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(Phasmida: Phylliidae) from Yap Island, Micronesia,
representing a range expansion for the family

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A new species of *Phyllium* (*Phyllium*) Illiger (Phasmida: Phylliidae) from Yap Island, Micronesia, representing a range expansion for the family

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Abstract. A new species of leaf insect from the celebicum species group, *Phyllium* (*Phyllium*) *yapicum* Cumming and Teemsma, **new species** (Phasmida: Phylliidae), is described from a female specimen from the California Academy of Sciences collection, United States. This new species is the first recorded species of Phylliidae from the country of Micronesia and represents a notable range expansion for the family. With *Phyllium* (*Phyllium*) *yapicum* Cumming and Teemsma, **new species**, currently only known from a female holotype; a key to females is included for the celebicum species group.

Key words. Taxonomy, walking leaf.

Introduction

The current known range of the Phylliidae (Fig. 1) reaches from the Seychelles Islands to the west (Audinet-Serville 1838), Tibet to the north (Liu 1993), New Caledonia to the south (Sharp 1898), and Fiji to the east (Blanchard 1853). *Phyllium* (*Phyllium*) *yapicum* Cumming and Teemsma **n. sp.** is here described from Yap Island, Micronesia, which places this new species over 1,000 kilometers outside of the currently known family range [based on distance from Yap Island to the closest regions with known phylliid species occurring: Manokwari, Irian Jaya, Indonesia (1,230 km); Morotai, Indonesia (1,340 km); and Davao, Mindanao, Philippines (1,400 km) (approximate distances found using www.timeanddate.com)].

Many new species of Phylliidae in the last few decades have been species identified from previously known populations that were erroneously identified as *Phyllium* (*Phyllium*) *siccifolium* (Linnaeus 1758) or other historic species. For example, *Phyllium* (*Phyllium*) *monteithi* Brock and Hasenpusch (2003) from eastern Australia and *Phyllium* (*Phyllium*) *hausleithneri* Brock (1999) from Peninsular Malaysia, have both for several decades been erroneously identified as *Phyllium* (*Ph.*) *siccifolium*. This new record from the country of Micronesia is notable as it is the first record of a specimen for the family Phylliidae within the country, and it is the first record of Phylliidae outside the well-established range which has had little expansion in several decades.

Phyllium (*Phyllium*) *yapicum* Cumming and Teemsma **n. sp.**, with a broad thorax and parallel sided abdomen, appears to be most morphologically similar to *Phyllium* (*Phyllium*) *ericoriai* Hennemann et al. (2009), *Phyllium* (*Phyllium*) *bonifacioi* Lit and Eusebio (2014), and *Phyllium* (*Phyllium*) *tibetense* Liu (1993). Geographically, of these three species, *Phyllium* (*Ph.*) *ericoriai*, and *Phyllium* (*Ph.*) *bonifacioi*, logically fit as the closest relations, because these two species are native to the Philippines, the island nation to the west of Micronesia.

Within the celebicum species group, there are currently eleven recognized species with three of those named in the last decade alone: *Phyllium* (*Ph.*) *ericoriai*, *Phyllium* (*Ph.*) *bonifacioi*, and *Phyllium* (*Phyllium*) *chrisangi* Seow-Choen (2017). *Phyllium* (*Phyllium*) *yapicum* Cumming and Teemsma **n. sp.** marks the twelfth species from this steadily expanding group.

Materials and Methods

Measurements of the holotype were made to the nearest 0.1 mm using digital calipers. Photos of the holotype were taken in the California Academy of Natural Sciences using Visionary Digital Big Kahuna setup (Dun, Inc.) with a Canon 5d Mark 3 Canon f2.5, 50mm macro lens with studio flash lighting. Post processing was done in Lightroom CC and Photoshop CC. Images were focus stacked with Zerene Stacker.

The holotype *Phyllium (Phyllium) yapicum* Cumming and Teemsma **n. sp.** is retained within the California Academy of Natural Sciences type collection under CASTYPE #19438. The authors over the years have examined Phylliidae specimens from many of the largest natural history collections and have yet to find additional specimens from Micronesia to add as paratype material for this new species. Additionally, a search through the California Academy of Sciences collection records by the curator did not reveal additional information regarding the collector or if additional Micronesian material was recovered from this trip and deposited in additional collections. As with many species of Phylliidae this new species must be described from the single unique holotype.

Phyllium (Phyllium) yapicum Cumming and Teemsma, new species

(Fig. 2A–C, 3A–C, 4A–C)

Holotype. Female: FEDERATED STATES OF MICRONESIA, Yap Island, Kaday: XI-10-1980 (M. R. Lundgren, Collector): Deposited in the California Academy of Natural Sciences type collection, red type label: CASTYPE #19438.

Differentiation. The exterior lobe of the profemora is wider than the interior lobe and with developed alae, *Phyllium (Phyllium) yapicum n. sp.* is placed within the celebicum species group, as described by Hennemann et al. 2009. *Phyllium (Ph.) yapicum n. sp.* appears most similar in its morphology to *Phyllium (Ph.) ericoriai*, *Phyllium (Ph.) bonifacioi*, and *Phyllium (Ph.) tibetense* because of the form of the thorax and the broad boxy shape of the abdomen. From all three species *Phyllium (Ph.) yapicum n. sp.* can be differentiated by the unique interior lobe of the protibiae which is mostly situated in the proximal half; the distal half is reduced to a slender sliver of a lobe (Fig. 4A).

Phyllium (Ph.) yapicum n. sp. can further be differentiated from these species by several additional features. It can be differentiated from *Phyllium (Ph.) tibetense* by the lack of lobes on the exterior pro- and metatibiae, since *Phyllium (Ph.) tibetense* has clear but small exterior lobes on all tibiae. This is one of the few features that differentiate the two species as both species share many similar morphological characteristics such as mesopleurae that are prominently marked with tubercles (Fig. 4B), an exterior lobe of the profemora with notable serration (Fig. 3C), and an abdomen shape that is identical. The distant distribution of these two species, SW-China (Tibet) for *Phyllium (Ph.) tibetense* and Micronesia for *Phyllium (Ph.) yapicum n. sp.*, seems unlikely that they are of the closest relation despite their numerous morphological similarities.

A more likely relation to *Phyllium (Ph.) yapicum n. sp.* would be the two celebicum species group members from the Philippines, *Phyllium (Ph.) ericoriai* and *Phyllium (Ph.) bonifacioi*. Both of these species have rather boxy abdominal shapes similar to that of *Phyllium (Ph.) yapicum n. sp.*, and they possess a thorax with mesopleurae that distinctly diverge throughout the entire length. From both species, *Phyllium (Ph.) yapicum n. sp.* can be differentiated by the exterior lobe of the profemora with distinct serration (Fig. 3C) while *Phyllium (Ph.) ericoriai* and *Phyllium (Ph.) bonifacioi* have smooth exterior lobes, and also by the mesopleurae with prominent tubercles (Fig. 4B), as *Phyllium (Ph.) ericoriai* and *Phyllium (Ph.) bonifacioi* have mesopleurae with finer serration and lack of prominent tubercles.

Unfortunately, only the female is known for *Phyllium (Ph.) yapicum n. sp.* lending an incomplete look into its likely relation. If the eggs and male morphology were known, it is likely a clearer position within the celebicum species group could be inferred. Eggs from both *Phyllium (Ph.) ericoriai* and *Phyllium (Ph.) bonifacioi* possess a rather unique morphology when compared to other phylliids. Therefore, it would have been ideal to compare eggs of *Phyllium (Ph.) yapicum n. sp.* to these and other phylliids. However, due to the poor condition of the holotype, coupled with the thin appearance of the abdomen, it does not appear to have lived long enough as an adult to develop many, if any, eggs. Thus, the authors refrained from attempting to remove eggs from the abdomen for examination. With males of

Phyllium (*Ph.*) *ericoriai* and *Phyllium* (*Ph.*) *bonifacioi* having rather different morphologies, *Phyllium* (*Ph.*) *ericoriai* with a boxy abdomen and *Phyllium* (*Ph.*) *bonifacioi* with a rounded abdomen, it will be interesting to discover the male morphological structure of *Phyllium* (*Ph.*) *yapicum* n. sp. to see if it resembles either species.

Coloration. Overall coloration a pale yellow mixed with light brown, darker brown along the midline, thorax, and head likely from rot or being initially preserved in alcohol. Like other members of the family Phylliidae, it is assumed to be a vibrant green in life.

Morphology. Head capsule slightly longer than wide, the vertex is irregular with small nodes throughout and a slight sagittal furrow on the anterior half of the vertex. Posteromedial tubercle with a single point, no notable setae on or around the posteromedial tubercle. Frontal convexity broad at first but then quickly tapering to a rounded point and slightly bending upward at the apex, sparsely covered in thin transparent setae. Antennal fields similar in size to the compound eyes, not significantly broad. Antennal fields with the interior margin flush to the base of the scapus, lateral margin slightly wider than base of scapus. Frontal suture between antennal fields, small but distinct. Antennae consisting of nine segments, segments I–VII with few, sparsely spaced setae. Segments VIII and IX with dense, pale setae. Segment IV somewhat compressed when compared to the other terminal segments, similar in height to the pedicellus. Pars stridens on segment III with 36–40 fine teeth. Compound eyes moderately sized and slightly protruding away from the head capsule. Pronotum with an anterior margin that is slightly concave with a relatively smooth but distinct rim. Lateral margins of pronotum slightly diverge on the anterior third followed by straight converging margins to the posterior rim. Posterior rim slightly convex with a weak rim, width slightly more than half of the anterior rim width. Pronotum lateral and posterior with moderate rims which are marked by unevenly sized and spaced nodes. Face of the pronotum is marked by a distinct pit near the center and a slightly larger pit near the anterior rim along the sagittal plane, the remainder of the pronotum face is slightly textured with slight granulation. Prosternum is uniformly granulous, with nodes of even size and slightly uneven spacing. Meso- and metasternum heavily marked throughout with randomly spaced granules. Granulation of the metasternum continues onto abdominal sternite II which is fully covered in granulation, and partially onto sternites III and IV. Mesopraescutum anterior margin approximately as wide as long and lateral margins converge to a slightly narrower posterior. Anterior rim prominent and covered with irregularly granulose nodes in addition to two notable nodes at the apex. Lateral margins of the mesopraescutum with five to six major tubercles of uneven size, and three to four additional small nodes mixed throughout. Mesopraescutum surface irregularly granulose with those along the sagittal plane slightly more prominent and more densely packed. Mesopleurae starting at the anterior margin, uniformly diverging towards the posterior. Mesopleurae lateral margin with five major tubercles and five to six minor tubercles, which can be directly adjacent to, or evenly spaced between major tubercles. Face of the mesopleurae with a prominent pit on the anterior quarter, and a slight pit near the center of the mesopleurae, the remainder of the surface is slightly lumpy and marked with several small granules. Tegmina extending approximately half-way through abdominal segment VII. Alae moderately developed, extending into abdominal segment III. Abdominal segments II through the anterior half of IV uniformly diverging, posterior half of IV through the anterior two thirds of abdominal segment VII subparallel. The posterior one third of VII through the anal abdominal segment converge to a rounded apex. Subgenital plate stout, only slightly projecting under the anal abdominal segment and ending in a broad point (Fig. 3A). Cerci only slightly cupped and with a lumpy irregular surface. Gonapophyses long and slender reaching the apex of the anal abdominal segment (Fig. 3A). Profemora exterior lobe broad with an obtuse angle, wider than interior lobe. Profemora exterior lobe anterior half marked with four to five small serrate teeth pointing anteriorly. Profemora interior lobe posterior half smooth except for a small well-defined tooth on the anterior fifth. Anterior half with five large prominent looping teeth evenly spaced (Fig. 3C). Mesofemora and mesotibiae absent from holotype. Exterior lobe of metafemora thin and lacking teeth, relatively straight and hugging the shaft of the metafemora. Interior lobe of the metafemora with seven serrate teeth on the distal half. Protibiae lacking exterior lobe, interior lobe only on the proximal two thirds, in the shape of a scalene triangle. Metatibiae simple, lacking lobes.

Measurements of holotype [mm]. Length of body (including cerci and head, excluding antennae) 73.4, length/greatest width of head 6.3/5.9, pronotum 4.7, mesonotum 6.9, length of tegmina 44.5, alae length approximately 12.0-13.0 (accurate measurement unavailable due to tegmina obscuring view), greatest width of abdomen 28.9, profemora 17.9, mesofemora missing from specimen, metafemora 17.2, protibiae 12.1, mesotibiae missing from specimen, metatibiae 13.2, antennae 3.9.

Distribution. Currently only known from the type locality, Kaday, Yap Island, Micronesia. With the Phylliidae being such cryptic insects, it is not surprising that they have gone overlooked on this small island nation. It would be interesting to know if this species or congeners also occur on the other nearby islands. The country of The Republic of Palau, with larger islands than Yap Island, and with a closer proximity to other phylliid rich areas, may eventually reveal additional species. Even the island of Guam could be a possibility since it is situated to the northeast of Yap Island. It is hoped further examination of material collected from Micronesia and nearby islands will reveal the geographic distribution with more clarity.

Etymology. This species is named for the type locality: Yap Island, Micronesia. As a significant range expansion for the family, it is fitting to use an adjectival name for this notable occasion.

Key to females of known species of the celebicum species group

Adapted from the Hennemann et al. (2009) key. Distributional data cited in this key obtained from Hennemann et al. (2009), Cumming et al. (2017), Thanasinchayakul (2006), and Seow-Choen (2017).

Females of *Ph. (Ph.) parum* Liu, 1993 and *Ph. (Ph.) yunnanense* Liu, 1993 are currently unknown.

Morphologically the holotype of *Ph. (Ph.) rayongii* Thanasinchayakul, 2006 is indistinguishable from *Ph. (Ph.) westwoodii* Wood-Mason, 1875 and therefore cannot be separated in a dichotomous key. The authors question the validity of *Ph. (Ph.) rayongii* and suspect it is simply a synonym of *Ph. (Ph.) westwoodii* based on the following reasoning. *Phyllium (Ph.) westwoodii* is a morphologically variable species, especially in regards to abdominal shape, and from examination of photos of the holotype *Ph. (Ph.) rayongii* (Brock et al. 2018), the specimen clearly falls within the intraspecific variation of *Ph. (Ph.) westwoodii* discussed at length by Hennemann et al. (2009). Thanasinchayakul (2006) based their morphological key and most of their discussion on species solely on abdominal shape, not on other stable diagnostic features with more differentiation ability. such as the profemora, thorax, or antennae. We expect that if Thanasinchayakul (2006) examined these stable features in a series of specimens, they would likely have not described *Ph. (Ph.) rayongii* as a separate species.

1. Metatibia with exterior lobe. **2**
- Metatibia without exterior lobe **3**
- 2(1). Small species (body length < 80mm); abdominal segment VII gradually narrowing; exterior lobes of meso- and metatibiae distinct, expanding over almost entire length of tibia; Sri Lanka ***Ph. (Ph.) athanyus* Westwood, 1859**
- Large species (body length 106.5mm); abdominal segment VII roundly angulate; all tibiae with a small, rounded lobe near apex of tibia; SW-China (Tibet) . ***Ph. (Ph.) tibetense* Liu, 1993**
- 3(1). Mesopleurae distinctly diverging throughout the entire length **4**
- Mesopleurae narrow for the anterior one third to one half, then remainder prominently diverging **7**
- 4(3). Abdominal segment VI with parallel or slightly subparallel lateral margins giving the abdomen a boxy appearance **5**
- Abdominal segment VI with converging lateral margins giving the abdomen a spade shaped appearance; S. China (Guangxi Prov.) ***Ph. (Ph.) rarum* Liu, 1993**
- 5(4). Protibiae interior lobe reaching end to end in a smooth triangle that is evenly distributed on the distal and proximal ends or only slightly shifted towards the distal end **6**
- Protibiae interior lobe unevenly distributed, almost entirely on the proximal half, with the distal half greatly reduced; Micronesia, Yap Is. ***Ph. (Ph.) yapicum* Cumming and Teemsma n. sp.**

- 6(5). Abdominal segment VII lateral margin with distinct lobe; angle of profemora exterior lobe approximately 90 degrees; Philippines (Luzon Is., Batan Is., Marinduque Is., Catanduanes Is.) *Ph. (Ph.) ericoriai* Hennemann et al., 2009
- Abdominal segment VII lateral margin with indistinct lobe and converging posteriorly; angle of profemora exterior lobe obtuse; Philippines (Northern Luzon Is.) *Ph. (Ph.) bonifacioi* Lit and Eusebio, 2014
- 7(3). Angle of exterior lobe of profemora > 90°, angle rounded 8
- Exterior lobe of profemora acutely angled (< 90°), angle distinct; Indonesia (Sulawesi) *Ph. (Ph.) celebicum* de Haan, 1842
- 8(7). Alae about half of the length of the tegmina; Singapore *Ph. (Ph.) chrisangi* Seow-Choen, 2017
- Alae greater than two thirds the length of tegmina; Andamans, Myanmar, Thailand, Laos, Kamputchea, Vietnam and S-China *Ph. (Ph.) westwoodii* Wood-Mason 1875/
Thailand: *Ph. (Ph.) rayongii* Thanasinchayakul, 2006

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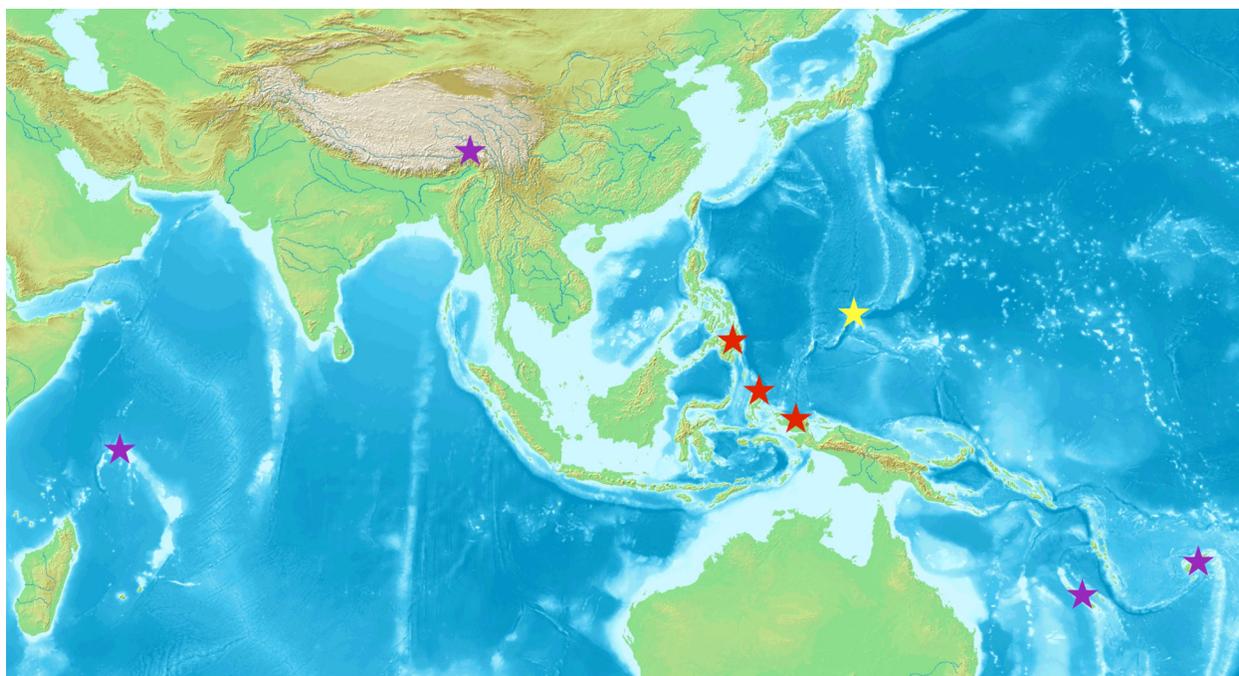


Figure 1. Historic range extremes for the Phylliidae (purple), the notable range expansion marked by *Phyllium* (*Phyllium*) *yapicum* new species (yellow), and the other Phylliidae rich areas nearest to Yap Island, Micronesia (red). Adapted from public domain map retrieved from https://commons.wikimedia.org/wiki/File:WorldMap-A_non-Frame.png.

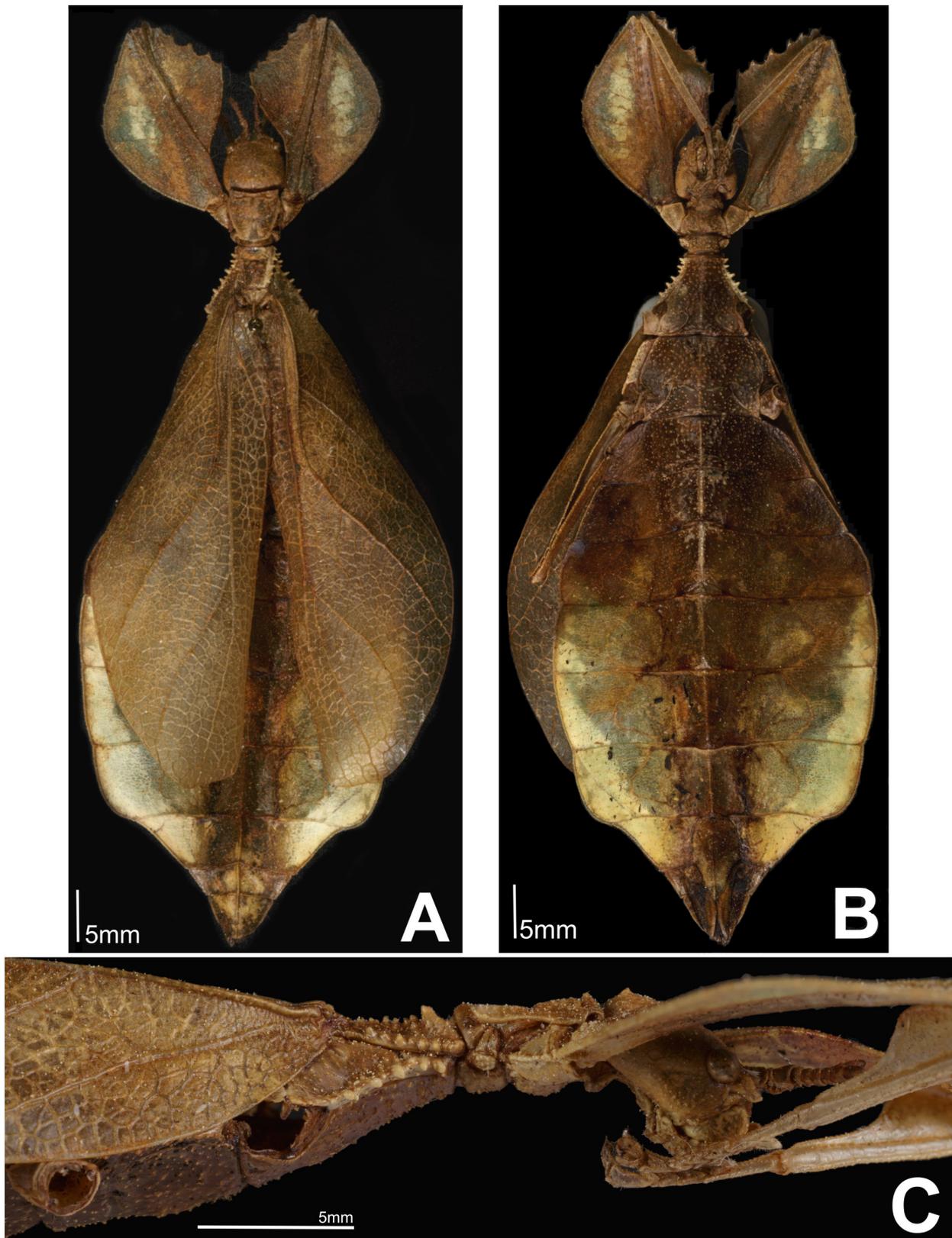


Figure 2. Holotype of *Phyllium (Phyllium) yapicum* new species. A) Dorsal view. B) Ventral view. C) Thorax side view.

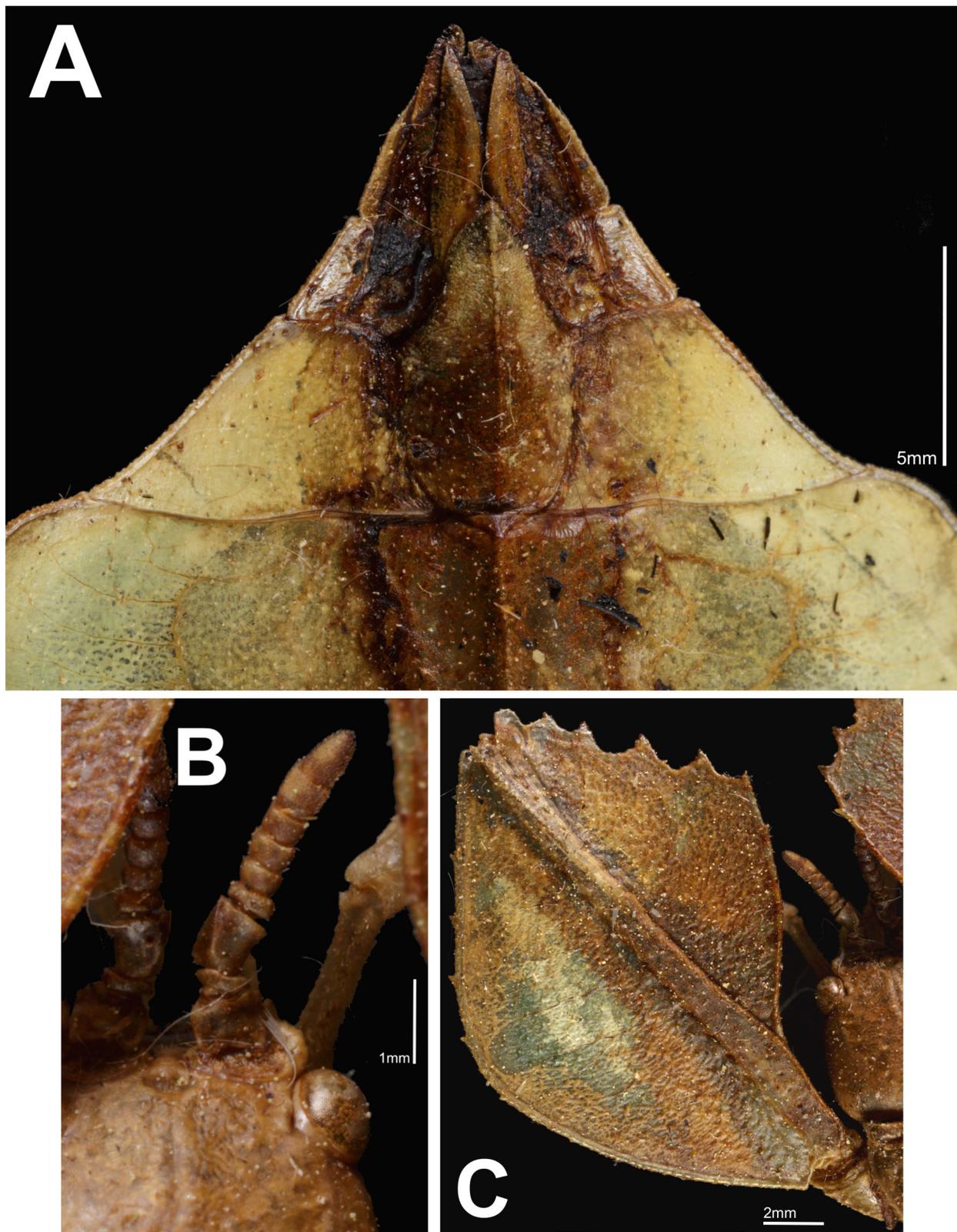


Figure 3. Holotype of *Phyllium (Phyllium) yapicum* new species. **A)** Genitalia, ventral view. **B)** Antennae and anterior half of head. **C)** Left profemora.

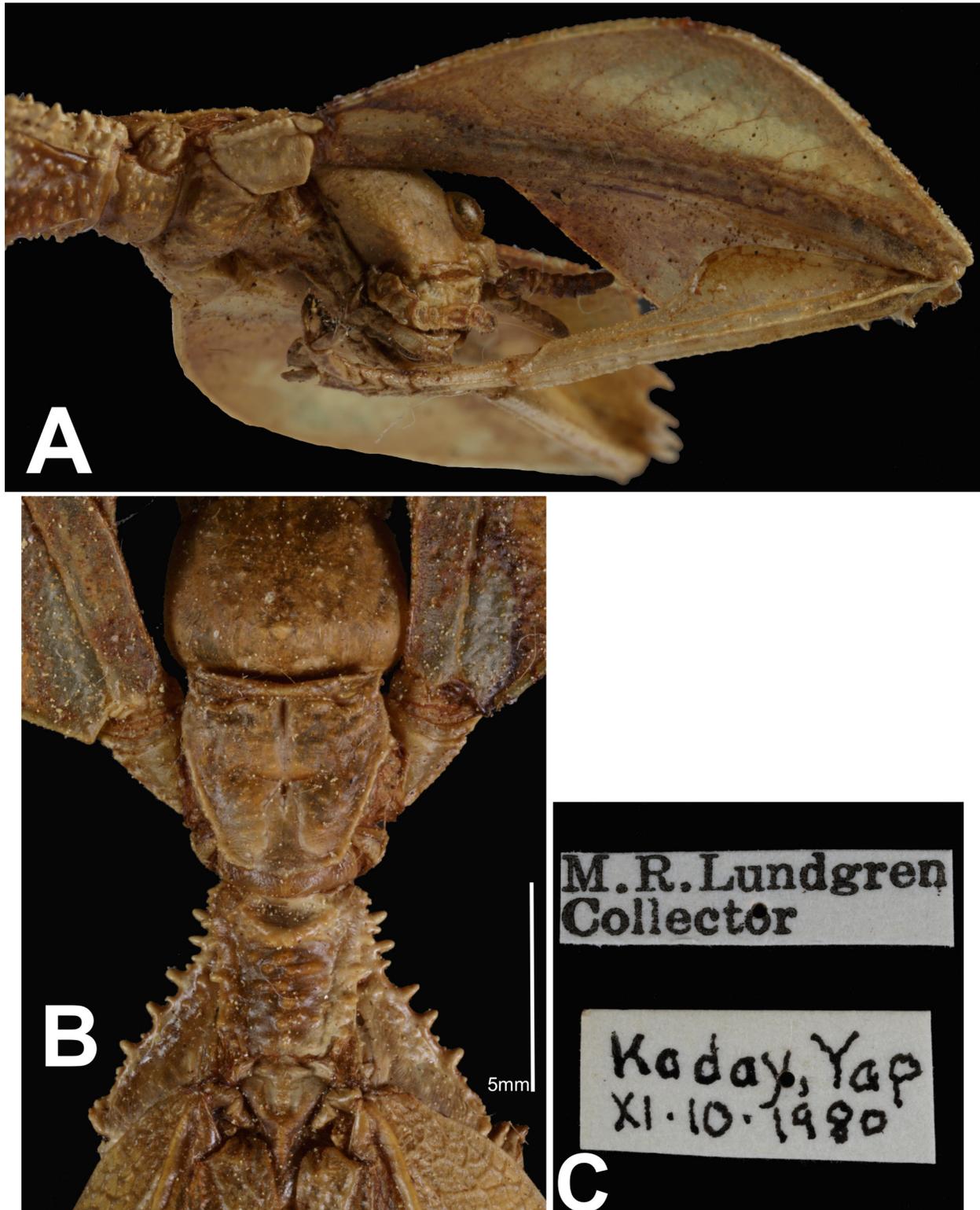


Figure 4. *Phyllium* (*Phyllium*) *yapicum* new species. A) Right protibia, lateral view. B) Dorsal close-up of base of head and thorax. C) Collection label.

