



## A revision of the genus *Phellopsis* LeConte (Coleoptera: Zopheridae)

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### Abstract

The world species of *Phellopsis* LeConte are revised based on the examination of all available material. *Phellopsis obcordata* (Kirby) and *P. porcata* (LeConte) are found to be valid vicariant species isolated in old growth boreal forest habitats of eastern and western North America, respectively. *Phellopsis robustula* Casey and *P. montana* Casey are placed as junior synonyms of *P. porcata* NEW SYNONYMIES. On the Asian continent, *P. imurai* Masumoto is placed in synonymy with *P. amurensis* (Heyden) NEW SYNONYMY. *Phellopsis amurensis* (Heyden) now has a documented range that extends from the coastal mountains of Russia's Primorskii Krai into the Korean peninsula. The other two described species found to be valid are *P. suberea* Lewis, known only from Japan, and *P. chinense* (Semenow) from west central China. *Phellopsis yulongensis* NEW SPECIES is described from the Yunnan Province of western China. Redescriptions of all valid species are provided, with comments on the history of the genus, biology and biogeography of the group. A key and illustrations are provided for the identification of all known *Phellopsis* species.

**Key words:** Coleoptera, Zopheridae, new species, taxonomy

### Introduction

The genus *Phellopsis* LeConte is the only component of the tribe Phellopsini (Ślipiński and Lawrence 1999), and can be separated from other large Zopherinae by having 11-segmented antennae and slightly open procoxal cavities. It forms a distinct cluster based on a unique combination of characters (Ślipiński and Lawrence 1999) and hypothesized synapomorphies including the laterally lobed ventrites. The members of *Phellopsis* are widely distributed in the Holarctic, but exhibit very little interspecific morphological diversity. This similarity among species has led to considerable taxonomic confusion. This revision is the first for the genus as a whole, provides a key to species, full species descriptions, illustrations, taxonomic history, synoptic catalog and distribution maps for all included species.

### Taxonomic history

LeConte (1862) erected *Phellopsis* for *Bolitophagus obcordatus* Kirby 1837 from Canada and New England, and *Nosoderma porcatum* LeConte 1853 from California and Oregon. In his 1853 description, LeConte noted the strong resemblance between *P. porcata* and *P. obcordata*, an observation that started the confused history of the taxonomy of the North American species.

Several authors have dealt with the problem of distinguishing these allopatric species in North America. Horn (1870) stated that the species were difficult to diagnose, but treated them as distinct species based on color and sculpture. Henshaw (1881) first synonymized the two species in his catalog of species described by

LeConte. LeConte's speculation about the species' validity continued even after his death in 1881. In a posthumous (for LeConte) publication, LeConte and Horn (1883) stated that the two named populations were likely parts of a single species, but then retained both names as valid. Casey (1907a), adding to the quandary, stated that they were in fact quite distinct and also supported both as full species. No further changes were made for over 80 years and the purported species were distinguished by geographic origin due to the lack of a good diagnostic character (C.A. Triplehorn pers. comm. to M.A. Ivie). Then, without comment, Campbell (1991) returned to Henshaw's (1881) placement of *P. porcata* as a junior synonym of *P. obcordata*. This placement was recognized and commented on by Ivie (2002).

Casey (1907a) had described two additional western species, *P. robustula* Casey from Idaho and *P. montana* Casey from California, but these names have been mostly ignored, and were mentioned only by Boddy (1965) and Ivie (2002), and in a few catalogs and checklists (e.g. Gebien 1936). A decision on their official status has languished for 100 years.

The Asian species have a very different taxonomic history. In 1885, Heyden described *Pseudonosoderma* (type species *Pseudonosoderma amurensis* Heyden 1885) from the Russian Far East. Unfortunately, the genus was mistakenly placed in the Byrrhidae section of the Zoological Record of 1885 (Sharp 1886, Champion 1894, Lewis 1895) and was not recognized as a zopherid when *Phellopsis suberea* Lewis 1887 was described from Japan and Russia. Semenow (1893), did note the correct relationship of Heyden's genus, and added *Pseudonosoderma chinense* from the Gansu Province of China.

The following year Champion (1894) synonymized *Pseudonosoderma* and *Phellopsis*. The fact that *P. suberea* was based on a series of specimens from both Japan and Russia (Lewis 1887) led Champion (1894) to place *P. suberea* as a synonym of the Russian *P. amurensis*. Lewis contradicted Champion's synonymy in a note (Lewis 1895) asserting that the two were in fact distinct species. He acknowledged that the single specimen he originally cited (Lewis 1887) from Russia as *P. suberea* was in fact *P. amurensis*, and restricted the former name to the Japanese populations. However, since no holotype was established, the syntype series was mixed, and no lectotype has been designated, the correct interpretation of Lewis's name remained uncertain. Establishment in this paper of a lectotype from the Japanese syntypes finally solidifies Lewis' and subsequent authors' views as the correct one.

The most recent species addition to *Phellopsis* is *P. imurai* Masumoto 1990 from South Korea. Masumoto (1990) also provided the first key to the Asian species of *Phellopsis*. However, he based that key at least in part on misidentified specimens, further adding to the confusion in this difficult genus.

At the beginning of this study, we were faced with one recognized trans-North-American species, two North American names of uncertain status, and four east-temperate Asian species of confused definition. Our work has shown that there are two North American and four Asian species, these being significantly different in their species limits from the previous assessment.

## Materials

The current study was based on the examination of over 3,400 adult specimens of the genus *Phellopsis*, as well as an equal number from related genera. The number of North American specimens available for the current work is considerably larger than that of the Asian species and is a better representation of the expected variability of the species. The numbers of adults examined in each species are: *P. porcata* (n = 2,573), *P. obcordata* (n = 752), *P. amurensis* (n = 19), *P. suberea* (n = 58), *P. chinensis* (n = 12), and *P. yulongensis* NEW SPECIES (n = 12). The availability of adult specimens was sufficient to complete a thorough examination of morphology and delimit each species. Larval representatives were examined for only the North American species, with a single late instar of each species examined. The larva of *P. amurensis* is described from Russia (Keleinikova and Mamaev 1971), but specimens were not available for examination.

The material for this investigation was obtained on loan from most of the North American entomological collections, as well as many collections in Europe, and a few Asian collections. It proved extremely difficult to obtain loans from Chinese institutions, and we were ultimately unsuccessful. All of the material examined from China is housed in collections outside of that country. Specimens were obtained from or are deposited in the institutions and collections listed by the following codens (the curator responsible for the loan is listed in parentheses).

AAPC	Albert Allen Personal Collection, Boise, Idaho, USA (Albert Allen)
ASUT	Arizona State University, Tempe, Arizona, USA (David Pearson)
BMNH	The Natural History Museum, London, United Kingdom (Maxwell V. L. Barclay)
BPBM	Bernice P. Bishop Museum, Honolulu, Hawaii, USA (Alistair S. Ramsdale)
BYUC	Brigham Young University, Provo, Utah, USA (Shawn M. Clark)
CASC	California Academy of Sciences, San Francisco, California (Norm Penny and David H. Kavanaugh)
CMNC	Canadian Museum of Nature, Ottawa, Ontario, Canada (François Génier)
CNCI	Canadian National Collections of Insects, Ottawa, Ontario, Canada (Patrice Bouchard)
CSCA	California State Collection of Arthropods, Sacramento, California, USA (Chuck Bellamy)
CSUC	Colorado State University, Fort Collins, Colorado, USA (Boris C. Kondratieff)
DBTC	Donald B. Thomas Personal Collection, Weslaco, Texas, USA (Donald Thomas)
DEI	Deutsches Entomologisches Institut, Leibniz-Zentrum für Agrarlandschaftsforschung, Müncheberg, Germany (Lothar Zerche)
DKYC	Daniel K. Young Personal Collection, Madison, Wisconsin, USA (Daniel K. Young)
EIHU	Hokkaido University, Sapporo, Japan (Mashiro Ohara)
EMEC	University of California, Berkeley, California, USA (Cheryl Barr)
ENMU	Eastern New Mexico University, Portales, New Mexico, USA (Darren A. Pollock)
FMNH	Field Museum, Chicago, Illinois, USA (James H. Boone)
FSCA	Florida State Collection of Arthropods, Gainesville, Florida, USA (Paul E. Skelley)
HNHM	Hungarian Natural History Museum, Budapest, Hungary (Otto Merkl)
HUMB	Humboldt State University, Arcata, California, USA (Michael Camann)
INHS	Illinois Natural History Survey, Champaign, USA (Colin Favret)
IRCW	University of Wisconsin, Madison, Wisconsin, USA (Steven Krauth)
JEWC	James E. Wappes Personal Collection, Bulverde, Texas, USA (James E. Wappes)
LACM	Natural History Museum of Los Angeles County, Los Angeles, California, USA (Weiping Xie)
LSAM	Louisiana State Arthropod Museum, Baton Rouge, Louisiana, USA (Victoria Bayless).
LUND	Lund University, Lund, Sweden (Roy Danielsson)
MCPM	Milwaukee Public Museum, Milwaukee, Wisconsin, USA (Susan Borkin)
MAIC	Michael A. Ivie Private Collection, Bozeman, Montana, USA (Michael A. Ivie)
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA (Philip D. Perkins)
MIZ	Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland (Wioletta Tomaszewska)
MSUC	Michigan State University, East Lansing, Michigan, USA (Gary L. Parsons)
MTEC	Montana Entomology Collection, Montana State University Bozeman, Montana, USA (Michael A. Ivie).
NCSU	North Carolina State University Insect Collection, Raleigh, North Carolina, USA (Robert Blinn)

NHMB	Natural History Museum Basel, Switzerland (Michael Brancucci and Eva Sprecher-Uebersax)
NHMW	Naturhistorisches Museum Wien, Vienna, Austria (Heinrich Schönmann)
NMNH	National Museum of Natural History, Washington D.C., USA (Warren E. Steiner)
NMPC	National Museum of Natural History, Prague, Czech Republic (Svatopluk Bílý)
OSAC	Oregon State Arthropod Collection, Oregon State University, Corvallis, USA (Andrew Brower)
OSUC	The Ohio State University, Columbus, Ohio, USA (Charles A. Triplehorn)
RLAC	Rolf L. Aalbu Personal Collection, Sacramento, California, USA (Rolf L. Aalbu)
ROME	Royal Ontario Museum, Toronto, Ontario, Canada (Brad Hubely)
SBMN	Santa Barbara Museum of Natural History, California, USA (Michael S. Caterino)
SEMC	Snow Entomological Collections, University of Kansas, Lawrence, Kansas, USA (Zachary H. Falin)
SMDV	Spencer Entomological Museum, University of British Columbia, Vancouver (Karen M. Needham)
TAMU	Texas A&M University, College Station, Texas, USA (Edward G. Riley)
UTSC	Utah State University, Logan, Utah, USA (Colin Brammer)
UASM	Strickland Museum, University of Alberta, Edmonton, Canada (Danny Shpeley)
UCDC	Bohart Museum of Entomology, University of California-Davis, California, USA (Steve L. Heydon)
UCMC	University of Colorado Museum, Boulder, Colorado, USA (Virginia Scott)
UCRC	University of California-Riverside, California, USA (Douglas Yanega)
UGCA	Georgia Museum of Natural History, Athens, Georgia, USA (Cecil L. Smith)
UMMZ	University of Michigan, Ann Arbor, Michigan, USA (Mark F. O'Brien)
UNSM	University of Nebraska State Museum, Lincoln, Nebraska, USA (Frederico C. Ocampo)
WFBM	William F. Barr Entomological Museum, University of Idaho, Moscow, Idaho, USA (Frank W. Merickel)
WSUC	Washington State University, Pullman, Washington, USA (Richard Zack)
WVDA	West Virginia Department of Agriculture, Charleston, West Virginia, USA (Laura T. Miller)
ZIN	Russian Academy of Sciences, St. Petersburg, Russia (Mark G. Volkovitsh)

## Methods

This revision was primarily based on morphological characters of adult specimens following the operational species concept of Whitehead (1972). This concept assumes that if one group of organisms shares a set morphological characters which are absent in another group, then the difference is due to genetic differences between the groups. If these supposed genetically-based gaps between the groups are significant, then the groups are defined as different species with unique combinations of characters.

Specimens were initially separated based on geographic location, and then compared to other populations looking for consistent, unique morphological characters that would support the recognition of different species. The members of the genus *Phellopsis* are relatively homogeneous morphologically, and a set of informative species-level characters had never been identified. We identified a working set of morphological characters that varied within the genus, and allowed for discrimination of the species.

Frequently, specimens of the genus are encrusted with a greasy exudate as well as accumulated debris, such as sand and soil, making structures difficult to examine. In order to examine both external and internal morphological structures, specimens were relaxed and cleaned (Ivie 2002b) by first placing them in hot water (90–100° C) for 5–10 minutes. Once relaxed, specimens were placed in an ammonium hydroxide solution

(Parsons'® household ammonia) in an ultrasonic cleaner for 10–15 minutes, followed by a distilled water rinse. Any remaining encrustations were then scraped away using the point of an insect pin. The cleaning process significantly enhances the visibility of the surface sculpture, without compromising the specimen. Specimens thus prepared were then ready for dissection and disarticulation, which was used to study structures such as mouthparts and genitalia.

Nomenclature of morphological structures follows Doyen (1966), Doyen and Lawrence (1979), Lawrence and Britton (1991) and Ślipiński and Lawrence (1999). Definitions specific to this study are few. A tubercle is defined as rounded protuberance of the cuticle that has a single inserted seta. This differs from a nodule, which is used to refer to the large rounded or tear-drop shaped elevation of an entire cuticular area that may have multiple setae and/or tubercles on its surface. The term “setiferous fossae” was recently used in the Zopherinae (García-París *et al.* 2001) to refer to pits in the cuticular surface with a single inserted seta. Here they are referred to as setose punctures following Harris (1979). Other sculpture definitions follow Harris (1979) and Nichols (1989).

Specimens were studied on a Leica® Wild M3C stereoscope equipped with a 150w fiber optic illuminator. Habitus images of larger specimens were made using an Olympus DP11 digital camera system, mounted to a NIKON® micro-NIKKOR 105 mm lens. Images of smaller morphological characters and structures were made using a JVC (DC Ky-F75U) digital camera mounted on a Leica® MS5 stereoscope, attached to an IBM IntelliStation M Pro® with a 1GHz Pentium4® processor. Enhancements to digital images were made using the Syncrosopy AutoMontagePro® version 5.03.0020 Beta 5005 software and edited in Adobe PhotoShop® 5.5. Line drawings were made by tracing digital images with a drawing tablet in Adobe PhotoShop® 5.5.

Type specimens were examined for all named species except *P. amurensis* (DEI) which was not available for loan. Specimens of this species were examined from the type locality and confidently represent the true identity of the species.

Transcription of label data from type specimens follows Ivie (1985): the end of each line on a label is indicated by a “;” (semicolon); the individual labels are separated by a “/” (slash). Lines of text with notes about the label (i.e. about the paper used or handwriting) have the actual text from the label separated from the notes by quotation marks (“”), lines without notes do not include these marks. The summarized distribution data follows the format COUNTRY: PROVINCE or STATE: County, Borough, Census Area, or Municipality.

## Taxonomy of the genus

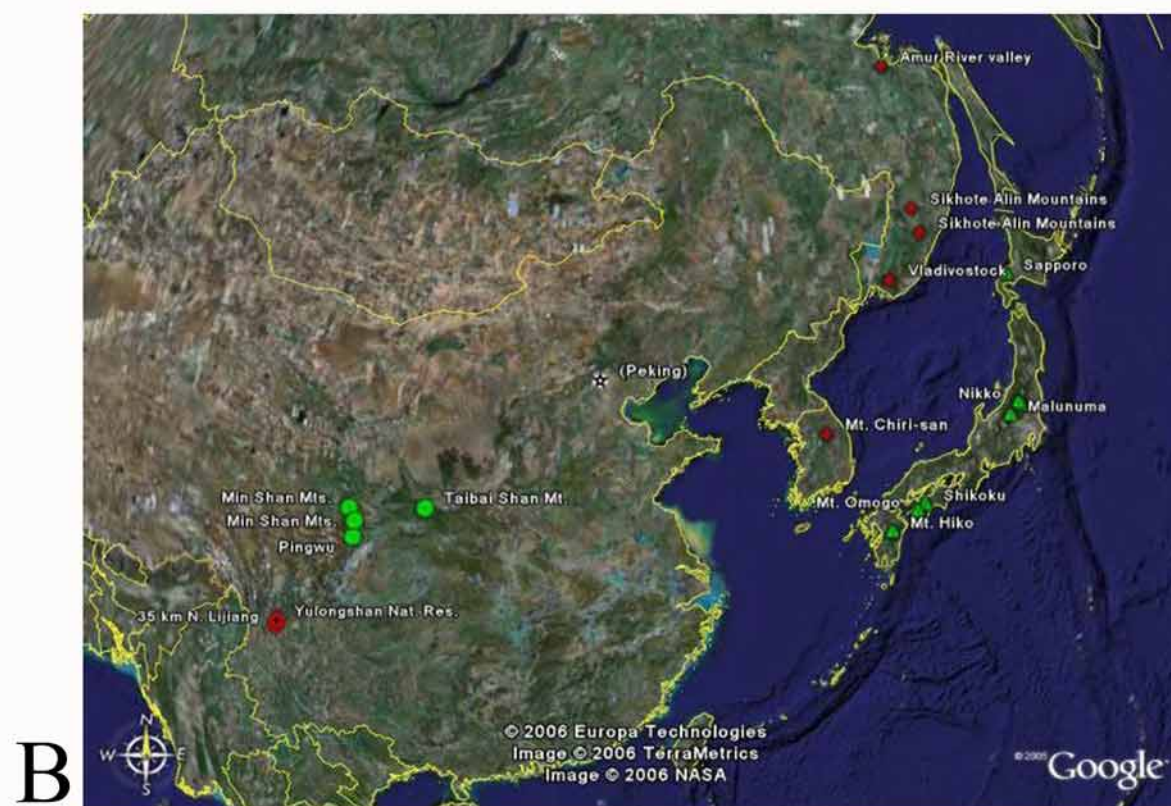
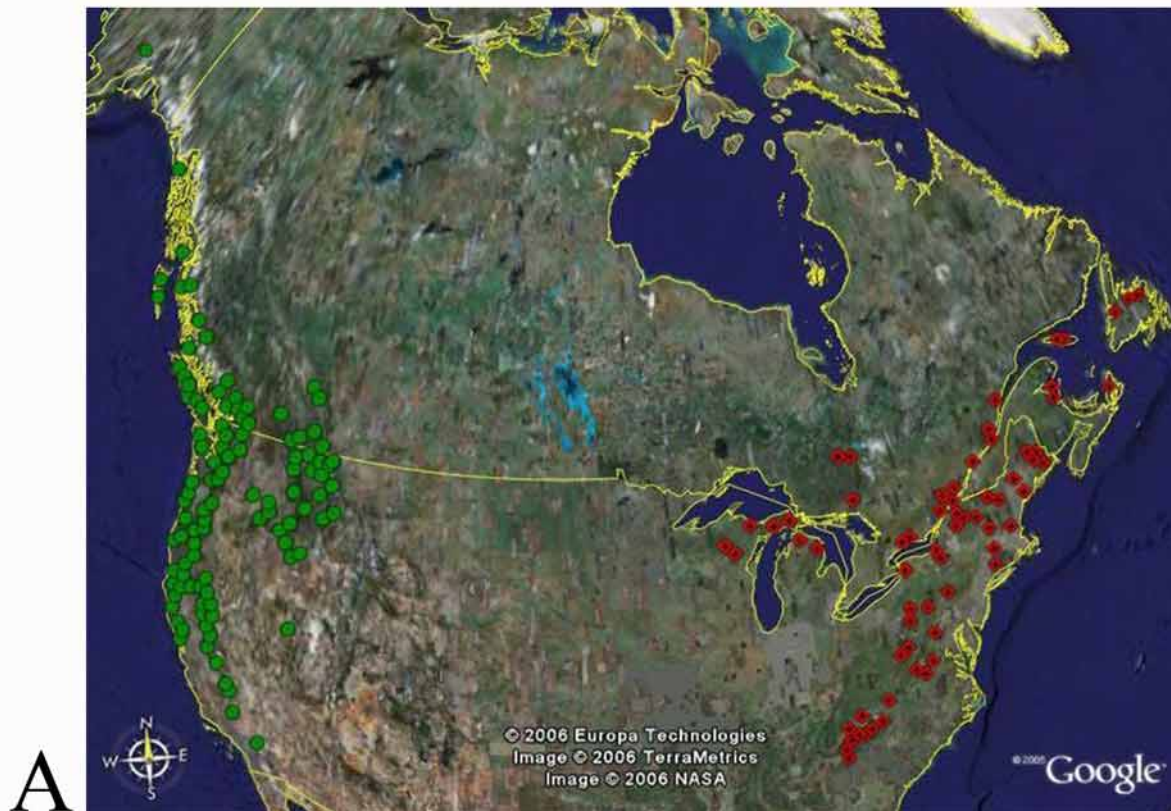
### *Phellopsis* LeConte

(Figs. 1–6)

*Phellopsis* LeConte, 1862: 216. (Type species *Bolitophagus obcordatus* Kirby 1837, subsequent designation by Casey, 1907b: 470). Horn, 1870: 271, 273. Henshaw, 1881: 203, 255. LeConte and Horn, 1883: 365. Champion, 1884: 44. Fairmaire, 1894: C1. Lewis, 1887: 218–220. Lewis, 1894: 379, pl. xiii, fig. 1. Champion, 1894: 114. Lewis, 1895: 447. Casey, 1907a: 44–46. Casey, 1907b: 470, 480–481. Reitter, 1916: 130–131. Leng, 1920: 223. Bradley, 1930: 183, 322. Böving and Craighead, 1931: 41, pl. 52. Gebien, 1936: 668. Crowson, 1955: 127. Arnett, 1962: 650, 668. Boddy, 1965: 77–78, pl. x. Arnett, 1968: 650, 668. Arnett, 1971: 650, 668. Keleinikova and Mamaev, 1971: 125–128. Arnett, 1973: 650, 668. Doyen, 1976: 267, 270–271. Doyen and Lawrence, 1979: 341–345. Papp, 1984: 162–163. Arnett, 1985: 350. Masumoto, 1990: 87–91. Campbell, 1991: 252. Lawrence, 1991: 518–519. Egorov, 1992: 504–505. Steiner, 1992: 25–30. Lawrence, 1994: 341–344. Ślipiński and Lawrence, 1999: 21, 23. Steiner, 1999: 125, 138–139. García-París *et al.*, 2001: 145. Ivie, 2002: 460.

*Pseudonosoderma* Heyden, 1885: 305. (Type species *Pseudonosoderma amurensis* Heyden 1885 by monotypy). Semenov, 1893: 499. Synonymy by Champion 1894: 114.

**Diagnosis:** The members of this genus are easily distinguished from all other large (> 9 mm) Zopherinae by the presence of 11-segmented antennae and slightly open procoxal cavities.



**FIGURE 1.** A. Map of specimen records for North American *Phellopsis* spp. *P. porcata*, green circles; *P. obcordata* red diamonds. B. Map of specimen records for Asian *Phellopsis* spp. *P. yulongensis* red diamonds; *P. chinensis* green circles; *P. amurensis* red cross; *P. suberea* green triangles.

**Description (male):** Length 11–22 mm. Body elongate, parallel sided; elytra 1.9–2.4X longer than pronotum; reddish brown to black; dorsal surface granulose, covered in small dark tubercles, each with single inserted setae; secondary vestiture setose; elytral and pronotal sculpture forming similar pattern in all species (Figs. 2–4).

Head with suprantennal ridges distinctly raised above widely separated antennal insertions (Fig. 6); not constricted behind eyes; dorsal surface of head with varying intensity of tubercles between suprantennal ridges and frons; margin of suprantennal ridge emarginate, flat, or convex. Antennae 11-segmented, not reaching beyond middle of prothorax; capitate with moderate 3 segmented club; antennomere 2 transverse, shorter than 1 or 3; antennomere 3 slightly elongate but less than twice as long as wide, shorter than 4 and 5 combined; antennomeres 9 and 10 with lateral patch of sensilla, 11 with apex covered in sensilla. Subgenal ridges present. Eye emarginate, coarsely faceted, frontal margin with golden setae; area directly behind with small elevated glabrous piece. Labrum visible, transverse, punctate, apical margin with dense fringe of setae. Mandible acutely bidentate, apex curved mesally; median tooth, setose-fringed membranous prosthema, and mola present. Maxillary surfaces with setae inserted in small punctures, variably sculptured; maxillary palpifer and basistipes with long bristle-like setae; apical maxillary palpomere rounded; galea and lacinia densely setose, lacinia hooked laterally, with one or two small teeth. Labial palps broadly separated, inserted laterally; ligula shallowly emarginate to smooth, setose. Submentum with setose pit (Fig. 7). Gula strongly narrowed or not; posterior tentorial pits present along suture, often indistinct.

Pronotum with lyriform ridge divided by midline; large apicolateral nodule; lateral margin slightly explanate or thickened; pronotum widest anterior to midline, anterior angles produced and broadly rounded; posterior angles obtuse; base narrower than elytral base; lateral margin of pronotum variably arcuate, with dense intertuberculate setae at margin, presence of setae varying in species on hypomeron. Hypomeron lacking any hint of antennal cavities. Prosternum in front of procoxae longer than midlength between procoxal cavities; prosternum anterior to procoxae at midline longer than prosternal process; prosternal process gradually expanded then narrowed, apical margin concave or biconcave; strongly elevated and curved dorsally behind coxae; procoxal cavities circular, widely separated, and narrowly open.

Scutellum abruptly elevated, notched anteriorly to rounded. Elytron with scutellary striole; with 7 rows of punctures distinct to obscure, rounded or irregular; epipleuron complete; distinct paired tubercles on elytron at start of apical declivity, a single tubercle near apex, apex rounded and slightly emarginate; elytra not fused. Mesepisternum widely separated, with round fovea or vermiculate, occasionally with small tubercles; mesocoxal cavities closed laterally, moderately separated; mesoventral process extending to middle of mesocoxal cavity.

Exposed portion of metepisternum long and narrow; metaventral median line long; metacoxal extending laterally to reach elytron; cavities moderately separated. Brachypterous, flight wings reduced to small elongate or rounded membranous pads.

Tarsal formula 5-5-4; tarsi and claws simple; tarsal setae on ventral surface of tarsomeres variably shorter and thicker than dorsal surface; all tibia with paired apical spurs; apical margin ringed with small spines; femora and tibia with length of pro<meso<meta; length of meta- tibia 0.06–0.12X longer than the femur; ventral surfaces of all femora with elongate glabrous area.

Intercoxal process of Ventricle 1 (V1) broadly truncate; abdomen with 5 ventrites; first 4 connate, V1 weakly to strongly depressed behind the coxae, V5 with preapical groove divided into two sinuous pits (Fig. 4E–F); V3 and V4 with laterally expanded lobes, V2 occasionally with hint of expansion; laterotergite 3 variably expanded and coupled with internal surface of elytron. Aedeagus as in Fig. 8A–F.

**FEMALE:** The female lacks the setose pit on the submentum, but is similar in all other external morphological characters. The female genitalia distally terminate in a single-segmented, elongate gonostylus that is setose on the apex. Tergite eight and the proctiger are densely clothed in appressed setae. The pleated membrane lacks setation, and the coxite is setose laterally and at the apex.

LARVA: Not defined at the generic level (see description of the larva of *P. obcordata* below).

**NOTES:** The generic identity of this group has been relatively stable since LeConte's description. The only issue was Heyden's description of *Pseudonosoderma*, which contained *P. amurensis* and *P. chinensis* for a short time. *Pseudonosoderma* is clearly synonymous with *Phellopsis* (Champion 1894).

**Biology.** Adults and larvae both feed on fungi associated with decaying trees in old growth boreal forests (Steiner 1992, Ivie 2002). Adults are surface feeders, while larvae burrow into the substrate.

Adults of the genus have been collected on a variety of xylophilous fungi growing on both coniferous and deciduous trees in various states of decay (label data, pers. obs., Steiner 1992, Ivie 2002). Several reports in the literature have associated adults with specific habitats. *Phellopsis obcordata* adults have been reported feeding on *Piptoporus betulinus* (Bull.:Fr.) P. Karst. on a paper birch log (*Betula papyrifera* Marsh), and *Fomes annosus* (Fr.) Cooke on dead balsam fir (*Abies balsamea* Mill.) in Maine, and from *P. betulinus* on sweet birch (*Betula lenta* L.) in Maryland (Steiner 1992). *Phellopsis porcata* adults have been associated with fungi on western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) on Vancouver Island (Guppy 1951) and on *Lentinus* fungus in Montana (Russell 1968). In Japan, *P. suberea* was described from xylophilous bracket fungi of the genus *Boletus* on large oak trees (*Quercus* sp.) (Lewis 1894). *Phellopsis amurensis* was reported on Poraceae fungi from a mixed forest of spruce, fir, birch, and other deciduous trees in the Sikhote-Alin Mountains of southern Primorskii Krai, Russia (Lafer 2002).

Adults use thanatosis (death feigning) as a predator avoidance mechanism, a behavior that has been documented in several groups of beetles (Chemsak and Linsley 1970, Allen 1990, Oliver 1996, Miyatake 2001, and Miyatake *et al.* 2004) and specifically in the Zopherinae (Evans and Hogue 2004). When disturbed, adults drop to the ground with appendages retracted, and remain motionless for a significant time period (pers. obs., Steiner 1992). Their rough bodies blend perfectly with bark chips and detritus at the base of trees or litter on the ground, making a good search image critical to collecting species of this group.

The larvae of *Phellopsis obcordata* have been found living in shelf fungi in dense woodland (Peterson 1951) and conks of the fungi *Piptoporus betulinus* (Polyporales: Fomitopsidaceae) (Steiner 1999). In Western North America, the larvae of *P. porcata* bore through soft wood, where they feed on white sheet fungi between the laminae of large rotting spruce (*Picea* sp.) stumps (Ivie 2002). Wood boring has also been reported for the larva of *P. amurensis* (Keleinikova and Mamaev 1971), but this is probably another case of fungal association.

### Key to the Species of *Phellopsis*

- 1 Lateral margin of elytra appearing smooth in dorsal view (Fig. 2A–B); North America. .... 2
- Lateral margin of elytra appearing serrate in dorsal view (Fig. 3, 4A–D); Asia ..... 3
- 2 Hypomerone lacking intertuberculate setae (Fig. 2C); lateral margin of pronotum strongly bisinuate in lateral view; elytral punctures large, discal tubercles less than ¼ diameter of puncture; posterior margin of prointercoxal process straight to weakly concave. Eastern North America. .... *P. obcordata* (Kirby)
- Hypomerone with dense setae between tubercles (Fig. 2D); lateral margin of pronotum arcuate to weakly bisinuate in lateral view; elytral punctures small, discal tubercles about ½ diameter of punctures; posterior margin of prointercoxal process bisinuate. Western North America.....*P. porcata* (LeConte)
- 3 Outer margin of suprantennal ridge emarginate; head between frons with very large tubercles (Fig. 6B); gula at narrowest point approximately 0.2X the width of the apex of the submentum (Fig. 7A). Japan.....  
..... *P. suberea* Lewis
- Outer margin of suprantennal ridge straight to convex (Figs. 6A, C, D); head between frons with at most small indistinct tubercles (Figs. 6A, C, D); gula approximately 0.65X width of the apex of the submentum (Fig. 7B). Mainland Asia..... 4
- 4 Elytral humerus with nearly 90° notch (Fig. 3A, 4A); striae with linear series of rounded punctures; sub-



- gena with raised tubercles. Russian Far East and Korean Peninsula. .... *P. amurensis* (Heyden)
- Elytral humerus rounded or flattened but not distinctly notched (Fig. 3B–D, 4B–D); striae with irregular punctures; subgenera with indistinct, flat tubercles (Fig. 7B) ..... 5
- 5 Setae of pronotal disc broad, scale-like, golden (Fig. 5A); elytral disc irregularly squarrose; ventrites with very large flat tubercles (Fig. 4E); pronotal disc between and anterior to lyriform ridges lacking distinct tubercles; disc of hypomerion with intertuberculate setae. Central China. .... *P. chinensis* (Semenov)
- Setae of pronotal disc narrow, hair-like, red (Fig. 5B); elytral disc plain and striate; ventrites with smaller tubercles (Fig. 4F); pronotal disc between and anterior to lyriform ridges with distinct tubercles; disc of hypomerion lacking intertuberculate setae. Western China. .... *P. yulongensis* Foley and Ivie **n.sp.**

## Taxonomy of the species

### *Phellopsis obcordata* (Kirby)

(Figs. 1A, 2A, 2C, 8A)

*Bolitophagus obcordatus* Kirby, 1837: 236.

*Boletophagus obcordatus* LeConte, 1853: 235. LeConte, 1862: 216. LeConte and Horn, 1883: 365. Casey, 1907b: 470.

Ślipiński and Lawrence, 1999: 23. (*lapsus calami*)

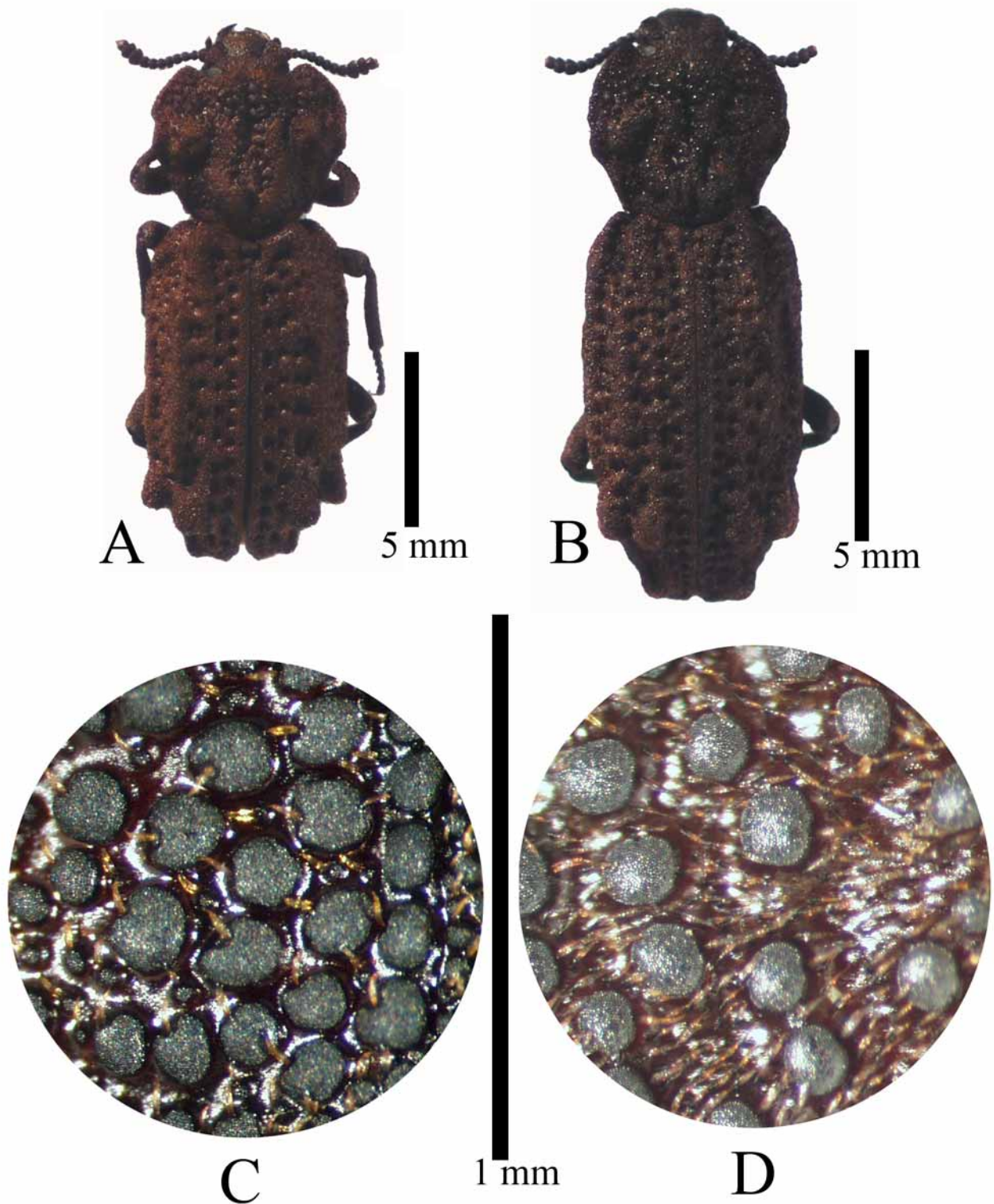
*Nosoderma obcordatum*: Heyden, 1885: 307. LeConte, 1853: 235.

*Phellopsis obcordata*: Horn, 1870: 273. Hubbard and Schwarz, 1878: 640. Henshaw, 1881: 255 [in part]. Lewis, 1887: 219. Champion, 1894: 114. Hamilton, 1895: 341. Leng, 1920: 223. Leonard, 1928: 401. Böving and Craighead, 1931: pl. 52. Chagnon, 1935: 278. Gebien, 1936: 668. Brimley, 1938: 190. Triplehorn, 1952: 1–3. Peterson, 1960: 180, fig. C48. Dillon and Dillon, 1961: 464, pl. xlvi. Chagnon and Robert, 1962: 330. Boddy, 1965: 78. Pielou, 1966: 1235. Pielou and Verma, 1968: 1184. Keleinikova and Mamaev, 1971: 125. Arnett, 1983: 17. Papp, 1984: 162. Lawrence, 1991: 518–519. Campbell, 1991: 252[in part]. Steiner, 1992: 25–30. Lawrence, 1994: 341. Downie and Arnett, 1996: 1080. Ślipiński and Lawrence, 1999: 21. Steiner, 1999: 138–139. Ivie, 2002: 458–460[in part]. Triplehorn and Johnson, 2005: 435.

**Diagnosis:** Distinguished from the other North American species, *P. porcata*, by the lack of intertuberculate setae on the hypomerion (Fig. 2C). Other useful characters include the presence of large distinct round punctures on the elytra, 10–13 between the apical edge of the scutellary striole and subapical nodule; the ridge in the 3<sup>rd</sup> elytral interval very weak or absent medially and more strongly arcuate around the scutellum; the strongly bisinuate lateral margin of the pronotum; the smooth basal connecting ridge between the 1<sup>st</sup> and 3<sup>rd</sup> elytral interval which lacks a depression; and the lateral subapical nodule of the declivity strongly directed away from the plane of the body. This species can be confused with *P. amurensis*, but has the tuberculation on the apical half of the pronotum stronger, and the lateral elytral margin smooth rather than serrate.

**Description (male):** Length 11–16 mm. Reddish brown to dark brown; dorsal setose vestiture sporadic; most elytral punctures large and clearly visible; vestiture consisting of short, slightly thickened setae, lacking significant intertubercle setation on prothoracic and elytral surfaces. Head on dorsal surface with weak indistinct tubercles between frons; outer margin of suprantennal ridges concave; lateral margin of epistoma anterior to suprantennal ridge short (0.12–0.17 mm); ventral surface of head with distinct and regular tubercles; gula wide; subgenal ridge rounded, with slight depression medially; subgenal ridge longer, extending below eye; eye set below genal surface. Post-occipital suture deep and narrowly divided. Last antennomere with micro-setose patch of sensilla oval; preapical patches oblong. Ligula shallowly emarginate.

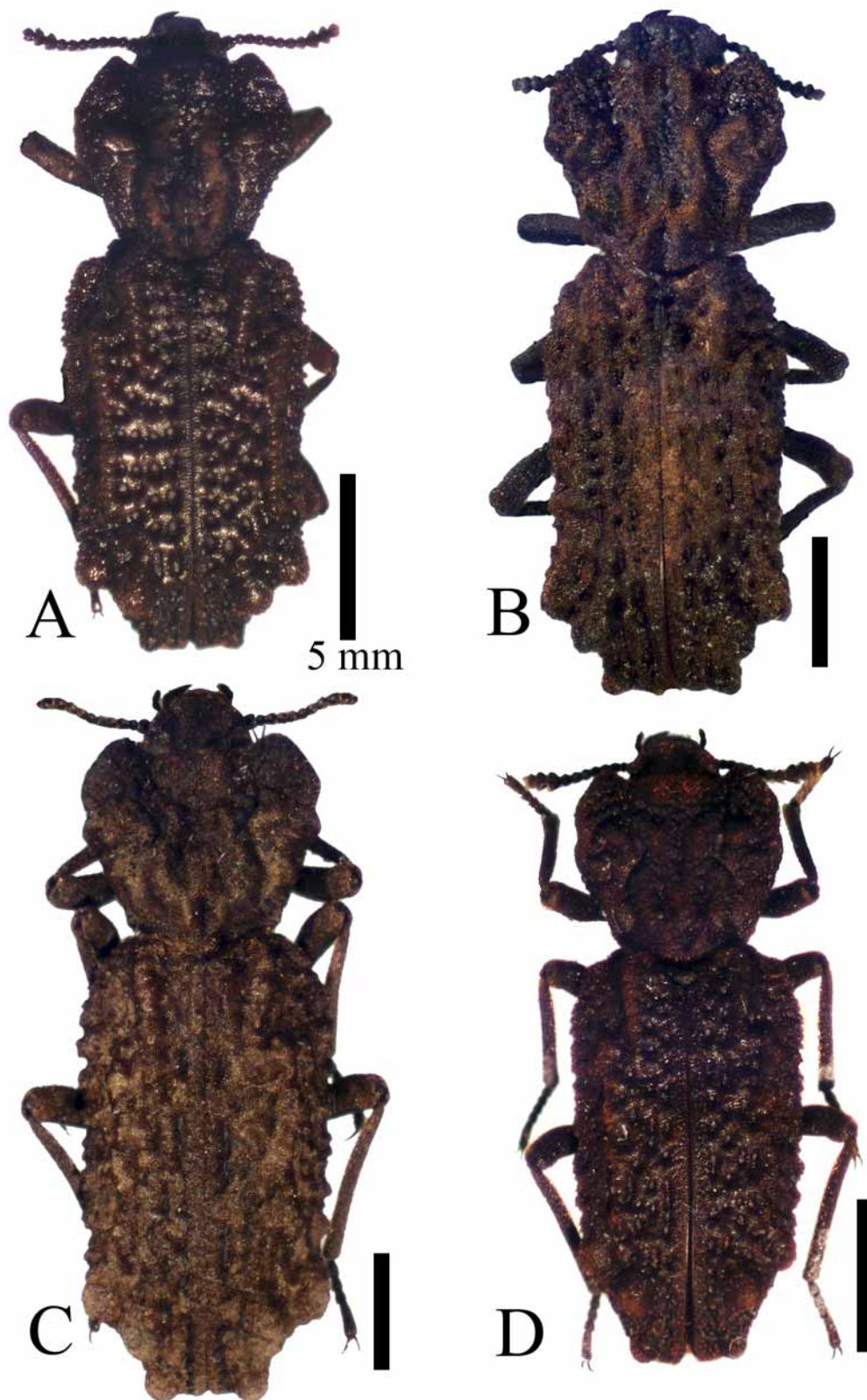
Pronotum evenly tuberculate; paired elevations on apical margin of pronotum broadly and weakly divided at midline; lateral margin of pronotum strongly bisinuate; hypomerion without intertuberculate setae, cuticular surface between tubercles with smooth microsculpture.



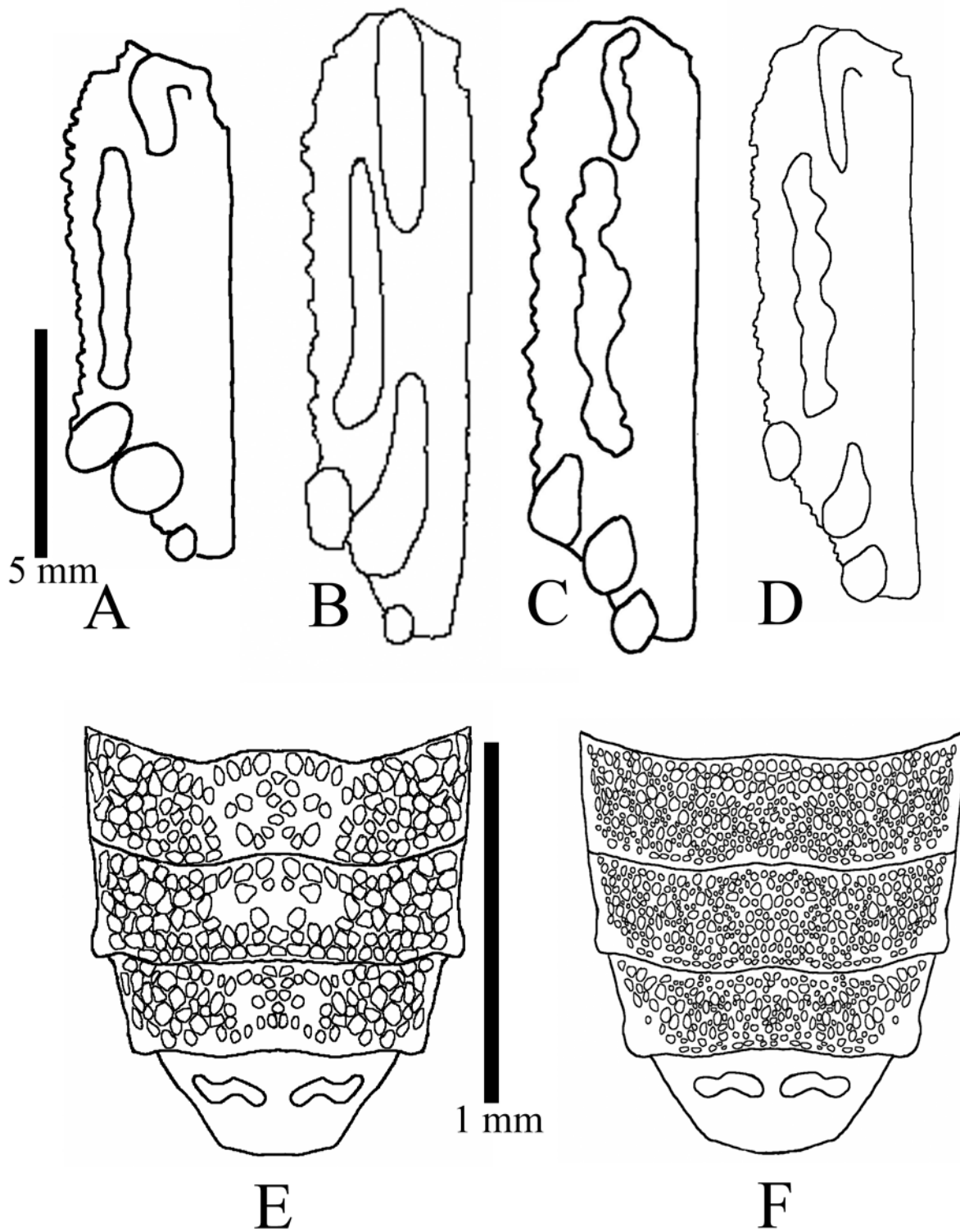
**FIGURE 2.** Dorsal habitus photos of North American *Phellopsis* spp. A. *Phellopsis obcordata*; B. *P. porcata*; Hypomeral setae of *Phellopsis* spp. C. *Phellopsis obcordata*; D. *P. porcata*.

Dorsal elytral surfaces with small, often obscure tubercles; humerus slightly flattened; scutellum oval, shallowly set below elytral ridges; scutellary striole distinct; 10–13 large, rounded elytral punctures along midline between scutellary striole and large nodule at start of apical declivity; median subapical elytral nodule usually noticeably larger than lateral nodule; lateral nodule of apical declivity usually strongly projected away from body plane at approximately 45° angle; paired nodules considerably larger than single nodule near apex;

ridges in 3<sup>rd</sup> and 5<sup>th</sup> elytral intervals, overlapping at most only at base and apex but not medially; nodule in 3<sup>rd</sup> interval never connected to ridge; area around elytral suture weakly elevated and flattened, never with large tubercles. Metasternum with small, relatively uniform tubercles; ventrite tuberculation reduced medially, uniformly spaced laterally. Tarsal setation more dense on ventral surface, setae relatively uniform in thickness.



**FIGURE 3.** Dorsal habitus photos of the Asian *Phellopsis* spp. A. *Phellopsis amurensis*; B. *P. suberea*; C. *P. chinensis*; D. *P. yulongensis*.



**FIGURE 4.** Elytral sculpture of Asian *Phellopsis* spp. A. *Phellopsis amurensis*; B. *P. suberea*; C. *P. chinensis*; D. *P. yulongensis*; Ventrites 2–5 of *Phellopsis* spp. found in China. E. *Phellopsis chinensis*; F. *P. yulongensis*.

Aedeagus (Fig. 8A), relatively short and broad; apex of parameres almost straight; apical margin of basal stop with moderate concave depression medially, and lightly setose.

FEMALE: Same as male except lacking setose pit on submentum.

LARVA: (modified from Peterson 1951 and Lawrence 1991). Body elongate, 15–25 mm when extended, subcylindrical, white or creamy in color; head, pronotum, asperities, and legs lightly sclerotized; tarsal claws,

urogomphi, and mouthparts heavily sclerotized.

Head subquadrate, lateral margins rounded, dorsoventrally flattened, prognathus, with sparse patches of short setae, 5 stemmata on each side, frontal arms lyriform. Antennae 3-segmented, anterolaterally inserted. Mandibles large, prognathus, apical tip bidentate. Maxilla thick and fleshy, with apical setae; cardo bifid.

Prothorax enlarged, partly enclosing head when retracted. Meso- and metathorax with arcuate rows of asperities, followed by sparse patches of asperities; spiracles annular-biforous.

Abdominal segments subequal in size, segments 1–6 with dorsal rows and patches of asperities, 9 with sclerotized granulate basal spots and well-developed recurved urogomphi; ventral surface of 2–8 with progressively strong patches of asperities, 8 with dense patch. Legs short, 5-segmented; coxae large and transverse, short setae concentrated on apical surfaces, claw elongate hook.

**Variation:** The dorsal elytral sculpture is less variable than in *P. porcata*. Southern Appalachian specimens (North Carolina, Tennessee, West Virginia, and Georgia) frequently have the humeri more flattened and pointed apically.

**Distribution (Fig. 1A):** Restricted to boreal forests of eastern portions of North America, widespread but uncommon from Newfoundland south to Northern Georgia and west to northern Wisconsin and the Upper Peninsula of Michigan. In more southern locales the species appears to be confined to higher elevations of the Appalachian Mountains.

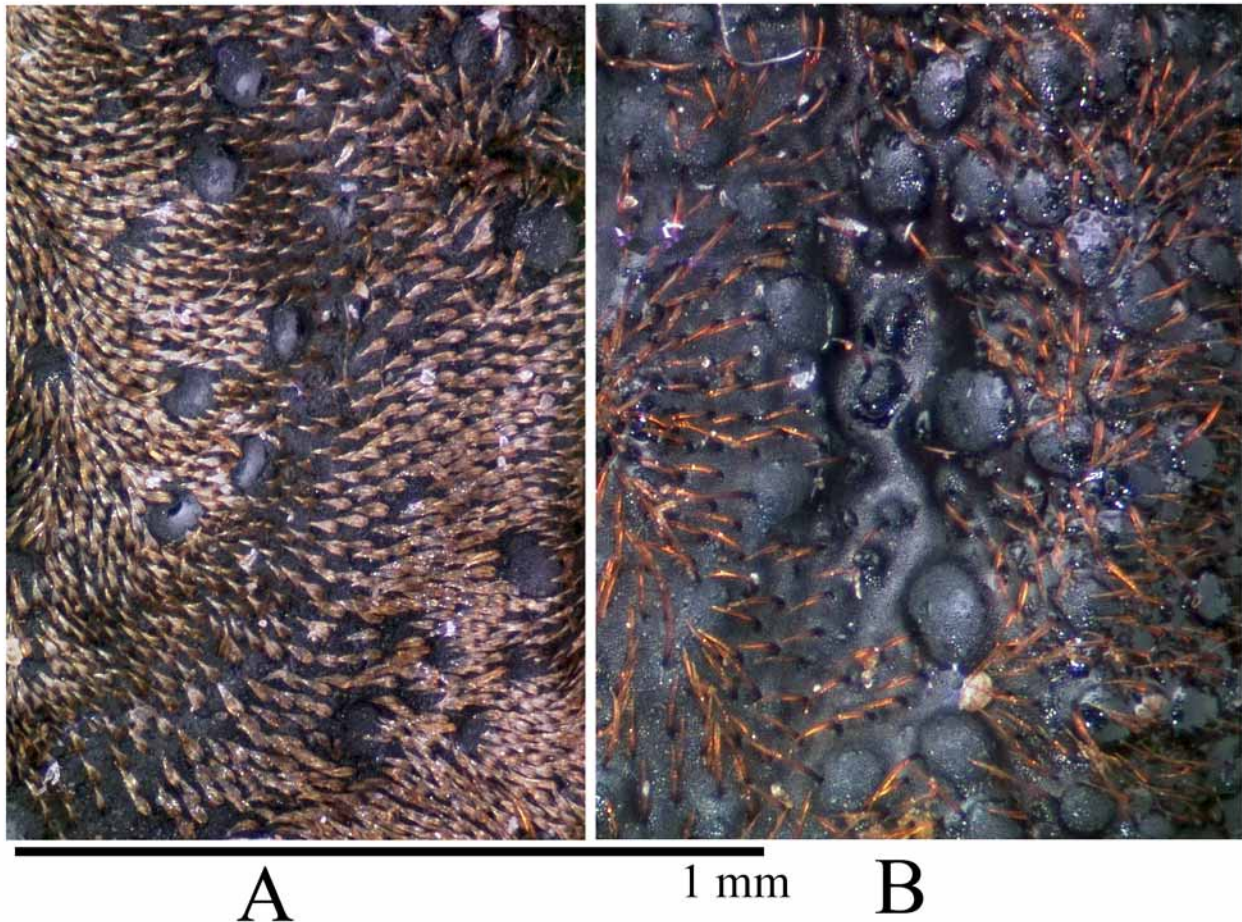
**Recorded distribution:** A summary of the distribution from the 752 specimens examined is presented here as COUNTRY: PROVINCE or STATE: county (when available). For complete label data see Foley (2006). CANADA: NEW BRUNSWICK, NEWFOUNDLAND, NOVA SCOTIA, ONTARIO, QUEBEC. UNITED STATES: CONNECTICUT: Litchfield. GEORGIA: Rabun. MASSACHUSETTS: Worcester. MARYLAND: Garrett. MAINE: Cumberland, Hancock, Kennebec, Knox, Lincoln, Penobscot, Piscataquis, Washington. MICHIGAN: Cheboygan, Emmet, Marquette, Schoolcraft. NORTH CAROLINA: Avery, Buncombe, Burke, Haywood, Macon, Watauga. NEW HAMPSHIRE: Coos, Grafton, Rock, Carr. NEW JERSEY: Hudson (Steiner 1992) NEW YORK: Erie, Essex, Franklin, Herkimer, St. Lawrence, Tompkins, Ulster, Wayne. PENNSYLVANIA: Dauphin, Forest, Huntingdon, Monroe, Westmoreland. TENNESSEE: Blount, Carter, Sevier, Tusculum. VIRGINIA: Albemarle, Giles, Highland, Lee, Madison, Page, Washington. VERMONT: Addison, Bennington, Lamoille. WISCONSIN: Florence, Forest. WEST VIRGINIA: Greenbrier, Pendleton, Pocahontas, Preston.

**Types:** LECTOTYPE, here designated: Specimen of undetermined sex in the BMNH. Circle label with “N. Scotia” on underside; “5969, B” on front/ Round red-ringed “Type” label/ *Bolitoph obcordatus*; N. Scotia 5969; Rev. W. Kirby/ white card “Lectotype” underlined in red, *Bolitophagus obcordatus*; Kirby 1873; designated by M.A. Ivie 2005.

**Notes:** The name *P. obcordata* has recently been applied to an assumed trans-North American species (Campbell 1991, Ivie 2002), but is here restricted to the species occurring in Eastern North America. The historical discussion of the North American species names has been tumultuous and has included very little diagnostic support. A summary of this history is provided in the taxonomic history of the genus above. The difficulty in separating the two North American species was frequently acknowledged by ambiguous characterizations of the relationship (LeConte 1853, Horn 1870, LeConte and Horn 1883), or stated as very clearly defined (Casey 1907a). We have found that 100% of specimens can be assigned to one of the 2 North American species recognized here using the characters in the key and diagnosis. These characters are correlated with a geographic division across the North American Great Plains. This division is well supported based on the glaciations and subsequent drying out of the North American Great Plains (Kavanaugh 1988, Marek and Kavanaugh 2005). Hopefully this taxonomic confusion has now been resolved.

Roughly 40% of specimens examined were collected pre-1940, and represented a more geographically broad distribution than the post-1940 specimens. This may be an indication of a negative correlation between human disturbance in Eastern North America and habitat availability. The post-World War II distribution of

this species appears to be restricted to highly fragmented old growth remnants of a historically widespread forested habitat and has drawn some interest as a biological indicator of old growth forest habitats (Steiner 1992).



**FIGURE 5.** Pronotal surface setation of *Phellopsis* sp. found in China. A. *Phellopsis chinensis*; B. *P. yulongensis*.

***Phellopsis porcata* (LeConte)**

(Figs. 1A, 2B, D, 8B)

*Nosoderma porcatum* LeConte, 1853: 235. LeConte, 1862: 216. LeConte and Horn, 1883: 365.

*Phellopsis porcata*: Horn, 1870: 273. Henshaw, 1881: 255. LeConte and Horn, 1883: 365. Champion, 1894: 114. Casey, 1907a: 44–45. Leng, 1920: 223. Gebien, 1936: 668. Guppy, 1951: 28. Peterson, 1960: 180, fig. C48. Boddy, 1965: 78, pl. x. Papp, 1984: 163. Campbell, 1991: 252. Downie & Arnett, 1996: 1080. Arnett, 1983: 17. Boddy, 1965: 78. Ivie, 2002: 458–460.

*Noserus plicatus* (not LeConte) Milne *et al. et al.*, 2000: 585, pl. 224.

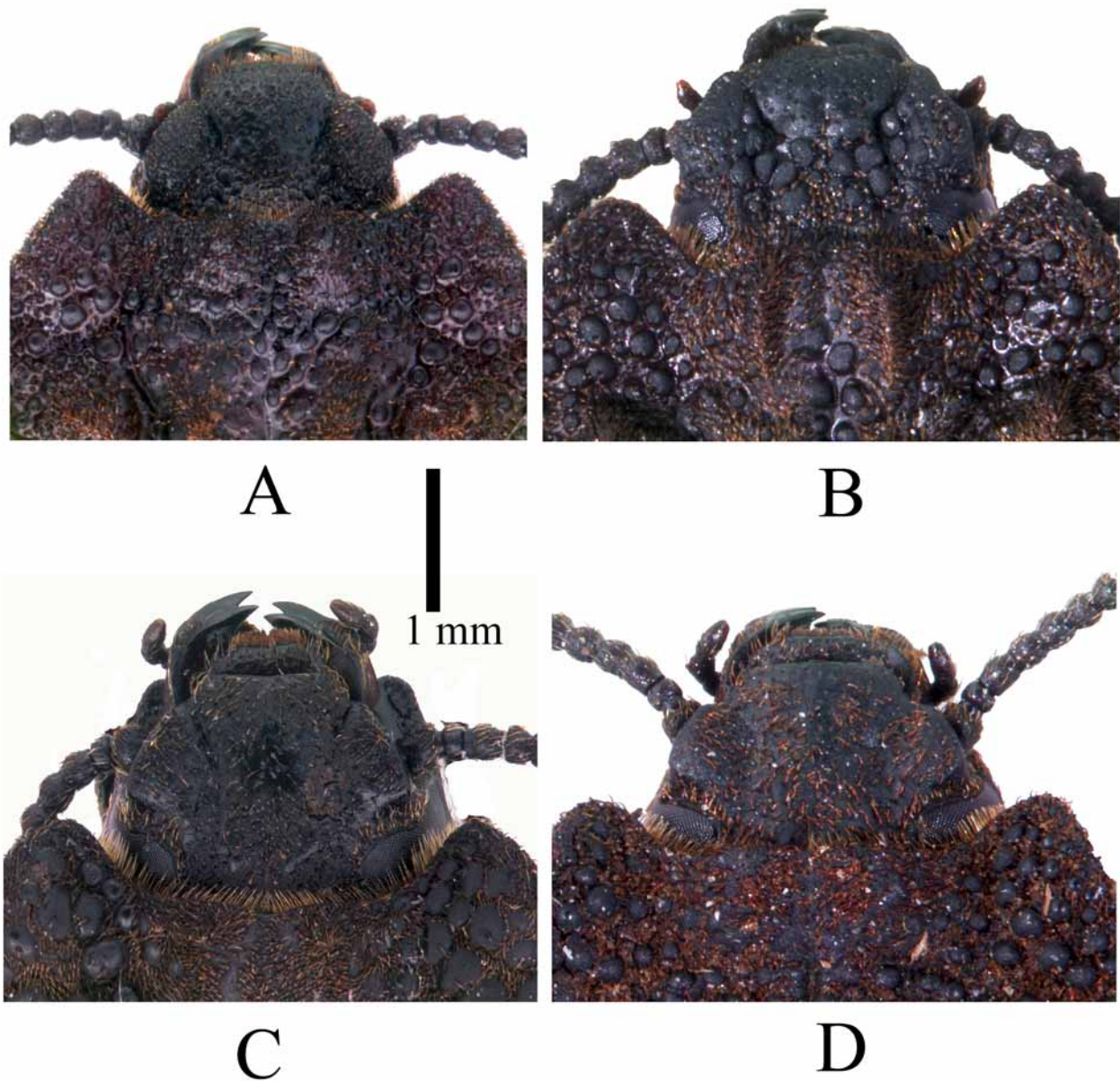
*Phellopsis robustula* Casey, 1907a: 45. Leng, 1920: 223. Gebien, 1936: 668. Boddy, 1965: 78. Arnett, 1983: 17. **NEW SYNONYMY**

*Phellopsis montana* Casey, 1907a: 46. Leng, 1920: 223. Gebien, 1936: 668. Arnett, 1983: 17. **NEW SYNONYMY**

*Phellopsis obcordata*, (Not Kirby). Henshaw, 1881: 255 [in part]. Campbell, 1991: 252 [in part]. Ivie, 2002: 460 [in part].

**Diagnosis:** Distinguished from the other North American species, *P. obcordata*, by having dense intertubercle setation on the hypomeron (Fig. 2B). Other useful characters include, the 14–18 smaller elytral punctures between the apical edge of the scutellary striole and subapical nodule, arcuate lateral margin of the pronotum,

more complete ridge in the 3<sup>rd</sup> elytral interval, generally denser setose vestiture, the basal connecting ridge between the 1<sup>st</sup> and 3<sup>rd</sup> elytral interval distinctly depressed, and the nodules of the apical declivity directed almost parallel with the body plane.

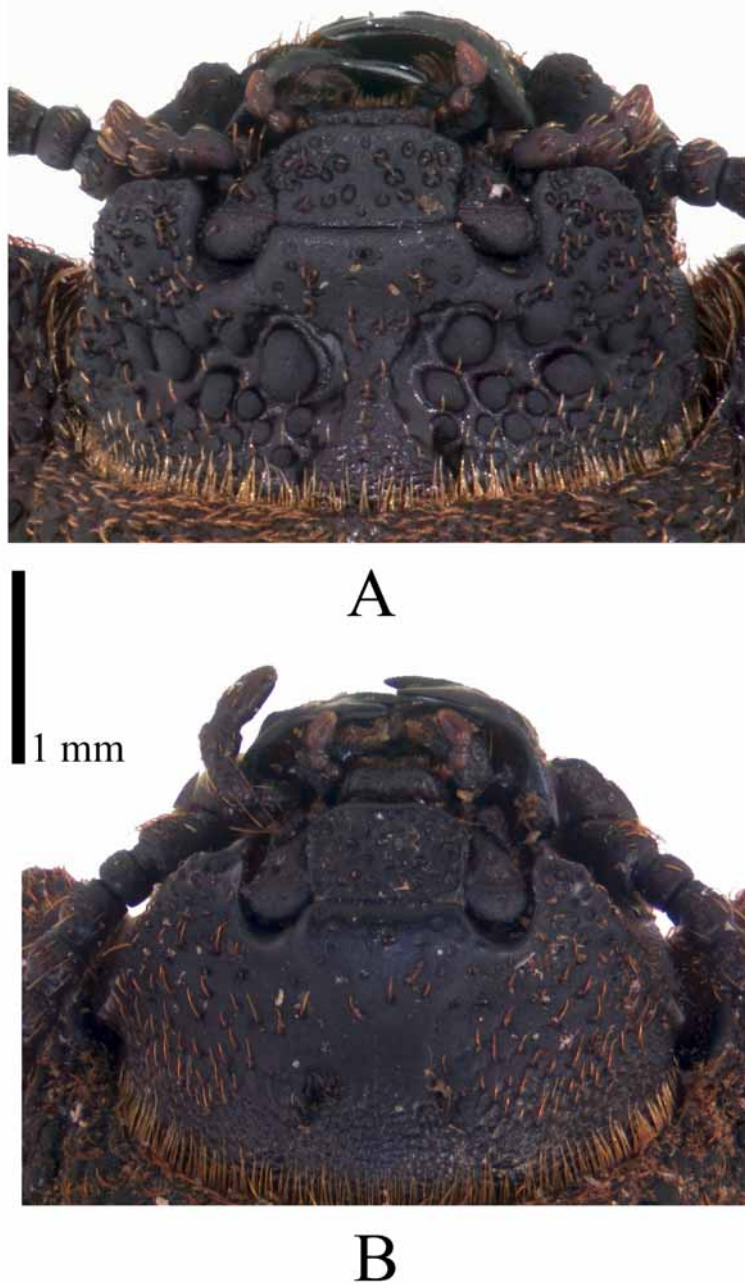


**FIGURE 6.** Dorsal head surface of the Asian *Phellopsis* spp. A. *Phellopsis amurensis*; B. *P. suberea*; C. *P. chinensis*; D. *P. yulongensis*.

**Description (male):** Length 12–18 mm. Reddish brown to black; dorsal vestiture very dense slightly obscuring elytral punctures; vestiture consisting of dense long, relatively thin setae; considerable amount of intertuberculate setation on pronotal and elytral surfaces.

Head on dorsal surface with weak indistinct tubercles between frons; outer margin of suprantennal frontal ridges concave; lateral margin of epistoma anterior to suprantennal ridge short (0.04–0.10 mm), almost in same plane; ventral surface of head with irregular tubercles; gula wide; subgenal ridge rounded, with slight depression medially; subgenal ridge longer, extending below eye; eye set below genal surface. Post occipital suture deep and narrowly divided. Last antennomere with micro-setose sensilla patch oblong. Ligula shal-

lowly emarginate; maxillary palpifer with thickened setae; basistipes with paired thickened setae inserted laterally and strongly recurved; lacinia narrowed with median tuft of setae.



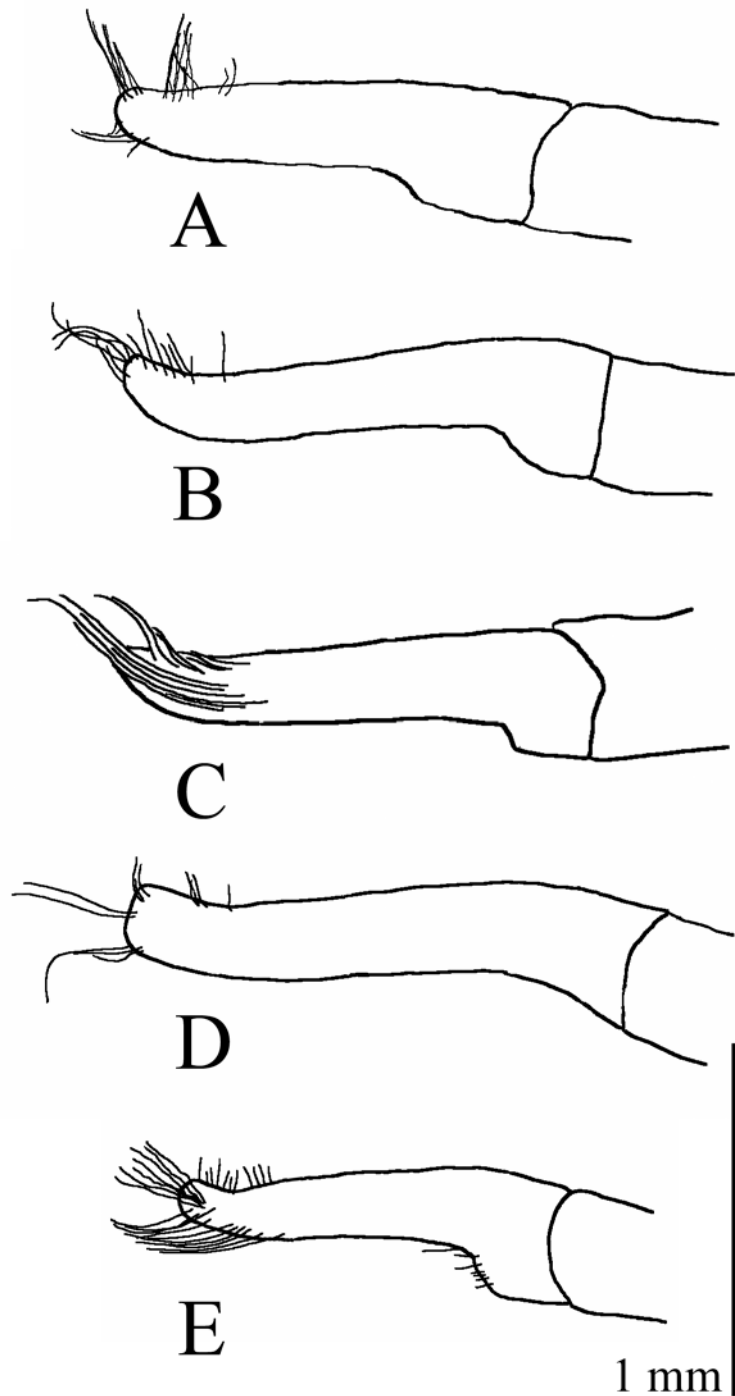
**FIGURE 7.** Ventral head surface of *Phellopsis* spp. A. *Phellopsis suberea*; B. *P. yulongensis*.

Pronotum evenly tuberculate across median portion; paired elevations on apical margin of pronotum broad and weakly divide by midline, nearly fused; lateral margin of pronotum arcuate to weakly bisinuate; hypomeron with dense intertuberculate setae.

Dorsal surface of elytra usually with obvious tubercles; humerus rounded; scutellum rounded set below elytral ridges, scutellary striole distinct; 14–18 elytral punctures along midline between scutellary striole and large median nodule at start of apical declivity; median and lateral nodule of declivity usually subequal in size; lateral nodule almost parallel with plane of body; paired nodules slightly smaller to subequal in size to single nodule near apex; ridges in 3<sup>rd</sup> and 5<sup>th</sup> elytral intervals usually overlapping weakly for most of length; nodule in 3<sup>rd</sup> elytral interval almost always connected to ridge; area around elytral suture strongly elevated usually with row of distinct tubercles. Metasternum with uniform moderately sized tubercles; ventrite tuber-



culation reduced medially, uniformly spaced laterally. Tarsus with ventral setae slightly thickened and spur like, heavier than dorsal setae.



**FIGURE 8.** Lateral view of male parameres of *Phellopsis* spp. A. *Phellopsis obcordata*; B. *P. porcata*; C. *P. suberea*; D. *P. chinensis*; E. *P. yulongensis*.

Aedeagus (Fig. 8B) elongate, apical margin of basal stop with weak concave depression medially; parameres laterally with short setae along margin of basal stop; apex of parameres curved dorsally.

FEMALE: Similar to male except lacking setose pit on the submentum.

LARVA: Differs from *P. obcordata* having more pronounced asperities on all surfaces with the patch on the ventral surface of A8 much denser; urogomphus more strongly recurved; lyriform frontal arms more bulbous.

**Variation:** Probably the most variable of all *Phellopsis* species; this could be attributed to the fact that this species is represented by the greatest number of available specimens, and/or because it has the largest geographical range. This variation includes the strength of the ridge in the 3<sup>rd</sup> elytral interval, size and shape of elytral punctures, and density of dorsal vestiture. Specimens from the inland forests east of the Columbia Plateau in Idaho, Montana, eastern Oregon and Washington, and eastern British Columbia and Alberta (including the Casey type of *P. robustula*) have the elytral humerus slightly flattened and sharpened apically, the depression between the 1<sup>st</sup> and 3<sup>rd</sup> connecting ridge weaker, the ridge in the 3<sup>rd</sup> sharpened apically, the pronotal margin more arcuate but not notched, and a generally denser setose vestiture. Specimens from Alaska and western British Columbia occasionally have the pronotal margins weakly bisinuate, a stronger connecting ridge between the 1<sup>st</sup> and 3<sup>rd</sup> elytral interval, more distinct elytral punctures, and reduced dorsal tuberculation. Two eastern Nevada specimens examined (RLAC) are typical of specimens found in California populations.

**Distribution (Fig. 1A):** Restricted to western North America where it can be locally common in suitable habitat. This species tracks the forests of the western cordilleras from Alaska as far south as the Transverse Ranges of California and in the east from the western edge of Alberta south through western Montana and Idaho north of the Snake River. An outlying population in Nevada's Ruby Mountains needs more study.

**Recorded distribution:** A summary of the distribution from the 2,573 specimens examined is presented here as COUNTRY: STATE or PROVINCE: County, Borough, or Census Area (when available). Complete label data may be found in Foley (2006).

CANADA: BRITISH COLUMBIA: ALBERTA. UNITED STATES: ALASKA: Haines, Ketchikan, Matanuska, Skagway-Hoonah-Angoon, Wrangell-Petersburg. CALIFORNIA: Alpine, Amador, Butte, Calaveras, Del Norte, Douglas, El Dorado, Glenn, Humboldt, Inyo, Lassen, Mendocino, Modoc, Nevada, Placer, Plumas, San Diego, San Bernadino, Santa Cruz, Shasta, Sierra, Siskiyou, Sonoma, Tehama, Trinity, Tuolumne, Yuba Co. IDAHO: Ada, Boise, Bonner, Boundary, Clearwater, Idaho. Kootenai, Latah, Shoshone, Valley. MONTANA: Flathead, Glacier, Lake, Lincoln, Missoula, Ravalli. NEVADA: Elko, Washoe. OREGON: Benton, Clackamas, Coos, Deschutes, Douglas, Hood River, Jackson, Jefferson, Josephine, Kane, Klamath, Lane, Lincoln, Linn, Union, Wallowa, Wasco, Yamhill. WASHINGTON: Asotin, Chelan, Clallam, Clark, Cowlitz, Jefferson, King, Kitsap, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Walla Walla, Whatcom, Yakima.

**Types:** *Nosoderma porcatum* LeConte. HOLOTYPE in MCZ ♂ missing right metatarsus. Gold circle/Red square type 4508 label/ *Phellopsis porcata* Lec./ Jan.-Jul. 2005 MCZ Image Database.

*Phellopsis robustula* Casey. HOLOTYPE in NMNH ♀ missing left proleg and antenna. "Id.[aho]/ Casey bequest 1925/ Orange rectangle Type USNM 46373/ hand written *robustula* Csy."

*Phellopsis montana* Casey. HOLOTYPE in NMNH ♀ intact. "Cal.[ifornia]/ Casey bequest 1925/ orange rectangle Type USNM 46372/ hand written *montana* Csy.". PARATYPE in NMNH ♀ missing right mesotarsus. USNM orange label stating "This ex.; clearly placed with *porcata* in Csy box; is doubtless the Placer Co. paratype of *montana*."/ Placer Co. Cal.

**Notes:** The confusion regarding the identity of this species is covered under *P. obcordata* and in the taxonomic history of the genus. The type specimens and others identified by Casey as *P. robustula* or *P. montana* show typical variation of the species throughout the known range. This species was considered for indicator status of old growth habitat in Oregon but was ultimately rejected as a useful species because it could not be "adequately collected" (USGS 2003).

### ***Phellopsis suberea* Lewis**

(Figs. 1B, 3B, 4B, 6B, 7A, 8C)

*Phellopsis suberea* Lewis, 1887: 219. Champion, 1894: 114. Lewis, 1894: 379, pl. xiii, fig. 1. Lewis, 1895: 447. Reitter,

1916: 131. Gebien, 1936: 668. Nakane, 1963: 235, pl. 118. Chûjô, 1985: 344, pl. 58. Masumoto, 1990: 87–91. Kim *et al.*, 1994: 176.

*Phellopsis suberosus* Fairmaire, 1894: C1. (*lapsus calami*)

**Diagnosis:** The species is probably the most distinct member of the genus and is easily separated from all other *Phellopsis* species by the large tubercles on the apex of the head limited by a strong transverse depression (Fig. 6B), the presence of a narrowed gula (Fig. 7A), and emarginate outer margin of the suprantennal ridges (Fig. 6B).

**Description (male):** Length 14.5–22 mm. Elongate species, light to dark brown; dorsal vestiture consisting of golden scale like setae. Dorsal surface of head (Fig. 6B) with strong tuberculation between frons; suprantennal frontal ridges with outer margin distinctly emarginate; lateral margin of epistoma anterior to suprantennal ridge short (0.12–0.15 mm); ventral surface of head with very large tubercles, lateral profile arched; gula strongly narrowed, narrowest point apical of gular pits; subgenal ridge produced apically, rounded margin; subgenal ridge shorter, not extending below eye, eye at same level as gena.

Ligula transverse with smooth apical edge; mandible with inner tooth rounded, small tooth apical of prosthema blunt, prosthema setose only on apex not wrapping around mola, molar surface smooth; maxilla with galea, palpifer, and basistipes ruggedly sculptured; galea with secondary row of setae; palpifer with setae of several widths, twice as wide as setae on galea and lacinia; two thick setae on basistipes set in deep fossae; cardo with depressed apical margin; lateral profile of galea arched; densely setose.

Pronotum evenly tuberculate, widest apical to midline and strongly angled to narrowed base; paired elevations on apical margin of pronotum narrowly pointed and well divide along midline; lateral margin of pronotum bisinuate; hypomeron with large tubercles, intertuberculate area glabrous. Mesepisternum with irregularly shaped elongate punctures and elevations.

Elytra narrow and elongate, only slightly wider than widest portion of pronotum; scutellum rounded, scutellary striole distinct; elytral humerus sharply produced posteriorly, not rounded or flattened laterally; lateral margins of elytra appearing strongly serrate; elytral punctures variable, typically elongate, but also rounded; 3<sup>rd</sup> and 4<sup>th</sup> rows of punctures indistinct from each other at midpoint, staggered and overlapping, not forming distinct rows; ridge in 1<sup>st</sup> elytral interval slightly elevated around scutellum; ridge in 3<sup>rd</sup> interval strongly elevated and almost straight in basal third, becoming weak in middle, and terminating in large tear drop shaped tubercle; ridge in 5<sup>th</sup> interval indistinct in apical portion, originating where ridge in 3<sup>rd</sup> weakens, becoming strong and arcuate outwards, terminating in weak tubercle followed by a gap and then a large tubercle joining 5<sup>th</sup> and 7<sup>th</sup> lateral serrate ridge; paired nodules of apical declivity considerably larger than single nodule near apex. Metasternum bituberculate with small and large sized tubercles. Base of pro-tibia strongly narrowed and curved. Ventrites 1–3 obtusely ridged along midline. Tarsus with ventral setae modified as small spurs, distinctly heavier than dorsal setae.

Aedeagus (Fig. 8C); apical margin of basal stop with v-shaped depression medially; lateral portion of parameres with elongate depression near base; tip of median lobe laterally flattened.

**FEMALE:** Similar to male except lacking setose pit on the submentum.

**LARVA:** Unknown.

**Variation:** This species has been recorded from all of the large islands of Japan, and individual populations are presumed to be isolated on these islands, but no observable morphological variation between populations has been noted.

**Distribution (Fig. 1B):** All major islands of the country of Japan.

**Recorded distribution:** A summary of the distribution from the 58 specimens examined (AAPC, BMNH, CAS, EIHU, HNHM, NHMB, OSUC, USNM) is presented here. Complete label data may be found in Foley (2006). JAPAN: SHIKOKU: Ehime. HONSHU: Gumma, Mie, Shizuoka, Tochigi. KYÛSHÛ: Fukuoka, Ôita. HOKKAIDÔ: Sapporo.

**Types:** *Phellopsis suberea* Lewis. LECTOTYPE here designated, specimen of undetermined sex in BMNH, mounted on card. Label data: "Yuyama" written in pencil on underside of card /round red-ringed type label/ *Phellopsis suberea* Lewis Type/ "Japan" underlined in yellow; G. Lewis 1910–320; Yuyama 10.V.–14.V.81/ white card "Lectotype" underlined in red; *Phellopsis suberea*; Lewis 1887; designated by M.A. Ivie 2005. PARALECTOTYPES here designated: 8 specimens: 6 in BMNH with same data as lectotype; 1 in BMNH labeled in pencil Sapporo/"Japan" underlined in yellow; G. Lewis. 1910–320/Sapporo 5.VIII.–16.VIII.1880; 1 in the HNHM, Yuyama; 10.V.–14.V.81/ Japan underlined in yellow; G. Lewis; 1910–320/British Museum/ *Suberea*/ Sammiuna Adr. Schuster/ Rectangle red banded Paratypus label 1887; *Phellopsis suberea*; Lewis/ white card, Paralectotype underlined in red; *Phellopsis suberea*; Lewis 1887; designated by M.A. Ivie 2005.

The specimen that probably correlated with that mentioned by Lewis in the original description from "Chiuzenji" was excluded from the type series because the label date did not match the data that were published. Other specimens in the BMNH bearing the Lewis "Yuyama" label were excluded from the type series because they are clearly smaller than the described length, and were pinned unlike the card mounted types, or they were collected by Lewis from localities not mentioned in the description of the species.

The incorrectly identified syntype mentioned by Lewis (1887) in the original description from Siberia and later corrected to *P. amurensis* (Lewis 1895), was not present with the rest of the Lewis material in the BMNH. If found, it would qualify for paralectotype status.

**Notes:** This species has been mistakenly recorded from South Korea (Weon *et al.* 2000), but these records almost certainly refer to *P. amurensis*. The rather convoluted history of this species is covered in the taxonomic history of the genus above.

### ***Phellopsis amurensis* (Heyden)**

(Figs. 1B, 3A, 4A, 6A)

*Pseudonosoderma amurense* Heyden, 1885: 306. Semenow, 1893: 499. Champion, 1894: 114. Fairmaire, 1894: C1. Lewis, 1895: 447.

*Phellopsis amurensis*: Reitter, 1916: 130. Leng, 1920: 223. Gebien, 1936: 668. Keleinikova and Mamaev, 1971: 124–128. Gaedike, 1986: 360. Masumoto, 1990: 91. Egorov, 1992: 505. Ślipiński and Lawrence, 1999: 23.

*Phellopsis imurai* Masumoto, 1990: 87. **NEW SYNONYMY**

*Phellopsis subaenea* Weon *et al.*, 2000: 119. (*lapsus calami* for *Phellopsis suberea*, MISIDENTIFICATION)

**Diagnosis:** This species is similar in general elytral structure to *P. obcordata* but has the lateral elytral margins serrate and suprantennal frontal ridges strongly elevated like the other Asian species. It is distinguished from these species by the more stout form, rounded elytral punctures and presence of strongly notched humeri (Figs. 3A, 4A).

**Description (male):** Length 14.5–19 mm. Dark brown to black; dorsal vestiture consisting of golden hair-like setae. Head with dorsal surface (Fig. 6A) with tuberculation between the frons weak; outer margin of suprantennal frontal ridges smooth; post occipital suture narrow and deep; lateral margin of epistoma anterior to suprantennal ridge longer (0.24–0.29 mm); ventral surface of head with distinct raised tubercles; gula wide, narrowest point at gular pits; subgenal ridge produced apically, rounded margin; subgenal ridge shorter, not extending below eye; eye at same level as gena. Ligula subquadrate with slightly emarginate apical edge; mandibular prostheca with brush of setae at apex.

Pronotum evenly tuberculate, apical margins acutely rounded; paired elevations on apical margin of pronotum distinctly separated along midline; lateral margin weakly bisinuate; hypomeron lacking intertuberculate setae.

Lateral profile of elytra flattened medially in dorsal plane; elytral humerus flattened with a distinct notch;

lateral margins of elytra serrate; scutellum oval set well below elytral ridges; scutellary striole distinct and deep; 10–12 rounded elytral punctures between striole and start of nodule at apical declivity; 3<sup>rd</sup> and 4<sup>th</sup> rows of punctures forming distinct rows at midpoint; ridge in 5<sup>th</sup> elytral interval starting at mid-point of meta-sternum and extending to the apical margin of ventrite 3, distinct gap between ridge and nodule of declivity; nodule in 3<sup>rd</sup> elytral interval connected to ridge; median subapical nodule larger than lateral one; nodule at apex of elytron smaller than median subapical nodule; paired subapical nodules of declivity overlapping for a significant width in the same lateral plane, almost entire width. Mesepisternum with regular small punctures; metasternum bituberculate. Ventrites 1–3 flat, with numerous uniformly distributed small tubercles. Tarsus with ventral setae modified as spurs, distinctly heavier than dorsal setae.

Aedeagus with basal stop of parameres only moderately enlarged, shorter in length; apical margin of stop smooth.

**FEMALE:** Similar to male except lacking setose pit on the submentum.

**LARVA:** Described by Keleinikova and Mamaev (1971).

**Distribution (Fig. 1B):** Probably relatively widely distributed geographically from the coastal mountains of the Amur River valley in Russia, through southern portion of the Korean Peninsula (including North Korea).

**Recorded distribution:** Complete label data may be found in Foley (2006). A summary of the distribution from the 19 specimens examined (BMNH, HNHM, NHMB, ZIN) is presented here, **RUSSIA:** coastal Mountains from Amur River valley to Khrebet Sikhote Alin Mountains north of Vladivostok. **SOUTH KOREA:** Chonwangbong.

**Variation:** Little morphological variation is seen in specimens throughout the species range.

**Types:** *Pseudonosoderma amurense* Heyden. Holotype in DEI not examined.

*Phellopsis imurai* Masumoto. **PARATYPE** ♂ in HNHM with median lobe on card, missing both mesotarsi and left meta-leg. Chonwangbong, 950–1500m, Mt. Chiri-san; Kyongsangnam-do; 7.VI.1989 [KOREA]; Imura & Mizunuma lg/ pink rectangle label “Paratype”; handwritten “*Phellopsis*”; *imurai* Masumoto. The holotype is deposited in the National Science Museum, Tokyo and was not examined.

**Notes:** While correctly identifying the generic synonymy of *Pseudonosoderma*, Champion (1894) incorrectly synonymized *P. suberea* with *P. amurensis*. Lewis (1895) corrected a previous misidentification of *P. amurensis* as a syntype of *P. suberea* and recognized both species as distinct returning all of the available Asian names to valid status within *Phellopsis*.

Masumoto (1990) commented that *P. imurai* was a relative of *P. amurensis*, but compared it to *P. suberea*, from which it clearly differs. A paratype of *P. imurai* is the only Korean specimen examined, and is lighter in color (possibly teneral) than many typical specimens of *P. amurensis*, but morphologically does not differ from Russian specimens.

While only reported from the Sikhote-Alin Mountain Range of the Primorski Krai, Amur River valley and mountainous regions of South Korea, it is expected that *P. amurensis* occurs in suitable habitat areas all along the western slope of the Sea of Japan. This includes North Korea, and possibly far-eastern areas of the Jilin and/or Heilongjiang provinces of China in the Changbai Shan Mountains where deforestation may be less than total. Specimens from Korea (identified as *P. suberea*, almost certainly incorrectly) have been reported from Cheongrangli, Hongcheon, Kangwon, Kwangheung, Kyeongki, and Seoul (Weon *et al.* 2000).

### ***Phellopsis chinensis* Semenow**

(Figs. 1B, 3C, 4C, E, 5A, 6C, 8D)

*Pseudonosoderma chinense* Semenow, 1893: 499.

*Phellopsis chinensis*: Champion, 1894: 114. Reitter, 1916: 131. Gebien, 1936: 668. Masumoto, 1990: 87–91.

**Diagnosis:** This species can be distinguished from all other species of *Phellopsis* by the absence of the basal stop on the parameres of the male (Fig. 8D). It can be differentiated externally from *P. amurensis* by the rounded to flat elytral humeri (Figs. 3C, 4C), elongate and irregular elytral punctures, rugged nature of the elytral ridges (Fig. 3C, 4C), and smooth ventral surface of the head, and from *P. yulongensis* by the very large tubercles on the ventral body surface (Fig. 4E) and overall golden scale like vestiture (Fig. 5A).

**Description (male):** Length 12.5–21 mm. Robust species; dorsal setose vestiture golden consisting of dense flattened broad scale-like setae (Fig. 5A); dorsal elytral sculpture very rugged and squarrose.

Head with dorsal surface (Fig. 6C) with tuberculation almost completely reduced; lateral margin of epistoma anterior to suprantennal ridge long (0.32–0.35 mm); tubercles on ventral surface of head large and flattened creating a relatively smooth surface; gular sutures weakly defined; gula wide, narrowest point near gular pits; subgenal ridge produced apically, rounded margin; subgenal ridge shorter, not extending below eye; eye at same level as gena. Ligula subquadrate with slightly emarginate apical edge.

Pronotal disc between and anterior to lyriform ridges lacking distinct tubercles; paired elevations on apical margin of pronotum distinctly separated along midline; lateral margin of pronotum bisinuate, thickened; hypomeron with very large tubercles, dense intertuberculate setae present; prosternal process slightly bi-impressed. Metasternum bituberculate with very large and very small tubercles.

Lateral profile of elytra rounded in dorsal plane; elytral humerus broadly rounded; scutellum rounded; scutellary striole distinct and deep; lateral margin strongly serrate; ridge in 5<sup>th</sup> elytral interval starting at or just before metacoxae and extending to mid point of ventrite 3; nodule at apex of elytron slightly smaller to subequal in size to lateral subapical nodule; median subapical nodule larger than lateral and apical ones; paired subapical nodules overlapping for a modest width in the same lateral plane, slightly offset. Tubercles on ventrites large and flattened (Fig. 4E). Tarsus with ventral setae modified as small spurs, distinctly heavier than dorsal setae.

Aedeagus (Fig. 8D); ventral surface of parameres broadly arcuate in lateral view, lacking basal stop.

FEMALE: Similar to male but lacking setose pit on submentum.

LARVA: Unknown

**Variation:** Two specimens from Gansu (1 ♂, 1 ♀) have the dorsal elytral sculpture reduced in intensity, and the lateral aspect of the elytra slightly flattened.

**Distribution (Fig. 1B):** Mountains of Central China from the following provinces GANSU, SICHUAN, and SHAANXI.

**Recorded distribution:** CHINA: GANSU: Min Shan Mts., h-2700; 70km W. from Wudu; 15.06.2005.; Leg. A. Gorodinski (3 MAIC. 1 BMNH). Min Shan Range; 70km N.W. Wudu; 1 vi 1997; 2100m; Leg. A. Gorodinski (2 AAPC). Hin Shan Range; 2100m 70km N.W.; Hodo I-VI-97; Leg. A. Gorodinski (1 AAPC). Min Shan Mts.; 76km N.W. Wudu; 25 vii 2000; Leg. A. Gorodinski (1 AAPC). SICHUAN: Near Pingwu; 1.07.2005.; Leg. A. Gorodinski (3 MAIC). SHAANXI: 100km.S.W. of Xian; Taibai Shan Mt.; Near Houzhezi village; 30.07.2005.; Leg. A. Gorodinski (1 MAIC).

**Type:** *Pseudonosoderma chinense* Semenow HOLOTYPE ♂ in ZIN, missing left protarsus. Hand written on card [in Russian] “pass near village Morpin to south”; 4.VII85/ folded piece of paper “2-4.811.85”; [in Russian] top of a pass from village of Morpin to the south/ handwritten on graph paper “*Pseudonosoderma chinense*”; m; typum, unknown character-II-92/ gold hexagon dot/ red rectangle label “Holotypus”/ yellow rectangle “Zoological Institute”; Russian Academy; of Sciences.; St. Petersburg, RUSSIA.

**Notes:** The specimen identified as *P. chinensis* (HNHM), and assumed to have been examined by Masumoto (1990), does not accurately represent the holotype of *P. chinensis* Semenow (ZIN). That specimen is here designated a paratype of *P. yulongensis* NEW SPECIES. The misidentification of *P. chinensis*, addition of *P. yulongensis* new species, and inclusion of *P. imurai* (here synonymized with *P. amurensis*) renders the current key to Asian species (Masumoto 1990) outdated.

***Phellopsis yulongensis* Foley and Ivie n. sp.**

(Figs. 1B, 3D, 4D, F, 5B, 6D, 7B, 8E)

**Diagnosis:** This species can be distinguished from *P. amurensis* by having reduced tuberculation on the ventral surface of the head (Fig. 7B), the humeri flattened not notched, and the elytral punctures elongate rather than rounded. It is distinguished from *P. chinensis* by having a more uniformly tuberculate pronotal disc, reduced sculptural intensity (Figs. 3D, 4D), smaller and more frequent tubercles on the ventrites (Fig. 4F), the reddish vestiture composed of thin setae (Fig. 5B), and the presence of a distinct stop at the base of the male parameres (Figs. 8E).

**Description (male):** 14–19 mm long. Reddish to black; dorsal vestiture consisting of thin reddish thread like setae, red especially on vertex of head and pronotum (Fig. 5B); elytral sculpture consisting of sinuate ridges and distinct nodules.

Head with dorsal surface with tuberculation almost completely reduced (Fig. 6D); lateral margin of epistoma anterior to suprantennal ridge long (0.34–0.37 mm); antennomeres 9 and 10 with elongate sensilla patch extending partially around base of previous segment; antennomere 11 conical at apex; tubercles on ventral surface of head large and flattened creating a relatively smooth surface; gular sutures weakly defined; gula wide, narrowest point at gular pits; subgenal ridge produced apically, rounded margin; subgenal ridge shorter, not extending below eye; eye at same level as gena.

Mandible with molar surface smooth without distinct ridges, membranous prostheca with short dense fringe of setae; maxilla with galea, palpifer, and basistipes weakly sculptured; galea with secondary row of setae; lacinia with two small hooks laterally in the same plane, surrounded by a whorl of setae restricted to the margin creating hollow space in lateral width; palpifer with four thick setae, twice as wide as setae on galea and lacinia; basistipes with two thinner setae set in small fossae. Post occipital suture shallow and broad.

Pronotum with tuberculation uniformly distributed and similar in size; pronotal disc between and anterior to lyriform ridges with distinct tubercles; paired elevations on apical margin of pronotum broad and weakly divide by midline, nearly fused; lateral margin of pronotum arcuate to weakly bisinuate, weakly explanate; hypomeron with moderate sized tubercles, lacking intertuberculate setae; prosternal process bisinuate. Lateral profile of elytra flattened medially in dorsal plane; lateral margin weakly serrate; humerus flattened; scutellum oval, scutellary striole shallow; ridge in 5<sup>th</sup> elytral interval starting approximately at mid point of metasternum and extending to the midpoint of ventrite 3; paired nodules of declivity not overlapping for a considerable width in the same lateral plane, strongly offset; median subapical nodule larger than lateral or apical ones; nodule at apex subequal in size to lateral subapical nodule. Metasternum bituberculate, with moderate and small sized tubercles.

Tubercles on ventrites average sized and rounded (Fig. 4F); laterotergite 3 not greatly expanded, in dorsal view with elytron removed; intercoxal process of V1 broad, flattened at the apex, strongly elevated. Tarsus with ventral setae slightly thickened, not distinctly spur like, heavier than dorsal setae.

Aedeagus (Fig. 8E); basal stop of parameres with well developed fringe of setae; apical margin concave medially.

**FEMALE:** Similar to male but lacking setose pit on submentum.

**LARVA:** Unknown.

**Variation:** The type series is morphologically very consistent.

**Distribution:** CHINA: YUNNAN.

**Types:** HOLOTYPE: CHINA-Yunnan 24.-29.6; 50 km N Lijang, 1993; Yulonshan Nat. Res.; E. Jendek & O. Sausa leg/ red rectangular label with a box around text "PARATYPE; *Phellopsis yulongensis*; ♂; Foley & Ivie 2007" (from MAIC, deposited in Center of Zoological Evolution and Systematics, Zoological Museum of China, Academia Sinica, Beijing). PARATYPES; CHINA-Yunnan 24.-29.6; 50 km N Lijang, 1993; Yulonshan Nat. Res.; E. Jendek & O. Sausa leg/ red rectangular label with a box around text "PARATYPE; *Phellopsis*

*sis yulongensis*; Foley & Ivie 2007" (4 MAIC). CHINA-Yunnan 1.-19.VII; HEISHUI, 35 km N Lijang; 27°13'N 100°19'E; 1993; E. Jendek leg 1992/ blue rectangular label with a box around text "PARATYPE; *Phellopsis yulongensis*; Foley & Ivie 2007" (4 MAIC --1 disarticulated). CHINA-Yunnan 1.-19.VII; HEISHUI, 35 km N Lijang; 27°13'N 100°19'E; 1993; S. Becvar lgt. 1992/ blue rectangular label with a box around text "PARATYPE; *Phellopsis yulongensis*; Foley & Ivie 2007" (1 HNHM). CHINA, N.W. Yunnan, 3200m; Haba Shan - Haba; N 27°22'54.3", E 100°06'03.2"; 15.7.2006, lgt. Janata M./ BMNH{E}; 2006-157; M. Janata (2 BMNH).

**Etymology:** This species is named for the type locality, the Yulongshan Nature Reserve, in acknowledgement of the role that the conservation of old growth habitat areas will play in the preservation of so many rare animals in all regions of the world. The persistence of relatively natural boreal and temperate forest ecosystems will be vital to the continued survival of this genus.

**Notes:** The two species found to occur in China are narrowly divided by the boundary between the Southwest China and Central China zoogeographic regions (Jäch and Ji 1995). The area of Southwest China where *P. yulongensis* is found has been considered one of the most diverse temperate regions in the world (UNESCO 2007).

### Synoptic catalog of the *Phellopsis* species

*Phellopsis* LeConte 1862

*Pseudonosoderma* Heyden 1885

*Phellopsis obcordata* (Kirby) 1837

*Phellopsis porcata* (LeConte) 1853, RETURNED TO VALID STATUS

*P. robustula* Casey 1907, NEW SYNONYMY

*P. montana* Casey 1907, NEW SYNONYMY

*Phellopsis amurensis* (Heyden) 1885

*P. imurai* Masumoto 1990, NEW SYNONYMY

*Phellopsis suberea* Lewis 1887

*Phellopsis chinensis* (Semenow) 1893

*Phellopsis yulongensis* Foley and Ivie, NEW SPECIES

### Biogeography

The genus *Phellopsis* shows a disjunct distribution pattern across the northern Pacific Ocean. This Nearctic-Eastern Palearctic distribution pattern has been found in a variety of organisms (Sanmartin et al. 2001, Xiang et al. 1998, Enghoff 1993, Enghoff 1995, Campbell 1993, etc.) and was identified as a possible result of the vicariance of a pan-Holarctic ancestor (Enghoff 1993) with subsequent extinctions in adjacent areas (Sanmartin et al. 2001) such as Europe and the North American Great Plains (Marek and Kavanaugh 2005).

Faunal and floral diversity is variable between the different Holarctic infraregions, with the Eastern Palearctic usually the richest, and the Western Palearctic the most depauperate (Sanmartin et al. 2001). *Phellopsis* fits this pattern well with four species present in the Eastern Palearctic and none documented from the Western Palearctic.

All speciation events in the genus appear to be the result of broad allopatric isolation, either on large islands (Japan), or by broad areas that were once, or still are, unsuitable habitat. In North America it seems that the boreal forest areas of northern Canada would be suitable habitat for the genus, but specimens have not been reported east of Alberta, or west of Ontario. The absence of the genus in the north-central boreal forests



could be the result of the previous isolation of the group to glacial refugia (Marek and Kavanaugh 2005). This isolation would have been followed by the inability of the species to recolonize suitable habitat based on its limited dispersal abilities. There may be a temperature limit on *Phellopsis* or its hosts that has restricted rebound into this area from the more temperate coastal areas, or there may simply not yet have been enough time for individuals to extend the species range that far.

### Habitat conservation

The fact that this genus appears to require old growth habitat could be a reason why the North American species were collected more commonly in the past (pre-1940). Recent collections frequently occur in protected “natural areas” of preserved old growth habitat in places such as Glacier and Great Smoky Mountain National Parks, and other protected U.S. Forest Service lands (label data). The fragmentation of old growth boreal forests and limited dispersal abilities of the genus suggest that current populations are highly isolated and gene flow between them is perhaps non-existent. The wide-range persistence of the genus *Phellopsis* will require conservation efforts directed at the limited remaining suitable old growth forest habitats around the world.

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