et al.* 2020), as well Mews and Sperber (2008) considered this species as belonging to *Phalangopsis*. *Arachnopsis speluncae* Mello-Leitão, 1937 was synonymized firstly to *Phalangopsis speluncae* Chopard, 1968 and recently synonymized with the genus *Eidmanacris* Chopard, 1956 by Campos *et al.* (2017). The type locality for this species is Santa Bárbara municipality, Minas Gerais state, Brazil.

Considering the valid species: *Phalangopsis longipes* Serville, 1831 was kept in the genus as previously mentioned; *Arachnopsis carvalhoi* (Costa-Lima & Costa-Leite, 1953) was synonymized with the genus *Phalangopsis* by Chopard, 1968, with the type locality being the region of the Paru d'Este River, Amazonas state, Brazil; *Phalangopsis gaudichaudi* Saussure, 1874 was described for Brazil using a female specimen, but the description of this species can be possibly considered a *nomen dubium*, since there is no information about the locality and type species depository in its original description; *Phalangopsis flavilongipes* Desutter-Grandcolas, 1992 was described for the Arataye river region, which is an affluent of Approuague River, near to Pararé rapids, French Guiana and finally *Phalangopsis arenita* Mews and Sperber, 2008 and *Phalangopsis*

bauxitica Mews and Sperber, 2008 were described using male holotypes found in Brazil rainforests in Amazonas and Pará state, respectively.

Lastly, *Phalangopsis tesselata*, cited by Serville (1831), is not present in literature, probably being a *nomen nulum* for the group, since there are no records for locality and deposit of such species.

The number of studies regarding cave biology is increasing throughout the years in Brazil (Ferreira *et al.* 2018; Wynne *et al.* 2019). Such studies are revealing a large number of undescribed species, and considering the large number of unexplored caves in Brazilian territory (CECAV, 2019) many species certainly remain undiscovered. Thus, this work brings the description of five new species of *Phalangopsis* Serville, 1831 from caves in the Brazilian Amazon. In addition, we present data on the natural history and ecology of the new species as well as hypothesis about the variations of tegmina size in relation to the subterranean lifestyle for the genus. Finally, we provide a pictorial key based on adult males for the *Phalangopsis* species.

Material and Methods

The individuals were captured by active search in the caves and immediately preserved on 70% ethanol solution. The genitalia were removed and treated with 10% aqueous solution of potassium hydroxide (KOH) for about five to ten minutes to clarify the structures, removing membranes and muscle tissues. Afterwards they were kept in 70% ethanol solution and its morphologies were analyzed under a Stemi 508 (ZEISS) stereomicroscope as well was the body morphology.

Photographs and measurements were obtained using an Axio Zoom V16 (ZEISS) stereomicroscope. The terminology used to the male phallic sclerites was proposed by Desutter (1987, 1988) and modified by Desutter-Grandcolas (2003).

The software QGIS 3.4.4 was used to elaborate the distribution maps. The points of occurrence were taken from all literature known to the group (Cigliano et al., 2020) and the shape files were accessed in http://www.forest-gis.com/download-de-shapefiles.

Study Area

The caves were sampled in the Amazonas, Mato Grosso and Pará states in Brazil, always associated to the Neotropical forests ecoregion domains (Olson et al, 2001).

Between the northwestern and eastern border among the Brazilian states of Pará and Tocantins occurs the group of siliciclastic rocks known as “Estrondo”, composed by the Morro do Campo Formation, which consists of mainly quartzitic rocks (Auler, 2019). In this area is located the Serra dos Martírios State Park (São Geraldo do Araguaia municipality, Pará state), with an outstanding quartzitic mountain situated close to the western margin of the Araguaia river. In this area, the Andorinhas cave stands out, with more than 1 km of labyrinthine conduits, although many other smaller caves are also found, some of which were investigated in this study (Remanço dos Botos cave and Macacos cave). Also encompassing siliciclastic formations, the speleological region of Juruena-Sucunduri (Apuí and Apiacás municipalities, in the states of Amazonas and Mato Grosso respectively) represents a less explored area, with caves associated to siliciclastic lenses (Auler, 2019), some of them investigated in this study (Casa de Pedra da Navalha cave, Oncinha cave and Casa de Pedra do Pena cave).

Within the Grão-Pará geological group (of iron-ore lithology) occurs the Serra dos Carajás region, composed of large plateaus (e.g. Serra Norte, Serra Leste, Serra Sul)

separated by depressions in the landscape. This region presents more than 2,000 caves, discovered mainly during environmental licensing studies for mining activities. This area is located along the municipalities of Canaã dos Carajás, Curionópolis, and Parauapebas, Pará state (Auler, 2019). To the east of Serra dos Carajás occurs the geological region of São Félix (also of iron-ore lithology), which covers the municipality of São Félix do Xingu, possibly a distinct geological domain (Macambira, 1997), which still needs further studies (Valentin & Olivito 2011).

Taxonomy

Depository. Holotype and 6 paratypes of *Phalangopsis quartzitica* **n. sp.** (3 ♂♂ and 3 ♀♀); holotype and 9 paratypes of *Phalangopsis araguaia* **n. sp.** (8 ♂♂ and 1 ♀♀); holotype and 10 paratypes of *Phalangopsis ferratilis* **n. sp.** (6 ♂♂ and ♀♀); holotype and 5 paratypes of *Phalangopsis kyju* **n. sp.** (2 ♂♂ and 3 ♀♀) and holotype and 5 paratypes of *Phalangopsis kysuia* **n. sp.** (1 ♂♂ and 4 ♀♀) were deposited in the "Coleção de Invertebrados Subterrâneos de Lavras" (ISLA), Centro de Estudos em Biologia Subterrânea, Setor de Biodiversidade Subterrânea, Departamento de Biologia, Universidade Federal de Lavras (Federal University of Lavras), Minas Gerais, Brazil.

Abbreviations: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ect.mp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.

Results

***Phalangopsis quartzitica* n. sp.**
(Figures 2–7, 8–14, 15–18, 19–23, 24–29, 148; Table 1 and 4)

Material examined. Holotype ♂, code ISLA 65740, Brazil, Pará, municipality of São Geraldo do Araguaia, Andorinhas cave (6°16'55.98"S; 48°32'33.52"O), 17.ii.2018, Sperandei, V. F., leg. Holotype condition: integrate. **Paratypes**, 3 ♂ ♂ (ISLA 65737; 65738; 65739) and 3 ♀♀ (ISLA 65736; 65741; 65743), same data of holotype. **Individuals examined**, 1 ♂♂ (ISLA 65742) and 1 ♀♀ (ISLA 65744), same data of holotype.

Distribution. Andorinhas Cave in the municipality of São Geraldo do Araguaia, Pará, Brazil.

Etymology. The specific epithet "*quartzitica*" refers to the quartzite, the matrix rock of the cave where this specie was found.

Diagnosis. Combination of the following characteristics: pseudepiphallic dorsal branch, thin and developed, projecting for the interior of the sclerite, the apex presents a visible dilation in frontal and lateral view (Figs 2, 4 and 5; Pd.db); pseudepiphallic paramere 2 developed, shape discoidal, projecting towards the exterior of the sclerite (Figs 3–5, Ps.P2); pseudepiphallic arm elongated (Fig 2, Ps.arm); pseudepiphallic median lobes developed and projecting dorsally, shape sub-quadrangular elongated towards the endophallus in frontal view and globular in dorsal view (Figs 2, 4–5, Ps.m.1); pseudepiphallic branch little projected dorsally in dorsal view (Figs 2, 4–5; Ps.b); upper

central and lower part of ectophallic arc horizontally curved (Fig. 3, Ect. Arc); endophallic distal portion slightly developed in thickness (Fig. 6, a, End.d).

Description, male holotype. Body color: general body coloration uniformly brownish, dorsal head whitish brown (Fig. 8); pronotum strong yellowish brown, with whitish discoloration spots (Figs 8 and 10); abdomen brown dorsally, white and translucent ventrally; legs yellowish brown, whitish at the start of the femur (Figs 15–18); cerci uniformly whitish brown. **Head**: slightly pubescent; elongated in front view (3.728 and 2.739 mm, length and width respectively); vertex marked with four dark vertical stripes, two starting from the eye's region reaching the occiput, two starting from the antennas bases and reaching the occiput as two darkish spots (Fig. 8); gena, clypeus and labrum whitish, mandibles brownish yellow, dark brown near to the labrum; all maxillary palpomeres slightly pubescent, first and second shorter than the others and whitish, third and fourth palpomeres presenting similar size, the fourth is slightly larger, fifth palpomere lightly longer than fourth, claviform, arched and whitish at tip (Fig. 8); all labial palpomeres whitish, pubescent and increasing in size, third palpomere claviform (Fig. 8); scape pubescent, yellowish brown at the base and whitish toward the pedicel, pedicel dark yellowish brown, antennomeres uniformly yellowish brown (Figs 8 and 9); compound eyes black, with a small depigmented region near the scape insertion; ocelli absent (Figs 8 and 9). **Thorax**: pronotum yellowish dark brown; anterior, medial and posterior portion with spots whitish distributed along the sagittal axis in dorsal view (Fig. 10); dorsal disk broader than long, lateral lobes rounded, anterior and posterior margins sub-straight and with the presence of long bristles (Fig. 10). **Legs.** In general, femur, tibia and tarsus pubescent; first tarsomere serrulated; femur always smaller than tibia (μ=14.748 ± 0.587 mm; μ= 17.050 ± 0.640 mm, femur and tibia respectively, Leg III, n=4) (Figs 15–18). Leg I (Figs 15 and 16): tibia ventrally serrated and armed with two same-sized ventro apical spurs, tympanum absent; first tarsomere almost thrice longer than second and third together. Leg II (Figs 15 and 16): tibia ventrally serrated and armed with two same-sized ventral apical spurs; first tarsomere ventrally serrated and thrice bigger than the second and third together. Leg III: femur dilated; tibia serrulated, armed with four subapical spurs on outer side (Fig. 17) and three on inner side (Fig. 18), three apical spurs on outer (Fig. 17; a, b, c) and four on the inner side (Fig. 18; d, e, f, g), the inner being the longest; first tarsomere about thrice longer than the second and third together, armed with two apical spurs (Figs 17–18). **Right Tegmen**: pubescent, few sclerotized and underdeveloped, stridulatory file absent, poorly marked veins and with glandular thickening at the distal margin (Fig. 11). **Abdomen**: cerci pubescent and elongated, with long bristles at the base; supra-anal plate sub-quadrangular with long bristles at distal portion, base with two small lateral projections, apex slightly rounded and base curved inside (Figs 12 and 13); sub-genital plate sub-quadrangular, oval, short, base rounded, apex sub-triangular and lightly sharp (Figs 13 and 14).

Observations in Paratypes. Male phallic sclerites (paratype ISLA 65737, Fig. 2–6) **Pseudepiphallus**: dorsal branch well sclerotized, thin and developed, projecting for the interior of the sclerite, the apex presents a visible dilation in frontal and lateral view, (Figs 2, 4 and 5, Pd.db), this structure is very similar to Ps.db of *Phalangopsis ferratilis* **n. sp.**; paramer 1 slightly cambered triangular, with a depression on lateral external face, connecting to the paramer two and A sclerite by a membranous tissue (Figs 3–5, Ps.P1); paramer 2 developed, shape discoidal, projecting towards the exterior of the sclerite and

more developed compared to paramer 1 (Figs 3–5, Ps.P2); pseudepiphallic arm elongated (Figs 2, Ps.arm); A sclerite vestigial and fused to Ps.arm, reaching paramer 1 and visible at ventral view (Fig. 5, A); pseudepiphallic medium lobes developed and projected dorsally, shape sub-quadrangular elongated towards the endophallus in frontal view and globular in dorsal view (Figs 2, 4–5, Ps.m.1); pseudepiphallic little projected dorsally in dorsal view, covering part of the proximal region of the ectophallic apodemes (Figs 4–5, Ps.b). **Ectophallic invagination**: apodemes thin and curved dorsally, with a small break in the proximal part of the projections, followed by a inclining in dorsal and lateral view, apex little sclerotized and dilated (Figs 2 and 4, Ect.ap.); lateral bar well developed, elongated in all its extension, internal face slightly projecting towards the Endophallus (Fig. 3, Ect.lb); median projection undeveloped (Fig. 3, Ect.mp); upper central and lower part of ectophallic arc horizontally curved (Fig. 3, Ect.arc). **Endophallus**: endophallus partially projected dorsally in lateral view (Fig. 6, b, End); endophallic distal portion slightly developed in thickness (Fig. 6, a, End.d), with a small vertical groove (Fig. 6, a-c, End.d); median portion narrow (Fig. 6, a-c, End.mp); apodeme reduced (Fig 6, a-c, End.ap).

Female: body size bigger than the male (♀ μ=19.976 ± 0.638mm, n=3); apterous; femur always smaller than tibia; supra-anal plate pubescent and rounded in distal portion, with long bristles, base curved inside with two small lateral projections (Fig. 19); sub-genital plate short, lightly pubescent, V-shaped, presenting a slight indentation (Fig. 20); ovipositor elongated, strong yellowish brown, sword-shaped with sharp apex (μ=11.736 ± 1.140mm, n=3) (Figs 21–23). **Female genitalia.** Copulatory papilla triangular shaped, slightly flattened dorsoventrally (Fig. 7, a and b), the edges of the middle part are slightly bulged (Fig. 7, a and c); presents a dorsal opening of triangular shape in the proximal portion and a small rounded orifice in the distal portion (Fig. 7, a-c).

Ecological Remarks: Individuals of *Phalangopsis quartzitica* **n. sp.** were found in a single quartzite cave (Andorinhas cave, Fig. 24) located in the "Serra das Andorinhas" region (São Geraldo do Araguaia municipality, Pará state). However, this cave is located at the top of the mountain, differently from the caves were *Phalangopsis araguaia* **n. sp.** were observed (that are also inserted in the same mountain). The Andorinhas cave is considerably large, with around 1 km of extension (Auler, 2019). Specimens of *Phalangopsis quartzitica* **n. sp.** are quite common along the cave, being observed in several areas, usually in considerable densities. However, they showed an obvious preference for aphotic and moistened areas, preferring the cave walls (Figs 28 and 29) as observed for the other species herein described. Specimens of *Phalangopsis quartzitica* **n. sp.** were mainly feeding on bat guano, especially from insectivorous bats. Among the predators that were observed feeding on the crickets, there are scorpions (*Tityus metuendus* Pocock, 1897, Fig. 25) and whip-spiders (*Heterophrynus* sp., Fig. 27). The cave has entrances on either the side cliffs of the mountain (where occurs a typical Amazon rainforest) and the top of the mountain, which presents a savanna-like vegetation. Although the side cliffs and the top of the mountain are relatively well preserved, the landscape surrounding the mountain is strongly altered, especially by the removal of the original vegetation for agriculture. The cave receives sporadic human visitors, who seem to only go through the main conduit of the cave, thus not presenting a threat for the invertebrate community. Finally, it is important to highlight that no sampling was conducted outside caves in this study. Hence, despite the fact that specimens of *P. quartzitica* were only found in one cave, they are probably not troglobitic, given the

absence of any obvious troglomorphic traits. Therefore, further studies including external samplings are needed to better understand the actual distribution of this species.

***Phalangopsis araguaia* n. sp.**
(Figures 30–35, 36–42, 43–46, 47–51, 52–56, 148; Table 1 and 3)

Material examined. Holotype ♂, code ISLA 65748, Brazil, Pará, municipality of São Geraldo do Araguaia, Remanso dos Botos cave (6°22'6.96"S; 48°23'38.04"O), 20.ii.2018, Sperandei, V. F., leg. Holotype condition: integrate, legs detached and stored in microtubes. **Paratypes**, 4 ♂ ♂ (ISLA 65746; 65747; 65753; 65754), same data of holotype; municipality of São Geraldo do Araguaia, Macacos cave (6°25'19.30"S; 48°24'34.88"O), 20.ii.2018, 4 ♂ ♂ (ISLA 65745; 65750; 65751; 65752) and 1 ♀ (65749), Sperandei, V. F., leg.

Distribution. Remanso dos Botos and Macacos cave in the municipality of São Geraldo do Araguaia, Pará state.

Etymology. The specific epithet "*araguaia*" make mention to the Araguaia river, to which Remanso dos Botos and Macacos caves are close.

Diagnosis. Combination of the following characteristics: paramer 2 underdeveloped, concave and presenting equal size that paramer 1 (dorsal view) (Figs. 31–33, Ps.P2); pseudepiphallic arm long and inclined internally (Fig. 30, Ps.arm); pseudepiphallic median lobes developed and widely projected dorsally, tilted towards the exterior in dorsal view, shape sub-quadrangular in both lobules (front view) (Figs 30, 32–33; Ps.m.l); pseudepiphallic branch developed, forming an acute projection sclerotized covering the endophallus (dorsal view) (Figs 30, 32–33; Ps.b); upper central part of the ectophallic arc with two vestigial vertical projections, lower part curved horizontally (Fig. 31, Ect. arc); endophallic distal portion developed in thickness, forked and with a small vertical furrow (Fig. 34, a, End.d).

Description, male holotype. Body color: general body coloration uniformly brownish; dorsal head light yellow (Fig. 36); pronotum dark yellowish brown with more accentuated whitish discoloration spots than in *Phalangopsis quartzitica* (Fig. 38); abdomen brownish dorsally, translucent and yellowish white ventrally; legs yellowish brown, whitish at the femur's proximal region (Figs 43–46); cerci uniformly whitish brown. **Head**: lightly pubescent; elongated in front view (4.364 and 3.113 mm, length and width respectively); vertex marked with four vertical dark stripes reaching the occiput, two starting from the antenna base and two starting from the compound eyes (Fig. 36); gena and labrum whitish, clypeus greyish white, mandibles brownish yellow; all maxillary palpomeres slightly pubescent, first and second shorter than the others and whitish, third and fourth palpomeres similar size, the forth lightly larger and whitish yellow, fifth palpomere a little longer than fourth, claviform, curved, yellowish and whitish at the tips (Fig. 36); all labial palpomeres whitish, pubescent and increasing in size, third palpomere claviform (Fig. 36); scape pubescent, yellowish at the base and brownish toward the pedicel, pedicel light brown, antennomeres uniformly light brown; compound eyes black, with a small depigmented region near the scape insertion; ocelli absent (Figs 36 and 37). **Thorax**: pronotum dark yellowish brown; anterior, medial and posterior portion with whitish spots distributed along the sagittal axis in dorsal view (Fig. 38); dorsal disk broader than long, lateral lobe rounded, posterior and anterior margins sub-straight and with long bristles (Fig. 38). **Legs.** In general, femur, tibia and tarsus

pubescent; first tarsomere serrulated; femur always smaller than tibia (μ=17.619 ± 4.052 mm; μ= 20.408 ± 5.001 mm, femur and tibia respectively, Leg III, n=9) (Figs 43–46). Leg I (Figs 43 and 44): tibia armed with two apical spurs and ventrally serrulated, tympanum absent; first tarsomere thrice bigger than the second and third together. Leg II (Figs 43 and 44): tibia serrulated ventrally, armed with two same-sized ventral apical spurs; first tarsomere ventrally serrated and almost thrice longer than the second and third together. Leg III (Figs 45 and 46): femur dilated; tibia serrulated, armed with three subapical spurs on inner (Fig. 46) and four on the outer side (Fig. 45), three apical spurs on outer (Fig. 45; a, b, c) and four on inner side (Fig. 46; d, e, f, g), the inner ones are the longest; first tarsomere almost thrice longer than the second and third tarsomeres together, armed with two apical spurs. (Figs 45 and 46). **Right Tegmen**: developed, stridulatory file absent, covering the first abdominal tergite, presenting more clearly marked veins than the other species in this study and bigger glandular thickening at the distal margin (Fig. 39). **Abdomen**: cerci pubescent and slender, with bristles at its base; supra-anal plate short, sub-quadrangular with bristles at the distal region, base with two lateral projections, apex sub-straight and base curved inside (Figs 40 and 41); subgenital plate oval, sub-quadrangular, base sub-straight, apex with a rounded reentrancy (Figs 41 and 42).

Observations in Paratypes. Male phallic sclerites (paratype ISLA 65746, Figs 30–34) **Pseudepiphallus**: dorsal branch well sclerotized, thin and developed, projecting to the interior of the sclerite as an arched shape (Fig 30–33, Ps.db), similar to Ps.db of *Phalangopsis kyju* **n. sp.**; paramer 1 cambered triangular, with depressions in all its faces, connected to the paramer 2 and sclerite A by a membranous tissue (Figs 31–33, Ps.P1); paramer 2 underdeveloped, concave and presenting equal size that paramer 1 (Figs 31–33, Ps.P2); pseudepiphallic arm elongated and inclined internally (Fig. 30, Ps.arm); A sclerite vestigial and fused with Ps.arm, reaching the paramer 1 and visible at the ventral view (Fig. 31, A); pseudepiphallic medium lobes very developed, lightly rounded and projected dorsally, tilted towards the exterior in dorsal view, lobes sub-quadrangular at frontal view (Figs 30, 32 and 33; Ps.m.l), in this species this structure is more developed than in *Phalangopsis quartzitica* **n. sp.**; pseudepiphallic branch developed, forming an acute projection sclerotized covering all the endophallus and part of the proximal region of the ectophallic apodeme at dorsal view (Figs 30, 32 and 33; Ps.b). **Ectophallic invagination**: apodeme thin, curved internally but with its distal portion slightly curved externally and apex little sclerotized (Figs 30–32, Ect.ap); lateral bar developed, broad and lightly rounded, external face slightly projecting out of the genitalia (Fig. 31, Ect.lb); median projection undeveloped (Fig. 31, Ect.mp); upper central part of the ectophallic arc with two vestigial vertical projections, lower part curved horizontally (Fig. 31, Ect.arc). **Endophallus**: endophallus curved dorsally in lateral view (Fig. 34, b, End); endophallic distal portion developed in thickness, forked and with a small vertical furrow (Fig. 34, a, End.d); medium portion short and lightly narrow (Fig. 34, a– c, End.mp); apodeme reduced (Fig. 34, a–c, End.ap).

Female: body size bigger than the male (♀ 24.041 mm); apterous; femur always smaller than tibia; supra-anal plate pubescent, with rounded distal portion, showing long bristles, base curved inside with two small lateral projections (Fig. 47); subgenital plate short, lightly pubescent, V-shaped, presenting a slight indentation (Fig. 48); ovipositor elongated, strong yellowish brown, sword-shaped with sharp apex (16.454 mm) (Figs 49–51). **Female genitalia.** Copulatory papilla triangular shaped, thinner than in *P. quartzitica*

n. sp., lightly flattened dorsoventrally (Fig. 35, a and c); edges lightly bulged in the middle portion (Fig. 35, a and c); presents a dorsal opening of triangular shape in the proximal portion and a little rounded orifice in the distal portion (Fig. 35, a–c).

Ecological Remarks: Specimens of *Phalangopsis araguaia* **n. sp.** were found in two quartzite caves in a region locally known as "Serra das Andorinhas", located in São Geraldo do Araguaia municipality (Pará state). Such caves are relatively small (Remanso dos Botos cave is 125 meters while Macacos cave is 80.5 meters of extension), and are inserted at the base of the massive quartzite outcrop, which correspond to the Serra das Andorinhas mountain ridge. Specimens were mainly observed in the deeper portions of the caves (aphotic and with high moisture content). The main organic deposits within the caves are guano piles produced by bats with distinct feeding habits, as frugivory (*Carolia* sp.) and insectivory (*Peropteryx* sp. and *Natalus* sp.). In one of the caves (Remanso dos Botos cave, Fig. 53), the seeds transported by the bats germinate, resulting in sprouts that were also consumed by the crickets (Fig. 54). Specimens of *P. araguaia* are mainly observed in the cave walls (Figs 55 and 56). Although the caves are quite preserved (only few signs of human use were observed, especially stepping), the external area is partially altered, exhibiting signs of deforestation and fire (Fig. 52). Furthermore, access to the caves is quite easy, since their entrances are located close to each other and close to a road (around 100 meters). As mentioned for *P. quartzitica*, no samplings were conducted outside caves in this study. Furthermore, *P. araguaia* do not present any troglomorphic traits. Hence, despite the fact that specimens of *P. araguaia* were only found in two caves, they are probably not troglobitic. Therefore, further studies including external samplings are needed to better understand the actual distribution of this species.

***Phalangopsis ferratilis* n. sp.**
(Figures 57–62, 63–69, 70–73, 74–78, 79–82, 148; Table 2 and 3)

Material examined. Holotype ♂, code ISLA 65756, Brazil, Pará, municipality of Canaã dos Carajás, ST-0041 cave (6°18'48.14"S; 50°5'34.91"O), 23.i.2016, BioEspeleo leg. Holotype condition: integrate, legs detached and stored in microtubes. **Paratypes**, municipality of Canaã dos Carajás, ST-0041 cave (6°18'48.14"S; 50°5'34.91"O), 23.i.2016, 1 ♂ (ISLA 65757) and 1 ♀ (ISLA 65758), BioEspeleo; 19.vii.2016, 3 ♀♀ (ISLA 65755; 65759; 65760), BioEspeleo; ST-0042 cave (6°18'48.37"S; 50° 5'33.09"O), 1.ii.2016, 2 ♂♂ (ISLA 65761; 65762) and 1 ♀ (ISLA 65763), BioEspeleo; 14.vii.2016, 2 ♂♂ (ISLA 65766; 65767), BioEspeleo. **Individual examined**, municipality of Canaã dos Carajás, S11C-0179 cave (6°22'47.87"S; 50°22'51.01"O), 03.vii.2015, BioEspeleo, 1 ♂ (ISLA 65768); Canaã dos Carajás, S11C-0096 cave (6°24'16.99"S; 50°23'10.04"O), 26.viii.2015, BioEspeleo, 1 ♂ (ISLA 65769); Canaã dos Carajás, S11C-0111 cave (6°24'4.22"S; 50°23'34.21"O), 31.viii.2015, BioEspeleo, 1 ♂ (ISLA 65770); Canaã dos Carajás, S11C-0170 cave (6°21'56.36"S; 50°22'58.78"O), 05.iv.2016, BioEspeleo, 1 ♂ (ISLA 65771); Canaã dos Carajás, S11C-0184 cave (6°24'35.34"S; 50°23'48.79"O), 09.iv.2016, BioEspeleo, 1 ♂ (ISLA 65772); Canaã dos Carajás, S11C-0108 cave (6°23'54.14"S; 50°23'20.16"O), 08.iv.2016, BioEspeleo, 1 ♂ (ISLA 65773) and 1 ♀ (ISLA 65774); municipality of Curionópolis, Pará, Brazil, SL063 cave (5°58'43.90"S; 49°37'16.40"O), 2011, BioEspeleo, 1 ♂ (ISLA 65775); Curionópolis, SL037 cave (5°58'39.49"S; 49°37'53.12"O), 2011, BioEspeleo, 1 ♂ (ISLA 65776); Curionópolis, SL002 cave (5°57'50.36"S; 49°38'57.37"O), 2011, BioEspeleo, 1 ♂ (ISLA 65777);

Curionópolis, SL075 cave (5°57'54.21"S; 49°37'54.70"O), 2011, Bio Espeleo, 1 ♂ (ISLA 65778) and 2 juvenile (ISLA 65779; 65780); Curionópolis, SL001 (5°57'56.94"S; 49°38'56.48"O), 2011, BioEspeleo, 2 ♂♂ (ISLA 65781; 65783) and 1 ♀ (ISLA 65782); municipality of Parauapebas, Pará, Brazil, N5SM1-006 cave (6°6'33.10"S; 50°8'5.69"O), BioEspeleo, 1 ♂ (ISLA 65784) and 1 ♀ (ISLA 65785); Parauapebas, N5SM2-045 cave (6°8'0.30"S; 50°8'4.15"O), BioEspeleo, 1 ♂ (ISLA 65786) and 1 ♀ (ISLA 65787); Parauapebas, N5SM2-037 cave (6°7'57.24"S; 50°8'3.57"O), BioEspeleo, 1 ♂ (ISLA 65788) and 1 ♀ (ISLA 65789).

Distribution. Subterranean environments in the municipalities of Canaã dos Carajás, Curionópolis and Parauapebas, Pará state, Brazil.

Etimology. The specific name "*ferratilis*" from the latin ferrātus "made of iron", refers to the iron caves where the individuals of this species were found.

Diagnosis. Combination of the following characteristics: pseudepiphallic dorsal branch, thin and developed, projecting for the interior of the sclerite, the apex presents a visible dilation in frontal and lateral view (Figs 57–60, Pd.db); pseudepiphallic paramere 1 developed, proportion similar to pseudepiphallic paramere 2 (lateral and dorsal view) (Fig.58–60, Ps.P1); pseudepiphallic paramere 2 developed, projecting dorsally, discoidal and sub-linear in the distal portion (dorsal view) (Fig. 57–60, Ps.P2); pseudepiphallic arm elongated and externally tilted (dorsal view) (Fig. 57, Ps.arm); pseudepiphallic medium lobes developed, elongated lobes projecting towards the endophallus (frontal view) and distended U-shaped in dorsal view (Figs 57, 59–60; Ps.m.l); upper central and lower part of ectophallic arc horizontally curved in opposite directions (Fig. 58, Ect. arc); endophallic distal portion not developed in thickness (dorsal view) (Fig. 61, a, End.d).

Description, male holotype. Body Color: general body coloration uniformly brownish, dorsal head yellowish brown (Fig. 63); pronotum strong yellowish brown, with some whitish discoloration spots (Figs 63 and 65); abdomen white and translucent ventrally and brown dorsally; legs dark yellowish brown, whitish at the start of the femur (Figs 70–73); cerci uniformly whitish brown. **Head**: slightly pubescent; elongated in frontal view (4.166 and 3.016 mm, length and width respectively); vertex marked with two dark vertical stripes starting in the eye's region and reaching the occiput and two dark vertical stripes starting at the antenna base and sharpening while reach the occiput (Fig. 63); gena whitish yellow, clypeus and labrum whitish, mandibles yellowish brown, whitish near the labrum; all maxilary palpomeres slightly pubescent, first and second shorter than the others and whitish, third and fourth palpomeres whitish yellow and same size, fifth palpomere a little longer than the forth, curved, claviform, yellowish and whitish at the tip (Fig. 63); all labial palpomeres whitish, pubescent and increasing in size, third palpomere claviform (Fig. 63); scape pubescent, dark yellowish brown at the base and whitish at the proximal region, pedicel yellowish brown, antennomeres uniformly yellowish brown (Figs 63 and 65); compound eyes black with a small depigmented area near the scape insertion; ocelli reduced (Figs 63 and 65). **Thorax**: pronotum yellowish brown; anterior, medial and posterior regions with whitish spots distributed along the sagittal axis in dorsal view (Fig. 65); dorsal disk broader than long, lateral lobes rounded, anterior and posterior margins sub-straight and with long bristles (Fig. 65). **Legs.** Generally, femur, tibia and tarsus pubescent; first tarsomere serrulated; femur always smaller than tibia (μ= 15.080 ± 1.974 mm; μ= 17.472 ± 1.964 mm, femur and tibia respectively, Leg III, n=7) (Figs 70–73). Leg I (Figs 70 and 71): tibia serrulated, with two apical ventral spurs, tympanum absent; first tarsomere thrice longer than the third and

second together. Leg II (Figs 70 and 71): tibia ventrally serrulated, with two same-sized apical ventral spurs; first tarsomere ventrally serrated and three times longer than the second and third together. Leg III (Figs 73–75): femur dilated; tibia serrulated, armed with four subapical spurs on outer side (Fig. 73) and three on inner side (Fig. 74), three apical spurs on outer (Fig. 73; a, b, c) and four on the inner side (Fig. 74; d, e, f, g), the inner being the longest; first tarsomere about thrice longer than the second and third together, armed with two apical spurs (Figs 73 and 74). **Right Tegmen**: little pubescent, undeveloped, stridulatory file absent, few sclerotized with little glandular thickness and poorly marked veins (Fig. 66). **Abdomen**: cerci pubescent and elongated; supra-anal plate sub-quadrangular, presenting long bristles at its distal portion and two reduced lateral projections at its base, apex lightly rounded and base curved inside (Figs 67 and 68); sub-genital plate sub-quadrangular, broad, apex sub-straight with a small center sharp projection and base slightly rounded (Figs 68 and 69).

Observations in Paratypes. Male phallic sclerites (paratype ISLA 65757, Fig. 57–61) **Pseudepiphallus**: dorsal branch well sclerotized, developed and thin, projecting to the interior of the sclerite, the apex presents a dilatation visible in frontal and lateral view (Figs 57–60, Ps.db.), the structure is similar to the Ps.db of *Phalangopsis quartzitica* **n. sp.**; paramer 1 cambered triangular, developed, proportion similar to pseudepiphallic paramere 2 at dorsal and lateral view, connecting to A sclerite and paramer 2 by a membranous tissue (Figs 58–60, Ps.P1); paramer 2 developed, shape discoidal, sub-linear in the distal portion (dorsal view) and projecting dorsally (Figs 57–60, Ps.P2); pseudepiphallic arm elongated and externally tilted (Fig. 57, Ps.arm); A sclerite vestigial and fused to Ps. arm, reaching the paramer 1 and visible at ventral view (Fig. 58, A); pseudepiphallic medium lobes developed, projecting dorsally, elongated lobes projecting towards the endophallus at frontal view and distended U-shaped in dorsal view (Figs 57, 58–59; Ps.m.1); pseudepiphallic branch projected dorsally, covering part of the proximal portion of the ectophallic apodemes (Figs 57, 59–60; Ps.b). **Ectophallic invagination**: apodemes thin and curved towards the interior of the sclerite, apex little sclerotized and dilated (Figs 57–59, Ect.ap.); lateral bar well developed, elongated in all its extension (Fig. 58, Ect.lb); median projection undeveloped (Fig. 58, Ect.mp); upper central and lower part of ectophallic arc horizontally curved in opposite directions (Fig. 58, Ect.arc). **Endophallus**: endophallus partially projected dorsally in lateral view (Fig. 61, b); endophallic distal portion not developed in thickness, with a small vertical groove (Fig. 61, a–c, End.d); median portion narrow (Fig. 61, a–c, End.mp); apodeme reduced (Fig 61, a–c, End.ap).

Female: body size larger than male (♀ μ=19.607 ± 3.278mm, n=3); apterous; femur always smaller than tibia; supra-anal plate pubescent and slightly elongated, distal portion rounded and bearing long bristles and base curved inside, lateral projections reduced (Fig. 74); sub-genital plate short, slightly pubescent, V-shaped, showing a clear indentation at the distal portion (Fig, 75); ovipositor elongated, yellowish brown, sword-shaped with sharp apex (μ=13.941 ± 0.580mm, n=3) (Figs 76–78). **Female genitalia.** Copulatory papilla triangular shaped, slightly flattened dorsoventrally (Fig. 62, a and b), edges of the middle part straight (dorsal and ventral view) (Fig. 62, a and c); presents a dorsal opening of triangular shape in the proximal portion and a small rounded orifice in the distal portion (Fig. 62, a–c).

Ecological Remarks: The area where *Phalangopsis ferratilis* **n. sp.** occurs is known as Carajás region and is located in eastern Pará state, in the Amazon forest. This

area is of outstanding relevance in Brazil (both environmental and economic), due to its huge iron ore reserves. The area can be divided in distinct regions, locally known as "morros" (meaning "hills") which, in fact, comprises sets of ferruginous outcrops. In the region, considering a set of 360 sampled iron ore caves, specimens of *P. ferratilis* were observed in 292 caves (which corresponds to approximately 81% of the caves in the area). The average horizontal projection of the caves is 30 meters (but the cave sizes were quite variable, from 5 to 205 meters) (Fig. 79). Specimens of *P. ferratilis* were rarely observed in the entrance zones, but are abundant in deeper areas within the caves (usually aphotic). They seem to prefer moist areas inside the caves. For one of the areas in the Carajás region (locally known as "Morro I" and "Morro II"), we tested if there was any correlation between the population abundances within the caves and the respective cave size (horizontal projections, given in meters). The regression test showed a strong positive and significant relation between those variables, for a sample considering 144 caves ($F_{(1,142)}$=256.77; R= 0.802; R^2= 0.644; p<0.0000) (Fig. 83). Therefore, the cave size seems to be an important factor determining the population size of this species. Given that they are mostly abundant in aphotic zones, bigger caves may shelter more individuals probably due to its most extensive aphotic areas. Potential organic resources include especially bat guano (Figs 80 and 82) that may constitute one of the motives why bigger populations are preferentially found in larger caves (in addition to the moister conditions). Larger caves may shelter bigger bat colonies, which produces higher amounts of guano. Specimens of *P. ferratilis* are mainly observed in the cave walls (Fig. 81), although, when foraging, they can be found in the floor. It is important to note that samplings where not performed in the external environments, so the actual distribution of this species remains largely unknown.

***Phalangopsis kyju* n.sp.**
(Figures 84–89, 90–96, 97–100, 101–105, 106–109, 148; Table 2 and 4)

Material examined. Holotype ♂, code ISLA 65731, Brazil, Pará, municipality of São Félix do Xingu, SFX_0034 cave (6°23'20.02"S; 51°52'45.08"O), 30.ii.2018, Ativo Ambiental. Holotype condition: integrate, legs detached and store in microtubes. **Paratypes**, municipality of São Félix do Xingu, SFX_0021 cave (6°23'35.93"S; 51°52'14.68"O), 01.ii.2018, 1 ♂ (ISLA 65730), Ativo Ambiental; São Félix do Xingu, SFX_0022 cave (6°23'32.89"S; 51°52'20.53"O), 01.ii.2018, 1 ♂ (ISLA 65733), Ativo Ambiental; São Félix do Xingu, SFX_0024 cave (6°23'27.60"S; 51°52'27.88"O), 01.ii.2018, 1 ♀ (ISLA 65734), Ativo Ambiental; São Félix do Xingu, SFX_0001 cave (6°25'11.90"S; 51°50'50.76"O), 03.ii.2018, 1 ♀ (ISLA 65735), Ativo Ambiental; São Félix do Xingu, SFX_0005 cave (6°24'57.40"S; 51°50'55.06"O), 16.i.2018, 1 ♀ (ISLA 65732), Ativo Ambiental.

Distribution. Caves in the municipality of São Félix do Xingu, Pará state.

Etymology. The word "*kyju*" means "cricket" in the native language of the Tupi-Guarani people located in the Xingu region.

Diagnosis. Combination of the following characteristics: pseudepiphallic paramere 2 distant from the pseudepiphallic dorsal branch, globular and projected for the interior of the sclerite (Fig. 85–87, Ps.P2); pseudepiphallic arm short and lightly tilted internally (Fig. 84, Ps.arm); pseudepiphallic median lobes developed and widely projected dorsally, both lobules dilated oval shaped (front view) (Figs 84, 86–87; Ps.m.l); pseudepiphallic branch developed, forming an acute projection semi-sclerotized covering the endophallus

(dorsal view) (Fig. 84, 86–87; Ps.b); upper central and lower part of ectophallic arc horizontally curved in opposite directions (Fig. 85, Ect. Arc); endophallic distal portion slightly forked, developed in thickness (dorsal view) (Fig. 88, End.d).

Description, male holotype. Body color: general body coloration brownish, dorsal head dark brownish yellow (Fig. 90); pronotum strong yellowish brown, with whitish discoloration spots (Figs 90 and 92); abdomen brown at dorsal view and white translucent ventrally; brownish yellow legs, whitish ventrally at the start of the femur (Figs 97–100); cerci uniformly whitish brown. **Head**: slightly pubescent; elongated at frontal view (4,209 and 3,226 mm, length and width respectively); vertex marked with two vertical dark stripes starting at the antenna's bases and tapering near the occiput and two vertical dark stripes starting from the eye's region (Fig. 90); gena whitish yellow, clypeus and labrum whitish, mandibles brownish yellow; all maxilary palpomeres slightly pubescent, first and second maxillary palpomeres shorter than the others and whitish, third and fourth palpomeres similar size, yellowish and equally pubescent, fifth palpomere lightly longer than fourth, curved, claviform, pubescent, yellowish and whitish at the tip (Fig. 90); all labial palpomeres whitish, pubescent and increasing in size, third palpomere claviform (Fig. 90); scape dark yellowish brown, whitish at the base and pubescent, pedicel and antennomeres dark yellowish brown (Figs 90 and 91); compound eyes black, with a small depigmented portion near the scape base; ocelli absent (Figs 90 and 91). **Thorax**: pronotum strong yellowish brown; anterior, medial and posterior region with whitish spots distributed along the sagittal axis in dorsal view (Fig. 92); lateral lobes rounded, dorsal disk broader than long, anterior and posterior margins sub-straight, presenting long bristles (Fig. 92). **Legs.** In general, femur, tibia and tarsus pubescent; first tarsomere serrulated; femur always smaller than tibia (μ=20.820 ± 0.898 mm; μ= 24.303 ± 1.157 mm, femur and tibia respectively, Leg III, n=3) (Figs 97–100). Leg I (Figs 97 and 98): tibia serrulated ventrally, armed with two ventro apical spurs, tympanum absent; first tarsomere about thrice longer than the second and third together. Leg II (Figs 97 and 98): tibia serrulated ventrally, with two same-sized apical ventral spurs; first tarsomere thrice longer than the second and third together. Leg III (Figs 99 and 100): femur dilated; tibia serrated ventrally, armed with four subapical spurs on outer side (Fig. 99) and three on inner side (Fig. 100), three apical spurs on outer (Fig. 99; a, b, c) and four on the inner side (Fig. 100; d, e, f, g), the inner being the longest; first tarsomere three times longer than the second and third together, armed with two apical spurs (Figs 99 and 100). **Right Tegmen**: little developed, stridulatory file absent, pubescent, covering almost all first abdominal tergite, with glandular thickening at the distal margin and weakly marked veins. (Fig. 92). **Abdomen**: cerci elongated and pubescent, with long bristles at its base; supra-anal plate sub-quadrangular with long bristles at the apex, base with two small lateral projections, apex rounded and base curved inside (Figs 94 and 95); sub-genital plate sub-quadrangular, lightly oval, base sub-straight, apex lightly rounded (Figs 95 and 96).

Observations in Paratype series. Male phallic sclerites (paratype ISLA 65730, Fig. 84–88) **Pseudepiphallus**: dorsal branch well sclerotized, thin and developed, curved towards the interior of the sclerite (Figs 84–87, Ps.db), the structure is very similar to Ps.db of *Phalangopsis araguaia* **n. sp.**; paramer 1 cambered triangular, slightly sharp and with a depression in its external lateral face, connecting to paramer 2 and A sclerite by a membranous tissue (Figs 85–87, Ps.P1); paramere 2 distant from the pseudepiphallic dorsal branch, globular and projected for the interior of the sclerite (Figs 85–87, Ps.P2);

pseudepiphallic arm short and lightly tilted internally (Fig. 84, Ps.arm); A sclerite vestigial and fused to Ps.arm, reaching the paramer 1 and visible at ventral view (Fig. 85, A); pseudepiphallic median lobes developed and widely projected dorsally, both lobules dilated oval shaped (Figs 84, 86–87; Ps.m.l), the Ps.m.l of this species is the most developed of all species here described; branch developed, projecting dorsally, forming an acute projection semi-sclerotized, covering almost half of the ectophallic apodeme and all the endophallus (Figs 84, 86–87; Ps.b). **Ectophallic invagination**: apodemes thin, curved internally in dorsal view and dorsally in lateral view, apex little sclerotized and dilated (Figs 84–86, Ect.ap); lateral bar developed and rounded in its internal face (Fig. 85, Ect.lb); median projection undeveloped (Fig. 85, Ect.mp); upper central and lower part of ectophallic arc horizontally curved in opposite directions (Fig. 85, Ect. Arc). **Endophallus**: endophallus partially curved dorsally in lateral view (Fig. 88, b); endophallic distal portion slightly forked, developed in thickness and with a small vertical groove (Fig. 88, End.d); median portion lightly narrow (Fig. 88, End.mp); apodeme reduced (Fig. 88, End.ap).

Female: body size bigger than male (♀ μ=20.303 ± 0.799mm, n=3); apterous; femur always smaller than tibia; supra-anal plate pubescent and very short, sub-straight at distal portion and showing long bristles, base curved inside and lateral projections very reduced (Fig. 101); subgenital plate short, lightly pubescent, sub-quadrangular, distal portion curved inside (Fig. 102); ovipositor elongated, yellowish brown, sword-shaped with pointed apex (μ=15.806 ± 0.201mm, n=3) (Figs 103–105). **Female genitalia.** Copulatory papilla triangular shaped, slightly flattened dorsoventrally, thinner than in *Phalangopsis ferratilis* **n. sp.** (Fig. 89, a and b), edges of the middle part sub-straight (dorsal and ventral view) (Fig. 89, a and c); presence of a dorsal opening of triangular shape in all its extension and a small rounded orifice in distal portion (Fig. 89, a–c).

Ecological Remarks: The region where *Phalangopsis kyju* **n. sp.** occurs (São Félix do Xingu) presents around 90 known ferruginous caves. Individuals of such species were observed in approximately 40% of the caves in the area. The average horizontal projection of the caves is 27 meters and they present, in average, 88 m² of area. Specimens of *P. kyiu* are rarely observed in the entrance zones (euphotic areas, Fig. 106), but are rather abundant in deeper areas within the caves (usually aphotic, Fig. 107). They seems to prefer moist areas inside the caves. The main organic resources occurring in those caves is bat guano and root mats from the external vegetation, but it seems that their abundance is not directly determined by such organic deposits, since there are some caves devoid of such substrates but with dense populations. This may indicate that such species is also capable of foraging in external environments. Specimens are mainly observed in the cave walls (Figs 108 and 109). Since external samplings were not conducted in the area, it is not possible to estimate the actual distribution of this species in the region.

***Phalangopsis kysuia* n. sp.**
(Figures 110–115, 116–122, 123–126, 127–131, 132–135, 148; Table 2 and 3)

Material examined. Holotype ♂, code ISLA 65725, Brazil, Mato Grosso, municipality of Apiacás, Casa de Pedra da Navalha cave (7°28'50.70"S; 58°12'36.40"O), 09.ix.2011, Ferreira, R. L., leg. Holotype condition: integrate, legs detached and stored in microtubes. **Paratypes**, municipality of Apiacás, Mato Grosso state, Brazil, Oncinha cave (8°8'49.00"S; 57°13'17.44"O), 14.ix.2011, 1 ♀ (ISLA 65726), Ferreira, R. L., leg;

municipality of Apuí, Amazonas state, Brazil, Casa de Pedra do Pena cave (8°20'13.40"S; 58°19'23.20"O), 12.v.2011, 1 ♀ (ISLA 65724) and 12.ix.2011, 1 ♂ (ISLA 65727) and 2 ♀♀ (ISLA 65728; 65729), Ferreira, R. L., leg.

Distribution. Casa de Pedra da Navalha cave and Oncinha cave in the municipality of Apiacas, Mato Grosso state; and Casa de Pedra do Pena cave in the municipality of Apuí, Amazonas state.

Etymology. The word "kysuia" means "cricket" in the native language of the Apiacá, which is one of the ethnic people from the Juruena region, where the species was found.

Diagnosis. Combination of the following characteristics: pseudepiphallic dorsal branch greatly reduced and curved internally toward the pseudepiphallic paramers (Figs 110–113, Ps.db.); pseudepiphallic median lobes well rounded, dorsally projected, shape quadrangular (in front view), distal portion distant from pseudepiphallic branch (lateral view), narrow and globular in dorsal view (Figs 110, 112–113; Ps.m.l); pseudepiphallic branch developed, forming an semi-acute projection covering partially the endophallus (dorsal view) (Fig. 110, 112–113; Ps.b); pseudepiphallic arm short and inclined internally (Fig. 110, Ps.arm); ectophallic lateral bar flattened, external face tilted out the genitalia, apex projecting inside the sclerite with a rounded apex (Fig. 111, Ect.lb); upper central part of ectophallic arc curved in U format, lower part slightly curved horizontally (Fig. 111, Ect. arc); proximal projections of ectophallic apodemes expanded in width (dorsal view) (Figs 110, 112–113; Ect. ap); endophallic distal portion slightly developed (dorsal view) (Fig. 114, End.d).

Description, male holotype. Body color: general body coloration yellowish brown, dorsal head light yellowish brown (Fig. 116); pronotum yellowish brown with whitish discoloration spots (Figs 116 and 118); abdomen grayish white translucent ventrally and yellowish brown dorsally; brownish yellow legs, whitish at the start of the femur (Figs 123–126); cerci yellowish brown. **Head**: lightly pubescent; elongated in front view (3.721 and 2.554 mm, length and width respectively); vertex marked with two vertical dark stripes starting at the eye's region and two starting at the antenna's base, both reaching the occiput (Fig. 116); gena whitish yellow, clypeus whitish brown, labrum whitish and mandibles yellowish brown; all maxillary palpomeres slightly pubescent, first and second palpomeres whitish, and smaller than the others, third and fourth palpomeres similar size and yellowish, fifth palpomere a little longer than the forth, yellowish, whitish at the tips, claviform and curved (Fig. 116); all labial palpomeres whitish, pubescent and increasing in size, third palpomere claviform (Fig. 116); scape yellowish brown and pubescent, pedicel and antennomeres yellowish brown; compound eyes black, with a small depigmented area near the base of the scape; ocelli absent (Figs 116 and 117). **Thorax**: pronotum yellowish brown; anterior, medial and posterior portion with whitish spots distributed along the sagittal axis at dorsal view (Fig. 118); lateral lobes rounded, dorsal disk broader than long; anterior and posterior margins sub-straight and with long bristles (Fig. 118). **Legs.** In general, femur, tibia and tarsus pubescente; first tarsomere serrulate; femur always smaller than tibia (μ=16.911 ± 4.156 mm; μ= 19.697 ± 5.472 mm, femur and tibia respectively, Leg III, n=2) (Figs 123–126). Leg I (Figs 123 and 124): tibia serrated ventrally, armed with two same-sized apical ventral spurs, tympanum absent; first tarsomere about three times longer than the second and third together. Leg II (Figs 123 and 124): tibia ventrally serrulated, armed with two same-sized ventral apical spurs; first tarsomere ventrally serrated and approximately thrice bigger than the second and

third tarsomeres together. Leg III (Figs 125 and 126): femur dilated; tibia serrulated, armed with four subapical spurs on outer (Fig. 125) and three on inner side (Fig. 126), three apical spurs on outer side (Fig. 125; a, b, c) and four on the inner (Fig. 126; d, e, f, g), the inner ones being the longest; first tarsomere about thrice longer than the second and third together, showing two apical spurs. **Right Tegmen**: Absent (Fig. 119). **Abdomen**: cerci slender and pubescent; supra-anal plate sub-quadrangular with long bristles at the apex, base with two reduced lateral projections, apex rounded and base curved inside (Figs 120 and 121); sub-genital plate sub-quadrangular, broader than long, base straight, apex sub-triangular and sharp (Figs 121 and 122).

Observations in paratype series. Male phallic sclerites (paratype ISLA 65727, Fig. 110–114) **Pseudepiphallus**: dorsal branch well sclerotized but greatly reduced when compared with other *Phalangopsis* (*P. ferratilis* **n. sp.** e.g.), curved internally toward the pseudepiphallic paramers (Figs 110–113, Ps.db.); paramer 1 cambered triangular, with a depression on its lateral external face, connecting to the paramer 2 and sclerite A by a membranous tissue (Fig 111–113, Ps.P1); paramer 2 stocky discoidal (in dorsal view), same size than the paramer 1, less developed than the paramer 2 of *Phalangopsis ferratilis* **n. sp.** (Fig 111–113, Ps.P2); pseudepiphallic arm short and inclined internally (Fig. 110, Ps.arm); A sclerite vestigial, fused with the Ps.arm, reaching the paramer 1 and visible at ventral view (Fig. 111, A); pseudepiphallic median lobes well rounded, dorsally projected, shape quadrangular at frontal view, distal portion distant from pseudepiphallic branch in lateral view, narrow and globular in dorsal view (Figs 110, 112–113; Ps.m.l); pseudepiphallic branch developed, forming an semi-acute projection covering partially the endophallus (dorsal view) (Figs 110, 112–113; Ps.b). **Ectophallic invagination**: apodeme shorter and broader than in other *Phalangopsis*, curved internally, apex little sclerotized and expanded in width (Figs 110-113, Ect.ap.); ectophallic lateral bar flattened, external face tilted out the genitalia, apex projecting inside the sclerite with a rounded apex (Fig. 111, Ect.lb); median projection undeveloped (Fig. 111, Ect.mp); upper central part of ectophallic arc curved in U format, lower part slightly curved horizontally (Fig. 111, Ect. Arc). **Endophallus**: endophallic distal portion slightly developed in thickness, apex projecting dorsally, with a small vertical groove (Fig 114, a–c, End.d); median portion narrow (Fig 114, a–c, End.d); apodeme reduced (Fig 114, a–c, End.d).

Female: body size bigger than male (♀ μ=20.822 ± 1.446mm, n=4); apterous; femur always smaller than tibia; supra-anal plate pubescent and lightly elongated, rounded in distal portion and with long bristles, base curved inside and presence of two rounded lateral projections(Fig. 127); sub-genital plate short, lightly pubescent, U-shaped, presenting a lightly indentation (Fig. 128); ovipositor elongated, yellowish brown, presenting sword-shaped with pointed apex (μ=12.452 ± 0.766mm, n=4) (Figs 126-128). **Female genitalia.** Copulatory papilla triangular shaped, slightly flattened dorsoventrally (Fig. 115, a and b); edges of middle part sub-straight (dorsal and ventral view) (Fig. 115, a and c); presence of a triangular opening in all its extension and a small rounded orifice in the distal portion (Fig. 115, a–c).

Ecological Remarks: Specimens of *Phalangopsis kysuia* **n. sp.** were found in three siliciclastic caves in the Juruena National park, located in the border between the Mato Grosso and Amazonas Brazilian states, in the Amazon forest. Although other nine caves were also inventoried in the region, specimens were only found in these three caves. Individuals were only observed in the aphotic, moist and deeper areas of the caves, and its non-occurrence in the other caves may be due to their small extension (thus, their inner

portions were not completely aphotic). In one of the caves (Casa de Pedra da Navalha), the population was quite small, and only few specimens were observed, apparently feeding on the guano of insectivorous bats (*Peropteryx* sp.). On the other hand, the Casa de Pedra do Pena cave, which comprises the largest sampled cave in the area, presented an expressive population, which only occurred in a lateral and isolated chamber of the cave. Although the main conduit of this cave is quite voluminous, the distances between the two cave entrances is relatively small, what makes this chamber lightened (Fig. 132). However, there is a secondary conduit, connected to the main chamber (Fig. 133), which has more stable and moistened conditions (Fig. 134). The individuals were observed feeding on bat guano, especially produced by frugivorous bats (*Carolia* sp.). The area is quite remote and can only be accessed by boat or small aircraft. Thus, the whole area is well preserved, including both the caves, which showed no signs of human presence, and the forest surrounding them, which is completely preserved within a radius (from the caves) of at least 100 km. It is worth noting that samplings where not performed in the external environments, so the actual distribution of this species remains unknown.

***Phalangopsis arenita* Mews & Sperber, 2008**
(Figures 136–139 and 148)

Ecological Remarks: *Phalangopsis arenita* was described in 2008, based on specimens collected in Maroaga cave, which is a sandstone cave located in Presidente Figueiredo municipality, Amazonas state, Brazil (Mews & Speber, 2008). Despite the good morphological species description, the authors unfortunately did not provide any data on its ecology or habitat (as well as photos of living specimens), only mentioning, in the original description, information on the lithology, cave extension and the presence of a stream inside the cave. Since we are providing information of the habitat and conservation status of the species herein described, we decided to present this topic for this previously described species, considering that one of the authors (RLF) visited the Maroaga cave few years ago. Specimens of *P. arenita* were observed in almost all the cave extension, excepting the entrance area (Fig. 136). The cave main conduit is trespassed by a stream (Fig. 138), and many lateral chambers are connected to the main chamber. The crickets are mainly observed on the cave's walls (Figs 137 and 139) and sometimes are concentrated in some spots. The main organic resources are guano produced by bats of distinct diets, especially insectivorous and frugivorous bats. At the deeper potion of the cave, there is a voluminous chamber where a big guano pile occurs. This chamber presents a high density of *P. arenita*. Predators include especially the whip-spiders (*Heterophrynus* sp.). Maroaga cave is inserted within the limits of a State park, so the external area surrounding the cave is highly preserved. There are other caves in the area, but most of them are smaller. However, in some of those caves, specimens of *P. arenita* were also observed, always in the aphotic areas. Maroaga cave is a touristic cave, but visitors are only allowed to visit the areas close to the entrance; hence, humans do not disturb the deepest chamber, where the higher density of crickets was observed.

Discussion

General traits of Phalangopsis *Serville, 1831 species*

Phalangopsis Serville, 1831 is characterized by its spider-like form, general aspect of appendices elongated (Serville, 1831; Desutter, 1990), ocelli reduced as in *P. longipes* Serville, 1831; *P. flavilongipes* Desutter-Grandcolas, 1992; *P. arenita* Mews & Sperber, 2008 and *P. carvalhoi* (Costa Lima & Costa Leite, 1953) or absent as in *P. bauxitica* Mews, 2008; *P. araguaia* **n. sp.**; *P. quartzitica* **n. sp.**; *P. ferratilis* **n. sp.**; *P. kyju* **n. sp.** and *P. kysuia* **n. sp..** The tympanum is present (e.g. *P. arenita*) or absent (e.g. *P. bauxitica* and all species herein described) (Desutter-Grandcolas, 1992) and stridulatory device functional (e.g. *P. longipes* and *P. arenita*) or non-functional (e.g. *P. flavilongipes*, *P. bauxitica*, *P. kyju* **n. sp.**, *P. araguaia* **n. sp.**, *P. quartzitica* **n. sp.** and *P. ferratilis* **n. sp.**). The male genitalia is distinguished from other genus, like *Uvaroviella* Chopard, 1923 and *Aclodes* Hebard, 1928, by its developed and dorsally projected pseudepiphallic median lobes, pseudepiphallic dorsal branch hook-shaped, endophallus elongated but with apodeme and rami very reduced (Desutter, 1990; Desutter-Grandcolas, 1992; Mews & Sperber, 2008).

When analyzing the dorsal morphology of the right tegmen of the species from this genus, with an exception for *P. gaudichaudi* Saussure, 1874, and *P. carvalhoi* (Costa-Lima & Costa Leite, 1953), both described from female specimens and *P. kysuia* **n. sp. (**apterous species) it is possible to distinguish three groups by the presence and development of wings: ***I*** – *P. longipes* Serville, 1831 and *P. arenita* Mews & Sperber, 2008 which present relatively developed tegmen and functional stridulatory device (Desutter-Grandcolas, 1992; Mews & Sperber, 2008); ***II*** – *P. flavilongipes* Desutter-Grandcolas, 1992; *P. bauxitica* Mews & Sperber, 2008; *P. kyju* **n. sp.** and *P. araguaia* **n. sp.** that have reduced and almost overlapping tegmen, with pars stridens absent and ***III*** – *P. quartzitica* n. sp. and *P. ferratilis* n. sp., which present vestigial wings with no *pars stridens*. Besides that, for the species of the three groups (***I, II*** e ***III***) there is possibly a glandular thickening on the borders of the wings, feature highlighted by Mews & Sperber, 2008 in the description of *P. arenita* and *P. bauxitica* and also on the species herein described.

Lastly, when analyzing the differences on the male genitalia, the distinction between this species is noticeable allowing comparisons. Thus, we chose to elaborate a pictorial key based on adult male individuals for the known *Phalangopsis* species based in all information available in literature (Desutter-Grandcolas, 1992; Mews & Sperber, 2008; Cigliano *et al.* 2020) along with the morphological analysis of the species herein described (Fig. 148).

Comparisons based on the male genital morphology

We opted here to make a comparison of all structures covering mainly the Pseudepiphallus, one of the sclerites that presents the higher complexity and distinction within the genus *Phalangopsis* Serville, 1831 according to our morphological analysis. We discussed the structures of Pseudoepiphallus according to the nomenclature of Desutter-Grandcolas (2003).

The pseudepiphallic dorsal branch (Ps.db) seems to be very conservative, presenting only small variations in size and degree of inclination. In most species (excepting *P. kysuia* **n. sp.**) it is long, hook-shaped and curved internally (Fig. 148, in dorsal view). In *P. kyju* **n. sp.** and *P. araguaia* **n. sp.** the dorsal branch is more elongated, showing a greater inclination towards the pseudepiphallic paramers (Ps.P1 and Ps.P2) when compared to the other species. *P. arenita* and *P. bauxitica* also present a broader

dorsal branch, being the first one slightly larger than the second. In contrast, *P. kysuia* **n. sp.** has the major variations, being the dorsal branch extremely short, broad and almost not exceeding the height of the pseudepiphallic paramers. The other species (*P. longipes*, *P. flavilogipes*, *P. ferratilis* **n. sp.** and *P. quartizitica* **n. sp.**) have the ps.db with median development and slope.

On the other hand, the pseudepiphallic median lobes (Ps.m.l.) illustrate greater variation among species, especially in size, inclination degree and shape (in dorsal, lateral and frontal view). All species exhibit a great development in such a structure, in dorsal view, what makes possible to compare this structure among almost all species. In *P. longipes* this structure is V-shaped; while in *P. arenita* the upper central part is curved and the lower part is more curved but in the opposite direction; in *P. flavilongipes* it is narrow and little developed; in *P. bauxitica* the upper central part is bulged and the lower part is slightly curved but in the opposite direction; in *P. kyju* **n. sp.** it is widely projected and the lower part is also slightly curved but in the opposite direction; *P. araguaia* **n. sp.** exhibits a structure that tilts perpendicularly towards sclerite; in *P. ferratilis* **n. sp.** the structure is distended U-shaped; and finally, *P. quartizitica* **n. sp.** and *P. kysuia* **n. sp.** present globular Ps.m.l, though this structure is narrow in *P. ksyuia* **n. sp.**

Regarding the pseudepiphallic arm (Ps.arm) variations in inclination are quite evident, allowing to group some species. *P. longipes, P. flavilongipes, P. bauxitica* and *P. quartizitica* **n. sp.**, features a Ps.arm narrow with a not inclined arm (horizontally linear in dorsal view). On the other hand, *P. arenita*, *P. kysuia* **n. sp.**, *P. araguaia* **n. sp.** and *P. kyju* **n. sp.** present this structure leaning towards the central part of the sclerite. In *P. araguaia* **n. sp.** and *P. kyju* **n. sp.** the inclination degree seems to be slighly higher than in other species. Finally, in P. *ferratilis* **n. sp.** this structure tilts slightly out of the sclerite.

When analyzing the pseudepiphallic paramers, the paramer one (Ps.P1) appears to be very conservative and less developed when compared to the paramer two (Ps.P2). On the other hand, the paramer two (Ps.P2) presents several differences in size, shape and inclination among the different species. We opted here to highlight the differences in the dorsal view. In *P. longipes* this structure is cambered triangular; in *P. arenita* it is concave discoidal; in *P. ferratilis* **n. sp.** it is discoidal, but projecting dorsally; in *P. quartizitica* **n. sp.** it is highly discoidal and in *P. kysuia* **n. sp.** it is stook discoidal. In the other species, this structure exhibits a globular shape: in *P. flavilogipes* it is globular and in *P. bauxitica* it is lightly globular; in *P. kyju* **n. sp.** it is globular, but projected for the inner part of the sclerite, in a similar way to observed for *P. araguaia* **n. sp.**, but Ps.P2 is undeveloped in this species.

Regarding the ectophallic invagination, the most variable structures are the apodemes (Ect.ap), which can vary in size, dorsal and lateral inclination. In the dorsal view, the ectophallic apodemes in *P. longipes*, *P. arenita* and *P. kysuia* **n. sp.** are broad and not so elongated when compared to the other species. In all other species, the apodemes exceed pseudepiphallic branch (Ps.b). It is possible to see that *P. arenita* presents the apex of the apodeme rounded and broad, while in *P. longipes* and *P. kysuia* **n. sp.** the apex is expanded in width. In the other species (*P. flavilogipes, P. bauxitica, P. kyju* **n. sp.**, *P. araguaia* **n. sp.**, *P. ferratilis* **n. sp.**, *P. quartzitica* **n. sp.**) this structure is more elongated and thin. Furthermore, in *P. flavilongipes* and *P. araguaia* **n. sp.** the apex is curved externally.

It was also possible to observe that the pseudepiphallic branch (Ps.b) is projected dorsally on all species (lateral view). Furthermore, only in *P.kyju* **n. sp.** and *P. araguaia*

n. sp. this structure forms an acute projection covering the endophallus (End.) (in dorsal view). Lastly, we detected the presence the A sclerite in the species herein described, being vestigial and not very evident.

Is the tegmina reduction related to the subterranean lifestyle within the genus?

Within Orthoptera, morphological changes related to the subterranean lifestyle are frequently represented by integumentary depigmentation, reduction or absence of ommatidia (Desutter-Grandcolas, 1998), as well as the elongation of appendages, mainly the locomotor ones (Desutter-Grandcolas, 1998). Even though in some groups the apterism or reduction of wings may represent a modification for the subterranean life (Desutter-Grandcolas, 1998), among the *Phalangopsis* species features as the eyes complexity and appendage size, show no alterations when compared to winged and non-winged species as demonstrated in this study.

When comparing the right tegmen of the species here described, it is possible to identify different levels of sclerotization and size. *P. araguaia* **n. sp.** has the most developed right tegmen, which is the biggest and more sclerotized one (Figs 140 and 141). *Phalangopsis kyju* **n. sp.** has a smaller right tegmen when compared to *P. araguaia*, but shows the same level of sclerotization (Figs 142 and 143). *Phalangopsis ferratilis* **n. sp.** presents the right tegmen almost half the size of the right tegmen of *P. araguaia*, and less sclerotized than *P. kyju* (Figs 144 and 145). *Phalangopsis quartzitica* **n. sp.** presents the smaller right tegmen of the species herein described (Figs 146 and 147). Lastly, *P. kysuia* **n. sp.** is apterous.

This reduction of wings is a morphological feature considered by some authors as troglobiomorphosis (Desutter-Grandcolas, 1997 [1999]), but this hypothesis certainly deserves caution. In *Phalangopsis* Serville 1831, the absence of wings (tegmen) is not related to troglobitic condition, since species with apterism or wing reduction (as those here described) do not present any other morphological traits that could be considered as indicative of subterranean-restricted habitat. All species here described are troglophilic, certainly harboring populations in both external and subterranean environments. This fact demonstrates the importance of including ecological (Dessuter-Grandcolas 1995), physiological, behavioral and other morphological features to determinate the degree of specialization that a given species presents in relation to the subterranean environments.

As an example of a dubious troglobitic species within Phalangopsidae, it is worth mentioning the species *Endecous apterus* Bolfarini & Souza-Dias, 2014. This species, found in caves in the Ituaçu region (Bahia state, Brazil) was considered troglobitic only because of its apterous condition. Although the authors have mentioned "pale coloration" and the loss of auditory tympana (the later related to the apterism, since no sound is produced), no other typically troglomorphic traits were noted, such as eye reduction or appendage elongation. According to the authors who described this species, "*During three nights of collection, we found no specimen in the surroundings of the cave or at entrance zone*" (text directly transcribed from the original description) (Souza-Dias et al. 2014). However, it is important to note that three nights are not enough time to assess the absence of a given species outside caves. Eventually, suitable external habitats for this species only occur far from the caves that were sampled. Furthermore, despite the fact that the species was originally found in only two caves, it also occurs in many other caves in the area, some of each associated to distinct and distant outcrops, suggesting low possibility of migration through subterranean voids (Ferreira, RL pers. obs). Hence it is likely that

E. apterus is not a troglobitic species, but a troglophilic one, as many other species within this genus in Brazil.

This study expanded the number of known species for *Phalangopsis*, which now accounts for 11 species. From this total, seven species have a cave as type locality (the five new species here described and also *P. arenita* and *P. bauxitica*) what indicates the preference for subterranean habitats in many species from this genus. Future studies will certainly increase the knowledge about this genus, which contains species constantly threatened by human actions such as mining activities (Ferreira *et al*. 2014; Ferreira *et al.* 2018) and the deforestation of the Amazon rainforest, that increased 30% between 2018 and 2019 (INPE, 2019). Especially, the mining activities represent a concern, since important habitats for many species, which are the caves (Mews & Sperber, 2008; Jaffé *et al*. 2016; Guimarães *et al*. 2019) are frequently destroyed by such activities.

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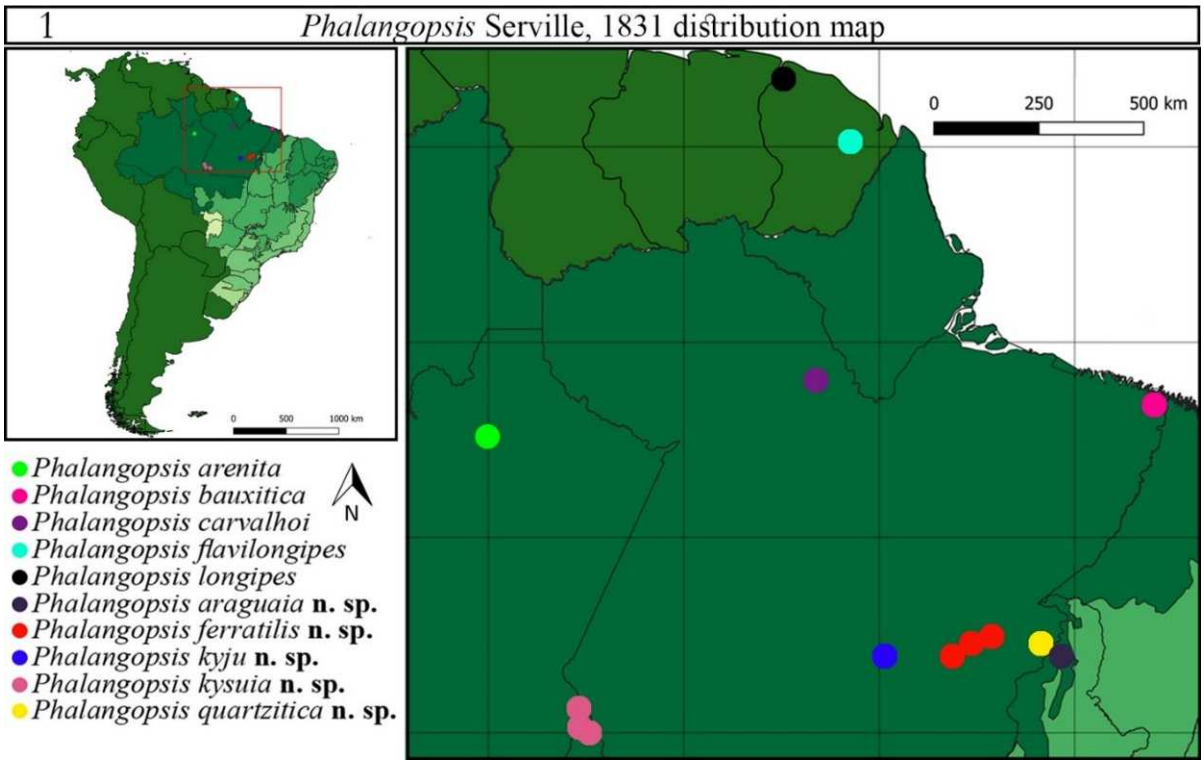
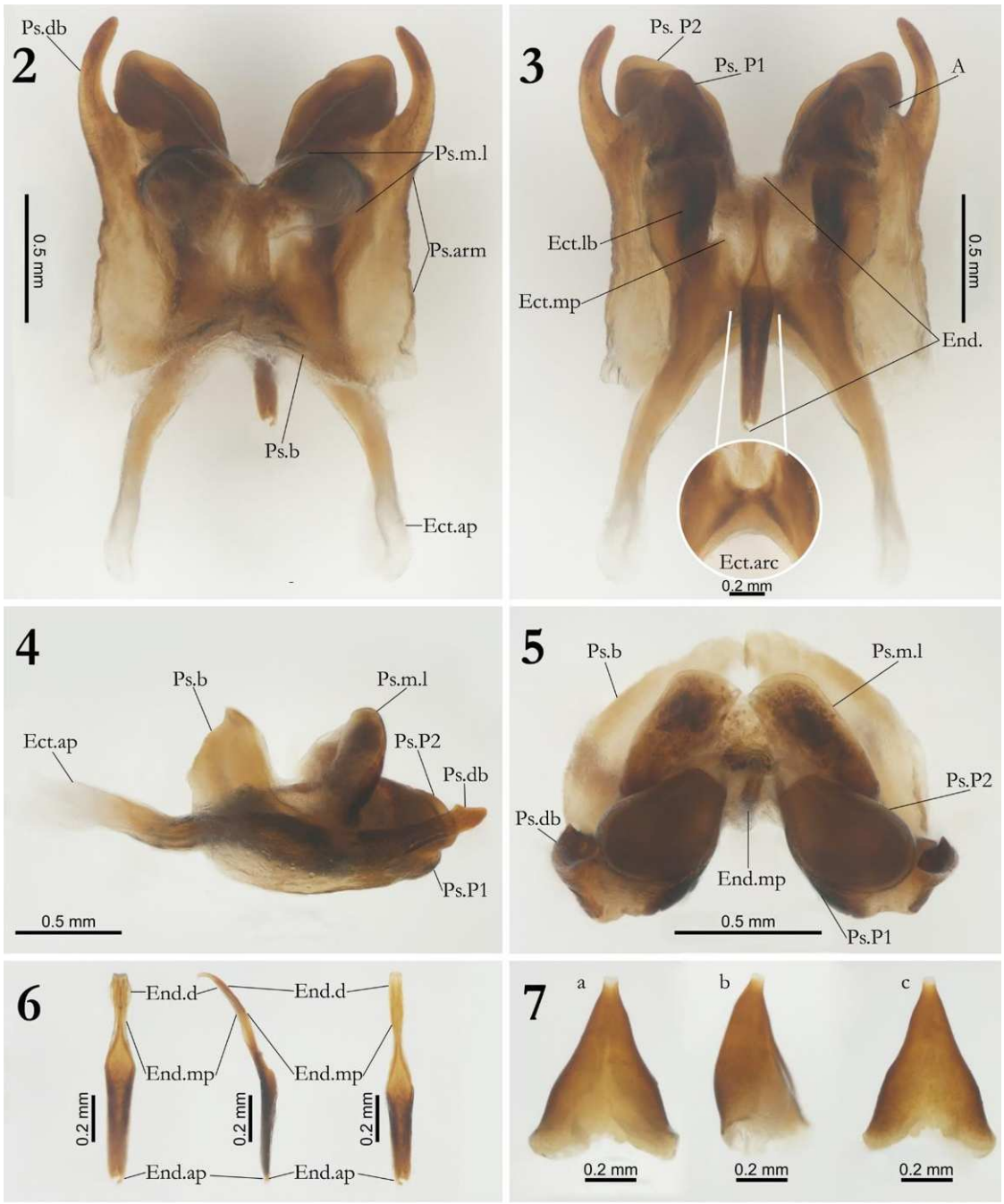
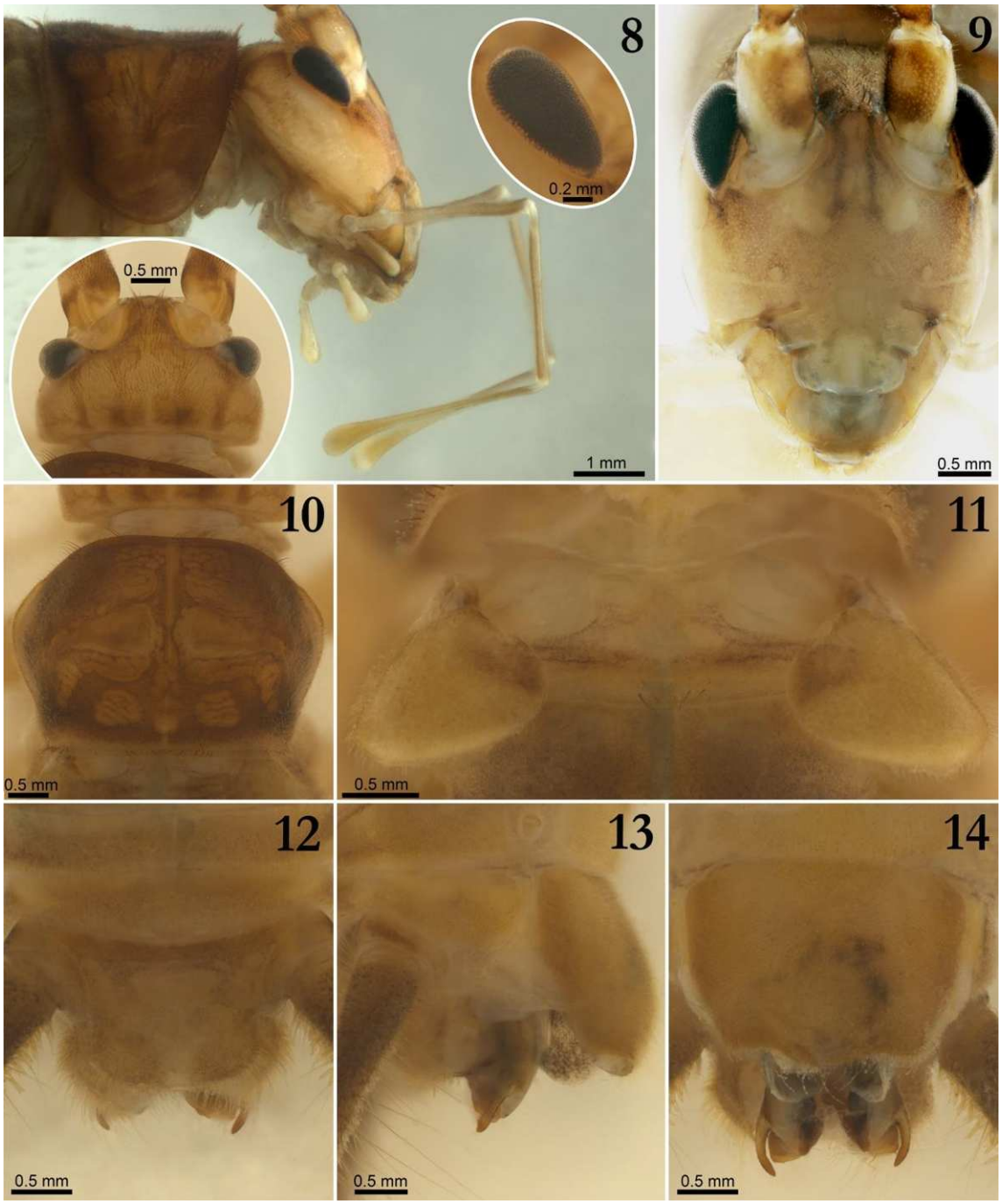


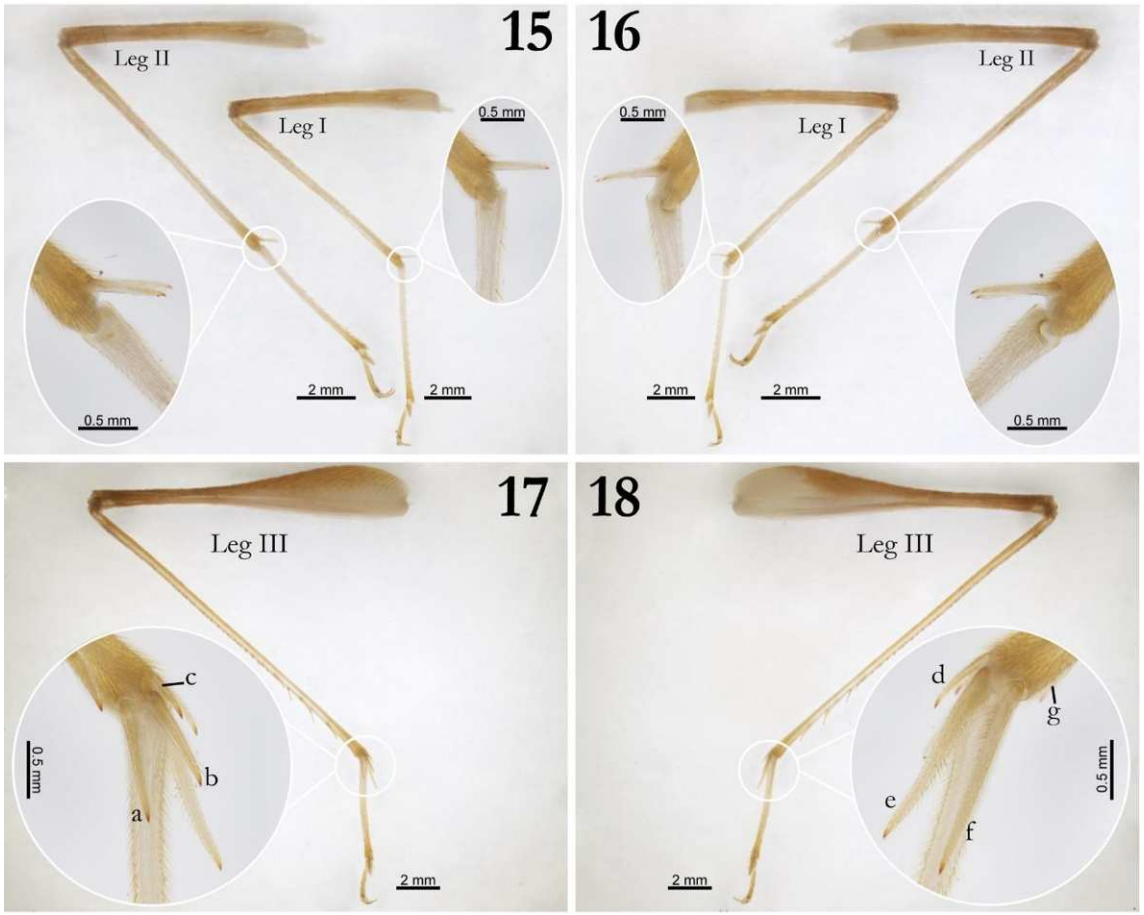
FIGURE 1. Distribution map of the species with known locations of genus *Phalangopsis* Serville, 1831.



FIGURES 2–6. *Phalangopsis quartzitica* ***n. sp.*** Phallic sclerite of paratype ♂ (ISLA 65737). 2–dorsal view; 3–ventral view; 4–lateral view; 5–frontal view; 6–endophallic sclerite in dorsal, lateral and ventral view, respectively. 7–genital papilla of paratype ♀ (ISLA 65736). a–dorsal view; b–lateral view; c–ventral view. *Abbreviations*: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ectmp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.



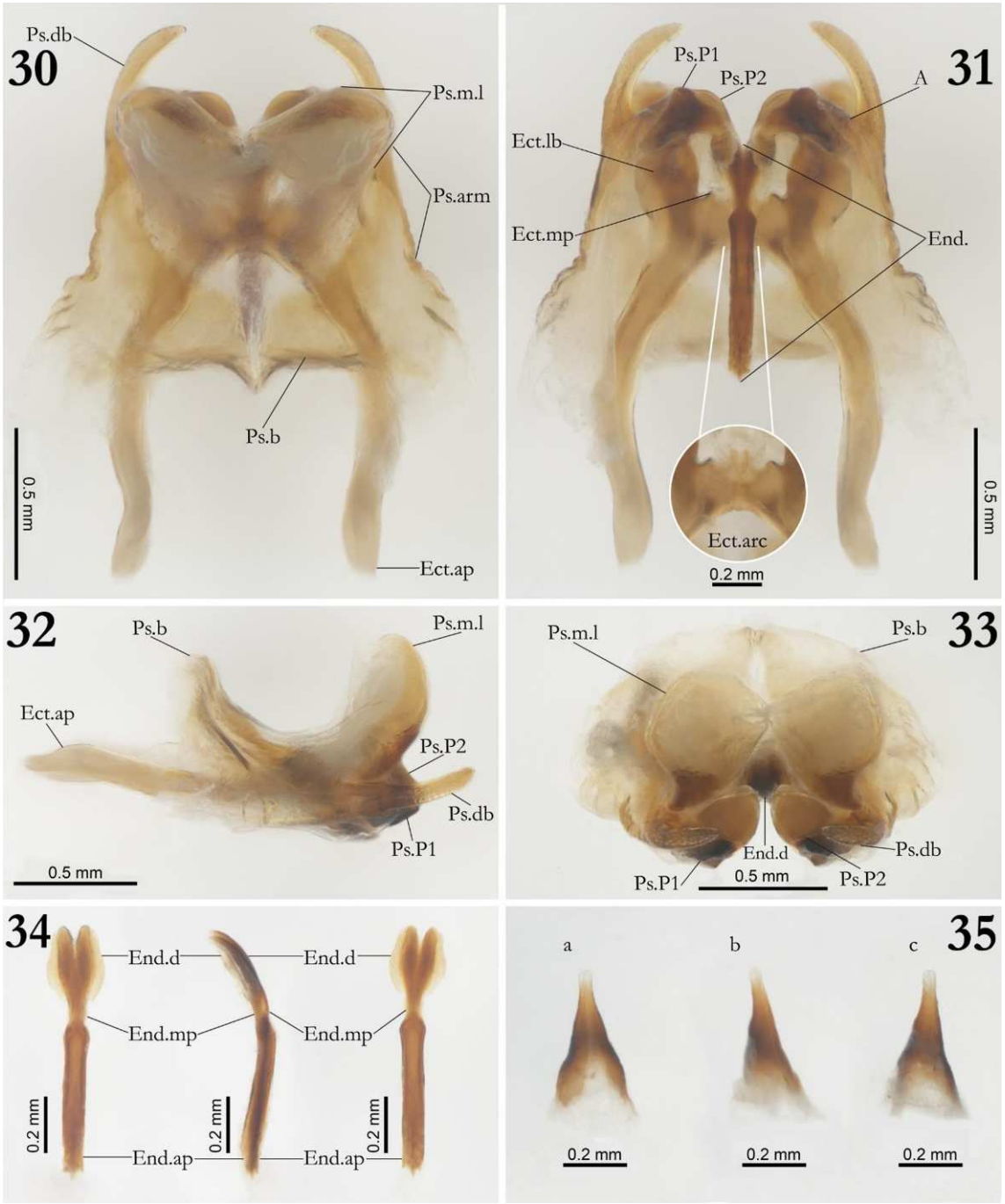
FIGURES 8–14. *Phalangopsis quartzitica* **n. sp.** Holotype morphology. 8–head in lateral and superior view; 9–head in frontal view; 10–pronotum in dorsal view; 11–right tegmen and metanotal glands, dorsal view; 12–supranal plate, dorsal view; 13–supranal and subgenital plates, lateral view; 14–subgenital plate, ventral view.



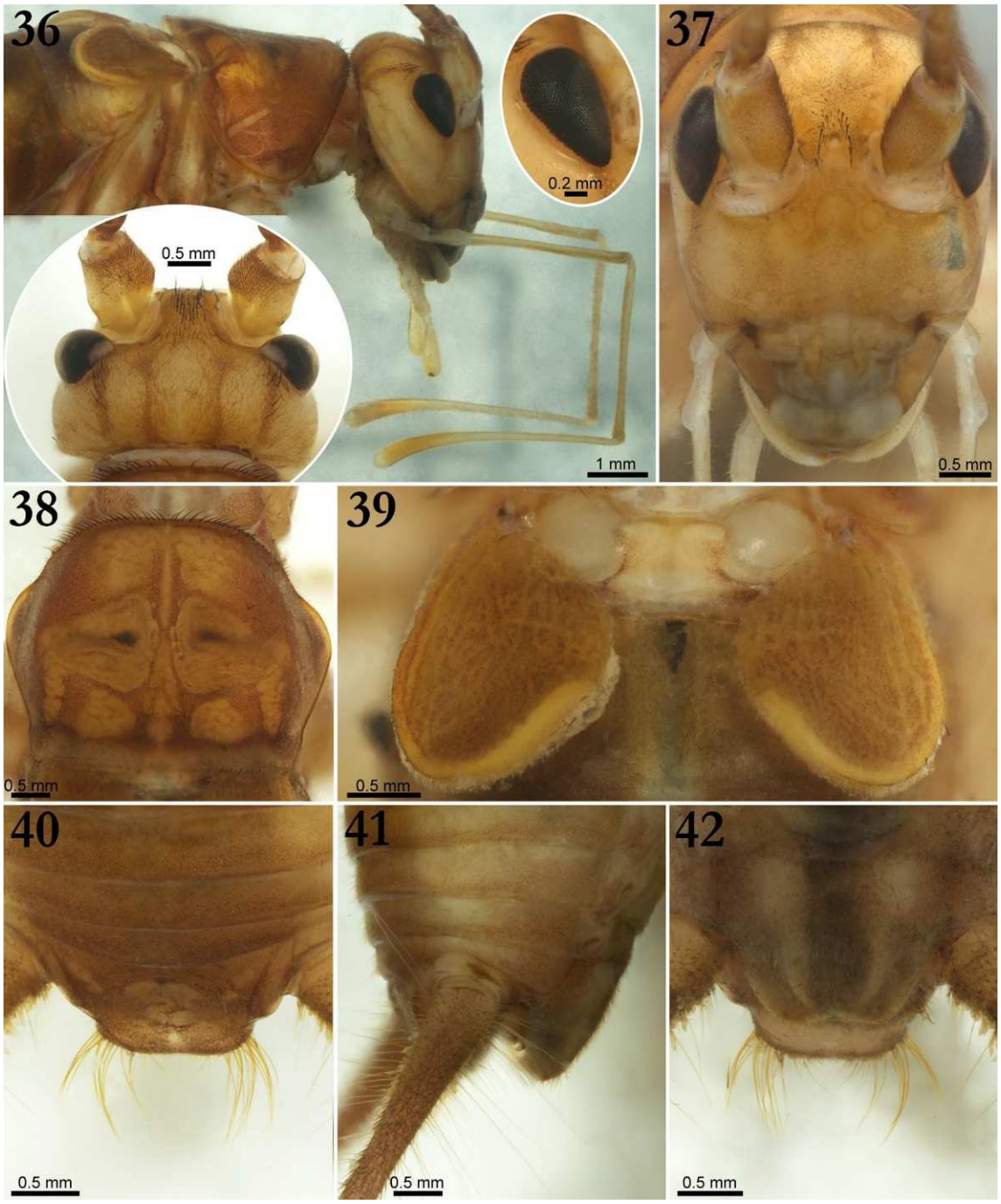
FIGURES 15–18. *Phalangopsis quartzitica* **n. sp.** Holotype legs morphology. 15–right legs I and II, outer view; 16–right legs I and II, inner view; 17–right leg III and apical spurs (**a**; **b**; **c**), outer view; 18–right leg III and apical spurs (**d**; **e**; **f**; **g**), inner view.

FIGURES 19–23. *Phalangopsis quartzitica* **n. sp.** ♀ ISLA 65736. 19–supranal plate; 20–subgenital plate; 21, 22 and 23–ovipositor apex, dorsal, lateral and ventral view, respectively.

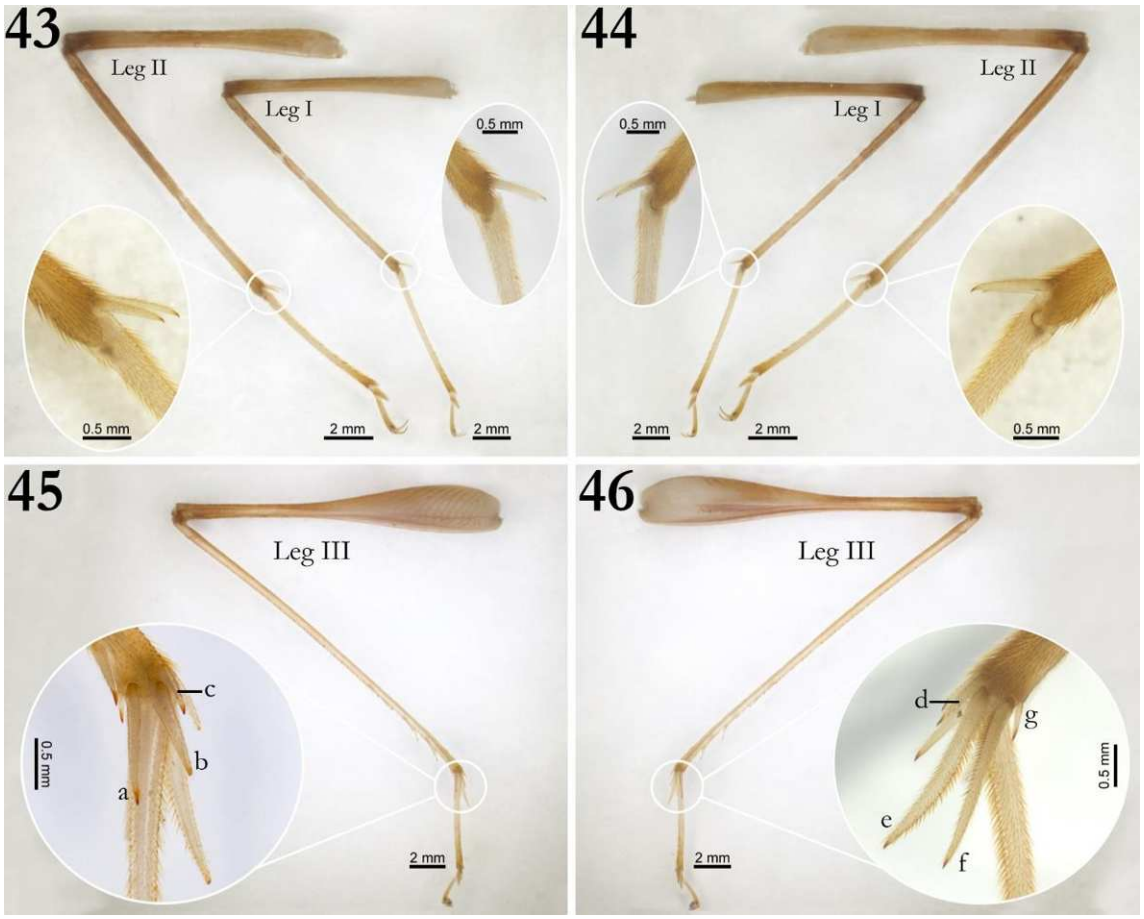
FIGURES 24–29. Study area and habitats of *Phalangopsis quartzitica* **n. sp.** 24–external environment of Andorinhas cave; 25–*Phalangopsis quartzitica* being prayed by *Tityus metuendus* Pocock, 1897; 26–Andorinhas cave's entrance; 27–♀ of *Phalangopsis quartzitica* **n. sp.** being preyed by *Heterophrynus sp.* at Andorinhas cave; 28 and 29–♂ and ♀ of *Phalangopsis quartzitica* **n. sp.**, respectively, from Andorinhas cave.



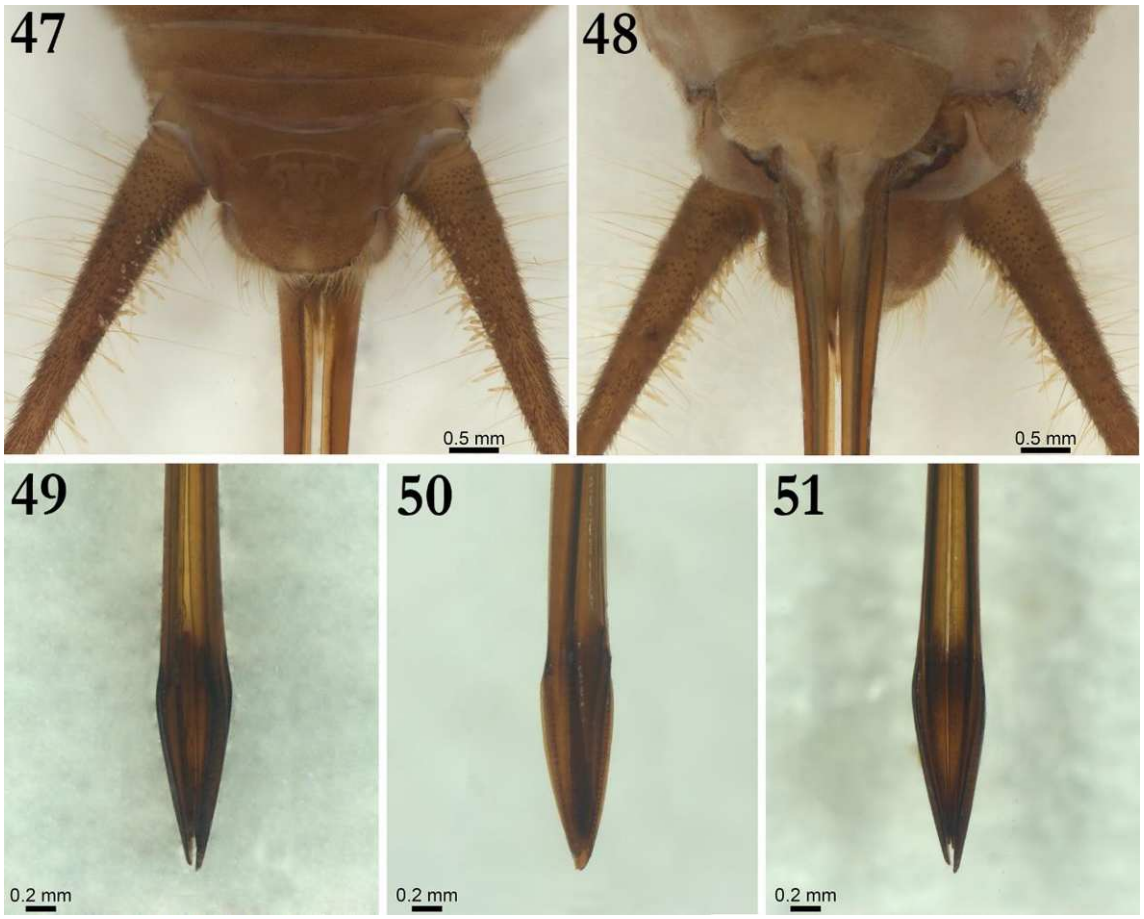
FIGURES 30–34. *Phalangopsis araguaia* ***n. sp.*** Phallic sclerite of paratype ♂ (ISLA 65746). 30–dorsal view; 31–ventral view; 32–lateral view; 33–frontal view; 34–endophallic sclerite in dorsal, lateral and ventral view, respectively. **35**–genital papilla of paratype ♀ (ISLA 65749). a–dorsal view; b–lateral view; c–ventral view. *Abbreviations*: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ect.mp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.



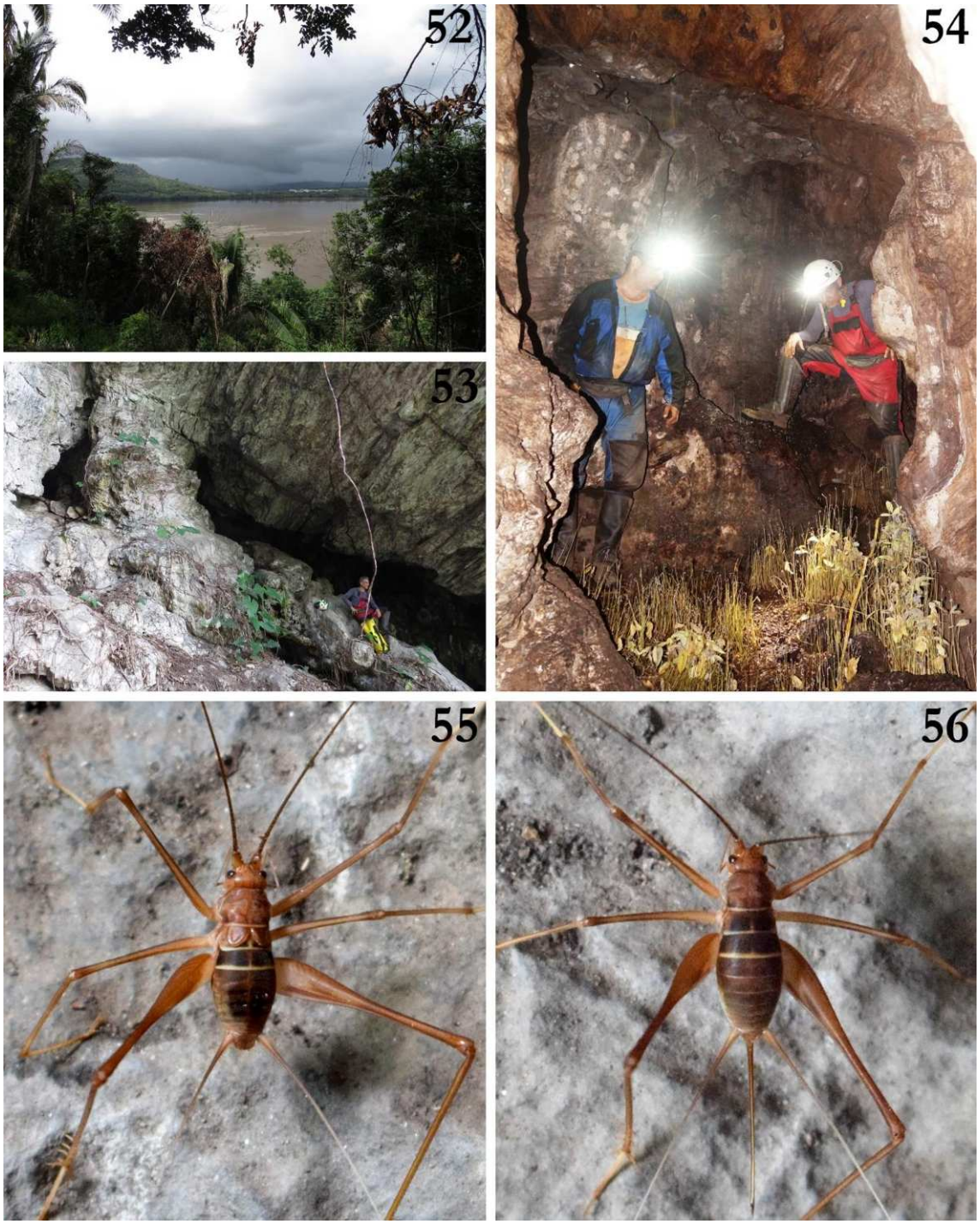
FIGURES 36–42. *Phalangopsis araguaia* **n. sp.** Holotype morphology. 36–head in lateral and superior view; 37–head in frontal view; 38–pronotum in dorsal view; 39–right tegmen and metanotal glands, dorsal view; 40–supranal plate, dorsal view; 41–supranal and subgenital plates, lateral view; 42–subgenital plate, ventral view.



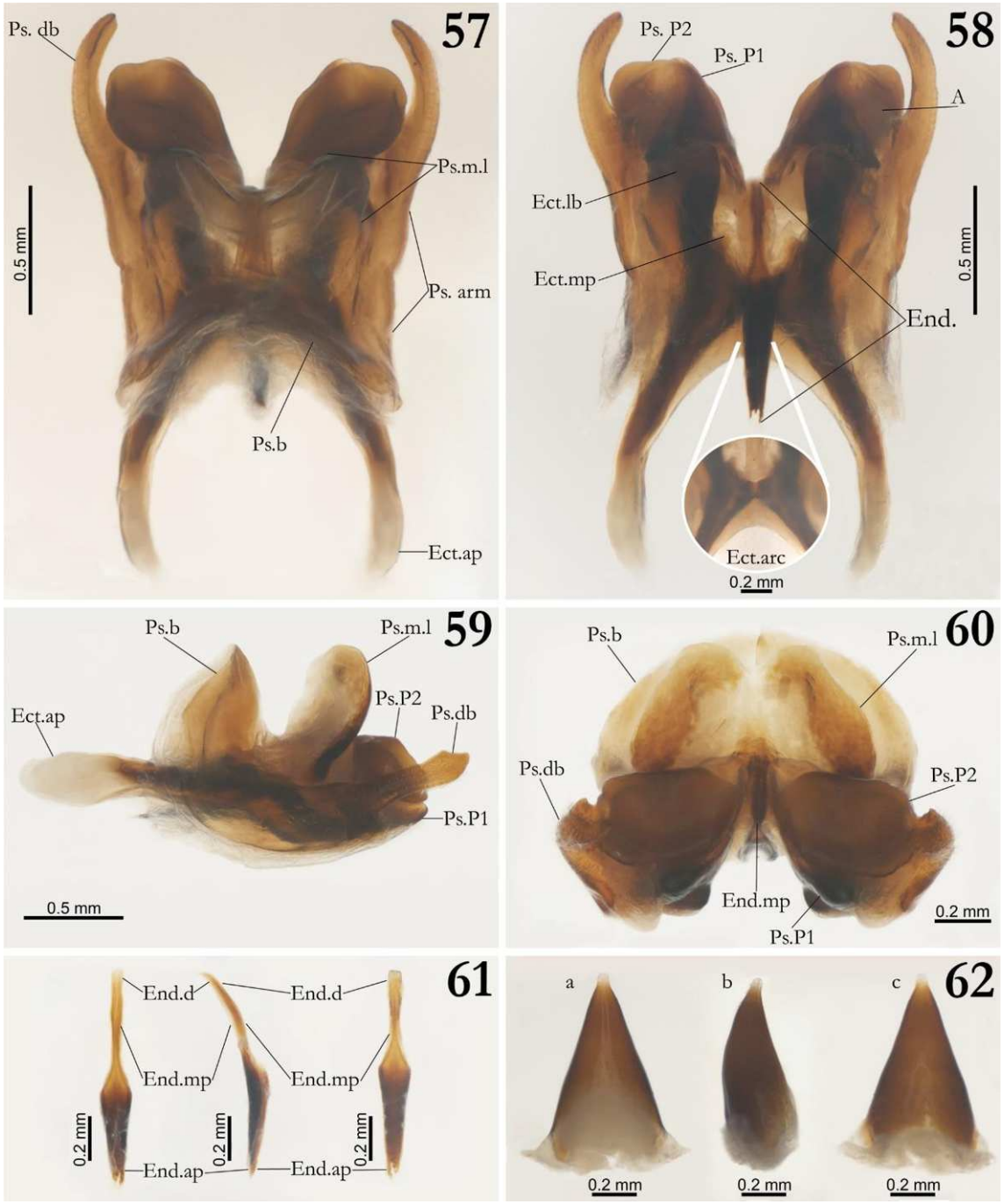
FIGURES 43–46. *Phalangopsis araguaia* **n. sp.** Holotype legs morphology. 43–legs I and II, outer view; 44–right legs I and II, inner view; 45–right leg III and apical spurs (**a**; **b**; **c**), outer view; 46–right leg III and apical spurs (**d**; **e**; **f**; **g**), inner view.



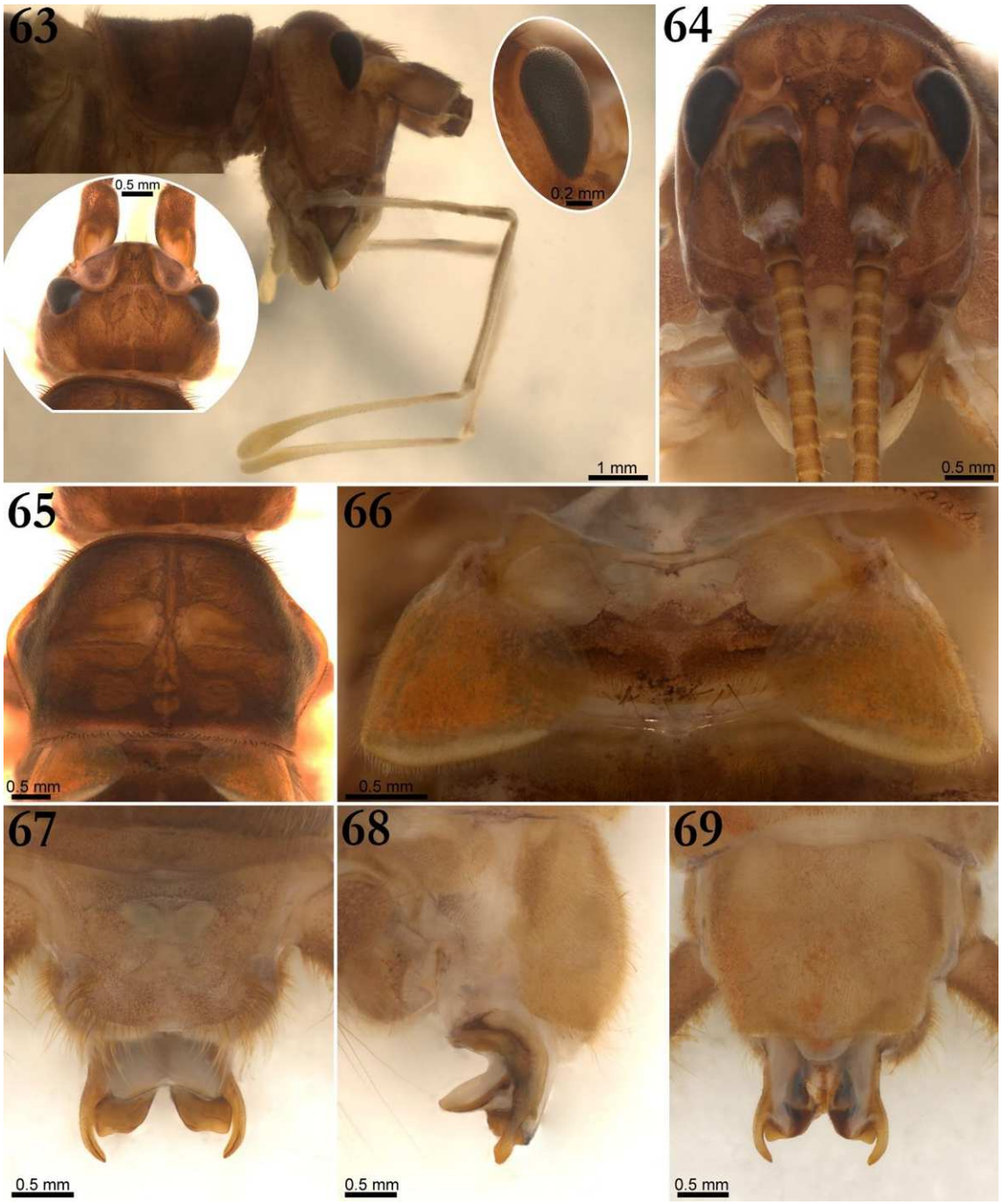
FIGURES 47–51. *Phalangopsis araguaia* **n. sp.** ♀ ISLA 65749. 47–supranal plate; 48–subgenital plate; 49, 50 and 51 – ovipositor apex, dorsal, lateral and ventral view, respectively.



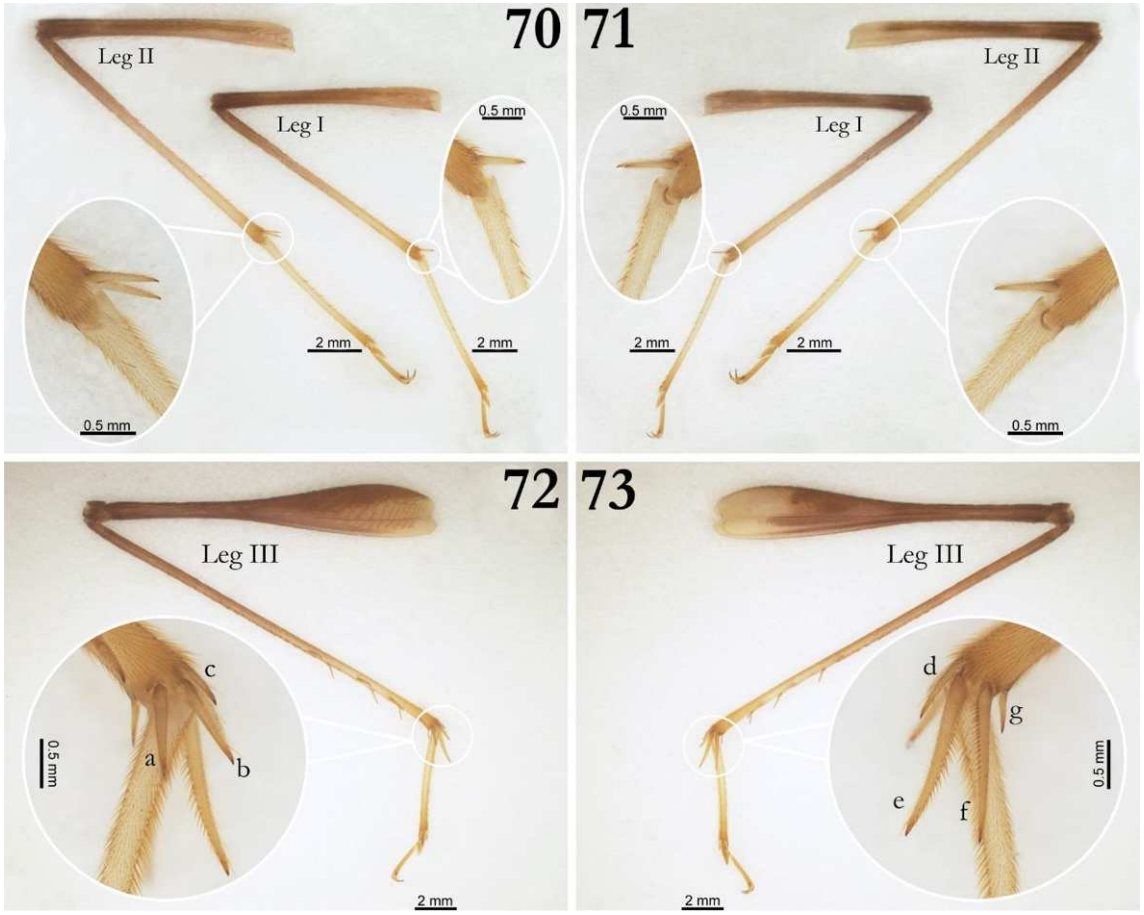
FIGURES 52–56. Study area and habitats of *Phalangopsis araguaia* **n. sp.** 52–external environment of Macacos cave; 53–entrance of Macacos cave; 54–Macacos cave's internal environment; 55 and 56–♂ and ♀ of *Phalangopsis araguaia* **n. sp.** from Macacos cave.



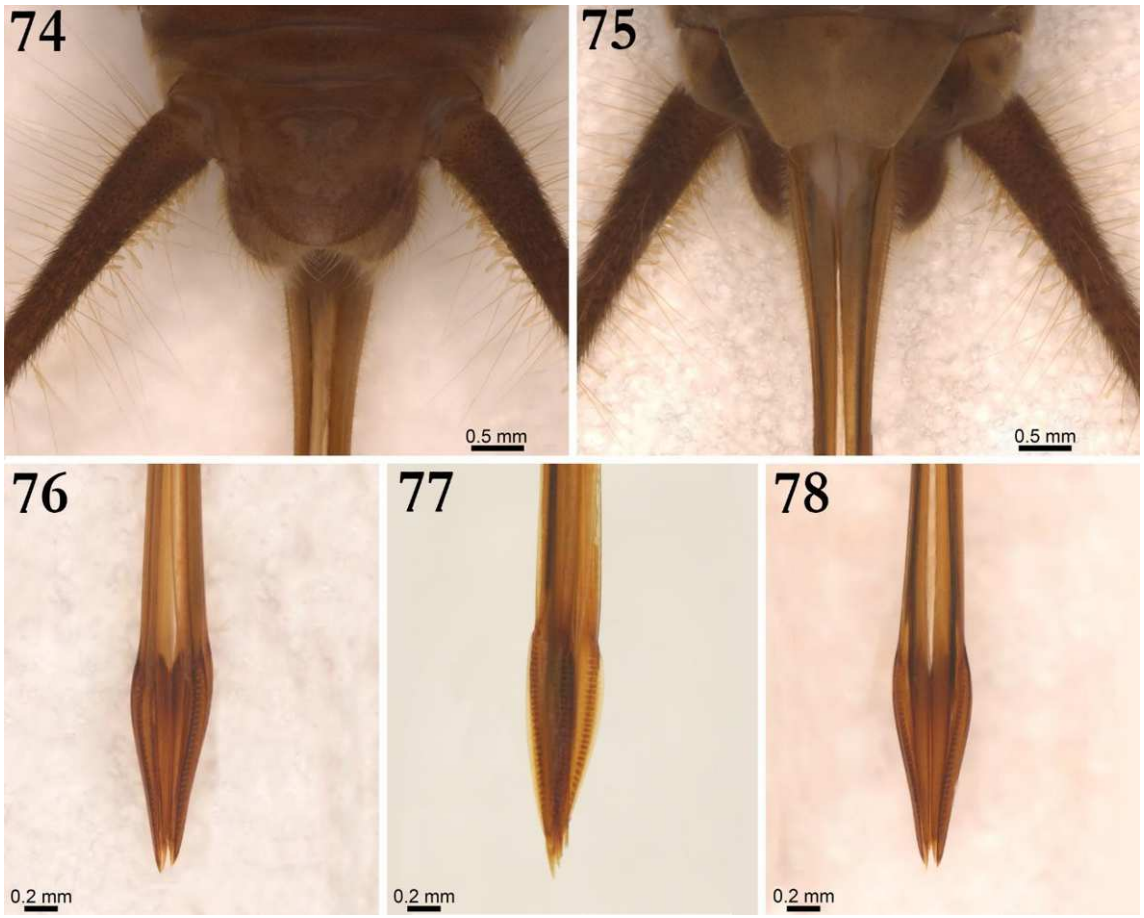
FIGURES 57–61. *Phalangopsis ferratilis* ***n. sp.*** Phallic sclerite of paratype ♂ (ISLA 65757). 57–dorsal view; 58–ventral view; 59–lateral view; 60–frontal view; 61–endophallic sclerite in dorsal, lateral and ventral view, respectively. **62**–genital papilla of paratype ♀ (ISLA 65755). a–dorsal view; b–lateral view; c–ventral view. *Abbreviations*: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ect.mp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.



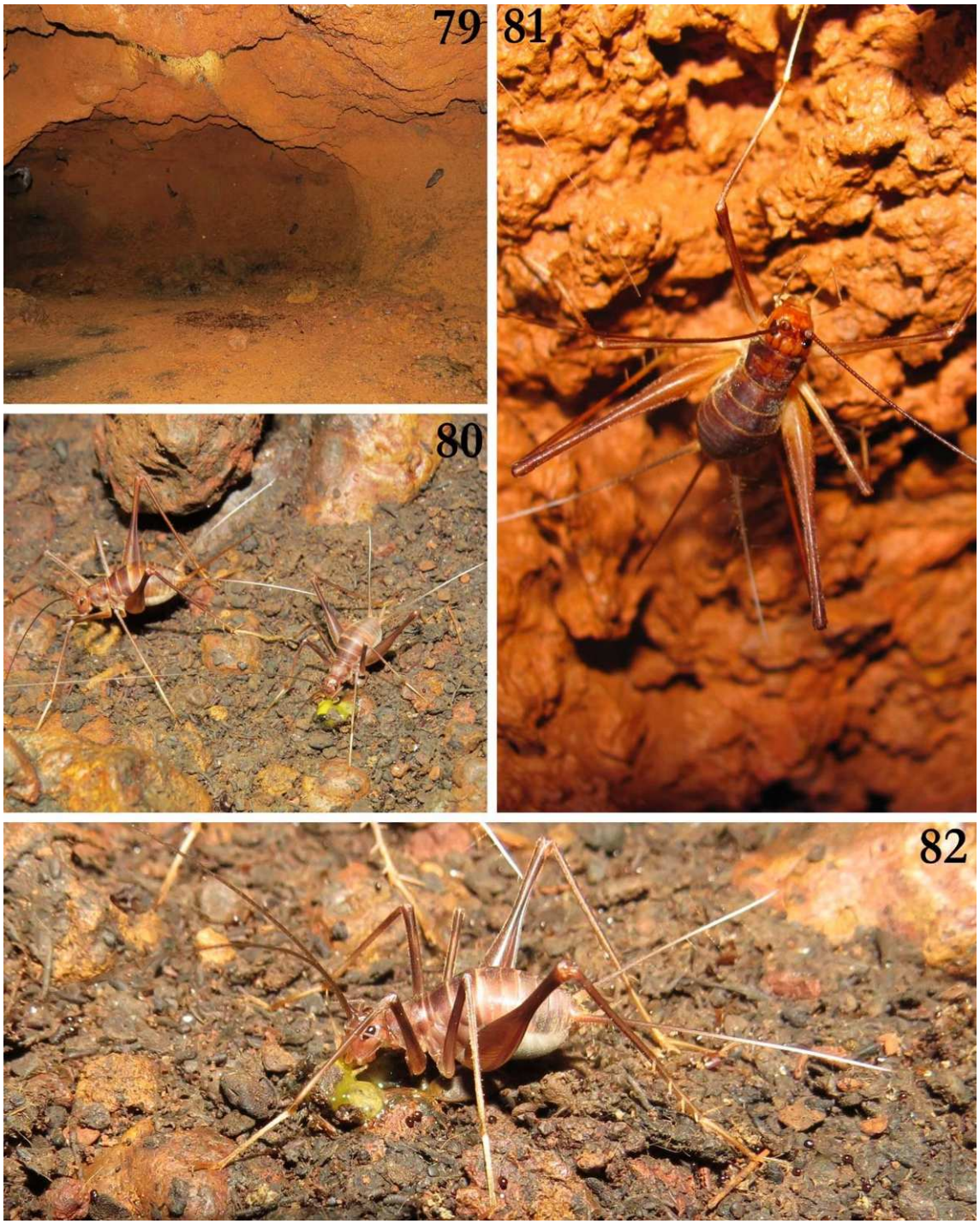
FIGURES 63–69. *Phalangopsis ferratilis* **n. sp.** Holotype morphology. 63–head in lateral and superior view; 64–head in frontal view; 65–pronotum in dorsal view; 66–right tegmen and metanotal glands, dorsal view; 67–supranal plate, dorsal view; 68–supranal and subgenital plates, lateral view; 69–subgenital plate, ventral view.



FIGURES 70–73. *Phalangopsis ferratilis* **n. sp.** Holotype legs morphology. 70–right legs I and II, outer view; 71–right legs I and II, inner view; 72–right leg III and apical spurs (**a**; **b**; **c**), outer view; 73–right leg III and apical spurs (**d**; **e**; **f**; **g**), inner view.



FIGURES 74–78. *Phalangopsis ferratilis* **n. sp.** ♀ ISLA 65755. 74–supranal plate; 75–subgenital plate; 76, 77 and 78–ovipositor apex, dorsal, lateral and ventral view, respectively.



FIGURES 79–82. Study area and habitats of *Phalangopsis ferratilis* **n. sp.** 79–ST–0041 cave; 80–specimens of *Phalangopsis ferratilis* **n. sp.** feeding on bat guano; 81–♀ of *Phalangopsis ferratilis* **n. sp.**; 82–# f of *Phalangopsis ferratilis* **n. sp.** feeding on bat guano.

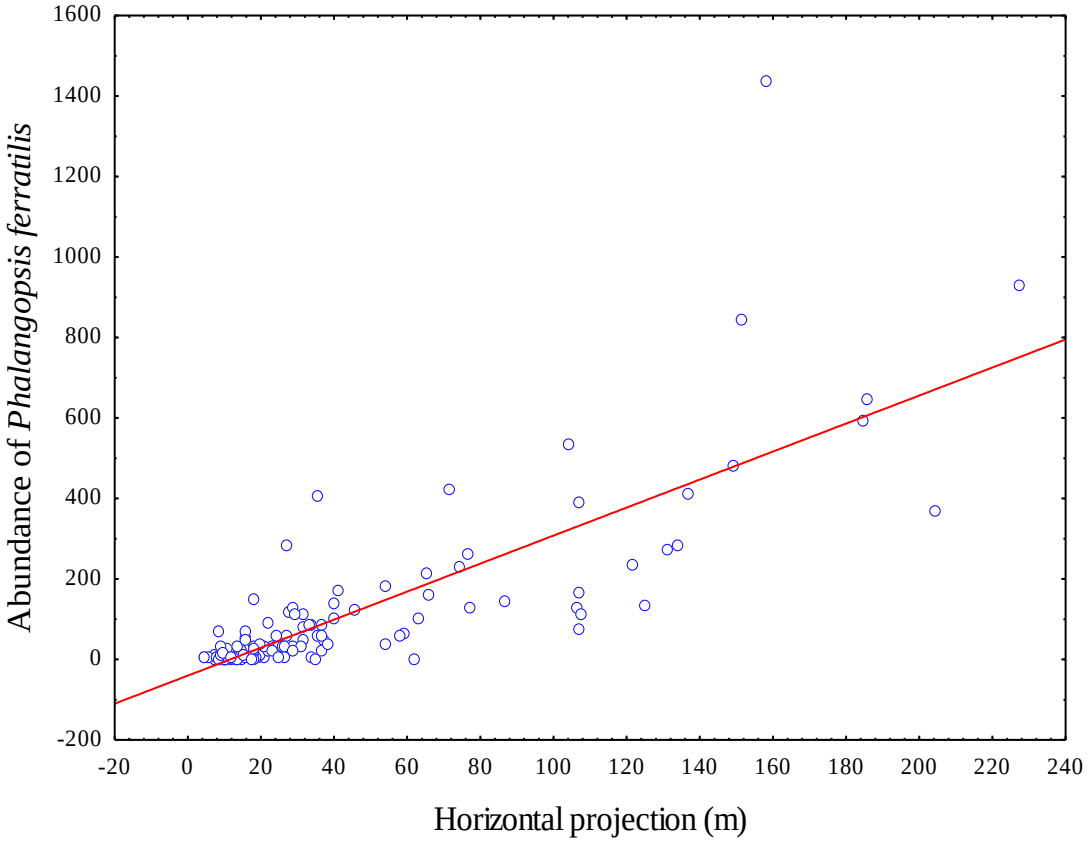
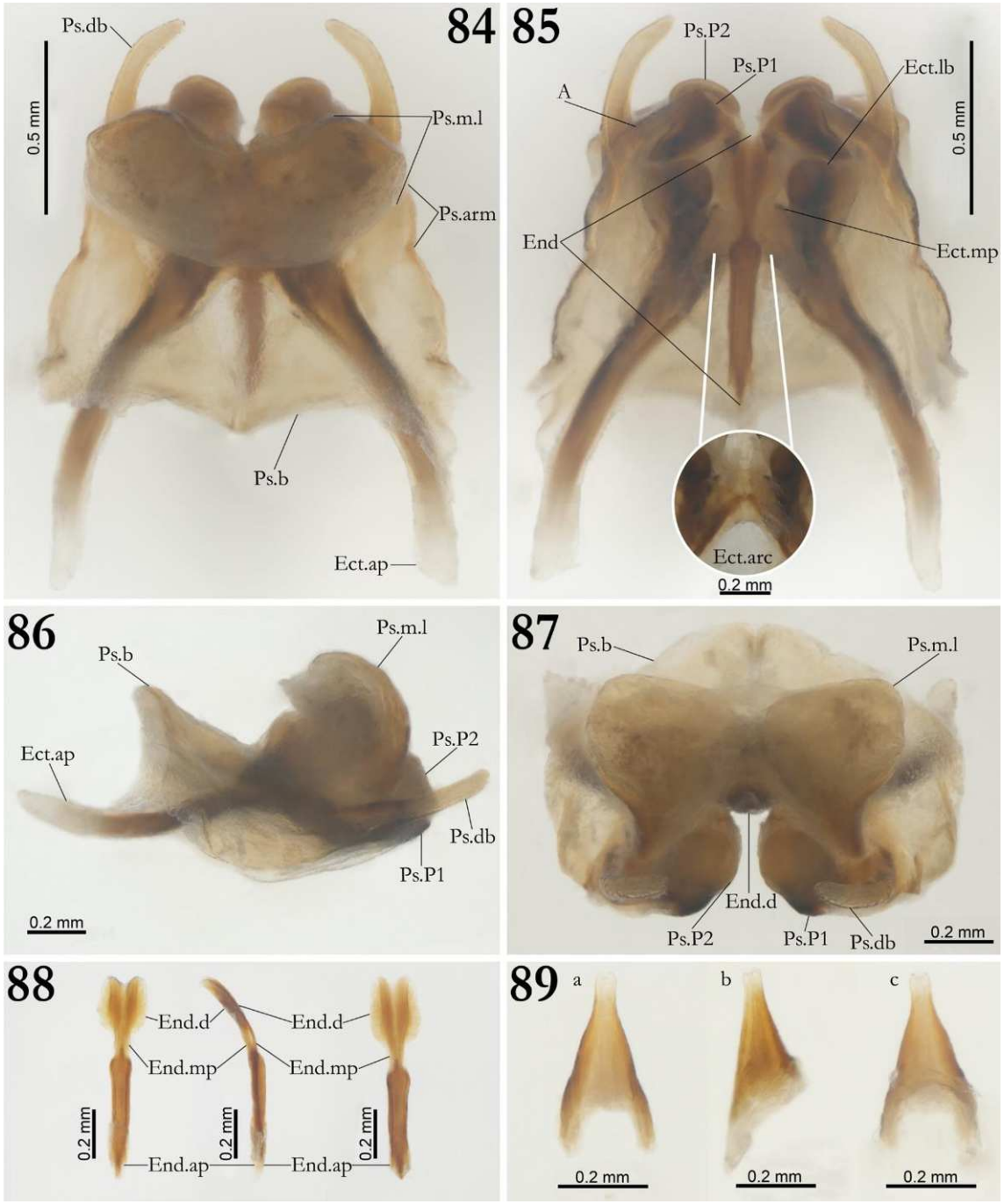
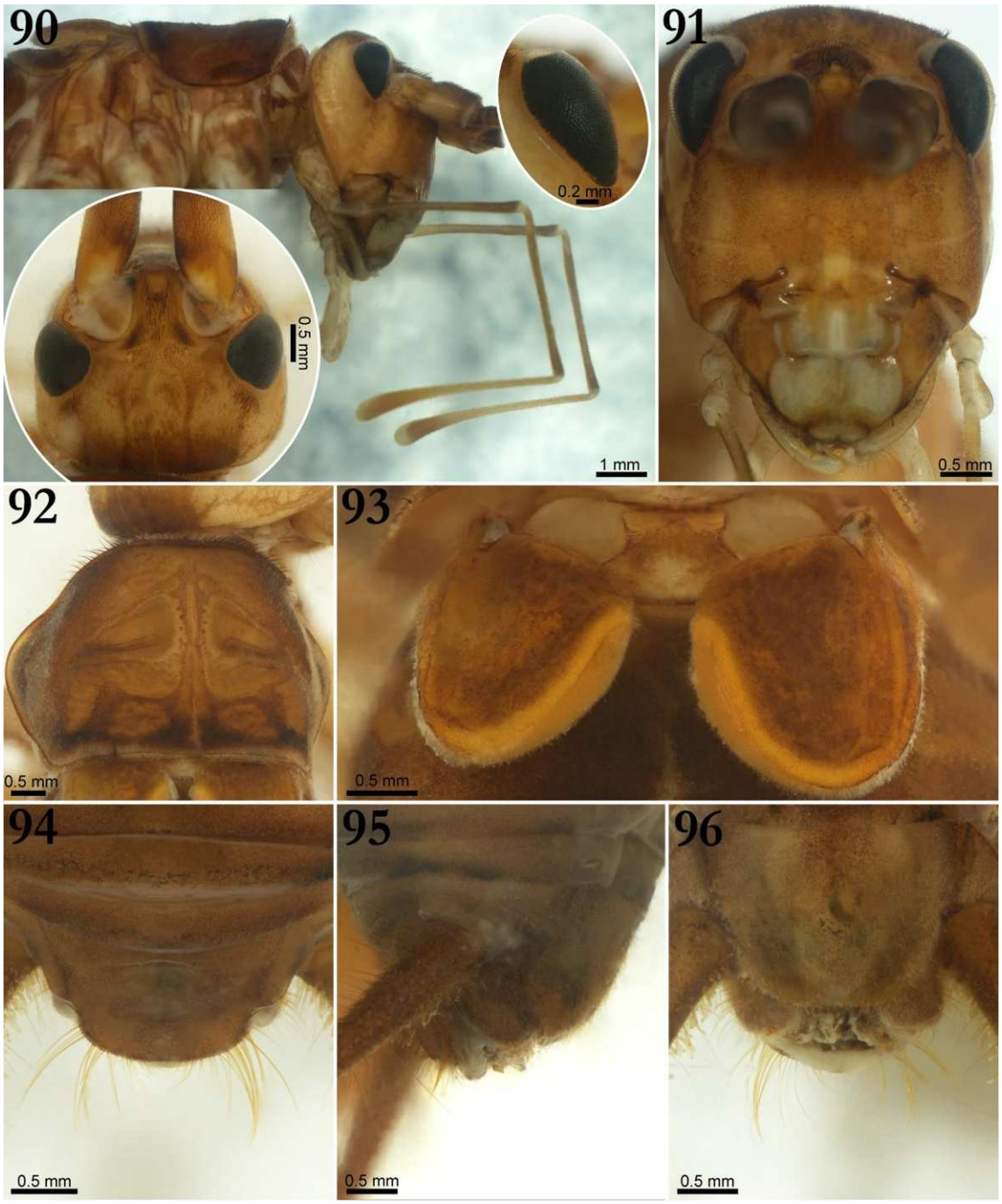


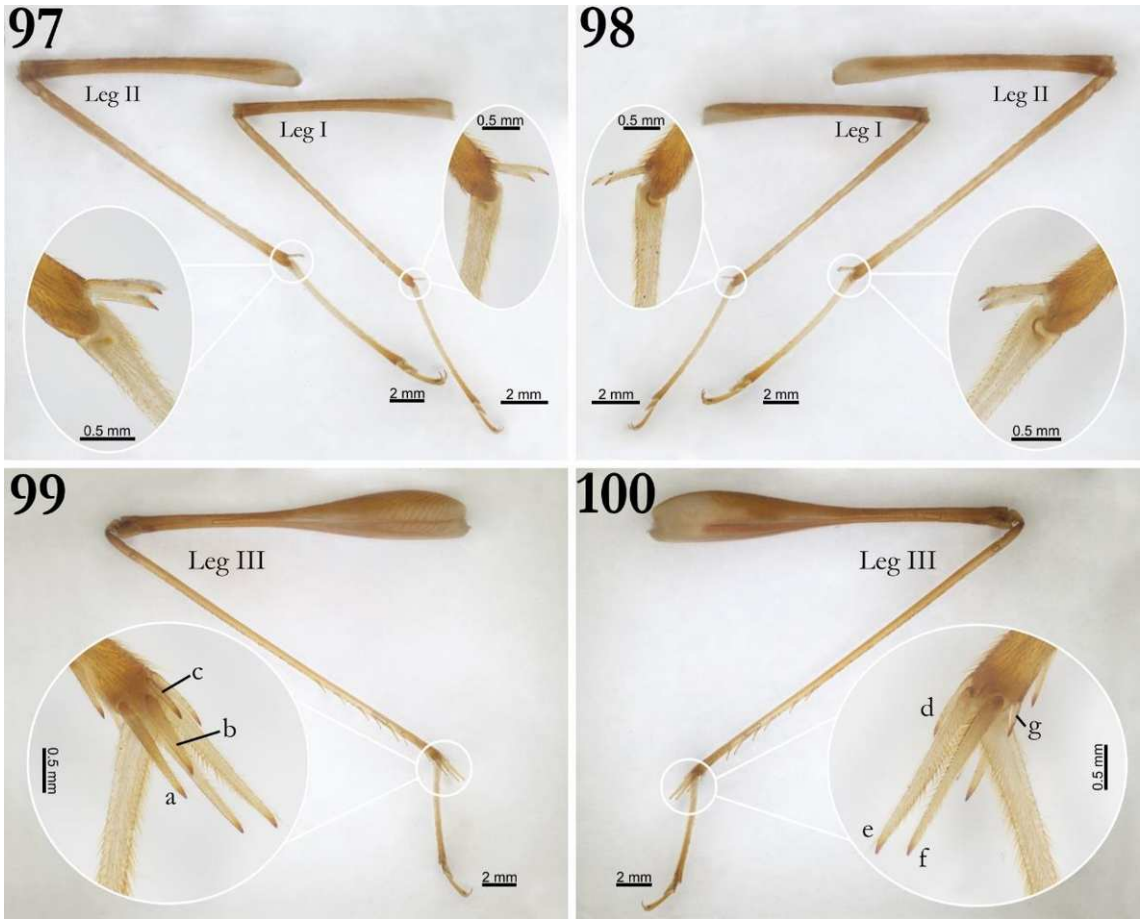
FIGURE 83. Correlation between abundance of *Phalangopsis ferratilis* **n. sp.** and horizontal projection of the caves in Carajás region (Pará state, Brazil).



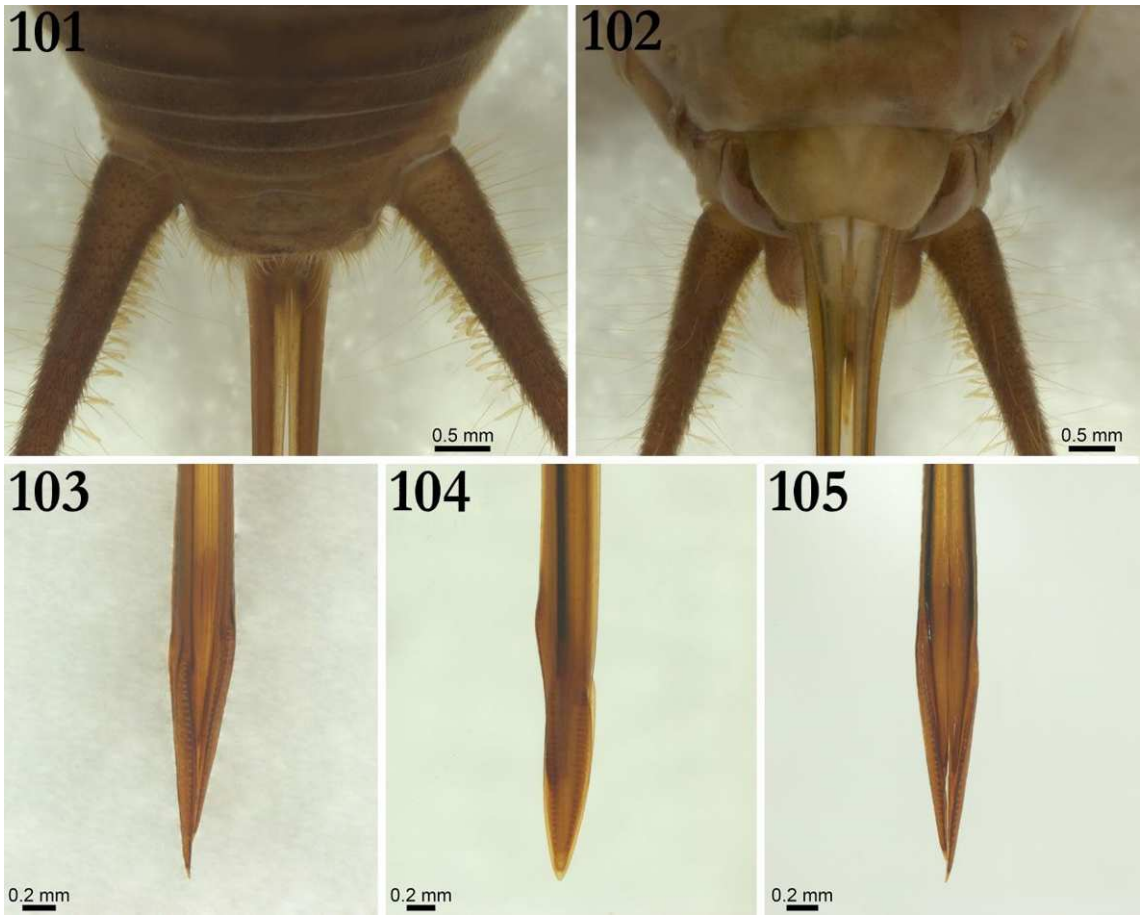
FIGURES 83–88. *Phalangopsis kyju* ***n. sp.*** Phallic sclerite of paratype ♂ (ISLA 65730). 83–dorsal view; 84–ventral view; 85–lateral view; 86–frontal view; 87–endophallic sclerite in dorsal, lateral and ventral view, respectively. **88**–genital papilla of paratype ♀ (ISLA 65732). a–dorsal view; b–lateral view; c–ventral view. *Abbreviations*: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ect.mp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.



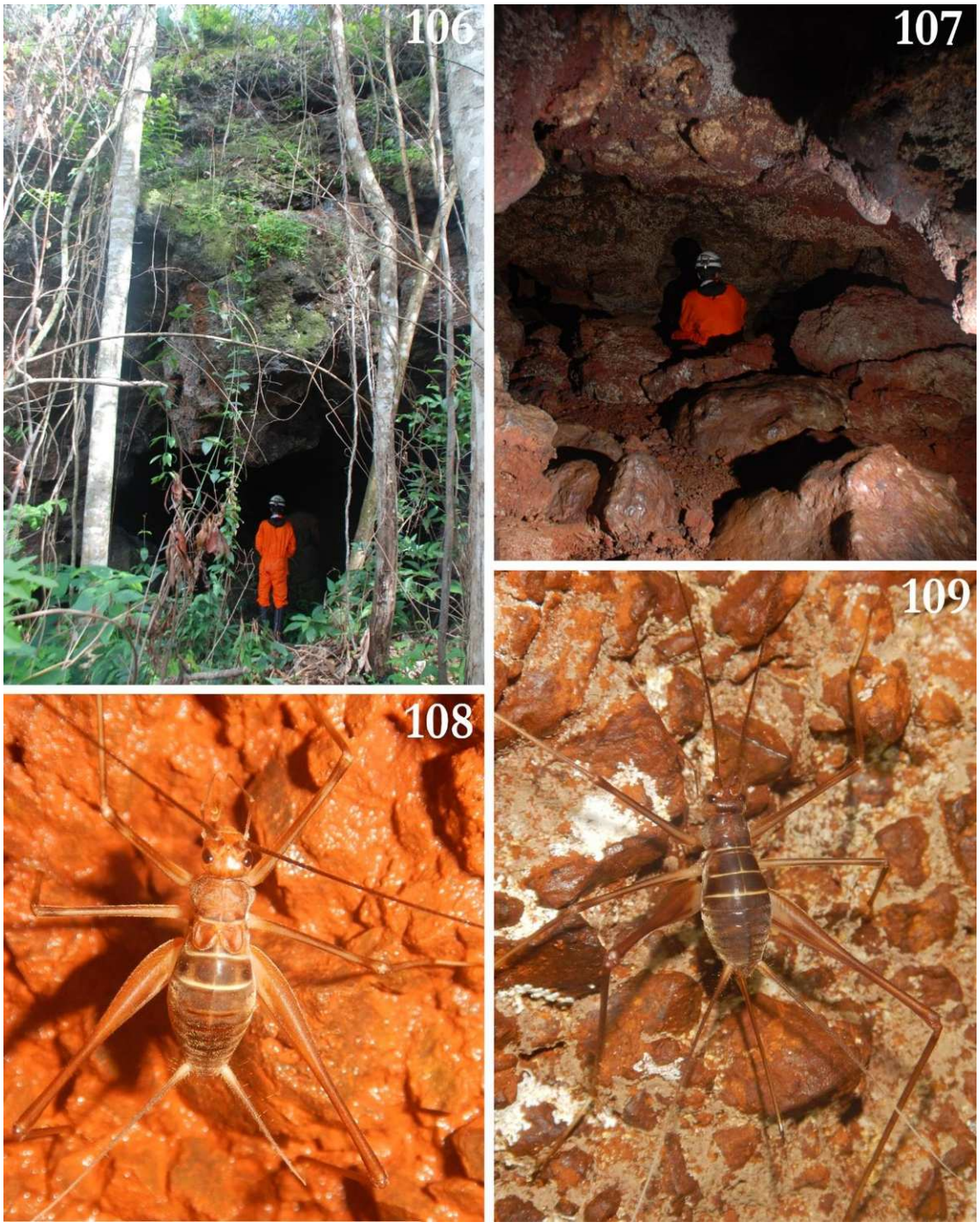
FIGURES 89–95. *Phalangopsis kyju* **n. sp.** Holotype morphology. 89–head in lateral and superior view; 90–head in frontal view; 91–pronotum in dorsal view; 92–right tegmen and metanotal glands, dorsal view; 93–supranal plate, dorsal view; 94–supranal and subgenital plates, lateral view; 95–subgenital plate, ventral view.



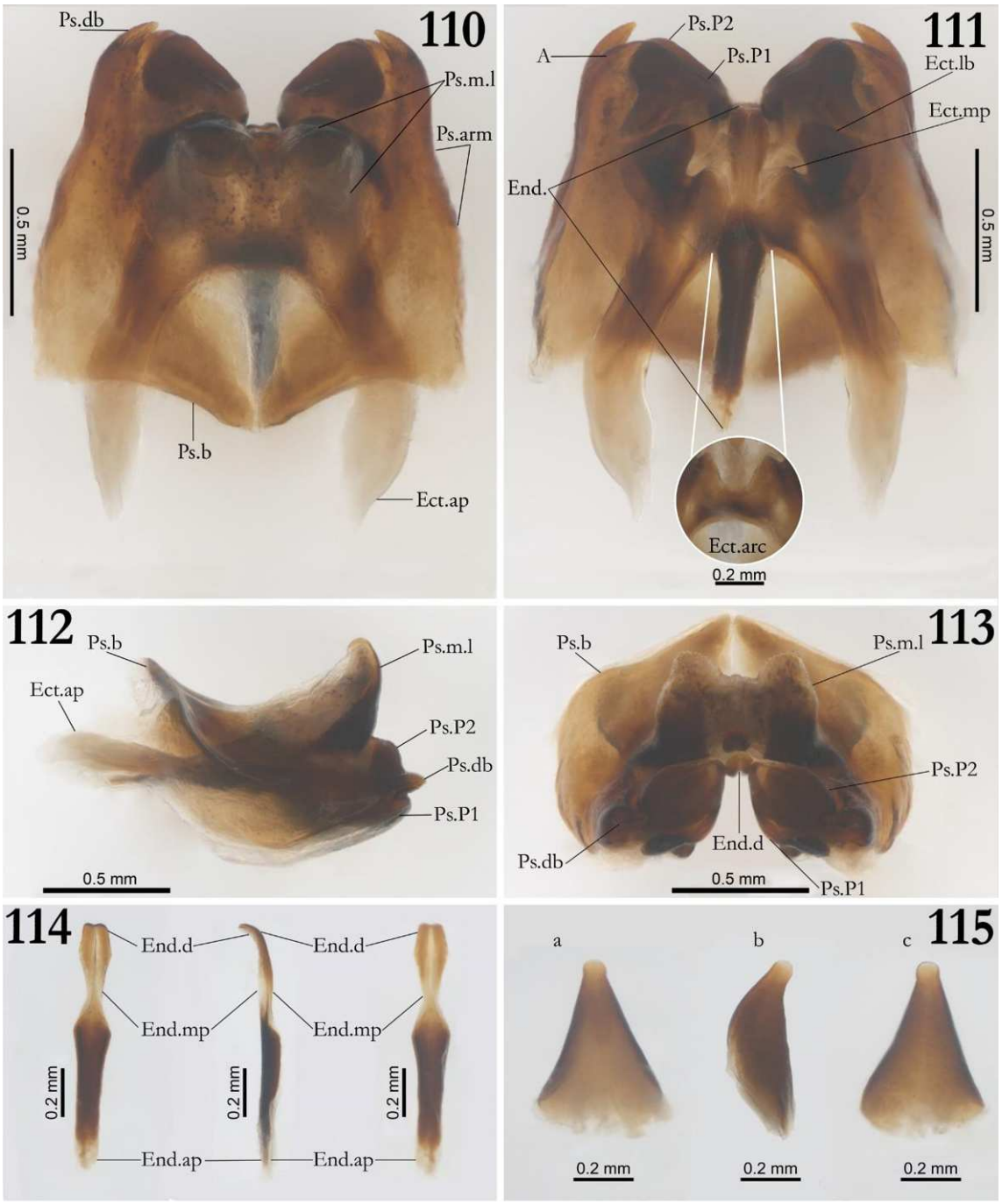
FIGURES 96–99. *Phalangopsis kyju* **n. sp.** Holotype legs morphology. 96–right legs I and II, outer view; 97–right legs I and II, inner view; 98–right leg III and apical spurs (**a**; **b**; **c**), outer view; 99–right leg III and apical spurs (**d**; **e**; **f**; **g**), inner view.



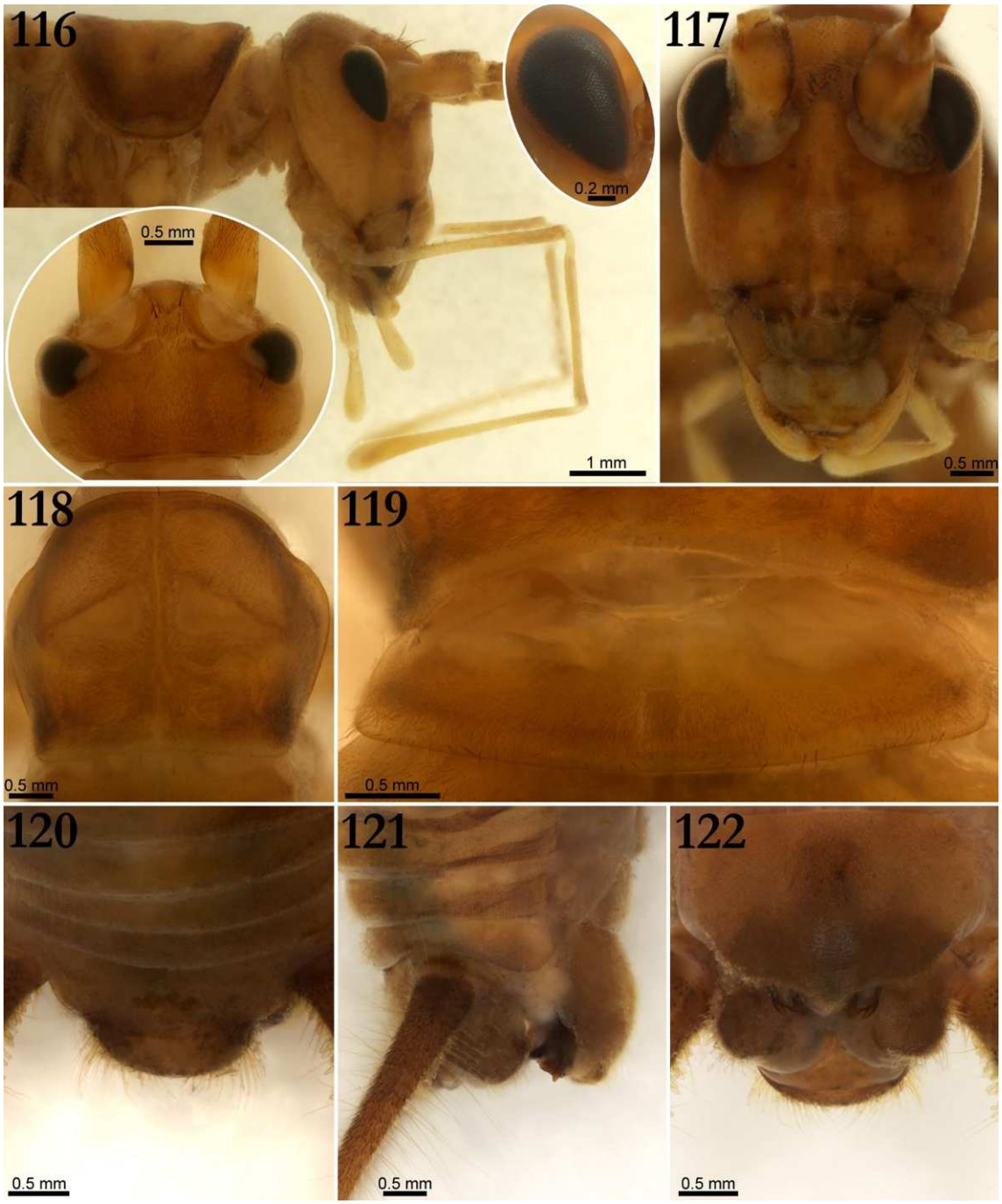
FIGURES 100–104. *Phalangopsis kyju* **n. sp.** ♀ ISLA 65732. 100–supranal plate; 101–subgenital plate; 102, 103 and 104–ovipositor apex, dorsal, lateral and ventral view, respectively.



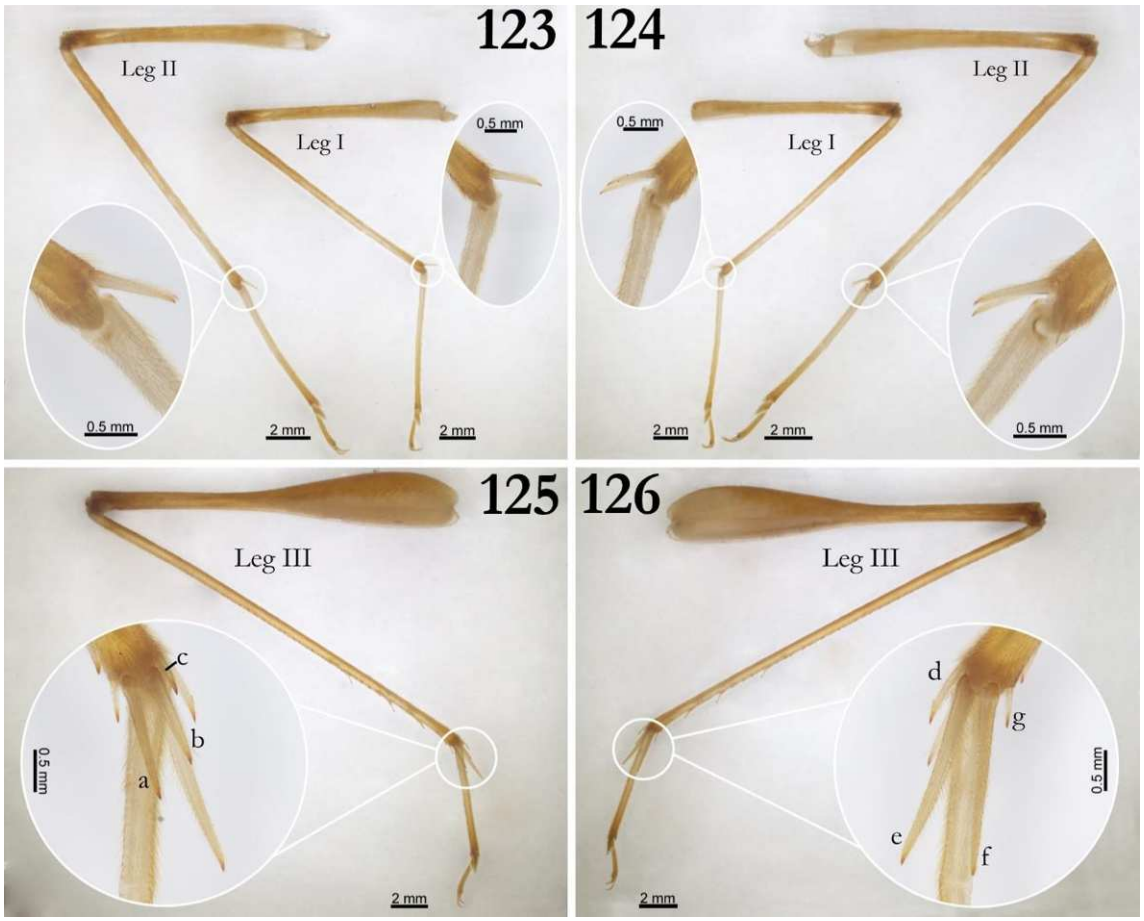
FIGURES 106–109. Study area and habitats of *Phalangopsis kyju* **n. sp.** 106–entrance of SFX_001 cave; 107–SFX_001 cave; 108–♂ of *Phalangopsis kyju* **n. sp.** from SFX_0070 cave; 109–♀ of *Phalangopsis kyju* **n. sp.** from SFX_0026 cave.



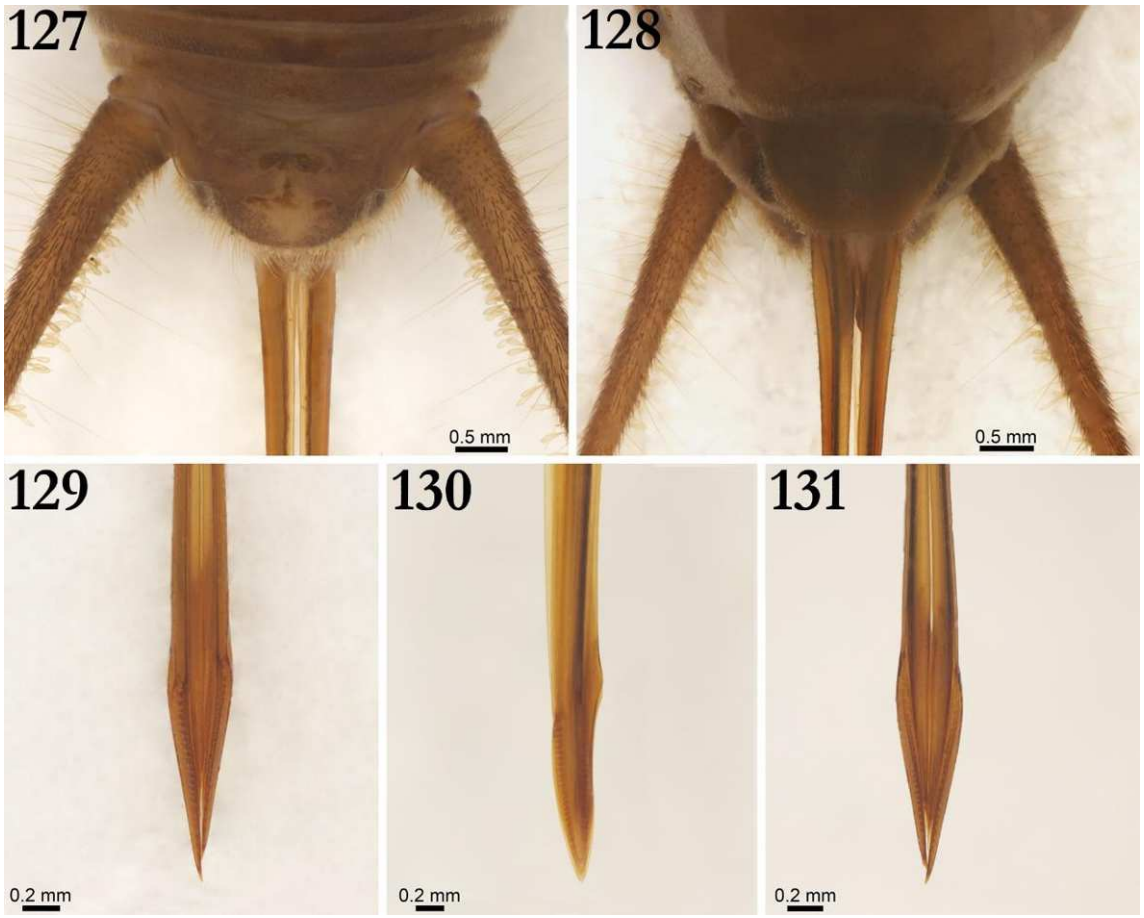
FIGURES 109–114. *Phalangopsis kysuia* ***n. sp.*** Phallic sclerite of paratype ♂ (ISLA 65727). 109–dorsal view; 110–ventral view; 111–lateral view; 112–frontal view; 113–endophallic sclerite in dorsal, lateral and ventral view, respectively. **114**–genital papilla of paratype ♀ (ISLA 65724). a–dorsal view; b–lateral view; c–ventral view. *Abbreviations*: **Ps.db**, psudepiphallic dorsal branch; **Ps.P1**, pseudepiphallic paramere 1; **Ps.P2**, pseudepiphallic paramere 2; **Ps.m.l**, pseudepiphallic median lobes; **A**, sclerite A; **Ps.arm**, pseudepiphallic arm; **Ps.b**, pseudepiphallic branch; **Ect.ap**, ectophallic apodeme; **Ect.lb**, ectophallic lateral bar; **Ect.mp**, ectophallic median portion; **Ect.arc**, ectophallic arc; **End**, endophallus; **End.d**, endophallic distal portion; **End.mp**, endophallic median portion; **End.ap**, endophallic apodeme.



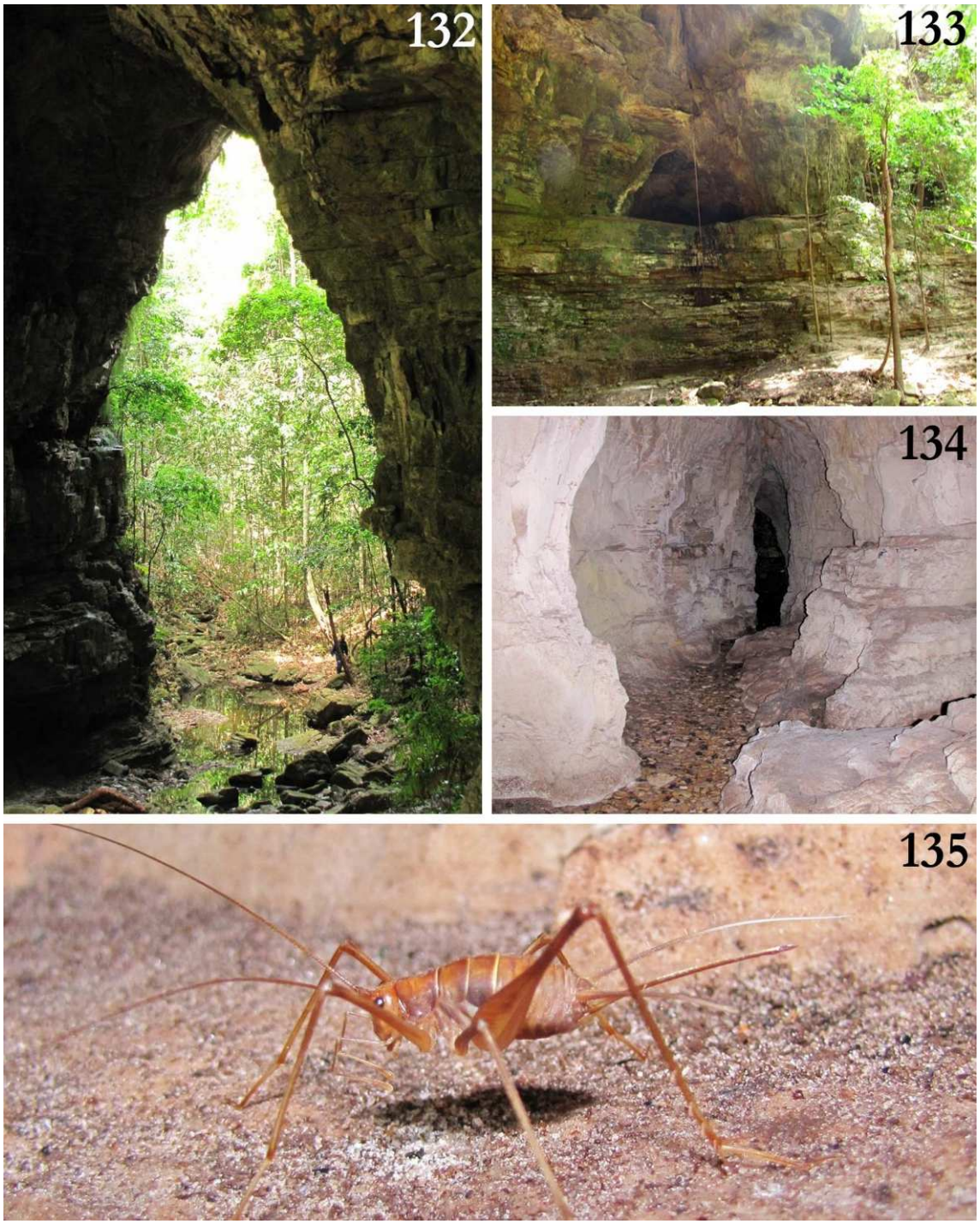
FIGURES 115–121. *Phalangopsis kysuia* **n. sp.** Holotype morphology. 115–head in lateral and superior view; 116–head in frontal view; 117–pronotum in dorsal view; 118–absence of right tegmen and metanotal glands, dorsal view; 119–supranal plate, dorsal view; 120–supranal and subgenital plates, lateral view; 121–subgenital plate, ventral view.



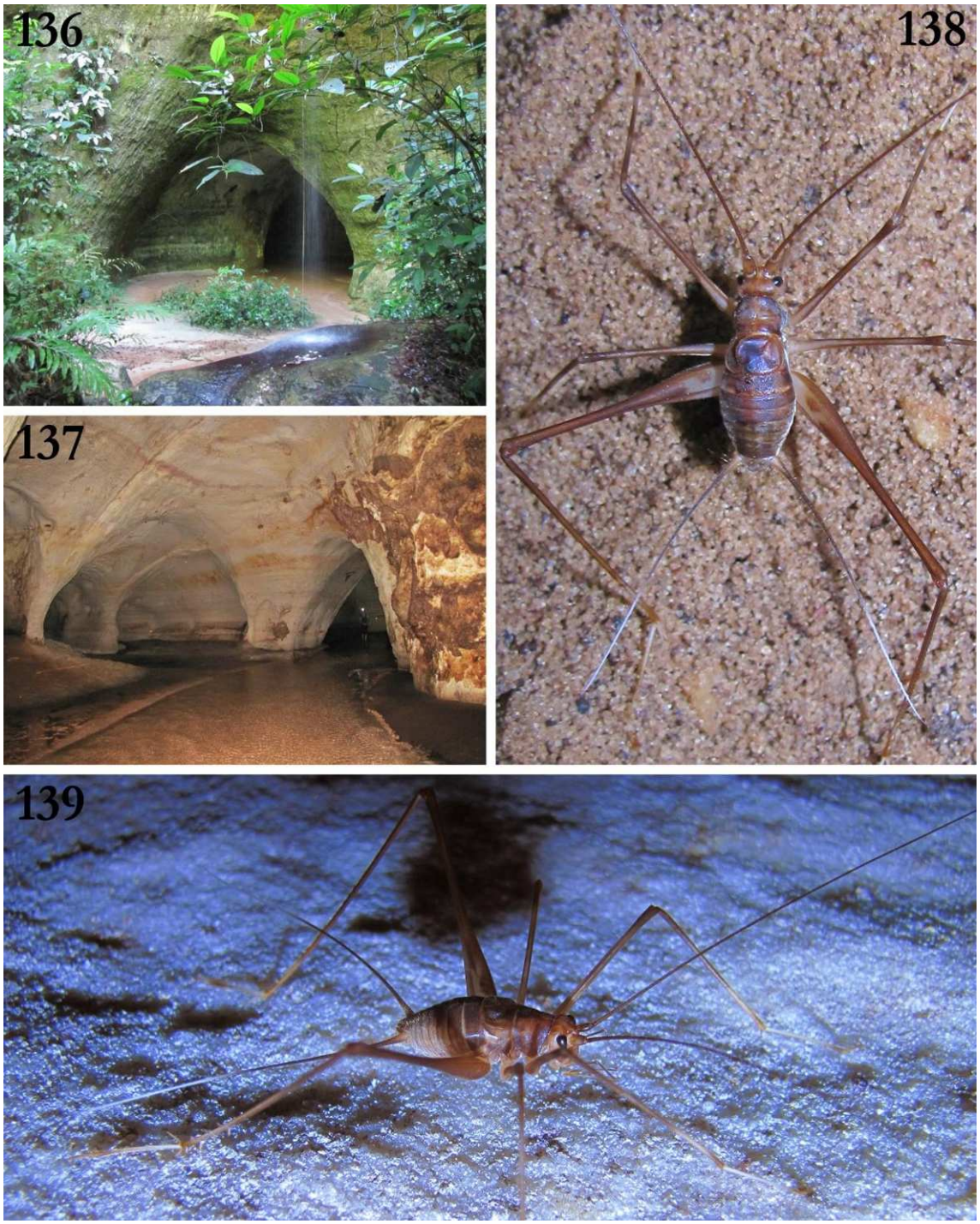
FIGURES 122–125. *Phalangopsis kysuia* **n. sp.** Holotype legs morphology. 122–right legs I and II, outer view; 123–right legs I and II, inner view; 124–right leg III and apical spurs (**a**; **b**; **c**), outer view; 125–right leg III and apical spurs (**d**; **e**; **f**; **g**), inner view.



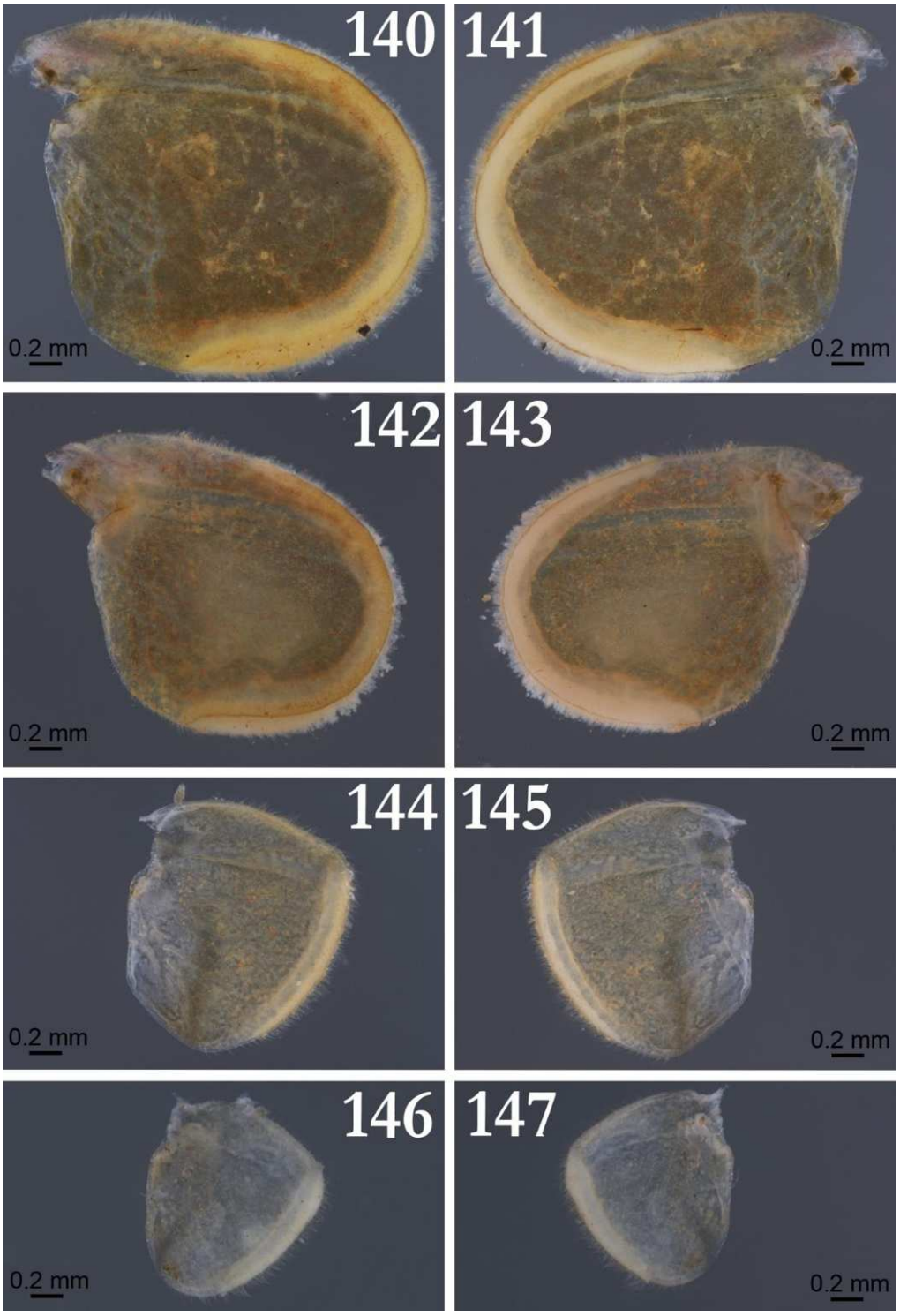
FIGURES 126–130. *Phalangopsis kysuia* **n. sp.** ♀ ISLA 65724. 126–supranal plate; 127–subgenital plate; 128, 129 and 130–ovipositor apex, dorsal, lateral and ventral view, respectively.



FIGURES 132–135. Study area and habitats of *Phalangopsis kysuia* **n. sp.** 132–external environment of Casa de Pedra do Pena cave; 133–Casa de Pedra do Pena cave's entrance; 134–Casa de Pedra do Pena cave; 135–♀ of *Phalangopsis kysuia* **n. sp.** from Casa de Pedra do Pena cave.



FIGURES 136–139. Study area and habitats of *Phalangopsis arenita* Mews & Sperber, 2008. 136–Maroaga cave's entrance; 137–Maroaga cave; 138 and 139–♂ of *Phalangopsis arenita* Mews and Sperber, 2008 from Maroaga cave.



FIGURES 140–147. Right tegmen. 140 and 141–*Phalangopsis araguaia* **n. sp.**, dorsal and ventral view; 142 and 143–*Phalangopsis kyju* **n. sp.**, dorsal and ventral view; 144 and 145–*Phalangopsis quartzitica* **n. sp.**, dorsal and ventral view; 146 and 147–*Phalangopsis ferratilis* **n. sp.**, dorsal and ventral view.

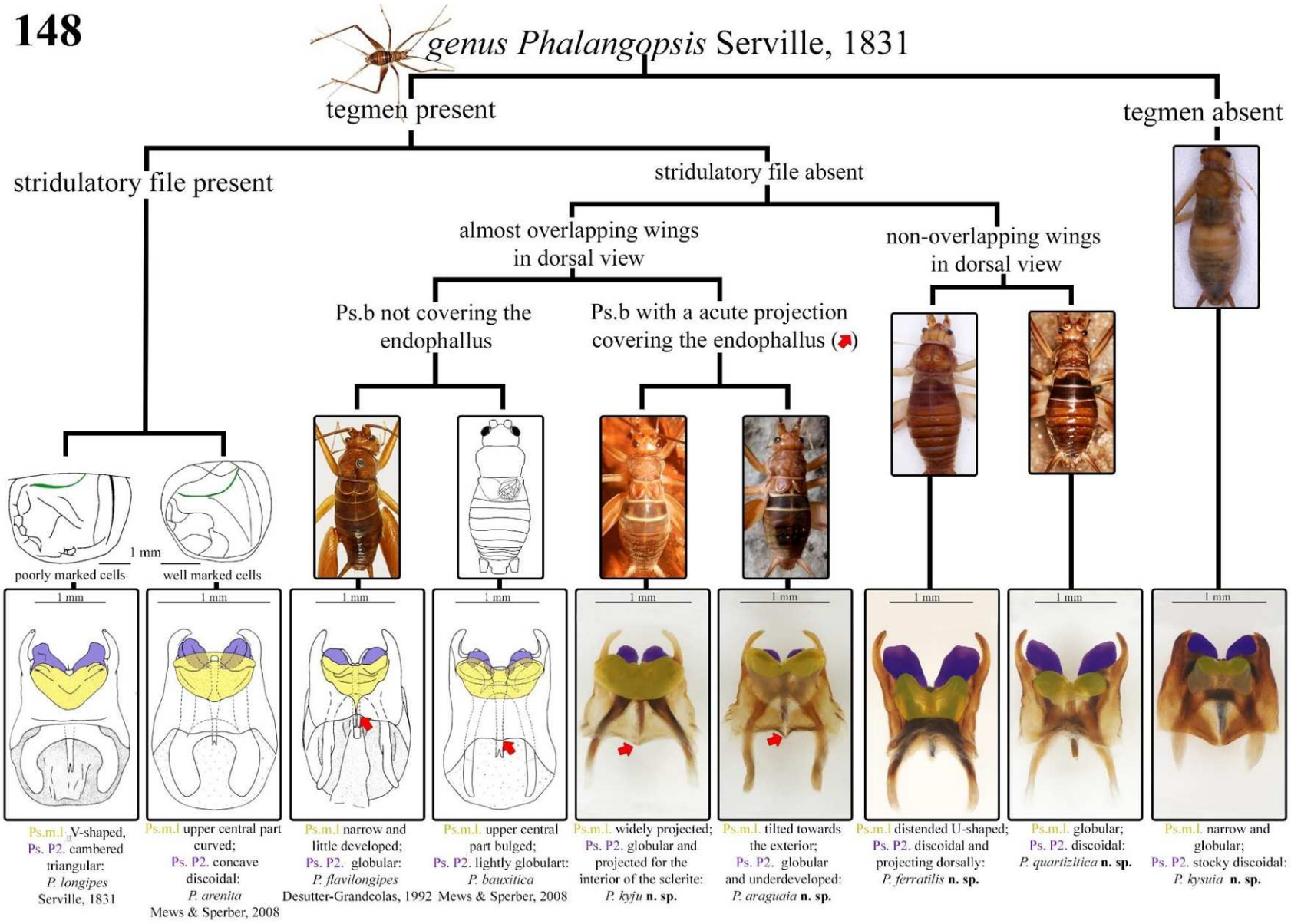


FIGURE 148: Pictorial key for the species of *Phalangopsis* Serville, 1831, based on known adult male specimens (some images were modified from Desutter-Grandcolas, 1992, page 129, figs 42, 43, 46 and 47; Mews & Sperber, 2008, page 649, fig. 1-C, page 650, fig. 2-A, page 652, figs A, C and D, page 653, fig 5-A; dorsal pic of *P. flavilongipes* available in https://science.mnhn.fr/ (Credit - Guy Le Corvec 2016).

TABLE 1. *Phalangopsis quartzitica* **n. sp.** (n° = 4) and *Phalangopsis araguaia* **n. sp.** (n° = 9), adult male morphological measurements (mm), mean (Med.) and standard deviation (D.P.).

	Phalangopsis quartzitica **n. sp.**						*Phalangopsis araguaia* **n. sp.**										
♂	65737	65738	65739	65740	Med.	D.P.	65745	65746	65747	65748	65750	65751	65752	65753	65754	Med.	D.P.
Head width	2.825	2.985	2.753	2.739	2.826	0.113	3.119	3.647	3.345	3.113	2.842	2.981	2.609	2.361	2.571	2.954	0.406
Head length	3.920	4.075	3.663	3.728	3.847	0.187	4.263	4.980	4.855	4.364	4.070	4.075	3.891	3.322	3.586	4.156	0.539
Intra ocular	1.705	1.903	1.727	1.596	1.733	0.127	1.994	2.441	2.038	1.840	1.707	1.940	1.548	1.381	1.604	1.833	0.317
Femur III	14.255	15.398	none	14.591	14.748	0.587	17.815	24.281	22.634	19.706	15.876	17.738	14.495	11.972	14.056	17.619	4.052
Tibia III	16.594	17.781	none	16.775	17.050	0.640	20.412	28.445	26.847	23.063	17.577	20.918	16.994	13.689	15.731	20.408	5.001
Body	17.420	16.135	15.522	18.430	16.877	1.303	18.394	23.404	20.472	20.122	18.356	16.861	17.130	15.396	16.489	18.514	2.471
Pronotum width	2.816	3.314	2.865	2.956	2.988	0.225	3.543	4.007	3.768	3.546	3.200	3.454	3.066	2.728	3.051	3.374	0.398
Pronotum length	2.558	2.934	2.440	2.527	2.615	0.219	2.761	3.594	3.558	3.020	2.657	2.782	2.651	2.153	2.941	2.902	0.453
Wing width	0.894	0.732	0.869	0.939	0.859	0.089	0.940	2.207	1.921	1.666	0.567	1.476	0.510	none	0.459	1.218	0.688
Wing lenght	0.866	0.855	0.646	0.996	0.841	0.145	0.918	2.019	1.805	1.923	0.885	1.814	0.890	none	0.780	1.379	0.552

TABLE 2. *Phalangopsis ferratilis* **n. sp**. (n° = 7); *Phalangopsis kyju* **n. sp.** (n° = 3); *Phalangopsis kysuia* **n. sp.** (n° = 2). adult male morphological measurements (mm). mean (Med.) and standard deviation (D.P.).

	Phalangopsis ferratilis **n. sp.**									*Phalangopsis kyju* **n. sp.**					*Phalangopsis kysuia* **n. sp.**			
♂	65755	65756	65757	65761	65762	65766	65767	Med.	D.P.	65730	65731	65733	Med.	D.P.	65725	65727	Med.	D.P.
Head width	3.147	3.016	2.919	3.305	3.001	2.697	2.874	2.994	0.195	3.382	3.226	3.690	3.433	0.236	3.287	2.554	2.921	0.518
Head length	4.301	4.166	4.246	4.494	4.116	4.057	3.99	4.196	0.169	4.397	4.209	4.539	4.382	0.166	4.779	3.721	4.250	0.748
Intra ocular	1.901	1.738	1.732	2.03	1.825	1.772	1.691	1.813	0.118	1.929	1.739	2.470	2.046	0.379	1.997	1.493	1.745	0.356
Femur III	17.771	16.35	15.046	16.51	14.528	13.229	12.124	15.080	1.974	19.898	20.872	21.691	20.820	0.898	19.849	13.972	16.911	4.156
Tibia III	19.506	19.064	17.771	19.022	16.804	16.061	14.073	17.472	1.964	23.723	23.551	25.635	24.303	1.157	23.566	15.828	19.697	5.472
Body	17.955	21.915	18.275	19.961	17.36	14.776	14.247	17.784	2.702	18.804	19.967	19.211	19.327	0.590	21.181	19.416	20.299	1.248
Pronotum width	3.606	3.127	3.036	3.386	2.993	2.811	2.717	3.097	0.312	3.431	3.521	3.541	3.498	0.059	3.788	3.232	3.510	0.393
Pronotum length	2.94	2.587	2.666	2.631	2.118	2.51	2.387	2.548	0.254	2.799	3.084	2.774	2.886	0.172	3.348	2.369	2.859	0.692
Wing width	none	0.984	0.949	1.125	0.605	0.732	0.846	0.874	0.187	1.727	1.695	1.666	1.696	0.031	absent	absent	absent	absent
Wing lenght	none	1.047	0.929	0.784	0.63	0.649	0.734	0.796	0.164	1.545	1.917	1.738	1.733	0.186	absent	absent	absent	absent

TABLE 3. *Phalangopsis araguaia* **n. sp.** (n° = 1); *Phalangopsis kysuia* **n. sp.** (n° = 4); *Phalangopsis ferratilis* **n. sp**. (n° = 7); adult female morphological measurements (mm). mean (Med.) and standard deviation (D.P.).

Phalangopsis araguaia **n. sp.**		*Phalangopsis kysuia* **n. sp.**						*Phalangopsis ferratilis* **n. sp.**				
♀	65749	65724	65726	65728	65729	Med.	D.P.	65758	65759	65763	Med.	D.P.
Head width	3.469	2.928	2.888	3.122	2.488	2.857	0.266	3.375	3.452	3.295	3.374	0.079
Head length	5.125	4.062	3.941	4.708	3.404	4.029	0.536	4.945	4.856	4.578	4.793	0.191
Intraocular	2.468	1.748	1.889	1.961	1.787	1.846	0.097	2.142	1.987	2.065	2.065	0.078
Femur III	22.344	16.641	18.565	17.831	16.667	17.426	0.941	18.76	18.901	16.477	18.046	1.361
Tibia III	25.224	18.982	21.228	20.718	19.624	20.138	1.021	21.704	21.717	18.577	20.666	1.809
Body	24.041	19.373	19.804	22.278	21.831	20.822	1.446	22.412	16.004	20.404	19.607	3.278
Pronotum width	3.965	3.387	3.836	3.743	3.57	3.634	0.198	3.608	3.861	3.304	3.591	0.279
Pronotum length	3.557	2.68	3.063	2.772	2.784	2.825	0.165	3.148	3.187	2.861	3.065	0.178
Ovopositor	16.454	13.141	13.074	11.933	11.66	12.452	0.766	14.025	14.474	13.323	13.941	0.580

TABLE 4. *Phalangopsis quartzitica* **n. sp.** (n° = 3) and *Phalangopsis kysuia* **n. sp.** (n° = 3); adult female morphological measurements (mm). mean (Med.) and standard deviation (D.P.).

	Phalangopsis quartzitica **n. sp.**					*Phalangopsis kyju* **n. sp.**				
♀	65736	65741	65743	Med.	D.P.	65732	65734	65735	Med.	D.P
Head width	3.185	3.281	3.269	3.245	0.052	3.645	3.555	3.694	3.631	0.071
Head length	4.259	4.401	4.356	4.339	0.073	4.718	5.011	5.435	5.055	0.360
Intraocular	1.863	1.793	1.899	1.852	0.054	2.182	2.166	2.157	2.168	0.013
Femur III	15.704	15.701	16.572	15.992	0.502	21.723	21.281	21.237	21.414	0.269
Tibia III	18.086	18.346	19.175	18.536	0.569	25.483	24.698	25.303	25.161	0.411
Body	20.180	20.487	19.261	19.976	0.638	19.383	20.703	20.824	20.303	0.799
Pronotum width	3.423	3.431	3.633	3.496	0.119	3.794	3.848	4.273	3.972	0.262
Pronotum length	2.939	2.847	3.034	2.940	0.094	3.360	3.324	3.214	3.299	0.076
Ovopositor	10.500	12.747	11.962	11.736	1.140	15.574	15.909	15.934	15.806	0.201