Research article

A new species of *Microphotina* Beier, 1935 from the southernmost region of Amazonia (Mantodea: Photinaidae)

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Abstract. A new species of *Microphotina* Beier, 1935 (Mantodea: Photinaidae: Microphotinini), *Microphotina cristalino* sp. nov., is described from Mato Grosso, Brazil based on two male specimens. The new species extended the distribution of *Microphotina* to the southern limits of the Amazon rainforest, in the Cerrado-Amazônia ecotone. A synthesis of the taxonomy, systematics, natural history, and geographic distribution of *Microphotina* spp. is provided, along with an updated dichotomous key to species. The hypothesis that *Microphotina* represents a canopy-dwelling lineage is formulated. The role of praying mantises as flagship species for insect and Amazon conservation is briefly discussed.

Keywords. Conservation, Microphotinini, natural history, praying mantis, species discovery.

Introduction

The Photinaidae Giglio-Tos, 1915 is one of the eight families comprising the clade Amerimantodea Schwarz & Roy, 2019, informally known as Polymorphic Earless Praying Mantises or PEPM (Rivera & Svenson 2016, 2020). Endemic to the neotropics, the Photinaidae are either foliage dwellers or stem-crawlers (Rivera & Svenson 2016). Based on a molecular phylogeny, Rivera & Svenson (2016) established the tribe Microphotinini Rivera & Svenson, 2016 to accommodate the smallest members of this lineage: *Chromatophotina* Rivera, 2010 (2 spp.) and *Microphotina* Beier, 1935 (4 spp.). Whereas the two known species of *Chromatophotina* are restricted to the Western Amazon rainforest (Andean foothills and adjacent lowlands of Peru, Ecuador, and Colombia) (Rivera & Svenson 2016, 2020), *Microphotina* is widespread across the Amazon (Fig. 1) and includes the following species: *M. vitripennis* (Saussure, 1872), *M. viridescens* (Chopard, 1912), *M. viridula* Roy, 2019 and *M. panguanensis* Schwarz, Ehrmann & Stiewe, 2020. Although the non-monophyletic status of *Microphotina* remains contentious
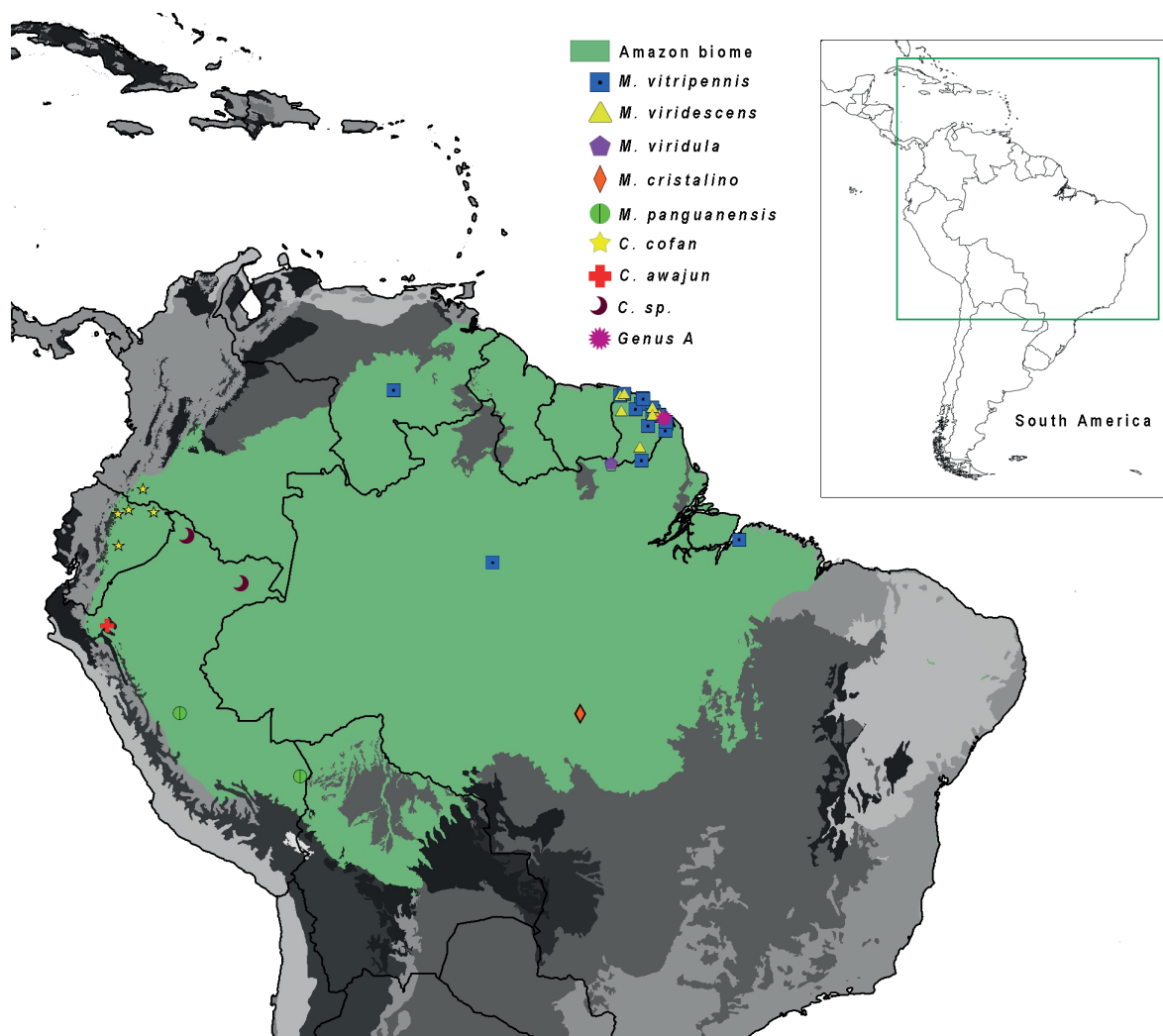

Fig. 1. Geographic distribution of Microphotinini Rivera & Svenson, 2016. Whereas Genus A (= Microphotinini Gen. n. sp. n. of Rivera & Svenson 2016, Fig. 4) is only known to French Guiana and *Chromatophotina* Rivera, 2010 is restricted to Western Amazon, *Microphotina* Beier, 1935 ranges across this entire biome. Collecting events are restricted to the periphery of the Amazon rainforest, whereas interior regions remain largely without records. Distributional data from combined sources (see Discussion); data from French Guiana (Moulin & Roy 2020) provided by Nicolas Moulin.

(Rivera & Svenson 2016, 2020), all members share the following morphological traits: i) head with a narrow lower frons that is at least 4 × as wide as long; ii) prozona of pronotum with parallel lateral margins; iii) forefemora with 13–15 anteroventral spines. *Microphotina* is arguably one of the most rarely collected taxa within the Amerimantodea clade, as they are only occasionally found on ground-level vegetation and thus are seldom collected there. Males are only reliably collected at light traps; females, on the contrary, remain virtually unknown. A single, poorly preserved female specimen is all that is known of this sex (François & Roy 2015) in 150 years of taxonomic history. Besides taxonomic accounts, nothing is known about the natural history of *Microphotina*.

In this study, we identify and describe a new species of *Microphotina* from the southernmost part of the Brazilian Amazon (Mato Grosso State), where the genus was previously unknown. We provide insights into the systematics, biogeography, and natural history of *Microphotina* by integrating data from the literature and field observations. We also elaborate a key to assist with the identification of all known species. Finally, we briefly discuss how conservation initiatives may benefit from integrating praying mantis biodiversity research into nature outreach campaigns.

Material and methods

Collecting site

The type series was obtained during a 64-day (April–June 2021) praying mantis survey at the Reserva Particular do Patrimônio Natural Cristalino (RPPN Cristalino hereafter) (9°35′47.3″ S, 55°55′56.2″ W), a private reserve located in the municipality of Alta Floresta, Mato Grosso State, Brazil. RPPN Cristalino protects more than 7000 hectares of Amazon rainforest within the Cerrado-Amazônia ecotone, the world's largest savanna-forest transition (Marques *et al.* 2019). RPPN Cristalino contains a variety of ecosystems such as non-flooded forests ('terra firme'; Fig. 2A), seasonally flooded forests ('igapós'), dry forests ('campinaranas'), and rock outcrops ('campos rupestres'). Altitude ranges from 168 to 390 m. The climate is hot and humid, with annual averages of 26ºC for temperature and 2400 mm for precipitation (ICMBio 2010). However, unlike the northern Amazon, this region has a marked dry season during which rain is scarce, receiving less than 10 mm from June until August. The average temperature during our field season was 26.5ºC, and the average humidity was 82%. The few rainy days we experienced were especially concentrated in April. We took advantage of the existing trail infrastructure surrounding the RPPN Cristalino headquarters (260 m) to access collecting sites. Our survey combined two non-lethal methods to maximize the taxonomic diversity of sampled specimens: active search (35 nights) and light traps (62 nights). The active search consisted of at least five hours/night with two individuals searching the forest (from leaf litter to up to 4 m above the ground) using Fenix UC35 flashlights, totalizing more than 175 hours of search per person. The light trap (Fig. 2B) consisted of a white cloth sheet fitted with a 250 W mixed mercury vapor bulb (De Camargo & Cavalcanti 1999). One light trap was set up on different sites around the reserve headquarters using a 150 m wire extension, whereas the other remained fixed at the lodge's balcony. Light traps operated continuously from 6:00 p.m. until 5:30 a.m. of the next day. We checked light traps at least three times per night: 7:00 p.m., 1:00 a.m., and 5:00 a.m. (approximated times).

Specimen handling

All specimens obtained were kept alive inside foldable paperboard boxes large enough (12.5 cm × 10 cm × 10 cm) to enable free movement. Each box had 50% of its sides made of fine mesh to allow airflow and facilitate observation. We kept all specimens alive on a diet of wild-caught insects (particularly moths) until they died of natural causes. We followed Brannoch *et al.* (2017) for external morphological nomenclature, spination formula, specimen preparation, and genital dissection; however, we introduced modifications to some procedures. For example, we pinned specimens keeping the right foreleg coxae closer to the pronotum to allow for quick comparison between the length of that structure and the

pronotum. For genital extraction, we first immersed the tip of the abdomen in warm water (50ºC) for one hour. Once softened, we extracted the male genital complex under a dissecting stereo microscope using a scalpel and pins. We immersed isolated structures into a vial containing KOH 10% and then placed it in a hot water bath for approximately one hour. After removing soft tissues, we preserved all

Fig. 2. Austral Expedition, praying mantis survey at RPPN Cristalino, 2021. **A**. View from a tower 50 m above ground, highlighting the dense, diverse, and multi-layered canopy (terra firme ecosystem). **B**. Mobile white cloth light trap operating at dawn.

genital components and associated parts (cerci, supraanal plate) inside microvials containing glycerin. Terminology for male genital structures follows Brannoch *et al.* (2017), adding a label for the basal lobe of the ventral phallomere in agreement with Schwarz & Roy (2019). We used a digital caliper to make anatomical measurements on both right- and left-side external structures. The morphological description focuses on those structures emphasized in previous species descriptions to enable effective comparisons. Because pinned specimen's coloration varies widely according to the preparation method, age, and storage conditions, we choose to report in vivo coloration instead.

Imaging and mapping

We photographed living specimens with a handheld Canon 80D DSLR camera with Canon EF 100 mm Macro USM lens, Yongnuo YN560 IV Speedlite flash, and a custom-made softbox. The incorporation of a Venus Optics Laowa 100 mm x2 ultra macro lens to this setup enabled imaging of pinned specimens and details. We used an iPhoneXs to obtain images of genitalia structures under a Digilab DI15-2B stereo microscope. Image edition was accomplished using Adobe Lightroom (post-production) and Adobe Photoshop (background standardization and structure individualization for plates). Adobe Illustrator enabled the formulation of line drawings. A map outlining the distribution of *Microphotina* spp. was generated with ArcMap ver. 10.5.

Institutional abbreviartion

MPEG = Museu Paraense Emílio Goeldi, Belém, Pará, Brazil.

Abbreviations for male genital structures

afa = anterior process (left phallomere)
bl = basal lobe (ventral phallomere)
LP = left phallomere
paa = posterior process (left phallomere)
RP = right phallomere
VP = ventral phallomere

Results

Taxonomy

Class Insecta Linnaeus, 1758
Order Mantodea Burmeister, 1838
Family Photinaidae Giglio-Tos, 1915
Subfamily Photinainae Giglio-Tos, 1915
Tribe Microphotinini Rivera & Svenson, 2016
Genus *Microphotina* Beier, 1935

***Microphotina cristalino* sp. nov.**
urn:lsid:zoobank.org:act:889DF5D8-9672-49C3-BBC0-B1A3329419DD
Figs 3–6

Diagnosis

The new species can be easily recognized by the following combination of characters: i) subgenital plate distally with a broadly-angled notch; ii) styli short, almost as long as wide, triangular; iii) afa reduced, forming a short, well-sclerotized, blunt process; iv) posterior process (paa) hammerhead-like with irregular margins.

Etymology

The specific epithet derives from RPPN Cristalino where the new species was discovered, a private reserve that plays an important role in protecting the biodiversity of one of the most threatened areas in the Amazon biome. '*Cristalino*' is the main river in the region and also happens to mean 'translucid' in Portuguese, which alludes to the translucent quality of the body and crystal-clear wings of our new
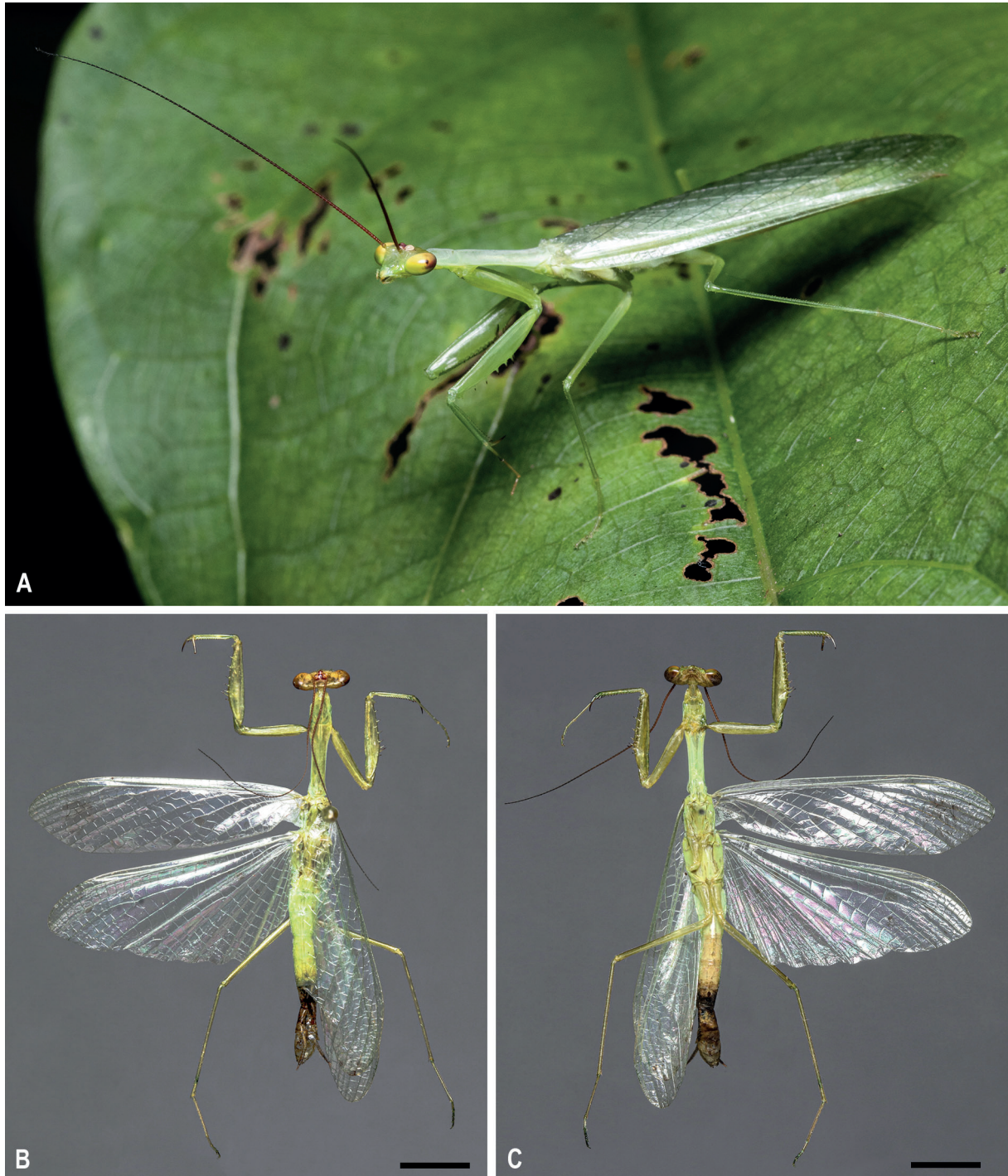

Fig. 3. *Microphotina cristalino* sp. nov., ♂, holotype (MPEG 05050654). **A**. Live specimen photographed in studio. **B–C**. Pinned specimen. **B**. Dorsal view. **C**. Ventral view. Scale bars = 5mm.

species. Because the name refers to the reserve, the river, and the Portuguese word, we choose to use it as a noun in apposition to name the new species.

Material examined

Holotype
BRAZIL • ♂; Mato Grosso, Alta Floresta, RPPN Cristalino; 9°35′47.3″ S, 55°55′56.2″ W; alt. 260 m; 7 May 2021; Projeto Mantis leg.; Amazônia, terra firme, white cloth light trap; MPEG 05050654.

Paratype
BRAZIL • 1 ♂; same collection data as for holotype; 12 May 2021; Projeto Mantis leg.; MPEG 05050655.

Description

Male holotype MPEG 05050654
Habitus. Small, green photinaid with red antennae and colorless, hyaline wings. Live specimen in Fig. 3A and Fig. 6; pinned specimen in Fig. 3B–C.

Measurements (in mm; measurements in parenthesis correspond to the paratype). Body length 28.55 (27.67) (to tip of supraanal plate), 32.8 (31.75) (to tip of wings); head length 2.17 (2.34); head width 4.42 (4.68); lower frons length 0.36 (0.34); lower frons width 1.56 (1.53); antennae length 18.00 (20.00); pronotum length 7.78 (7.76); maximum width of pronotum 1.97 (2.00); minimum width of pronotum 1.11 (1.23); prozona length 2.00 (2.12); metazona length 5.78 (5.64); forecoxa length 5.66 (5.48); forefemur length 6.33 (6.23); forefemur width 1.40 (1.23); foretibia length 4.36 (4.08); mesofemur missing (7.16); mesotibia missing (4.98); metafemur length 7.70 (7.54); metatibia length 8.48 (8.50); tegmen length 20.8 (21.24); tegmen width 6.38 (7.09); costal field at midpoint 0.67 (0.50); wing length 19.40 (19.68); wing width 9.30 (10.30); cerci length 2.51 (2.36).

Coloration (in vivo; Figs 3A, 6). Head in general light green, except for the following parts: labrum yellowish; mandibles cyan around the labrum; palp segments green to cyan to yellow, matching neighboring head structures in color; ocellar tubercle reddish pink; scape and pedicel of antennae green, flagellum red on its basal ⅓, becoming darker distally. Pronotum whitish green; forelegs vivid green, femoral and tibial spines green with dark tips. Meso- and metathorax pale green; wings iridescent, fully hyaline, membrane colorless, veins greenish (more evident on the costal field); cursorial legs vivid green. Abdomen pale green dorsally and beige ventrally.

Head (Fig. 4A–B). Distinctly wider than long. Juxtaocular bulges weakly developed, slightly more elevated than the imaginary line connecting the top of compound eyes, vertex slightly convex, scarcely more elevated than juxtaocular bulges, eyes kidney-shaped, lateral margin rounded. Ocellar tubercle undeveloped, ocelli prominent, elliptical, arranged forming angle of about 120º. Lower frons narrow, 4.3 × as wide as long (4.5 in paratype). Clypeus wider than long, trapezoidal. Antennae long and filiform, flagellomeres become increasingly elongated distally (Fig. 4C–E).

Thorax. Pronotum relatively slender (Fig. 4F–G), lateral margins smooth, lacking denticles, 3.9 × as long as its maximum width, supracoxal expansion indistinctly marked. Lateral margins of prozona almost parallel, anterior margin rounded. Metazona 2.9 (2.7 in paratype) times as long as prozona, with concave margins.

Prothoracic legs. Relatively slender. Forecoxae about as long as metazona, margins and overall surface smooth, inner aspect of forecoxae with scarce pilosity, especially on its basal third, apical lobes divergent. Spination formula: F=4DS/14AvS/5PvS; T=15(L)-14(R)AvS/17(L)-16(R)PvS [paratype foretibiae:

AvS = 17(L)-16(R), PvS = 16(L)-15(R)]. Forefemora (Fig. 4H) with tibial spur groove at the proximal third of the corresponding femur. The third discoidal spine is the longest, followed by the second, which is slightly longer than the fourth, and the first is very small, almost indistinct (in the paratype, the second discoidal spine is slightly smaller than the fourth on the left forefemur). Anteroventral forefemoral spines
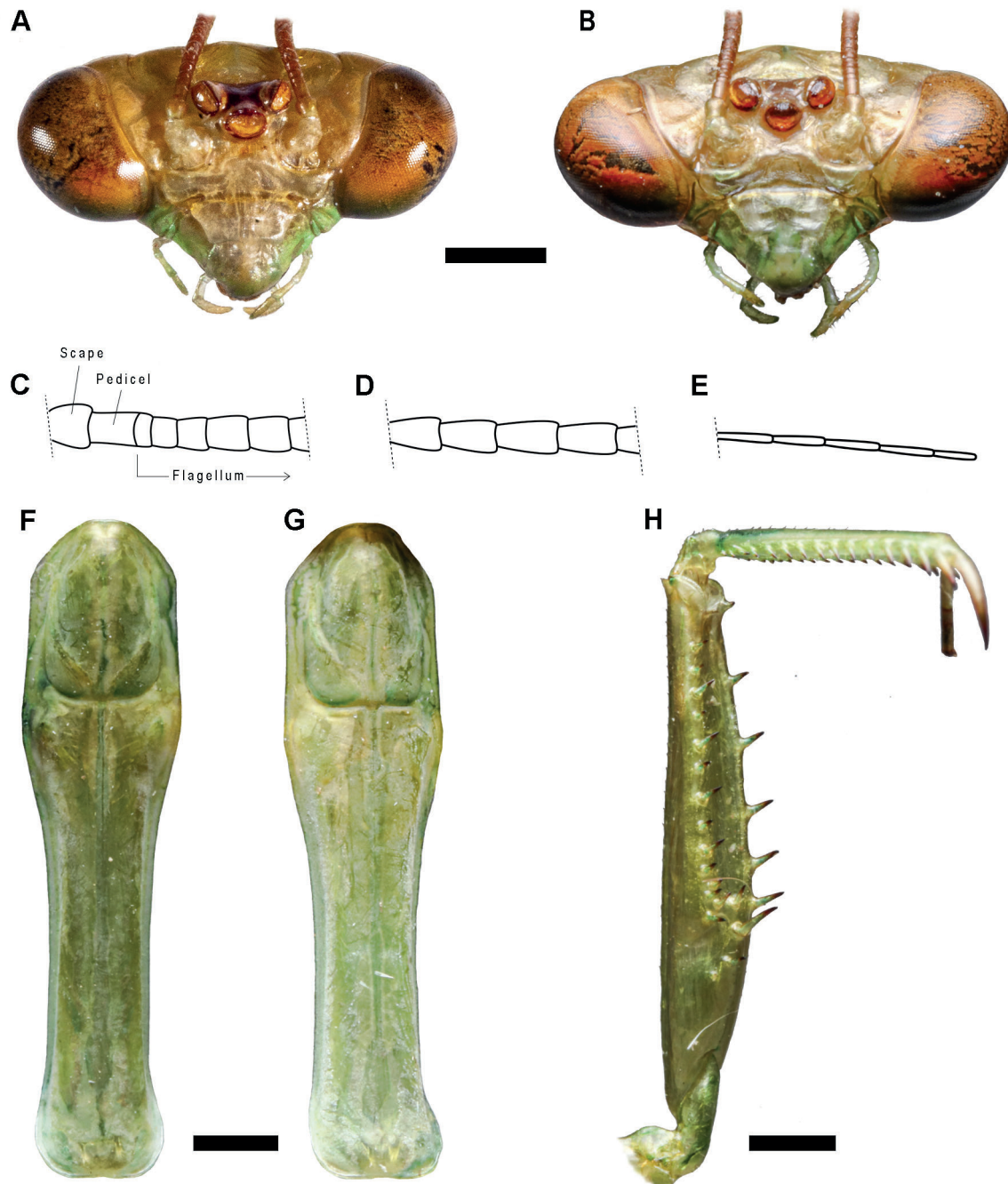

Fig. 4. *Microphotina cristalino* sp. nov., ♂, external morphology. **A–B**. Head, frontal view. **A**. Holotype (MPEG 05050654). **B**. Paratype (MPEG 05050655). **C–E**. Holotype, (MPEG 05050654), antenna, highlighting sectional variation of antennomeres. **C**. Basal section. **D**. Mid-section. **E**. Apex. **F–G**. Pronotum. **F**. Holotype (MPEG 05050654). **G**. Paratype (MPEG 05050655). **H**. Holotype (MPEG 05050654), left foreleg, showing spine configuration. Scale bars = 1mm.
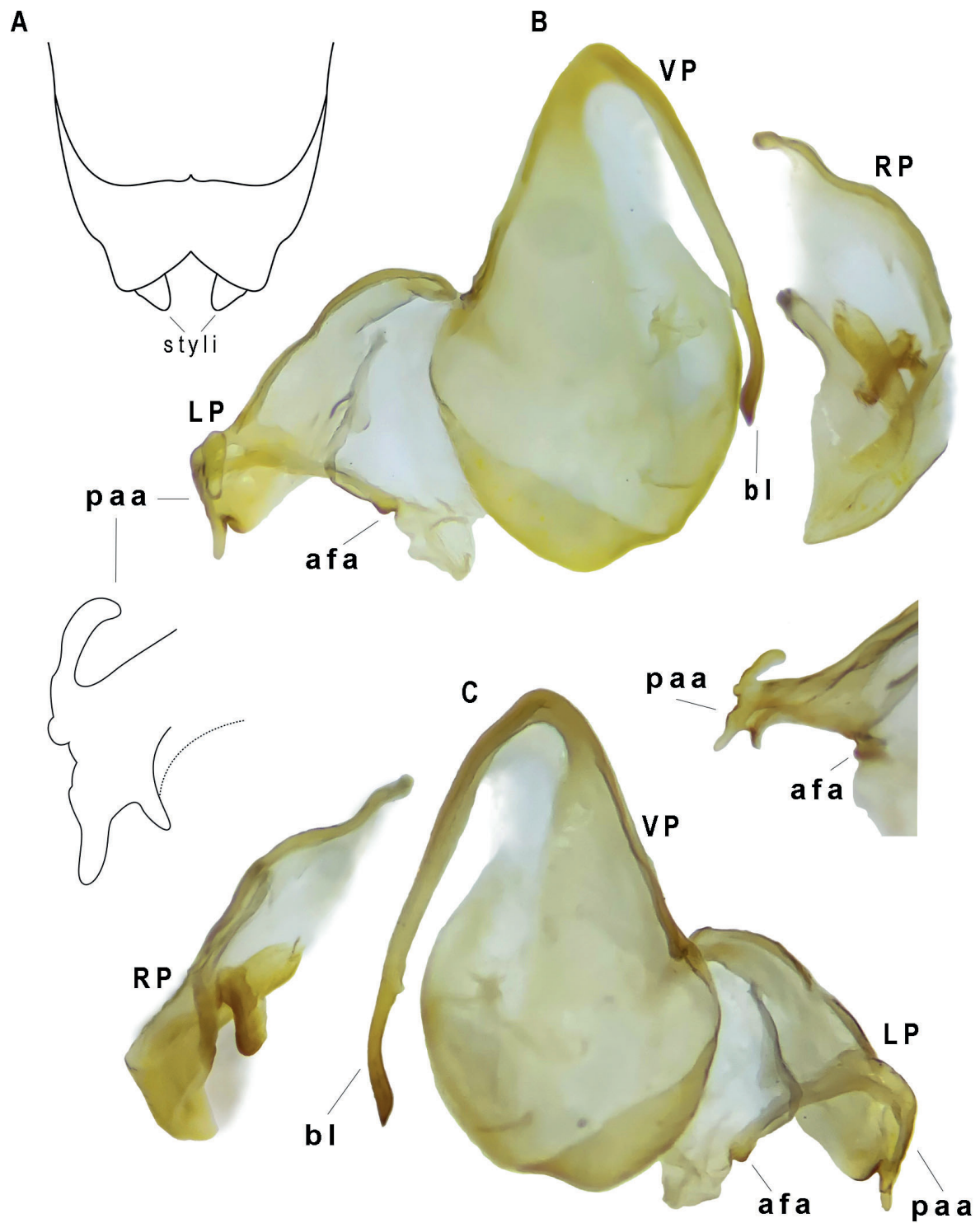
Fig. 5. *Microphotina cristalino* sp. nov., ♂, holotype (MPEG 05050654), subgenital plate and genital structures. **A**. Subgenital plate. **B**. Genital complex in dorsal view detailing the hammerhead-shaped paa, and its irregular margins. **C**. Genital complex in ventral view.

equidistant and similar in size (except for 11ᵗʰ and 13ᵗʰ spines, which are considerably shorter), with configuration iIiIiIiIiIiIi ('I' articulated spines; 'i' non-articulated spines; '**i**' smallest non-articulated spines), four basal most spines arranged in two rows. Posteroventral forefemoral spines equidistant, cuticle between spines smooth. Genicular lobes each bearing small spine. Foretibial spines slightly decumbent, increasing in size distally, posteroventral spines smaller than anteroventral spines, the latter with its distalmost spine around a third of length of tibial spur (in paratype, distalmost anteroventral spine half as long as tibial spur). Metatarsus longer than remaining tarsomeres combined, euplantula well developed.

Wɪɴɢs. Fore- and hindwings iridescent, fully hyaline, and unpigmented. Costal field of forewings narrow, with 26–29 parallel cross-veins; stigma indistinct. Hindwings at rest surpass forewings by about 1.5 mm (1.0 mm in the paratype).

Mᴇsᴏ- ᴀɴᴅ ᴍᴇᴛᴀᴛʜᴏʀᴀᴄɪᴄ Lᴇɢs. Slightly setose. Mesothoracic tibiae shorter than their corresponding femora, metathoracic tibiae longer. Mesothoracic metatarsus marginally shorter than remaining tarsomeres combined, metathoracic metatarsus much longer.

Aʙᴅᴏᴍᴇɴ. Slender, without lobes or projections, parallel-sided. Supraanal plate triangular, apex rounded. Cerci pilose, longer than supraanal and subgenital plates, with 12 cercomeres each, first cercomere consisting of few fused segments, last cercomere conical with rounded tip, considerably longer than wide. Subgenital plate distally with broadly-angled notch (Fig. 5A), styli triangular, short, almost as wide as long, with rounded apex.

Gᴇɴɪᴛᴀʟɪᴀ. Ventral phallomere (Fig. 5B–C): guttiform; bl elongated, narrow, slightly sinuous proximally, pre-apically bent, tip well sclerotized; inner aspect of bl with a preapical irregularity (same is absent in paratype). Left phallomere (Fig. 5B–C): afa strongly reduced, consisting of small, blunt protuberance that is only slightly more sclerotized than surrounding regions (a well-developed, membranous lobe, can be observed anterior to afa); paa produced and robust, hammerhead-like, distal margins irregular.

Female
Unknown.

Differential diagnosis

The males of all species of *Microphotina* are similar in their external morphology. Most differential characters however are found within genital structures and appendages associated with the terminal abdominal segments. *Microphotina cristalino* sp. nov. can be distinguished from its congeners for its subgenital plate with a broadly-angled, distal notch. From all known species, *M. cristalino* sp. nov. seems aligned with *M. panguanensis*. Both species share fully hyaline and unpigmented wing membranes, and the distinctive hammerhead-like paa of the left phallomere. However, in the new species the paa has conspicuously irregular margins, unlike *M. panguanensis*. Furthermore, *M. cristalino* sp. nov. has a higher metazona/prozona ratio value range (2.66–2.9) compared to *M. panguanensis* (2.4–2.5), and cerci comprised of 12 cercomeres (13 in *M. panguanensis*). The new species can be individually differentiated from its congeners as follows: i) from *M. vitripennis* for lacking a patch of setae on the ventral phallomere and a strongly reduced afa; ii) from *M. viridescens* for lacking green/yellowish pigmentation in the apex of the wings; iii) from *M. viridula* for having a hammerhead-like paa on its left phallomere.

Natural history and distribution

The new species was discovered during a praying mantis survey at RPPN Cristalino that yielded 231 specimens, representing at least 28 species in 25 genera. The two males of *M. cristalino* sp. nov.

were obtained by light trapping and represented less than 1% of the total catch of the survey. Active search did not yield any specimen of *Microphotina* despite considerable collecting effort. Both males arrived at the trap between 3:00–5:00 a.m., during the new moon phase, 5-day apart. The holotype and the paratype lived for 18 and one day, respectively, after collection. Their cryptic behavior consists of pressing their body against a perching surface, forelegs positioned laterally, and head held in an almost prognathous position (Fig. 6).

Fig. 6. *Microphotina cristalino* sp. nov., ♂, holotype (MPEG 05050654), cryptic behavior. **A**. Lateral view showing head almost in prognathous position. **B**. Dorso-lateral view, with forelegs laterally coupled to pronotum. Photographed in studio.

Discussion

Taxonomy and systematics

Microphotinini and its constituent members have received increased attention from taxonomists during the last decade. Published contributions include taxonomic assessments, descriptions of new species, and insights into phylogenetic affinities (Rivera 2010; Medellín & Salazar 2011; Ippolito & Lombardo 2012; François & Roy 2015; Rivera & Svenson 2016, 2020; Schwarz & Roy 2019; Moulin & Roy 2020; Schwarz *et al.* 2020). Thanks to these advances, certain patterns are now recognizable. Available evidence suggests that: i) Microphotinini comprises two clades and at least four independent lineages and ii) *Microphotina* is paraphyletic (Rivera & Svenson 2016, 2020; Schwarz *et al.* 2019) (Fig. 7A). *Microphotina* spp. exhibiting Type 3 genitalia (Rivera & Svenson 2020), which include *M. cristalino* sp. nov. and *M. panguanensis*, may need to be relocated into their own genus to account for its paraphyletic relationship with *Microphotina* s. str. and to conform to the principle of monophyly of phylogenetic classifications (Henning 1966). However, we refrain from taking this action until more specimens of *Microphotina* (Type 3 genitalia) can be gathered and effectively compared, in addition to *M. viridula*,
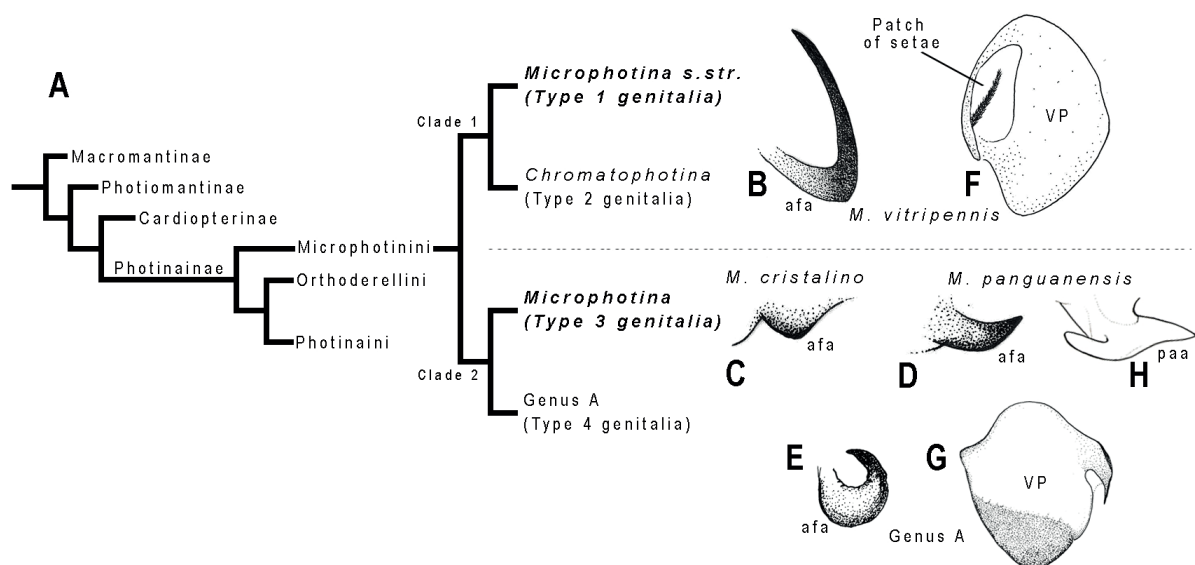

Fig. 7. Systematics of Microphotinini Rivera & Svenson, 2016. Higher-level molecular phylogeny of Photinaidae Giglio-Tos, 1915 (A) summarizing evolutionary relationships among Microphotinini and relevant genital traits according to Rivera & Svenson (2016, 2020). Distinct genital traits define four lineages and an equal number of genital types (outlined in Rivera & Svenson 2020). *Microphotina* Beier, 1935, as currently understood, is paraphyletic, a relationship further supported by divergent genital traits. *M. vitripennis* (Saussure, 1872) is the type species of the genus; thus, from a strictly nomenclatural perspective, it represents a 'true' species of *Microphotina*, that is, *Microphotina* sensu stricto (s. str.). In Clade 1, a well-developed, long and strongly curved (hook-like) afa (B) is a genital trait common to *M. vitripennis* and *Chromatophotina* Rivera, 2010 spp.; however, *M. vitripennis* is unique in having an elongated patch of setae on its ventral phallomere (F, in ventral view). Clade 2, with its strongly reduced afa (C–E), comprises *Microphotina* (in part; Type 3 genitalia) and Genus A (= Microphotinini gen. et sp. nov. of Rivera & Svenson 2016: fig. 4). In the first, the paa is markedly hammerhead-like (H), a feature Genus A lacks; further, the ventral phallomere of the latter has a strongly reduced bl (G, dorsal view), a unique feature among the Microphotinini, in which the bl is typically narrow and elongated (as in Fig. 5B). Abbreviations: See Material and methods. Genital structures and phylogenetic tree branches not to scale. Fig. 7E–G from Rivera & Svenson (2020).

whose affinities cannot yet be fully realized with available data. Comprehensive knowledge of females is also lacking. Only a single female specimen from French Guiana, attributed to *M. vitripennis*, has been documented (François & Roy 2015). The alluded specimen, poorly preserved, renders knowledge of female morphology incomplete; however, it resembles in many respects the otherwise well-documented females of *Chromatophotina* (Rivera 2010; Medellín & Salazar 2011; Ippolito & Lombardo 2012; see brief diagnosis in Rivera & Svenson 2020). The eventual collection and recognition of the elusive females of *Microphotina* spp., along with the nymphs and egg cases, is critical to shedding light on the taxonomy and systematics of this obscure photinaid lineage.

Key for the identification of species of *Microphotina* (males only)

1. Left phallomere: afa large, hook-like (Fig. 7B) 2
− Left phallomere: afa strongly reduced, shape variable (Fig. 7C–E) 3

2. Ventral phallomere bearing elongated patch of setae ventrally (Fig. 7F) (*Microphotina* s. str.) ....
....***M. vitripennis*** Saussure, 1872
− Ventral phallomere lacking patch of setae .... ***Chromatophotina*** spp.

3. Ventral phallomere: bl narrow and elongated (Fig. 5B) (*Microphotina*, in part) 4
− Ventral phallomere: bl broad and short (Fig. 7G) ....Genus A

4. Wings with a subopaque, yellowish green region apically .... ***M. viridescens*** (Chopard, 1912)
− Wings fully hyaline, unpigmented 5

5. Left phallomere: paa hammerhead-like (Figs 5B, 7H) 6
− Left phallomere: paa simple ....***M. viridula*** Roy, 2019

6. Left phallomere: paa margins smooth (Fig. 7H), afa unguiform (Fig. 7D) ....
....***M. panguanensis*** Schwarz, Ehrmann & Stiewe, 2020
− Left phallomere: paa margins irregular (Fig. 5B), afa blunt (Fig. 7C) ....***M. cristalino*** sp. nov.

Updated checklist of *Microphotina* sensu lato

Microphotina cristalino sp. nov. – Type locality in RPPN Cristalino, Mato Grosso, Brazil.

Microphotina panguanensis Schwarz, Ehrmann & Stiewe, 2020 – Type locality in Huánuco, Peru. The record of *Microphotina* sp. in Rivera (2010) from Madre de Dios (Peru) also corresponds to *M. panguanensis*.

Microphotina viridescens (Chopard, 1912) – Originally described under *Photina* Burmeister, 1838. Type locality in French Guiana, with additional records from that country in François & Roy (2015). It is sympatric to *M. vitripennis* in the northern part of the country.

Microphotina viridula Roy, 2019 – Type locality in the Mitaraka mountain range, southern French Guiana.

Microphotina vitripennis (Saussure, 1872) – Originally described under *Cardioptera* Burmeister, 1838. Type locality in French Guiana, with additional records from that country in François & Roy (2015). Presumably the most widespread member of *Microphotina*, also reported from Venezuela (Cerdá 1997) and Brazil (Terra 1995; Dantas *et al.* 2008). However, Venezuelan and Brazilian records require corroboration.

Natural history and distribution

Members of Microphotinini are seldom collected in reported surveys and remain rare in scientific collections (Rivera & Svenson 2020). For instance, Schwarz *et al.* (2020) found four specimens of *M. panguanensis* among over 430 praying mantis specimens collected at Panguana Field Station (Peru) in 50 years of prospection using multiple methods. Likewise, the multi-taxa expedition that revealed *M. viridula* in French Guiana employed at least seven trapping methods capable of capturing Mantodea, yielding only thirteen specimens of *Microphotina* out of 398 praying mantis specimens obtained (Touroult *et al.* 2018; Roy 2019). A canopy light trap survey in Manaus, Brazil (Dantas *et al.* 2008) yielded only seven specimens of (presumably) *M. vitripennis* out of 254 samples. Pooling together the results from these studies and our own work at RPPN Cristalino, *Microphotina* represented only 26 (1.98%) out of 1313 specimens. These figures reinforce the view that *Microphotina* is a rarely sampled taxon across its known distribution.

Because of their rarity in reported field surveys and collections, it has been difficult to determine habitat preference for any species of *Microphotina*. However, by piecing together data from the literature and our own field observations we are now in the position to provide some insights. The literature reported adult males of *M. vitripennis*, *M. viridescens*, *M. viridula*, and *M. panguanensis* coming to light traps all year round (Dantas *et al.* 2008; François & Roy 2015; Roy 2019; Schwarz *et al.* 2020). Females, on the contrary, have no flying capabilities (as is the rule for Photinaidae females) and rarely, if at all, are found at ground level (François & Roy 2015). The fact that males are attracted to light traps through the year, and the conspicuous absence of females, nymphs, and egg cases at ground level, strongly suggest that *Microphotina* spp. are multivoltine, canopy-dwelling praying mantises. These insects likely hunt among the upper-level foliage where they hide by pressing their body against the undersurface of leaves, a cryptic strategy also documented in other Photinaidae, such as the foliage-dwellers *Photina* Burmeister, 1838 and *Macromantis* Saussure, 1871 (Rivera & Svenson 2016; L.L., J.R. pers. obs.) and the stem-crawlers *Paraphotina* Giglio-Tos, 1915 and *Orthoderella* Giglio-Tos, 1897 (Brunner & Gandolfi 1990; L.L., J.R. pers. obs.). The finding of specimens of *Microphotina* among canopy fogging samples (Rivera & Svenson 2016) provides additional support to this hypothesis.

Microphotina was known to occur in the Northwestern regions of the Amazon rainforest throughout most of its taxonomic history. Recent contributions (Rivera 2010; Rivera & Svenson 2020; Schwarz *et al.* 2020) extended its range to western Amazonia. The presence of *M. cristalino* sp. nov. at the RPPN Cristalino considerably extends its distribution to the southern boundaries of the Amazon rainforest, specifically to the Cerrado-Amazônia ecotone region. Vertical distribution ranges from 7 to 310 m (with the highest elevation in Mitaraka, French Guiana). The Amazonian region where the RPPN Cristalino is located is also distinctive for its marked seasonality, with a dry season that is severe enough to affect forest composition and primary productivity (Zappi *et al.* 2011; Xu *et al.* 2015). The discovery of *Microphotina* in such conditions makes its presence in forest patches within neighboring xeric biomes, such as in the Cerrado, Chaco, and Caatinga, more likely. These biomes form ecotones with the Amazon rainforest and have a long and well-documented history of biotic connectivity and exchange (e.g., Costa 2003; Löwenberg-Neto & Carvalho 2009; Sobral-Souza *et al.* 2015; Marques *et al.* 2019; Fernandes *et al.* 2022). This finding makes the existence of *Microphotina* in the Atlantic Rainforest of Brazil also a possibility. Recent discoveries have revealed the presence of Amazonian taxa in the Atlantic Rainforest, such as *Vates* Burmeister, 1838 and *Macromantis* (Rivera *et al.* 2020; M. Scherrer, pers. comm.), suggesting hidden praying mantis diversity in this ecosystem. In summary, existing data suggest that *Microphotina* is likely to be found throughout the Amazon basin, mainly in non-flooded terra firme habitats. The genus may be more diverse than acknowledged.

Conservation of local praying mantis communities

Several natural reserves and conservation units within Mato Grosso constitute refugees for local biodiversity. These include the RPPN Cristalino, Parque Estadual Cristalino, Parque Nacional Juruena, and other RPPNs, in addition to lands managed by local indigenous communities. Together, these areas protect thousands of hectares and represent an important ecological corridor representative of the original fauna and flora of the region. However, the multiple threats that the Amazon rainforest currently faces, including historical records of deforestation, are pushing this biome closer to its "tipping point" (Imazon 2022; Lovejoy & Nobre 2018). The RPPN Cristalino is located within the "Arc of Deforestation", corresponding to the southernmost region of the Amazon where deforestation is rampant (Fearnside 2005). For instance, the rate of deforestation in Mato Grosso State has steadily increased in recent years, reaching record levels by 2021 (Imazon 2022). Likewise, the Cerrado-Amazônia ecotone has already lost over 40% of its original vegetation (Marques *et al.* 2019). Since the Amazon rainforest can take decades to regenerate (Elias *et al.* 2020), a seemingly canopy-dwelling species like *M. cristalino* sp. nov. has already effectively lost a significant part of its habitat in the state. In addition to habitat loss and population fragmentation, poaching represents an emergent conservation issue for praying mantises. These insects are part of the (legal and illegal) growing international market of exotic invertebrate pets (Battiston *et al.* 2022). Although Brazilian species are rarely commercialized, they remain vulnerable as deforestation creates new opportunities for poachers to access species from previously inaccessible areas, including natural reserves (Symes *et al.* 2018). Rare and novel species are attractive targets for wildlife traders (Lindenmayer & Scheele 2017) and praying mantises are no exception (Battiston *et al.* 2022). As the global demand for new-to-market species increases their value, data deficiencies prevent the assessment of the conservation status of virtually all Neotropical taxa, including *M. cristalino* sp. nov. This is the usual case for insects, most of which lack comprehensive accounts of their spatiotemporal distribution, relative abundance, as well as their ecological requirements, and degree of sensitivity to habitat disturbances (Cardoso *et al.* 2011), all essential data to inform conservation efforts.

Linking the charismatic praying mantises to Amazon conservation

Live insects are considered an important teaching tool for children and adults alike (e.g., Killermann 1998; Saul-Gershenz 2009). As in birdwatching, outdoor activities focused on insects help rise nature awareness among the public, fostering support for conservation efforts (Le *et al.* 2021). Praying mantises are insects whose mystifying charm has inspired a sense of awe through the ages (Prete & Wolfe 1992). Their anthropomorphic appearance, docility, and complex behaviors endow praying mantises with a unique charisma among insects, making them ideal flagship organisms to promote insect conservation (Barua *et al.* 2012; Greyvenstein *et al.* 2020). Our work in RPPN Cristalino exemplifies the role of praying mantises in such a context. This study is part of "Austral: Mantis da Amazônia", an expedition launched by Projeto Mantis (PM), an independent scientific organization whose research focus and scientific communication strategy revolves around these iconic insects. In partnership with Greenpeace Brasil, PM linked the expedition with an online outreach campaign focusing on Amazon conservation and praying mantis species discovery. Blog entries and publications on social media (e.g., Greenpeace Brasil 2021) linked praying mantis biodiversity research with nature-related topics, such as insect taxonomy and species discovery, the ecological importance of insects, ongoing threats to their populations, and conservation needs. These publications reached thousands of viewers, including at least 30 newly recruited donors who attributed their decision to contribute to Greenpeace conservation programs to the impact that the outreach campaign had on them. In addition, over 40 RPPN Cristalino visitors attended a series of short, on-site lectures delivered by the PM research team, followed by activities where attendees readily interacted with live praying mantises, including *M. cristalino* sp. nov., openly expressing admiration and a sense of wonder for these insects. Our experience at RPPN Cristalino, albeit anecdotic, goes on to show that recruiting praying mantises as flagship species may assist nature educators, scientists, and ecotourism managers in achieving their conservation goals (Greyvenstein

et al. 2020). We anticipate that the discovery of *M. cristalino* sp. nov. will spark further conservation initiatives at the RPPN Cristalino and continue enlightening individuals interested in appreciating and protecting tropical biodiversity.

Conclusions

The discovery of *M. cristalino* sp. nov. increased the number of species of this Amazonian genus by up to five. The discovery of this new species considerably expanded the known range of *Microphotina* to include the southernmost limits of the Amazon rainforest, specifically to the Cerrado-Amazônia ecotone. The collection of only two individuals of *M. cristalino* sp. nov. during the Austral expedition reinforces the importance of lengthy surveys in revealing elusive species. Keeping specimens alive under reasonable conditions during fieldwork proved an effective practice for gaining insights into their behavior and natural history. Although the monophyly of Microphotinini seems conclusive, additional taxonomic sampling is necessary to examine phylogenetic affinities within the tribe, with a particular focus on the non-monophyletic *Microphotina* (Rivera & Svenson 2016; Schwarz & Roy 2019). The circumscription of hidden diversity (Rivera & Svenson 2020; Moulin & Roy 2020), and the discovery and characterization of females of *Microphotina* spp. represent additional lines of inquiry necessary to improve our taxonomic understanding of this obscure lineage.

Considering all available information, we hypothesized that *Microphotina* represents a canopy-dwelling lineage of praying mantises. Canopy shelter a novel and rich biodiversity, but tropical forest canopies remain one of the least explored habitats on Earth (Lowman *et al.* 2013). Despite advances in canopy research (Lowman & Schowalter 2012), surveying methodologies applied to arthropods are limited and logistically challenging. For example, canopy fogging techniques, such as pyrethrum knockdown, results in considerable bycatch of non-target taxa, and have limitations in terms of deployment time and spatial coverage (Basset *et al.* 2003). Likewise, suspended canopy walkways, towers, or cranes, provide a glimpse into canopy biodiversity, yet they are spatially limited and costly to install and upkeep (Lowman & Bouricius 1995; Basset *et al.* 2003). Nevertheless, those areas where such infrastructure is available could represent good prospects for launching surveys aiming to explore little-known praying mantis communities at the canopy level. Developing new methodologies to facilitate access to such habitats and enable their effective and sustained sampling is a challenge that needs to be undertaken to better understand praying mantis diversity in the Amazon rainforest.

The Amazon rainforest is home to a sizable proportion (~50%) of Brazilian Mantodea species (Ehrmann 2002; Agudelo *et al.* 2007; Rivera & Svenson 2020). However, this region remains poorly sampled for praying mantises. Most distributional records are restricted to areas around large settlements or along main riverbeds. The southern limits of the Amazon rainforest and the Cerrado-Amazônia ecotone represent a notable gap. Increased sampling efforts along this rich yet highly disturbed region will likely reveal a novel praying mantis fauna. Our experience at RPPN Cristalino showed that conservation initiatives may benefit from integrating praying mantis species discovery into nature outreach campaigns, helping to raise awareness of the importance of the Amazon biodiversity. Studies assessing the impact of praying mantises on people's attitudes toward nature could provide further insights on how to harness their charisma to encourage nature appreciation and support of conservation actions by the public.

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