

## Two New Species of Sucking Lice (Phthiraptera: Anoplura: Polyplacidae) From Endangered, Hibernating Lemurs (Primates: Cheirogaleidae)

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### Abstract

*Lemurpediculus robbinsi* sp. nov. is described from Crossley's dwarf lemur, *Cheirogaleus crossleyi* A. Grandidier, and *Lemurpediculus claytoni* sp. nov. is described from Sibree's dwarf lemur, *Cheirogaleus sibreei* Forsyth Major, from Madagascar. Both sexes of each new louse species are illustrated and distinguished from the two previously known species of *Lemurpediculus*: *L. verruculosus* (Ward) and *L. petterorum* Paulian. With the addition of two new species to the genus, an amended description of *Lemurpediculus* is provided. The two hosts of the new louse species are morphologically similar, endangered, obligately hibernating lemurs. These two species of lemurs are sometimes sympatric in rainforests in eastern Madagascar. Despite the morphological similarity of the two host species, their lice are morphologically distinct and are easiest to identify based on the shape of the subgenital plate of the female and the shape of the genitalia in the male. Both new species of lice should be considered to be endangered because their hosts are endangered. It is not known if either of the new species of lice are vectors of pathogens or parasites to their hosts.

**Key words:** Phthiraptera, Anoplura, new species, dwarf lemurs, Madagascar

The dwarf and mouse lemurs of Madagascar (family Cheirogaleidae) are small-bodied nocturnal lemurs, and include the smallest primates in the world (Dammhahn and Kappeler 2005). They are unique in that they are heterothermic (i.e., use torpor and hibernation), with some mouse lemurs undergoing daily torpor, prolonged torpor, or weeks-long hibernation, whereas all species of dwarf lemurs are obligate hibernators (Dausmann et al. 2004, Kobbe et al. 2011, Blanco et al. 2013). Ectoparasites of cheirogaleids are inadequately known (Blanco et al. 2013, Zohdy and Durden 2016), and sucking lice (Phthiraptera: Anoplura) have been described from only one of the >30 species of cheirogaleids currently recognized (Lei et al. 2014, Hotaling et al. 2016). The single described species, *Lemurpediculus verruculosus* (Ward), is an ectoparasite of the eastern mouse lemur, *Microcebus rufus* É. Geoffroy, as documented by Durden et al. (2010). Another species, *Lemurpediculus petterorum* Paulian, parasitizes a different species of lemur which was stated to probably be *Lepilemur mustelinus* I. Geoffroy by Paulian (1958). Sucking lice are often host specific (Durden and Musser 1994), and because few lemur species have been sampled for ectoparasites, there are probably additional undescribed species of *Lemurpediculus* associated with other species of cheirogaleids. In this paper, we describe two new species of

*Lemurpediculus* from endangered cheirogaleids known from rain forests in eastern Madagascar, one from Crossley's dwarf lemur, *Cheirogaleus crossleyi* A. Grandidier, the other from Sibree's dwarf lemur, *Cheirogaleus sibreei* Forsyth Major.

The sucking louse genus *Lemurpediculus* is assigned to the anopluran family Polyplacidae because its members have five-segmented antennae, no notal pit on the thorax, small forelegs with a small terminal tibio-tarsal claw, large subequal mid and hindlegs each with a robust tibio-tarsal claw, and six spiracles on each side of the abdomen (Kim and Ludwig 1978). The genus *Lemurpediculus* was erected by Paulian (1958) to include *Lemurpediculus petterorum* Paulian, 1958 and *L. verruculosus* which Paulian (1958) reassigned from *Lemurphthirus* to *Lemurpediculus*. Paulian (1958) diagnosed members of the genus *Lemurpediculus* as ectoparasites of nocturnal lemurs and included the following characters (additional to characters for Polyplacidae), translated from French, in his description of the genus: body elongate; head oval—well separated from thorax and longer than wide; antennae not modified in males as secondary sexual characters; a pair of long setae immediately posterior to the thoracic sternal plate, tergites and paratergites absent—except for a single tergite on the penultimate abdominal segment of females; abdomen with a row of setae on each segment dorsally and ventrally;

abdominal spiracles annulated and present on segments 3 to 8; female abdomen wide and obtusely truncate posteriorly with a patch of setae on each side of the last segment; male abdomen narrower and lacking a patch of setae on each side of the last segment; female genital plate consisting of two broad conjoined sections— anterior section with or without two membranous lacunae; abundant setae posterior to female subgenital plate and a transverse sclerite present posterior to these setae; male genitalia with spindle-like median lobe longer than the robust parameres; male genitalia pointed apically (anteriorly) somewhat like pincers of an earwig.

The objective of this study is to provide an updated (amended) description of the genus *Lemurpediculus* using currently accepted morphological characters for Anoplura and to describe two new species, effectively doubling the number of species assigned to this genus.

## Materials and Methods

Lice were collected from live-trapped dwarf lemurs. To capture dwarf lemurs, Tomahawk traps were baited with fermented pieces of banana set 3–10 m high at 17:00. Traps were checked the following morning at 5:00 and all captured dwarf lemurs were taken to the campsite for data collection. At the campsite, dwarf lemurs were sexed, weighed, measured, and checked for ectoparasites. Lice were stored in 70% ethanol in individually labelled vials. All lemurs were released at their capture site following collection of data and ectoparasites. Research protocols complied with those of the Institutional Animal Care and Use Committee in the USA (26-17-03 and 2010-0069, University of Massachusetts, Amherst; 11-06-03, Dartmouth College; A040-12-02, Duke University) and research was conducted in accordance with permits granted by the Malagasy government (233/07/MINENV.EF/SG/DGEF/DPSAP/SSE; 202/11 and 227/13/MEF/SG/DGF/DCB.SAP/SCB).

Lice selected for detailed examination were cleared in 10% potassium hydroxide for ~24 h, rinsed in distilled water, dehydrated through an ethanol series, rinsed in xylene and then slide mounted in Canada balsam following standard techniques (Durden et al. 2010). Slide-mounted lice were examined at high magnification under phase-contrast using an Olympus BH-2 microscope (Olympus Corporation of the Americas, Center Valley, PA). Drawings of diagnostic morphological features were made from specimens examined at 100×–400×. Specimen measurements were made using a calibrated graticule fitted into a microscope eyepiece. Stacked photographic images of whole specimens of primary types of both sexes for each new species were prepared using a Visionary Digital K2/SC long-distance microscope (Infinity Photo-Optical Company, Boulder, CO).

Descriptive format for the new species follows Durden et al. (2010) and names and abbreviations of setae and morphological structures follow Kim and Ludwig (1978). Names of setae and certain structures are spelled out in full at first mention (with the abbreviation listed parenthetically) and then abbreviated when subsequently mentioned. Holotypes and Allotypes of both new species of lice are deposited in the U.S. National Museum of Natural History (NMNH) (Smithsonian Institution), Department of Entomology, Washington DC.

Lemur taxonomy and common names used in this paper follow Groves (2005).

## Nomenclature

This paper and the nomenclatural acts it contains have been registered in Zoobank ([www.zoobank.org](http://www.zoobank.org)), the official register of the International Commission on Zoological Nomenclature. The LSID (Life Science Identifier) number of the publication is: urn:lsid:zoobank.org:pub:E991375A-53C7-40A0-A338-B99FB4CA0126

## Results

### Amended Description of *Lemurpediculus*

With standardization of terminology for anopluran morphology (Kim and Ludwig 1978) and a doubling of the number of species assigned to this genus, our amended description of *Lemurpediculus* is as follows (characters diagnostic for the family Polyplacidae are not repeated here):

Head, thorax, and abdomen lightly sclerotized. Head suboval; antennae unmodified in males. Thorax slightly wider than head and elongate with distinctly separated coxae. Thoracic sternal plate extended either anteriorly or posteriorly, with pair of long setae immediately posterior to thoracic sternal plate, sometimes borne on small sclerite. Abdomen wider than thorax, lacking paratergites, tergites and sternites—except for ventral subgenital plate in both sexes, small terminal transverse sclerite in female and curved tergite on penultimate segment in female. Row of central setae on all abdominal segments dorsally and ventrally although some setae on terminal segments are small. Annulated spiracles present on abdominal segments 3–8. Female abdomen terminally broad; male abdomen more fusiform. Gonopods VIII and IX indistinct in female with more or less contiguous patch of setae associated with both gonopods combined. Female subgenital plate well sclerotized and divided into two distinct large sections joined by central stalk; lateral arms of two sections separated (in *L. verruculosus*, *L. robbinsi* sp. nov., and *L. claytoni* sp. nov.) or joined (in *L. petterorum*). Ventral transverse sclerite present in female posterior to vulvar fimbriae. Male genitalia with long basal apodeme, robust parameres, and curved anterior endomere.

### *Lemurpediculus robbinsi* sp. nov. (Figs. 1 and 2)

#### Male (Figs. 1A and 2A, B)

(urn:lsid:zoobank.org:act:6235E5F9-E29F-4C3E-8F82-34B5D99EE8B8)

Total body length: 0.99–1.16 mm; mean, 1.09 mm ( $n = 4$ ). Head, thorax, and abdomen lightly sclerotized.

Head: More heavily sclerotized along anterior margin; longer than broad with squarish, slightly convex anterior margin. Maximum head width, 0.150–0.163 mm (mean, 0.17 mm,  $n = 4$ ). One long Dorsal Principal Head Seta (DPHS), one small Dorsal Accessory Head Seta (DAcHS) anteromedial to DPHS, one Dorsal Posterior Central Head Seta (DPoCHS), two to three Dorsal Preantennal Head Setae (DPaHS), two Sutural Head Setae (SHS), three Dorsal Marginal Head Setae (DMHS), three to four Apical Head Setae (ApHS), and one fairly large Ventral Preantennal Head Seta (VPaHS) on each side. Antennae five-segmented with basal segment wider than long and much larger than second segment; fourth segment slightly extended posterolaterally.

Thorax: Longer than wide, slightly wider than head. Maximum thorax width, 0.193–0.228 mm (mean, 0.210,  $n=4$ ). Thoracic sternal plate (Fig. 2A) lightly sclerotized, with anterior extension and partially undulating lateral margins; tiny sclerite bearing two long setae immediately posterior to thoracic sternal plate. Dorsal Principal Thoracic Seta (DPTS) length 0.117–0.130 mm, mean 0.121 mm ( $n=7$ ); no Dorsal Mesothoracic Setae (DMsS); mesothoracic spiracle maximum diameter 0.028–0.033 mm, mean 0.031 mm ( $n=7$ ). Legs with subtriangular coxae; forelegs each terminating in small tibio-tarsal claw; mid and hindlegs each terminating in large, robust tibio-tarsal claw, subequal in size.

Abdomen: Wider than thorax. Maximum abdomen width, 0.363–0.485 mm (mean, 0.387 mm,  $n=4$ ). Six annulated spiracles on each side. Paratergal plates, tergites, and sternites absent. One row of two long Dorsal Central Abdominal Setae (DCAS) anteriorly, followed by seven rows of four long DCAS. Seven Dorsal Lateral Abdominal Setae (DLAS) on each side; except for most anterior DLAS, each adjacent to corresponding spiracle. One row of four long Ventral Central Abdominal Setae (VCAS) anteriorly, followed by five rows of three to four long VCAS and two rows of two slightly shorter VCAS. Six Ventral Lateral Abdominal Setae (VLAS) on each side each adjacent to corresponding spiracle. One long and one tiny seta immediately posterior to first spiracle and borne on small protuberance; next four spiracles each with tiny posterior seta only.

Genitalia (Figs. 1A and 2B): Subgenital plate (Fig. 1A) well sclerotized, narrowing anteriorly to broadly rounded apex. Basal apodeme much longer than parameres and other genitalic components combined, slightly expanded posteriorly into two small apices on each side; C-shaped anterior endomere with posteriorly diverging

arms; Y-shaped aedeagal sclerite located between arms of anterior endomere; parameres broad anteriorly and tapering posteriorly to blunt apex, somewhat bulging medially in central portion; pseudopenis and associated lateral sclerites fairly broad and extending posteriorly well beyond apices of parameres; pseudopenis terminating in acute apex.

#### Female (Figs. 1B and 2C, D)

Body length: 1.43–1.63 mm; mean, 1.54 mm ( $n=3$ ). Head, thorax, and abdomen as in male unless indicated otherwise.

Head (Fig. 2C): slightly wider than in male. Maximum head width, 0.185–0.200 mm (mean, 0.194 mm,  $n=3$ ).

Thorax: Maximum thorax width, 0.280–0.305 mm (mean, 0.290,  $n=3$ ). DPTS length 0.136–0.143 mm, mean 0.139 mm ( $n=6$ ). Mesothoracic spiracle maximum diameter 0.030–0.032 mm, mean 0.31 mm ( $n=6$ ).

Abdomen: Maximum width, 0.485–0.605 mm (mean, 0.555 mm,  $n=3$ ). One broad, curved tergite immediately posterior to subgenital plate. Row of two long DCAS anteriorly, followed by eight rows of four long DCAS and one row of six shorter DCAS and then one row of five shorter Tergal Abdominal Setae (TeAS). Seven rows of four to five long VCAS.

Genitalia (Fig. 2D): Subgenital plate with distinct anterior and posterior sections connected by central stalk; posterior section diamond shaped, with broad posterior apex; anterior section broadly curved with convex anterior margin and less sclerotized posterolateral extensions that terminate in acute apex on each side; four small setae inserted along posterior margin of anterior section on each side of connecting stalk with lateral seta smaller than other setae on each side. Vulvar fimbriae distinct and extensive; three to

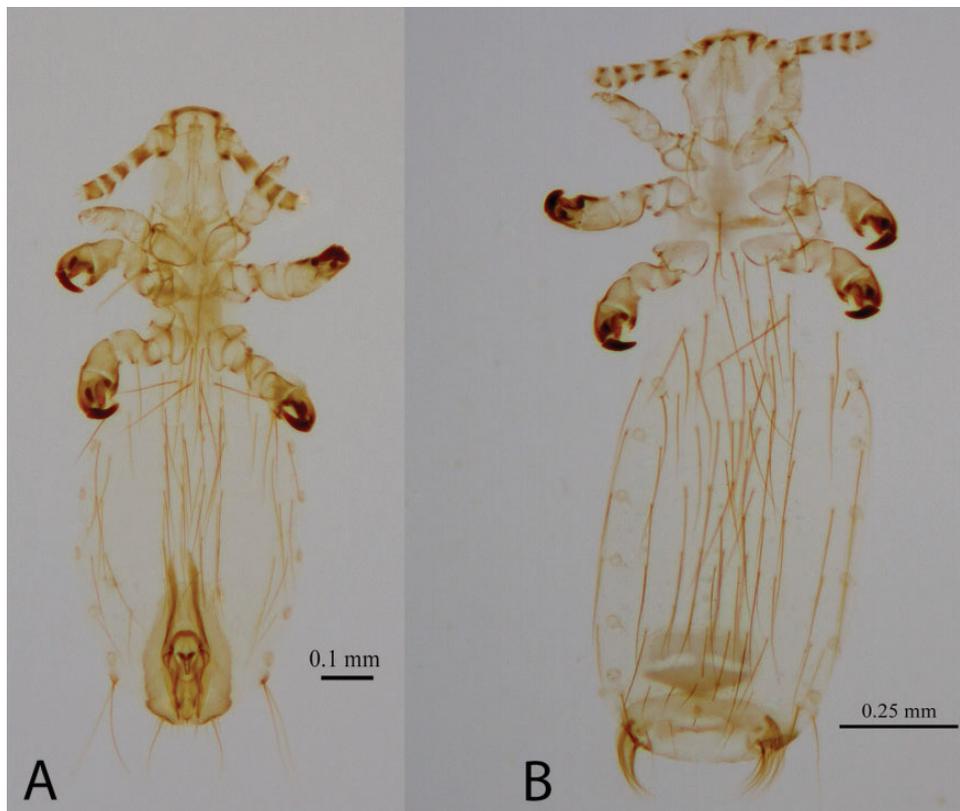


Fig. 1. *Lemurpediculus robbinsi* sp. nov. (A) Holotype male. (B) Allotype female.

four short lateral setae on each side located between vulvar fimbriae and posterior section of subgenital plate. Gonopods VIII and IX indistinct and with 16–18 contiguous curved setae on each side; postero-medial setae stouter than antero-lateral setae. Dumb-bell shaped subterminal transverse sclerite present with two associated small setae. Four to five small terminal setae on each side of genital opening.

**HOLOTYPE** ♂ ex *Cheirogaleus crossleyi* A. Grandidier (Crossley's dwarf lemur) (juvenile female named "Williana"), MADAGASCAR: Marojejy National Park, Marojejia, campsite # 2 (14° 26'2.4" S, 49° 45'43.8" E), elevation 684 m, 26 February 2014, Coll: Marina B. Blanco. Deposited in NMNH (accession barcode, USNMENT01193888).

**ALLOTYPE** ♀ ex *C. crossleyi* (adult male named "Edmond"), MADAGASCAR: Tsinjoarivo, Vatateza Forest (19° 43'15" S, 47° 51'25" E), elevation 1396 m, 11 December 2007, Coll: Marina B. Blanco. Deposited in NMNH (accession barcode, USNMENT01193820).

**PARATYPES** 1♂ same data as Holotype. 2♂, 2♀ ex *C. crossleyi* (female named "Anjara"), MADAGASCAR: Tsinjoarivo, Andasivodihazo Forest Fragment (19° 41'15" S, 47° 46'25" E), elevation 1660 m, 8 March 2012, Coll: Marina B. Blanco. Deposited in Anoplura Collection of L. A. Durden.

**ETYMOLOGY:** This species is named for Richard G. Robbins, formerly of the Armed Forces Pest Management Board, Walter Reed Army Institute of Research, Washington DC, in recognition of his remarkable contributions to ectoparasitology spanning more than four decades.

### ***Lemurpediculus claytoni* sp. nov. (Figs. 3 and 4)**

#### **Male (Figs. 3A and 4A, B)**

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Body length: 1.08–1.20 mm; mean, 1.16 mm ( $n = 3$ ). Head, thorax, and abdomen lightly sclerotized.

Head: Similar to that of *L. robbinsi* sp. nov. but more heavily sclerotized along anterior margin; longer than broad with squarish, slightly convex anterior margin. Maximum head width, 0.166–0.185 mm, mean, 0.173 ( $n = 3$ ). One long DPHS, one small DACHS anteromedial to DPHS, one DPoCHS, two to three DPaHS, two SHS, three DMHS, three to four ApHS, one fairly large VPaHS, and one Oral Seta (OrS) on each side. Antennae five-segmented with basal segment wider than long and much larger than second segment; fourth segment slightly extended posterolaterally.

Thorax: Longer than wide; slightly wider than head. Maximum thorax width, 0.233–0.257 mm (mean, 0.248 mm,  $n = 3$ ). Thoracic sternal plate (Fig. 4A) poorly sclerotized, with anterior extension and broadly rounded antero-lateral margins narrowing to acute posterior apex; tiny sclerite bearing two long setae immediately posterior to thoracic sternal plate. DPTS borne on small protuberance; DPTS length 0.120–0.127 mm, mean 0.124 mm ( $n = 3$ ); no Dorsal Mesothoracic Setae (DMsS); mesothoracic spiracle maximum diameter 0.021–0.032 mm, mean 0.028 mm ( $n = 6$ ). Legs with subtriangular coxae; forelegs each terminating in small tibio-tarsal claw; mid and hindlegs each terminating in large, robust tibio-tarsal claw, subequal in size.

Abdomen: Wider than thorax. Maximum abdomen width, 0.450–0.470 mm (mean, 0.458 mm,  $n = 3$ ). Six annulated spiracles on each side; tergites, sternites, and paratergal plates absent. Two rows of two long DCAS followed by seven rows of four to five long DCAS. Six DLAS on each side each adjacent to corresponding spiracle. Six rows of four long VCAS and then two rows of two VCAS. Six VLAS on each side each adjacent to corresponding spiracle. One long and one tiny seta immediately posterior to first spiracle and borne on small protuberance; next four spiracles each with tiny posterior seta.

Genitalia (Fig. 4B): Subgenital plate similar to that of male *L. robbinsi* sp. nov. but narrowing less acutely anteriorly (Fig. 3). Basal apodeme much longer than parameres and other genitalic components combined; expanded posteriorly to blunt postero-lateral apex on each side; almost C-shaped, subcircular anterior endomere with posteriorly converging arms; Y-shaped aedeagal sclerite between arms of anterior endomere; parameres comma-shaped, very broad especially in central region, each with acute antero-medial and postero-medial apices; pseudopenis and associated sclerites narrow and extending well beyond apices of parameres; pseudopenis terminating in acute apex.

#### **Female (Figs. 3B and 4C, D)**

Body length: 1.65–1.66 mm, ( $n = 2$ ). Head, thorax, and abdomen as in male unless indicated otherwise.

Head (Fig. 4C) slightly wider than in male. Maximum head width, 0.201–0.212 mm ( $n = 2$ ).

Thorax: Maximum width, 0.285–0.295 mm ( $n = 2$ ). DPTS length 0.137 mm ( $n = 1$ ) (only one unbroken DPTS present). Mesothoracic spiracle maximum diameter 0.032–0.036 mm, mean 0.35 mm ( $n = 4$ ).

Abdomen: Maximum width, 0.710–0.790 mm ( $n = 2$ ). One broad, curved tergite immediately posterior to subgenital plate. One pair of long DCAS anteriorly followed by eight rows of four to five long DCAS, then one row of five slightly shorter DCAS and one row of fairly short TeAS. Seven rows of four to five long VCAS.

Genitalia (Fig. 4D): Subgenital plate with distinct anterior and posterior sections connected by central stalk; both sections subequal in size; posterior section with acute posterior and lateral apices; anterior section slightly convex anteriorly and with acute lateral apices; four to five small setae on each side of stalk along posterior margin of anterior section with lateral seta on each side smaller than other setae. Vulvar fimbriae distinct, mostly confined to region postero-medial to subgenital plate. Three to four short setae on each side between vulvar fimbriae and posterior section of subgenital plate. Gonopods VIII and IX indistinct with ~18 curved setae associated with gonopod VIII and six slightly stouter curved setae associated with gonopod IX on each side. Dumb-bell shaped subterminal transverse sclerite present with two small associated setae. Three to four small terminal setae on each side of genital opening.

**HOLOTYPE** ♂ ex *Cheirogaleus sibreei* Forsyth Major (Sibree's dwarf lemur) (juvenile male named "Armand"), MADAGASCAR: Tsinjoarivo, Andasivodihazo Forest Fragment (19° 41'15" S, 47° 46'25" E), elevation 1660 m, 9 March 2011, Coll: Marina B. Blanco. Deposited in NMNH (accession barcode, USNMENT01193918).

**ALLOTYPE** ♀, same collection data as Holotype. Deposited in NMNH (accession barcode, USNMENT01193933).

**PARATYPES** 1♂, 1♀, same data as Holotype and Allotype. 1♂ ex *C. sibreei* (subadult male named "Jules"), same locality and

collector as Holotype and Allotype but 15 March 2011. Deposited in Anoplura Collection of L. A. Durden.

**ETYMOLOGY:** This species is named for Dale H. Clayton, University of Utah, in recognition of his contributions to understanding the biology and systematics of lice.

## Discussion

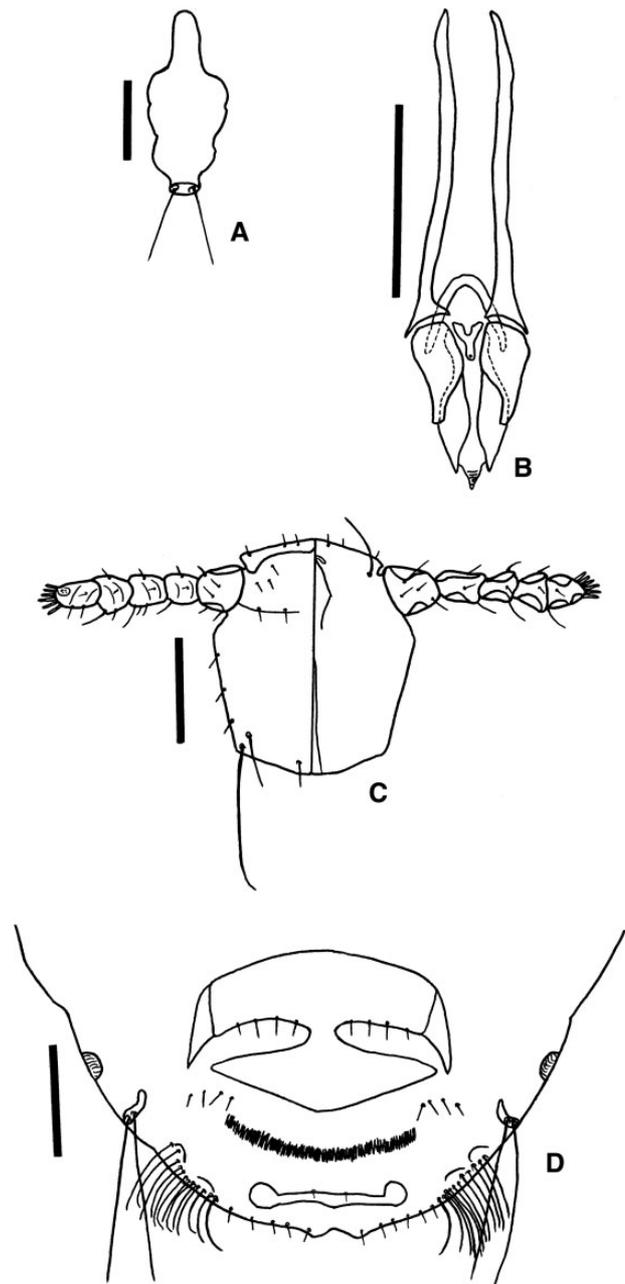
Males of *Lemurpediculus* can easily be separated by examination of the genitalia in cleared slide-mounted specimens. In *L. petterorum* males, the parameres are about equal in length to the basal apodeme (shown in Paulian 1958), whereas in the three species associated with cheirogaleid lemurs, the parameres are much shorter than the basal apodeme. The shape of the parameres can be used to separate these three species. The parameres have slightly concave medio-lateral margins in *L. claytoni* sp. nov. and distinctly rounded convex medio-lateral margins in both *L. verruculosus* and *L. robbinsi* sp. nov. The medial margins of the parameres of *L. robbinsi* sp. nov. have a distinct rounded bulge which is absent in *L. verruculosus* (shown in Durden et al. 2010). Further, the pseudopenis extends well beyond the posterior apices of the parameres in *L. robbinsi* sp. nov. but just barely beyond the apices in *L. verruculosus* (shown in Durden et al. 2010). Externally, the thoracic sternal plate of *L. petterorum* (shown in Paulian 1958) lacks an anterior projection which is clearly present in the other three species.

Females of all four known species of *Lemurpediculus* can easily be separated based on the shape of the subgenital plate which can be clearly observed in either cleared or uncleared specimens. In *L. petterorum*, the anterior and posterior portions of the subgenital plate are joined centrally and laterally with two large lateral lacunae (as shown in Paulian 1958), whereas the anterior and posterior sections of this plate are not joined laterally in the three species associated with cheirogaleid lemurs. In females of *L. verruculosus*, the anterior portion of this plate is three to four times larger than the posterior portion as illustrated by Ward (1951). The anterior and posterior sections of the subgenital plate are subequal in size in females of *L. claytoni* sp. nov., whereas the anterior portion is slightly larger than the posterior portion in *L. robbinsi* sp. nov. Also, the shape of the female subgenital plate is very different between these species as shown in Figs. 2D and 4D.

With the description of the two species included in this paper, there are now four recognized species of *Lemurpediculus*. Three of these species, *L. verruculosus*, *L. robbinsi* sp. nov., and *L. claytoni* sp. nov., parasitize cheirogaleid lemurs while the host of the fourth species, *L. petterorum* Paulian, was stated by Paulian (1958) to probably be *Lepilemur mustelinus* (weasel lemur), which belongs to a different lemur family, the Lepilemuridae. Based on available data, all four of these species of lice appear to be host specific. In some cases, the lice may be easier to distinguish than their hosts, particularly for the lice associated with *C. crossleyi* and *C. sibreei*, that are described in this paper.

This represents the first description of lice from obligate primate hibernators, which can spend up to half of the year underground. Although currently unknown, this may have implications in the life cycle of these ectoparasites, as their bloodmeal supply may be significantly reduced during periods of host hibernation. Conversely, since these hosts are inactive during hibernation, this could represent an optimal period for blood-feeding by ectoparasites because of the absence of host behavioral defenses. Several species of sucking lice parasitize true hibernators or hosts undergoing seasonal torpor, such as certain species of ground squirrels and chipmunks and can

obviously survive this period of host inactivity (Marshall 1981, Durden 1983, Durden and Musser 1994). Our data also confirm the host specificity of sucking lice parasitizing lemurs, as *C. crossleyi* individuals living at Marojejy, separated by more than 500 km to the northeast from those living at Tsinjoarivo, share the same louse species, whereas *C. crossleyi* and *C. sibreei* living sympatrically at Tsinjoarivo are parasitized by different louse species. This calls attention to the possibility of using lice as tools for investigating the biogeography of poorly known nocturnal lemurs. Sibree's dwarf lemur is ranked as Critically Endangered by IUCN (2016), and is restricted to high elevation forests in Madagascar, whereas Crossley's dwarf lemur is ranked as Data Deficient (IUCN 2016) and occupies



**Fig. 2.** *Lemurpediculus robbinsi* sp. nov. (A) Thoracic sternal plate of male. (B) Male genitalia. (C) Head of female. (D) Female genitalia. All scale bars, 0.1 mm.

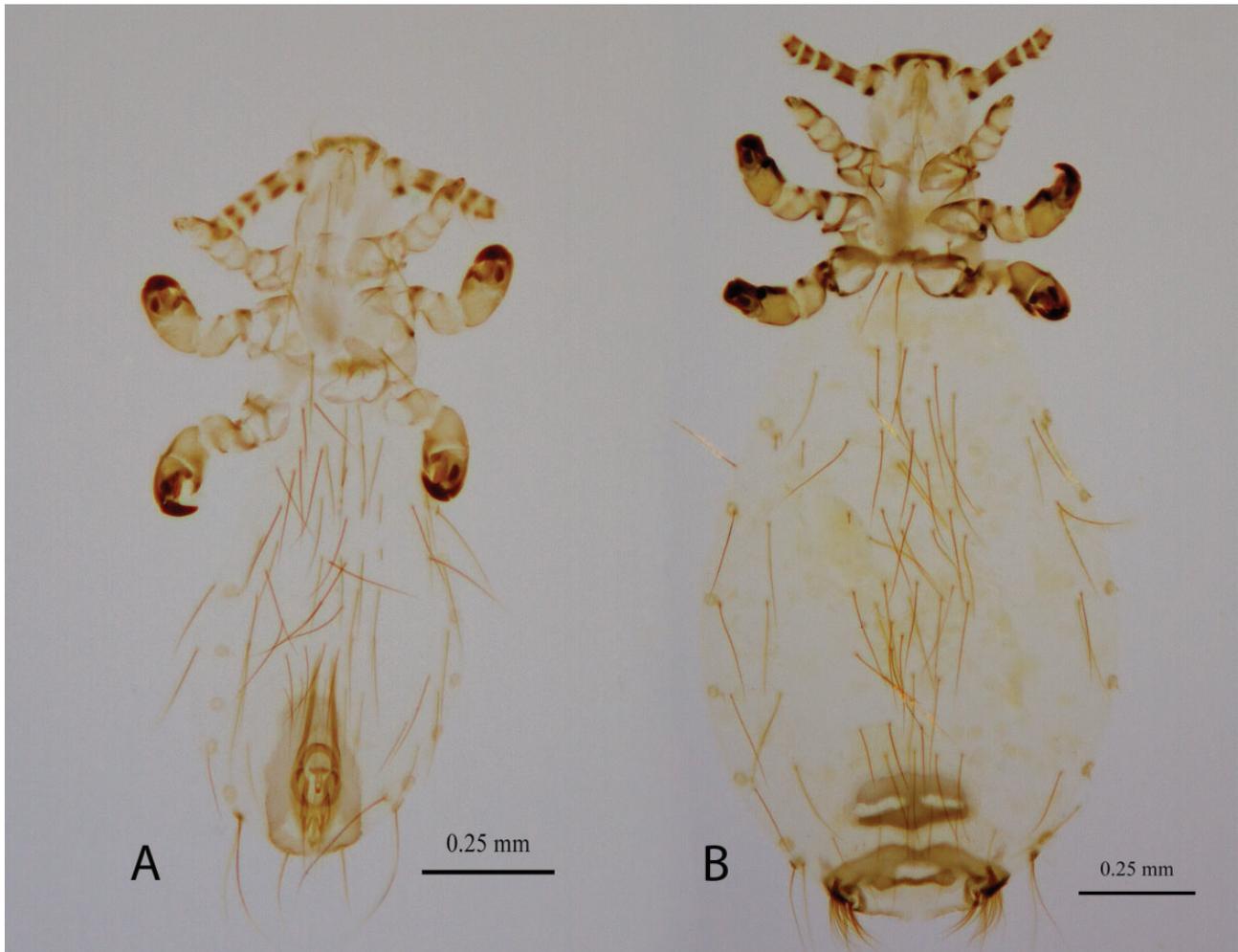


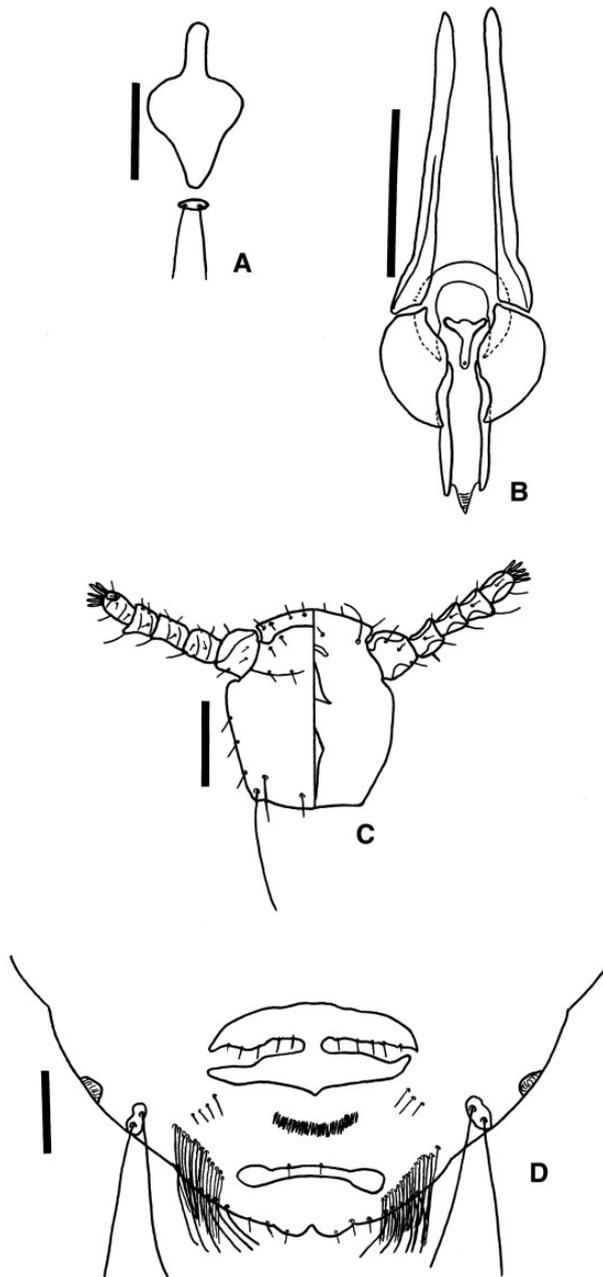
Fig. 3. *Lemurpediculus claytoni* sp. nov. (A) Holotype male. (B) Allotype female.

a variety of eastern rainforests, from low elevation to high plateau habitats. If the ecological flexibility of hosts is reflected in that of their respective louse species, *L. claytoni* n. sp. may be a highly vulnerable species.

Members of one additional genus of polyplacid sucking lice, *Phthirpediculus* Ewing, with three described species, are also ectoparasites of lemurs (Durden and Musser 1994, Durden et al. 2010). However, members of this louse genus are associated with larger lemurs: *P. avahidis* Paulian parasitizes *Avahi laniger* (Gmelin) (eastern woolly lemur—family Indriidae) (Paulian 1960), *P. brygooi* Clay parasitizes *Eulemur mongoz* (L.) (mongoose lemur—Family Lemuridae) (Clay 1977), and *P. propithecii* Ewing parasitizes *Propithecus edwardsi* Grandidier (Milne-Edward's sifaka—Family Indriidae) (Ewing 1923, Durden and Musser 1994). Further, one species of philopteric chewing louse, *Trichophilopterus babakotophilus* Stobbe, exclusively parasitizes lemurs (Price et al. 2004). However, contrary to the host specificity exhibited by all known species of sucking lice associated with lemurs, *T. babakotophilus* is not host specific. This louse has been recorded from six species of larger lemurs (Paulian 1961, Price et al. 2004, Klompen et al. 2015): *Indri indri* (Gmelin) (indri—family Indriidae), *Propithecus diadema* Bennett (Diademed Sifaka—family Indriidae), *Propithecus verreauxi* Grandidier (Verreaux's Sifaka—family Indriidae), *Eulemur*

*coronatus* (Gray) (Crowned lemur—family Lemuridae), *Eulemur macaco* (L.) (black lemur—family Lemuridae), and *E. mongoz*. Perhaps significantly, *E. mongoz* is the only species of primate currently known to be parasitized by both chewing lice and sucking lice. Based on the large number of lemur species from which ectoparasites have been inadequately or never sampled, and the host specificity of all known sucking lice that parasitize lemurs, these data suggest that a wider diversity of Anoplura is associated with lemurs than is currently known.

As with many other wild mammal hosts, most individual lemurs are probably infested with relatively small numbers of lice that do not have detrimental effects unless the host is immunologically or physically impaired in which case louse numbers may increase dramatically (Durden 2001). Large numbers of lice can result in more time spent grooming and greater host blood loss. With few exceptions, very little is known about the potential for sucking lice of wild mammals to transmit pathogens to their hosts (Durden 2001) and nothing is currently known about any potential vectorial role of lice that parasitize lemurs. However, some pathogens and parasites of lemurs, including certain viruses, bacteria and protozoans could feasibly be transmitted by sucking lice. Future research should address the potential for blood-feeding ectoparasites, including sucking lice, to transmit pathogens to lemurs, particularly in light of the



**Fig. 4.** *Lemurpediculus claytoni* sp. nov. (A) Thoracic sternal plate of male. (B) Male genitalia. (C) Head of female. (D) Female genitalia. All scale bars, 0.1 mm.

threatened or endangered status of many species of these primates. Conversely, there is as much biodiversity in each species of ectoparasite associated with lemurs as there is in each lemur host species. Many authors have advocated conserving (or coconserving) parasites of rare hosts for this reason and because parasites play a role in driving genetic diversity in host populations (Durden and Keirans 1996, Whiteman and Parker 2005). The easiest way to conserve parasites of rare hosts is to conserve the hosts, to avoid treating rare wild and captive hosts with antiparasitic agents, and to refrain from manually removing their parasites. Unfortunately, some ectoparasites of rare hosts have been driven to extinction through purposeful removal by humans including the chewing louse, *Colpocephalum*

*californici* Price and Beer, that was once a host-specific ectoparasite of the California condor, *Gymnogyps californianus* (Shaw) (Dunn et al. 2009, Jørgensen 2015). It is hoped that future conservation plans for lemurs will also consider the conservation of their unique host-specific parasites.

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