

**Supplementary Material 2.** Morphological diagnoses and additional information for lucanid taxa present in Colombia.

**Lucanidae Latreille, 1804 (Coleoptera: Scarabaeoidea)**

**Composition and Distribution across the Americas.** There are 270 species in 82 genera recorded for the Americas. Across this range, Brazil is the country with the most studied diversity, represented by 76 species in 14 genera, followed by Peru (42/13) and Ecuador (22/6). There are 19 lucanid species recorded from Colombia in five genera (Cáceres *et al.* in review), most of them associated with mountain forests.

**Diagnosis.** Body strongly flattened to slightly convex; ventral surfaces of body (excluding head) strongly punctate. Vestiture variable, from conspicuous to apparently glabrous; with simple to dendritic setae. Head, transverse, anteriorly emarginate. Clypeus fused to frons, sometimes separated from labrum. Labrum variable in shape, projected ventrally between mandibles, or anteriorly forming an oblique angle. In major males, mandibles strongly developed, usually two times longer than head length or more in major males, with stronger teeth, reduced in small specimens; female mandibles reduced, often with acuminate apex, asymmetric in several taxa. Antennae non-geniculate to geniculate. Temporal process frequently present. Ocular canthus present or absent, complete or only covering anterior portion of eyes. Elytral surface often striate, sometimes with longitudinal costae. Prosternal process slender to broad and strongly developed. Metaventrite strongly convex to somewhat flattened; discrimen usually present as a complete to incomplete groove. Abdomen with five or six visible ventrites. Male aedeagus symmetric, with median lobe variable in shape, basally articulated with a sclerotized dorsal cross-bar at base; internal sac evertible to permanently everted. Female genitalia with elongate styli; proximal and distal coxites continuous to

partially separated, sometimes with distal coxites strongly reduced, producing a narrowed apex; accessory gland conspicuous; spermatheca sub-cylindrical.

**Bibliographic resources.** Catalogs: Van Roon (1910), Didier and Séguy (1953), Benesh (1960), Maes (1992), Krajcik (2001, 2003), Paulsen (2019). Faunistic studies in South America: Luederwaldt (1935), Paulsen (2010). Additional references: Holloway (2007; morphology), Grossi and Paulsen (2009; taxonomic notes), Kim and Farrell (2015; molecular phylogeny).

**Remarks.** Lucanidae is considered one of the early-divergent lineages within Scarabaeoidea (Iablokoff-Khnzorian 1977, Howden 1982, Lawrence and Newton 1982, Scholtz 1990, Browne and Scholtz 1995, Smith *et al.* 2006, Lawrence *et al.* 2011, Ahrens *et al.* 2014, Gunter *et al.* 2016, Zhang *et al.* 2018, Cai *et al.* 2022), with its monophyly well-supported, the most important challenge for current researchers is working on proposing a consistent classification system, as there are few recognized tribes but according to recent phylogenetic analysis suggest the existence of several taxa which need validation. In Colombia, efforts must focus on conducting field collections to get a better understanding of the diversity and life history of stag beetles in the country.

### **Syndesinae MacLeay, 1819 (Scarabaeoidea: Lucanidae)**

**Global composition and distribution.** Together with Lampriminae, Syndesinae is one of the least diversified subfamilies of stag beetles. There are only four genera currently included in Syndesinae: *Ceruchus* MacLeay, 1819 and *Sinodendron* Hellwig, 1792 for the Holarctic region, *Syndesus* MacLeay, 1819 for the Asutrasian region, and *Psilodon* Perty, 1830 as the only South American representative.

**Diagnosis.** Head transverse, anterior margin strongly to weakly emarginate; eyes conspicuous, large, nearly as long as lateral margins of head, inner margins reaching frons;

ocular canthus absent; antennae non-geniculate with supra-antennal projections covering antennal insertion (Figs. 1, 4, 5 in Onore *et al.* 2011). Male mandibles slightly to strongly curved inwards, reduced in *Sinodendron* and somewhat flattened in *Ceruchus*. Female mandibles reduced, often with acuminate apex. Pronotum convex to somewhat flattened, slightly to strongly projected anteriorly, with a conspicuous pronotal process (Fig. 3 in Grossi and Aguiar 2014; Figure for *Sinodendron* in Paulsen 2019: <https://unsm-ento.unl.edu/Guide/Scarabaeoidea/Lucanidae/SYN/SINO/Sinodendron.html>) except in *Ceruchus*. Elytral with well-defined striae in Syndesini and *Sinodendron*; *Ceruchus* with fine to moderate punctation. Male aedeagus usually symmetric with evertible internal sac. Female genitalia with narrowed distal coxite; styli elongate, setose.

**Remarks.** The only syndesine taxon recorded for South America is *Psilodon*, frequently considered in most catalogs as a synonym of the Australasian genus *Syndesus*. These two genera are extremely under-represented in collections, and updated data for all species is very scarce. These two genera represent the tribe Syndesini, which has never been subject to phylogenetic analysis, as the only syndesine genera included in recent phylogenies are *Ceruchus* and *Sinodendron*. Given the strong morphological and distributional differences between the Holarctic and Austral Syndesinae, the subfamily needs a cladistic and taxonomic treatment in order to clarify its position within Lucanidae.

***Psilodon* Perty, 1830 (Lucanidae: Syndesinae: Syndesini)**

**Global composition and distribution.** *Psilodon* is the only known Syndesine taxon described for the Neotropical region (Brazil, Bolivia, Colombia, Ecuador).

**Diagnosis.** Body color brown to black, with dark-red tones in most species, sometimes with pale and dark specimens in the same species. Head anteriorly emarginate, dorsally with v-shaped excavation along frons, extended anteriorly (Figs. 1, 4, 5, 7 in Onore *et al.* 2011);

vertex convex, concealed under pronotal projection. Labrum with convex and rounded apex, projected between mandibles. Mentum subtrapezoidal. Gula conspicuous and convex, visible in lateral view. Antennae non-geniculate, with six or seven lamellae. Eyes conspicuous, almost as long as sides of head. Mandibles of males with one median tooth (alpha), sometimes located close to apex forming a concave region (in Andean species), a basal lobe (beta) and an internal tooth (gamma) (Fig. 1 in Grossi and Aguiar 2014); females with narrow mandibles, slightly enlarged dorsally, with no teeth, instead a dorsal longitudinal tooth-like surface from base to apex (Fig. 3 in Onore *et al.* 2011). Pronotum projected anteriorly, with conspicuous pronotal tubercle; female pronotum less projected with reduced pronotal tubercle; surface with longitudinal medial groove, usually complete, sometimes interrupting female tubercle, punctation variable, from moderate to coarse, sometimes with superficial excavations and lateral constrictions. Elytra with well-defined striae and interstitial costae; humeri not-striate, with tooth-like lateral projections (Figs. 2, 5, 10 in Grossi and Aguiar 2014), which are absent in some Andean species. Protibiae distally enlarged, with several strong teeth and tooth-like projections among teeth (Figs. 2, 4, 5, 10 in Grossi and Aguiar 2014); meso- and metatibiae with two to several acute teeth and tooth-like projections, setose, enlarged at apex. Male aedeagus with phallobase subtriangular, with strong to somewhat fine anterior constriction, also with subparallel to slightly convex sides; median lobe enlarged basally except in Andean species. Female genitalia narrowed distally; apex of styli somewhat divergent, internally forming an oblique angle, narrowed apically, surface strongly punctate with conspicuous setae; anterior and posterior coxites continuous, proximally abruptly narrowed.

**Bibliographic resources.** Grossi and Aguiar (2014) provides a species identification key.

**Remarks.** Extremely similar to the Australasian genus *Syndesus* MacLeay, 1819. *Psilodon* is probably the South American stag beetle genus with the widest distribution. *Psilodon* species

in Colombia are considered very rare to observe and poorly referenced in the field and national collections. *Psilodon aequinoctiale* is known from forested areas between 1500 and 1800 m.a.s.l. at the Western Cordillera, in the department of Huila (Moreno and Bonilla 1994). The second Colombian species, *P. paschoali* is also distributed in the Western Cordillera, with records at the Andean forests of the “Serranía de los Yariguíes”, at 2200 m. The specimen from the original description was collected using artificial white light and is only known from this locality (Pardo-L and Ríos-M 2010). The aspects of the life cycle and the phenology of these species remain unknown, although it is presumed that the development of their larvae occurs on decomposing logs.

#### **Lucaninae Latreille, 1804 (Scarabaeoidea: Lucanidae)**

**Diagnosis.** Strong sexual dimorphism, mainly represented by the strongly developed mandibles in major males. Body flattened. Head subquadrate. Clypeus fused to frons. Eyes reduced, 0.5-times or less than lateral margins of head. Antennae geniculate, with variable number of lamellae. Pronotal disc usually with distinct longitudinal groove; margins carinate, except for a short portion anteriorly. Scutellar shield exposed. Elytra non-striate, with variable size punctures. Prosternal process distinct. Discrimen as longitudinal groove along metaventricle. Median lobe of aedeagus with permanently everted sac. Females with stronger punctuation and more conspicuous vestiture than males. In ventral view, female genitalia with elongate styli, truncate at apex; distal and proximal coxites distinctly separated, somewhat narrowed and convex.

**Remarks.** Lucaninae stag beetles are the most representative and diverse within the family. They show the characteristic morphology of stag beetles, and are the most represented among scientific and non-scientific collections. Despite its importance, the classification at the suprageneric level lacks consensus, with only four accepted tribes (Bouchard *et al.* 2011), but

with additional well-supported tribal-level clades based on recent phylogenetic analyses (Kim and Farrell 2015).

***Sphaenognathus* Buquet, 1838 (Lucaninae: Chiasognathini)**

**Global composition and distribution.** Tropical Andes with occurrences in Bolivia, Peru, Ecuador, Colombia, and Venezuela.

**Diagnosis.** Body frequently large (2–7 cm), with conspicuous metallic reflections, usually with highly conspicuous setae on head, pronotum, and elytra. Antennal club with six to seven lamellae. Anterior margin of head weakly emarginate; antero-lateral angles with supra-antennal projection usually acuminate, covering base of scape. Male mandibles curved inwards, narrowed apically; apex acuminate, serrate, at least twice longer than head. Females with reduced and broader mandibles, somewhat flattened, serrate. Ocular canthus complete. Pronotum subtrapezoidal, wider in females; surface strongly punctate in males. Elytral surface non-striate, rugose, sometimes with longitudinal smooth spots. Protibiae distinctly enlarged in females. Phallobase of male aedeagus subtriangular; median lobe wide, in ventral view, almost trapezoidal with long and slender everted internal sac. Female genitalia with shortened styli, rounded apically, sometimes inserted before apex of distal coxite.

**Bibliographic resources.** Besides original descriptions, the only reference work including all species was provided by Chalumeau and Brochier (2007). Notes on life history and immature stages description: Onore (1994).

**Remarks.** Most Colombian species of *Sphaenognathus* are distributed along cloud forest landscapes, with a broad altitudinal range between 2000 m to 3900 m, at High Andean mountain forests and Páramos (Ríos and Salazar 2005, Salazar *et al.* 2010). However, some records of *Sphaenognathus* species come from areas of sub-Andean forest at 1700 m.a.s.l. *Sphaenognathus* is the genus with the highest number of occurrences and is also the most

represented in national collections. In spite of this, it has not been subject to recent studies, and the entire genus needs taxonomic revision in order to clarify species limits and recognize species accurate distributional ranges.

***Aegognathus* Leuthner, 1883 (Lucaninae: Sclerostomini)**

**Global composition and distribution.** *Aegognathus* is endemic from South America, with most species distributed along the Tropical Andes (Peru, Ecuador, and Colombia). There are three species distributed across the Brazilian Atlantic Forest.

**Diagnosis.** Body from entirely black to reddish and bluish with black spots. Ventral surfaces with punctation variable in size, almost uniform along prosternum, meso and metaventrite. Head and pronotal surface shagreened. Male head transverse and emarginate; ocular canthus covering anterior third of eye; mandibles strongly curved inwards, with one median tooth; mandibles straight in *Aegognathus aguire* Arnaud and Bomans, 2007, in that case head wider than elytra. Pronotum with longitudinal groove on disc, anterior margin with continuous fringe of setae. Elytral surface with coarse, dense to contiguous punctures. Abdominal ventrites laterally carinate. Genitalia mostly subtriangular, sometimes elongated and cylindrical, with long everted sac, flat and short in *A. dulima*; dorsal cross bar X-shaped. Females similar to males, except for darker color, reduced head; mandibles short, asymmetric, with acuminate apex and one laminar tooth; body surface with coarse, dense to contiguous punctures.

**Bibliographic resources.** Taxonomic revisions: Weinreich (1963); Cáceres and Grossi (2023). Original description for Colombian species: van de Poll (1886); Cáceres *et al.* (2019), including identification key for the Andean species. Recent records for *A. leuthneri*: Bartolozzi *et al.* (1991).

**Remarks.** In Colombia, this group of beetles is extremely rare. The immature stages are unknown, and the detection of adults is very rare, although it is known that they are attracted by artificial lights and live in Andean cloud forest areas (Cáceres *et al.* 2019). The first species described for Colombia *Aegognathus leuthneri* lacked a specific locality, and given difficulties accessing type material, it is unclear if this is actually a Colombian species, as the most recent records are from Ecuador.

***Cantharolethrus* Thomson, 1862 (Lucaninae: Sclerostomini)**

**Global composition and distribution.** The genus is composed of five species and three subspecies. It is distributed in Central America (Costa Rica, Nicaragua, and Panama) and South America, with records in Peru, Ecuador, and Colombia.

**Diagnosis.** Body length 35–45 mm, entirely black in color. Male body with finely punctate surface, without conspicuous setae. Females with strong punctation and irregular surface on head and pronotum. Male head subtrapezoidal; anterior margin of head as wide as posterior margin of pronotum. Head vertex and frons with v-shaped median depression. Antennal club with three lamellae, with serrate flagellum. Male mandibles strongly developed, 2.0 times longer than head length, apex oriented downwards, bifurcate, sometimes with median strong tooth. Female mandibles reduced, asymmetric, with acuminate apex. Ocular canthus only covering anterior portion of eye. Elytra non-striate, flattened distally. Male aedeagus with subtriangular phallobase; median lobe basally enlarged, with median constriction and flattened internal sac. Female genitalia with subparallel coxites; styli truncate at apex, with fine lateral projection.

**Bibliographic resources.** For Colombian occurrences of species and subspecies: Buquet (1843), Parry (1875), Pardo-L (2017).



**Remarks.** To date, the species of *Cantharolethrus* in Colombia are the only ones known from lowland humid forest habitats of the biogeographical Chocó region, from 800 m.a.s.l. to sub-Andean forest areas between 1300 and 1700 m.a.s.l., and in areas such as the Saladito (Valle del Cauca) and the Calima-Darién region in the Western Cordillera, in cloud forests above 2000 m.a.s.l. (Ríos and Salazar 2005). These beetles are usually found alive and eventually congregate on the vegetation in heavily wooded areas, related to decomposing logs and eventually attracted by artificial lights (Ríos and Salazar 2005). For Colombia, the known records of *C. luxerii luxerii* are known from the Western Cordillera, especially towards the Pacific slope in the Chocó biogeographic region. The known records of localities in other regions such as the departments of Huila and Cundinamarca, could be related to labels with erroneous data in relation to the illegal trade of these species.

***Onorelucanus* Bartolozzi & Bomans, 1989 (Lucaninae: Sclerostomini)**

**Global composition and distribution.** The genus is mainly distributed along the Tropical Andes, with four species recorded from Peru, five from Ecuador and only one from Colombia.

**Diagnosis.** Body color variable but often with blackish tones on head and pronotum, with reddish to bluish reflections along elytra. Head subquadrate to somewhat trapezoidal, anteriorly slightly emarginate. Vertex and frons with V-shaped depression. Ocular canthus covering anterior portion of eyes. Male mandibles from slightly to strongly curved, truncate to somewhat acuminate at apex, with variable number of teeth projected internally or directed upwards. Females with reduced mandibles, asymmetric, with acuminate apex. Body surface apparently smooth in males, finely punctate, with minute setae; females with stronger punctation. Elytra striate, with fine to large punctation, dense to contiguous. Male aedeagus with a strong constriction between proximal and distal phallobase; median lobe reduced,

quadrate; internal sac slightly enlarged basally, nearly uniformly wide until apex. Female with subparallel coxites; distal coxite somewhat enlarged apically, with subquadrate styli.

**Bibliographic resources.** For Colombian species: Westwood (1875). Recent taxonomic treatments: Grossi and Paulsen (2009). Taxonomic revisions of South American Stag Beetles: Weinreich (1960).

**Remarks.** There is only one specimen known from Colombia, and the locality reported in the original description is not clear, but this record is believed to come from the Boyacá Department. With no recent collections, the only information regarding this species is from Ecuador (Fukinuki 2004, Grossi and Paulsen 2009). There is little information for most species. Its identification is difficult due to the lack of reference material and available males for most species, making it difficult to distinguish between species given the extremely high resemblance among *Onorelucanus* females.

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