TAXONOMIC STUDIES IN THE METALLIC WOOD-BORING BEETLE FAMILY (COLEOPTERA: BUPRESTIDAE*: SPHENOPTERA* AND *CHALCOPHORA*)

by

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of the requirement for the degree
of

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in

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ABSTRACT

Taxonomic studies of groups of *Sphenoptera* Dejean and *Chalcophora* Solier are presented, resolving several long-standing problems. Species of *Sphenoptera* of interest for potential use as biocontrol agents for the noxious weed *Chondrilla juncea* are reevaluated taxonomically. Results of field surveys conducted to increase knowledge of the biology of these species are reported, with little indication of these species' potential for biological control.

The *Sphenoptera* of the former U.S.S.R. are divided into 39 species-groups. Each species group is characterized on adult morphology, illustrations were provided, the member species listed, and distributions noted. Both a classic dichotomous key and an electronic LUCID key are provided for these species-groups to assist in identification.

The species-groups *Sphenoptera* (*Sphenoptera*) exarata-group and *S.* (*Deudora*) rauca-group are revised, with 5 and 7 species respectively. Each included species is redescribed, diagnosed, illustrated, and distribution and taxonomic histories documented. Dichotomous and electronic keys are provided for the species of these species groups. The species *Sphenoptera clarescens* Kerremans and *Sphenoptera egregia* Jakovlev are synonymized with *Sphenoptera signata* Jakovlev and *Sphenoptera lateralis* Faldermann, respectively.

The status of two North American names in *Chalcophora* Solier -- *C. angulicollis* (LeConte) and *C. virginiensis* (Drury)-- is resolved, with both now being recognized as valid. All North American (north of Mexico) *Chalcophora* are redescribed, diagnosed, keyed, and their nomenclature and distributions reviewed.

Disclaimer: This thesis is not intended to meet the provision of the ICZN (1999) regarding the publication of new nomenclatural acts [Art. 8.2]. No name or nomenclatural act proposed herein should be considered available as defined by the ICZN.

CHAPTER 1:
INTRODUCTION

The Family Buprestidae

Buprestidae is a large and diverse family of beetles, in the superfamily Buprestoidea, commonly known as the metallic wood-boring beetles. These large and often colorful beetles are found in terrestrial habitats worldwide, except in Antarctica. Larvae develop in plant tissue: some are leaf miners (e.g. *Trachys* spp., *Brachys* spp.), some form galls on limbs and twigs (e.g. *Agrilus* spp.), some bore through the roots of plants (e.g. *Sphenoptera* spp.), but a majority bore into the wood or bark of living or dead trees (Nelson et al. 2008).

The approximately 14,600 named species in Buprestidae are presently placed into 469 genera, 48 tribes, and 6 subfamilies (Bellamy and Volkovitsh 2005). The large number of species and incredible diversity of forms warrants the use of higher-level taxa such as subfamilies, tribes, subgenera, and species-group names, which aid in the organization and study of the family. The currently accepted higher-level classification can be found in Bellamy (2003, 2008), however, the prevalence of ambiguous characters, enormous variation within species, and lack of modern phylogenetic analysis has led to much disagreement over the higher classification of Buprestidae, and the placement of many taxa is still uncertain. Despite having received much study, there remain many taxonomic problems worthy of study in this family.,

The history of the classification of Buprestidae is a long one. The name *Buprestis* predates Linnaeus' system of classification and is derived from the Greek words *bous*

"cattle", and *prestos* "to inflate", which actually refers to the Greek name for another family, the Meloidae (Verdugo 2005). Linnaeus used the name *Buprestis* as a generic name for the first 19 species of metallic wood-boring beetles described (Linnaeus 1758, Nelson et al. 2008).

The family-group name Buprestidae was first proposed by Leach (1815). Prior to his description, all named "buprestids" were placed in the genus *Buprestis* Linnaeus 1758 or *Trachys* Fabricius 1801. It was not long after the description of Buprestidae that Dalman (1817) divided the family into two groups, "Exscutellatae" and "Scutellatae", based on the presence or absence of a visible scutellum (Hołyński 1993).

The next era of buprestid systematics involved placing the then known species into newly defined genera. In 1833, Dejean coined several new generic names in his catalogue of Coleoptera, including the genera *Chalcophora* Dejean and *Sphenoptera* Dejean. These two groups are presently riddled with taxonomic problems, whose solutions should be relevant to other areas of biological research. *Sphenoptera* have potential for use as biological control agents, and studies of *Chalcophora* may lead to biogeographical insights. Each of these groups is discussed separately below.

Goals and Objectives

The overall goal of my thesis research was to address specific taxonomic and life history issues within the family Buprestidae, specifically the two aforementioned genera: *Sphenoptera* and *Chalcophora*.

The specific objectives addressed in the following chapters are:

Chapter 2: to clarify the identities of several candidate species in *Sphenoptera* Dejean 1833 for use as a biological control agent for the noxious weed *Chondrilla juncea*.

Chapter 3: to refine the definitions of Mark Kalashian's *Sphenoptera* Dejean 1833 species-groups for the Western Palaearctic based on extensive examination of the morphology of type specimens, non-type material, and review of previously-published species descriptions. This should make it easier for biological control workers to identify western Palaearctic *Sphenoptera* to at least species-group and potential biological control agents to species.

Chapter 4: to resolve taxonomic problems for the two species-groups in *Sphenoptera* Dejean 1833 which contain the candidate species for biological control.

Chapter 5: to resolve the ambiguity concerning the species status of two North American species of *Chalcophora* Solier 1833 – *C. angulicollis* (LeConte) 1857 and *C. virginiensis* (Drury) 1770.

Electronic Addendum: to develop a computerized illustrated electronic key in LUCID ® for species-groups of *Sphenoptera* Dejean 1833 in the former U.S.S.R. to allow for consistent and easy identification by non-specialists.

CHAPTER 2:
BIOLOGICAL CONTROL OF *CHONDRILLA JUNCEA* USING BEETLES IN THE GENUS *SPHENOPTERA*

Introduction

Of particular interest to this study are three species of *Sphenoptera* that have been documented to feed on plants of the genus *Chondrilla*: *S. foveola* (Gebler), *S. clarescens* Kerremans, and *S. signata* Jakovlev. All three species are rhizophagous; the larva feeds on the roots of *Chondrilla,* creating a tunnel in sandy soil built from a mixture of latex from the plant and the surrounding soil. The larva then pupates in a pupal chamber made of sand and latex, and emerges as an that adult feeds on foliage and oviposits at the base of the *Chondrilla* plant (Emelyanova et al. 1932). *Sphenoptera* species have been subjects of past biological control research (for *Chondrilla* and other weeds) and show promise for weed biological control. One species, *S. jugoslavica* Obenberger, has been successfully released and established for biological control of *Centaurea diffusa* Lam. in the western U. S. (Wilson et al. 2004). *Chondrilla* biocontrol research has been performed on two *Sphenoptera* species and a third was recently reported on *C. juncea* in Turkey.

Sphenoptera (Deudora) clarescens, the first *Chondrilla*-feeding species, was described by Kerremans in 1909 from a single specimen from Luristan, Persia (now Iran) in von Bodemeyer's collection. The holotype remained the only representative of the species until 1978, when a beetle found by S. Hasan (1978) feeding on *C. juncea* in Iran was identified by Dr. A. Descarpentries in Paris, France, as this species (Hasan 1978).

The populations in the north-central regions of Iran were reported to be quite large, though only a single specimen is known from adjacent Azerbaijan. Hasan documented the biology and host preferences. However, the beetle's host range was not specific enough and it was deemed too risky for release as a biological control agent. In 2005, *S. clarescens* was found again, this time in eastern Turkey, feeding on *C. juncea* (Littlefield and Markin 2005).

Unfortunately, some of Kerremans' types and Hasan's vouchers have not been located by past workers (Volkovitsh, pers. comm.), so questions remain surrounding this species. Are the species described by Kerremans and identified by Descarpentries the same species? Is *S. clarescens* a valid species, and does it feed solely on *C. juncea*? And did the specimens collected and reared by Hasan belong to a single species, or were multiple similar species used in his trials?

The second of these species, in Kalashian's *Sphenoptera* exarata-group (Kalashian, pers. comm.), *S. (s. str.) foveola*, was named in 1825 by Gebler from a specimen from north of Lake Zaisan in Kazakhstan. It has long been known to feed on species of *Chondrilla*, as it is a pest on *C. ambigua* grown for rubber production. The first major work on the biology of the species was conducted by scientists in that industry. Emelyanova et al. (1932) described the life cycle and biology of *S. foveola*. In addition, they described the host range of the beetle in *Chondrilla* species in Kazakhstan, detailed the larval habits, and identified several parasitoids.

More recent studies on *S. foveola*, though, have been in relation to their use as a biological control agent for *C. juncea*, rather than as a pest. Interest in *S. foveola* as a

biological control agent has been revived by the Russian Biocontrol Group in St. Petersburg, Russia, where they have conducted the most thorough studies to date on the biology and life history of *S. foveola* and its relationship to a different species of *Chondrilla*, *C. ambigua*. Studies of host-range and oviposition studies have been conducted in the field in Kazakhstan and in the lab in St. Petersburg (Dolgovskaya and Cristofaro 2005).

A third species, in Kalashian's *Sphenoptera* rauca-group (Kalashian, pers. comm.), *S.(Deudora) signata* Jakovlev was reported in both Turkey and Armenia to feed on *C. juncea* (Mark Volkovitsh, pers. comm.). Adults and larvae were taken and reared from *C. juncea* in Turkey, and identified as *S. signata*, and in Armenia, *S. signata* was taken in sweep samples where *Chondrilla* was present and foliage was dense.

Thorough systematics research is integral to biological control programs, because it can rule out inadequate species and possibly mean the difference between introducing a monophagous or polyphagous species. Here, I resolve the taxonomic problems in the two species-groups in *Sphenoptera* which contain the candidate species for biological control, the *S.* exarata- and *S.* rauca-groups, to ensure that the identities of the candidate species are fully understood. In addition, I located both the type material of *S. clarescens* and vouchers from Hasan's biological control study, to determine whether the species described by Kerremans is indeed the same species that was collected by Hasan in Iran.

In addition, I traveled to the native range of *C. juncea* to make preliminary biological observations concerning the plausibility of an introduction to the U. S. of one of the candidate species for use as a biological control agent and to collect beetles for the

establishment of a colony of *Sphenoptera* spp. in quarantine in Bozeman, Montana, USA.

Materials and Methods

Field Methods

One of the major goals of this project was to retrieve enough individuals of the candidate biological control agents to establish and maintain a viable colony in quarantine in Bozeman, Montana. I traveled to the native range of these *Sphenoptera* species to explore the native habitat and collect all life stages of the beetles. The eastern European countries of Turkey and Armenia fall within the range of two of the three biocontrol candidate species, and thus are ideal regions in which to conduct my fieldwork.

From 3-21 June 2008, I traveled to central and southern Armenia (Figure 1), as well as central Turkey (Figure 2), to collect *Sphenoptera* species from *C. juncea*. I traveled with Mark Yu. Kalashian from the Armenian Academy of Sciences, Michael A. Ivie from Montana State University, and Mark G. Volkovitsh from the Russian Academy of Sciences in Armenia, and I was accompanied by Massimo Cristofaro BBCA, Italy, Alessio DeBiase, University of Rome, Michael A. Ivie, and Urs Schaffner from CABI, Switzerland, in Turkey.

I chose 41 of sampling localities in both Armenia and Turkey, so as to optimize the area collected in the limited time that we have in the field. Sites were chosen based on several factors. First and most important, I concentrated on sites in close proximity to past recorded collection localities for either *S. signata* or *S. foveola*. In Armenia, Gorovan

Sands (3.3km ESE of Vedi, 39˚53'38.1" N; 44˚44'06.7" E) and Aragats Mountains, (0.9km S of Byurakan, 40˚19'22.0" N; 44˚16'02.2" E) were chosen because of verified collection of *S. foveola* and *S. signata*, respectively, in the past. In Turkey, *S. signata* larvae were reported by Massimo Cristofaro, feeding on *Chondrilla* between Ürgüp and Yeşilhisar along Route 50-09 (38.53248˚ N; 35.11176˚ E) and between Kayseri and Avanos on Route D300 W (38.68060˚N; 35.20985˚ E) and, therefore, collection efforts were centered near those two localities.

Additionally, habitat availability played a role in site selection. Areas with abundant *Chondrilla* plants and sandy soil are ideal habitats for *S. foveola* and *S. signata* (Emelyanova et al. 1932), and therefore were specifically targeted among sampling sites.

Once in the field, I searched for living adults, feeding damage, larvae, pupae, and eggs. Some specimens of both the biological control candidate species, as well as all other *Sphenoptera* species, were to be killed and preserved in 95% ethanol for further morphological and potentially genetic study. I also attempted to observe the living beetles in the field, to make note of habitat preferences, host preferences, and life cycle.

Two methods of collection were used based on the biology and habits of *Sphenoptera* (Emelyanova et al. 1932): sweeping/beating and digging. When resting, *Sphenoptera* adults remain on the stem of their host plants or on other nearby vegetation. To collect adults, I swept *Chondrilla* plants and the surrounding vegetation with a sweep net in areas where the vegetation is low and herbaceous and I beat vegetation with a beating sheet and stick where vegetation was either too high or too thorny for sweep netting. In addition, we took note of and collected other invertebrates found feeding on

Chondrilla.

To find the rhizophagous larvae, I dug into the soil surrounding the *Chondrilla* plant, then gently dislodged the plant from the surrounding soil and examined the roots, crown, and soil for any feeding damage, active larvae, eggs, or pupae.

Living specimens, along with a portion of the host plant, were placed in 6 oz plastic containers with screw-top lids and placed in a cooler to prevent overheating of the specimens. The beetles were to then be transported back to Bozeman using protocols defined by APHIS and brought to a quarantine facility in Bozeman, Montana.

Materials

The second goal of this study was to clarify the specific indentities of the candidate agents. This required the examination of pinned material in the genus Sphenoptera from several museums.

The material examined for the *Sphenoptera* biological control research was borrowed mainly from institutions in Europe. The vouchers from Hasan's study and Kerremans' type of *Sphenoptera clarescens* were compared to material of several closely related species of *Sphenoptera* from the Zoological Institute and Mark Yu. Kalashian's private collection.

Material was examined from the following institutions:

MYKC – Mark Yu. Kalashian Collection, Yerevan, Armenia.

NMPC – National Museum, Prague, Czech Republic.

NMNH -- Muséum National d'Histoire Naturelle, Paris, France.

ZIN -- Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

Results

Results – Systematics

The Kerremans type of *S. clarescens*, which was expected to be in Prague, Czech Republic, after much searching, was found by Mark Volkovitsh in the Muséum National d'Histoire Naturelle in Paris, France. This specimen (Figures 3 and 4) was examined and found to be a specimen of *Sphenoptera signata*, the same species found feeding on *Chondrilla juncea* in central Turkey.

The voucher specimens from Hasan's 1978 biological control were located by Mark Kalashian and retrieved from the National Museum, Prague, Czech Republic. (Figures 5 and 6). These specimens were compared to other species of *Sphenoptera* and the series was found to be composed entirely of *S. aeneomicans*.

Revisions of the species-groups *Sphenoptera* (s. str.) exarata-group and *Sphenoptera* (*Deudora*) rauca-group follow in the subsequent chapters.

Results – Field Study

None of the target *Sphenoptera* species were collected in either Turkey or Armenia on the June 2008 collecting trip. Almost 2000 plants were pulled over the course of three weeks in Turkey (1010 plants) and Armenia (810 plants). Adults, eggs, feeding damage, or larvae were not observed on any *C. juncea* plant. This gives us reasonable indication that there is no *Sphenoptera* species which feeds on *C. juncea* in great numbers at the sampled sites in Armenia and Turkey.

Discussion and Conclusions

The earlier collection of *S. signata* in Armenia may be attributed to incidental collection of an individual which had emerged from a plant other than *Chondrilla* in the vicinity of the area swept. Another possible explanation is that these individuals may be attributed to the collection of a beetle species that is either exceedingly uncommon in the area sampled, or has a wide host range which only includes *C. juncea* in periods when food is scarce or population levels are so high that the beetles are forced to oviposit in *C. juncea*. Kalashian and Volkovitsh (2005b) indicated that *S. signata* is very common within its range, so the more likely explanation is the latter.

This leads us to the conclusion that *S. signata* may not an ideal candidate for introduction as a biological control agent because it is too uncommon. Additionally, if *S. signata* is polyphagous and only feeds on *C. juncea* during times of intense pressure, then release for biological control purposes would not be appropriate, as we would be putting native plants at risk. In either case, the habits of *S. signata* thus far suggest that further research into its release as a biological control agent would be unproductive.

The beetles that Descarpentries (Hasan 1978) determined to be *S. clarescens* represent an important host record for the species *S. aeneomicans*. Supported by Hasan's records of the polyphagy of *S. clarescens sensu* Hasan, this species can be ruled out as a biological control agent.

Although the identity of *S. foveola* is clear, and it is well known that *S. foveola* feeds on *Chondrilla* species, further research may be needed on host range, since in its native range, it feeds almost exclusively on *C. ambigua*, not *C. juncea*.

Further research on *Sphenoptera* species as biological control agents of *C. juncea* in the Western U.S. should be limited, and resources should be concentrated on other means of control, whether that focus is on other potential biological control agents or on mechanical or chemical control.

This research has shown that the investigation of the taxonomic history of a potential biological control organism and the correction of poor systematic work is essential to the implementation of a successful biological control program. It has also increased the body of knowledge of species whose identities were unclear and whose biology was unknown.

Further Information on the History of *Chondrilla* Biological Control

Chondrilla juncea, or rush skeletonweed, is an introduced composite plant often classified as a noxious weed in the western United States. *Chondrilla juncea* is a tall (up to1.5 meters tall) spindly herbaceous plant with bare, green stems with small, lanceolate leaves growing along the length of the stem, and a rosette of pinnatisect leaves at the base. The flowers are typical of most Asteraceae, being small, yellow, with multiple florets arranged in a bunch on a central capitulum. When damaged, the plant exudes milky-white latex, which has historically been used to make rubber and chewing gum (Emelyanova et al. 1932). The plant's native range is throughout Eurasia, and extends westward into disturbed and cultivated areas in western Europe. However, it probably originated in central Asia, with the center of diversity for *Chondrilla* species in Uzbekistan and Kazakhstan (Wapshere 1971).

Chondrilla juncea causes extensive problems outside of its native range. *Chondrilla juncea* was first reported in Australia in the early 20th century, where it causes a great number of problems on land cultivated for grains. It was reported in the United States in the 1870s (McVean 1966). The plant moved westward from the East Coast of the US, and by the late 1930s it was causing severe problems on rangeland in the Pacific Northwest (Supkoff et al. 1988), where it today affects more than 2.5 million hectares of land in the western US (Sheley et al. 1999).

Chondrilla juncea causes reduced yields in many irrigated dryland crops, particularly those in sandy soils. Additionally, *C. juncea* latex gums up farming equipment, leading to increased downtime and reduced harvesting efficiency. This plant also reduces the quality of forage on rangeland, often outcompeting more nutritious plants (Washington NWCB 2007).

The need for control of this plant is quite clear, and several attempts at biological control of this plant have already been made using organisms that are native to central Asia. Wapshere (1974) suggested that potential biological control agents for *C. juncea* would most likely come from the area where diversity of *Chondrilla* species is highest. Recently studied biological control agents include a rust fungus, a mite, a root-feeding beetle, and a root-feeding moth.

Several studies detailed the biology of one of the more promising agents, *Puccinia chondrillina* Bubak and Syd., a rust fungus, including effects of photoperiod and other environmental variables on infection rate (Blanchette and Lee 1987). Additionally, since there are varying genotypes of *Chondrilla* present in the Western US, Burdon et al.

(1984) found that differing genotypes (resistant and susceptible) had differing infection rates by *Puccinia chondrillina*.

The eriophyid mite, *Aceria chondrillae*, forms galls on the stems of *Chondrilla* and has been introduced throughout much of the invasive range of *Chondrilla* as a biological control agent. In greenhouse experiments to decrease the number of flowers (and thereby number of seeds) produced by the plant and decreased the plant's ability to regenerate rosettes. This may help limit the spread and total biomass in areas that were affected (Cullen et al. 1982). However, Cullen and Moore (1983) found that, like *Puccinia chondrillina*, *Aceria chondrillae* injures different strains of *Chondrilla* differently in Australia, injuring the most widespread strain most effectively, while injuring few or no plants of the other strains.

A root-feeding moth, *Bradyrrhoa gilveolella* Treitschke (Lepidoptera: Pyralidae), has also been tried in the past as a control agent in Australia and the western US, but has had limited success (Cullen 1980).

In northern California, Supkoff et al. (1988) found that a combination of biological control organisms (*Puccinia chondrillina*, *Cystiphora schmidti,* and *Aceria chondrillae*) reduced the density of *C. juncea* up to 87% at some locations.

The current biological control agents have not been shown to adequately control *Chondrilla juncea*. Therefore, introduction of a root-feeding beetle could enhance a biological control program by filling in the gaps left by other agents, or by synergistically affecting the plant's fitness along with the other biological control agents.

CHAPTER 3:
REVIEW OF THE SPHENOPTERA SPECIES-GROUPS OF THE FORMER U.S.S.R., WITH A KEY TO SPECIES-GROUPS.

Introduction: Genus *Sphenoptera*

Taxonomic History

Sphenoptera is an exclusively Old-World genus of buprestids, widespread in the Palaearctic, Afrotropical, and Oriental regions (Bellamy 2008). Containing more than 1,000 currently valid species, it is one of the largest genera of Coleoptera. This group historically has been extremely difficult to work with, due to the enormous amount of intraspecific variation and the overwhelming number of species. As a result, taxonomists have divided the genus into 16 subgenera and, more recently, many species-groups (Bellamy 2008).

After the nominotypical subgenus, the first formally described subgenus, the African *Strobilodera*, was defined by Fairmaire in 1884, and soon after, Jakovlev (1889) published a revision of *Sphenoptera* in which he described three subgenera – *Chilostetha*, *Chrysoblemma*, and *Hoplistura* – some of the largest in terms of number of species. Then, in 1898 and 1901, he described two more subgenera, *Deudora* and *Tropeopeltis*. Jan Obenberger in 1926 described five subgenera, mainly African – *Archideudora*, *Buprestochila*, *Chiloblemma*, *Chilostethura*, and *Tropeoblemma* – and revised many of the known species in existing subgenera. Most recently, the small subgenus *Sphenopterella* was described from Uzbekistan (Volkovitsh and Kalashian 1994).

Currently, Mark Yu. Kalashian, of the National Academy of Sciences in Yerevan,

Armenia, has been at work dividing western Palaearctic members of the genus into species-groups based on morphological characters (Kalashian pers. comm.). However, this has proven difficult in many cases. In *Sphenoptera*, many species have been described based on a single specimen, and examination of *Sphenoptera* collections, even in large museums, often reveals rather short series (<20 individuals) for even the most common species. Moreover, large degrees of intraspecific variation makes it difficult to define species, let alone identify them (Kalashian and Sakalian 2007). This has led to the description of excess species. Some common species have as many as 30 synonyms! Therefore, the use of higher-level taxon grouping (such as species-groups and subgenera) is extremely helpful in understanding this rather large genus.

Although several published keys to species of *Sphenoptera* exist, most are outdated or are quite limited in geographic scope. The first key to *Sphenoptera* was produced by Marseul (1865) in his *Monographie des Buprestides*. The largest and most complete work on the genus was a revision of Sphenopterini completed by Kerremans (1913), in his *Monographie des Buprestides*. The monograph of this tribe included a key to the world species of *Sphenoptera*, This work, while immense (over 600 pages long, including plates), is functionally useless for many groups, as most species were to be keyed out based solely on size and color. The obvious weakness of this work was recognized by one of his contemporaries, Obenberger (1926a), who described it not only as almost an identical copy of Jakovlev's work, but also factually incorrect. Obenberger (1926a) also stressed the need for a good key to *Sphenoptera* species and indicated that it would be difficult for such a vast number of species (Obenberger estimated that the genus

contained over two thousand species).

Several regional keys to *Sphenoptera* exist, including the Balkan Peninsula (Kalashian and Sakalian 2007), the Iberian Peninsula (Verdugo 2005), and the Ethiopian region (Jakovlev 1902a). Other keys are of limited taxonomic breadth – Jakovlev's 1898 and 1900 keys cover only the subgenus *Deudora*, and Obenberger's 1927 key only treats *Sphenoptera* (s. str.). Bílý's (2003) treatment of Central European *Sphenoptera* covers detailed descriptions and bionomy, but lacks a key.

The need for a complete key to *Sphenoptera* subgenera and species-groups is clear – the misidentification rate of these beetles is extraordinarily high, as high as 90% in some institutions (particularly those in the New World) (pers. obs.). A key to species-groups is important, not simply for pure taxonomic work, but because a demand exists in the applied fields as well. However, species-group definitions exist only for the species occurring in the former U.S.S.R. Because the center of diversity for the rhizophagous groups of interest in biological control is the region that was once included in the former U.S.S.R., and definitions of species-groups only exist for that region, my goal is to produce a key to species-groups of this area.

Herein, I refined the definitions and present a dichotomous key of Mark Kalashian's *Sphenoptera* species-groups for the region of the former U.S.S.R. This involved extensive study of the morphology of both type and non-type material, and a thorough review of previously published species descriptions. Additionally, I developed a companion illustrated electronic key in LUCID® Key Builder for subgenera and species-groups of this same region to allow for simple identification by non-specialists

and to prevent future mistakes in identification (Electronic Addendum I).

Biology

The adult beetles often rest at the base of their host plant or under rocks at night and in chilly hours, emerging to fly during the warmest part of the day. Their flight is erratic and they are infamously fast – probably the direct cause of the small number of specimens collected (Obenberger 1919). The adults mate on or around the foliage of the host plant, and females lay single eggs at the base of the plant (Bílý 2003).

Most *Sphenoptera* larvae feed in or around the roots of their host plant and pupate in the soil surrounding the roots or at the crown of the plant. The life cycle varies among species, but the larva may overwinter one or two years before pupating and emerging as an adult.

As a genus, *Sphenoptera* species are extraordinarily varied in their host preferences, though most species are rather specific, in that they only feed on one or two host plant species. A majority of species have shrubby host plants in the families Fabaceae and Asteraceae.

Several species are economically important pests in their native range. *Sphenoptera* (*Hoplistura*) *kolbei* is a pest of cotton in Sudan and much of northwestern Africa (Obenberger 1926a); *Sphenoptera* (*Sphenoptera*) *foveola* is a pest of latex production in central Asia (Emelyanova 1932), though I suspect that with the move to synthetic rubber and production of latex from the rubber tree, this now only causes minor, local economic damage; *Sphenoptera* (*Sphenoptera*) *antiqua* is a pest of *Onobrychis sativa* (sanfoin) in central Europe (Yuksel 1966); and *Sphenoptera* (*Sphenoptera*)

barbarica feeds on leguminous forage plants in the Iberian Peninsula (Verdugo 2005).

Systematics

This work covers the *Sphenoptera* subgenera and species-groups currently known to occur in the region of Asia and Europe once encompassed by the former U. S. S.R., and now includes several independent countries, including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Uzbekistan, and Ukraine. Distribution information and species-group memberships, however, are given for the entire range of the species-group. Recorded distribution is taken from Bellamy (2008) unless otherwise noted.

Many areas are poorly collected, so some species from the region may not be mentioned here. Only those which are currently known to occur in the former U.S.S.R. are keyed. Much revisionary work on the genus is currently being conducted by Mark Kalashian and Mark Volkovitsh, so many taxonomic changes may be expected in the near future.

The key omits one subgenus and three species-groups due to lack to available material. The omitted groups are: subgenus *Cyphostetha*, *S.* (*Chrysoblemma*) jakowlewi-group, *S*. (*Deudora*) afflicta-group, and *S*. (*Deudora*) simplex-group. These omissions are discussed below in individual entries.

Materials and Methods

Materials

Material was borrowed from or examined on site at several major entomological collections (see list below). Visits to institutions in Europe, which house *Sphenoptera* collections included the National Museum in Prague, Czech Republic, which houses the Jan Obenberger collection, the Zoological Institute at the Russian Academy of Sciences in St. Petersburg, Russia, where Jakovlev's collection is located, and to Mark Yu. Kalashian's private collection in Yerevan, Armenia. In addition, material for taxonomic study was collected in the field in Armenia and Turkey during June 2008. Finally, valuable gifts of material were received from Mark Kalashian and Mark Volkovitsh. A total of 479 specimens were examined in this study.

Specimens from the following collections were examined in this study (curators listed in parentheses):

AMNH – American Museum of Natural History, New York, USA (Lee Herman).

BMNH – The Natural History Museum, London, UK (Max Barclay).

MAIC – Michael A. Ivie Collection, Bozeman, USA.

MTEC-- Montana State Entomology Collection, Montana State University, Bozeman, USA (Michael A. Ivie).

MYKC – Mark Yu. Kalashian Private Collection, Yerevan, Armenia.

NMPC – National Museum, Prague, Czech Republic (Jiri Hajek).

NMHN – Muséum National d'Histoire Naturelle, Paris, France.

USNM – National Museum of Natural History, Washington, USA (Steven W.

Lingafelter).

ZIN – Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia (Mark G. Volkovitsh).

Methods – Imaging and Drawing

Morphological characters that distinguish *Sphenoptera* species were observed through a dissecting stereo-microscope (Leica® Wild M3C) with a Techni-quip® 150W fiber optic illuminator. Photographs of large species were taken with an Olympus® DP-11 bracket-mounted digital camera with a Nikon® Micro-Nikkor 105mm lens. I photographed smaller specimens (and particular characters) with a JVC® 3CCD KY-F750 digital camera mounted to a Leica® MS5 dissecting microscope with a Schott® Fostec DCR 111 fiber optic illuminator and a foam coffee cup as a light diffuser. Both cameras are attached to an IBM IntelliStation M Pro® and the images are processed using Syncroscopy Auto-montage Pro® ver. 5.03.0020 Beta and enhanced in Adobe Photoshop® CS4.

Line drawings were traced from photographs in Pigma® Micron pen on Mylar vellum or smooth Bristol-board. Digital enhancements to the drawings were made using Adobe Illustrator® CS4.

Methods – Morphology

Homologies and character names were established for *Sphenoptera* through the use of morphological study, illustrations in Verdugo 2005 and Bright 1987, as well as through the morphological study of the Buprestidae completed by Gebhardt (1932).

The cuticle of older specimens is frequently coated with greasy exudate or dust from years of storage in drawers, and because these beetles are xylophagous, they can be covered with sap and dirt from emergence. Specimens that were deemed too dirty to discern morphological characters were relaxed in boiling water for 10 minutes, then placed in an ultrasonic cleaner with ammonia. The ammonia bath was followed by a rinse in distilled water. However, in certain groups of *Sphenoptera*, visible patterns of waxy secretions are important characters for distinguishing species. In such cases, cleaning and relaxing was kept to a minimum to prevent the dissolution of waxes from the cuticle.

Genitalia were extracted from relaxed specimens through the terminal opening in the abdomen between seventh tergite and fifth sternite (Lawrence and Britton 1994). A pair of sharp forceps were inserted and the three apical abdominal segments were removed along with the genitalia.

The genitalia were then treated in one of two ways: 1) mounted on the head of a pin to be photographed and subsequently glued to a card below the insect or 2) slide mounted. To slide mount, the entire package was heated in a 15% potassium hydroxide solution for one to two hours to macerate the soft tissues. Cleared genitalia were then rinsed with several washes of distilled water and the sclerites disarticulated.

The cleared genitalia were then slide mounted in glycerin-gelatin for examination, photography, and storage (Zander 1997). A small cube ($0.5cm^3$) of glycerin-gelatin is placed in a well slide on a hot plate until it is melted. Then, the cleared and disarticulated genitalia were arranged on the slide and a cover slip is carefully placed on top. The genitalia were then examined with either a Wild® M20 compound microscope (for

smaller specimens) or a Leica® Wild M3C Stereo-microscope (for larger specimens). Once the genitalia were thoroughly examined, they were either removed from the glycerin-gelatin and placed in a genitalia vial with glycerin, or the slides were stored horizontally in a covered slide cabinet.

Methods – LUCID Key

Two types of keys were developed in the computer program LUCID Key Builder: 1) an interactive, picture-based key and 2) a traditional dichotomous key. Characters from examination of type and other specimens and species descriptions were recorded in a matrix of characters and taxa in a spreadsheet. The characters and taxa were then transferred to the character matrix in LUCID Key Builder. The characters were appropriately coded in the matrix for presence/absence, one of several character states, or as a continuous variable (i.e. size, proportions).

Photos and line drawings of all characters states and taxa are included. Each character state may have associated with it several figures, e.g. a line drawing for clarity and a photo of the character state in a representative specimen. Additionally, habitus photographs are included for most taxa. The resultant matrix-based key was used to create a dichotomous key within LUCID Key Builder. The dichotomous key was developed for use in printed publications and for instances when computer access is not readily available.

The computer-based key was then evaluated for clarity, ease of use, and accuracy using the built-in key evaluation tools in LUCID key builder. In addition, the keys will be tested by both *Sphenoptera* experts and non-experts in the identification of actual

Sphenoptera to assure that the key is useable by non-expert workers.

Characters and Morphology

The lack of well-defined characters for distinguishing species has historically been the most difficult aspect of working with *Sphenoptera*. Many workers produced keys and descriptions based solely on size or color, and given the enormous amount of variation in those characters in the group, this is inadequate. Differences in nutrition and soil chemistry may bring about different colors in the exoskeleton of the beetle, and age and grease can drastically change the luster or color of a specimen. Size also varies significantly as a result of nutrition and sex. Even with the availability of good keys to certain groups, identified specimens in museums were often determined by a quick glance and matching of similar specimens (this proves to be rather problematic with groups differing only by subtle characters) and matching the region of origin (pers. obs.).

Obenberger's vast works, Jakovlev's revisions, and Volkovitsh and Kalashian's recent taxonomic works were all used for the selection of characters. Kalashian and Sakalian's 2007 key to the species of Balkan *Sphenoptera* was used as a model for the present key. Additionally, many of the characters were learned through personal communication with experts of the genus – Mark Kalashian and Mark Volkovitsh – and through direct observation of specimens.

Characters chosen for this key were found to be consistent across long series of specimens, consistent across species within a species-group, and varied considerably between species groups. Sexually dimorphic characters are exceedingly important in this

group. The characters which separate males and females vary significantly from subgenus to subgenus, so they are explained in the individual subgeneric diagnoses.

Color and size are included as characters, but only secondarily, for use in confirming the identity of a particular species-group or when color is extraordinarily diagnostic of a particular species.

Characters, States, and Definitions

Character 1. -- body flattened dorsally: refers to the slight or strong median adpression of the dorsum:

1) elytral suture depressed below level of third stria (Figure 23);

2) elytral suture raised or flat relative to level of third stria (Figure 24).

Character 3. – elytral shape: refers to the overall shape of the lateral margins of both elytra:

1) elytra parallel in anterior 2/3 (Figure 25);

2) elytra subparallel in anterior 2/3 (Figure 26);

3) elytra narrowed from humeri (Figure 27).

Character 3. -- body shape:

1) wide wedge (Figure 24);

2) narrow wedge (Figure 28)

3) oval (Figure 29);

4) narrowly elongate – parallel-sided (Figure 30).

Character 4. – dorsal elytral lateral bands of wax: this refers to the presence of lateral bands of white wax on the elytra and pronotum; this wax may not be present if the

specimen has been cleaned, and its absence is therefore not a reliable character for determination of taxon:

1) present (Figure 31);

2) absent (Figure 27).

Character 5. –body shape: this refers to the amount of convexity of the body in lateral view:

1) elytra humped relative to pronotum (Figure 32);

2) elytra evenly curved relative to pronotum (Figure 33);

3) elytra flat relative to pronotum (Figure 34).

Character 6. –ventro-lateral band of setae: abdomen setose laterally, with glabrous band mesad of each; mirors are shining, impunctate areas which interrupt ventro-lateral setal band:

1) present, without mirrors (Figures 36);

2) present, with mirrors (Figure chign3);

2) absent (Figure 34).

Character 7. – ventro-lateral wax band: lateral portions of meso- and metathorax, and abdomen covered in wax; often associated with the ventro-lateral setal band; this wax may not be present if the specimen has been cleaned, and its absence is therefore not a reliable character for determination of taxon:

1) present (Figure 36);

2) absent (Figure 35).

Character 8. – interstriae elevated: refers to the subcarinate structure of all interstriae on

the elytron:

1) all elevated (Figure 37a);

2) only alternate interstriae strongly elevated (Figure 38a);

3) only alternate interstriae weakly elevated (Figure 38b);

4) all flat (Figure 37b).

Character 9. – color: refers to the overall color of the dorsum (Figure 39):

1) light bronze (Figure 39a);

2) bronze-black (Figure 39b);

3) coppery (Figure 39c);

4) purple (Figure 39d);

5) coppery with blue laterally (Figure 39e);

6) black (Figure 39f);

7) green (Figure 39g);

8) gold-green (Figure 39h);

9) gold (Figure 39i);

10) red (Figure 39j);

11) bicolor green/red (Figure 39k);

12) blue-black (Figure 39l);

13) blue (Figure 39m);

14) green with brown stripes (Figure 39n).

Character 10. – elytral stria shape: refers to the shape of the punctures which make up each individual stria; observed in the anterior 2/3 of elytron (Figure 40):

1) elongate dashes (Figure 40a);

2) deep, even punctures (Figure 40b);

3) shallow punctures (Figure 40c);

4) no apparent striae (Figure 40d).

Character 11. – luster: this refers to the sheen of the dorsum; a beetle which is recognized as glossy does not have any metallic luster; a chagreened beetle may (silky-metallic) or may not (matte) have a metallic luster; viewed dorsally (Figure 41):

1) glossy (Figure 41a);

2) metallic (Figure 41b);

3) chagreened silky-metallic (Figure 41c);

4) chagreened matte, not metallic (Figure 41d).

Character 12. – interstrial punctation: this refers to the density of coarse and fine punctures on the interstrial spaces of the elytra (Figure 42):

1) only coarse punctation, dense (Figure 42a);

2) only coarse punctation, sparse (Figure 43b);

3) coarse and fine punctation (Figure 42b);

4) only fine punctation (Figure 43a).

Character 13. – apical continuity of elytral striae: refers to striae reaching apex without becoming obsolete:

1) complete; strial punctures longitudinally confluent, forming a complete line in apical 1/3 (Figure 44);

2) obsolete; strial punctures separate in apical 1/3 (Figure 45).

Character 14. – supra-antennal cavity ridge: refers to the strength of the carina above the antennal insertion:

1) strongly elevated, acutely carinate (Figure 46);

2) weakly elevated, carina absent (Figure chrmar2);

3) weakly elevated, weakly carinate (Figure 48).

Character 15. – sulcus of the anterior margin of the pronotum: refers to the thin sulcus which borders the anterior margin of the pronotum:

1) present (Figure 49);

2) absent (Figure 50).

Character 16. – posterio-lateral furrows of pronotum: refers to the deep longitudinal excavations on either side of the of the posterior ½ of the pronotal disc:

1) deep (Figure 51);

2) absent (Figure 55).

Character 17. – lateral flattened plates of pronotum: this refers to the presence of two lateral planar regions near the base of the pronotum:

1) pronotum with lateral flattened plates (Figure 53);

2) pronotum evenly rounded (Figure 52).

Character 18. – lateral furrows of pronotum: this refers to the presence to two longitudinal furrows between the disc and lateral margins of the pronotum:

1) present, wide (Figure 54);

2) present, narrow (Figure 52);

3) absent (Figure 55).

Character 19. – lateral wrinkling of pronotum: this refers to the presence of serially confluent punctures laterally on the pronotum – these punctures appear as scalloped wrinkles:

1) present (Figure 56);

2) absent (Figure 55).

Character 20. – lateral border of pronotum: this refers to the dorsal visibility of the lateral carina of the pronoum:

1) entirely visible from above (Figure 52);

2) anterior 1/3 not visible from above (Figure 55).

Character 21. – pronotal punctation: refers to the pattern of punctation on the disc of the pronotum:

1) coarse, even across entire pronotum; punctures separated by less than 2x diameter (Figure 57);

2) coarse, confluent laterally – sparse on disc (Figure 58);

3) coarse laterally, distinctly finer on disc (Figure 59);

4) fine, even across entire pronotum; punctures separated by more than 3x diameter (Figure 60).

Character 22. – pronotal shape: refers to the shape of the lateral pronotal borders when viewed dorsally:

1) Narrowed from base (Figure 57);

2) Parallel to apical 1/3 (Figure 52);

3) parallel to apical 2/3 (Figure 53);

4) subparallel to apical 1/2 (Figure 56);

5) square (Figure 51);

6) subparallel (Figure 61);

7) widened to apical 1/3 (Figure 62);

8) evenly rounded; anterior and posterior widths subequal (Figure 63).

Character 23. – median furrow of pronotum: this character refers to the median longtudinal furrow of the pronotum:

1) present, deep (Figure 54);

2) present, shallow (Figure 56);

3) absent (Figure 60).

Character 24. – widest part of pronotum:

1) posterior border (Figure 57);

2) at basal 1/3 (Figure 59);

3) at apical 1/3 (Figure 62).

Character 25. -- median punctation vitta of pronotum: this character refers to the presence of a median vitta of dense punctation on the pronotum; this vitta may be densely setose, if wax present, then vitta is present:

1) present (Figure 52);

2) absent (Figure 55).

Character 26. -- posterior depression of pronotum: this refers to the deep rounded or v-shaped depression immediately anterior the scutellum:

1) anchor-shaped (Figure 64);

2) rounded (Figure 65);

3) broad V (Figure 58);

4) absent (Figure 59).

Character 27. – pronotum beaded laterally: this character refers to the groove of the lateral carina of the pronotum that results in a beaded edge:

1) grooved (Figure 66);

2) simple (Figure 67).

Character 28. – sinuosity of lateral pronotal margins: this character refers to the shape of the lateral carina of the pronotum in lateral view:

1) straight (Figure 68);

2) weakly sinuate (Figure 69);

3) strongly sinuate (Figure 70).

Character 29. – lateral margin of pronotum dipping ventrally : refers to the carina of the pronotum which dips ventrally of the level of the procoxal edge:

1) present (Figure 71);

2) absent (Figure 69).

Character 30. – dual-punctation on pronotum: this refers to the presence of small punctures between larger ones on the pronotal disc:

1) present (Figure 72);

2) absent (Figure 73).

Character 31. – microreticulation posteriorly on pronotum: this character refers to the presence of very fine reticulation in a narrow band at the base of the pronotum; the

reticulation may continue anteriorly:

1) present (Figure 74);

2) absent (Figure 75).

Character 32. – posterior emargination of pronotum: this character refers to the shelf-like impression of the posterior border of the pronotum:

1) present (Figure 76);

2) absent (Figure 66).

Character 33. – structure of scutellum:

1) scutellum transverse with raised, obvious transverse carina setting off narrow triangle posteriorly (Figure 77);

2) scutellum not transverse, without obvious carina (Figure 78);

3) scutellum with longitudino-posterio-groove of scutellum: (Figure 79).

Character 34. – emargination of prosternal process: refers to the composition of the lateral and posterior borders of the prosternal process:

1) prosternum margined with continuous groove extending around apex (Figure 80);

2) process margined with grooves not continuous around apex (Figure 81);

3) emargination not grooved laterally, consisting of confluent punctures (Figure 82);

4) emargination not grooved laterally, position marked with line of discrete punctures (Figure sphhexa3)

5) prosternum with out evidence of emargination (Figure 85).

Character 35. – median prosternal depression: this refers to the deep longitudinal impression of the prosternum:

1) present (Figures 84, 85);

2) absent (Figure 82).

Character 36. – prosternal punctation: this character refers to the density of the punctation on the disc of the prosternal process:

1) fine, generally distributed (Figure 86);

2) moderate, sparse (Figure sphhexa3);

3) coarse, concentrated medially (Figure 82);

4) coarse, generally distributed (Figure 85).

Character 37. – protibiae emarginate apically in male: refers to the bifurcate apex of the male protibia:

1) present (Figure 87);

2) absent (Figure 88).

Character 38. – protibial curvature of male: this character refers to the degree of arc in the male protibia. This curve is represented by outer margin, as opposed to Character 45:

1) strongly, nearly angularly curved (Figure 89);

2) weakly, evenly curved (Figure 90);

3) straight (Figure 91).

Character 39. – protibial emargination in male: this character refers to a subapical emargination on the inner margin of the male protibia:

1) present, strong (Figure 89);

2) present, weak (Figure 92);

3) absent (Figure 91).

Character 40. – protibial row of spines in male: this character refers to the density of a row of spines on the interior face of the male protibia:

1) closely spaced (Figure 89);

2) widely spaced (Figure 93).

Character 41. – mesotibial curvature of male: this character refers to the degree of arc in the male mesotibia, viewing the outer margin:

1) strongly curved (Figure 94);

2) weakly curved (Figure 95);

3) straight (Figure 96).

Character 42. – mesotibial emargination of male: this character refers to the presence of an emargination subapically on the inner face of the male mesotibia:

1) extremely emarginate

2) strongly emarginate (Figure 96);

3) weakly emarginate (Figure 95);

4) emargination absent (Figure 97).

Character 43. – mesotibial tooth of male: this character refers to the strength of the expanded distal emargination of the inner margin of the metatibia (indicated by arrow):

1) tooth-like (Figure 96);

2) acute (Figure 95);

3) rounded (Figure 97).

Character 44. – metacoxal tooth: this character refers to the presence of a prominent tooth on the meso-posterior margin of the metacoxa:

1) as acute tooth (Figure 850);

2) margin evenly rounded (Figure 99).

Character 45. – metatibial emargination of male: this character refers to the presence of an emargination subapically on the inner face of the male mesotibia:

1) extremely emarginate (Figure 103);

2) strongly emarginate (Figure 100);

3) weakly emarginate (Figure 101);

4) emargination absent (Figure 102).

Character 46. – metatibial row of teeth in male: this character refers to the presence of a row of cuticular teeth on the interior face of the metatibia:

1) present (Figure 101);

2) absent (Figure 100).

Character 47. – metatibial tooth of male: this character refers to the strength of subapical tooth on the ventral surface of the metatibia of the male:

1) present, strong (Figure 100);

2) present, weak (Figure 101);

3) absent (Figure 102).

Character 48. – Hind and middle tibia cross-section: this refers to the shape of the hind and mesotibiae of both sexes in cross-section:

1) rounded (Figure 104);

2) flattened (Figure 105);

Character 49. – abdominal setae: refers to the setal pattern on the median area of abdominal sternites:

1) setae dense (Figure 108);

2) setae sparse, or absent (Figure 109).

Character 50. – apical abdominal ventrite of male: this character refers to the shape of the apex of the apical ventrite of the male:

1) truncate (Figure 108);

2) rounded (Figure 109);

3) emarginate (Figure 110).

Character 51. – elytral apex shape at posterior-most point:

1) toothed or apically acute (Figure 850);

2) rounded (Figure 112);

3) truncate; square(Figure 113);

4) narrowly rounded (Figure 114).

Character 52. – point laterally on elytral apex: this character refers to the point on which is just laterad the apex of the elytron and furthest from the elytral suture:

1) toothed (Figure 115);

2) weakly angulate (Figure 114);

3) rounded (Figure 117).

Character 53. – point suturally on elytral apex: this character refers to the point on which is just mesad the apex of the elytron and closest to the elytral suture:

1) toothed (Figure 850);

2) weakly angulate (Figure 114);

3) rounded (Figure 112).

Character 54. – abdominal patch of yellow setae: this character refers to the distinct patch of yellow setae present on the apical ventrite:

1) present (Figure 116);

2) absent (Figure 110).

Character 55. – separately rounded elytra: this character refers to the visibility of the apical abdominal tergite through the two elytra, viewed from above:

1) elytral apices separately rounded (Figure 117);

2) elytral apices coadapted (Figure 118).

Character 56. – elytral shelves: this character refers to the distinctly angulate lateral elytral apices:

1) present (Figure 121);

2) absent (Figure 122).

Key to Species-groups of the Former U.S.S.R.

The ideal specimen to be keyed out is an uncleaned male beetle. Several couplets require the use of genitalia or male sexual dimorphic characters and cleaning the specimen many remove wax, which is important for the identification of some groups.

1 Pronotal carina dipping ventrad to level of procoxae (Figure 71); elytra without apparent elytral striae (Figure 40); antennal ridge weakly elevated, without

carina (Figure 47) ..... subgenus *Sphenopterella*

1’ Pronotal carina remaining straight or slightly sinuate laterally, never dippng ventrad to level of procoxae (Figure 70); elytra with apparent striae (Figure 40); antennal ridge strongly or weakly elevated, always with carina (Figure 48, Figure 46) 2

2 (1’) Hind and middle tibiae rounded in cross-section (Figure 104); each elytron with three sharp points apically (Figures 115, 98) .....…... 3

2’ Hind and middle tibiae flattened in cross-section (Figure 105); each elytron with either a sharp point suturally and laterally and rounded in the middle, rounded, or truncate (Figures 112, 113, 114) ..…..... 13

3 (2) Metacoxa with prominent tooth on meso-posterior margin (Figure 98) *and* with depression medially on prosternum (Figure 85) or if no depression medially on prosternum, with complete striae (Figure 44); typically bronze or black .....…4

3’ Metacoxa without prominent tooth medially (Figure 99), or if with tooth, without median prosternal depression (Figure 86) or striae obsolete (Figure 45); typically metallic green or greenish-gold ..... subgenus *Chrysoblemma* 6

4 (3) Male hind tibiae strongly emarginate (Figure 100); without latero-ventral setal band (Figure 34); scutellum transverse, with or without carina (Figures 77, 78) ..... subgenus *Tropeopeltis*

4’ Male hind tibiae with straight, without emargination (Figure 102); with ventro-lateral setal band (Figure 32); scutellum not transverse, without strong carina (Figure 78) ..... subgenus *Hoplistura* 5

5 (4') Emargination of prosternum absent (Figure 85); male hind tibiae with teeth (Figure 101) ..... *S.* (*Hoplistura*) balassogloi-group

5' Emargination of prosternum present (Figure 80); male hind tibiae without teeth (Figure 102) ..... *S.* (*Hoplistura*) mesopotamica-group

6 (3') Male mesotibiae strongly curved (Figure 94); pronotum with median impression ..... *S.* (*Chrysoblemma*) bifulgida-group

6' Male mesotibiae straight or slightly curved (Figures 96, 95); pronotum with or without median impression 7

7 (6') Antennal cavity ridge strong, with acute carina (Figure 46); elytral striae complete posteriorly (Figure 44) 8

7' Antennal cavity ridge weak, with weak carina (Figure 48); elytral striae obsolete posteriorly (Figure 45) 10

8 (7) Pronotum beaded laterally (Figure 66) 9

8' Pronotum not beaded laterally (Figure 67) ..... *S.* (*Chrysoblemma*) pubescens-group (in part)

9 (8) Abdomen with mirrors (Figure 119); male protibiae emarginate apically (Figure 87) ..... *S.* (*Chrysoblemma*) scovitzii-group

9' Abdomen without mirrors (Figure 120); male protibiae not emarginate apically (Figure 88) ..... *S.* (*Chrysoblemma*) tamarisci-group

10 (7') Pronotum microreticulate posteriorly (Figure 74); Elytral interstriae with dense, coarse punctures (Figure 41) 11

10' Pronotum not microreticulate posteriorly (Figure 75); elytral interstriae with sparse,

coarse punctures (Figure 42) 12

11 (10) Scutellum with longitudino-posterio-groove (Figure 79); anterior border of pronotum not bordered with sulcus (Figure 49) .... *S.* (*Chrysoblemma*) pubescens-group (in part)

11’ Scutellum without longitudino-posterio-groove (Figure 78); anterior border of pronotum bordered with sulcus (Figure 50) .... *S.* (*Chrysoblemma*) tomentosa-group

12 (10’) Anterior border of pronotum bordered with sulcus (Figure 50); ventro-lateral setal band present (Figure 32); sutural and lateral points of elytral apex small (Figure 114) ..... *S.* (*Chrysoblemma*) orichalcea-group

12’ Anterior border of pronotum not bordered with sulcus (Figure 49); ventro-lateral setal band absent (Figure 34); sutural and lateral points of elytral apex prominent (Figure 115) ..... *S.* (*Chrysoblemma*) artemesiae-group

13 (2) Prosternal process margined with continuous groove extending around apex (Figure 80); all interstriae flat or all interstriae elevated posteriorly (Figure 38) and male mesotibiae without apical tooth or with weak tooth (Figures 97 and 95) ..... subgenus *Chilostetha* 14

13’ Prosternal process margined with lateral grooves not continuous around apex (Figure 81), or bordered with punctation (Figures 82, 83); if with continuous groove, then alternate interstriae elevated (Figures 38) and/or male mesotibiae with strong apical tooth (Figure 96) 19

14 (13) Pronotal lateral margins extending only half-way to anterior border

..... *S.* (*Chilostetha*) popovii-group

14’ Pronotal lateral margins extending nearly to anterior border (Figure 69) 15

15 (14’) Anterior margin of pronotum not bordered with sulcus (Figure 50); pronotum with confluent punctation laterally; abdomen with mirrors (Figure 119) 16

15’ Anterior margin of pronotum bordered with sulcus (Figure 49); pronotum with even punctation or slightly denser punctation laterally; abdomen with or without mirrors (Figure 120) 17

16 (15) Pronotum with band of dense punctation medially .... *S.* (*Chilostetha*) insidiosa-group

16’ Pronotum without band of dense punctation medially .... *S.* (*Chilostetha*) basalis-group

17 (15’) Male and female with patch of yellow setae at apex of abdomen (Figure 116) ..... *S.* (*Chilostetha*) puberula-group

17’ Male and female with patch of white setae (Figure 110), or setae absent on apex of abdomen 18

18 (16’) Abdomen with dense setae medially (Figure 106); elytral interstriae not elevated (Figure 37b); scutellum without transverse carina (Figure 78) .... *S.* (*Chilostetha*) infantula-group

18’ Abdomen with sparse setae medially (Figure 107); elytral interstriae elevated (Figure 37a); scutellum with transverse carina (Figure 77) .... *S.* (*Chilostetha*) laportei-group

19 (13') Body nearly oval (Figure 26); pronotum with lateral carina completely visible in dorsal aspect (Figure 52); pronotal disc without depressions (Figure 52); odd and even elytral interstriae with different structure, odd interstriae with punctation sparser than even (Figure 38) ..... subgenus *Deudora* 20

19' Pronotum with lateral carina visible only posteriorly, for no more than ½ length (Figure 55); alternate elytral interstriae similar in sculpture (Figure 38), though may be elevated (Figure 39n). If pronotal carinae completely visible in dorsal aspect and elytral interstriae elevated, then pronotum with depression along middle and elytra depressed basally (Figure 53) .... subgenus *Sphenoptera s. str.* 24

20 (19) Prosternal process with grooves laterally, not strongly impressed medially (Figure 81) 21

20' Prosternal process with groove extending around apex (Figure 80), or strongly impressed medially (Figure 84) 22

21 (20) Pronotum with three distinct punctation vittae (Figure 52); abdomen with dense medial setae and lateral setal band separated by glabrous band (Figure 106); male mesotibiae and metatibiae strongly emarginate, with strong apical spine (Figures 96 and 100) ..... *S*. (*Deudora*) rauca-group

21' Pronotum without three distinct punctation vittae (Figures 56 and 62); abdomen with sparse setae medially, lateral setal band absent; male mesotibia and metatibia without emargination and without apical spine (Figure 97) .... *S*. (*Deudora*) smyrneensis-group

22 (20') Prosternum strongly impressed medially (Figure 84); male mesotibiae and metatibiae extremely emarginate distally (Figure 103) .... *S.* (*Deudora*) sulciventris-group

22' Prosternum with groove extending around apex, without strong impression medially (Figure 80); male mesotibia and metatibia emarginate at most 23

23 (22') Pronotum with prominent wrinkles laterally (Figures 56 and 62); elytral striae composed of elongate dashes (Figure 40a) ..... *S.* (*Deudora*) sculpticollis-group

23' Pronotum without prominent wrinkles laterally, with punctation (Figure 60); elytral striae composed of short dashes (Figure 40c) ..... *S.* (*Deudora*) micans-group

24 (19') Lateral silhouette convex (Figure 32); elytral suture raised or flat relative to level of third stria (Figure 64), if suture depressed below level of third stria, then with deep depression immediately anterior the scutellum (Figure 65)..... 25

24' Elytra flat relative to pronotum or weakly convex (Figures 33 and 34); elytral suture depressed below level of third stria (Figures 53, 54, and 55) 27

25 (24) Pronotum with posterior depression immediately anterior the scutellum (Figures 64 and 65); elytra parallel to apical 2/3 (Figures 24 and 25) .... *S.* (*Sphenoptera*) exarata-group

25' Pronotum without visible indentations (Figure 60); elytra subparallel to apical 2/3 or narrowed from humeri (Figures 26 and 27) 26

26 (25') Elytra narrowed from humeri (Figure 27); pronotal punctation significantly more dense laterally ..... *S.* (*Sphenoptera*) hypocrita-group

26' Elytra subparallel in apical 2/3 (Figure 26); pronotal punctation even, fine (Figure 60)

..... *S.* (*Sphenoptera*) tragacanthae-group

27 (24') Alternate elytral interstriae strongly elevated (Figure 38a) 28

27' Alternate elytral interstriae flat (Figure 38c) 31

28 (27) Prosternal process with continuous, V-shaped groove; color distinct – alternating bronze and green stripes (Figure 39n) ..... *S.* (*Sphenoptera*) latesulcata-group

28' Prosternal process without groove, bordered only laterally with discrete or confluent punctures; color anything but bronze with green stripes 29

29 (28') Pronotum with three deep furrows, each with dense setae and a band of wax (wax may be lost through age or washing) (Figure 54); scutellum with longitudino-posterio-groove..... *S.* (*Sphenoptera*) canaliculata-group

29' Pronotum without three deep, waxy furrows (Figure 53); scutellum without longitudino-posterio-groove..... 30

30 (29') Elytra with distinct shelves (Figure 121); elytral apices truncate .....

..... *S.* (*Sphenoptera*) extensocarinata-group

30' Elytra without distinct shelves (Figure 122); elytral apices rounded .....

..... *S.* (*Sphenoptera*) laticeps-group

31 (27') Color vivid cyan-blue..... *S.* (*Sphenoptera*) cyanea-group

31' Color not vivid cyan-blue 32

32 (31') Humeri expanded laterally beyond pronotum to form distinct carina; pronotum not expanded laterally (Figure sphcal6) ..... *S.* (*Sphenoptera*) chalybaea-group

32' Humeri not expanded laterally beyond pronotum to form distinct carina; pronotum square-shaped (Figure 53) or not (Figure 64) 33

33 (32') Pronotum square-shaped (Figure 53); abdomen with broken lateral band of setae, with mirrors (Figure 119); cupreous or black in color; elytral apices rounded (Figure 112); dorsum (especially pronotum) heavily sculptured .... *S.* (*Sphenoptera*) antiqua-group

33' Pronotum not expanded laterally (Figure 64); abdomen with continuous band or setae or broken band of setae laterally (Figures 119 or 120), with or without mirrors 34

34 (33') Abdomen with complete lateral band of setae; pronotum with lateral flattened plates ..... *S.* (*Sphenoptera*) cuprina-group

34' Abdomen with broken band of lateral setae, with triangular patches of setae laterally on each ventrite; pronotum without lateral flattened plates .... *S.* (*Sphenoptera*) sulcata-group

Species-group Designations

Subgenus *Chiloblemma* Obenberger, 1926

Diagnosis: This subgenus can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; long tarsi; transverse carina of scutellum; elytral apex rounded with strong lateral and sutural points.

Notes: This subgenus contains one species in the Palaearctic, *S.* (*Chiloblemma*) *hispidula*, and is in desparate need of revision. Examination of specimens reveals that this species may belong in the subgenus *Chilostetha*.

Sphenoptera (*Chiloblemma*) *hispidula* has been recorded from *Artemisia* spp. (Kalashian pers. comm.).

Subgenus *Chilostetha* Jakovlev, 1889

Diagnosis: This subgenus can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; hind and middle tibiae flattened in cross-section; each elytron with three sharp points apically or with middle point rounded or very broadly acute; prosternal process with continuous groove to apex; alternate interstriae evenly structured; and male mesotibiae with weak or absent apical tooth.

Notes: This subgenus is rather closely allied with *Chrysoblemma*, with some species-groups, such as the puberula-group, bearing very close resemblance to this subgenus. Most individuals in this subgenus are gold or light bronze in color and rather cylindrical in body shape. Also, all males in this group have emarginate last ventrites (except members of the laportei-group).

Some members of this subgenus were recently revised in Kalashian et al. (2005a), in which the authors synonymized over 40 names in the subgenus and resolved many taxonomic problems.

This subgenus ranges within Central Asia and Central Europe (Obenberger 1916) and contains approximately 58 species worldwide, 18 species occur in the region of the

former U.S.S.R., with a single species, *Sphenoptera vestita* of uncertain placement (possibly belonging to new subgenus, along with *S. liauteyi*).

S. infantula-group

(Figure 123, 175)

S. cauta cauta Jakovlev 1904: Armenia; Austria; Bosnia-Herzegovina; Bulgaria; Czech Republic; Greece; Hungary; Iran; Italy; Jordan; Macedonia; Slovakia; Slovenia; Spain; Syria; Turkey. (Host: *Artemesia* spp.(Mark Volkovitsh pers. comm.))

S. cauta palea Obenberger 1952: Kazakhstan; Russia, South European Territory; Ukraine.

S. infantula Reitter 1895: Armenia; Azerbaijan.

S. mingrelica Obenberger 1926: Georgia.

Diagnosis: This species-group can be separated from other species in the subgenus *Chilostetha* by the following combination of characters: anterior border of pronotum margined; pronotum with even punctation or slightly denser punctation laterally; abdomen with or without mirrors Male and female with patch of white setae on apex of abdomen; elytral interstiae not elevated; and scutellum without transverse carina.

Notes: While not occuring in this region, an economically important species, *S. jugoslavica*, belongs to the infantula-group. This species has been introduced to the United States and Canada as a biological control agent for *Centaurea diffusa*, diffuse knapweed.

This group also includes the species *S. tezcani*, which ranges through Turkey and Iran.

S. substriata-group

(Figures 44, 124, 176)

S. substriata Krynicki 1834: Austria; Bulgaria; Czech Republic; Greece; Hungary; Kazakhstan; Macedonia; Moldova; Poland; Romania; Russia, Central Territory; Slovakia; Turkey; Ukraine; Yugoslavia. (Host plants: *Artemesia* spp. (Volkovitsh pers. comm.); *Dianthus* spp. (Bílý 2003))

Diagnosis: This species-group can immediately separated from others in the subgenus by the following combination of characters: scutellum with transvese carina; abdomen with sparse setae medially; elytral interstriae elevated; both sexes with patch of white setae apically on abdomen; anterior border and posterior border of pronotum margined; pronotum with slightly denser punctation laterally.

Notes: The substriata-group is the only species-group in *Chilostetha* which possesses a transverse carina on the scutellum.

Only a single species occurs in the region, though a second species in the group, *S. laportei*, is distributed across the European continent, feeding on the same host plant genera.

S. basalis-group

(Figure 125, 177)

S. basalis basalis Morawitz 1861: Azerbaijan; Bosnia-Herzegovina; Bulgaria; Croatia; Hungary; Kazakhstan; Moldova; Romania; Russia, Central European Territory, South European Territory, West Siberia; Serbia; Ukraine; Yugoslavia. (Host plant: *Artemesia* spp. (Mark Volkovitsh pers. comm.)).

S. kiachtae Obenberger 1952: Russia, East Siberia.

Diagnosis: Members of the basalis-group are distinguished from others in the subgenus by the small size, presence of mirrors on the abdomen; lack of band of dense pronotal punctation medially and lack of confluent punctation laterally; and absence of posterior and anterior emargination on the pronotum.

Notes: This species-group is closely related to the next one, the insidiosa-group. They differ only in pronotal puncation and size. Members of the basalis-group are significantly smaller than those in the insidiosa-group.

S. insidiosa-group

(Figures 57, 67, 110, 126, 127, 178, 179)

S. canescens canescens Motschulsky 1860: Afghanistan; Kazakhstan; Turkmenistan; Uzbekistan. (Host plant: *Artemesia* spp. (Verdugo 2005))

S. canescens eximia Jakovlev 1886: Afghanistan; Turkmenistan; Uzbekistan.

S. densesculpta Jakovlev 1908: Mongolia; Russia, East Siberia.

S. egena Mannerheim 1852: Mongolia; Russia, Siberia.

S. insidiosa Mannerheim 1852: China, Northern Territory; Mongolia; North Korea; Russia, East Siberia.

Diagnosis: Members of the insidiosa-group are distinguished from others in the subgenus by the presence of mirrors on the abdomen; stripe of dense pronotal punctation medially and confluent pronotal punctation laterally; and absence of posterior and anterior emargination on the pronotum.

Notes: The *S. insidiosa* species-group is closely allied with the preceding basalis-

group, resembling them in all ways except for the three bands of punctation on the pronotum. Even so, this character is subtle, and is often only visible from certain viewing angles.

This species group contains one of the largest beetles in the subgenus *Chilostetha* – *S. canescens*. This species greatly resembles beetles of the subgenus *Chrysoblemma*, but lacks characters which would place it in that group, such as the rounded mesotibiae and metatibiae.

S. puberula-group

(Figures 48, 116, 129, 181)

S. eroylandusica Zykov and Alexeev 1993: Turkmenistan.

S. puberula Jakovlev 1887: Armenia; Azerbaijan; Iran; Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan. (Host Plants: *Artemisia* spp. (Mark Kalashian pers. comm.))

S. robustithoracis Zykov and Alexeev 1993: Turkmenistan.

S. vediensis Kalashian 1994: Armenia.

Diagnosis: Members of this species-group can immediately be identified by the patch of golden setae present ventrally on the the abdominal apex of both sexes. Additionally, they possess the following combination of characters: anterior border of pronotum margined with sulcus; pronotum with even punctation or slightly denser punctation laterally; and abdomen without mirrors.

S. popovii-group

S. popovii Mannerheim, 1852: Russia, Eastern Siberia, Far East; Mongolia; China.

Diagnosis: This species group can be distinguished from all others in the subgenus by the short lateral margin of the pronotum; the lack of sulcus at the anterior border of the pronotum; and the distinctive body shape.

Subgenus *Chrysoblemma* Jakovlev, 1889

Diagnosis: This subgenus is rather heterogenous in form, though members of this group are largely green in color with certain members being gold, green-gold, red, or bluish in color. They can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; hind and middle tibiae rounded in cross-section; each elytron with three sharp points apically (though the middle point can be rather obtuse); metacoxa without prominent tooth on meso-posterior margin, or if with tooth (some individuals in the artemesiae group), prosternum without median depression and elytral striae obsolete.

Notes: This subgenus has many problems, where some species are actually closely allied with subgenus *Chilostetha* and may belong with that subgenus. A few species groups (pubescens and tomentosa-groups) share many characters with *Chilostetha*, including the lack of an emarginate prosternum and and the slightly rounded middle of elytral apex.

This subgenus is almost exclusively Palaearctic in distribution (Obenberger 1919) and includes the only published species-group, the *S*. (*Chrysoblemma*) pubescens-group, defined by Kalashian and Volkovitsh (2006).

Chrysoblemma contains approximately 63 species worldwide, 32 species occur in the region of the former U.S.S.R., all of which are currently placed in species-groups.

S. tomentosa-group

(Figures 130, 131, 182, 183)

S. amplicollis Jakovlev 1899: Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan.

S. hauseri Reitter 1895: Afghanistan; Iran; Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan. (Host plants: *Haloxylon* spp. (Alexeev et al. 1991))

S. sancta Reitter 1890: Armenia; Azerbaijan; Iran; Israel; Turkey. (Host plants: *Salsola* spp. (Volkovitsh pers. comm.),

S. tomentosa Jakovlev 1886: Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan.

Diagnosis: Distinguished from other species in the subgenus by the lack of a sulcus at the anterior border of the pronotum; lack of longitudino-posterio-groove of the scutellum; microreticulation of the pronotum; dense, coarse punctation of elytral interstriae; obsolete striae posteriorly; absence of lateral bead on the pronotum; curved, lack of emargination male protibia; absence of mirrors on ventrites; and the straight mesotibiae of the male.

Notes: This group is closely allied with the S. pubescens-group, which shares the characteristically punctate elytral interstriae. Members of this group vary consideraably in size and color, with *S. hauseri* superficially resembling members of the subgenus *Chilostetha*.

S. pubescens-group

(Figure 79, 132, 184)

S. gracilis Jakovlev 1900: Kazakhstan, Turkmenistan.

S. medvedevi Kalashian and Volkovitsh 2006: Tajikistan.

S. pubescens Jakovlev 1886: Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan. *S. punctatissima* Reitter 1895: Afghanistan; Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan. (Host plant: *Haloxylon* spp. (Alexeev et al. 1991))

S. viridula Jakovlev 1905: Kazakhstan; Tajikistan; Turkmenistan.

Diagnosis: Distinguished from other species in the subgenus by the longitudino-posterio-groove of the scutellum; anterior border of the pronotum with sulcus; microreticulation of the pronotum; dense, coarse punctation of elytral interstriae; incomplete striae posteriorly; absence of lateral bead on the pronotum; curved, un-emarginate male protibia; absence of mirrors on ventrites; and the straight mesotibiae of the male.

Notes: This is the only formally described species-group (Kalashian and Volkovitsh 2006). Most species in this group have shallow, weakly-ridged antennal cavities, except for *S. medvedevi*, which has deep antennal cavities. This species-group is probably closely related to the tomentosa-group.

S. jakowlewi-group

S. amoena Jakovlev, 1901: Iran; Turkmenistan.

S. araxidis Reitter, 1890: “Araxethal” (Armenia or Azerbaijan).

S. dushakensis Kalashian, 1994: Turkmenistan; Uzbekistan.

S. geghardica Kalashian and Zykov, 1994: Azerbaijan; Armenia.

S. jakowlewi Reitter, 1895: Azerbaijan; Armenia.

S. tschitscherini Jakovlev, 1899: Armenia; Azerbaijan; Kazakhstan; Turkmenistan; Uzbekistan. (Host plant: *Salsola* spp. (pers. obs.))

Notes: Unfortunately, no specimens were available for study of this species-group.

S. artemisiae-group

(Figures 28, 80, 104, 115, 133, 134, 185, 186)

S. alexeevi Kalashian and Volkovitsh 1993: Kazakhstan.

S. artemisiae Reitter 1889: Afghanistan; Armenia; Azerbaijan; Georgia; Iran; Israel; Turkey; Turkmenistan. (Host plant: *Artemisia* spp. (Alexeev et al. 1991))

S. viridiaurea Kraatz 1882: Afghanistan; Iran; Israel; Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan. (Host plants: *Climacoptera* spp., *Salsola leptoclada*, *Kochia* spp., *Suaeda* spp., and *Alhagi* spp. (Alexeev et al. 1991))

Diagnosis: Beetles in the artemesiae-group are small in size (<1cm), have a narrow, subparallel body shape, strongly pronounced eyes, head nearly as wide as pronotum, and straight male mesotibiae. They can be distinguished from other species in the subgenus by the following combination of characters: supra-antennal ridge weak, with weak carina; obsolete elytral striae posteriorly; pronotum not beaded laterally; pronotum lacking microreticulation posteriorly; sparsely punctate elytral interstriae; pronotum not margined by sulcus at anterior border; absence of a ventro-lateral setal band; and prominent sutural and lateral points of elytral apex.

Notes: This group also includes a fourth species, *S. formosula*, which is known only from Iran.

S. tamarisci-group

(Figures 35, 88, 135, 136, 187, 188)

S. hammadae Kalashian and Volkovitsh 1997: Tajikistan.

S. kerzhneri Volkovitsh and Kalashian 2001: Kazakhstan; Uzbekistan.

S. khnzoriani Kalashian 1996: Armenia.

S. ovata Alexeev 1978: Tajikistan. (Host plants: *Climacoptera* spp., *Horaninovia* spp., *Salsola leptoclada*; *Alhagi* spp. (Alexeev et al. 1991))

S. striatipennis Jakovlev 1885: Iran; Kazakhstan; Mongolia; Tajikistan; Turkmenistan; Uzbekistan.

S. tamarisci beckeri Dohrn 1866: Afghanistan; Armenia; Azerbaijan; China, Northwest Territory; Georgia; Iran; Kazakhstan; Kyrgyzstan; Mongolia; Russia, South European Territory; Tajikistan; Turkey; Turkmenistan; Ukraine; Uzbekistan.

S. zarudnyi schatinensis Alexeev and Zykov 1991: Armenia; Azerbaijan; Georgia; Iran; Turkey. (Host plant: *Amygdalus* spp. (Kalashian pers. comm.))

Diagnosis: Distinguished from other species in the subgenus by the strong, acutely carinate supra-antennal ridge; complete striae posteriorly; lateral bead of the pronotum; strongly curved, unforked male protibia; absence of mirrors on ventrites; and the straight mesotibiae of the male.

Notes: Members of this species group closely resemble members of the scovitzii-group, however, beetles in the tamarisci-group lack mirrors laterally on the ventrites. The

species *S. heroica* is also included in this group by Mark Kalashian, however, it only occurs in Iran (not-the former U.S.S.R.).

S. scovitzii-group

(Figures 46, 66, 87, 119, 137, 138, 189, 190)

S. antoniae Reitter 1891: Armenia; Azerbaijan.

S. ignita Reitter 1895: Kazakhstan; Russia, Orenburg; Tajikistan; Turkmenistan; Uzbekistan.

S. scovitzii scovitzii Faldermann 1835: Afghanistan; Armenia; Azerbaijan; Chad; Egypt; Iran; Iraq; Israel; Kazakhstan; Kyrgyzstan; Russia, South European Territory; Tajikistan; Turkey; Turkmenistan; Uzbekistan. (Host plants: *Climacoptera turcomanica*, *Salsola leptoclada*, *Alhagi* spp. (Alexeev et al. 1991))

Diagnosis: Distinguished from other species in the subgenus by the strongly carinate supra-antennal ridge; complete striae posteriorly; lateral bead of the pronotum; forked male protibia; presence mirrors on ventrites; and the straight mesotibiae of the male.

Notes: Members of this group are green in color, as is typical for Chrysoblemma, however, one species, *S. ignita*, has festive metallic red and green coloration. The abdominal setation in this group is broken laterally by triangular mirrors laterally on each abdominal segment.

S. orichalcea-group

(Figures 45, 59, 72, 86, 99, 120, 139, 140, 191)

S. lutulenta Jakovlev 1905: Turkmenistan.

S. orichalcea (Pallas) 1781: Armenia; China, Northern Territory, Northwest Territory; Kazakhstan; Kyrgyzstan; Mongolia; Russia, Central European Territory, North European Territory, South European Territory, West Siberia; Tajikistan; Turkmenistan; Uzbekistan.

S. tristicula Reitter 1895: Armenia; Azerbaijan; Georgia; Turkey; Turkmenistan.

Diagnosis: Distinguished from other species in the subgenus by the following combination of characters: supra-antennal ridge weak, with weak carina; obsolete elytral striae posteriorly; pronotum without bead laterally; pronotum lacking microreticulation posteriorly; sparsely, finely punctate elytral interstriae; pronotum with anterior border margined with sulcus; presence of a ventro-lateral setal band; and small sutural and lateral points of elytral apex.

Notes: This group displays distinctively dense and even punctation and micropunctation on the pronotum and elytra, giving beetles in this group a distinctive "silky" luster. Additionally, the prosternal process of males of this group is covered with very dense, shallow punctation or a very dense carpet of setae.

While this group is small, it is one of the most diverse in shape and size in the subgenus *Chrysoblemma*. The cosmopolitan species *S. orichalcea*, has several diferent color morphs (coppery-red, violet metallic, green metallic) and ranges in size considerably based on nutrition as a larva. This variation in color and size has lead to description of innumerable extraneous species – over fifteen names were synonymized with *S. orichalcea* by Volkovitsh and Kalashian in 2003.

S. bifulgida-group

S. bifulgida Reitter, 1898: Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan.

Diagnosis: Distinguished from others in the subgenus by the strongly pronounced sexual dimorphism in mesotibiae (male mesotibae strongly curved) and the longitudinal depression on the pronotum.

Subgenus *Cyphostetha* Jakovlev 1893

S. coerulea Jakovlev 1898: Armenia; Afghanistan; Iran; Turkmenistan; Turkey.

S. nox Jakovlev 1900: Iran.

Notes: Material from this subgenus was not available for study.

Subgenus *Deudora* Jakovlev 1899

Diagnosis: This subgenus can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; hind and middle tibiae flattened in cross-section; each elytron with three points apically or with middle region rounded or very broad; pronotum without depressions or impressions (though may have narrow furrows); prosternal process bordered only laterally, or if bordered with continuous groove to apex (as in micans- and sculpticollis-groups) then alternate interstriae differently structured and male mesotibia with prominent apical tooth.

Notes: Most individuals in this subgenus are small, dark bronze in color and rather elongate ovate in body shape. Differences in male tibial structure can separate out most of the species-groups.

Species in this subgenus is notoriously difficult to identify, as most species look superficially similar, with only subtle differences between species. However, within a species, size and shape varies greatly. As a result, many species were described from single localities from singletons. Kalashian et al. (2005b) solved many of these taxonomic issues, synonymizing over forty names in *Deudora*, and removing from synonymy several valid species.

Deudora contains approximately 60 species worldwide, mainly in central Asia and Europe, 26 species occur in the region of the former U.S.S.R., eight of which are not keyed out here – six contained in two species-groups and two which are not currently placed in species-groups – *S. segregata* and *S. costata*.

S. smyrneensis-group

(Figures 26, 97, 141, 192)

S. smyrneensis Gory 1841: Armenia; Azerbaijan; Iran; Israel; Jordan; Lebanon; Syria; Turkey.

Diagnosis: Members of this species-group can be distinguished from others in the subgenus *Deudora* by the following combination of characters: prosternal process with groove not extending to apex, prosternal process not strongly impressed medially; pronotum without three distinct punctation vittae; abdomen with only sparse setae medially, lateral setal band absent; and male mesotibiae and metatibiae not emarginate, without apical spine.

Notes: This species group is distinctive within the subgenus *Deudora*, in that males do not differ from females in the curvature, spines, or emargination of the meso-

and metatibiae.

S. afflicta-group

S. afflicta Jakovlev 1900: Kazakhstan; Turkmenistan; Uzbekistan.

S. mitroshinae Kalashian and Volkovitsh 2007: Turkmenistan; Tajikistan; Uzbekistan (Kalashian and Volkovitsh 2007). (Host plants: *Anabasis salsa* (Kalashian and Volkovitsh 2007)).

Notes: Specimens of this species-group were not available for study and are not discussed here.

S. rauca-group

(Figures 3, 4, 5, 6, 33, 52, 76, 81, 91, 96, 100, 106, 108, 114, 142, 193, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262)

S. aeneomicans Kraatz 1882: Afghanistan; Armenia; Azerbaijan; China, Northwest Territory; Georgia; Iran; Kazakhstan; Kyrgyzstan; Tajikistan; Turkey; Turkmenistan; Uzbekistan.

S. signata Jakovlev 1887: Armenia; Azerbaijan; Bulgaria; Greece; Iran; Israel; Jordan; Kyrgyzstan; Macedonia; Syria; Turkey; Turkmenistan.

Diagnosis: This group can be distinguished from the other species-groups in the subgenus by the following combination of characters: pronotum with three distinct punctation vittae; prosternal process with lateral grooves not extending to apex, and prosternal process not strongly impressed medially; abdomen with dense setae medially and lateral setal band, separated by glabrous band; and male mesotibiae and metatibiae

strongly emarginate, with strong apical spine.

Notes: This group was previously considered two separate groups (rauca-group and gemmata-group), but is combined here based on characters discussed in the following revision of the group. Additionally, *S. misella*, which was originally placed in this taxon is moved to the *S. sculpticollis* group. Five other species belong to this group, which do not occur in the former U.S.S.R.. For additional information, notes and comments, see following revision.

S. simplex-group

S. kepelensis Zykov and Alexeev, 1992: Afghanistan; Tajikistan; Turkmenistan; Uzbekistan.

S. simplex Jakovlev, 1893: Armenia; Azerbaijan; Greece; Iran; Turkey.

S. tamerlani Obenberger, 1929: Uzbekistan.

S. tenax Jakovlev, 1902: "Arax Valley".(Armenia or Azerbaijan).

Notes: Members of this group were not available for study.

S. sculpticollis-group

(Figures 56, 62, 143, 144, 194, 195)

S. baumanni Niehuis 1999: Turkey; Armenia (Volkovitsh and Kalashian 2006).

S. khosrovica Kalashian 1990: Armenia.

S. misella Jakovlev 1900: Armenia; Georgia; Iran; Turkey. (Host Plant: *Astragalus* spp. (Kalashian pers. comm.))

S. sculpticollis Heyden 1886: Armenia; Azerbaijan; Georgia; Iran; Iraq; Israel; Lebanon;

Syria; Turkey. (Host Plant: *Centaurea* spp. (Kalashian pers. comm.))

Diagnosis: The sculpticollis-group can be separated from other species-groups in the subgenus *Deudora* by the following combination of characters: prosternum with continuous groove, reaching apex; prosternal process without strong impression medially; male mesotibiae and metatibiae strongly emarginate; pronotum with prominent wrinkles laterally; elytral striae composed of elongate dashes.

Notes: Members of this species group, while they vary considerably in size, have a consistent set of distinguishing characters, particularly the continually emarginate prosternal process and the laterally wrinkled pronotum. *S. misella*, though tiny, is transferred from the rauca-group to this group based on the possession of the preceding combination of characters.

S. sulciventris-group

(Figures 34, 84, 103, 145, 196)

S. bucharica Jakovlev 1900: Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan.

S. conjuncta Jakovlev 1900: Uzbekistan.

S. hamata Jakovlev 1899: Afghanistan; Kyrgyzstan; Tajikistan; Uzbekistan.

S. incerta Jakovlev 1887: Armenia; Azerbaijan; Iran; Turkey.

S. koenigi Jakovlev 1891: Iran; Kazakhstan; Turkmenistan.

S. sulciventris Jakovlev 1886: Afghanistan; Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan.

S. tibialis Jakovlev 1886: Afghanistan.

S. *zhelochovtsevi* Alexeev 1978: Tajikistan.

Diagnosis: Members of this group can immediately be distinguished from others in the subgenus by the presence of extremely emarginate meso- and metatibiae in the male and the deeply excavate prosternal process.

Notes: The excavate male meso- and metatibiae are unique to this group.

S. curta-group

(Figures 68, 146, 197)

S. curta Jakovlev, 1885: Iran; Kazakhstan; Tajikistan; Turkmenistan; Uzbekistan.

S. manifesta Jakovlev 1900: Armenia; Azerbaijan; Georgia; Iran.

S. micans Jakovlev 1900: Armenia; Iran; Turkey.

Diagnosis: This group can be distinguished from other species-groups in *Deudora* by the following combination of characters: pronotum without prominent wrinkles laterally, with punctation; elytral striae composed of short dashes; prosternal process with lateral grooves which continue to apex; prosternal process without strong impression medially; male mesotibiae and metatibiae strongly emarginate.

Notes: Members of this group are larger than most other species in the subgenus Deudora and have a distinctively bordered pronotum.

subgenus *Hoplistura* Jakovlev, 1889

Diagnosis: This subgenus can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; hind and middle tibiae rounded in cross-section; each elytron with three sharp points apically; metacoxa with prominent tooth on posterio-medial margin;

prosternum with median impression; and elytral striae complete.

Notes: Three species in *Hoplistura* occur in this region, though most of the diversity is in Africa and the Oriental region (Obenberger 1919). This subgenus is closely allied with *Chrysoblemma*, and the distinction between the two is not clear.

S. mesopotamica-group

(Figures 27, 69, 102, 147, 198)

S. mesopotamica Marseul 1865: Afghanistan; Armenia; Azerbaijan; Georgia; Iran; Iraq; Kazakhstan; Tajikistan; Turkey; Turkmenistan; Uzbekistan. (Host plants: *Tamarix* sp. (Kalashian pers. comm.))

Diagnosis: This species-group can be distinguished from all other species-groups by its possession of all of the characters of the subgenus *Hoplistura* as well as a medially emarginate prosternum; elytra with micropunctation; and lack of a row of teeth on the male hind tibiae.

Notes: The mesopotamica-group is rather well defined, with only a single, widespread Palaearctic species in the group.

S. balassogloi-group

(Figures 85, 92, 98, 148, 150, 199)

S. balassogloi balassogloi Jakovlev 1885: Afghanistan; Armenia; Azerbaijan; Georgia; Iran; Iraq; Israel; Kazakhstan; Tajikistan; Turkey; Turkmenistan; Uzbekistan. (Host plants: *Tamarix* sp. (Volkovitsh pers. comm.))

S. semenovi Jakovlev 1889: Afghanistan; Azerbaijan; Iran; Kazakhstan; Mongolia;

Tajikistan; Turkmenistan; Uzbekistan. (Host plants: *Tamarix* sp. (Alexeev et al. 1991)).

Diagnosis: This species can be distinguished from others in its subgenus by the presence of a row of strong teeth on the male metatibia and absence of median emargination of the prosternum.

Notes: The balassogloi-group is rather well defined, with only two species in the group.

Subgenus *Sphenoptera* Dejean, 1833

Diagnosis: This subgenus can be distinguished from all other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; hind and middle tibiae flattened in cross-section; each elytron rounded or truncate apically, though may have small spine suturally; pronotum with median depression or without; prosternal process with grooves laterally which do not extend to apex, or if bordered with continuous groove to apex then border in a distinct V-shape; alternate interstriae may be elevated, but always evenly structured; male mesotibia with prominent apical tooth; male with truncate last ventrite.

Notes: Most individuals in this subgenus are large, and color varies greatly in this group, ranging from metallic violet to bronzy with green stripes. Body shape also varies, though most species in this group have a rather wide wedge-shaped form (hence the genus name, *Sphenoptera* – "wedge-wing").

Two distinct groups exist within the subgenus, a group in which all of the members have evenly rounded pronota, and another group in which the pronoum is strongly apressed

medially. Members of the latter group often have flattened, crenulate plates laterally on the pronotum, and the pronotum is expanded laterally to form a sort of flange.

Again, as with *Deudora* and *Chilostetha*, an assortment of taxonomic problems within this subgenus were solved by Kalashian et al. (2005b) and Kalashian and Volkovitsh (2009).

Sphenoptera sensu stricto is the most speciose and widespread subgenus, with approximately 140 species throughout the Palaearctic. Seventy-six species occur in the region of the former U.S.S.R., with nine of these species of uncertain placement in species-groups -- *S. barbata* Jakovlev; *S. signifera* Jakovlev ; *S. fissifrons* Marseul ; *S. exigua* Jakovlev ; *S. manca* Obenberger; *S. mixta* Jakovlev; *S. marseulii* Saunders; *S. commixta* Obenberger*;* and *S. krali* Obenberger. These species, many of which are known from single specimens, are currently being worked on by Mark Kalashian and placed into groups.

<u>*S.* tragacanthae-group</u>

(Figures 29, 53, 60, 150, 151, 152, 153, 157, 208, 201, 202, 203, 204)

S. abbreviata abbreviata Jakovlev 1899: Armenia; Iran; Turkey.

S. anthracina Jakovlev 1887: Armenia; Azerbaijan; Iran; Turkmenistan.

S. bicarinata Jakovlev 1887: Armenia; Azerbaijan; Iran (Volkovitsh and Kalashian 2006).

S. coracina (Steven) 1829: Armenia; Azerbaijan; Bulgaria; Georgia; Greece; Crete; Iran; Iraq; Israel; Macedonia; Lebanon; Syria; Turkey; Ukraine; Russia, South European Territories (Volkovitsh and Kalashian 2006).

S. ebenina Jakovlev 1900: Afghanistan; Uzbekistan; Turkmenistan.

S. eugenii Jakovlev 1898: Armenia; Azerbaijan; Georgia; Iran.

S. korshinskii Jakovlev 1900: Uzbekistan.

S .oporina Jakovlev 1903: Armenia; Azerbaijan.

S .tragacanthae (Klug) 1829: Ethiopia; Gambia; Mali; Moçambique; Niger; Senegal; Somalia; Sudan; Afghanistan; Armenia; Azerbaijan; Egypt; Georgia; Greece; Iran; Iraq; Kyrgyzstan; Lebanon; Libya; Pakistan; Syria; Turkey; Turkmenistan; Ukraine. (Host Plants: *Astragalus* spp. (pers. obs.))

S. violacea Jakovlev 1898: Iran; Tukmenistan.

Diagnosis: This group can be separated from all others in the sugenus by the arcuate lateral silhouette; the lack of impressions on pronotum; elytra subparallel in apical 2/3; and pronotal punctation even and fine across entire disc.

Notes: This group is rather variable, with many distinct forms appearing within the group – beetles range in size from one of the smallest in the subgenus (S. oporina) to one of the largest (*S. tragacanthae*). Individuals within a species also vary greatly in color and size.

The wide-ranging species, *S. tragacanthae*, has been described many times, probably due to the wide variation in size.

The tragacanthae-group and the hypocrita group are very closely allied.

S. hypocrita-group

(Figures 154, 205)

S. caesia Jakovlev 1904: Uzbekistan.

S. chalcosoma Obenberger 1927: Armenia

S. cuprifrons Faldermann 1835: 'Transcaucasia'

S. hypocrita Mannerheim 1837: Armenia; Azerbaijan; Georgia; Iran; Jordan; Pakistan; Russia, South European Territory; Turkey; Turkmenistan.

S. rangnowi Kerremans 1909: Afghanistan; Armenia; Azerbaijan; Iran; Turkmenistan.

S. subtilis Jakovlev 1898: Iran; Turkmenistan.

S. tristis Jakovlev 1886: Turkmenistan.

S. varia Jakovlev 1887: Uzbekistan.

Diagnosis: This group can be separated from all others in the sugenus by the arcuate lateral silhouette, the lack of impressions on pronotum; elytra narrowed from humeri; and pronotal punctation significantly more dense laterally.

Notes: This species-group is closely allied with the preceding group, the tragacanthae-group, based on the unimpressed pronotum. Additionally, both of these groups share the characters of the anterior emargination of the pronotum, and microtuberculate sculpturing dorsally.

S. exarata-group

(Figures 24, 25, 32, 49, 50, 58, 64, 65, 74, 75, 82, 83, 89, 90, 93, 94, 95, 105, 117, 155, 206, 225, 227, 228, 229, 231, 233, 232, 234, 236, 237, 238, 240, 241, 242, 243, 244, 250)

S. exarata (Fischer von Waldheim) 1824: Afghanistan; Armenia; Azerbaijan; China, Northwest Territory; Iran; Kazakhstan; Kyrgyzstan; Russia, South European Territory; Tajikistan; Turkmenistan; Uzbekistan.

S. foveola (Gebler) 1825: Kazakhstan; Kyrgyzstan; Russia, South European Territory; Turkmenistan.

S. lateralis Faldermann 1836: Afghanistan; Kazakhstan; Kyrgyzstan; Russia, South European Territory; Turkmenistan; Uzbekistan.

S. magna Gory and Laporte 1839: Iran; Iraq; Israel; Jordan; Saudi Arabia; Syria; Turkey.

S. pilipes Jakovlev 1886: Kazakhstan; Kyrgyzstan.

Diagnosis: This species-group can be distignuished from others in the subgenus by the deep posterior depression of the pronotum, and elytra which are parallel in the apical 2/3, then sharply narrowed posteriorly.

Notes: This species group contains a species which has been identified as a potential biological control agent, and is dicussed further in the following revision.

S. cyanea-group

S. cyanea Jakovlev, 1898: Afghanistan; Iran; Kazakhstan; Turkmenistan.

S. lia Jakovlev, 1901: Turkmenistan; Uzbekistan.

Diagnosis: This species-group can be distinguished from others in the subgenus by the distinct light metallic blue color, and the shallowly impressed pronotum.

S. chalybaea-group

(Figures 55, 70, 78, 156, 207)

S. chalybaea chalybaea Ménétriés 1848: Afghanistan; Azerbaijan; Kazakhstan; Iran; Turkmenistan.

S. depressiuscula Obenberger 1927: Kyrgyzstan; Uzbekistan.

S. pseudochalybaea Richter 1945: Kazakhstan; Uzbekistan.

S. serripes Jakovlev 1900: Turkmenistan.

S. subtricostata Kraatz 1882: Kazakhstan; Tajikistan; Uzbekistan.

Diagnosis: This group can be distinguished from others in the *Sphenoptera* subgenus by the following combination of characters: humeri expanded laterally beyond pronotum to form distinct carina; pronotum evenly rounded laterally; elytra flat relative to pronotum; elytral suture depressed below level of third stria; and alternate elytral interstriae flat, with chagreening.

S. antiqua-group

(Figures 53, 157, 158, 159, 208, 209, 210)

S. antiqua antiqua (Illiger) 1803: Algeria; Armenia; Austria; Azerbaijan; Bosnia-Herzegovina; Bulgaria; Croatia; Czech Republic; France; Georgia; Greece; Hungary; Iran; Iraq; Israel; Italy, Romagna, Sardinia, Sicily; Macedonia; Montenegro; Morocco; Portugal; Romania; Russia; Serbia; Slovakia; Spain; Turkey. (Host plant: *Astragalus monspessulanus*; *Onobrychis sativa*; *Trifolium montanum* (Bílý 2003))

S. *arcana* Jakovlev 1908: Armenia; Iran; Iraq; Turkey (Volkovitsh and Kalashian 2006)

S. fallatrix Obenberger 1927: "Transcaucasia"

S. rugulosa rugulosa Faldermann 1835: "Azerbaijan; Armenia; Iran; Turkey.

Diagnosis: This group can be distinguished from others in the subgenus *Sphenoptera* by the following combination of characters: humeri not expanded laterally beyond pronotum to form distinct carina; pronotum square in shape; alternate elytral interstriae not strongly elevated; abdomen with broken lateral band of setae, with mirrors; cupreous or black in color; elytral apices rounded; dorsum (especially pronotum) heavily

sculptured.

Notes: Most individuals belonging to this group are also a brilliant magenta ventrally, however this varies slightly between specimens.

S. latesulcata-group

(Figures 51, 118, 160, 211)

S. latesulcata Jakovlev 1886: Azerbaijan; Armenia; Georgia; Turkey; Turkmenistan.

Diagnosis: This species can immediately be distingulished from others in the subgenus by the distinctive bronze and green striped coloration and continuous V-shaped groove of the prosternal process.

Notes: This species is distinctive in the subgenus, in body shape and coloration, and does not fit into any other species-groups.

S. cuprina-group

(Figures 23, 109, 112, 161, 162, 163, 164, 212, 213, 214, 215)

S. aerata Jakovlev 1887: Armenia; Azerbaijan; Iran; Kazakhstan; Turkmenistan; Uzbekistan.

S. cuprina cuprina Motschulsky 1860: Armenia; Azerbaijan; Bulgaria; China, Northwest Territory; Greece, Crete; Italy, Sicily; Kazakhstan; Russia, Central European Territories, South European Territories; Ukraine.

S. cyphogastra Jakovlev 1900: Uzbekistan.

S. diluta Jakovlev 1899: Armenia.

S. intaminata Jakovlev 1908: Azerbaijan; Turkey.

S. manderstjernae Jakovlev 1886: China, Northwest Territory; Kazakhstan; Kyrgyzstan; Uzbekistan.

S. margellanica Kraatz 1882: Afghanistan; Uzbekistan.

S. navicula Jakovlev 1908: Turkmenistan.

S. notata Jakovlev 1898: Afghanistan.

S. obscuriventris Motschulsky 1860: China, Northern Territory; Kazakhstan; Kyrgyzstan; Mongolia; Russia, East Siberia, West Siberia.

S. pliginskii Obenberger 1927: Ukraine.

S. repetekensis Obenberger 1927: Afghanistan; Iran; Turkmenistan; Uzbekistan.

S. spreta Jakovlev 1899: Kazakhstan; Kyrgystan.

S. stenophthalma Jakovlev 1899: Kazakhstan.

S. viridicoerulea Kraatz 1882: Turkmenistan; Uzbekistan.

Diagnosis: This species-group can be distinguished from other species-groups in the subgenus *Sphenoptera* by the following combination of characters: abdomen with complete lateral band of setae, without mirrors; pronotum with lateral flattened plates; pronotum not expanded laterally; humeri not expanded laterally beyond pronotum to form distinct carina; alternate elytral interstriae not strongly elevated; elytra flat relative to pronotum; and elytral suture depressed below level of third stria.

S. laticeps-group

(Figures 122, 165, 216)

S. laticeps Jakovlev 1886: China, Northwest Territory; Kazakhstan; Kyrgyzstan; Mongolia; Tajikistan; Turkey; Uzbekistan.

S. lucidicollis Kraatz 1882: Uzbekistan.

S. olivacea Kraatz 1882: Turkmenistan, Uzbekistan.

S. propinqua Kraatz 1882: Tajikistan; Uzbekistan.

S. purpuriventris Kraatz 1882: Uzbekistan.

S. suvorovi Jakovlev 1908: Kazakhstan.

Diagnosis: This group can be separated from the other groups in the subgenus by the following combination of characters: body very narrow; elytra without distinct shelves; elytral apices rounded; pronotum without three deep, waxy furrows; scutellum without longitudino-medial-groove; prosternal process emargination not grooved, consisting of discrete punctures; alternate elytral interstriae strongly elevated; elytra flat relative to pronotum; elytral suture depressed below level of third stria.

Notes: This group is under revision currently by Mark Kalashian.

S. sulcata-group

(Figures 107, 166, 167, 217, 218)

S. danilevskyi Kalashian 2002: Kazakhstan.

S. *irregularis* Jakovlev 1886: Kazakhstan; Kyrgyzstan; Mongolia; Russia, East Siberia.

S. *krali* Obenberger, 1927: Afghanistan; Uzbekistan.

S. longipennis Jakovlev 1904: Kazakhstan; Kyrgyzstan.

S. sulcata sulcata (Fischer von Waldheim, 1824) Armenia; Azerbaijan; China, Northwest Territory; Georgia; Iran; Kazakhstan;Mongolia; Russia, East Siberia, West Siberia; Turkmenistan.

Diagnosis: Members of the sulcata-group may be differentiated from other groups

in the subgenus by the presence of the following combination of characters: abdomen with broken band of lateral setae, with triangular patches of setae laterally on each ventrite; pronotum without lateral flattened plates pronotum not expanded laterally; abdomen with continuous band or setae or humeri not expanded laterally beyond pronotum to form distinct carina; pronotum not square in shape; color not vivid cyan-blue; alternate elytral interstriae weakly or not elevated; elytra flat relative to pronotum; elytral suture depressed below level of third stria.

S. extensocarinata-group

(Figures 113, 121, 168, 169, 220)

S. arnoldii Alexeev 1975: Mongolia; Russia, East Siberia.

S. extensocarinata Jakovlev 1889: China, Northern Territory; Mongolia; Russia, East Siberia.

S. inermis Kerremans, 1898: China, Northern Territory; Mongolia; Russia, East Siberia.

Diagnosis: Members of the extensocarinata-group may be differentiated from other groups in the subgenus by the presence of elytral shelves and truncate elytral apices.

S. canaliculata-group

(Figures 31, 36, 54, 170, 171, 172, 221, 222)

S. canaliculata (Pallas) 1781: China, Northern Territory; Mongolia; Russia, East Siberia; Tibet.

S. demissa Marseul 1866: Afghanistan; Armenia; Azerbaijan; Iran; Iraq; Turkey;

Turkmenistan.

S. lapidaria (Brullé) 1832: Albania; Azerbaijan; Bulgaria; Egypt; France; Greece, Crete; Hungary; Iran; Iraq; Israel; Italy, Sicily; Lebanon; Russia, South European Territory; Spain; Syria; "Transcaucasia"; Turkey.

Diagnosis: Members of the canaliculata-group may be differentiated from other groups in the subgenus by the following combination of characters: pronotum with three deep furrows, each with dense setae and a band of wax (wax may be lost through age or washing); scutellum with median impression.

Notes: This is yet another distinctive species-group in the subgenus *Sphenoptera*, oftentimes they may be immediately distinguishable by the three dorsal bands of whitish wax. However, in some specimens this may be lost, so presence of the longitutinal furrows is the only reliable character.

Subgenus *Sphenopterella* Volkovitsh and Kalashian, 1994

(Figures: 30, 47, 61, 71, 73, 173, 223)

S. margaritae Volkovitsh and Kalashian 1994 : Uzbekistan

Diagnosis: This subgenus is rather distinctive and presents several characters that are atypical for the genus *Sphenoptera*, and can therefore be easily distinguished from the other subgenera by the following combination of characters: pronotal carina never dipping ventrad to level of pronotal edge; absence of apparent striae on elytra; supra-antennal ridge very weak, without carina.

Notes: Only one species in the subgenus Sphenopterella occurs in the former U.S.S.R., *S. margaritae*. The other species in the subgenus, the recently described *S.*

vlastae Kalashian and Volkovitsh 2006, has a range limited to Iran.

Subgenus *Tropeopeltis* Jakovlev

(Figures 77, 101, 174, 224)

S. anthaxoides Reitter 1895: Armenia; Azerbaijan; Iran; Iraq; Turkey.

S. calligoni Kalashian and Volkovitsh 1997: Kazakhstan; Turkmenistan.

S. kaznakowi kaznakowi Jakovlev 1899: Afghanistan; Iran; Tajikistan; Turkmenistan; Uzbekistan.

S. schneideri Reitter 1898: Kazakhstan; Uzbekistan; Turkmenistan.

S. servistana Obenberger 1929: Iran; Iraq; Turkmenistan.

Diagnosis: The subgenus *Tropeopeltis* can be distinguished from all other subgenera of *Sphenoptera* by the following combination of characters: lateral pronotal carina slightly sinuate laterally, never dipping ventrad to level of pronotal edge; hind and middle tibiae round in cross-section; each elytron with three sharp points apically; metacoxa with prominent tooth medially; elytra with complete striae; male hind tibiae strongly emarginate; abdomen without lateral setal band; and scutellum with or without transverse carina.

Notes: This subgenus is much more speciose outside of the former Soviet Union, with most of its diversity on the African continent and a few species in the Oriental region. It is also one of the “trispinose” subgenera which are unique among *Sphenoptera* in that they are mainly xylophagous.

Discussion

The subgenera *Chiloblemma* and *Cyphostetha* were not included in this key due to lack of available material, however the status of one of these subgenera, *Chiloblemma*, remains unclear anyway. The jakowlevi-group, afflicta-group, and simplex-group were also not included due to lack of material.

The defined species-groups are not limited to those listed in this key. The *Sphenoptera* (*Sphenoptera*) pharao-group, which contains only a single species from northern Africa, is not included in this work, as well as the *S*. (*Chilostetha*) convicta-group from the Middle East. These were omitted because they do not occur in this region. Mention of these species groups is necessary, however, to call attention to the need for work on a global scale. Much of the diversity in this genus is restricted to the African and Oriental regions, and these species need to be placed in species-groups as well for a comprehensive look at the genus.

With almost 1,000 species in the genus, there is still much taxonomic work to be done, and Kalashian and Volkovitsh are currently at work revising several of the species-groups in the subgenus *Sphenoptera*, including many of the species which were listed as *incertae sedis* here, to continue the series of taxonomic *Sphenoptera* publications.

Revisions of two species-groups within this system revealed several issues with those groups, specifically the transfer of *S. misella* to the *S*. sculpticollis-group from the rauca-group; the consolidation of the *S*. rauca-group and *S*. gemmata-group; and the synonymy of several species in both the *S*. exarata-group and rauca-group. This is

indicative that there may be problems with other species-groups, which might warrant in depth study and revision of each species-group.

Once this is far enough along to where the subgenera and species-groups are well defined, a modern phylogenetic study based on genetics and a large suite of morphological characters is the next step. This would aid in the determination of the relatedness of taxa within the genus. A phylogeny based on genetic characters would be particularly informative for this group, as it would bypass the large amount of morphological variation within the group and possibly reveal some interesting patterns and relationships.

CHAPTER 4:
REVISION OF THE *SPHENOPTERA* (*SPHENOPTERA*) EXARATA-GROUP

Introduction

This species-group is being revised because a species from central Asia, *Sphenoptera foveola*, has been identified as a potential biological control agent of *Chondrilla juncea*, and a thorough revision of the group is necessary to ensure the identity of the potential biological control agent. With proper identification of relationships between species in this group, we can make inferences about the biology and host specificity of this *S. foveola*. Additionally, the provided key will allow for simple identification of members of this group by future workers.

The *Sphenoptera* (*Sphenoptera*) exarata-group is a rather small group within the subgenus *Sphenoptera* which is defined by the member species' possession of a deep depression immediately anterior of the scutellum and their distinct parallel-sided body shape.

Five species are currently included in the *S*. exarata-group:

S. foveola (Gebler) 1825

S. exarata (Fischer von Waldheim) 1824

S. magna Gory and Laporte 1839

S. pilipes Jakovlev 1886

S. lateralis Faldermann 1836

Key to Species

1 Anterior margin of pronotum bordered with a thin sulcus (Figure 229); lateral band of setae absent or interrupted; protibia of male with spines on interior face separated by a distance less than length of spine (Figure 225); elytral striae flattened, made up of elongate dashes (Figure 227) 2

1' Anterior margin of pronotum unbordered (Figure 240); lateral band of setae complete; protibia of male with spines on interior face separated by a distance equal to of greater than than length of spine (Figure 206); elytral striae weakly sculptured, made up of fine punctation (Figure 228) .....…..…… 3

2 (1) Elytral apices distinctly truncate, revealing a significant portion of last ventrite (Figure 231); widest part of pronotum in apical 1/3, with dense, deep, confluent punctation laterally (Figure 233); male mesotibiae straight (Figure 490); abdominal sterna laterally with indistinct setose band (almost absent) and mirrors ....*S. exarata* (Fischer von Waldheim)

2' Elytral apices rounded, only a small portion of last ventrite visible, if at all (Figure 232); widest part of pronotum at base, with denser punctation laterally (Figure 234); male mesotibiae strongly curved (Figure 236); abdominal sterna laterally with triangular setose patches ..... *S. magna* Gory and Laporte

3(1') Body strongly impressed medially; pronotum microtuberculate (Figure 237); body cupreous with blue laterally, though sometimes bronzy .....*S. lateralis* Faldermann

3' Body weakly or unimpressed medially; without microtubercles (Figure 238); body unicolored .....…… 4

4(3') Elytron with heavy sculpturing (Figure 241); elytral suture raised relative to level of third stria, unimpressed medially, without scattered depressions (Figure 242) .... *S. foveola* (Gebler)

4' Elytron with light sculpturing (Figure 240); elytral suture depressed relative to third stria, with scattered depressions (Figure 244) .... *S. pilipes* Jakovlev

Sphenoptera (*Sphenoptera*) *exarata* (Fischer von Waldheim) 1824

(Figures 49, 58, 83, 105, 117, 117, 227, 229, 231, 233, 490, 491)

Buprestis exarata Fischer von Waldheim 1824:169; Mannerheim 1837:95 (? synonym of *dianthi*); Marseul 1866:351 (? synonym of *dianthi*); Gemminger and Harold 1869:1416.

Sphenoptera exarata: Saunders 1870:12; Saunders 1871:87; Kerremans 1892:188; Kerremans 1903:113; Jakobson 1913:782; Kerremans 1913:129; Obenberger 1930a:223; Richter 1945:147; Richter 1948:388; Alexeev, *et al*. 1991:855; Volkovitsh and Alexeev 1992:155; Volkovitsh and Alexeev 1994:428; Volkovitsh and Kalashian 2006:364.

Buprestis dejeanii Zubkov 1829:156.

Sphenoptera dejeanii: Dejean 1833:81; Dejean 1836:91; Mannerheim 1837:93; Gory and Laporte 1839:3; Ménétriés 1848:30; Marseul 1866:337; Gemminger and Harold 1869:1418; Saunders 1870:11; Saunders 1871:86; Jakovlev 1901b:52; Kerremans 1903:112; Kerremans 1911:632; Kerremans 1912: 32; Jakobson 1913:782; Obenberger 1927:45; Obenberger 1930:222; Richter 1945:174 (syn. of *exarata*);

Richter 1948:388; Bílý 1972:251; Volkovitsh and Kalashian 2006:364.

Sphenoptera orichalcea (not (Pallas) 1781). Morawitz 1861:166; Marseul 1866:337 (syn. of *dejeani*); Kerremans 1892:192; Obenberger 1927:45; Obenberger 1930:222.

Sphenoptera spectabilis Kraatz in Heyden and Kraatz 1883:354; Marseul 1889:282; Kerremans 1892:195; 1903a:123; 1912b:32; Obenberger 1927:45; 1930a:222; Volkovitsh and Kalashian 2006:364 (syn. of *exarata*).

Sphenoptera prosternalis Jakovlev 1885:130; Marseul 1889:286; Kerremans 1892:193; Heyden 1893:89; Kerremans 1903:122; 1912b:42; Jakobson 1913:782; Obenberger 1927:46; Obenberger 1930a:233; Volkovitsh and Kalashian 2006:364 (lectotype, syn. of *exarata*).

Sphenoptera interrupta Kerremans 1909b:276; Kerremans 1912:32; Jakobson 1913:783; Obenberger 1930:222; Volkovitsh and Kalashian 2006:364 (syn. of *exarata*).

Sphenoptera araxana Obenberger 1915:52; 1927a:46; 1930a:222; Volkovitsh and Kalashian 2006:54 (syn. of *exarata*), 364.

Sphenoptera nomadica Obenberger 1916:247; 1927a:29; 1930a:231; Volkovitsh and Kalashian 2006:54 (syn. of *exarata*), 364.

Sphenoptera sumakovi Obenberger 1927:29; 1930a:326; Volkovitsh and Kalashian 2006:54 (syn. of *exarata*), 364.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) exarata-group by the following combination of characters: Protibia of male with spines on interior face separated by a distance less than length of one spine; elytral striae composed of dashed line punctation; elytral apices distinctly truncate, exposing

apical abdominal tergite; pronotum widest in apical 1/3, with dense confluent punctation laterally, anterior border margined with sulcus; and the straight male mesotibiae.

Description: Male. Length 17-20 mm, width 5-7mm across at widest point. Body entirely light metallic bronze. Head with shallow depression medially, heavily punctuate with dense, shallow, even punctures, almost crenulate, glabrous. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.1-1.3 times as wide as long, widest in apical one-third; with deep, wide, "v"-shaped depression posteriorly; lateral carina weakly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles square; anterior margin weakly sinuate, with carina; dorsal surface with dense, even micropunctation, heavily punctuate laterally, with sparse punctures medially; posterior pronotal angles square to obtuse (90-95°); posterior border sinuate, without emargination. Protibia of male with spines on interior face separated by a distance less than length of one spine, with tuft of setae apically; slightly emarginate and slightly curved; tibia and femora sparsely punctate. Prosternum covered with deep pits, each with a single white seta; pits denser laterally and continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, with two lateral rows of dense punctures; sparsely punctate medially. Mesofemur with sparse, even pits. Mesotibia straight, slightly emarginate, with prominent tooth apically; with row of closely spaced spines posteriorly. Elytra subparallel basally, narrowing sharply in apical third. Elytron with distinct broken striae, composed of elongate dash-shaped punctures; interstriae densely micropunctate, with scattered shallow punctures, interstrial structure flat and even; transverse elytral

wrinkles slightly stronger basally. Elytral apex truncate, flaring slightly, exposing last ventrite; elytral apex with weak sutural spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits. Metatibia straight, emarginate slightly; apical tooth present; tibia with row of closely-spaced spines posteriorly. Abdomen ventrally lightly setose, setae slightly denser laterally and posteriorly; abdominal apex rounded.

Female: Same as described male except for the following characters: all tibiae straight, with no emargination; abdominal apex more arcuate.

Variation: Of all of the species in the S. (Sphenoptera) exarata-group, this species displayes the least variation in color and size. This species does however, vary greatly in the amount of wrinkling on the elytra, ranging from almost completely smooth to entirely wrinkled. Additionally, the depth of the median depression of the pronotum varies greatly between individuals.

Types Examined: LECTOTYPE: *S. prosternalis* Jakovlev, 1885: Chinas (h, rus);; Oshanin (h);; prosternalis n. sp. (h) (ZIN).

Notes: Based on external characters and genitalic characters, this species appears to be closely allied with *S.* (*Sphenoptera*) *magna*. Both *S. magna* and *S. exarata* have a sulcus at the anterior border of the pronotum, closely-spaced spines on the protibia, and an incomplete lateral setal band. Additionally, the aedeagus for both of these species is very similar to that of members of the tragacanthae-group, and is therefore of the "tragacanthae-type". Based on this evidence, and that these two species share many characters with the tragacanthae-group, I would place this sub-group closer to tragacanthae-group than to their own group members.

Host Records: *Glycyrrhiza glabra* (Fabaceae) – Licorice (Volkovitsh pers. comm.).

Recorded Distribution: Afghanistan; Armenia; Azerbaijan; China (Northwest Territories); Iran; Kazakhstan; Kyrgyzstan; Russia (South European Territories); Tadjikistan; Turkmenistan; Uzbekistan (Bellamy 2008). Russia (East Siberia) (Kerremans 1909b); Turkey (New Record; ZIN).

Sphenoptera (*Sphenoptera*) *foveola* (Gebler) 1825

(Figures 24, 50, 64, 75, 93, 95, 155, 206, 228, 240, 241, 242, 243)

Buprestis foveola Gebler 1825:46; 1830:75; 1859:454; Morawitz 1861:167; Marseul 1866:348; Gemminger and Harold 1869:1417.

Sphenoptera foveola Saunders 1870:14; Saunders 1871:86; Kerremans 1892:188; Kerremans 1903:112; Kerremans 1909b:272; Jakobson 1913:782; Kerremans 1913:115; Obenberger 1927:50; Obenberger 1930:224; Richter 1945:147; Volkovitsh and Kalashian 2006:365.

Sphenoptera strandi Obenberger 1920:113; Obenberger 1927:51;; Volkovitsh and Kalashian 2006:54 (syn. of *foveola*), 365.

Sphenoptera usta Obenberger 1927:51 (var. of *foveola*); Obenberger 1930:224.

Sphenoptera pilipes strandi: (not *pilipes* Jakovlev 1886) Obenberger 1930:233.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) exarata-group by the following combination of characters: Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine; elytral striae composed of small, uneven punctation; elytral apices acute, without

visible apical ventrite; pronotum widest at base, with even punctation; unicolorous body; heavy sculpturing of elytron; lack of scattered depressions; lack of pronotal microtuberculate sculpturing; and elytral suture raised relative to level of third stria.

Redescription: Male. Length 13-22 mm, width 5-8mm across at widest point. Body entirely shining black, dark metallic purple, or dark metallic bronze. Head with very shallow depression medially, lightly punctuate with sparse, shallow punctures and even micropunctures. Antenna shining black; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.2-1.4 times as wide as long, widest at posterior border; with deep, anchor-shaped depression posteriorly; lateral carina weakly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles square; anterior margin weakly sinuate, carina absent; dorsal surface with sparse, even micropunctation and even, sparse punctures, which become more dense laterally; posterior pronotal angles acute to square (85-90°); posterior border sinuate, without emargination. Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine, with tuft of setae apically; slightly emarginate and strongly curved; tibia and femora sparsely punctate. Prosternum covered with sparse, deep punctures, each with a single golden seta; pits denser laterally and continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, with two lateral rows of evenly-spaced deep punctures; sparsely punctuate medially. Mesotibia slightly curved and slightly emarginate, with weak tooth apically; with row of widely-spaced spines posteriorly. Elytra subparallel basally, narrowing sharply in apical third. Elytron with unclear broken striae,composed of shallow

punctures; interstriae strongly crenulate, with scattered shallow punctures. Elytral apex acute, with a rounded angle; elytral apex without sutural spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits. Metatibia straight; apical tooth present; tibia with row of widely-spaced spines posteriorly. Abdomen ventrally lightly setose, abdominal apex rounded. Ventrally with a lateral band of dense setae (which may be covered with a white wax).

Female: Same as described male except for the following characters: all tibiae straight, with no emargination; abdominal apex more arcuate.

Variation: This species varies greatly in both color and size, ranging from 13 to 22 mm in length, and while most specimens examined were black, individuals could have a dark bronze, blue, or purple or metallic sheen. Additionally, Obenberger (1927) described an abberation from southern Russia, *S. foveola* ab. *usta*, which was said to be of a slightly different black pitch, and identified specimens were with slightly stronger crenulations on elytra.

Larva: The larva of this species was described by Alexeev in 1981.

Types Examined: *S. foveola* Gebler, 1825: 46 (*Buprestis*) [syntype?], m*: golden square/ Sph. foveola Gebl., type (h) B. Jakovlev det. (p)/ Sphenoptera foveola Gebl, etc., cum lectotypo comp. Volkovitsh, 1993 (ZIN)

Notes: This species is rather well defined, and based on the narrow aedeagus that resembles the genitaia of members of the subgenus Deudora, or "Deudora-type" aedeagus, and the lack of a sulcus at the anterior border of the pronotum, belongs in a "subgroup" with *S*. (*Sphenoptera*) *pilipes* and *S*. (*Sphenoptera*) *lateralis*.

The biology and status as a potential biological control agent or *Sphenoptera foveola* were discussed in Chapter 2.

Host Records: *Chondrilla* spp. (Asteraceae) – Rush Skeletonweed (Emelyanova, Russian Biocontrol Group)

Recorded Distribution: Kazakhstan; Kyrgyzstan; Turkmenistan; Russia (South European Territories) (Bellamy 2008). Armenia; Tadjikistan (New Records).

Sphenoptera (*Sphenoptera*) *lateralis* Faldermann 1836

(Figures 32, 65, 237, 243)

Buprestis lateralis Faldermann 1836:366.

Sphenoptera lateralis: Dejean 1836:91; Mannerheim 1837:95; Gory and Laporte 1839:11; Marseul 1866:347; Gemminger and Harold 1869:1417; Saunders 1871:86; Heyden and Kraatz 1882b:303; Kerremans 1892:190; Heyden 1893:89; Heyden 1896:56; Kerremans 1903:112; Jakobson 1913:783; Kerremans 1913:122; Obenberger 1927:50; Obenberger 1930:227; Richter 1945:147; Cobos 1966:312; Alexeev, *et al*. 1992:390; Volkovitsh and Alexeev 1994:428; Volkovitsh and Kalashian 2006:365.

Buprestis pallasia Gebler 1832:42 (preoccupied by *pallasia* Schönherr 1817); Mannerheim 1837:94; Marseul 1866:360; Obenberger 1930:227.

Sphenoptera faldermanni Dejean 1836:91 (*nomen nudum*); Mannerheim 1837:96; Gemminger and Harold 1869:1417; Kerremans 1892:190. (Unavailable name)

Sphenoptera faldermanni Kerremans 1913:123; Obenberger 1927:50; Obenberger 1930:227 (ab. of *lateralis*).

Sphenoptera canaliculata: (not (Pallas) 1781). Gory and Laporte 1839:9 (syn. of *canaliculata*).

Sphenoptera egregia Jakovlev 1901a:170; Kerremans 1903:120; Jakobson 1913:782; Kerremans 1913:126; Obenberger 1927:49; 1930a:223; Volkovitsh and Alexeev 1994:428; Volkovitsh and Kalashian 2006:364. syn. nov.

Sphenoptera luctifica Jakovlev 1904:310 (***nom. nov.*** for *luctuosa* Jakovlev 1904); Jakobson 1913:783; Obenberger 1927:49; Obenberger 1930:229; Volkovitsh and Kalashian 2006:365. syn. nov.

Sphenoptera luctuosa Jakovlev 1904:177 (preocc. by *luctuosa* Thomson 1878); Kerremans 1913:116; Obenberger 1927:49; Obenberger 1930:229; Volkovitsh and Kalashian 2006:365. syn. nov.

Sphenoptera foveithoracica Kerremans 1913:116 (***nom. nov.*** for *luctuosa* Jakovlev 1904, ***nom. supfl.***); Obenberger 1927:49 (syn. of *luctifica*); Obenberger 1930:229; Volkovitsh and Kalashian 2006:365. syn. nov.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) exarata-group by the following combination of characters: Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine; elytral striae composed of small, uneven punctation; elytral apices truncate, without visible apical ventrite; pronotum widest at base, with heavier punctation laterally and microtuberculate sculpturing; cupreous body, blue metallic laterally; heavy sculpturing of elytron; lack of scattered depressions; and elytral suture strongly depressed below level of third stria.

Redescription: Male. Length 8-15 mm, width 3.5-6 mm across at widest point. Body dorsally cupreous, with metallic blue or purple laterally; ventrally blue black; impressed medially, with latero-medial elevations. Head with very shallow depression medially, punctuate with dense, deep punctures and even microtubercles. Antenna shining black with cupreous sheen; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.6-1.8 times as wide as long, widest at posterior border; with deep, rounded depression posteriorly; lateral carina weakly sinuate, extending nearly to anterior 1/4; with fringe anteriorly; anterior angles square; anterior margin very weakly sinuate, carina absent; dorsal surface evenly covered with microtubercles, densely punctate, punctures more dense laterally; posterior pronotal angles acute (80-85°); posterior border sinuate, without emargination. Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine, with tuft of setae apically; slightly emarginate and strongly curved; tibia and femora sparsely punctate. Prosternum covered with sparse, shallow punctures, laterally with golden setae; pits denser laterally and continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, with two lateral rows of strongly confluent deep punctures; very sparsely punctuate medially. Mesotibia slightly curved and slightly emarginate, with strong tooth apically; with row of widely-spaced spines posteriorly. Elytra arcuate basally, narrowing sharply in apical third. Elytron with unclear broken striae,composed of dense, shallow punctures; interstriae strongly crenulate, with scattered shallow punctures. Elytral apex acute, with a weak sutural spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse

pits. Metatibia straight; apical tooth present; tibia with row of widely-spaced spines posteriorly. Abdomen ventrally lightly setose, abdominal apex strongly rounded. Ventrally with a lateral band of dense setae (which may be covered with a white wax).

Female: Female differs from the described male in having all straight tibiae without emargination or teeth.

Variation: This species varies greatly in size, though it remains relatively constant in terms of color. The color varies from dark cupreous-black to nearly black, with borders of purple to blue. There seems to be a great deal of variation in the amount of punctation on the pronotum.

Types Examined: *S. egregia* Jakovlev 1901a HOLOTYPE: Tedzhen 1893;; Glazunov;; egregia Jak. (ZIN)

S. luctifica Jakovlev 1904b HOLOTYPE: Ur. Ulang-Su; 18.IX-1.X.89; Gr. Grzhimaylo;; luctuosa;; luctifica;; Sph. luctifera Type det. Jakovlev;; T, coll. (ZIN)

S. lateralis Faldermann, 1836 HOLOTYPE: golden square;; Turcmen.;; lateralis Fald., Turcom.;; Sph. lateralis Jak.. det. (ZIN)

Notes: The status of two species in the exarata-group is in question, and it appears that two species in the group – *S*. (*Sphenoptera*) *luctifica* and *S*. (*Sphenoptera*) *egregia* are synonyms of *S*. (*Sphenoptera*) *lateralis*. I was informed of the potential synonymy of *S. luctifica* by Mark Kalashian while in St. Petersburg, and careful examination of the type specimen of *S. luctifica* revealed that it shared the same characters with *S. lateralis*. This synonymy will be published by Kalashian.

While comparing the type of *S. egregia* with specimens of *S. lateralis*, in St. Petersburg, I noted some striking similarities between the two. The protibiae of *S. egregia* have a widely-spaced row of spines on the interior face, as in *S. lateralis*; the elytral apices are truncate and the pronotum widest at base with heavier punctation laterally, as in *S. lateralis*, and the pronotum bears the distinct microtubercles of *S. lateralis*. The type of *S. egregia* is also the same distinctive color as *S. lateralis*. Furthermore, *S. egregia* is only known from a single specimen and is from within the range of *S. lateralis*.

While the host plants of the two are different (Kaplin 1981) – *S. lateralis* is known from *Anabasis* spp. and *S. egregia* is known from *Acanthophyllum* spp., these may represent two biological races of the same species, and are therefore synonymized here.

Host Records: *Acanthophyllum stenostegium* (Caryophyllaceae) – (Kaplin 1981); *Anabasis* spp. (Chenopodiaceae) – Itsigek (Kalashian pers. comm.)

Distribution: Turkmenistan; Afghanistan; Kazakhstan; Kyrgyzstan; Russia (South European Territories); Turkmenistan; Uzbekistan; China (Northern Territories) (Bellamy 2008). (Turkey?? – dubious record)

Sphenoptera magna Gory and Laporte 1839

(Figures 25, 74, 89, 94, 225, 232, 234, 236, 243, 250)

Sphenoptera magna Gory and Laporte 1839:3; Marseul 1866:332; Gemminger and Harold 1869:1417; Saunders 1871:85; Kerremans 1892:191; Kerremans 1903:112; Kerremans 1908:100; Kerremans 1912:59; Jakobson 1913:782; Obenberger 1927:27; Obenberger 1930: 229; Bílý 1980:120; Bílý 1985:164; Bílý

1990:34; Halperin and Argaman 2000:106; Volkovitsh and Kalashian 2006:365.

Sphenoptera alexandri Obenberger, 1927:33; Volkovitsh and Kalashian, 2006:55, Kalashian and Volkovitsh 2009.

Sphenoptera lacertosa Dejean 1833:81 (*nomen nudum*); Dejean 1836:91; Gemminger and Harold 1869:1417; Kerremans 1892:191. (Unavailable name)

Sphenoptera tragacanthae: (not (Klug) 1829). Volkovitsh and Kalashian, 2006:55, Kalashian and Volkovitsh 2009: 449.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) exarata-group by the following combination of characters: Protibia of male with spines on interior face separated by a distance less than the length of one spine; elytral apices rounded, without visible apical ventrite; pronotum widest at base, with slightly denser punctation laterally and anterior emargination; unicolorous body; and body lacking median impression.

Redescription: Male. Length 19-23 mm, width 7-8.5 mm across at widest point. Body entirely dark metallic bronze to black. Head shallowly depressed medially, punctuate with sparse, shallow punctures. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.5 times as wide as long, widest at base; with wide, shallow, "U"-shaped depression posteriorly; lateral carina weakly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles square; anterior margin weakly sinuate, with carina; dorsal surface with dense, even fine punctation, heavily punctuate laterally, with sparse, even punctures medially; with microreticulation posteriorly; posterior pronotal angles acute to

square (86-90°); posterior border sinuate, without emargination. Protibia of male with spines on interior face separated by a distance less than the length of one spine, with tuft of setae apically; protibia emarginate and strongly curved; tibia and femora sparsely punctate. Prosternum with deep pits, each with a single golden seta; pits denser laterally and continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, emarginate laterally; very sparsely punctate medially. Mesofemur with sparse, even pits. Mesotibia strongly curved, slightly emarginate, with prominent tooth apically; with row of closely-spaced spines posteriorly. Elytra subparallel basally, narrowing sharply in apical third. Elytron with distinct broken striae,composed of elongate dash-shaped punctures; interstriae finely punctate, interstriae with many fine wrinkles; transverse elytral wrinkles slightly stronger basally. Elytral apex rounded; elytral apex with sutural spine absent. Metacoxa with distinctly expanded medially, anterior and posterior edges parallel laterally; covered with sparse pits and setae. Metatibia straight, emarginate slightly; apical tooth present; tibia with row of closely-spaced spines posteriorly. Abdomen ventrally lightly setose, with vitta of dense setae laterally; abdominal apex truncate.

Female: Same as male except for the following characters: all tibiae straight, without emargination; abdominal apex rounded.

Variation: Very little variation displayed. Minor differences in size; overall, individuals brassy to black.

Types examined: none

Notes: This species is the most clearly defined among beetles in the *S*. exarata-

group and displays a close relation to *S. exarata*. The aedeagus is similar to that of individuals in the S. tragacathae-group.

Host Records: *Salsola* sp. (Compositae) – Tumbleweed (Kalashian pers. comm.)

Recorded Distribution: Iran; Iraq; Israel; Jordan; Saudi Arabia; Syria; Turkey (Bellamy 2008).

Sphenoptera pilipes Jakovlev 1886

(Figures 82, 90, 238, 240, 244)

Sphenoptera pilipes Jakovlev 1886:92; Marseul 1889:271; Kerremans 1892:193; Heyden 1893:89; Kerremans 1903:112; Jakobson 1913:783; Kerremans 1913:131; Obenberger 1927:51; Obenberger 1930:233; Kalashian, *et al*. 2005b:98 (lectotype); Volkovitsh and Kalashian 2006:366.

Sphenoptera winkleri Obenberger 1920:108; Obenberger 1927:51; Obenberger 1930:233 (ssp. of *pilipes*); Volkovitsh and Kalashian 2006:54 (syn. of *pilipes*), 366.

Sphenoptera romanovi Obenberger 1927:50; Obenberger 1930:234; Volkovitsh and Kalashian 2006:54 (syn. of *pilipes*), 366.

Sphenoptera anchorifera Obenberger 1952:20; Kalashian, *et al*. 2005b:98 (syn. of *pilipes*, lectotype); Volkovitsh and Kalashian 2006:366.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) exarata-group by the following combination of characters: Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine; elytral striae composed of small, uneven punctation; elytral apices acute, without visible apical ventrite; pronotum widest at base, with even punctation; unicolorous body;

light sculpturing of elytron; lack of pronotal microtuberculate sculpturing; and body with weak median impression and numerous scattered depressions.

Redescription: Length 12-16 mm, width 5-7 mm across at widest point. Body entirely glossy black to dark black-bronze; weakly impressed dorso-medially, with scattered wrnkles. Head with very shallow depression medially, lightly punctuate with sparse, shallow punctures and even micropunctures. Antenna shining black; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.3 times as wide as long, widest at posterior border; with shallow, “U”-shaped depression posteriorly; lateral carina weakly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles square; anterior margin weakly sinuate, carina absent; dorsal surface with sparse, even, fine punctation and even, sparse punctures, which become more dense laterally; posterior pronotal angles square to slightly obtuse (90-93°); posterior border sinuate, without emargination. Protibia of male with spines on interior face separated by a distance greater than or equal to length of one spine, with tuft of setae apically; slightly emarginate and strongly curved; tibia and femora sparsely punctate. Prosternum covered with dense, deep, arcuate pits, each with a single golden seta; pits denser laterally and continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, with two lateral rows of confluent deep arcuate punctures; densely punctuate medially. Mesotibia straight and slightly emarginate, with weak tooth apically; with row of widely-spaced spines posteriorly. Elytra subparallel basally, narrowing sharply in apical third. Elytron with unclear broken striae,composed of shallow punctures; interstriae weakly crenulate, interstriae weakly

elevated, with dense coarse and fine punctures. Elytral apex rounded; elytral apex without sutural spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits. Metatibia straight; apical tooth present; tibia with row of widely-spaced spines posteriorly. Abdomen ventrally lightly setose, abdominal apex weakly truncate. Ventrally with a lateral band of dense setae (which may be covered with a white wax).

Female: All tibiae straight, without emargination; abdominal apex rounded.

Variation: Minor variations in color and size present, color ranges to glossy black to metallic bronze-black.

Types Examined: *Sphenoptera pilipes* Jakovev LECTOTYPE: Naryn;; type;; pilipes Jak.;; Sph.; type pilipes B. Jak.;; B. Jakowlew det.;; К. В. Яковлева;; LECTOTYPUS; Sphenoptera; pilipes Jakovlev 1886; Desg. Kalashian and Volkovitsh, 2007. (ZIN, 6 specimens)

Notes: This species well defined, and shows clear affinity to *S. (Sphenoptera) foveola* in body shape, genitalia which are of the "Deudora-type", lack of a sulcus at the anterior border of the scutellum. This species, though, has rather distinct wrinking on the dorsal surface and has a different host plant from *S. foveola*.

Host Records: *Scorzonera* spp. (Compositae) – Salsify (Pravidin 1952).

Recorded Distribution: Kazakhstan; Kyrgyzstan (Bellamy 2008). Uzbekistan; Siberia (Obenberger 1927).

Discussion

Species included in this group were rather straightforward and clear, with very

little overlap in form, and little overlap in host plants. It is clear that Sphenoptera foveola is a well-defined species, restricted to host plants in the genus *Chondrilla*, on which they occur in great numbers.

Two species required synonymy, both synonyms of *S. lateralis*. These species, *S. luctifica* and *S. egregia*, are known only from the type specimens, and examination of morphological characters revealed their conspecificity with *S. lateralis*.

One thing that is worth noting here is the presence of to distinct subgroups within this species-group. The first sub-group, which includes *S. magna* and *S. exarata* differs from those in the second subgroup, not only in the external characters presented in the first couplet of the key, but also in both male and female genitalic characters.

I suggest that this group be split into two, not as new species-groups, but as add-ons to existing species-groups to which they bear an affinity. The character of a depression in the pronotum could've easily arisen multiple times in the subgenus *Sphenoptera*, (note that the anterior sulcus of the pronotum arises several times throughout the genus), and these two groups could actually belong with other species-groups. The exarata subgroup shares many characters with the S. tragacanthae-group, and may be included in this group. The foveola sub-group may continue to be an independent entity, as its members do not possess the diagnostic characters of other groups within the subgenus.

CHAPTER 5:
REVISION OF THE *SPHENOPTERA* (*SPHENOPTERA*) RAUCA-GROUP

Introduction

The Sphenoptera (Deudora) rauca-group contains two species which, based on literature records (Hasan 1978) and specimen records, have been identified as potential biological control agents of *Chondrilla juncea*.

The *Sphenoptera* (*Sphenoptera*) rauca-group is a rather small group within the subgenus *Sphenoptera* which is defined by the member species' distinct abdominal setation pattern, the presence of three punctation vittae on the pronotum, and the male tibiae. Seven species are currently included in the *S.* rauca-group:

S. aeneomicans Kraatz 1882

S. gemmata (Olivier) 1790

S. rauca (Fabricius) 1787

S. radicicola Obenberger 1929

S. signata Jakovlev 1887

S. ventrisculpta 1916

S. vittaticollis (Lucas) 1844

Key to Species

1 Pronotum with three narrow bands of setae (Figure 247); metacoxa with posterior border slightly sinuate (Figure 249) 2

1' Pronotum with three light bands of punctation (Figure 248), if any; metacoxa with

posterior border emarginate (Figure 250) .....…..... 4

2 (1) Apical abdominal ventrite with three longitudinal glabrous mirrors (Figure 251); pronotum with three strongly impressed bands of dense setae (Figure 253); often covered in wax .....…….…… *S. vittaticollis* Lucas

2’ Apical abdominal ventrite with only a single, median longitudinal mirror or completely hirsute (Figure 252); pronotum with three unimpressed or impressed bands of sparse setae (Figure 247); never covered in wax 3

3(2’) Body size small (6-11mm long, 1.5-3.5mm wide), measured at widest point); aedeagus narrow (4.1 times as long as wide), with strongly pointed base (Figure 254) ..... *S. gemmata* (Olivier)

3’ Body size large (12.5-17mm long, 4.5-5.5mm wide, measured at widest point); aedeagus wide, ovate (3.5 times as long as wide), with rounded base (Figure 255) .....…..... *S. rauca* (Fabricius)

4(1’) Anterior border of scutellum straight, free from any impressions; small in size (7.5-9mm long, 2.5-3mm wide, measured at widest point) .....… *S. signata* (Jakovlev)

4’ Anterior border of scutellum with a light impression, scutellum heart-shaped (Figure 257); large in size (11-12.5mm long, 4.5-5mm wide, measured at widest point) .....…*S. aeneomicans* Kraatz

Sphenoptera aeneomicans Kraatz 1882

(Figures 33, 142, 193, 250, 256, 258)

Sphenoptera aeneomicans Kraatz in Heyden and Kraatz 1882:317; Kerremans 1885:146; Jakovlev 1887:55; Marseul 1889:276; Kerremans 1892:183; Heyden 1893:88;

Jakovlev 1899:327; Jakovlev 1902:579; Kerremans 1903:118; Jakobson 1913:784; Kerremans 1913:224; Obenberger 1929b:44; Obenberger 1930:238; Kalashian, *et al*. 2005b:91; Volkovitsh and Kalashian 2006:357.

Sphenoptera acuminata Jakovlev 1898:331; Jakovlev 1900:403; Jakovlev 1902b:565, 579; Kerremans 1903:118; 1909b:282; Jakobson 1913:784; Kerremans 1913:228; Obenberger 1926b:635; 1929g:42; 1930a:238; Kalashian, *et al*. 2005b:92 (lectotype); Volkovitsh and Kalashian 2006:357. syn. nov.

Sphenoptera unidentata Jakovlev 1890:137; Kerremans 1892:197; Jakovlev 1899:330, 334; Jakovlev 1900:403; Jakovlev 1902:565, 583; Kerremans 1903:113; Jakobson 1913:784; Kerremans 1913:229; Obenberger 1926b:636; Obenberger 1929b:49; Obenberger 1930:249; Cobos 1966:312; Bílý 1972:252; Alexeev, *et al*. 1991:855; Volkovitsh and Alexeev 1994:429; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:358.

Sphenoptera veselyi Obenberger 1915:53; Obenberger 1926a:632; Obenberger 1929b:47; Obenberger 1930:249; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*); Volkovitsh and Kalashian 2006:358.

Sphenoptera aladaghensis Obenberger 1920:116; Obenberger 1929:48; Obenberger 1930:238; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera aeneofulgens Obenberger 1929b:26, 120; Obenberger 1930:238; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera persica Obenberger 1929b:26, 121; Obenberger 1930:244; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:358.

Sphenoptera ushinskii Obenberger 1929b:26; 122; Obenberger 1930:249; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:358.

Sphenoptera ahriman Obenberger 1929b:48; Obenberger 1930:238; Bílý 1983:78; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera amasiae Obenberger 1929b:49; Obenberger 1930:239; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera baicalensis Obenberger 1929b:53; Obenberger 1930:240; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera fabichi Obenberger 1952:14; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera fleischeri Obenberger 1952:15; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*, lectotype); Volkovitsh and Kalashian 2006:357.

Sphenoptera moganensis Obenberger 1955:12; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*); Volkovitsh and Kalashian 2006:358.

Sphenoptera hoberlandti Obenberger 1955:13; Kalashian, *et al*. 2005b:91 (syn. of *aeneomicans*); Volkovitsh and Kalashian 2006:357.

Sphenoptera clarescens: (not Kerremans 1909a). Hasan 1978. (Vouchers: NMPC)

Diagnosis: This species can be distinguished from all other species in the *S*.

(*Sphenoptera*) rauca-group by the following combination of characters: pronotum wrinkled laterally; pronotum with three light bands of punctation, if any; setae present on medial area of metacoxa; anterior border of scutellum with a light impression, scutellum "heart-shaped";and large in size (11-12.5mm long, 4.5-5mm wide, measured at widest point).

Redescription: Male. Length 11-12.5 mm, width 4.5-5mm across at widest point. Body entirely metallic bronze to bronze-black. Head with shallow depression medially, punctute with sparse, shallow, even punctures; band of whitish setae near interior margin of the eye. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.4x as long as wide, sides evenly arcuate to apex; with shallow impression posteriorly, punctation more dense laterally, appearing as wrinkles, with three weak punctation vittae, one mesad and one laterally on each side; lateral carina straight, extending nearly to anterior margin; with fringe anteriorly; anterior angles acute; anterior border weakly sinuate, margin absent; posterior pronotal angles acute to square (87-90°); posterior border sinuate, emargination present. Scutellum with shallow impression along anterior border, heart-shaped. Protibia with several longitudinal rows of spines, with tuft of setae apically; without emargination and slightly curved; tibia and femora sparsely punctate. Prosternum covered with dense wrinkles, wrinkles continuing to the ventral surface of the pronotum. Prosternal process subparallel, expanding slightly behind procoxae, emarginate only laterally; sparsely punctate medially. Mesotibia straight, weakly emarginate, with prominent tooth apically. Elytra subparallel basally, narrowing in apical third. Elytron with broken striae,composed of

elongate dash-shaped punctures; interstriae densely micropunctate, with scattered shallow punctures, alternate interstriae with differing structure, weakly elevated. Elytral apex rounded,with weak sutural spine and weak or absent lateral spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits; medial area with setae. Metatibia straight, without emargination; apical tooth present; tibia with row of spines posteriorly. Abdomen ventrally densely setose, with band of dense setae and row of glabrous mirrors laterally; apical abdominal ventrite truncate, with three longitudinal mirrors. Aedeagus narrow, 3.6 times as long as wide.

Female: As male, with rounded apical abdominal ventrite rounded; meso and meta tibiae with only weak spine; and protibiae straight.

Variation: This species varies considerably in size and overall body shape across its wide geographic range, which led to the naming of numerous synonyms (Kalashian et al. 2005b). Additionally, the density and depth of the pronotal punctation varies considerably across individuals.

Types examined: None.

Notes: This species is rather well defined, and is the only species in the rauca-group with lateral wrinkling of the prontoum.

The *Sphenoptera clarescens* which was studied by Hasan in a biological control study in Iran were misidentified, and actually belong to *S. aeneomicans*. The vouchers for the study were located by Mark Kalashian in the National Museum in Prague, Czech Republic. These vouchers were identified by Dr. Kalashian, and the identification confirmed by myself. Most likely Descarpentries identified the specimens based on

range and their membership in the subgenus *Deudora*.

The species *Sphenoptera acuminata* is treated as a synonym of *S. aeneomicans* here, as the information has been relayed to me by Mark Kalashian, however, I have not confirmed this synonymy.

Host Records: *Chondrilla juncea*; *Chicorium* spp.; *Lactuca sativa* (Hasan 1978).

Recorded Distribution: Armenia; Azerbaijan; Georgia; Afghanistan; Iran; Kyrgyzstan; Kazakhstan; China, Northwest Territories; Tajikistan; Turkmenistan; Turkey; Uzbekistan.

Sphenoptera (*Deudora*) *gemmata* (Olivier) 1790

(Figures 52, 106, 108, 247, 252, 254, 259)

Buprestis gemmata Olivier 1790a:90; Gemminger and Harold 1869:1417; Saunders 1871:87,137.

Anthaxia gemmata: Gistel 1857:135

Sphenoptera gemmata: Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:218; Théry 1930:178; Schaefer 1938:80 (as valid species); Théry 1942:41; Schaefer 1950:104; Cobos 1952b:58; Gobbi 1971:42; Curletti 1985:234; Cobos 1986:312; Curletti 1994:46; Arnáiz 1999:169; Halperin and Argaman 2000:106; Arnáiz, et al. 2002:45; Verdugo 2005:170; Kalashian, et al. 2005b:89; Volkovitsh and Kalashian 2006:358; Kalashian and Sakalian 2007:20.

Buprestis lineata Fabricius 1792:217; Olivier 1790a:plate 8, Fig. 80; 1790b:220;Fabricius 1794:108; Fabricius 1801:136, 211;

Sphenoptera lineata: Dejean 1833:81; Dejean 1836:92; Mannerheim1837:96; Gory and

Laporte 1839:19; Gistel 1856:135; Gemminger and Harold 1869:1417; Saunders 1870:19 (syn. of *lineola*); Saunders 1871:88; Kerremans 1903:113; Kerremans 1913:218; St. Claire-Deville 1914:299; Escalara 1914:202; Obenberger 1929b:40; Obenberger 1930:245; Théry 1930:178; Théry 1938:90 (syn. of *lineola*); Théry 1942:41; Cobos 1949:444; Schaefer 1950:104 (syn. of *gemmata*); Zimsen 1964:152; Cobos 1986:312 (syn. of *gemmata*); Kalashian,et al. 2005:89; Volkovitsh and Kalashian 2006:358.

Buprestis lineola Herbst 1801:284; Gory and Laporte 1839:19; Marseul 1866:369 (syn. of *geminata*); Gemminger and Harold 1869:1417; Saunders 1870:19; 1871:88; Kerremans 1892:190;1903:113; 1908:100; 1909:282; 1913:218; Obenberger 1930:246; Théry 1930:179;1938:90; 1942:41; Schaefer 1950:104 (syn. of gemmata); Cobos 1986:312 (syn. of *gemmata*);Kalashian, et al. 2005b:89; Volkovitsh and Kalashian 2006:358.

Sphenoptera geminata: (not Dejean 1833). Marseul 1866:369.

Sphenoptera raucoides Obenberger 1920:119; Obenberger 1926a:635; Obenberger 1929b:38, 39; Obenberger 1930:246; Théry 1930:179; Kalashian, et al. 2005b:90 (syn. of *gemmata*, lectotype); Volkovitsh and Kalashian 2006:358.

Sphenoptera rauca: (not (Fabricius) 1787). Obenberger 1930:245; Théry 1942:41; Kocher 1956:125 (var. of *rauca*).

Sphenoptera striata: (not Gory and Laporte 1839).Théry 1938:90 (syn. of lineola).

Sphenoptera lapidaria: (not Brullé 1832). Muskovits and Hegyessy 2002:27,150; Kalashian and Sakalian 2007:20.

Sphenoptera quadrifossa Obenberger 1929b:40 (ab. of rauca); Obenberger 1929b:390; Obenberger 1930:245; Théry 1942:41; Schaefer 1950:104,107 (ab. of gemmata); Cobos 1952b:59; Kalashian, et al. 2005b:90 (syn. of gemmata sicelidis, lectotype). (Unavailable name)

Sphenoptera geminata var. laevis Rey 1891:6; Reitter, et al. 1906:416; Jakobson 1913:784; St. Claire-Deville 1914:299; Obenberger 1929a:390; Obenberger 1929b:40; Obenberger 1930:245; Théry 1942:41;

Sphenoptera gemmata laevis: Schaefer 1950:104,107 (var. of gemmata); Cobos 1952b:59; Kalashian, et al. 2005b:90 (syn. of gemmata); Volkovitsh and Kalashian 2006:358 (ssp. of gemmata).

Sphenoptera gemmata sicelidis Obenberger 1916:251; Obenberger 1926b:635; Obenberger 1929a:390; Obenberger 1929b:25, 120; Obenberger 1930:247; Curletti 1985:234 (ssp. of gemmata); Curletti 1994:47; Kalashian, et al. 2005b:90 (lectotype); Volkovitsh and Kalashian 2006:358.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) rauca-group by the following combination of characters: pronotum with three unimpressed bands of dense setae; setae absent on medial area of metacoxa; apical abdominal ventrite with only a single, median longitudinal mirror; never covered in wax; body size small (6-11mm long, 1.5-3.5mm wide), measured at widest point); and aedeagus narrow (4.1 times as long as wide), with strongly pointed base.

Redescription: Male. Length 6-11 mm, width 1.5-3.5 mm across at widest point. Body entirely metallic bronze to bronze-black. Head with shallow depression medially,

punctate with sparse, shallow, even punctures; band of whitish setae near interior margin of the eye. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.8x as wide as long; sides evenly arcuate to apex; free from impressions, punctation slightly more dense laterally, with three dense punctation vittae with setae, one mesad and one laterally on each side; lateral carina slightly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles acute; anterior border weakly sinuate, margin absent; posterior pronotal angles square to acute (45-60°); posterior border sinuate, emargination present. Scutellum free from impressions. Protibia with several longitudinal rows of spines, with tuft of setae apically; without emargination and slightly curved; tibia and femora sparsely punctate. Prosternum covered with deep punctation. Prosternal process subparallel, expanding slightly behind procoxae, emarginate only laterally; sparsely punctate medially. Mesotibia straight, strongly emarginate, with very prominent tooth apically. Elytra subparallel basally, narrowing in apical third. Elytron with broken striae,composed of elongate dash-shaped punctures; interstriae densely micropunctate, with scattered shallow punctures, alternate interstriae with differing structure, alternate interstriae weakly elevated. Elytral apex acute,with weak or strong sutural spine and weak or absent lateral spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits; medial area lacking setae. Metatibia straight, weakly emarginate; strong apical tooth present; tibia with row of spines posteriorly. Abdomen ventrally densely setose, with band of dense setae and row of glabrous mirrors laterally; apical abdominal ventrite truncate, with single medial longitudinal mirror. Aedeagus narrow, 4.1 times as long as

wide.

Female: As male, with rounded apical abdominal ventrite rounded; meso and meta tibiae not emarginate, with only weak spine; and protibiae straight.

Variation: This species displays an incredble amount of variation in size and in the amount of punctation on the pronotum. The pronotum may have three very well defined punctation vittae on the pronotum, or it may have three light punctation vittae on the pronotum. While most individuals are between 8 and 11mm long, one specimen, a female from Gibralter, was exceptionally small -- only 6mm in length, greatly smaller than most others in the species.

Types Examined: None

Notes: This species is very similar to both *S. rauca* and *S. vittaticollis* , so much that the three have gone in and out of synonymy with one another several times (Kalashian and Volkovitsh 2005b), which is due mainly to the vast overlap in characters and the lack of a good character set to distinguish the three. These species are currently considered good species.

My observation of these species agrees with that, with significant and consistant differences in aedeagal structure between *S. gemmata* and *S. rauca* and the difference in abdominal setation between *S. gemmata* and *S. vittaticollis*.

Host Records: Composites and legumes; Crepis spp. (Verdugo 2005)

Recorded Distribution: Algeria; Croatia; Egypt; France (Corsica); Greece; Israel; Italy (Sardinia, Sicily); Morocco; Portugal; Spain; Syria; Turkey (Bellamy 2008).

Sphenoptera radicicola Obenberger 1929

Sphenoptera radicicola Obenberger 1929b:22, 118; Obenberger 1930:244; Kalashian, *et al*. 2005b:96 (lectotype); Volkovitsh and Kalashian 2006:359

Notes: This species is only known from a single specimen, and the type, located in the NMPC, was not available for study.

Recorded Distribution: Syria (Bellamy 2008).

Sphenoptera rauca (Fabricius) 1787

(Figures 76, 100, 249, 255, 260)

Buprestis rauca Fabricius 1787:177; Gmelin 1790:1927; Olivier 1790b:218; Fabricius 1793:191; Fabricius 1801:192; Herbst 1801:277; Schönherr 1817:224; Gory and Laporte 1839:13; Gistel 1856:135; Rosenhauer 1856:133; Marseul 1866:366; Gemminger and Harold 1869:1418.

Sphenoptera rauca: Saunders 1870:27; Saunders 1871:87; Kerremans 1892c:194; Fauconnet 1892:248; Acloque 1896:275 (var. of *gemellata*); Jakovlev 1899:329, 333; Jakovlev 1900:402; Kerremans 1903:113; Reitter, *et al*. 1906:416; Kerremans 1908:99; Jakobson 1913:784; Kerremans 1913: 218; Sahlberg 1913:129; Peyerimhoff 1915:28; Obenberger 1926b:635; Théry 1926:18, 27; Obenberger 1929a:390; Obenberger 1929b:40; Obenberger 1930:244; Portevin 1931:317; Obenberger 1932:60; Théry 1936:8; Théry 1937:229; Théry 1938:90; Théry 1942:41; Schaefer 1950:108; Cobos 1950:154; Cobos 1952a:59; Kocher 1956:125, 153; Pochon 1963:66; Zimsen 1964:152; Cobos 1969:6; Bílý 1973:14; Alfieri 1976:101; Bílý 1979:48; Kalashian 1985b:719; Cobos 1986:313; Bílý

1989:61; Sakalian 1990:68; Sparacio 1990:72; Curletti 1994:45; Mühle, *et al.* 2000:90; Arnáiz, *et al*. 2002a:45; Muskovits and Hegyessy 2002:28, 151; Sakalian 2003:55; Bílý 2003:74; Verdugo 2005c:151; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359; Kalashian and Sakalian 2007:20.

Buprestis metallica Fabricius 1793:210; Fabricius 1801:210; Dejean 1821:29; *Sphenoptera metallica*: Dejean 1833:81; Dejean 1836:92; Gory and Laporte 1839:19; Gistel 1856:135; Kiesenwetter 1857:109; Marseul 1866:377; Gemminger and Harold 1869:1418; Saunders 1870:27 (syn. of *rauca*); Saunders 1871:87; Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:218; Obenberger 1930:245; Théry 1930:179; Portevin 1931:316; Théry 1938:90; Théry 1942:41; Schaefer 1950:108; Cobos 1952b:60; Zimsen 1964:155; Cobos 1986:313; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Buprestis geminata Illiger 1803:244; Schönherr 1817:224; Dejean 1821:29; Steven 1830:163; Steven 1832:87.

Sphenoptera geminata Dejean 1833:81; Solier 1833:300; Dejean 1836:92; Mannerheim 1837:96; Gory and Laporte 1839:19; Gistel 1856:135; Lacordaire 1857:69; Marseul 1866:369; Gemminger and Harold 1869:1417; Saunders 1870:27 (syn. of *rauca*); Reitter 1877:199; Sériziat 1880:205; Kerremans 1892:194; Xambeu 1893:7; Acloque 1896:275; Klimant and Zoufal 1899:416; Mainardi 1899:11; Warnier 1901:96; Kerremans 1903:113; Kerremans 1908:100; Kerremans 1913:218; Obenberger 1929a:390; Obenberger 1930:246; Théry 1930:179; Portevin 1931:316; Théry 1938:90 (syn. of *rauca*); Théry 1942:41; Schaefer

1950:104, 108; Cobos 1952b:60; Cobos 1986:313 (syn. of *rauca*); Bellamy 2001a:27; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Chrysodora geminata: Gistel 1834:11

Buprestis striola Illiger 1803:94.

Sphenoptera striola: Saunders 1870:19 (syn. of *lineola*); Saunders 1871:88; Kerremans 1892:190; Kerremans 1903:113; Kerremans 1913:218; Obenberger 1930:246; Théry 1942:41; Cobos 1986:313; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Sphenoptera striolata: (Misspelling of *Sphenoptera striola* Illiger 1803). Théry 1930:179; Schaefer 1950:108; Cobos 1952b:60.

Sphenoptera barbara Solier (*nomen nudum*): Gemminger and Harold 1869:1418. (Unavailable name)

Sphenoptera punctipennis Solier (*nomen nudum*): Gemminger and Harold 1869:1418; Kerremans 1892:191 (syn. of *metallica*). (Unavailable name)

Buprestis sulcipennis Dahl (*nomen nudum*): Dejean 1833:81 (*Sphenoptera*); Dejean 1836:92; Gemminger and Harold 1869:1417; Kerremans 1892:194; Obenberger 1930:245. (Unavailable name)

Sphenoptera conjecturalis Dufour *in* Dejean 1833:81 (*nomen nudum*); Dejaen 1836:92; Gemminger and Harold 1869:1417. (Unavailable name)

Sphenoptera banonii Dejean 1836:92 (*nomen nudum*); Gemminger and Harold 1869:1419; Kerremans 1892:194; Obenberger 1930:245. (Unavailable name)

Sphenoptera bassii Gory and Laporte 1839:13; Gistel 1856:135; Gemminger and Harold

1869:1418; Saunders 1871:87; Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:218; Obenberger 1930:245; Théry 1930:179; Théry 1942:41; Schaefer 1950:108; Cobos 1952b:60; Cobos 1986:313; Kalashian, *et al*. 2005b:89 (lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera similis Gory and Laporte 1839:14; Gemminger and Harold 1869:1419; Saunders 1871:87; Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:218; Obenberger 1930:245; Théry 1930:179; Théry 1942:41; Schaefer 1950:108; Cobos 1952d:60; Cobos 1986a:313; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Sphenoptera bravaisii Gory and Laporte 1839:30; Gemminger and Harold 1869:1418; Saunders 1871:87; Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:218; Obenberger 1930:245; Théry 1930:179; Théry 1942:41; Schaefer 1950:108; Cobos 1952b:60; Cobos 1986:313; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Sphenoptera carduorum Chevrolat 1840:14; Gory 1841:302; Lacordaire 1857:69; Gemminger and Harold 1869:1418; Saunders 1871:87; Kerremans 1892:194; Kerremans 1903:114; Kerremans 1913:219; Escalera 1914:202; Obenberger 1930:246; Théry 1930:179; Théry 1942:41; Schaefer 1950:108; Cobos 1952b:62; Cobos 1986:313; Kalashian, *et al*. 2005b:89; Volkovitsh and Kalashian 2006:359.

Sphenoptera celtiberica Gory 1841:302; Gistel 1856:135; Marseul 1866:367; Gemminger and Harold 1869:1418; Saunders 1871:87; Kerremans 1892:194; Kerremans 1913:218; Obenberger 1929b:40; Obenberger 1930a:246; Théry 1930:179; Théry

1942:41; Schaefer 1950:108; Cobos 1952b:62; Cobos 1986:313; Kalashian, *et al*. 2005b:89 (lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera celtibrica: (Misspelling of *Sphenoptera celtiberica* Gory 1841) Kerremans 1903:114.

Sphenoptera africana Jakovlev 1900:402 (var. of *rauca*); Jakovlev 1902b:284, 564, 581; Jakobson 1913:784; Kerremans 1913:219 (syn. of *rauca*); Obenberger 1929b:40, 42; Obenberger 1930a:246; Théry 1930:179; Théry 1937:230; Théry 1942:41; Volkovitsh and Kalashian 2002:201 (syn. of *rauca*); Volkovitsh and Kalashian 2006:359.

Sphenoptera gemmata africana: (not *Sphenoptera gemmata* (Olivier) 1790). Cobos 1986:313.

Sphenoptera metallica (not Fabricius 1793) Loakimow 1904:22; Sakalian 2003:55.

Sphenoptera sulciventris: (not Jakovlev 1886). Kerremans 1913: 222.

Sphenoptera heliobia Obenberger 1929b:55; Obenberger 1930a:242; Kalashian, *et al*. 2005b:89 (syn. of *rauca*, lectotype); Volkovitsh and Kalashian 2006:359.

Diagnosis: This species can be distinguished from all other species in the *S*. (*Sphenoptera*) gemmata-group by the following combination of characters: pronotum with three narrow unimpressed bands of dense setae; setae absent on medial area of metacoxa; apical abdominal ventrite with only a single, median longitudinal mirror or completely hirsute; never covered in wax; body size large (12.5-17mm long, 4.5-5.5mm wide, measured at widest point); and aedeagus wide, ovate (3.5 times as long as wide), with rounded base.

Redescription: Male. Length 12-17 mm, width 5.5-4.5 mm across at widest point. Body entirely metallic bronze to bronze-black. Head with shallow depression medially, punctate with sparse, shallow, even punctures; band of whitish setae near interior margin of the eye and sparse setae on frons. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.6x as wide as long; sides evenly arcuate to apex; with shallow median longitudinal impressions, punctation slightly more dense laterally, with three dense punctation vittae with setae, one mesad and one laterally on each side; lateral carina slightly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles acute; anterior border weakly sinuate, margin absent; posterior pronotal angles square to acute (45-60°); posterior border sinuate, emargination present. Scutellum free from impressions. Protibia with several longitudinal rows of spines, with tuft of setae apically; without emargination and slightly curved; tibia and femora sparsely punctate. Prosternum covered with deep punctation. Prosternal process subparallel, expanding slightly behind procoxae, emarginate only laterally; sparsely punctate medially. Mesotibia slightly curved, strongly emarginate, with very prominent tooth apically. Elytra subparallel basally, narrowing in apical third. Elytron with broken striae,composed of elongate dash-shaped punctures; interstriae densely micropunctate, with scattered shallow punctures, alternate interstriae with differing structure, alternate interstriae weakly elevated. Elytral apex acute,with weak or strong sutural spine and weak or absent lateral spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits; medial area lacking setae. Metatibia straight, weakly emarginate; strong apical tooth present; with row of spines posteriorly.

Abdomen ventrally densely setose, with band of dense setae and row of glabrous mirrors laterally; apical abdominal ventrite truncate, with single medial longitudinal mirror or entirely hirsute. Aedeagus wide, ovate, 3.5 times as long as wide.

Female: As male, with rounded apical abdominal ventrite rounded; meso and meta tibiae not emarginate, with only weak spine; and protibiae straight.

Variation: This species, like the previous two displays a significant amount of variation in size and pronotal punctation.

Types examined: None.

Notes: This species externally most closely resembles *S. gemmata*. While the two generally don't overlap in size, they are virtually identical in every external character. Internally, however, these species differ significantly, with *S. rauca* bearing a wide, rounded aedeagus, and *S. gemmata* with a narrow, pointed aedeagus. Therefore, I will retain the two as separate species.

Host Records: *Cynara scolymnus*, *Carduus* spp., *Cirsium* spp. (Bily 2003) *Cynara alba*, *Cynara cardunculus*; *Onoporodon* spp. (Verdugo 2005)

Recorded Distribution: Sudan; Albania; Algeria; Armenia; Azerbaijan; Bosnia-Herzegovina; Bulgaria; Czech Republic; Egypt; France; Greece; Hungary; Italy, Sicily; Libya; Macedonia; Morocco; Portugal; Romania; Spain; Syria; Tunisia; Turkey; Yugoslavia (Bellamy 2008).

Sphenoptera (*Deudora*) *signata* Jakovlev 1887

(Figures 3, 4, 5, 6, 81, 91, 96, 248, 257, 261)

Sphenoptera signata Jakovlev 1887:65; Kerremans 1892:195; Jakovlev 1899:329; Jakovlev 1902b:582; Kerremans 1903:122; Jakobson 1913:784; Kerremans 1913:217; Obenberger 1926:636; 1929g:51; Obenberger 1930:247; Kalashian, *et al*. 2005b:90 (lectotype); Volkovitsh and Kalashian 2006:359; Kalashian and Sakalian 2007:21.

Sphenoptera obsoleta Jakovlev 1890:136; Kerremans 1892:192; Jakovlev 1899:329, 335; Jakovlev 1900:102, 405; Jakovlev 1902b:567, 581; Kerremans 1903:121; Jakobson 1913:784; Kerremans 1913:247; Obenberger 1926b:636; Obenberger 1929b:46; Obenberger 1930:244; Katbeh-Bader 1996:49; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype).

Sphenoptera satelles Jakovlev 1899:331; Jakovlev 1900: 403; Jakovlev 1902b:565, 582; Kerremans 1903:122 (*satelletes*); Jakobson 1913:784; Kerremans 1913:221; Obenberger 1929b:24, 48; Obenberger 1930:246; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera addenda Jakovlev 1900:413; Jakovlev 1902b:564, 579; Kerremans 1903:118; Jakobson 1912a:784; Kerremans 1913:223; Obenberger 1929b:24, 49, 120; Obenberger 1930:328; Volkovitsh and Alexeev 1994:429; Halperin and Argaman 2000:105; Mühle, *et al.* 2000:90; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359; Kalashian and Sakalian 2007:21.

Sphenoptera gemmata: (not *gemmata* Olivier 1790); Schaefer 1950:107; Tassi 1968:6; Curletti 1994:45; Mühle, *et al.* 2000:90.

Sphenoptera jejuna Jakovlev 1900:405, 417; Jakovlev 1902b:567, 580; Kerremans 1903:121; Jakobson 1913:784; Kerremans 1913:245; Obenberger 1926b:636; Obenberger 1929b:25, 120; Obenberger 1930:243; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera detrita Jakovlev 1902b:568, 572, 580; Jakobson 1913:784; Kerremans 1913: 248; Obenberger 1926b:636; Obenberger 1929b:46; Obenberger 1930:241; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera clarescens Kerremans 1909a:283; Jakobson 1913:785; Kerremans 1913:106; Obenberger 1927:47; Obenberger 1930:261; Obenberger 1952:110; Volkovitsh and Kalashian 2006:363. **syn. nov.**

Sphenoptera destituta Obenberger 1929b:25, 46; Obenberger 1930:241; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera julia Obenberger 1929b:50; Obenberger 1930:243; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera araxicola Obenberger 1929b:50; Obenberger 1930:239; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera buresi Obenberger 1932:61; Sakalian 2003:57; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359; Kalashian and Sakalian 2007:21.

Sphenoptera hierosolymitana Obenberger 1946:25; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera jureceki Obenberger 1946:26; Katbeh-Bader 1996:49; Kalashian, *et al*. 2005b:88, 90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera arsinoe Obenberger 1952:22; Bílý 1983:78; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Sphenoptera gyaurdagensis Obenberger 1955:14; Kalashian, *et al*. 2005b:90 (syn. of *signata*, lectotype); Volkovitsh and Kalashian 2006:359.

Diagnosis: This species can be distinguished from all other species in the *S.* (*Sphenoptera*) gemmata-group by the following combination of characters: pronotum with three light bands of punctation, if any; setae present on medial area of metacoxa; anterior border of scutellum straight, free from any impressions; and small in size (7.5-9mm long, 2.5-3mm wide, measured at widest point).

Redescription: Male. Length 7.5-9 mm, width 2.5-3 mm across at widest point. Body entirely metallic bronze to bronze-black. Head with shallow depression medially, punctate with sparse, shallow, even punctures; band of whitish setae near interior margin of the eye. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.3x as long as wide, widened to apical 1/3; free from impressions or with very shallow median longitudinal impression, punctation more dense laterally, appearing as wrinkles, with three weak punctation vittae, one mesad and one laterally on each side; lateral carina straight, extending nearly to anterior margin; with fringe anteriorly; anterior angles square; anterior border weakly sinuate, margin absent; posterior pronotal angles square to obtuse (90-93°); posterior border sinuate, emargination present. Scutellum without impressions. Protibia with

several longitudinal rows of spines, with tuft of setae apically; without emargination and slightly curved; tibia and femora sparsely punctate. Prosternum sparsely, deeply punctate. Prosternal process subparallel, expanding slightly behind procoxae, emarginate only laterally; sparsely punctate medially. Mesotibia straight, strongly emarginate, with prominent tooth apically. Elytra subparallel basally, narrowing in apical third. Elytron with broken striae,composed of elongate dash-shaped punctures; interstriae densely micropunctate, with scattered shallow punctures, alternate interstriae with differing structure, weakly elevated. Elytral apex rounded,with weak sutural spine and weak or absent lateral spine. Metacoxa with weakly sinuate posterior margin; covered with sparse pits; medial area with setae. Metatibia straight, with strong incuration; apical tooth present; tibia with row of spines posteriorly. Abdomen ventrally densely setose, with band of dense setae and row of glabrous mirrors laterally; apical abdominal ventrite truncate, entirely pubescent. Aedeagus narrow, 3.4 times as long as wide.

Female: As male, with rounded apical abdominal ventrite rounded; meso and meta tibiae with only weak spine; and protibiae straight.

Variation: Many specimens in this species have differing punctation densities in the three punctation vittae of the pronotum, varying from three distinct vittae to almost non-existent vittae. Additionally, this species varies a great deal in size.

Types Examined: *Sphenoptera jejuna* Jakovlev, HOLOTYPE: Caucasus.; Araxesthal.;Leder, Reitter.;; Type;; Deud.; Type jejuna Jak.; B. Jakowlew det.;; jejuna m.;; Пр. N8 ♂;; Satelles?; ?= Jak.;; Holotypus. (ZIN)

Sphenoptera addenda Jakovlev HOLOTYPE: Amasia [Turkey];; Type;; addenda;;

Deud.; type addenda;; addenda Jak.;; holotype. (ZIN)

Sphenoptera detrita Jakovlev HOLOTYPE: Caucasus.; Araxesthal.;Leder, Reitter.;; Type;; detrita m.;; К. В. Яковлева;; Deud.; type detrita ; B. Jakowlew det.;; Holotypus;; Sphenoptera; (Deudora) addenda JAK.; det. M. Neihuis 2001 (ZIN)

Sphenoptera satelles Jakovlev HOLOTYPE: Caucasus.; Araxesthal.;Leder, Reitter.;; Deud.; type satelles Jak. ; B. Jakowlew det.;; Type;; К. В. Яковлева;; satelles Jak. ;; Siewersi Rtt. 105;; Пр. N9 ♂;; Holotypus;; addenda ♂; det. Neih. (ZIN)

Sphenoptera clarescens Kerremans HOLOTYPE: v Bodemeyer; Luristan; Persia;; Museum Paris; Coll Ch Kerremans; 1923 ;; TYPE;; clarescens; Kerr type. (MNHN)

Notes: This species is rather easily distinguishable from *Sphenoptera aeneomicans* by its size and the structure of the scutellum.

The type of *Sphenoptera clarescens* Kerremans 1909, which is was identified as a potential biological control agent, was located by Mark Volkovitsh in the Muséum national d'Histoire naturelle, in Paris, France. The type, a battered, dusty, and dirty specimen was examined by Drs. Kalashian and Volkovitsh, as well as myself, and was found to be identical to this species, *S. signata*. *Sphenoptera signata* is common in Iran and central Asia (Kalashian and Volkovitsh 2005b), and many species, including this one, were described from singletons from one locality. Therefore, I will synonymize *Sphenoptera clarescens* Kerremans with *Sphenoptera signata.*

The *Sphenoptera clarescens* later collected by Hasan (1978) and determined by Descarpentries were found to be misidentified *Sphenoptera aeneomicans*.

Host Records: *Chondrilla juncea* (from specimens).

Distribution: Armenia; Adzerbaijan; Bulgaria; Greece; Iran; Israel; Jordan; Kyrgyzstan; Macedonia; Syria; Turkey; Turkmenistan (Bellamy 2008). Iraq; Lebanon (Volkovitsh et al. 2005).

Sphenoptera ventrisculpta Obenberger 1916

Sphenoptera ventrisculpta Obenberger 1916: 252; Obenberger 1926b:635; Obenberger 1929b:54; Obenberger 1930:249; Théry 1942:41;; Volkovitsh and Kalashian 2006:360.

Sphenoptera gemmata vittaticollis: (not *Sphenoptera gemmata vittaticollis* Lucas 1844). Cobos 1986: 313.

Recorded Distribution: Algeria; Tunisia (Bellamy 2008).

Sphenoptera (*Deudora*) *vittaticollis* Lucas 1844

(Figures 114, 251, 253, 262)

Sphenoptera vittaticollis Lucas 1844:50; Chevrolat 1844a:134 (syn. of *rauca*); Chevrolat 1844b:239; Lucas 1846:158; Lacordaire 1857:69; Marseul 1866:362; Gemminger and Harold 1869:1419; Saunders 1871:87; Kerremans 1892:197; Kerremans 1903:114; Jakobson 1913:783; Kerremans 1913:219; Obenberger 1926b:633; Obenberger 1929b:54; Obenberger 1930:249; Théry 1930:179; Théry 1936:8; Théry 1942:41; Kocher 1956:125 (var. of *rauca*); Alfieri 1976:101 (ssp. of *rauca*); Cobos 1986:312 (ssp. of *gemmata*); Kalashian, *et al*. 2005b:90 (valid species, lectotype); Volkovitsh and Kalashian 2006:360; Kalashian and Sakalian 2007:20.

Sphenoptera sulcata Marseul 1866:367 (preocc. by *sulcata* Fischer von Waldheim 1824); Saunders 1871:88; Kerremans 1892:196; Jakovlev 1899:330, 333; Kerremans 1900:402; Kerremans 1902:563, 583; Kerremans 1903:113; Kerremans 1908:100; Kerremans 1913:213; Obenberger 1929b; Obenberger 1930:239; Théry 1930:179, 240 (syn. of *kordofana*); Théry 1936:8; Théry 1942:41; Cobos 1986:312 (syn. of *gemmata vittaticollis*); Kalashian, *et al*. 2005b:91; Volkovitsh and Kalashian 2006:360; Kalashian and Sakalian 2007:20.

Sphenoptera aulacophora Jakobson 1912:136 (*Spenoptera*, *nom. nov.* for *sulcata* Marseul 1866); Jakobson 1913:784; Obenberger 1930:239; Théry 1936:8; Kalashian, *et al*. 2005b:91; Volkovitsh and Kalashian 2006:360; Kalashian and Sakalian 2007:20.

Sphenoptera korfodana Kerremans 1913:213 (*nom. nov.* for *sulcata* Marseul 1866); Obenberger 1915:51 (*kordofana*, synonym of *sulcata*); Obenberger 1930:240 (*kordofana*, synonym of *aulacophora*); Théry 1930:179 (*kordofana*), 230; Théry 1936:8; Théry 1939:247; Théry 1942:41; Kocher 1956:126; Cobos 1986:313 (*kordofana*, synonym of *gemmata vittaticollis*); Niehuis 1996:135; Kalashian, *et al*. 2005b:91; Volkovitsh and Kalashian 2006:360.

Sphenoptera glyphoderes: (not Abeille de Perrin 1901). Obenberger 1929b:54; Obenberger 1930:240; Kalashian, *et al*. 2005b:91; Kalashian and Sakalian 2007:20.

Sphenoptera rotundicollis: (not Gory and Laporte 1839). Mühle, *et al.* 2000:91; Kalashian, *et al*. 2005b:91; Kalashian and Sakalian 2007:20.

Diagnosis: This species can be distinguished from all other species in the *S*.

(*Sphenoptera*) rauca-group by the following combination of characters: setae absent on medial area of metacoxa; apical abdominal ventrite with three longitudinal glabrous mirrors; pronotum with three strongly impressed bands of dense setae; body often covered in whitish wax.

Redescription: Male. Length 9-14 mm, width 3-6 mm across at widest point. Body entirely metallic bronze to bronze-black. Head with shallow depression medially, punctate with sparse, shallow, even punctures; band of whitish setae near interior margin of the eye and sparse setae on frons. Antenna shining dark bronze; arising just inside lower half of inner margin of eye; antennomeres with sparse setae. Pronotum 1.6x as wide as long; sides evenly arcuate to apex; with shallow median longitudinal impression, punctation slightly more dense laterally, with three dense, lighty impressed, waxy punctation vittae with setae, one mesad and one laterally on each side; lateral carina slightly sinuate, extending nearly to anterior margin; with fringe anteriorly; anterior angles acute; anterior border weakly sinuate, margin absent; posterior pronotal angles acute (45-60°); posterior border sinuate, emargination present. Scutellum free from impressions. Protibia with several longitudinal rows of spines, with tuft of setae apically; without emargination and slightly curved; tibia and femora sparsely punctate. Prosternum covered with deep punctation. Prosternal process subparallel, expanding slightly behind procoxae, emarginate only laterally; sparsely punctate medially; lightly impressed medially. Mesotibia slightly curved, strongly emarginate, with very prominent tooth apically. Elytra subparallel basally, narrowing in apical third. Elytron with broken striae,composed of elongate dash-shaped punctures; interstriae densely micropunctate,

with scattered shallow punctures, alternate interstriae with differing structure, heavily sculptured, alternate interstriae weakly elevated. Elytral apex acute,with weak or strong sutural spine and weak or absent lateral spine. Metacoxa with very weakly sinuate posterior margin; covered with sparse pits; medial area lacking setae. Metatibia straight, weakly emarginate; strong apical tooth present; with row of spines posteriorly. Abdomen ventrally densely setose, with band of dense setae and row of glabrous mirrors laterally; apical abdominal ventrite truncate, with three longitudinal mirrors. Aedeagus narrow, 3.9 times as long as wide.

Female: As male, with rounded apical abdominal ventrite rounded; meso-and meta tibiae not emarginate, with only weak spine; and protibiae straight.

Variation: The density of punctation and setae in the three pronotal vittae varies from specimen to specimen, as does size. The wax that covers this beetle may be absent, if the specimen is old or has been cleaned.

Types Examined: None.

Notes: The amount of variation in size and in structure of the three pronotal vittae makes this species difficult to distinguish from the other two western species in the group. So much so that the name *S. vittaticollis* was synonymized several times with these species. However, a character on the last ventrite splits this species away from *S. gemmata* and *S. rauca*. *Sphenoptera vittaticollis* possesses three mirrors on the apical abdominal ventrite and this is distinctive of the species.

Host Records: none recorded.

Recorded Distribution: Algeria; Egypt; Greece; Israel; Morocco; Sudan; Tunisia

(Bellamy 2008).

Discussion

The identities of three ambiguous species within this group were clarified here, with the aedeagus structure immediately separating *S. gemmata* from *S. rauca*.

It is interesting to note that both *S. aeneomicans* and *S. signata*, which key out together in the first couplet, range mostly in Asia, whereas *S. gemmata*, *S. rauca*, and *S. vittaticollis* are all mainly European and North African in range, and again, key out together in the first couplet. It may be inferred then, that these two species might be closely related, and the initial division of the species-group based on size is only a superficial one.

CHAPTER 6:
A RESOLUTION OF THE IDENTITIES OF TWO NORTH AMERICAN SPECIES OF *CHALCOPHORA*

Introduction

Taxonomic History

The genus *Chalcophora* was erected in 1833 by Dejean for the Palaearctic species *Buprestis mariana* (Linnaeus 1758). Currently, there are 15 valid species of *Chalcophora* worldwide, with five nominal species occurring in North America north of Mexico (NANM) (Bellamy 2003, 2008): *C. angulicollis* (LeConte), *C. fortis* LeConte, *C. georgiana* (LeConte), *C. liberta* (Germar), and *C. virginiensis* (Drury). The status of two of these, *C. angulicollis* and *C. virginiensis*, however, remains unclear.These species have repeatedly been synonymized and removed from synonymy most recently by Bright (1987) and Nelson et al. (2008).

Drury (1770) described *Buprestis virginiensis* in *Illustrations of Natural History of Exotic Insects*. Two other names existed before 1800 for *Chalcophora* from eastern North America, *C. cupreomaculata* Goeze and *C. virginica* Gmelin, but these were later found to be synonyms of *C. virginiensis* (Saunders 1871 and LeConte 1860). In 1857, LeConte described the western species *Buprestis angulicollis* from an individual collected in Sacramento, California, by Mr. M. Wittick. LeConte distinguished it from the Eastern species by its larger size, more angular pronotal margins, and wider dilations of the second and third elytral carinae. One year later, in 1858, Fitch placed *B. virginiensis* in *Chalcophora*, and proposed *C. oregonensis* for the western form. He also described

another eastern species, *C. novaeboracensis*. These were both synonymized by Leconte (1860) – *C. novaeboracensis*, along with a Gmelin name, *C. virginica,* were synonymized with *C. virginiensis*, and *C. oregonensis* was synonymized with *C. angulicollis*. In this work, LeConte also described an eastern species, *C. lacustris*, which was later found to be synonymous with *C. virginiensis* by Wellso (1976).

Interestingly, Obenberger (1913) described a new subspecies *C. mariana* ssp. *filigriana* of the Palaearctic species, but this was found to be a specimen of *C. virginiensis* (Bílý 1981), indicating that, perhaps through human transport, this species has been introduced to Europe.

Additional species were added by Casey, in1909 and 1914 he described a total of six new species of *Chalcophora* from the United States: *C. obliterata, C. brevicollis, C. antennalis*, *C. montana, C. prominens*, and *C. ingens*. Four of these, *C. obliterata, C. antennalis, C. brevicollis*, and *C. ingens* were later synonymized with *C. virginiensis* by Kerremans (1909b) and Chamberlain (1926). The remaining two were subsequently synonymized with *C. angulicollis* by Kerremans (1909b) and Leng (1920). Muttkowski (1910) described an eastern species, *C. melanotum* which was later sunk into *C. virginiensis* (Leng 1920). Kerremans (1919) described another western species, *C. pallida*, but this was also found to be a synonym of *C. angulicollis* (Barr 1971).

In Kerremans (1909b) monograph, he synonymized the two large North American *Chalcophora* species, proposing one transcontinental species under the oldest name, *C. virginiensis*. Casey (1914) defended the separation of the two, and diagnosed *C. angulicollis* as having proportionately more elongate elytra and no sutural spine, unlike

C. virginiensis. The two species remained separate in several other subsequent publications, including Leng (1920), and Barr (1971), until 1987, when Bright, in his keys to metallic wood-boring beetles of Canada and Alaska, resynonymized the two species. Bright (1987) was unable to find any clear, consistent differences in either external morphology or genitalia, and attributed the naming of numerous superfluous species to variation in sculpturing and coloration. Nelson et al. (2008) removed the two species from synonymy without any explicit explanation and a consensus on the validity of the two species has never been reached.

My goal is to resolve the ambiguity concerning the status of these eastern and western North American populations of *Chalcophora – C. angulicollis* and *C. virginiensis* by comparing morphological and geographical data for specimens of both forms, paying particular attention to the populations in the north-central US and south-central Canada, where populations may overlap. As such, this is not a revision, and no attempt has been made to examine all specimens and types. This species complex is well known and I restricted my study to the status of these two species.

The key to resolving the status of these two nominal species may be in their distribution, because if the two species are indeed reproductively isolated, then some geographic gap between the eastern and western populations is to be expected. Distribution data for Canada (Bright 1987) shows no overlap in the ranges of the two species, and would lead one to believe that, unless there are *Chalcophora* in eastern Alberta, Minnesota, and the upper peninsula of Michigan, that the two populations would be at least geographically isolated from one another.

The problem with *Chalcophora* variation is not limited to North America. In his revision of East Asian *Chalcophora*, Kurosawa 1974 discovered an inordinate number of subspecies and variations, which, as he stated, "…are not always clear-cut because of intermediate individuals". Therefore, it seems that there is much work to be done on this group worldwide.

Biology

Fitch (1858) detailed the habits and life cycle of four *Chalcophora* species, which all have similar life cycles. *Chalcophora virginiensis* larvae mine beneath the bark in living pine trees (*Pinus* spp.), excavating long, flat, serpentine tunnels under the bark. The larvae then bore into the heartwood to pupate and emerge as adults in the spring or fall. In addition to *Pinus* spp., Bright (1987) also recorded *Chalcophora* species from *Pseudotsuga menziesii* (Mirbel) Franco, *Abies grandis* (Douglas ex D. Don) Lindley, and *Abies concolor* (Gordon et Glendinning) Hildebrand.

Materials and Methods

Materials

The material examined for the *Chalcophora* research was borrowed mainly from institutions in North America. Examination of numerous representatives from both nominal species from all over North America was required to determine the range of variation within species and how this relates to the biogeography of the complex. Additionally, I examined many specimens of the other three NANM species to determine the amount of variation in these species. A total of 594 specimens were examined.

Label information for types presented as in Ivie (1985). Non-type data are summarized in a spreadsheet as material examined (See Appendix).

Specimens from the following collections were examined in this study (curators listed in parentheses):

CNC – Canadian National Collection of Insects, Ottowa, Ontario, Canada (Anthony E. Davies).

LSAM – Louisiana State Arthropod Museum, Louisiana State University, Baton Rouge, Louisiana, USA (Victoria Bayless).

MTEC -- Montana State Entomology Collection, Montana State University, Bozeman, Montana, USA (Michael A. Ivie).

SEMC -- Snow Entomology Collection, University of Kansas, Lawrence, Kansas, USA (Zachary H. Falin).

UMSP -- University of Minnesota Insect Collection, St. Paul, Minnesota, USA (Philip J. Clausen).

USNM – National Museum of Natural History, Washington, DC, USA (Steven W. Lingafelter).

WFBM – William F. Barr Entomological Museum, University of Idaho, Moscow, Idaho, USA (James B. Johnson).

Methods – Imaging

Morphological characters that distinguish *Chalcophora* species were observed through a a Leica® Wild M3C dissecting stereo-microscope with a Techni-quip® 150W fiber optic illuminator. Particular characters were photographed with a JVC® 3CCD

KY-F750 digital camera mounted to a Leica® MS5 dissecting microscope, with a Schott® Fostec DCR 111 fiber optic illuminator and a bottomless foam coffee cup as a light diffuser. The camera is attached to an IBM IntelliStation M Pro® and the images were processed using Syncroscopy Auto-montage Pro® ver. 5.03.0020 Beta and enhanced in Adobe Photoshop® CS4. Habitus photos for large specimens were constructed from several stitched-together photos.

Methods – Morphology

The cuticle of older specimens is frequently coated with greasy exudate or dust from years of languishing in drawers, and additionally, since these beetles are xylophagous, they can be covered with sap and dirt. Specimens that were deemed too dirty to discern morphological characters were relaxed in boiling water for ten minutes, then placed in an ultrasonic cleaner with dilute Parsons® Household Ammonia. The ammonia bath was then followed by several rinses in distilled water to remove all traces of the ammonia and dirt.

Genitalia were extracted from relaxed specimens through the caudal opening in the abdomen between seventh tergite and fifth ventrite. Genitalia were examined and subsequently glued to a card below the specimen. For photographs, the genitalia were mounted on the head of a pin using Elmers ® glue and photographed ventrally and dorsally using the Automontage set-up.

Results

Although numerous extraneous species have been described in the past, it appears

that all of the currently recognized species (as in Nelson et al. 2008) are indeed valid. In particular, the two species of interest – *C. virginiensis* and *C. angulicollis* – are distinct eastern and western species of *Chalcophora*. There is a small disjunct in the distribution in central North America, and there exists a set of characters which are always different between the two species (Figure 282).

Characters used in the past, which involved size, color, and cuticular sculpturing, should not be used to define species in this group. Within the genus *Chalcophora*, many external characters do not vary consistently between species. The large amount of variation in these characters led to the naming of numerous invalid species. Genitalic characters are much more appropriate for the definition of species.

Several of the characters shown to be useful to distinguish species are subtle, but they were consistent within a single species. The aedeagi of the western and eastern species, when viewed separately, appeared very similar, but when viewed together, and grouped by distribution, the subtle difference in proportions became obvious. Additionally, once individuals were separated by distribution, patterns in the penultimate maxillary palpomere and elytral serrations emerged.

This group exemplifies the need to choose good characters for the identification of species. Once a consistent and clear set of characters were chosen for this group, identification became both simple and reliable.

Taxonomic Work

Chalcophora angulicollis (LeConte, 1857)

(Figures 266, 268, 273, 278, 264)

(For more complete synonymy see Bellamy (2008))

Buprestis angulicollis LeConte 1857

Chalcophora oregonensis Fitch 1858

Chalcophora angulicollis ssp. *montana* Casey 1909

Chalcophora prominens Casey 1909

Chalcophora pallida Kerremans 1919

Diagnosis: This species can be distinguished from all other NANM species by the following combination of characters: two strong longitudinal ridges present on the interior face of the protibia; shining black in color; aedeagus >3.3 times as long as wide; posterior elytral margins weakly serrate to crenulate; penultimate segment of maxillary palp flattened, 1.5 times as long as wide. It is the only *Chalcophora* species in western North America.

Redescription: Length 20-30 mm, width 12-14 mm across at widest point. Blackish, with a slight metallic copper luster; shining bronze to copper ventrally. Head deeply incised medially, heavily punctate, sparsely setose. Penultimate segment of maxillary palp flattened, 1.5 times as long as wide. Antenna dark brown; arising just inside inner margin of eye; antennomeres quadrate, with sparse setae apically. Pronotum widest in basal two-thirds; lateral borders angulate to arcuate, moderately crenulate in apical one-third; with fringe anteriorly; anterior angles acute, projecting forward around

head; dorsal surface heavily sculptured, with depressed patches of dense punctation interspersed with smooth, black elevations; pronotal elevations narrow; elevation pattern variable. Protibia with broad tooth apically, with two prominent longitudinal ridges; tibia with two short apical spines; tibia and femora sparsely, evenly punctate and lightly setose, with tuft of setae apically, which extends along the length of the tibia. Prosternal process expanded behind procoxae, with two longitudinal grooves. Elytra subparallel, narrowing in apical two-thirds. Elytron heavily sculptured, with depressed patches of dense punctation interspersed with smooth black elevations; elytral elevations wide; elytral sculpturing variable; lateral border weakly serrate or crenulate to smooth, never strongly serrate. Elytral apex trunate to broadly rounded, with weak sutural spine or sutural spine absent. Ventrally setose; ventrites evenly punctate, posterior border smooth; apical ventrite deeply notched with a V-shaped notch posteriorly. Aedeagus 3.2 times as long as wide; with wide paramere, wrapping around median lobe, with tuft of setae apically; tegmen deeply incised medially; median lobe wide, apex acute (45°), with median ridge dorsally.

Female: Generally larger; last ventrite rounded posteriorly, notch absent.

Variation: The extraordinary amount of variation within this and the following species has been the cause of many problems with the taxonomy of the genus. *Chalcophora angulicollis*, and most species in the genus, vary considerably in body shape, color, size, and amount of cuticular sculpturing. This is to be expected from a species that develops in wood, as the amount and quality of resources available singificantly influences the development of the young beetle and, in turn, the size and

shape of the adult.

Types Examined: *C. angulicollis ssp. montana* -- "Boulder; Co. Col. ;; CASEY; bequest; 1925 ;; montana - 2; PARATYPE USNM; 35735 ;; PARA- LECTOTYPE; Chalcophora; angulicollis; montana Casey; 1989; C.L. BELLAMY." "Boulder; Co. Col. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35735 ;; montana ;; LECTOTYPE; Chalcophora; angulicollis; montana Casey; 1989; C.L. BELLAMY." (2 specimens, USNM)

C. prominens HOLOTYPE – "Fla. ;; CASEY; bequest; 1925 ;;TYPE USNM; 35737 ;; prominens Csy." (USNM)

Notes: Benoit (1963) indicated that C.A. Frost collected several *C. angulicollis*, from Quebec and Ontario in eastern Canada. However, based on the characters that Benoit used for both *C. virginiensis* and *C. angulicollis*, which included size, width of sculpturing, and and pronotal shape, it is unlikely that these specimens belong in *C. angulicollis*. Specimens examined from Quebec, Saskatchewan, and Ontario indicate that Ontario is within the range of *C. virginiensis*, not *C.angulicollis*.

Host Records: *Pinus ponderosa* Douglas ex C. Lawson, *P. contorta* Douglas ex Loudon, *Pseudotsuga menziesii* (Mirbel) Franco, *Abies grandis* (Douglas ex D. Don) Lindley, *Abies concolor* (Gordon et Glendinning) Hildebrand (Barr 1971).

Recorded Distribution: CANADA: Alberta, British Columbia, Northwest Territories. UNITED STATES: Arizona, California, Colorado, Idaho, Montana, Nebraska, New Mexico, Oregon, South Dakota, Washington, Wyoming. Outside NANM: Mexico, Central America, Japan, Europe.

Chalcophora virginiensis (Drury, 1770)

(Figures 265, 267, 272, 277)

(For more complete synonymy see Bellamy (2008))

Buprestis virginiensis Drury 1770

Buprestis cupreomaculata Goeze 1777

Buprestis virginica Gmelin 1790

Chalcophora novaeboracensis Fitch 1858

Chalcophora virginiensis var. *immaculata* Fitch 1858

Chalcophora lacustris LeConte 1860

Chalcophora virginiensis ssp. *obliterata* Casey 1909

Chalcophora lacustris ssp. *brevicollis* Casey 1909

Chalcophora melanotum Muttkowski 1910

Chalcophora mariana ssp. *filigriana* Obenberger 1913

Chalcophora virginiensis ssp. *antennalis* Casey 1914

Chalcophora ingens Casey 1914

Diagnosis: This species can be distinguished from all other NANM species by the following combination of characters: two strong longitudinal ridges present on the interior face of the protibia; shining black in color; width of the aedeagus (4 times as long as wide); posterior elytral margins weakly to strongly serrate; penultimate segment of maxillary palp cylindrical, 1.8 times as long as wide; and by its eastern North American range.

Redescription: Length 18-30 mm, width 11-14 mm across at widest point.

Blackish, with a slight metallic copper luster; ventrally shining bronze to copper. Head deeply incised medially, heavily punctate, sparsely setose. Penultimate segment of maxillary palp cylindrical, 1.8 times as long as wide. Antenna dark brown; arising just inside inner margin of eye; antennomere quadrate, with sparse setae apically. Pronotum widest in basal two-thirds; lateral borders arcuate, moderately crenulate on apical one-third; with fringe anteriorly; anterior angles acute, projecting forward around head; dorsal surface heavily sculptured, with depressed patches of dense punctation interspersed with smooth, black elevations; pronotal elevations narrow; elevation pattern variable. Protibia with broad tooth apically, with two prominent longitudinal ridges; tibia with two short apical spines; tibia and femora sparsely, evenly punctate and lightly setose, with tuft of setae apically, which extends along the length of the tibia. Prosternal process expanded behind procoxae, with two longitudinal grooves. Elytra subparallel, narrowing in apical two-thirds. Elytron heavily sculptured, with depressed patches of dense punctation interspersed with smooth black elevations; elytral elevations wide; elytral sculpturing variable; lateral border weakly to strongly serrate posteriorly. Elytral apex trunate to broadly rounded, with weak sutural spine or sutural spine absent. Ventrally setose; ventrites evenly punctate, posterior border smooth; apical ventrite deeply notched with a V-shaped notch posteriorly. Aedeagus four times as long as wide; with wide paramere, wrapping around median lobe, with tuft of setae apically; tegmen deeply incised medially; median lobe wide, apex acute (45°), with median ridge dorsally.

Female: Generally larger; last ventrite rounded posteriorly, notch absent.

Variation: There exists a great deal in variation in size, color, and cuticular

sculpturing in this group.

The currently chosen characters vary little within the species; the genitalia have consistent proportions, the penultimate segment of the maxillary palp is always cylinidrical in this species, and the interior face of the protibia always has strong ridges. The serration of the elytra varies slightly within the species, but still remains a good character for identification.

Types Examined: HOLOTYPE: *C. virginiensis* ssp. *obliterata* – "Fla. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35731 ;; obliterata Csy." (USNM)

HOLOTYPE: *C. lacustris* ssp. *brevicollis* – "Mass. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35732 ;; brevicollis Csy." (USNM)

HOLOTYPE: *C. virginiensis* ssp. *antennalis* – "Idaho ;; CASEY; bequest; 1925 ;; TYPE USNM; 35734 ;; antennalis Csy." (USNM)

HOLOTYPE: *C. ingens* – "CASEY; bequest; 1925 ;; TYPE USNM; 35736 ;; ingens Csy." (USNM)

Notes: The variation in external characters in *C. virginiensis* is similar to that of *C. angulicollis*, and some of the characters used in the old definitions are shared between the two, so that there are many *C. virginiensis* that closely resemble *C. angulicollis*. In fact, one synonym, *C. lacustris*, was named simply as an eastern species which displayed many external characters of *C. angulicollis*.

Additionally, there is a disjunction in distribution in central North America, with no specimens recorded from eastern South Dakota, North Dakota, or in eastern Alberta and eastern Saskatchewan. This disjunction between the eastern and western species

further supports the status of these two species.

Host Records: *Larix laricina* (Du Roi) K. Koch (from specimens), *Picea abies* (L.) H. Karst, *Pinus echinata* Miller, *P. palustris* Miller, *P. resinosa* Aiton, *P. rigida* Miller, *P. strobus* L., *P. taeda* L., *P. virginiana* Miller, *Taxodium distichum* (L.) Richard (Nelson et al. 2008).

Recorded Distribution: CANADA: Manitoba, New Brunswick, Saskatchewan. UNITED STATES: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia, Washington DC, West Virginia, Wisconsin. Outside NANM: Mexico, Central America, Japan, Europe.

During the course of this study, the other NANM species were examined. Diagnoses and redescriptions are provided here for consistency.

Chalcophora fortis LeConte, 1860

(Figures 271, 275, 281, 263)

(For more complete synonymy see Bellamy (2008))

Chalcophora fortis LeConte 1860

Chalcophora laurentica Casey 1909

Chalcophora cupreola Casey 1914

Diagnosis: The largest of the North American *Chalcophora, C. fortis* is easily distinguished from all other species by the following combination of characters: one weak longitudinal ridge present on the interior face of the protibia; coppery-gold to green

metallic in color; posterior elytral margin strongly crenulate to serrate; truncate to rounded elytral apex with weak spine or spine absent; aedeagus with parameres wide, wrapping around median lobe; large, 26-33 mm; north-eastern North America.

Redescription: Length 26-33 mm, width 12-16 mm across at widest point. Blackish, with metallic green-copper luster; ventrally shining bronze to metallic green. Head deeply incised medially, heavily punctate, sparsely setose. Antenna dark brown; arising just inside inner margin of eye; antennomere quadrate, with sparse setae apically. Pronotum widest in basal two-thirds; lateral borders subparallel, heavily crenulate in apical one-third; with fringe anteriorly; anterior angles acute, projecting forward around head; dorsal surface heavily sculptured, with depressed patches of dense punctation interspersed with smooth, black elevations; pronotal elevations narrow; elevation pattern variable. Protibia with broad tooth apically, lacking prominent longitudinal ridges posteriorly or with one very weak ridge; tibia with two short apical spines; tibia and femora sparsely, evenly punctate and lightly setose, with tuft of setae apically, which extends along the length of the tibia. Prosternal process expanded behind procoxae, with two longitudinal grooves. Elytra subparallel, narrowing in apical one-third. Elytron heavily sculptured, with depressed patches of dense punctation interspersed with smooth black elevations; elytral elevations narrow; elytral sculpturing variable; lateral border weakly to strongly serrate posteriorly. Elytral apex trunate to broadly rounded, with weak sutural spine or sutural spine absent. Ventrally setose; ventrites evenly punctate, posterior border smooth; apical ventrite deeply notched with a V-shaped notch posteriorly. Aedeagus with paramere wide, wrapping around median lobe, with tuft of setae apically;

tegmen deeply incised medially; median lobe wide, apex acute (70°), with two lateral ridges dorsally.

Female: Generally larger; last ventrite rounded posteriorly, notch absent.

Variation: Compared to other species in the genus, *C. fortis* displays very little variation. The size, color, and density of setae ventrally vary only slightly, though sculpturing patterns vary considerably from individual to individual.

Types Examined: LECTOTYPE: *C. laurentica* -- "Ont. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35739 ;; laurentica; Csy. ;; LECTOTYPE; CHALCOPHORA; laurentica ♂; Casey; 1989; C.L. Bellamy". PARALECTOTYPES: "Ont. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35739 ;; laurentica - 2; Csy. ;; PARA - LECTOTYPE; CHALCOPHORA; laurentica ; Casey; 1989; C.L. Bellamy". "Ont. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35739 ;; laurentica - 3; Csy. ;; PARA - LECTOTYPE; CHALCOPHORA; laurentica ; Casey; 1989; C.L. Bellamy". (USNM) HOLOTYPE: *C. cupreola* -- "Kas. ;; CASEY; bequest; 1925 ;; TYPE USNM; 35740 ;; cupreola Csy." (USNM)

Notes: *Chalcophora fortis* appears to be a very distinct species, with a range restricted to north-eastern North America.

Host Records: *Pinus strobus* L. (Nelson et al. 2008).

Distribution: CANADA: Ontario, Manitoba, New Brunswick, Quebec. UNITED STATES: Connecticut, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Wisconsin.

Chalcophora georgiana (LeConte, 1857)

(Figures 270, 276, 280)

(For complete synonymy see Bellamy (2008))

Buprestis liberta Laporte and Gory 1836 (Primary junior homonym of *Buprestis liberta* Germar 1824)

Buprestis georgiana LeConte 1857 (Replacement name for *Buprestis liberta* Laporte and Gory 1836)

Chalcophora iridescens Casey 1909

Diagnosis: This species can be easily separated from all other species of NANM *Chalcophora* by the following combination of characters: two weak longitudinal ridges present on the interior face of the protibia or ridges absent; coppery-gold to green metallic in color; posterior elytral margin strongly crenulate to serrate; elytral apex acute, with strong sutural spine; aedeagus with parameres narrow, not wrapping around median lobe; large, 20-29 mm; south-eastern North America.

Redescription: Length 20-29 mm, width 10-14 mm across at widest point. Metallic copper to light metallic green dorsally; ventrally shining bronze to metallic green. Head deeply incised medially, heavily punctate, sparsely setose. Antenna cupreous; arising just inside inner margin of eye; antennomere quadrate, with sparse setae apically. Pronotum widest at base; lateral borders subparallel; with fringe anteriorly; anterior angles acute, projecting forward around head; dorsal surface heavily sculptured, with depressed patches of very dense, convergent punctation interspersed with smooth, coppery elevations; pronotal elevations wide; elevation pattern variable. Protibia with

broad tooth apically, lacking prominent longitudinal ridges posteriorly or with two very weak ridges; tibia with two short apical spines; tibia and femora sparsely, evenly punctate and lightly setose, with tuft of setae apically, which extends along the length of the tibia. Prosternal process expanded behind procoxae, with two longitudinal grooves. Elytra subparallel, narrowing in apical one-third. Elytron heavily sculptured, with shallowly depressed patches of dense punctation interspersed with smooth coppery elevations; elytral elevations wide, shallow; elytral sculpturing variable; lateral border crenulate to weakly serrate posteriorly. Elytral apex acute, with prominent sutural spine. Ventrally setose; ventrites evenly punctate, posterior border smooth; apical ventrite deeply notched with a V-shaped notch posteriorly. Aedeagus with paramere narrow, not wrapping around median lobe, with tuft of setae apically; tegmen deeply incised medially; median lobe narrow, apex strongly acute (20°), with two lateral ridges dorsally. FEMALE: Generally larger; last ventrite rounded posteriorly, notch absent.

Variation: When compared to other species in the genus, *C. georgiana* displays very little variation. The size, color, and density of setae ventrally vary only slightly, though sculpturing patterns vary considerably from individual to individual.

Types examined: HOLOTYPE: *C. iridescens* – "CASEY; bequest; 1925 ;; TYPE USNM; 35733 ;; iridescens Csy. ;; CASEY determ.; georgiana -12". (USNM)

Notes: While Kerremans (1909b) pointed out certain affinities of *C. georgiana* to *C. liberta* Germar, to the point of almost synonymizing it, *C. georgiana* appears to be a well-defined species. Externally, this species closely resembles the *C. virginiensis/C. angulicollis* complex, however the male genitalia share the character of thin parameres,

which don't wrap around the median lobe, with *C. liberta*.

Host Records: *Pinus caribea* Morelet, *P. echinata* Miller, *P. palustris* Miller, *P. taeda* L. (Nelson et al. 2008).

Recorded Distribution: UNITED STATES: Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, Pennsylvania, South Carolina, Virginia.

Chalcophora liberta (Germar, 1824)

(Figures 269, 274, 279)

(For complete synonymy see Bellamy (2008))

Buprestis liberta Germar 1824

Buprestis borealis Laporte and Gory 1836

Chalcophora parviceps Casey 1909

Diagnosis: This, the smallest North American species of *Chalcophora* may be distinguished from other *Chalcophora* by the following combination of characters: protibia with two weak longitudinal ridges posteriorly, or ridges absent; coppery-gold to green metallic in color, sometimes brilliant metallic orange; posterior elytral margin smooth to weakly crenulate, never serrate (Figure 8); elytral apex truncate to rounded, without sutural spine; aedeagus with parameres narrow, not wrapping around median lobe (Figure 13); size small, 15-25 mm; north-eastern North America.

Redescription: Length 15-25mm, width 6-10mm across at widest point. Brilliant orange-copper to metallic green dorsally; ventrally shining bronze to metallic green. Head deeply incised medially, heavily punctate, sparsely setose. Antenna dark brown; arising just inside inner margin of eye; antennomere quadrate, with sparse setae apically.

Pronotum widest in basal half; lateral borders arcuate; with fringe anteriorly; anterior angles acute, projecting forward around head; dorsal surface heavily sculptured, with depressed patches of very dense, convergent punctation interspersed with smooth, black elevations; pronotal elevations narrow; elevation pattern variable. Protibia with broad tooth apically, lacking prominent longitudinal ridges posteriorly or with two very weak ridges; tibia with two short apical spines; tibia and femora sparsely, evenly punctate and lightly setose, with tuft of setae apically, which extends along the length of the tibia. Prosternal process expanded behind procoxae, with two longitudinal grooves. Elytra subparallel, narrowing in apical two-thirds. Elytron heavily sculptured, with depressed patches of very dense, convergent punctation interspersed with smooth, black elevations; elytral elevations narrow; elytral sculpturing variable; lateral border smooth to weakly crenulate posteriorly, never serrate. Elytral apex truncate to broadly rounded, without sutural spine. Ventrally setose; ventrites evenly punctate, posterior border smooth; apical ventrite deeply notched with a V-shaped notch posteriorly. Aedeagus with paramere narrow, not wrapping around median lobe, with tuft of setae apically; tegmen deeply incised medially; median lobe narrow, apex strongly acute (20°), with single ridge dorsally.

Female: Generally larger; last ventrite rounded posteriorly, notch absent.

Variation: The color and luster of this beetle can vary from brilliant metallic coppery-orange to dull black. Additionally, there is an enormous amount of variation in size, the amount of sculpturing on the elytra and pronotum, and the density of setae ventrally.

Types Examined: HOLOTYPE: *C. parviceps* – "N.Y; T.B.A. ;; CASEY; Bequest; 1925 ;; TYPE USNM; 35741 ;; parviceps; Csy". (USNM)

Notes: *Chalcophora liberta* is the smallest *Chalcophora* in the Nearctic region, and is distinctive when compared to other *Chalcophora* species. However, small *C. virginiensis* are often found in collections misidentified as *C. liberta*. *Chalcophora liberta* is generally a northern species, and the few records of *C. liberta* from the southeastern United States (Florida, North Carolina) were found to be misidentified, small *C.virginiensis*. Therefore, identification based on size alone is not appropriate for this species.

Host Records: *P. resinosa* Aiton, *P. strobus* L. (Nelson et al. 2008).

Recorded Distribution: CANADA: Manitoba, Ontario, Quebec. UNITED STATES: Alabama, Connecticut, Indiana, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New York, Pennsylvania, Texas, West Virginia, Wisconsin.

Key to Species

1. Protibia with one or two weak longitudinal ridges on interior face (Figure 263), or ridges absent; usually coppery-gold to green metallic in color .....…... 2

1'. Protibia with two strong longitudinal ridges on interior face (Figure 264); usually shining black in color. .....…..…..…..… 4

2 (1). Elytral margin posteriorly smooth to weakly crenulate, never serrate (Figure 269); aedeagus with parameres narrow, not wrapping around median lobe (Figure 274); small, 15-25 mm; coppery-gold to green metallic in color; north-eastern North America .....

….....…….....……*C. liberta* (Germar)

2’. Elytral margin posteriorly strongly crenulate to serrate (Figure 271); aedeagus with parameres narrow, not wrapping around median lobe (Figure 275) or parameres wide, wrapping around median lobe (Figure 276); large, 26-33 mm; coppery-gold to green metallic in color; eastern North America.....3

3(2’). Elytral apex acute, with strong spine (Figure 270); aedeagus with parameres narrow, not wrapping around median lobe; southern United States .... *C. georgiana* (Germar)

3’. Elytral apex truncate, with weak spine, or spine absent (Figure 271); aedeagus with parameres wide, wrapping around median lobe; north-eastern North America ....…… *C. fortis* LeConte

4(1’). Aedeagus >3.9 times as long as wide (measured at midpoint) (Figure 272), posterior elytral margin weakly to strongly serrate (Figure 267), penultimate segment of maxillary palp cylindrical, >1.7 times as long as wide (Figure 265) (measured at widest point); eastern North America.....……*C. virginiensis* (Drury)

4’. Aedeagus <3.3 times as long as wide (Figure 273); posterior elytral margin weakly serrate to crenulate (Figure 268); penultimate segment of maxillary palp flattened, <1.6 times as long as wide (Figure 266); western North America.…*C. angulicollis* (LeConte)

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APPENDICES

APPENDIX A:

FIGURES

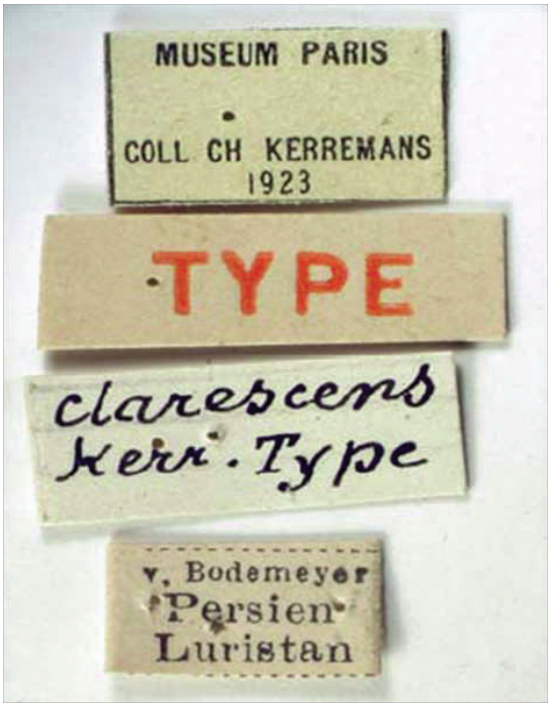




1. *Chondrilla juncea* sampling localities in Armenia (9-20 June 2008).
2. *Chondrilla juncea* sampling localities in Turkey (22-27 June 2008).



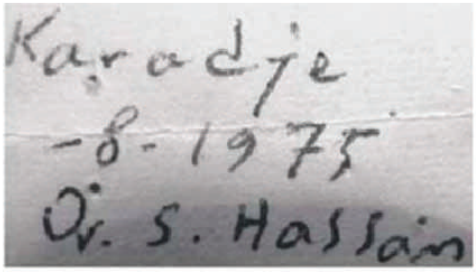
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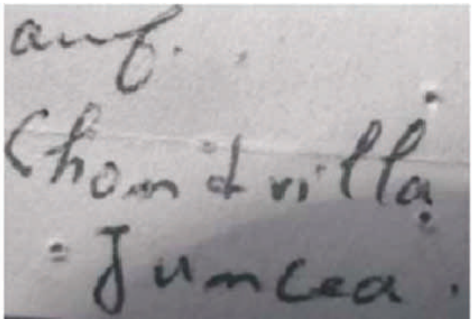


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3. *Sphenoptera clarescens* Kerremans type specimen. (Photo: Mark Volkovitsh)
4. Labels from *Sphenoptera clarescens* Kerremans type specimen. 5. *Sphenoptera clarescens* Kerremans voucher specimen from Hasan's 1978 biological control study. (Photo: Mark Kalashian) 6. Labels from *Sphenoptera clarescens* Kerremans voucher specimen from Hasan's 1978 biological control study. (Photo: Mark Kalashian)



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7. Site A08-3, near Garni, Armenia, 11 June 2008. 8. Site A08-3, near Garni, Armenia, 11 June 2008. 9.Site A08-6, Khosrov Reserve, Armenia, 13 June 2008. 10. Site A08-7, near Surenavan, Armenia, 15 June 2008. 11. Site A08-9, Gorovan Sands, Armenia, 15 June 2008. 12. Site A08-15, near Byurakan, Armenia, 19 June 2008.



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13. Site T08-1, near Goreme, Turkey, 22 June 2008. 14. Site T08-3, near Kayseri, Turkey 22 June 2008. 15. Site T08-7, near Urgup, Turkey, 23 June 2008. 16. Site T08-8, Sultansazligi Milli Parki, Turkey, 23 June 2008. 17. Site T08-11, near Boztepe, Turkey, 24 June 2008. 18.Site T08-14, near Demirkadsik , Turkey, 25 June 2008.



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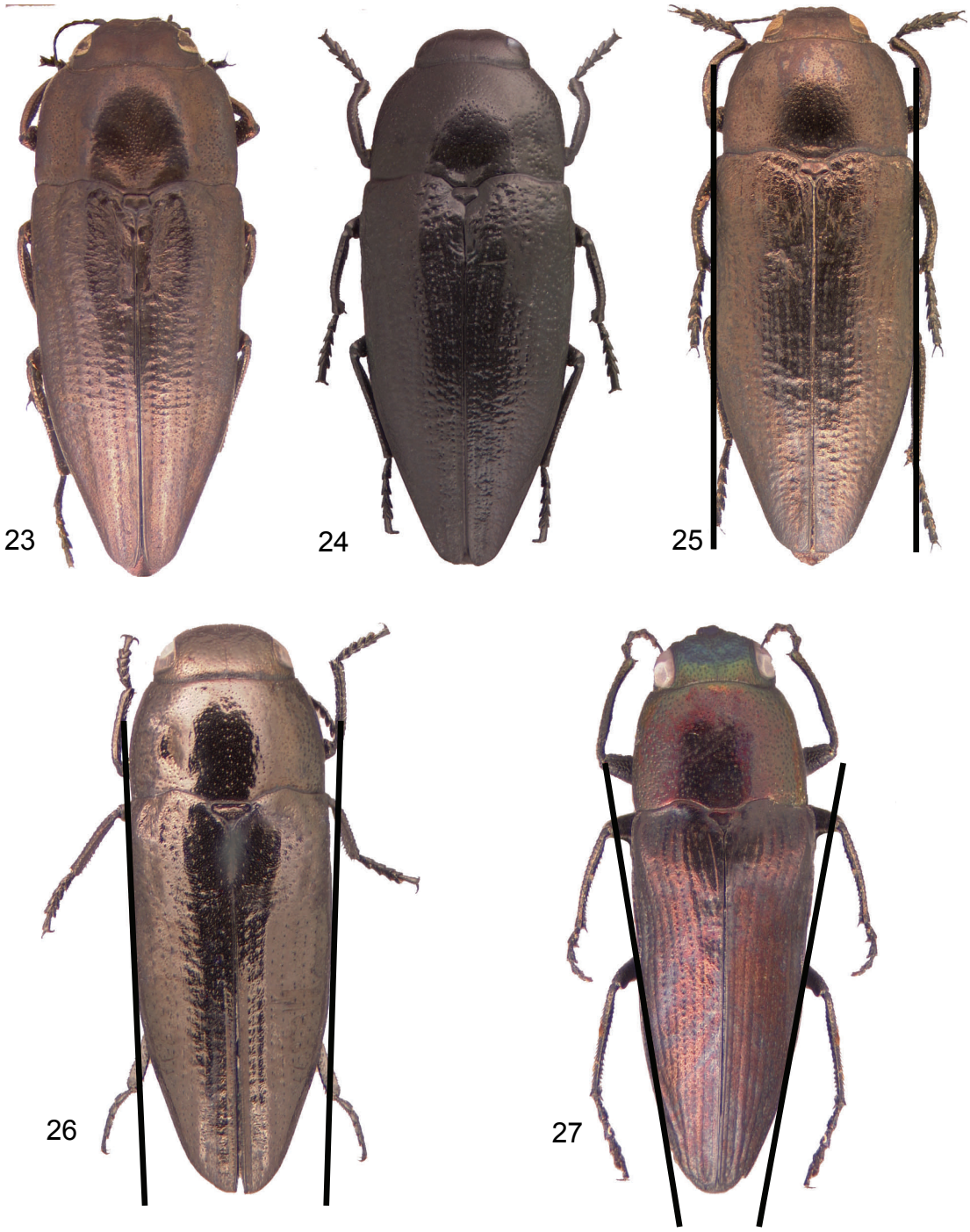


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19. Typical *Chondrilla juncea* plant near Surenavan, Armenia. 20. *Mylabris* sp. feeding on foliage of *Chondrilla* plant (Photo: Mark Volkovitsh) 21. Spider mite damage on *C. juncea* in Turkey. 22. *Mordellestina sp.* damage on *C. juncea* root in Armenia.



23. *S.* (*Sphenoptera*) *manderstjernae* dorsal habitus. 24. *S.* (*Sphenoptera*) *foveola* dorsal habitus. 25. *S.* (*Sphenoptera*) *magna* dorsal habitus. 26. *S.* (*Deudora*) *smyrneensis* dorsal habitus. 27. *S.* (*Hoplistura*) *mesopotamica* dorsal habitus.



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31

28. *S.* (*Chrysoblemma*) *artemesiae* dorsal habitus. 29. *S.* (*Sphenoptera*) *oporina* dorsal habitus. 30. *S.* (*Sphenopterella*) *margaritae* dorsal habitus. 31. *S.* (*Sphenoptera*) *canaliculata* dorsal habitus.

32



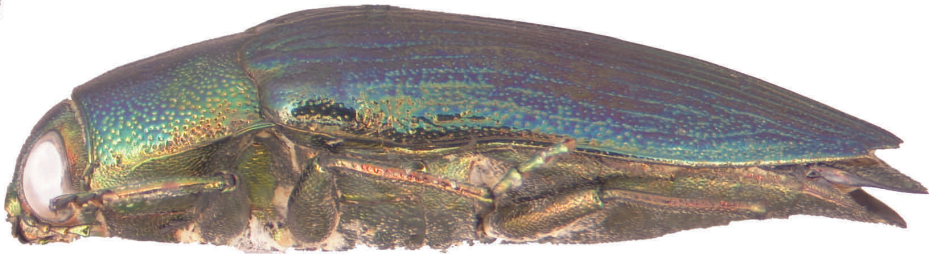
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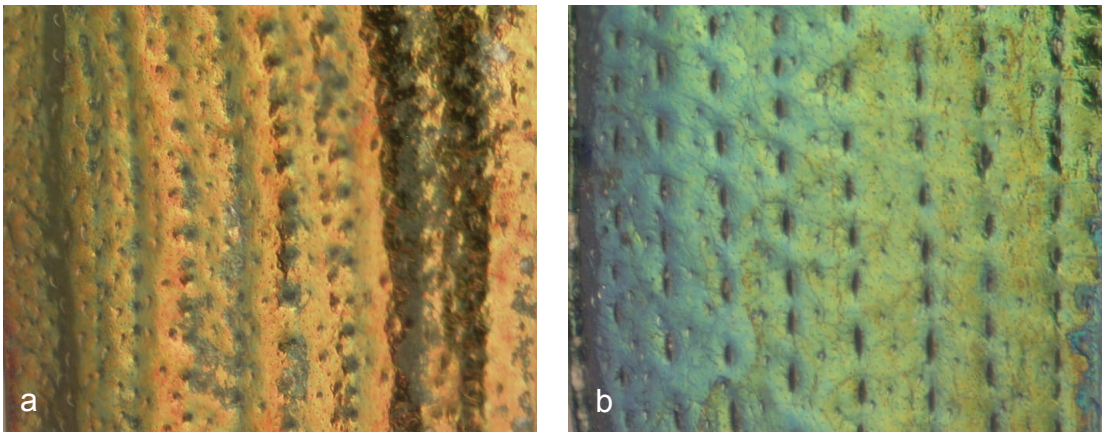


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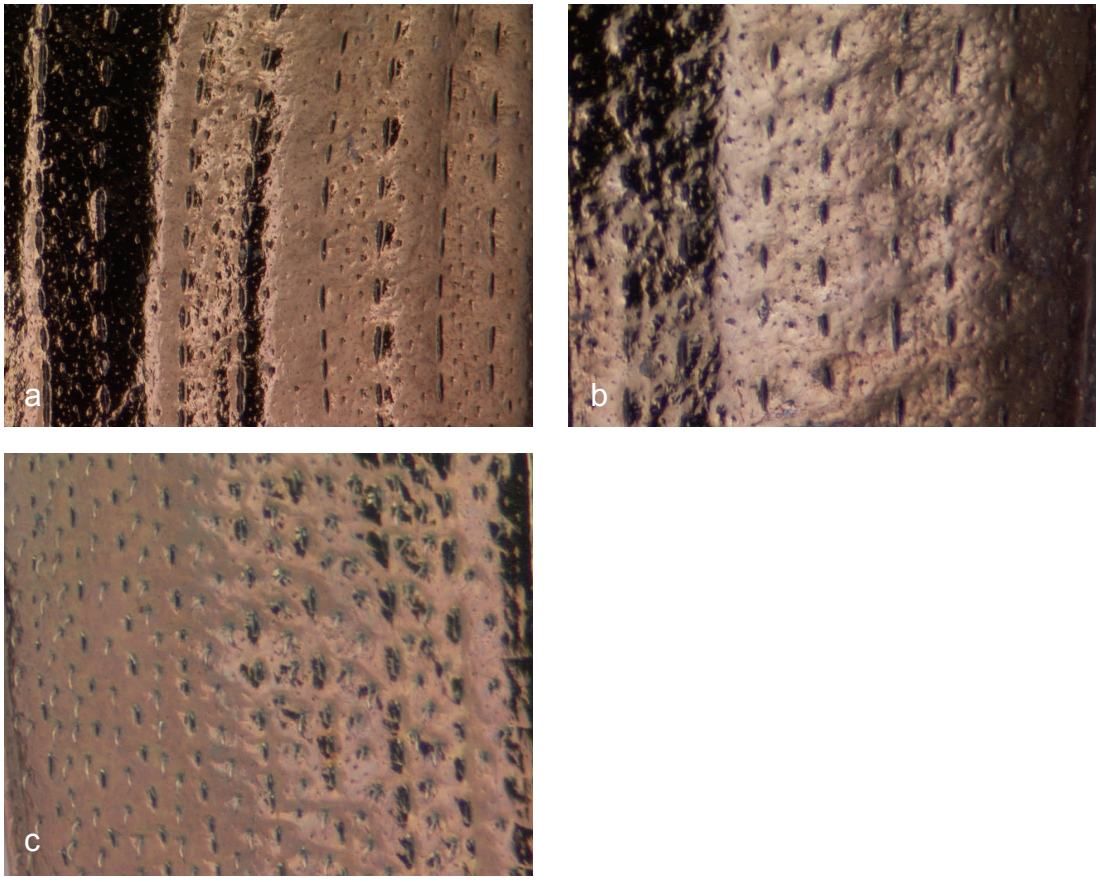


32. *S.* (*Sphenoptera*) *lateralis* lateral habitus. 33. *S.* (*Deudora*) *aeneomicans* lateral habitus. 34. *S.* (*Deudora*) *bucharica* lateral habitus. 35. *S.* (*Chrysoblemma*) *striatipennis* lateral habitus. 36. *S.* (*Sphenoptera*) *canaliculata* lateral habitus.

37

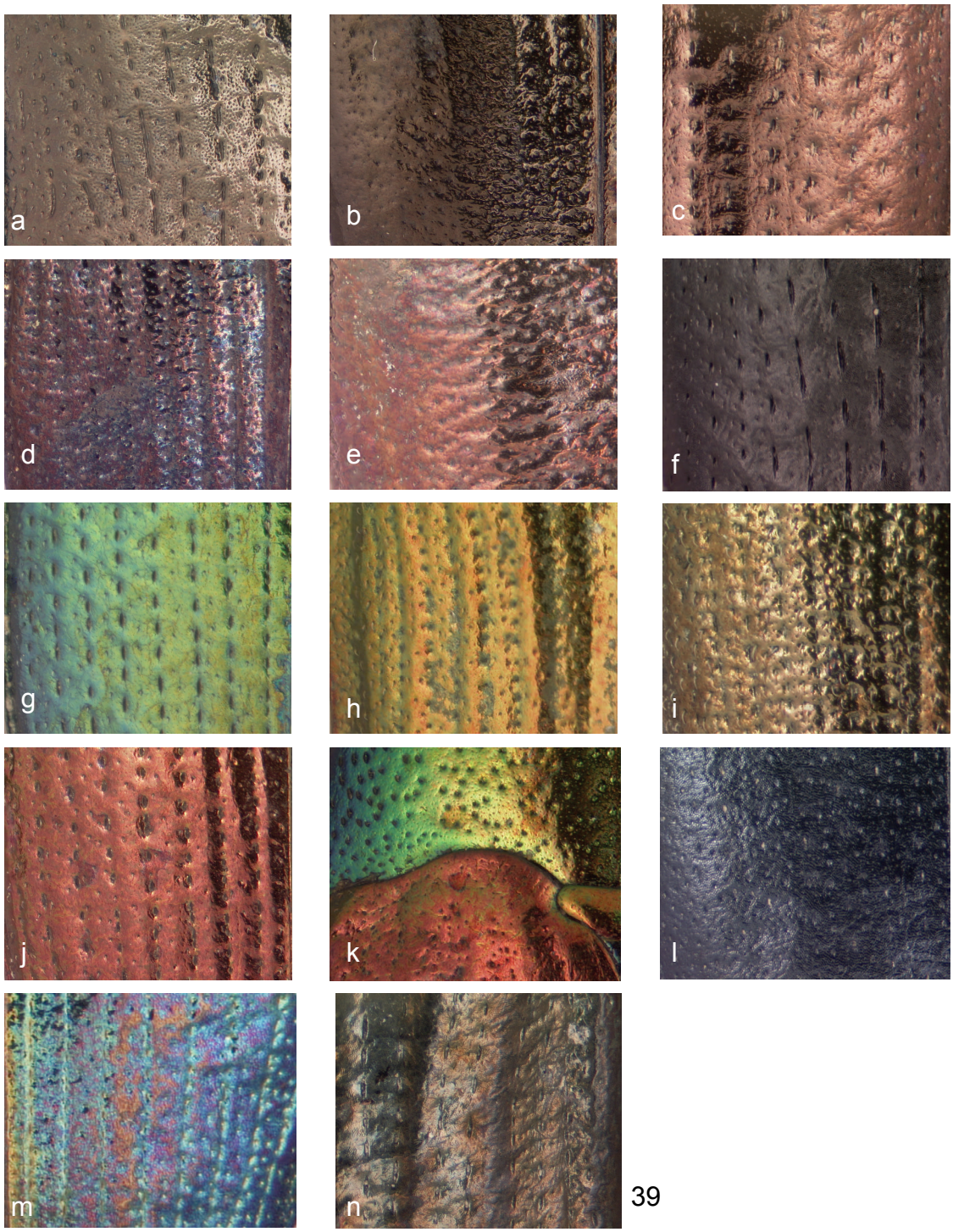


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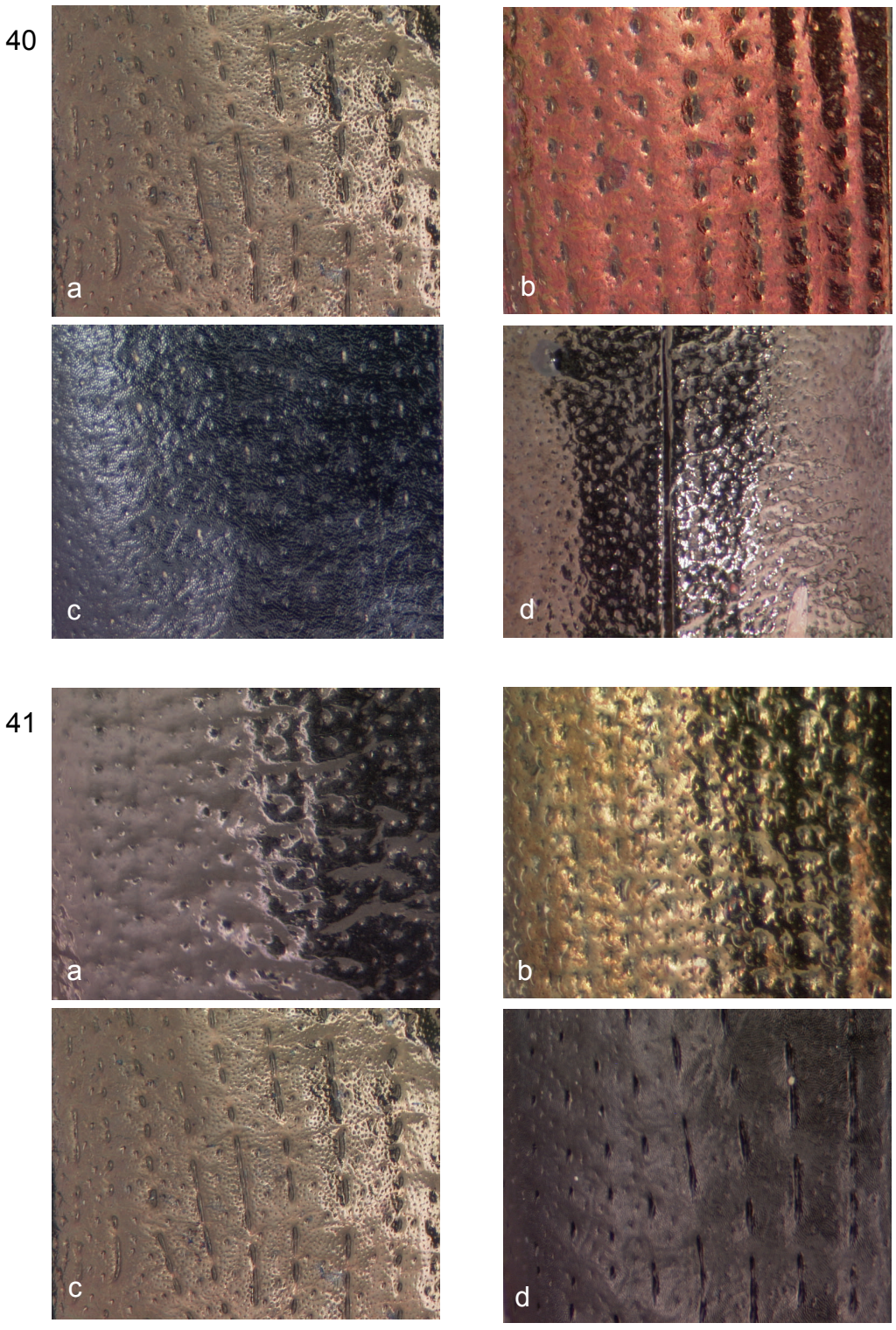
37. Elytral interstriae a) elevated b) flat. 38. Alternate elytral interstriae a) strongly elevated b) weakly elevated c) not elevated.

37

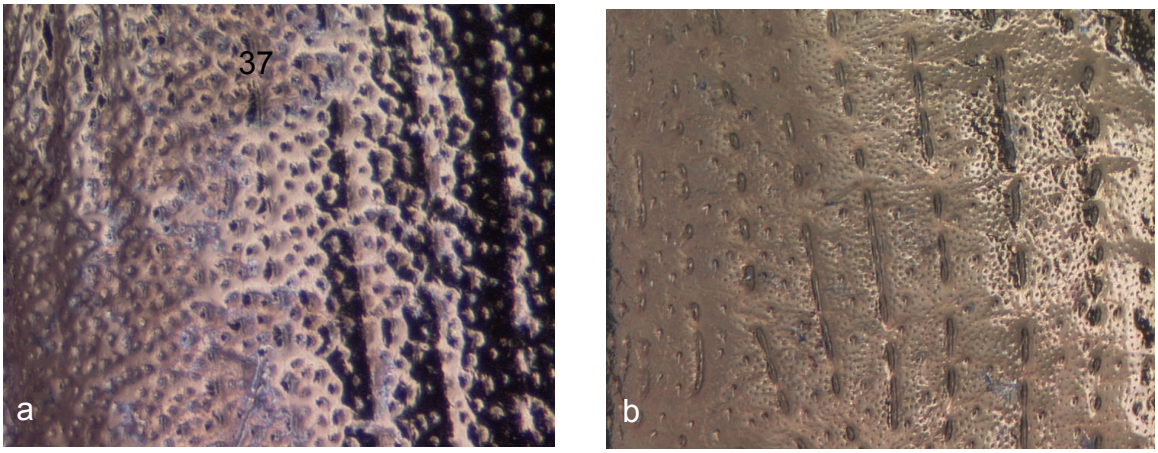


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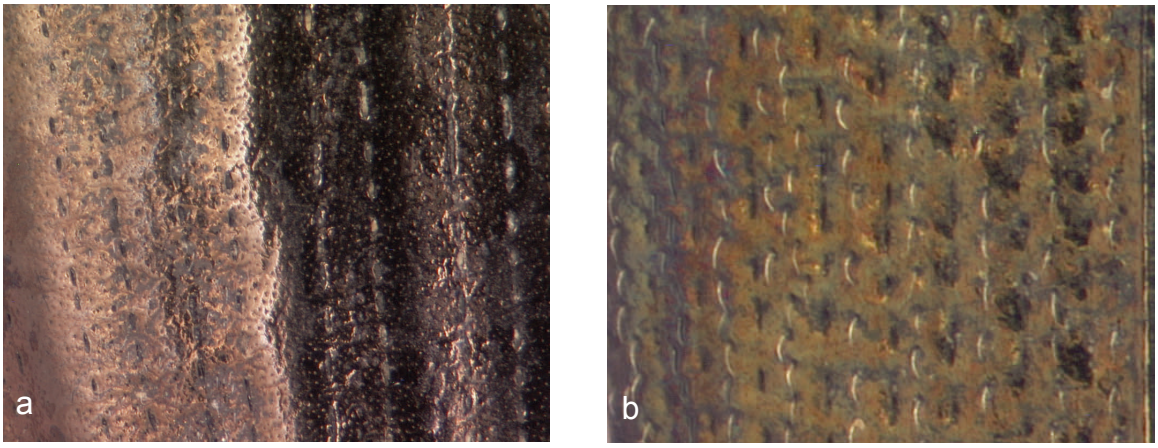
39. Color a) light bronze; b) bronze-black; c) cupreous; d) purple; e) cupreous with blue laterally; f) black; g) green; h) gold-green; i) gold; j) red; k) bicolor green/red; l) blue-black; m) blue; n) green with brown stripes.



40. Elytral striae structure a) elongate dashes; b) deep, even punctures; c) shallow punctures; d) no apparent striae. 41. Luster a) glossy; b) metallic; c) silky-metallic; d) matte, with chagreening.

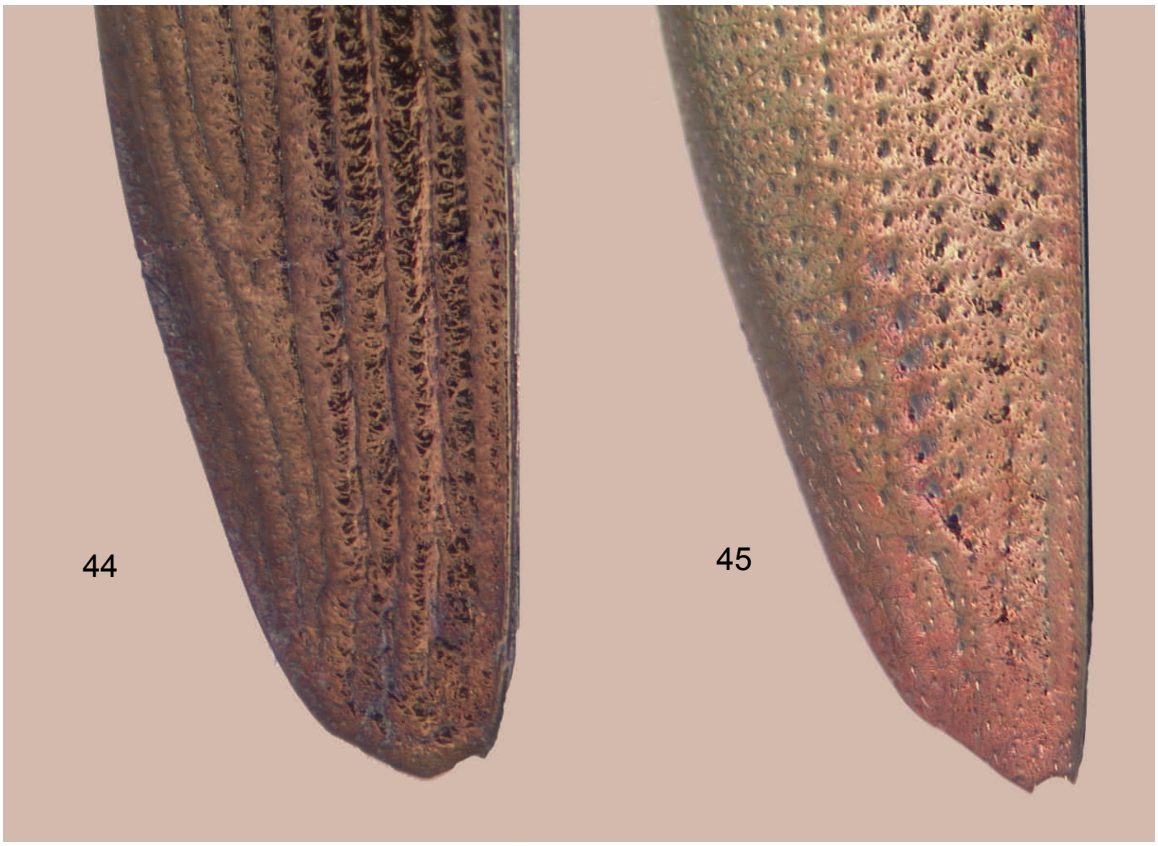


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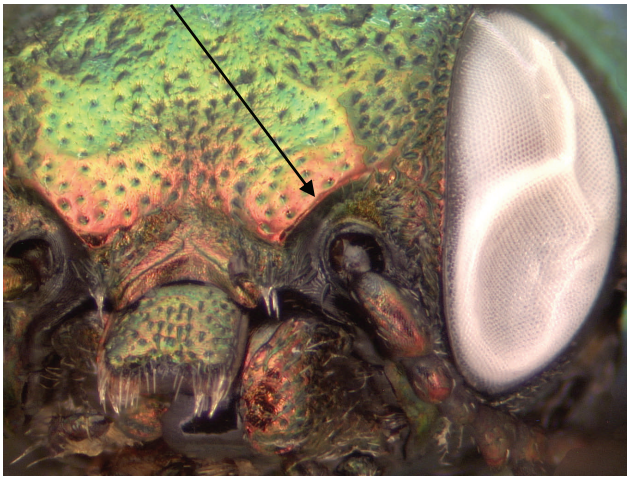
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42. Elytral interstrial punctation a) present, dense; b) present, sparse. 43. Elytral interstrial micropunctation a) present; b) absent.

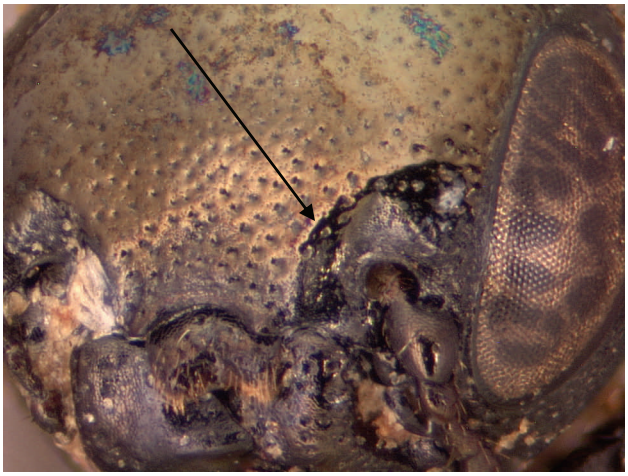


44. *S.* (*Chilostetha*) *substriata* elytral apex — elytral striae complete
45. *S.* (*Chrysoblemma*) *orichalcea* elytral apex — elytral striae obsolete

46



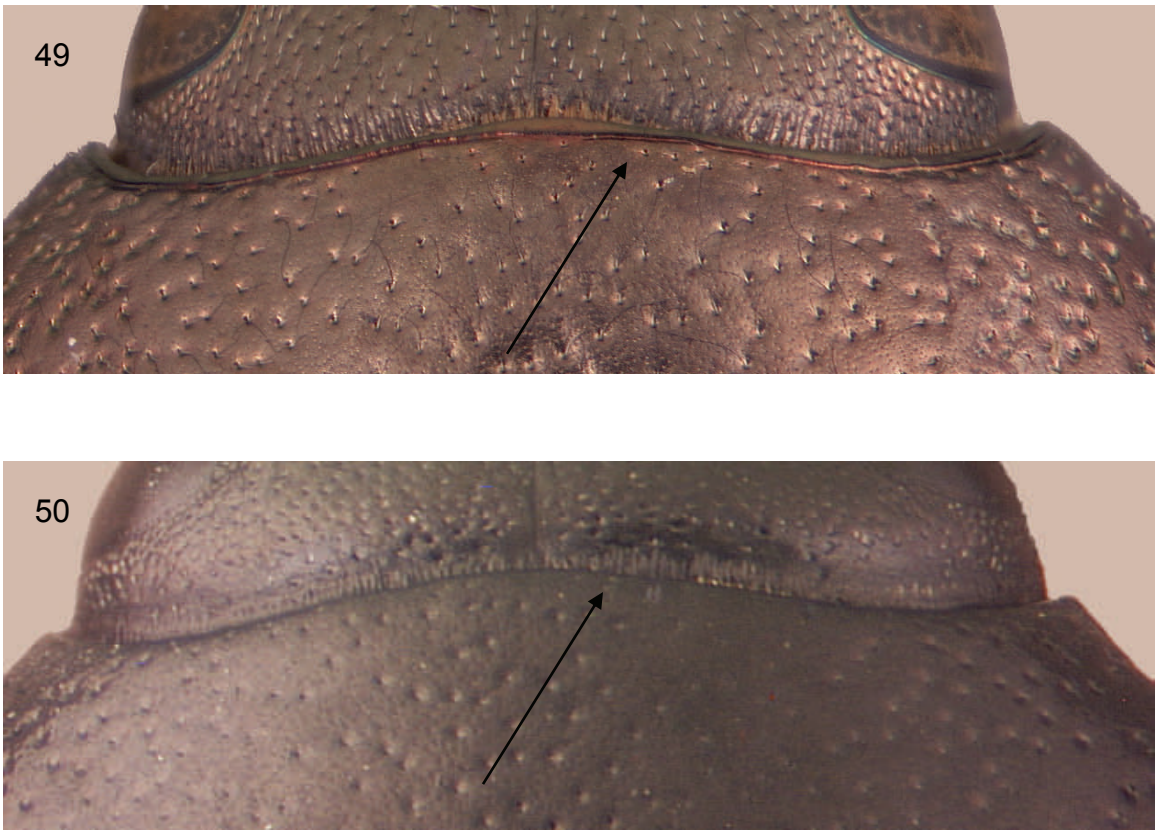
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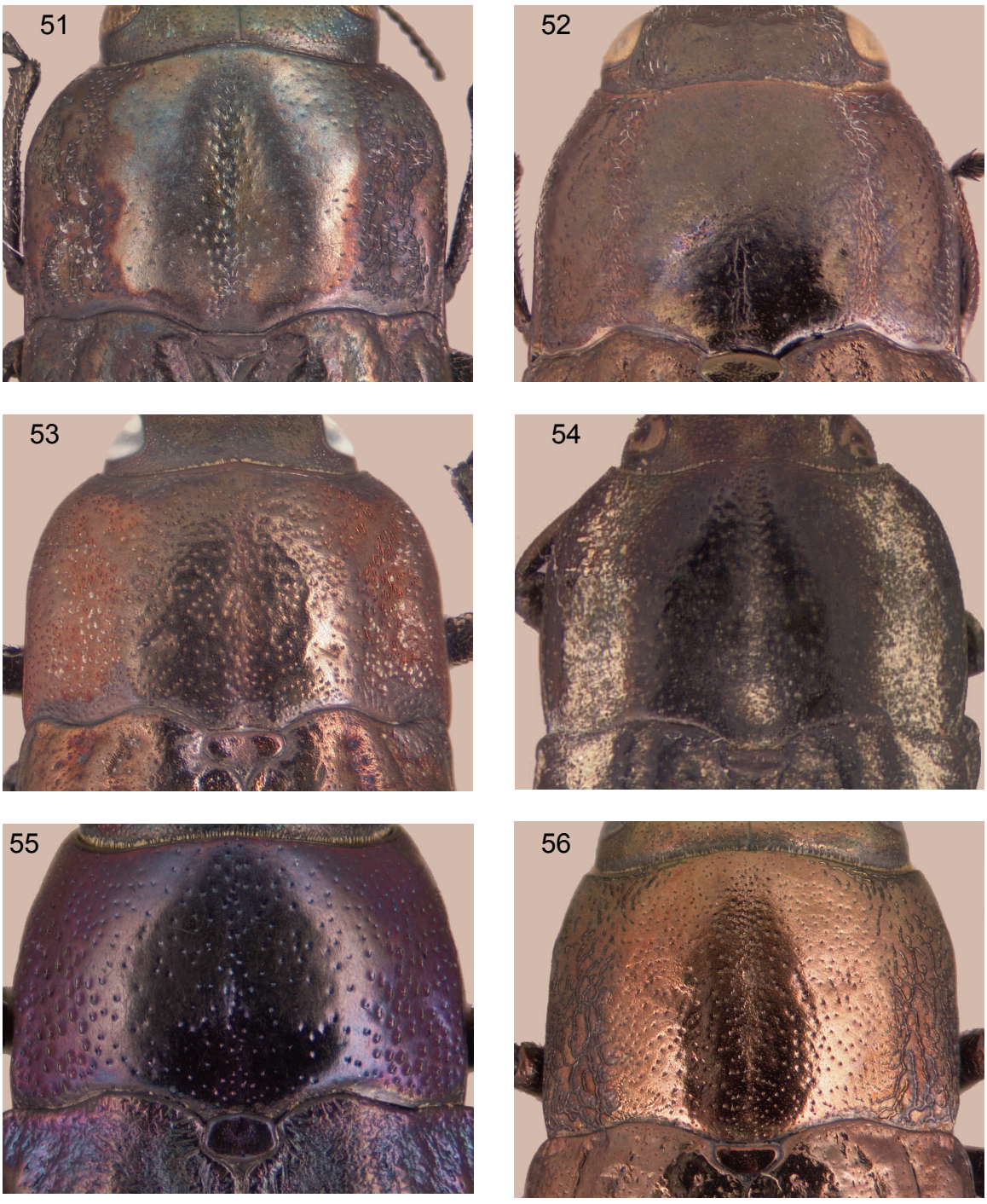
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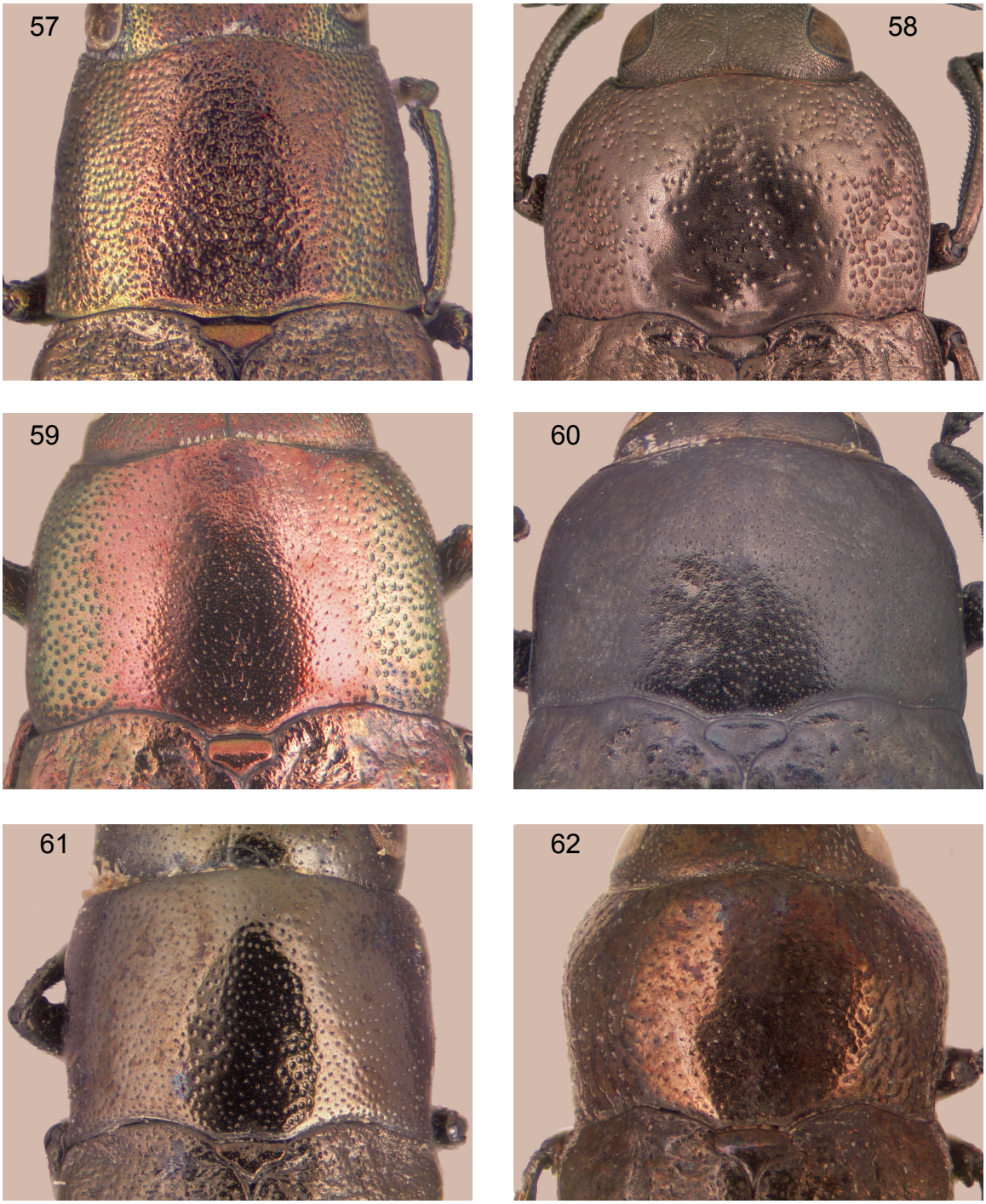
46. *S.* (*Chilostetha*) *scovitzii* antennal ridges. 47.*S.* (*Sphenopterella*) *margaritae* antennal ridges. 48. *S.* (*Chilostetha*) *pubescens* antennal ridges.



49.*S.* (*Sphenoptera*) *exarata* anterior margin of pronotum 50. *S.* (*Sphenoptera*) *foveola* anterior margin of pronotum.



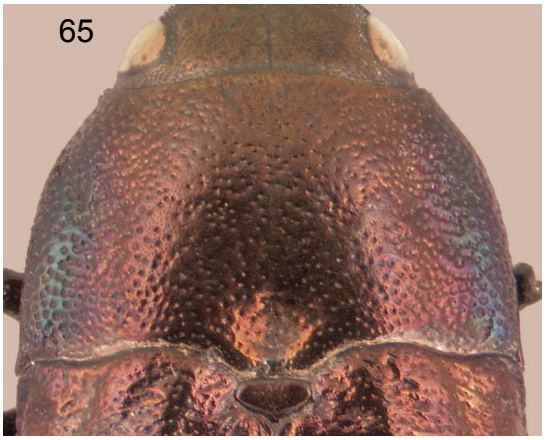
51. *S.* (*Sphenoptera*) *latesulcata* pronotum. 52. *S.* (*Deudora*) *gemmata* pronotum.
53. *S.* (*Sphenoptera*) *antiqua* pronotum. 54. *S.* (*Sphenoptera*) *canaliculata* pronotum.
55. *S.* (*Sphenoptera*) *chalybaea* pronotum. 56. *S.* (*Deudora*) *sculpticollis* pronotum.



57. *S.* (*Chilostetha*) *canescens* pronotum. 58. *S.* (*Sphenoptera*) *exarata* pronotum. 59. *S.* (*Chrysoblemma*) *orichalcea* pronotum. 60. *S.* (*Sphenoptera*) *tragacanthae* pronotum. 61. *S.* (*Sphenopterella*) *margaritae* pronotum. 62. *S.* (*Deudora*) *misella* pronotum.



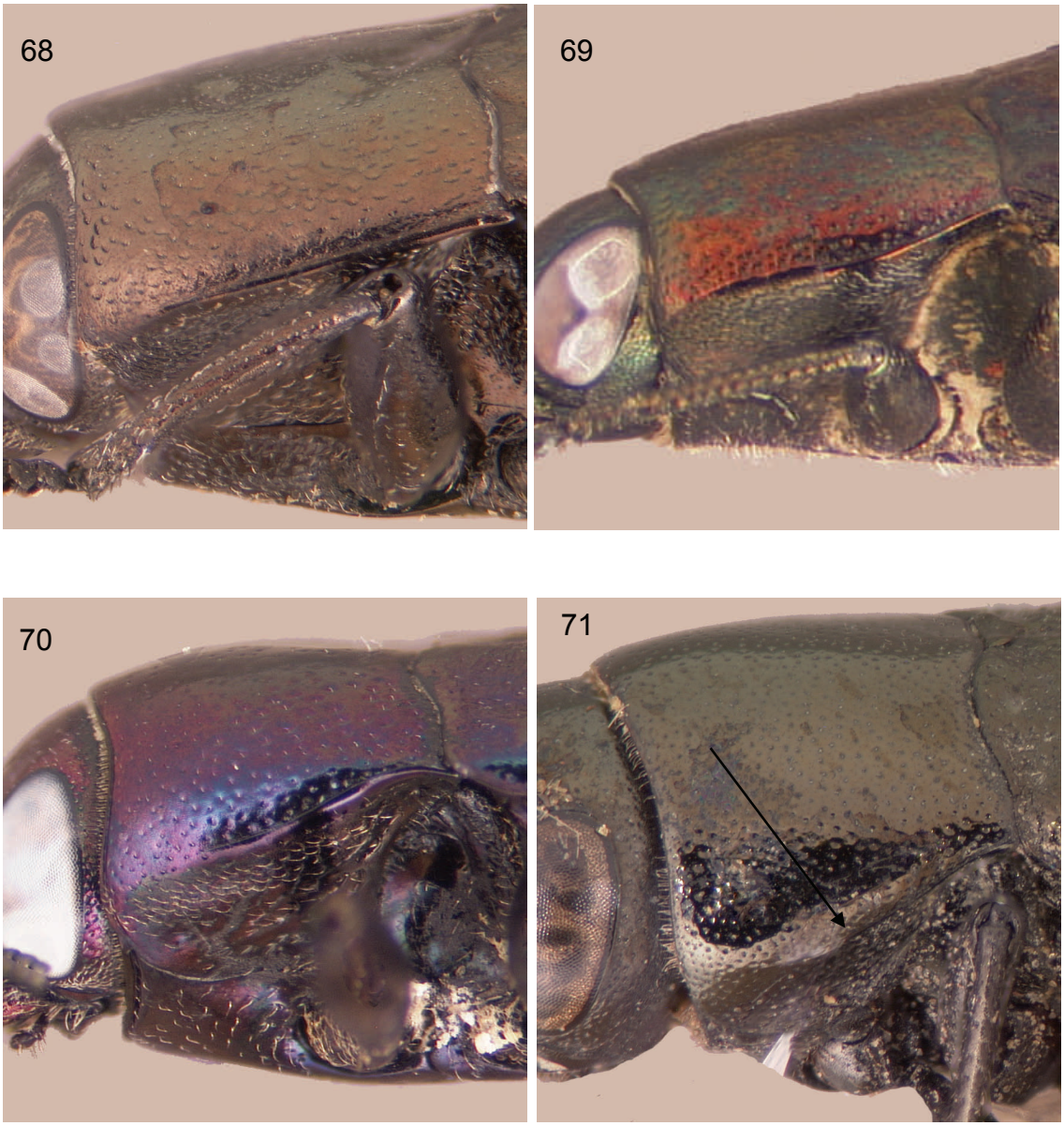




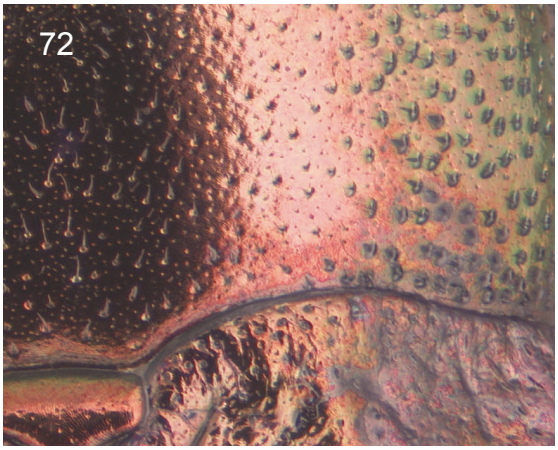


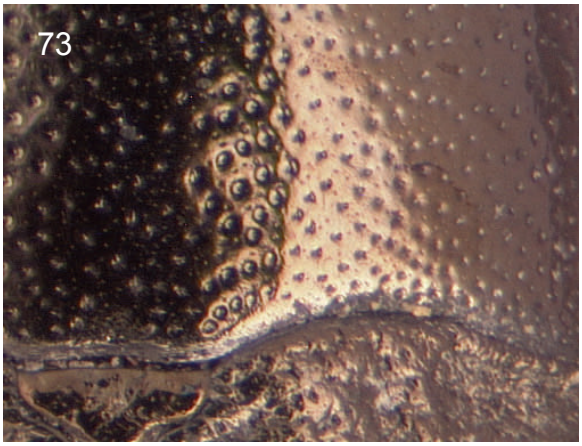


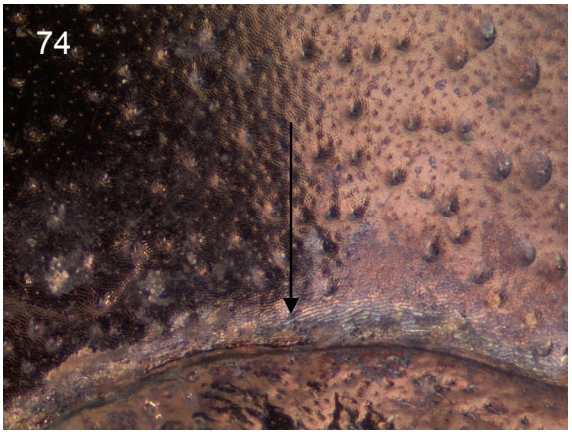
63. *S.* (*Sphenoptera*) *pharao* pronotum. 64. *S.* (*Sphenoptera*) *foveola* pronotum.
65. *S.* (*Sphenoptera*) *lateralis* pronotum. 66. *S.* (*Chrysoblemma*) *ignata* pronotum.
67. *S.* (*Chilostetha*) *canescens* pronotum.

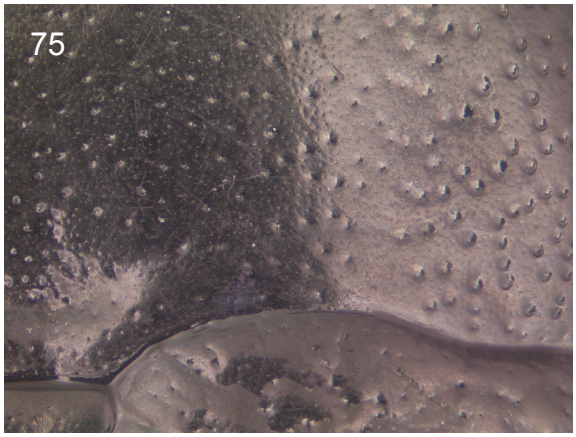


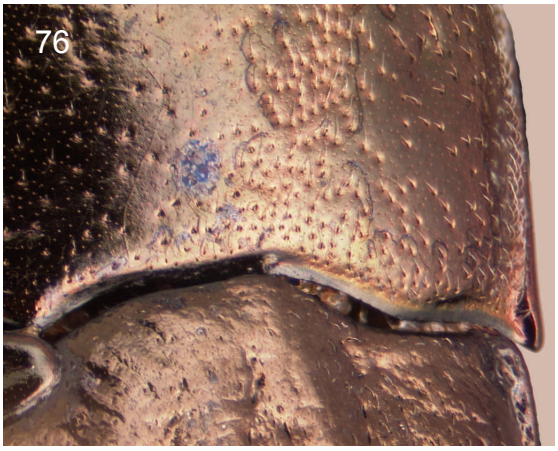
68. *S.* (*Deudora*) *micans* pronotum lateral view. 69. *S.* (*Hoplistura*) *mesopotamica* pronotum lateral view. 70. *S.* (*Sphenoptera*) *chalybaea* pronotum lateral view. 71. *S.* (*Sphenopterella*) *margaritae* pronotum lateral view.





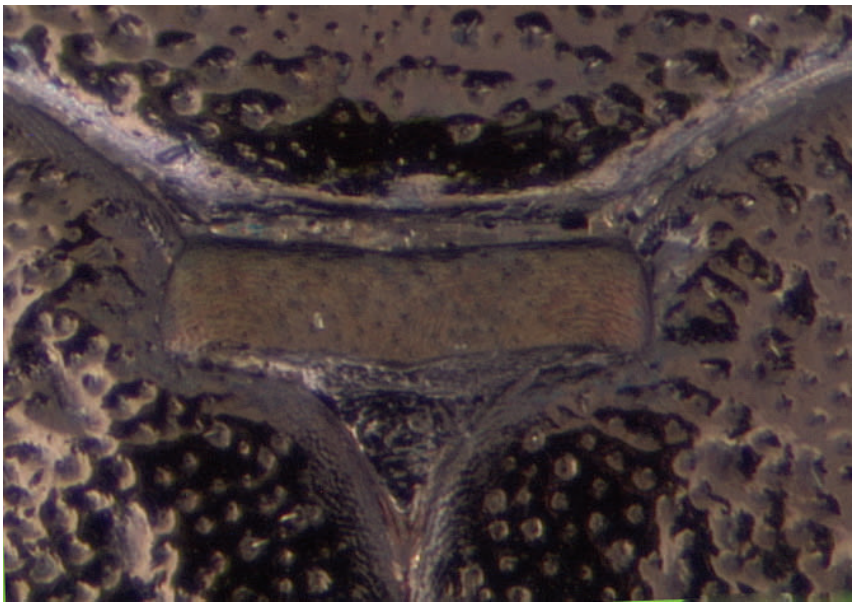




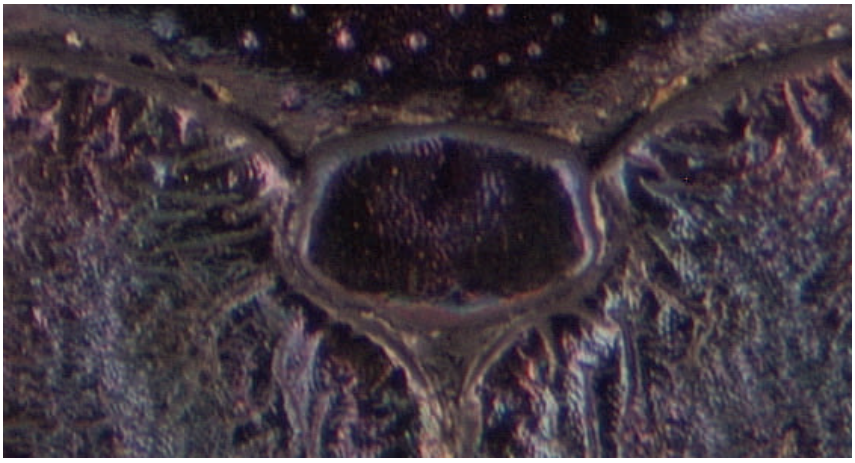


72. *S.* (*Chrysoblemma*) *orichalcea* pronotum. 73. *S.* (*Sphenopterella*) *margaritae* pronotum 74. *S.* (*Sphenoptera*) *magna* pronotum. 75. *S.* (*Sphenoptera*) *foveola* pronotum. 76. *S.* (*Deudora*) *rauca* pronotum.

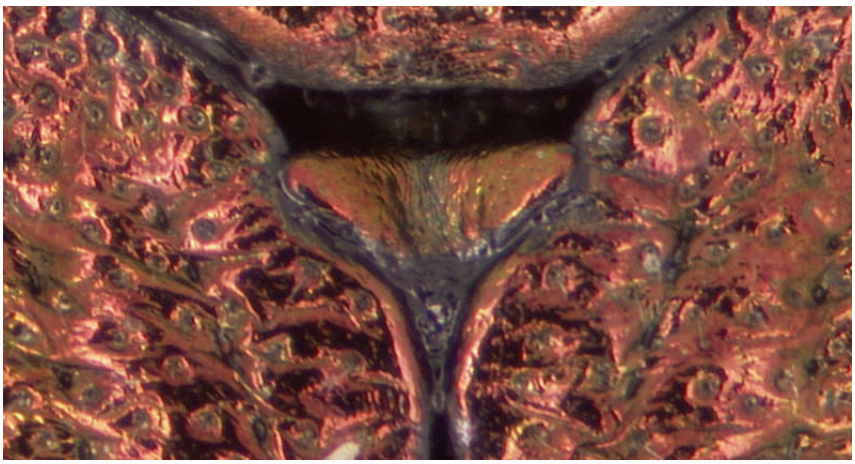
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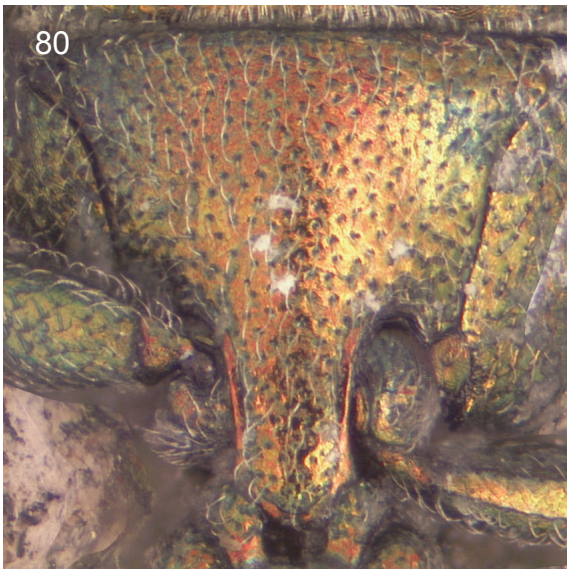
78



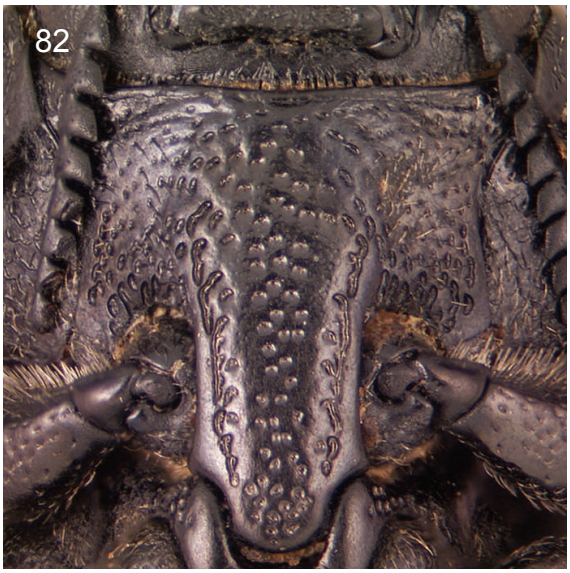
79

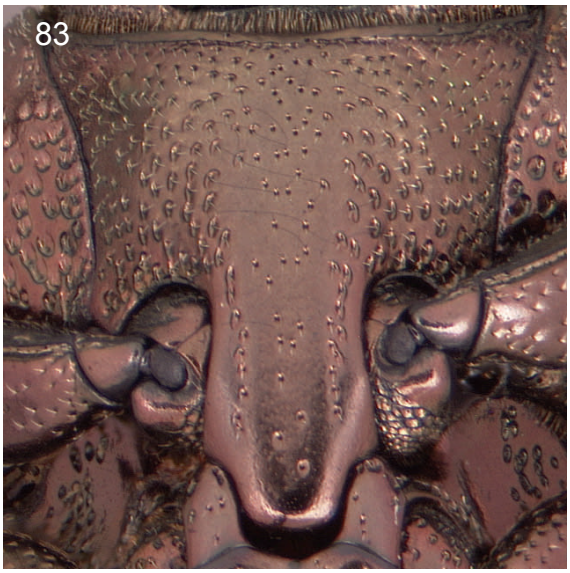


77. *S.* (*Tropeopeltis*) *tappesi* scutellum. 78. *S.* (*Sphenoptera*) *chalybaea* scutellum. 79. *S.* (*Chrysoblemma*) *punctatissima* scutellum.

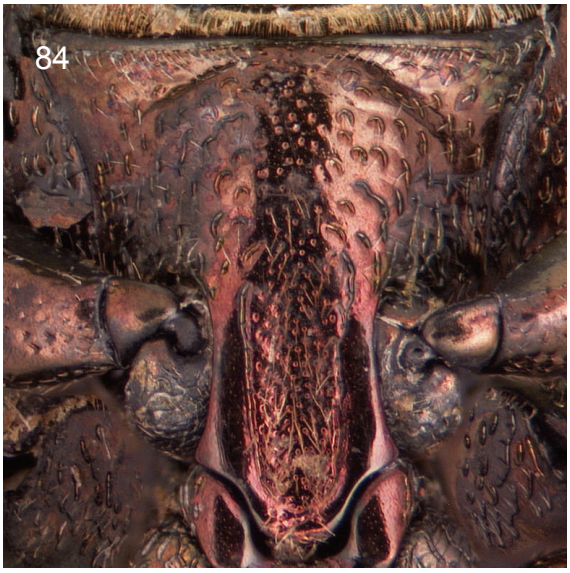


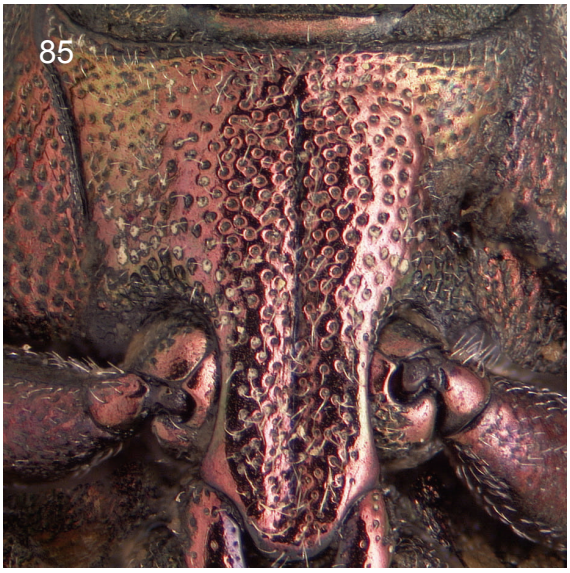


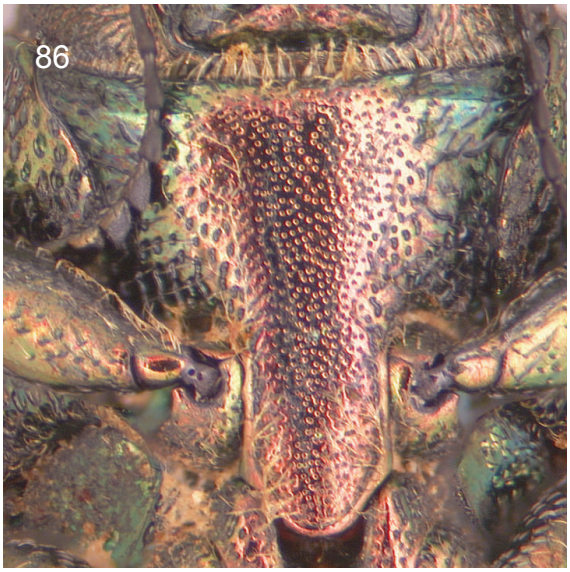




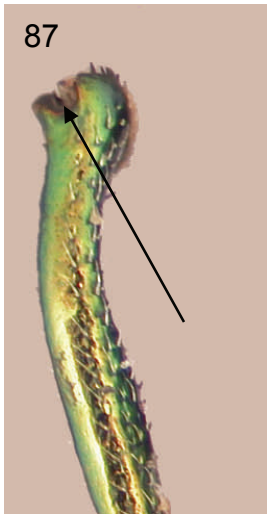
80. *S.* (*Chrysoblemma*) *viridaurea* prosternum. 81. *S.* (*Deudora*) *signata* prosternum. 82. *S.* (*Sphenoptera*) *pilipes* prosternum. 83. *S.* (*Sphenoptera*) *exarata* prosternum.





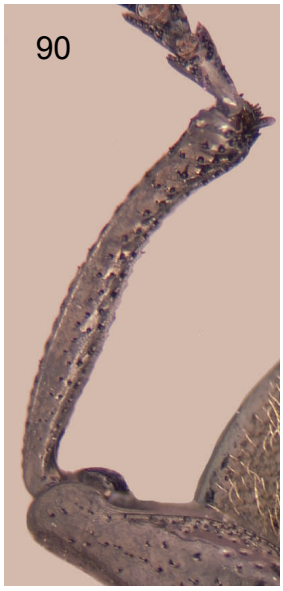


84. *S.* (*Deudora*) *sulciventris* prosternum. 85. *S.* (*Hoplistura*) *balassogloi* prosternum. 86. *S.* (*Chrysoblemma*) *orichalcea* prosternum.







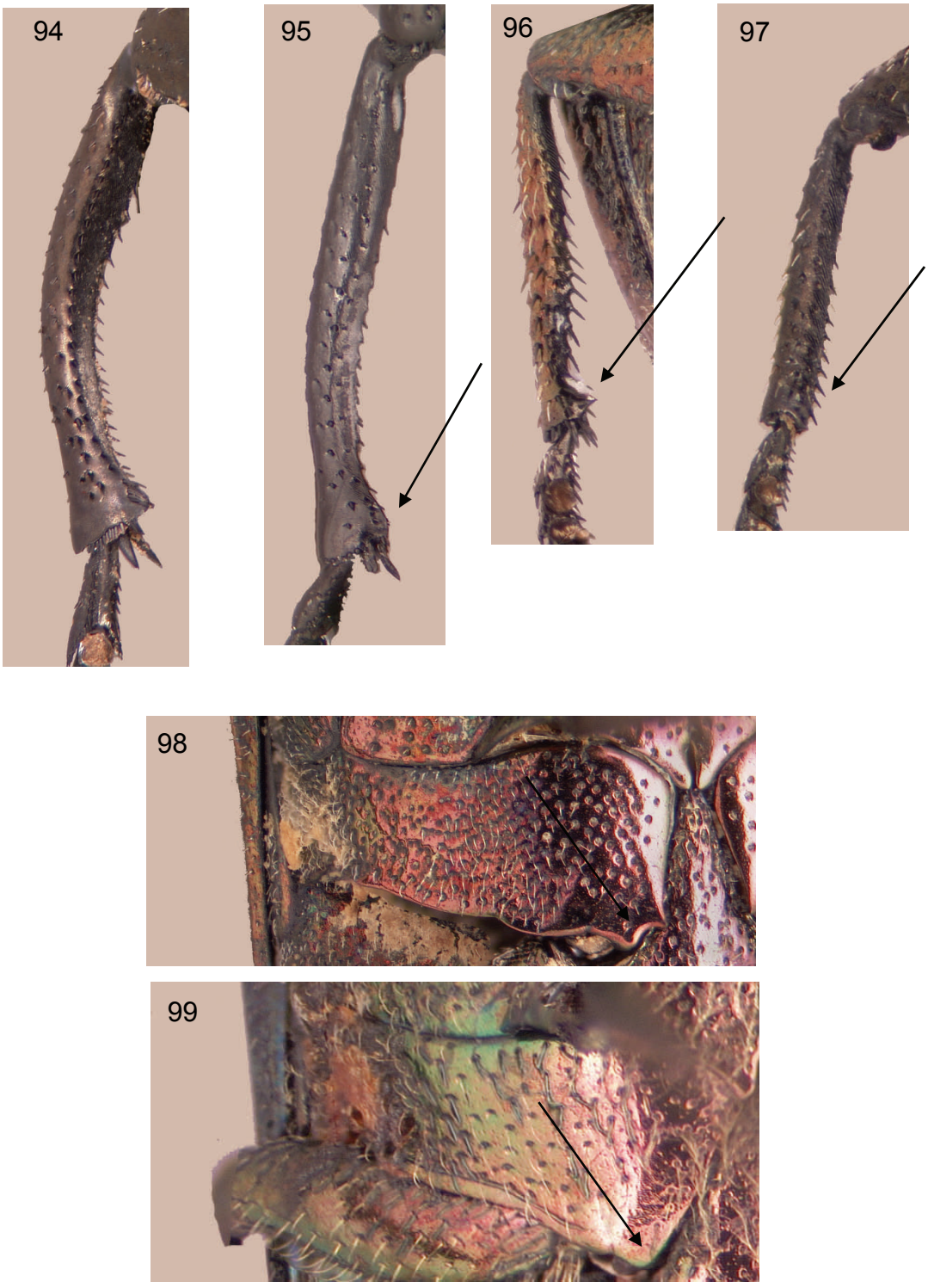




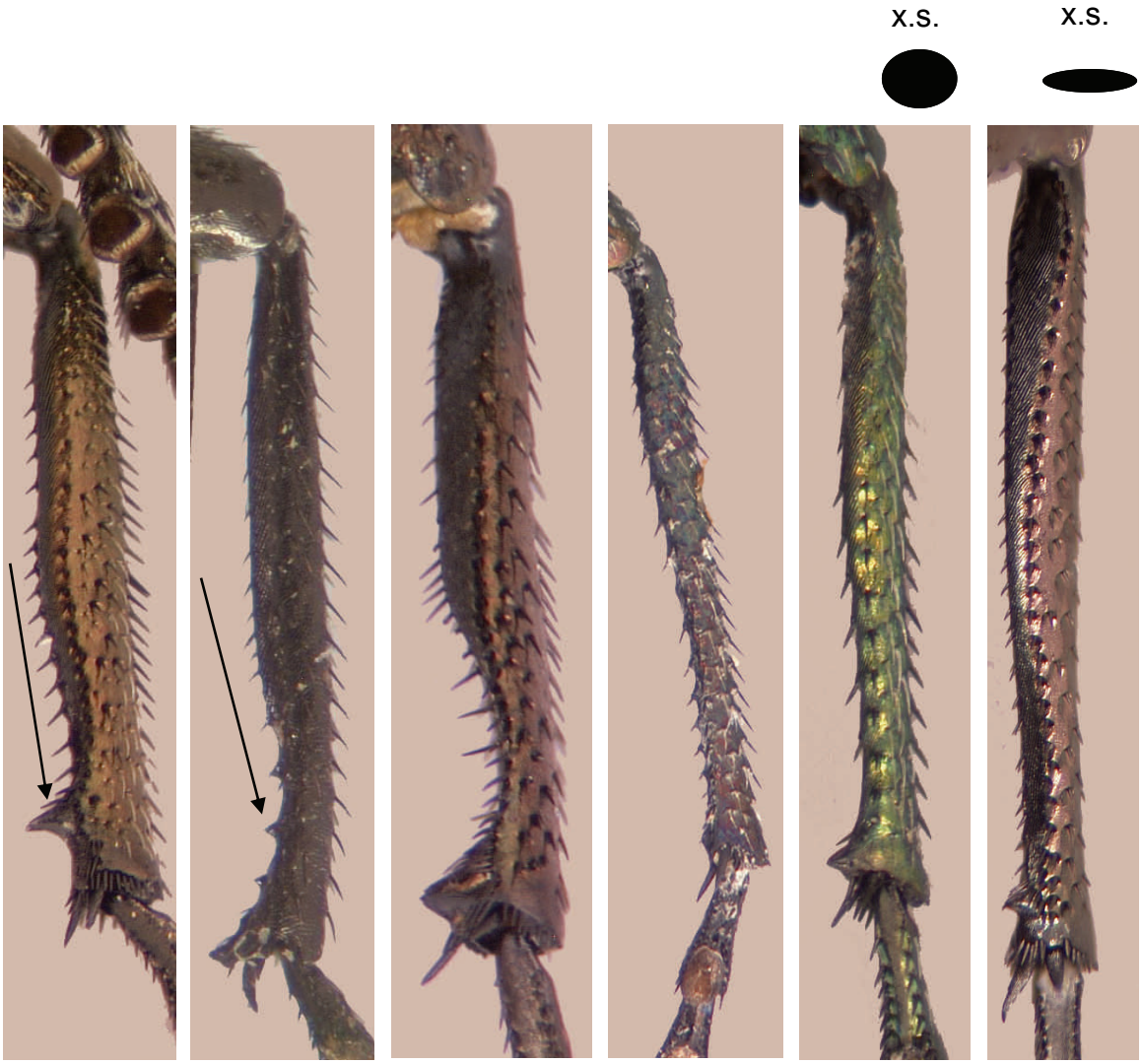




87. *S.* (*Chrysoblemma*) *ignata* protibia. 88. *S.* (*Chrysoblemma*) *tamarisci* protibia.
89. *S.* (*Sphenoptera*) *magna* protibia. 90. *S.* (*Sphenoptera*) *pilipes* protibia.
91. *S.* (*Deudora*) *signata* protibia 92. *S.* (*Hoplistura*) *balassogloi* protibia.
93. *S.* (*Sphenoptera*) *foveola* protibia.



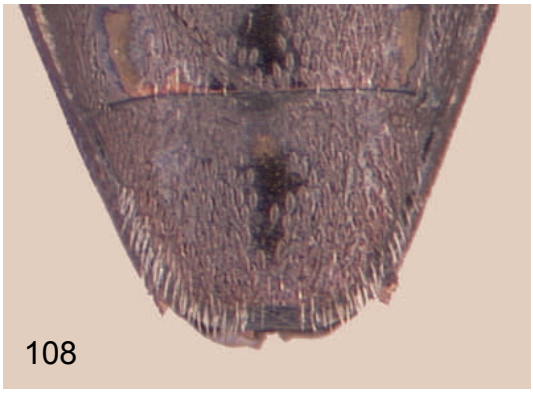
94. *S.* (*Sphenoptera*) *magna* mesotibia. 95. *S.* (*Sphenoptera*) *foveola* mesotibia.
96. *S.* (*Deudora*) *signata* mesotibia. 97. *S.* (*Deudora*) *smyrneensis* mesotibia.
98. *S.* (*Hoplistura*) *balassogloi* metacoxa. 99. *S.* (*Chrysoblemma*) *orichalcea* metacoxa.

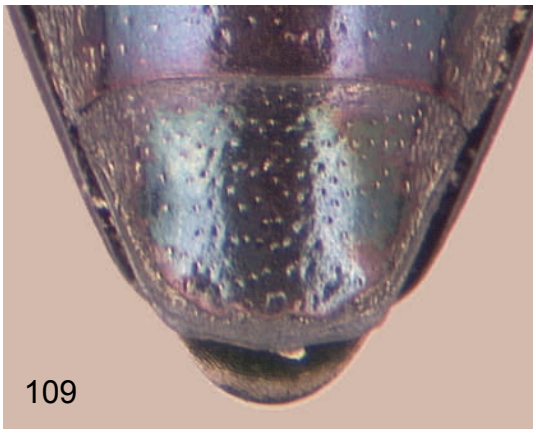


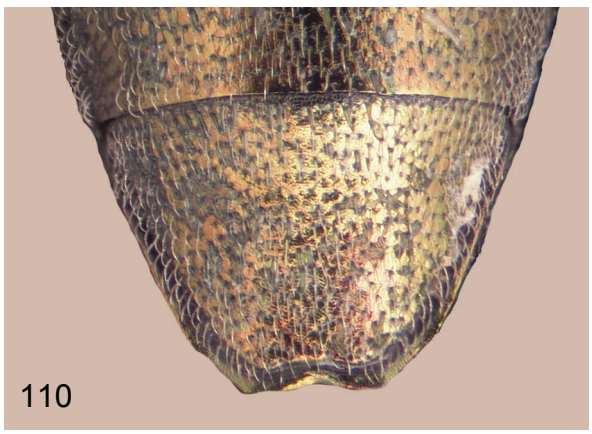
100. *S.* (*Deudora*) *rauca* metatibia. 101. *S.* (*Tropeopeltis*) *tappesi* metatibia.
102. *S.* (*Deudora*) *sulciventris* metatibia. 103. *S.* (*Hoplistura*) *mesopotamica* metatibia.
104. *S.* (*Chrysoblemma*) *artemisae* metatibia. 105. *S.* (*Sphenoptera*) *exarata* metatibia.











106. *S.* (*Deudora*) *gemmata* abdomen ventral view. 107. *S.* (*Sphenoptera*) *sulcata* abdomen ventral view. 108. *S.* (*Deudora*) *gemmata* apical abdominal ventrite, male. 109. *S.* (*Sphenoptera*) *cuprina* apical abdominal ventrite, male. 110. *S.* (*Chilostetha*) *canescens* apical abdominal ventrite, male.









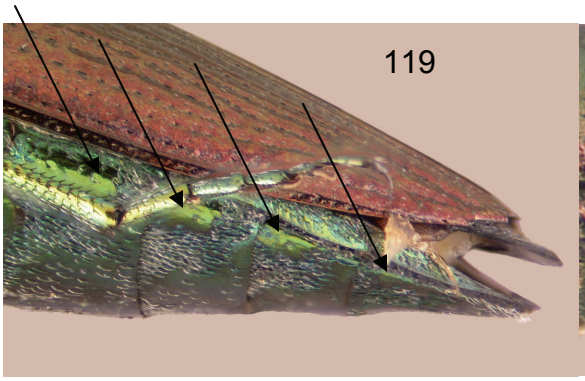


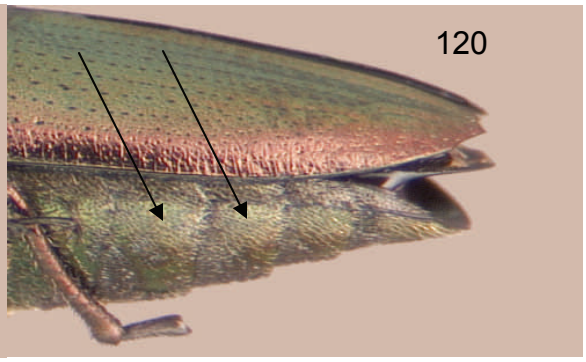


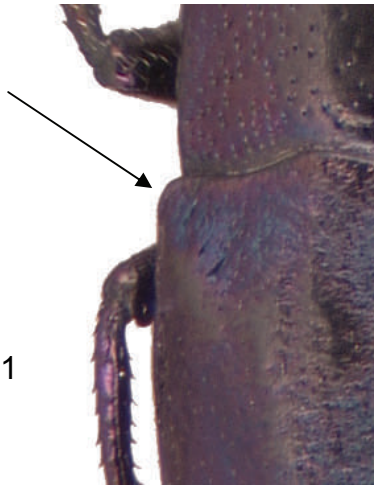
111. *S.* (*Hoplistura*) *balassogloi* elytral apex. 112. *S.* (*Sphenoptera*) *cuprina* elytral apex. 113. *S.* (*Sphenoptera*) *extensocarinata* elytral apex.
114. *S.* (*Deudora*) *vittaticollis* elytral apex. 115. *S.* (*Chilostetha*) *viridaurea* elytral apex.
116. *S.* (*Sphenoptera*) *puberula* abdominal apex, male.







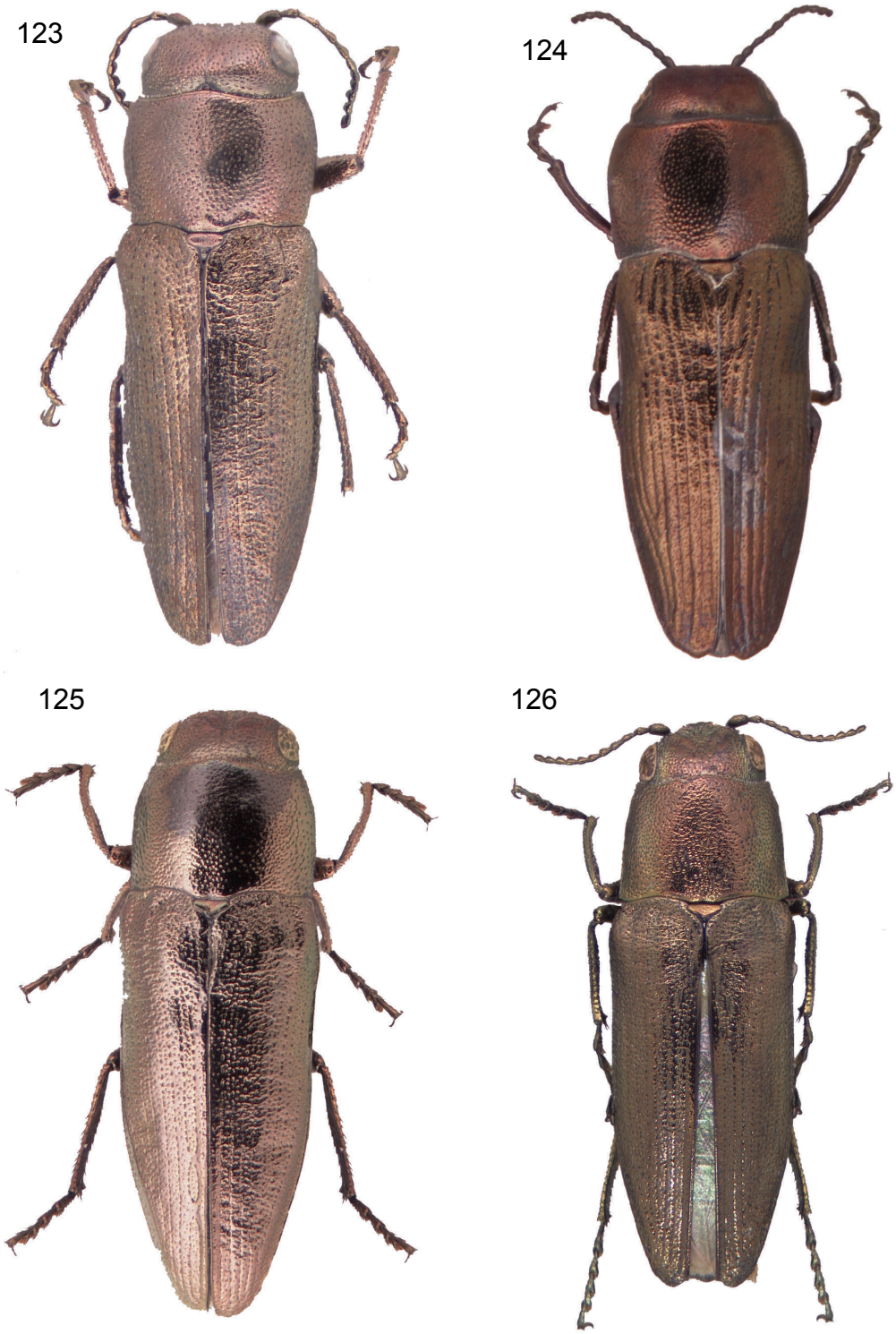




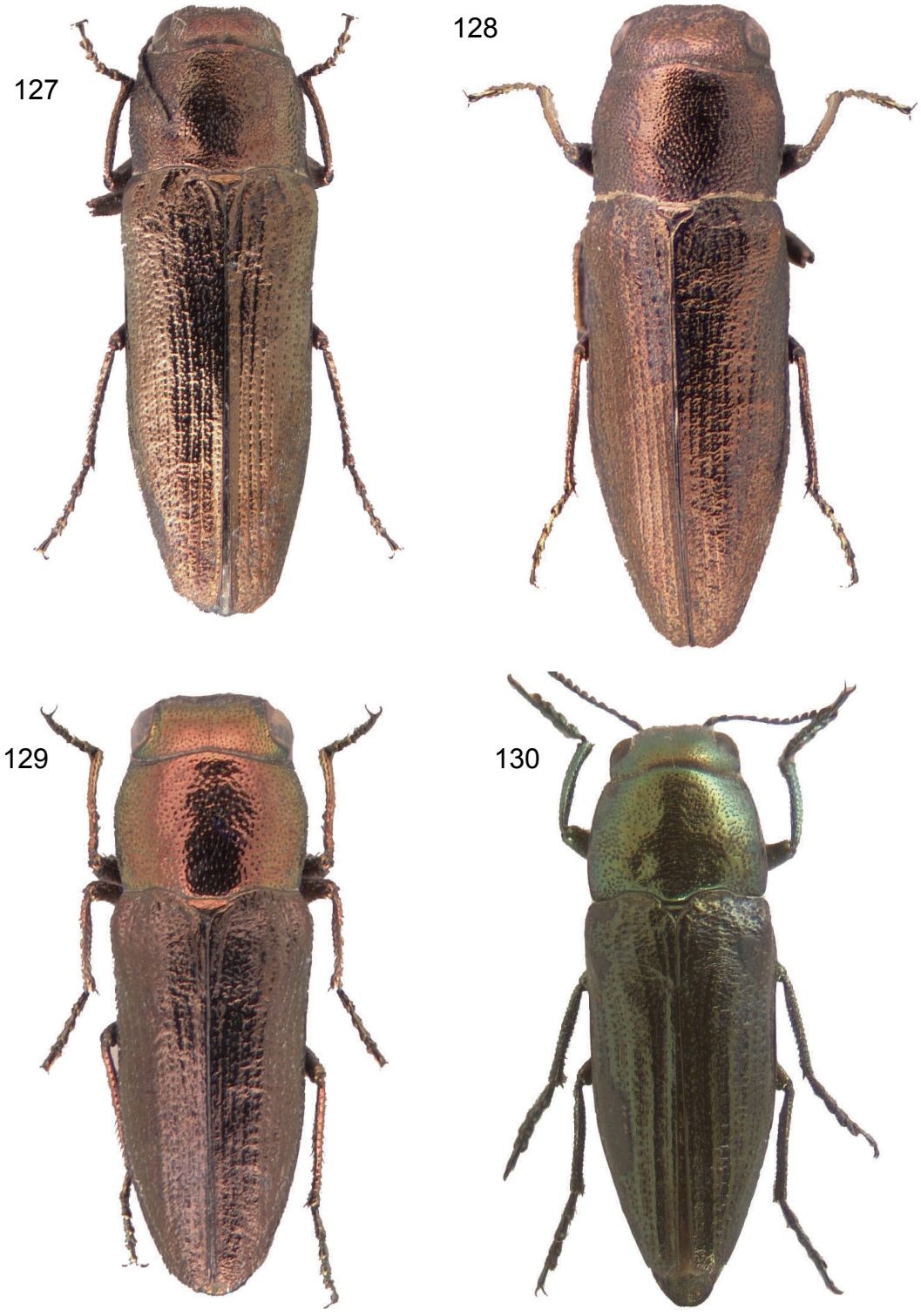




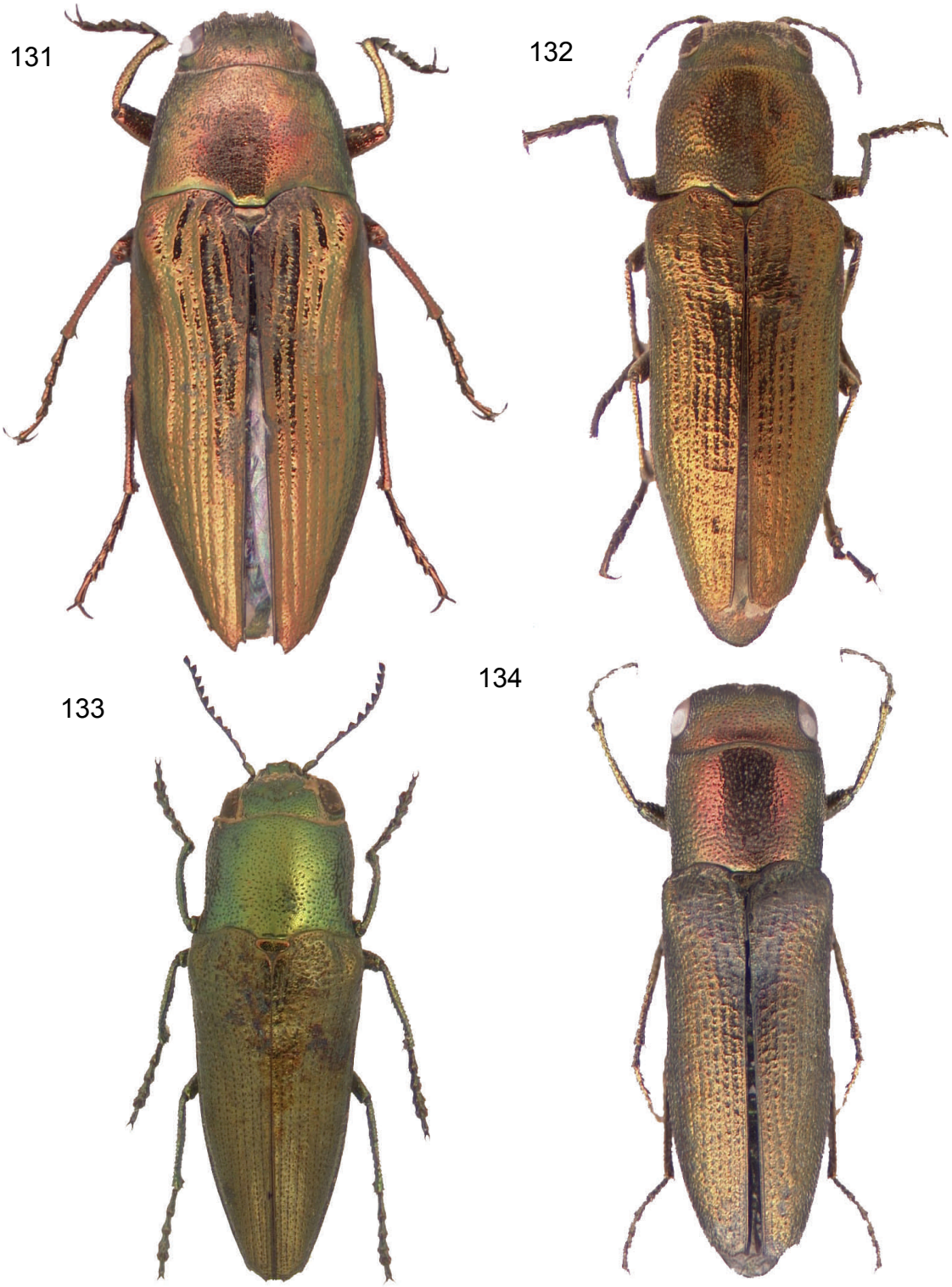
117. *S.* (*Sphenoptera*) *exarata* elytral apices. 118. *S.* (*Sphenoptera*) *latesulcata* elytral apices. 119. *S.* (*Chrysoblemma*) *ignita* abdomen, lateral view. 120. *S.* (*Chrysoblemma*) *orichalcea* abdomen, lateral view. 121. *S.* (*Sphenoptera*) *chalybaea* elytral humerus. 122. *S.* (*Sphenoptera*) *extensocarinata* elytron. 123. *S.* (*Sphenoptera*) *laticeps* elytron.



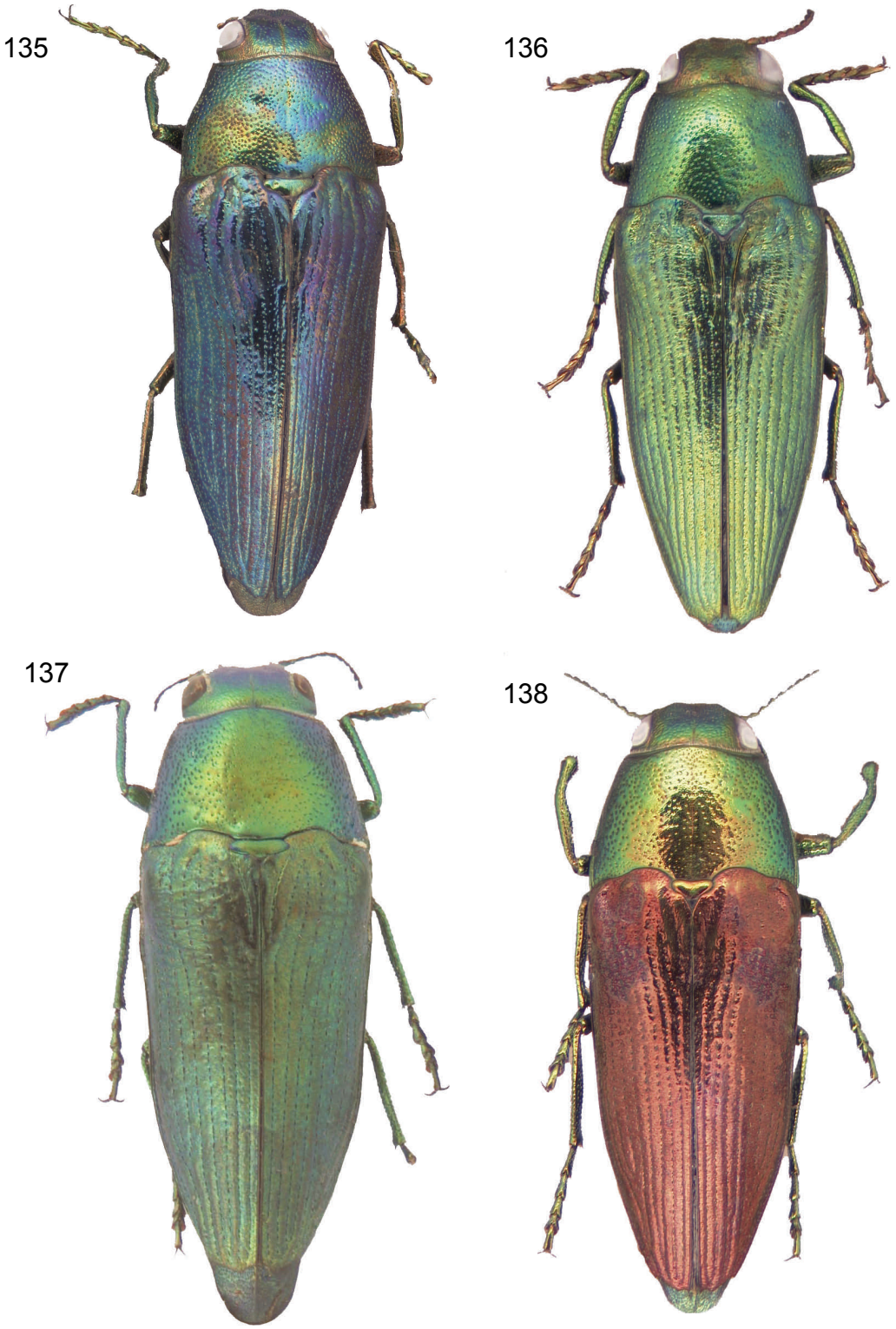
123. *S.* (*Chilostetha*) *cauta* dorsal habitus. 124. *S.* (*Chilostetha*) *substriata* dorsal habitus. 125. *S.* (*Chilostetha*) *basalis* dorsal habitus. 126. *S.* (*Chilostetha*) *canescens* dorsal habitus.



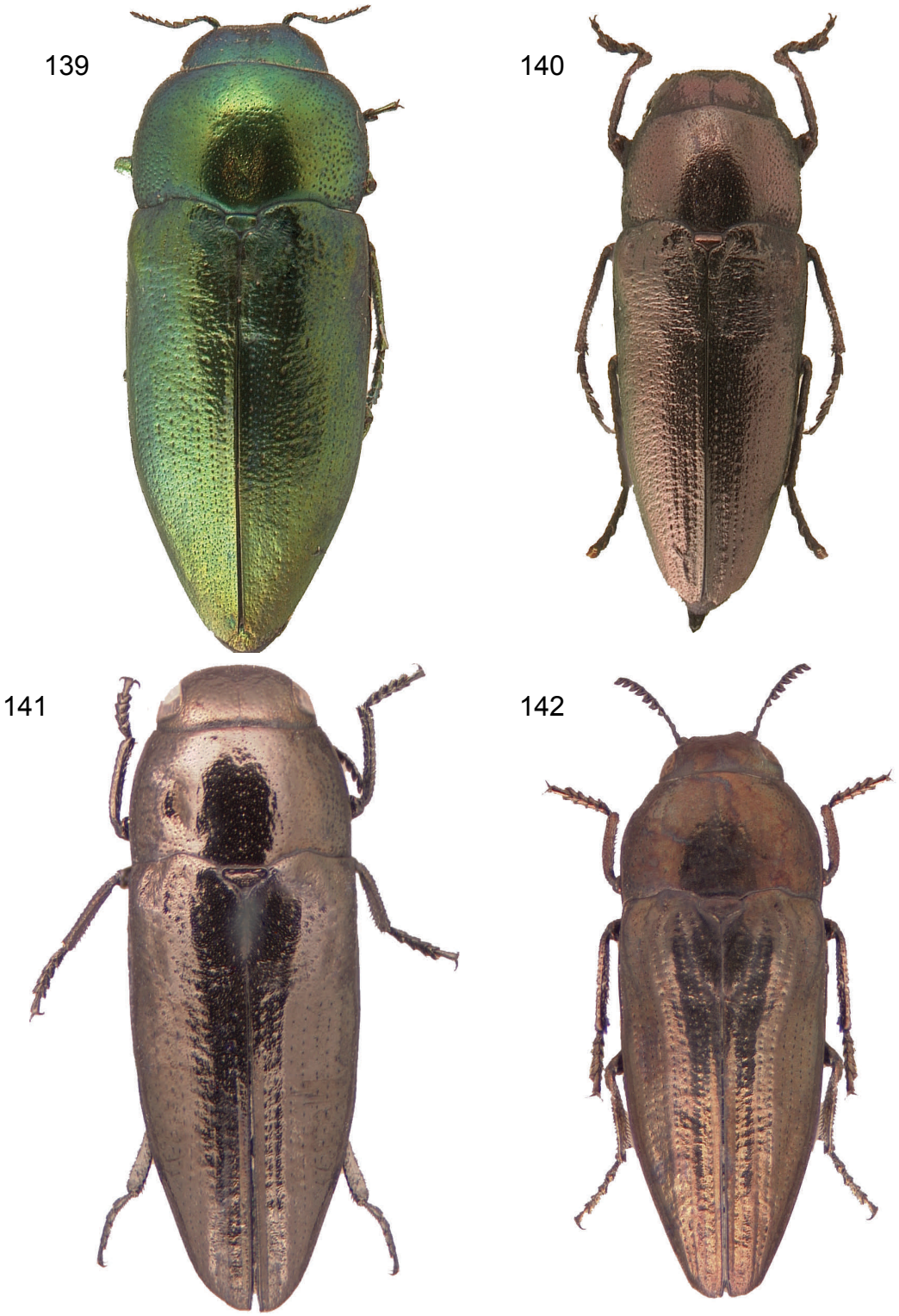
127. *S*. (*Chilostetha*) *densesculpta* dorsal habitus. 128. *S*. (*Chilostetha*) *insidiosa* dorsal habitus. 129. *S*. (*Chilostetha*) *puberula* dorsal habitus. 130. *S*. (*Chrysoblemma*) *sancta* dorsal habitus.



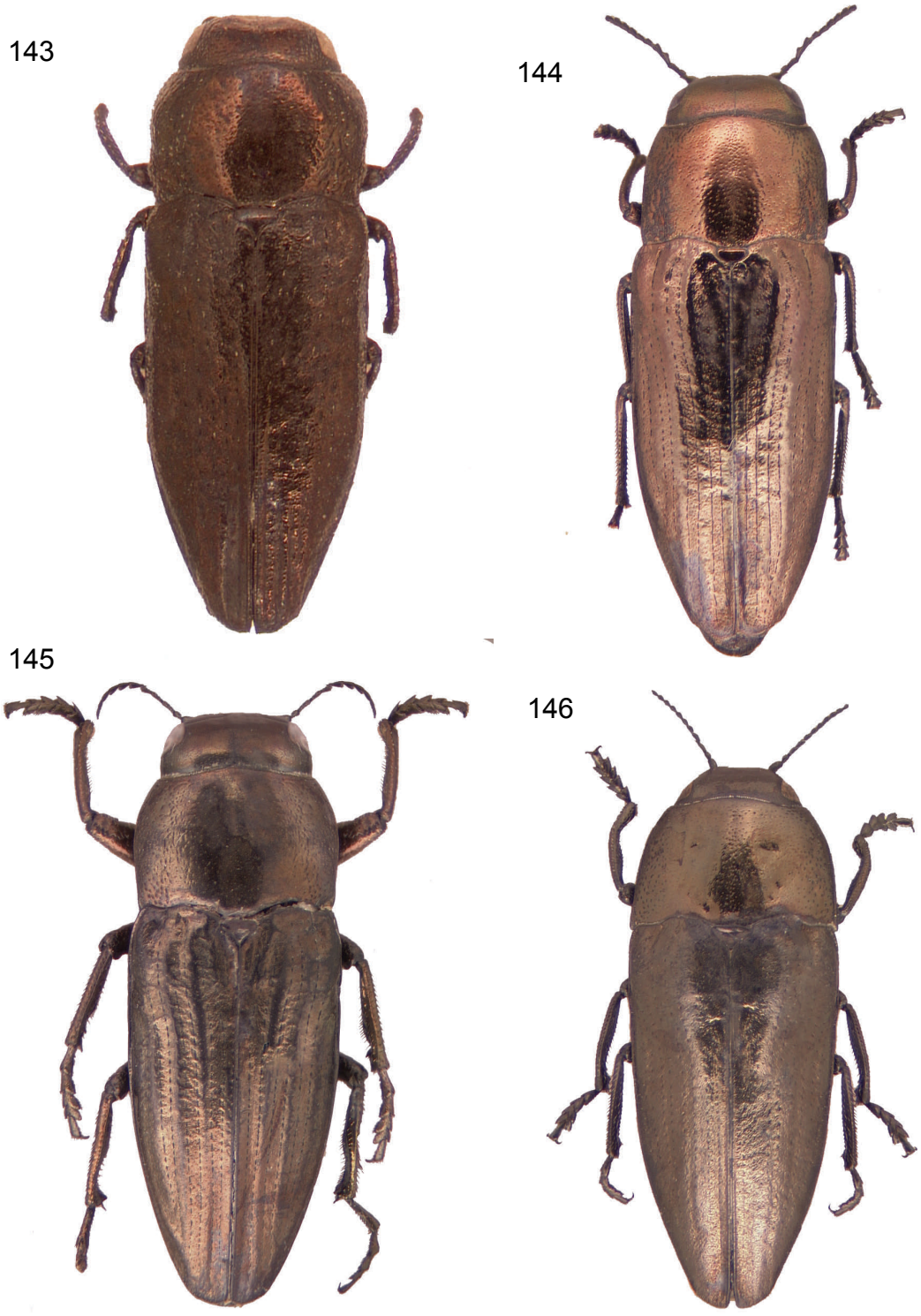
131. *S*. (*Chrysoblemma*) *hauseri* dorsal habitus. 132. *S*. (*Chrysoblemma*) *punctatissima* dorsal habitus. 133. *S*. (*Chrysoblemma*) *artemisiae* dorsal habitus.
134. *S*. (*Chrysoblemma*) *viridaurea* dorsal habitus.



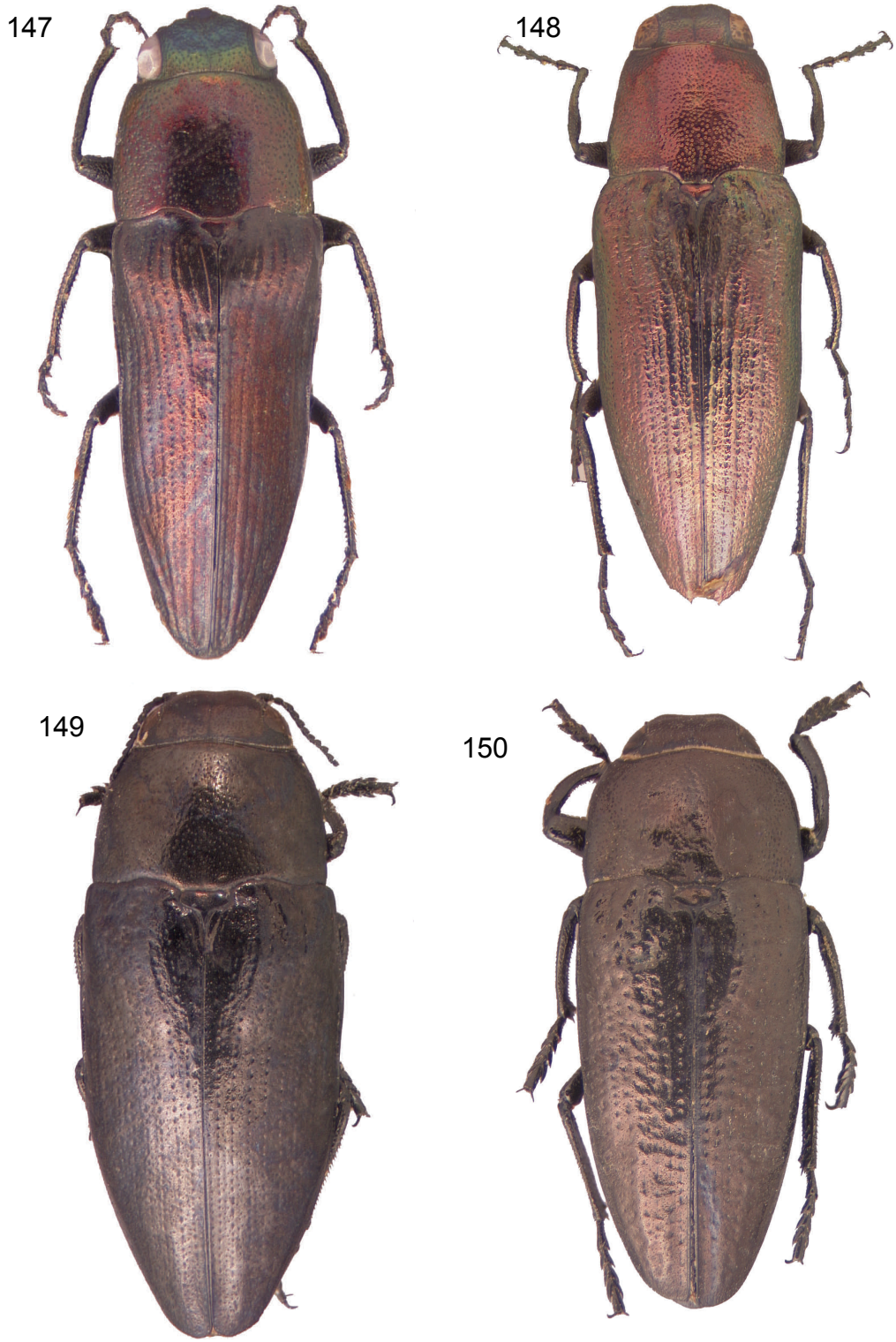
135. *S*. (*Chrysoblemma*) *striatipennis* dorsal habitus.136. *S*. (*Chrysoblemma*) *tamarisci beckeri* dorsal habitus. 137. *S*. (*Chrysoblemma*) *scovitzii* dorsal habitus.
138. *S*. (*Chrysoblemma*) *ignita* dorsal habitus.



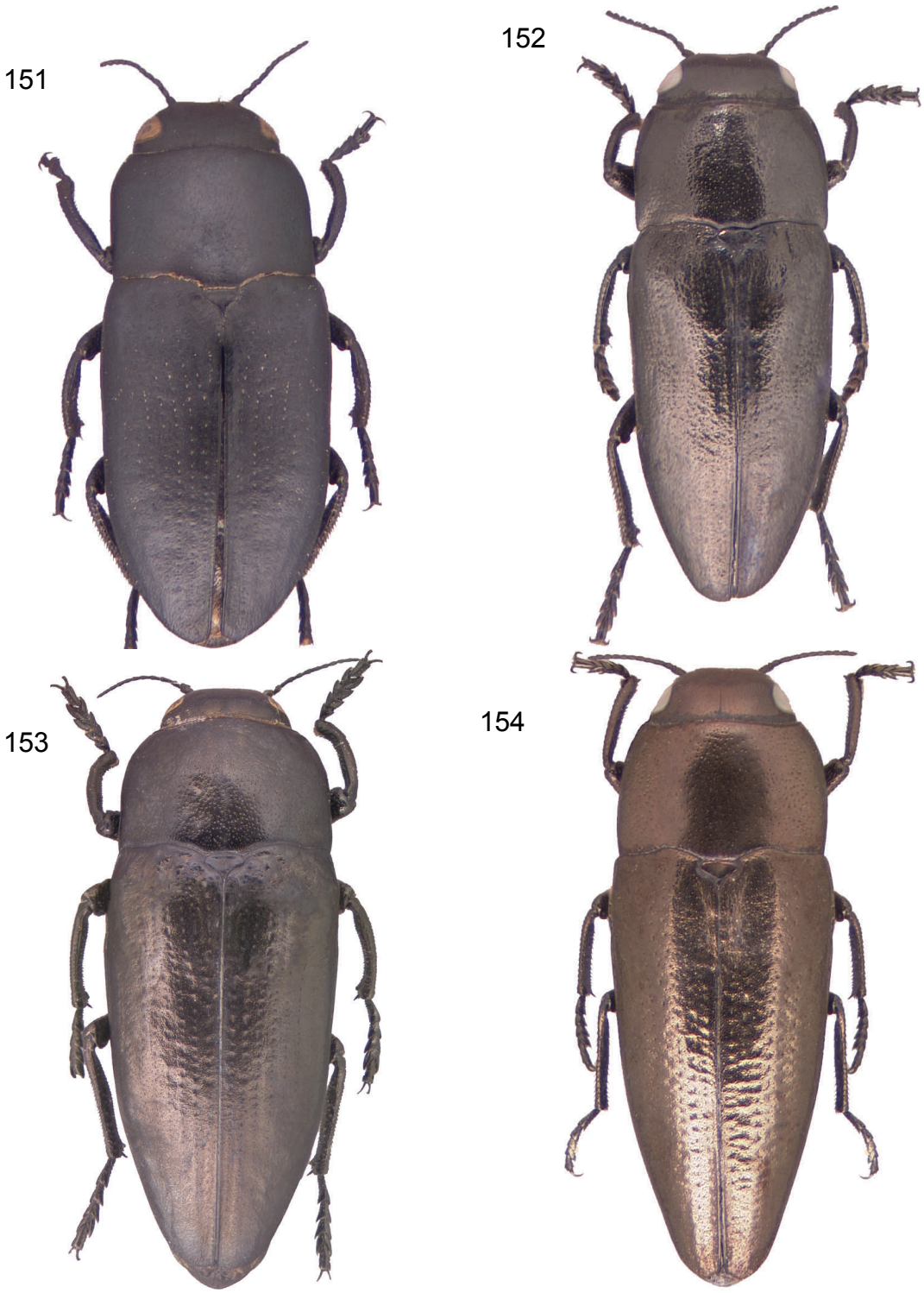
139. *S*. (*Chrysoblemma*) *orichalcea* dorsal habitus. 140. *S*. (*Chrysoblemma*) *orichalcea* dorsal habitus. 141. *S*. (*Deudora*) *smyrneensis* dorsal habitus. 142. *S*. (*Deudora*) *aeneomicans* dorsal habitus.



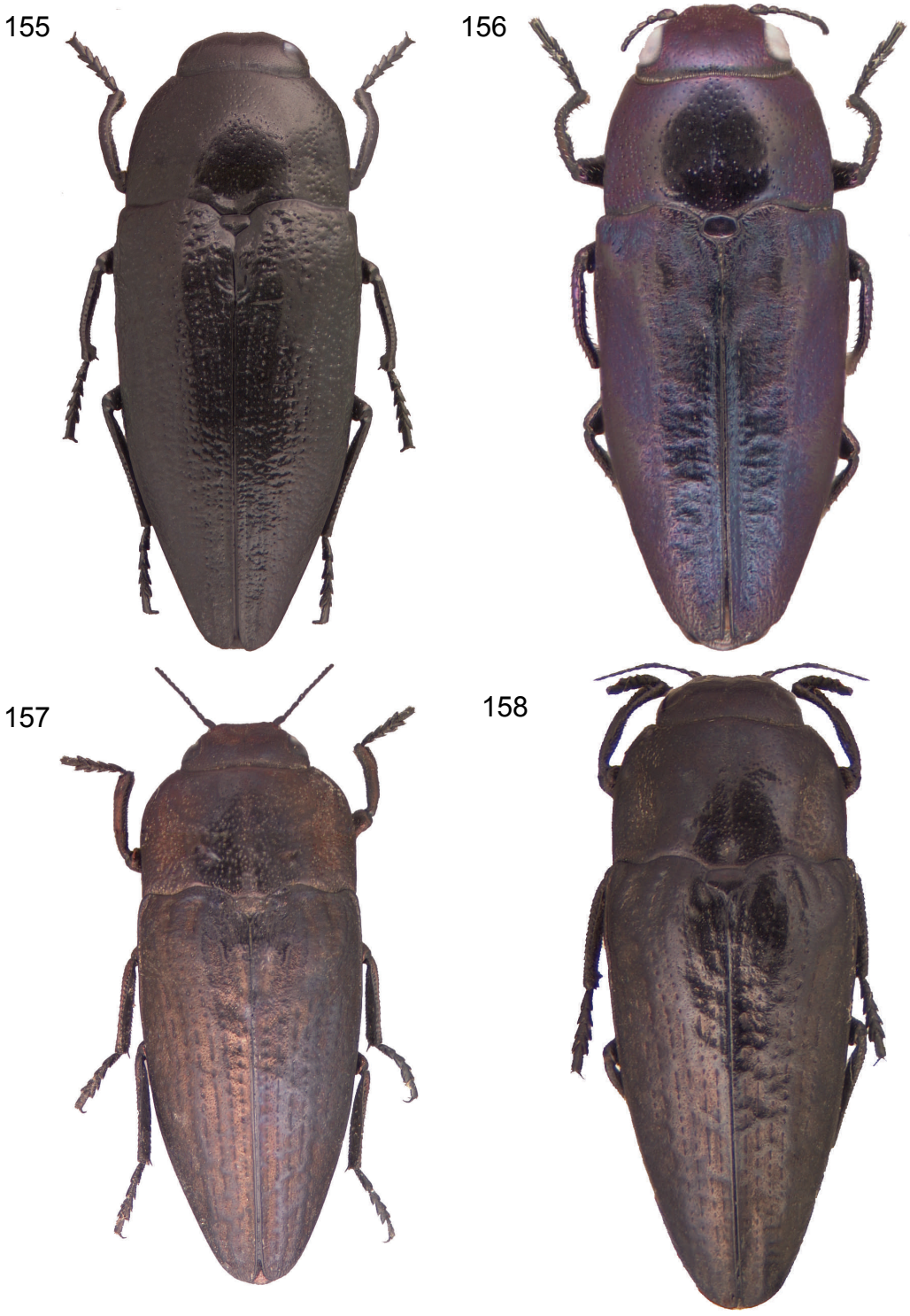
143. *S*. (*Deudora*) *misella* dorsal habitus. 144. *S*. (*Deudora*) *sculpticollis* dorsal habitus. 145. *S*. (*Deudora*) *sulciventris* dorsal habitus. 146. *S*. (*Deudora*) *micans* dorsal habitus.



147. *S*. (*Hoplistura*) *mesopotamica* dorsal habitus. 148. *S*. (*Hoplistura*) *balassogloi* dorsal habitus. 149. *S*. (*Sphenoptera*) *anthracina* dorsal habitus. 150. *S*. (*Sphenoptera*) *coracina* dorsal habitus.



151. *S*. (*Sphenoptera*) *eugenii* dorsal habitus. 152. *S*. (*Sphenoptera*) *oporina* dorsal habitus. 153. *S*. (*Sphenoptera*) *tragacanthae* dorsal habitus. 154. *S*. (*Sphenoptera*) *hypocrita* dorsal habitus.



155. *S*. (*Sphenoptera*) *foveola* dorsal habitus. 156. *S*. (*Sphenoptera*) *chalybaea* dorsal habitus. 157. *S*. (*Sphenoptera*) *antiqua* dorsal habitus. 158. *S*. (*Sphenoptera*) *rugulosa* dorsal habitus.

159



160



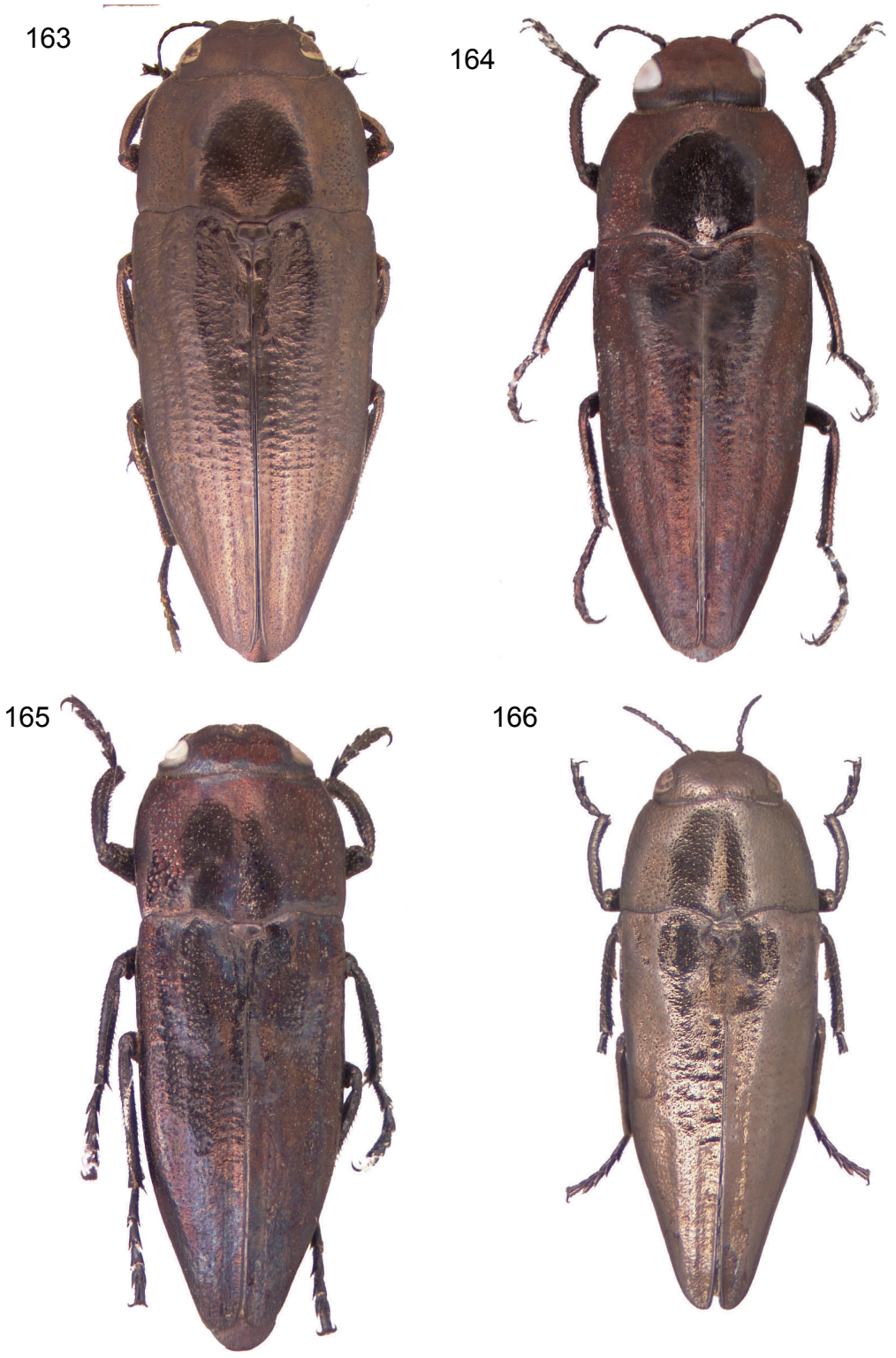
161



162



159. *S.* (*Sphenoptera*) *fallatrix* dorsal habitus. 160. *S.* (*Sphenoptera*) *latesulcata* dorsal habitus. 161. *S.* (*Sphenoptera*) *cuprina* dorsal habitus. 162. *S.* (*Sphenoptera*) *pligshinskii* dorsal habitus.



163. *S.* (*Sphenoptera*) *manderstjernae* dorsal habitus. 164. *S.* (*Sphenoptera*) *repetekensis* dorsal habitus. 165. *S.* (*Sphenoptera*) *laticeps* dorsal habitus. 166. *S.* (*Sphenoptera*) *sulcata* dorsal habitus.

167



168



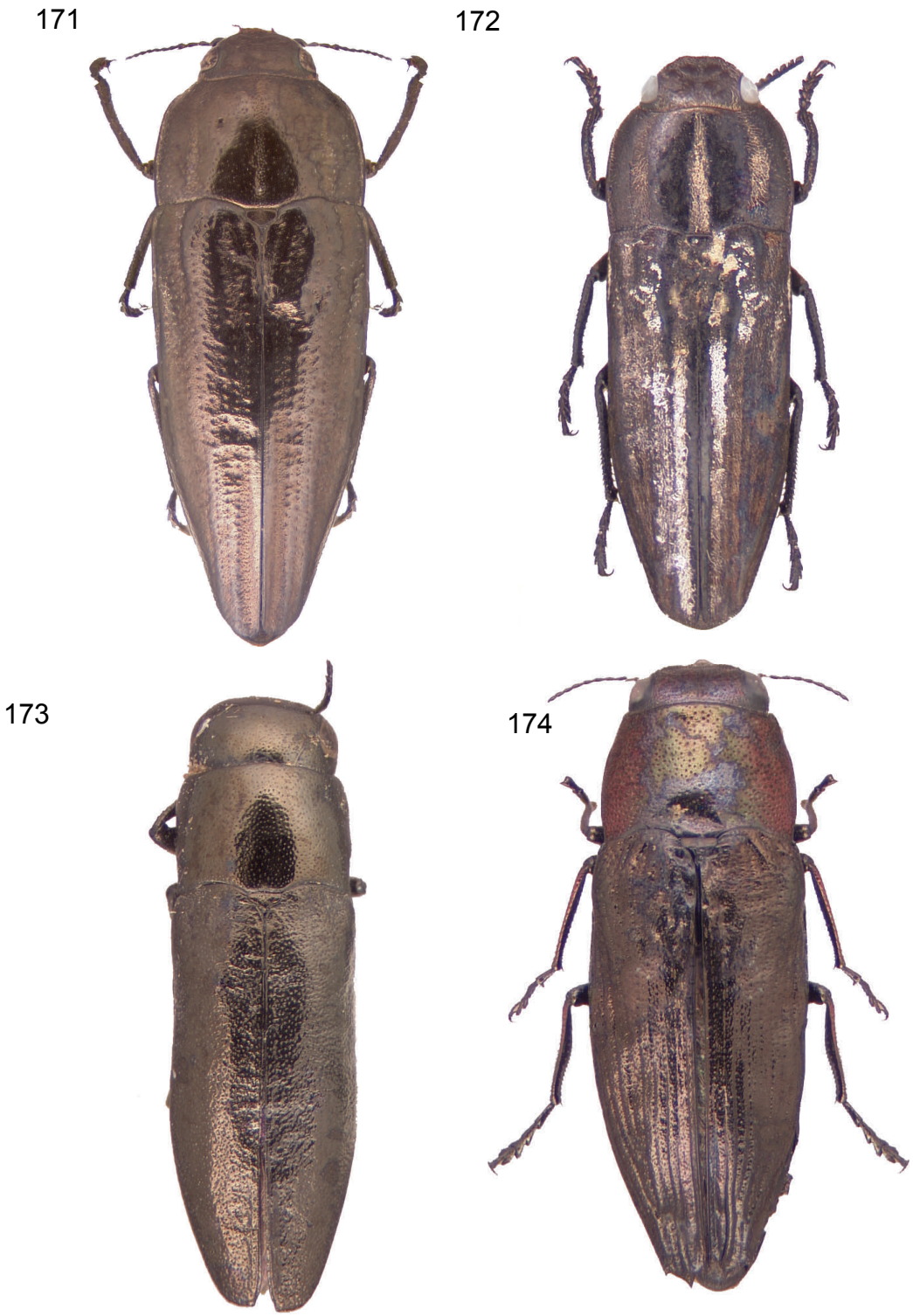
169



170



167. *S.* (*Sphenoptera*) *irregularis* dorsal habitus. 168. *S.* (*Sphenoptera*) *extensocarinata* dorsal habitus. 169. *S.* (*Sphenoptera*) *inermis* dorsal habitus. 170. *S.* (*Sphenoptera*) *canaliculata* dorsal habitus.



171. *S.* (*Sphenoptera*) *demissa* dorsal habitus. 172. *S.* (*Sphenoptera*) *lapidaria* dorsal habitus. 173. *S.* (*Sphenopterella*) *margaritae* dorsal habitus. 174. *S.* (*Tropeopeltis*) *kaznakowi* dorsal habitus.

175



176



177



178



175. *S*. (*Chilostetha*) *cauta* lateral habitus. 176. *S*. (*Chilostetha*) *substriata* lateral habitus. 177. *S*. (*Chilostetha*) *basalis* lateral habitus. 178. *S*. (*Chilostetha*) *canescens* lateral habitus.

179



180



181



182



179. *S*. (*Chilostetha*) *densesculpta* lateral habitus. 180. *S*. (*Chilostetha*) *insidiosa* lateral habitus. 181. *S*. (*Chilostetha*) *puberula* lateral habitus. 182. *S*. (*Chrysoblemma*) *sancta* lateral habitus

183



184



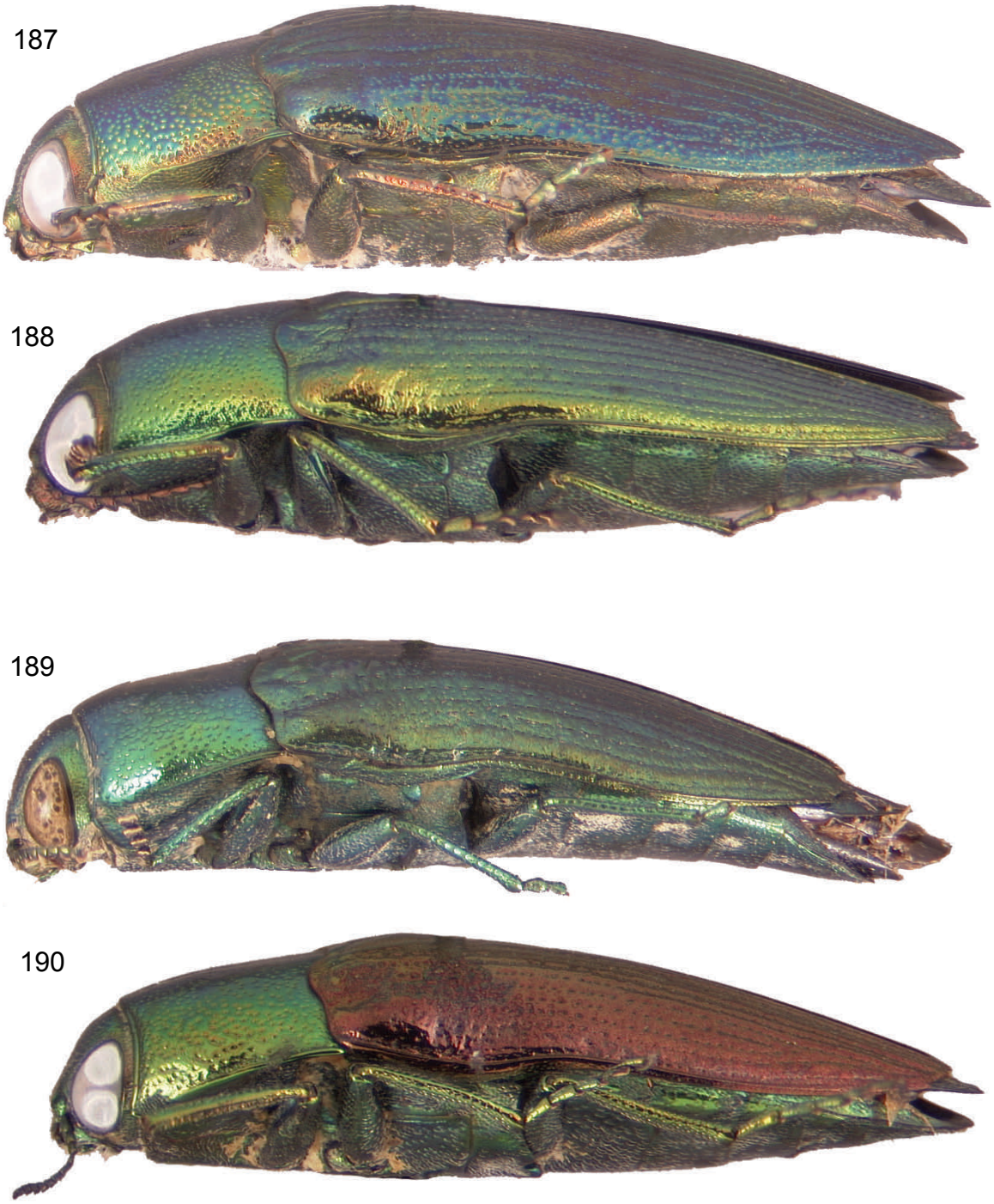
185



186



183. *S*. (*Chrysoblemma*) *hauseri* lateral habitus. 184. *S*. (*Chrysoblemma*) *punctatissima* lateral habitus. 185. *S*. (*Chrysoblemma*) *artemisia* lateral habitus. 186. *S*. (*Chrysoblemma*) *viridaurea* lateral habitus.



187.*S*. (*Chrysoblemma*) *striatipennis* lateral habitus. 188. *S*. (*Chrysoblemma*) *tamarisci beckeri* lateral habitus. 189. *S*. (*Chrysoblemma*) *scovitzii* lateral habitus. 190. *S*. (*Chrysoblemma*) *ignita* lateral habitus.

191



192



193



194



191. *S*. (*Chrysoblemma*) *orichalcea* lateral habitus. 192. *S*. (*Deudora*) *smyrneensis* lateral habitus. 193. *S*. (*Deudora*) *aeneomicans* lateral habitus. 194. *S*. (*Deudora*) *misella* lateral habitus.

195



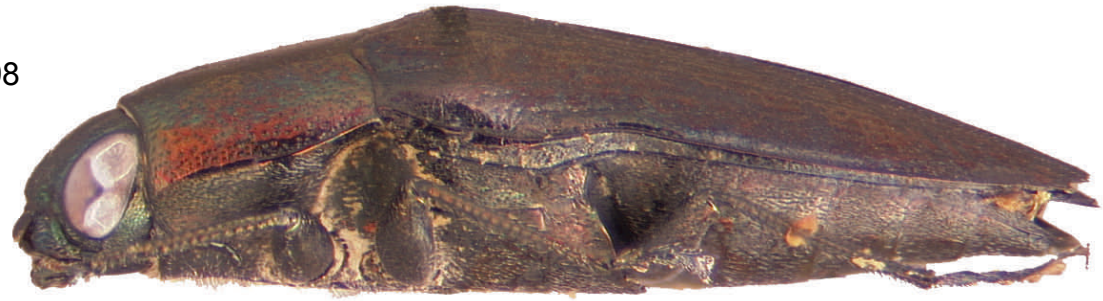
196



197



198



195. *S*. (*Deudora*) *sculpticollis* lateral habitus. 196. *S*. (*Deudora*) *sulciventris* lateral habitus. 197. *S*. (*Deudora*) *micans* lateral habitus. 198. *S*. (*Hoplistura*) *mesopotamica* lateral habitus.

199



200



201



202



199. *S*. (*Hoplistura*) *balassogloi* lateral habitus. 200. *S*. (*Sphenoptera*) *anthracina* lateral habitus. 201. *S*. (*Sphenoptera*) *coracina* lateral habitus. 202. *S*. (*Sphenoptera*) *eugenii*

203



204



205



206



203. *S*. (*Sphenoptera*) *oporina* lateral habitus. 204. *S.* (*Sphenoptera*) *tragacanthae* lateral habitus. 205. *S*. (*Sphenoptera*) *hypocrita* lateral habitus. 206. *S*. (*Sphenoptera*) *foveola* lateral habitus.

207



208



209



210



207. *S*. (*Sphenoptera*) *chalybaea* lateral habitus. 208. *S*. (*Sphenoptera*) *antiqua* lateral habitus. 209. *S*. (*Sphenoptera*) *rugulosa* lateral habitus. 210. *S*. (*Sphenoptera*) *fallatrix* lateral habitus.

211



212



213



214



211. *S*. (*Sphenoptera*) *latesulcata* lateral habitus. 212. *S*. (*Sphenoptera*) *cuprina* lateral habitus. 213. *S*. (*Sphenoptera*) *pligshinskii* lateral habitus. 214. *S*. (*Sphenoptera*) *manderstjernae* lateral habitus.

215



216



217



218



215. *S*. (*Sphenoptera*) *repetekensis* lateral habitus. 216. *S*. (*Sphenoptera*) *laticeps* lateral habitus. 217. *S*. (*Sphenoptera*) *sulcata* lateral habitus. 218. *S*. (*Sphenoptera*) *irregularis* lateral habitus.

219



220



221



222



219. *S*. (*Sphenoptera*) *extensocarinata* lateral habitus. 220. *S*. (*Sphenoptera*) *inermis* lateral habitus. 221. *S*. (*Sphenoptera*) *canaliculata* lateral habitus. 222. *S*. (*Sphenoptera*) *lapidaria* lateral habitus.

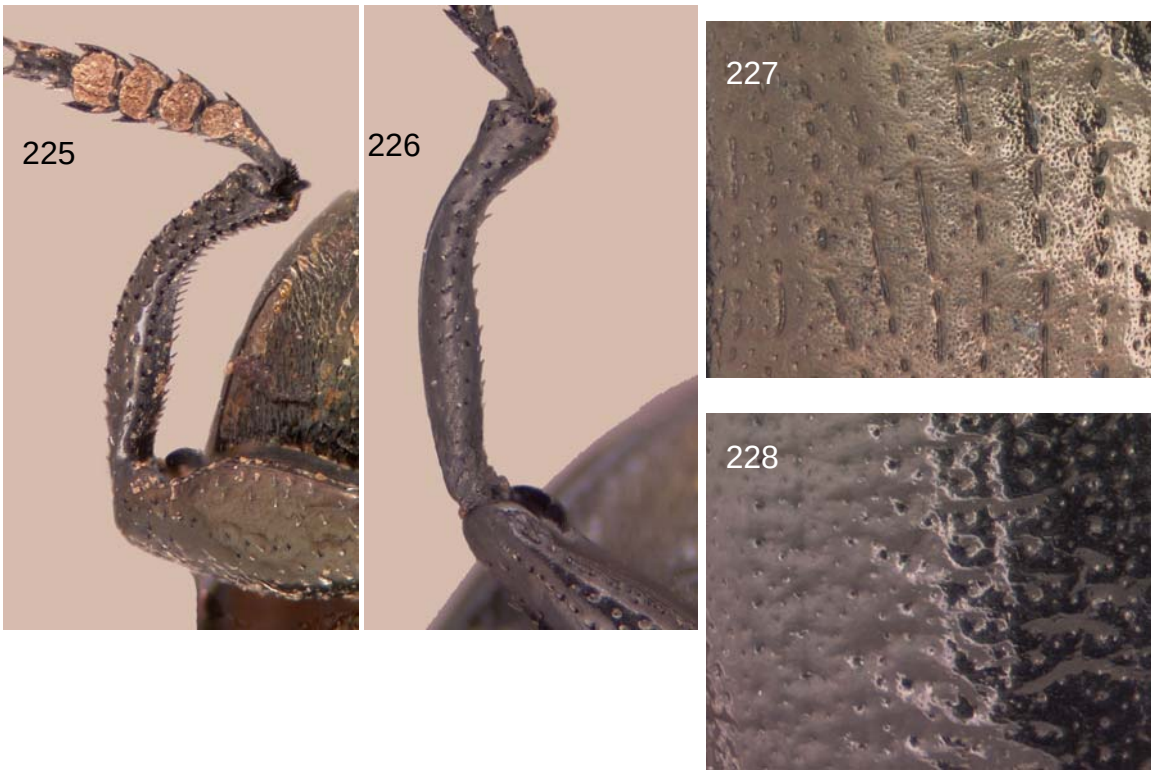
223



224



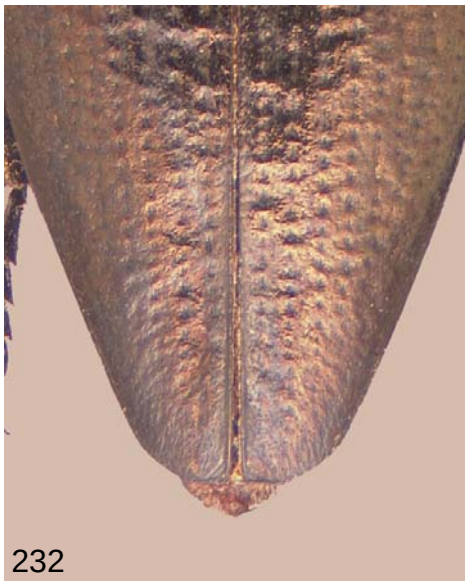
223. *S*. (*Sphenopterella*) *margaritae* lateral habitus. 224. *S*. (*Tropeopeltis*) *kaznakowi* lateral habitus.





225. *S*. (*Sphenoptera*) *magna* protibia, male. 226. *S*. (*Sphenoptera*) *foveola* protibia, male. *S*. (*Sphenoptera*) *exarata* elytral striae. 228. *S*. (*Sphenoptera*) *foveola* elytral striae. 229. *S*. (*Sphenoptera*) *exarata* anterior pronotal margin. 230. *S*. (*Sphenoptera*) *foveola* anterior pronotal margin.


231


232

233



234



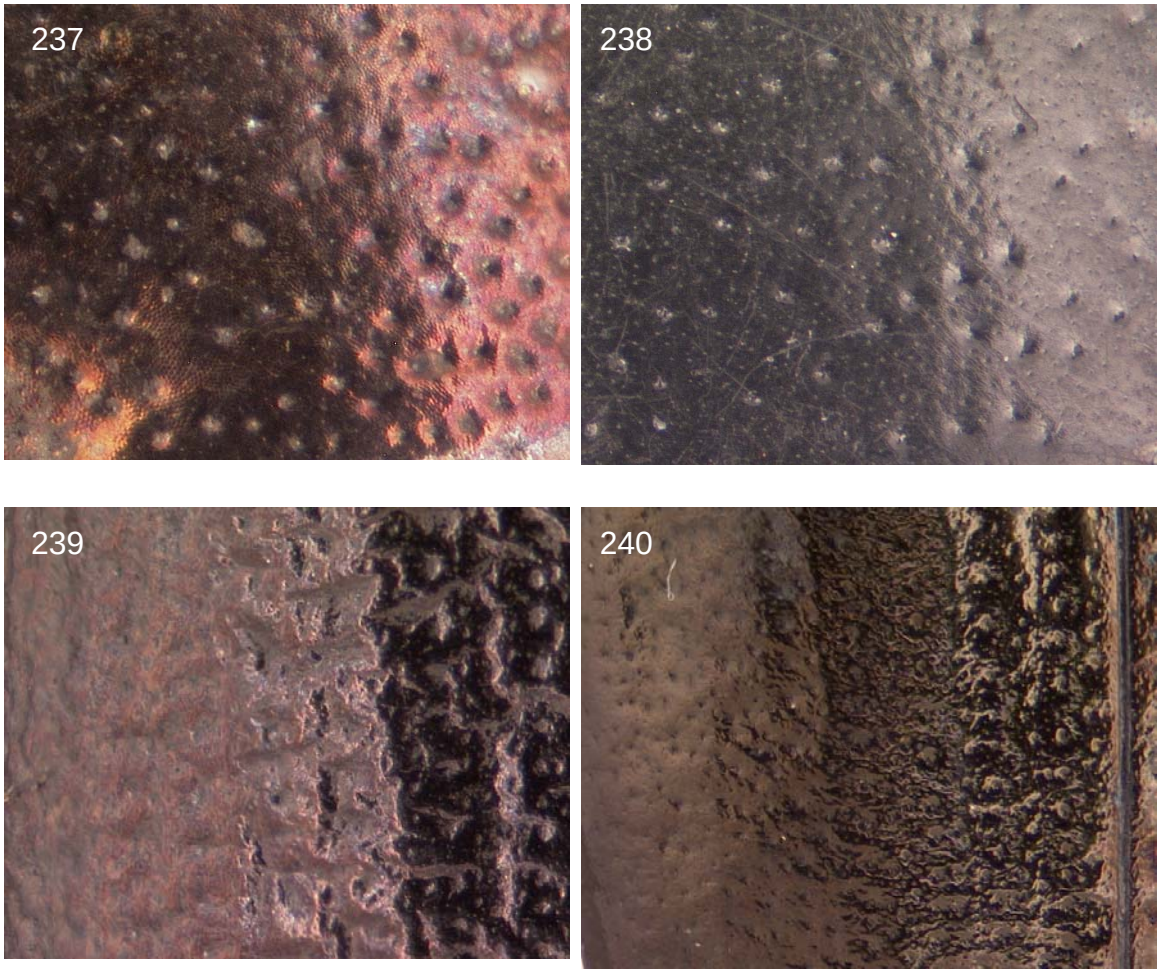
235



236



231. *S*. (*Sphenoptera*) *exarata* elytral apices. 232. *S*. (*Sphenoptera*) *magna* elytral apices. 233. *S*. (*Sphenoptera*) *exarata* pronotum. 234. *S*. (*Sphenoptera*) *magna* pronotum. 235. *S*. (*Sphenoptera*) *exarata* mesotibia, male. 236. *S*. (*Sphenoptera*) *magna* mesotibia, male.



237. *S*. (*Sphenoptera*) *lateralis* pronotal sculpture. 238. *S*. (*Sphenoptera*) *pilipes* pronotal sculpture. 239. *S*. (*Sphenoptera*) *foveola* elytron.
240. *S*. (*Sphenoptera*) *pilipes* elytral sculpture.

241



242



243



244



245



241. *S*. (*Sphenoptera*) *exarata* dorsal habitus. 242. *S*. (*Sphenoptera*) *foveola* dorsal habitus. 243. *S*. (*Sphenoptera*) *lateralis* dorsal habitus.
244. *S*. (*Sphenoptera*) *magna* dorsal habitus. 245. *S*. (*Sphenoptera*) *pilipes* dorsal habitus





245. *S*. (*Sphenoptera*) *foveola* aedeagus
246. *S*. (Sphenoptera) *magna* aedeagus

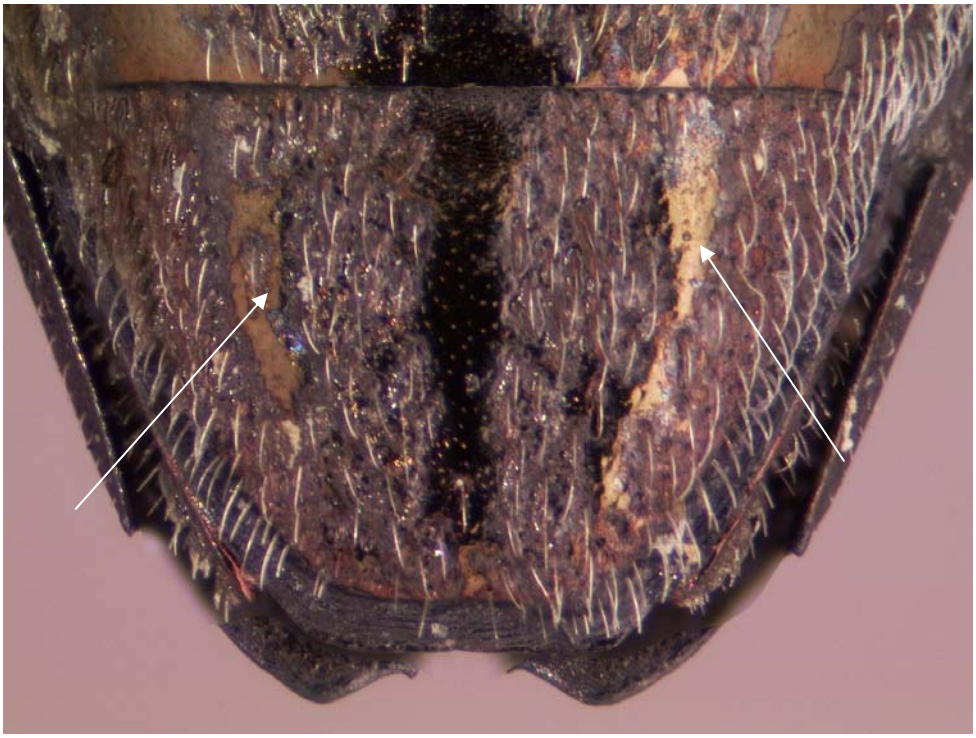




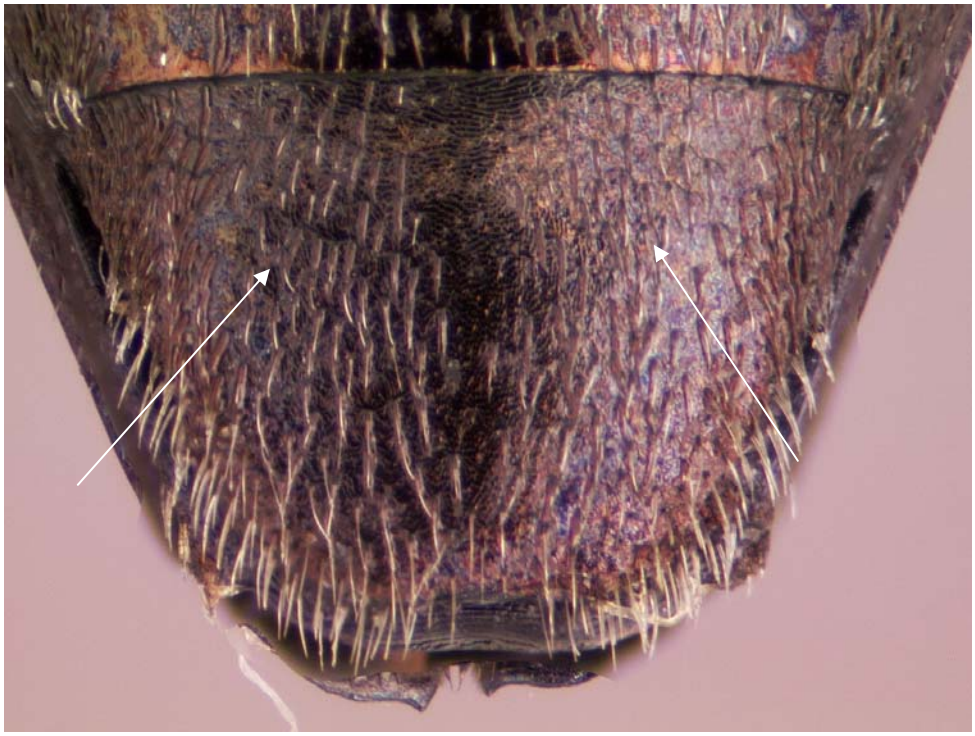




247. *S.* (*Deudora*) *gemmata* pronotum. 248. *S.* (*Deudora*) *signata* pronotum
249. *S.* (*Deudora*) *rauca* metacoxa. 250. *S.* (*Deudora*) *aeneomicans* metacoxa.

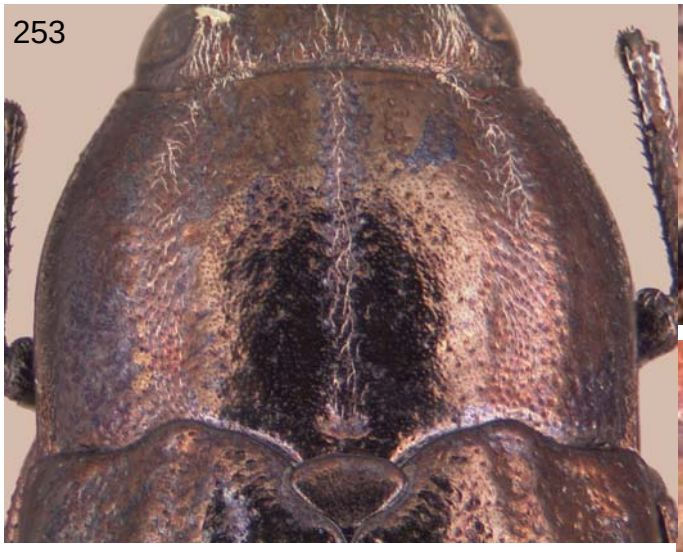


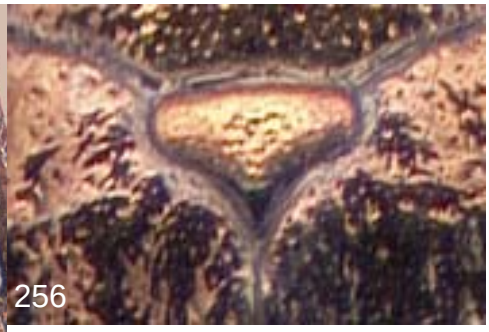
251



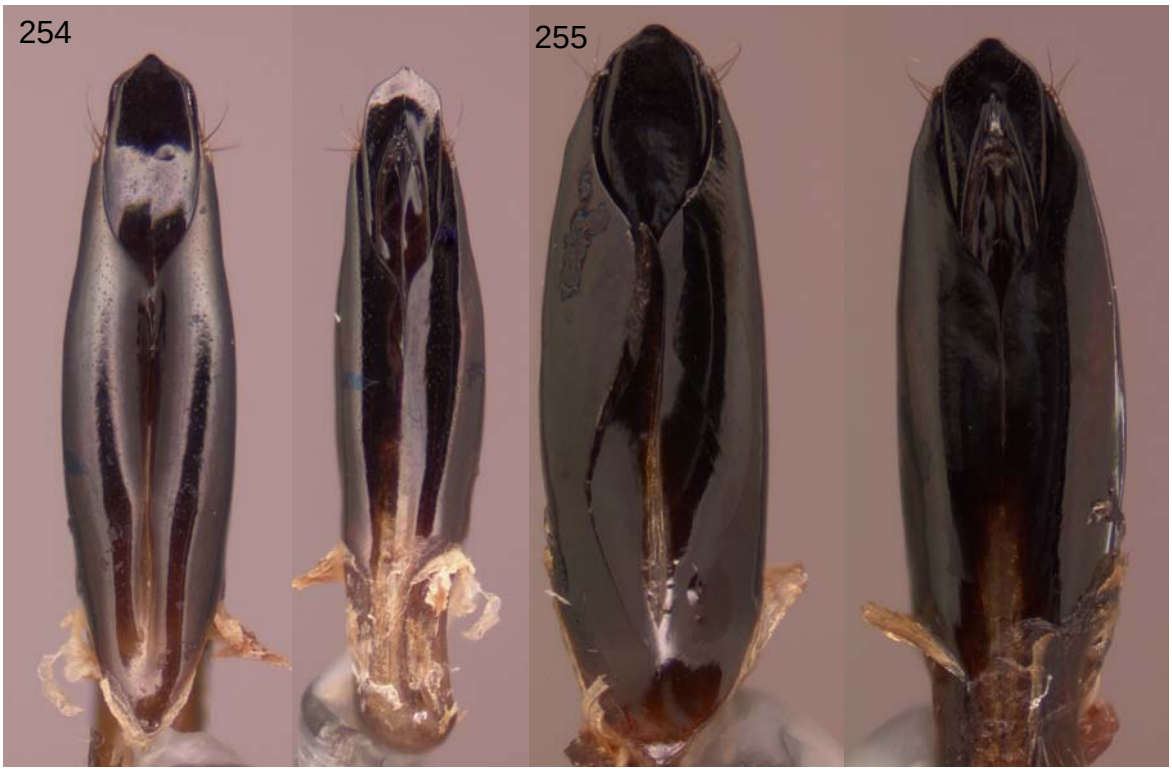
252

251. *S.* (*Deudora*) *vittaticollis* apical abdominal ventrite. 252. *S.* (*Deudora*) *gemmata* apical abdominal ventrite.

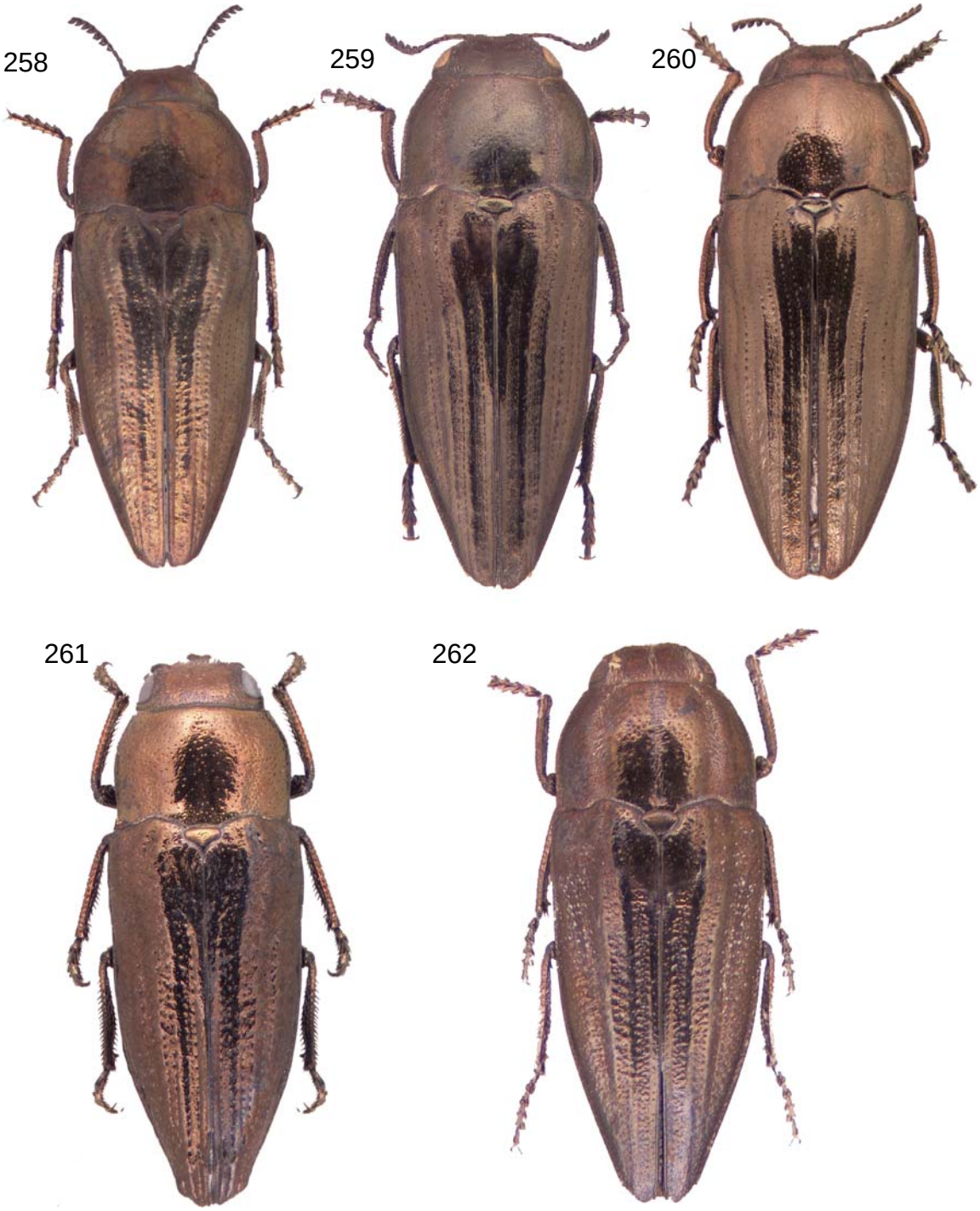








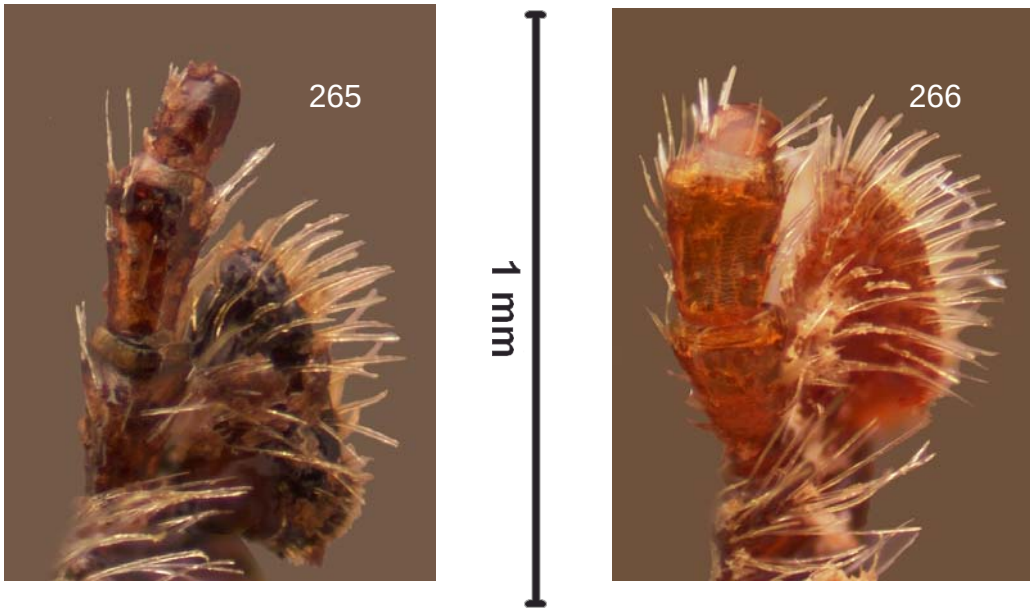
253. *S.* (*Deudora*) *vittaticollis* pronotum. 254. *S.* (*Deudora*) *gemmata* aedeagus.
255. *S.* (*Deudora*) *rauca* aedeagus. 256. *S.* (*Deudora*) *aeneomicans* scutellum.
257. *S.* (*Deudora*) *signata* scutellum



258. *S.* (*Deudora*) *aeneomicans* dorsal habitus. 259. *S.* (*Deudora*) *gemmata* dorsal habitus. 260. *S.* (*Deudora*) *rauca* dorsal habitus. 261. *S.* (*Deudora*) *signata* dorsal habitus. 262. *S.* (*Deudora*) *vittaticollis* dorsal habitus.



263. *C. fortis* protibia, posterior face. 264. *C. angulicollis* protibia, posterior face.



265. *C. virginiensis* maxillary palpus. 266. *C. angulicollis* maxillary palpus.



267. *C. virginiensis* elytral apex. 268. *C. angulicollis* elytral apex. 269. *C. liberta* elytral apex. 270. *C. georgiana* elytral apex. 271. *C. fortis* elytral apex.

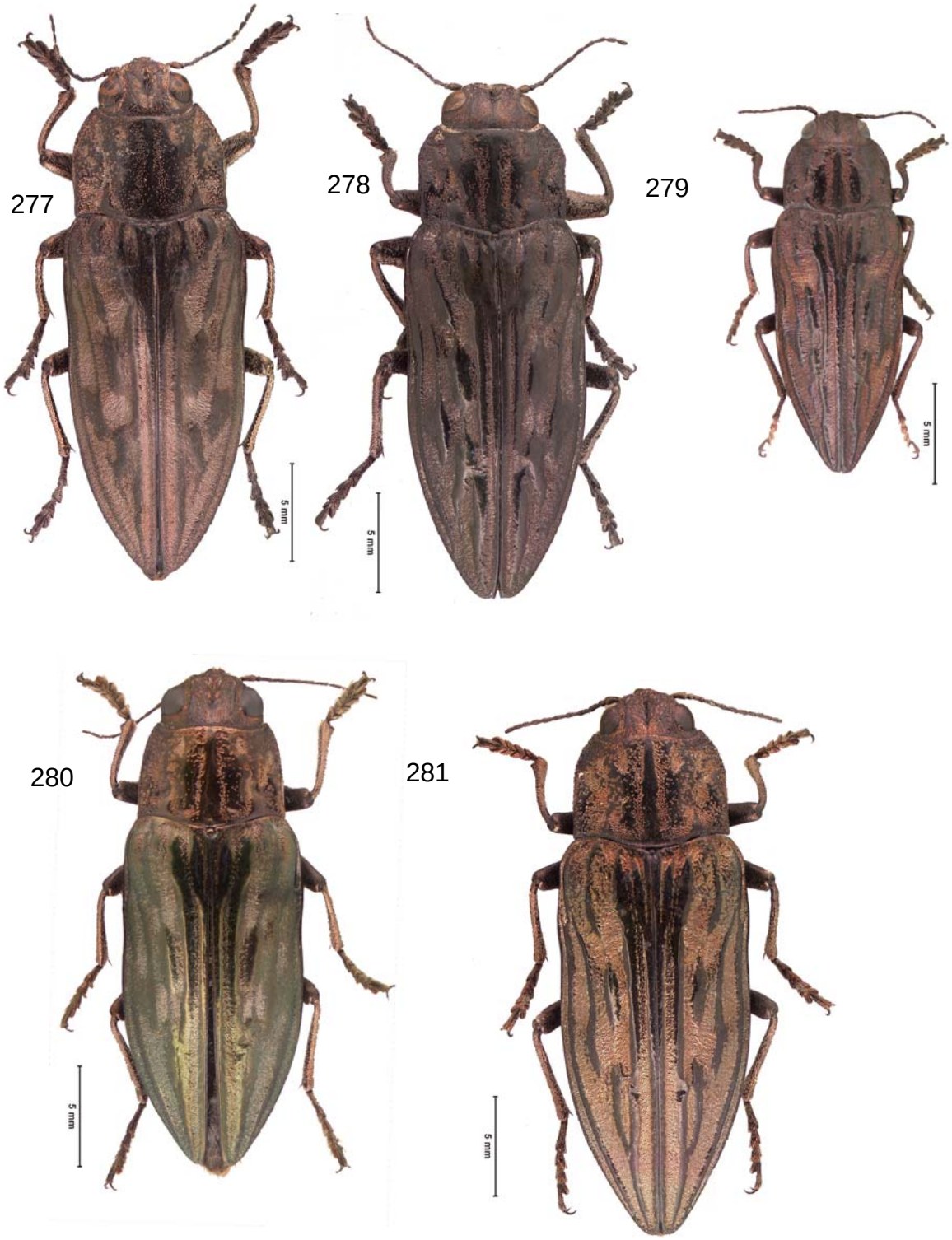




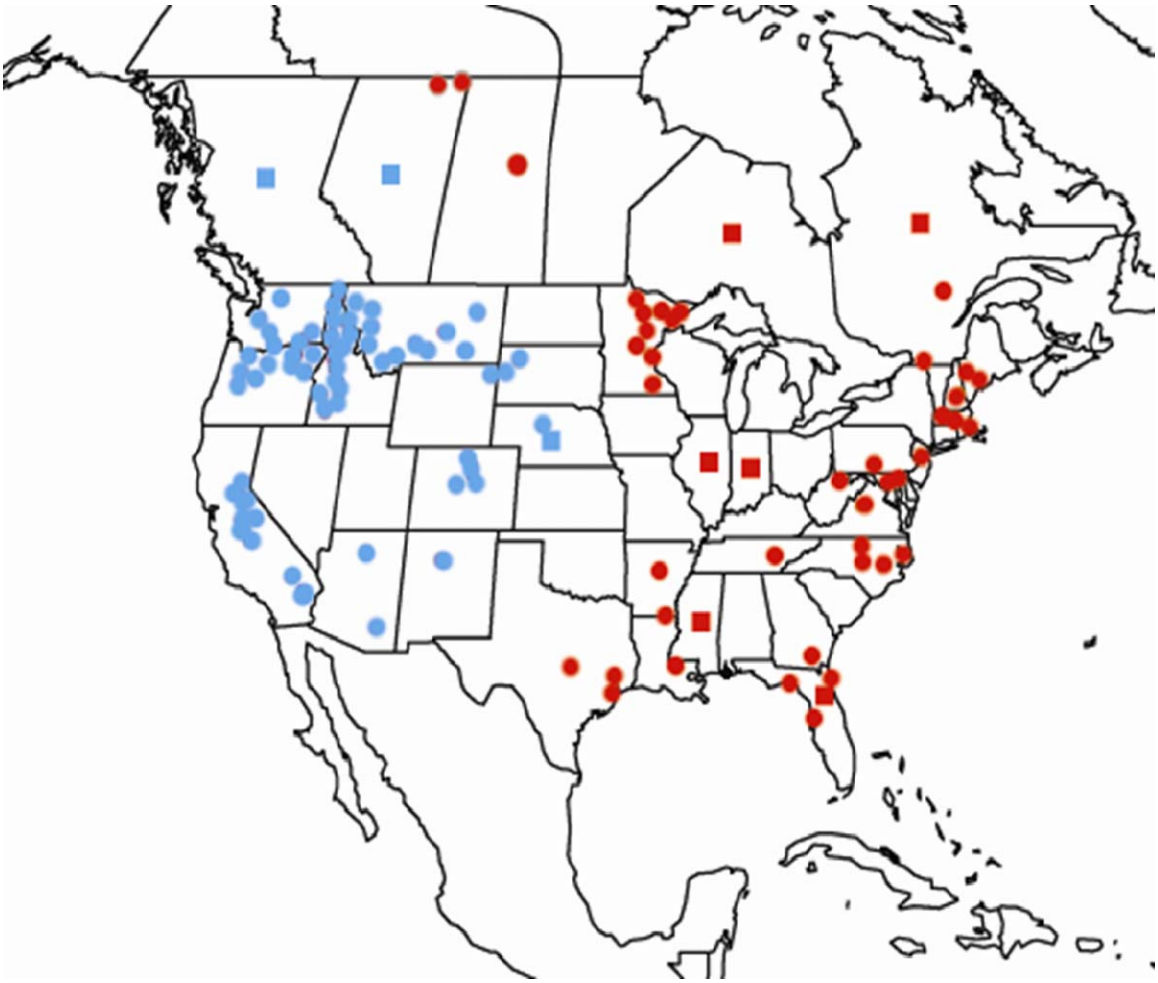
272. *C. virginiensis* male genitalia, dorsal/ventral. 273. *C. angulicollis* male genitalia, dorsal/ventral. 274. *C. liberta* male genitalia, dorsal/ventral. 275. *C. fortis* male genitalia, dorsal/ventral.



276. *C. georgiana* male genitalia, dorsal/ventral.



277. *C. virginiensis* habitus, USA, Arkansas. 278. *C. angulicollis* habitus, USA, Idaho. 279. *C. liberta* habitus, USA, Wisconsin. 280. *C. georgiana* habitus, USA, Florida. 281. *C. fortis* LeConte, habitus, USA, New York.



282. Distribution map of *C. angulicollis* and *C. virginiensis* in North America, indicating the disjunction between the two populations.

APPENDIX B:

FIELD SAMPLING SITES

(SEE CD IN LIBRARY)

APPENDIX C:

MATERIAL EXAMINED

(SEE CD IN LIBRARY)

APPENDIX D:

LUCID MATRIX

(SEE CD IN LIBRARY)

APPENDIX E:

KEY TO *SPHENOPTERA* SPECIES-GROUPS
OF THE FORMER U.S.S.R.

(SEE CD IN LIBRARY)