Contributions to Entomology 75 (2) 2025, 355–360 | DOI 10.3897/contrib.entomol.75.e170564

CONTRIBUTIONS TO ENTOMOLOGY

SENCKENBERG

Research Article

Lophotettix verhaaghi (Orthoptera, Tetrigidae), a new species of pygmy grasshoppers from Peru with a 3D scan of the holotype

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https://zoobank.org/B42AA83D-728E-44BF-AE74-351B1C951C49

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Academic editor: Lara-Sophie Dey | Received 30 August 2025 | Accepted 3 November 2025 | Published 2 December 2025

Abstract

The genus *Lophotettix* Hancock, 1909 belongs to a small subfamily of Tetrigidae, Lophotettiginae Hancock, 1909. To date, it included six species that are rarely observed and lack reliable distribution data. In this paper, we describe a new species, *L. verhaaghi* **sp. nov.**, from Peru and provide a digital 3D model of its holotype. The new species resembles *L. alticristatus* but has rounded lateral lobes and fewer projections on the anterior margin of the pronotal crest. The distribution patterns of Lophotettiginae across multiple zones of endemism in the Amazonian region are discussed.

Key Words

Amazonian region, Lophotettiginae, Neotropics, pygmy hoppers, taxonomy

Introduction

The subfamily Lophotettiginae Hancock, 1909, is endemic to the Neotropical region and includes some of the rarest and most poorly known members of Tetrigidae (Kasalo et al. 2022; Itrac-Bruneau and Doucet 2023). It comprises only two genera, *Phelene* Bolívar, 1906, and *Lophotettix* Hancock, 1909, the latter being known from extremely few specimens (Itrac-Bruneau and Doucet 2023). Since the review of the genus *Lophotettix* (Silva et al. 2019a; Kasalo et al. 2022), a sixth species was added to the genus based on a couple of specimens from Costa Rica (Kasalo et al. 2025). Here, we describe yet another new species belonging to *Lophotettix*, *Lophotettix verhaaghi* sp. nov., from Peru.

In a previous paper, we described *Phelene reinschmidti* from Ecuador, and in that paper, we also provided a 3D model of its holotype to increase the availability of key taxonomic data (Kasalo et al. 2024). Currently, basic photographs of insect-type specimens—some of which were described centuries ago (Mertens et al. 2017; Ströbel et al. 2018)—are often still lacking, which drastically reduces the ability of taxonomists to revise taxa. These limitations are even more prevalent in the case of rarely observed and collected species, such as those belonging to the genus *Lophotettix*. Consequently, in this paper we provide a 3D model of the holotype of *L. verhaaghi* sp. nov. based on synchrotron X-ray microtomography, making it the second tetrigid species for which such data are available.

Materials and methods

Taxonomy, nomenclature, and measurements

The holotype of the new species was loaned from the Zoologische Staatssammlung München (ZSM) and will be deposited at the Museo de Historia Natural (UNMSM) in Lima, Peru. The transfer of type material to UNMSM is in accordance with the terms defined in the collection permit used to obtain the material (see Acknowledgments).

The taxonomy follows Cigliano et al. (2025). Morphological terminology follows Tumbrinck (2014). Measurements follow Tumbrinck (2014), Storozhenko and Pushkar (2015), and Subedi and Kasalo (2023). Nomenclature is in accordance with the International Code of Zoological Nomenclature (ICZN 1999). Photographs of the type specimen were taken by one of the co-authors (MV) at SMNK using a Canon EOS R5 with either a Canon EF 100 mm f/2.8L MACRO IS USM for the dorsal, ventral, and lateral images or a Laowa 25 mm f/2.8 Ultra Macro 2.5–5X for images of smaller details. Stacked imaging was performed using a WeMacro rail. Images were then stacked using Helicon Focus.

The following measurements were made and are labeled in the text as indicated: body length—**BL**; vertex width—**VW**; eye width—**EW**; scutellum width—**SW**; pronotum length—**PL**; pronotum lobe width—**PLW**; pronotum height—**PH**; tegmen length—**TL**; tegmen width—**TW**; alae length—**AL**; fore femur length—**FFL**; fore femur width—**FFW**; mid femur length—**MFL**; mid femur width—**MFW**; post femur length—**PFL**; post femur width—**PFW**; hind tibia length—**HTL**; first tarsal segment (basal) length—**FTL**; third tarsal segment (apical) length (without claws)—**TTL**; subgenital plate length—**SPL**; ovipositor dorsal valve length—**ODL**; ovipositor ventral valve length—**OVL**. The measurements were made using ImageJ 1.53t software.

Synchrotron X-ray microtomography

The female holotype of *L. verhaaghi* sp. nov. was scanned in four height steps at the high-throughput tomography station of the Imaging Cluster of the KIT Light Source of Karlsruhe Institute of Technology (KIT), using a beam diffracted by a double multilayer monochromator (DMM). The measurements were performed at a magnetic field of the wiggler of 2.7 T, resulting in a flux density at 16 keV with an energy bandwidth of 2%. To reduce the heat load on the DMM, the beam was prefiltered with 3 mm of pyrolytic graphite. We employed an air-bearing rotary stage (RT150S, LAB Motion Systems) for sample rotation and a fast indirect detector system consisting of a 200 µm LuAG scintillator, a double-objective white-beam microscope (Optique Peter; Douissard et al. 2012), and a 12-bit pco.dimax high-speed camera (Excelitas PCO GmbH) with 2016 × 2016 pixels and a physical size of 11 µm. A magnification of 2× resulted in an effective pixel size of 6.11 µm. For each scan, we acquired 200 dark-field images, 100 flat-field images, and 3,000 equiangularly spaced radiographic projections in a range of 180° at 150 frames per second. The control system Concert (Vogelgesang et al. 2016) was used for automated data acquisition and online reconstruction of the tomographic slices for data quality assurance. The 3D tomographic reconstruction was performed with Tofu (Faragó et al. 2022) and included ring removal and 8-bit conversion.

Post-processing of tomographic data

The individual tomographic volumes were registered and merged in Amira 2022.2, which was also used for presegmentation. The presegmented labels served as input for semi-automatic segmentation with Biomedisa (Lösel et al. 2020). The Biomedisa result was imported back into Amira. Minor errors and artifacts caused by the strong X-ray absorption of the pin were corrected manually. The pin itself was digitally removed, and the holes were filled. The final label field was converted into a polygon mesh and exported as an OBJ file. CINEMA 4D R20 was employed for smoothing of the surface and for polygon reduction. The polygon-reduced model was then imported into Deep Exploration, converted into the U3D format, and integrated into a 3D PDF document.

Results

Taxonomy

Family Tetrigidae Rambur, 1838
Subfamily Lophotettiginae Hancock, 1909

Genus *Lophotettix* Hancock, 1909

References. *Lophotettix* Hancock, 1909: 388 (original description of the genus); Hancock 1914: 328 (revision); Günther 1938: 306 (catalogue); Yin et al. 1996: 880 (catalogue); Cadena-Castañeda & Cardona Granda 2015: 452 (catalogue); Silva et al. 2019a: 348 (revision); Kasalo et al. 2022: 225 (revision); Kasalo et al. 2023: 45 (catalogue); Itrac-Bruneau and Doucet 2023: 626 (new records from French Guiana); Kasalo et al. 2025: 11 (new species, DNA barcoding).

Diagnosis. Head wide with wide scutellum. Antennae composed of around 11 antennomeres. Antennomeres flattened. Median carina of pronotum forming a crest. Femora with teeth and lappets. The genus and its species are reviewed in detail in Kasalo et al. (2022).

Type species. *Lophotettix* (*Lophotettix*) *brevicristatus* Hancock, 1909.

Composition. 7 species, including the herein-described one.

Distribution. Central and South America.

Subgenus *Corticotettix* Kasalo & Skejo, 2022

Diagnosis. Crest (Fig. 1D) longer than half the length of the pronotum. Crest rectangle-like or resembles a forward-facing fin.

Type species. *Lophotettix* (*Corticotettix*) *unicristatus* Hancock, 1909

Composition. *L.* (*C.*) *unicristatus*, *L.* (*C.*) *hancocki*, *L.* (*C.*) *alticristatus*, *L.* (*C.*) *verhaaghi* sp. nov.

Distribution. South America.

***Lophotettix* (*Corticotettix*) *verhaaghi* Kasalo, Skejo & Husemann, sp. nov.**

https://zoobank.org/A46AB4BC-3393-40DE-BEBF-7BDCBEDD930C

Description (Fig. 1). Macropronotal.

Head. In anterior view, top of vertex a little below upper margin of eyes. Vertex more than two eyes wide. Frontal costa bifurcation in lower third of eye height. Facial carinae forming long rectangular shape. Paired ocelli at lower margin of eyes. Antennal grooves below level of bottom margin of eyes. Antennae composed of 10 visible segments; all segments flattened, with the distal ones being extremely so; last segment white. In dorsal view, vertex of isosceles trapezoidal shape. Medial carina barely visible in anterior third of vertex. Lateral carinae of vertex in form of small tubercles.

Pronotum. Prozonal carinae as long as eye as seen in dorsal view, strongly convergent caudad. Median carina visible throughout length of pronotum, forming long, tall, jagged, vaguely rectangular crest in lateral view (extending from anterior margin of pronotum to level of hind knees). Crest strongly undulated in dorsal view. Anterior margin of crest with two distinct protrusions (excluding the one at the corner of anterior and dorsal margin). Pronotal surface covered in small tubercles and carinulae. Humeral angles wide and blunt. Lateral lobes rectangular with rounded edges, projected laterally.

Wings. Tegmina large and oval. Alae reaching pronotal apex; dark brown to black with orange venation.

Legs. Anterior femora expanded in the proximal half. Middle femora wholly expanded, with a shallow indentation in middle of dorsal margin and small tubercle in middle of ventral margin. Anterior and middle tibiae a little expanded in middle. Anterior and middle tarsi with long first segment and extremely long second segment. Hind femur robust, with three tubercles on dorsal margin; long and sharp antegenicular tooth, genicular tooth moderately sized and smooth. Hind tibia thin, serrated along caudal margin. Hind tarsus long; first segment extremely long, with two small sharp proximal pulvilli and longer distal pulvillus; pulvilli clearly separated from each other; third segment approximately equally long as first.

Terminalia. Ovipositor elongated, serrated.

Diagnosis. Crest extending from anterior part of prozona to the level of the hind knee; forming three distinct peaks, diminishing in size, one above head, one above tegmen, and one past hind femur insertion point. Edge of crest jagged. Anterior margin of crest with two distinct protrusions (excluding the one at the corner of anterior and dorsal margins). Crest strongly undulated in dorsal view. Apex of lateral lobes weakly bilobated with rounded edges.

Comparative diagnosis. Distinct from *L.* (*C.*) *unicristatus* and *L.* (*C.*) *hancocki* by distinctly rounded edges of apex of lateral lobes of the pronotum (sharp in the former two species) and straight anterior margin of the crest (concave in former two). Most similar to *L.* (*C.*) *alticristatus*, but differentiated by distinctly rounded edges of apex of lateral lobes (sharp in *L.* (*C.*) *alticristatus*), anterior margin of crest with two distinct protrusions, excluding the one at the corner of anterior and dorsal margin (three distinct protrusions in *L.* (*C.*) *alticristatus*, with the additional one residing near the base of pronotum), and middle protrusion on the anterior margin of crest shaped like a simple spine (composed of two tubercles in *L.* (*C.*) *alticristatus*). The illustration of characters used to differentiate *L.* (*C.*) *verhaaghi* sp. nov. and *L.* (*C.*) *alticristatus* is provided in Fig. 2.

Type series. Peru • 1 ♀ holotype; Panguana, Dept. Huanuco, Rio Llullapichis; -9.616667, -74.933333; 20.XI-7.XII.2008; E. Diller leg; UNMSM.

Type locality. Panguana, Dept. Huanuco, Rio Llullapichis.

Measurements. BL 10,8; VW 1,4; EW 0,58; SW 0,28; PL 14,7; PLW 4,07; PH 6,25; TL 1,94; TW 0,75; AL 12,22; FFL 2,46; FFW 0,61; MFL 2,81; MFW 0.95; PFL 5,8; PFW 2,3; HTL 5,05; FTL 1,04; TTL 0,97; SPL 0,9; ODL 1,51; OVL 1,56

Distribution. Peru, potentially present across the western margin of the Amazonian region.

Etymology. The specific epithet is the Latinized genitive of the surname Verhaagh. The species is named in dedication to Dr. Manfred Verhaagh (SMNK, Karlsruhe, Germany) for his lifelong work on insects, specifically also Peruvian ants, and his strong interest in communicating science to the public.

Notes. We 3D scanned the holotype of this species, and the model is available in the RADAR4KIT repository at https://dx.doi.org/10.35097/q6vpw436jjshv9aj. For a discussion on the utility of 3D scans in Tetrigidae taxonomy, see Kasalo et al. (2024).

Discussion

Specimens of the genus *Lophotettix* are recorded extremely rarely and are uncommon even in museum collections (Itrac-Bruneau and Doucet 2023), which makes them difficult to study. A good example is *L. alticristatus*, which was described from Brazil without a specified type locality (Hancock 1909). Much later, a few specimens were found in Ecuador and identified as *L. alticristatus* in the literature (Kasalo et al. 2022) and on iNaturalist (2025) (observations 65896183 and 111218133).

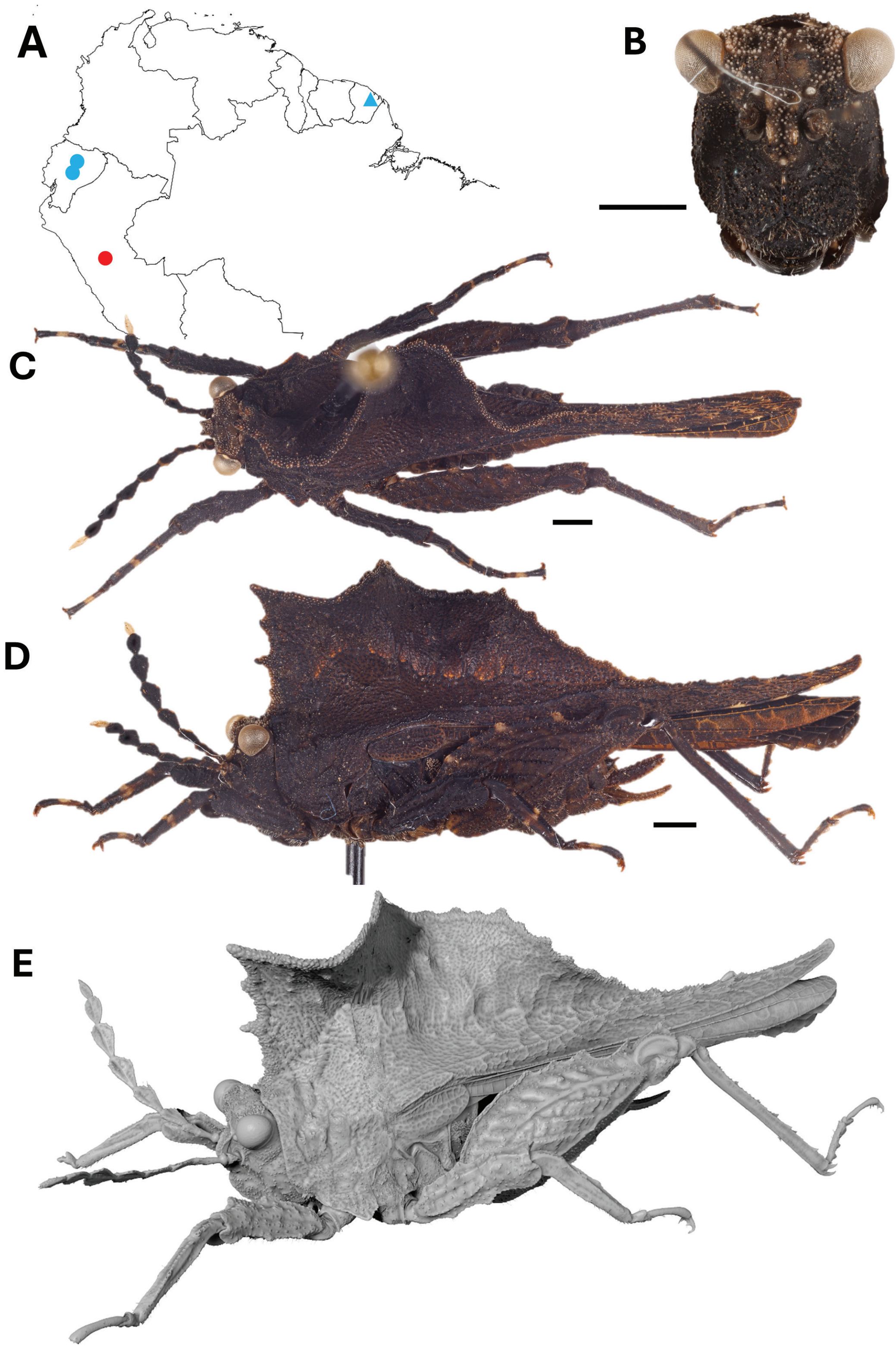

Figure 1. The female holotype of *Lophotettix verhaaghi* sp. nov. **A.** Localities where *L. verhaaghi* sp. nov. (red circle: type locality; blue circle: resembling *L. verhaaghi* sp. nov.) and *L. alticristatus* (blue triangle) have been recorded; **B.** Head in frontal view; **C.** Body in dorsal view; **D.** Body in lateral view; **E.** Digital 3D reconstruction based on synchrotron X-ray microtomography. Scale bars: 1 mm.

Following the discovery of the *L. verhaaghi* sp. nov. holotype in Peru, we found that specimens from the western parts of the Amazonian region (Fig. 1A: blue dots) are morphologically distinct from the holotype of *L. alticristatus* described from Brazil. Itrac-Bruneau and Doucet (2023) reported a specimen from French Guiana that is highly similar to the holotype of *L. alticristatus*, suggesting that this species could be distributed in the northeastern parts of the Amazonian region. The Amazonian region includes several distinct areas of endemism (Silva et al. 2019b; Henriques et al. 2024; Penhacek et al. 2024). In most Lophotettiginae species, as currently understood, the

Figure 2. The comparison of diagnostic characters in *Lophotettix verhaaghi* sp. nov. and *L. alticristatus*. **A.** Apex of lateral lobe in *L. verhaaghi* sp. nov. has rounded edges; **B.** Apex of lateral lobes in *L. alticristatus* has sharp edges; **C.** Anterior margin of crest in *L. verhaaghi* sp. nov. lacks the bottom protrusion, while the middle protrusion is shaped like a simple spine; **D.** Anterior margin of crest in *L. alticristatus* exhibits the bottom protrusion, while the middle protrusion is composed of two tubercles. Photos of *L. alticristatus*: Josef Tumbrinck.

few known localities are scattered across multiple areas of endemism (Silva et al. 2019a; Kasalo et al. 2022, 2024). This distribution across relatively isolated regions, coupled with the fact that some populations exhibit apparent morphological differences (Kasalo et al. 2022, 2024), suggests the possibility that even more distinct species of Lophotettiginae may be recognized in the future.

We described the new species based on the shape of the lateral lobes of the pronotum and the anterior margin of the crest, both of which have previously been noted as useful diagnostic characters. A recent DNA barcoding study on Neotropical Tetrigidae found the shape of the lateral lobes of the pronotum to be species-specific, allowing for the separation of highly similar species based on the dentation of the apical part of the lateral lobes (Kasalo et al. 2025). Besides the lateral lobes of the pronotum, the anterior margin of the crest is considered diagnostically important for *Lophotettix* because it appears highly invariable among specimens of the same species (Silva et al. 2019a; Kasalo et al. 2022; Itrac-Bruneau and Doucet 2023). Unfortunately, an extensive molecular study of this genus may still be far off due to the low availability of specimens.

Acknowledgments

We cordially thank Juliane Diller and Erich Diller (ZSM, Germany) for permission to work in the Panguana Research Station and for providing logistical support, as well as Carlos Vásquez Módena (Moro), his wife Nery Panduro Ramirez, and their son Hibrain. We thank the Peruvian nature conservation authority and forestry office [Servicio Forestal y de Fauna Silvestre (SERFOR), Ministerio de Agricultura y Riego (MINAGRI)] for collection permits (Instituto Nacional de Recursos Naturales (INRENA) 2003–2008: No. 0/6-2003-INRENA-IFFS-DCB-No. 124-2008-INRENA-IFFS-DCB; Dirección General Forestal y de Fauna Silvestre (DGFFS) 2009–2013: No. 334-2009-AG-DGFFS-DGEFFS-No. 0276-2013-AG-DGFFS-DGEFFS; SERFOR 2014–2019: No. 007-2014-SERFOR-DGGSPFFS-No. 0406-2017-SERFOR-DGGSPFFS) and export permits (INRENA 2003–2008: No. 0002376-AG-INRENA-No. 011855-AG-INRENA; DGFFS 2009–2013: No. 001075-AG-DGFFS-No. 000521-MINAGRI-DGFFS; SERFOR 2014–2019: No. 0000326-SERFOR-No. 003492-SERFOR), and the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos for collaboration.

We thank Angelica Cecilia, Marcus Zuber, and Elias Hamann for their assistance at the beamline, and Clément Tavakoli for tomographic reconstruction. We acknowledge the KIT Light Source for the provision of instruments at their beamlines and thank the Institute for Beam Physics and Technology (IBPT) for operating the Karlsruhe Research Accelerator (KARA). We are also grateful to Tomislav Domazet-Lošo for reading an early version of this manuscript and providing valuable comments.

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