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Two new species of *Liodessus* Guignot, 1939 diving beetles from Northern Peru (Coleoptera, Dytiscidae, Hydroporinae)

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Abstract

The diving beetles *Liodessus altoperuensis* **sp. nov.** and *Liodessus caxamarca* **sp. nov.** (Dytiscidae, Hydroporinae, Bidessini) are described from the high altitudes of the Puna regions of north western Peru. They occur in shallow and exposed mossy peatland puddles. We delineate the two species using structures such as male genitalia, beetle size, shape and colour pattern. Mitochondrial Cox1 data were also generated, and revealed clusters congruent with morphological evidence. Altogether fourteen *Liodessus* species are now known from the Andean region.

Key Words

Dytiscidae, *Liodessus*, new species, Peru

Introduction

There are 32 species of *Liodessus* Guignot, 1939 known from the Americas. Twelve of these have been recorded from the Andean region (Balke et al. 2020; Megna et al. 2019; Nilsson and Hájek 2020), but species from the high altitudes of the Páramo and Puna regions remain poorly studied. Only recently, several new species were described from above 2,800 m altitude (Balke et al. 2020; Megna et al. 2019). We suggested that many more new species of *Liodessus* remain to be discovered in the vast Andean highland ecosystem, most of them likely endemic to one or a few Páramo or Puna areas, respectively. To address this in a combined evidence pipeline, we suggested a DNA sequence based platform for the study of these insects (Balke et al. 2020), using the Barcode of Life Data System (BOLD) of the Canadian Centre for DNA Barcoding (www.boldsystems.org) (Ratnasingham and Hebert 2007).

Material and methods

The beetles were studied with a Leica M205C stereo microscope at 10–160×. Habitus images were taken with a Canon EOS 5 DS camera fitted with a 10× Mitutoyo ELWD Plan Apo objective attached to a Carl Zeiss Jena Sonnar 3.5 / 135 MC as focus lens. The male genitalia were imaged with a 20× Mitutoyo ELWD Plan Apo. Illumination was with three SN-1 LED segments from Stonemaster. Image stacks were generated using the Stackmaster macro rail (Stonemaster) (10×: 0.007 mm steps; 20×: 0.003 mm steps), and images were then assembled using Helicon Focus 4.77TM. To study the distribution of mtD-

NA sequence diversity in four populations of *L. caxamarca*, haplotype networks were constructed using the TCS algorithm (Clement et al. 2000) implemented in PopART (Leigh and Bryant 2015). The distribution basemap was created with primap MapCreator 3.0, Professional Edition and modified in Adobe Illustrator.

The following acronyms are used in the text: MUSM (Natural History Museum of San Marcos National University, Lima, Peru) and ZSM (SNSB-Zoologische Staatssammlung, München, Germany). Codes such as PER_YSM_2018_45 are our field locality codes.

Results

Liodessus caxamarca sp. nov.

http://zoobank.org/B49889C3-039A-4847-B74F-497F767EE6DE

Figs 1A–D, 2A, 3A–C, 4, 5, 6

Type locality. Peru, Cajamarca, Encañada District, Conga, -6.934, -78.442.

Holotype. Male (MUSM): Peru: Cajamarca, Cajamarca, Encañada District, Conga, 4030 m, 7.ix.2018, -6.934, -78.442, Y. S. Megna & N. Zenteno (PER_YSM_2018_46).

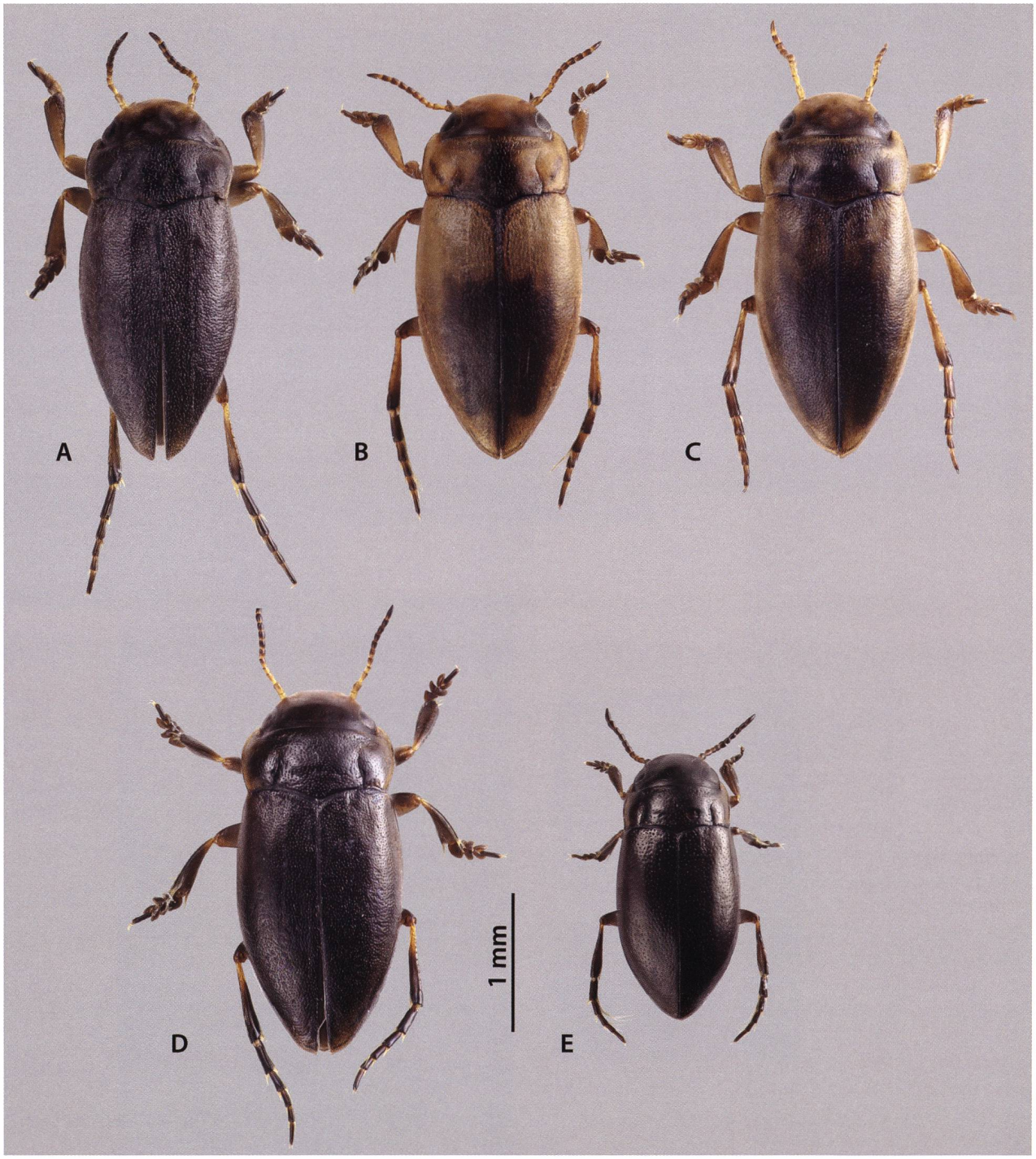

Figure 1. *Liodessus* spp.: Dorsal habitus of *Liodessus caxamarca* sp. nov., female paratypes from locality PER_YSM_2018_046 (**A**), PER_YSM_2018_047 (**B**), PER_YSM_2018_046 (**C**), male paratype PER_YSM_2018_046 (**D**); *Liodessus altoperuensis* sp. nov., male paratype from locality PER_YSM_2018_050 (**E**).

Figure 2. *Liodessus* spp., female paratypes: Metathoracic wing of paratypes of *Liodessus caxamarca* sp. nov. (**A**); *Liodessus altoperuensis* sp. nov. (**B**).

254 Paratypes (MUSM, ZSM). 100 exs.: same data as holotype; 30 exs.: Peru: Cajamarca, Cajamarca, Encañada District, Conga, 4013 m, 7.ix.2018, -6.95, -78.354, Y. S. Megna & N. Zenteno (PER_YSM_2018_45); 55 exs.: Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3928 m, 8.ix.2018, -6.887, -78.595, Y. S. Megna & N. Zenteno (PER_YSM_2018_47); 23 exs.: Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3947 m, 8.ix.2018, -6.892, -78.599, Y. S. Megna & N. Zenteno (PER_YSM_2018_48); 23 exs.: Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3961 m, 8.ix.2018, -6.894, -78.6, Y. S. Megna & N. Zenteno (PER_YSM_2018_49); 41 exs.: Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3933 m, 8.ix.2018, -6.902, -78.603, Y. S. Megna & N. Zenteno (PER_YSM_2018_50); 12 exs.: Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3935 m, 8.ix.2018, -6.91, -78.614, Y. S. Megna & N. Zenteno (PER_YSM_2018_51).

Description of holotype. Habitus with distinct discontinuity between pronotum and elytra (as in Fig. 1D). Total length: 2.8 mm; length without head 2.4 mm; maximum width: 1.3 mm.

Colouration. Dark brown to blackish dorsally and ventrally (as in Fig. 1D).

Surface sculpture. Head more or less smooth and with few setiferous punctures in front of a faint cervical line, faint microreticulation present along sides of eyes; with distinct distinct microreticulation but without punctures posteriorly of occipital line. Pronotum and elytron shiny; with dense and coarse setiferous punctation.

Structures. Antenna stout. Head with faint cervical line that dissolves into serial punctures laterally; with rounded clypeus. Pronotum with distinct lateral bead; with distinct and deep basal striae (as in Fig. 1D). Elytron without obvious basal striae on left side and very short

Figure 3. *Liodessus* spp. males: *Liodessus caxamarca* sp. nov., holotype, median lobe of aedeagus in ventral view (**A**), same in lateral view (**B**), right paramere external surface view (**C**); *Liodessus altoperuensis* sp. nov. holotype, median lobe of aedeagus in ventral view (**D**), same in lateral view (**E**), right paramere external surface view (**F**).

and inconspicuous on right hand side; without sutural line. Without basal epipleural transverse carina. Metathoracic wings short, about half the length of elytron (Fig. 2A).

Genitalia. Median lobe of aedeagus curved in lateral view, tip thin and appearing fragile; in ventral view slender and gently narrowed towards tip (Figs 3A, B); lateral lobes (parameres) bisegmented and comparably broad (Fig. 3C).

Variation. Total length: 2.5–2.8 mm; length without head: 2.2–2.5 mm; maximum width: 1.1–1.4 mm. The elytral stria can be short yet well visible to very faint to absent. The color is rather variable, from comparably lightly colored (Fig. 1B), to more or less dark brown to blackish (Figs 1A–D). Specimens from localities #45 and #46 in Encañada District, Conga are overall darker than from the other localities. This is however not reflected in the haplotype tree we calculated from our *cox1* data (Fig. 5). We assessed the length of the metathoracic wings in 10 specimens, which all had the same wing length. This does not rule out the possibility that a certain number of specimens can be fully winged.

Figure 4. Distribution area (orange dot) of *Liodessus caxamarca* sp. nov. and *Liodessus altoperuensis* sp. nov. in the northern Andes of Peru.

Female. Dorsal surface dull due to presence of well impressed microreticulation between surface punctation (Figs 1A–C, 2A).

BOLD platform. We provided 27 entries in the "COLLI" project, all retrieved in one cluster. Assignment to that cluster was unambiguous, meaning all specimens were correctly assigned to this morphologically delineated species.

Etymology. Named after the Caxamarca pre Inca culture that inhabited the area between 200–1,300 AD, and also gave the name to the Department Cajamarca. The name is a noun in the nominative standing in apposition.

Comparative notes. The species is well characterized by its size, discontinuous habitus, shape of male genitalia (Figs 3A, B) and *cox1* signature.

Distribution. Only known from the high Andes in north western Peru (Fig. 4).

Habitat. Shallow and exposed peatland puddles, collected with strainer out of mats of vegetation including mosses (Fig. 6).

Liodessus altoperuensis sp. nov.

http://zoobank.org/9952954C-5C28-454E-82C2-4FD45BC1A35D

Figs 1 E, 2 B, 3 D–F, 4, 6

Type locality. Peru, San Pablo, Tumbaden District, Alto Peru, -6.902, -78.603.

Holotype. Male (MUSM): Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3933 m, 8.ix.2018, -6.902, -78.603, Y. S. Megna & N. Zenteno (PER_YSM_2018_50).

30 Paratypes (MUSM, ZSM). 28 exs., same data as holotype. 1 ex. Peru: Cajamarca, Cajamarca, Encañada District, Conga, 4030 m, 7.ix.2018, -6.934, -78.442, Y. S. Megna & N. Zenteno (PER_YSM_2018_46); 1 ex. Peru: Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3928 m, 8.ix.2018, -6.887, -78.595, Y. S. Megna & N. Zenteno (PER_YSM_2018_47).

Description of holotype. Habitus with little discontinuity between pronotum and elytra, therefore appearing more parallel sided (Fig. 1E). Total length: 2.1 mm; length without head 1.8 mm; maximum width: 1.0 mm.

Colouration. Blackish dorsally and ventrally (as in Fig. 1E).

Surface sculpture. Head with faint microreticulation, frons and clypeus more or less smooth and with few setiferous punctures; with distinct microreticulation but without punctures posteriorly of a faint cervical line. Pronotum and elytron shiny; with dense and coarse setiferous punctation; pronotum with faint microreticulation along anterior margin and towards pronotal disc.

Structures. Antenna stout. Head with faint cervical line that dissolves into serial punctures laterally; with rounded clypeus. Pronotum with distinct lateral bead; with distinct and deep basal striae (as in Fig. 1E). Elytron faint basal striae only obvious under certain angles of illumination; without sutural line. Without basal epipleural transverse carina. Metathoracic wings short, about half the length of elytron (as in Fig. 2B).

Genitalia. Median lobe of aedeagus with inner side comparably straight in lateral view, tip slightly bent and comparably robust; in ventral view slender and gently narrowed towards tip (Figs 3D, E); lateral lobes (parameres) bisegmented and narrow, very typical for the genus (Fig. 3F).

Variation. Total length: 1.9–2.2 mm; length without head: 1.7–1.8 mm; maximum width: 0.9–1.0 mm. The elytral stria can be short yet well visible to very faint to absent. We assessed the length of the metathoracic wings in 10 specimens, which all had the same wing length. This does not rule out the possibility that a certain number of specimens can be fully winged.

Female. Dorsal surface as in male, shiny (Fig. 2B).

BOLD platform. We provided 10 entries in the "COLLI" project, all retrieved in one cluster. Assignment to that cluster was unambiguous, meaning all specimens were correctly assigned to this morphologically delineated species.

Etymology. Named after the type area. The name is an adjective in the nominative singular.

Comparative notes. The species is well characterized by its smaller size, almost entirely black coloration, elytral plica very short or absent, shape of male genitalia and *cox1* signature.

Distribution. Only known from the high Andes in north western Peru (Fig. 4).

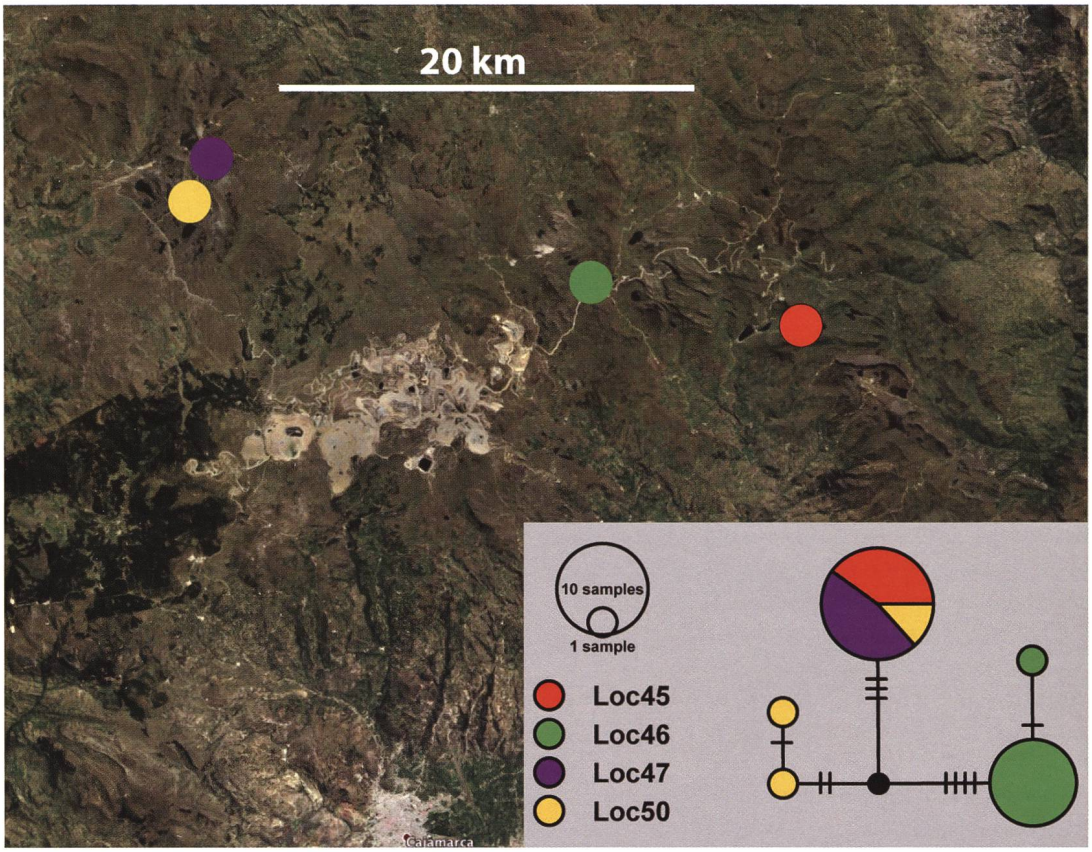

Figure 5. Localities of *Liodessus caxamarca* sp. nov. sampled for *cox1* data, and haplotype tree inferred using TCS software. Each bar along the lines connecting the 5 haplotypes indicates one inferred nucleotide substitution. The base map was taken from GoogleEarth.

Figure 6. Habitats and landscapes at localities Cajamarca, Cajamarca, Encañada District, Conga, 4030 m [PER_YSM_2018_046] (**A, B**) and Cajamarca, San Pablo, Tumbaden District, Alto Peru, 3935 m [PER_YSM_2018_51] (**C, D**).

Habitat. Shallow and exposed peatland puddles, collected with strainer out of mats of vegetation including mosses (Fig. 6).

Discussion

As mentioned above, we established a DNA sequence based platform for the study of the Andean *Liodessus* species, using the Barcode of Life Data System (BOLD). Our project on the BOLD platform is "COLLI", being an acronym for "Colombian and Andean *Liodessus*". We use the standard genetic marker for molecular biodiversity assessment, the 5' end of the mitochondrial cytochrome c oxidase 1 gene (cox1 or CO1), also referred to as the "DNA barcode" (Hebert et al. 2003) (also see the comprehensive background data in the BOLD Handbook under boldsystems.org for technical details). We are aware that this is only a single marker which is not related to speciation (Kwong et al. 2012), with known issues for species delineation, including in Dytiscidae (Hawlitschek et al. 2012; Hendrich et al. 2010), but have found the approach very useful in many lineages at the species and even population level (Hendrich et al. 2010; Lam et al. 2018; Megna et al. 2019). Careful cross checking of morphological and molecular taxonomic evidence is the foundation of our investigation. We delineate our new species based on morphological structures. At the same time, we can confirm monophyly of the mtDNA sequence based clusters that contain the samples of the two new species described here. These data can thus be used to assign for example larval samples, or as a reference for environmental DNA metabarcoding. The data can also serve as a reference for the discovery and description of additional *Liodessus* species from the Andes.

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