



General Entomology

Low-cost circular LED dome lighting system for Insecta (Hexapoda) image capture in self-assembly stereomicroscope

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Abstract. The use of high-resolution images in studies of morphology, taxonomy and systematics has been increasingly frequent, especially in Insecta. However, suitable lighting systems are still very expensive and/or difficult to use. On the other hand, currently the use of 3D printers has helped to make lighting equipment more accessible for researchers to equip their laboratories. Here we present a low-cost circular LED dome lighting system for capturing scientific micro and macro photography on a self-assembly stereomicroscope. We also present the necessary components for making the dome, as well as the elements used to capture the photographs.

Keywords: Entomology; image capture; insect photography; scientific photographs.

Photographs are being used more and more in studies of insect morphology, taxonomy and systematics and this increase goes hand in hand with the improvement of optical equipment in science. For this, adequate lighting is essential in capturing good photographs. Good quality photographs, in addition to be a record of the specimen, can be used to work with vector graphics programs (KAWADA & BUFFINGTON 2016; BÄUMLER *et al.* 2020).

Thus, proper lighting is essential in capturing good photos because some insects have cuticles that reflect light, such as metallic colored beetles, which can prejudice the acquisition of good photos. Generally, depending on the model, the standard lighting devices that come with stereomicroscopes are not suitable for good quality photographs for publication.

Currently, there is equipment on the market suitable for capturing high quality scientific images. However, these equipments are still very expensive and/or difficult to handle, which requires adequate training to operate them. More recently, 3D printing has helped to make lighting equipment that has allowed researchers to equip their laboratories in a more accessible way (KERR *et al.* 2008; KAWADA & BUFFINGTON 2016; BÄUMLER *et al.* 2020).

Here we present a circular LED dome lighting system for capturing scientific micro and macro photography on a self-assembly stereomicroscope with low financial cost. We also present the necessary components for making the dome, as well as the elements used to capture the photographs.

MATERIAL AND METHODS

Building the system. To build the system we use a white plastic container used to store food, with 135 mm in diameter and 142 mm in height (Figure 1A) (or can use a PVC pipe with the bottom capped); a piece of white EVA (Ethylene Vinyl Acetate); a "ribbon of LED white lamps" (Figure 1B); a power source of direct current/alternating current, with follow specifications (FOYU AC/DC ADAPTOR, Model: JCY-1220, INPUT: AC100-240V~50/60Hz, OUTPUT: 12VAC/DC2A) (Figure 1C); plain white paper or vellum paper (Figure 1D); and adhesive tape for prepare the filters used in impermeabilization of the light reflections emitted by the lights of the LED ribbon in the insects cuticle. All these components to build the dome can be easily found in supermarkets and/or stationery store and the power source can be founded an electrical equipment store. The total amount spent to build the equipment is around US\$ 16,00-20,00.

The first step is: cut the EVA to the diameter of the container and coat the bottom of the container; then drill a hole on the lateral surface of the container, at the inferior part near the base, and connect "ribbon of LED" with the power source; after connect, cover the inner lateral surface of the container, arranging the "ribbon of LED" in spiral, starting from the bottom to the surface of the container.

The second step is to make the supports to place the pinned insects (Figure 1 E-G). For this it is necessary cover a petri dish with EVA or only use an EVA piece (Figure 1G). Then, cover

the EVA with white paper to standardize the background color of the images (this type of support allows you to pin the insect in dorsal view) (Figure 1F-G); black or gray paper can be used to cover the EVA, but we chose white paper because is the default color used in the background of images in our publications. To make the support to fix the insect in a lateral view, you will need to use two pieces of EVA, one circular with 95 mm in diameter and other rectangular with 6 cm long by 5 cm wide and 6 sewing pins. To mount the bracket, you will fix on the rectangular piece of EVA in the lateral portion of the circular piece, as aid of pins, forming an angle of 90° (Figure 1E).

The step three is to prepare the light diffuser filter to control the reflexes emitted by the LED lights of the container on the insect's body during the images capture (Figure 1D). To prepare the filter, a plain white paper or vellum paper, forming a cylinder with 91 mm in diameter and 106 mm in height (Figure 1D). Was used a filter with this diameter to allow access of the objective lens of the stereomicroscope in the circular illuminator and the free vertical movement of the equipment during the images capture.

Specimen Preparation. We used pinned insects from different orders of Insecta belonging to the Entomological Collection Professor Johann Becker of Museu de Zoologia da Universidade Estadual de Feira de Santana, Bahia, Brazil (MZFS).

Digital imaging. Images were obtained using a stereomicroscope self-assembly (Figure 2A), model Leica M205 C with FusionOptics™, with an attached digital

camera (Figure 2B), model Leica DFC295. The Leica M205 C stereomicroscope contains a fully integrated ring light (Figure 2C), model Leica LED 5000 RL, attached to the objective lens (LEICA 2020a).

The capture and self-assembly of the images of the insects or their structures is done with Leica LED5000 RL fully integrated ring light it is completely controlled using Leica Application Suite (LAS) version 3.6.0 (LEICA 2020b), software is installed on the LEICA M205C. First, images of a beetle were captured with the equipment coupled to the stereomicroscope (Figure 2C) and then images were captured with the system built by us (Figure 4A) to compare the quality of the images. Although, the main objective of the manuscript is to demonstrate the possibility of building a lighting system, with low-cost components, which can be used to obtain high quality micro and macro photographs not only on Leica equipment but on equipment from other manufacturers as well.

To configure the camera, we use the follow options Expose ajust: Expouse (8,91), Gain (2,1x), Saturation (1,5-this value may vary more or less depending on the specimen) Gama (0,79-this value may vary more or less depending on the specimen) and Multifocus: Steps (Blended max), Accuracy (70-80, depending the specimens). The plates preparation and final image editions were made using Adobe Photoshop CS6.

To capture an image of insects with a total length equal to or less than 2.5 mm, self-assembly of photographs of the entire body of the specimen was used (Figure 5A-C). For insects with a total length greater than 2.5 mm in length, dorsal images

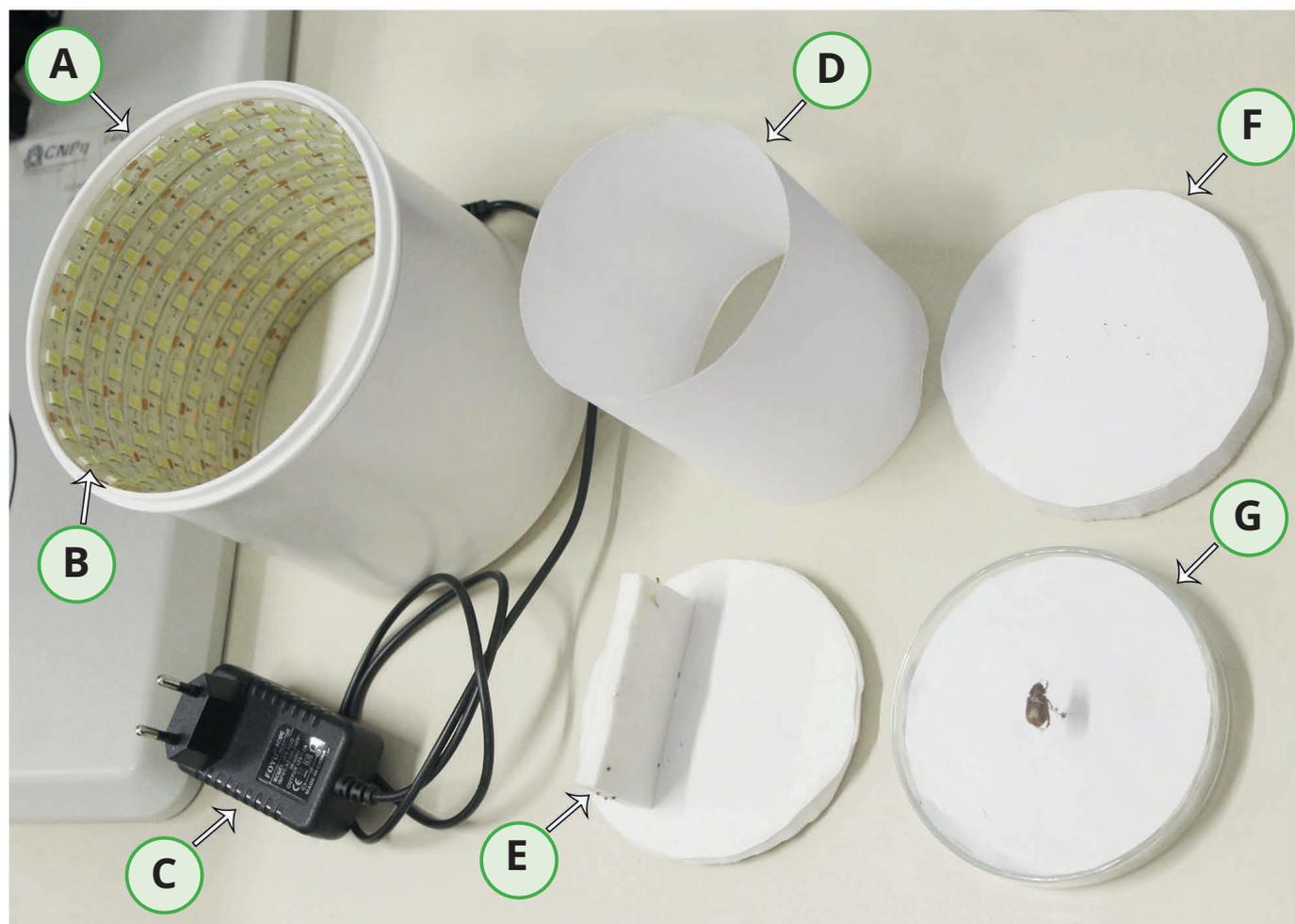


Figure 1. Circular LED dome lighting system: **A)** circular illuminator; **B)** ribbon of white lamps of LED; **C)** power source; **D)** white paper filter; **E)** support to fix the insects in lateral view; **F-G)** supports to fix the insects in dorsal view.



Figure 2. Stereomicroscope self-assembly, model Leica M205 C: **A)** stereomicroscope; **B)** digital camera; **C)** fully integrated ring light; **E)** support with pinned insect.



Figure 3. Stereomicroscope self-assembly, model Leica M205 C: **A)** circular LED dome lighting system.

of the specimen body were taken in four separate parts and then (Figure 6A-D), after self-assembly of the images of each part of the body, the four images were superimposed using Adobe Photoshop CS6 to form the final image of the specimen body (Figure 6E).

RESULTS AND DISCUSSION

All necessary materials for assembling the dome as well as all accessories are listed in the above. The procedure for assembling all parts of system is shown in (Figure 1). Once assembled, the low-cost circular LED dome lighting system can be easily used by any researcher who knows how to handle the Leica M205 C with FusionOptics™, with an attached digital camera, model Leica DFC295.

Our system allows the capture of images of the entire body specimen (Figures 4B; 5A-D; 7A-B; 8A, C), body part details (Figures 4D; 8B, D) or from smaller structures in body of specimen (Figure 7C-H). For specimens with a total length greater than 2.5 mm, image capture is possible in separate parts (Figure 6A-D) and then superimposed in an image editing program (Figure 6E).

Comparing the images obtained through the lighting system coupled to the stereomicroscope Leica M205 C with FusionOptics™, with an attached digital camera, model Leica DFC295 with the images obtained through our lighting system, we were able to better control the incidence of light in the specimen. When using the system stereomicroscope, the illumination that falls on the specimen's body is only dorsally (Figure 2), so many details of structures or parts of the specimen's body are not highlighted in the photograph (Figure 4A, C). On the other hand, when we use our low-cost lighting system coupled to the equipment (Figure 3A), the images are able to better contemplate the structures or parts of the specimen's body (Figure 4B, D).

Compared to the illumination system proposed by KAWADA & BUFFINGTON (2016), the position of the circular LED (or LED ring lights), i.e., inner or below the dome has given similar results. Beside this, the inferior result of the images obtained when using the lighting system coupled with the stereomicroscope Leica can also be a consequence of the LED ring used in superior position with respect the specimen photographed.

Currently, lighting systems to be coupled to equipment already exist on the market, however the cost of obtaining them is unfortunately still very expensive (VOLLMAR *et al.* 2010), which makes it impossible for researchers to obtain them, given that public investment in Brazilian science has fallen dramatically in recent years (ANGELO 2019; ESCOBAR 2019).

Some light dome models for capturing scientific micro and macrophotographs have already been proposed by (KERR *et al.* 2008; KAWADA & BUFFINGTON 2016; BÄUMLER *et al.* 2020). However, these models use 3D printing techniques, unlike the model presented by us that we propose in this paper. On the other hand, our equipment was developed with ready-made parts that can be easily found in supermarkets and electrical equipment stores.

Another advantage of our lighting system is that there is no limitation for obtaining the images, it is possible to photograph any type of insect or other material, from small to large specimens, through the photographs in separate parts and then superimposed in an editing program of images. Furthermore, anyone who knows how to use the stereomicroscope Leica M205 C with FusionOptics™, with an attached digital camera, model Leica DFC295 can handle our lighting system easily.

Despite cuts in public investment in Brazilian science in recent years (ANGELO 2019; ESCOBAR 2019), so that researchers can maintain their research projects, as well as equip their

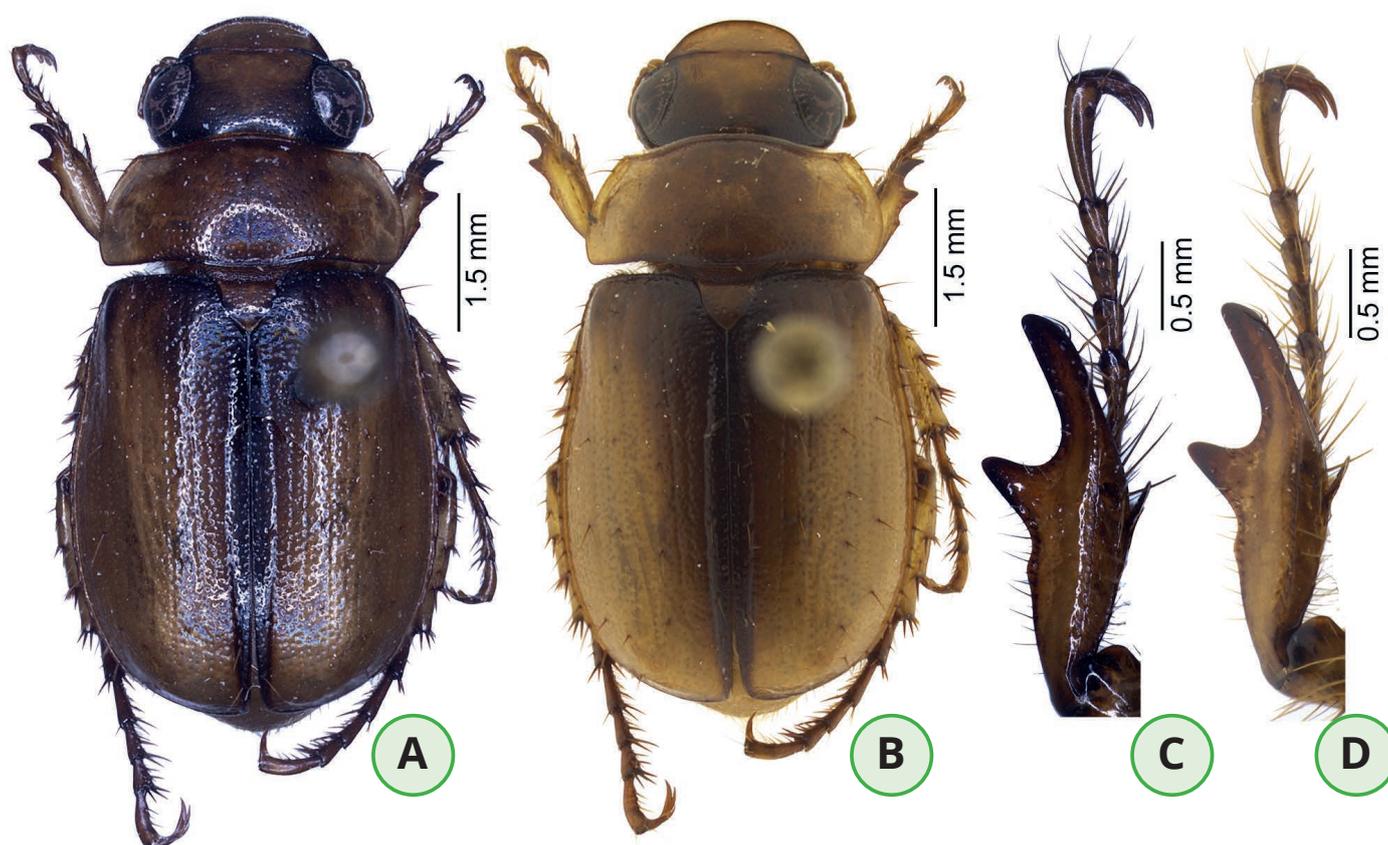


Figure 4. Same specimen of *Lobogeniates alvarengai* Martínez (Coleoptera: Scarabaeoidea: Melolonthidae: Rutelinae: Geniatini): **A-B** dorsal view; **C-D** image of protibia of *Lobogeniates alvarengai* Ohaus; **A and C** image capture with fully integrated ring light; **B and D** image capture with circular LED dome lighting system.

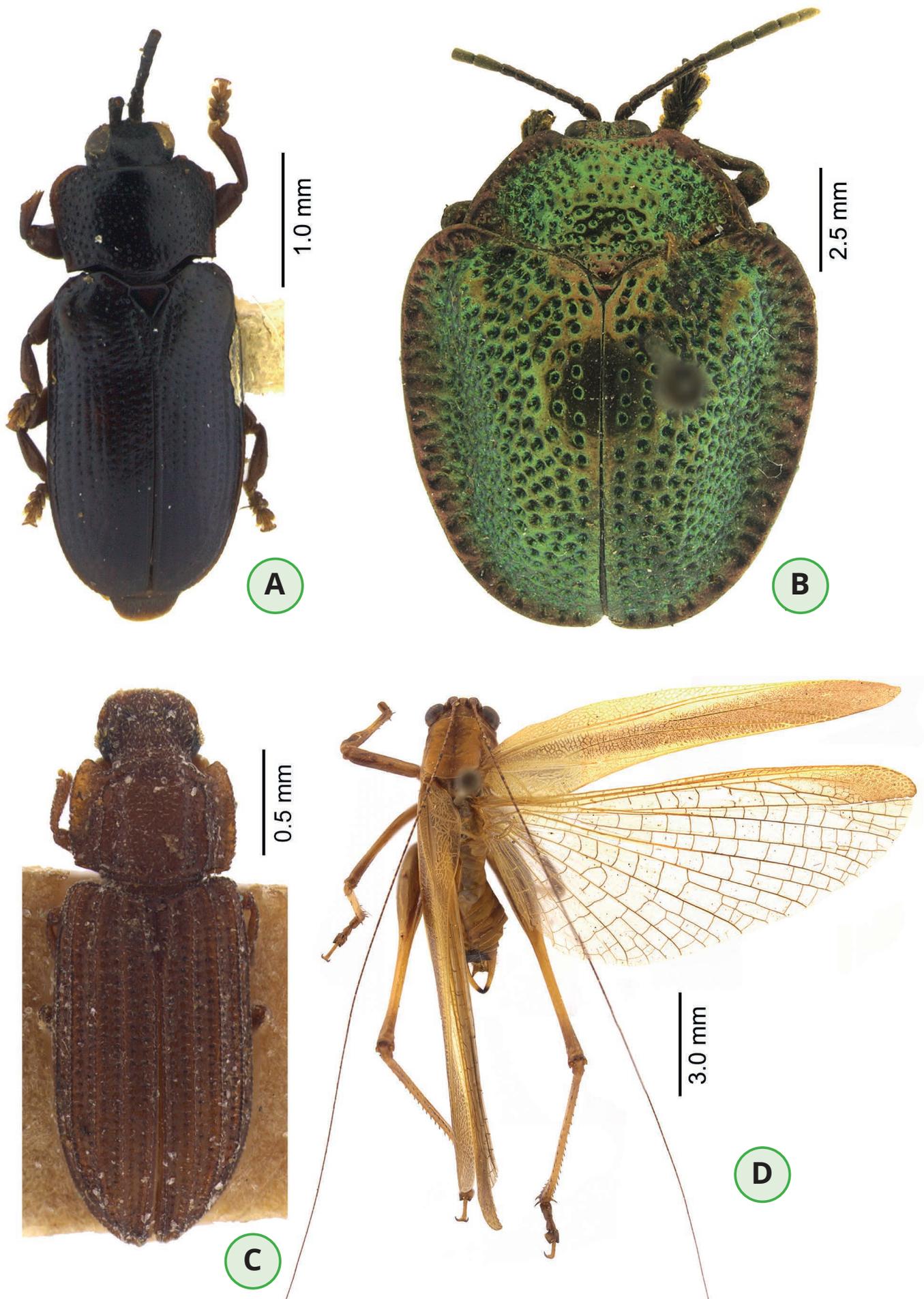


Figure 5. Insect specimens obtained circular LED dome lighting system: **A)** paratype of *Cephaloleia diplothemium* Uhmann (Coleoptera: Chrysomelidae); **B)** Cassidinae Gyllenhal (Coleoptera: Chrysomelidae); **C)** lectotype of *Bitoma palmarum* Bondar (Coleoptera: Zopheridae); **D)** paratype of *Ctenophorema balneare* Piza syn. of *Homotocha laminata* Brunner von Wattenwyl (Orthoptera: Tettigoniidae); **A, C-D)** (modified from FERREIRA *et al.* 2020: 537-538).

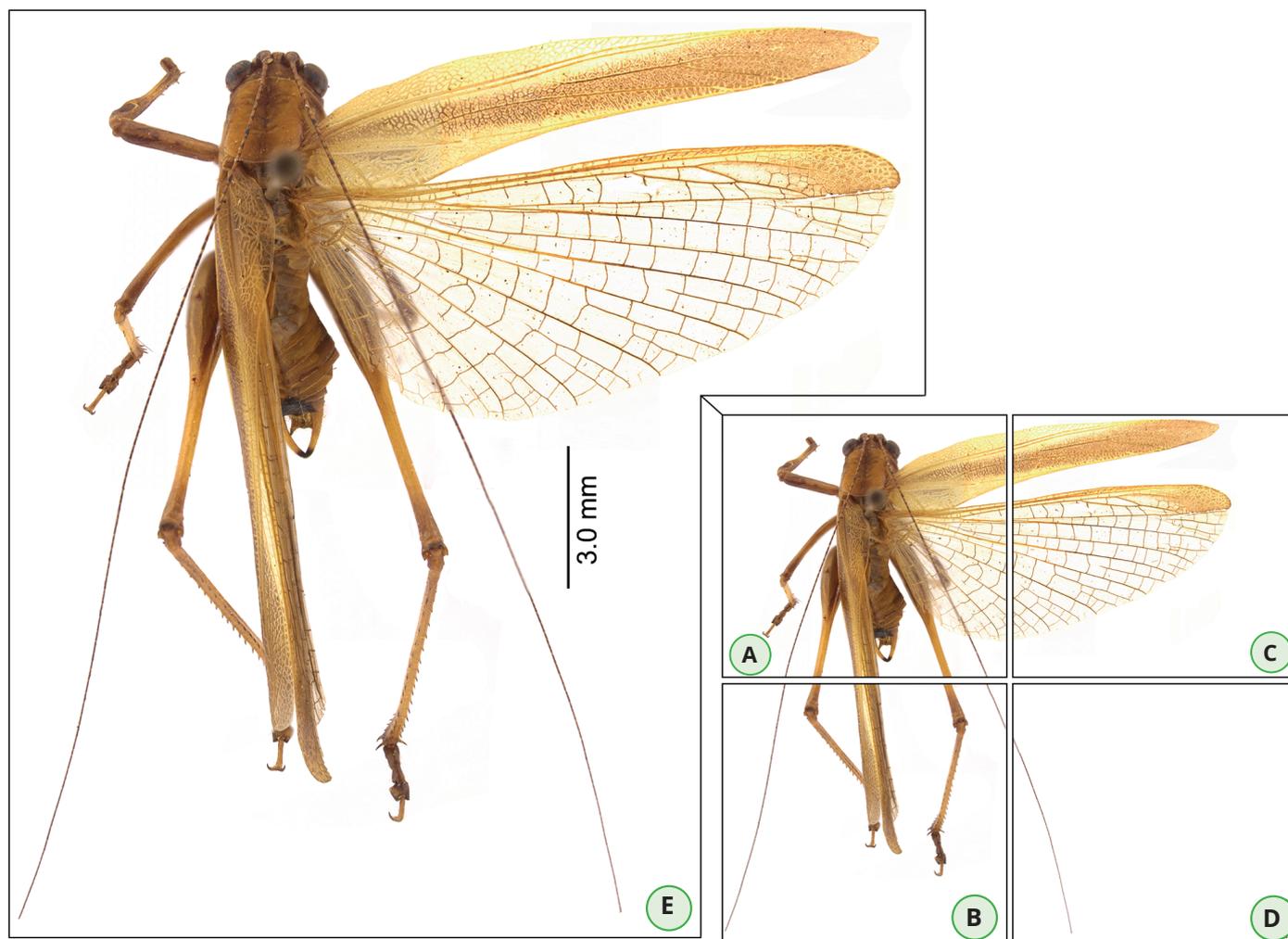


Figure 6. Paratype of *Ctenophorema balneare* Piza syn. of *Homotoicha laminata* Brunner von Wattenwyl (Orthoptera: Tettigoniidae) (modified from FERREIRA et al. 2020: 539), image capture with fully integrated ring light in dorsal overview: **A-D** as pictogram **E** single image for 4 images stacked.

laboratories, researchers still manage with their creativity to carry out quality research, by adapting equipment with low-cost materials.

Finally, the system proposed here is not unique to be used in the self-assembly of this model of Leica stereomicroscope. However, this system has not been tested in other models or brands, this dome type can be used more comprehensively, including in photographs taken by DSLR cameras attached to camera stand supports with adjustable height.

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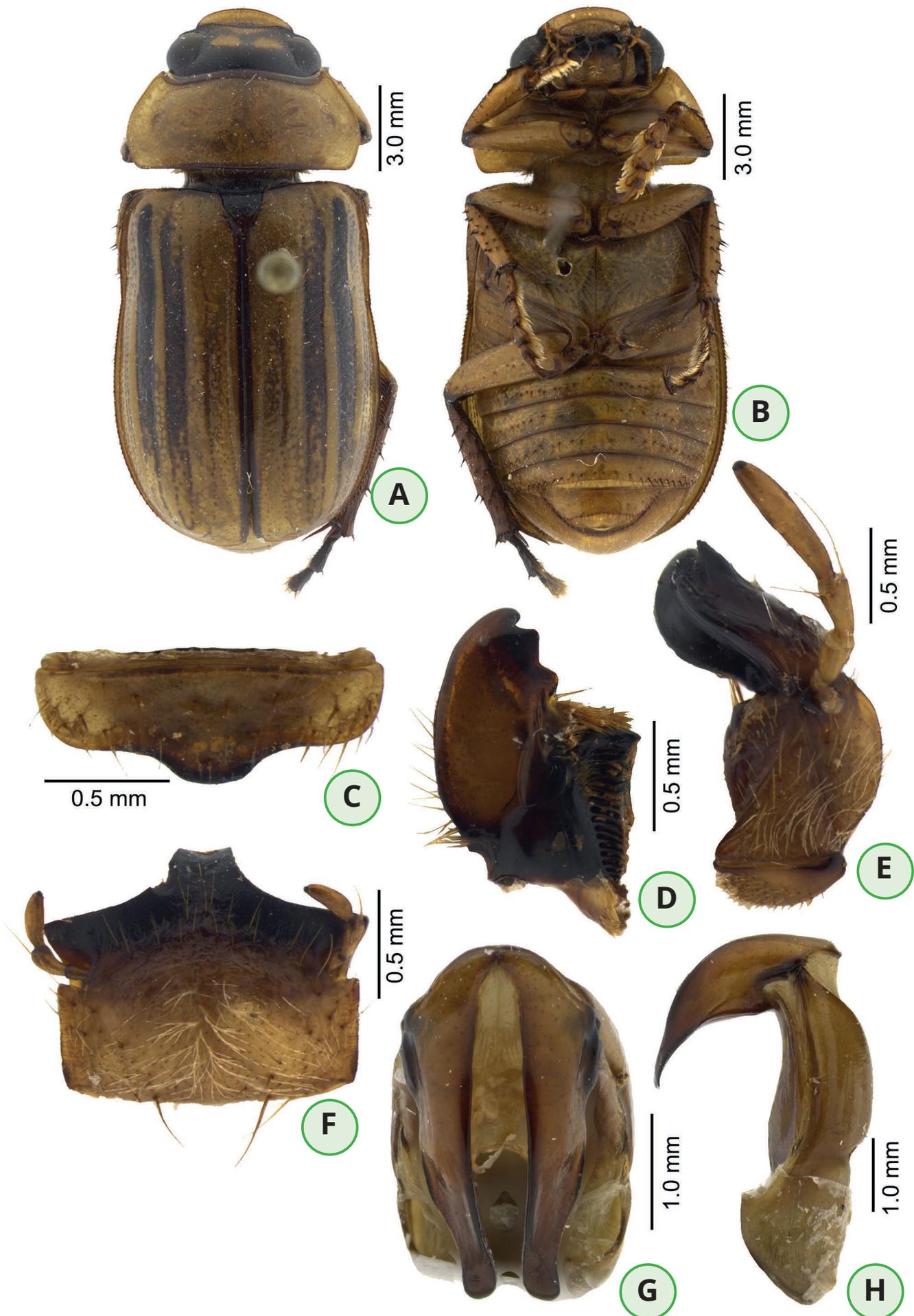


Figure 7. *Trizogeniates curvatus* Ferreira, Bravo, Grossi & Seidel (Coleoptera: Scarabaeoidea: Melolonthidae: Rutelinae: Geniatini) (modified from FERREIRA *et al.* 2019: 9). **A-B)** holotype male in dorsal and ventral views; **C)** labrum in dorsal view of the holotype; **D)** left mandible in dorsal view of the holotype; **E)** left maxilla in ventral view of the holotype; **F)** labium in ventral view of the holotype; **G-H)** parameres of the holotype in caudal and lateral views.

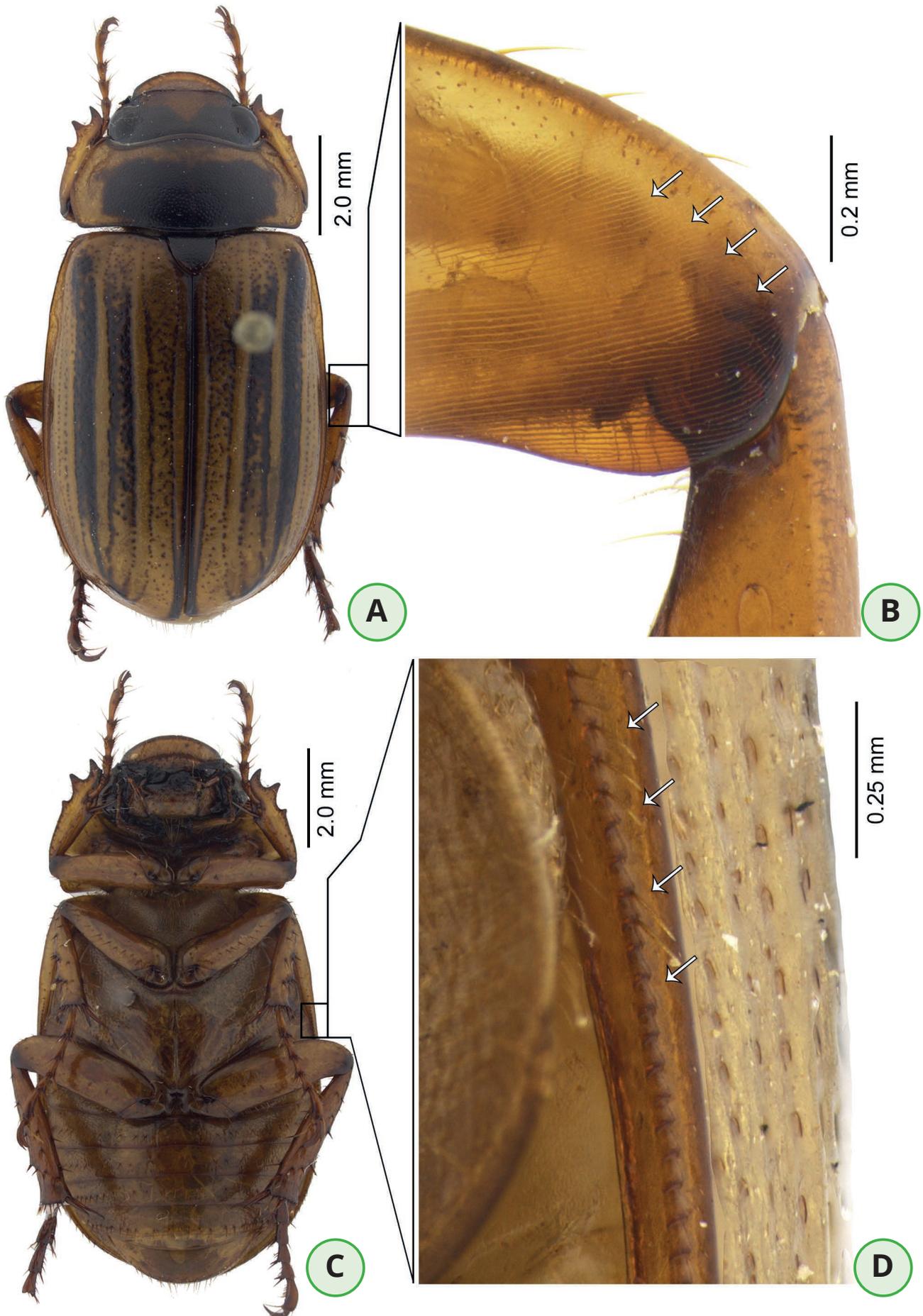


Figure 8. *Trizogeniates vittatus* (Lucas) (Coleoptera: Scarabaeoidea: Melolonthidae: Rutelinae: Geniatiini): **A)** female in dorsal view; **B)** stridulatory apparatus; **C)** female in ventral view; **D)** epipleuron region.

