

**STUDIES IN THE TAXONOMY AND BIODIVERSITY OF
SOUTH AFRICAN ORTHOPTEROIDS**

By

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ABSTRACT OF THE DISSERTATION
STUDIES IN THE TAXONOMY AND BIODIVERSITY OF
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Dissertation Director:

Dr. Michael L. May

Chapter 1: A volume co-authored by Daniel Otte and Lauren Spearman which was published in 2005 (*Mantida Species File*) lists the taxonomic histories for all mantid species described up until 2005. In 2009, the published catalog was converted to a freely accessible, searchable online catalog [<http://Mantodea.SpeciesFile.org>]. Both published media include 17 families (including fossils), 47 subfamilies, 51 tribes, 446 genera and 2452 species.

Chapter 2: Two South African parks, Mountain Zebra (MZNP) and Vaalbos (VNP) National Parks, were sampled to determine the density, diversity, compositional similarity, and seasonal species turnover of the grasshopper communities. The two parks represented two of the biomes found in South Africa: grassland in MZNP and savanna in VNP. Overall 50 species were documented consisting of 2,454 individual adult grasshoppers collected over the course of two seasons from both localities. The effectiveness of the sampling protocol is discussed with suggestions for future grasshopper community studies.

Chapter 3: The South African flightless Hemiacridinae genus *Loryma* is revised for the first time, with 21 new species described. Species keys, a preliminary reference chart of species, extensive photography of external and internal morphology, and distribution maps are provided. Morphology figures labeled with internal and external terminology are included. Two provisional *Loryma* species-groups are proposed: Epiphallic Apodeme species-group and the No Epiphallic Apodeme species-group. The majority of the Epiphallic Apodeme species-group members are found in succulent karoo biome, with one species in the grassland biome, whereas the majority of the No Epiphallic Apodeme species-group members are found in the fynbos biome. *Lorymaini* is addressed, tribe members *Hemiloryma*, *Dirshacris* and *Labidioloryma* are photographed, a list of diagnostic differences is provided, and a key to the genera is given.

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CHAPTER 1:
Mantida Species File
Catalog of the Mantids of the World

ABSTRACT

This chapter represents a volume co-authored by Daniel Otte and Lauren Spearman which was published in 2005 (*Mantida Species File*) and lists the taxonomic histories for all mantid species described up until 2005. In 2009, the published catalog was converted to a freely accessible, searchable online catalog [<http://Mantodea.SpeciesFile.org>]. Both published media include 17 families (including fossils), 47 subfamilies, 51 tribes, 446 genera and 2452 species.

INTRODUCTION

This volume covers all mantid species described up until 2005. It includes 17 families (including fossils), 47 subfamilies, 51 tribes, 446 genera and 2452 species. It is the first mantid species catalog which includes a complete taxonomic history of the world's mantids.

This catalog was initiated in the early 1990's at The Academy of Natural Sciences of Philadelphia by the senior author, Daniel Otte. Data were assembled arbitrarily at first, by using the extensive reprint library on orthopteroid insects at the Academy. In 1999 the authors (Otte and L.A. Spearman) began a concerted effort to assemble all references dealing with the systematics of mantids using Zoological Record (since 1904). Catalog data from publications before 1906 were taken from Kirby (1904).

While nearing completion of this catalog in 2002, Ehrmann published *Mantodea Gottesanbeterinnen der Welt*. We found Ehrmann's 2002 publication helpful for confirming type depositories that we were unaware of. In any cases of disagreement with Ehrmann, or in cases in which we could not confirm who had the correct information in a given situation, we noted both Ehrmann's and our information. There is however a significant difference between Ehrmann's catalog and *Mantida Species File*. Our catalog provides a complete taxonomic history for each species, which allows users to trace changes in nomenclature and classification.

The higher taxonomy of mantids remains extremely unstable. At all taxonomic levels (families through species), many mantid groups await rigorous cladistic analyses. Major taxonomic revisions are needed. The primary function of this catalog is to assemble the taxonomic record necessary to assist researchers attempting revisions.

This catalog gives the type specimen collection locality only and does not presume to give the distribution of species. In most cases, the taxonomy of mantids is too unreliable and the collections are too shallow and scarce to discuss species' distributions. (Table 1).

Table 1. The distribution of known mantid species in order of magnitude.

Africa	980
Indomalaysia (Pakistan to Malaysia and Indoesia).....	481
South America (Panama Canal to Tierra del Fuego).....	354
Eurasia (northern Europe and Asia: England to China).....	286
Australasia (New Guinea and Australia).....	158
Central America (Mexico to Panama and Caribbean islands).....	98
Indian Ocean islands (mostly Madagascar).....	54
North America (United States and Canada).....	24
Pacific Ocean islands	5

Mantids' cryptic and solitary nature has made them difficult to collect, and historically, mantids have never been considered pests and therefore were seldom the subjects of intensive fieldwork or study. Mantid types are spread across the world and there are rarely series collected, making the work of the few systematists who have worked on them exceedingly difficult. More systematists are needed, some types still remain to be found in museum around the world, and extensive field research is needed.

The remaining sections of this chapter exist in their published catalog form [Otte, Daniel and Lauren Spearman. 2005. *Catalog of the Mantids of the World*. Dictyopteran

Species File Series. Orthopterists' Society. 489pp.], and online [Otte, Daniel, Lauren Spearman and Martin B.D. Stiewe. *Mantodea Species File Online*. Version 1.0/3.5. <<http://Mantodea.SpeciesFile.org>>], which is submitted for the purpose of this dissertation submission as “supplemental files.”

CHAPTER 2:

Grassland and savanna grasshopper community composition in Mountain Zebra and Vaalbos National Parks, South Africa

ABSTRACT

Two South African parks, Mountain Zebra (MZNP) and Vaalbos (VNP) National Parks, were sampled to determine the density, diversity, compositional similarity, and seasonal species turnover of the grasshopper communities. The two parks represented two of the biomes found in South Africa: grassland in MZNP and savanna in VNP. Overall 50 species were documented consisting of 2,454 individual adult grasshoppers collected over the course of two seasons from both localities. Transect sampling yielded 8 species in MZNP in the spring, 19 species in MZNP in the autumn, 19 species in VNP in the spring and 17 species in VNP in the autumn. There were no grasshopper species shared between MZNP and VNP. The seasonal species turnover in MZNP was significant with only 1 shared species, whereas VNP had 12 shared species between the seasons. Species and individual mean densities, species dominance and evenness, seasonal changes in the predominance of different subfamilies, species turnover and beta diversity, species accumulation curves and richness estimators are all provided for both parks. The effectiveness of the sampling protocol is discussed with suggestions for future grasshopper community studies.

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INTRODUCTION

Grasshoppers are ideal subjects for biodiversity, conservation and management studies because they are diverse and abundant, relatively easy to capture, and they are sensitive to plant species composition, succession, and microclimate changes (Joern 1983; Fielding et al. 2001; Chambers and Samways 1998; Otte and Joern 1975). Of the 553 grasshopper species recorded for South Africa (Otte and Naskrecki 1997, Otte and Eades 2002), nearly half are endemic, and it has been suggested that the fauna may be twice as large as what has been documented thus far (Green 1998; Foord et al. 2002; Otte pers. comm.).

The more significant impediments to using grasshoppers more extensively in biodiversity, conservation and management studies in South Africa are threefold; 1) there are few if any orthopterists or orthopteran taxonomists being trained and working in South Africa, 2) few taxonomic revisions of the grasshopper fauna of southern Africa have been completed (impeding identification of described species and discovery of new species), and 3) very few studies provide baseline data on orthopteran community species composition. Despite a long tradition of plant surveys across South Africa, there have been few attempts to follow up such studies with insect surveys, even though the region has a large, endemic insect fauna.

The purpose of this study was to provide baseline datasets of the grasshopper communities from two seasons in two designated vegetation types, within Mountain Zebra National Park (hereafter MZNP) and Vaalbos National Park (hereafter VNP). To fully understand the effects of native grazers, livestock overgrazing, and the various burning regimes on protected and unprotected lands in South Africa, study of the

dominant insect herbivores in this region is critical. Methods for surveys of grasshopper and other insect communities with should allow for the documentation of: species rarity, species phenology, and the climatic conditions and vegetation types that affect species composition. Orthopteran studies that do not meet these criteria, and do not create voucher collections for future reference, are at risk of publishing data that are unintentionally misleading (see discussion below). The sampling design used in this study is described in detail, with arguments for its effectiveness in sampling the diverse grasshopper communities across South Africa, suggested modifications, and recommendations for future collecting.

Research Sites.

Mountain Zebra National Park.

The primary purpose of MZNP is the conservation of the endangered Cape Mountain Zebra (*Equis zebra zebra*), although secondary objectives of the park have been conservation and maintenance of unique floral and faunal elements of the region (van der Walt 1980; National Parks Board 1979). Located 24 kilometers west of Cradock in the Eastern Cape, MZNP is located in a climatic and vegetation transitional zone between the arid karoo biome vegetation in the west, and the drier “Sweetveld” grassland biome vegetation in the east (van der Walt 1980; Tidmarsh 1948) (figures 1 and 2). Van der Walt (1980). who extensively characterized the vegetation of MZNP. explains that the tension between these two biomes is evident in the region, citing studies (Roux 1966a; Roux 1966b) that have shown that seasonal rainfall in the area has had a profound effect on the growth of grasses and karoo shrubs, and drying of the region (due to climate

change, for example) would favor karoo vegetation, aiding further expansion of the nama karoo biome. The grassland and karoo biomes are also under great threat in South Africa owing to farming and ranching, which typically result in over-grazing by sheep and cattle. Overgrazing in this transitional zone between the two biomes also favors expansion of karoo, as the grasses are preferentially eaten by grazing livestock, promoting a greater dominance of shrubs typical of karoo, although the diversity of the karoo is damaged as well from overgrazing. The grassland vegetation type at MZNP has is considered economically desirable because it is ideal for winter grazing (Lubke et al. 1996).

Lubke et al. (1996) cites MZNP as having one of the few remaining good examples of south-eastern mountain grassland (fig. 3), a poorly conserved vegetation type (22,676 km², 32% transformed, 0.33% conserved). South-eastern mountain grassland lies between 1,350 and 2,150 m altitude (Lubke et al. 1996), with rainfall ranges of 450-600 mm per year (though the average recorded by park staff at MZNP for 1965-2004 is 405 mm per year; Lubke et al. 1996, Robyn Woods, MZNP pers. comm.). Typically 70% of the annual rainfall occurs between October and March (van der Walt 1980). Average annual rainfall and the sampling dates of this study are shown in figure 5. Temperatures for south-eastern mountain grassland range from -13°C-40°C (annual mean = 15°C), with winters having severe frosts (Lubke et al. 1996).

This study focused on the grasshopper community found within the vegetation type which is described as rocky plateau grassland, or the *Themeda tiandra* – *Felicia filifolia* community (van der Walt 1980). This community is remnant of a formerly widespread plateau grassland and is dominated by three grasses: *Themeda tiandra*,

Eragrostis curvula and *Tragus koeleroides* (van der Walt 1980). Acocks (1971) describes *Themeda tiandra* as South Africa's most important grass, eluding to its economic importance for grazing. The presence, though small, of the small shrub *Felicia filifolia* is considered a indicator of habitat degradation (van der Walt 1980).

The over-grazed form of the rocky plateau grassland is called degraded plateau grassland, or the *Themeda tiandra* – *Pentzia globosa* community. Along with the dominant grass, *Themeda tiandra*, this community contains *Pentzia globosa*, which is the dominant dwarf shrub that helps to characterize this vegetation type (van der Walt 1980). The degraded plateau grassland was where the sampling transect of this grasshopper study was conducted 25 years later, in 2005-2006. The area was described as having a significant amount of stone rubble (30% cover) with still largely intact topsoil (van der Walt 1980). These features, in combination with the still dominant presence of *Themeda tiandra*, made van der Walt (1980) suggest that the area was prime for reverting back to rocky plateau grassland after only a short period of time if there was no grazing. Since 1980, MZNP did acquire more adjacent land for grazing the native antelope and zebra, but it can only be speculated at this point in time that this has relieved the grazing pressure in portions of the *Themeda tiandra* – *Pentzia globosa* community as van der Walt had suggested might happen with the removal of grazers. It is possible that with less grazing pressure and 25 years of time, the site could have reverted back to a less degraded or recovered state but this conclusion awaits future vegetation studies of the area. There is presently a grazing exclusion study being conducted near the grasshopper study location, but park managers are unable to make a definitive statement at this time regarding the degree and extent that the study area has changed within the described

parameters of what is characterized as rocky plateau grassland and degraded plateau grassland. Though an exclusively entomological effort, our study noticed that the grassland habitat did not appear to have a large presence of dwarf shrubs (the site was selected because of the density of grass and activity of grasshoppers).

This study was the first survey of the grasshoppers in MZNP that was specific to an area within the rocky plateau grassland-degraded plateau grassland. This study is also the first grasshopper survey that examined seasonal change in species composition by sampling before and after the rainy season. Another MZNP grasshopper study was conducted by Gebeyehu and Samways (2002), although it was examining and contrasting the grasshopper community found within and outside (with cattle overgrazing) park boundaries. Gebeyehu and Samways (2002) did not examine the higher altitude grassland plateau region of the park, but rather sampled within the transitional, more karoo-dominated vegetation types within and outside the park.

Vaalbos National Park.

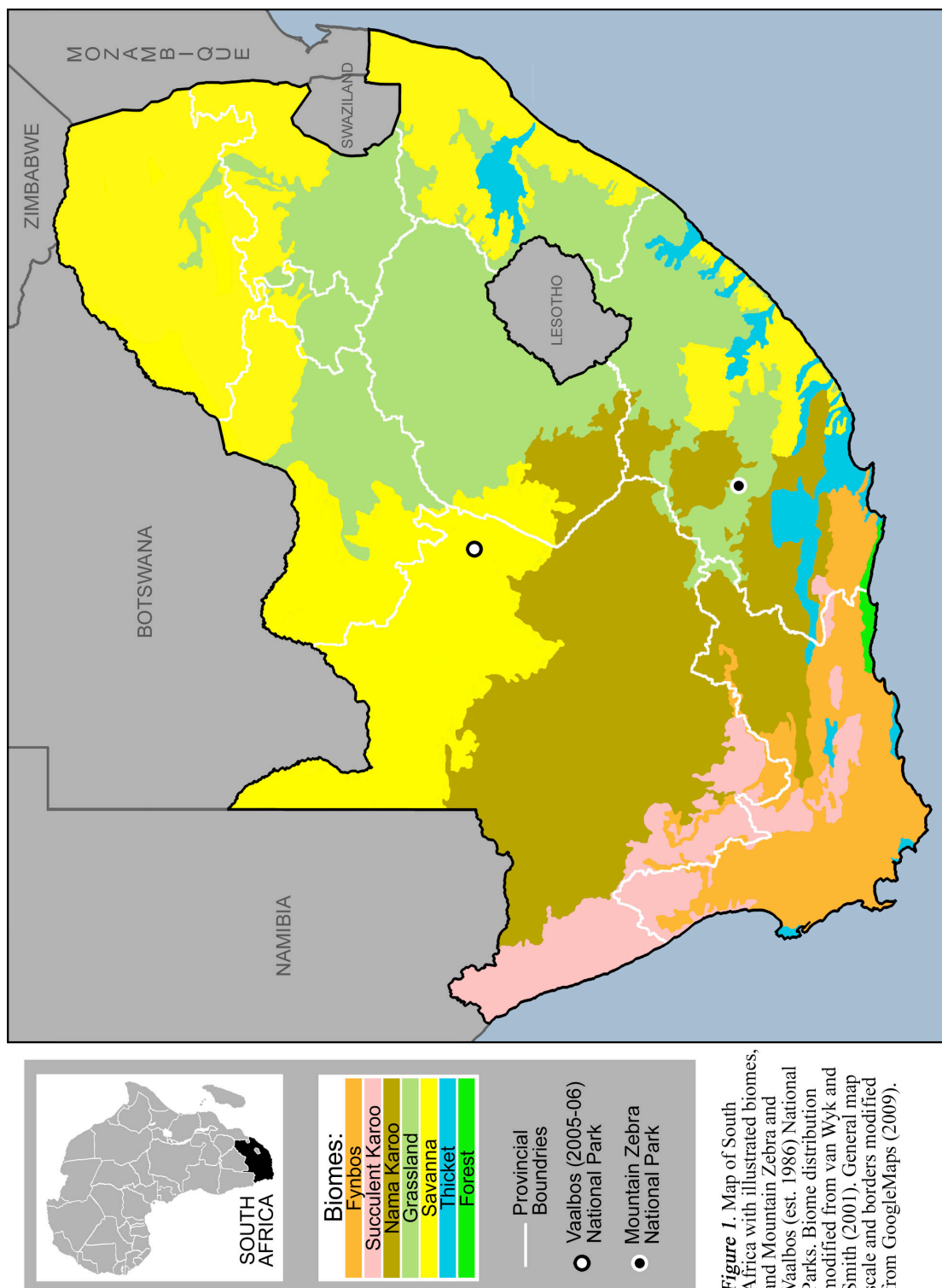
Located approximately 61 kilometers NNW of Kimberley in the Northern Cape Province, VNP was established only in September 1986 (Bezuidenhout 1994) (figures 1 and 2). Due to land reclamation litigation, the park was closed to the public in 2005-2006, to allow for capture of the park's large mammals for reestablishment in a new Vaalbos National Park to be declared at a future date in a new location. It is critical to note for future reference that this study was conducted in the VNP that was established in 1986 because in the near future, there will be a *new* VNP with the same name but in a new location, undoubtedly with different vegetation and insect community composition. This

study was the first and last survey of the grasshoppers for the first VNP, and land use likely will change dramatically from when the surveys were conducted. If adjacent land use is an accurate predictor, the land is likely ultimately be used largely for strip mining. The hope is that the species records gathered in this study can be used for a remaining adjacent provincial park, Rooipoort Nature Reserve, the lone protected land in this mining region that shares many vegetation community similarities with VNP (Bezuidenhout 2009).

Found within the savanna biome, VNP is designated as being of the Kimberley thorn bushveld (fig. 4), described as a type of open savanna which is highly threatened and poorly conserved (27,103 km², \pm 55% transformed, 3.12% conserved) (Acocks 1953, van Rooyen and Bredenkamp 1996). Because VNP no longer exists in the Kimberley thorn bushveld region, the estimated proportion of conserved Kimberley thorn bushveld is now well below the 3.12% reported by van Rooyen and Bredenkamp (1996). The principal economic uses of Kimberley thorn bushveld have been for livestock grazing, game farming, and mining (van Rooyen and Bredenkamp 1996).

Kimberley thorn bushveld occurs at 1,000 -1,200 meters, and rainfall ranges between 400 to 500 mm per year (van Rooyen and Bredenkamp 1996). Within VNP, the summer rainfall (June – May) has been described as erratic, ranging from 700-300 mm per year (mean for 1987-1993 = 400 mm; Bezuidenhout 1994). Average annual rainfall and the sampling dates of this study are shown in figure 5. The average temperature of Kimberley thorn bushveld is about 19°C (van Rooyen and Bredenkamp 1996), and the temperatures for VNP have ranged between -4°C and 44°C, with frost occurring in winter months (Bezuidenhout 1994).

This study focused on the grasshopper community within the savanna vegetation type described as a *Schmidtia pappophoroides* – *Themeda triandra* grassland community (Bezuidenhout 1994). This type of savanna is named after the dominant grass *Schmidtia pappophoroides* and a diagnostic grass species *Themeda triandra* (Bezuidenhout 1994). The three dominant grasses are *Schmidtia pappophoroides*, *Eragrostis lehmanniana* and *Aristida congesta*, and dominant forbes are *Indigofera daleoides*, *Hermannia tomentosa* and *Convolvulus multifidus* (Bezuidenhout 1994). A canopy layer occurs in the *Schmidtia pappophoroides* – *Themeda triandra* community, in the form of the sparsely distributed tree, *Acacia erioloba* and sparsely distributed shrubs such as *Grewia flava* and *Tarachonanthus camphorates* (Bezuidenhout 1994). These canopy species (*Acacia erioloba*, *Grewia flava* and *Tarachonanthus camphorates*) were encountered in only 2 of total 48 quadrats at VNP during this grasshopper study.



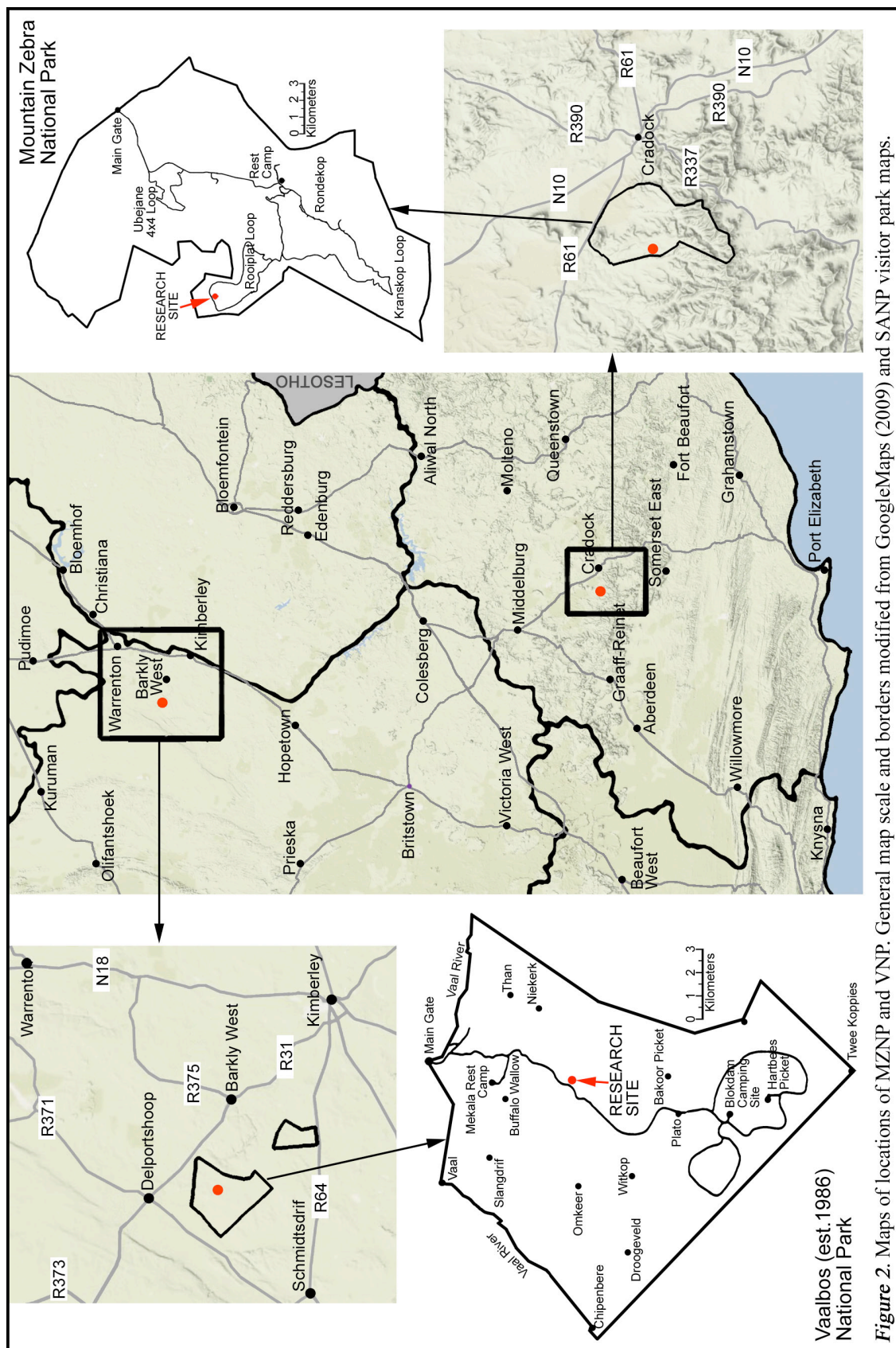




Figure 3. Photograph of Mountain Zebra National Park transect study site.



Figure 4. Photograph of Vaalbos National Park (est. 1986) transect study site.

MATERIALS AND METHODS

Sampling Localities.

Mountain Zebra National Park.

The location sampled in MZNP is designated by the four GPS coordinates provided in table 1. It lies entirely within a rocky plateau grassland-degraded plateau grassland community in south-eastern mountain grassland (van der Walt 1980, Lubke et al. 1996).

Table 1. Approximate area encompassing transects sampled at Mountain Zebra National Park in the spring of 2005 and autumn of 2006.

transect 1, quadrat 1	S 32°11.431'	E 25°24.692'	1341 m elevation
transect 1, quadrat 12	S 32°11.484'	E 25°24.681'	1346 m elevation
transect 4, quadrat 1	S 32°11.425'	E 25°24.653'	1356 m elevation
transect 4, quadrat 12	S 32°11.477'	E 25°24.617'	1357 m elevation

Vaalbos National Park.

The location sampled in VNP is designated by the four GPS coordinates provided in table 2. It lies entirely within a *Schmidtia pappophoroides* – *Themeda triandra* grassland community within Kimberley thorn bushveld savanna (Bezuidenhout 1994, van Rooyen and Bredenkamp 1996).

Table 2. Approximate area encompassing transects sampled at Vaalbos National Park in the spring of 2005 and autumn of 2006.

transect 1, quadrat 1	S 28°30.552'	E 24°18.810'	1146 m elevation
transect 1, quadrat 12	S 28°30.577'	E 24°18.872'	1146 m elevation
transect 4, quadrat 1	S 28°30.584'	E 24°18.796'	1124 m elevation
transect 4, quadrat 12	S 28°30.622'	E 24°18.848'	1124 m elevation

Note about other localities sampled.

A total of 6 sites were sampled (2 fynbos, 2 grassland, 2 savanna) in an attempt to examine differences in grasshopper community composition between biomes, between sites within the same biome, and between seasons at the same site. MZNP and VNP were the only two parks where both sampled seasons were deemed successful because there were no weather abnormalities that disrupted the planned sampling events and the grasshopper abundances were high enough to allow for statistical analysis.

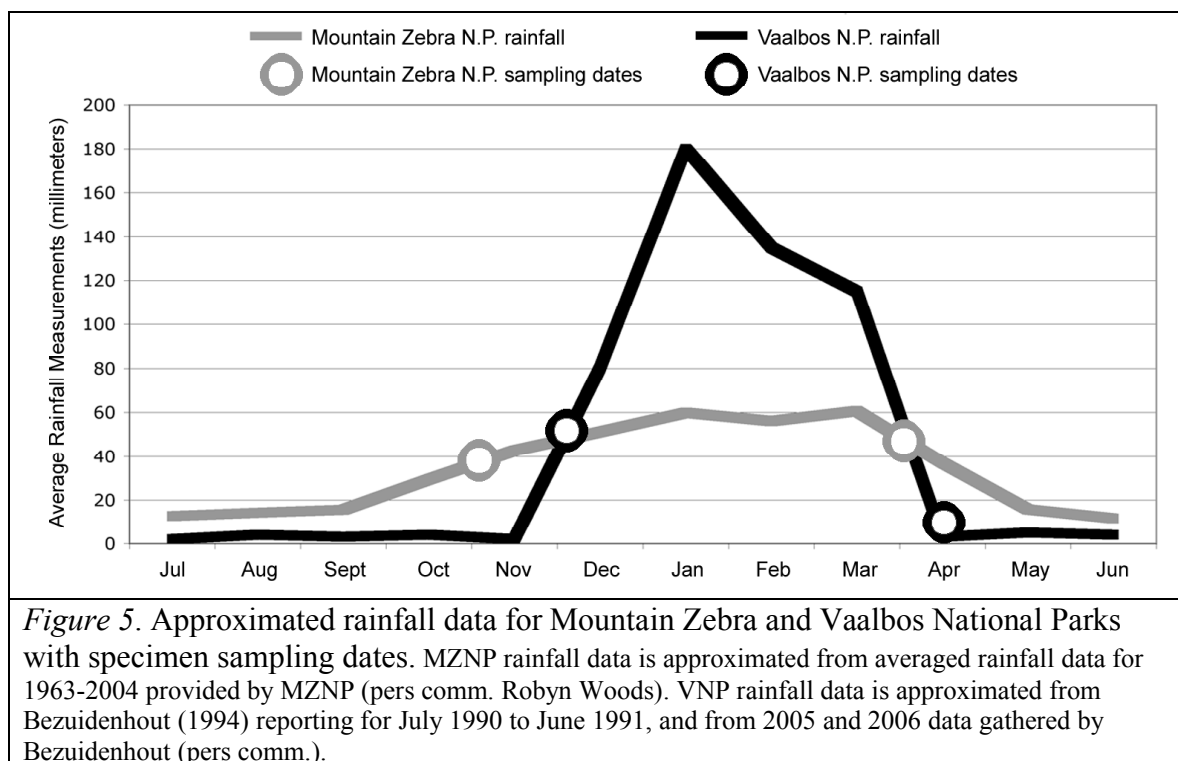
Sampling Methods.

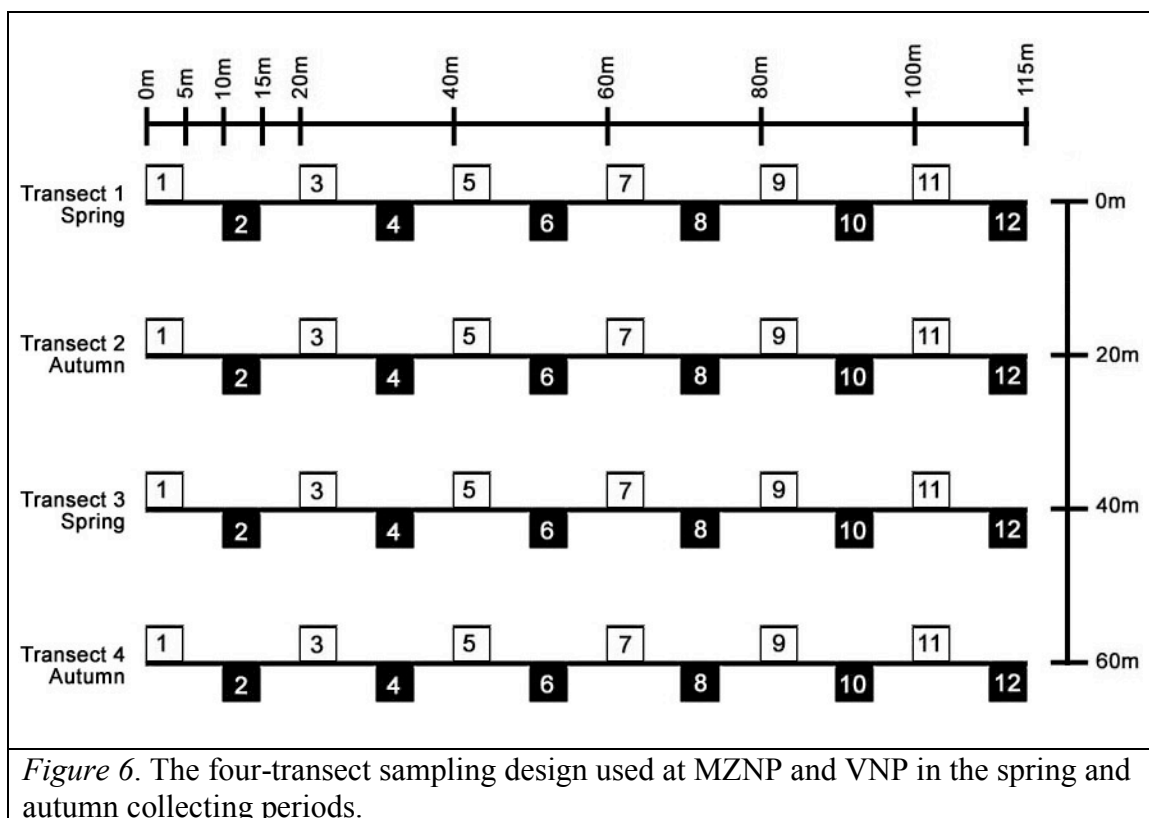
A stratified random sampling protocol was performed using 4 parallel transects with 12 quadrats each (figure 6). The four transects were 20 meters apart and each was 115 meters in length. Transects 1 and 3 were sampled in the spring (Oct.26-Nov.5 at Mountain Zebra N.P., and Dec.1-3 at Vaalbos N.P.); transects 2 and 4 were sampled in the autumn (Mar.23-25 at Mountain Zebra N.P., and Apr.12-14 at Vaalbos N.P.). Quadrats were 5x5 m² and spaced 5 meters apart along the length of each transects. On a typical sampling day, half of the quadrats on one transect were sampled in the morning, and half of those on the other transect were sampled in the afternoon. In ideal weather conditions, all 24 quadrats of both transects could be sampled in 4 days. Sampling transects 1 and 3 in the spring, and 2 and 4 in the autumn was planned to minimize microhabitat differences between transects, and the daily sampling protocol was implemented to avoid disturbing quadrats before sampling.

Sampling was conducted on days when there was mostly direct sunlight, minimal wind, and warm to hot temperatures. Grasshopper activity was reduced when any two of

the following conditions arose: cool temperatures, moderate to high winds, or overcast sunlight. Wind speed, temperature and relative humidity were recorded for each quadrat using a Kestrel 3000 pocket weather station (data included on collection specimen labels). Neither locality had been burned within 3 years prior to sampling.

For added sampling consistency, every quadrat was sampled by the same two experienced collectors, who worked together in each 5x5 meter squared quadrat for 30 minutes. Half a transect, 6 quadrats, took 3 hours to sample. This allowed for a consistent measure of grasshopper abundance per unit space and time. Within quadrats specimens were collected by sweep-netting and poke+stare methods (see Appendix table 1 for details). If a grasshopper flew or jumped outside the quadrat boundary during sampling, a collector pursued it for no more than a 5 meter distance.





Calculating diversity measures.

EstimateS 8.0 (Colwell, 2006) was used to calculate diversity estimators, species accumulation curves and shared species estimators and indices. Microsoft Excel 2004 was used to generate data figures.

RESULTS AND DISCUSSION

Species abundance, individual abundance and density.

The combined spring and autumn sampling results for MZNP were 26 species and 636 individual adult grasshoppers. Only one species (*Pnorisa squalis*) was shared between the spring and autumn samples. The combined spring and autumn sampling results for VNP was 24 species and 1,818 individual adult grasshoppers. Twelve species were shared between the spring and autumn samples. MZNP and VNP shared no species. Thus, 50 species in all were collected during this study, among 2,454 individual adult grasshoppers. Abundances, species names and taxonomic placement for both seasons in both parks is provided in table 3 (MZNP) and table 4 (VNP).

The sampling regime covered an area of 1,200 m² per site, with 24 hours of sampling within quadrats at each site. The mean numbers of grasshopper species and individuals collected at MZNP and VNP in the spring and autumn samples are given in figures 7 and 8. The MZNP spring sampling effort yielded a mean of 6.58 individuals and 2.21 species per quadrat, while in autumn sampling yielded a mean of 19.92 individuals and 5.63 species per quadrat. Comparable figures for VNP were 14.33 individuals and 5.33 species per quadrat in spring, 61.42 individuals and 6.83 species per quadrat in autumn.

Grasshopper density was greatest in the autumn in both parks, as expected for orthopteran sampling, although the extraordinary autumn density of the grasshoppers in VNP was 3 times that of the MZNP autumn sample. Grasshopper density was so great in the VNP autumn sample that two collectors were unable to collect all the grasshoppers in the 5x5 m² quadrats within the 30 minute time allotment, so grasshopper individual

density was even higher than reported. Species richness was also greater in the autumn than in spring for both MZNP and VNP.

The likely explanation for the increased density of individual grasshoppers in the autumn at both MZNP and VNP is that the autumn sample follows the summer rains which results in a burst of new plant growth in both the grasslands and savanna, particularly evident among the grass species. Increased vegetation biomass supports an increased abundance of grasshoppers, and in one study where the grasshopper density in a South African savanna site peaked in autumn, the grasshoppers removed up to 16% of the grass cover (Gandar 1982). VNP might also have a higher carrying capacity for grasshoppers because it has an overall higher average summer rainfall as compared to MZNP, though without knowledge of the amount of grasshopper vegetation consumption that occurs at either park or the density and biomass of potential grasshopper food plants, we can only speculate that VNP has a higher carrying capacity as compared to MZNP.

Additionally, VNP might have a greater autumn density as compared to MZNP because VNP has relatively more mild winter conditions, which might increase the survivorship of over-wintering nymphs or eggs possibly resulting in a greater initial abundance of adult grasshoppers in early autumn.

Table 3. Mountain Zebra National Park spring and autumn species with abundances (* = denotes species collected in both seasons).

No.	Family	Subfamily	Species	Mtn. Zebra N.P. Spring samples	Mtn. Zebra N.P. Autumn samples
1.	Acrididae	Acridinae	<i>Acrida sulphuripennis</i> (Gerstaecker, 1869)		4 0.8%
2.			<i>Anaeolopus socius</i> (Stål, 1861)		2 0.4%
3.			<i>Gymnobothrus carinatus</i> Uvarov, 1941		9 1.9%
4.			<i>Gymnobothrus</i> near <i>carinatus</i> Uvarov, 1941	103 65.2%	
5.			<i>Orthochthya d. dasynemis</i> (Gerstaecker, 1869)		116 24.3%
6.		Calliptaminae	<i>Acorypha</i> sp. (<i>Caloptenopsis femoralis</i>)	1 0.6%	
7.		Catantopinae	<i>Catantops</i> , new species	1 0.6%	
8.		Cyrtacanthacridinae	<i>Acanthacris ruficornis</i> (Fabricius, 1787)		1 0.2%
9.		Euryphyminae	<i>Brachyphymus basuto</i> Dirsh, 1956	1 0.6%	
10.			<i>Euryphymus tuberculatus</i> Martinez, 1898		11 2.3%
11.			<i>Euryphymus</i> sp.		1 0.2%
12.			<i>Platacanthoides bituberculatus</i> Uvarov, 1922		15 3.1%
13.		Eyrepocnemidinae	<i>Eyrepocnemis plorans meridionalis</i> Uvarov, 1921		42 8.8%
14.			<i>Heteracris calliptamoides</i> Uvarov, 1921		6 1.3%
15.		Gomphocerinae	<i>Anablepia dregei</i> (Ramme, 1929)	3 1.9%	
16.			<i>Leva callosa</i> Uvarov, 1922		2 0.4%
17.			<i>Pnorisa squalus</i> (Stål, 1861)*	40 25.3%	178 37.2%

18.		<i>Pseudognothela media</i> (Uvarov, 1921)		1	0.2%
19.		<i>Rhaphotitha palpalis</i> (Uvarov, 1929)		79	16.5%
20.		<i>Rhaphotitha</i> sp. 2	3	1.9%	
21.	Hemiaceridae	<i>Loryma zebrata</i> , new species	6	3.8%	
22.	Oedipodinae	<i>Tmetonota abrupta</i> (Walker, 1870)		2	0.4%
23.		<i>Acrotylus</i> sp. 1		2	0.4%
24.		<i>Gastrimargus</i> sp.		4	0.8%
25.		<i>Oedaleus flavus</i> (Linnaeus, 1758)		1	0.2%
26.	Pamphagidae	<i>Hoplolopha horrida</i> (Burmeister, 1838)		2	0.4%
			158		478

Table 4. Vaalbos National Park spring and autumn species with abundances (* = denotes species collected in both seasons).

No.	Family	Subfamily	Species	Vaalbos N.P.	
				<i>Spring samples</i>	<i>Autumn samples</i>
1.	Acrididae	Acridinae	<i>Truxalis burtti</i> Dirsh, 1951	12	3.5%
2.		Catantopinae	<i>Cryptocatantops crassifemoralis</i> Johnsen, 1991	1	0.3%
3.			<i>Phaeocatantops decoratus</i> (Gerstaecker, 1869)	1	0.3%
4.			<i>Xenocatantops zernyi</i> (Ramme, 1929)*	139	40.4%
5.	Cyrtacanthacridinae		<i>Cyrtacanthacris tatarica</i> (Linnaeus, 1758)	1	0.3%
6.	Euryphyminae		near <i>Calliptamicus</i> sp.	15	4.4%

7.		<i>Rhachitopsis</i> near <i>crassus</i> (Walker, 1870)		5	0.3%
8.	Gomphocerinae	<i>Pseudocarcyptera carvalhoi</i> (Bolivar, 1890)*	14	4.1%	11.2%
9.		<i>Rhaphotiitha platypternoides</i> (Karny, 1910)*	24	7.0%	26.3%
10.		<i>Rhaphotiitha</i> sp. 1*	1	0.3%	0.3%
11.		<i>Brachycrotaphus tryxalicerus</i> (Fischer, 1853)*	1	0.3%	0.3%
12.		<i>Leva callosa</i> Uvarov, 1922*	69	20.1%	24.2%
13.		<i>Mesopsis abbreviatus</i> (Beauvois, 1806)	2	0.6%	
14.		<i>Mesopsis laticornis</i> (Krauss, 1877)*	3	0.9%	0.3%
15.		<i>Paragymnobothrus</i> near <i>rufipes</i> (Uvarov, 1925)			0.3%
16.		<i>Phorisa squalus</i> (Stål, 1861)*	2	0.6%	0.1%
17.		<i>Pseudognathota rehni</i> Karny, 1910			0.4%
18.		<i>Thyridota dispar</i> Uvarov, 1925*	37	10.8%	27.8%
19.	Oedipodinae	<i>Acrotylus deustus</i> (Thunberg, 1815)*	14	4.1%	0.5%
20.		<i>Oedaleus flavus</i> (Linnaeus, 1758)*	1	0.3%	2.1%
21.	Tropidopolinae	<i>Pseudotristria cylindrica</i> (Uvarov, 1953)*	6	1.7%	0.1%
22.	Pyrgomorphidae	<i>Pyrgomorpha (Phymelloides) granulata</i> Stål, 1875			0.1%
23.		<i>Zonocerus elegans</i> (Thunberg, 1815)			0.2%
24.	Thericleidae	<i>Thericleidae</i> sp.	1	0.3%	
			344		1474

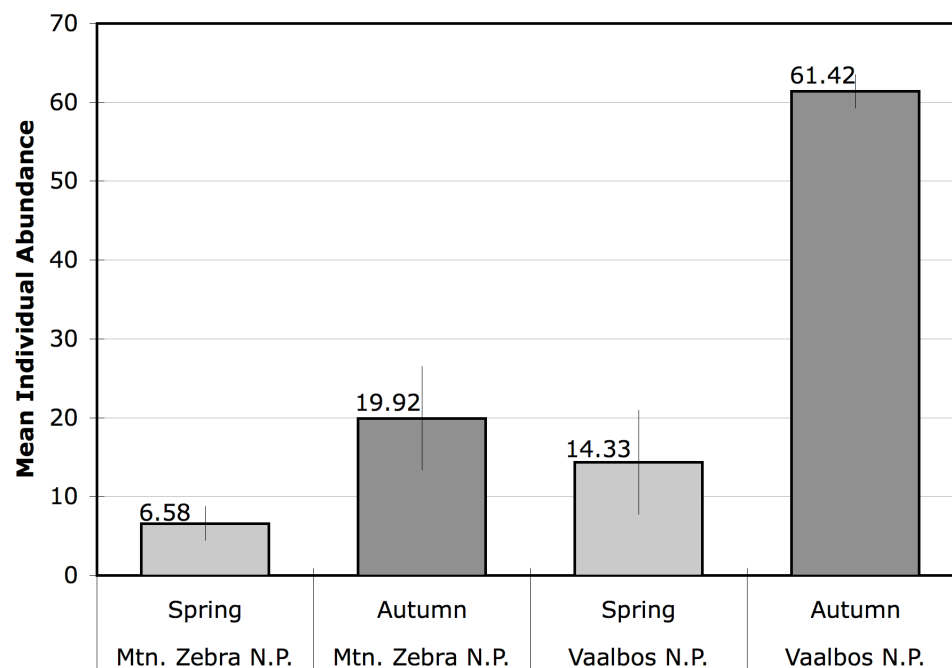


Figure 7. Mean individual grasshopper abundance per 30 minutes of sampling effort in a 5x5 m² sampling quadrats. Standard deviations: MZNP spr. = 2.19, MZNP aut. = 6.61, VNP spr. = 6.64, VNP aut. = 13.77.

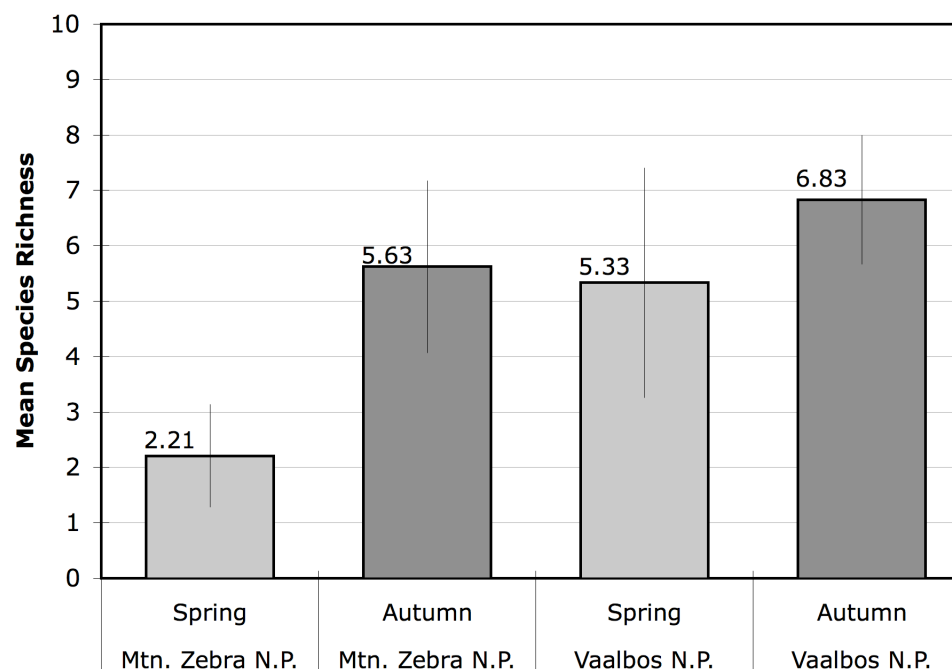


Figure 8. Mean grasshopper species richness per 30 minutes of sampling effort in a 5x5 m² sampling quadrat. Both season samples are shown for both MZNP and VNP. Standard deviations: MZNP spr. = 0.93, MZNP aut. = 1.56, VNP spr. = 2.08, VNP aut. = 1.17.

Species dominance and evenness.

Rank/abundance plots for both seasons within MZNP and VNP are shown in figures 9 - 12. The steep slope of MZNP spring plot reflects the presence of two very abundant species *Gymnobothrus near carinatus* (65.2%) and *Pnorisa squalus* (25.3%) which account for 90.5% of the individual grasshoppers sampled (figure 9). The more gradual slope of the plot of the MZNP autumn sampling shows a more even distribution of species. The four most abundant species, *Pnorisa squalus* (25.3%), *Orthochtha dasyncnemis dasyncnemis* (24.3%), *Rhaphotittha palpalis* (16.5%), and *Eyprepocnemis plorans meridionalis* (8.8%) account for 73.1% of the total individual grasshoppers sampled (figure 10).

It is interesting to note that *Pnorisa squalis*, the only species collected in both seasons at MZNP, accounts for approximately 25% of the grasshoppers in each season. Being a dominant species in both the spring and autumn suggests that this bivoltine species is well adapted to the seasonal changes at MZNP.

A gradual slope of the plot of the VNP spring sampling shows a relatively even distribution of species, although there are ten species that each represent <1% of the total individual grasshoppers, a likely artifact of having too few samples (figure 11). The four most abundant species for the VNP spring sample, *Xenocatantops zernyi* (40.4%), *Leva callosa* (20.1%), *Thyridota dispar* (10.8%), and *Rhaphotittha platypternoides* (7.0%) accounted for 78.3% of the total individual grasshoppers (figure 11). The steep staggered slope of the VNP autumn plot reveals an uneven distribution of species, with the four most abundant species, *Thyridota dispar* (27.8%), *Rhaphotittha platypternoides* (26.3%),

Leva callosa (24.2%), and *Pseudoarcyptera carvalhoi* (11.2%), accounting for 89.5% of the total individual grasshoppers sampled (figure 12).

The same 3 species, *Rhaphotittha platypternoides*, *Leva callosa*, and *Thyridota dispar* are dominant in both the spring and autumn samples at VNP. In the VNP autumn sample, these 3 species exist in nearly equal proportion with each other, which raises the question of what about their biology allows them to coexist at such equal abundances. Our autumn sample was conducted at an ideal time immediately after the summer rains, and it would be interesting to see how the abundances of these 3 species would change over the course of a month, given enough time to see possible effects of species' competition (degree of resource overlap), predation, disease or parasitism. The VNP spring sample was conducted later in the spring season, and the same three species, *Rhaphotittha platypternoides*, *Leva callosa*, and *Thyridota dispar*, were found to be in different proportional abundances, 7.0%, 20.1%, and 10.8% respectively. It could be asked if this difference in proportional abundance in the spring is, in part, the result of competition between the species. Or perhaps the lower proportional abundance in the spring of *Rhaphotittha platypternoides* and *Thyridota dispar* is because of competitive advantages that the most dominant spring species, *Xenocatantops zernyi* (40.4%) might have in the community, whereas *Leva callosa* is seemingly not as affected by the seasonal compositional change (20.1% in spring, 24.2% in autumn).

Higher taxonomy of community composition.

The MZNP spring sample included only 1 family, Acrididae, and 6 subfamilies. In the MZNP spring sample, the Acridinae account for 65% of the total individual abundance and 13% of the species, whereas the Gomphocerinae account for 29% of the total individual abundance and 38% of the species (figure 13, table 5). The MZNP autumn sample consisted of 2 families, Acrididae and Pamphagidae, with 6 Acrididae subfamilies. Acridinae account for 27% of the total individual abundance and 21% of the species, whereas the Gomphocerinae account for 54% of the total individual abundance and 21% of the species (figure 14, table 6). Oedipodinae also account for 21% of the species in the MZNP autumn community.

It could be hypothesized that the Acridinae and Gomphocerinae might compete for the same resources in which case Acridinae are perhaps better adapted to spring conditions (and the preceding winter conditions) as evidenced by their greater abundance in that season, whereas in the autumn, when there is more consumable biomass and a more favorable climate, the Gomphocerinae are able to dominate the resources more effectively.

The VNP spring sample consisted of 2 families, Acrididae and Pyrgomorphidae, with 5 Acrididae subfamilies. In the VNP spring sample, the Gomphocerinae account for 44% of the individuals and 47% of the species, while Catantopinae account for 41% of the individuals but only 16% of the species (figure 15, table 7). The VNP autumn sample consisted of 2 families, Acrididae and Thericleidae, with 7 Acrididae subfamilies. In the VNP autumn sample, the Gomphocerinae account for 91% of the individuals and 59% of the species (figure 16, table 8).

Gomphocerinae dominate both seasons at VNP, although in the spring, the Catantopinae are nearly equally dominant suggesting that Catantopinae, and specifically *Xenocatantops zernyi* (found in both seasons although at dramatically different abundances [40% spring; 1% autumn]) (table 4), is well adapted to spring conditions and perhaps is not able to compete as effectively for resources in the autumn.

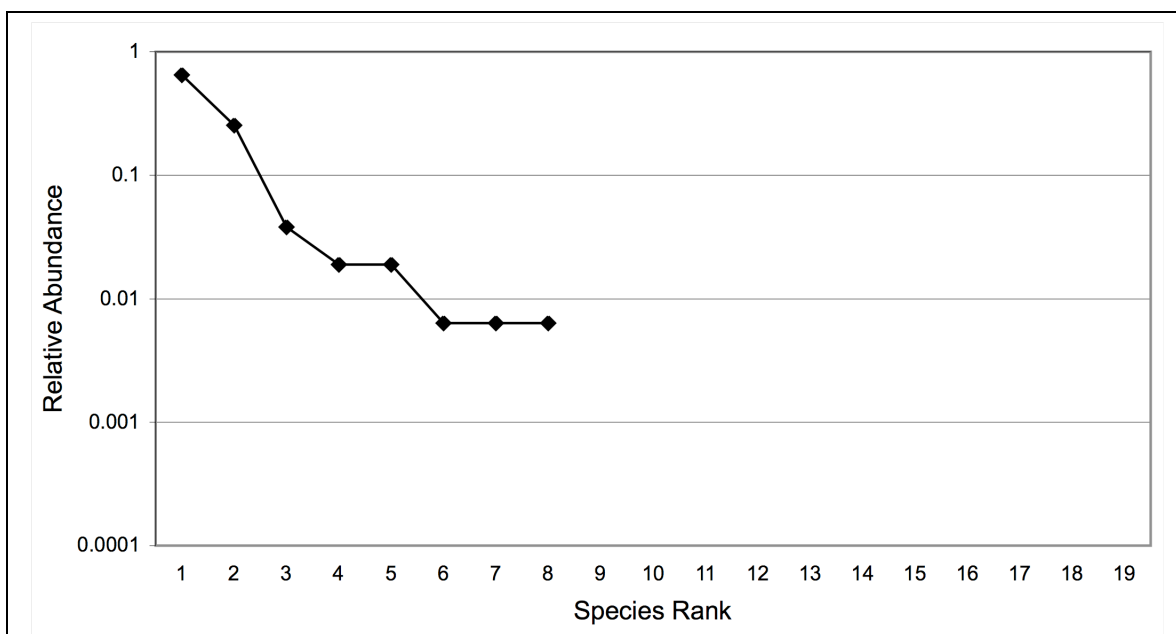


Figure 9. Mountain Zebra N.P. spring sample rank-abundance curve of 8 species.

[1-*Gymnbothrus* near *carinatus*; 2-*Pnorisa squalus*; 3-*Loryma zebrata*, n.sp.; 4-*Anablepia dregei*; 5-*Rhaphotittha* sp. 2; 6-*Acorypha* (*Caloptenopsis femoralis*); 7-*Brachyphymus basuto*; 8-*Catantops*, n.sp..]

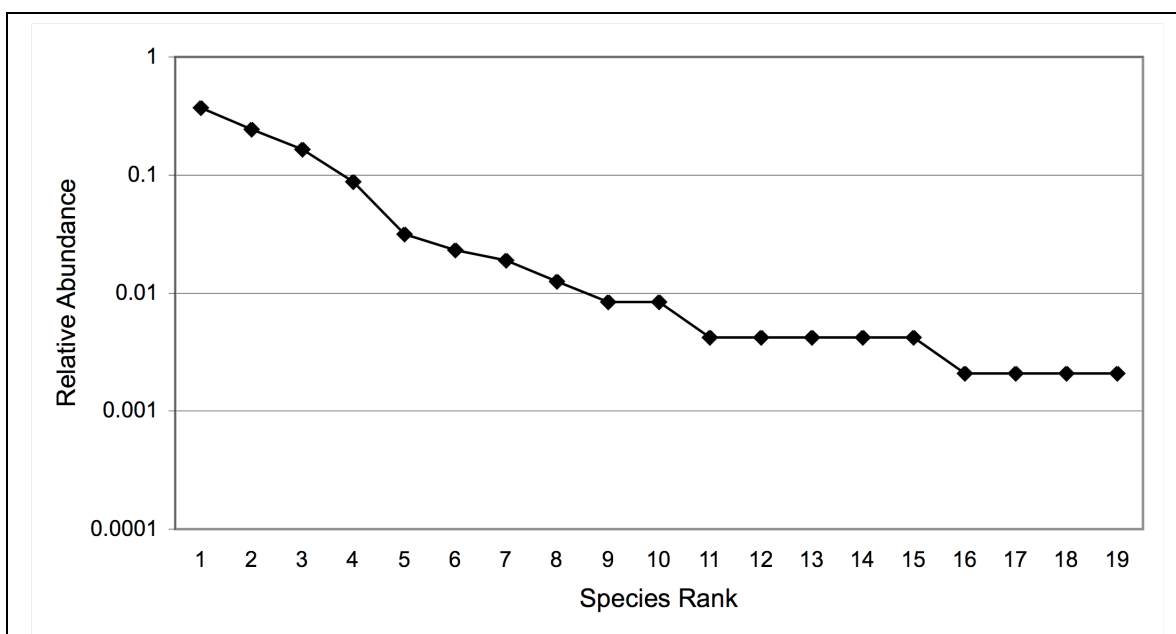


Figure 10. Mountain Zebra N.P. autumn sample rank-abundance curve of 19 species.

[1-*Pnorisa squalus*; 2-*Orthochtha d. dasyncnemis*; 3-*Rhaphotittha palpalis*; 4-*Eyprepocnemis plorans meridionalis*; 5-*Platacanthoides bituberculatus*; 6-*Euryphymus tuberculatus*; 7-*Gymnbothrus carinatus*; 8-*Heteracris calliptamoides*; 9-*Acrida sulphuripennis*; 10-*Gastrimargus* sp.; 11-*Anaeolopus socius*; 12-*Acrotylus* sp. 1; 13-*Leva callosa*; 14-*Tmetonota abrupta*; 15-*Hoplolopha horrida*; 16-*Pseudogmothela media*; 17-*Acanthacris ruficornis*; 18-*Oedaleus flavus*; 19-*Euryphymus* sp..]

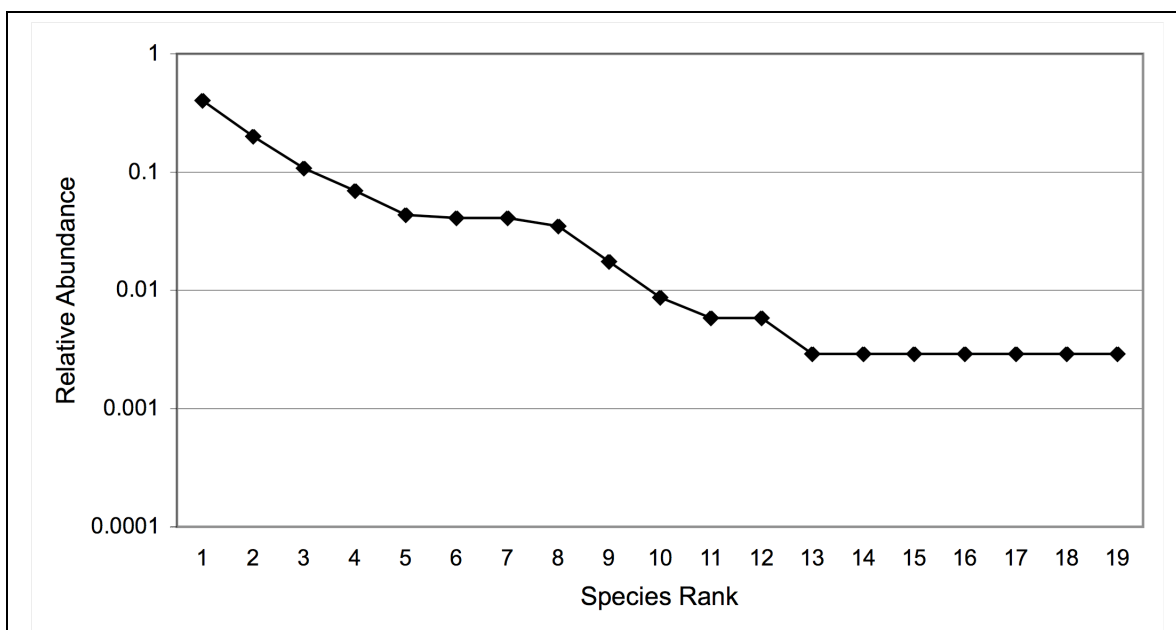


Figure 11. Vaalbos N.P. spring sample rank-abundance curve of 19 species.

[1-*Xenocatantops zernyi*; 2-*Leva callosa*; 3-*Thyridota dispar*; 4-*Rhaphotittha platypternoides*; 5-near *Calliptamicus*; 6-*Pseudoarcyptera carvalhoi*; 7-*Acrotylus deustus*; 8-*Truxalis burtti*; 9-*Pseudotristria cylindrica*; 10-*Mesopsis laticornis*; 11-*Pnorisa squalus*; 12-*Mesopsis abbreviatus*; 13-*Brachycrotaphus tryxalicerus*; 14-*Oedaleus flavus*; 15-*Cyrtacanthacris tatarica*; 16-*Phaeocatantops decoratus*; 17-*Rhaphotittha* sp. 1; 18-*Cryptocatantops crassifemoralis*; 19-*Thericleidae* sp..]

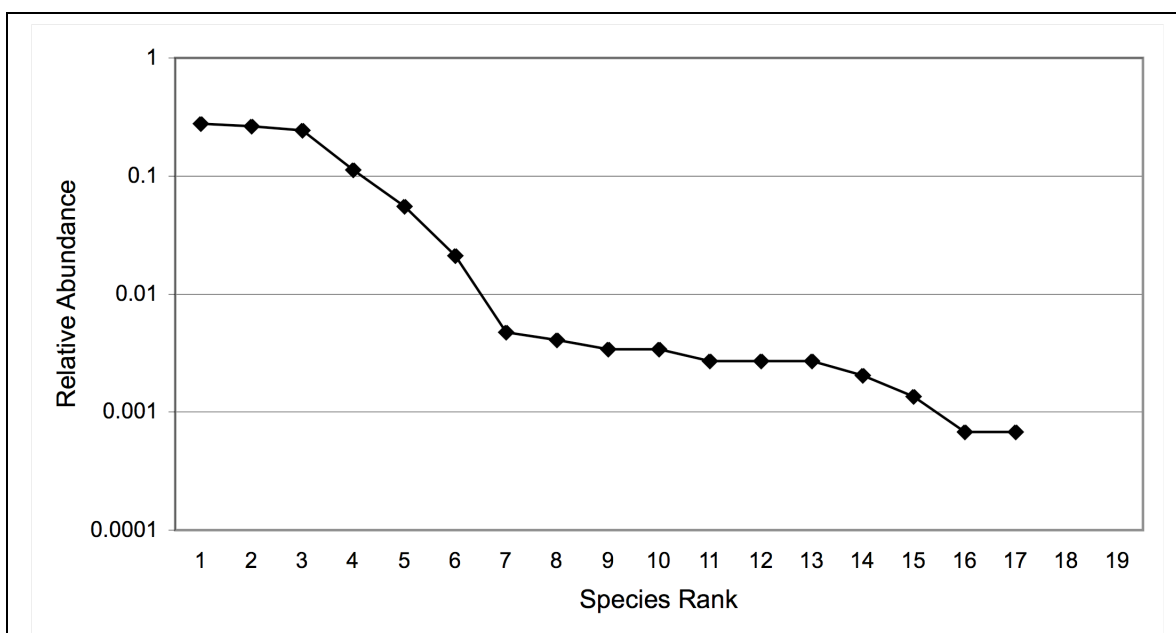
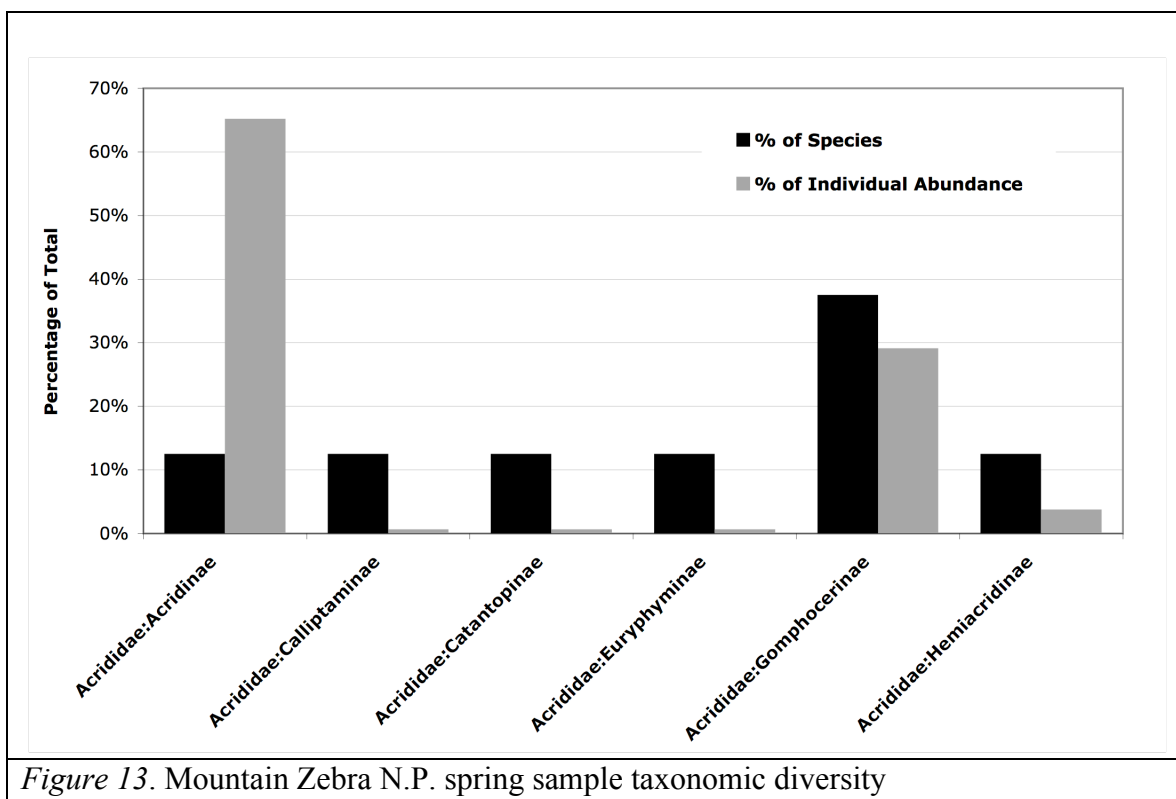


Figure 12. Vaalbos N.P. autumn sample rank-abundance curve of 17 species.

[1-*Thyridota dispar*; 2-*Rhaphotittha platypternoides*; 3-*Leva callosa*; 4-*Pseudoarcyptera carvalhoi*; 5-*Xenocatantops zernyi*; 6-*Oedaleus flavus*; 7-*Acrotylus deustus*; 8-*Pseudogmothela rehni*; 9-*Paragymnobothrus* near *rufipes*; 10-*Rhachitopsis* near *crassus*; 11-*Rhaphotittha* sp. 1; 12-*Mesopsis laticornis*; 13-*Brachycrotaphus tryxalicerus*; 14-*Zonocerus elegans*; 15-*Pseudotristria cylindrica*; 16-*Pyrgomorpha* (*Phymelloides*) *granulata*; 17-*Pnorisa squalus*.]



Family : Subfamily	No. of Species	% of Species	Individual Abundance	% of Individual Abundance
Acrididae : Acridinae	1	13%	103	65%
Acrididae : Calliptaminae	1	13%	1	1%
Acrididae : Catantopinae	1	13%	1	1%
Acrididae : Euryphyminae	1	13%	1	1%
Acrididae : Gomphocerinae	3	38%	46	29%
Acrididae : Hemiacridinae	1	13%	6	4%
Total =	8		158	

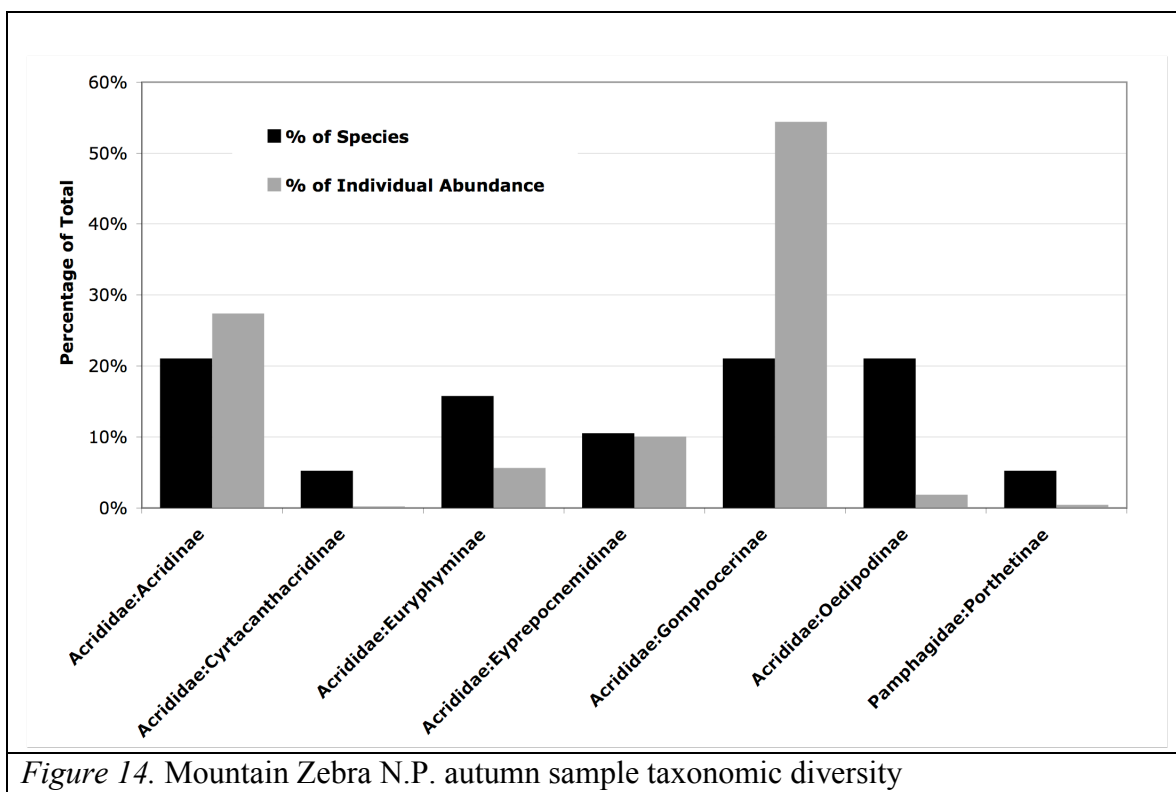


Table 6. Mountain Zebra N.P. autumn sample taxonomic diversity

Family : Subfamily	No. of Species	% of Species	Individual Abundance	% of Individual Abundance
Acrididae : Acridinae	4	21%	131	27%
Acrididae : Cyrtacanthacridinae	1	5%	1	<1%
Acrididae : Euryphyminae	3	16%	27	6%
Acrididae : Eyprepocnemidinae	2	11%	48	10%
Acrididae : Gomphocerinae	4	21%	260	54%
Acrididae : Oedipodinae	4	21%	9	2%
Pamphagidae : Porthetinae	1	5%	2	<1%
Total =	19		478	

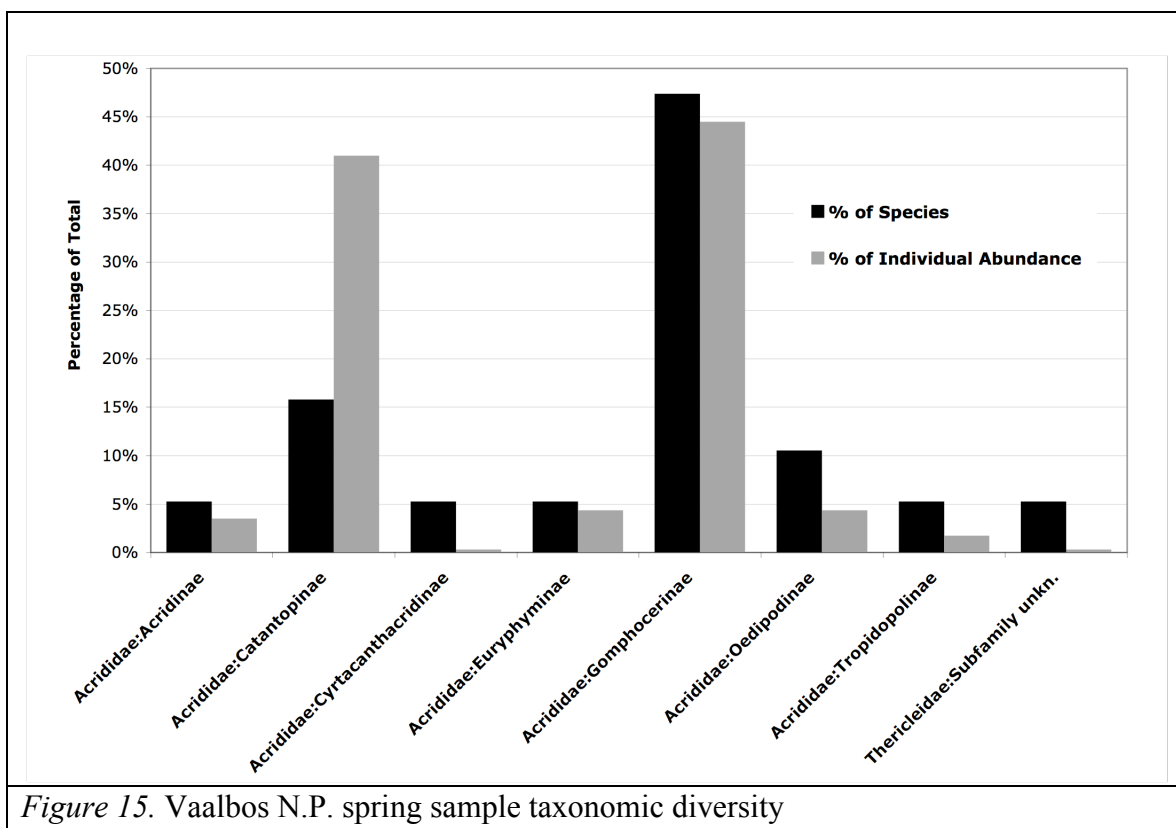


Table 7. Vaalbos N.P. spring sample taxonomic diversity

Family : Subfamily	No. of Species	% of Species	Individual Abundance	% of Individual Abundance
Acrididae : Acridinae	1	5%	12	3%
Acrididae : Catantopinae	3	16%	141	41%
Acrididae : Cyrtacanthacridinae	1	5%	1	<1%
Acrididae : Euryphyminae	1	5%	15	4%
Acrididae : Gomphocerinae	9	47%	153	44%
Acrididae : Oedipodinae	2	11%	15	4%
Acrididae : Tropidopolinae	1	5%	6	2%
Thericleidae : Subfamily unkn.	1	5%	1	<1%
Total =	19		344	

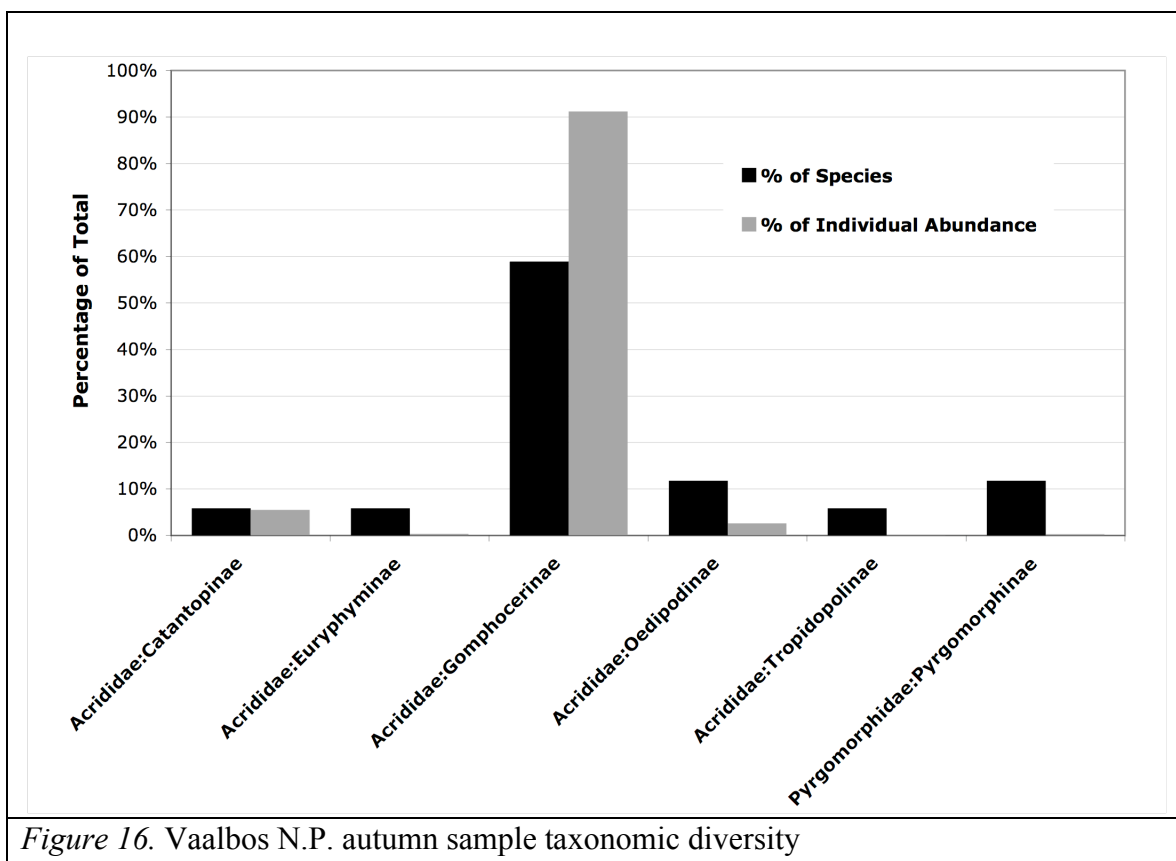


Table 8. Vaalbos N.P. autumn sample taxonomic diversity

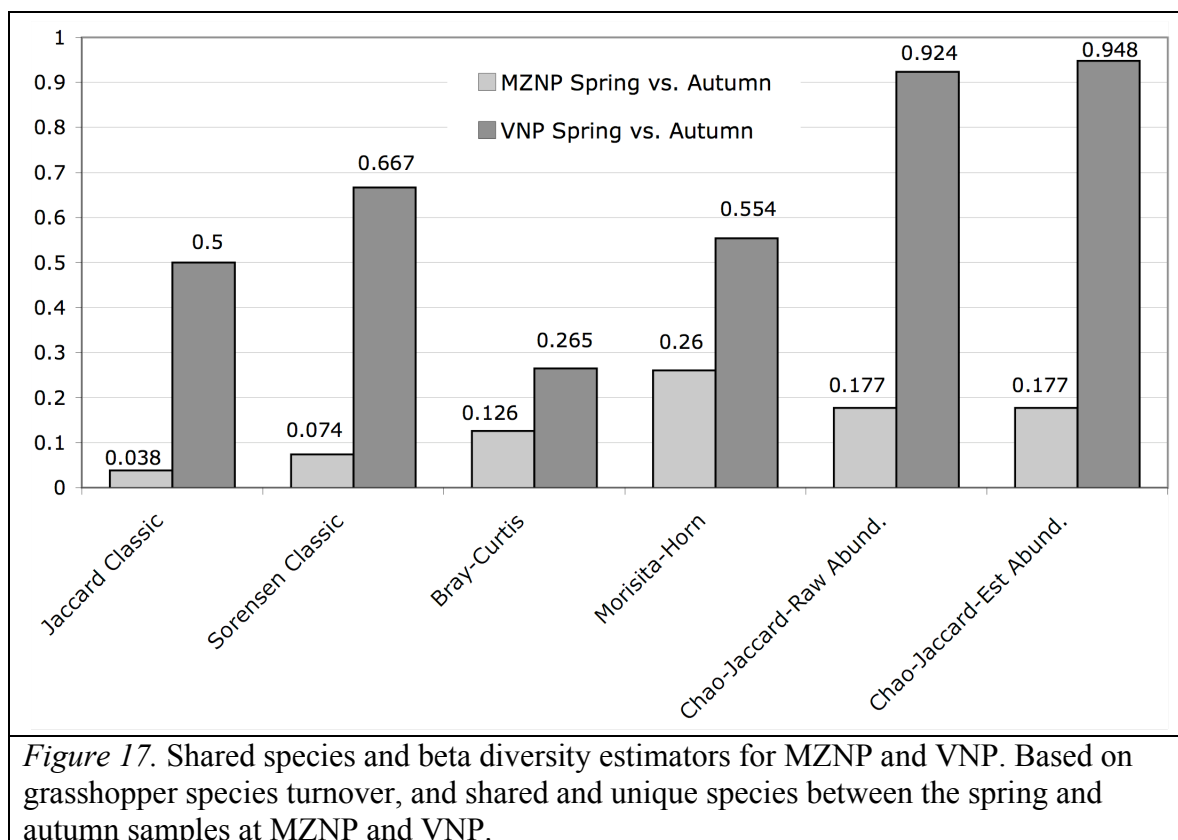
Family : Subfamily	No. of Species	% of Species	Individual Abundance	% of Individual Abundance
Acrididae : Catantopinae	1	6%	81	5%
Acrididae : Euryphyminae	1	6%	5	<1%
Acrididae : Gomphocerinae	10	59%	1344	91%
Acrididae : Oedipodinae	2	12%	38	3%
Acrididae : Tropidopolinae	1	6%	2	<1%
Pyrgomorphidae : Pyrgomorphinae	2	12%	4	<1%
Total =	17		1474	

Species turnover and beta diversity.

Figure 17 shows various quantitative and qualitative shared species estimators, a reflection of the degree of similarity (or degree of species turnover), contrasting beta diversity between the seasons within MZNP and VNP. Table 2 in the Appendix includes the names, descriptions and references for the selected species turnover measures and beta diversity estimators. Jaccard Classic, Sorensen Classic, Bray-Curtis and Morista-Horn indices are all considered reliable and informative according to multiple studies cited in Magurran (2004) and Colwell (2006), but because 3 of the 4 sampling efforts probably were insufficient to fully document the alpha diversity (see species accumulation curves, figures 16 and 17), it is difficult to assess the accuracy of these various. Nonetheless, it is apparent from the raw data that the seasonal species turnover at MZNP is dramatic, with only a single species found in both seasons. VNP sampling revealed approximately 50% seasonal turnover, which, though less striking, still indicates a seasonally very dynamic assemblage.

Because so little is known about the biogeography, phenology, and physiology of most South African grasshopper species, I can only speculate here as to why the sampled MZNP grasshopper community appears to have much higher seasonal species turnover than the VNP grasshopper community. Perhaps MZNP has a greater proportion of univoltine species (one generation annually), compared to VNP (with a greater proportion of bivoltine or multivoltine species), because winters in MZNP are characterized by occasional severe frosts. Such events may prevent some grasshopper species from overwintering successfully as subadults at MZNP, a requirement if a species is to be bi- or multivoltine. Studies of grasshopper temperature responses and life cycle might

determine whether these characteristics might limit survival and development. Sampling habitats between MZNP and VNP might allow us to see where species composition changes and how turnover also changes in additional, perhaps transitional communities.



Species accumulation curves and richness estimators.

Evaluation of the accuracy of the many diversity estimators for organisms in the field is still very incompletely evaluated (Gotelli and Colwell 2001, Chao et al. 2009). In studies like this one, which address an entirely unknown fauna with necessarily incomplete sampling, the choice of analytical methods is therefore difficult. To increase the applicability of this study's results for future comparative studies, multiple diversity estimators were selected and paired with the species accumulation curves for each site and season in figures 18 and 19. Table 3 in the Appendix includes the names, descriptions and references for the selected metrics.

The MZNP spring sampling effort (figure 18 A) yielded 8 species. The ACE, ICE, Chao1 and Jack1 estimators all converged on approximately 11 species, indicating that the survey may have missed 3 species. At this site and season, though the doubletons and duplicates means decrease to 0 by the 24th sample, the singletons (3 sp.) and uniques (3 sp.) means do not. The angle of the species accumulation (or species observed, SOB) trajectory decreases but does not plateau indicating that the full diversity of this site was not recorded and further sampling was needed.

The MZNP autumn sampling effort (figure 18 B) yielded 19 species. The ICE estimator converged on +/-32 species, Jack1 predicted +/- 27 species, and ACE predicted +/-23 species. Chao1 gave the estimate closest to the observed species with a prediction of 20.6 species. At this site and season, the duplicates mean was decreasing by the 24th sample, singletons and doubletons means remain level, and the uniques mean appears to increase. The angle of the species accumulation (SOB) trajectory decreases but does not

plateau indicating that the full diversity of this site was not recorded and further sampling is needed.

The VNP spring sampling effort yielded 19 species (figure 19A) The ACE, ICE and Chao1 estimators all predicted +/-32 species. The Jack1 estimator gave the lowest prediction of 26.7 species. At this site and season, the duplicates (1 sp.) and doubletons (2 sp.) means appear level by the 24th sample, and the singletons (7 sp.) and uniques (8 sp.) means still appear to be increasing. The angle of the species accumulation (SOB) trajectory decreases but does not plateau indicating that the full diversity of this site was not recorded and further sampling was needed.

The VNP autumn sampling effort yielded 17 species (figure 19B). Most the richness estimators (ACE, ICE and Chao1) converged to +/-17 species, meeting the observed species (SOB) trajectory, although Jack1 estimates 18.92 species. At this site and season, the doubletons (1 sp.) mean appears to be increasing by the 24th sample, whereas the duplicates (4 sp.), singletons (2 sp.), and uniques (2 sp.) means appear to be decreasing. The angle of the species accumulation (SOB) trajectory appears to be nearly level, and paired with the results of the richness estimators, it is likely that sampling effort at VNP in the autumn was successful with documenting the true diversity of this site.

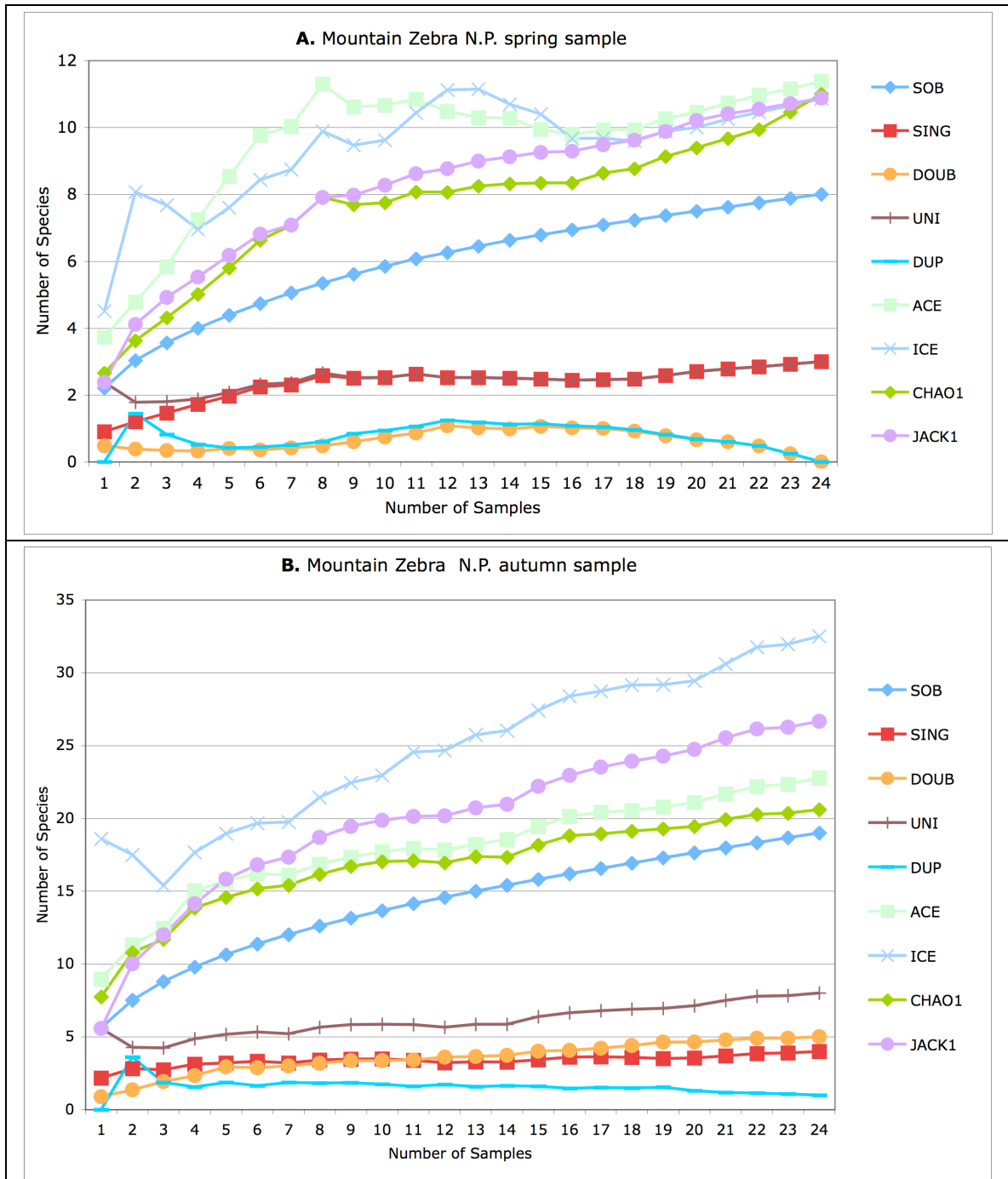
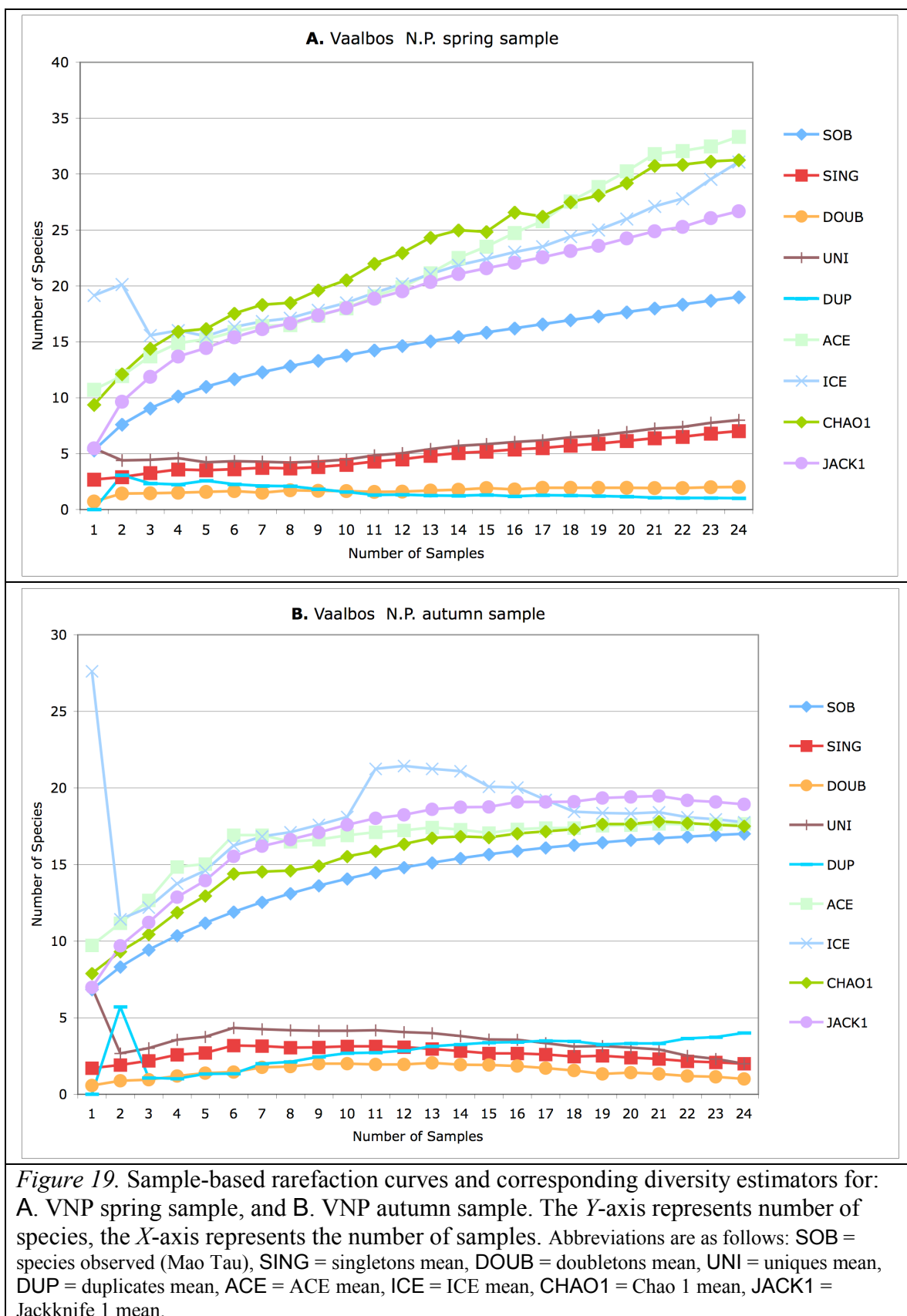


Figure 18. Sample-based rarefaction curves and corresponding diversity estimators for: A. MZNP spring sample and B. MZNP autumn sample. The Y-axis represents number of species, the X-axis represents the number of samples. Abbreviations are as follows: SOB = species observed (Mao Tau), SING = singletons mean, DOUB = doubletons mean, UNI = uniques mean, DUP = duplicates mean, ACE = ACE mean, ICE = ICE mean, CHAO1 = Chao 1 mean, JACK1 = Jackknife 1 mean.



Discussion of sampling protocol.

The results of the species accumulation curves indicate that for the MZNP spring and autumn samples, and the VNP spring sample, additional quadrats would probably have revealed greater species richness just as the richness estimators indicate. As well, the decision to collect in the spring and autumn, on either side of the rainy season, at both MZNP and VNP resulted in the unexpected discovery of higher species richness than initially expected, and a higher than expected degree of species turnover between seasons. Often grasshoppers are only sampled in the autumn, when they are known to be more abundant, but neglecting the spring grasshopper fauna would certainly lead to a dramatic underestimate of actual grasshopper diversity.

I am confident that the sampling protocol did accurately estimate densities of individuals because it entailed a very fine-scaled examination of the habitat. After sampling the quadrat for 30 minutes, there were typically very few grasshoppers left to find. This protocol seems to be very effective for establishing a baseline understanding of previously unstudied grasshopper communities.

In contrast with this study protocol, Gebeyehu and Samways (2002) amassed grasshopper data by doing species counts while walking long transects in a single direction (5m x 100m), with grasshopper collection only if species identification was uncertain. They found no difference between the grasshopper community composition in overgrazed private land and that of native grazed parkland, though they did report a significantly reduced grasshopper density in overgrazed land.

The Gebeyehu and Samways (2002) design is reminiscent of butterfly transect sampling protocols in which the collector walks a transect in one direction, counting and

identifying butterflies as they take flight. This is a very well-established protocol that works well for butterflies because they nearly always take flight from vegetation with approaching disturbance by a collector (unless they are damaged or heavily parasitized), and they usually can readily be identified in flight. The latter is especially true if the fauna has been previously documented, as is often the case with many butterfly faunas (butterfly larval plant host specificity research might also help to predict the potential pool of species ahead of time as well). However, grasshoppers do not share the characteristics that make one-directional sampling and sight identification ideal, especially not in South Africa where the diversity is estimated to be twice the documented 553 species, and their vegetation specificity is also virtually unstudied (Otte and Naskrecki 1997, Otte and Eades 2002). Moreover, many species closely resemble each other, and grasshopper coloration and size is often variable, necessitating dissection and/or microscopic examination for accurate identification. For these reasons, all specimens should be collected.

The 2005-2006 grasshopper sampling protocol allowed me to appreciate the many predator escape behaviors that different grasshopper species exhibit. This cannot be ignored when selecting a sampling protocol. Though the natural history of most South African grasshoppers (locust species aside) are unknown, marked differences in predator escape behaviors among species clearly occur. Some species take flight immediately upon disturbance and fly great distances. Others jump varying distances and with varying persistence. Some species jump and then crawl significant distances once on the ground, whereas other species jump and stay in the general area in which they landed. A new species, *Loryma zebrata* (see chapter 3) documented from the MZNP spring sample,

jumped once on average then crawled to the base of a mound of grass if they didn't initially jump directly into a mound of grass. Even when the grass was examined carefully and then aggressively, *Loryma zebrata* often did not attempt to flee but rather crawled deeper into the grass base and remained still.

Crossing through a quadrat multiple times allows the researcher the opportunity to document a greater proportion of species that exhibit a greater variety of predator escape behaviors. A one-directional transect survey may miss species that exhibit different predator escape behaviors. It would be expected that those species that take flight and do not crawl, or those that cling high on the vegetation (at sweep-net height), would be disproportionately abundant in samples.

Lastly, the Gebeyehu and Samways (2002) study did not appear to time researchers within the transects nor did they indicate how many collectors were sampling per unit space, which certainly can greatly affect grasshopper density estimates (as it would certainly have done so in this study).

Suggestions for future grasshopper field sampling in South Africa:

1) For first-time surveys of the grasshopper fauna, a smaller scale quadrat protocol with a fixed number of collectors and timed sampling periods will give the most accurate density measurements and the greatest chance of replicable and comparable sampling results. Crossing through smaller quadrats multiple times will likely yield better accuracy for estimating densities of species and individuals particularly if the grasshopper community contains species with different predator escape behaviors.

2) When documenting the grasshopper fauna for conservation or burning management purposes, researchers should consider sampling the fauna before and after the rainy season. For example, if a researcher chose to only sample at MZNP in the autumn (the season typically sampled) to determine the richness of the community before or after a burn, they would first underestimate the grasshopper richness of the site by nearly half because the seasonal species turnover is so dramatic, and secondly, they would miss any effects the burn might have on the spring grasshopper community. At MZNP an exclusively spring species, *L. zebrata* (n.sp.), is an excellent example of a species that is likely to be of higher conservation concern because it is univoltine, flightless, and appears to have a small species range.

3) Until a grasshopper community is well studied, all surveyed material must be collected, preserved and deposited in natural history collections for purposes of new species discovery, revisionary work, or for documenting ecological and distributional data. We should appreciate the multitude of possible uses that natural history collections provide future researchers (whether the material is examined 1 year or 100 years from now), especially when the fauna is vastly understudied and the chance of new species discovery is high.

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APPENDIX

Appendix Table 1. Detailed description of specimen collecting methods

<p><i>Sweep-netting:</i> Using an insect net sweep through the top foot of loose soft vegetation or tall grass. This sweeping action is accomplished with speed and power because grasshoppers may drop off the vegetation ahead of the net. After a maximum of two-three sweeps, the net is opened and examined carefully to pull grasshoppers from the debris.</p>
<p><i>Poke+Stare (Visual Search):</i> Examine microhabitat and search visually for grasshoppers and poke branches or leaves to move the vegetation or substrate only slightly (unlike beating or sweeping where vegetation is struck with force). Walk or crawl low through the habitat checking ground, leaf litter, grass, shrubs, and around rocks and trees etc. This technique minimizes disturbance impact. This method was used after the sweep-netting method to discover species that exhibit a different predator evasion technique (not jumping but rather crawling, hiding and waiting).</p>

Appendix Table 2. Explanation of shared species and similarity indexes used for figure 17, generated using EstimateS 8.0. This table is modified from EstimateS 8.0 user's guide (Colwell 2006).

EstimateS 8.0 variable abbv.	Explanation	Reference
Jaccard Classic	Classic Jaccard sample similarity index. Quantitative index.	Chao et al. 2005
Sorensen Classic	Classic Sorensen incidence-based sample similarity index. Qualitative, presence/absence.	Chao et al. 2005
Bray-Curtis	Bray-Curtis sample similarity index / Sorensen quantitative index.	Magurran 1988; Magurran 2004
Morisita-Horn	Morisita-Horn sample similarity index. Quantitative index. Highly sensitive to the abundance of the most abundant species (Wolda 1981; Magurran 2004).	Magurran 1988; Magurran 2004

Chao-Jaccard-Raw Abund.	Chao's Jaccard Raw Abundance-based similarity index. Uncorrected for unseen species. Probability that two randomly chosen individuals, one from each of the 2 samples, both belonging to species shared by both samples (but not necessarily to the same shared species) (Colwell 2006).	Chao et al. 2005
Chao-Jaccard-Est Abund.	Chao's estimator for Chao's Jaccard Abundance-based similarity index. Corrected for unseen species.	Chao et al. 2005

Appendix Table 3. Explanation of richness estimators used for the figures 18 and 19, generated using EstimateS 8.0. This table is modified from EstimateS 8.0 user's guide (Colwell, 2006).

figure abbrev.	EstimateS 8.0 variable abbrev.	Explanation	Reference
SOB	Sobs (Mao Tau)	Number of species in pooled samples (given empirical data).	Colwell et al. 2004
SING	Singletons Mean	Number of species represented by only one individual within the pooled samples.	Colwell & Coddington 1994
DOUB	Doubletons Mean	Number of species represented by only two individuals within the pooled samples.	Colwell & Coddington 1994
UNI	Uniques Mean	Number of unique species that occur in only one sample within the pooled samples.	Colwell & Coddington 1994
DUP	Duplicates Mean	Number of species that occur in only two samples within the pooled samples.	Colwell & Coddington 1994
ACE	ACE Mean	Abundance-based Coverage Estimator of species richness. Based on abundances of species than have between 1 and 10 individuals (Magurran 2004).	Chao et al. 2000; Chazdon et al. 1998
ICE	ICE Mean	Incidence-based Coverage Estimator of species richness. Based on species found in at least or less than 10 sampling units (Magurran 2004).	Chao et al. 2000; Chazdon et al. 1998
CHAO1	Chao1 Mean	Chao 1 richness estimator. Estimates minimum richness and assumes homogeneity, based on the number of rare species in a sample (using singletons and doubletons) (Magurran 2004).	Chao 1984
JACK1	Jack1 Mean	First-order Jackknife richness estimator. Uses the number of species that occur only in a single sample (Magurran 2004).	Burnham & Overton 1978, 1979; Smith & van Belle 1984; Heltshe & Forrester 1983

CHAPTER 3:

Taxonomic revision of the South African grasshopper genus *Loryma* (Orthoptera: Acrididae: Hemiacridinae)

ABSTRACT

The South African flightless Hemiacridinae genus *Loryma* is revised for the first time, with 21 new species described. Species keys, a preliminary reference chart of species, extensive photography of external and internal morphology, and distribution maps are provided. Morphology figures labeled with internal and external terminology are included. Two provisional *Loryma* species-groups are proposed: Epiphallic Apodeme species-group and the No Epiphallic Apodeme species-group. The majority of the Epiphallic Apodeme species-group members are found in succulent karoo biome, with one species in the grassland biome, whereas the majority of the No Epiphallic Apodeme species-group members are found in the fynbos biome. *Lorymaini* is addressed, tribe members *Hemiloryma*, *Dirshacris* and *Labidioloryma* are photographed, a list of diagnostic differences is provided, and a key to the genera is given.

The following new species are proposed: *EPIPHALLIC APODEME SPECIES-GROUP*: *ashleyi*, new species; *carolynae*, new species; *magna*, new species; *browni*, new species; *khoi*, new species; *namaqua*, new species; *san*, new species; *mayi*, new species; *zebrata*, new species; *bonteboki*, new species; *karoo*, new species; *NO EPIPHALLIC APODEME SPECIES-GROUP*: *mirabunda*, new species; *cederbergensis*, new species; *lapollai*, new species; *tsitsikamma*, new species; *waboom*, new species; *solveigae*, new species; *larsenorum*, new species; *umoja*, new species; *lyra*, new species; *ottei*, new species.

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INTRODUCTION

Since the genus was created in 1878 by Stål, the South African grasshopper genus *Loryma* has received little attention from researchers. These small to mid-sized grasshoppers are found primarily in the fynbos and succulent karoo regions of western South Africa, where they are not frequently encountered during fieldwork. These short-winged grasshoppers are fast, strong jumpers that can still be exceedingly difficult to catch even though they cannot fly (fig.1).

Fieldwork by H. Dick Brown during the late 1950s and 1960s considerably expanded the number of *Loryma* specimens available for study. Though he did not publish formal taxonomic papers exclusively about *Loryma*, Brown did describe two members of *Lorymaini*, *Dirshacris* and *Hemiloryma*, and Brown's field studies collected many of the undescribed species that are included in this present study. More recent fieldwork by Daniel Otte and this author revealed in fact that this formerly monotypic genus is far more diverse than has been previously thought.

This study represents the first taxonomic revision of *Loryma*. Extensive use of auto-montage pictures provides the first documentation of 22 species (21 new species) of *Loryma* now known from South Africa. One thing that has become clear in the course of this work is that male *Loryma* genitalic characters are of utmost importance in identifying specimens. *Loryma* species display a wide range of genitalic forms. In fact, the quick examination of the cerci of Brown's specimens housed in the National Insect Collection in Pretoria is what made it immediately clear that the genus was far more diverse than initially suspected.

It is difficult to say with completion of this study how many more *Loryma* species remain to be discovered. Several factors suggest that there are more species to find. Despite the discovery of 21 new species in the course of this study, these new species are represented by relatively few specimens, suggesting that diversity may be far greater once more specimens are collected. Furthermore, it appears that *Loryma* species have small ranges, and large areas, particularly in mountains, remain to be surveyed across southern and western South Africa. Finally, *Loryma* are found in areas that are known to possess high insect species richness and endemism. I hope that this study will provide a comparative framework for the study of this diverse grasshopper genus.

Taxonomic History of the Genus Loryma and Putative Relatives

Tribe Lorymaini Otte, 1995

Loryma Stål, 1878 [type species: *Loryma perficita* (Walker, 1870)]

Dirshacris Brown, 1959 [type species: *Dirshacris aridus* Brown 1959]

Hemiloryma Brown, 1973 [type species: *Hemiloryma deserticola* Brown 1973]

Labidioloryma Grunshaw, 1986 [type species: *Labidioloryma strictoforceps* Grunshaw 1986]

The genus *Loryma* was created by Stål (1878) when he transferred *Platyphyma vittipennis* Stål, 1875 to his new genus. No taxonomic changes were made to the monotypic *Loryma* until Dirsh (1956) transferred *Aphanaulacris perficita* (Walker, 1870), a senior synonym of *Platyphyma vittipennis*, to *Loryma*. At that point the type species for *Loryma* became *L. perficita* (= *L. vittipennis*). No other species level studies have been completed until the present study.

The higher-level classification of *Loryma* has remained uncertain for most of the taxonomic history of the genus. Dirsh placed the genus within the Hemiacridinae, a

subfamily he described based on some of the following characters concerning the phallic complex: cingulum well differentiated, strongly sclerotized, with mostly membranous rami, and valves enclosed in sheath of rami (1956). The monophyly of the hemiacridines remains uncertain (Grunshaw 1986, Brown 1973, Otte pers. comm.). Putative close relatives were described by Brown: *Dirshacris* (1959) and *Hemiloryma* (1973). He considered these three genera the *Loryma* genus-group. Grunshaw (1986) later described *Labidioloryma*, which he considered part of the *Loryma* genus-group. Some main characters defining the genus-group were the reduced to vestigial wings and a spatulate prosternal process. While *Labidioloryma* is known from Malawi, all other genera are apparently restricted to Namibia and South Africa. Otte (1995) considered the genus-group as the tribe Lorymaini, but without further comment.



Figure 1. Live field photo of *Loryma* species. Species (probably *L. carolynae*), from Namaqualand, in the Northern Cape Province of South Africa. Photo by Piotr Naskrecki.

Overview of Natural History and Geographic Range

Loryma biology, behavior and ecology are not fully documented. It has been inferred that *Loryma* is univoltine, because adults have only been collected primarily during core months of the South African spring (September-December). Though it was originally thought to be a nearly exclusive fynbos biome genus (Brown 1973), we can now document species from the fynbos (≈ 10 spp.), succulent karoo (≈ 11 spp.) and grassland biomes (1 sp.) (fig. 2). Of the two species groups proposed in this work, the Epiphallic Apodeme species-group (hereafter EA species-group) and No Epiphallic Apodeme species-group (hereafter NEA species-group), most of the EA species-group have been found in the succulent karoo and grassland biomes, whereas the NEA species-group appears to inhabit primarily the fynbos biome. The interesting distribution of species-group members can be seen in figures 3, 4 and 5. The fynbos biome (or Cape Floristic region) receives winter rains, the succulent karoo receives sporadic winter and summer rains. Such a strong correlation between morphological differences and the various biomes suggests an interesting phylogenetic and biogeographic history that warrants further study.

MATERIALS AND METHODS

Sources of Material

Specimens examined for this study are deposited in the following institutions:

ANSP: Academy of Natural Sciences, Philadelphia, Pennsylvania, USA

SAMC: Iziko South African Museum, Cape Town, South Africa

SANC: South African National Collection of Insects, Pretoria, South Africa

BMNH: Natural History Museum, London, United Kingdom

Analysis of Morphology

Various morphological features are diagrammed in figures 6-15. Morphological terminology follows various sources: Uvarov (1966), Vickery and Kevan (1983), Snodgrass (1935), Roberts (1941), Dirsh (1956), Grunshaw (1986), and Otte (pers. comm.). In this study I define the shoulders of cerci as the anteriodorsal angle of the base of the cerci projecting from beneath tergite-X (examples of no shoulder: *L. ottei*, fig. 57 F; low shoulder: *L. umoja*, fig. 53 F; and pronounced shoulder: *L. zebrata*, fig. 33 F).

Coloration. Most of the material examined for this revision was either dry-collected by Dick Brown between 1958-1972 and deposited in the SANC, or was collected by Dan Otte of the ANSP in 2005-2007 and placed temporarily in 95% ethanol in anticipation of extracting DNA at a later time. Some of the older material has darkened significantly, partially due to time but also perhaps partly because most material was not gutted before being deposited. For this reason, coloration of head, pronotum and abdomen of the older material can appear deceptively dark. The younger material that was temporarily preserved in ethanol was partially bleached of color. Field photography allowed for establishing how much pigmentation can and has been lost with age, lack of

specimen gutting, and temporary ethanol storage. Coloration is addressed in species descriptions using all information possible, but color is never the exclusive feature used in species diagnosis. We strongly suggest that in future field work on *Loryma*, specimens be photographed alive to record their true coloration (and variation of coloration within populations), gutted as soon as possible from between the junction of the top of the head and the anterior margin of the pronotum, that only a minor leg is removed for ethanol preservation, and that the material is dried quickly to maximize color preservation. Coloration features of *Loryma* are diagrammed in figure 6.

Tegmen description. The central, most prominent vein of the reduced wings of *Loryma* is referred to here as the radial vein, although it is likely that the vein seen is the fusion of multiple veins including the radial vein. For purposes of discussing species-level differences in coloration, tegmen bands are numbered and named for efficiency. Bands are listed in order from the most dorsolateral to ventrolateral margins of the tegmen: i. dorsal margin band, ii. radial vein band, iii. posteroradial band, iv. ventral margin band. It must be noted that the radial vein band (ii.) is so named because the radial vein is most often centered within the black band itself, although the pigmentation is never limited to the radial vein alone. Tegmen coloration features of *Loryma* are diagrammed in figure 6.

Measurements. All measurements are presented in millimeters. The length of the abdomen of prepared specimens can vary dramatically, so body length is limited to the length from the tip of the vertex of the head to the apex of the folded posterior femur (after Grunshaw, 1986). The hind femoral measurement is shown as a ratio of length to width (L/W), where width is the greatest distance between the upper and outer carina.

Cerci length is discussed by comparison to that of the supra-anal plate. Cerci of many species curve upward or inward, but the length was always measured parallel to the long body axis from the most anterior point of the cercal articulation to the point of its most posterior extent in dorsal or lateral view and not by measuring the actual curved length of the cerci.

Age of the adult specimens. A thick, rounded shape of the endophallic plate of the aedeagus and the length and thickness of the apodeme of cingulum are quick indicators that the specimen dissected is an older adult male. It is very important, especially when distinguishing between closely related species that the specimens compared are both older adult males. Younger adult males have thinner and shorter endophallic plates and apodemes, and in posterior view, the aedeagus, rami of the cingulum and portions of the aedeagal sheath are not nearly as sclerotized, so that proportions and angles of the structures can appear different. The morphological differences in genitalia of younger and older adult males of the same *Loryma* species are shown in figure 7.

Documentation tools. Digital color images were created using a Q-Imaging digital camera attached to a Leica MZ16 microscope using Syncroscopy Auto-Montage software. Measurements were made using calipers and Auto-Montage software.

Inference of Species Boundaries

Species boundaries were determined on the basis of finding multiple discrete morphological characters that separated specimens into diagnosable groups based on those characters. These characters are considered to represent morphological support for reproductive isolation of the diagnosed species. Species are primarily based on male genitalia because features of these structures provided a range of morphological variation that was easiest to qualify. Female *Loryma* may be of use in determining species boundaries as well, but until more male-female associated specimens are collected, the use of female *Loryma* morphology in determining species is of limited utility. Where possible, females have been associated with males in this study. In locations where multiple *Loryma* species were collected, females were successfully associated with the males of their species by matching the leg and wing color patterns. Only one species, *L. perficita*, the type species for the genus, is known only from the female. Association with a male for this species will require more fieldwork and/or molecular analysis.

DESCRIPTION OF THE GENUS *LORYMA*

General body shape and body coloration. Body length ranges (vertex of head to posterior apex of hind femur): male size range 12.62 mm – 24.42 mm; female size range 14.03 mm – 37.94 mm. Male general body shape, and in particular the head itself, is bullet-like. Females, with their larger size and girth have proportionately wider heads and bodies and are more barrel shaped. The general body coloration is of contrasting stripes which can be quite distinct, with white, cream or yellow colored stripes contrasted against the darker coloration of the remainder of the body in shades of black, brown or gray. Paired longitudinal stripes (medial and lateral) extended along the top and sides of the head, pronotum, portions of the thorax (mesepisternum occasionally, mesepimeron and metepisternum always), tegmina, and along the length of the abdomen (to the supra-anal plate).

Head and pronotum. Antennae segments compressed, i.e. length equal to or less than width, and uniform in shape. Antennal length not exceeding combined length of head and pronotum. Head conical. Strength of banding of head variable, sometimes distinct at one place diffuse at another. Eyes always with small band of coloration across apex of dorsal margin that meets occipital band of head and then pronotal band of lateral carinae. Genal band meeting pronotal lateral band of lateral lobe. Pronotum with distinct primary sulcus interrupting color of lateral band of lateral lobe. Number and placement of secondary sulci of pronotum varies by species. Lateral carinae strongly developed, some species with lateral carinae with minute elevated edge. Posterior margin of dorsal field weakly, moderately or strongly emarginate medially (figure examples of weakly

emarginate: *L. tsitsikamma*, fig. 45C; moderately emarginate: *L. san*, fig. 29C; and strongly emarginated: *L. ashleyi*, fig. 17C).

Mesothorax and Metathorax. Prosternal process spatulate, curved, full structure nearly rectangular with rounded edges, narrowed slightly at mid-length but widened terminally. Mesosternal interspace at least twice as long as wide (longitudinally rectangular). Metasternal interspace reduced to short sulcus where metasternal furca and the metasternal lobes converge. Posterior margin of sternal plate excurved posteriorly.

Tegmen. Tegmina reduced, sometimes nearly ovoid, fully covering large, open tympanum. Each tegmen banded, most often with 4 regions of color, occasionally with 2 adjacent regions indistinguishable, creating 3 regions of coloration, very rarely with tegmenal banding reduced to black with small rounded area, triangle or stripe of white to yellow.

Legs. Hind femora in males with ratio of length to width of 3.23 in smallest species (*L. carolynae*), and 4.08 in largest species (*L. magna*). Upper carinula and medial area with mottled black coloration, variable between and, less extensively, within species. Margin of lower carinula rarely blackened and weakly developed if present. Posterior femur, tibia and tarsus coloration variable between and possibly within species. In some species, the posterior femur and/or knee reddish or orange. Tibia and tarsi reddish, orange, bluish-black, blackish or with muted yellow to cream color. Leg coloration often faded in poorly preserved older specimens or those preserved in ethanol. Outer and inner posterior tibial spine counts range from 9 to 11. Tibial spines with black pigmented tips.

Male external and internal genitalia. Cerci well developed, highly modified and species specific. Most flattened lateromedially, incurved at apices, extending beyond

posterior margin of subgenital plate. Most species with cerci that widen apically (gently to strongly). Cerci of a few species not extending beyond margin of subgenital plate, and either not incurved but rather dramatically flattened and spatulate or with hook-like cerci curling dorsally in lateral view. In a few species, apical margins of cerci accented by black pigmentation.

Phallic complex and epiphallus also highly modified and species specific. Bridge of epiphallus either strongly thickened and curved or with medial apodeme, but not both. Epiphallic lobes and lateral sclerites of the cingulum both variable from distinctly triangular to more rounded. Ectophallus and endophallus joined by moveable hinged connection. Dorsal and lateral valves of aedeagus narrow with smaller apical openings, or wide and thickened with similarly wide open valves. Distal and basal portions of aedeagal sheath significantly sclerotized with either continuous or separated areas of spines and papillae. Most ventral portion of rami of cingulum wider than or as narrow as most distal portion of aedeagal sheath.

Female ovipositor. Ovipositor valves short with weakly recurved apices, most species with valves black to brown on apices (Grunshaw, 1986).

Differentiating Loryma from putative relatives

Loryma can be differentiated from the other genera of the Lorymaini by the following combinations of morphological characteristics, modified from Grunshaw (1986). Asterisks (*) indicate putative synapomorphies for *Loryma*.

1) *Loryma* are found in the fynbos, succulent karoo and grassland biomes of South Africa (fig. 2); *Hemiloryma* (fig. 2) and *Dirshacris* are found in the desert, nama karoo and savanna biomes of South Africa and Namibia; *Labidioloryma* is found in forest canopy openings in Malawi.

2) Antennae of *Loryma*, *Hemiloryma* and *Dirshacris* with more compressed segments (width of segment larger than height) and length is shorter than the combined length of the head and pronotum; antennae of *Labidioloryma* with slightly inflated segments in apical two-thirds, and length is longer than combined lengths of head and pronotum.

3) Pronotum of *Loryma* with strongly developed lateral carinae* (fig. 8); pronotum of *Hemiloryma* (fig. 9), *Dirshacris* (fig. 10) and *Labidioloryma* (fig. 11) without lateral carinae.

4) Mesosternal interspace about half as broad as long, widening posteriorly, each mesosternal lobe having larger area than the mesosternal interspace* in *Loryma* (fig. 12); mesosternal interspace about as broad as long, widening posteriorly (trapezoidal); each mesosternal lobe about equal in area compared to mesosternal interspace in *Hemiloryma*

(fig. 12); mesosternal interspace slightly broader than long, lateral and posterior margins of mesosternal lobes oriented at right-angles to each other, each mesosternal lobe having equivalent area as mesosternal interspace in *Dirshacris* (fig. 12); mesosternal interspace about as broad as long, widening posteriorly, each mesosternal lobe about half the area as mesosternal interspace in *Labidioloryma* (Grunshaw, 1986).

5) Prosternal process spatulate, lamelliform, length greater than width, narrowing mid-length in *Loryma* (fig. 12); “prosternal process spatulate, sloping backwards and with weakly bilobate apex” in *Hemiloryma* (fig. 12; Brown 1973), “prosternal process transverse, lamelliform, square-shaped and sloping backwards” in *Dirshacris* (fig. 12; Brown 1959); no prosternal process in *Labidioloryma*, instead area appears “collar-like with raised medial hump” (Grunshaw 1986).

6) Furcula of last abdominal tergite absent in *Loryma*, *Dirshacris* and *Labidioloryma*; furcula present in *Hemiloryma* (fig. 9).

7) Cerci of *Loryma* highly modified*, with expanded or tapered apices, inturned medially at apices or flat for entire length in some species; cerci of *Hemiloryma* (fig. 9) incurved with acute apices, cercal apices dorsoventrally orientated; cerci of *Dirshacris* (fig. 10) incurved with acute apices, cercal apices more lateromedially orientated; cerci of *Labidioloryma* (fig. 11) conical, straight and unmodified.

- 8) Ovipositor valves in female short and recurved in *Loryma*, *Hemiloryma* and *Dirshacris*; ovipositor valves straight, very elongate in *Labidioloryma* (Grunshaw 1986).
- 9) Phallic complex of *Loryma* with highly modified, highly sclerotized aedeagal sheath aedeagal valves and rami or cingulum*, aedeagal sheath expanding broadly with sclerotized spines or papillae, aedeagal valves can appear short with tapered apices to being long with wide open apices, the rami can appear wider or smaller than the width of the apices of the aedeagal sheath.
- 10) Ectophallus and endophallus of *Loryma* joined by flexible hinge-like connection*, the two structures oriented at a roughly 135° angle; ectophallus and endophallus of *Hemiloryma* (fig. 13; Brown 1973) and *Dirshacris* (Grunshaw 1986) not joined by flexible connection, both somewhat dorsoventrally flattened and narrowed (most noticeable in lateral view); connection of ectophallus and endophallus of *Labidioloryma* not known (Grunshaw 1986).
- 11) Bridge of epiphallus of *Loryma* evenly curved without medial apodeme or angled with a medial apodeme, the lobes moderately sclerotized and rounded or triangular, lateral sclerites ranging from very small to moderate in size and rounded to elongate; bridge of epiphallus of *Hemiloryma* evenly curved without medial apodeme, lobes strong, thick, sclerotized, and textured with papillae, approximately square, lateral sclerites very large, rounded and flattened; bridge of epiphallus of *Dirshacris* angled, lobes moderately sclerotized and more triangular in form; bridge of epiphallus of *Labioloryma* angled,

lobes square but angled outward laterally with most posterior portion of apices bearing an additional apodeme (lateral sclerites unknown).

Key to the Males of the Lorymaini

1. Tegmina vestigial; tympanum closed.....***Dirshacris***
- Tegmina reduced and lobiform; tympanum open.....**2**
2. Cerci short, not surpassing supra-anal plate, conical and straight.....***Labioloryma***
- Cerci longer, always surpassing supra-anal plate, variable in shape but never conical....**3**
3. Furcula absent; pronotum with strongly developed lateral carinae.....***Loryma***
- Furcula present; pronotum lacking lateral carinae.....***Hemiloryma***

SYNOPSIS OF *LORYMA* SPECIES

Group Uncertain

1. *Loryma perficita* (Walker), 1870: 660

Epiphallid Apodeme Species-Group of *Loryma*

2. *Loryma ashleyi*, new species
3. *Loryma carolynae*, new species
4. *Loryma magna*, new species
5. *Loryma browni*, new species
6. *Loryma khoi*, new species
7. *Loryma namaqua*, new species
8. *Loryma san*, new species
9. *Loryma mayi*, new species
10. *Loryma zebrata*, new species
11. *Loryma bonteboki*, new species
12. *Loryma karoo*, new species

No Epiphallid Apodeme Species-Group of *Loryma*

13. *Loryma mirabunda*, new species
14. *Loryma cederbergensis*, new species
15. *Loryma lapollai*, new species
16. *Loryma tsitsikamma*, new species
17. *Loryma waboom*, new species
18. *Loryma solveigae*, new species
19. *Loryma larsenorum*, new species
20. *Loryma umoja*, new species
21. *Loryma lyra*, new species
22. *Loryma ottei*, new species

Discussion of Loryma Species Groups

I have elected to divide *Loryma* into two species groups: Epiphallic Apodeme species-group (hereafter EA species-group) and No Epiphallic Apodeme species-group (hereafter NEA species-group). These species-group naming choices are unorthodox and provisional. I have chosen to do so because it is unclear which species-group would have the genus type species, *Loryma perficita* (Walker), as a component species and would be therefore named after *L. perficita*. Once it is determined with confidence that *L. perficita* is a member of one of the species-groups (once a male is associated with the female holotype), that species-group will be named the Perficita species-group, and the other species-group will be named after one of its component species.

For the time being, I have decided to name the two species-groups primarily based on the overall structure of the epiphallus and the aedeagal valves. The EA species-group consists of species that: 1) have a medial apodeme on the bridge of the epiphallus, and 2) have valves that are narrowed (regardless of length), with small apical openings. The NEA species-group consists of species that: 1) have a thickened and curved bridge of the epiphallus, without a medial apodeme, and 2) have valves that are wide and tubular or are flattened so that they appear thinner in lateral profile and wider in posterior view (regardless of length), with medium to large apical openings. Further morphological distinctions can be seen by comparing the phallic complexes of the two species-groups in figures 14 and 15.

KEY TO MALES OF *LORYMA*

1. Bridge of epiphallus with medial apodeme (as in fig. 18 G).....2
 - Bridge of epiphallus without medial apodeme (as in fig. 40 G).....12

2. Cerci curved dorsally, apices sharply pointed, hook-like in lateral view; tegmen bands iii.+iv. with indistinct boundaries, anterior white to yellow oval patch atop black or black-brown; yellow-cream patch not extending beyond mid-length of tegmen (as in figs. 17 & 19).....3
 - Cerci not curved dorsally, apices not hook-like in lateral view; tegmen band iii. white to yellow (whether diffuse, mottled or distinct), extending full length of tegmen, from base to apex paralleling radial vein.....4

3. Distal hind femur, knee, and base of tibia orange, tibia at mid-length blue, distal tibia blended to black; sclerotized membranes encircling ventral valves of aedeagus more narrow (figs. 19 & 20).....*L. carolynae*
 - Distal hind femur not orange, knee and proximal tibia with area of brown-black speckling, tibia faintly blue-gray at mid-length, distal tibia blended brown-black; sclerotized membranes encircling ventral valves of aedeagus widened and expanded (fig. 17 & 18).....*L. ashleyi*

4. Medial apodeme of supra-anal plate with triangular apex (fig. 35 G).....*L. bonteboki*
 - Medial apodeme of supra-anal plate with rounded apex (as in figs. 29 G & 57 G).....5

5. Males large (23.64 – 24.42 mm); cerci tubular in middle section between apex and base (figs. 21 & 23).....6
- Males small to medium-sized (< 24 mm); cerci not tubular, more-or-less flattened between apex and base.....7
6. Tegmen band ii. black, both margins diffuse and iii.+iv. mottled black and yellow , boundaries indistinct; medial margins of apex of cerci in posterior view emarginate (fig. 23 I); basal portion aedeagal sheath as in fig. 24 A & C.....*L. browni*
- Tegmen band ii. black, margins distinct, iii. yellow, distinct margins except faded posteroventrally, and iv. black, margins distinct; medial margins of apex of cerci in posterior view straight (fig. 21 I); basal portion of aedeagal sheath as in fig. 22 A & C.....*L. magna*
7. Tegmen band iii. distinct, yellow-cream, extending full length of tegmen from base to apex.....8
- Tegmen band iii. not distinct from iv., yellow, if present, only found at apex, not extending length of tegmen, base of tegmen in iii.+iv. black9
8. Tibiae mostly or partially orange (fig. 29); in lateral view, distance between ventral base of ectophallus and dorsal surface of aedeagal arch shorter than from the dorsal surface of aedeagal arch to apices of aedeagal valves (fig. 30 E).....*L. san*
- Tibia without orange and partially to mostly blue and black (fig. 33); in lateral view, distance between ventral base of ectophallus and dorsal surface of aedeagal arch longer

than from the dorsal surface of aedeagal arch to apices of aedeagal valves (fig. 34 E).....

.....*L. zebrata*

9. Tegmen bands iii.+iv. not yellow; in lateral view, distance from the dorsal surface of aedeagal arch to apices of aedeagal valve at least 1/2 as long as from ventral base of ectophallus to dorsal surface of aedeagal arch.....**10**

- Tegmen bands iii.+iv. at least partly yellow; in lateral view, distance from dorsal surface of aedeagal arch to apices of aedeagal valve less than 1/3 as long as from ventral base of ectophallus to dorsal surface of aedeagal arch.....**11**

10. Cerci widest at medial bend, abruptly tapering just before apices, has notched shape in posterior view (fig. 25 F-I); aedeagal sheath with areas of sclerotized papillae distally and basally; in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two distinct emarginations of different sizes, a smaller posterior and a broader more anterior emargination (fig. 26 A-C).....*L. khoi*

- Cerci widest beyond medial bend, towards apex, not notched in posterior view (fig. 31 F-I); aedeagal sheath with areas of sclerotized spines distally and basally; in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two distinct emarginations of equal sizes (fig. 32 A-C).....*L. mayi*

11. Tegmen band iii.+iv. with mottled yellow and black area (fig. 27); in posterior view, medial margins of aedeagal sheath emarginate just before apex of sheath (fig. 28 A-C); ectophallus structure ventral to arch of aedeagus as in fig. 28 E.....*L. namaqua*

- Tegmen band iii.+iv. with distinct yellow triangle at apical margin (fig. 37); in posterior view, medial margins of aedeagal sheath straight to apex of sheath (fig. 38 A-C)

ectophallus ventral to arch of aedeagus as in fig 38 E.....*L. karoo*

12. In lateral view, apices of aedeagal valves with bulbous sclerotized lobes that curl anteriorly; in posterior view, medial surfaces of apices of ventral valves together appear sharply pointed dorsally (figs. 40 and 42).....**13**

- In lateral view, apices of aedeagal valves without bulbous sclerotized lobes that curl anteriorly; in posterior view, medial surfaces of apices of ventral valves together do not appear sharply pointed dorsally (as in fig. 55).....**14**

13. Apices of aedeagal valves with sclerotized lobes small (fig. 40 A-F); emargination of region bridging zygoma of cingulum and distal portion of aedeagal sheath U-shaped in lateral view (fig. 40); lateral sclerites of cingulum acutely triangular; basal and distal portions of aedeagal sheath as in fig. 40.....*L. mirabunda*

- Apices of aedeagal valves with sclerotized lobes large (fig. 42 A-F); emargination of region bridging zygoma of cingulum and distal portion of aedeagal sheath V-shaped in lateral view (fig. 42); lateral sclerites of cingulum not acutely triangular; basal and distal portions of aedeagal sheath as in fig. 42*L. cederbergensis*

14. Cerci each abruptly bent nearly 45° medially halfway along its length; cerci maintain constant width before fold, beyond which dorsal margins taper ventrally toward medioventral point (fig. 57 F-I).....*L. ottei*

- Cerci not abruptly bent nearly 45° medially, at most weakly curved medially at apices;
apices of cerci dorsally pointed, rounded or blunt toward apex.....**15**

15. Cerci roughly rectangular in shape, each nearly constant width along its length, apices bluntly rounded (fig. 55 F-I).....***L. lyra***

- Width of each cercus increases or decreases at approximately 2/3 cercus length, apices broadly rounded, abruptly pointed or angled dorsally.....**16**

16. Each cercus boot-shaped, nearly constant width for 2/3 of its length, expanded dorsally in distal 1/3; in posterior view apical margins nearly vertical (fig. 45 F-I).....
.....***L. tsitsikamma***

- Each cercus narrows slightly along its length then expands apically, never boot-shaped; in posterior view apical margins markedly convergent upward.....**17**

17. Apices of aedeagal valves with unsclerotized membranous tissue extending outward to form two funnel-shaped rims (fig. 54 B & C).....***L. umoja***

- Apices of aedeagal valves without unsclerotized membranous tissue.....**18**

18. In posterior view with deep lateral excavations just below distal portion of each aedeagal valve (fig. 44 C).....***L. lapollai***

- In posterior view without such excavations, only with small lateral constriction just below distal portion of each aedeagal valve**19**

- 19.** In posterior view, rami of cingula not distinctly wider than distal portion of aedeagal sheath (fig. 48 C).....*L. waboom*
- In posterior view, rami of cingula distinctly wider than distal portion of aedeagal sheath.....**20**
- 20.** Lateral sclerites of cingulum produced to form narrow posterior lobe, in lateral view apex extending past posterior margin of aedeagal sheath and cingulum (fig. 50 B); lateral margin of aedeagal valves as in fig. 50 F.....*L. solveigae*
- Lateral sclerites of cingulum not so produced, in lateral view not extending past posterior margin of aedeagal sheath and cingulum (fig. 52 B); lateral margin of aedeagal valves as in fig. 52 F.....*L. larsenorum*

Table 1. Comparison of morphological features of *Loryma* species

Abbreviations: DF=dorsal field; P=prozona; PDF=prozona dorsal field; PLL=prozona lateral lobe; LL=lateral lobe; M=metazona; MDF=metazona dorsal field; MLL=metazona lateral lobe; MC=medial carinae; LC=lateral carinae; PF=posterior femur; K=knee of femur; T=tibia; PT=proximal tibia; MT=mid-length tibia; DT=distal tibia; TR=tarsi; MA=medial apodeme; PC=phallic complex





	Locality	Size & body length (mm)	Pronotum sculpturing	Tegmen banding	Hind Leg	Cerci sculpturing	Epiphallus
1. <i>L. perficita</i>	"Cape Province"	f. holotype rough estimate of +/- 21.44; m. unknown	MDF weak 2° sulcus between MC and LC; MC and LC not cut by sulci		"...[hind femur] partly red beneath, ... hind tibiae red..."	male unknown	male unknown
2. <i>L. ashleyi</i>	Northern Cape, vic. Kamieskroon	Small sp.; m. 12.62; f. 16.93	PDF very weak 2° sulcus; MDF very weak 2° sulcus; MLL broken 2° sulcus; MC and LC not cut by sulci		K mottled black-brown; PT with brown-black speckling; MT faint blue; DT tibia brown and black	with MA; PC fig. 18	
3. <i>L. carohynae</i>	Northern Cape, vic. Nababeep	Small sp.; m. 11.20; f. 14.03	MLL very weak or no 2° sulcus; MC and LC not cut by sulci		PF, K and PT with orange (PT with faint to pronounced brown-black speckling atop orange); MT blue; DT with black	with MA; PC fig. 20	
4. <i>L. magna</i>	Northern Cape; Swarberg Pass, S of Prince Albert	Large sp.; m. 24.42; f. 37.94	PDF with 2° sulcus between MC and LC; MC and LC are not cut by sulci		PF faint orange; K, T and TR with orange	with MA; PC fig. 22	

Table 1 continued

Locality	Size & body length (mm)	Pronotum sculpturing	Tegmen banding	Hind Leg	Cerci sculpturing	Epiphallus
5. <i>L. browni</i>	Eastern Cape, vic. Willowmore and Joubertina, Large sp.; m. 23.64; f. 36.07	P and M without secondary sulci; MC and LC not cut by sulci		DF and K with small amount of orange; PT with minute orange-gray; T and TR mostly orange		with MA; PC fig. 24
6. <i>L. khoi</i>	Eastern Cape, in S vic. Willowmore, in E vic. Joubertina Medium-sized sp.; m. 14.50; f. 22.31	P and M without 2° sulci; MC and LC not cut by sulci		DF and K with small amount of orange; PT mixed orange-gray; T and TR mostly orange		with MA; PC fig. 26
7. <i>L. namaqua</i>	Northern Cape, vic. Kharkans in Namaqualand Medium-sized sp.; m. 17.76; f. 28.88	PDF with 2° sulci between the MC and LC; M without 2° sulci; MC and LC not cut by sulci; more dorsal portion of P of LL with indentation (male and female)		PF, K, T and TR with dark orange		with MA; PC fig. 28
8. <i>L. san</i>	Northern Cape, vic. Sutherland Small sp.; m. 13.71; f. unknown	P and M without 2° sulci; MC and LC not cut by sulci		T and TR mostly blue to black (blue PT, black DT)		with MA; PC fig. 30
9. <i>L. mayi</i>	Western Cape, Theronberg Pass, vic. Ceres Small sp.; m. 14.63; f. 19.48	PDF with weak 2° sulci between MC and LC; MC and LC not cut by sulci		PF and K with faint orange; T and TR with strong orange		with MA; PC fig. 32

Table 1 continued

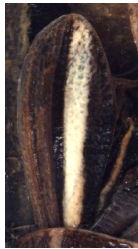

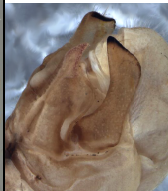
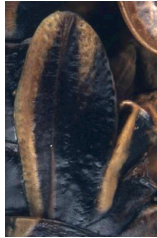

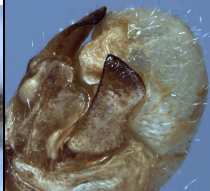






Locality	Size & body length (mm)	Pronotum sculpturing	Tegmen banding	Hind Leg	Cerci sculpturing	Epiphallus
10. <i>L. zebrata</i> Eastern Cape, vic. Middelberg, Cradock, Graaff-Reinet	Medium-sized sp.; m. 16.10; f. 20.59	PDF with 2° sulci between MC and LC; MC and LC not cut by sulci		PF, K and PT with black-brown speckles atop cream; MT speckled coloration dissipates; DT and TR orange		with MA; PC fig. 34
11. <i>L. bonteboki</i> Western Cape, vic. Swellendam, S of Montagu	Medium-sized sp.; m. 19.80; f. 26.80	PDF with 2° sulci between MC and LC; PLL with depressions with raised edges just posterior of LC; MC and LC not cut by sulci		PF and K faint orange; PT with faint to moderate black-brown speckles atop variable white-cream; PT and TR bright orange (at MT coloration transitions)		with MA; PC fig. 36
12. <i>L. karoo</i> Northern and Western Cape, vic. Kamieskroon, Bitterfontein, Calvinia, Gannaga Pass, Middelpos	Medium-sized sp.; m. 15.73; f. 25.42	PDF with 2° sulci between MC and LC; MC and LC not cut by sulci		PF and K with faint orange; T and TR with strong orange; (PT possibly with mottled brown atop orange)		with MA; PC fig. 38
13. <i>L. mirabunda</i> Western Cape, vic. Picketberg	Medium-sized sp.; m. 16.58; f. 22.15	PLL with 2° sulci weakly cutting, PDF with 2° sulci weakly cutting between MC and LC; M with deep 2° sulci cutting MC, LC, DF and LL		PF, K, T and TR with faint orange; PT with slight gray mottling		with no MA; PC fig. 40
14. <i>L. cederbergensis</i> Western Cape, Cederberg Wilderness, Piekiers-kloofpass Olifantsrivierb erge	Medium-sized sp.; m. 15.70; f. 22.96	PLL with 2° sulci weakly cutting, PDF with 2° sulci weakly cutting between MC and LC; M with deep 2° sulci cutting MC, LC, DF and LL		PF, K, T and TR with faint orange; PT with slight gray mottling		with no MA; PC fig. 42

Table 1 continued

Locality	Size & body length (mm)	Pronotum sculpturing	Tegmen banding	Hind Leg	Cerci sculpturing	Epiphallus
15. <i>L. lapollai</i>	Medium-sized sp.; m. 16.00; f. unknown	PLL with very weak 2° sulci; PDF with 2° sulci very weakly cutting between MC and LC; M with deep 2° sulci cutting MC, LC, DF and LL		PF, K, T and TR with faint orange; PT to MT with subtle mottled gray		with no MA; PC fig. 44
16. <i>L. tsitsikamma</i>	Medium-sized sp.; m. 18.82; f. 24.59	M with 2° sulci of DF, cutting LC (not MC) and LL		PF, K, T and TR with orange; PT with additional subtle mottled brown-black		with no MA; PC fig. 46
17. <i>L. waboom</i>	Medium-sized sp.; m. 18.25; f. unknown	PDF with very weak 2° sulci between MC and LC; MDF with very weak 2° sulci between MC and LC; MC and LC not cut by sulci		PF, K, T and TR with orange; PT with additional subtle mottled brown-black		with no MA; PC fig. 48
18. <i>L. solveigae</i>	Medium-sized sp.; m. 18.59; f. unknown	PDF with very weak 2° sulci between MC and LC; MDF with weak 2° sulci between MC and LC; in some specimens LC is cut		PF, K, T and TR orange; PT with additional subtle mottled brown-black		with no MA; PC fig. 50
19. <i>L. larsenorum</i>	Medium-sized sp.; m. 18.26; f. unknown	PLL with weak, broken 2° sulci; MDF with weak 2° sulci between MC and LC which weakly cuts MC, MLL with 2° sulci		PF, K with orange; T and TR with bright orange-red		with no MA; PC fig. 52

Table 1 continued

Locality	Size & body length (mm)	Pronotum sculpturing	Tegmen banding	Hind Leg	Cerci sculpturing	Epiphallus
20. <i>L. umoja</i> Western Cape, N of Somerset West, S of Helderberg	Medium-sized sp.; m. 16.24; f. unknown	PLL with 2° sulci weak broken, PDF with 2° sulci weak; M with 2° sulci cuts MC and LC of DF, extends onto LL		PF, K, T and TR with orange		with no MA; PC fig. 54
21. <i>L. tyra</i> Western Cape, S of Kwaggas- kloofdam	Medium-sized sp.; m. 16.84; f. 20.91	PDF with weak 2° sulci, PLL with weak 2° sulci, MDF with 2° sulci cuts MC and LC, and extends onto LL		PF, K, T and TR without any significant coloration		with no MA; PC fig. 56
22. <i>L. ottei</i> Western Cape, S of Tulbagh, vic. OudePost, NNW of Malmesbury	Medium-sized sp.; m. 15.94; f. 19.07	PLL with weak 2° sulci, PDF with very weak 2° sulci, MDF with 2° sulci that cuts MC and LC, and extends onto LL		PF and K with faint orange; majority of T and TR without significant coloration, TD 1/3 length with patch of black- gray on ventral surface opposite spines		with no MA; PC fig. 58

LORYMA SPECIES ACCOUNTS

1. *Loryma perficita* (Walker)

female figure: 16

Heteracris perficita, Walker, 1870: 660. Holotype female, SOUTH AFRICA: “Cape Province” (BMNH) [examined]. Uvarov, 1925[1924]: 287, combination in *Aphanaulacris*; Johnston, 1956: 246, catalog; Dirsh, 1956: 121-272, combination in *Loryma*; Dirsh, 1965: 203, catalog; Johnston, 1968: 150, catalog.

Platyphyma vittipennis, Stål, 1875: 32. Holotype female, SOUTH AFRICA: “Terra capensis” (Lund) [not examined]. Stål, 1878: 49, combination in *Loryma*; Johnston, 1956: 246, catalog; Dirsh, 1956: 121-272, combination in *Loryma* and junior synonym of *L. perficita*.

Diagnosis of Female: It is not recommended that females be used for species identification, but because the male is unknown for *L. perficita*, four morphological features can be considered in diagnosing the females (fig. 16): 1) pronotum dorsal field with weak secondary sulcus in metazona between medial and lateral carinae; 2) tegmen with four areas of coloration; 3) length to width ratio of hind leg femur, and orange coloration of tibia and tarsi; 4) supra-anal plate with apparently unique combination of size, sculpturing, texture and lack of a sulcus (other known *Loryma* females with sulcus stretching between lateral edges of supra-anal plate).

Description: *Body length.* Medium species; female holotype estimated body length is 21.44* mm (*imprecise estimate because apex of knee of the solitary hind femur is missing and damaged, and leg has been crudely reattached); actual length from vertex of head to tip of ovipositor apices is 21.29 mm. *Body coloration.* Female specimen, known

only from dried museum material, mostly brown with cream colored banding; tips of recurved ovipositor valves black.

Male external features. No male was described or associated with the original description of the holotype female by Walker in 1870.

Female external features (fig. 16). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin diffuse, lower margin distinct; genal band distinct with tapered anterior and posterior ends; pronotal band of lateral carinae narrow; lateral lobe band distinct and cut by primary sulcus; metazona with weak secondary sulcus between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci.

Wing. Tegmina oval, its length is less than twice as long as wide; tegmen banding: i. mottled cream-yellow with brown, diffuse ventral margin; ii. black-brown; iii. distinct cream, expanded at apical margin; iv. distinct black-brown.

Hind legs. The holotype has only one remaining hind femur, which is significantly damaged medially (punctured with pin), and the distal end is missing, making measurement difficult; the tibiae and tarsi are missing as well. Walker (1870) noted in his description that the hind femora are a little longer than the abdomen (a difficult measurement given how abdomen length changes with preparation), and is “partly red

beneath, with two rows of black dots on the outer side; hind tibiae red, much shorter than the hind femora, their spines with black tips.”

Supra-anal plate. The sculpturing, texture, and absence of a sulcus on the supra-anal plate (figure 16 G) are seemingly characteristic.

Distribution: Distribution is uncertain because the locality label indicates collection from the “Cape Province” of South Africa, which at the time of collection in the 1860s encompassed the area of the three modern provinces of the Western Cape, Northern Cape and Eastern Cape.

Discussion: Associating a male to the holotype female will require further fieldwork and museum study. A confident association can be accomplished if males and females are collected at the same locality, at the same time, and no other *Loryma* species are thought to be sympatric. If two or more species are sympatric and morphologically similar, collecting mated pairs will be necessary to elucidate who belongs with whom).

Loryma perficita may be a fynbos species because the morphological features discussed above appear most similar to NEA species-group females, which are found most frequently with the fynbos biome.

2. *Loryma ashleyi*, new species

male figures: 17, 18; female figure: 59

Holotype male, SOUTH AFRICA: Northern Cape Province; 3 miles S of Kamieskroon, 4.ix.1961 (H.D. Brown, W. Fürst), temp.loc.code L35 (ANSP); from the same location: 8 paratype males, 7 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #1.

Diagnosis of Male: From Kamieskroon region of Northern Cape; small species; mostly black tegmen, with small cream-colored spot at base; knees mottled black-brown, proximal tibiae with brown-black speckling, tibia faint blue at mid-length, distal tibia brown and black; hook-like cerci with pointed apices; aedeagal valves narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. carolynae*

Description: *Body length.* Smaller species; male type 12.62 mm; female type 16.93 mm.

Body coloration. Male specimens, known only from dried museum material, mostly black-brown with yellow-cream banding. Female specimens, known only from dried museum material, mostly black-brown with cream-colored banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 17). *Head and Pronotum.* Band coloration across apex of eye margin; occipital band with upper margin diffuse and mottled, lower margin distinct; genal band with diffuse upper and lower margins; pronotal band of lateral carinae distinct; lateral lobe band distinct and cut by primary sulcus. Prozona of dorsal field with very weak secondary sulcus; metazona with two secondary sulci, the first a very weak sulcus of dorsal field, the second a broken sulcus of lateral lobe; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally, highlighted with yellow; posterior margin of dorsal field very strongly emarginate medially.

Meso- and Metathorax. Mesepisternum mottled yellow, mesepimeron mottled yellow and black; pleural sulcus black; metepisternum black with distinct thick yellow band. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i.+ii. with indistinct boundaries, mottled yellow and black (black along radial vein margin proximally, atop radial vein distally); iii.+iv. with indistinct boundaries, distinct yellow to cream oval spot with broken distal margin surrounded by black coloration. *Hind legs.* Hind femur length to width ratio 3.20; margin of upper carinula and medial area with diffuse dark brown, medial area with two diffuse cream patches; margin of lower carinula without black; knees mottled black-brown; proximal tibiae with brown-black speckling; tibia faint blue at mid-length; distal tibia brown and black; posterior tibia with approximately 9 outer and 9 inner spines, all with black apices.

Abdomen. Abdominal lateral bands mottled black and faintly extend to tergite IX. *Cerci.* Longer than supra-anal plate, extending about as far posteriorly as margin of subgenital plate; hook-like with blackened margins, curving dorsomedially to apices, shoulders pronounced; thickest at base, thickened and laterally flattened at mid-length, thinnest at pointed apex.

Male internal features (fig. 18). *Phallic complex.* Aedeagal valves narrowed with small openings; valves short (fig. 18 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath sloping very little ventrally; lateral sclerites of cingulum rounded (fig. 18 B, E); distal portion of aedeagal sheath with

sclerotized short spines covering a crescent shaped area which expands ventrolaterally; basal portion of aedeagal sheath with sclerotized area lacking ridge of papillae or spines, with diffuse, rounded margin; distal and basal portions of aedeagal sheath with separated areas of sclerotization; basal portions of aedeagal sheath project upward with slight outward angle toward pronounced apex of distal portion of aedeagal sheath (fig. 18 C); in posterior view, rami of cingula only slightly wider than most ventral distal portion of aedeagal sheath; most dorsal distal portion of sheath 1/4 width of rami of cingula (fig. 18 C, F). *Epiphallus*. In dorsal view lobes each rounded at apex, bridge with pronounced medial apodeme; epiphallic lateral sclerites very elongate and flattened (fig. 18 G, H).

Etymology: Named to honor my father, Ashley Spearman, respected architect, teacher, and dedicated community volunteer for more than 30 years.

Distribution (fig. 3): This species was collected in early September near Kamieskroon in Namaqualand, within the succulent karoo biome. *Loryma ashleyi* is confirmed sympatric with *L. karoo* and is thought to be sympatric with *L. namaqua* and *L. carolynae*.

Discussion: Future sampling in this Namaqualand region might yield more species with small body size and hook-like cerci. *Loryma ashleyi* shares many morphological characteristics with *L. carolynae*, a putative relative, including: very small body size, very similar wing coloration pattern, hook-shaped cerci, and similar phallic complex features. To distinguish between *L. ashleyi* and *L. carolynae* the following morphological features should be examined: 1) in *L. carolynae*, the knee of the femur and basal tibia are

orange, whereas *L. ashleyi* lacks orange coloration (figs. 19 and 17); 2) in *L. ashleyi*, the membrane wrapped around the lateral and posterior portion of the apices of the aedeagal ventral valves are more expanded, whereas the equivalent membranous area of *L. carolynae* is narrowed and much reduced (note arrows in figs. 18 and 20). The apices of the aedeagal valves for the two species should always be examined and compared. The sculpturing of the lobes of the epiphallus of both species can be deceptively variable.

3. *Loryma carolynae*, new species

male figures: 19, 20; female figure: 59

Holotype male, SOUTH AFRICA: Northern Cape Province; 8 kilometers S of Nababeep, 7.x.1972 (H.D. Brown, E. Koster, A.Prinsloo), temp.loc.code L38 (ANSP); from the same location: 6 paratype males, 9 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #2.

Diagnosis of Male: From Nababeep region of Northern Cape; small species; mostly black tegmen, with small cream colored spot at tegmen base; knees and proximal tibia orange, proximal tibia with faint to pronounced brown-black speckling atop orange, mid-length tibia blue, distal tibia black; hook-like cerci with pointed apices; aedeagal valves narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. ashleyi*

Description: *Body length.* Smaller species; male type 11.20 mm; female type 14.03 mm.

Body coloration. Male specimens, known only from dried museum material, mostly black with yellow to cream-colored banding. Female specimens, known only from dried

museum material, mostly black with yellow-cream colored banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 19). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin diffuse and mottled, lower margin distinct; genal band with upper margin distinct, lower margin diffuse; pronotal band of lateral carina distinct; lateral lobe band distinct and cut by primary sulcus; metazona with very weak or no secondary sulci of lateral lobe; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe strongly angled ventrally, highlighted with yellow; posterior margin of dorsal field very strongly emarginate medially.

Meso- and Metathorax. Mesepisternum mottled yellow-black, mesepimeron mottled black; pleural sulcus black; metepisternum with distinct thick yellow band. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i.+ii. indistinct boundaries, very dark mottled black-brown; iii.+iv. indistinct boundaries, distinct yellow-cream oval-shaped spot surrounded by black. *Hind legs.* Hind femur length to width ratio 3.23; margin of upper carinula and medial area black, medial area with two patches of yellow-cream; margin of lower carinula without black; posterior femora, knees and proximal tibiae with orange, proximal tibiae with faint to pronounced brown-black speckling atop orange; mid-length of tibiae with blue; distal tibiae with black; posterior tibia with approximately 9 outer and 9 inner spines, all with black apices.

Abdomen. Abdominal lateral bands black, extending to supra-anal plate; orange on lateral surface of tergite-X and supra-anal plate. *Cerci.* Shorter than supra-anal plate but extending beyond apex of subgenital plate; curving dorsomedially to apices; hook-like with blackened margins, shoulders pronounced; thickest at base, thinnest and pointed at cerci apices.

Male internal features (fig. 20). *Phallic complex.* Aedeagal valves narrowed, with small openings; valves moderate in length (fig. 20 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath slopes very little ventrally; lateral sclerites of cingulum rounded (fig. 20 B, E); distal portion of aedeagal sheath with sclerotized short spines covering crescent-shaped area which expands ventrolaterally; basal portion of aedeagal sheath without sclerotized papillae or spines; distal and basal portions of aedeagal sheath with separated areas of sclerotization; in posterior view, width of rami of cingula slightly greater than distance between ventral margins of distal portion of aedeagal sheath, about 4 times distance between dorsal margins of distal portion of sheath; basal portions of aedeagal sheath project upward with moderate V-shaped outward angle toward pronounced apex of distal portion of sheath (fig. 20 C, F). *Epiphallus.* In dorsal view, lobes triangular, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 20 G, H).

Etymology: Named to honor my mother, Carolyn Jones, a ground-breaking, dedicated designer of Montessori educational tools for children around the world for more than 30 years.

Distribution (fig. 3): This species was collected in early October, near Nababeep within Namaqualand, within the succulent karoo biome. The full range of this species remains to be determined. *L. carolynae* is thought to be sympatric with *L. ashleyi*.

Discussion: Future sampling in this Namaqualand region may yield more species with small body size and hook-like cerci. A putative relative of *L. carolynae* is *L. ashleyi*, given the many morphological characteristics they share. Refer to the discussion section of the *L. ashleyi* description for distinguishing characters of the two species.

4. *Loryma magna*, new species

male figures: 21, 22; female figure: 59

Holotype male, SOUTH AFRICA: Northern Cape Province; Swartberg Pass, (S of Prince Albert), 11.xii.1961, (H.D. Brown, W. Fürst, F. Pick), temp.loc.code L33 (ANSP); from the same location: 13 paratype males, 2 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #3.

Diagnosis of Male: From Swartberg Pass, in Groot Swartberge, S of Prince Albert in Western Cape; large species; tegmen with four distinct bands; knees, tibiae and tarsi orange; long tong-like cerci, each at mid-length less than 1/2 as wide as at expanded, flattened apices; aedeagal valves narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. browni*

Description: *Body length.* Large species; male type 24.42 mm; female type 37.94 mm.

Body coloration. Male specimens, known only from dried museum material, mostly black with yellow banding. Female specimens, known only from dried museum material, black with yellowish banding. Female also appears to have had greenish pigmentation on head, pronotum and upper marginal area of femur; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 21). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper and lower margin distinct; genal band distinct; pronotal band of lateral carina distinct; lateral lobe band distinct, cut by primary sulcus; in some specimens prozona with secondary sulcus between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe weakly angled ventrally and highlighted yellow; posterior margin of dorsal field weakly emarginate medially.

Meso- and Metathorax. Mesepisternum with diffuse yellowish band, mesepimeron with muted yellow and black; pleural sulcus black; metepisternum with distinct yellow band.

Wing. Tegmina oval and elongate, more than twice as long as wide; tegmen banding: i. distinct yellow, posteroventral margin indistinct; ii. distinct black; iii. distinct yellow, posteroventral margin faded; iv. distinct black. *Hind legs.* Hind femur length to width ratio 4.08; margin of upper carinula and medial area diffuse black; margin of lower carinula without black; faint orange on posterior femora; knees, tarsi and tibiae with orange; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black, extend to supra-anal plate. *Cerci.* Long tong-like cerci; cercus longer than supra-anal plate, extends beyond length of subgenital plate; cerci curve 90° medially inward to apices; shoulders pronounced; mid-length cerci less than 1/2 as wide as apices; cerci apices expanded, flattened and triangular with thin blackened medial margins.

Male internal features (fig. 22). *Phallic complex.* Aedeagal valves narrowed with small openings; valves of moderate length (fig. 22 A, D); in lateral view, region bridging the zygoma of cingulum and distal portion of aedeagal sheath sloping very little ventrally; lateral sclerites of cingulum triangular (fig. 22 B, E); distal and basal portions of aedeagal sheath with sclerotized papillae; distal portion aedeagal sheath with moderately widened apex expanding laterally, with larger area of sclerotized papillae; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotized papillae; in posterior view, rami of cingula 1.5x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with moderate V-shaped outward angle toward apex of distal portion of sheath (fig. 22 C, F). *Epiphallus.* Lobes rounded; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened. (fig. 22 G, H).

Etymology: The specific epithet *magna* is Latin for large or great, in reference to the fact that this species appears to be one of the two largest *Loryma* species documented thus far (*L. browni* being the other very large species).

Distribution (figs. 2 & 3): This species was collected in mid-December, in the Swartbergpas of the Groot Swartberge, S of Prince Albert, found within the fynbos biome adjacent to a regional patch of succulent karoo biome in the Western Cape. The full range of this species remains to be determined. *L. magna* is confirmed sympatric with *L. browni*.

Discussion: A putative relative of *L. magna* is *L. browni* given the many morphological characteristics they share: both are very largest for *Loryma* species, have similar black coloration with striking contrast of yellow striping and similarly colored legs, and have long tong-like cerci. To distinguish between *L. magna* and *L. browni* the following morphological features should be examined: 1) the tegmina are different, in *L. magna* all 4 bands have distinct margins, in *L. browni* the bands are indistinguishable or have blended margins (in particular iii.+iv. are indistinguishable); 2) in posterior view, the apices of the cerci of *L. magna* appear triangular, whereas in *L. browni* these appear rounded at the tips, with a shallow S-shaped medial margin; 3) in dorsal and posterior view, the sculpturing of cingulum is different, and the distal portion of aedeagal sheath of *L. magna* is more expanded and angled laterally, whereas the same structure of *L. browni* is narrowed in comparison.

5. *Loryma browni*, new species

male figures: 23, 24; female figure: 59

Holotype male, SOUTH AFRICA: Eastern Cape Province; 22 miles SE (of) Willowmore, Niewekloof, 13.xi.1958 (H.D. Brown), temp.loc.code L24 (ANSP); from the same location: 12 paratype males, 6 paratype females (SANC) (ANSP) (SAMC) (BMNH); 1 paratype male, SOUTH AFRICA: Eastern Cape

Province; 10 miles E. (of) Joubertina, Langkloof, 17.xi.1958 (H.D. Brown), temp.loc.code L25 (ANSP) (SANC) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #4.

Diagnosis of Male: From region S of Willowmore and E of Joubertina, in Eastern Cape; large species; two general regions of tegmen coloration; knees, tibiae and tarsi orange; long tong-like cerci, at mid-length nearly 1/2 as wide as expanded, flattened apices; aedeagal valves narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. magna*

Description: *Body length.* Large species; male type 23.64 mm; female type 36.07 mm.

Body coloration. Male specimens, known only from dried museum material, mostly black-brown with yellow-cream banding. Female specimens, known only from dried museum material, mostly black-brown with yellow-cream banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 23). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin slightly diffuse, lower margin distinct; genal band distinct; pronotal band of lateral carina distinct; lateral lobe band distinct and cut by primary sulcus; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with mottled yellow; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum mottled with muted yellow and black, mesepimeron with mottled black; pleural sulcus black; metepisternum with distinct yellow band. *Wing.* Tegmina oval and elongate, more than twice as long as wide; tegmen banding: i. distinct yellow, faded posteroventral margin; ii. black, upper and lower margins very diffuse; iii.+iv. indistinct boundaries, mottled black and yellow. *Hind legs.* Hind femur length to width ratio 3.74; margin of upper carinula without black (faded black on upper marginal area); medial area mottled black; margin of lower carinula without black; proximal tibia with minute orange-gray speckling; tibiae and tarsi mostly orange; small amount of orange on distal femur and knee; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black; faint black at base of supra-anal plate. *Cerci.* Longer than supra-anal plate, extending beyond margin of subgenital plate; each curving nearly 90° medially before apices, shoulders pronounced; at mid-length less than 1/2 as wide as apices; apices expanded, flattened, tip rounded, with shallow S-shaped medial margin accented by thin blackened dorsomedial marginal area.

Male internal features (fig. 24). *Phallic complex.* Aedeagal valves narrowed with small openings; valves short (fig. 24 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath without significant slope; lateral sclerites of cingulum rounded (fig. 24 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with slightly widened apices that expand laterally, with larger area of sclerotized papillae; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotized papillae; in

posterior view, rami of cingula 2 1/3x width of distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with very slight outward angle toward apices of distal portion of sheath (fig. 24 C, F). *Epiphallus*. Lobes rounded; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 24 G, H).

Etymology: Named *L. browni* to honor H. Dick Brown, collector of half the material in this revision alone, whose contributions to African orthoptera research will continue on indefinitely thanks to his work with the South African National Collection of Insects (Pretoria), and the decades of adventures earning him the legendary status of one of the last great African “Locust Hunters.” This species is chronologically the very first new *Loryma* species Dick Brown ever collected.

Distribution (fig. 3): This species was collected in two locations in mid-November, near Willowmore and Joubertina, found within succulent karoo near Joubertina, and either the succulent karoo or fynbos biomes near Willowmore; the Willowmore collection site is in a transitional area between the two biomes, so further fieldwork is need to resolve which of the two biomes, or if both biomes, have suitable habitat for this species. The more northern (type) locality near Willowmore is SE of Boesmanspoortberg, and the more southern locality near Joubertina is between the Suuranysberge and Tsitsikammaberge. The full range of this species remains to be determined. Though not determined to be sympatric, *L. browni* is found closest to the ranges of *L. magna* and *L. waboom* in the N, and even closer to those of *L. tsitsikamma* and *L. solveigae* in the S.

Discussion: A putative relative of *L. browni* is *L. magna* given the many morphological characteristics they share. Refer to the discussion section of the *L. magna* description for distinguishing characters of the two species.

6. *Loryma khoi*, new species

male figures: 25, 26; female figure: 59

Holotype male, SOUTH AFRICA: Northern Cape Province (near Western Cape border); Botterkloof Pass, 56 kilometers S of Nieuwoudtville, 27.ix.1972 (H.D. Brown, E.Koster, A.Prinsloo), temp.loc.code L07d (ANSP); from this location: 6 paratype males, 2 paratype females (SANC) (ANSP) (SAMC) (BMNH). SOUTH AFRICA: Western Cape Province (near Northern Cape border); Van Rhyns Pass, 9 kilometers W of Nieuwoudtville, 28.ix.1972 (H.D Brown, E.Koster, A.Prinsloo), temp.loc.code L07a (SANC); from this location: 2 paratype males (SANC) (ANSP). The holotype is labeled as LAS TYPE #5.

Diagnosis of Male: From region S of Willowmore and E of Joubertina, in Eastern Cape; medium-sized species; two general regions of tegmen coloration; knees, tibiae and tarsi orange; cerci simple, notched apices turn inward; aedeagal valves narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. namaqua*

Description: *Body length.* Medium-sized species; male type 14.50 mm; female type 22.31 mm. *Body coloration.* Male specimens, known only from dried museum material, mostly black with yellow-cream banding. Female specimens, known only from dried museum material, mostly black with yellow-cream banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 25). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper and lower margin distinct; genal band distinct; pronotal band of lateral carina distinct; lateral lobe band distinct, cut by primary sulcus. Prozona and metazona without secondary sulci; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe strongly angled ventrally, highlighted with mottled yellow-cream; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with wide, diffuse yellow-cream band, mesepimeron with mottled dark coloration; pleural sulcus black; metepisternum with distinct yellow-cream band. *Wing.* Tegmina oval, more than twice as long as wide; tegmen banding: i.+ii. with indistinct boundaries, ventral yellow-cream blended into mottled yellow-black of radial vein region; iii.+iv. with indistinct boundaries, nearly solid mottled black. *Hind legs.* Hind femur length to width ratio 3.50; margin of upper carinula and medial area mottled black; medial area with two patches of white-cream; margin of lower carinula without black; small amount of orange on distal femur and knee; mixed orange-gray on proximal tibia; tibiae and tarsi mostly orange; posterior tibia with approximately 9-10 outer and 9-10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black, tapered, and extending onto supra-anal plate. *Cerci.* Each approximately same length as supra-anal plate, not extending posteriorly beyond margin of subgenital plate, curving nearly 90° medially before apices; at mid-length thinner than at shoulders, the latter pronounced; cerci

widening at point of medial bend , then tapering just before apices, appearing notched; apices have thin blackened margins.

Male internal features (fig. 26). *Phallic complex.* Aedeagal valves narrowed with small openings; valves of moderate length (fig. 26 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two marginal notches, posterior one small, anterior broader and shallower; lateral sclerites of cingulum rounded at apex (fig. 26 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with apex strongly expanded dorsolaterally, with larger area of sclerotized papillae; distal and basal portions of aedeagal sheath with nearly separated areas of sclerotization; in posterior view, rami of cingula 1 1/2x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with subtle hour-glass shaped curve toward apex of distal portion of sheath (fig. 26 C, F). *Epiphallus.* Lobes triangular; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 26 G, H).

Etymology: Named in honor of the native Khoi people of southwestern South Africa.

Distribution (figs. 3 & 4): This species was collected in late November, W and S of Nieuwoudtville, in Van Rhyns Pass in the Bokkeveldberge, and in Botterkloof Pass near Stinkfonteinberge. Both locations are in the succulent karoo biome near the margins of the fynbos biome. Further fieldwork is needed to determine if this species is also found in

the fynbos biome. The full range of this species remains to be determined. Though not confirmed to be sympatric, *L. kхой* is found closest to the range of *L. karoo*.

Discussion: *L. kхой* is similar to *L. namaqua* in that the two species both have notched cerci, tegmen bands i. and ii. with blended margins, and iii. and iv indistinct [??]. To distinguish between *L. kхой* and *L. namaqua* the following morphological features should be examined: 1) in *L. kхой* the prozona and metazona lack secondary sulci, *L. namaqua* has secondary sulci of the prozona of the dorsal field; 2) *L. kхой* has no yellow-cream in tegmen bands iii.+iv., *L. namaqua* has yellow-cream mottling in iii.+iv.; *L. namaqua* has longer aedeagal valves, and the species differ in the sculpturing of the cingulum and aedeagal sheath in posterior and lateral views.

7. *Loryma namaqua*, new species

male figures: 27, 28, 64; female figures: 60, 64

Holotype male, SOUTH AFRICA: Western Cape Province; a few kilometers N of Kharkams along N7, S 30°17.937', E017°53.641', 8.xi.2007 (D. Otte, E. Rohwer), D.Otte loc.code 07-43, spec.code DL003 (ANSP); from the same location: 3 paratype males, 2 paratype females (SANC) (ANSP). The holotype is labeled as LAS TYPE #6.

Diagnosis of Male: From N of Kharkams, Western Cape; prozona of dorsal field with secondary sulcus between medial and lateral carinae, metazona without secondary sulci; tegmen with three areas of coloration; posterior femora, knees, tibiae and tarsi with dark orange; cerci simple, notched apices turn inward, aedeagal valves short and narrowed with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. kхой*, *L. karoo*

Description: *Body length.* Medium-sized species; male type 17.76 mm; female type 28.88 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black with gray and white-yellow banding. Female specimens, known from dried museum material and field photography, mostly light brown with gray and cream banding; tips of recurved ovipositor valves do apparently lack significant pigmentation. Males and females with same leg coloration.

Male external features (fig. 27). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin slightly mottled, lower margin distinct; genal band distinct; pronotal band of lateral carinae distinct; lateral lobe band distinct, cut by primary sulcus. Prozona with secondary sulcus between medial and lateral carinae of dorsal field; metazona without secondary sulci; medial and lateral carinae not cut by sulci; more dorsal portion of prozona of lateral lobe with indentation (male and female). Posteroventral margin of lateral lobe strongly angled ventrally and highlighted with white-gray; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum and mesepimeron with mottled gray; pleural sulcus black; metepisternum with distinct wide yellow-cream band. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i. distinct yellow; ii. distinct black, tapers posteriorly; iii+iv. indistinct boundaries, mottled yellow and black (more black at proximal end, more yellow at distal end). *Hind legs.* Hind femur length to width ratio 3.34; margin of upper carinula and medial area with a little faint gray-black; posterior

femora, knee, tibiae and tarsi with dark orange (seen in field photography, lost after preservation in ethanol); posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black with yellow highlights between bands, extending to supra-anal plate. *Cerci.* Longer than supra-anal plate, not extend beyond posterior margin of subgenital plate; curving nearly 90° medially before apices; mid-length of cerci thinner than shoulders, latter pronounced; cerci widening at the point of medial bend, then tapering before apices, appearing notched in posterior view; apices with thin blackened margins.

Male internal features (fig. 28). *Phallic complex.* Aedeagal valves narrowed with small openings; valves short (fig. 28 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two marginal notches, posterior one very small and shallow, anterior moderate and gradual; lateral sclerites of cingulum obtusely angulate at apex (fig. 28 B, E); distal and basal portions of aedeagal sheath with sclerotized spines; distal portion of aedeagal sheath with apices moderately expanded laterally; distal and basal portions of aedeagal sheath with nearly separated sclerotized areas; some sclerotized papillae on the soft tissue near apices of ventral valves; in posterior view, rami of cingula 2x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath projecting upward almost parallel, then diverge toward apices of distal portion of sheath (fig. 28 C, F). *Epiphallus.* Lobes rounded; in dorsal view,

bridge with pronounced medial apodeme; epiphallallic lateral sclerites elongate and flattened (fig. 28 G, H).

Etymology: Named *L. namaqua* after the beautiful Namaqualand, a biodiversity hotspot in northwest South Africa.

Distribution (fig. 3): This species was collected in early November, near Kharkans within Namaqualand, within the succulent karoo biome. The full range of this species remains to be determined. *L. namaqua* is confirmed sympatric with *L. ashleyi*, and thought to be sympatric with *L. karoo*. Though not thought to be sympatric, *L. namaqua* is found near the range of *L. carolynae*.

Discussion: The cerci of *L. namaqua*, *L. koi* and *L. karoo* have similarities. Refer to the discussion section of the *L. koi* description for distinguishing characters of *L. namaqua* and *L. koi* and to the discussion section of the *L. karoo* description to for distinguishing characters of *L. namaqua* and *L. karoo*.

8. *Loryma san*, new species

male figures: 29, 30

Holotype male, SOUTH AFRICA: Northern Cape Province; 6 kilometers SW of Sutherland, 25.ix.1972 (H.D. Brown, E.Koster, A.Prinsloo), temp.loc.code L12 (ANSP); from the same location: 2 paratype males (SANC) (ANSP). No females collected. The holotype is labeled as LAS TYPE #7.

Diagnosis of Male: From SW of Sutherland, Northern Cape; no secondary sulci of pronotum; tegmen with four areas of coloration; proximal tibiae blue, distal tibiae black,

tarsi mottled black; simple cerci shape that turn inward medially; aedeagal valves exceptionally long, narrow and anterodorsally curved, with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. mayi*

Description: *Body length.* Smaller species; male type 13.71 mm. *Body coloration.* Male specimens, known only from dried museum material, mostly black with yellow-cream banding.

Male external features (fig. 29). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper and lower margins distinct; genal band distinct; pronotal band of lateral carinae distinct; lateral lobe band distinct with mildly mottled posterior terminus, wider and emarginate mid-length, cut by primary sulcus; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe strongly angled ventrally and highlighted mottled black-cream; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum and mesepimeron with dark, mottled black-cream; pleural sulcus black; metepisternum with short and thin distinct yellow-cream band. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i. mottled black-light brown; ii. mottled black with indistinct dorsal margin; iii. distinct yellow-cream; iv. distinct black. *Hind legs.* Hind femur length to width ratio 3.46; margin of upper carinula

and medial area with mottled black, medial area also with two patches of white-cream; margin of lower carinula and knees without black; tarsi and tibiae mostly blue proximally, black distally; posterior tibiae with approximately 9-10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands with black, extending to supra-anal plate.

Cerci. Approximately same length as supra-anal plate, not extending beyond posterior margin of subgenital plate; each gently curving 90° medially before apices; shoulders moderately pronounced; at mid-length cerci approximately same width as distal ends of cerci; tips of cerci gently angled, simple, without or with very thin blackened apical margins.

Male internal features (fig. 30). *Phallic complex.* Aedeagal valves narrow with small openings; valves exceptionally long and anterodorsally curved (fig. 30 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two marginal notches of equal and moderate size and depth; lateral sclerites of cingulum strongly triangular (fig. 30 B, E); distal portion of aedeagal sheath with sclerotized spines, apices slightly expanded laterally; basal portion of aedeagal sheath with ridge of smaller sclerotized spines; distal and basal portions of aedeagal sheath with nearly separated areas of sclerotization; in posterior view, rami of cingula more than 2x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath projecting vertically upward or bowing inward very slightly before opening to apices of distal

portion of sheath) (fig. 30 C, F). *Epiphallus*. Lobes triangular; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate (fig. 30 G, H).

Etymology: Named in honor of the indigenous San people of southern Africa.

Distribution (figs. 3 & 4): This species was collected in late September, near Sutherland in the Roggeveldberge, within the succulent karoo biome, near margin of the fynbos biome. The full range of this species remains to be determined.

Discussion: This species was collected in late September, near Sutherland in the Roggeveldberge, within the succulent karoo biome, near margin of the fynbos biome. The full range of this species remains to be determined.

Discussion: This species was described with conservative criteria because I suspect that with further fieldwork and DNA analysis of *L. san* will prove to yield cryptic species. *L. san* may be related to *L. mayi* because the two species have similar cerci and a similar phallic complex. To distinguish between *L. san* and *L. mayi* the following characteristics should be examined: 1) *L. san* has four areas of tegmen bands, whereas *L. mayi* has only two distinguishable tegmen bands; 2) *L. san* lacks pronotal secondary sulci, whereas the prozona of *L. mayi* has weak pronotal secondary sulci between the medial and lateral carinae of the dorsal field; 3) in *L. san* the proximal tibiae are blue and the distal tibia black, whereas in *L. mayi* the proximal tibiae are orange with brown-black speckling and

the distal tibia orange; 4) *L. san* aedeagal valves are very long, and those of *L. mayi* are of moderate length.

9. *Loryma mayi*, new species

male figures: 31, 32; female figure: 59

Holotype male, SOUTH AFRICA: Western Cape Province; Theronberg Pass, 22 kilometers ENE of Ceres, 24.ix.1972 (H.D. Brown, E.Koster, A.Prinsloo), temp.loc.code L15 (ANSP); from the same location: 4 paratype males, 5 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #8.

Diagnosis of Male: From Theronberg Pass, ENE of Ceres, Western Cape; prozona of dorsal field with weak secondary sulci between medial and lateral carinae, medial and lateral carinae not cut by sulci; tegmen with two areas of coloration; posterior femora, knees, tibiae and tarsi with orange; cerci simple with apices turning inward medially; basal aedeagal sheath with sclerotized papillae, and distal aedeagal sheath with spines; aedeagal valves of moderate length and narrow with small openings; medial apodeme of epiphallus bridge present.

Compare with: *L. san*

Description: *Body length.* Small species; male type 14.63 mm; female type 19.48 mm.

Body coloration. Male specimens, known only from dried museum material, mostly black with yellow-cream banding. Female specimens, known only from dried museum material, mostly black-brown with yellow-cream banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 31). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin mottled and diffuse, lower margin distinct; genal band distinct with posterior terminus tapered and mottled; pronotal band of lateral carinae distinct; lateral lobe band distinct with slightly broken posterior terminus, wider and emarginate at mid-length, cut by primary sulcus. Prozona with weak secondary sulci between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci; posteroventral margin of lateral lobe strongly angled ventrally and highlighted with mottled black and cream; posterior margin of dorsal field moderately emarginate medially.

Meso- and Metathorax. Mesepisternum and mesepimeron with dark, mottled black-cream coloration; pleural sulcus black; metepisternum with distinct yellow-cream band 2/3 length of visible metepisternum. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i.+ii. with indistinct boundaries, ventral yellow band blended into mottled yellow-brown of radial vein region; iii.+iv. indistinct boundaries, nearly solid mottled brown. *Hind legs.* Hind femur length to width ratio 3.27; margin of upper carinula and medial area with faint broken brown-black, medial area also with two faint patches of white-cream; margin of lower carinula with thin faint brownish-black line; posterior femora and knees with faint orange; tibiae and tarsi with strong orange; posterior tibia with approximately 9-10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black, extending to supra-anal plate.

Cerci. Approximately as long as supra-anal plate, not extending beyond posterior margin

of subgenital plate; cerci gently curving 90° medially before apices; shoulders moderately pronounced; at mid-length only slightly thinner than distal ends; apices gently angled and spatulate, without or with very thin blackened apical margins.

Male internal features (fig. 32). *Phallic complex.* Aedeagal valves narrow with small openings; valves of moderate length (fig. 32 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with two marginal notches of equal and moderate size and depth; lateral sclerites of cingulum triangular with rounded apices (fig. 32 B, E); distal portion of aedeagal sheath with sclerotized spines and slightly expanded apices laterally; basal portion of aedeagal sheath with ridge of sclerotized spines; distal and basal portions of aedeagal sheath with nearly separated areas of sclerotization; in posterior view, rami of cingula 2x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project vertically upward toward apices of distal portion of sheath (fig. 32 C, F). *Epiphallus.* Lobes triangular; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 32 G, H).

Etymology: Named *L. mayi* to honor Michael L. May.

Distribution (fig. 4): This species was collected in late September, in the Theronberg Pass near Ceres, within the fynbos biome, near the margin of the succulent karoo biome. The collection site is in the Waboomberg and Warm Bokkeveld area. In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for September was

40mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined. *L. mayi* is thought to be sympatric with *L. lapollai*.

Discussion: A putative relative of *L. mayi* is *L. san*, given their similar cerci and phallic complex sculpturing. Refer to the discussion section of the *L. san* description to for distinguishing characters of the two species.

10. *Loryma zebrata*, new species

male figures: 33, 34, 66; female figures: 60, 66

Holotype male, SOUTH AFRICA: Eastern Cape Province; 10 miles SW of Middelburg, 24.ix.1960 (H. Dick Brown), temp.loc.code L27 (ANSP); from the same location: 1 paratype male (SANC). SOUTH AFRICA: Eastern Cape Province: Mountain Zebra National Park, vic. Cradock, Rooiplaat Loop, elev. 1349m; S32°11'426 E25°24'666, 27.x.2005 (L.Spearman & J.LaPolla), Spearman coll. code S3T3Q1; from same location: 2 paratype male, 4 paratype female (ANSP). SOUTH AFRICA: Eastern Cape Province; Renosterberg; vic. Middelburg; 27.ix.1960 (H.Dick Brown), temp.loc.code L30a; from same location: 17 paratype male, 5 paratype female (ANSP) (SANC) (BMNH). SOUTH AFRICA: Eastern Cape Province; 27 miles NE of Graaff-Reinet; 23.i.1963 (M.J.D. White), temp.loc.code L29; from same location: 1 paratype male, 5 paratype female (ANSP) (SANC). The holotype is labeled as LAS TYPE #9.

Diagnosis of Male: From sites within Sneeuwerge, Eastern Cape; prozona of dorsal field with secondary sulcus between medial and lateral carinae, medial and lateral carinae not cut by sulci; tegmen with four areas of coloration, band iii. very straight and even; posterior femora, knees and proximal tibiae with black-brown speckles atop cream, distal tibiae and tarsi with orange; cerci curve less than 90° medially before apices, at mid-length thinner than apices, apices gently spatulate and tapered; basal aedeagal sheath with

sclerotized papillae, and distal aedeagal sheath with spines; aedeagal valves narrowed, small openings; valves of moderate length; medial apodeme of epiphallus bridge present.

Compare with: *L. mayi*, *L. san*

Description: *Body length.* Medium-sized species; male type 16.10 mm; female type 20.59 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black-brown with white-cream banding. Female specimens, known from dried museum material and field photography, mostly black-brown with white-cream banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 33). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin mottled and diffuse, lower margin distinct; genal band distinct, posterior terminus tapered; lateral carina band distinct, with slightly mottled medial margins; lateral lobe band distinct, cut by primary sulcus, anterior and posterior terminus mottled. Prozona with secondary sulcus between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with white-cream (sometimes mottled); posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with mottled cream-black, mesepimeron with mottled cream-black; pleural sulcus black; metepisternum with long distinct yellow-

cream band. *Wing*. Tegmina oval and elongate, more than twice as long as wide; tegmen banding: i.+ii. indistinct boundaries, mottled brown-black coloration becoming black along ventral margin (below radial vein); iii. distinct straight and uniform cream; iv. distinct black. *Hind legs*. Hind femur length to width ratio 3.33; margin of upper carinula and medial area with mottled black, medial area with two patches of faint white-cream; margin of lower carinula without or with very thin black line; posterior femora, knees and proximal tibiae with black-brown speckles atop cream; speckled coloration dissipates at mid-length of tibiae, distal tibiae and tarsi orange; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black, extending to supra-anal plate. *Cerci*. Approximately same length as supra-anal plate, may extend beyond posterior margin of subgenital plate; curving less than 90° medially before apices; shoulders pronounced; thinner at mid-length than at apices; apices gently spatulate and tapered.

Male internal features (fig. 34). *Phallic complex*. Aedeagal valves narrowed with small openings; valves of moderate length (fig. 34 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath sloping slightly posteroventrally; lateral sclerites of cingulum broad, rounded (fig. 34 B, E); distal portion of aedeagal sheath with area of larger sclerotized spines, apices slightly expanded laterally; basal portion of aedeagal sheath with ridge of smaller sclerotized spines; distal and basal portions of aedeagal sheath with nearly separated areas of sclerotization; in posterior view, rami of cingula almost 2x as wide as distal portion of aedeagal sheath;

basal portions of aedeagal sheath project upward with moderate V-shaped outward angle toward apices of distal portion of sheath (fig. 34 C, F). *Epiphallus*. Lobes more triangular; in dorsal view, bridge with wide and pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 34 G, H).

Etymology: Named after one of this species' notable collecting sites, South Africa's beautiful Mountain Zebra National Park and in honor of the park's many dedicated stewards.

Distribution (fig. 5): This species was collected from multiple locations across multiple months: from late September near Middelberg (Renosterberg), to late October SE of Cradock (Swaershoek), and late January NE of Graaff-Reinet (Voor Sneeuweg). All collections sites are within the grassland biome, though the area is surrounded by the nama karoo biome. The collection site in Mountain Zebra National Park near Cradock is designated as south-eastern mountain grassland (Lubke et al. 1996). The full range of this species remains to be determined. Though not thought to be sympatric, *L. zebrata* is found closest to *Hemiloryma* that have been found in the encircling nama karoo.

Discussion: The cerci and phallic complex sculpturing of *L. zebrata* most closely resembles that of *L. san* and *L. mayi*. To distinguish between *L. zebrata*, *L. san* and *L. mayi* the following characteristics should be examined: 1) *L. zebrata* and *L. san* have four areas of tegmen banding coloration, whereas *L. mayi* has indistinguishable tegmen banding margins with two areas of coloration; 2) *L. zebrata* and *L. mayi* have a secondary

sulcus of the prozona between medial and lateral carinae of the dorsal field, whereas *L. san* lacks pronotal secondary sulci; 3) in *L. zebrata* and *L. mayi* the proximal tibiae are orange with brown-black speckling, the distal tibiae orange, whereas in *L. san* the proximal tibiae are blue and the distal tibia black; 4) in lateral view *L. zebrata* region bridging zygoma of cingulum and distal portion of aedeagal sheath slopes slightly ventrally, whereas *L. mayi* and *L. san* have two distinct notches in this region.

11. *Loryma bonteboki*, new species

male figures: 35, 36, 65; female figures: 60, 65

Holotype male, SOUTH AFRICA: Western Cape Province; S end of Kogmanskloof, S of Montagu, 1.xii.2007 (D. Otte), Otte loc.code 07-70, spec.code DL010 (ANSP); from the same location: 1 paratype male (SANC). SOUTH AFRICA: Western Cape Province, Bontebok National Park, vic. Swellendam, Eastern Drive, elev. 124m, S34°04'864S E20°28'110E, 14.x.2005, Spearman coll. code: S2T3Q1 (Spearman & LaPolla); from same location: 5 paratype male, 2 paratype female (ANSP). The holotype is labeled as LAS TYPE #10.

Diagnosis of Male: From sites in the SE Langeberg, Western Cape; prozona of dorsal field with secondary sulcus between medial and lateral carinae, prozona of lateral lobe with two depressions with raised rims just lateral to lateral carinae, medial and lateral carinae not cut by sulci; tegmen with four areas of coloration; posterior femora and knee with faint orange, proximal tibiae with moderate black-brown speckles atop white-cream, posterior tibiae and tarsi with bright orange; supra-anal plate with extraordinarily long, triangular apex; cerci curving gently less than 90° medially before apices, at mid-length thinner than at apices, apices expand to point dorsomedially, with blackened apical margins and scattered atypically thickened long hairs; aedeagal valves narrowed with small openings; valves of moderate length; medial apodeme of epiphallus bridge present.

Compare with: *L. magna*, *L. browni*

Description: *Body length.* Medium-sized species; male type 19.80 mm; female type 26.80 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black-brown with yellow-cream banding. Female specimens, known from dried museum material and field photography, variable with some specimens mostly brown-black with yellow-cream banding and other specimens with green on head, pronotum, medial line of abdomen and upper marginal area of femur; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 35). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin diffuse, lower margin distinct; genal band distinct with tapered posterior end; pronotal band of lateral carinae distinct; lateral lobe band distinct and wider immediately posterior to primary sulcus. Prozona with secondary sulcus between medial and lateral carinae of dorsal field; prozona of lateral lobe with two depressions with raised edges just lateral to lateral carinae; medial and lateral carinae are not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with yellow-cream; posterior margin of dorsal field moderately to strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with mottled diffuse cream-black band, mesepimeron mottled diffuse cream-black; pleural sulcus black; metepisternum with

distinct long yellow-cream band. *Wing*. Tegmina oval, less than twice as long as wide; tegmen banding: i. distinct yellow-cream, slightly mottled posterior margin; ii. distinct black-brown; iii. distinct yellow-cream, thin anteriorly and thick posteriorly; iv. distinct black-brown, minimal mottling at posterior end. *Hind legs*. Hind femur length to width ratio 3.56; margin of upper carinula and medial area with mottled black; margin of lower carinula without black; posterior femora and knee with faint orange; proximal tibiae with faint to moderate black-brown speckles atop variable white-cream; posterior tibiae and tarsi with bright orange (proximal and distal tibiae color transitions at mid-length); posterior tibiae with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black, extend to supra-anal plate; supra-anal plate with extraordinarily long, triangular apex. *Cerci*. Shorter than supra-anal plate, because of elongated apex of latter, and not extending beyond posterior margin of subgenital plate; curving gently less than 90° medially before apices; shoulders moderately pronounced; at mid-length thinner than at apices; apices expanded to point dorsomedially, with blackened apical margins and scattered atypically thickened long hairs.

Male internal features (fig. 36). *Phallic complex*. Aedeagal valves narrowed with small openings; valves of moderate length (fig. 36 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with smaller posterior marginal notch, broader deeper more anterior notch; lateral sclerites of cingulum triangular (fig. 36 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae;

distal portion of aedeagal sheath with widened apices markedly expanded laterally, creating large area of sclerotized papillae; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotization, (although in lateral view, basal and distal portions of sheath appear nearly separate); in posterior view, rami of cingula 1.5x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with moderate V-shaped outward angle toward apices of distal portion of sheath (fig. 36 C, F). *Epiphallus*. Lobes generally triangular; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 36 G, H).

Etymology: Named after one of this species' notable collecting sites, South Africa's beautiful Bontebok National Park, and in honor of the park's many dedicated stewards and the many kind people we came to know in historic Swellendam.

Distribution (fig. 4): This species was collected from two locations during different months: from mid-October near Swellendam (S of Eastern Langeberge) to early December S of Montagu (in Kogmanskloof in Langeberge). Both collections sites are within the fynbos biome, with vegetation designation of west coast renosterveld (Rebelo 1996b). In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for October was 30mm, November was 14mm, and December was 17mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined.

Discussion: The body and hind leg coloration, length of cerci, and phallic complex sculpturing of *L. bonteboki* is most similar to *L. magna* and *L. browni*, although the species are easily distinguishable by examining the following characteristics: 1) *L. bonteboki* has extraordinarily long, triangular apex of supra-anal plate, thus far unique within *Loryma*; 2) *L. bonteboki* is a medium sized species, *L. magna* and *L. browni* are the largest known in the genus; 3) the cerci of *L. bonteboki* are more lateromedially flattened mid-length compared to *L. magna* and *L. browni*, in which the cerci at mid-length are rounded; 4) in posterior view the rami of the cingulum and aedeagal sheaths of *L. bonteboki*, *L. magna* and *L. browni* are all sculptured differently.

12. *Loryma karoo*, new species

male figures: 37, 38; female figure: 60

Holotype male, SOUTH AFRICA: Western Cape Province; 12 miles WNW of Calvinia, 6.ix.1968 (H.D. Brown) (ANSP); from the same location: 2 paratype males, 2 paratype females (SANC), temp.loc.code L08 (ANSP). SOUTH AFRICA: Northern Cape Province; Gannaga Pass, 27 kilometers S of Middelpos, 26.ix.1972, (H.D. Brown, E.Koster, A.Prinsloo), loc.code L17; from the same location: 17 paratype males, 17 paratype females (SAMC) (ANSP) (BMNH). SOUTH AFRICA: Western Cape Province; 4 miles N of Bitterfontein, 3.ix.1961, (H.D. Brown, W. Fürst), loc.code L22; from the same location: 2 paratype males (SAMC) (ANSP). SOUTH AFRICA: Northern Cape Province; 3 miles S of Kamieskroon, 4.ix.1961. (H.D. Brown, W. Fürst), loc.code L31c; from the same location: 10 paratype males, 7 paratype females (SAMC) (ANSP) (BMNH). The holotype is labeled as LAS TYPE #11.

Diagnosis of Male: From sites in NW from Kamiesroon in Namaqualand to the SE in the Onder-Bokkeveld, Western and Northern Cape; prozona of dorsal field with secondary sulcus between medial and lateral carinae, medial and lateral carinae not cut by sulci; tegmen with three areas of coloration, iii.+iv. with small triangular yellow area; posterior femora, knees, tibiae and tarsi with orange; cerci bend 90° medially before apices, thin at mid-length, tapering gradually beyond medial bend, pointed at apices; aedeagal valves

narrowed with small openings, valves short; medial apodeme of epiphallus bridge present.

Compare with: *L. namaqua*

Description: *Body length.* Medium-sized species; male type 15.73 mm; female type 25.42 mm. *Body coloration.* Male specimens, known only from dried museum material, black with yellow-cream banding. Female specimens, known only from dried museum material, black-brown with yellow-cream banding; apices of recurved ovipositor valves black. Males and females with same leg coloration.

Male external features (fig. 37). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin mottled and diffuse, lower margin distinct; genal band distinct, tapered posterior terminus; pronotal band of lateral carinae distinct, slightly mottled medial margin; lateral lobe band distinct, cut by primary sulcus. Prozona with secondary sulcus between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted mottled yellow-black; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with mottled yellow-black, mesepimeron with mottled yellow-black; pleural sulcus black; metepisternum with distinct yellow band, wider at anterior end. *Wing.* Tegmina oval, twice as long as wide; tegmen banding: i.

distinct yellow; ii. distinct black, width greatest mid-length, tapers posteriorly; iii.+iv. indistinct boundaries, mostly black coloration with small triangular yellow area at apical margin. *Hind legs.* Hind femur length to width ratio 3.32; margin of upper carinula and medial area with mottled black, medial area with two patches of white-cream; margin of lower carinula and knees without black; posterior femora and knee with faint orange; tibiae and tarsi with strong orange (anterior tibiae possibly with mottled brown atop orange); posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black, extending onto supra-anal plate.

Cerci. Approximately same length as supra-anal plate, not extending beyond posterior margin of subgenital plate; bend 90° medially before apices; shoulders pronounced; thinner at mid-length than apices; cerci tapering gradually beyond medial bend, pointed at apices.

Male internal features (fig. 38). *Phallic complex.* Aedeagal valves narrowed with small openings; valves short (fig. 38 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath with smaller posterior marginal notch, gentle broader more anterior notch; lateral sclerites of cingulum triangular (fig. 38 B, E); distal and basal portions of aedeagal sheath with sclerotized spines; distal portion of aedeagal sheath with apices widely expand laterally; distal and basal portions of aedeagal sheath have nearly separated areas of sclerotization; sclerotized papillae on soft tissue near apices of ventral valves; in posterior view, rami of cingula 1.5x as wide as distal

portion of aedeagal sheath; basal portions of aedeagal sheath project upward with moderate V-shaped angle toward apices of distal portion of sheath (fig. 38 C, F).

Epiphallus. Lobes triangular; in dorsal view, bridge with pronounced medial apodeme; epiphallic lateral sclerites rounded and flattened (fig. 38 G, H).

Etymology: Named *L. karoo* for the succulent karoo biome, a biodiversity hotspot with endemic flora and fauna, which needs further study, protection and preservation.

Distribution (figs. 3 & 4): This species was collected from multiple locations during one month: from early September S of Kamieskroon (Namaqualand), to early September N of Bitterfontein, to early September WNW of Calvinia (Hantam region), and late September in Gannaga Pass, S of Middelpos (Roggeveldberge). The first site listed (nearest Kamieskroon) is found well within the succulent karoo biome, although the three latter sites (nearest Bitterfontein, Calvinia and Middelpos) are within the succulent karoo biome but very close to the margins of the fynbos biome. In Calvinia, the closest large city, the 30-year average (1961-1990) monthly rainfall for September was 13mm, the greatest average monthly rainfalls being: 26mm in March, 27mm in April, 22mm in May, 34mm in June, 23mm in July, and 24mm in August (SAWS, 2009). The full range of this species remains to be determined. In its most northeastern collection site, *L. karoo* is confirmed sympatric with *L. ashleyi* and thought to be sympatric with *L. namaqua*.

Discussion: A putative relative of *L. karoo* is *L. namaqua*, given similar morphological characteristics such as: 1) tegmen coloration in three regions with indistinguishable

margins between iii.+iv.; 2) prozona with secondary sulci between medial and lateral carinae of dorsal field; 3) hind leg with orange coloration; 4) cerci sculpturing similar, with tapered apices; 5) very similar sculpturing and sclerotization of phallic complex. To distinguish between *L. karoo* and *L. namaqua* the following characteristics should be examined: 1) *L. karoo* with small triangular area of yellow in tegmina area iii.+iv., *L. namaqua* with large mottled yellow-black in iii.+iv.; 2) *L. karoo* cercal apices gradually tapered beyond medial bend at 1/2 along its length, *L. namaqua* emarginate just before apex, appearing notched in posterior view; 3) basal portions of aedeagal sheath project upward with moderate V-shaped toward apices of distal portion of sheath in *L. karoo*, in *L. namaqua* basal portions project upward almost parallel, then diverge near apices of distal portion of sheath.

13. *Loryma mirabunda*, new species

male figures: 39, 40, 64; female figures: 60, 64

Holotype male, SOUTH AFRICA: Western Cape Province; along Boesmansrivier, W of Picketberg, S 32°43.631', E 018°39.071', 3.xi.2007 (D. Otte, E. Rohwer), Otte loc.code 07-18Boes, spec.code DL032 (ANSP); from the same location: 2 paratype females (ANSP). The holotype is labeled as LAS TYPE #12.

Diagnosis of Male: From W of Picketberg, Western Cape; prozona of lateral lobe with weak secondary sulci, prozona of dorsal field with weak secondary sulcus between medial and lateral carinae, metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with gray mottling; cerci flattened lateromedially, rectangular, and not curving medially before apices; aedeagal valves extraordinarily long and narrowed, moderate openings, apices of valves

with small sclerotized bulbous lobes that curl anteriorly; no medial apodeme on epiphallus bridge.

Compare with: *L. cederbergensis*

Description: *Body length.* Medium-sized species; male type 16.58 mm; female type 22.15 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black and gray with white-cream banding. Female specimens, known from dried museum material and field photography, mostly light brown and gray with some black and white-cream banding; apices of recurved ovipositor valves brown-black. Males and females have same leg coloration.

Male external features (fig. 39). *Head and Pronotum.* Band across apex of eye margin; band on ecdysial line distinct with mottled margins; occipital band diffuse and mottled, with only lower margin distinct; genal band with upper margin distinct, lower margin diffuse; band of medial carina distinct with mottled margins; lateral carina band diffuse and mottled, with only lower margin distinct; lateral lobe band distinct and cut by primary sulcus. Prozona with two secondary sulci, one weakly cutting lateral lobe, the second weakly cutting dorsal field between medial and lateral carinae, not vertically aligned with first; metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted white-cream; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct white-cream band, mesepimeron with mottled white-cream; pleural sulcus black; metepisternum with distinct thick white-cream band along 3/4 its visible length. *Wing.* Tegmina oval, less than twice as long as wide; tegmen banding: i. mottled white-cream and brown, diffuse ventral margin; ii. distinct black; iii. distinct white-cream, with widened and mottled ventro-apical margin; iv. mottled black band; areas ii.+iii.+iv. with apical margin of white-cream. *Hind legs.* Hind femur length to width ratio 3.93; margin of upper carinula and medial area with mottled black, medial area with two patches of white-cream; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with faint orange, anterior tibiae with slight gray mottling; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black with white-cream highlights between the bands; bands extending to supra-anal plate. *Cerci.* each a little longer than supra-anal plate, not extending beyond posterior margin of subgenital plate; not curving medially inward significantly before apices; shoulders not pronounced; at mid-length cerci slightly thinner than at apices, cerci flattened lateromedially, apices expanded and rectangular with blackened apical margins and each with two atypically thickened long dark hairs.

Male internal features (fig. 40). *Phallic complex.* Aedeagal valves narrowed, with moderate openings; valves extraordinarily long; apices of valves with small sclerotized

bulbous lobes curling anteriorly (fig. 40 A, D); in lateral view, margin of region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, U-shaped; lateral sclerites of cingulum acutely triangular (fig. 40 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with apices slightly expanded laterally, with larger area of sclerotized papillae; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotized papillae; in posterior view, rami of cingula same width as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward without any, or a very subtle, outward angle toward apex of distal portion of sheath (fig. 40 C, F). *Epiphallus*. Lobes narrowly rounded; in dorsal view, bridge curved and without apodeme; epiphallic lateral sclerites assumed to be very small (lost in dissections) (fig. 40 G, H).

Etymology: The specific epithet *mirabunda* is Latin for full of wonder, in reference to the wondrous sculpturing of this species' cingulum and aedeagus.

Distribution (figs. 3 & 4): This species was collected in early November, in the Picketberg region, within the fynbos biome. In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for November was 14mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined. Though not thought to be sympatric, *L. mirabunda* is closest to the range of *L. cederbergensis*.

Discussion: A putative relative of *L. mirabunda* is *L. cederbergensis*, because they share many morphological characteristics including: 1) lateromedially flattened, broad rectangular cerci that do not curve inward; 2) very similar tegmen banding coloration, mottling and margins; 3) mottled coloration of head and pronotum, orange coloration of hind legs; 4) prozona with two secondary sulci (weakly cutting lateral lobe and dorsal field respectively), metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe; and 5) similar phallic complex sculpturing, the valves extraordinarily long and their apices with small sclerotized bulbous lobes that curl anteriorly.

To distinguish between *L. mirabunda* and *L. cederbergensis* the following morphological features should be examined: 1) *L. mirabunda* has narrower cerci (length to width, $\approx 3:1$ compared to $\approx 2.5:1$ in *L. cederbergensis*) and at mid-length the cerci proportionately narrower than in *L. cederbergensis*; 2) region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave and U-shaped in lateral view in *L. mirabunda*, in *L. cederbergensis* this concavity resembles a wide open V-shape; 3) basal portions of aedeagal sheath project upward without any or very subtle outward angle toward apex of distal portion of sheath for *L. mirabunda*, but in *L. cederbergensis* the basal portions of aedeagal sheath project upward with subtle hour-glass shape finishing with an outward thickened curve at apex of distal portion of sheath.

Geographically, it appears that *L. mirabunda* might be limited to the Piketberg region, whereas *L. cederbergensis* might be found in the Olifantsrivierberg and Cederberg regions.

14. *Loryma cederbergensis*, new species

male figures: 41, 42, 61; female figures: 60, 61

Holotype male, SOUTH AFRICA: Western Cape Province; 2 kilometers N of N7 on Olifantsberge, Piekerierskloofpass, 9.xi.2007 (D. Otte, E. Rohwer), Otte loc.code 07-46, spec.code DL142 (ANSP); from the same location: 7 paratype males, 2 paratype females (SANC) (ANSP) (SAMC). D. Otte collection location code: 07-46. SOUTH AFRICA: Western Cape Province, Cederberg Wilderness Park, vic. Algeria Restcamp, elev. 675m; S32°23'733 E19°05'214, 7.x.2005 (L.Spearman & J.LaPolla), Spearman coll.code S1T3Q1; from the same location: 1 paratype male (SANC) (ANSP) (SAMC). The holotype is labeled as LAS TYPE #13.

Diagnosis of Male: From Olifantsberge and Cederberg Wilderness, Western Cape; prozona of lateral lobe with weak secondary sulci, prozona of dorsal field with weak secondary sulcus between medial and lateral carinae, metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with gray mottling; cerci flattened lateromedially, rectangular, and not curving medially before apices; aedeagal valves extraordinarily long and moderately narrow with moderately large openings, apices of valves with large bulbous sclerotized lobes that curl anteriorly; no medial apodeme on epiphallus bridge.

Compare with: *L. mirabunda*

Description: *Body length.* Medium-sized species; male type 15.70 mm; female type 22.96 mm. *Body coloration.* Male specimens s, known from dried museum material and field photography, mostly black-brown and gray with white-cream banding. Female specimens, known from dried museum material and field photography, mostly light

brown and gray with some black, with white-cream banding; apices of recurved ovipositor valves brown-black. Males and females have same leg coloration.

Male external features (fig. 41). *Head and Pronotum.* Band across apex of eye margin; band on ecdysial line mottled; occipital band diffuse and mottled, with only lower margin distinct; genal band with upper margin distinct, lower margin diffuse; band of medial carina distinct with mottled margins; lateral carina band diffuse and mottled, with only lower margin distinct; lateral lobe band distinct and cut by primary sulcus. Prozona with two secondary sulci, one weakly cutting lateral lobe, the second weakly cutting dorsal field between medial and lateral carinae; metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with white-cream; posterior margin of dorsal field weak to moderately emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct white-cream band, mesepimeron mottled white-cream; pleural sulcus black; metepisternum with distinct white-cream band. *Wing.* Tegmina oval, less than twice as long as wide; tegmen banding: i. mottled white-cream and brown, dorsal margin lightest area of color; ii. distinct, thin black-brown; iii. distinct white-cream, widened and mottled at ventro-apical margin; iv. mottled black-brown. Area iii.+iv. with white-cream apical margin. *Hind legs.* Hind femur length to width ratio 3.36; margin of upper carinula and medial area with very little mottled black, medial area also with two patches of white-cream; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with faint orange, anterior tibiae

with slight gray mottling; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black-brown with white-cream highlights between the bands; bands extend to supra-anal plate. *Cerci.* A little longer than supra-anal plate, not extending beyond posterior margin of subgenital plate; not curving significantly inward before apices; shoulders very subtle; at mid-length slightly thinner than at apices; flattened lateromedially, apices rectangular, sometimes with blackened apical margins.

Male internal features (fig. 42). *Phallic complex.* Aedeagal valves moderately narrow with moderately large openings; valves extraordinarily long, apices of valves with large bulbous sclerotized lobes that curl anteriorly (fig. 42 A, D); in lateral view, margin of region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, V-shaped; lateral sclerites of cingulum rounded (fig. 42 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with moderately thickened apices that expand laterally, with large area of sclerotized papillae, basal sheath with relatively few sclerotized papillae; distal and basal portions of aedeagal sheath have uniform and continuous distribution of sclerotized papillae; in posterior view, rami of cingula is 1 1/4 x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with subtle hour-glass shape ending with an outward curve at apices of distal portion of sheath (fig. 42 C, F).

Epiphallus. Lobes rounded; in dorsal view, bridge curved and without medial apodeme; epiphallallic lateral sclerites are extremely small (fig. 42 G, H).

Etymology: Named after one of this species' notable collecting sites, South Africa's harsh but enchanting Cederberg Wilderness (Cape Nature), and in honor of the park's dedicated stewards, Donnie Malherbe, Rika du Plessis, the many hard working rangers, and our adopted Cederberg valley family, the Nieuwoudts of Jamaka Organic farms.

Distribution (figs. 3 & 4): This species was collected from two locations across two months: from early October within the Cederberg Wilderness Reserve, to early November in the Piekerierskloofpass (Olifantsrivierberge). Both collections sites are within the fynbos biome, with vegetation designation of mountain fynbos (Rebelo 1996a). In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for October was 30mm, and for November was 14mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined. Though not thought to be sympatric, *L. cederbergensis* is closest to the range of *L. mirabunda*.

Discussion: A putative relative of *L. cederbergensis* is *L. mirabunda* given the many morphological characteristics they share. Refer to the discussion section of the *L. mirabunda* description to for distinguishing characters of the two species.

15. *Loryma lapollai*, new species

male figures: 43, 44, 62

Holotype male, SOUTH AFRICA: Western Cape Province; vic. Klondyke, E of Swaarmoedpas, S 33°18.486', E019°35.375', 11.xi.2007 (D. Otte, E. Rohwer), Otte loc.code 07-52, spec.code DL062/DL063 (ANSP); from the same location: 4 paratype males (SANC) (ANSP) (SAMC). No females collected. The holotype is labeled as LAS TYPE #14.

Diagnosis of Male: From vic. Klondyke, E of Swaarmoedpas, Western Cape; prozona of lateral lobe with weak secondary sulci, prozona of dorsal field with weak secondary sulcus between medial and lateral carinae, metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange, anterior to mid-length tibiae with subtle mottled gray; cerci flattened lateromedially and do not curve medially before apices, at mid-length wider than at apices, apices triangular and tapered to point, with blackened apical margins; aedeagal valves moderately narrowed, with moderate openings and length; in posterior view, two distinctive lobes are visible on lateral surfaces of aedeagal valves, projecting dorsolaterally immediately posterior to valve apices; no medial apodeme on epiphallus bridge.

Compare with: *L. umoja*

Description: *Body length.* Medium-sized species; male type 16.00 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black-brown with white-cream banding.

Male external features (fig. 43). *Head and Pronotum.* Band across apex of eye margin; band on ecdysial line distinct with mottled margins; occipital band with upper margin diffuse and mottled, lower margin distinct; genal band with upper margin distinct, lower margin distinct with tapered posterior end; band of medial carina distinct with mottled margins, lateral carina band mottled and very thin; lateral lobe band distinct, cut by primary sulcus. Prozona with two secondary sulci, one very weakly cutting lateral lobe, the second very weakly cutting dorsal field between medial and lateral carinae; metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted white-cream; posterior margin of dorsal field weakly emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct white-cream band, mesepimeron with mottled black; pleural sulcus black; metepisternum with distinct white-cream band.

Wing. Tegmina oval, approximately twice as long as wide; tegmen banding: i. mottled black to light brown; ii. distinct black, radial vein highlighted in brown; iii. distinct white-cream, slightly widened and mottled ventral apical margin; iv. distinct black. *Hind legs.* Hind femur length to width ratio 3.72; margin of upper carinula and medial area mottled black, medial area also with one patch of cream; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with faint orange, tibiae anterior to mid-length with additional subtle mottled gray; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands black with white-cream highlights between bands, extending to supra-anal plate. Supra-anal plate faint orange. *Cerci.* Longer than supra-anal plate, extending beyond posterior margin of subgenital plate; not curving significantly inward before apices; shoulders subtle; at mid-length cerci than at apices; flattened lateromedially, apices triangular and tapered to point, with blackened apical margins.

Male internal features (fig. 44). *Phallic complex.* Aedeagal valves moderately narrowed, with moderate openings; valves of moderate length (fig. 44 A, D); in lateral view, margin of region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave; lateral sclerites of cingulum triangular (fig. 44 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae, more extensive on distal portion; distal portion of aedeagal sheath with strongly thickened and widened apices that expand laterally; distal and basal portions of aedeagal sheath uniformly and continuously sclerotization; in posterior view, rami of cingula narrower than distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with wide open curve outward toward apices of distal portion of sheath (fig. 44 C, F); in posterior view, two distinctive lobes visible on lateral surfaces of valves, lobes projecting dorsolaterally immediately posterior to distal portion of valves. *Epiphallus.* Lobes rounded distally; in dorsal view, bridge thickened and curved, without medial apodeme; epiphallic lateral sclerites extremely small (fig. 44 G, H).

Etymology: Named *L. lapollai* to honor John S. LaPolla.

Distribution (fig. 4): This species was collected in mid-November, near Klondyke (E of Warm Bokkeveld, N of Hexrivierberge), within the fynbos biome, near the margin of the succulent karoo biome. In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for November was 14mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined. *L. lapollai* is thought to be sympatric with *L. mayi*.

Discussion: Within the EA species-group, *L. lapollai* most closely resembles *L. umoja* because they share some external morphological characteristics including: 1) flattened, pointed cerci that do not bend medially inward, with blackened apical margins; 2) prozona with two secondary sulci (one weakly cutting lateral lobe, other weakly cutting dorsal field between medial and lateral carinae), metazona with deep secondary sulcus cutting medial and lateral carinae, dorsal field and lateral lobe; 3) four-banded tegmen, with similar coloration, margins and mottling; 4) orange hind femur, tibiae and tarsi. Though *L. lapollai* and *L. umoja* share multiple external morphological similarities, the phallic complexes of *L. lapollai* and *L. umoja* are very distinct.

To distinguish between *L. lapollai* and *L. umoja* the following morphological features should be examined: 1) cerci of *L. lapollai* have more acutely triangular apices, *L. umoja* cerci apices more blunt; 2) rami of cingulum and aedeagal sheath sculptured differently, *L. lapollai* with distal portion of aedeagal sheath same width as rami of cingulum, and *L. umoja* with distal portion of aedeagal sheath smaller than width of rami

of cingulum; 3) in posterior view, two distinctive lobes visible on lateral surfaces of valves of *L. lapollai*, projecting dorsolaterally immediately posterior to distal portion of valves, but in *L. umoja*, valves narrowed immediately posterior to their apices, from which fleshy membrane flares outward (trumpet-like).

16. *Loryma tsitsikamma*, new species

male figures: 45, 46; female figure: 59

Holotype male, SOUTH AFRICA: Eastern Cape Province; 11 miles W of Kareedouw, (near) Langkloof, 18.xi.1958 (H.D. Brown), temp.loc.code L23b (ANSP); from the same location: 4 paratype males, 1 paratype female (SANC) (ANSP) (SAMC). SOUTH AFRICA: Eastern Cape Province; 10 miles W of Kareedouw, Langkloof, 18.xi.1958, (H.Dick Brown), temp.loc.code L23a, 3 paratype males, 4 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #15.

Diagnosis of Male: From W of Kareedouw, Eastern Cape; metazona with secondary sulcus cutting dorsal field, lateral carinae and lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with mottled brown-black; cerci flattened lateromedially and do not curve medially before apices, apices broadly expanded with a straight, vertical edge and with apical margins distinctly blackened; aedeagal valves long and wide with moderate openings; no medial apodeme on epiphallus bridge.

Compare with: *L. waboom*, *L. solveigae*, *L. larsenorum*

Description: *Body length.* Medium-sized species; male type 18.82 mm; female type 24.59 mm. *Body coloration.* Male specimens, known only from dried museum material, mostly black with yellow-cream banding. Female specimens, known only from dried

museum material, mostly black with yellow-cream banding; apices of recurved ovipositor valves black. Males and females have same leg coloration.

Male external features (fig. 45). *Head and Pronotum.* Band across apex of eye margin; occipital band with upper margin diffuse and mottled, lower margin distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling; pronotal band of lateral carinae very thin with mottled margins; lateral lobe band distinct, cut by primary sulcus. Metazona with secondary sulcus of dorsal field, cutting lateral carinae (not medial carinae) and lateral lobe. Posteroventral margin of lateral lobe moderately angled ventrally, highlighted cream; posterior margin of dorsal field weakly emarginate medially.

Meso- and Metathorax. Mesepisternum and metepisternum each with distinct cream band, mesepimeron with mottled black; pleural sulcus black. *Wing.* Tegmina oval, approximately twice as long as wide; tegmen banding: i. mottled black-brown; ii. distinct black, dorsal margin diffuse; iii. distinct white-cream, slightly widened and mottled at ventral apical margin; iv. distinct black, becomes mottled apically. *Hind legs.* Hind femur length to width ratio 3.70; margin of upper carinula and medial area mottled black; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with additional subtle mottled brown-black; posterior tibiae with approximately 9-10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black and extending to supra-anal plate; supra-anal plate faint orange. *Cerci.* Approximately same length as supra-anal plate, extending slightly beyond margin of subgenital plate; not curving significantly inward before apices; shoulders subtle; at mid-length thinner than at apices, flattened lateromedially, broadly expanded apically; apical margins distinctly blackened, with straight, nearly vertical edge.

Male internal features (fig. 46). *Phallic complex.* Aedeagal valves wide, with moderate openings; valves long (fig. 46 A, D); in lateral view, margin of region bridging zygoma of cingulum and distal portion of aedeagal sheath with deep narrowly U-shaped concavity in lateral view; lateral sclerites of cingulum triangular (fig. 46 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with strongly thickened apices expanded laterally, with larger area of sclerotized papillae, basal sheath with fewer sclerotized papillae; distal and basal portions of aedeagal sheath uniformly and continuously sclerotized; in posterior view, rami of cingula narrower than distal portion of aedeagal sheath; basal portions of aedeagal sheath widely divergent, projecting upward opening smooth outward curve toward apices of distal portion of sheath (fig. 46 C, F); in posterior view, aedeagal valves with two small lateral lobes; sclerotized spots on soft tissue near ventral valve apices. *Epiphallus.* Lobes relatively narrow, rounded distally; in dorsal view, bridge thickened, curved and without medial apodeme; epiphallic lateral sclerites assumed very small (lost in dissections) (fig. 46 G, H).

Etymology: On a suggestion from H. Dick Brown, the collector, this species is named *L. tsitsikamma* for the mountainous, biotically diverse Tsitsikamma region of South Africa.

Distribution (fig. 5): This species was collected in mid-November, W of Kareedouw (in Langkloof), within the fynbos biome. The full range of this species remains to be determined. Though not determined to be sympatric, the known range of *L. tsitsikamma* is close to that of *L. solveigae*.

Discussion: Within the EA species-group, *L. tsitsikamma* has unique boot-shaped cerci. However, the internal genitalia of *L. tsitsikamma* most closely resemble those of *L. waboom*, *L. solveigae* and *L. larsenorum*, suggesting that all these species may be closely related. The internal morphological characteristics that they all share include: 1) triangular sclerites of the cingulum; 2) in lateral view, a U-shaped region bridging the zygoma and distal portion of aedeagal sheath; 3) aedeagal valves that are anteroposteriorly flattened, appearing thinner in lateral view, wider in posterior view; 4) a similar pattern of width variation of the circumference of the distal portion of the aedeagal valves; 5) a similar pattern of sculpturing of the cingulum and basal and distal portions of the aedeagal sheath.

To distinguish *L. tsitsikamma* from *L. waboom*, *L. solveigae*, and *L. larsenorum*, the following morphological features should be examined: 1) cerci of *L. tsitsikamma* are unique, boot-shaped and with very blackened apical margins, whereas the other species have rounded flattened spatulate cerci with little or no black along apical margins; 2) in lateral view in *L. tsitsikamma* the distance from the base of the ectophallus to the arch of

aedeagus is only about half as long as the distance from the arch of aedeagus to the apex of the aedeagal valves (0.5:1), whereas corresponding length ratios are notably greater for *L. waboom*, *L. solveigae* and *L. larsenorum*, i.e., 1:1, 1:1, and 1:0.5 respectively; 3) in posterior view, the rami of the cingulum and distal portion of the aedeagal sheath are equally wide in *L. tsitsikamma* and *L. waboom*, but are significantly wider than the distal portion of the aedeagal sheath in *L. solveigae* and *L. larsenorum*; 4) in posterior view, the sculpturing of the apices of the aedeagal valves is different in each species.

17. *Loryma waboom*, new species

male figures: 47, 48

Holotype male, SOUTH AFRICA: Western Cape Province; Swartberg Pass, (S of Prince Albert), 11.xii.1961 (H.D. Brown, W. Fürst, F. Pick), temp.loc.codes L28 and L34 (ANSP); from the same location: 3 paratype male (ANSP). No females collected. The holotype is labeled as LAS TYPE #16.

Diagnosis of Male: From Swartberg Pass S of Prince Albert, Western Cape; prozona and metazon of dorsal field each with very weak secondary sulcus between medial and lateral carinae, medial and lateral carinae not cut by sulci; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with additional subtle mottled brown-black; cerci broadly expanded spatulate, flattened lateromedially and not curving medially before apices; aedeagal valves of moderate length and wide, with moderate openings; no medial apodeme on epiphallus bridge.

Compare with: *L. solveigae* and *L. larsenorum* (cerci and genitalia), *L. tsitsikamma* (genitalia)

Description: *Body length.* Medium-sized species; male type 18.25 mm. *Body coloration.*

Male specimens, known only from dried museum material, mostly black with yellow-cream banding.

Male external features (fig. 47). *Head and Pronotum.* Band across apex of eye margin; occipital band wide with upper margin diffuse and mottled, lower margin distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling; pronotal band of lateral carinae with very thin mottled margins; lateral lobe band distinct, cut by primary sulcus. Prozona and metazona each with very weak secondary sulcus between medial and lateral carinae of dorsal field; medial and lateral carinae not cut by sulci. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with mottled cream; posterior margin of dorsal field weakly emarginate medially.

Meso- and Metathorax. Mesepisternum with diffuse cream band, mesepimeron with mottled black; pleural sulcus black; metepisternum with distinct cream band. *Wing.* Tegmina oval, less than twice as long as wide; tegmen banding: i. mottled brown; ii. mottled black, dorsal margin diffuse; iii. distinct white-cream, slightly widened mid-length, mottled at ventral apical margin; iv. distinct but thin black, mottled along dorsal margin. *Hind legs.* margin of upper carinula and medial area with mottled black, medial area with two cream patches; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with orange, anterior tibiae with additional subtle mottled brown-black; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black, extending to supra-anal plate; supra-anal plate and cerci orange. *Cerci.* Approximately same length as supra-anal plate, not extending beyond posterior margin of subgenital plate; not curving significantly inward before apices; shoulders subtle; at mid-length wider than pointed apices, although cerci further widen 2/3 length; cerci remain flattened lateromedially, broadly expanded; apices of cerci tapered, spatulate.

Male internal features (fig. 48). *Phallic complex.* Aedeagal valves wide, moderate openings; valves of moderate length (fig. 48 A, D); in lateral view, margin of region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, U-shaped; lateral sclerites of cingulum acutely triangular (fig. 48 B, E); distal and basal portions of aedeagal sheath with areas of sclerotized papillae; distal portion of aedeagal sheath with strongly thickened apices expanding laterally, with larger area of sclerotized papillae, than basal sheath; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotization; in posterior view, rami of cingula approximately same width as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with wide open more V-shaped curve outward toward apices of distal portion of sheath (fig. 48 C, F); in posterior view, valves narrow immediately posterior to apices of aedeagal valves. *Epiphallus.* Lobes more-or-less triangular; in dorsal view, bridge curved, without medial apodeme; epiphallic lateral sclerites assumed to be small (lost in dissections) (fig. 48 G, H).

Etymology: Named *L. waboom* after the adjacent Waboombesberg peak within the Groot Swartberge of the Western Cape.

Distribution (figs. 4 & 5): This species was collected in mid-December, in Swartberg Pass of Groot Swartberge, within the fynbos biome. The full range of this species remains to be determined. *L. waboom* is confirmed sympatric with *L. magna*.

Discussion: Putative relatives of *L. waboom* are *L. tsitsikamma*, *L. solveigae* and *L. larsenorum* given the morphological characteristics they share. In particular, the cerci of *L. waboom* is most similar to that of *L. solveigae* and *L. larsenorum*. Refer to the discussion section of *L. tsitsikamma* for distinguishing characteristics of these four species.

18. *Loryma solveigae*, new species

male figures: 49, 50

Holotype male, SOUTH AFRICA: Eastern Cape Province; 10 miles SE Clarkson, (near) Humansdorp. 19.xi.1958 (H.D. Brown), temp.loc.code L19 (ANSP); from the same location: 2 paratype males (SANC) (ANSP). No females collected. The holotype is labeled as LAS TYPE #17.

Diagnosis of Male: From SE Clarkson vic. Humansdorp, Eastern Cape; prozona of dorsal field with very weak secondary sulcus between medial and lateral carinae, metazona of dorsal field with weak secondary sulcus between medial and lateral carinae; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi orange, anterior tibiae with subtle mottled brown-black; cerci flattened lateromedially and curved medially slightly before apices, narrowed slightly at mid-length, widening at 2/3 along

length, broadly expanded with rounded tapered apices with blackened dorsoapical margins; aedeagal valves wide with moderate openings and moderate length; no medial apodeme of epiphallus bridge.

Compare with: *L. waboom* and *L. larsenorum* (cerci and genitalia), *L. tsitsikamma* (genitalia)

Description: *Body length.* Medium-sized species; male type 18.59 mm. *Body coloration.* Male specimens, known only from dried museum material, mostly black with yellow-cream banding.

Male external features (fig. 49). *Head and Pronotum.* Band across apex of eye margin; occipital band distinct with upper margin mottled, lower margin distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling posteriorly; pronotal band of lateral carinae distinct; lateral lobe band distinct, cut by primary sulcus. Prozona with very weak secondary sulcus between medial and lateral carinae of dorsal field; metazona with weak secondary sulcus between medial and lateral carinae of dorsal field, in some specimens cutting lateral carinae. Posteroventral margin of lateral lobe moderately angled ventrally, highlighted mottled cream-brown; posterior margin of dorsal field moderate to strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with diffuse mottled cream band, mesepimeron mottled black-brown with cream; pleural sulcus black; metepisternum with distinct cream

band. *Wing*. Tegmina elongate and oval, more than twice as long as wide; tegmen banding: i. mottled brown; ii. mottled black, dorsal margin diffuse, radial vein brown; iii. distinct white-cream; iv. distinct black. *Hind legs*. Hind femur length to width ratio 4.19; margin of upper carinula and medial area mottled black; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi orange, anterior tibiae with additional subtle mottled brown-black; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black and extending onto supra-anal plate. Tergite-X, supra-anal plate and cerci orange. *Cerci*. Approximately same length as supra-anal plate, not extending beyond posterior margin of subgenital plate; curving medially slightly before apices; shoulders subtle; narrowing slightly at mid-length, widening at 2/3 length, then tapering slightly apically; cerci flattened lateromedially, broadly expanded with rounded apices with blackened dorsoapical margins.

Male internal features (fig. 50). *Phallic complex*. Aedeagal valves wide, moderate openings; valves of moderate length (fig. 50 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, shallowly U-shaped in lateral view; lateral sclerites of cingulum acutely triangular (fig. 50 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with thickened apices, moderately expanded laterally, with larger area of sclerotized papillae than on basal sheath; distal and basal portions of aedeagal sheath with uniform, continuous sclerotization; in posterior view, rami of cingula approximately 1.4x

as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with moderately open V-shaped curve outward toward apices of distal portion of sheath (fig. 50 C, F); in posterior view, valves slightly narrowed, then immediately expanded posterior to their apices. *Epiphallus*. Lobes generally narrow, rounded; in dorsal view, bridge thickened and curved, without medial apodeme; epiphallic lateral sclerites small (fig. 50 G, H).

Etymology: Named to honor Solveig Otte, nurse, author, and dedicated humanitarian whose crucial community work with underserved South Africans with HIV and AIDS is nothing short of angelic.

Distribution (fig. 5): This species was collected in mid-November, SE of Clarkson near Humansdorp, within the fynbos biome. The type collection site is S of Kareedouwberge in the Tsitsikamma region. The full range of this species remains to be determined. Though not determined to be sympatric, the known range of *L. solveigae* is closest to that of *L. tsitsikamma*.

Discussion: Putative relatives of *L. solveigae* are *L. tsitsikamma*, *L. waboom*, and *L. larsenorum* given the morphological characteristics they share. In particular, the cerci of *L. solveigae* is most similar to that of *L. waboom* and *L. larsenorum*, and the sculpturing and proportions of the cingulum and aedeagal sheath in posterior view of *L. solveigae* is most similar to *L. larsenorum*. Refer to the discussion section of *L. tsitsikamma* for distinguishing characteristics of these four species.

19. *Loryma larsenorum*, new species

male figures: 51, 52, 63

Holotype male, SOUTH AFRICA: Western Cape Province; N of Somerset West, S of Helderberg, S 34°03.833', E 018°52.453', 1.xi.2007 (D. Otte, E. Rohwer), Otte loc.code: 07-14B, spec.code DL050 and DL051 (ANSP); from the same location: 4 paratype males (SANC) (ANSP) (SAMC). The holotype is labeled as LAS TYPE #18.

Diagnosis of Male: From N of Somerset West, S of Helderberg, Western Cape; prozona of lateral lobe with weak, broken secondary sulcus, metazona of dorsal field with weak secondary sulci between medial and lateral carinae, and metazona of lateral lobe with secondary sulci; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange-red; cerci flattened lateromedially, broadly expanded, with rounded apices slightly curve medially; aedeagal valves wide and moderate in length to short, with moderate openings; no medial apodeme on epiphallus bridge.

Compare with: *L. waboom* and *L. solveigae* (cerci and genitalia), *L. tsitsikamma* (genitalia)

Description: *Body length.* Medium-sized species; male type 18.26 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black with yellow-cream banding.

Male external features (fig. 51). *Head and Pronotum.* Band across apex of eye margin; occipital band distinct with upper margin mottled, lower margin distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling posteriorly; pronotal

band of lateral carinae distinct with upper margin mottled; lateral lobe band distinct and cut by primary sulcus. Prozona with weak, broken secondary sulcus of lateral lobe; metazona with two secondary sulci, a weak sulcus between medial and lateral carinae of dorsal field that weakly cuts medial carinae, and second on lateral lobe. Posteroventral margin of lateral lobe strongly angled ventrally and highlighted with mottled cream; posterior margin of dorsal field weakly to moderately emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct cream band, mesepimeron with mottled black and cream; pleural sulcus black; metepisternum with distinct cream band.

Wing. Tegmina oval, twice as long as wide; tegmen banding: i. blended mottled cream to mottled brown; ii. black, dorsal margin diffuse; iii. distinct yellow-cream; iv. distinct black, apical margin highlighted cream. *Hind legs.* Hind femur length to width ratio 3.65; margin of upper carinula and medial area with broken gray, very little if any black; margin of lower carinula without black; posterior femora, knees with orange; tibiae and tarsi with bright orange-red; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black with white-cream highlights between bands, extending to tergite-X; orange on supra-anal plate, subgenital plate and cerci. *Cerci.* Shorter than supra-anal plate, not extending beyond posterior margin of subgenital plate; curving slightly medially before apices; shoulders subtle; narrowing slightly at 1/3 length, widening dramatically at 2/3 length, then tapering

dorsomedially toward apex. Cerci flattened lateromedially, broadly expanded with rounded apices.

Male internal features (fig. 52). *Phallic complex.* Aedeagal valves wide, moderate openings; valves moderate in length to short (fig. 52 A, D); in lateral view, region bridging zygoma of cingula and distal portion of aedeagal sheath deeply concave, shallowly U-shape in lateral view; lateral sclerites of cingulum triangular (fig. 52 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with thickened apices expanded slightly laterally, with larger area of sclerotized papillae, than on basal sheath; distal and basal portions of aedeagal sheath have uniform and continuous sclerotization; in posterior view, rami of cingula approximately 1.5x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath projecting upward with gentle open V-shaped curve outward toward apices of distal portion of sheath (fig. 52 C, F); in posterior view, valves appear narrowest immediately posterior to apices of valves. *Epiphallus.* Lobes narrow but rounded; in dorsal view, bridge thickened, moderately curved, without a medial apodeme; epiphallic lateral sclerites elongate and flattened (fig. 52 G, H).

Etymology: Named *L. larsenorum* to honor the Larsen family of Cape Town. The contributions and dedication of Dawn Larsen to the collections of the Iziko South African Museum Entomology Department is greatly appreciated and essential to researchers around the World. Dawn, Norman, and Nikki, my little South African family, have for

decades helped and taken a personal interest in those who seek to learn and study the fascinating terrestrial invertebrates of South Africa.

Distribution (fig. 4): This species was collected in early November, near Somerset West and S of Helderberg, within the fynbos biome. The full range of this species remains to be determined. *L. larsenorum* is confirmed sympatric with *L. umoja*.

Discussion: Putative relatives of *L. larsenorum* are *L. tsitsikamma*, *L. waboom*, and *L. solveigae* given the morphological characteristics they share. In particular, the cerci of *L. larsenorum* is most similar to that of *L. waboom* and *L. solveigae*, and the sculpturing and proportions of the cingulum and aedeagal sheath in posterior view of *L. larsenorum* is most similar to *L. solveigae*. Refer to the discussion section of *L. tsitsikamma* for distinguishing characteristics of these four species.

20. *Loryma umoja*, new species

male figures: 53, 54, 63

Holotype male, SOUTH AFRICA: Western Cape Province; N of Somerset West, S of Helderberg, S 34°03.833', E 018°52.453', 1.xi.2007 (D. Otte, E. Rohwer), Otte loc.code: 07-14B, spec.code DL064 (ANSP); from the same location: 3 paratype males (SANC) (ANSP) (SAMC). The holotype is labeled as LAS TYPE #19.

Diagnosis of Male: From N of Somerset West, S of Helderberg, Western Cape; prozona of lateral lobe with weak broken secondary sulci, prozona of dorsal field with weak secondary sulcus, metazona secondary sulcus cuts medial and lateral carinae of dorsal field, extending onto lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with orange; cerci flattened lateromedially and curve very little

medially before apices with blackened apical margins; aedeagal valves moderately wide and long with moderate openings; no medial apodeme on epiphallus bridge.

Compare with: *L. lapollai* (cerci), *L. lyra* and *L. ottei* (genitalia)

Description: *Body length.* Medium-sized species; male type 16.24 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black and gray-brown with cream banding.

Male external features (fig. 53). *Head and Pronotum.* Band across apex of eye margin; band on ecdysial line diffuse and mottled; occipital band diffuse with upper margin mottled, lower margin more distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling posteriorly; pronotal band of lateral carinae distinct with upper margin mottled, lower margin distinct; lateral lobe band distinct and cut by primary sulcus. Prozona with two secondary sulci, weak broken sulcus of lateral lobe and weak sulcus of dorsal field; metazona secondary sulcus cuts medial and lateral carinae of dorsal field, extends onto lateral lobe. Posteroventral margin of lateral lobe moderate to strongly angled ventrally and highlighted cream; posterior margin of dorsal field moderately emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct cream band, mesepimeron with mottled cream and black; pleural sulcus black; metepisternum with distinct cream band.

Wing. Tegmina oval, less than twice as long as wide; tegmen banding: i. blended mottled

cream to mottled brown-black; ii. distinct black, dorsal margin diffuse, radial vein brown-cream; iii. distinct yellow-cream; iv. distinct black, apical margin highlighted cream.

Hind legs. Hind femur length to width ratio 3.58; margin of upper carinula and medial area with mottled black and gray, medial area with two patches of white-cream; margin of lower carinula without black; posterior femora, knees, tibiae and tarsi with orange; posterior tibia with approximately 11 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black with white-cream mottled highlights between bands, extending to supra-anal plate. *Cerci.* Longer than supra-anal plate, not extending beyond posterior margin of subgenital plate; cerci curving very little medially before apices; shoulders moderate; narrowing slightly for most of length, widening slightly at 3/4 length before tapering dorsomedially toward apex; flattened lateromedially, with blackened apical margins.

Male internal features (fig. 54). *Phallic complex.* Aedeagal valves moderately wide, moderate openings; valves long (fig. 54 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, V-shaped in lateral view; lateral sclerites of cingulum broadly triangular (fig. 54 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with thickened apices, moderately expanded laterally, with larger area of sclerotized papillae than on basal sheath; distal and basal portions of aedeagal sheath with uniform and continuous sclerotization; in posterior view, rami of cingula a little wider than distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with gentle

open V-shaped curve outward toward apices of distal portion of sheath (fig. 54 C, F); in posterior view, valves narrowest immediately posterior to apices of valves; apices of valves with fleshy membrane flaring outward, trumpet-like); scattered sclerotized papillae on posterior surface of membranous tissue of ventral valve. *Epiphallus*. Lobes rounded; in dorsal view, bridge thickened and gently curved, without medial apodeme; epiphallallic lateral sclerites very small (fig. 54 G, H).

Etymology: The specific epithet *umoja* is Swahili for “unity” and the name of all-female village founded on principles of women’s rights. This species is named to honor two inspiring and resilient South African women, Susan Swart and Brona Nomangesi Magwa, dear friends whose love and support made my time in South Africa a deeply personal, unforgettable experience.

Distribution (fig. 4): This species was collected in early November, near Somerset West and S of Helderberg, within the fynbos biome. The full range of this species remains to be determined. *L. umoja* is confirmed sympatric with *L. larsenorum*.

Discussion: The external male morphology of *L. umoja* most closely resembles that of *L. lapollai*. The internal male genitalia most closely resemble that of *L. lyra* and *L. ottei*. Refer to the discussion sections of both *L. lapollai* and *L. lyra* for distinguishing characteristics of these species.

21. *Loryma lyra*, new species

male figures: 55, 56, 62; female figures: 60, 62

Holotype male, SOUTH AFRICA: Western Cape Province; S of Kwaggaskloofdam, S 33°47.373', E019°27.043', 11.xi.2007 (D. Otte, E. Rohwer), Otte loc.code 07-53, spec.code DL024 (SANC); from the same location: 2 paratype females (SANC). The holotype is labeled as LAS TYPE #20.

Diagnosis of Male: From S of Kwaggaskloofdam, Western Cape; prozona of dorsal field with very weak secondary sulcus, prozona of lateral lobe with weak secondary sulcus, metazona with secondary sulci cutting medial and lateral carinae of dorsal field, extending onto lateral lobe; tegmen with four areas of coloration; posterior femora, knees, tibiae and tarsi with cream color; cerci flattened lateromedially, almost rectangular and curving very little medially before apices, prominently blackened dorsal and posterior apical margins; aedeagal valves very wide and long with large openings; no medial apodeme on epiphallus bridge.

Compare with: *L. umoja* and *L. ottei* (genitalia), *L. mirabunda* and *L. cederbergensis* (cerci)

Description: *Body length.* Medium-sized species; male type 16.84 mm; female type 20.91 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black and gray-brown with cream banding. Female specimens, known from dried museum material and field photography, black, brown and gray with cream; some female specimens with color variation, orange pigmentation on dorsal surfaces of head, pronotum, abdomen and upper marginal area of femur; apices of recurved ovipositor valves black. Males and females generally with same leg coloration,

although the latter highly variable (for the females especially, see live field photography in fig. 62).

Male external features (fig. 55). *Head and Pronotum.* Band across apex of eye margin; band on ecdysial line very diffuse and mottled; occipital band diffuse with upper margin mottled, lower margin more distinct; genal band with upper margin distinct, lower margin distinct with minimal mottling posteriorly; pronotal band of lateral carinae diffuse and narrowed, with upper margin mottled, lower margin distinct; lateral lobe band distinct and cut by primary sulcus. Prozona with two secondary sulci, very weak sulcus of dorsal field and weak sulcus of lateral lobe; metazona with secondary sulcus cutting medial and lateral carinae of dorsal field, extending onto lateral lobe. Posteroventral margin of lateral lobe moderately angled ventrally and highlighted with cream; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct cream-gray band, and mesepimeron with more mottled cream-gray band; pleural sulcus black; metepisternum with distinct cream band. *Wing.* Tegmina oval, approximately twice as long as wide. Tegmen banding: i. mottled brown and black; ii. black, dorsal margin diffuse, radial vein brown; iii. distinct yellow-cream, wider at apex than base, with slight mottling at apex; iv. distinct black. *Hind legs.* Hind femur length to width ratio 3.62; margin of upper carinula and medial area with very little broken brown to gray, medial area with two faint white-cream patches; margin of lower carinula without black; posterior femora, knees, tibiae

and tarsi with cream color; posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black with white-cream, mottled highlights between bands; bands extending to supra-anal plate. *Cerci.* Longer than supra-anal plate, extending beyond posterior margin of subgenital plate; curving very little medially before apices; shoulders of cerci nearly absent; of uniform width for most of length, tapering slightly toward apex for last 1/3 of length ; flattened lateromedially, almost rectangular, with prominently blackened dorsal and posterior apical margins.

Male internal features (fig. 56). *Phallic complex.* Aedeagal valves very wide, large openings; valves long (fig. 56 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, broadly V-shape in lateral view; lateral sclerites of cingulum roughly triangular (fig. 56 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with thickened apices expanded laterally, with larger area of sclerotized papillae than on basal sheath; apices of distal sheath curling outward and forward, appearing bi-lobed in posterior view; distal and basal portions of aedeagal sheath with uniform and continuous distribution of sclerotization; in posterior view, rami of cingula 1.2x as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward and outward with gentle hour-glass shaped curve toward apices of distal portion of sheath (fig. 56 C, F); in lateral view (less visible in posterior view), valves narrowed immediately posterior to apices of valves, with fleshy membrane flaring outward broadly (trumpet-like);

scattered sclerotized papillae on posterior surface of membranous tissue of ventral valve. *Epiphallus*. Lobes rounded, elongate; in dorsal view bridge very thickened and curved, without medial apodeme; epiphallal lateral sclerites assumed to be very small (lost in dissections) (fig. 56 G, H).

Etymology: The specific epithet *lyra* is Greek for lyre or harp, in reference to the lovely shape created by the cingulum and aedeagal sheath together in posterior view.

Distribution (fig. 4): This species was collected in mid-November, S of Kwaggaskloofdam, within the fynbos biome. The type collection site is N of Hammansberg in the Breëriviervallei. In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for November was 14mm, the greatest average monthly rainfalls being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009). The full range of this species remains to be determined.

Discussion: Within the EA species-group, *L. lyra* has cerci that are most similar to *L. mirabunda* and *L. cederbergensis* because of their more rectangular shape. However, the internal genitalia of *L. lyra* most closely resembles that of *L. umoja* and *L. ottei*, which might suggest that these species are closely related. The internal morphological characteristics that they all share include: 1) moderately triangular sclerites of cingulum; 2) in lateral view, very similar region bridging zygoma and distal portion of aedeagal sheath ; 3) aedeagal valves with large sometimes flared or trumpet-like apices; 4) similar pattern of sculpturing of the cingulum and basal and distal portions of the aedeagal sheath

(in posterior view appearing harp-shaped), with cingulum wider than the distal portion of the aedeagal sheath, sclerotization of the basal and distal portions of the aedeagal sheath forming an open U-shape, and the distal portion of the aedeagal sheath thickened, sometimes expanding and curling outward.

To distinguish *L. lyra* from *L. umoja* and *L. ottei*, the following morphological features should be examined: 1) cerci of *L. ottei* are unique having a dog-eared shape, whereas *L. lyra* and *L. umoja* have flattened spatulate cerci without any medial folding before apices; 2) in posterior view, the distal portion of the aedeagal sheath of *L. lyra* has two areas of lateral expansion, whereas *L. umoja* has only one such area, and *L. ottei* has the least lateral expansion and lateral outward curl of the distal sheath; 4) in lateral view, the aedeagal valves of *L. umoja* appear narrow and pinched inward before the apices, whereas *L. lyra* and *L. ottei* have aedeagal valves that maintain an even width and diameter for their length until the fleshy apices that flare outward (to greatest degree with *L. lyra*).

22. *Loryma ottei*, new species

male figures: 57, 58, 61; female figure: 60

Holotype male, SOUTH AFRICA: Western Cape Province; along R46 S of Tulbagh, S 33°19.800', E019°09.572', 10.xi.2007 (D. Otte, E. Rohwer), Otte loc.code 07-50, spec.code DL006 (ANSP). SOUTH AFRICA: Western Cape Province; OudePost 15 miles NNW of Malmesbury, 9.ix.1967, (H.D. Brown), loc.code L11; from the same location: 10 paratype males, 4 paratype females (SANC) (ANSP) (SAMC) (BMNH). The holotype is labeled as LAS TYPE #21.

Diagnosis of Male: From S of Tulbagh and NNW of Malmesbury, Western Cape; prozona of lateral lobe with weak secondary sulcus, prozona of dorsal field with very weak secondary sulcus of dorsal field, metazona with secondary sulcus cutting medial

and lateral carinae of dorsal field, extending onto lateral lobe; tegmen with four areas of coloration; posterior femora and knees with faint orange, majority of tibiae and tarsi with cream color, ventral surface of posterior tibiae with patch of black-gray; cerci flattened and abruptly folded nearly 45° medially at midlength, appearing dog-eared, with blackened apical margins; aedeagal valves long and extremely wide, extremely large openings; no medial apodeme on epiphallus bridge.

Compare with: *L. lyra*, *L. umoja*

Description: *Body length.* Medium-sized species; male type 15.94 mm; female type 19.07 mm. *Body coloration.* Male specimens, known from dried museum material and field photography, mostly black-brown with cream banding. Female specimens, known only from dried museum material, mostly black-brown with cream colored banding; tips of the recurved ovipositor valves black-brown. Males and females have same leg coloration.

Male external features (fig. 57). *Head and Pronotum.* Band across apex of eye margin; occipital band diffuse with upper margin mottled, lower margin more distinct; genal band with upper margin distinct, lower margin distinct, tapering posteriorly; pronotal band of lateral carinae diffuse and narrowed, upper margin mottled, lower margin distinct; lateral lobe band distinct, cut by primary sulcus. Prozona with two secondary sulci, weak sulcus of lateral lobe and very weak sulcus of dorsal field; metazona with secondary sulcus that cuts medial and lateral carinae of dorsal field, extending onto lateral lobe. Posteroventral

margin of lateral lobe moderate to strongly angled ventrally, highlighted with cream; posterior margin of dorsal field strongly emarginate medially.

Meso- and Metathorax. Mesepisternum with distinct cream band, mesepimeron with mottled cream-gray band; pleural sulcus black; metepisternum with distinct cream band.

Wing. Tegmina oval, a little less than twice as long as wide; tegmen banding: i. mottled cream and brown-black, diffuse ventral margin; ii. black band with dorsal margin diffuse, radial vein brown; iii. distinct yellow-cream, wider at apex than base, with moderate mottling at apex; iv. distinct black, mottled apex. *Hind legs.* Hind femur length to width ratio 3.55; margin of upper carinula and medial area with mottled black-brown and gray, medial area with two patches of cream; margin of lower carinula without black; posterior femora and knees with faint orange; majority of tibiae and tarsi with cream color, posterior 1/3 of tibiae with patch of black-gray on ventral surface (opposite spines); posterior tibia with approximately 10 outer and 10 inner spines, all with black apices.

Abdomen. Abdominal medial and lateral bands mottled black with cream highlights between bands, extending to supra-anal plate; supra-anal plate and cerci with faint orange. *Cerci.* Approximately same length as supra-anal plate, extending beyond posterior margin of subgenital plate; abruptly folded nearly 45° medially at midlength; shoulders absent; not narrowed before medial fold, then dorsal and ventral margins taper in ventrally oriented triangle toward apex; flattened lateromedially, appearing folded (“dog-eared”), with blackened apical margins.

Male internal features (fig. 58). *Phallic complex.* Aedeagal valves extremely wide, extremely large openings; valves long (fig. 58 A, D); in lateral view, region bridging zygoma of cingulum and distal portion of aedeagal sheath deeply concave, concavity L-shaped in lateral view; lateral sclerites of cingulum triangular (fig. 58 B, E); distal and basal portions of aedeagal sheath with area of sclerotized papillae; distal portion of aedeagal sheath with broad and thickened apices, moderately expanded laterally, with large area of sclerotized papillae, basal sheath with very few sclerotized papillae; distal and basal portions of aedeagal sheath with uniform and continuous sclerotization; in posterior view, rami of cingula less than twice as wide as distal portion of aedeagal sheath; basal portions of aedeagal sheath project upward with U-shaped curve, then project slightly outward toward apices of distal portion of sheath (fig. 58 C, F); in lateral and posterior view, valves wide throughout distal 1/3 of ectophallus; apices of valves with wide, open fleshy tube-like membrane. *Epiphallus.* Lobes rounded and elongate; in dorsal view, bridge very thickened and curved, without medial apodeme; sclerites very small, rounded and flattened (fig. 58 G, H).

Etymology: Named *L. ottei* to honor Daniel Otte.

Distribution (fig. 4): This species was collected from two locations across multiple months: from mid-September NNW of Malmesbury, to mid-October S of Tulbagh (W of Witsenberg, E of Voëlvleiberge). Both collection sites are within the fynbos biome. In Cape Town, the closest large city, the 30-year average (1961-1990) monthly rainfall for September was 40mm and for October was 30mm, the greatest average monthly rainfalls

being: 69mm in May, 93mm in June, 82mm in July, and 77mm in August (SAWS, 2009).

The full range of this species remains to be determined. Though not determined to be sympatric, the more eastern locality for *L. ottei* is closest to the known range of *L. mayi*.

Discussion: Within the EA species-group, *L. ottei* has unique dog-eared shaped cerci.

The internal male genitalia most closely resembles that of *L. lyra*, and more distantly that of *L. umoja*. Refer to the discussion section of *L. lyra* for distinguishing characteristics of these species.

The *L. ottei* holotype was the solitary specimen collected at the Tulbagh locality in 2007, whereas the 10 male and 4 female paratypes were collected together at a second locality in 1967. Though the holotype was the solitary find at the locality, the specimen is ideal for representing the species because it was photographed live and the dissection revealed that the specimen was an older adult male (collected in November). In contrast to the holotype, all paratype males were found to be slightly younger adult males (collected in September), though they were old enough to identify as being *L. ottei*. Both collection sites, although visited 40 years apart in time, are in the same approximate region of the Western Cape (see fig. 2). In the future, if further fieldwork or museum studies reveal heretofore unseen morphological or genetic features that suggest the paratypes are a different species from the holotype, all paratypes should be considered and kept together.

LORYMA BIOGEOGRAPHY AND FUTURE RESEARCH DIRECTION

Studies are currently underway to elucidate the *Loryma* phylogeny using DNA sequence and morphological data (Spearman and Ware *in prep*). However even without an established phylogeny there are some interesting trends and hypotheses regarding *Loryma* biogeography that can be discussed. Studies addressing the biogeographic patterns observed for other Cape insects have been limited because the necessary critical mass of phylogenetic and biogeographic research for the majority of Cape insects has not yet been achieved, though it has been established for example that butterflies are under-represented and gall-wasps are over-represented in the fynbos relative to the degree of floral diversity (Prochess and Cowling 2006).

Fortunately South Africa's botanical richness has been the focus of extensive study, and some of the prevailing hypotheses for South Africa's botanical diversity will likely inform entomologists as they attempt to decipher biogeographic patterns of the many diverse insect groups of the Cape region. With an estimated 8,650 species of vascular plants, of which 65% are endemic, South Africa's Cape Floristic region, though relatively small, is easily one of the most species-rich places on Earth, and is why the region's fynbos and succulent karoo biomes are listed as 2 of the world's biodiversity hotspots (Wilson 1998, Goldblatt 1997).

Goldblatt (1997) hypothesized that high diversity of plant species in the Cape region is the result of long-term climatic stability coupled with a large variety of diverse soils, complex topography and climatic diversity. It has been suggested that with this combination of conditions, extinction rates would be low and incidents of parapatric

speciation relatively high. Goldblatt (1997) examined 15 families from the Cape region, in primarily the fynbos biome, and found that families and genera that had the highest diversity also exhibited the lowest seed vagility, therefore promoting restricted gene flow. Cowling et al. (1998) examined the distribution and diversity of plants in the succulent karoo biome and found that greater diversification seemed associated with fire-sensitive lineages which have short generation times and limited gene flow, concluding that in this more arid biome, the immense diversification of species is not necessarily the result of the unusually stable climate, but instead the result of frequent fire events.

The South African Cape region changed into the Mediterranean-like climate we recognize today approximately 5.3 million years ago in the late Miocene to early Pliocene (Forest et al. 2007). Though the Cape has experienced a relatively stable climate, there have been climatic oscillations which certainly created repetitive contraction and expansion of the distribution ranges of many of the Cape plant groups (Forest et al 2007). Dynesius and Jansson (2000) addressed the affect that Milankovitch climatic oscillations have had on Earth's biota, but noted that the Cape floristic region seems to have experienced relatively little orbitally forced species' range dynamics (ORD). With little ORD, they propose there has been less selection against specialization and poor dispersal in the fynbos and succulent karoo biomes (Dynesius and Jansson 2000). Dynesius and Jansson (2000) described the region as possessing high species diversity with high specialization rates, narrow habitat specializations, and small geographical ranges. The work of these botanists and climatologists, and their conclusions regarding the characteristics and causes of the floral diversity and its distribution could be informative

for understanding the distribution and diversity of *Loryma* found in the fynbos and succulent karoo.

Loryma in the EA species-group are found primarily in the fynbos (≈ 10 spp.), and the NEA species-group are found in the succulent karoo (≈ 11 spp.) and grassland biomes (1 sp.) (figures 2-5). The two species-groups were constructed based primarily on genitalic features that seemingly divide the genus into two monophyletic groups. Two primary hypotheses could be proposed to explain the biogeographic pattern observed in *Loryma* in the Cape region. The first hypothesis is that *Loryma* species once had a large distribution across the fynbos, succulent karoo, or possibly into the nama karoo and grasslands. Environmental conditions changed, where widespread extinctions occurred leaving behind small, isolated populations. Now isolated from each other, these populations gradually speciated. If this scenerio were true, one might expect a phylogenetic pattern that does not reflect the geographic patterns of species distributions. For example, in this scenerio we would not necessarily expect to find sister species geographically close to one another.

The second hypothesis is that over time *Loryma* experienced many localized speciation events perhaps based on a combination of conditions discussed previously by Forest et al. (2007) and Goldblatt (1997). This second hypothesis appears more likely for three reasons: 1) *Loryma* are flightless, being incapable of wide dispersal across the complex topography of the region (low vagility), 2) the present but limited knowledge of *Loryma* species distribution suggests that *Loryma* have small species ranges, and 3) there are multiple examples of closely related *Loryma* species found in close proximity with each other. Some examples of likely closely related species being in close proximity with

each other are: *L. ottei* and *L. mirabunda* deep in the SW fynbos (fig.4), *L. ashleyi* and *L. carolynae* in the northern most Loryma range in the succulent karoo (fig.3), and *L. magna* and *L. browni* (fig.5).

Proches and Cowling (2006) surveyed the insect and plant diversity in South Africa to compare the diversity patterns and possible correlation to each other in fynbos, grassland, subtropical thicket and nama-karoo. The conclusion of the survey was that in lieu of previous research on butterflies (that underrepresented diversity) and gall wasps (that over represented diversity) in the fynbos, they believe that the insect diversity in the fynbos is comparable to that of neighboring biomes (Proches and Cowling 2006). Although this is an interesting conclusion, it must be noted the survey sampled only one fynbos location (area totaling 16 – 10 x 10 m plots) which was in the eastern margins of the biome, the survey was conducted in the “peak insect activity” period in the various locations (for fynbos determined to be October) which immediately underestimates the diversity of a location because of seasonal species turnover (see Chapter 2 for discussion), and lastly, the insect survey consisted of richness estimations using morphospecies which can easily underestimate diversity because cryptic species may go unnoticed (Otte *pers comm.*) and knowledge of species rarity or endemism is unrealized. Conservationists consider rare and endemic species to have a greater value when determining the overall diversity calibration of a community.

Without any doubt there remains a great deal of survey work to be completed to decipher the biogeography of Cape insects. Future work on the biogeography of *Loryma* will help to shed more light on the evolutionary patterns and processes of this fascinating place on Earth.

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FIGURES**Table 2. Genera and Species Distribution Maps**

<i>Loryma</i> distribution	fig. 2, Biome Map, p.175
<i>Hemiloryma</i> distribution	fig. 2, Biome Map, p.175
1. <i>L. perficita</i>	-
2. <i>L. ashleyi</i>	fig. 3, Distrib. Map 1, p.176
3. <i>L. carolynae</i>	fig. 3, Distrib. Map 1, p.176
4. <i>L. magna</i>	fig. 4, Distrib. Map 2, p.177; fig. 5, Distrib. Map 3, p.178
5. <i>L. browni</i>	fig. 5, Distrib. Map 3, p.178
6. <i>L. khoi</i>	fig. 3, Distrib. Map 1, p.176; fig. 4, Distrib. Map 2, p.177
7. <i>L. namaqua</i>	fig. 3, Distrib. Map 1, p.176
8. <i>L. san</i>	fig. 3, Distrib. Map 1, p.176; fig. 4, Distrib. Map 2, p.177
9. <i>L. mayi</i>	fig. 4, Distrib. Map 2, p.177
10. <i>L. zebrata</i>	fig. 5, Distrib. Map 3, p.178
11. <i>L. bonteboki</i>	fig. 4, Distrib. Map 2, p.177
12. <i>L. karoo</i>	fig. 3, Distrib. Map 1, p.176; fig. 4, Distrib. Map 2, p.177
13. <i>L. mirabunda</i>	fig. 3, Distrib. Map 1, p.176; fig. 4, Distrib. Map 2, p.177
14. <i>L. cederbergensis</i>	fig. 3, Distrib. Map 1, p.176; fig. 4, Distrib. Map 2, p.177
15. <i>L. lapollai</i>	fig. 4, Distrib. Map 2, p.177
16. <i>L. tsitsikamma</i>	fig. 5, Distrib. Map 3, p.178
17. <i>L. waboom</i>	fig. 4, Distrib. Map 2, p.177; fig. 5, Distrib. Map 3, p.178
18. <i>L. solveigae</i>	fig. 5, Distrib. Map 3, p.178
19. <i>L. larsenorum</i>	fig. 4, Distrib. Map 2, p.177
20. <i>L. umoja</i>	fig. 4, Distrib. Map 2, p.177
21. <i>L. lyra</i>	fig. 4, Distrib. Map 2, p.177
22. <i>L. ottei</i>	fig. 4, Distrib. Map 2, p.177

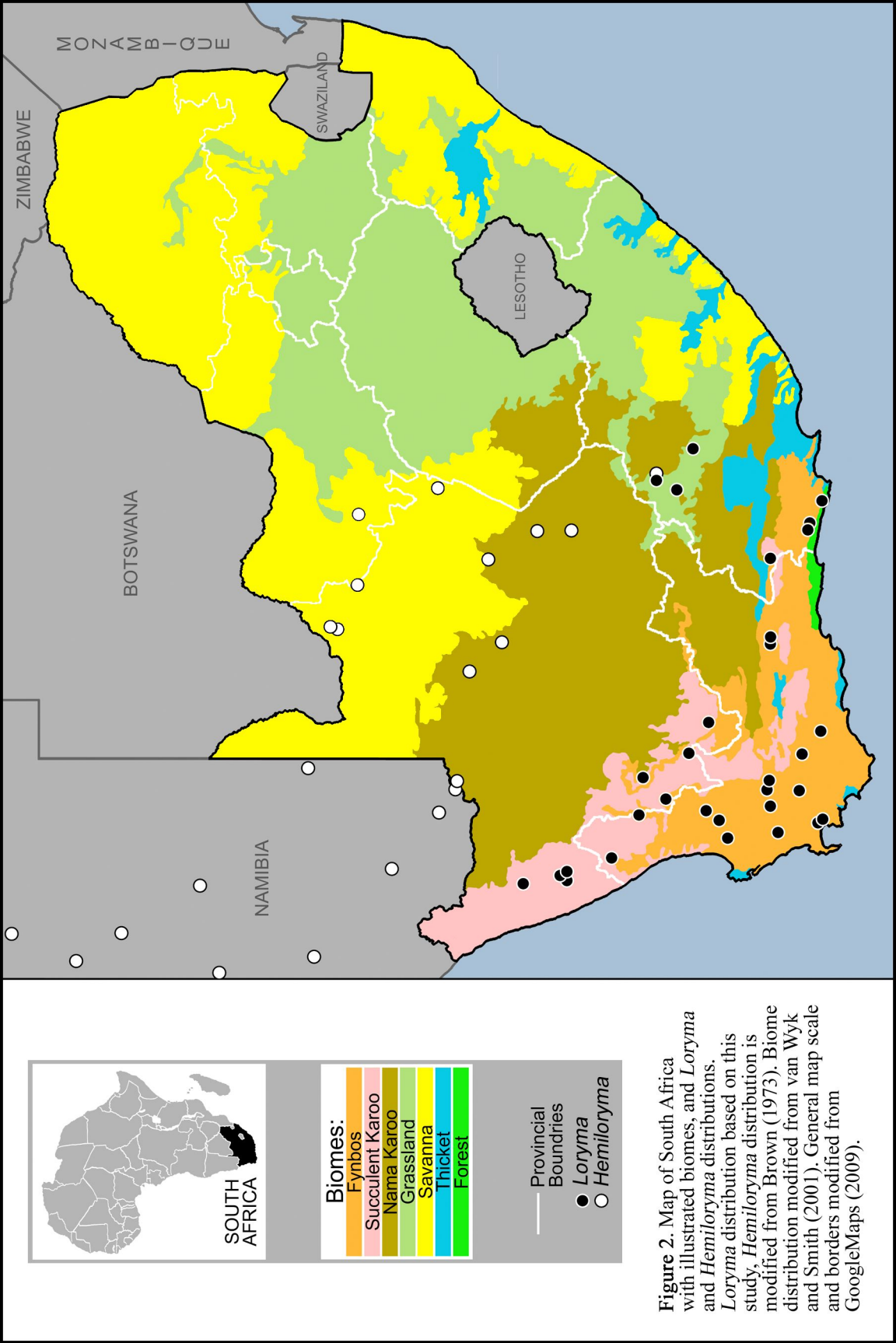
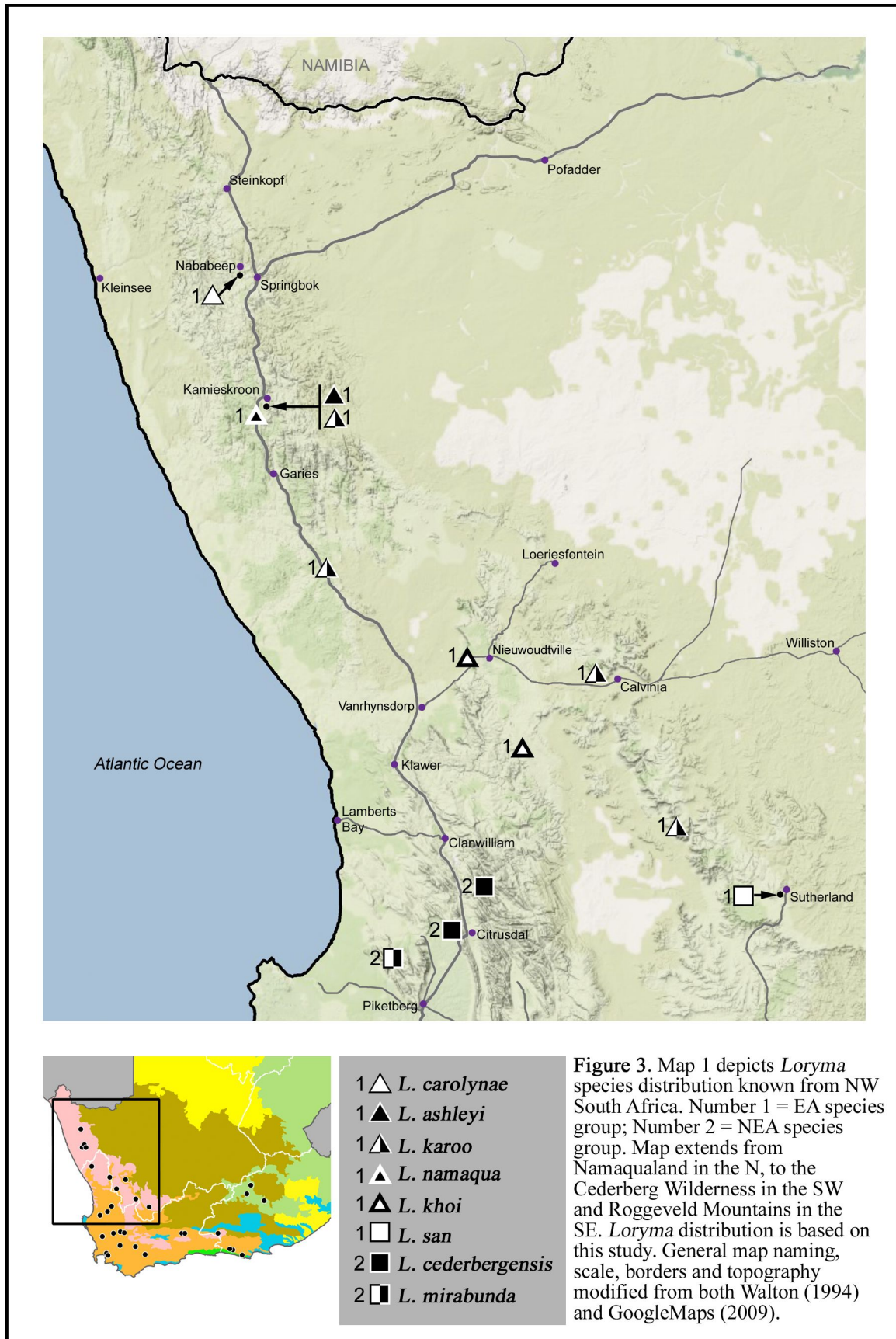


Figure 2. Map of South Africa with illustrated biomes, and *Loryma* and *Hemiloryma* distributions. *Loryma* distribution based on this study, *Hemiloryma* distribution is modified from Brown (1973). Biome distribution modified from van Wyk and Smith (2001). General map scale and borders modified from GoogleMaps (2009).



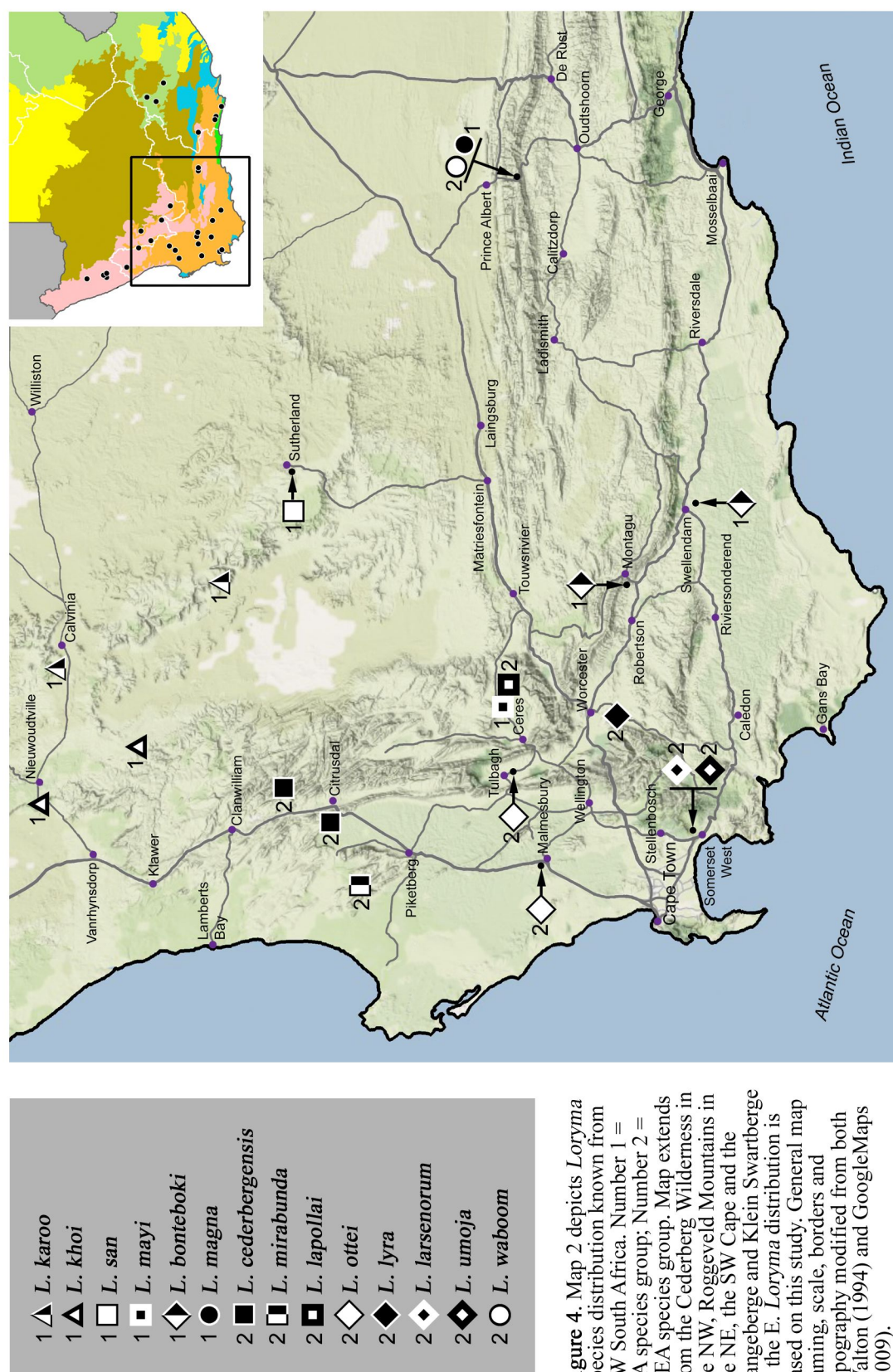
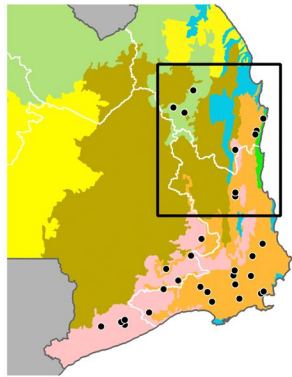
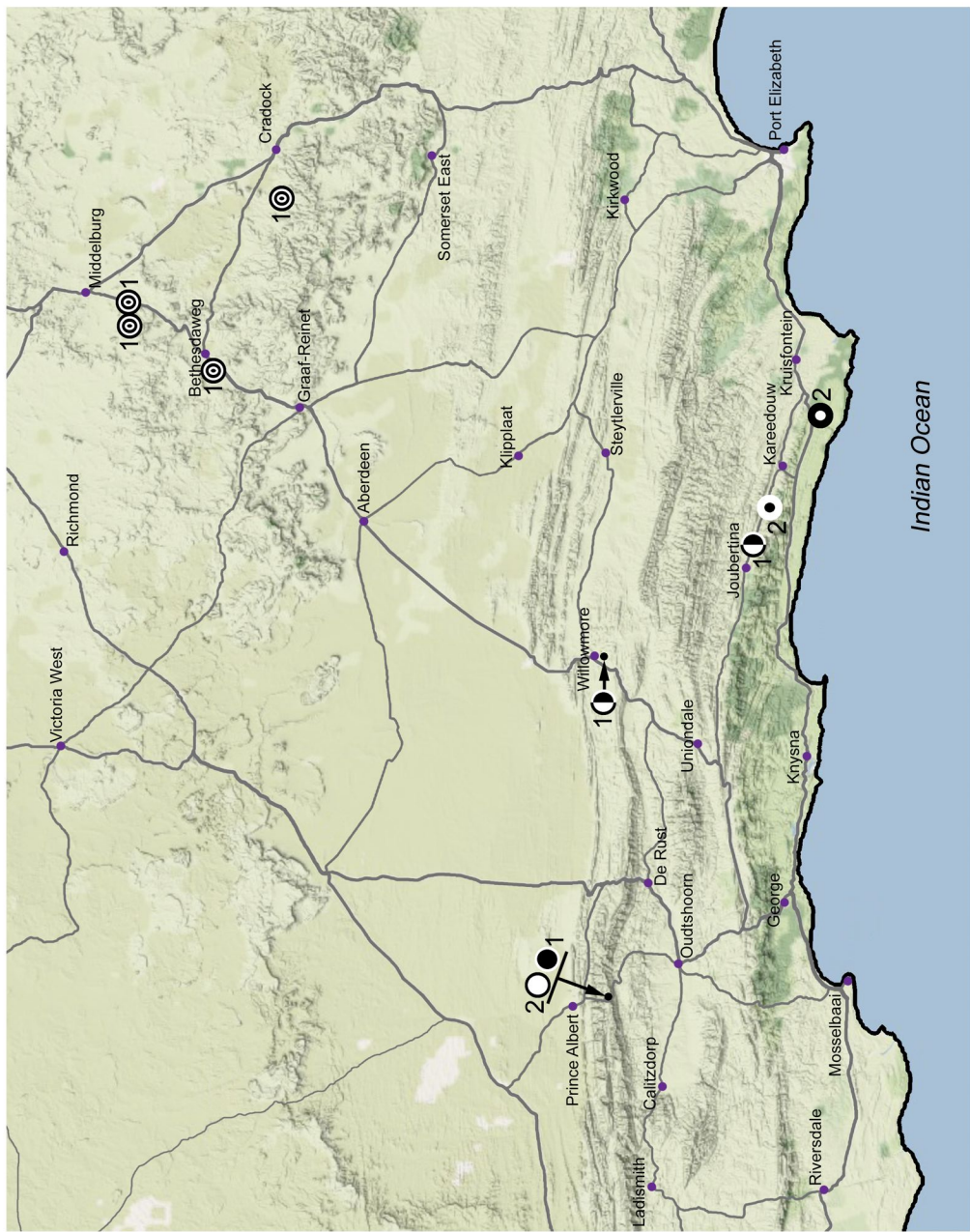


Figure 4. Map 2 depicts *Loryma* species distribution known from SW South Africa. Number 1 = EA species group; Number 2 = NEA species group. Map extends from the Cedarberg Wilderness in the NW, Roggeveld Mountains in the NE, the SW Cape and the Langeberge and Klein Swartberge in the E. *Loryma* distribution is based on this study. General map naming, scale, borders and topography modified from both Walton (1994) and GoogleMaps (2009).



- 1 ● *L. magna*
- 1 ◯ *L. browni*
- 1 ⊕ *L. zebrata*
- 2 ◯ *L. waboom*
- 2 ◯ *L. tsitsikamma*
- 2 ◯ *L. solveigae*

Figure 5. Map 3 depicts *Loryma* species distribution known from SE South Africa. Number 1 = EA species group; Number 2 = NEA species group. Map extends from the Langeberge and Klein Swartberge in the W, to the Coetzeeberge and Mountain Zebra National Park in the NE. *Loryma* distribution is based on this study. General map naming, scale, borders and topography modified from both Walton (1994) and GoogleMaps (2009).

Table 3. *Loryma General Morphology Figures*

Coloration, tegmen	fig. 6, p.180
Pronotum	fig. 8, p.182
Ventral thorax	fig. 12, p.186
Phallic complex, with cingulum removed and aedeagus revealed	fig. 15, p.189
Phallic complex, with epiphallus	fig. 14, p.188
Phallic complex, comparing adult age	fig. 7, p.181

Table 4. *Lorymaini Figures*

<i>Hemiloryma</i> external morphology	fig. 9, p.183
<i>Hemiloryma</i> internal morphology	fig. 13, p.187
<i>Dirshacris</i> external morphology	fig. 10, p.184
<i>Labidioloryma</i> external morphology	fig. 11, p.185

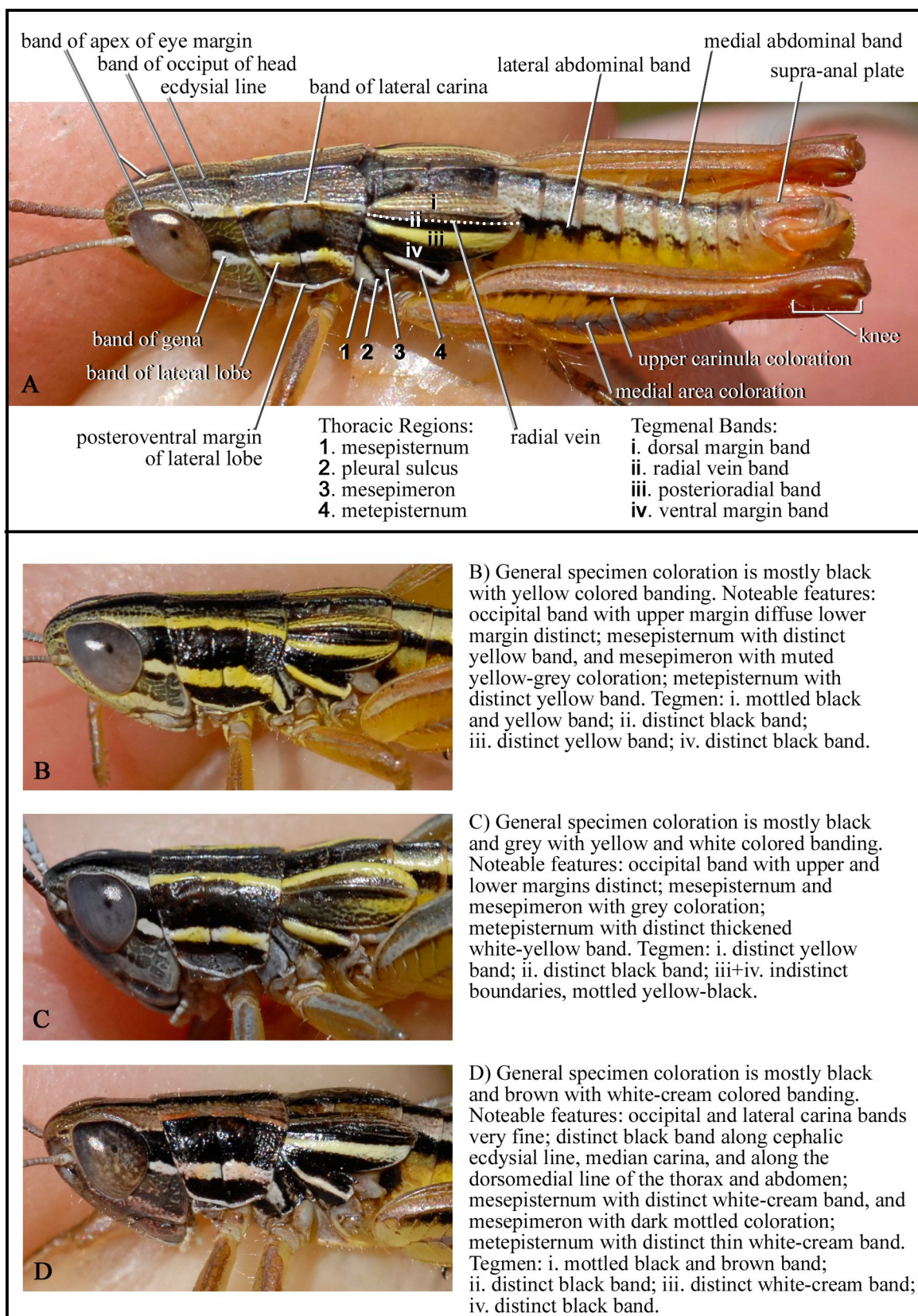
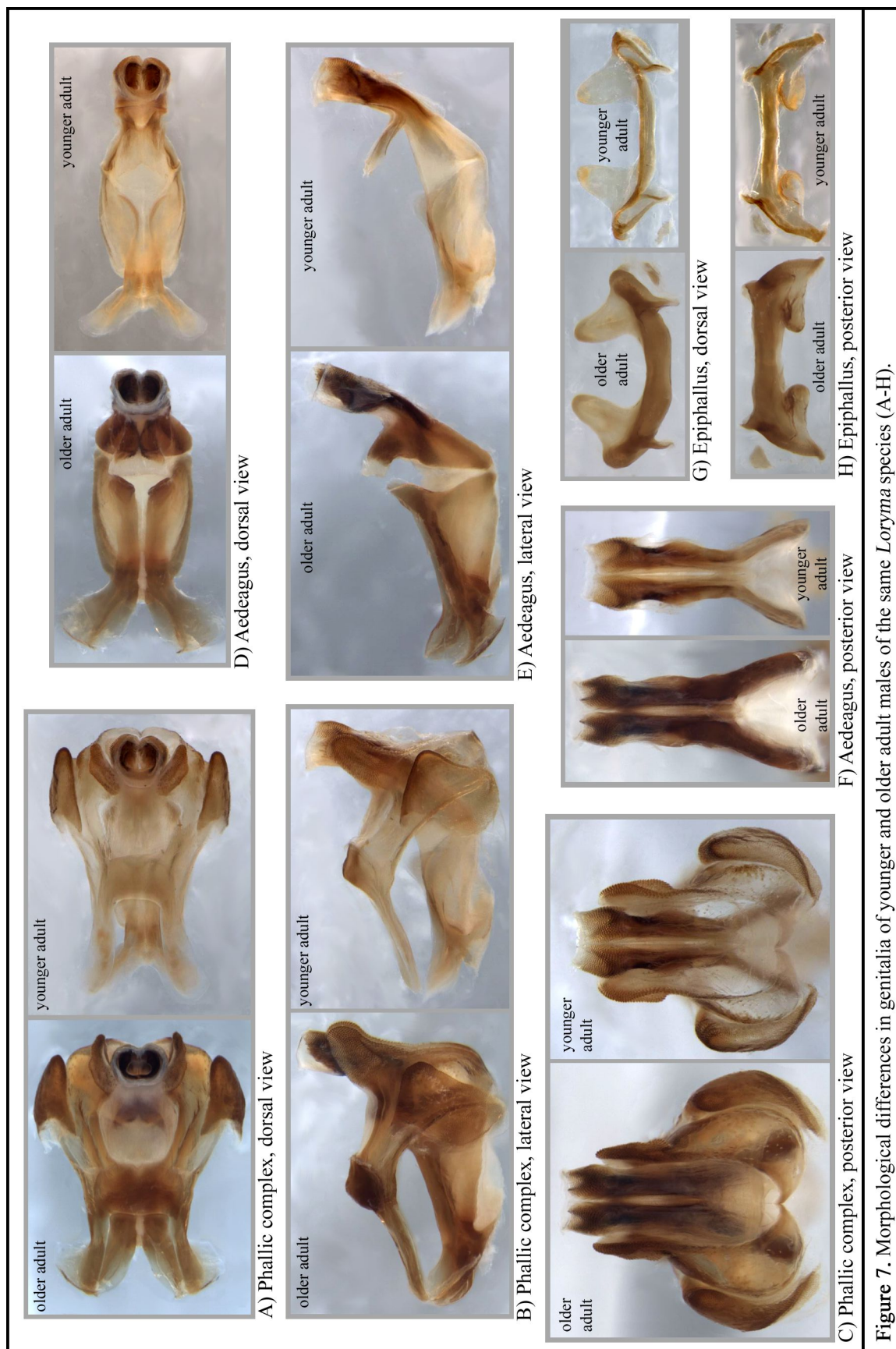


Figure 6. Morphological features associated with coloration of adult male *Loryma* (A-D). A) Labeled morphological features associated with *Loryma* coloration. Three live specimen examples (B-D).



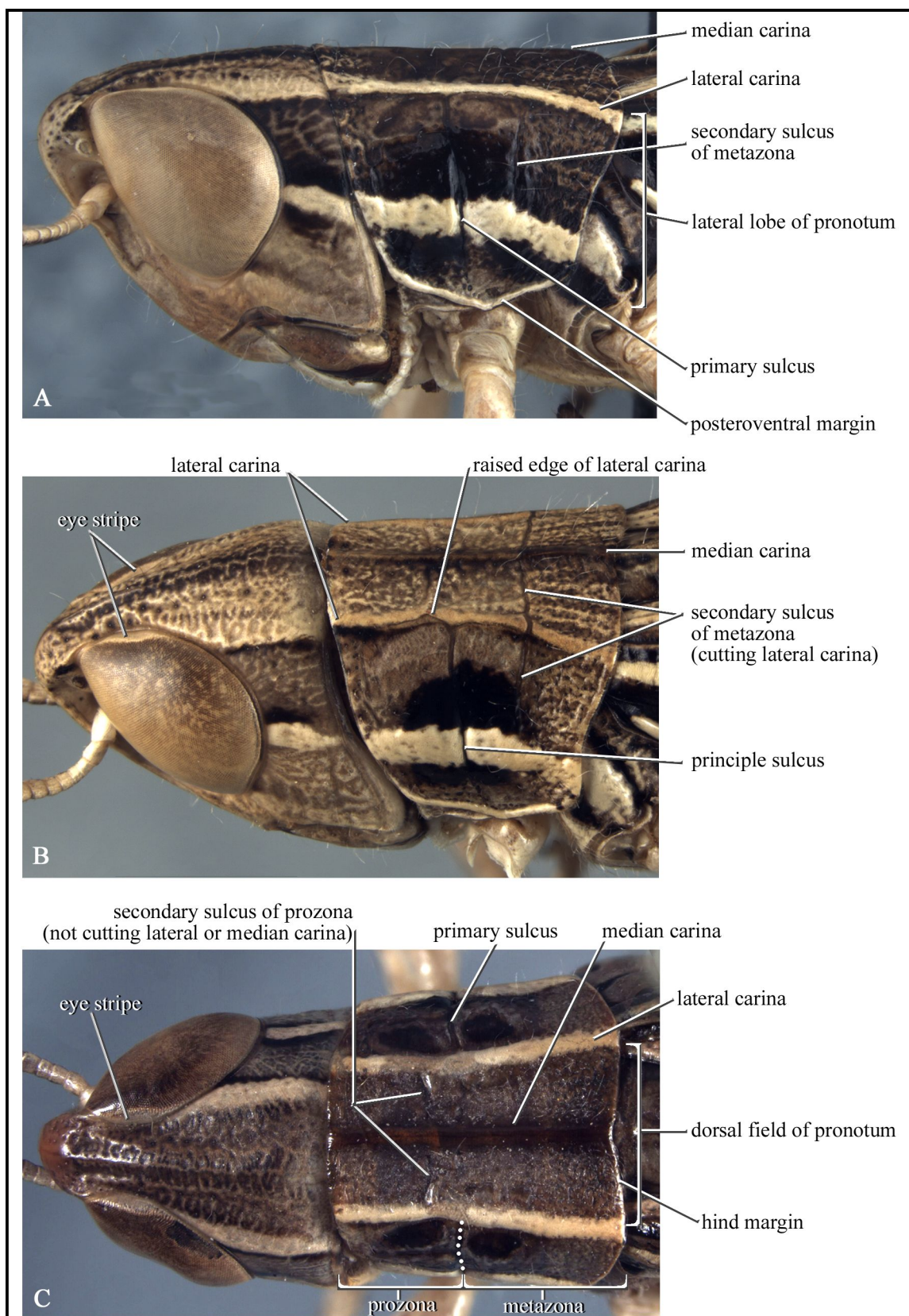


Figure 8. Morphological features and terminology for head and pronotum of *Loryma* (A-C). Three museum specimen examples A) lateral view; B) three-quarter view; C) dorsal view.

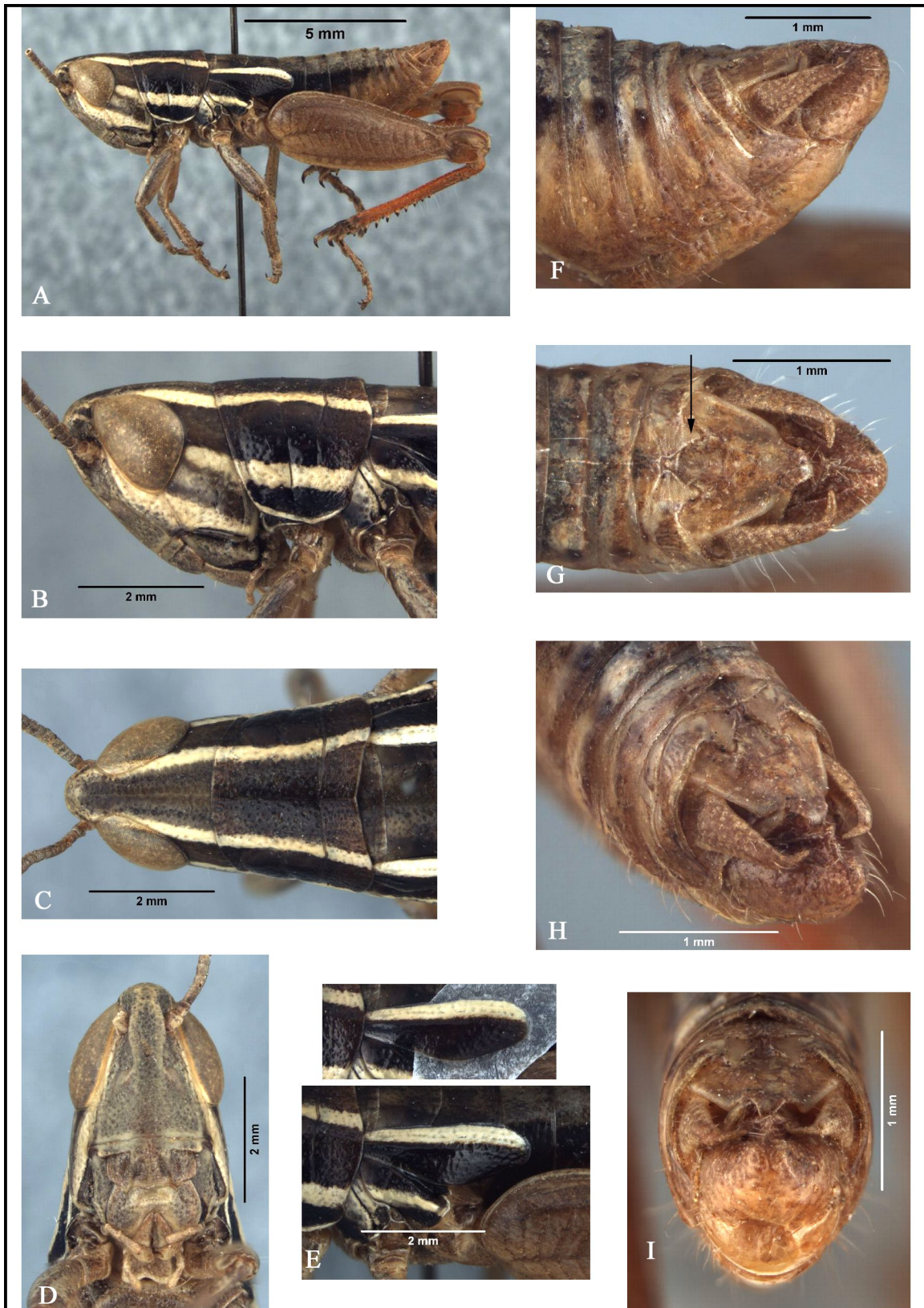


Figure 9. *Hemiloryma* sp. male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal (arrow indicates; H) three-quarter; I) posterior.

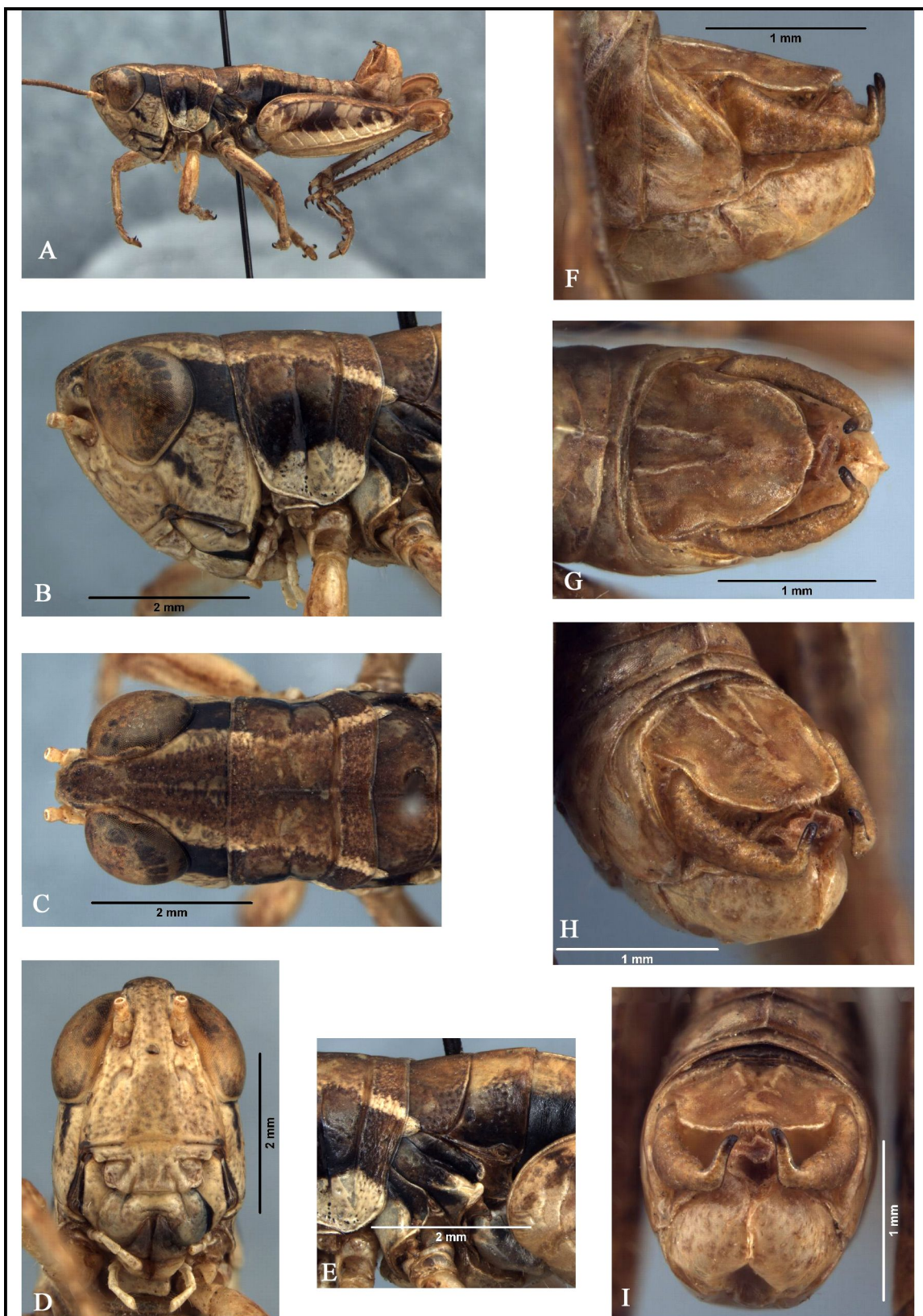


Figure 10. *Dirshacris* sp. male external morphology (A-H).

A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) vestigial tegmen. Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

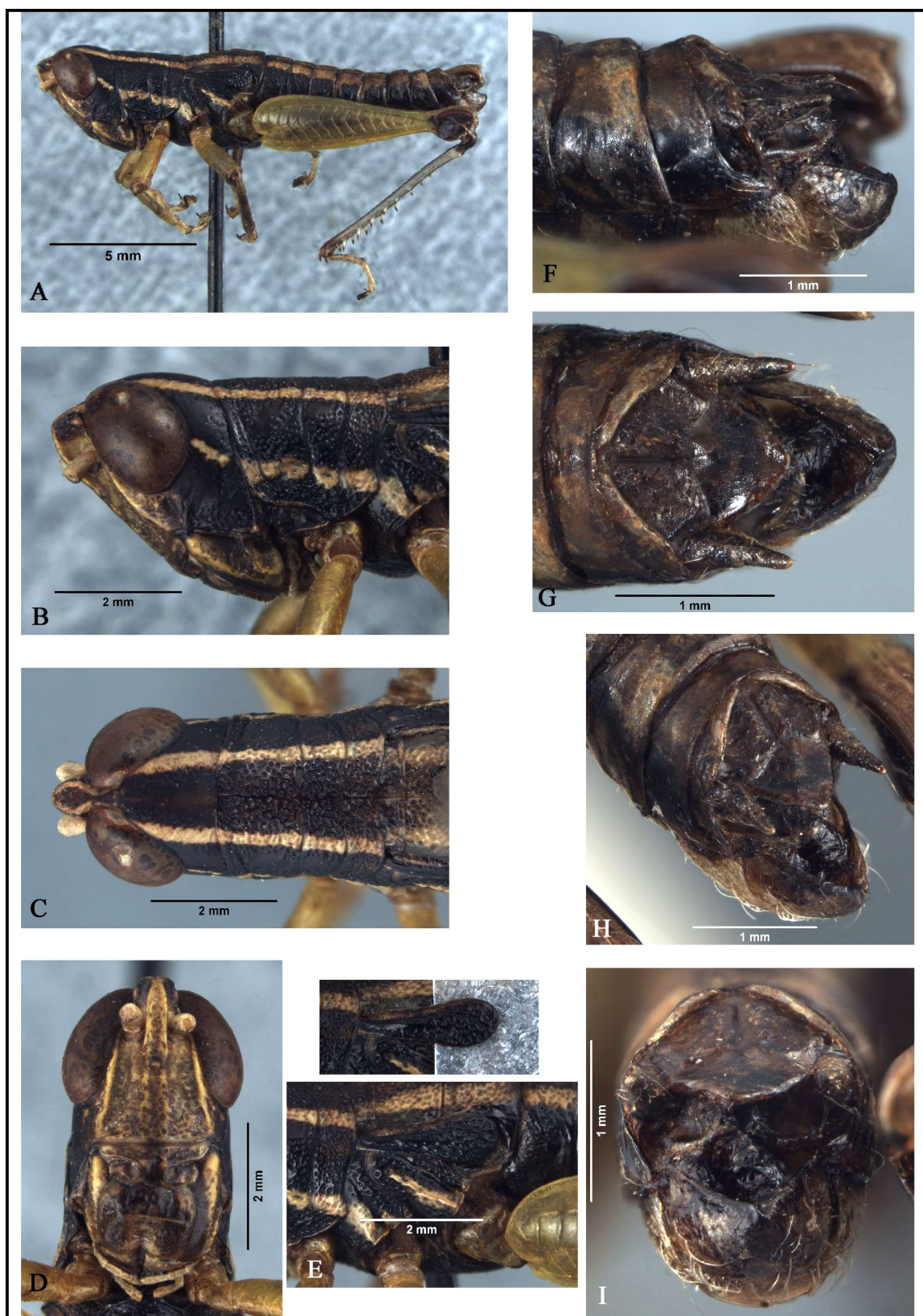
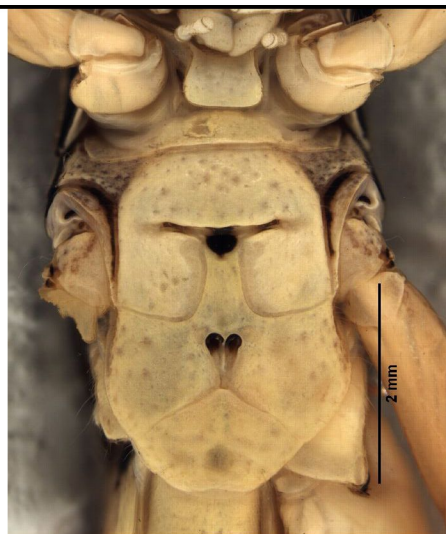


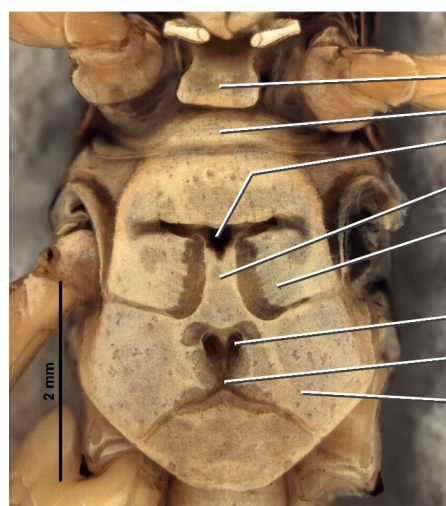
Figure 11. *Labioloryma strictoforceps* holotype male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



A) larger, narrow form



B) smaller, shorter, wider form



C) intermediate form

prosternal process
 presternum
 mesosternal furca
 mesosternal interspace
 mesosternal lobe
 metasternal furca
 metasternal interspace
 metasternal lobe

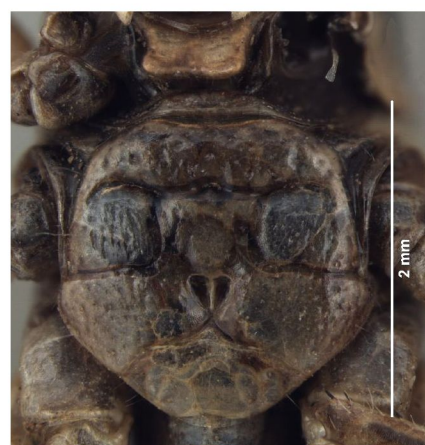
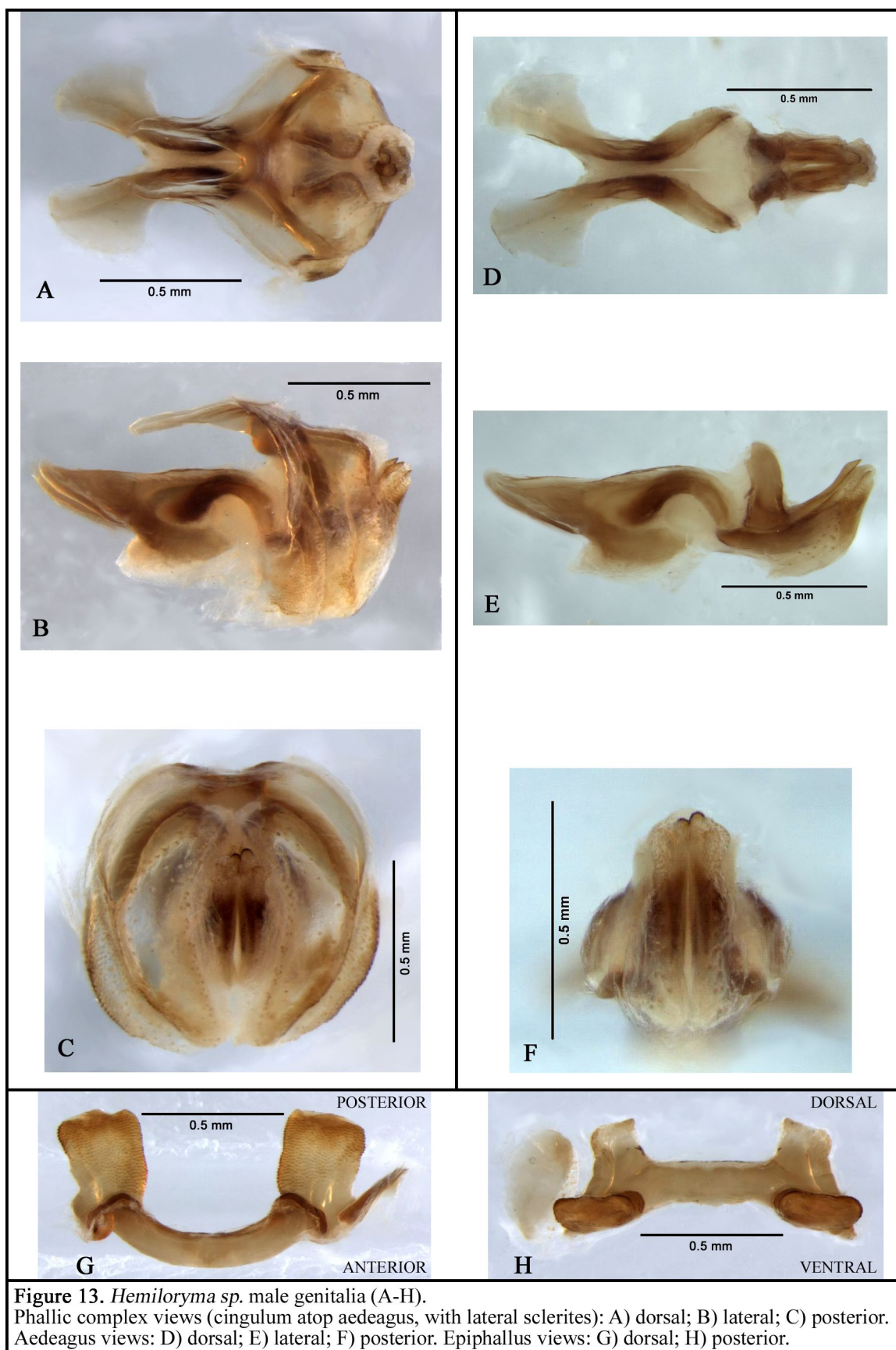
D) *Hemiloryma* sp.E) *Dirshacris* sp.

Figure 12. Morphological features, terminology and examples of range of size and shape variation for sternum of thorax of *Loryma* (A-C), and presumed closest relatives *Hemiloryma* (D) and *Dirshacris* (E).



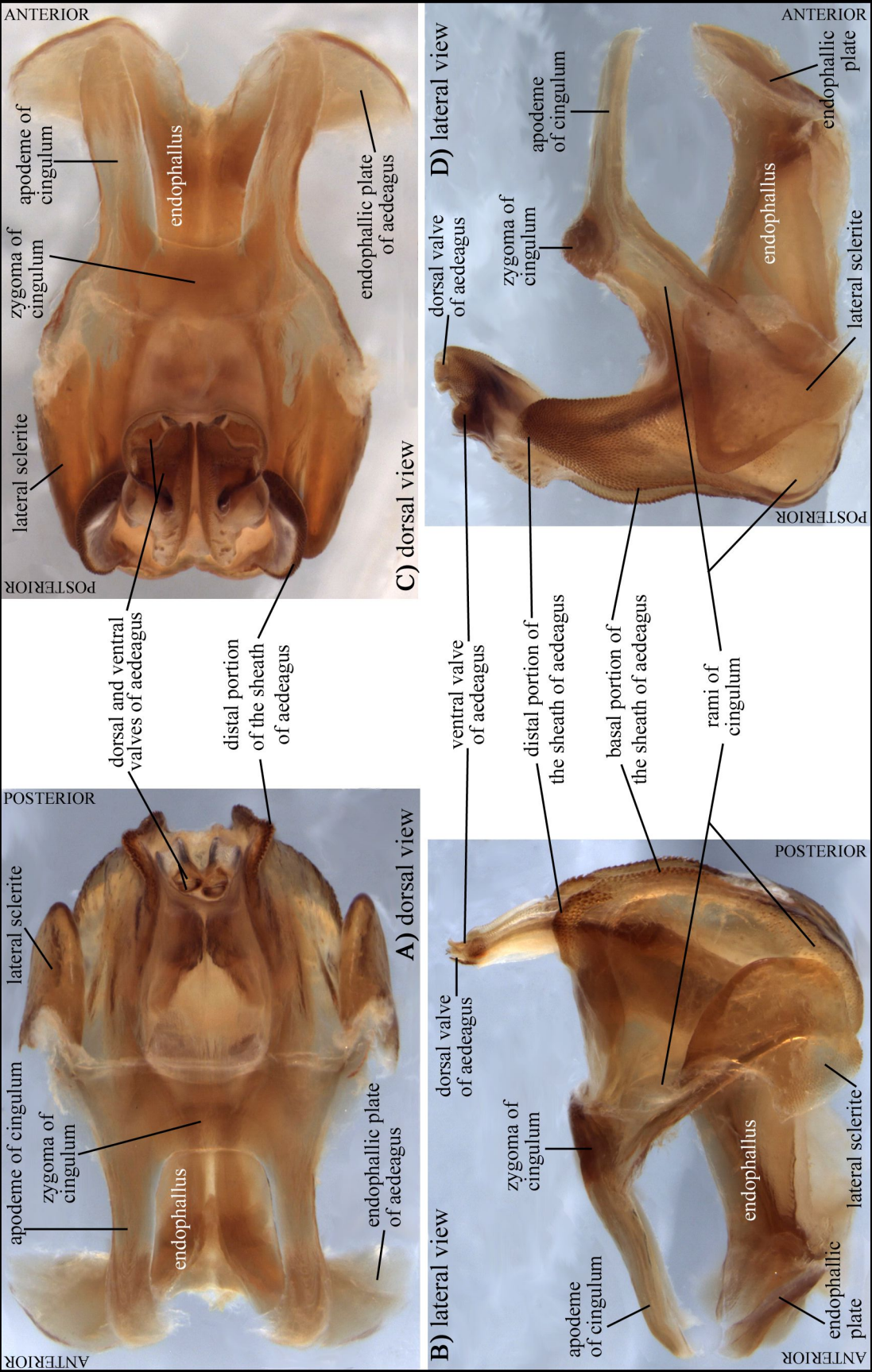


Figure 14. Morphological features associated with the phallic complex of *Loryma* (A-D). EA species-group species (A-B). NEA species-group species (C-D).

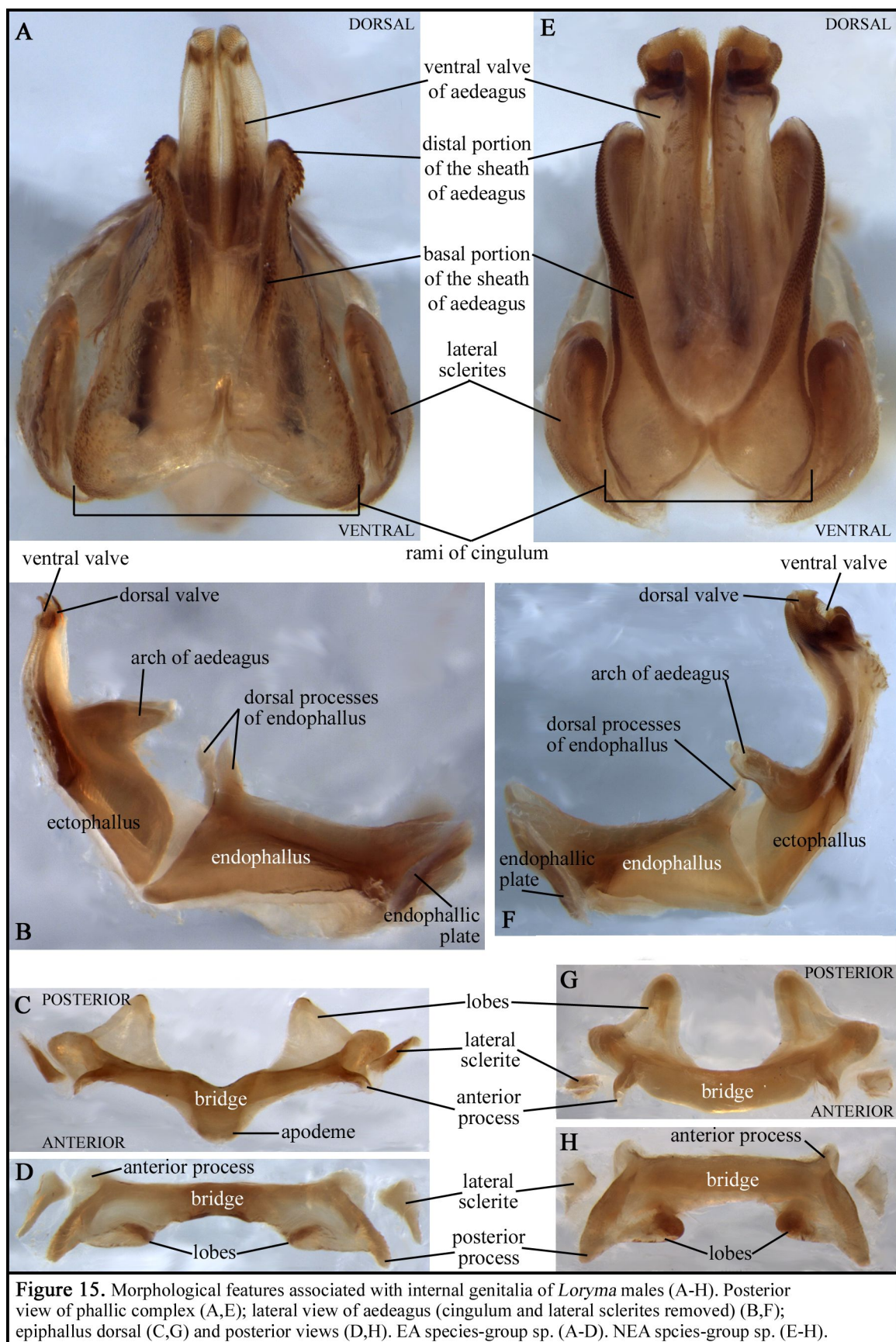


Table 5. Loryma Species Figures.

	Male external morphology	Male internal morphology	Male field photos	Female habitus	Female field photos
1. <i>L. perficita</i>	-	-	-	fig. 16, p.191	-
2. <i>L. ashleyi</i>	fig. 17, p.192	fig. 18, p.193	-	fig. 59, p.234	-
3. <i>L. carolynae</i>	fig. 19, p.194	fig. 20, p.195	-	fig. 59, p.234	-
4. <i>L. magna</i>	fig. 21, p.196	fig. 22, p.197	-	fig. 59, p.234	-
5. <i>L. browni</i>	fig. 23, p.198	fig. 24, p.199	-	fig. 59, p.234	-
6. <i>L. khoi</i>	fig. 25, p.200	fig. 26, p.201	-	fig. 59, p.234	-
7. <i>L. namaqua</i>	fig. 27, p.202	fig. 28, p.203	fig. 64, p.239	fig. 60, p.235	fig. 64, p.239
8. <i>L. san</i>	fig. 29, p.204	fig. 30, p.205	-	-	-
9. <i>L. mayi</i>	fig. 31, p.206	fig. 32, p.207	-	fig. 59, p.234	-
10. <i>L. zebrata</i>	fig. 33, p.208	fig. 34, p.209	fig. 66, p.241	fig. 60, p.235	fig. 66, p.241
11. <i>L. bonteboki</i>	fig. 35, p.210	fig. 36, p.211	fig. 65, p.240	fig. 60, p. 235	fig. 65, p.240
12. <i>L. karoo</i>	fig. 37, p.212	fig. 38, p.213	-	fig. 60, p.235	-
13. <i>L. mirabunda</i>	fig. 39, p.214	fig. 40, p.215	fig. 64, p.239	fig. 60, p.235	fig. 64, p.239
14. <i>L. cederbergensis</i>	fig. 41, p.216	fig. 42, p.217	fig. 61, p.236	fig. 60, p.235	fig. 61, p.236
15. <i>L. lapollai</i>	fig. 43, p.218	fig. 44, p.219	fig. 62, p.237	-	-
16. <i>L. tsitsikamma</i>	fig. 45, p.220	fig. 46, p.221	-	fig. 59, p.234	-
17. <i>L. waboom</i>	fig. 47, p.222	fig. 48, p.223	-	-	-
18. <i>L. solveigae</i>	fig. 49, p.224	fig. 50, p.225	-	-	-
19. <i>L. larsenorum</i>	fig. 51, p.226	fig. 52, p.227	fig. 63, p.238	-	-
20. <i>L. umoja</i>	fig. 53, p.228	fig. 54, p.229	fig. 63, p.238	-	-
21. <i>L. lyra</i>	fig. 55, p.230	fig. 56, p.231	fig. 62, p.237	fig. 60, p.235	fig. 62, p.237
22. <i>L. ottei</i>	fig. 57, p.232	fig. 58, p.233	fig. 61, p.236	fig. 60, p.235	-

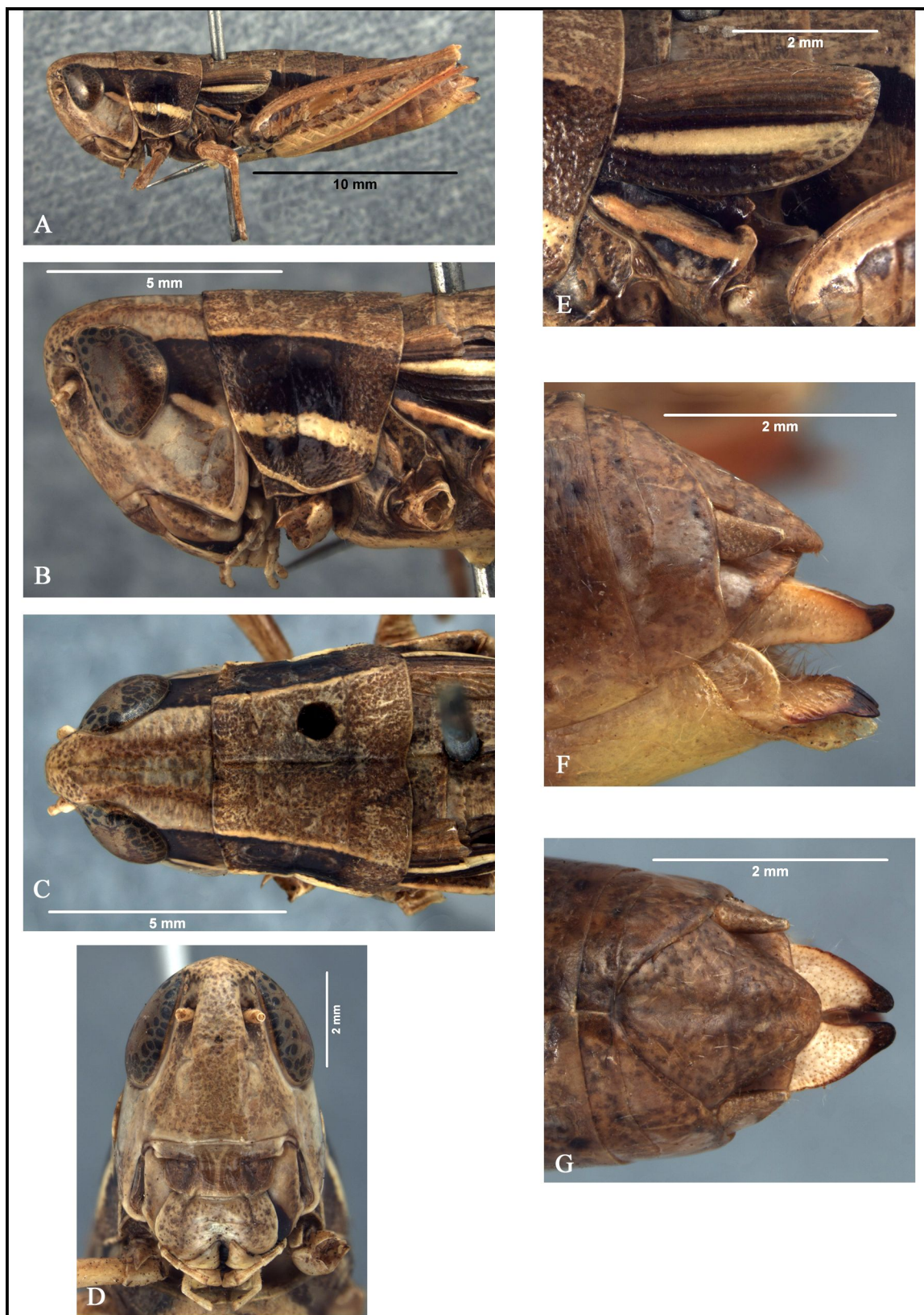


Figure 16. *Loryma perficita* (Walker) holotype female external morphology (A-G). A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen; F) lateral view ovipositor; G) dorsal view ovipositor and supra-anal plate.

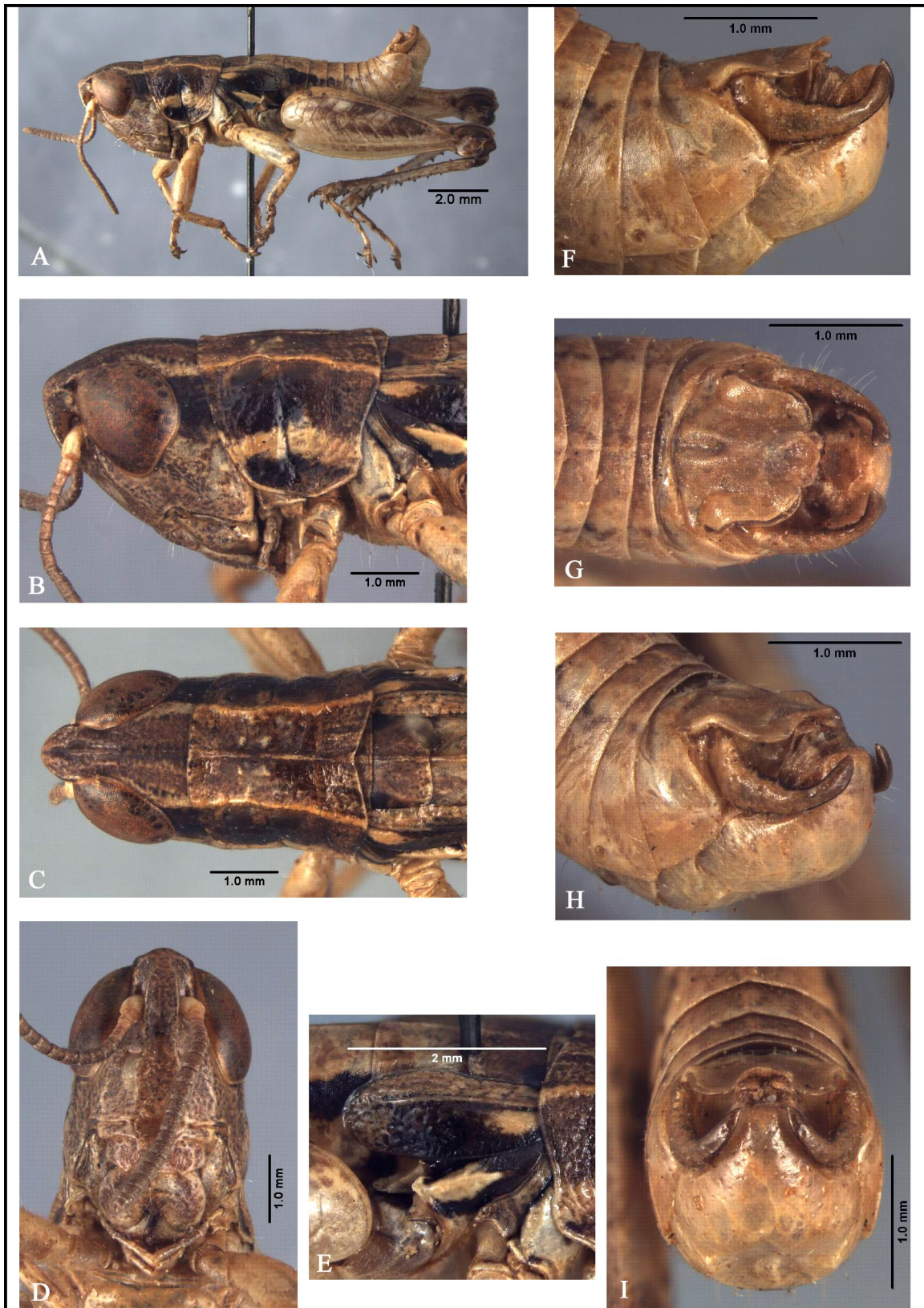
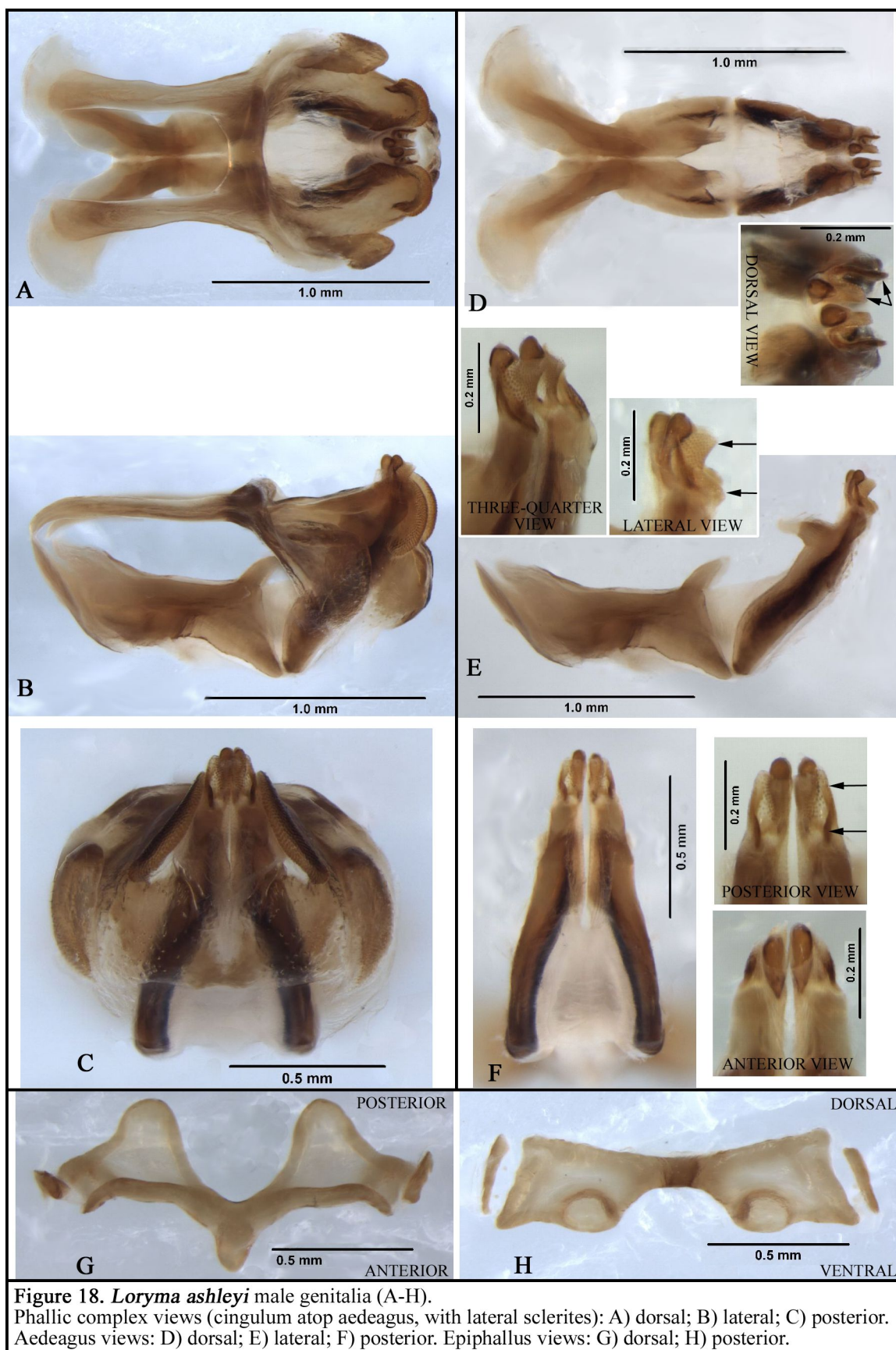


Figure 17. *Loryma ashleyi* male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



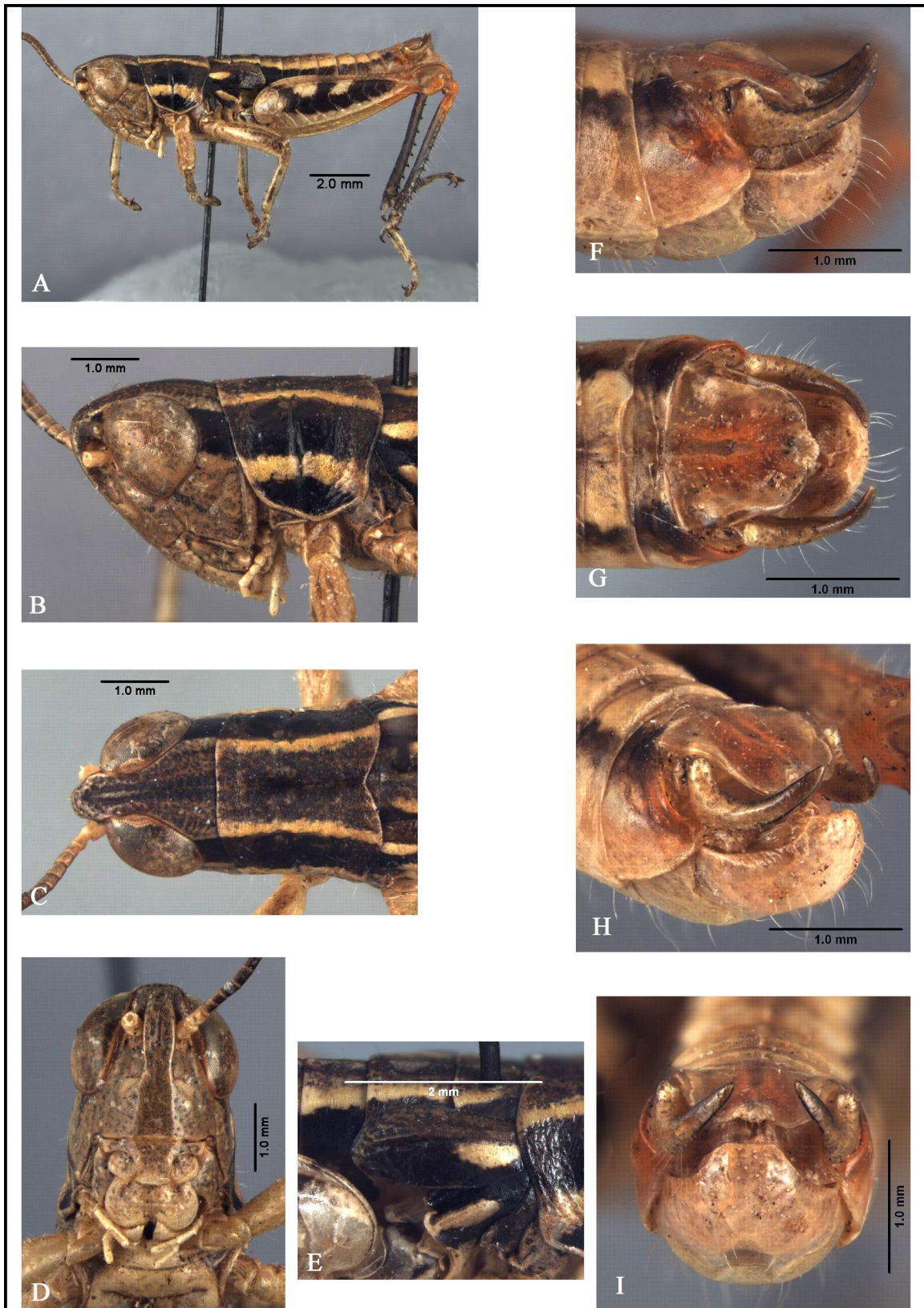


Figure 19. *Loryma carolynae* male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

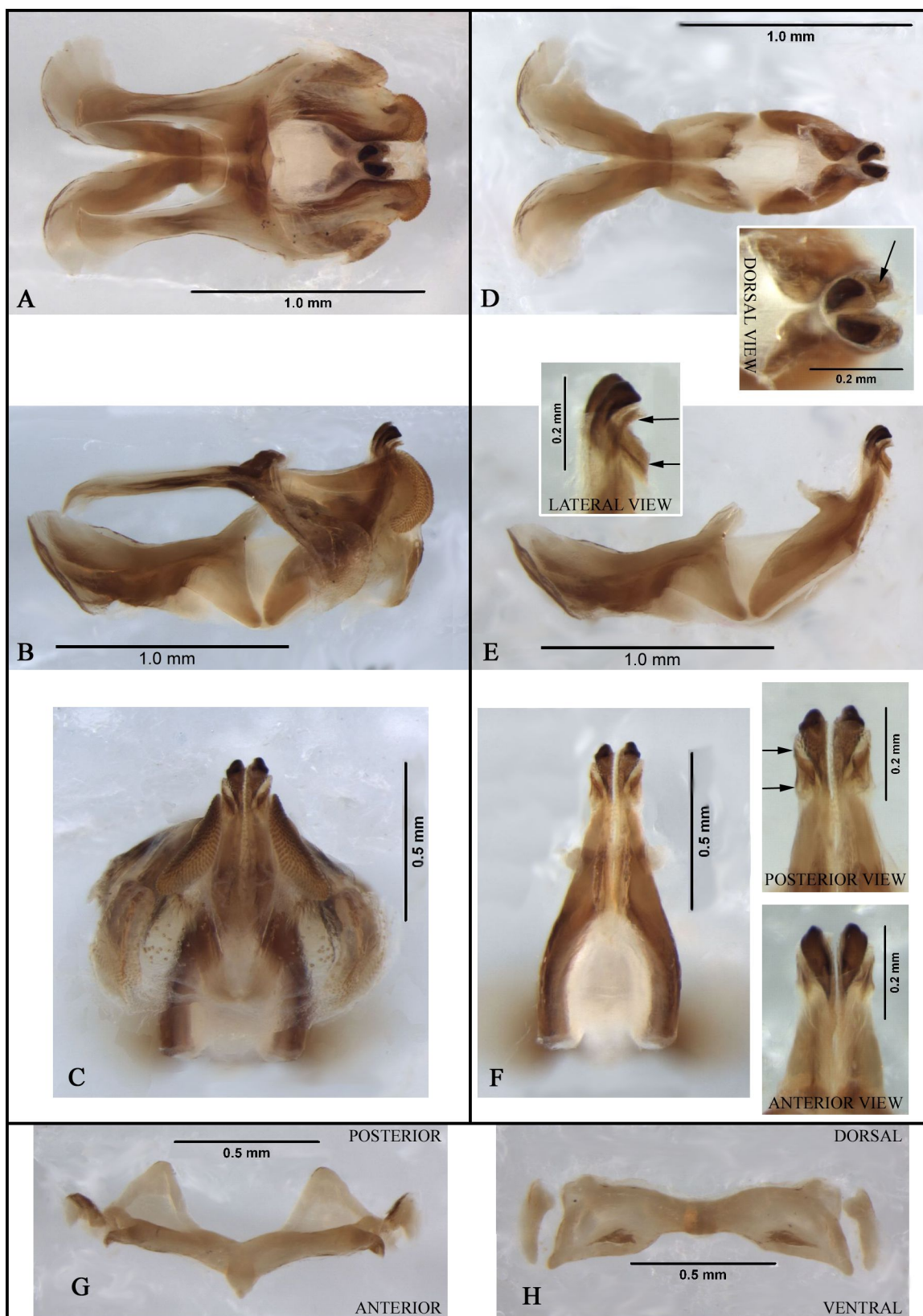


Figure 20. *Loryma carolynae* male genitalia (A-H). Phallic complex views (cingulum atop aedeagus, with lateral sclerites): A) dorsal; B) lateral; C) posterior. Aedeagus views: D) dorsal; E) lateral; F) posterior. Epiphallus views: G) dorsal; H) posterior.

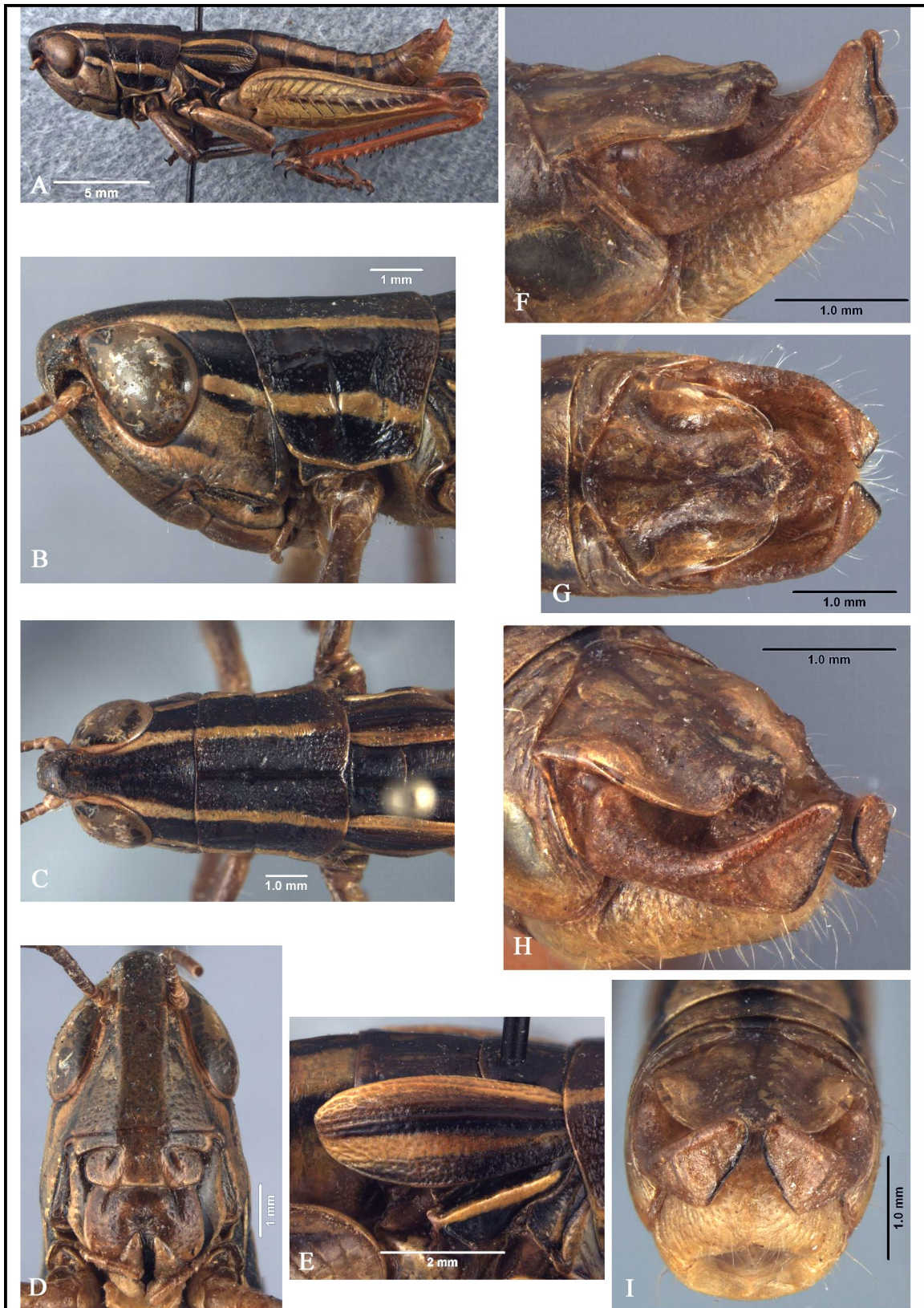
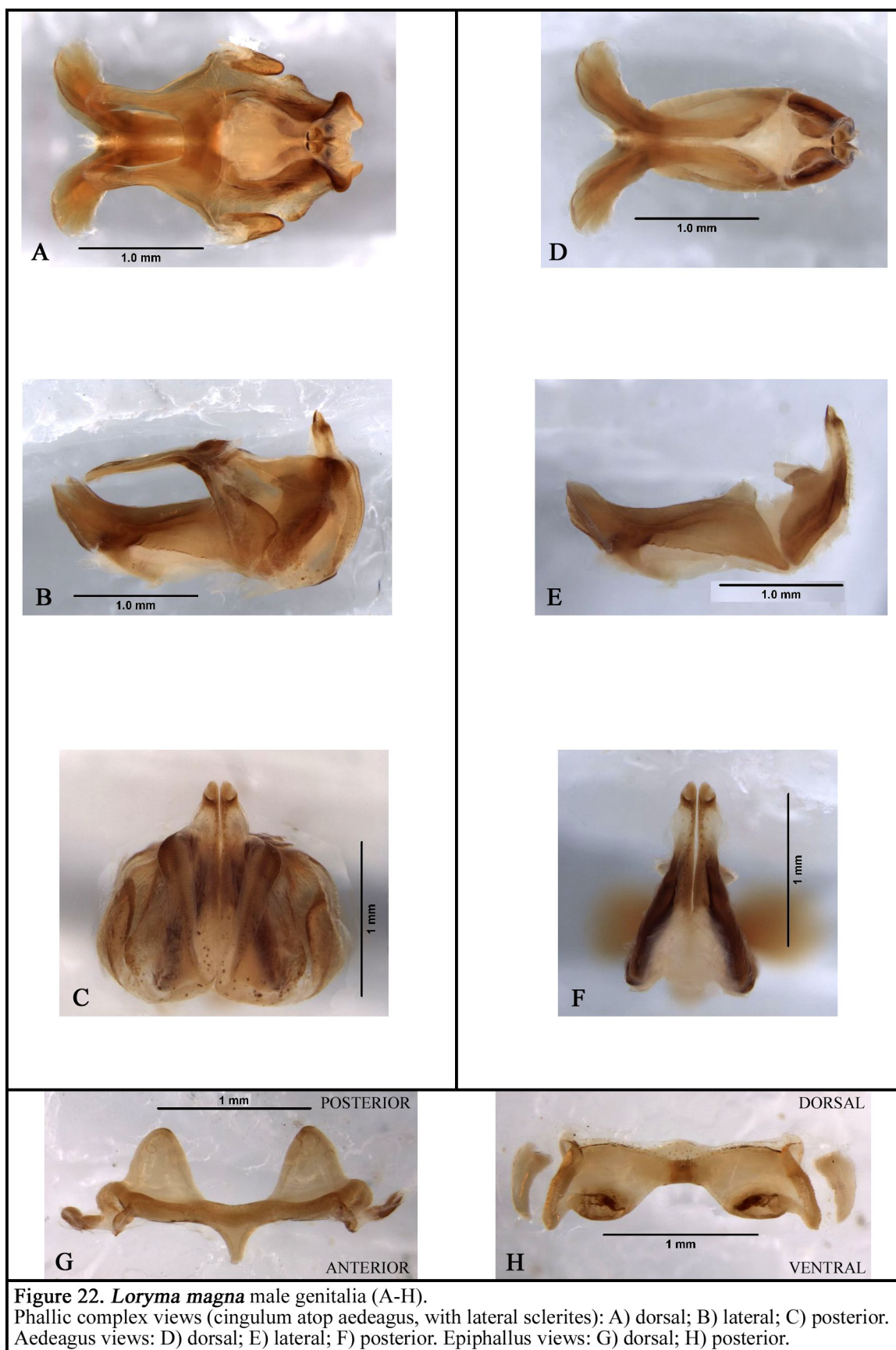


Figure 21. *Loryma magna* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



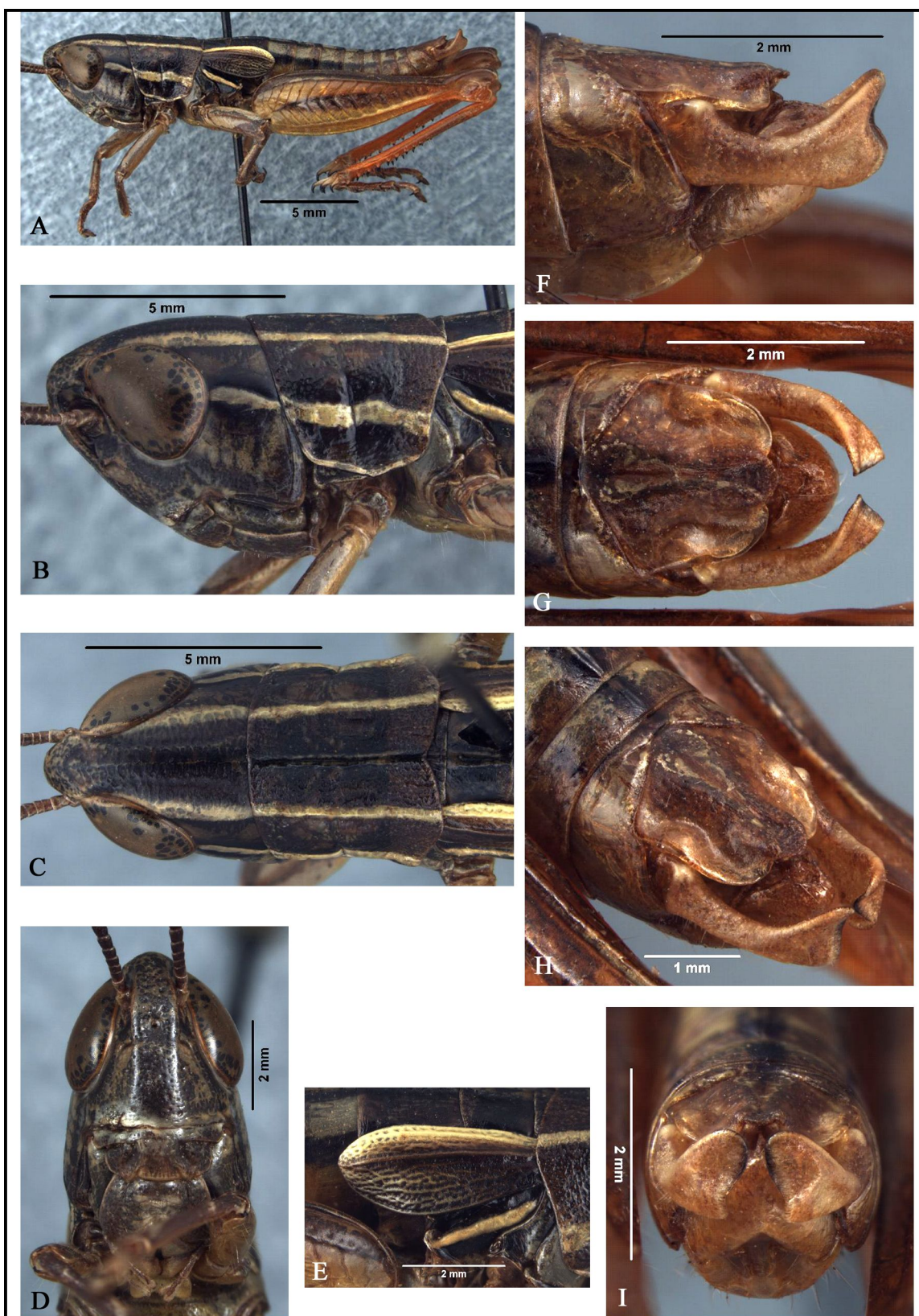


Figure 23. *Loryma browni* adult male external morphology (A-I). A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen. Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

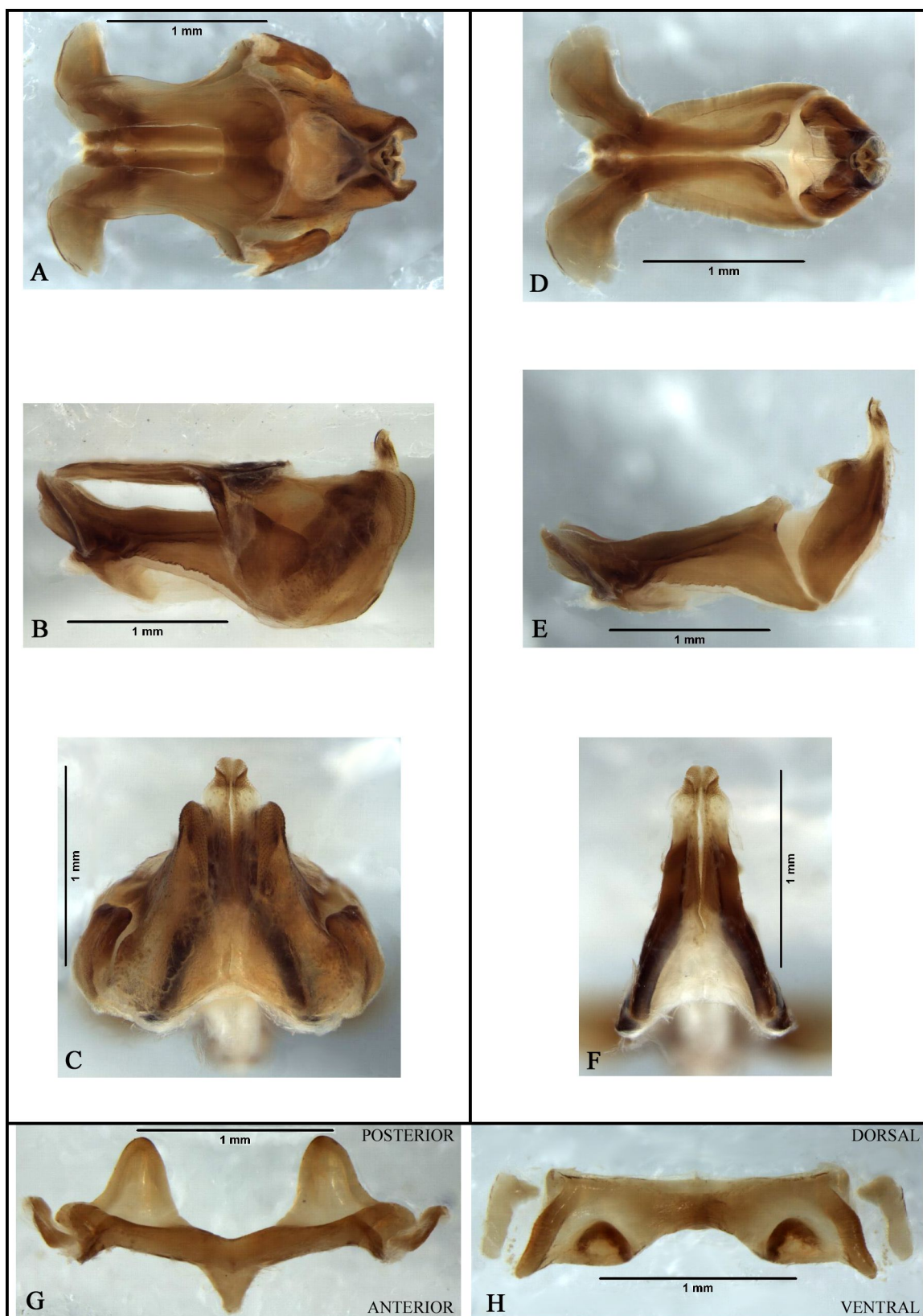


Figure 24. *Loryma browni* male genitalia (A-H). Phallic complex views (cingulum atop aedeagus, with lateral sclerites): A) dorsal; B) lateral; C) posterior. Aedeagus views: D) dorsal; E) lateral; F) posterior. Epiphallus views: G) dorsal; H) posterior.

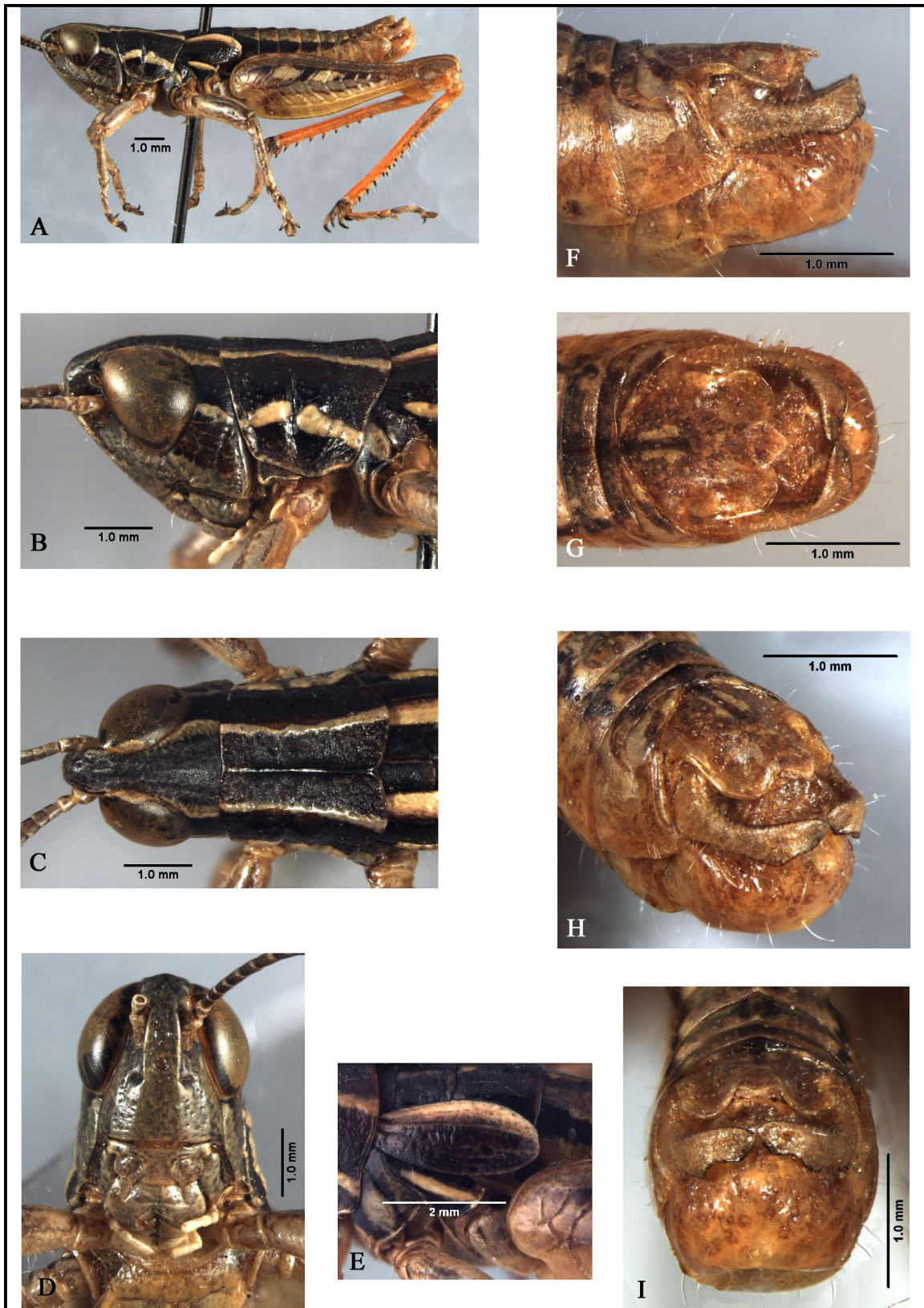


Figure 25. *Loryma khoi* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

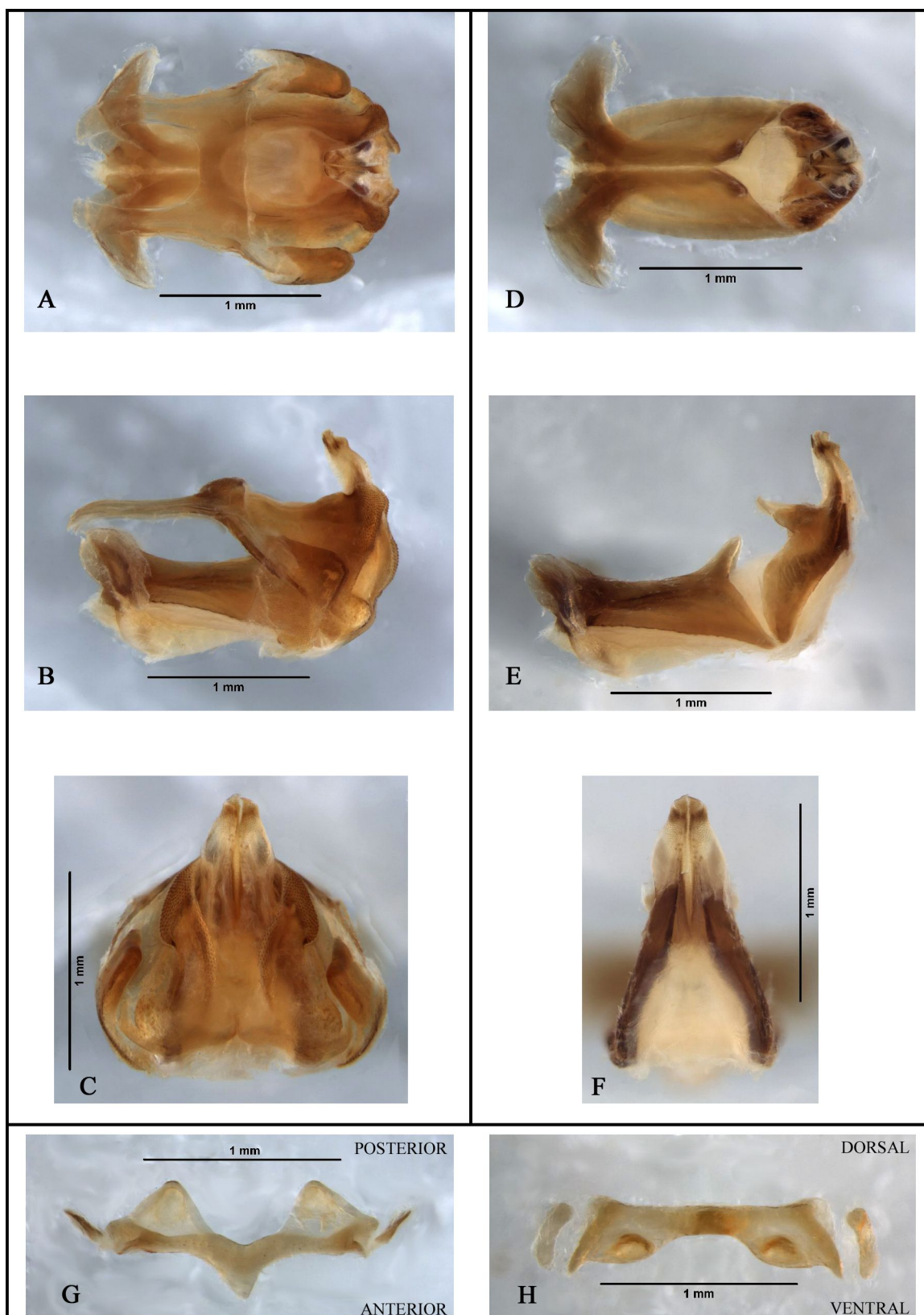


Figure 26. *Loryma khoi* male genitalia (A-H).
 Phallic complex views (cingulum atop aedeagus, with lateral sclerites): A) dorsal; B) lateral; C) posterior.
 Aedeagus views: D) dorsal; E) lateral; F) posterior. Epiphallus views: G) dorsal; H) posterior.

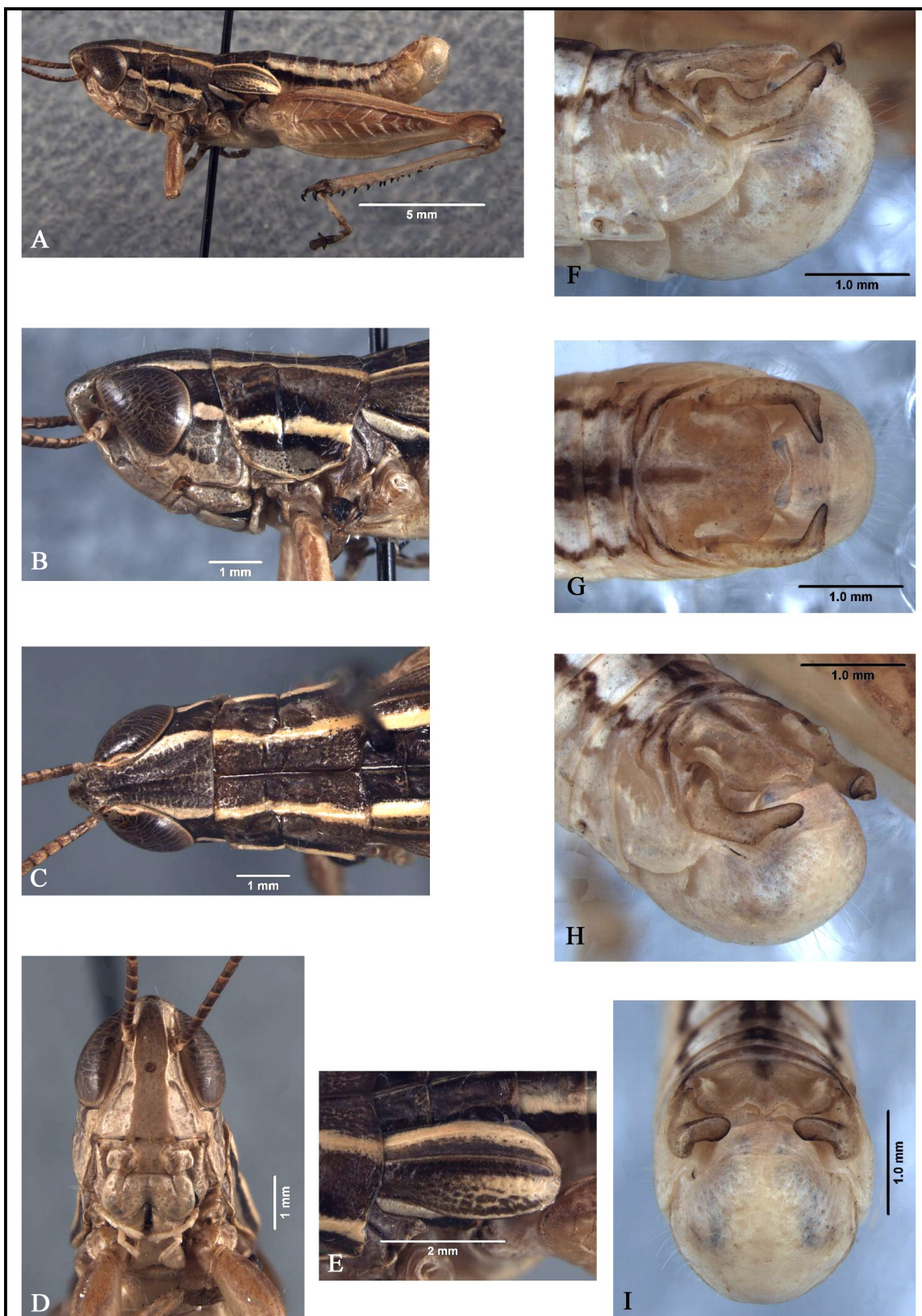
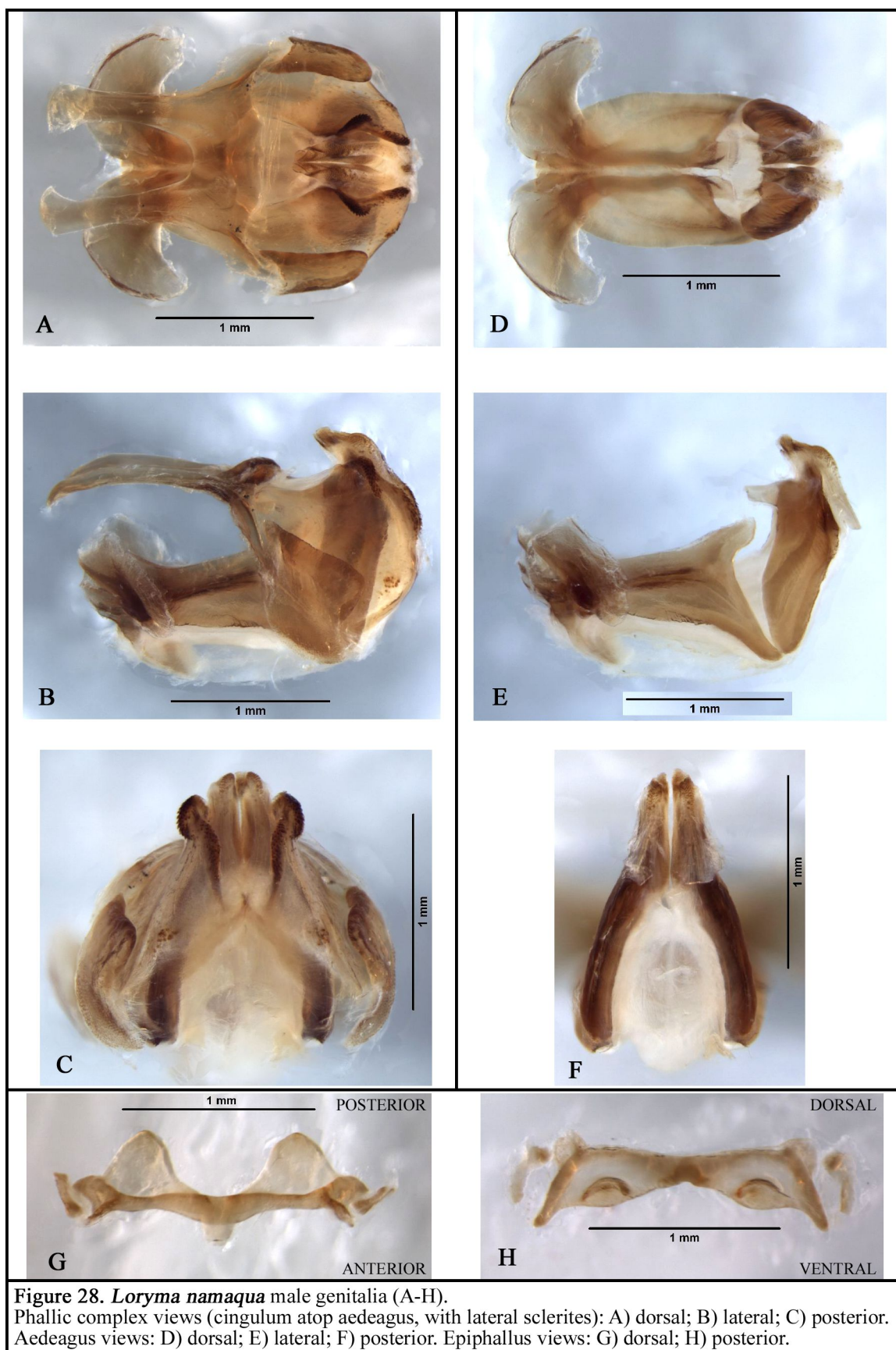


Figure 27. *Loryma namaqua* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



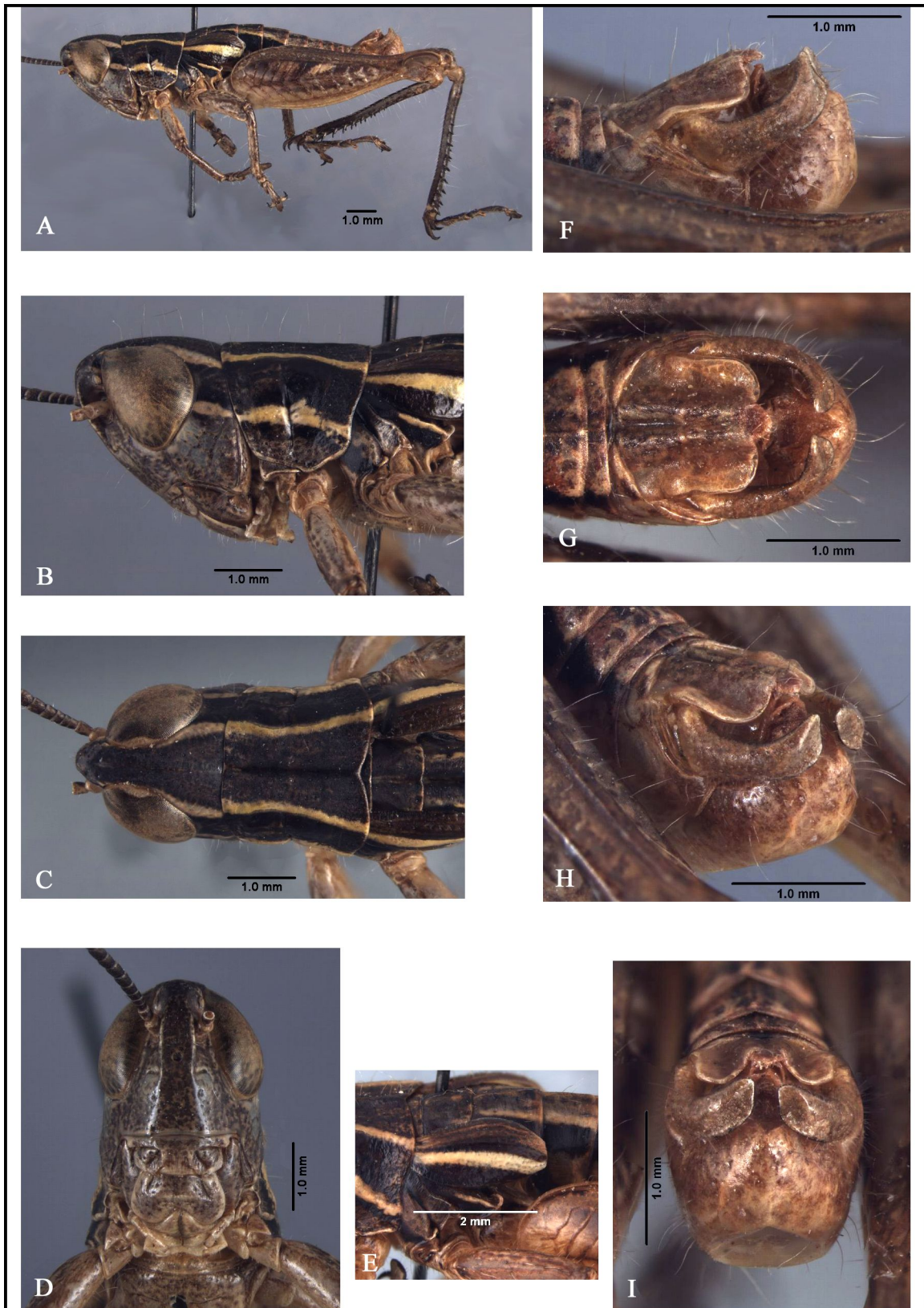
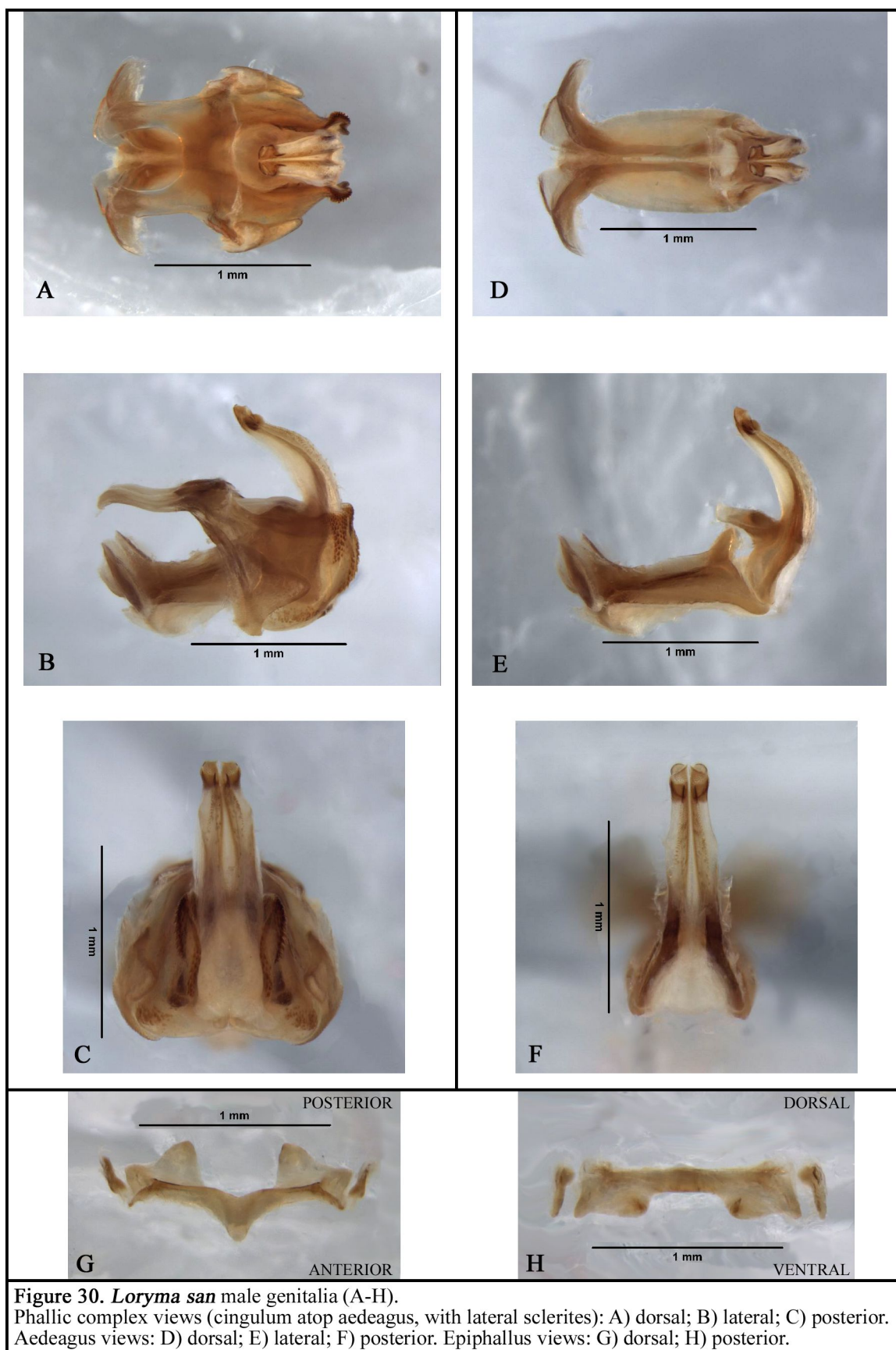


Figure 29. *Loryma san* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



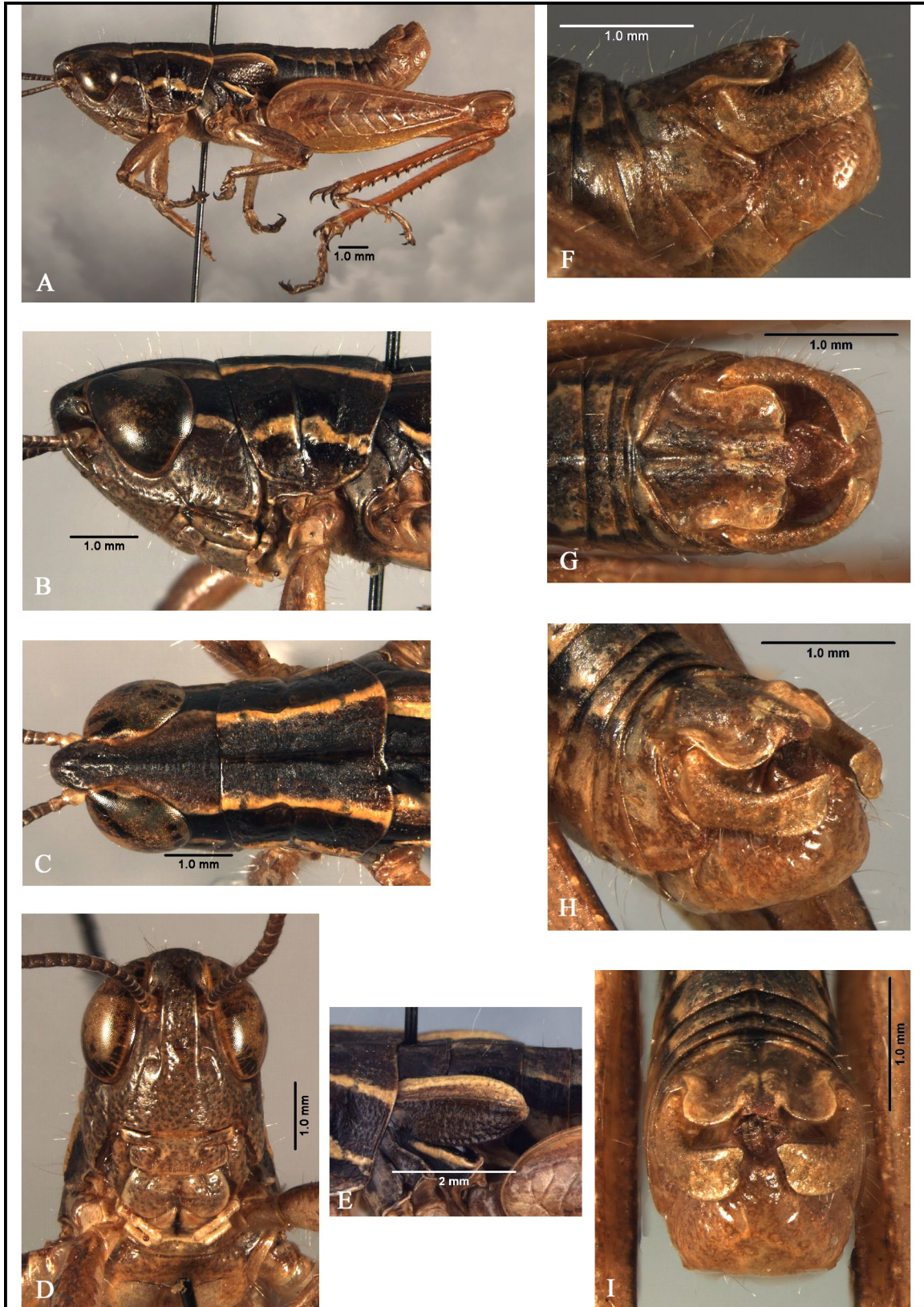


Figure 31. *Loryma mayi* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

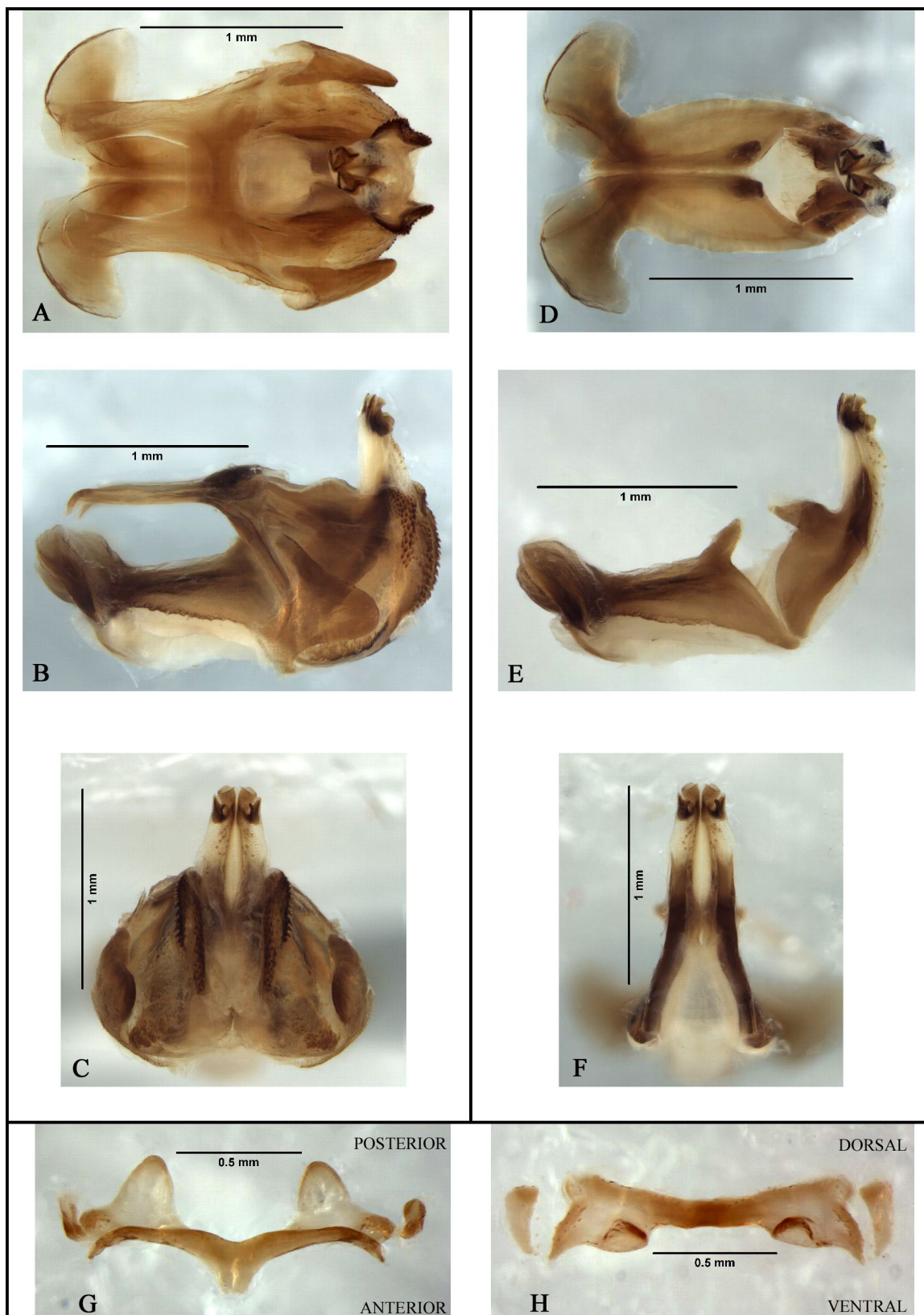


Figure 32. *Loryma mayi* male genitalia (A-H). Phallic complex views (cingulum atop aedeagus, with lateral sclerites): A) dorsal; B) lateral; C) posterior. Aedeagus views: D) dorsal; E) lateral; F) posterior. Epiphallus views: G) dorsal; H) posterior.

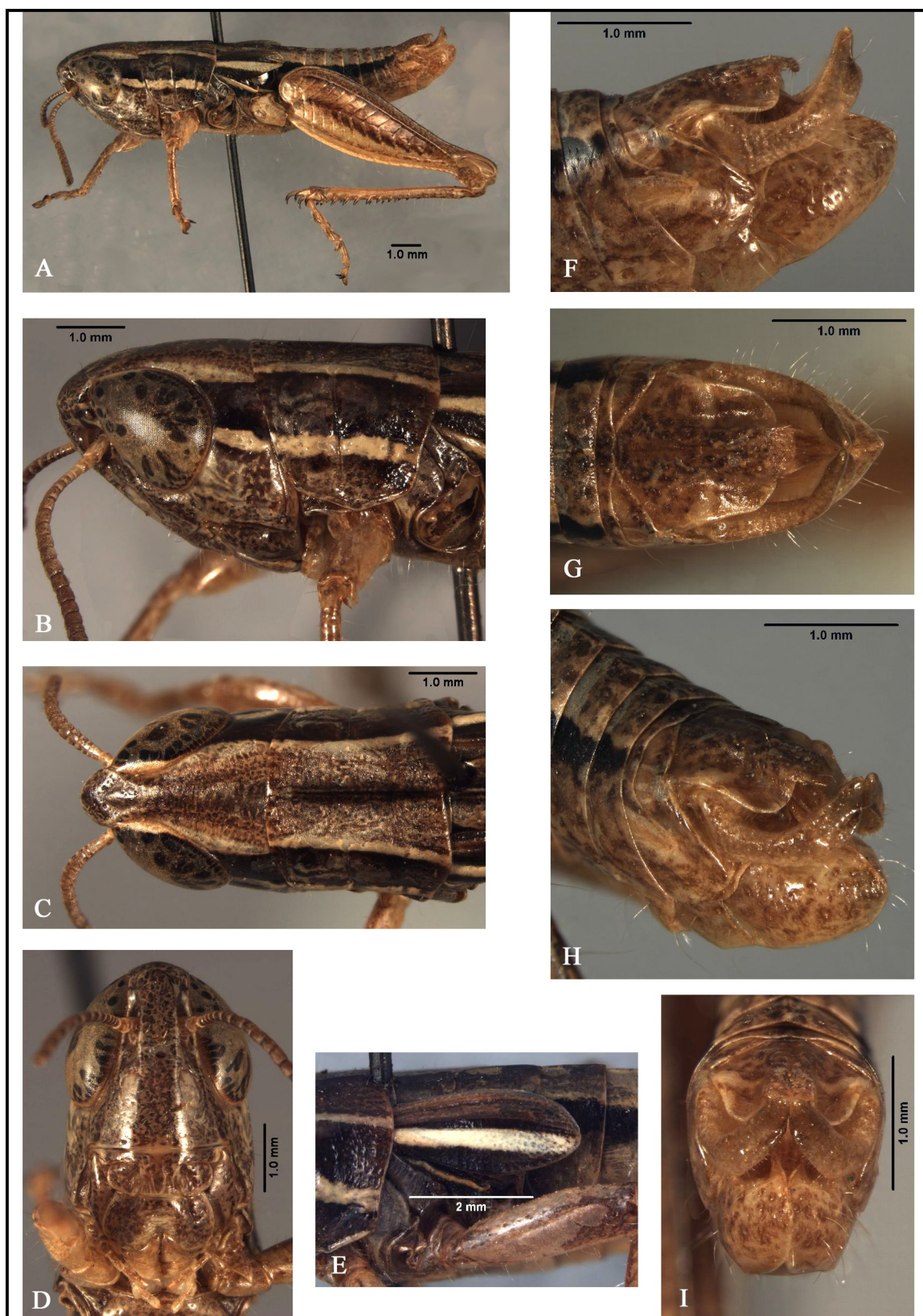
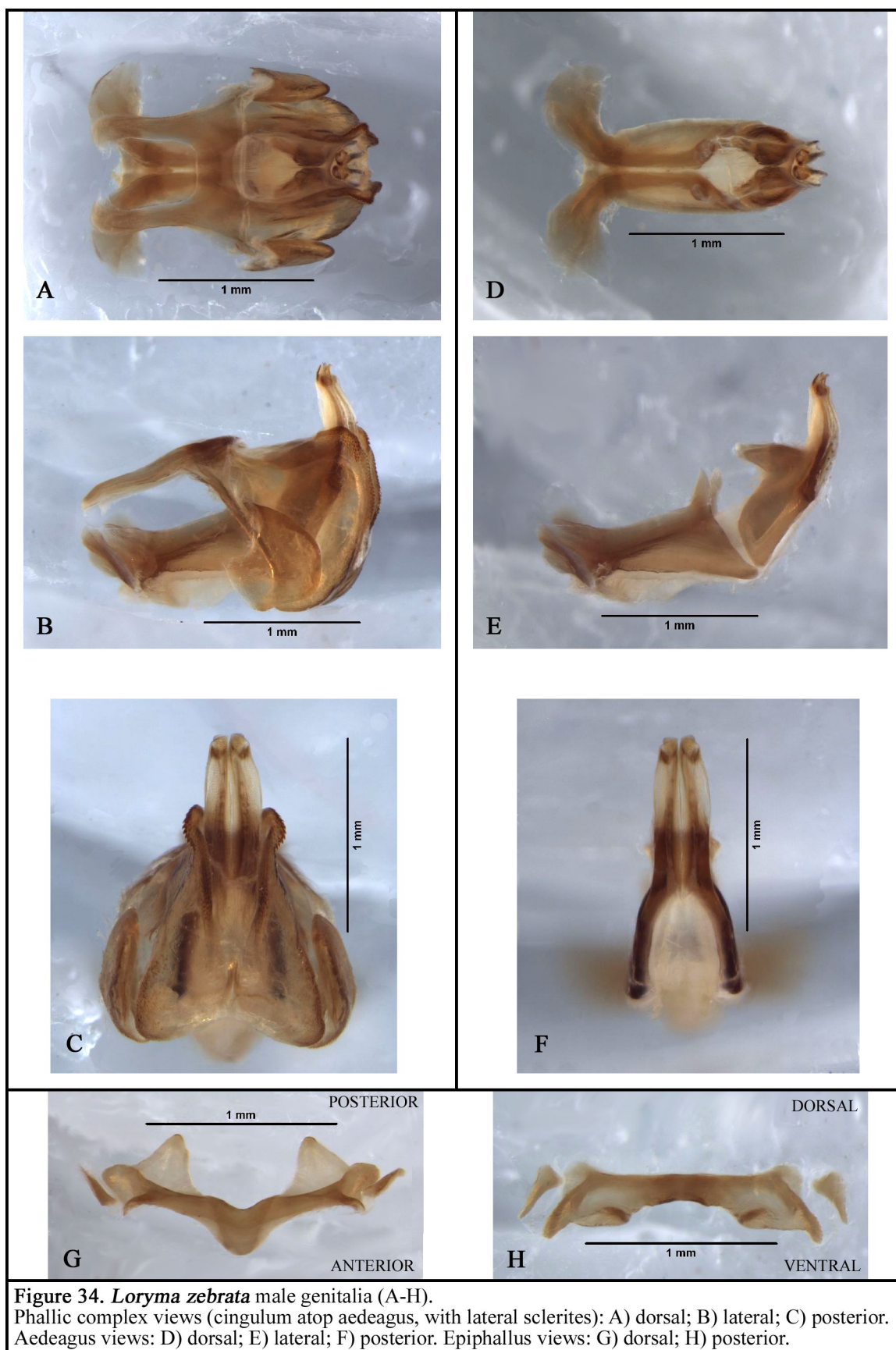


Figure 33. *Loryma zebrata* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



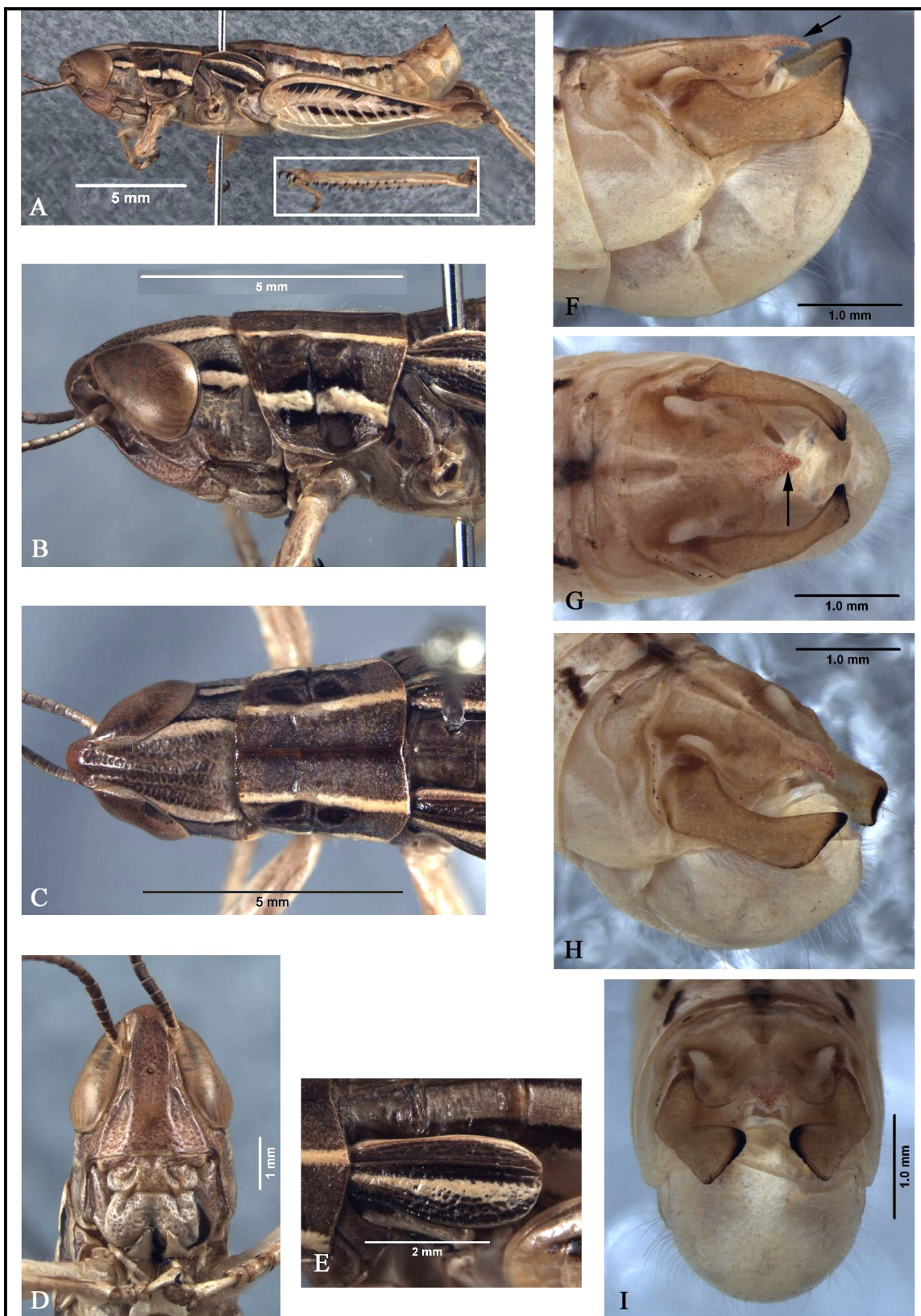
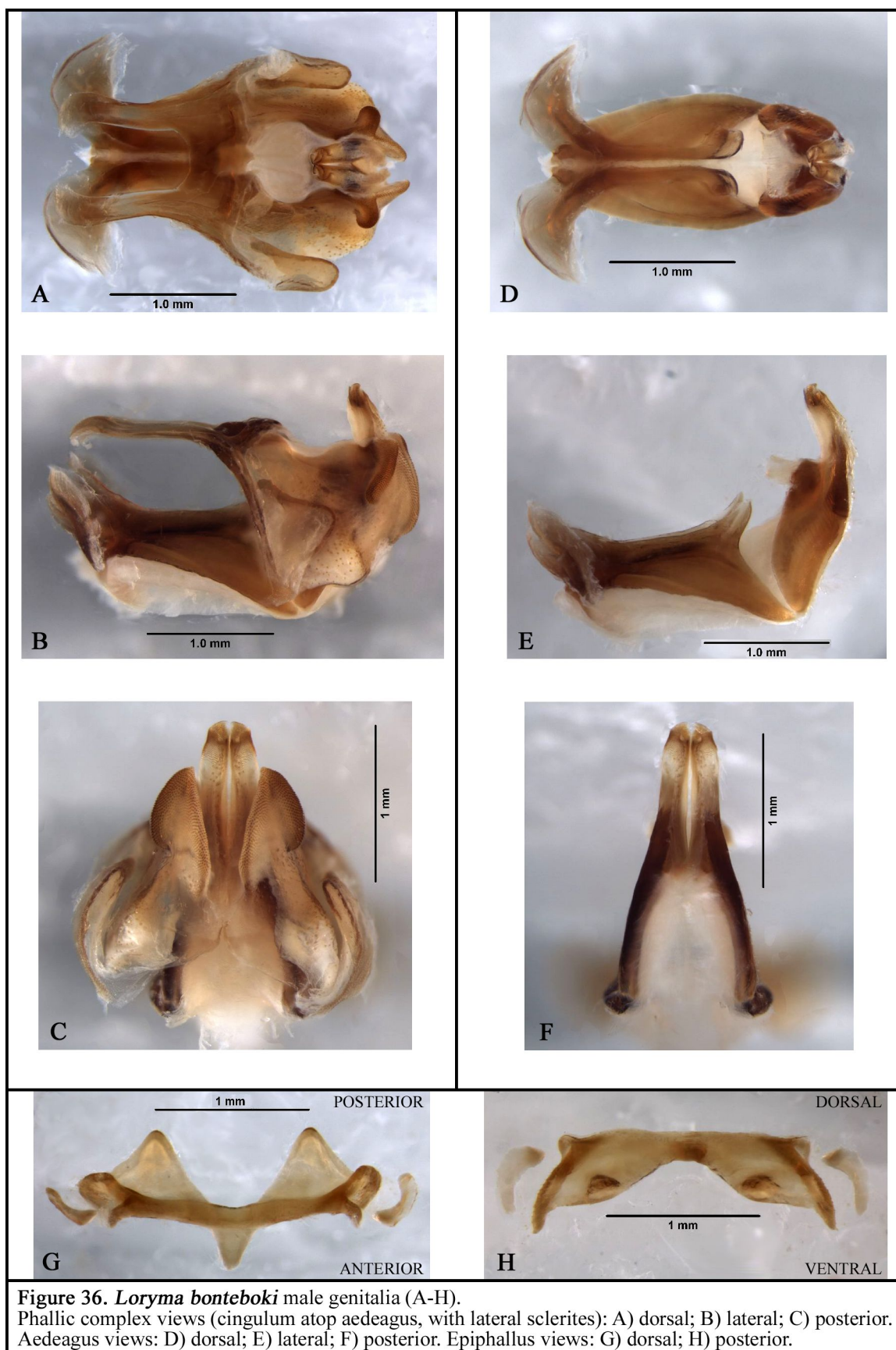


Figure 35. *Loryma bonteboki* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



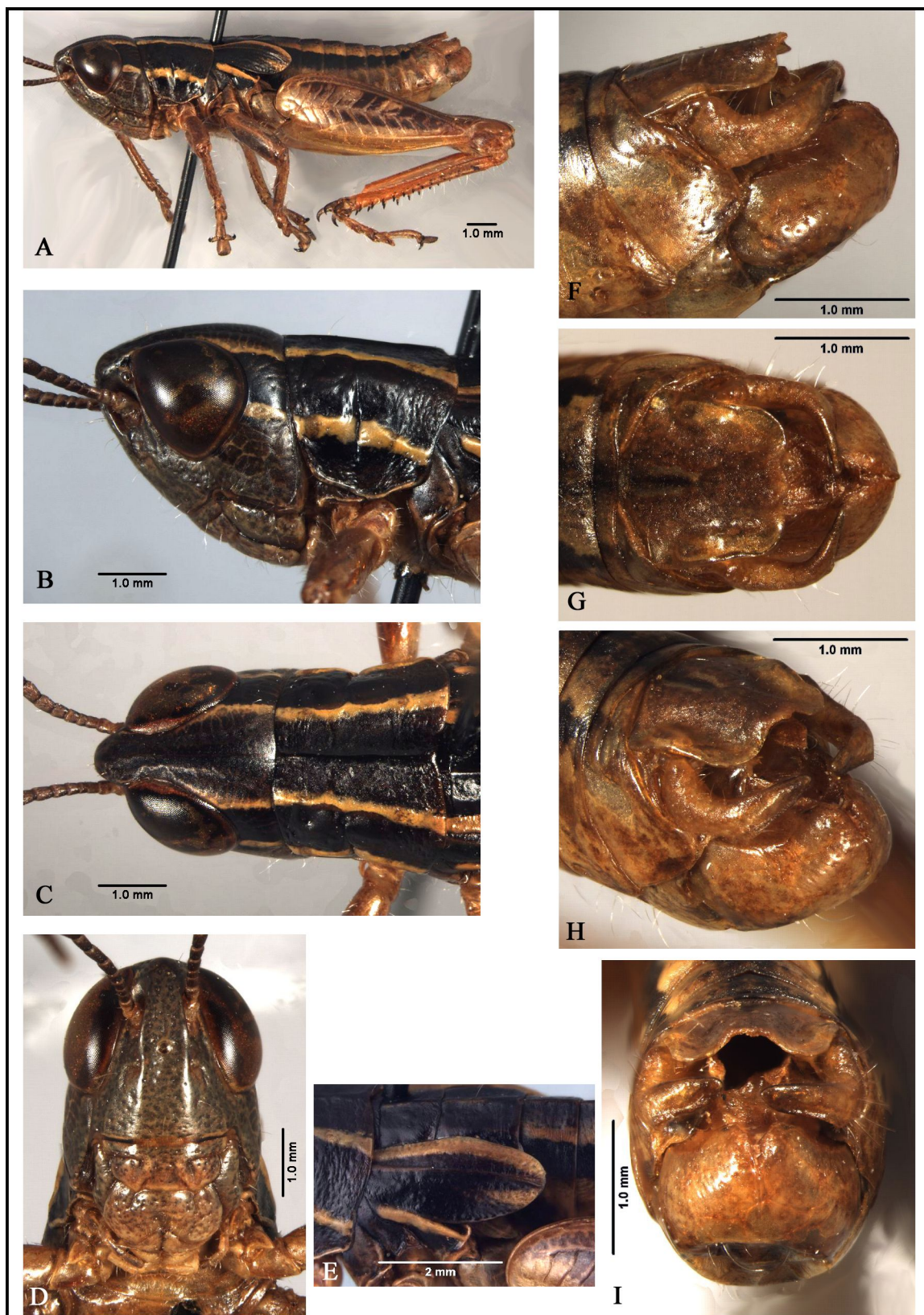
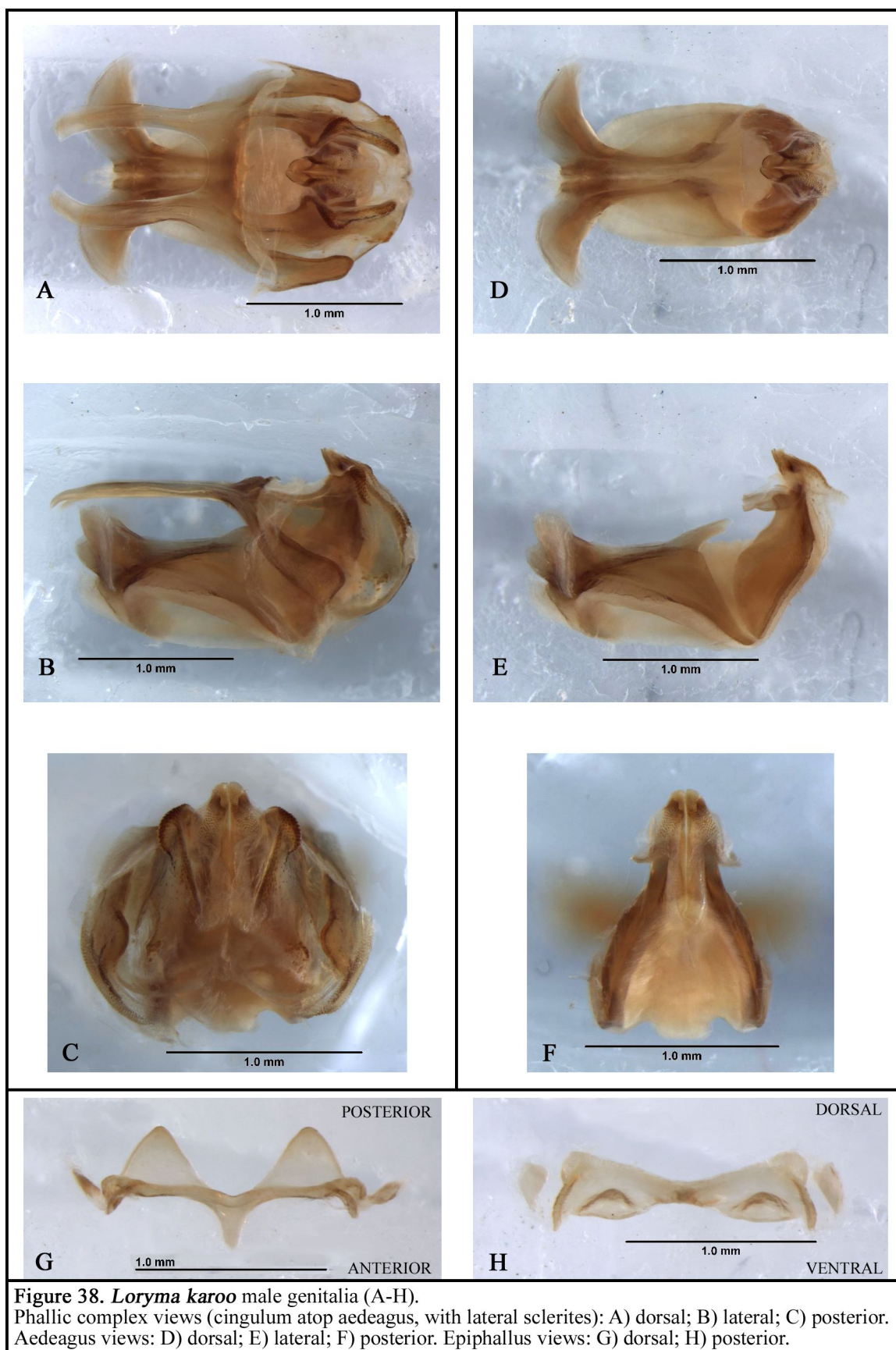


Figure 37. *Loryma karoo* adult male external morphology (A-I). A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen. Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



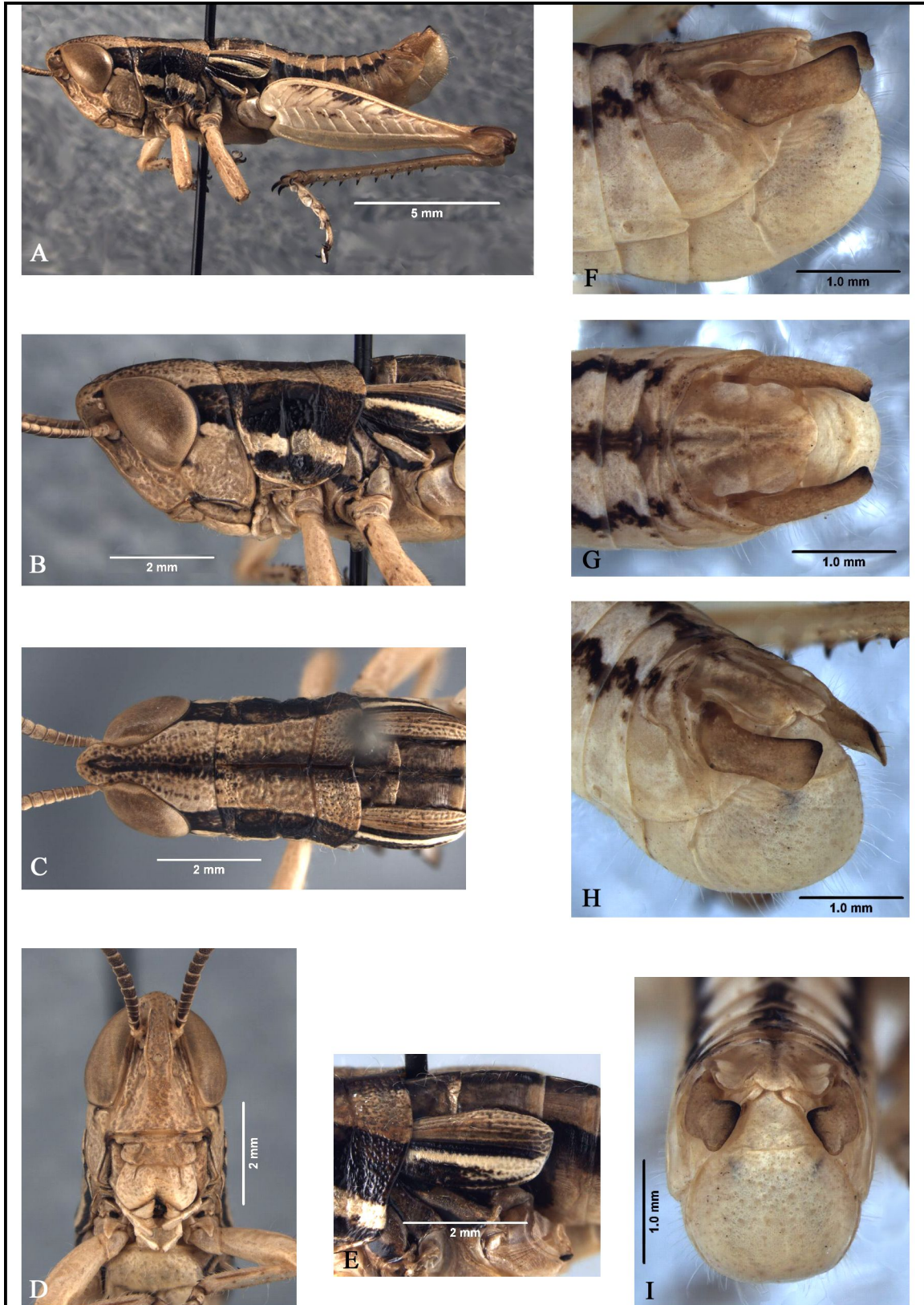
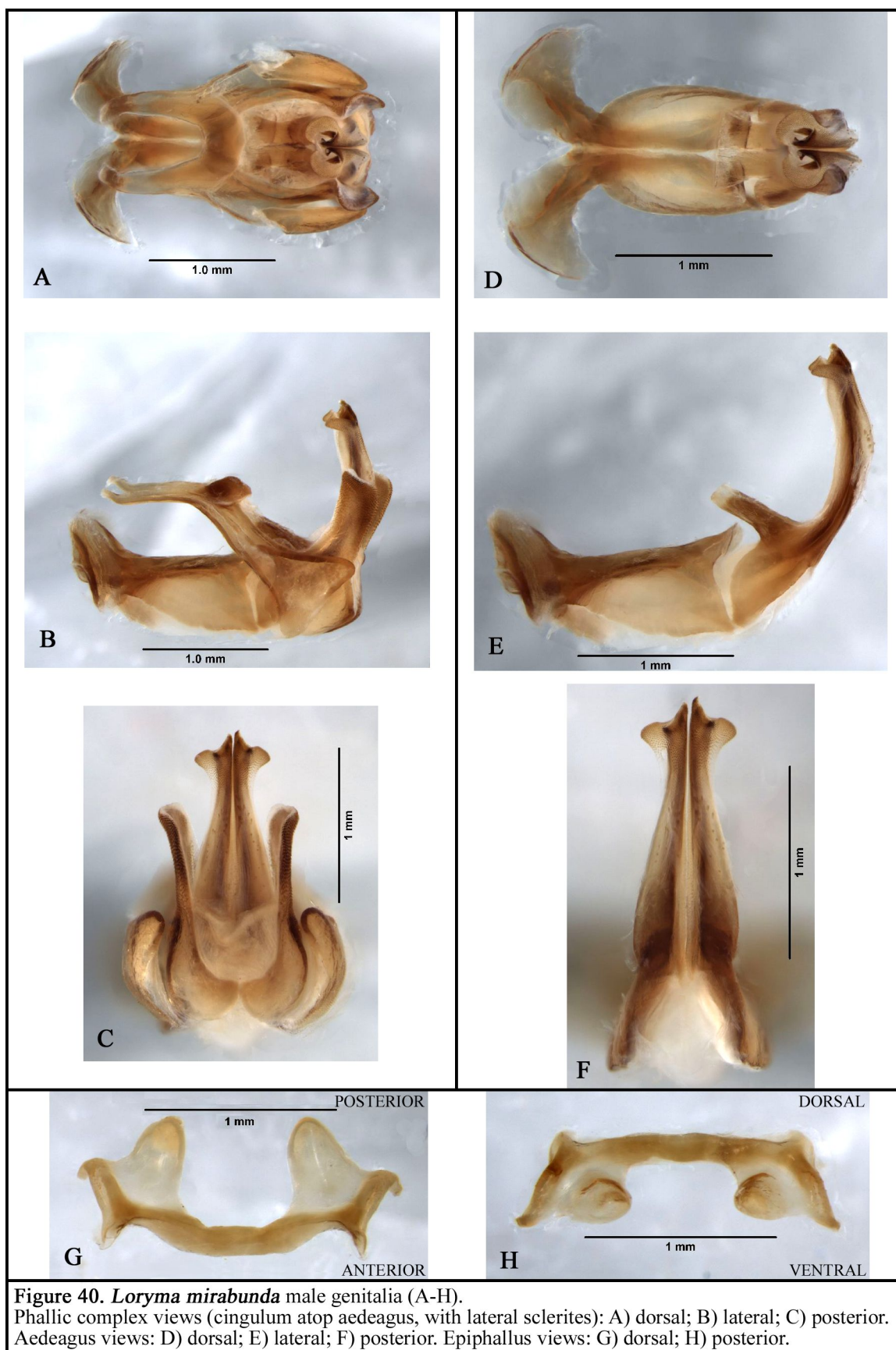


Figure 39. *Loryma mirabunda* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



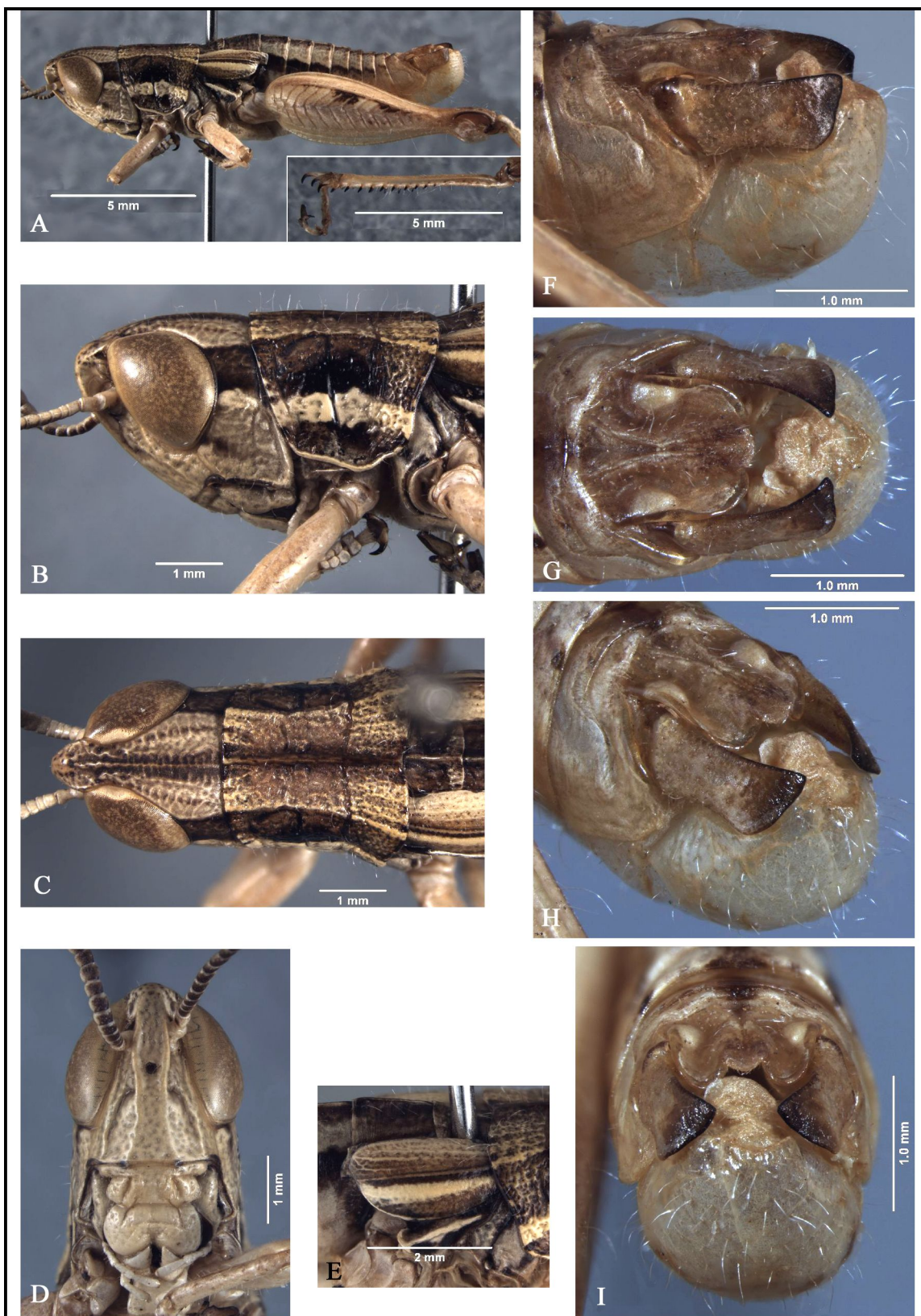
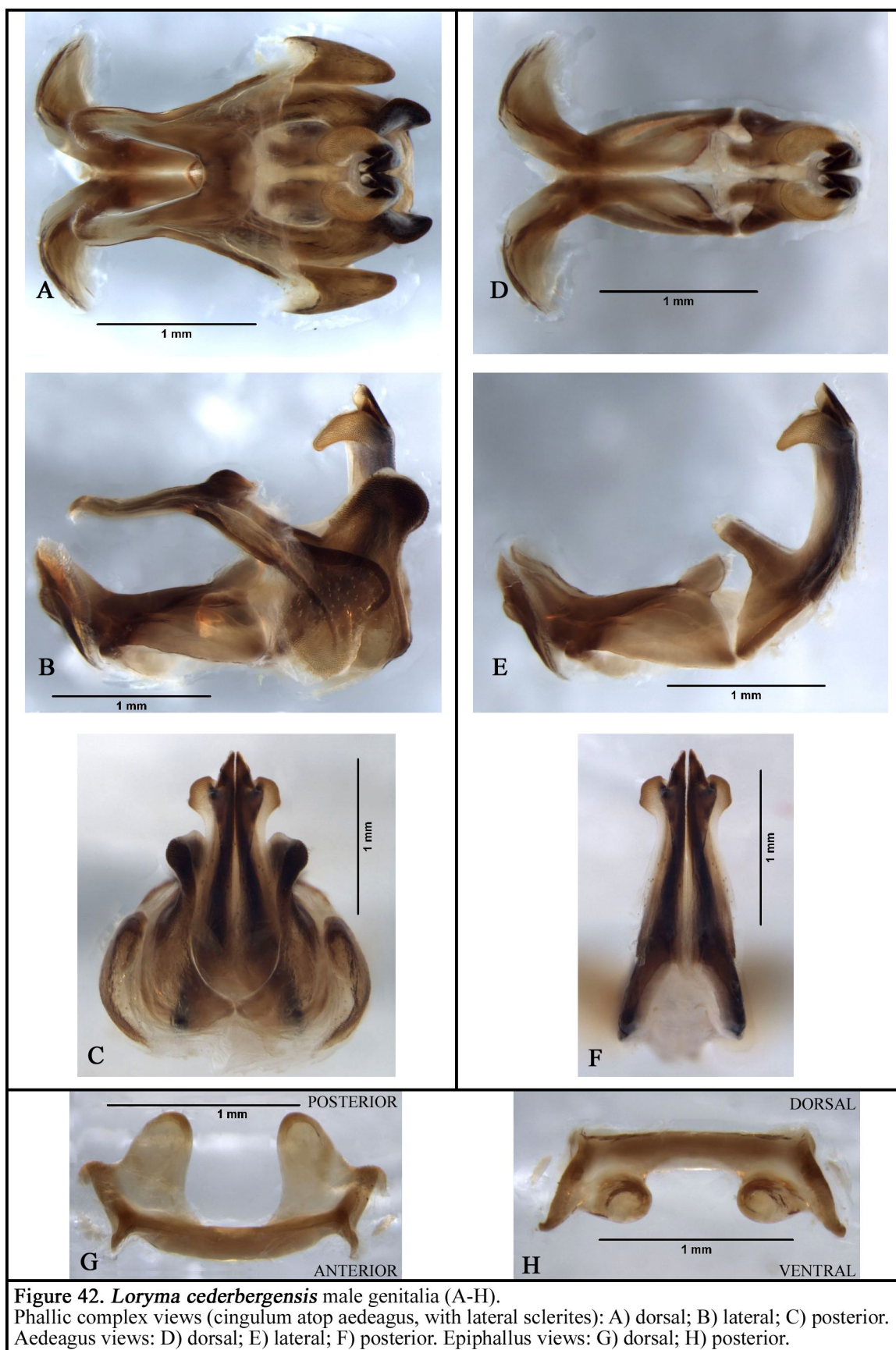


Figure 41. *Loryma cederbergensis* adult male external morphology (A-H).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



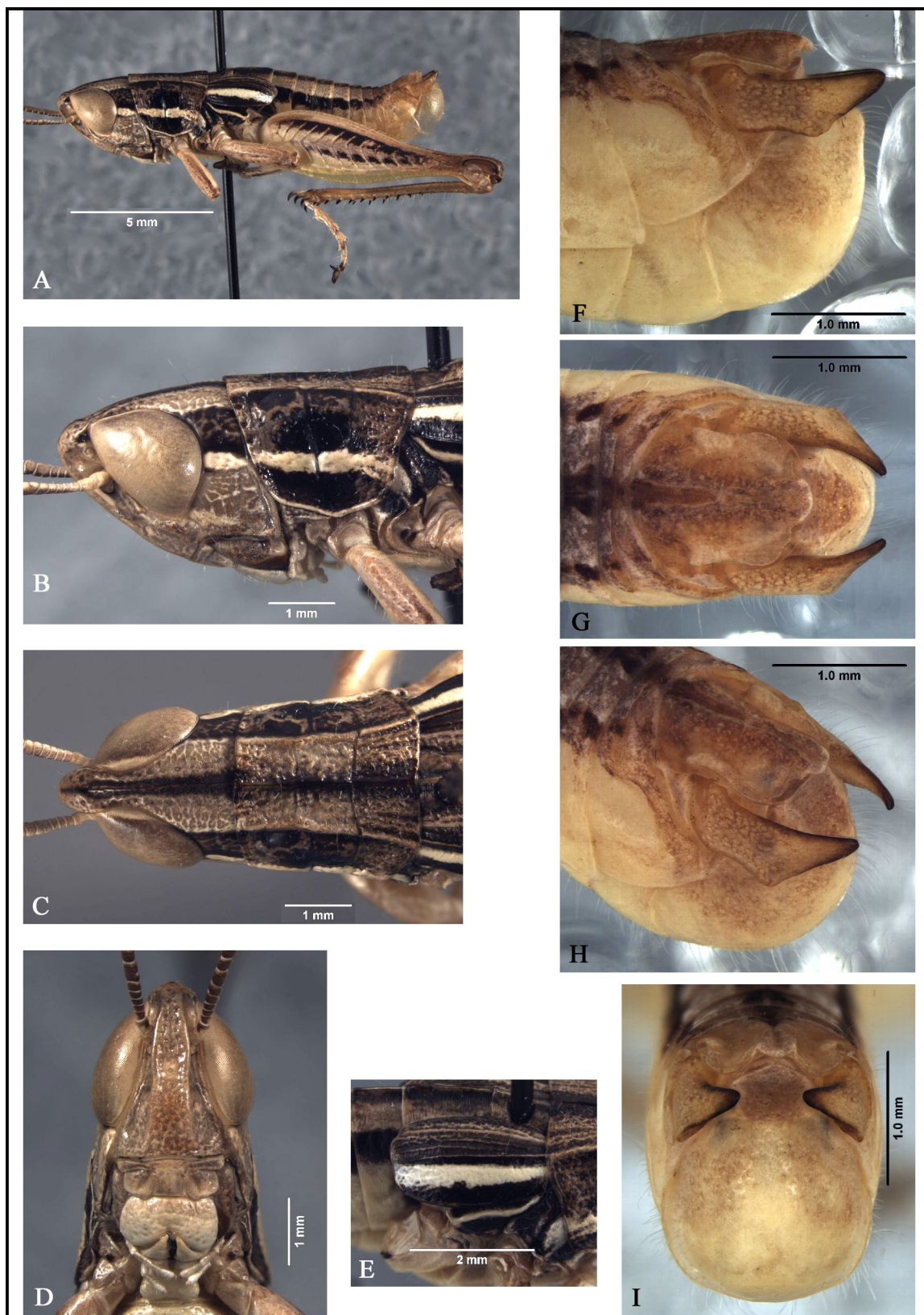
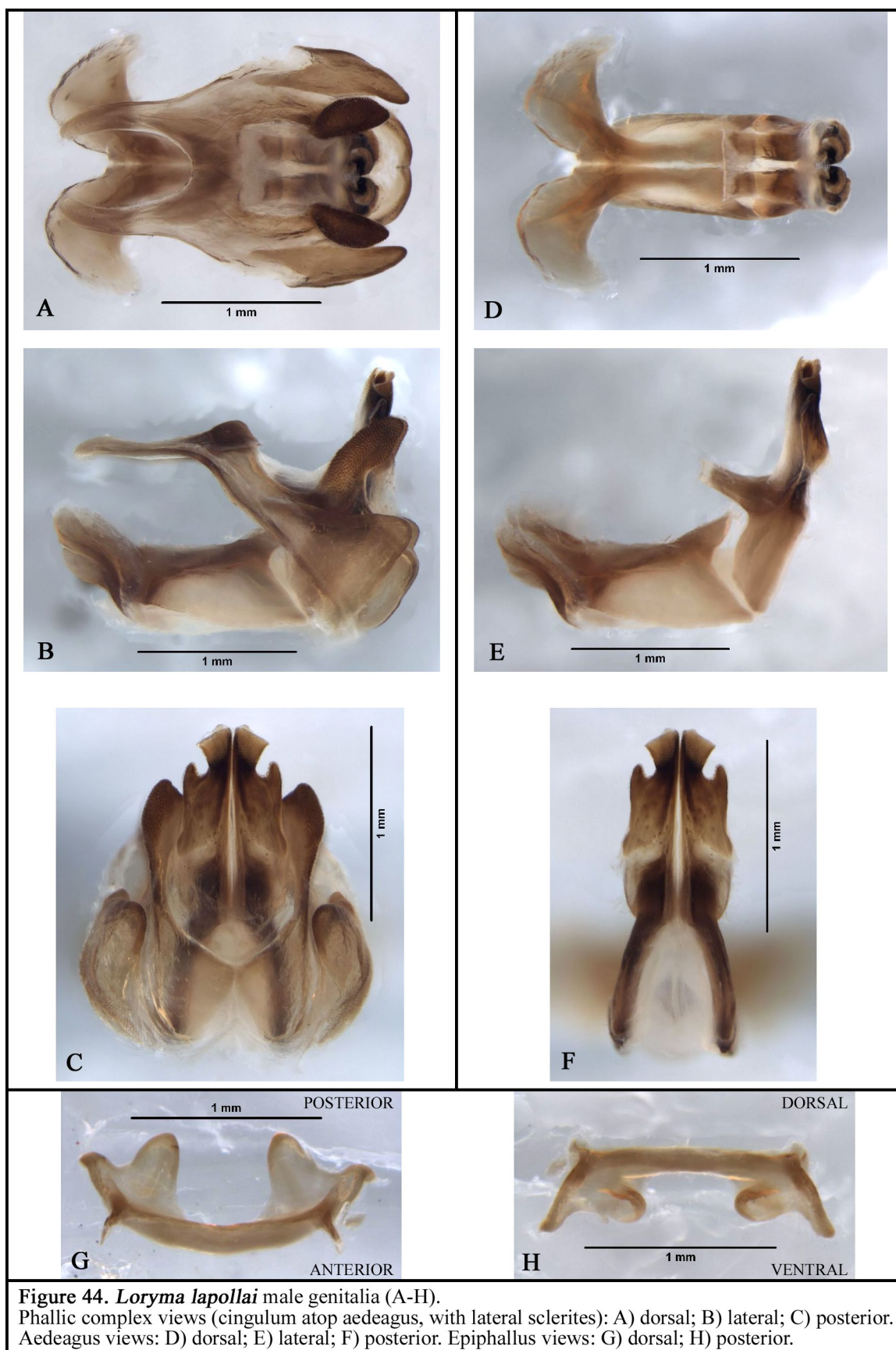


Figure 43. *Loryma lapollai* adult male external morphology (A-H).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



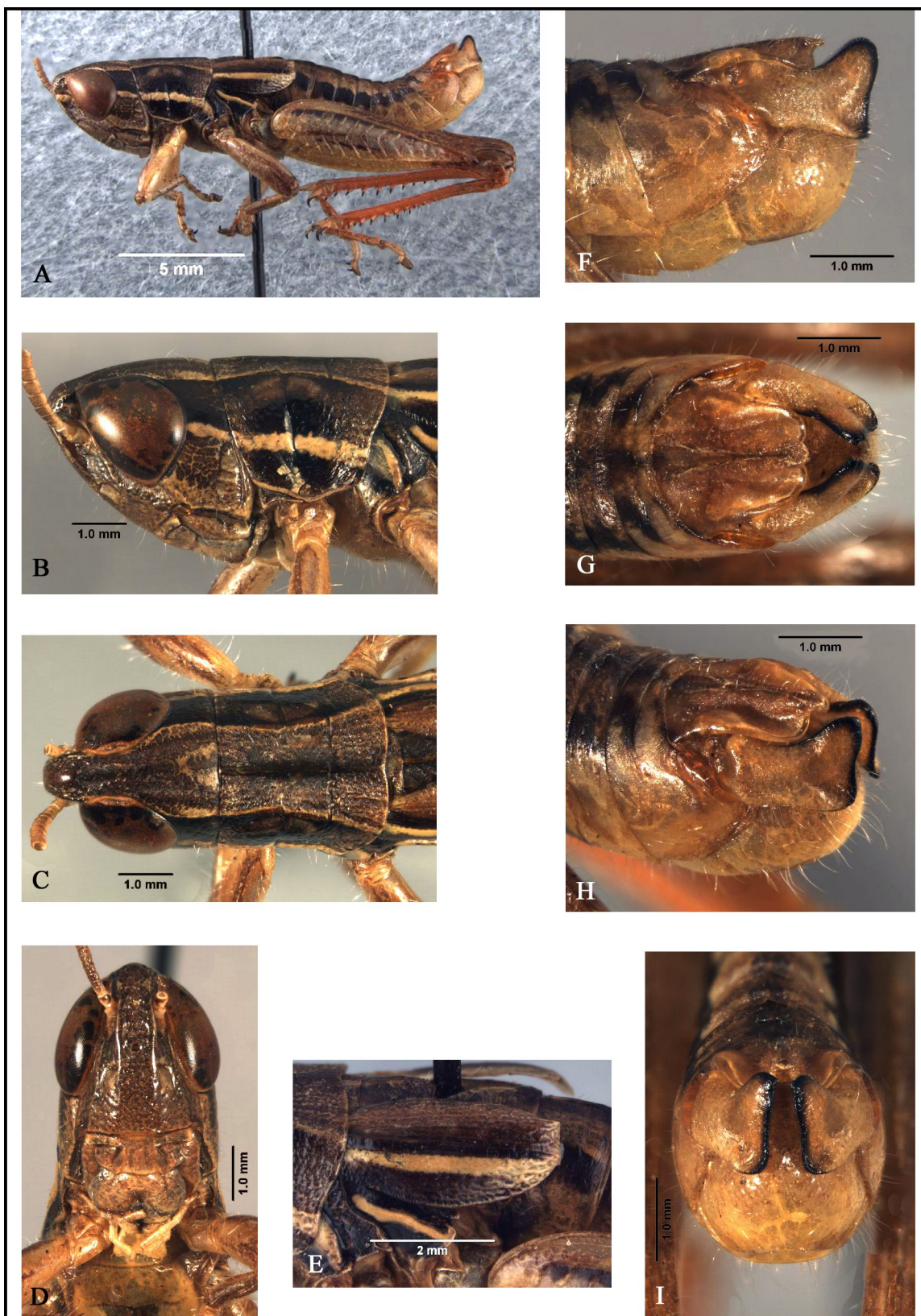
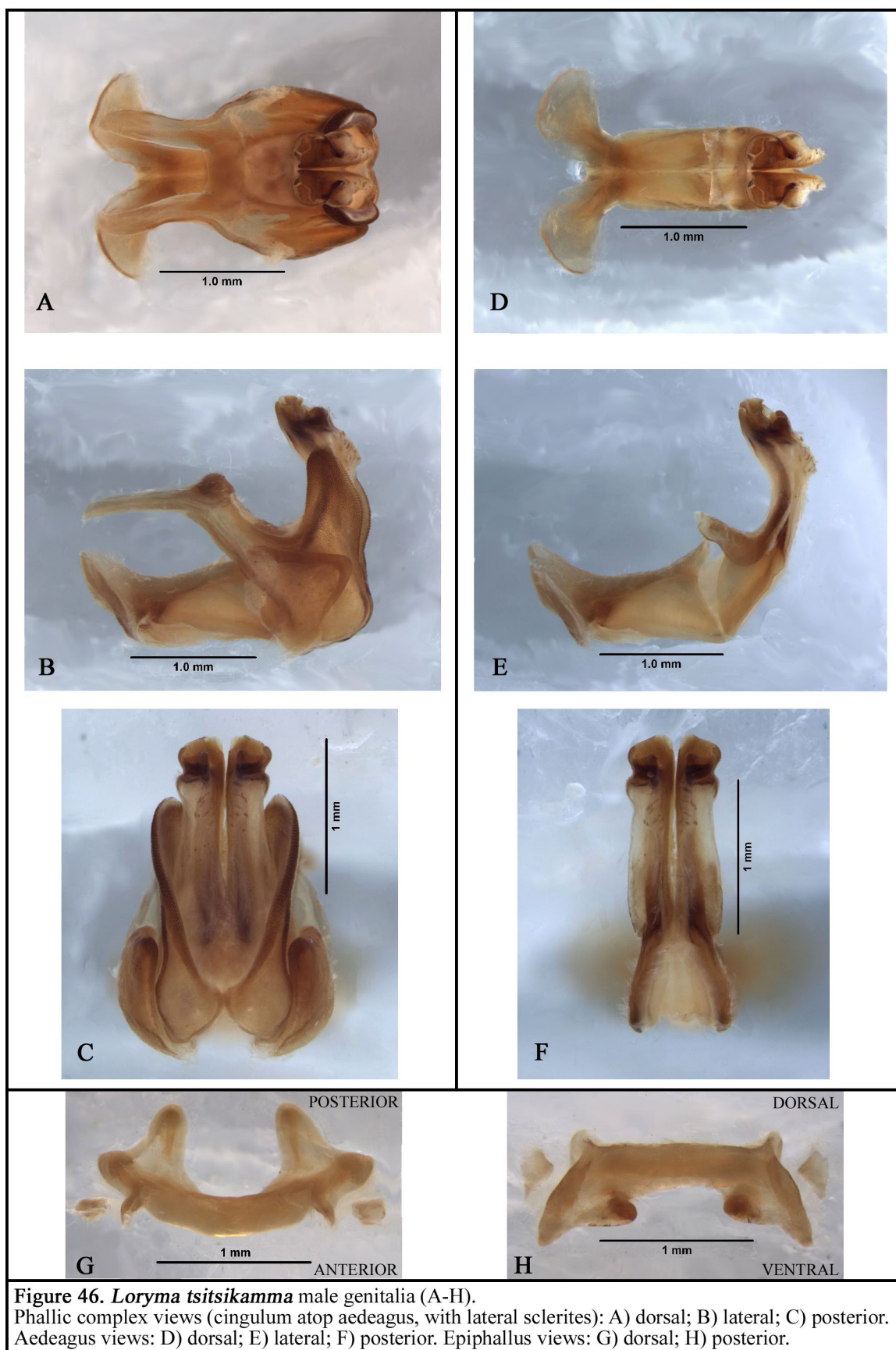


Figure 45. *Loryma tsitsikamma* adult male external morphology (A-I). A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen. Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



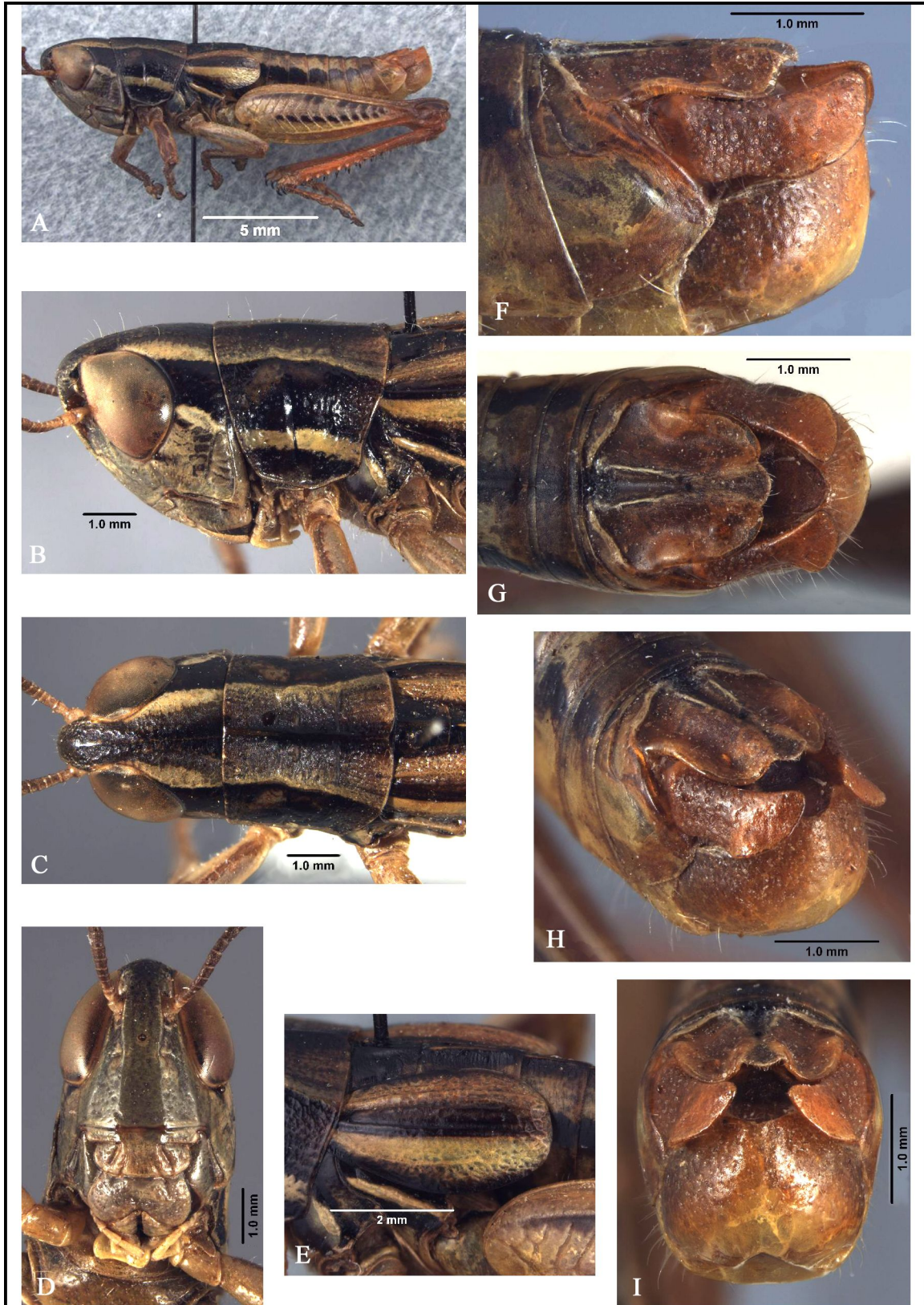
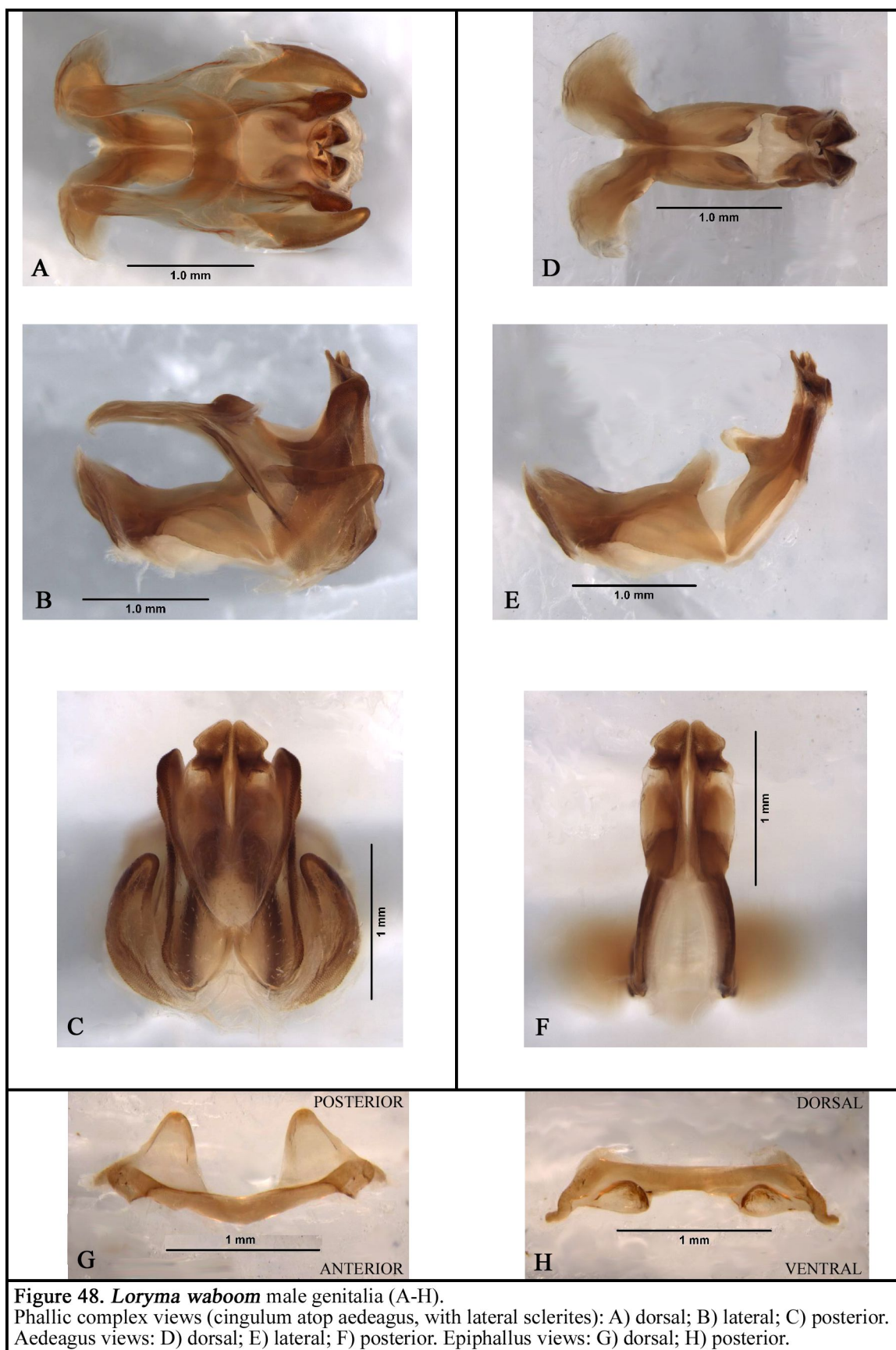


Figure 47. *Loryma waboom* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



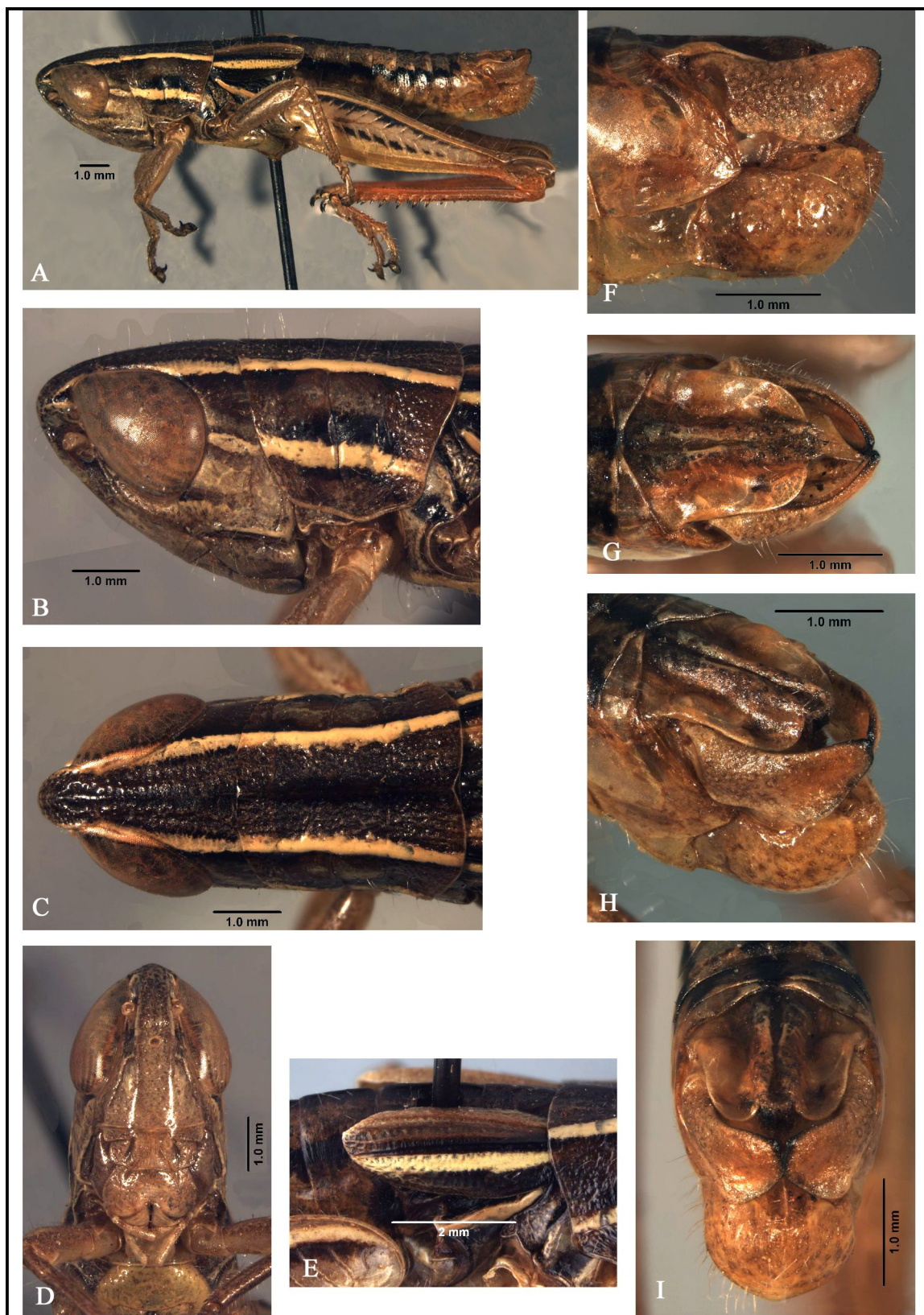
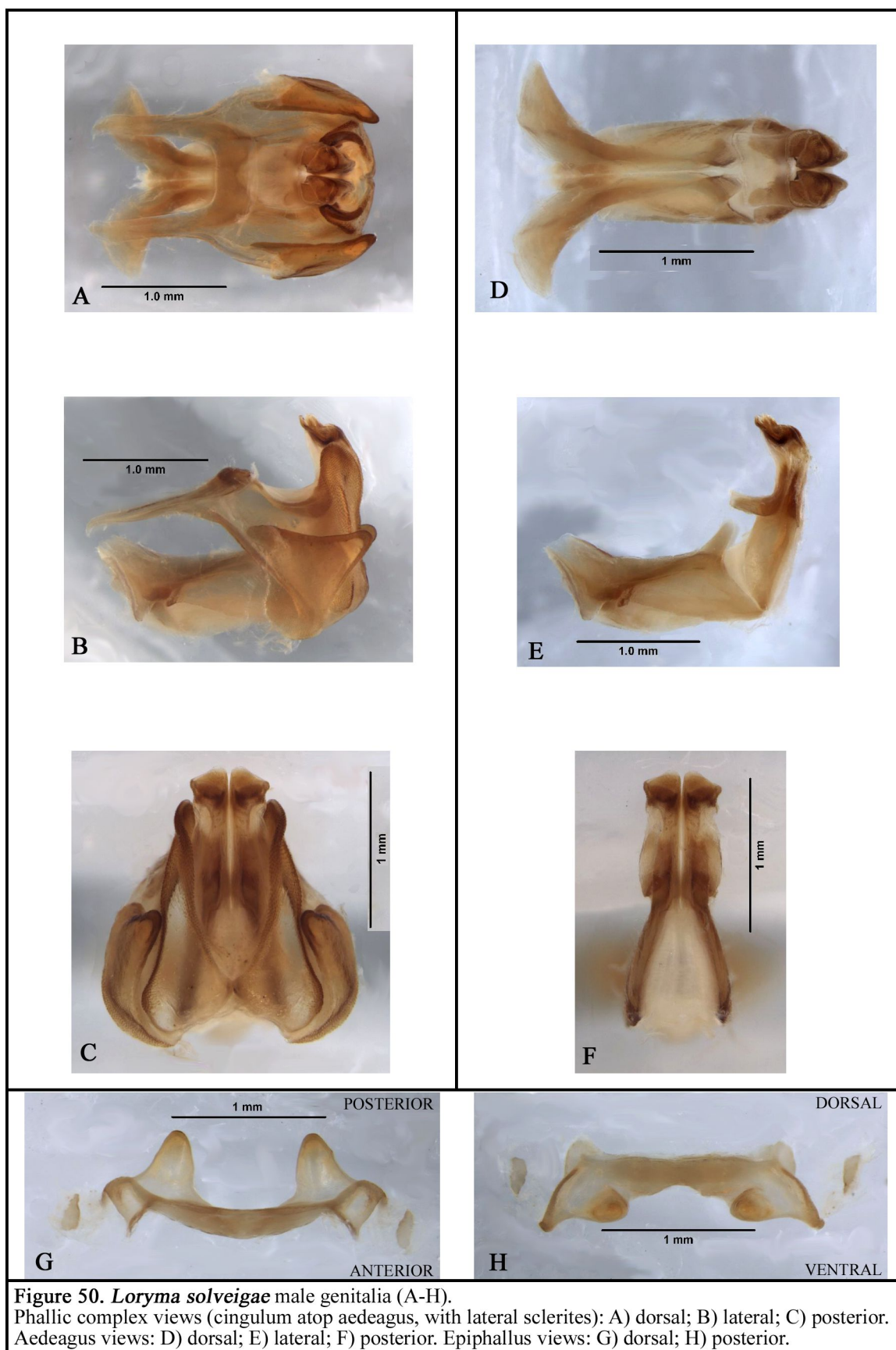


Figure 49. *Loryma solveigae* adult male external morphology (A-I). A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen. Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



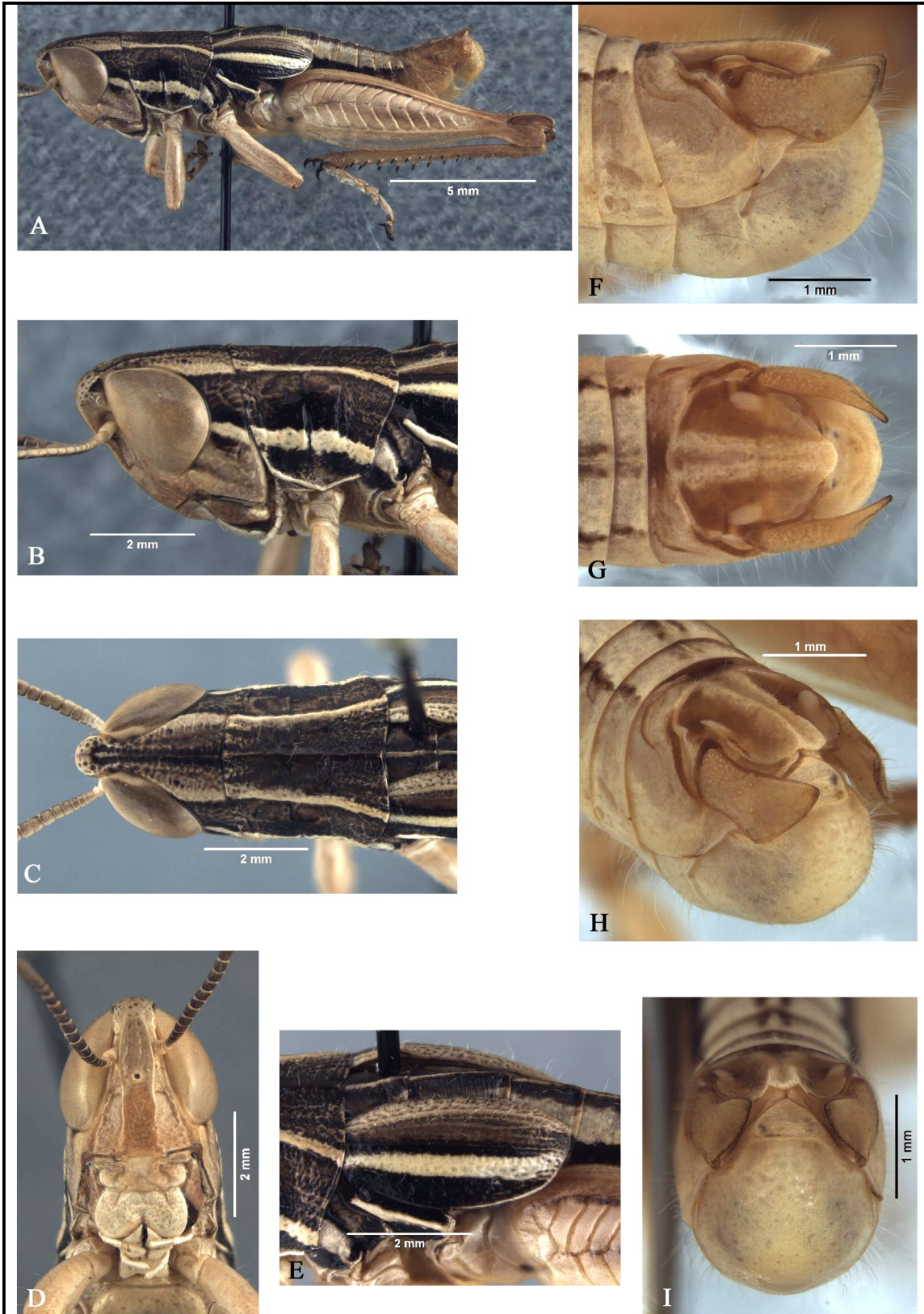
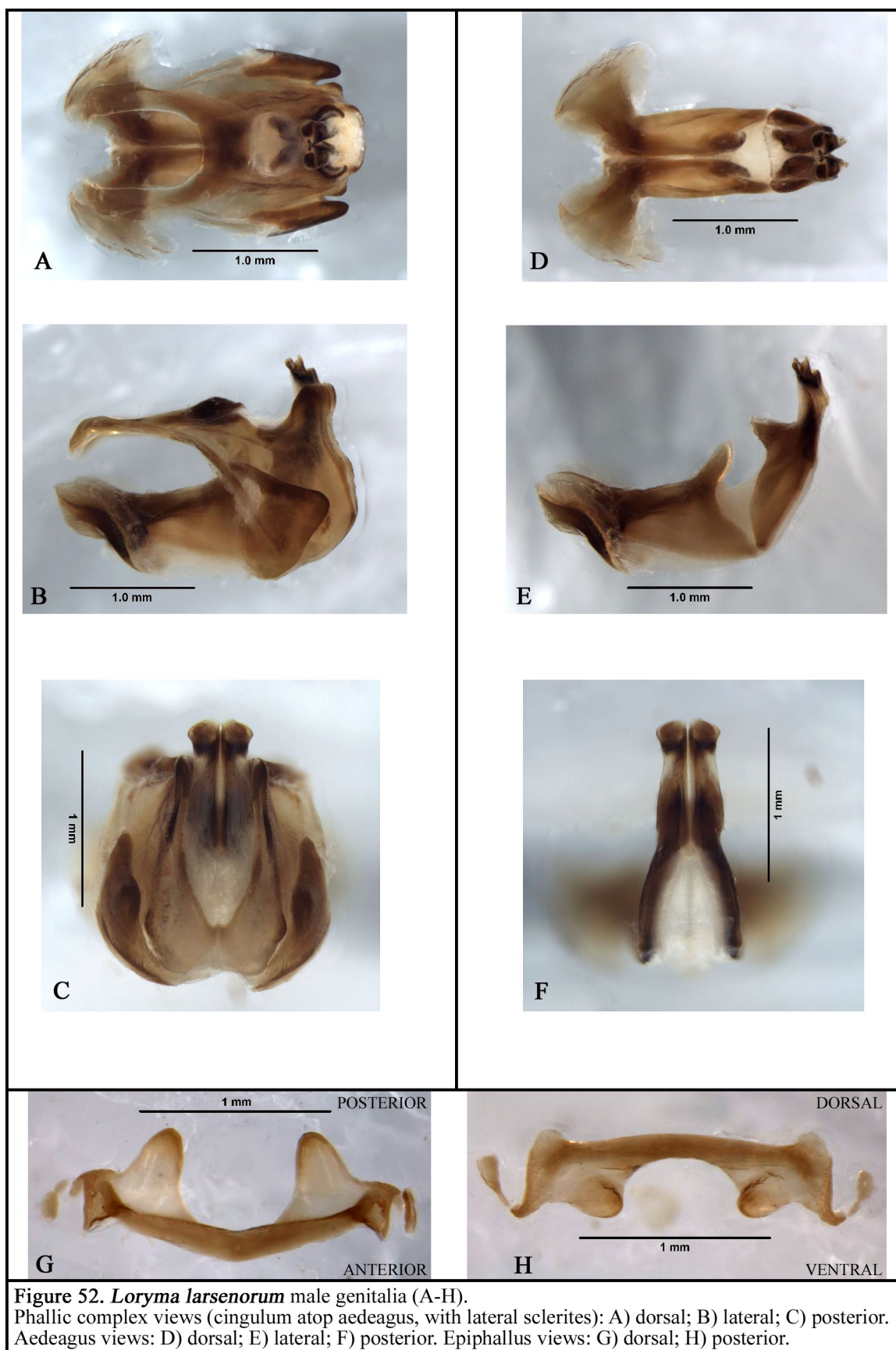


Figure 51. *Loryma larsenorum* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



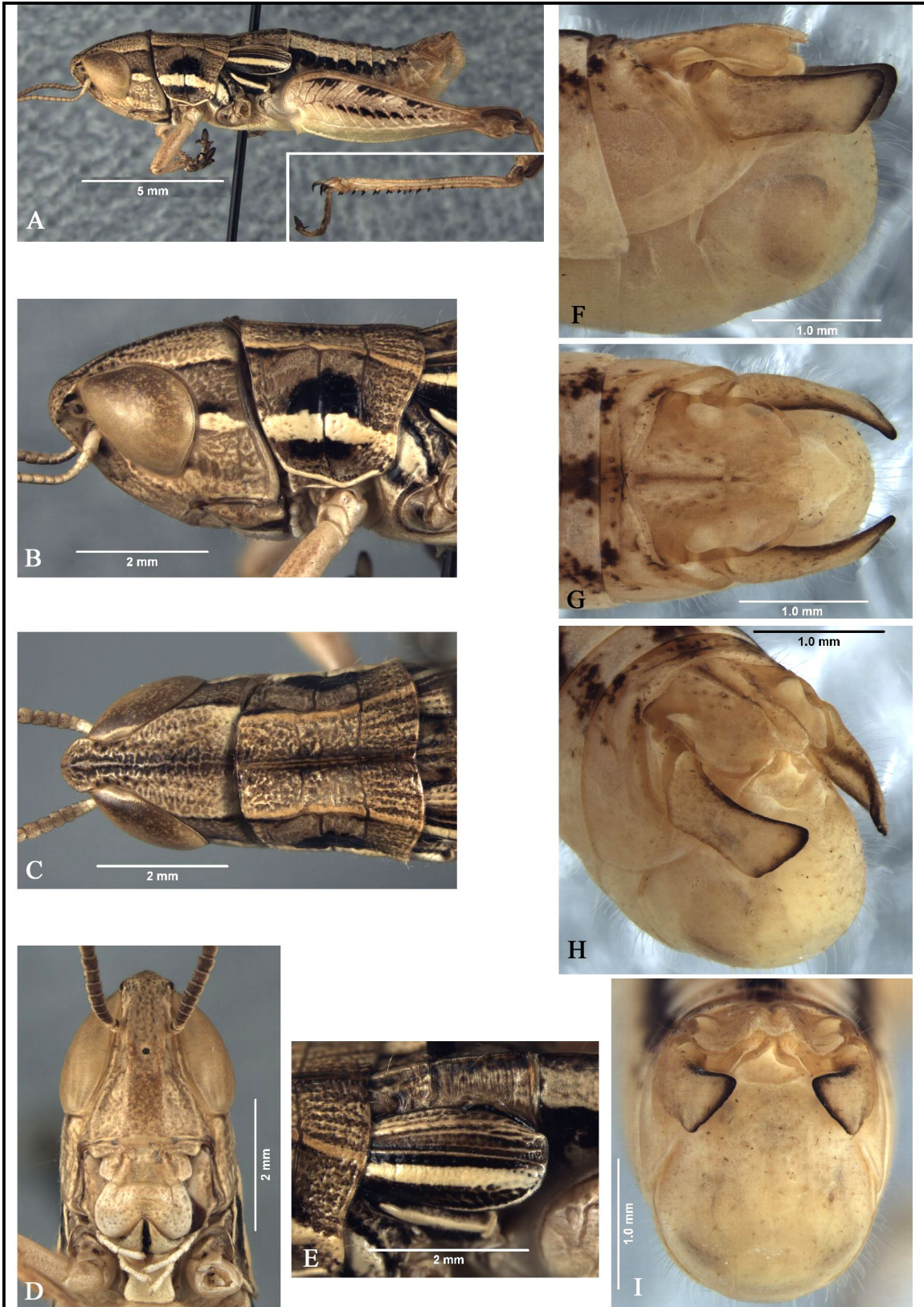
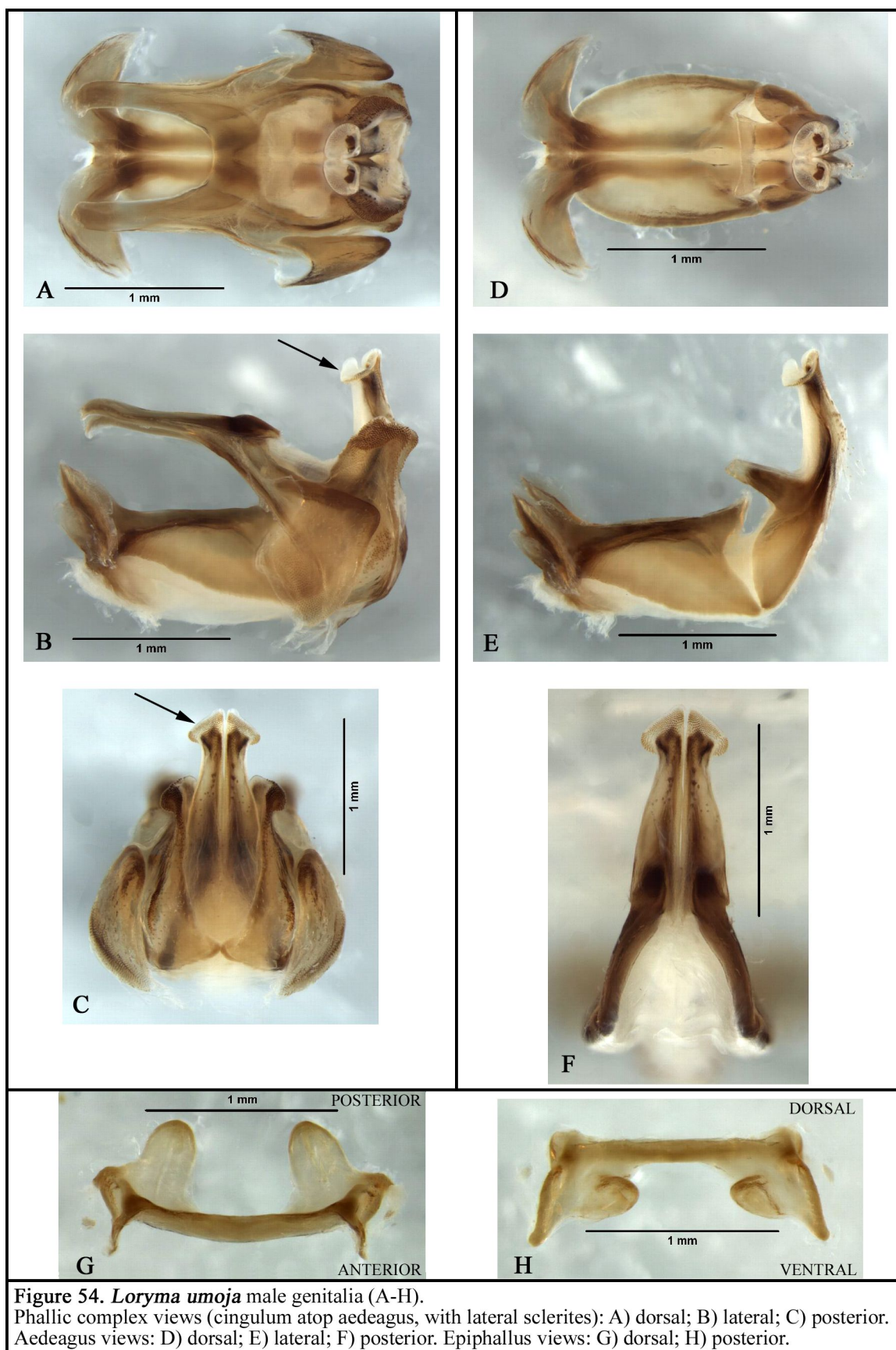


Figure 53. *Loryma umoja* male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



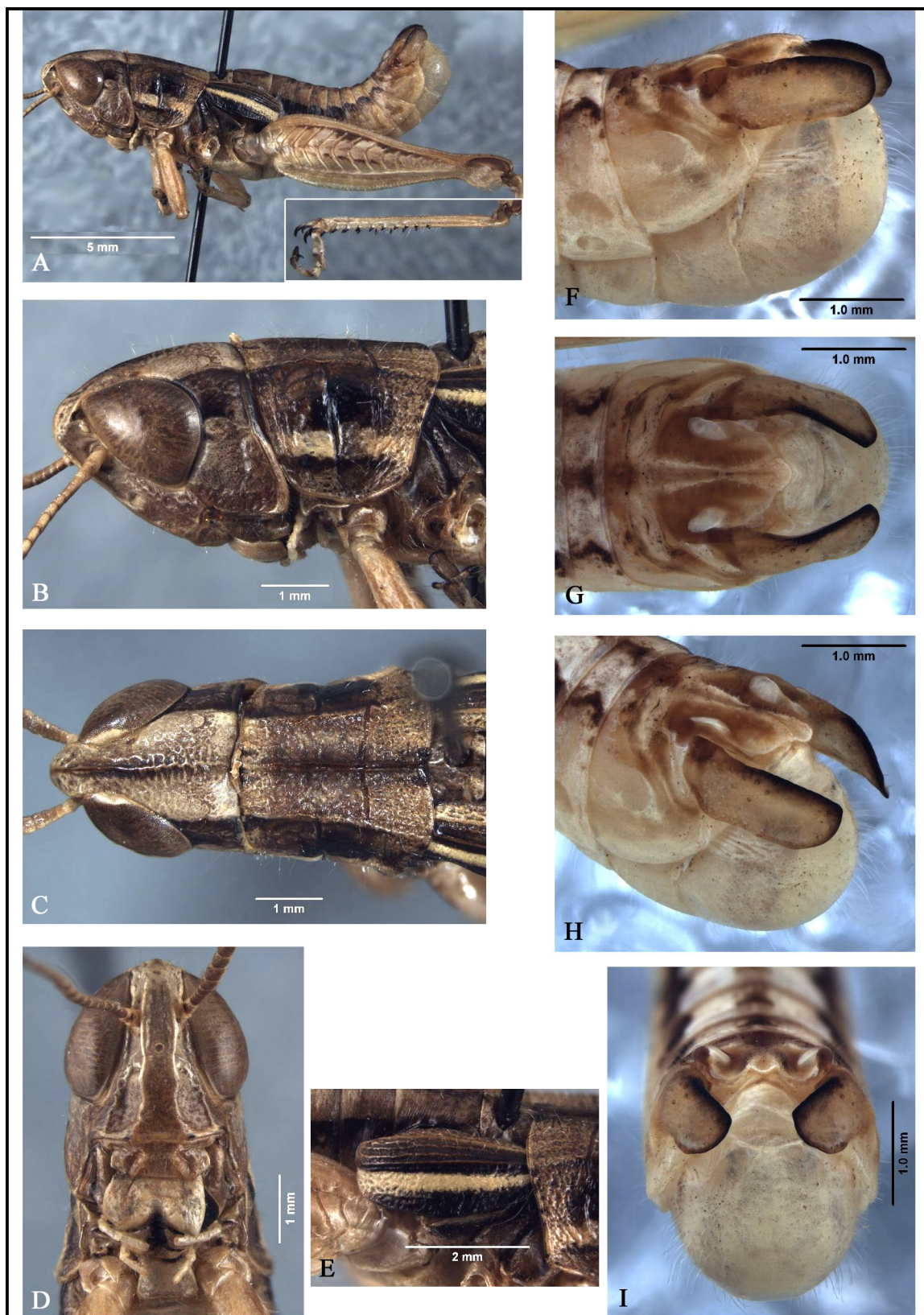
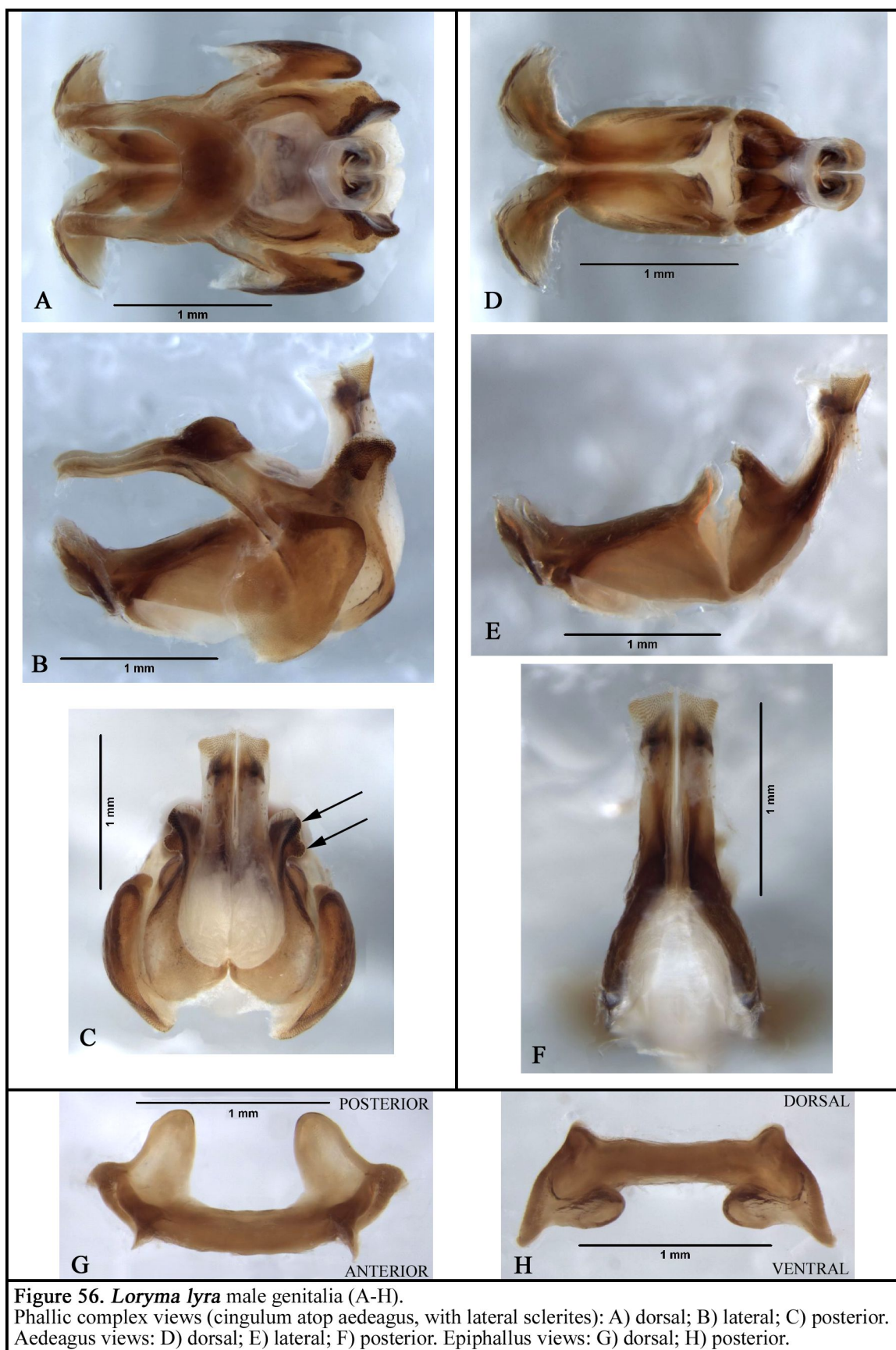


Figure 55. *Loryma lyra* adult male external morphology (A-H).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.



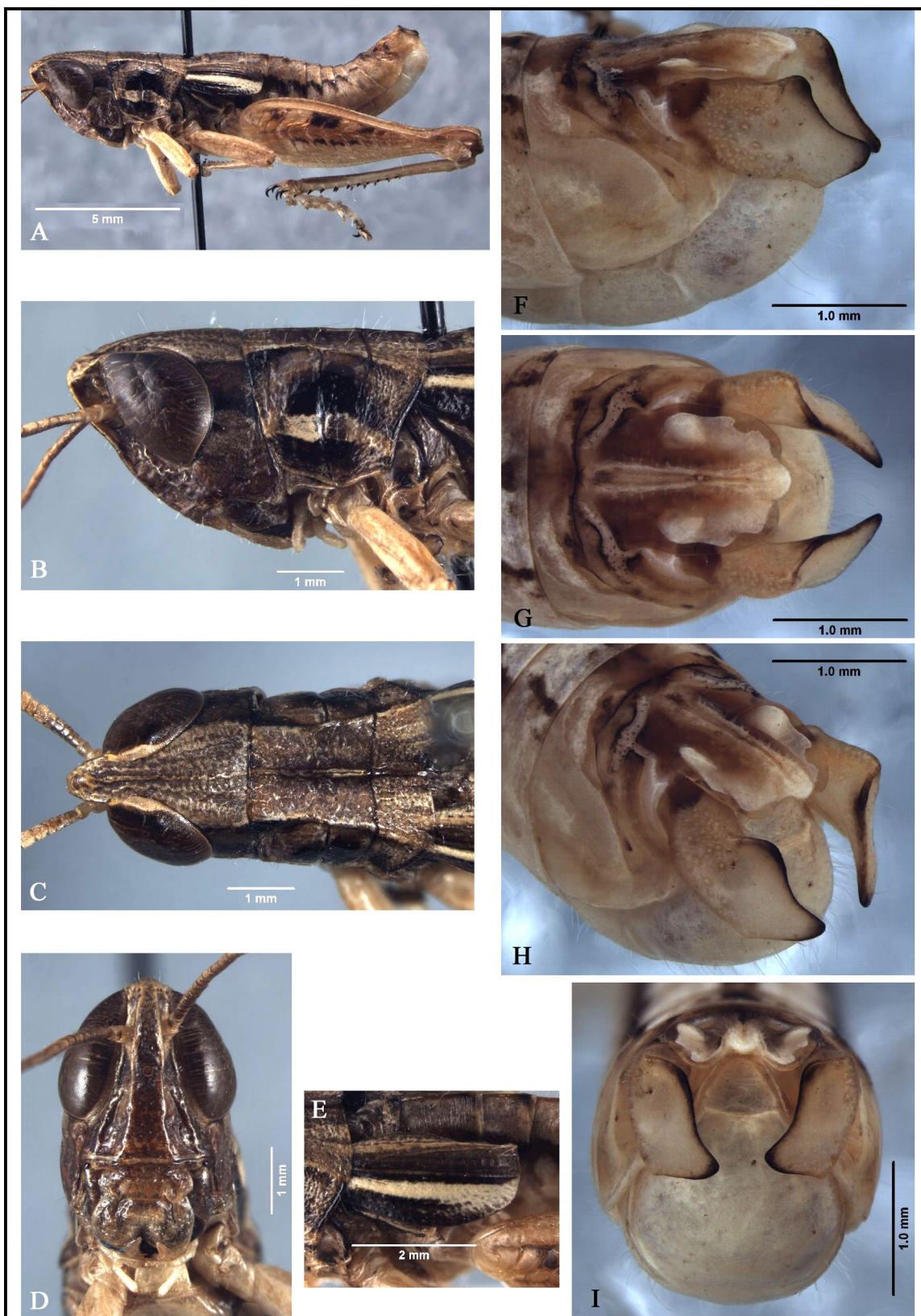
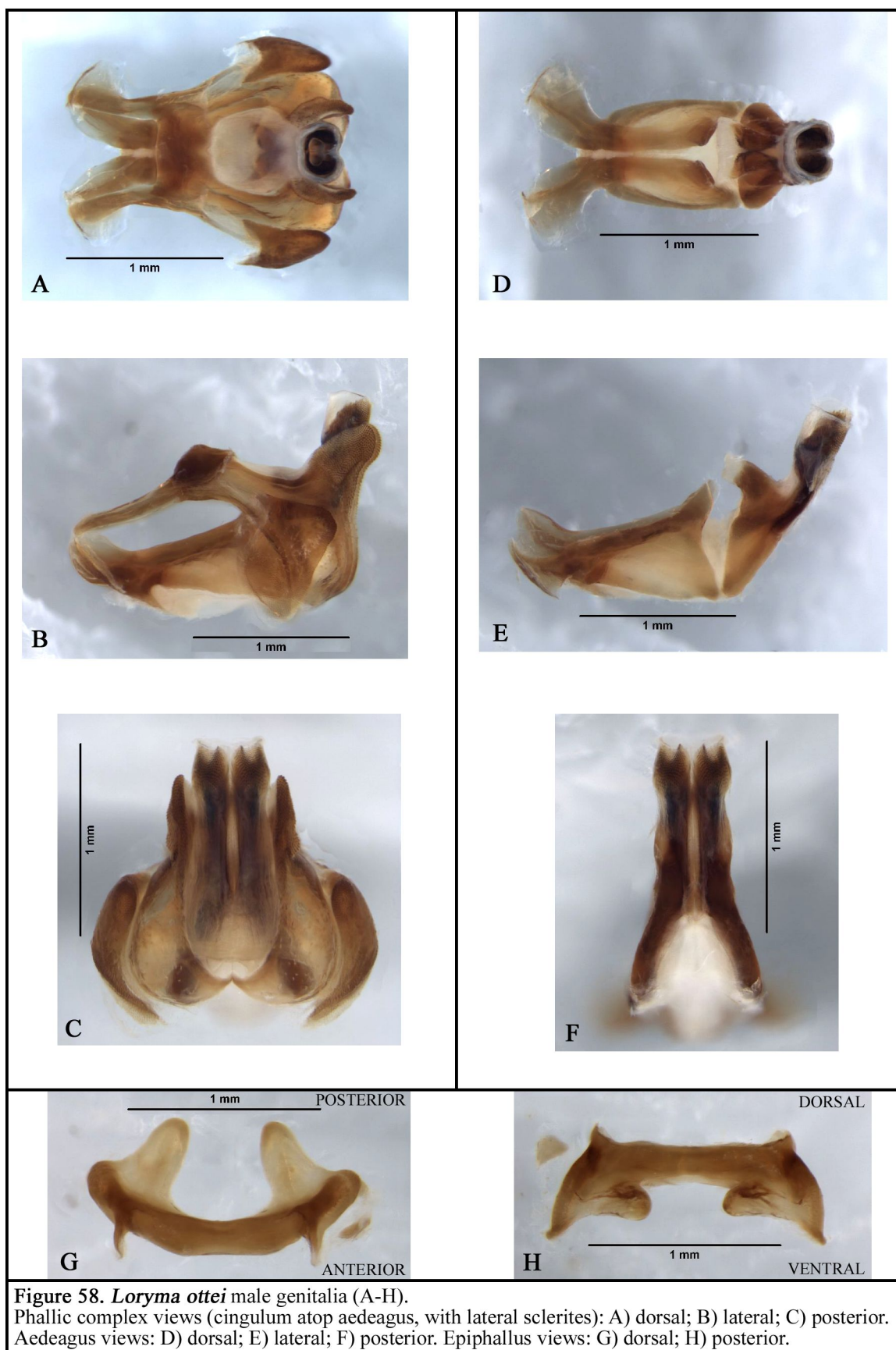


Figure 57. *Loryma ottei* adult male external morphology (A-I).
 A) body lateral; B) head and pronotum lateral; C) head and pronotum dorsal; D) head front; E) tegmen.
 Cerci views F-I: F) lateral; G) dorsal; H) three-quarter; I) posterior.

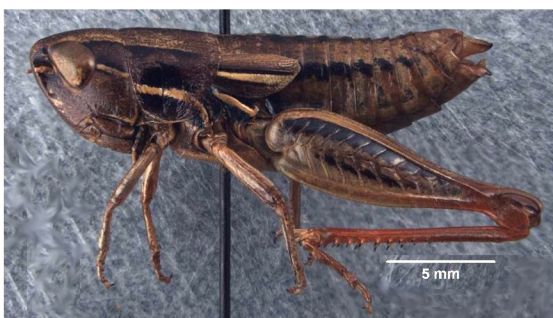




A) *L. magna*



B) *L. browni*



C) *L. tsitsikamma*



D) *L. khoi*



E) *L. mayi*



F) *L. ashleyi*



G) *L. carolynae*

Figure 59. *Loryma* females plate 1. Lateral view of external morphology for 7 species (A-G).



A) *L. namaqua*



B) *L. bonteboki*



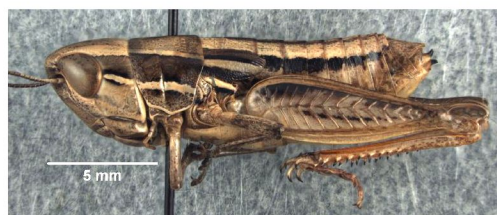
E) *L. ottei*



C) *L. karoo*



F) *L. lyra*



G) *L. zebrata*



D) *L. cederbergensis*



H) *L. mirabunda*

Figure 60. *Loryma* females plate 2. Lateral view of external morphology for 8 species (A-H).



A) *L. cederbergensis*, male



B) *L. cederbergensis*, female



C) *L. ottei*, male

Figure 61. *Loryma* species live photographs during field collection. Two species shown in A-C. All photos by D.Otte.



Figure 62. *Loryma* species photographs during field collection. Two species shown in A-D. Two *L. lyra* females showing color variation (C-D). All photos by D.Otte.



A) *L. larsenorum*, male



B) *L. umoja*, male



C) *L. umoja*, male

Figure 63. *Loryma* species live photographs during field collection (A-C). Two species shown in A-C. Two *L. umoja* males showing color variation (B-C). All photos by D.Otte.

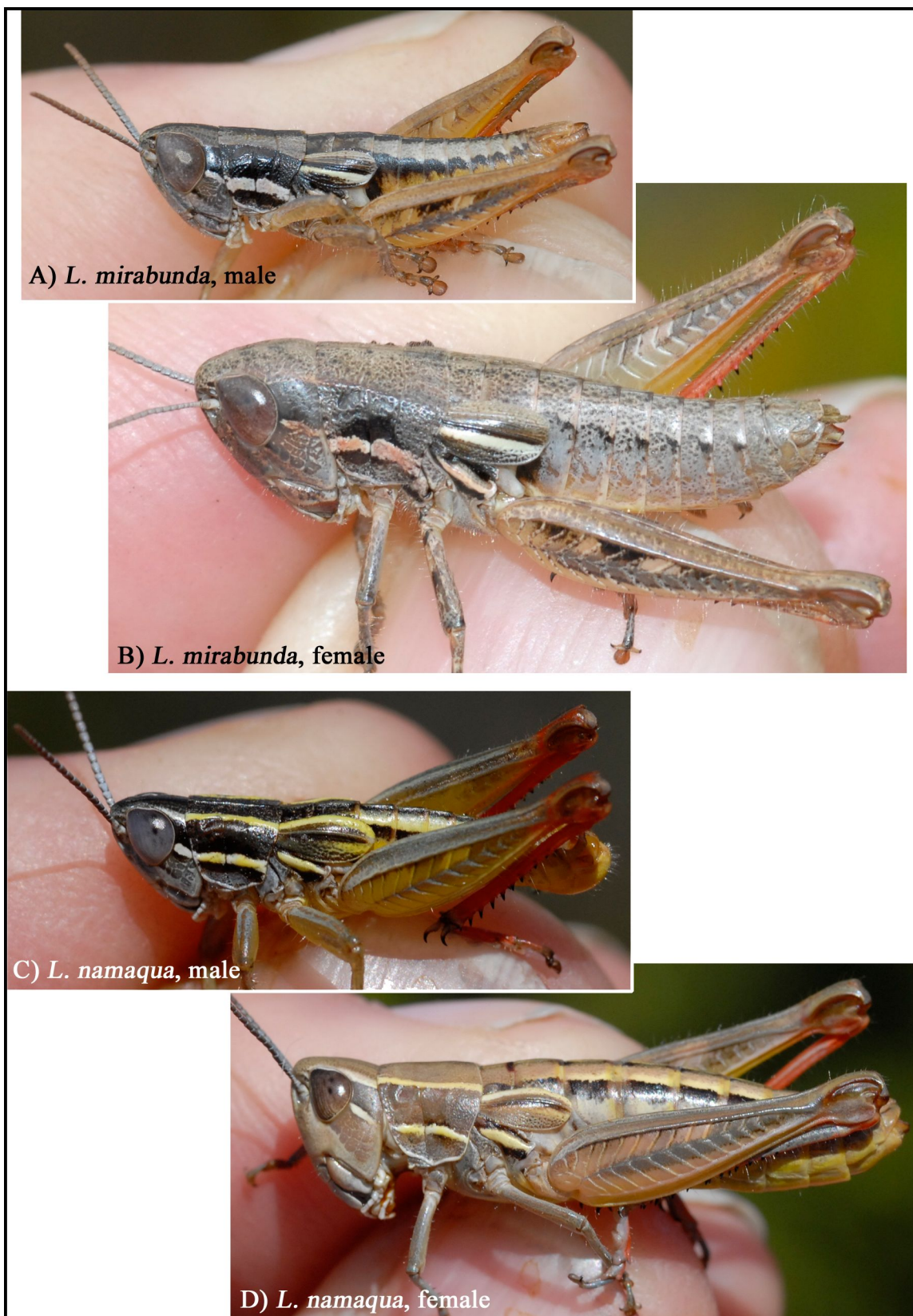


Figure 64. *Loryma* species live photographs during field collection.
Two species shown in A-D. All photos by D.Otte.

A) *L. bonteboki*, maleB) *L. bonteboki*, maleC) *L. bonteboki*, female dorsalD) *L. bonteboki*, femaleE) *L. bonteboki*, female

Figure 65. *Loryma* species photographs during field collection. One species shown in A-E. Two *L. bonteboki* females showing color variation (D-E). Note mites found on all specimens. All photos by L.Spearman.

A) *L. zebrata*, male



B) *L. zebrata*, male

Figure 66. *Loryma* species live photographs during field collection. One species shown in A-B. All photos by L.Spearman.

CURRICULUM VITAE

LAUREN A. SPEARMAN

Degree Dates

Arcadia University, Glenside, PA	Psycho-Biology	B.A., 1994 - 1998
Rutgers University, New Brunswick, NJ	Ecology & Evolution	Ph.D., October 2009

Appointments

2008, Spring	<i>Adjunct Instructor</i> , Dept. of Biological Sciences, Towson University, Towson, MD (Course: Ecology and Evolution)
2006 - <i>Present</i>	<i>Graduate Research Collaborator</i> (Entomology), National Museum of Natural History, Washington, DC
2001 - <i>Present</i>	<i>Graduate Research Collaborator</i> (Entomology), Academy of Natural Sciences, Philadelphia, PA
2002 - 2005	<i>Teaching Assistant</i> , Rutgers University, Life Sciences Division (Course: Anatomy & Physiology, 2 nd and 3 rd year as Head TA)
2001 - 2002	<i>Teaching Assistant</i> , Rutgers University, Life Sciences Division (Course: General Biology)
2000 - 2001	<i>Staff Scientist I</i> , Patrick Center for Environmental Research, Academy of Natural Sciences
1999 - 2000	<i>Museum Intern</i> , Biodiversity Division, Academy of Natural Sciences
1999 - 2000	<i>Administrative Assistant</i> , Scientific Publications Department, Academy of Natural Sciences
1997 - 2001	<i>Department Intern</i> , Department of Entomology, Academy of Natural Sciences
1998	<i>Research Assistant</i> and <i>Assistant Program Director</i> , Bioko Primate Protection Program, Beaver College (now Arcadia University), Glenside, PA (BPPP is now at Drexel University, Phila., PA)
1996	<i>Zoo Intern</i> , Sobell's Primate Pavilion, The Zoological Society of London, England

Publications

Ware, J., J. Litman, K. Klass and **L. A. Spearman**. 2008. Relationships among the major lineages of Dictyoptera: the effect of outgroup selection on dictyopteran tree topology. *Systematic Entomology*. 33, 429-450.

Naskrecki, P., C. S. Bazelet, **L. A. Spearman**. 2008. New species of flightless katydids from South Africa (Orthoptera: Tettigoniidae: Meconematinae). *Zootaxa* 1933: 19-32.

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