



ECOSYSTEMS

Species diversity of Tenebrionidae (Coleoptera) in mountaintops of extra-Andean volcanoes of Payunia (Argentina), with descriptions of two new species

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Abstract: The north of Neuquén province shares with the south of Mendoza province the subprovince Payunia of the biogeographical province of Patagonic steppe, which is characterized by the presence of approximately 800 volcanoes. Although we have conducted several samplings in volcanoes of Mendoza in past years to recognize the biodiversity of tenebrionids, it is still pending which is the role that these mountains have in the biota of tenebrionids in Neuquén. In this work we reported the results of two consecutive years of prospection in two volcanoes separated by 120 km between each other, Tromen and Auca Mahuida which have 3978 and 2215 meters above sea level respectively. We found that Auca Mahuida harbours a total diversity of 10 tenebrionid species and Tromen 9, but these communities were significantly different between them. From these prospectations two new endemic species of Tenebrionidae are described: *Scotobius aucamahuidensis* Silvestro sp. nov. (Tenebrioninae: Scotobiini) from Auca Mahuida and *Psectrascelis tromensis* Flores sp. nov. (Pimeliinae: Nycteliini) from Tromen. Photographs for these two new species are included, with comparisons to other known species of these genera. Based on these results we discuss the role of different factors that influence tenebrionid diversity and their implications to conserve biodiversity.

Key words: Mountains, Patagonian, monte, high-Andean, species turnover, biodiversity conservation.

INTRODUCTION

Tenebrionid beetles (Coleoptera: Tenebrionidae) are one of most diverse insects inhabiting xeric environments in southern South America (Cepeda-Pizarro et al. 2005a, b, Cheli et al. 2010, Carrara et al. 2011a). Their ability to survive in these environments lies in several morphological, physiological and ethological adaptations that they present (Zachariassen 1996, Flores 1998, Cloudsley-Thompson 2001). Among these are nocturnal habits to elude extreme warm conditions, large bodies to control

internal medium, interlocking of elytra and the presence of a subelytral cavity to control water conservation (Matthews et al. 2010). The presence of this sealed cavity in tenebrionids is generally accompanied by reduction or loss of wings (Matthews et al. 2010), becoming these species into flightless organisms (Carrara & Flores 2013). It has been suggested that these adaptations have positively influenced species survival (i.e. low extinction rates) and processes of speciation rates in tenebrionids (Cloudsley-Thompson 2001), which in turn can be hypothetically related as promoters of high species diversity

found in arid environments. For example, it is possible to hypothesize that morphological and ethological adaptations have increased tenebrionid survival because they allow to exploit more efficiently a great number of niches, which in turn reduce species extinction for competition (Carrara & Flores 2015). In addition, it is also possible to hypothesize that the reduction or loss of wings has increased tenebrionid speciation rates by isolation because low organisms vagility reduce individual migration between populations (Kergoat et al. 2014). Particularly, these hypotheses have been evaluated at regional scales (Carrara & Flores 2015) but remain pending to understand if they have validity as determinant of tenebrionid diversity at local scales.

In the actuality, one of the most prominent local systems to conduct diversity studies is that of mountaintop environments (Lomolino 2001). This is because it is expected that species that inhabit these environments will experience an increase in their extinction risk by the effects of environmental Global Change (Payne et al. 2017). Considering the researches in this topic it is possible to notice that practically none of these were entirely developed in arid environments of southern South America using insect as study object. We consider that increase this type of studies is important because insect life cycles have a strong dependence on environmental conditions (Menéndez 2007), and because it was estimated that the effect of Global Change will be greater in Southern than Northern hemisphere (Urban 2015), thus probably many of insects that inhabit mountaintops can be vulnerable to extinctions. An arid area within southern South America that called the attention of biogeographers by the presence of approximately 800 volcanoes (Hernando et al. 2012) is the subprovince Payunia of the Patagonian province (i.e., center-west of Argentina; Roig-Juñent et al.

2018). Although in recent years, as a result of several prospections in these volcanoes, it has been possible to describe new insect species from the top of mountains (e.g., Roig-Juñent & Sallenave 2005, Flores & Carrara 2006, Roig-Juñent et al. 2008), but still remain elusive the understanding of which factors have influenced the diversity in these environments.

In this work we report the results of two consecutive years of prospection in high elevational environments of two extra-Andean volcanoes from Payunia, Tromen (3978 masl) and Auca Mahuida (2214 masl), separated by 120 km each other. These volcanoes are surrounded by different vegetation types (Roig 1998): i.e., Tromen presents Altoandean and Patagonian vegetations; and Auca Mahuida presents Altoandean, Patagonian and Monte vegetations. Taking in account the short distance between them and the different characteristics of vegetation we can test to what extent these factors are responsible of tenebrionid diversity in these environments. First, if more niche availability promoted more species diversity, we expect higher species richness in Auca Mahuida, which is influenced by three vegetation types than in Tromen, which is influenced by two vegetation types. Second, if a distance effect promoted different speciation processes in these volcanoes, we expect that community assemblages have significant differences between them. Additionally, if speciation processes were by a reduced migration capability of individuals between populations, we expect that community assemblage similarities are higher at generic than at specific levels.

The objectives of this work are: (1) to provide a comprehensive description of species assembly that inhabit these volcanoes mountaintops and (2) to test the influence of vegetational types and distance effect as determinant of species diversity in mountain

environments. In addition, (3) as a result of our prospections we found two new microendemic species of Tenebrionidae belonging to the genera *Scotobius* Germar (Tenebrioninae: Scotobiini) and *Psectrascelis* Solier (Pimeliinae: Nycteliini) that we describe and illustrate.

The present publication of the new species is registered in the ZooBank Life Science Identifier with the following LSID code: urn:lsid:zoobank.org:pub:E5978F69-7E00-4274-B63A-2AA9C873C578.

MATERIALS AND METHODS

Study area

The study area is regionally located within the Patagonian biogeographic province (Roig-Juñent et al. 2018), specifically in the north of Neuquén province in central-western of Argentina (Figure

1). The two volcanoes prospected are considered as extra-Andean mountains, where Tromen and Auca Mahuida were located approximately at 100 km and 200 km east of the Andean mountain range, respectively. The different locations of these volcanoes give them different vegetational characteristics. For example, in Tromen prospection sites were between 2147 and 2610 m of altitude, where at the lower limit is characteristic a grassland steppe, with *Stipa* spp. and *Poa* spp. (Poaceae) being dominant (Chiapella & Ezcurra 1999) and at the higher limit are characteristic local communities belonging to high Andean vegetation (Chiapella & Ezcurra 1999), with *Uncinia lechleriana* (Cyperaceae) and *Pratia repens* (Campanulaceae) and shrub communities composed of *Berberis empetrifolia* (Berberidaceae), *Discaria nana* (Rhamnaceae),

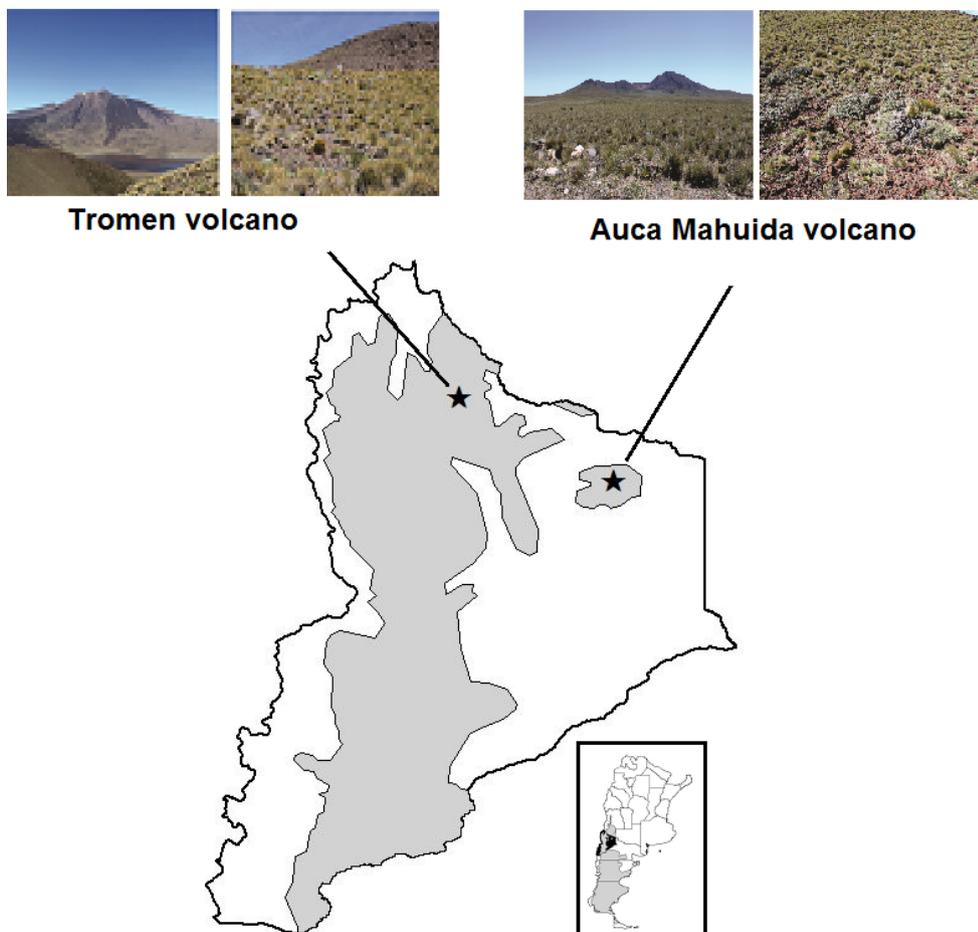


Figure 1. Study area: down-right box, Neuquén province within Argentina (black area) and the extension of Patagonian steppe (grey area); center, zoom to Neuquén province showing Patagonian steppe (grey area) and Monte (white area toward the right of Patagonian steppe) and spatial location of Tromen (right star) and Auca Mahuida (right star) volcanoes.

and *Chiliotrichum rosmarinifolium* (Asteraceae). Instead, in Auca Mahuida prospection sites were located between 1913 and 2020 m of altitude. Here, at the lower limit, the vegetation belongs to Patagonian steppe but with a strong influence of elements of Monte biogeographic province (Roig 1998), which downwards 1500 m become dominant surrounding entirely the mountain. At the higher limit, the vegetation presents some High-Andean biotic elements, such as *Calceolaria* sp. (Scrophulariaceae) shared with vegetation from Patagonian steppe (Roig 1998).

Sampling methods

Darkling beetles were sampled two consecutive years (2015-2016) between December and January. At each site we placed 32 pitfall traps for ten days, arranged in eight groups of four traps separated by 10 m from each other. Once the sampling finished, the four traps of each group were put together in a unique trap, and then considered as a sampling unit. Traps were cylindrical plastic containers of 10 cm diameter, with 100 cm³ of a 30% ethylene glycol-water solution to preserve the material. Once traps had been collected, samples were washed and placed in 90% ethanol. Beetles were identified to species; voucher specimens were deposited at the entomological collection of the Instituto Argentino de Investigaciones de las Zonas Áridas (IADIZA, CCT CONICET Mendoza, Argentina).

We follow Bouchard et al. (2011) and Flores & Aballay (2015) to assign species into tribes and subfamilies. For species identification we used keys and revisions from Kulzer (1963), Peña (1985), Flores (1999, 2004), Flores & Vidal (2001), Flores & Chani-Posse (2005), Silvestro (2018), Silvestro et al. (2012, 2015) and by comparisons with the material deposited in the entomological collection of IADIZA. Terminology used in the descriptions follows recent papers dealing with genera *Scotobius* and *Psectrascelis* (Flores 2007,

Silvestro et al. 2012). Type specimens of the new species are deposited in the following collections: Field Museum of Natural History, Chicago, USA (FMNH), Hungarian Natural History Museum, Budapest, Hungary (HNHM), Instituto Argentino de Investigaciones de las Zonas Áridas, Mendoza, Argentina (IADIZA), Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires, Argentina (MACN), Museo de Entomología Klaus Raven Büller, Universidad Nacional Agraria La Molina, Lima, Peru (MEKRB), Museo Nacional de Historia Natural, Santiago, Chile (MNHC), Museo de La Plata, La Plata, Argentina (MLPA), Natural History Museum, Basel, Switzerland (NHMB).

Statistical analyses

As first step, we assessed how complete the inventories of species obtained from our sampling design in the volcanoes were. This assessment is strongly important because species inventories can be only compared if they are complete enough (Jiménez-Valverde & Hortal 2003). To this end, we constructed for each volcano species accumulation curves that registered the increment of species according with the abundance of individuals. From these analyses were predicted the total species richness as the number of species expected when these curves reach their asymptotes (see, Jiménez-Valverde & Hortal 2003 for further explanations). Then, completeness was calculated as the ratio between the observed species richness in the area and the predicted asymptotic species richness. A completeness score higher than 70% is commonly used as a threshold that indicates a good sampling effort (Jiménez-Valverde & Hortal 2003). Species accumulation curves based on Hill numbers were used to calculate asymptotic species richness (Chao et al. 2014). We derived three diversity indexes from the first three Hill numbers: $q=0$ (richness), $q=1$ (Shannon diversity) and $q=2$ (Simpson diversity) (see Jost (2006)

for indexes calculation formulas). Following to Colwell et al. (2012) and Chao et al. (2014), from these curves we assessed for differences in species richness, Shannon and Simpson diversity indexes between both volcanoes by testing for the non-overlapping confidence of intervals at 95% (bootstrap method based on 100 replicates; Hsieh et al. 2016).

To evaluate for differences in tenebrionid assemblages between both volcanoes, we used a non-metric multidimensional scaling (NMDS). Specifically, this method performs an ordination of the tenebrionid communities in function of their species similarity (Legendre & Legendre 2012). For this analysis we constructed a matrix of biological similarity, using the Bray-Curtis index as a measure of distance on the taxa abundances (square root transformed) (Legendre & Legendre 2012). A permutation multivariate analysis of variance (PERMANOVA) was used to test for significant differences among species groups obtained from NMDS (Anderson 2001). This test allows comparing assemblages as function of factors (in this case, Auca/Tromen volcanoes) based on distance measurements (biological matrices of similarity). Because of PERMANOVA is not based on ranges, can be applied in a randomized blocks experimental design, which is advantageous compared to other similar tests (Anderson & Walsh 2013).

Species accumulation curves and diversity analyses were performed using the iNEXT package for R (Hsieh et al. 2016) and the NMDS and PERMANOVA with the functions metaMDS and adonis of the vegan package (Oksanen et al. 2018) for R (R Core Team 2012).

RESULTS

Several pitfall traps were barefoot by the action of different vertebrates that inhabit the

sampled area; thus of a total of 16 sampling units originally emplaced in each volcano (8 by year) we only considered 13 in Auca Mahuida and 15 in Tromen. Considering both volcanoes, we found a total of 639 individuals belonging to 16 species (Table I). Specifically, in Auca Mahuida we found a total of 356 individuals belonging to 10 tenebrionid species, and in Tromen 283 individuals belonging to 9 tenebrionid species. The asymptotic species richness predicted by volcano, according to species accumulation curves, was 11.99 species for Auca Mahuida, and 9 species for Tromen. These findings indicate that our species inventories were highly complete with scores of 83 % for Auca Mahuida and 100% for Tromen and allow for species comparisons between these volcanoes. In this sense, neither species richness nor diversity indexes curves (Figure 2) showed statistical differences between volcanoes because their confidence intervals at 95% were overlapped between them (Gotelli & Graves 1996).

The NMDS results showed that tenebrionid communities of both volcanoes, at species (Figure 3a) and genus (Figure 3b) levels, had different composition. From these plots, can be visually noted that assemblages were more distant in the ordering space at species than at genus level, suggesting differences in the communities' composition regard the taxonomic position. These differences were statistically supported by PERMANOVA analyses showing that species variation between volcanoes explained a 32.6% (pseudo-F (1, 27) = 13.051; $p < 0.001$) of assemblages differences, and that genus variation between volcanoes explained a 21.9% (pseudo-F (1, 27) = 7.5586; $p < 0.001$). These outcomes indicated that tenebrionid communities were more dissimilar at species level than at genus level.

Finally, from these surveys two new microendemic species of Tenebrionidae were

Table I. List of species with their taxonomic position and number of individuals found in each volcano.

Subfamily	Tribe	Genus	Species	Auca Mahuida	Tromen
Pimeliinae	Evaniosomini	<i>Achanius</i>	<i>Achanius</i> sp.	1	0
	Nycteliini	<i>Epipedonota</i>	<i>Epipedonota cristallisata</i>	7	0
		<i>Epipedonota</i>	<i>Epipedonota nitida</i>	34	38
		<i>Mitragenius</i>	<i>Mitragenius araneiformis</i>	93	2
		<i>Nyctelia</i>	<i>Nyctelia cicatriculata</i>	0	4
		<i>Nyctelia</i>	<i>Nyctelia garciae</i>	99	0
		<i>Nyctelia</i>	<i>Nyctelia producta</i>	0	77
		<i>Nyctelia</i>	<i>Nyctelia</i> sp.	38	0
	Epitragini	<i>Nyctopetus</i>	<i>Nyctopetus argentinus</i>	0	4
	Praociini	<i>Patagonopraocis</i>	<i>Patagonopraocis</i> sp.	2	0
		<i>Platesthes</i>	<i>Platesthes</i> sp.	0	2
		<i>Praocis</i>	<i>Praocis argentina</i>	0	61
	Nycteliini	<i>Psectrascelis</i>	<i>Psectrascelis</i> sp.	1	0
		<i>Psectrascelis</i>	<i>Psectrascelis tromensis</i> sp. nov.	0	26
Tenebrioninae	Scotobiini	<i>Scotobius</i>	<i>Scotobius punctatus</i>	13	69
		<i>Scotobius</i>	<i>Scotobius aucamahuidensis</i> sp. nov.	68	0

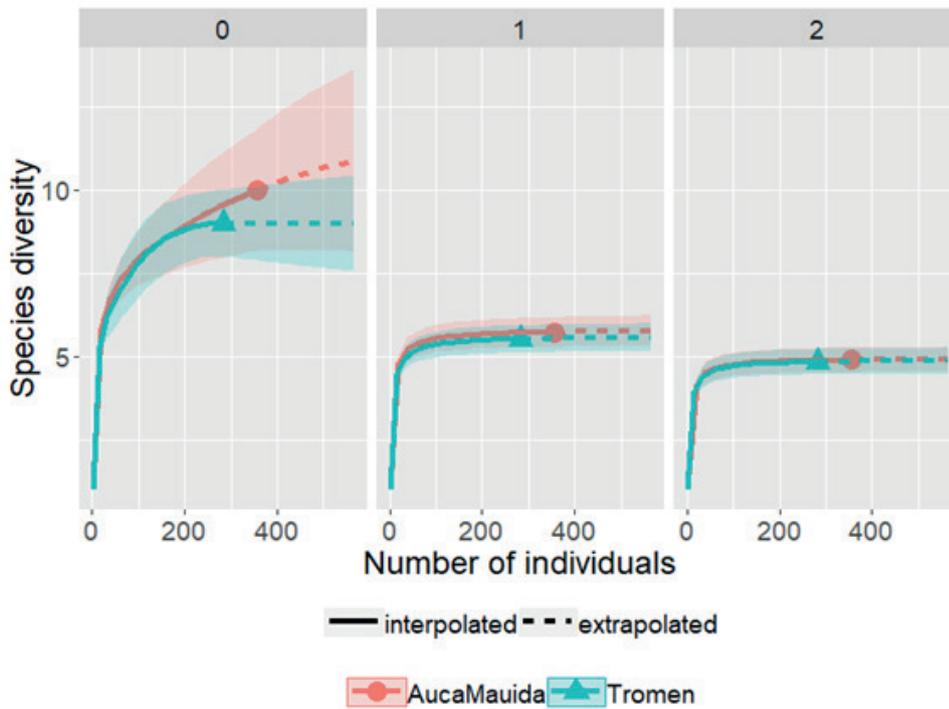


Figure 2. Species accumulation curves used to compare species diversity corrected by different number of individuals between volcanoes: 0) showing species richness; 1) showing Shannon index and 2) showing Simpson index.

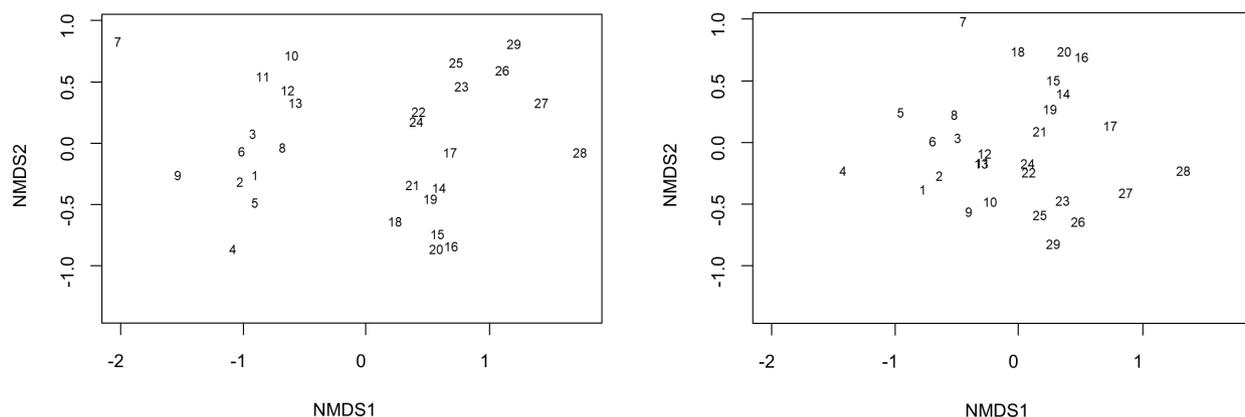


Figure 3. Non-metric multidimensional scaling (NMDS) ordination plots: based on a) species similarity and b) genus similarity. Auca Mahuida sites from 1 to 13, Tromen sites from 14 to 29.

found: *Scotobius aucamahuidensis* Silvestro sp. nov. (Tenebrioninae: Scotobiini) from Auca Mahuida, and *Psectrascelis tromensis* Flores sp. nov. (Pimeliinae: Nycteliini) from Tromen.

Descriptions of new species

Scotobius aucamahuidensis Silvestro sp. nov.
 ZooBank Life Science Identifier (LSID) - urn:lsid:zoobank.org:act:F0B40797-1E1C-4DC5-AC2B-C6761FD52B49

Diagnosis

Body dull, black to dark brown; clypeus and frons with strong round punctures; antennae short, surpassing midpoint of lateral margin of pronotum; pronotum wider than long, widest behind midpoint, with punctures of same size as clypeus punctures, separated by a distance smaller than one to three punctures diameter, and anterior angles produced; elytron oval, with wrinkles and punctures poorly marked, slightly smaller than pronotum punctures, not aligned in rows.

Scotobius aucamahuidensis superficially resembles *S. punctatus* Eschscholtz in pronotal aspect and punctures. It differs from *S. punctatus* which has the pronotum punctures separated by a distance smaller than one puncture diameter and elytron with nine longitudinal

rows of punctures of same size or smaller than pronotum punctures; intervals carina-shape slightly raised with small disperse punctures, turning backwards into rows of tubercles and converging postero-laterally.

Description

Length 11.1 – 13.8 mm (Figure 4). Body glabrous, black to dark reddish brown, dull.

Head. Labrum dark brown with round punctures slightly marked and disperse golden setae, anterior margin concave with thick golden setae. Clypeus and frons with strong round punctures, each with a central short seta; clypeal suture not covered by frons. Antennae short, surpassing midpoint of lateral margin of pronotum; antennomeres 2, 6 and 7 as long as wide, antennomere 3 longer than remaining, antennomeres 3 to 5 longer than wide, antennomeres 8 to 11 wider than long.

Thorax. Pronotum (Figure 5) concave, wider than long and widest behind midpoint, with punctures of same size as clypeus punctures, separated by a distance smaller than one to three punctures diameter; anterior margin concave, slightly narrower than posterior margin and anterior angles produced; lateral margin conspicuous (Figure 5), concave; posterior angles straight, not produced; posterior margin convex.

Elytron oval elongated (Figure 4), with punctures poorly marked, slightly smaller than pronotum punctures, distributed regularly; at lateral and posterior end with conical tubercles directed backward, without intervals carina-shape; pseudoepleuron occasionally with two rows of few sparse tubercles. Epipleuron conspicuous throughout, with conspicuous margin of equal width throughout.

Abdomen. Ventrites with poorly marked wrinkles and inconspicuous punctures, separated more than three times their diameter.

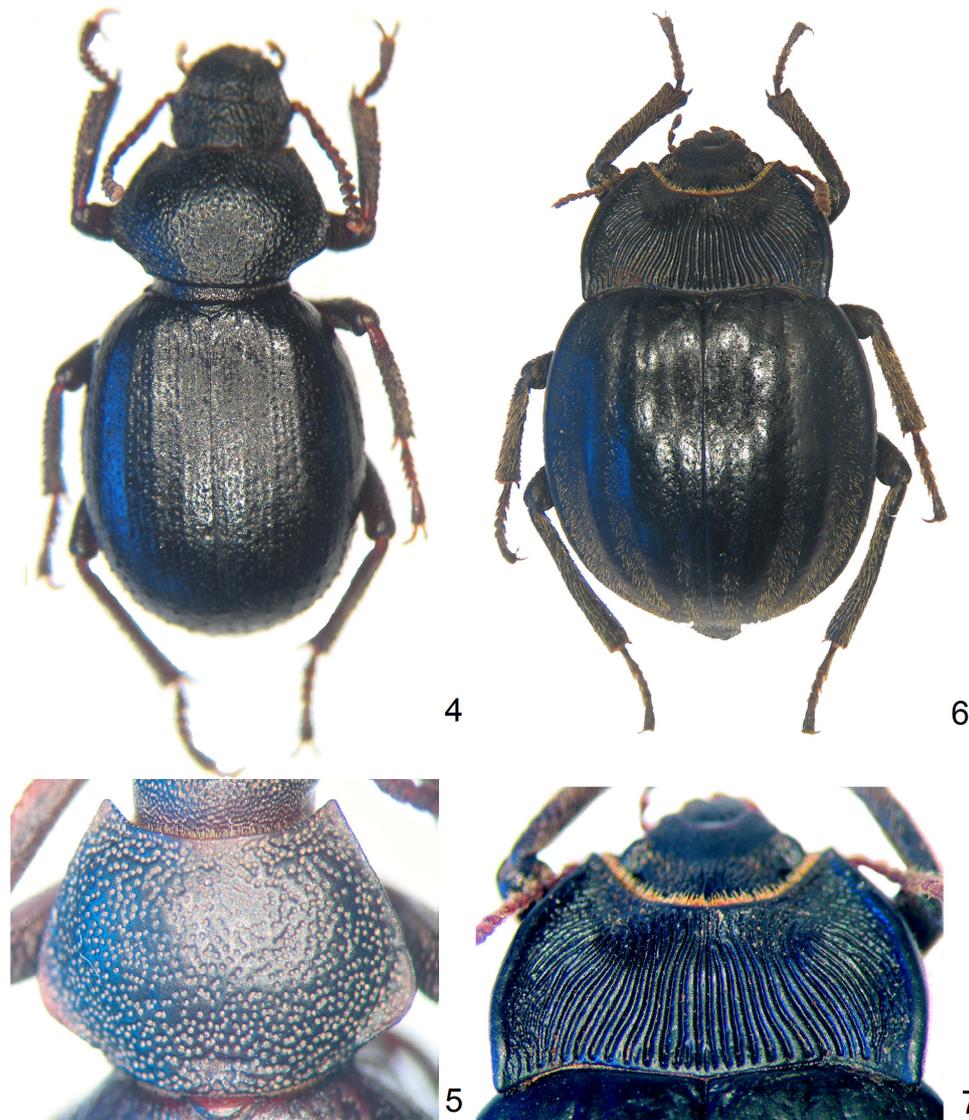
Legs punctate, each puncture with a short seta, metatibia straight at base, metafemoral-tibial articulation not reaching elytral apex.

Etymology

Its name is derived from the Auca Mahuida volcano (Natural Reserve, Neuquén province) in which all type specimens were collected.

Type material

Holotype, male: [Argentina, Neuquén Dto./ Añelo. Reserva Auca Mahuida/ 1913m. 2-12-XII-2016 / -37.73814, -68.90295 / G. Flores, R. Carrara,



Figures 4-7. *Scotobius aucamahuidensis* Silvestro sp. nov.: (4) habitus in dorsal view and (5) pronotum and *Psectrascelis tromensis* Flores sp. nov.: (6) habitus in dorsal view and (7) pronotum.

S. Roig] [*Scotobius / aucamahuidensis* sp. n. / HOLOTYPE male / Det. V. Silvestro 2018] (IADIZA). Allotype, female: with the same data as holotype (IADIZA). Paratypes: 17 with data [Argentina, Neuquén Dto./ Añelo. Reserva Auca Mahuida/ -37.7393, -68.9229, 2232m./ 12-22-XII-2015, Coll. S. Roig, R. Carrara, F. Campón, S. Lagos] (three males: 2 IADIZA, 1 FMNH, six females: 2 IADIZA, 1 MEKRB, 1 FMNH, 1 MACN, 1 MLPA, and 8 IADIZA without sexing); twelve paratypes with the same data as holotype (two females: 1 MACN, 1 MNNC; five males: 2 MACN, 2 MLPA, 1 MNNC, and five without sexing: 3 IADIZA, 1 NHMB, 1 HHNM); four paratypes: [Argentina, Neuquén Dto./ Añelo. Reserva Auca Mahuida/ 2212m, 2-12-XII-2016 / -37.73928, -68.92375 / S. Roig, G. Flores, R. Carrara] (one female MNNC, one male MEKRB and two without sexing IADIZA); two paratypes: [Argentina, Neuquén Dto./ Añelo. Reserva Auca Mahuida/ -37.7346, -68.9098, 1970 m / 12-22-XII-2015, R. Carrara/ S. Roig, S. Lagos, F. Campón] without sexing (IADIZA).

Remarks

Prior to this study, the genus *Scotobius* included 67 species / subspecies; these species have a high variability of shapes, sizes and structures (Silvestro 2018). Within the genus, *Scotobius aucamahuidensis* sp. nov. presents the morphological characters of the *Scotobius* species of the central Andean cordillera and pre-cordillera zones such as *S. punctatus* Eschscholtz 1831, *S. andrassyi* Kaszab 1969, and *S. obscurus* Kulzer 1955, among others. These species are characterized by lack of teeth in profemora and elytra without marked carinae.

Psectrascelis tromensis Flores sp. nov.

ZooBank Life Science Identifier (LSID) - urn:lsid:zoobank.org:act:520CEA45-5189-4B50-9CD3-44B00AB2BF4F

Diagnosis

Pronotum with longitudinal, parallel, thick wrinkles, with anterior margin broad, lateral margins thick and raised; epicanthus without tuft of setae; elytron with two thick, flat carinae with sparse punctures and intervals with abundant, small, not arranged punctures; epipleuron conspicuous throughout.

Psectrascelis tromensis sp. nov. superficially resembles *P. soniae* Guerrero & Vidal in elytral configuration, especially having two thick, flat glabrous carinae or with few short setae, with sparse punctures and intervals with abundant, small, not arranged punctures and golden setae. In *Psectrascelis tromensis* the pronotum has lateral margins raised, concave in anterior half, parallel in posterior half, with 20 or more longitudinal wrinkles occupying all the surface (Figure 7); in *P. soniae* the pronotum has lateral margins not raised, concave, surface with sparse punctures, lacking longitudinal wrinkles.

Description

Length 12.0–16.0 mm (Figure 6). Body, femora, and tibiae black, antennae, maxillary palpi, and tarsi brown or body, legs, antennae, and maxillary palpi brown; dorsal surface of elytra shiny and densely setose.

Head. Clypeus and frons with abundant long umbilicate setae, punctures uniformly distributed, separated by a distance of one puncture diameter; clypeal suture not marked, genoclypeal suture marked; frons with longitudinal, parallel wrinkles, formed by the fusion of punctures. Epicanthus and genae without tuft of setae. Antennae in male reaching 3/4 of lateral margin of pronotum, in female reaching a half of lateral margin of pronotum; with golden, short setae all along the surface of all antennomeres and long setae forming a ring transverse at midlength in antennomeres 3 to 11; antennomere 3 subrectangular, 4 to 10

subquadrate, 11 ovate; male: antennomeres 3, 4 and 11 longer than wide, 5 to 10 wider than long; female: antennomeres 3 to 6 and 11 longer than wide, 7 to 10 wider than long.

Thorax. Pronotum (Figure 7) with anterior and posterior angles acute; anterior margin broad, posterior margin bisinuate; lateral margins very thick, smooth, and raised, concave in anterior half, parallel in posterior half; pronotum widest at midpoint; disc flat and depressed in posterior half, lower than lateral margins, with longitudinal, thick wrinkles, 20 or more on midlength occupying all surface: in central quarters parallel, reaching anterior and posterior margin of pronotum, in lateral quarters oblique and joining together before anterior margin (Figure 7), with very short setae on wrinkles. Proepisternum not visible dorsally, with horizontal grooves and wrinkles not reaching lateral margin of pronotum, with short, dense setae on wrinkles. Prosternum arched, higher than mesosternum.

Elytron flat, with two thick, flat carinae equidistant between suture and lateral margin, glabrous or with few short setae, with sparse punctures (Figure 6); intervals wider than carinae with abundant, small, not arranged punctures and short, golden setae; lateral margin carina-shape, rounded; pseudopleuron with abundant punctures each bearing a seta, punctures of equal size on all elytron surface. Epipleuron conspicuous throughout, with edge, anterior margin not reaching elytral humeri and posterior angle of pronotum, texture similar to that of elytron, with abundant punctures each one bearing a seta, anterior quarter three times as width as posterior half.

Abdomen. Male smooth, female with small protuberances in sagittal medial line of visible sternites 1–4.

Legs with abundant long, golden setae. Ventral femoral surfaces densely setose; male

with distal half of metatibiae arcuate and expanded, 1.5 times as wide as proximal half, with short, golden setae forming a central oval velvet-like surface; female with metatibiae not arcuate nor expanded at apex.

Etymology

Its name is derived from the Tromen volcano (Natural Reserve, Neuquén province) in which all type specimens were collected.

Type material

Holotype, male: [Argentina, Neuquén/ Dto. Chos Malal, Parque Prov./ Tromen, Guardaparque, 2150m/ -37.110397, -70.080475 / 20.XII.2015, coll: S. Roig] [*Psectrascelis tromensis* sp. n. / HOLOTYPUS male / Det. G. Flores 2018] (IADIZA). Allotype, female: with the same data as holotype except date: 11.XII.2015 (IADIZA). Two paratypes males with the same data as holotype (IADIZA). One paratype female with the same data as allotype (IADIZA). Paratypes: [Argentina, Neuquén Dto. / Chos Malal, Reserva El Tromen / -37.1201, -70.072 2610m / 12-22.XII.2015, coll: S. Roig, / R. Carrara, F. Campón, S. Lagos] (one male, one female MACN); [Argentina, Neuquén Dto. / Chos Malal, Reserva El Tromen / C♀ Wayle 2560m, 2-12.XII.2016 / -37.06792, -70.12266 / G. Flores, R. Carrara, S. Roig] (eight females: 1 NHMB, 1 HHNM, 1 FMNH, 2 IADIZA, 1 MLPA, 1 MNNC, 1 MEKRB and three males: 1 FMNH, 1 MNNC, 1 MEKRB).

Remarks

The genus *Psectrascelis* comprises 81 species prior to this study (Flores 2007, Vidal & Guerrero 2007). With the description of *Psectrascelis tromensis* sp. nov. the number of species of the genus is 82, being the most diverse genus of Nycteliini (Flores 1997). *Psectrascelis tromensis* sp. nov. shares with the central Chilean species of the genus inhabiting regions V to VIII (*P. cinerea* Solier 1836, *P. arenaria* Germain 1855,

P. subcostata (Germain 1855), *P. similis* Kulzer 1954, *P. rojasi* Guerrero & Vidal 2007, *P. soniae* Guerrero & Vidal 2007, *P. aceitunoi* Guerrero & Vidal 2007, *P. rossoi* Vidal & Guerrero 2007, *P. elguetai* Guerrero & Vidal 2007) elytron with two thick carinae; instead, species of *Psectrascelis* inhabiting Patagonian steppe lack these carinae (*P. sulcicollis* Waterhouse 1841, *P. hirta* Kulzer 1954, *P. atra* Kulzer 1954, *P. punctipennis* Kulzer 1954, *P. lucida* Peña 1985, *P. latithorax* Peña 1985, *P. neuquenensis* Peña 1994). On the other hand, *Psectrascelis tromensis* sp. nov. shares with species of *Psectrascelis* inhabiting Patagonian steppe pronotum with longitudinal wrinkles occupying all the surface while the central Chilean species of the genus lack these longitudinal wrinkles on pronotum. *Psectrascelis tromensis* sp. nov. could be a representative of the genus of a generalized track using panbiogeographic approach that connect mesic areas in central Chile with arid Patagonian steppes in southern Argentina. This track is found in other genera of Pimeliinae and crosses the Andes between parallels 37°–41° South, where the mountain range presents low altitude (Flores & Pizarro-Araya 2006).

DISCUSSION

In this work we demonstrated that darkling beetles are successful organisms inhabiting arid environments not only in lowlands (Cheli et al. 2010, Carrara & Flores 2015) but also in mountains. Considering tenebrionid species found in both volcanoes we can notice that all of them showed several adaptations to survive to dry conditions. Following the different conditions of adaptations to aridity proposed by Sánchez-Piñero & Aalbu (2002), we can identify that 81.25 % of these species are most highly adapted because have elytra fused along

the midline and abdomen, subelytral cavity, absence of defensive glands and wingless; 12.50% (*Scotobius punctatus* and *Scotobius aucamahuidensis* sp. nov.) are highly adapted because are characterized as the previous group but with the presence of defensive glands; and a 12.50% (*Achanius* sp. and *Nyctopetus argentinus*) less adapted to aridity because they are characterized by the presence of the second pair of wings and elytra not fused along the midline and abdomen, nor subelytral cavity, and loss of defensive glands. These results can be compared with those of Sánchez-Piñero & Aalbu (2002) and Carrara et al. (2011a) who suggested that the environmental water stress conditions the spatial occurrence of tenebrionid beetles, so that only species that have developed strategies against water loss can survive in these environments. An evidence that supports this affirmation is the low number of species less adapted to aridity found in these samplings because they experience a high susceptibility to water loss (Sánchez-Piñero & Aalbu 2002). But, how they survive to high altitudinal conditions of low temperature and hypoxia? This question arises because temperature, pressure of oxygen and air density diminishes as altitude increases, which generates new physiological challenges for species thermoregulation and respiration (Dillon et al. 2006). Probably, the explanation resides in the adaptations developed to survive to arid conditions: for example, it was suggested that to deal with low temperatures in thermo-regulatory processes are strongly important insect size, shape, and behavior to maximize heat transfer processes (Dillon et al. 2006). In this sense, it is widely recognized that tenebrionids can change their habits to avoid or meet different climatic conditions, as well as control internal medium according with their body size (Zachariassen 1996, Cloudsley-Thompson 2001). For other side, it was suggested

that to deal with low pressure of oxygen insects may alter respiratory system or modify corporeal characteristics that ensure oxygen delivery (Dillon et al. 2006). In this sense, it has been reported that tenebrionids are able to reduce respiration and change their morphology under extreme environmental conditions (Cloudsley-Thompson 2001). Probably, the loss of flight capacity can be a morphological modification that promotes oxygen delivery, so that flight is a compromise in insect that inhabit high altitudes because is strongly dependent of high level of oxygen (Dillon et al. 2006).

Contrary to our first prediction, species richness did not differ between volcanoes, which implies that the number of biogeographic provinces does not influence tenebrionid diversity. This result contrast with that of Carrara et al. (2011a), who found that ecotonal environments of Monte and Patagonian biogeographic provinces positively influenced the coexistence of more species of tenebrionid in lowlands. Thus, our finding indicates reduced colonization capabilities of species that inhabit the Monte to higher altitudinal ecotonal environments in Auca Mahuida volcano. According with distribution patterns of collected tenebrionids in the volcanoes, it was noticed that species distributed in Monte also are distributed in Patagonian steppe (e.g. *Epipedonota cristallisata* (Lacordaire 1830), *Mitragenius araneiformis* Curtis 1845, *Praocis argentina* Kulzer 1962, *Achanius* sp., *Nyctelia cicatriculata* Berg 1889), and none species is distributed mainly in Monte (Flores 1999, Flores & Vidal 2001, data IADIZA collection). This can be related to the existence of hard environmental constraints that avoid to species distributed in Monte inhabit areas with lower temperature and hypoxia, to a high interspecific competition or both. Taking into account our second prediction, results showed a relatively low similarity at specific level between

tenebrionid community of both volcanoes, indicating a strong distance effect influencing different communities composition. This outcome in part can be related with process of isolation that has promoted speciation by interrupting gene flow among populations (Carrara & Flores 2013). As evidence of this, Roig-Juñent et al. (2008) sustained that for carabid beetles that inhabit mountains from Payunia, speciation processes were determined by successive past climatic changes that fragmented and isolated populations at higher altitudes. Probably, some tenebrionid species experience the same processes because a 50% of genera were shared between communities. That is, an ancestor widely distributed that suffered distribution range contractions by climatic changes, isolation of populations in mountaintops and speciation by gene flow interruption caused for low vagility (Kergoat et al. 2014). Furthermore, the two new species described in this work, added to other three that are under study, whose distribution is only known from these volcanoes, also suggest the importance of these mountains in speciation processes.

Finally, our findings have strong implications to be considered in biodiversity conservation because by first time we provide an exhaustive list of species that inhabit entirely arid high mountain environments in southern South America. From this list, we were able to describe two new microendemic species, *Scotobius aucamahuidensis* sp. nov and *Psectrascelis tromensis* sp. nov which have a high extinction risk because their limited geographic distributions (Myers 2003). In addition, according to the Intergovernmental Panel on Climate Change (IPCC), climate change is expected to affect specifically narrowly-distributed species that inhabit mountain areas (Gitay et al. 2002). This is because future warming in these regions is expected to be two to three times higher than

that recorded during the 20th century (Nogués-Bravo et al. 2007); thus, distributional ranges of mountain species should shift upwards and even shrink in some cases, especially for species that inhabit mountaintops, which will result in increased probability of extinction (Walther et al. 2005). So that, we strongly encourage that the species found in these volcanoes should be considered in further studies to assess how the effect of global climate change will influence their extinction risk.

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Rodolfo Carrara, wrote most of the original draft of the paper, performed data analysis and its interpretation. Rodolfo Carrara, Germán H. Cheli, Sergio A. Roig-Juñent and Gustavo E. Flores made substantial contributions to conception, design, acquisition of the data. Gustavo E. Flores and Violeta A. Silvestro performed species identification and the description of new species. Finally, all authors revised the article critically for important intellectual content and approved the manuscript version submitted to publishing.

