

**Sixty years of discovering scolytine
and platypodine diversity:
A tribute to Stephen L. Wood**

Edited by
Anthony I. Cognato & Miloš Knížek



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SIXTY YEARS OF DISCOVERING SCOLYTINE AND PLATYPODINE DIVERSITY:
A TRIBUTE TO STEPHEN L. WOOD

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A Festschrift for Stephen L. Wood

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We intended this Festschrift as a celebration of Dr. Stephen L. Wood's 85th birthday. Sadly Dr. Wood past away a little before his 85th birthday thus this volume pays tribute to his life's contribution to the study of bark and ambrosia beetles, which is summarized in the next article by Donald Bright. We arranged the volume geographically, starting with taxonomy of North American scolytines, followed by articles on new species introductions, biology, phylogeny. The articles treat species throughout the world, which reflects Dr. Wood's breadth of taxonomic knowledge. The contributing authors also reflect worldwide taxonomic expertise. Dr. Wood personally influenced and trained three generations of scolytine taxonomists, including some of these authors. He left a lasting impression on the careers of several of us, which we relay below.

Donald E. Bright: I first met Steve in 1957 while I was serving in the U. S. Army. Previously, I had been attending Colorado A & M College (now Colorado State University) where I met T. O. (Ted) Thatcher, a professor in the Department of Entomology. Ted became a friend in addition to an advisor and mentor. He mentioned that his brother-in-law was interested in bark beetles and had just accepted a position at BYU. During my Army service, I was fortunate to be stationed at Dugway Proving Grounds, Utah and I took the first opportunity I had to visit Steve at BYU. During the next two years, I, often with Steve, collected throughout Utah. I also was able to occasionally take my specimens to BYU to have Steve check my identifications. I especially remember one trip to the La Sal Mountains in southern Utah to collect a bark beetle species, *Pityoborus secundus* Blackman, known at that time from a few specimens from that one locality. On the 4th of July, 1958, Steve and I drove to the La Sal Mountains in my

old car. We found the beetles in some shaded-out branches of a Ponderosa pine at the bottom of a steep canyon. On the way out, the fuel pump on my car gave out and we barely made it out of the canyon. We spent that night somewhere near Moab, Utah, with me under the car replacing a fuel pump and Steve sleeping in the motel. Many other collecting trips were made which influenced and enhanced my enthusiasm for the study of this group of beetles. As a result of these experiences, I decided to attend BYU for my Masters Degree with Steve as my major advisor (Fig. 1).

Anthony I. Cognato: I first corresponded with Dr. Wood as a Ph.D. student in 1996. He offered thoughts and advice on *Ipini* taxonomy and lent me a rare book. Our correspondences were infrequent but substantial throughout my career. Most memorable was an allegory pertaining to molecular systematics where he described Colonel Thomas Casey's use of advanced optics of the late 1800's to see new morphological variation and to describe hundreds of beetle species and genera, which are now synonymized. I thanked him for the advice and assured him that my education in molecular systematics included the interpretation of DNA data for taxonomic decisions. Thus, we didn't always agree on taxonomic matters but *Pseudips* was our only major disagreement and our personal meetings were always friendly and professional. He was particularly helpful with the development of my career through the donation of



Figure 1. Steve Wood and his first graduate student, Don Bright, checking some beetles, 1960.

specimens and participating in my NSF-PEET study of tropical xyleborines through the mentorship of my students (Fig. 2). His guidance will be missed.

Miloš Knížek: My first contact with Professor Stephen L. Wood was dated rather long ago, in the beginning of 1980's, ten years after the start of my interest in bark beetles taxonomy. My dream, to meet him personally, was not possible in that time, because of the political situation in Czech Republic. With help of my father I contacted Steve by a letter, asking for some reprints. Steve immediately and fully supported me with his published studies and this support continued throughout my career. Early after the „velvet revolution“ in our country, when our borders were finally open to the world, I made an effort to meet as many specialists in bark beetle taxonomy as possible. On the occasion of the VIth European Congress of Entomology, which was organized by my colleagues in the Entomological Institute in Ceské Budejovice (Czech Republic) in 1998, I decided to organize the workshop on bark and timber beetles taxonomy to bring all these specialists together and meet them at the same time (Fig. 3). With help of Professor Antonín Pfeffer, the world wide known bark beetle taxonomist of palaeartic species and my "private teacher" in this field, we put together the list of possible participants this historical meeting. Unfortunately, Professor Pfeffer passed away suddenly, at 93. I continued to prepare the meeting with help of Larry Kirkendall and invited 55 specialists from



Figure 2. Three generations of scolytine systematists visiting Dr. Wood at BYU. From left to right: Sarah Smith, Stephanie Dole, Anthony Cognato, Bjarte Jordal and Stephen Wood, 2007.



Figure 3. A few scolytine systematists at the Vth European Congress of Entomology, České Budějovice, Czech Republic, August 23–29, 1998. From left to right: Donald E. Bright, Miloš Kníže, Lawrence R. Kirkendall, Stephen L. Wood, Anthony I. Cognato, Christian Stauffer.

around the world. This was my first occasion to personally meet Steve Wood. Despite his age Professor Wood impressed me with his enthusiasm and perfect knowledge of bark beetles (Fig. 4). We developed a close professional relationship and he soon invited me to visit his collection in Provo (Monte L. Bean Life Science Museum, Brigham Young University). Within one year with much help from Don Bright I went to BYU. I spent my whole visit working closely with Professor Wood where we engaged in motivating discussions of scolytine taxonomy. I stayed with Steve and his wife and got to know them personally. I spent many unforgettable moments with both of them. Steve's wife was very caring and very apprehensive that I would get hurt, during my weekend bark beetles collecting trips. She always told me: "Milos, please, do not climb the rocks in the mountains, many people died by falling off them!". Perhaps my answers and promises were not satisfactory enough, so, Steve added: "I am sure he will not climb the rocks, there are no bark beetles in the rocks". Meeting Professor Wood had exceptional influence on my scientific study as well as on my whole life. It is my honour to be the co-editor of this festschrift even though it is only a small repayment for what I learned from Steve.

Sarah M. Smith: I had the privilege of meeting Dr. Wood nine months into my graduate studies with Dr. Cognato. Although my visit at Brigham Young University lasted only a few days, Dr. Wood made a lasting impression on me. Throughout the rest of my master's degree, I remained in close contact with Dr. Wood and we had

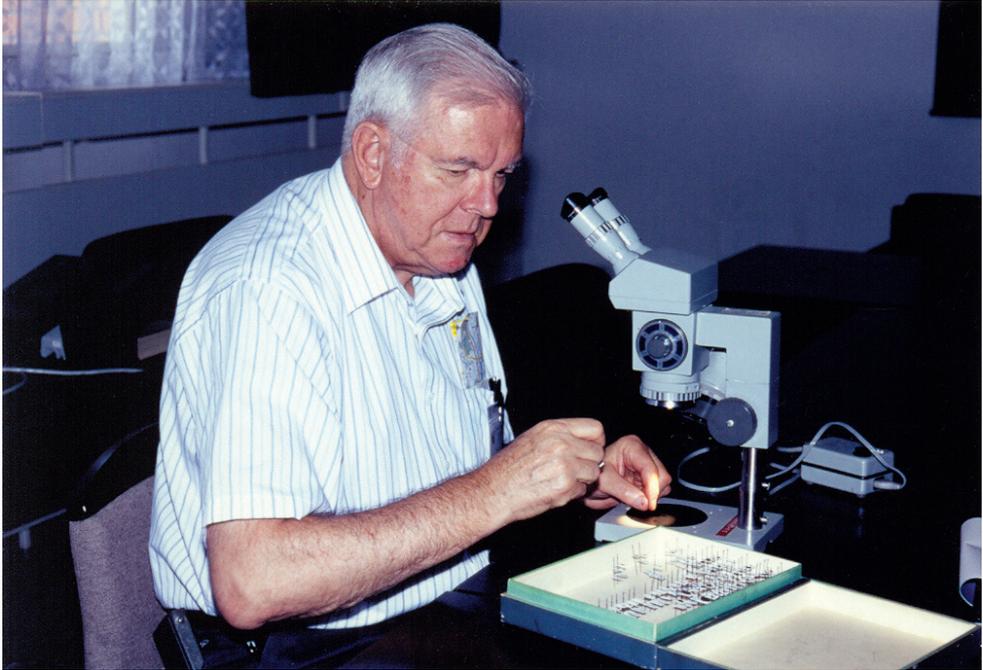


Figure 4. Stephen L. Wood at the “Bark and Timber Beetles Workshop” at the VIth European Congress of Entomology, České Budejovice, Czech Republic, August 23–29, 1998.

phone calls about every three months, the last of which was less than a month before he passed. His advice, both in person and on the phone, was profound and he always encouraged me in my studies. It is truly unfortunate that he passed away before the completion of my revision of *Camptocerus*, of which he very much wanted to see. I feel honored to work on a group of organisms that have had so much work done by a single individual. Dr. Wood continues to guide me in my work through his publications and I am motivated by his example. His contribution to the taxonomy of bark and ambrosia beetles was truly a remarkable feat.

Dr. Wood was delighted with the knowledge that we were preparing a Festschrift in his honor. We like to think that he would have been happy with this publication.

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Stephen Lane Wood

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Stephen Lane Wood was born in Providence, Utah, on July 2, 1924. From an early age, he had a keen interest in nature and wildlife. At age 14, Steve went to Nevada to visit his brother-in-law, T. O. (Ted) Thatcher, a specialist in scolytid systematics, who sent him into the woods to begin an insect collection for a class project. Steve dug his pocketknife into a pinhole in an aspen tree and eased out a small beetle, *Trypodendron retusum* (LeConte). In Steve's words, "The attraction was immediate and permanent." His interest in natural history led him to attend Utah State University where he received his B. S. degree in 1946 and M. S. degree in 1948, majoring in Entomology. His Masters thesis was a survey of the Scolytidae of Logan Canyon in Utah and their host plants (publication #1). He received his Ph.D. in 1953 from the University of Kansas with a dissertation on a taxonomic revision of the North American Cryphalini (publication #4). During his graduate studies Steve met and interacted with the leaders in the field of bark beetle systematics, which highlighted his burgeoning career (Fig. 1).

After graduation, Steve joined the staff of the Canadian National Collection of Insects, Ottawa, Ontario, and remained there for three years until family considerations and the call of the Utah mountains inspired him to change employment. In 1956, he accepted the position of Assistant Professor in the Department of Zoology and Entomology at Brigham Young University in Provo, Utah and remained there until his death. After retirement, Steve continued his association and his research at BYU at the Monte L. Bean Life Sciences Museum as Professor Emeritus and Curator of Coleoptera Emeritus until ill health forced him to terminate his activities in 2008.

Steve served on a number of university committees and professional assignments. He was editor of the Great Basin Naturalist for many years and created the Great Basin

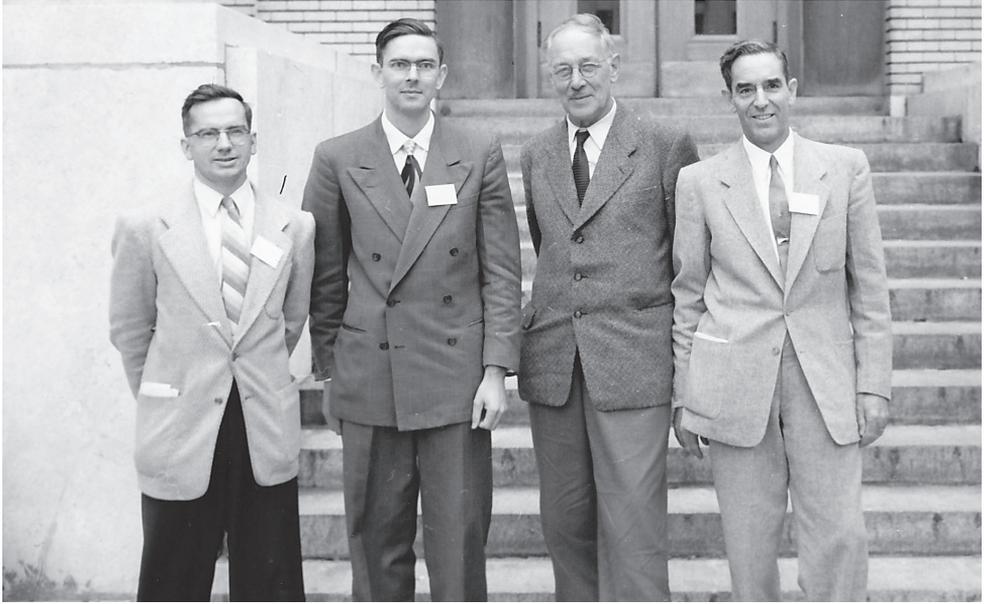


Figure 1. International Congress of Entomology, Montreal, Quebec. Left to right: Boyd Thomas, Canadian Forestry Service, worked on larval Scolytidae; Steve Wood; Karl Schedl, Austria, world authority on Scolytidae; W. H. (Bill) Anderson, Washington D. C., worked on Scolytidae at U. S. National Museum, Smithsonian Institution.



Figure 2. 1978, Steve working on BYU collection, obviously not on bark beetles!

Naturalist Memoirs series. He was a visiting Research Professor of Entomology at universities in San Jose, Costa Rica and Merida, Venezuela. He was the principal faculty planner in the development of the Monte L. Bean Life Science Museum on the BYU campus and was the Curator of the Coleoptera collection in the Life Science Museum until his retirement (Fig. 2).

Steve authored or co-authored 109 publications on scolytid and platypodid systematics and described and named over 1000 species as new to science. His collection, containing many thousands of specimens, was housed in 300 large museum drawers in the Monte L. Bean Life Science Museum. He donated his collection to the Smithsonian Institution in Washington D. C. In April and early May, 2009, the collection was consolidated into 160 drawers and was transported to the Smithsonian. Steve also built a library of thousands of published articles pertaining to scolytid systematics and biology which was donated to the Smithsonian Institution along with the specimen collection.

During his career, Steve assisted with, or was involved with, several large projects. Probably the most important were a study of the bark and ambrosia beetles of North and Central America, which culminated in the publication of a large monograph in 1982, and a study of the bark and ambrosia beetles of South America, which culminated in the publishing of another large monograph in 2007. The 1982 monograph mentioned above is the standard taxonomic reference for these important forest insects



Figure 3. Dr. Stephen Wood collecting scolytines in Mexico. Photo courtesy of Ladd Livingston who, as an undergraduate student, accompanied Steve in Mexico.



Figure 4. 1978, Steve examining photo enlargements of bark beetle parts. On the desk is a tray of beetles he has collected from all areas of the world.

and will likely continue so for decades to come. Likewise, the 2007 South American monograph will likely not be repeated for decades. Other projects included a study of the Scolytidae of Sri Lanka, which Steve expanded into a study of the Scolytidae of India, sponsored by the Smithsonian Institution and the Ceylon National Museum and a study of the Scolytidae of China, supported by a travel grant from the U. S. National Academy. This latter grant was used to bring Dr. Yin Hui-fen from Beijing to BYU. Neither of these latter two studies were completed and published due to financial constraints but preliminary manuscripts for both were prepared.

In 1981, I contacted Steve and suggested that we unite our efforts and compile a catalog of the world species of Scolytidae and Platypodidae. This collaboration resulted in the publication, in 1987, of a bibliography containing references to over 25,000 research articles, and in 1992, of a complete catalog of the Scolytidae and Platypodidae of the world.

Throughout his career, Steve was actively involved in collecting and observing bark beetle habits. He collected in at least 19 foreign countries, most Canadian Provinces, 25 states in Mexico, and in all contiguous states in the US except Washington and Vermont (Fig. 3). In 1972, he spent two weeks in New Guinea and two weeks in Australia and, in 1976, he spent two weeks in India and six weeks in Sri Lanka collecting beetles for the Smithsonian Institution. He collected in Venezuela, Colombia, Finland,

Central America, Japan and Russia (Fig. 4). His publications are replete with personal observations on the gallery pattern, site attacked, host plant, behavior, and other biological observations of the species treated.

Steve passed away on July 1, 2009, at the age of 84 in Provo, Utah of age-related causes. His influence on the systematics of the bark and ambrosia beetles of the world is immeasurable and will be felt for decades to come.

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New species and records of *Cactopinus* Schwarz with a key to species (Coleoptera, Curculionidae, Scolytinae)

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Abstract

Three new species in the genus *Cactopinus* Schwarz are described from Mexico and the U.S., bringing the total of known species to 21. New host and distribution records and a new key to species are included.

Keywords

Mexico, southwest U.S., host plants, epistomal horns

Introduction

The genus *Cactopinus* was described by Schwarz (1899) as a monotypic genus for *C. hubbardi*. Since that time an additional 17 species have been described by Blackman (1938: *pini*, *koebeli*, *rhois*), Wood (1957: *cactophthorus*, *spinatus*; 1967: *mexicanus*; 1969: *carinatus*, *granulifer*, *microcornis*, *nasutus*, *niger*; 1983: *atkinsoni*, *burjosi*, *granulatus*, *setosus*) and Bright (1967: *depressus*, *desertus*). The genus was most recently revised by Wood (1982) whose key included only 14 species (Wood 1982). Four species were described subsequently (Wood 1983). An additional 3 species are described here, bringing the total to 21 species. All species are found in Mexico and the southwestern

U.S. from Oaxaca northwards to southern California and Arizona in deserts, semi-arid scrublands, and seasonally dry forests.

The most noteworthy character of the genus is the presence of paired horns on the male epistomal process. In all species the 2 horns are apparently distinct from their base to their apex. In some species the horns are short and widely separated (Figs 2, 5). Otherwise the horns are fused at their bases and for most of their length, even though there is a clear suture between them (Figs 29, 33). In some species horns extend from the epistoma to the middle of the pronotum. In these species the horns apparently maintain some flexibility, based on the variation in position in preserved specimens. In some specimens the horn is straight (Fig. 23) while in others it is curved backwards over the frons and pronotum (Fig. 27). While the horns are not segmented, they have setae set into deep punctures along their length which might allow some flexibility. In some species the punctures are so pronounced that the horns have a serrate appearance (Fig. 33). The apex of the horns is parallel in some species (Fig. 12) or strongly divergent in others (Fig. 15) and may appear digitate (Figs 24, 28, 33). In addition to marked differences in horn length among species, the length of horns is strongly variable within species as well. In females of some species, indistinct, raised calluses are present in positions similar to the location of the base of the horns in males (Fig. 30). In addition to the primary epistomal horns, usually located in the center of the epistomal process, a short tubercle or projection is found on the anterolateral margins of epistoma near the base of the antennal insertion in most species (Fig. 2, 8, 17, 24). In *C. spinatus* Wood (Fig. 35) there is a distinct spine between the primary horns and this outer spine or projection.

Along with the development of the epistomal horns there has been a parallel anteroventral elongation of the head, particularly in males. This is evident even in species with relatively short horns (Figs 1, 10). The compound eyes have also been moved forwards and ventrally and are foreshortened by comparison with other scolytines. The male frons is generally concave from vertex to base of horns in lateral view. In some species, despite this longitudinal curvature, the resulting surface between the eyes is essentially flat (e.g., *cactophthorus* Wood, Fig. 11, 12). In most species, however, the frons is longitudinally concave as well with a well defined fossa that varies in extent (Figs 8, 17, 19). In most females the frons is flat or convex, often transversely impressed immediately above the epistoma. The size and shape of the antennal club varies among species in size relative to the size of the head and shape (rounded or oval). Antennal sutures vary from mostly straight to procurved, or weakly bisinuate.

In most groups of the Scolytinae (*sensu* Wood 1982) asperities are found between the anterior margin and the center of the pronotum, generally with a distinct summit near the middle. In *Cactopinus*, this summit is invariably on the posterior margin of the pronotum and in some cases is developed into a cone that strongly projects backwards. In some species the pronotal asperities are clearly arranged in a triangular pattern with the asperities broadly distributed near the anterior margin, tapering sharply to the summit (Figs 23, 25, 27, 29). In these species there is a sharp demarcation between the asperate areas and the non-asperate posterolateral area. In most species, asperities are also found on the posterolateral portions of the pronotum (Figs 3, 6, 13).

Many specimens in collections are covered with a crust of plant resins and boring dust. This can be cleaned off by soaking in acetone or ethyl acetate overnight, combined with gentle ultrasonic cleaning. Once cleaned the elytral surface of all species is shining. At the same time, the interstrial surface of the disc is generally irregular. Strial punctures (and sometimes interstrial punctures) are usually deep, although the striae themselves are generally not impressed. Granules are frequently associated with interstriae on the declivity (Figs 4, 7, 9), to the base of elytra in some cases (Fig. 3). In some species granules are associated with striae as well. The declivity of all species is steep in lateral view, ranging from nearly convex to deeply sulcate. Lateral elevations (usually interstriae 2–4) sometimes do not extend to the costal margin and extend beyond the apex of elytra in lateral view (Figs 1, 7), appearing as lobes. The apex of the declivity is normally truncate in dorsal view but weakly acuminate in some cases (Figs 26, 39).

While each species is host specific, generally at the genus level, collectively they are found in a variety of totally unrelated hosts. Hosts include pines (2 species), *Bursera* spp. (Burseraceae, 2 species), *Rhus* spp. (Anacardiaceae, 1 species), leaves of the Agavaceae (*Yucca* spp., 1 species; *Agave* spp., 1 species), and various genera and species of columnar cacti (14 species). Actual hosts of at least half of the species breeding in cacti are not known. The only thing that the different hosts have in common appears to be co-occurrence in arid plant communities. All species have the ability to breed in apparently completely dry host material. Partly as a consequence, it is typical to see signs of breeding by multiple generations within the same piece of host material. This appears to be an adaptation to the xeric habitats where these hosts occur. While this is unusual with the Scolytinae, similar behavior is found in other groups, notably the Micracina. Based on a subjective analysis of morphological characteristics, it would appear that columnar cacti are probably the ancestral hosts and that other hosts associations are derived (widely separated vs. basally fused epistomal horns; shorter vs. longer horns; weakly developed pronotal asperities and poorly developed summit vs. strongly pronounced asperities with posteriorly projecting summit).

All species, so far as is known, are monogynous, with galleries constructed by a single pair. Which sex initiates galleries is unknown. In cases where multiple generations breed in the same piece of host material it is not known whether beetles emerge upon maturity and re-enter host tissues or whether new galleries are initiated without emerging. Galleries of several species have been described by Wood (1957) and Bright (1967) as an irregular, elongate gallery, several times wider than the width of adults, frequently filled with frass, and with multiple larval mines proceeding from poorly defined egg niches. I have seen similar galleries in *C. agavensis* and *C. depressus*. In most cactus-breeding species it is difficult to interpret adult galleries. In several of those species I have observed that galleries are initiated in the areoles (clusters of spines) along the outer ridge of the ribs. Galleries are then excavated under the tough epidermis and eggs appear to be deposited in individual niches.

The following abbreviations are used for museums where specimens are deposited: USNM (U.S. National Museum), TAMU (Texas A&M University), FSCA (Florida State Collection of Arthropods), CAS (California Academy of Sciences), CEAM (Centro de Entomología y Acarología, Colegio de Postgraduados, Montecillo, México).

Systematics

Cactopinus woodi Atkinson, sp. n.

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Figs 1–4

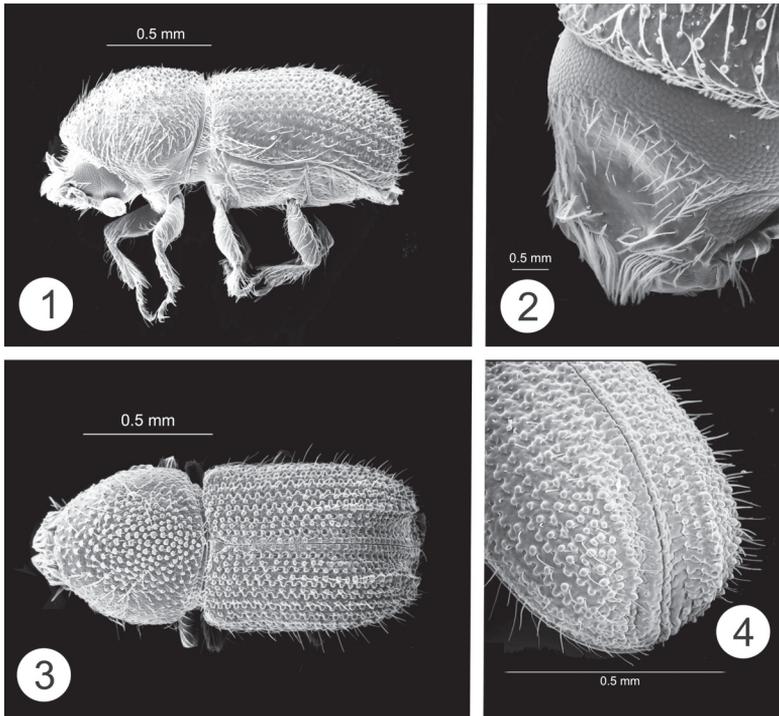
Description. This species is named in honor of Steve Wood, especially appropriate considering the large number of species in this genus that he described. It is easily recognized by its widely separated, short epistomal horns and by the large, uniform granules associated with all interstrial and strial punctures on the disc to its base and on the declivity, except for striae and interstriae 1 and 2.

Male. Color black. Length 1.4–1.6 mm, width 0.6–0.7 mm, length/width 2.3. Epistomal horns short, length 2–3× basal diameter, widely separated by distance greater than length; without any associated setae. Frons weakly concave from epistoma to upper level of eyes; concavity without raised margin dorsally or laterally; surface of concavity smooth, impunctate; setae sparse, short, most abundant on periphery of concavity. Antenna subcircular, sutures slightly procurved. Pronotum with asperities concentrated near middle; summit at posterior margin, not strongly pronounced; some asperities on postero-lateral areas; area of greatest concentration of asperities not sharply demarcated laterally. Striae deeply punctured; all punctures associated with rounded granules to base of elytra; granules occupying entire space between adjacent punctures. Interstriae 1.5× as wide as striae; setae uniseriate, each associated with a rounded granule to base. Granules on striae and interstriae similar in size. Declivity steep, rounded posteriorly, strongly sulcate. Striae 1 and 2 impressed; granules absent; punctures smaller than on disc; granules also absent from associated interstriae. Interstriae 3 narrowly elevated, forming a distinct crest; its granules larger than on disc. All other declivital striae and interstriae similar to those of disc. Lateral elevations highest in middle, projecting beyond apex of elytra in lateral view.

Female. Frons flattened, surface sparsely punctured, setose in central area. Other characters identical to those of males.

Materials examined. **HOLOTYPE** (male): “MEXICO: Baja California, Isla San Esteban, 6-V-1985, THA-289, *Stenocereus gummosus*, T.H. Atkinson // Holotype *Cactopinus woodi*, T.H. Atkinson 2009”. **ALLOTYPE** (female): same data as holotype. The holotype and allotype are deposited in the U.S. National Museum. **PARATYPES:** Same data as holotype and allotype (60) distributed as follows: USNM-10; TAMU-16; FSCA-10; CAS-10; CEAM-10; MEXICO: Baja California, Isla San Lorenzo, 6-V-1985, THA-285, *S. gummosus*, T.H. Atkinson (TAMU-9); MEXICO: Sonora, Isla Tiburón, 14-V-1985, THA-301, *Stenocereus thurberi*, T.H. Atkinson (TAMU-2); U.S.: Arizona, Pima Co., 1 mi N Organ Pipe Cactus Natl. Mon., Hwy 85, 13-II-2008, 32.204 N, 112.754 W, *Stenocereus thurberi*, T.H. Atkinson (TAMU-13).

Notes. This species has been collected in the dried ribs of its host cacti. As is the case with most other cactus-breeding species, successful breeding occurs in portions of



Figures 1–4. *Cactopinus woodi*, sp. n. **1** Male, lateral habitus **2** Male, frons **3** Male, dorsal habitus **4** Male, declivity.

stems that have dried out to a hard, yellowish color, without the black discoloration associated with decay. This situation most commonly occurs in erect, dead stems still attached to the host. In pieces that fall to the ground the upper surface is apparently too hot from direct exposure to the sun and the lower surface seems likely to decay from contact with the soil. Galleries are initiated at the areoles, clumps of spines that are found along the ridges of the ribs.

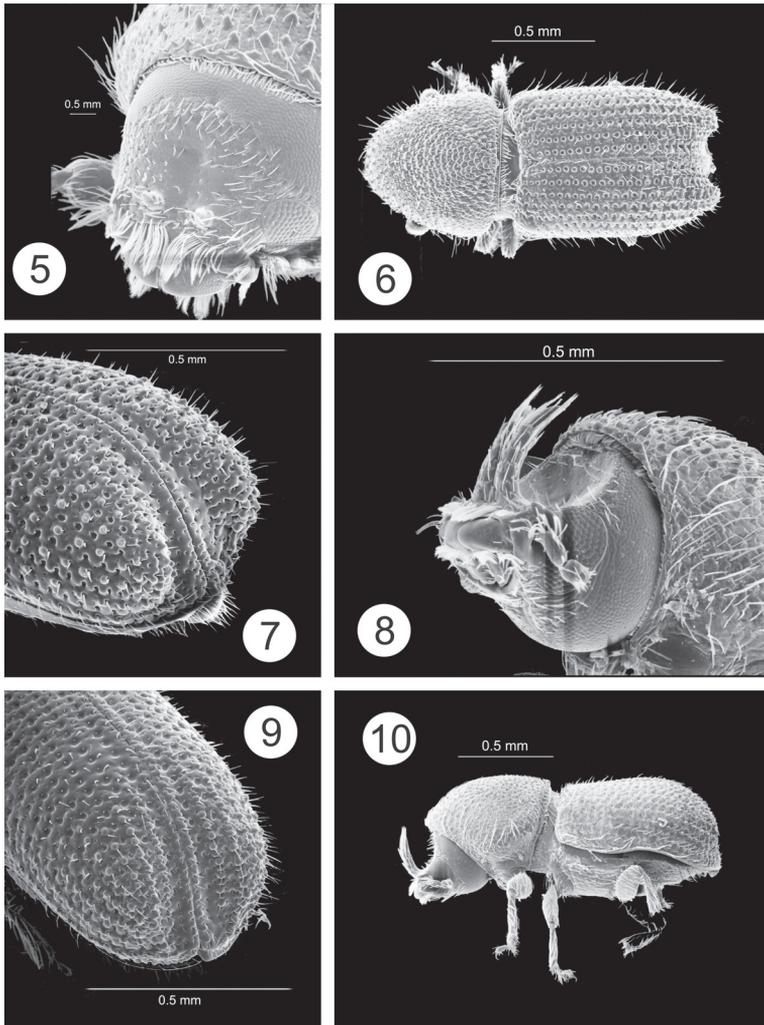
***Cactopinus sulcifrons* Atkinson, sp. n.**

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Figs 5–7

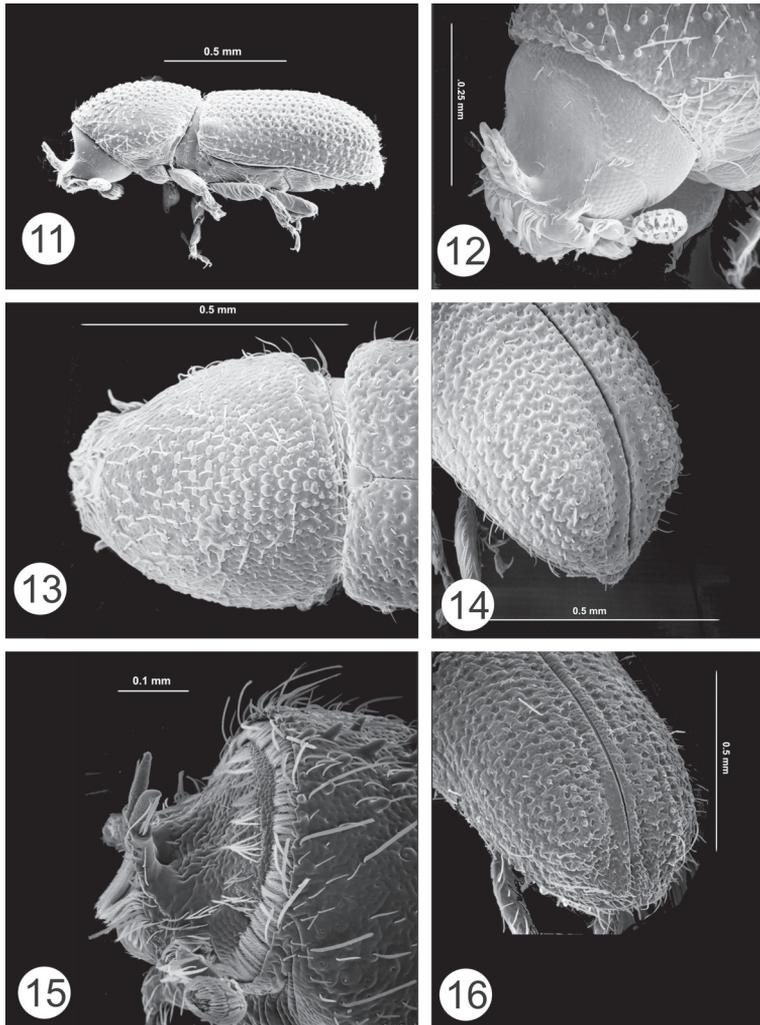
Description. This species is readily distinguished from other species with short, separated epistomal horns by the nearly flat male frons with only a narrow, longitudinal sulcus. This frontal sulcus is the basis for the specific epithet.

Male. Color black. Length 1.4–1.7 mm, width 0.6–0.7 mm; length / width 2.4. Epistomal horns short, pointed, height slightly greater than basal diameter; located near center of epistoma, separated by 1.5× height. Frons flattened with narrow longitudinal sulcus in center, not wider than the distance between the horns. Surface



Figures 5–10. 5–7 *Cactopinus sulcifrons*, sp. n. 5 Male, frons 6 Male, dorsal habitus 7 Male, declivity. 8–10 *Cactopinus atkinsoni* Wood. 8 male frons 9 Male, declivity 10 Male, lateral habitus.

sparsely punctured, with short setae; setae and punctures more abundant on periphery. Asperities on anterior margin tooth like, widely separated, becoming more abundant, flatter, and densely packed towards center and summit. Asperities are tightly packed, and slightly overlapping in a triangular pattern in the center and posterior of the pronotum, but less densely spaced asperities are abundant in posterolateral areas to the posterior margin. Striae not impressed, punctures deep, spaced within row by distance equal to their own diameters. Interstriae 1.5× as wide as striae with shallow uniseriate punctures. Vestiture of short strial setae and longer, erect interstitial setae, becoming longer posteriorly. Declivity steep, sulcate, with lateral elevations strongly elevated in middle, posterior margin rounded. All interstriae except 1–2 with rounded, uniseriate granules beginning at base of declivity. Punctures on striae 1 and 2



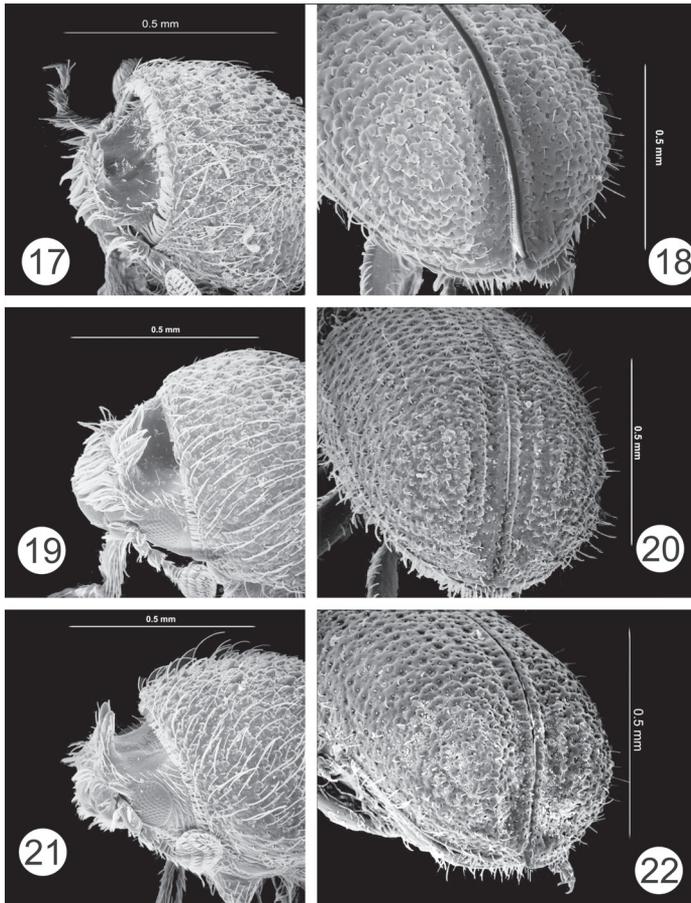
Figures 11–16. 11–14 *Cactopinus cactophthorus* Wood. 11 Male, lateral habitus 12 Male, frons 13 Female, pronotum 14 Male, declivity. 15–16 *Cactopinus burjosi* Wood 15 Male, frons 16 Male, declivity.

smaller than on disc. Lateral elevations very wide, consisting of elevated portions of interstriae 3–5.

Female. Frons transversely impressed above epistoma, convex above, surface sparsely punctured, setose in central area. Epistoma with low calluses in same position as male horns. Other characters identical to those of males.

Materials examined. HOLOTYPE (male): “MEXICO: Sonora, Isla Tiburón, 14-V-1985, THA-301, *Stenocereus thurberi*, T.H. Atkinson // Holotype *Cactopinus sulcifrons*, T.H. Atkinson 2009”. **ALLOTYPE** (female): same data as holotype. The holotype and allotype are deposited in the U.S. National Museum. **PARATYPES:** Same data as holotype and allotype (31) distributed as follows: USNM-2, TAMU-7, FSCA-6, CAS-6, CEAM-6.

Notes. The habits of *C. sulcifrons* are similar to those of *C. woodi*.



Figures 17–22. 17–18 *Cactopinus carinatus* Wood. 17 Male, frons 18 Male, declivity. 19–20 *Cactopinus niger* Wood. 19 Male, frons 20 Male, declivity. 21–22 *Cactopinus setosus* Wood. 21 Male, frons 22 Male, declivity.

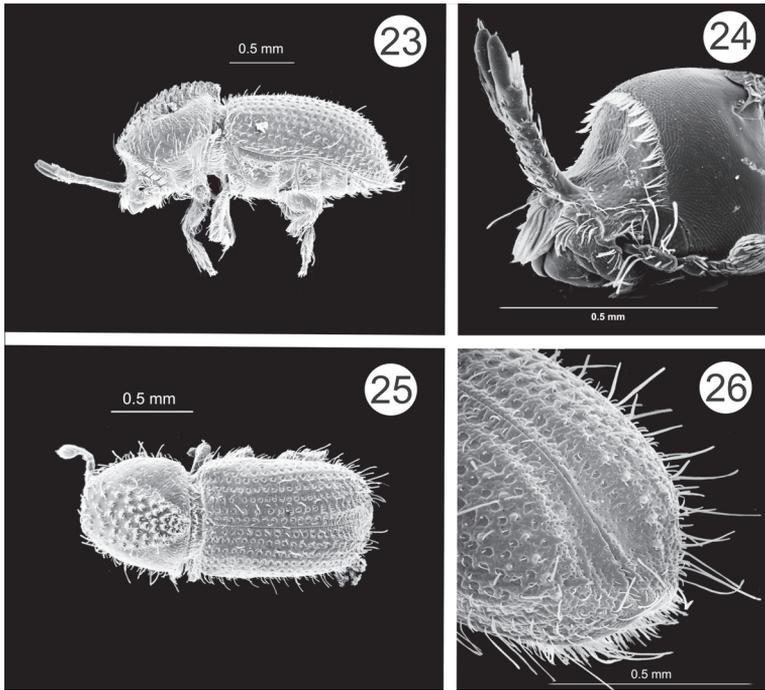
***Cactopinus agavensis* Atkinson, sp. n.**

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Figs 23–26

Description. This species most resembles *C. hubbardi*. It can be distinguished by the more sulcate elytral declivity with larger marginal teeth, the longer epistomal horns, and the more flattened male frons. The specific epithet is based on the name of the hosts in the genus *Agave*.

Male. Color black. Length 1.8–2.1 mm, width 0.7–0.9 mm, length / width 2.45. Epistomal horns long, projecting to middle of prothorax, fused along their length except for the terminal ¼. Frons horizontally concave, flattened laterally with small concave area in center; surface sparsely punctured, mostly without setae. Anterolateral margins of the epistoma with short, downward projecting spine near base of antennal insertion. Antenna



Figures 23–26. *Cactopinus agavensis*, sp. n. **23** Male, lateral habitus **24** Male, head **25** Female, dorsal habitus **26** Male, declivity.

elongate, 1.7 times longer than wide, sutures straight. Pronotum with asperities widely separated at anterior margin, most abundant in center; arranged in sharply defined triangular pattern with no asperities or granules in posterolateral portions. Clearly defined summit at posterior margin, strongly elevated into a point, projecting backwards over elytra. Striae not impressed, with deep punctures, separated by less than their own diameter. Interstriae not elevated, about twice as wide as striae; surface irregular, with numerous, fine, confused punctures. Vestiture of recumbent, short, strial setae, with long, ribbon-like interstitial setae, these longer than distance between rows. Declivity weakly sulcate, gradual, slightly acuminate posteriorly. Interstriae 1 and 2 wider on declivity than on disc. Punctures on striae 1 absent beyond declivital base, interstriae 1 and 2 with numerous, small, confused punctures. Interstitial granules on all other declivital interstriae except 1. Interstriae 2 strongly elevated, its granules slightly longer and sharper than those on other interstriae.

Female. 2 wide calluses present on epistoma, frons transversely impressed above. Frons shallowly concave above transverse impression, surface with shallow, large, closely set punctures. A fringe of setae along upper and lateral margins of convexity. Other characters identical to those of males.

Materials examined. **HOLOTYPE** (male): “Mexico: Mexico (state), Teotitlán, 2-VI-1982, 2,410 m, leaves *Agave atrovirens*, A. Equihua M. // Holotype *Cactopinus agavensis*, T.H. Atkinson 2009”. **ALLOTYPE** (female): same data as holotype. The holotype and allotype are deposited in the U.S. National Museum. **PARATYPES:**

Same data as holotype and allotype (11) distributed as follows: USNM-2; TAMU-5; CEAM-4. MEXICO: Mexico (state), Noplatepec, 11-VII-2008, leaves *Agave salmiana*, T.H. Atkinson & A. Equihua M. (TAMU-2, FSCA-5, CAS-5, CEAM-4); MEXICO: Guanajuato, Hwy 57, 9.6 km S intersection Hwy 110, 21.19881 N, 100.57501 W, 6-VII-2009, 1,989 m, leaves *A. salmiana*, T.H. Atkinson, THA 902 (TAMU-7, CEAM-6).

Notes. This species has been collected on 3 occasions in the central Mexican highlands from the large semi-domesticated agaves used historically for pulque production. These plants reach a very large size with individual leaves reaching a length of 1.5 m or more and armed with strong, recurved spines. The insect is found in dead, mostly dry leaves at the bottom of the rosette. In a healthy plant, the only way to get to these leaves is to basically take the plant apart, something that requires a lot of work and potential loss of blood on the part of would-be collectors. It is more easily collected from rosettes that are dying and beginning to fall apart after blooming, or in the occasional specimen growing on the edge of a terrace or wall such that the lower leaves can be reached. The beetles may enter the leaves from either the top or bottom surface and galleries resemble those described by Wood (1982). Apparently multiple generations may develop in the same dried leaf until it is consumed.

Key to males of *Cactopinus*

Information on hosts and distribution is included in the key as a general aid to users. Distributional information should only be used in a very general sense given that many species are still known only from type localities.

- 1 Asperities on pronotum large, chisel-like, forming distinct triangle with apex at posterior margin, clear demarcation between this area and posterolateral portions of pronotum, most asperities posterior to middle (Figs 23, 25, 27, 29); antennal club narrow, 1.7–2 times as long as wide, sutures straight (Fig. 33); hosts not restricted to cacti **14**
- Asperities on pronotum small, often granulate, more evenly distributed, not in clearly marked triangular pattern, apex indistinct or not strongly projecting backwards; most asperities anterior to middle (Figs 3, 6, 13); antennal club rounded, less than 1.3 times as long as wide, sutures weakly procurved to bisinuate (Fig. 21); all hosts columnar or arborescent cacti **2**
- 2 (1) Male epistomal horns clearly separated at base (Figs 2,5) **3**
- Male epistomal horns contiguous at base and fused along lower ½ or more of length (Figs 8, 12)..... **6**
- 3 (2) Epistomal horns 4–5 times longer than basal diameter, separated by less than half their length; frons deeply concave, abruptly margined at top. 1.3–1.6 mm. Jalisco *mexicanus* Wood

- Epistomal horns less than twice basal diameter (Figs 2, 5); frons weakly excavated, margins not abrupt **4**
- 4 (3) Epistomal horns about twice as long as basal diameter, separated by more than twice their length; frons shallowly concave; prominent granules on all declivital striae and interstriae to base. 1.4–1.6 mm. In *Stenocereus* spp. Arizona, Baja California, Sonora (Figs 1–4) **woodi Atkinson**
- Epistomal horns about as long as basal diameter, separated by slightly more than height; granules restricted to posterior portion of elytra and declivity **5**
- 5(4) Male frons concave over entire area between eyes, concavity extending beyond upper level of eyes; lateral convexities on declivity weakly elevated. 1.5–1.9 mm. Oaxaca **microcornis Wood**
- Male frons flattened, with narrow, shallow longitudinal impression from epistoma to upper level of eyes; lateral convexities on declivity abruptly, strongly elevated. 1.4–1.7 mm. In *Stenocereus* spp. Sonora. (Figs 5–7) **sulcifrons Atkinson**
- 6 (2) Granules present at least on posterior portion of discal interstriae as well as on declivity **7**
- Granules on elytral interstriae and /or striae restricted to declivity **8**
- 7(6) Frons deeply concave, concavity occupying entire distance between eyes, wider above eyes; declivity moderately sulcate, granules present on all interstriae. 1.6–1.8 mm. Jalisco **granulatus Wood**
- Frons less deeply concave, concavity occupying 80% of distance between eyes, not wider above eyes; declivity deeply sulcate, interstriae 1 and 2 shining, without granules. 1.3–1.6 mm. Oaxaca **granulifer Wood**
- 8(6) Frons deeply concave, concavity occupying 90–100% of distance between eyes **9**
- Frons shallowly concave or flattened, concavity if present occupying 60% or less of distance between eyes **11**
- 9(8) Upper part of concavity of frons wider above eyes, upper margin acute; declivity more pronounced, interstriae 2 narrowed, without granules except near base... **10**
- Upper part of frontal concavity not wider above eyes, upper margin less pronounced; declivity shallower, interstriae 2 not narrowed, with granules for its full length. 1.3–1.5 mm. In *Stenocereus* spp. Jalisco. (Figs 8–10)..... **atkinsoni Wood**
- 10(9) Upper half of frons bearing longitudinal carina; apex of pronotal summit not developed into backwards-projecting cone. 1.5–1.8 mm. In *Myrtillocactus*. Hidalgo, San Luís Potosí, Tamaulipas. (Figs 17, 18)..... **carinatus Wood**
- Upper half of frons without longitudinal carina; apex of pronotal summit developed into backwards-projecting cone. 1.4–1.7 mm. Puebla, Oaxaca **nasutus Wood**
- 11(8) Frons curved in lateral profile, but flat longitudinally; pronotal asperities weakly developed; declivity with relatively few, small granules on interstriae. 1.2–1.4 mm. Puebla. (Figs 29–32)..... **cactophthorus Wood**

- Frons weakly to prominently concave in central area between eyes; pronotal asperities larger; declivity with prominent granules on interstriae 2 and higher **12**
- 12(11) Horns reaching or exceeding upper level of frons, apical portions digitate, divaricate; interstria 1 on declivity not deeply impressed, lateral elevations not pronounced. 1.5–1.6 mm. In *Neobuxbaumia*. Morelos, Puebla. (Figs 11–14) ...
..... ***burjosi* Wood**
- Horns not reaching upper level of frons, outer sides parallel to apex, interstria 1 on declivity strongly impressed, lateral elevations prominent **13**
- 13(12) Frons with prominent concavity in middle of frons; outer sides of horns parallel, inner sides angled making obvious “V” shape; antennal sutures straight. 1.6–1.9 mm. In *Stenocereus*. Oaxaca, Querétaro. (Figs 19, 20) ... ***niger* Wood**
- Frons shallowly concave, concavity not well defined; inner sides of horns not strongly angled; antennal sutures bisinuate. 1.4–1.7 mm. In *Stenocereus* spp. Jalisco. (Figs 21, 22)..... ***setosus* Wood**
- 14(1) Declivity strongly sulcate, lateral elevations armed with teeth larger than granules on other interstriae, sutural interstriae depressed, widened prominently in middle; interstriae 2 curved outwards in compensation..... **15**
- Declivity weakly or not sulcate, sutural interstriae not widened on declivity, interstriae 2 not curved outwards..... **19**
- 15(14) Declivity with obvious teeth on interstriae 2 on lateral margin of declivity much larger than granules present on other interstriae **16**
- Declivity with granules on interstriae 2 only slightly larger than those on other interstriae..... **17**
- 16(15) Horns 1.5–2 times as long as frons; apex of pronotal asperities strongly pronounced, backwards projecting; teeth on interstriae 2 flattened laterally, height greater than twice basal width. 1.6–2.1 mm. In *Bursera* spp. SW U.S., NW Mexico. (Figs 32–34) ***desertus* Bright**
- Horns shorter, slightly longer than length of frons; apex of pronotal asperities not strongly pronounced; teeth on declivital interstriae 2 cone shaped, about 1.5 times as high as basal width. 1.4–1.7 mm. In *Bursera* spp. Oaxaca, Morelos, Jalisco. (Figs 35, 36) ***spinatus* Wood**
- 17(15) Body slender, 2.6 times longer than wide; interstriae 1 strongly impressed, sulcate anterior to declivity. 1.6–2.0 mm. In phloem of of *Pinus* spp. SW U.S. ***pini* Blackman**
- Body stouter, 2.4 times longer than wide; interstriae not impressed or sulcate anterior to declivity..... **18**
- 18(17) Frons weakly concave, impunctate; interstriae 1 and 2 on declivity not widened, granules on interstriae 2 small, rounded, restricted to base. 1.6–2.3 mm. In *Carnegiea gigantea*. Arizona, probably Sonora. (Figs 27–31).....
..... ***hubbardi* Schwarz**

- Frons weakly flattened longitudinally, densely, finely punctured; interstriae 1 and 2 on declivity widened in middle, granules on interstriae 2 larger than those on other interstriae, pointed, present to apex. 1.8–2.1 mm. In dry fleshy leaves of *Agave* spp. State of Mexico, Guanajuato. (Figs 23–26)
..... ***agavensis* Atkinson**
- 19(14) Declivity with coarse granules on interstriae 1–3. 1.3–1.8 mm. In *Rhus* spp. SW U.S. ***rhois* Blackman**
- Declivity without granules on interstriae 1–3..... **20**
- 20(19) Horns short, not reaching top of frons; elytral punctures shallow; granules not present on declivity, declivity narrowly sulcate. 1.3–1.5 mm. In leaves of *Yucca* spp. San Luís Potosí, Hidalgo, Nuevo León. (Figs 37–40)
..... ***depressus* Bright**
- Horns longer, exceeding top of frons; elytral punctures deeper; declivity not sulcate. 1.3–1.5 mm. In phloem of of *Pinus* spp. SW U.S., Baja California
..... ***koebeli* Blackman**

New host and distribution records

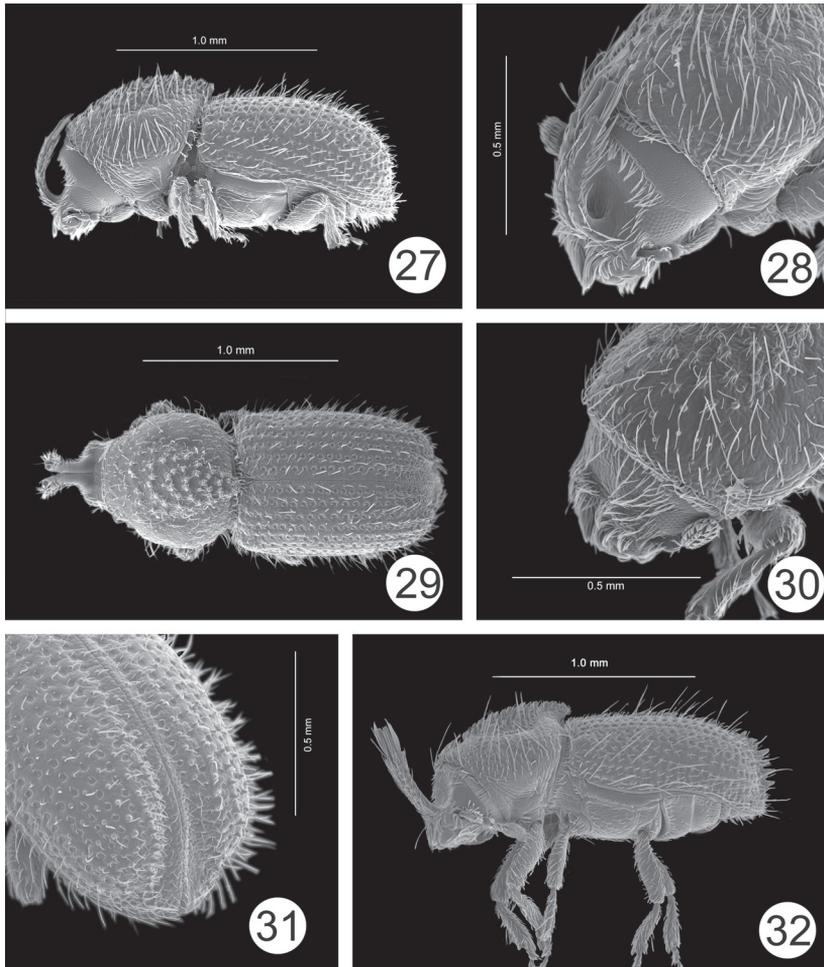
New collection records are only shown if they represent significant geographic range extensions or new host associations.

Cactopinus carinatus Wood

Previously known only from the type locality in Hidalgo from “giant cactus”. Mexico: San Luís Potosí: Hwy 57, 18 km S intersection Hwy 80; 22.76227 N, 100.49222 W; 6-VII-2009; 1,422 m; branches of *Myrtillocactus geometrizans*, coll. T.H. Atkinson (TAMU-8, CEAM-6); Mexico: Tamaulipas: outside Tula; 23.01077 N, 99.73729 W; 16-VIII-2009; 1,164 m; branches *Myrtillocactus geometrizans*, T.H. Atkinson (TAMU-4, CEAM-6, FSCA-4). These collections represent new state records and the first known host records for this species. *M. geometrizans* is one of the most widespread of the arborescent-columnar cacti in Mexico and is easily recognizable. It is known to occur in the vicinity of the type locality for *C. carinatus*. While it is premature to conclude that this species is the only host for *C. carinatus*, it is significant that it has not been collected in numerous recent collections from other species of cacti.

Cactopinus niger Wood

Previously known only from the type locality in Oaxaca from “giant cactus”. Mexico: Querétaro: Hwy 57D, 15 km N intersection Hwy 45D; 20.67390 N, 100.3046 W; 2,048 m; 6-VII-2009; dry stems of *Stenocereus queretaroensis*; T.H. Atkinson (TAMU-4, CEAM-4). This is the first known host record.



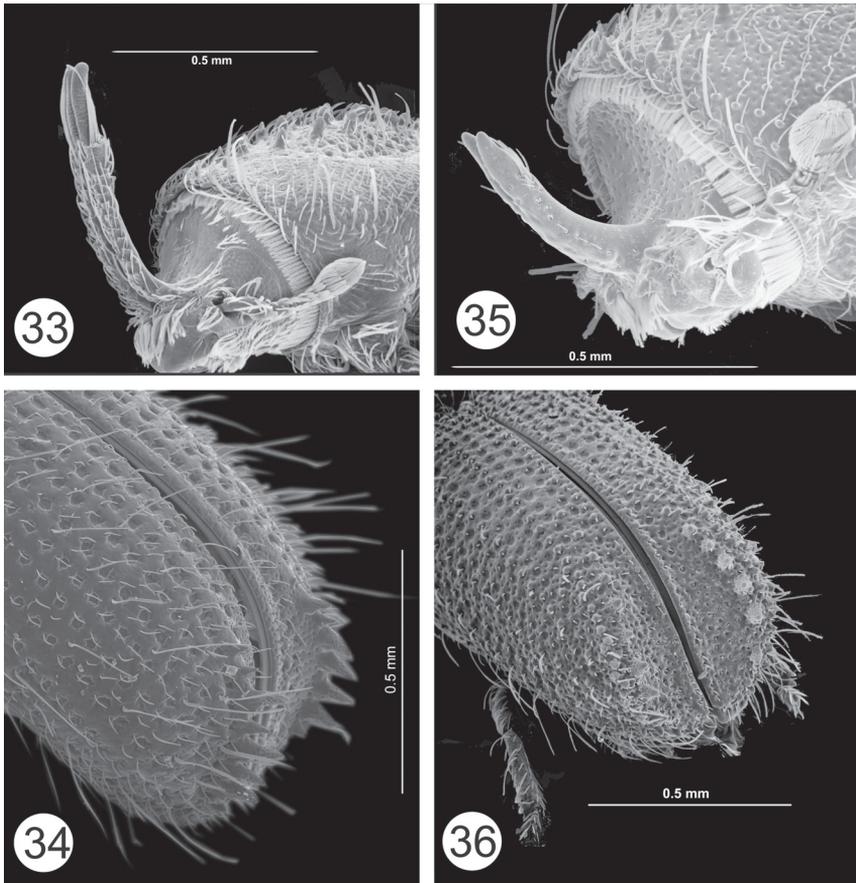
Figures 27–32. 27–31 *Cactopinus hubbardi* Schwarz. 27 Male, lateral habitus 28 Male, frons 29 Male, lateral habitus 30 Female, frons 31 Male, declivity. 32 *Cactopinus desertus* Bright, male, lateral habitus.

Cactopinus desertus Bright

Reported previously from southern California in the U.S. and from the Mexican states of Baja California and Sonora. Mexico: Baja California Sur; San José del Cabo, 11 mi SW; 28-VI-1967; blacklight; E.L. Sleeper, E.M. Fisher (CAS-1); BCS: Santa Victoria, 27/28-X-1968; 800'; blacklight; E.L. Sleeper, F.J. Moore (CAS-1); BCS: Loreto, 3 mi N; 10/11-XI-1968; blacklight; E.L. Sleeper, F.J. Moore (CAS-1)

Cactopinus spinatus Wood

Previously the only known hosts were tropical trees and shrubs of the genus *Bursera*, although Wood (1982) indicated that he had collected it from hosts that did not appear to be of that genus. Mexico: Oaxaca: Cuicatlán, 5 km N; 17.74010N, 96.94901 W; 665 m; 2-VII-2009; *Cyrtocarpa procera* (Anacardiaceae), T.H. Atkinson



Figures 33–36. **33–34** *Cactopinus desertus* Bright. **33** Male, frons **34** Male, declivity. **35–36** *Cactopinus spinatus* Wood **35** Male, frons **36** Male, declivity.

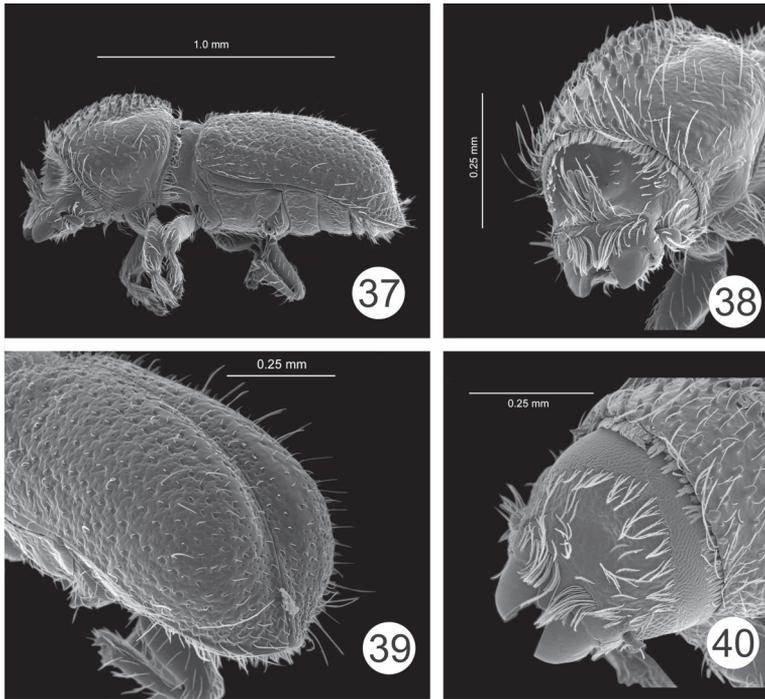
(TAMU-16, FSCA-8, CAS-8, CEAM-8). The families Burseraceae and Anacardiaceae are closely related both taxonomically and chemically.

Cactopinus rhois Blackman

This species has previously been reported from Los Angeles and Ventura Counties in southern California. CA: San Diego Co., Oak Grove Campground, Cleveland N.F.; 3-XII-1991; *Rhus trilobatus*; T.H. Atkinson, D.W. Hawks, L.R. Kirkendall (TAMU-2).

Cactopinus depressus Bright

Reported previously from the states of San Luís Potosí and Hidalgo. New Records: Mexico: Nuevo León: Hwy 57, y mi S. Entronque Roberto; 20-VI-1983; 1,768 m; from dry *Yucca* leaves; C.W. and L. O'Brien, G.B. Marshall (FSCA-5); Nuevo León: Mier y Noriega, 12 km NW; 10-XI-1976; 1,460m; from dry *Yucca* leaves; A.N. García Aldrete (FSCA-1).



Figures 37–40. *Cactopinus depressus* Bright. **37** Male, lateral habitus **38** Male, frons **39** Male, declivity **40** Female, frons.

Acknowledgements

This article would not have been possible without the help and support of Steve Wood, particularly for the gift of specimens of a large number of species of *Cactopinus* that he described. Armando Equihua, friend and collaborator, of the Colegio de Postgraduados collected the first specimens of *C. agavensis* and showed me how to find more in the field. Silvia Salas of the Sociedad para el Estudio de Recursos Bióticos de Oaxaca (SERBO) provided valuable logistical support for field work in Oaxaca. I would like to thank Ed Riley for invaluable curatorial at the insect collection of Texas A&M University. SEM photographs were taken using facilities of Texas A&M University (Microscopy and Imaging Center) and of the University of Florida.

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Notes on *Scolytus fagi* Walsh 1867 with the designation of a neotype, distribution notes and a key to *Scolytus* Geoffroy of America east of the Mississippi River (Coleoptera, Curculionidae, Scolytinae, Scolytini)

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Abstract

The identification of *Scolytus fagi* Walsh has been difficult because of the lack of diagnostic literature, the occurrence of several morphologically similar sympatric *Scolytus* species and the loss of the syntypes. In an effort to reduce taxonomic confusion, we designate a neotype for *S. fagi*, redescribe the male and female, add new distributional records and create a key for the identification of eastern *Scolytus* species.

Keywords

Scolytidae, bark beetle, taxonomy, Nearctic

Introduction

Specimens of *Scolytus fagi* Walsh have been rarely collected and within the past 140 years the species was only recorded from Illinois and Texas (Wood 1982). However, in 2009 specimens were collected in surprisingly large numbers from several locations in Pennsylvania. Initially, species identification of these specimens was difficult partially

due to vague species descriptions, inadequate keys, a lack of illustrations and most importantly the loss of the syntypes (Walsh 1867, Blackman 1934, Wood 1982). Walsh (1867) described *S. fagi* from a series of six syntypes collected from “southern Illinois” from what was presumably a beech tree (*Fagus* sp.). These specimens were stored in Walsh’s personal collection. Shortly after his death in 1869, the state of Illinois purchased his entire collection and moved it to the ‘fire-proof building’ of the Chicago Academy of Sciences (CASM). Unfortunately, the wing and nearly all of Walsh’s specimens were destroyed in the Great Chicago Fire of 1871 (Sheppard 2004). A few of Walsh’s Coleoptera and Lepidoptera specimens survived in the Chicago Academy of Sciences (Sheppard 2004), however the syntypes of *S. fagi* were not among them (J. Colby, pers. comm.). These circumstances warrant the designation of a neotype to maintain nomenclatural stability and reduce taxonomic confusion with morphologically similar sympatric species such as *S. muticus* Say and *S. quadrispinosus* Say.

In this publication, we designate a neotype for *S. fagi*, redescribe the male and female, add new distributional records and create a key for the identification of eastern *Scolytus* species.

Materials and methods

Scolytus specimens were examined from the following collections (following Evenhuis 2009) for the creation of the key:

- MCZ** Museum of Comparative Zoology, Cambridge, MA (Phil Perkins)
MSUC Albert J. Cook Arthropod Research Collection, East Lansing, MI (Gary Parsons)
NMNH National Museum of Natural History, Washington, DC (Natalia Vandenberg)
SEMC Snow Entomological Museum, Lawrence, KS (Zack Falin)
UMMZ University of Michigan Museum of Zoology, Ann Arbor, MI (Mark O’Brien).

Scolytus specimens collected by United States Forest Service Early Detection and Rapid Response Program in Missouri and Pennsylvania were also examined as part of this study.

Scolytus fagi Walsh

Scolytus fagi is known from a few specimens collected from Columbus, Texas, specimens from Illinois were difficult to locate. A single specimen of *Scolytus fagi* from Galesburg, Illinois was found in the collection of the MCZ (T.H. Atkinson, pers. comm.), and is here designated as the neotype. The specimen was examined by the

authors and was chosen because it matches Walsh's description, is from the same state as the type series and is in good condition.

Neotype. Male, vouchered in the MCZ and bearing the following labels:

- 1) "Galesburg/III"
- 2) "Liebeck/Collection"
- 3) "*S. fagi*/Walsh"
- 4) "*Scolytus fagi* Walsh/Det. Atkinson 88"

Redescription

Male: body length 3.5–6.0 mm long (\bar{x} = 5.0 mm; n = 20); 2.1–2.5 (\bar{x} = 2.37) times as long as wide. Color dark reddish brown to black. Dorsal habitus (Fig. 1a), lateral habitus (Fig. 1b).

Frons flattened, feebly concave, more strongly concave above epistoma and weakly concave above upper level of eyes, concave surface of frons punctate-granulate and densely covered with fine, long setae with apices directed toward the median line, basal and lateral margins of concavity with fewer, shorter, finer setae; median line devoid of granules, faintly aciculate and shining (Fig. 1d). Antennae dark reddish brown, club covered by short golden hair-like setae with two strongly procurved sutures.

Pronotum slightly longer than wide. Pronotum dark brown to black, margins reddish brown; pronotal surface shining, disk shallowly and minutely punctate, punctures on basal and its lateral sides larger and deeper; median line devoid of punctures on disk. Sparse, erect hair-like setae on apical and lateral margins of pronotum. Basal and lateral margins carinate, nearly straight.

Scutellum triangular, covered by fine recumbent golden hair-like setae and deeply set in the shagreened and subopaque scutellar impression. Elytra dark reddish-brown to black, slightly narrower than pronotum. Elytral strial punctures 2–3 times the size of those on interstriae, interstriae 2–2.5 times the width of striae; elytral surface shining, glabrous. Striae impressed, interstriae not impressed. Interstriae 9 and 10 and declivital interstriae covered with sparse and irregularly spaced setae. Elytral lateral edges feebly serrate, apex smooth, weakly emarginate.

Abdomen reddish-brown to black, surface of sternite 1, smooth, shining; sternites 2–5 shagreened, subopaque. Sternite 2 vertical (face at an angle of approximately 90° to first sternite) unarmed, coarsely punctured and covered with sparse setae. Apical margin of sternites 1–4 with a faintly raised margin. Sternite 5 longer than sternites 3 and 4 combined; apical fourth of sternite 5 subvertical, transversely impressed, more closely and coarsely punctured, moderately covered with abundant fine, hair-like setae each 2–3 times the length of setae on sternite 2. Genitalia (ventral view, Fig. 1f; lateral view, Fig. 1g).

Female (lateral habitus, Fig. 1c): similar to male except frons convex, faintly aciculate and devoid of granules, frons less abundantly covered by fine, long setae, basal and

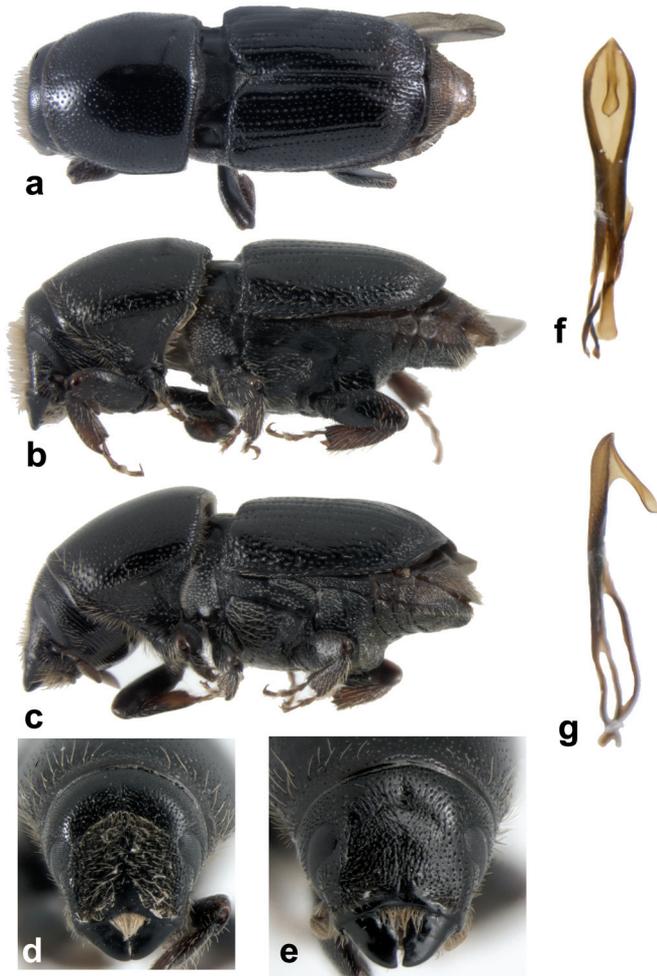


Figure 1. *Scolytus fagi* **a** male habitus dorsal **b** male habitus **c** female habitus **d** male frons **e** female frons **f** male genitalia, ventral view **g** male genitalia, lateral view.

lateral margins with fewer, shorter, finer setae (Fig. 1e). Abdominal sternite 5 with a strongly elevated transverse subapical carina.

Natural history

There is a single report of the life history by Packard (1890) in which *Scolytus fagi* was reported by Schwarz to colonize *Celtis texana* (= *Celtis laevigata* var. *texana*) in Texas and were “found boring in the solid wood in all stages... so numerous were the insects that the pattern of the larval burrow... was confused and undecipherable” (1890). Schwarz also reported that they did not appear to colonize healthy trees, but were very destructive to *Celtis laevigata* var. *texana* (1890).



Figure 2 a Sternite 2 oblique (*Scolytus rugulosus*) b sternite 2 vertical (*Scolytus fagi*).

In addition to *Celtis laevigata*, *S. fagi* has been reported to colonize *C. occidentalis* (Cannabaceae), no locality given (Blatchley and Leng 1916; Chamberlin 1939), *C. tenuifolia* (Bright and Skidmore 1994) in Ontario, *Fagus americana* (Fagaceae) no locality given (Blatchley and Leng 1916; Chamberlin 1939), *F. grandifolia*, no locality given (Wood 1982), and *Quercus* sp. (Fagaceae) in Mississippi (Atkinson et al. 1991).

Distribution

Scolytus fagi was known only from Illinois (Walsh 1867), Mississippi (Atkinson et al. 1991), Texas (Packard 1890), and southern Ontario (Bright and Skidmore 1994). Here we report new state records of *S. fagi* from Kansas, Ohio and Pennsylvania. It is likely that *Scolytus fagi* occurs throughout the range of its hosts and the sparse locality records are due to the inadequate sampling.

Kansas (vouchers deposited in the SEMC)

Bourbon Co.: Fort Scott, 9 mi SW, Hollister Wildlife Area, 1-14-VI-2005, canopy trap (1); 14-28-VI-2005 (3); 17-30-V-2006 (2); 30-V-7-VI-2006 (1); 7-15-VI-2006 (1); 26-VI-6-VII-2006 (1). *Douglas Co.*: 22-VI-2004, Lindgren trap, S. White SCW040326 (1); 14-VII-2004, Lindgren trap, S. White, SCW040430 (1); Baldwin, 2 mi NW, 9-16-VI-2005, canopy trap (1). *Geary Co.*: 3-VI-2004, rest stop, Lindgren trap, D. Martin, DJM040179 (1). *Johnson Co.*: Shawnee, 1.2 mi N of 43rd St, nr Kansas River, 2-9-VI-2005, canopy trap (2); 9-19-VI-2005 (1); 24-VI-5-VII-2005 (3). *Sedgwick Co.*: Derby, 0.5 mi S, NE of intersection K15 and 91st St, 21-30-VI-2005, canopy trap (1).

Ohio (voucher deposited in the MSUC)

“Ohio” (1).

Pennsylvania (vouchers deposited in the MSUC and additional specimens at the Pennsylvania Department of Agriculture)

Cumberland Co.: Roadway Dr @ Schneider Dr, 40.229030°N, 77.111580°W, 26.VI.2009, Coll. LR Donovall (25). *Dauphin Co.*: Wildwood on Industrial Rd, 40.316325°N, -76.888783°W, 6.VIII.2009, Coll. SE Spichiger, Ex. Lindgren-EtOH (2). *Lancaster Co.*: 7031 Elizabethtown Rd, 40.182583°N, -76.498783°W, 23.VII.2009, SE Spichiger, Ex. Lindgren-BEBB/EtOH (1). *York Co.*: 400 Mundis Race Rd, 40.030170°N, -76.705330°W, 10.vi.2009, Coll. S Rebert, Ex. Lindgren-Alpha/EtOH (4).

Key to the Scolytus Geoffroy of North America East of the Mississippi River

This key treats both sexes of *Scolytus* species and includes all species in America east of the Mississippi and all species known to colonize hardwoods in North America. *Scolytus* species are typically difficult to identify, especially females. Most current keys identify males, with females determined by association with males collected from galleries or based on *a priori* knowledge of the nuances of *Scolytus* sexual dimorphism. This key allows identification of *Scolytus* species regardless of the user’s familiarity with the genus. Terminology is similar to that used by Blackman (1934), Bright (1976) and Wood (1982) in their respective keys. Host records were obtained from Wood (1982) and Wood and Bright (1992) and all measurements excluding *S. fagi* were taken from Wood (1982).

- 1 At least one abdominal sternite with a spine 2
- Abdominal sternites without spines 5
- 2(1) Sternite 2 strongly concave, basal margin strongly produced and carinate with a median obtuse point, longitudinal median line weakly carinate on apical half; sternite 3 armed by three spines (1 median, 2 lateral) on apical margin; sternite 4 armed by a median spine on apical margin; sternite 5 with a weak transverse carina at middle of segment, apical half pubescent; frons flattened, coarsely longitudinally aciculate, frons covered with long hair-like setae; setae on lateral and dorsal margins thicker, longer, incurved. Length 2.9–5.0 mm; *Carya* spp. ***Scolytus quadrispinosus* Say male**
- Sternite 2 oblique to vertical, never concave, with a single median spine..... 3
- 3(2) Sternite 2 armed with a weakly laterally compressed spine, bulbous apically and wider than base in male, small and quadrate in female, however the shape of the spine can be highly variable. Elytral striae and interstriae punctures equal in size. Elytra bicolored, often with a dark band. Male frons flattened, weakly longitudinally aciculate covered with hair-like setae; hair-like setae on lateral and dorsal margins thicker, longer, incurved. Female frons strongly convex, weakly aciculate, frons setae sparse, short and fine. Introduced from Asia. Length 3.0–4.0 mm; *Ulmus* spp. ***Scolytus schevyrewi* Semenov**
- Sternite 2 with a conical median spine in both sexes, elytra without a banded appearance 4

- 4(3) Base of median spine reaching basal margin of sternite 2; sternites 3 and 4 with a small median tubercle on apical margins; lateral margins of sternites 2–4 with lateral teeth, sternite 5 concave with a carinate apical margin; elytral stria punctures larger than those of striae. Male frons flattened, coarsely longitudinally aciculate, abundantly covered by long hair-like setae of equal length. Female frons strongly convex, aciculate, frons setae sparse, short and fine; spine on sternite 2 smaller. Introduced from Europe. Length 1.9–3.1 mm. *Ulmus* spp. ***Scolytus multistriatus* (Marsham)**
- Base of median spine never reaching basal margin of sternite 2; lateral teeth never present on sternites; elytral stria punctures larger than those of interstriae. Male frons flat to weakly convex, moderately aciculate, abundantly covered by long hair-like setae of equal length. Female frons transversely impressed above epistoma and strongly convex above, weakly aciculate; frons setae sparse, short and fine; spine on sternite 2 smaller. Native. Length 2.2–3.3 mm; *Picea* spp. ***Scolytus piceae* (Swaine)**
- 5(1) Elytral interstriae and abdomen covered with very long fine hair-like setae (*Scolytus muticus*) **6**
- Elytral interstriae and abdomen with minute ground vestiture or with short, fine hair-like setae. **7**
- 6(5) Sternite 5 with a pair of strongly elevated areas on basal two-thirds, each densely covered with abundant fine, long hair-like setae, apical third strongly impressed. Sternite 2 vertical, abdomen covered in abundant fine, long hair-like setae. Elytral striae and interstriae punctures equal in size; interstriae with fine, very long hair-like setae. Frons flattened and concave, surface moderately longitudinally aciculate; hair-like setae on lateral and dorsal margins thicker, longer, incurved, remaining frons largely devoid of setae. Length 2.8–4.2 mm; *Celtis occidentalis*. ***Scolytus muticus* Say male**
- Sternite 5 weakly medially concave, lacking both elevated areas on basal two-thirds and dense patches of hair-like setae. Sternite 2 vertical, abdomen covered in abundant fine, long hair-like setae. Elytral striae and interstriae punctures equal in size; interstriae with fine, very long hair-like setae. Frons less strongly flattened, nearly convex and weakly concave medially, surface finely longitudinally aciculate; hair-like setae on lateral and dorsal margins thicker, longer, incurved, remaining frons largely devoid of setae. Length 2.8–4.2 mm; *Celtis occidentalis*. ***Scolytus muticus* Say female**
- 7(5) Sternite 2 oblique (face at an angle greater than 90° to sternite 1). Introduced species (Fig. 2a) **8**
- Sternite 2 vertical (face at an angle of approximately 90° to sternite 1). Native species (Fig. 2b) **9**
- 8(7) Elytral apex broadly rounded, sutural region strongly emarginate, apical margin sharply serrate, elytral interstriae with short erect setae. Sternites covered in long fine hair-like setae; sternite 5 with a weakly elevated transverse subapical carina. Pronotum coarsely, densely punctured. Male frons broadly con-

vex, weakly impressed near median line on apical third; weakly longitudinally aciculate; lightly covered by long erect hair-like setae. Female frons more convex and covered by fewer hair-like setae. Length 1.5–2.7 mm; *Crataegus* spp., *Cydonia* spp., *Malus* spp., *Prunus* spp., *Pyrus* spp., *Ulmus* spp.....

.....***Scolytus rugulosus* (Müller)**

- Elytral apex narrowly rounded, margins smooth, never obviously serrate (a row of punctures on epipleura may appear weakly serrate), elytra interstriae with short erect setae on declivity and lateral margins, surface largely glabrous. Male frons flattened, slightly impressed above epistoma, weakly convex, weakly longitudinally aciculate, frons with few short setae, setae longer more abundant on lateral margins just above epistoma; sternite 5 weakly sulcate, apical fifth rounded dorsally and moderately covered in fine hair-like setae. Female frons convex, finely aciculate with fewer hair-like setae than male; sternite 5 with a weakly elevated transverse subapical carina. Length 3.1–4.1 mm; *Malus* spp., *Prunus* spp., *Pyrus* spp., *Ulmus* spp.

.....***Scolytus mali* (Bechstein)**

- 9(7) Frons moderately longitudinally aciculate, with long, fine, incurved setae predominately on lateral and dorsal margins, fewer, shorter and finer setae medially. Frons nearly convex, impressed above epistoma. Sternite 5 with a moderately elevated transverse subapical carina. Elytral interstriae 1.5–2 times width of striae; elytral apex often serrate. Length 2.9–5.0 mm; *Carya* spp.....

.....***Scolytus quadrispinosus* Say female**

- Frons with setae uniformly distributed, fewer setae on lateral and dorsal margins, shorter, finer. Frons either granulate or faintly aciculate. Elytral apex smooth. *Scolytus fagi*.

.....**10**

- 10(9) Apical fourth of sternite 5 subvertical, transversely impressed, moderately covered with abundant fine, hair-like setae each 2–3 times the length of setae on sternite 2. Frons flattened, concave above epistoma, frons surface granulate, densely covered with fine, long setae; basal and lateral margins with fewer, shorter, finer setae. Elytral striae punctures 2–3 times the size of those on interstriae, interstriae 2–2.5 times the width of striae; surface shining, glabrous except for several short setae on declivity and lateral margins. Apex smooth. Length 3.5–6.0 mm; *Celtis* spp. *Fagus* spp.....

.....***Scolytus fagi* Walsh male**

- Sternite 5 with a strongly elevated transverse subapical carina. Frons convex, weakly concave between upper level of eyes; frons faintly aciculate, devoid of granules, moderately covered with fine, long setae; basal and lateral margins with fewer, shorter, finer setae. Elytral striae punctures 2–3 times the size of those on interstriae, interstriae 2–2.5 times the width of striae; surface shining, glabrous except for several short setae on declivity and lateral margins. Apex smooth. Length 3.5–6.0 mm; *Celtis* spp., *Fagus* spp.....

.....***Scolytus fagi* Walsh female**

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Steveoodia minutum, a new genus and species of Scolytidae (Coleoptera) from the West Indies. Studies on West Indian Scolytidae (Coleoptera) 6

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Abstract

A new genus of Scolytidae (Coleoptera), *Steveoodia*, from St. Lucia in the Lesser Antilles, is herein named and described. The type species, *Steveoodia minutum* **sp. n.** is also named. The genus is named in honor of the late Steven L. Wood for his many contributions to the systematics of the Scolytidae.

Keywords

Curculionidae, Micracini, bark beetle, Caribbean

Introduction

The West Indies have been recognized as one of the world's biodiversity "hotspots" (Mittermeier et al. 2005). This designation is based primarily on well-known groups such as vascular plants, mammals and birds. Since most insect groups are poorly documented, except perhaps butterflies, they are not generally considered in the usual biodiversity analysis; however, they probably constitute over 90% of the fauna.

A biodiversity study of the Scolytidae (Coleoptera) of the West Indies has been underway for a number of years and, for the past several years, I have been preparing a taxonomic monograph of the West Indian species of Scolytidae. While preparing that monograph, four specimens representing a new genus in the tribe Micracini were discovered.

Systematics

Stevewoodia gen. n.

urn:lsid:zoobank.org:act:31734B9E-0632-4122-971B-BB90DB3EA281

Diagnosis. With the character states of Micracini (Wood 1982) but differs by the 5-segmented antennal funicle, by the solid antennal club with the sutures not visible, and by the very small and slender body which is 0.75–0.85 mm in length, 3.1 times longer than wide. Additional generic characters are included in the species description.

Type species: *Stevewoodia minutum* Bright, sp. n.

Comments: This genus is named in honor of the late Steven L. Wood, Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah, USA, the preeminent authority on the systematics and taxonomy of the Scolytidae. Dr. Wood was my major professor while I was a graduate student at Brigham Young University many years ago, and remained a valued colleague until his death in July 2009.

Stevewoodia minutum sp. n.

urn:lsid:zoobank.org:act:92BC5FF3-F5AC-4AD6-88C7-3F8AE1B50353

Figs 1, 2

Materials examined. HOLOTYPE (male), “WEST INDIES: St. Lucia, Mon Repos, 6.5 km N Fox Grove Inn, 10–28.VI.2007, submontane forest FIT, 300 m, S. & J. Peck”// “HOLOTYPE *Stevewoodia minutum* D. E. Bright, 2009.” **ALLOTYPE**, 1 (female), same data as holotype. **PARATYPES** (2); 1 (female), “WEST INDIES: St. Lucia, Bordelais trap site, 185 m, 13.9689’N, 60.8859’W, 05–09 JULY 2009, F.I.T., C. A. Maier, M. L. Gimmel & K. J. Hopp” and 1 (male), “WEST INDIES: St. Lucia, Bordelais trap site, 185 m, 13.9689’N, 60.8859’W, 10–25 JUNE 2009, uv light, C. A. Maier & E. A. Ivie”

Description. The type specimens are presently in the author’s collection until the monograph is completed, at which time the holotype and allotype will be deposited in the Canadian National Collection of Insects, Ottawa, Ontario. The paratypes will be deposited in the collection of the West Indies Beetle Fauna Project at Montana State University, Bozeman.

Male. Length 0.75 mm, 3.1 times longer than wide; light brown. Frons convex; surface moderately shining, densely minutely-reticulate. Antennal club oval, about 1.7



Figure 1. *Stevewoodia minutum*, lateral view of male.



Figure 2. *Stevewoodia minutum*, lateral view of female.

times longer than wide, solid, without sutures; scape as long as funicle, without obvious setae. Pronotum 1.1 times longer than wide, widest at base; sides weakly arcuate, anterior margin broadly rounded, with a few, fine serrations; anterior slope steeply convex, bearing scattered, small asperities, each asperity with a longer, flattened scale at posterior margin; summit slightly elevated; posterior portion weakly transversely impressed behind summit, surface shining, minutely reticulate, with scattered, obscure, fine punctures. Elytra 1.7 times longer than wide; sides parallel on basal three-fourths, strongly converging to narrowly rounded apex; discal striae not impressed, punctured in even rows, punctures very large, very weakly impressed; discal interstriae much narrower than striae, smooth, glabrous. Declivity convex; each interstriae bearing a median row of short, erect scales and very small granules. Protibia flattened, rectangular, with parallel sides; terminal mucro undivided. Procoxae contiguous.

Female. Length 0.85 mm, 3.1 times longer than wide; light yellowish brown. Frons deeply concave from epistoma to well above upper eye level and laterally from

eye to eye, lateral margin of concavity acutely margined opposite eye and acutely extended into a short elevation at upper margin; surface brightly shining, smooth, glabrous, with a clump of very short setae (barely visible at 96×) below elevation at upper margin. Antennal club as in male, except longitudinal line absent; scape as in male, except bearing long setae. Pronotum as in male except vestiture on anterior slope hair-like, obscure. Elytra and declivity as in male except declivital granules smaller, obscure.

Comments. Adults of this species are easily distinguished from North American genera in the Micracini by their extremely small size, by the deeply concave female frons which bears a short, median elevation on the upper margin of the concavity, by the 5-segmented antennal funicle, by the narrow, elongate antennal club which is without visible sutures and by the presence of rows of erect scales on each declivital interstriae.

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Resurrection of *Dryotomicus* Wood and description of two new species from the Amazon River Basin (Coleoptera, Curculionidae, Scolytinae, Phloeotribini)

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Abstract

A cladistic analysis based on 20 morphological characters was conducted for 11 species representing two valid and two synonymized Phloeotribini genera. One hundred-eighty most-parsimonious trees were recovered and the *Dryotomicus* Wood species were monophyletic in a mostly unresolved strict-consensus tree. The unusual antennal morphology, with the length of the first two funicular segments equal to the last three segments and a scape which is twice the length of the funicle, distinguish *Dryotomicus* from the other Phloeotribini genera. Hence this genus is resurrected because of monophyly and diagnostic characters. *Dryotomicus oenophilis* sp. n. and *D. woodrex* sp. n. are described from Guyana and Peru, respectively. In the male specimen of *D. oenophilis*, the frons has one median and two large lateral carinae and in the male specimen of *D. woodrex*, the frons has three smaller median tubercles arranged transversely. *Phloeotribus puberulus* Chapuis and *P. tuberculatus* (Eggers) were monophyletic with the new *Dryotomicus* species and thus are transferred to this genus. Keys to the Phloeotribini genera and *Dryotomicus* species are given.

Keywords

Scolytidae, bark beetle, taxonomy, tropical biodiversity

Introduction

The most diverse and unknown scolytine fauna lies in the tropics. Although a recent monograph of the South American scolytines has been published, approximately another 2500 species remain undiscovered in the Neotropics (Wood 2007). Among these species, are lineages with previously unobserved morphologies, some of which represent undescribed genera. For example, Dole and Cognato (2007) described *Akrobothrus ecuadoriensis* because of the elytral depression around the scutellum, which is a rare character among scolytines. Similarly, we recently discovered two morphologically interesting species of the Phloeotribini collected from primary wet forests in Guyana and Peru. Although the pseudo-lamellate antennal club places these new species in *Phloeotribus* Latreille, the unusually long funicle and scape suggests the placement of these species in a different genus. Phloeotribini currently contains two genera: *Phloeotribus* which is represented by ~100 species distributed in the Holarctic, South America (with highest diversity), and Australia and *Aricerus* Blandford which is represented by three Australian- New Guinea species (Wood 1986). However, as many as nine previously recognized genera have been synonymized with *Phloeotribus* and, of these, the Neotropical genera *Eulytocerus* Blandford and *Dryotomicus* Wood resemble the recently collected specimens based on previous descriptions (Chapuis 1869; Blandford 1897; Schedl 1962; Wood 1962).

In this study, we assembled specimens of Neotropical, Nearctic, and Australian Phloeotribini and conducted a cladistic analysis, which justified the resurrection of *Dryotomicus* and the description of two new species.

Materials and methods

Specimens of one *Chramesus* (outgroup), one *Aricerus* and 11 *Phloeotribus* species, which included all species described as *Dryotomicus* and *Eulytocerus* (Wood and Bright 1992), from the A.J. Cook Arthropod Research Collection, East Lansing, MI [MSUC], the National Museum of Natural History at the Smithsonian Institute, Washington, D.C. [USNM], Snow Insect collection, Lawrence, KS [SMEC], The Natural History Museum, London [BMNH] and Institut Royal des Sciences Naturelles de Belgique (IRSNB) were examined and scored for 20 morphologically variable characters (Tables 1, 2).

Using this data matrix (Table 2), most parsimonious trees (mpts) were reconstructed by a branch and bound search in PAUP* 4.0 b10 PPC using default settings (Swoford 2002). Bootstrap values were determined by performing 500 pseudo-replicates in a heuristic search with simple stepwise addition replicates. Bremer support was calculated with TreeRot v.2 (Sorenson 1999).

Table 1. Characters and their states used in the phylogenetic analysis.

Character 1	Antennal club. 0: segments fused, 1: segments articulated.
Character 2	Antennal club, shape of first segment. 0: not applicable, 1: asymmetrical with a constant width, 2: Asymmetrical, expanded at base (j- shaped), 3: symmetrical chevron-shaped.
Character 3	Second funicular segment. 0: not longer than total length of segments 3-5, 1: longer than total length of segments 3-5.
Character 4	Length of scape. 0: not extending beyond the anterior margin of the pronotum, 1: extending beyond the anterior margin of the pronotum.
Character 5	Area between the antennal insertions and mandibles. 0: less than or equal to length of the mandibles, 1: greater than the length of the mandibles.
Character 6	Male frons with median tubercle(s). 0: absent, 1: one 2: > one.
Character 7	Male frons with lateral carina. 0: absent, 1: present.
Character 8	Male head sulcate from the apex of the eyes to the vertex. 0: absent, 1: present.
Character 9	Declivitous anterior edge of the pronotum. 0: absent, 1: present.
Character 10	Dorsum of the pronotum. 0: with dense, minute, oppressed setae, 1: with scattered longer erect setae.
Character 11	Anterior and lateral margins of the pronotum. 0: without asperities, 1: with asperities.
Character 12	Basal margin of the elytra. 0: crenulate, 1: carinate.
Character 13	Elytral striae. 0: deeply impressed, 1: shallowly impressed.
Character 14	First and second interstriae on elytral declivity. 0: raised above striae, 1: flush with striae.
Character 15	Third, fifth and seventh elytral interstriae on declivity. 0: with tubercles, 1: smooth.
Character 16	Scales on elytral declivity. 0: absent, 1: present.
Character 17	Tubercles on protibia (male). 0:3, 1:5, 2:6, 3:7, 4:8, 5:9.
Character 18	Protibiae. 0: without socketed teeth, 1: with socketed teeth.
Character 19	Metatibae. 0: widest at distal end, 1: widest near the middle.
Character 20	Metatibae. 0: with less than five denticles, 1: with more than five denticles.

Results and discussion

One hundred-eighty mpts were reconstructed for the 13 taxa. The strict consensus tree of the mpts was mostly unresolved except for the monophyly of *Dryotomicus* species (Fig. 1). This clade has a high bootstrap value (100), is supported by a relatively high Bremer value (4) and has several diagnostic characters (Fig. 1). The antennal funicle, in which the length of the first two funicular segments equals the last three segments, and the scape, which is twice the length of the funicle, are the most striking features. Antennal morphological variation is taxonomically important because these features diagnose *Aricerus* as well as species of *Phloeotribus* (Wood 1982, Wood 1986). Hence, given monophyly and the diagnostic characters, *Dryotomicus* is removed from synonymy with *Phloeotribus* and includes four species *D. puberulus* (Chapuis, 1869), *D. tuberculatus* (Eggers, 1943), *D. oenophilis* sp. n., and *D. woodrex* sp. n. Exclusion of *P. ovatus* (Egg-

Table 2. Character states used for the reconstruction of the Phloeotribini phylogeny (Fig. 1). Characters and states are in Table 1.

	Characters																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Arictus</i> sp.	1	3	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0
<i>Phloeotribus championi</i>	1	2	0	0	0	0	1	0	0	1	0	1	0	0	0	0	5	1	1	1
<i>Phloeotribus</i> sp. <i>Costa Rica</i>	1	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	?	1	0	1
<i>Phloeotribus</i> sp. <i>Ecuador</i>	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	1	1	1
<i>Phloeotribus frontalis</i>	1	2	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1
<i>Phloeotribus liminaris</i>	1	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	1	0	1
<i>Phloeotribus ovatus</i>	1	1	0	0	0	?	0	0	0	1	1	0	0	0	1	0	3	1	0	?
<i>Phloeotribus</i> sp. <i>Panama</i>	1	1	0	1	0	0	1	0	0	1	1	0	0	0	1	0	2	1	0	1
<i>Dryotomicus oenophilis</i> sp. n.	1	2	1	1	1	1	1	1	1	0	0	1	1	0	1	1	2	1	1	1
<i>Dryotomicus woodrex</i> sp. n.	1	2	1	1	1	2	1	1	1	0	0	1	1	1	0	1	2	1	1	1
<i>Phloeotribus puberulus</i>	1	2	1	1	1	?	?	?	1	0	0	1	1	0	0	1	2	1	1	1
<i>Phloeotribus tuberculatus</i>	?	?	?	?	?	?	?	?	1	0	0	1	1	0	1	1	?	1	1	1
<i>Chramesus</i> sp.	0	0	0	0	0	0	1	0	0	1	1	0	0	1	1	0	4	1	0	1

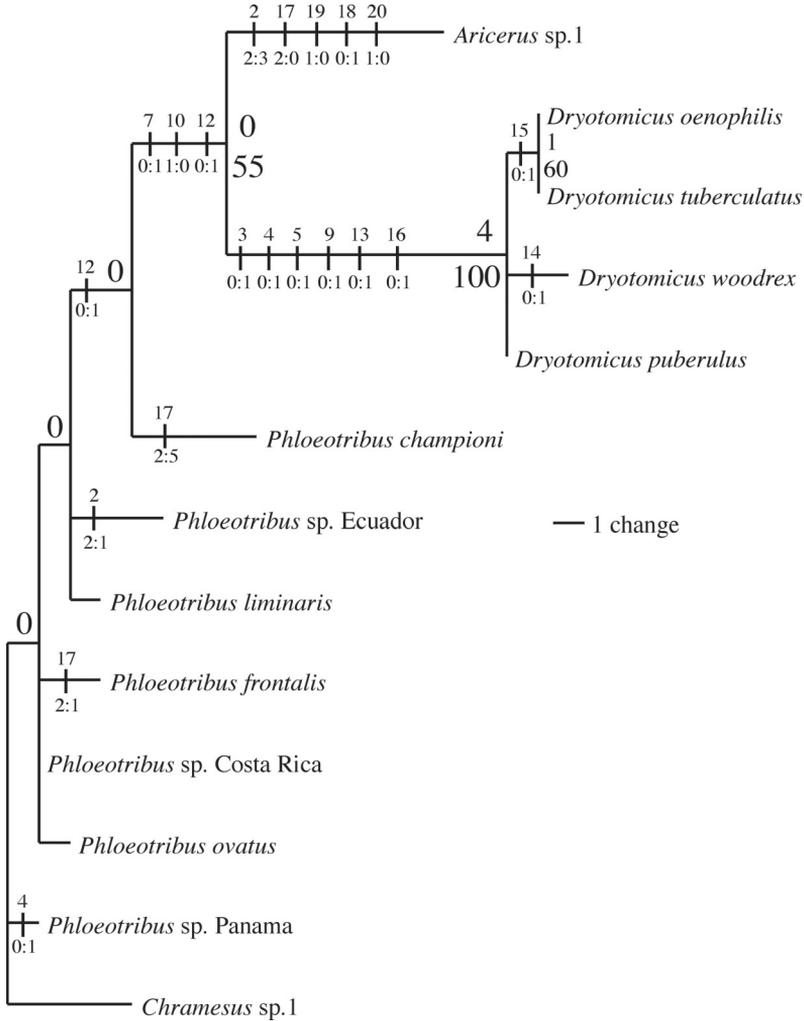


Figure 1. Phylogeny of Phloeotribini species, 1 of 180 most parsimonious trees (tree length=35, RC=0.6429). Numbers above branches are Bremer support and numbers below are bootstrap values (< 50 not shown). Nodes with zero Bremer support were unresolved in a strict consensus of the 180 mpts. Vertical lines represent unambiguous character state changes inferred using accelerated transformations. Numbers above vertical lines are the characters and numbers below are the character state changes.

ers, 1943) and *P. championi* (Blandford, 1897) from this clade confirms their synonymy with *Phloeotribus* (Wood and Bright 1992). Although the relationship of the *Phloeotribus* spp. is unresolved, many of the mpts suggest that this genus is potentially paraphyletic. The inclusion of more *Phloeotribus* spp. and data, especially DNA sequences, in future phylogenetic analyses would help to solidify the relationships among the genera.

The relationship of the four *Dryotomicus* species is mostly unresolved (Fig. 1). Low support values indicate a potential sister- relationship between *D. oenophilis* and *D. tuberculatus*. However this is a likely spurious result caused by missing character data for

D. tuberculatus; the only known specimen representing this species is missing its head. However, the distinct morphology of the male frons and elytral declivity distinguish the new species from *D. tuberculatus* (Fig. 1).

Systematics

Dryotomicus Wood, genus bona

Dryotomus Chapuis 1869: 46. Type species: *Dryotomus puberulus* Chapuis, monobasic, preoccupied by Swainson 1831: 301. Synonymy: Schedl 1962: 487. (References in Wood and Bright 1992: 216)

Dryotomicus Wood 1962: 76. *Dryotomus puberulus* Chapuis, automatic. Synonymy: Wood 1982: 256. (References in Wood and Bright 1992: 217)

Diagnosis. The asymmetrical first segment of antennal club, socketed teeth on the protibae, and rounded lateral margins of the pronotum distinguish this genus from *Aricerus*. The usual median tubercle(s) on the male frons, the longer second antennal funicular segment, declivitous anterior edge of the pronotum, the shallowly impressed elytral striae, and elytral declivity with scales and long setae distinguishes *Dryotomicus* from *Phloeotribus*.

Dryotomicus oenophilis, sp. n.

urn:lsid:zoobank.org:act:A2174B38-3EBD-4463-AB45-718C449F858D

Figs 2–5

Diagnosis. *Dryotomicus oenophilis* is distinguished from the other *Dryotomicus* species by a large medial tubercle and lateral carina with acute proximal tips on the male frons, interstriae 2 without long uniserial setae, and by raised interstriae of the elytral declivity having tubercles on interstriae 3, 5, and 7 (Fig. 3B).

Description. *Holotype*, male, total length 4.5 mm (3.8–4.5 mm, n=7), 2× longer than wide, color reddish-black (Fig. 2).

Head. Frons shagreen with setae as long as or longer than the large median tubercle, longest setae close to epistoma and frontal margins; a large median tubercle between antennal insertions and dorsal margin of eye; lateral carinae from epistoma to dorsal end of eye thicker at antennal insertion and ending acutely (Fig. 3A). Vertex, shagreen with setae approximately as long as or longer than large median tubercle; slightly concave with distinct slightly carinate lateral margins; obtuse median carina from median frontal tubercle to epistoma. Antennae, scape expanded distally and curved proximally beyond the anterior edge of pronotum, funicle five segmented, segments 1 and 2 about equal length and each as long as the combination of segments 3,

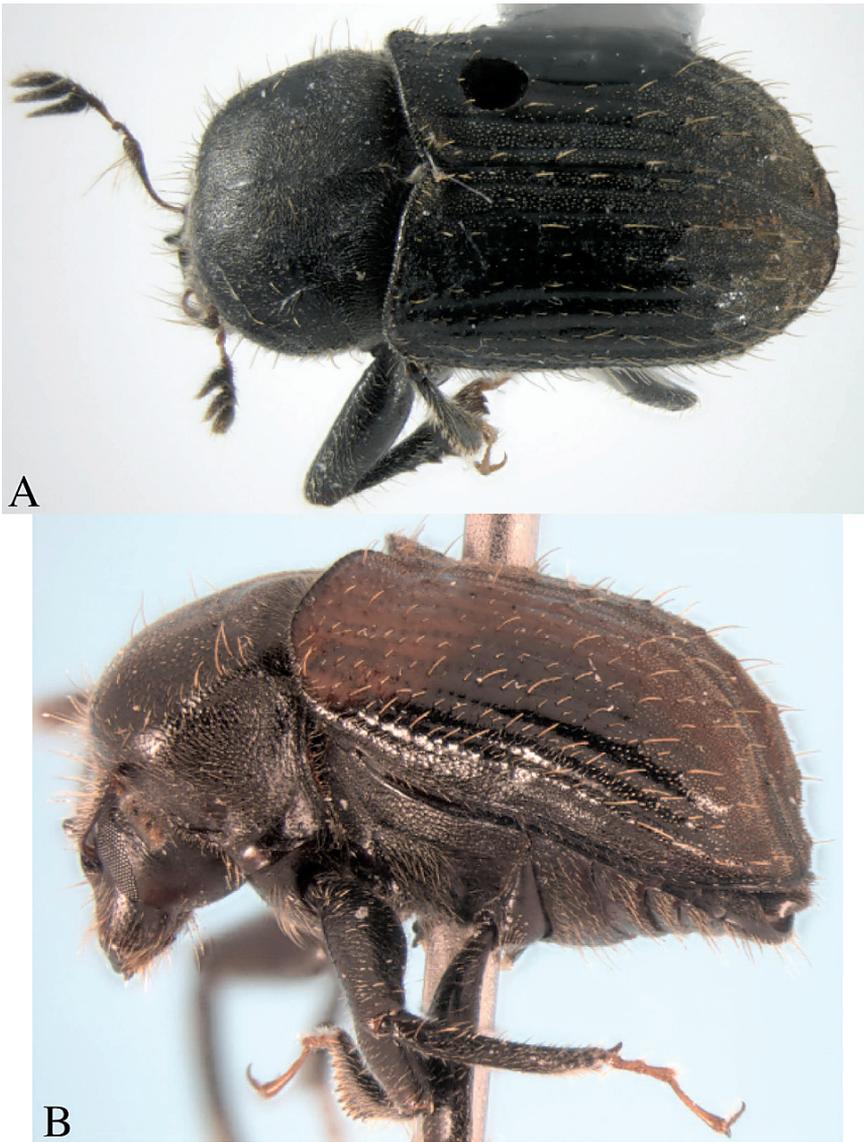


Figure 2. *Dryotomicus oenophilis* sp. n. male. Habitus, **A** Dorsal **B** Lateral.

4, 5, club pseudo-lamellate, asymmetric, basal segment 1 expanded at base (j-shaped). Eyes oval, ventrally acute (Fig. 3A).

Pronotal width 2.2 mm (1.7–2.2 mm, n=7), 0.64× longer than wide; quadrate flat summit not apparent, densely punctured with appressed minute pubescence and scattered longer setae approximately as long as the funicle concentrated anteriorly and laterally.

Elytra 1.2× longer than wide, 2× longer than pronotum, striae on disk impressed, punctures only evident near declivity; striae 4–9 marked by shallow, uniserial punctures;

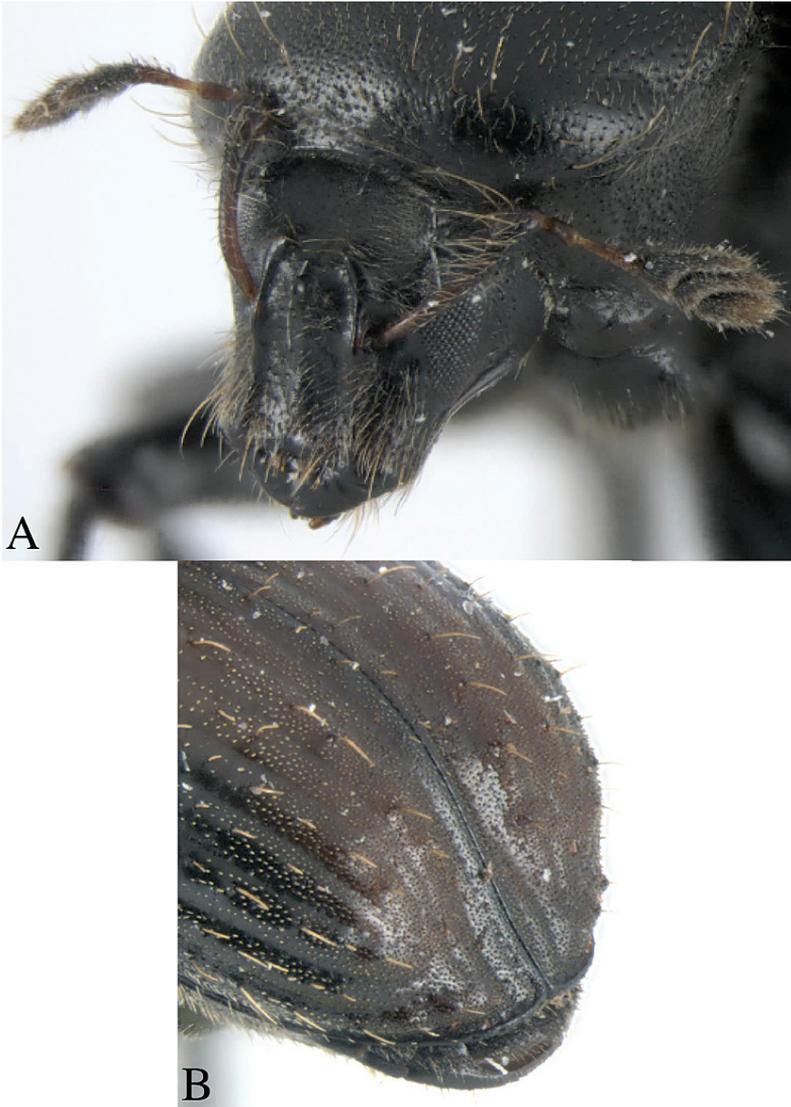


Figure 3. *Dryotomicus oenophilis* sp. n. male, **A** Frons **B** Elytral declivity.

interstriae on disk 2–3× width of striae, confused scales from base to apex on interstriae 1 and 2, interstriae 1 and 3–9 with long uniserial setae approximately as long as the funicle; interstriae 3–9 minutely punctured. (Figs 2, 3B). Elytral declivity with densely placed scales and scattered long setae; striae impressed; interstriae 3, 5, 7 each with 3 tubercles (Fig. 3B).

Male genitalia. Aedeagal body (median lobe) conical, apex acute, lateral margins heavily sclerotized medially on apical half, apophyses (struts) as long as body, attached ventrally; internal sac central area lightly sclerotized, lateral margins heavily sclerotized appearing as ventral apophyses (struts) directed apically, seminal trough at proximal end comprised of two lobes that curve medially (Fig. 4). Tegmen circular, weakly scler-

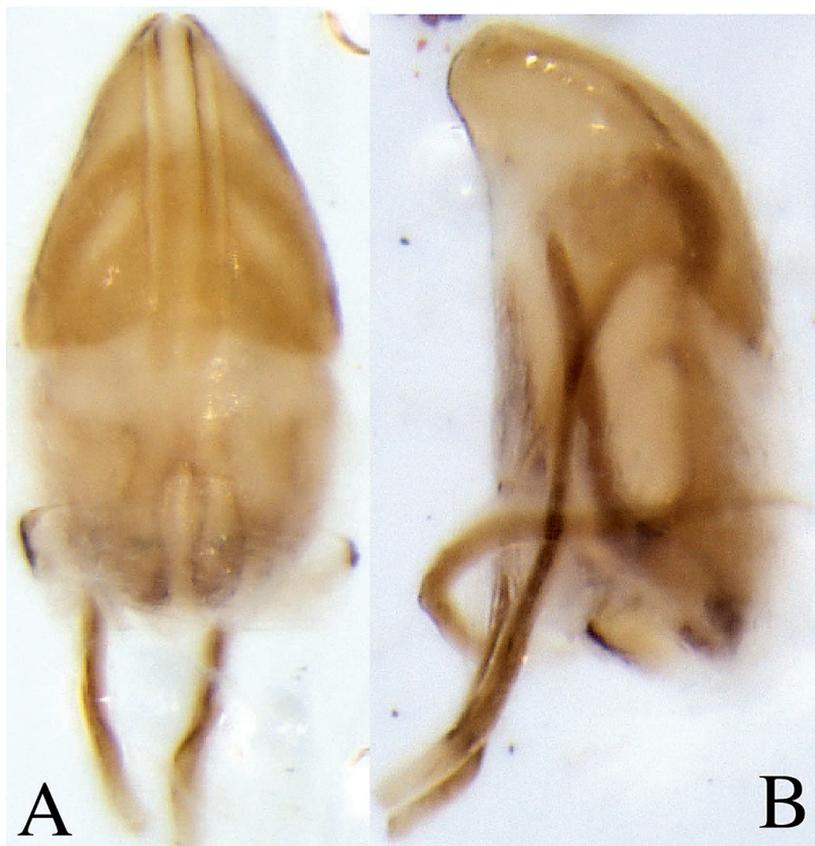


Figure 4. *Dryotomicus oenophilis* sp. n. male genitalia, **A** Dorsal **B** Lateral. Spiculum gastrale not shown.

rotised on dorsal side. Spiculum gastrale nearly as long as adeagus, crescent-shaped with small knob near the apicalend.

Female similar to male in most features, except frons flat to slightly convex, densely punctured, without median tubercles and carinae (Fig. 5A). Strial punctures on elytra more distinct, interstitial tubercles smaller (Fig. 5B).

Type material. Holotype and 6 paratypes (3 males and 3 females) bear two collection data labels, First: “GUYANA: Iwokrama Forest, GPS N 04,40.486’, W 58.41.028’, 4–9 March 2007, Cognato, Hulcr, Smith, Dole, McCall Colls”; Second: “Collected with ethanol trap”. The holotype is deposited in the Biodiversity Center at the University of Guyana and 4 paratypes are deposited in the A. J. Cook Arthropod Research Collection, Michigan State University, East Lansing; 2 paratypes are in the U.S. National Museum of Natural History, Washington D.C.

Notes. In Guyana, we collected all specimens from 20 plastic cups filled with 100 ml of 90% ethanol and nailed to trees 1.5 meters above ground.

Etymology. *oeno* (G) = wine, *philis* (G) = lover. The name “wine-lover” signifies the collection of all specimens from ethanol traps.



Figure 5. *Dryotomicus oenophilis* sp. n. female, **A** Lateral habitus **B** Frons.

***Dryotomicus woodrex*, sp. n.**

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Figs 6–8

Diagnosis. *Dryotomicus woodrex* is distinguished from the other *Dryotomicus* species by three medial tubercles arranged transversely on a tumescence on the male frons; the interstriae flush with striae on the elytral declivity.

Description. *Holotype*, male, total length 4.6 mm, 2× longer than wide, antennae reddish-black, head, legs, thorax, and elytra tannish (perhaps teneral). Pronotum tannish with dark diamond pattern (Fig. 6).



Figure 6. *Dryotomicus woodrex* sp. n. male. Habitus, **A** Dorsal **B** Lateral.

Head. Frons shagreen with setae approximately as long as or longer than funicle; three medial tubercles arranged transversely on a tumescence between antennal insertion and dorsal margin of eye; lateral carinae from epistoma to dorsal end of eye thicker at antennal insertions (Fig. 7A). Vertex shagreen with setae approximately as long or longer than funicle; slightly concave. Antennae, scape expanded distally and curved proximally beyond the anterior edge of pronotum, funicle 5-segmented, segments 1 and 2 about equal length and each as long as segments 3–5 combined, club pseudo-lamellate, asymmetric, segment 1 expanded at base (j-shaped). Eyes oval, ventrally acute (Fig. 3A).

Pronotal width 2.3 mm, 0.65× longer than wide; quadrate disk, summit not distinct, surface densely punctured with appressed pubescence and scattered longer setae approximately as long as funicle concentrated anteriorly and laterally.



Figure 7. *Dryotomicus woodrex* sp. n. male, **A** Frons **B** Elytral declivity.

Elytra 1.2× longer than wide, 2× longer than pronotum, striae on disk not impressed, punctures distinct; interstriae 3–4× width of striae, long uniserial setae approximately as long as funicle arising from granules (Fig. 6). Elytral declivity densely scaled with scattered long setae concentrated along the lateral margin (Fig. 7B).

Male genitalia. Aedeagal body (median lobe) conical, apex acute, lateral margins heavily sclerotized medially on apical half, apophyses (struts), as long as body, attached ventrally; internal sac central area lightly sclerotized, lateral margins heavily sclerotized appearing as ventral struts directed apically, seminal trough proximal end comprised of two parallel lobes (Fig. 8). Tegmen circular, weakly sclerotised on dorsal side. Spiculum gastrale destroyed by dissection.

Female is unknown.

Type material. Holotype bears the collection data label: “PERU: Dept. Loreto, 1.5km N Teniente Lopez, 4°35.66’S, 76°06.92’W, 22 July 1993, 210–240 m, Richard Leschen #164, ex: flight interception trap”. The holotype is deposited in the Snow Museum, University of Kansas [SMEC].

Etymology. The name “woodrex” honors Dr. Stephen L. Wood’s kingly contribution to the knowledge of scolytine and platypodine taxonomy. It is used as a noun in apposition.

***Dryotomicus puberulus* (Chapuis), comb. n.**

Dryotomicus puberulus (Chapuis) 1869: 46 (*Dryotomus*). Holotype: female, Cayenne; IRSNB, Brussels. (References in Wood and Bright 1992: 227)

Diagnosis. This species differs from other *Dryotomicus* spp. by the absence of tubercles from the third, fifth and seventh interstriae and the raised first and second interstriae of elytral declivity.

Redescription. See Wood (2007): 125.

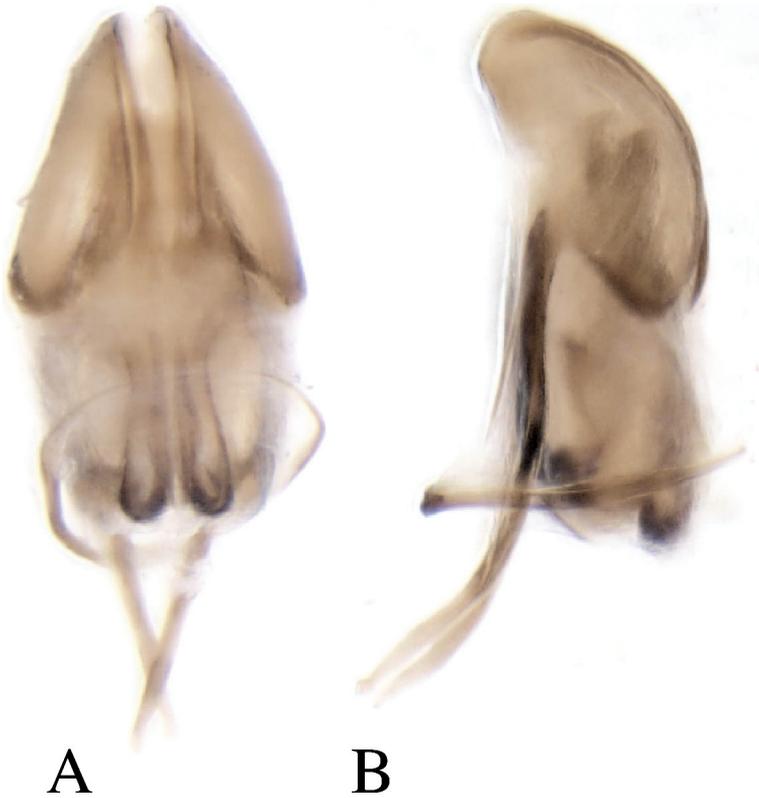


Figure 8. *Dryotomicus woodrex* sp. n. male genitalia, **A** Dorsal **B** Lateral.

***Dryotomicus tuberculatus* (Eggers), comb. n.**

Dryotomicus tuberculatus (Eggers) 1943: 348 (*Dryotomus*). Holotype: male ?, Bolivia (Cochabamba); USNM, Washington. (References in Wood & Bright 1992: 235)

Diagnosis. This species differs from other *Dryotomicus* spp. by the presence of tubercles on the third, fifth and seventh interstriae of the elytral declivity and rugose interstriae of elytral disk and with more than 3 tubercles (Fig. 10)

Redescription. See Wood (2007): 125–126

Key to Phloeotribini genera

- 1. First segment of antennal club symmetrical chevron-shaped (Fig. 9); protibia without socketed teeth; lateral margin of pronotum marked by asperites; Australia to New Guinea*Aricerus*
- First segment of antennal club asymmetrical; protibia with socketed teeth; lateral margin of pronotum rounded, without asperites **2**



Figure 9. *Aricerus* sp. antenna.

- 2. Second antennal funicular segment longer than total length of funicular segments 3–5; anterior edge of the pronotum declivitous; elytral declivity with scales and long setae..... *Dryotomicus*
- Second antennal funicular shorter than total length of funicular segments 3–5; anterior edge of the pronotum flat; elytral declivity with long setae only *Phloeotribus*

Key to *Dryotomicus* species

- 1. Elytral declivity with tubercles on the third, fifth and seventh interstriae ..2
- Elytral declivity without tubercles on the third, fifth and seventh interstriae.....3
- 2. Interstriae of elytral disk smooth and with 3 or fewer tubercles.....*D. oenophilis* sp.n.
- Interstriae of elytral disk rugose and with more than 3 tubercles (Fig. 10)*D. tuberculatus* (Eggers)
- 3. First and second interstriae on elytral declivity flush with striae *D. woodrex* sp. n.
- First and second interstriae on elytral declivity raised above striae (Fig. 11)....*D. puberulus* (Chapuis)



Figure 10. *Dryotomicus tuberculatus* elytra.



Figure 11. *Dryotomicus puberulus* elytral declivity.

Acknowledgements

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New data on Neotropical *Scolytus* Geoffroy, 1762 with description of five new species from Peru (Coleoptera, Curculionidae, Scolytinae)

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Abstract

Five new species of *Scolytus* Geoffroy, 1762 (Coleoptera: Curculionidae: Scolytinae) are described from Peru, namely *S. woodi*, *S. carveli*, *S. vagabundus*, *S. lindemani*, *S. mozolevskae*. The following new synonym is established: *Scolytus angustatus* Browne, 1970 (= *Scolytus facialis* Schedl, 1973, **syn. n.**) New records of the *Scolytus* species in Loreto, Junin, Cusco and Madre de Dios Provinces are given and the biology of the genus representatives is discussed.

Keywords

bark beetles, Coleoptera, Curculionidae, new species, Peru, Scolytinae, Scolytini, *Scolytus*, taxonomy

Introduction

An interest of entomologists to the Neotropical entomofauna studies has grown during last time. Humid tropical forests of the Amazon River basin makes researchers to amaze by the insects of unusual form and by their adaptations to live in the complex ecosystems. Scolytine (bark- and ambrosia-beetles) represent an important component

of the South American xylophilous complex. The special attention to these insects is attracted by their importance for forestry. Stephen L. Wood's monograph (2007) gave a new impulse for South American scolytine studies. By summarizing the extent knowledge on the Neotropic scolytine Wood has provided a base for further studies of this interesting group of insects.

Studies conducted recently have demonstrated the importance of the Neotropic faunal investigations, due to the fact that this region is still rich in the undescribed species new for science. Currently, many South American Scolytinae are known only from a single type specimen and knowledge of their biology and distribution so far is unknown. In some species the sex of type specimens was determined incorrectly. For example, a morphological feature of females of many Neotropic *Scolytus* species is the presence of specific forelocks, owing to these bunches of hairs of females accepted for males. Further entomological investigations in South America will allow making our knowledge about Scolytinae fauna and ecology more precise and will broaden our knowledge about the Scolytinae role in the xylophilous insect complexes in of the Neotropics.

In the Neotropic Region, the tribe Scolytini Latreille, 1807 is represented by genera *Scolytus* Geoffroy, 1762, *Camptocerus* Dejean, 1821, *Cnemonyx* Eichhoff, 1868 and *Scolytopsis* Blandford 1896. The tribe Scolytini attains its maximum diversity in the forests of the Central and South America. Investigations conducted during recent decades in the forests of Brasilia, Ecuador, Peru and Bolivia permitted expanding our knowledge about the species composition of Scolytini genera and about the biology of individual species in South America. New methods for insect collection allowed for the discovery and subsequent description of new species of *Scolytus* and *Camptocerus* in the Amazon River basin (Wood 2007, Petrov 2007, Smith and Cognato, in press). In the future, discovery of new taxa from the tribe Scolytini in the Neotropic Region is quite probable.

The genus *Scolytus* includes more than 120 species worldwide. Of these species, 37 are recorded from South America. However, paucity of collection materials prevents *Scolytus* species distribution range in the Neotropic Region objective analysis. However, one may already now assert that host-plants distribution is the limiting factor for the distribution of the *Scolytus* individual species. For the most *Scolytus* species, specialized oligophagy is typical, so far individual species may infest and breed in plant species from only one genus. Due to this fact, several species which breed in widely distributed lianas, possess wide distribution ranges from Mexico to Brasilia (*S. costatus*, *S. cristatus*), whereas the distribution of other species is limited by the basin of the Amazon River (*S. angustatus*, *S. bicinctus*, *S. amazonicus*). The similarity of the orographic and climatic conditions defines the principal similarity of the plant species composition and the forest ecosystems structure in the enormous territories from North to South. So far, it was not striking to find in Peruvian forests some of the *Scolytus* species (*S. antennatus* and *S. thoracicus*) previously known from the southern Brasilia territories. Another important factor, influencing the scolytine species range, is the vertical zonal-ity, which defines the change in plant composition in Andes. In South America at high elevations of 1800–3000 meters a.s.l. *Scolytus* species were not yet found. This feature

is distinctive from Neotropic region fauna compared to Eurasian fauna, including *Scolytus* species breeding at rather high elevations.

Different methods of insect trapping were used during collecting trips. Use of specific methods were determined by landscape peculiarities, forest ecosystem state and by presence of time for setting and serving of the traps. Usually barrier traps and light traps at night time are considered to be the most effective for collecting *Scolytus* in conditions of the South American rainforests. Nevertheless these methods do possess high efficiency, the information on biology of the species collected, namely host-specificity, peculiarities in the gallery construction etc. is lacking when these methods are used. So far, hand-collecting of beetles from the host trees is still preferential and necessary to obtain information on species biology and taxonomy.

Seventeen species from the genus *Scolytus* were collected during collecting trips in the provinces Loreto, Huanuco, Junin, Cusco and Madre de Dios in 1997, 2005–2009 when the humid rainforests of the Amazon, Madre de Dios, Ucayali and Uribamba river basins were visited. Most of the beetles were collected with the assistance of barrier traps.

Systematics

Scolytus amazonicus Schedl, 1972

Figs 1–2

Material examined. Brazil: Manaus, Amazonas; Holotype ♂, NHMW. Peru, Loreto province, 30 km SSW from Iquitos, Panguana vill., 29.01.1997 A.Petrov (1♀).

Diagnosis. The species is related to *S. barbatus* Schedl and *S. mozolevskae* sp.n., but can be distinguished by the structure of the second and third abdominal sternite and puncturation. The species also differs also from *S. barbatus* by the smaller size, the absence of a bundle of golden hairs on the second abdominal sternite and also by the less abundant hair-like vestiture on the lateral parts of the front.

Description. *Male:* body length 4.0–4.5 mm, 2.2–2.3 times as long as wide; body brown or reddish-brown, faintly shining, covered by pale hairs. Head reddish brown with mandibles nearly black. Front weakly convex from eye to eye and from epistoma to vertex, evenly longitudinally aciculate from vertex to epistoma. Lateral parts of front evenly rounded and covered with long golden hairs forming a brush. Antennae with reddish-brown scapus and funiculus and with blackish-brown club; club with narrow base, gradually widening towards apex, evenly rounded at apex. Pronotum 1.0–1.1 times as long as wide, reddish brown, its surface faintly shining, its punctures of variable size; punctures at base and in central portion of disk small, shallow, of elliptical form and significantly smaller compared to punctures at lateral sides in apical portion of pronotum; at base and in central part of pronotal disk punctures are sparse, in apical portion of pronotum punctures are densely set, confluent. Isolated hairs are set on lateral parts of pronotal apex. Pronotum is separated from propleura by acute lateral

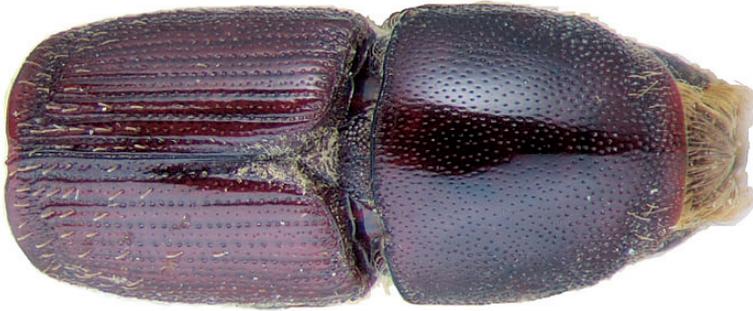


Figure 1. Habitus of *Scolytus amazonicus*, male

margin. Puncturation of lateral sides of pronotum (propleura) is inconspicuous, seen only under higher magnification, punctures are shallow and significantly smaller than punctures of pronotum lateral parts. Prothorax is covered by short, recumbent pale hairs. Scutellum triangular, set deeply in scutellar impression. Scutellum covered by minute pale scale-like hairs. Elytra 1.2–1.3 times as long as wide, equal in length to pronotum; striae distinctly, narrowly impressed, with round punctures, set close one to another; interstriae flat, with rows of small punctures. Towards elytral apex pale hairs form rows on interstriae and at lateral sides of elytra. Abdomen has first sternite set horizontal and nearly vertical second sternite. Third, fourth and fifth sternites form 45° angle with first sternite. First, fourth and fifth sternites are densely punctured with points of moderate size (Fig. 2). Puncturation of second and third sternites uneven, punctures are set on separate, slightly deepened areas and separated by dull, slightly elevated parts of surface lacking puncturation. Surface of the second and third sternites dull, the fourth glossy and shining. Legs reddish-brown. Femora with long pale hairs.

Female: body length 4.0 mm, 2.3 times as long as wide, pronotum 1.05 times as long as wide, elytra 1.1 times as long as wide, 1.1 times as long as pronotum; body reddish-brown, faintly shining, covered with pale hairs. In general similar to male, except front much more strongly convex and bearing a brush of middle-sized brownish hairs set in form of horseshoe. Upper margin of this brush attains upper level of eyes. Above upper portion of hair-brush overhangs one more brush of brown hairs originated from vertex. As in male puncturation of second and third abdominal sternites is uneven, punctures on these sternites located only on separate slightly deepened areas separated by dull slightly elevated surface without puncturation. Surface of second and third sternites dull, fourth glossy and shining. Second abdominal sternite is covered by densely set yellow hairs of moderate length; lateral sides of third sternite are armed with blunt tubercles. Fifth sternite medially impressed.

Notes. There are two males of *Scolytus amazonicus* preserved in the collection of K. Schedl. The specimen labeled as a female has a front with damaged frontal vestiture.

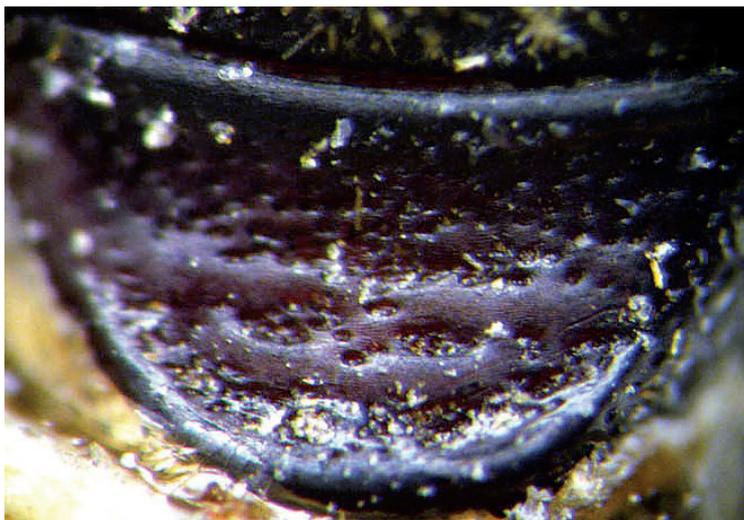


Figure 2. Punctuation of second sternite of *S. amazonicus*

Due to the front structure with the short brush of hairs, this specimen was erroneously treated as female. Based on the female trapped in Peru, both sexes are distinguished by the features described above. In S. L. Wood's monograph (2007), descriptions of both male and female are incorrect.

Scolytus angustatus Browne, 1970

Figs 3–4

Scolytus facialis Schedl, 1973, **syn.n.**

Material examined. Brazil: Santarem, Holotype of *Scolytus angustatus* Browne ♂, BMNH; Maturaca, Amazonas, alto Rio Cauaburi, 12–17.XII.1962, J. Bechyne, Holotype of *Scolytus facialis* Schedl ♀, NHMW. Peru: Loreto province, 60 km SW from Iquitos to Nauta, Itaya river, 120 m, S4°11' W73°26', 9–12.02.2007 A. Petrov (2♂♂, 2♀♀)

Diagnosis. The male of species is related to male *S. costellatus* Chapuis, distinguished by small punctures of frons, by the shorter, transverse costa in the basal centre of second abdominal sternite, in male lateral parts of second and third sternites with sharpened tubercles; in female front with median elevated line, longitudinal impression in upper portion of front and with two orange fringes overhanging front from vertex; front of female with slightly elevated median line from epistoma up to center of front, vertex with two symmetrically orange fringes

Description. *Male:* body length 2.9–3.6 mm, 2.1–2.2 times as long as wide; body reddish-brown, shining, covered with pale hairs. Head reddish brown with black mandibles and brown antennae. Front slightly convex, nearly flat, upper half feebly flat-



Figure 3. Head of *S. angustatus* male

tened, lower half with a weak median crest. Front minutely punctured, more abundant at lateral parts of front and above mandibles. Lateral sides of front evenly rounded and covered by long yellow recumbent hairs forming a brush. At upper part of front, hairs sparser. Central frontal area nearly devoid of hairs, its lower part with small keel-like tubercle. Antennae brown, club of elliptical form, longitudinally elongated. Pronotal length is approximately equal to its width, 1.0–1.1 times as long as wide, reddish brown, its surface shining, evenly punctured; in apical portion of pronotum points are larger and set denser. Apical portion of pronotum lateral sides with recumbent pale hairs. Pronotum separated from prothorax by a well-defined edge. Puncturation of lateral surface of prothorax (propleura) is shallow, unobscured. Prothorax covered by sparse, recumbent pale hairs.

Scutellum of triangular form, set deeply in scutellar depression, covered by short pale hairs.

Elytra 1.0–1.1 times as long as wide, 1.0–1.2 times as long as pronotum; striae distinctly, narrowly impressed; interstriae about three times as wide as striae. Interstitial punctures are small, organized into regular rows; there are larger fovea between the small punctures of interstriae; fovea with short pale hairs. Vestiture of elytra at interstriae of rather stout hairs, some rows extending to basal half (2, 5, 7), in other hairs present only near declivity (1, 3, 4, 6).

Central portion of first abdominal sternite curved backwards forming an arc. Second sternite is considerably impressed in relation to posterior margin of first sternite. Lateral sides of second sternite posterior margin with small denticles. Third, fourth and fifth abdominal sternites form an angle of 70° with first sternite. Lateral sides of third and fourth abdominal sternites carry pair of blunt small tubercles each. Fifth sternite is broadly impressed, with sharply elevated rim at posterior margin. Sternite surface is dull, faintly shagreen, covered with erect golden hairs of moderate length. Fifth sternite glabrous. Legs are reddish-brown, covered by short pale hairs.

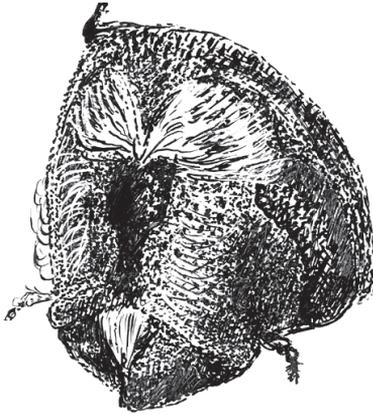


Figure 4. Head of *S. angustatus* female

Female differs from male by frontal structure and vestiture and also by form of abdomen.

Female: frons convex, without median tubercle, median one-fourth moderately sulcate from near middle of frons to vertex; lateral sides of female front are covered by densely set brown hairs of moderate length. Upper margin of frontal brush attains the upper margin of eyes; here paired bundles of longer, densely set hairs from vertex overhang frontal brush; apices of these bundles directed one to another. Elytra are essentially as in male, striae narrowly impressed; interstriae about three times as wide as striae. Vestiture of elytra in some rows extending to basal half (2, 5, 7), in other only near declivity (1, 3, 4, 6). Posterior margin of first segment is thickened and curved backwards in the form of horseshoe; second abdominal sternite set vertically. Lateral sides of abdominal sternites unarmed. Sternites are covered with long pale hairs with their apices curved.

Notes. S. L. Wood (2007) treated *S. facialis* as a separate species but did not include it into his species key due to the fact that “the exact placement of this species in classification cannot be determined until the male is found” (2007). Findings in Peru have provided males and solved the question of the placement of *S. facialis* in the genus.

***Scolytus antennatus* Schedl, 1935**

Fig. 5

Material examined. Brazil: Sao Paulo. Bahia, Cepec, Ilheus, 1.III.1961, blacklight, Kaston; Mato Grosso, Xingu, XI-1961, Alvarenga & Bokerman NHMW; Peru: Loreto province, 20 km NE from Iquitos, Momon river, Gen Gen vill., 120 m a.s.l., 6.02.2007. A. Petrov (1♂, 1♀).

Diagnosis. This species differs from other species of *Scolytus* by the strongly enlarged and elongated club of antennae in both sexes; club is more than three times

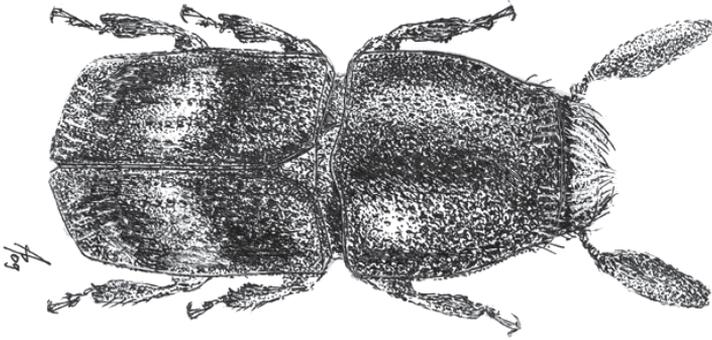


Figure 5. Habitus of *S. antennatus*

longer than the combined length of scapus and funiculus; also by the oblique light band on the elytra and by the peculiarities of abdomen in male and in female.

Description. *Male:* Length 1.9–3.1 mm, 2.1–2.6 times as long as wide; color reddish-brown. Front broadly flattened from epistoma to well above upper level of eyes; surface finely aciculate; all frontal surface is covered by pale hairs, at sides of front and in its upper part hairs are thicker and longer, their apices bend towards frontal centre; epistoma with brush of hairs overhanging mandibles. Antennae reddish-brown with strongly elongated club, length of club 0.7 mm, club 2.3 times as long as wide; length of club 3 times greater than the combined length of scapus and funiculus. Pronotum reddish-brown, 1.0–1.1 times as long as wide; surface shining, punctures small on base and disk, 3 times as large near anterior margin, larger in lateral areas of pronotum; anterior margin with sparse pale hairs. Lateral sides of the prosternite (propleura) abundantly punctured with small points bearing short, pale, scale-like hairs, punctures of prosternite are significantly smaller compared to punctures of lateral portion of pronotum.

Elytra bicolorous, central portion of elytra with an oblique light band. Elytra 1.2 times as long as wide; 1.1–1.3 times as long as pronotum; elytral puncturation is very variable, diameter of punctures may differ by 1/3 of diameter in separate specimens. Punctures form linear striae, the striae feebly to not impressed; interstriae smooth, shining, punctures very small. Declivity very weak with sparse, short, pale recumbent hairs. Abdomen is reddish-brown. Second abdominal sternite oblique, angle with first sternite obtuse, anterior margin of second sternite weakly elevated, subcostate, fifth sternite elevated in anterior portion, with a large, weakly compressed median spine on anterior half, in posterior portion fifth sternite is slightly impressed. Abdominal surface dull, very faintly shagreen, pale hairs at abdomen sparse and short, apices directed towards median portion of sternites. Legs reddish-brown with sparse hairs.

Female: similar to male except frons convex on upper half, vestiture less abundant, but much longer on upper half; second sternite with large dark tubercle of triangular

form occupying median portion of sternite from its anterior margin up to the middle; fifth sternite unarmed.

Notes. The species is recorded from Peru for the first time. The specimens were collected in the barrier trap set at a forest clearing.

Scolytus bicinctus Schedl, 1972

Fig. 6

Material examined. Brazil: Jacareacanda, Para, VI-1970, ER Barbosa. M.Alvarenga Collection. Holotype ♂; Peru: Loreto province, Morannon river, 20 km NNW from Nauta, Buen Fin vill., 130 m, 6.02.1995 A.Petrov (1♀); Junin province, Rio Perene, 8 km NNE from Puerto Ocopa, Cananeden vill., 1180 m, S11°49' W74°16' 6.02.2008 A.Petrov (1♂).

Diagnosis. Species differs from its relatives by structure of abdomen, by frontal and elytral puncturation.

Description. *Male:* body length 1.5–1.9 mm, 2.3 times as long as wide; body colour from reddish-brown to grayish-brown; surface faintly shining, nearly dull. Head reddish-brown or grayish-brown. Front broadly, rather strongly convex, surface obscurely reticulate, moderately punctured over entire area; vestiture of sparse, fine, short hairs, with most hairs located on lateral frontal parts and above mandibles; scape and funicle are reddish brown, lighter compared to club, antennal club with acutely angulate groove for suture 1 clearly marked, apex of club is evenly rounded. Pronotum 1.04–1.1 times as long as wide, its lateral sides parallel from basis up to middle of its length, towards apex lateral sides are strongly narrowed; pronotal surface faintly shining, evenly punctured by shallow punctures; these punctures becoming larger in apical portion of pronotum; sparse pale hairs located in apical portion of pronotum. Pronotum is separated from the prosternite (propleura) by a poorly developed, obtuse and smooth margin. Puncturation of lateral sides of prosternite very shallow and unobvious. Prosternite covered by small recumbent scale-like, pale hairs.

Scutelum triangular, set not deep in scutellular impression below elytral surface.

Elytra 1.3–1.4 times as long as wide, 1.25–1.3 times as long as pronotum; lateral sides of elytra nearly parallel up to short declivity, from beginning of declivity and up to suture elytra are narrowed, with their sides forming a 45° angle. Striae and interstriae weakly impressed, punctures in striae and interstriae about equal in size. Elytral surface from basis and to the apex is evenly covered by very short pale recumbent hairs. Central portion of posterior margin on first sternite and second sternite basis faintly projected backwards; the border between first and second sternites unobvious. Basis of the second sternite with two unobvious callus-like tubercles, lateral sides of the first sternite are narrowed. Lateral denticles of the second sternite posterior margin with clearly attenuated apices, conspicuous; second sternite is nearly vertical towards posterior margin of the first sternite. Third, fourth and fifth sternites forming angle of 45° with first sternite. Lateral sides of third and fourth sternites unarmed. Fifth sternite

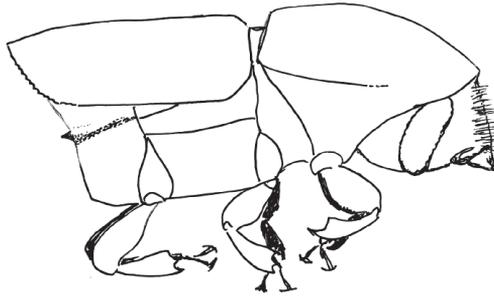


Figure 6. Habitus, lateral view of *S. bicinctus*, female

impressed near its posterior margin, the posterior margin forming an elevated rim. Surface of sternites is faintly shining, finely shagreen (reticulated) and evenly covered by recumbent pale hairs.

Legs are reddish brown, covered by sparse short hairs.

Female differs from male by more cylindrical form of body, by structure of front and of abdomen.

Female: body length 1.8 mm, 2.5 times as long as wide; color reddish brown. Front convex, without tubercles or impressions, its surface finely shagreen and evenly punctured, in central portion front has light transverse wrinkles; all frontal surface in female covered by short pale hairs; longer singular hairs on epistoma overhanging the mandibles. Apical constriction of the pronotum poorly developed; therefore pronotum seems to be broader than in male. Elytra essentially as in male, their surface is covered with minute pale recumbent hairs. Central portion of the first abdominal sternite is weakly projected backwards, its posterior margin smooth. Lateral sides of first sternite narrowed, second sternite much broader compared to the first. Second sternite set nearly vertical towards posterior margin of first sternite. Lateral portions of posterior margin on second sternite with small horizontal sharpened denticles. Third, fourth and fifth sternites forming a 70° angle with first sternite. Lateral sides of third and fourth sternites unarmed. Fifth sternite with median impression nearb posterior margin, and margin with an elevated keel. Surface of abdominal sternites faintly shining, finely shagreen and evenly covered by short recumbent pale hairs.

Notes. The species is found in Peru for the first time. Female is described for the first time here.

Scolytus canellae Wood, 2007

Fig. 7

Material examined. PERU: Loreto province, left bank of Amazon River 58 km SW from Iquitos to Nauta, Itaya river, 120 m a.s.l., 9.V.2009. A.V. Petrov (3 ♂♂).

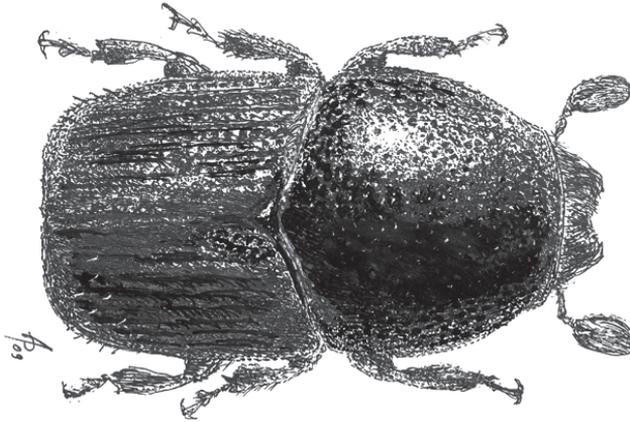


Figure 7. Habitus of *S. canellae*, male

Diagnosis. The species can be distinguished from other representatives of the genus by body shape, and by the form and position of the tubercle on the second abdominal sternite.

Male: body length 3.0–3.3 mm, 1.7–1.9 times as long as wide; body black, shining. Head black, its surface shining. Front transversely flattened eye to eye, longitudinally weakly convex from epistoma to vertex. Frontal surface densely longitudinally aciculate and with small shallow punctures between wrinkles. Median line slightly below frontal center weakly elevated, forming an inconspicuous tubercle (in some specimens with faintly elevated longitudinal keel). Frontal surface with densely set brown hairs, at lateral sides of front these hairs longer, their apices oriented towards center of the front. Median line devoid of hairs. Antennae reddish-brown or grayish-brown. Club of elliptical form with evenly rounded apex, covered with densely set short yellowish hairs. Pronotum 0.85–0.9 times as long as wide. Its surface smooth, shining, evenly punctured on base and on disc, punctures being larger near anterolateral angles. Pronotum is divided from propleura by the well developed acute margin. Lateral sides of prothorax (propleura) densely and evenly punctured by punctures equal to those at lateral margin of pronotum. Pronotum and propleura glabrous, with only 2–3 hairs at anterolateral margins.

Scutellum of triangular form, set deeply in scutellar impression.

Elytra black, 0.65–0.9 times as long as wide, 0.9 times as long as pronotum, striae and interstriae narrowly, about equally impressed, interstriae punctures spaced by 2 diameters of a puncture, punctures separated by diameter of puncture. Posterior elytral margin with sparse, short erect hairs forming short rows. Abdomen black, its surface dull, all sternites are evenly punctured, punctures on second sternite are slightly larger than punctures at sternites 3–5; width of second sternite two times greater than length, second sternite vertical in relation to first sternite, with a very small, median spine near posterior margin; fifth sternite with elevated posterior margin; sternites are covered with short erect brown hairs. Legs reddish-brown with short pale hairs.

Female: Similar to male except front more finely sculptured; second sternite without spine (Wood, 2007).

Notes. We have not seen female specimens. S.L. Wood described the species from pale teneral beetles, the mature imago is black.

***Scolytus carveli* sp.n.**

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Figs 8–12

Type locality. Peru, Loreto province, left bank of Amazon River, Itaya River, S 04.15.510 W 073.28.032.

Type material. Holotype ♂ (ZMM): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l., 73°26'W 4°11'S, 17.02.2008, leg.. A.Petrov. **Paratypes:** 1♂, 1♀ (Petrov collection): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l., 73°26'W 4°11'S, 17.02.2008, leg.. A. Petrov (1♂); PERU: LORETO PROVINCE: 70 km SW from Iquitos to Nauta, 130 m a.s.l., 27.02.2008, leg.. A. Petrov (1♀).

Diagnosis. This species is morphologically closely related to *Scolytus vagabundus* sp. n., from which can be distinguished by body size, by shape of carina-like tubercle and its position on second sternite; by absence of a median tubercle on fifth sternite and by abdomen vestiture character. The species differs from *S. pinnatus* by its size, by absence of tubercles and denticles on fourth sternite and by other features described below.

Description. *Male*: body length 1.9 mm, 2.3 times as long as wide; color dark brown, elytra reddish brown. Front faintly convex in central portion and faintly impressed in epistomal area; frontal surface faintly shining, longitudinally aciculate. Lateral sides of front covered by sparse grey hairs of moderate length, the hair apices directed towards frontal center. Antennae brown, covered by short golden hairs, club of elliptic form with the evenly rounded apex. Pronotum of equal length and width. Pronotum dark brown in colour, its basis more light in colour, reddish-brown; pronotal surface shining, punctured by small shallow punctures at basis and in central portion of disk; punctures on apical portion of pronotum and its lateral sides large and deep. Pronotum is separated from prosternite by the well-developed sharp lateral margin. Lateral sides of prosternite (propleura) punctured densely and evenly by punctures of moderately large size. Sparse, erect hairs limited to apical portion of pronotum.

Scutellum triangular, deeply set in the scutellar impression.

Elytra reddish-brown, central part darker, which gives an impression of a banded elytra. Elytra 1.28 times as long as wide, 1.0 times as long as pronotum; lateral sides of elytra nearly parallel up to short declivity, from beginning of declivity and up to sutural apex elytra sides narrowed forming an angle of 45°. Elytral suture slightly elevated from scutellar impression and up to elytral apex. Elytral surface shining, punctured



Figure 8. Habitus of *S. carveli*, male



Figure 9. Habitus of *S. carveli*, female

with regular rows of punctures, in posterior third of elytra striae slightly impressed. Interstriae flat and smooth, with sparse punctures, conspicuous only in posterior part of elytra. Posterior third of elytral interstriae with rows of pale, erect hairs. Abdomen reddish-brown. Second sternite set vertical, perpendicular to first sternite, anterior margin of second sternite weakly elevated, costate, second sternite armed by large, laterally compressed median carina, its apex truncate. Carina occupies position from basis of second sternite and up to its centre. Lateral sides of second and third sternites with small denticles, denticles on third sternite smaller and with a blunt apex. Surface of abdomen shining, punctured with very small punctures, covered with sparse short erect hairs. Legs reddish brown, covered by golden hairs.

Female: similar to male except front more convex, vestiture less abundant and shorter, abdominal sternite without carina, lateral sides of second and third sternites with small denticles as in male, on second sternite denticles with sharp apex, on third sternite denticles smaller and with blunted end.

Notes. Males have been collected into barrier traps set on *Protium*, that were cut three days before beetle collecting.

Distribution. Known only from the type locality.

Etymology. The species name relates to the similarity of the body of the bark beetle to the old ship carvel.



Figure 10. Habitus, lateral view of *S. carveli*, male

***Scolytus costellatus* Chapuis, 1869**

Fig. 13

Material examined: Peru: Loreto province, 58 km SW from Iquitos to Nauta, Rio Perene, 120 m a.s.l., 11.02.2005 A.Petrov (3♀♀), same locality, but 9–12.02.2007 (3♂♂, 2♀♀), same location but 5–8.02.2008 A.Petrov (1♂♂, 4♀♀). Junin province, Perene river, 11 km from Puerto Ocopa vill, Los Olivos, 1180 m a.s.l., 11°3.00'S 74°15.52'W 26–31.03.2009 A.Petrov (1♂, 2♀♀). Cusco province, 4 km SW from Machu Picchu, 1300 m, 21.IV.2009, A.Petrov, (1♀)

Diagnosis. Species differ from all other representatives of genus by the narrowed, pointed antennal club and by the reduced scutellum. Also diagnostic for the species are equally deepened elytral striae and interstriae, male second sternite with nearly sharp transverse carina, occupying most portion of second sternite base.

Description. Male: body length 3.2–4.1 mm, 1.8–1.86 times as long as wide; body black, shining. Head black, faintly shining, with dark brown mandibles. Front flat, evenly longitudinally aciculate from vertex and to lower portion of epistoma. Central portion of front is covered by sparse golden hairs, at lateral sides and on upper margin of front these hairs thicker and longer, with their apices directed towards the centre of front, forming a golden brush. Antennae with reddish-brown scapus and two first funicular segments; club and segments 3–7 of funiculus dark grayish-brown. Club with a narrowed and pointed apex covered with short gray hairs (Fig. 13). Pronotum 0.9–1.0 times as long as wide, central part of basis with the projection overhanging above scutellum, its surface smooth and shining, with small punctures at base and in central part, at anterolateral angles, punctures are larger and of moderate size. Apical margin of pronotum with sparse thin and short hairs. Pronotum is divided from prosternite by the well-developed acute lateral margin. Lateral sides of pronotum (propleura) are abundantly and evenly punctured with punctures of size equal to size of punctures at lateral margins of pronotum.

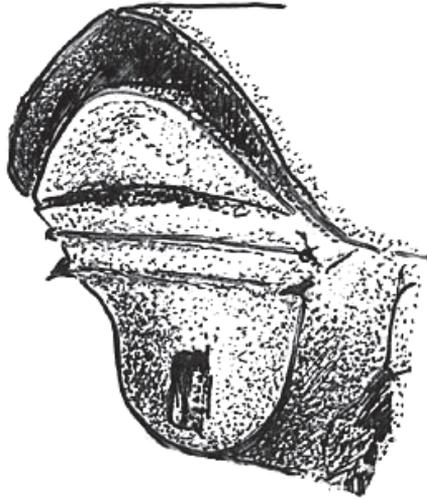


Figure 11. Sternites of abdomen of *S. carveli*, male

Scutellum is reduced, nearly obsolete.

Elytra 0.9–1.0 times as long as wide, 0.9–1.1 times as long as pronotum, striae and interstriae are equally sulcate from base to declivity of elytra; punctures in striae and interstriae are small, about equal in size, spaced by diameter of a puncture; entire elytral surface covered by short, erect, dark setae. Declivity weak, with strongly confused puncturation. Abdomen black, its surface nearly dull, sternites abundantly and densely punctured by punctures of different size, punctures on second sternite are four-time larger than punctures on sternites 3–5. Transversal length of second sternite is two-times greater its longitude, second sternite set subvertical to first sternite, its anterior margin subacutely costate on median area; fifth sternite with weakly elevated posterior margin; sternites covered by erect pale moderately long hairs. Legs black, tarsi reddish-brown, meso- and metafemora with long pale hairs.

Female: similar to male except front weakly convex, frontal width and form are very variable, in some females in upper portion of front there is a thin median line, vestiture in lateral margins shorter but abundant; second sternite with costa absent, its base rounded, anterior margin with small bifurcated callus, erect abdominal setae shorter than in male.

Notes: After examination of the type specimens of *S. pseudocostellatus* and *S. strigipennis* we concluded that both species are junior synonyms of *S. costellatus*. The features considered as species-specific fall into intraspecific variability of *S. costellatus*.

Host. Liana.

Biology. Infest the lianas that were mechanically damaged. The egg galleries very long, longitudinal, biramous. Egg chambers are located strictly on one side of the egg gallery. Number of egg chambers varies from 55 to 95. The larval galleries are perpendicular to the main egg gallery, do not cross one another, form a circle around the liana

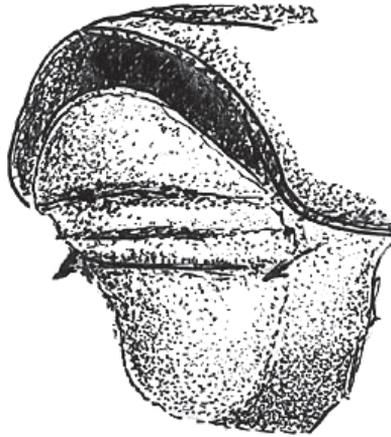


Figure 12. Sternites of abdomen of *S. carveli*, female

stem and run back towards the egg gallery from another side where deepen into xylem, where the pupal chambers are formed.

Scolytus cristatus Wood, 1969

Material examined. Peru: Junin province, Perene river, 8 km from Puerto Ocopa vill, 1180m a.s.l., Cananeden vill. 1180m a.s.l., 11°4.92'S 74°16.10'W, 2–7.02.2008, A.Petrov, (11♂♂7♀♀), same locality 5.IV.2008 A.Petrov (4♂♂4♀♀). Junin province, Perene river, 11km from Puerto Ocopa vill, Los Olivos, 1180m a.s.l., 11°3.00'S 74°15.52'W 25–26.03.2009 A.Petrov (1♂2♀♀).

Diagnosis. Second abdominal sternite is armed in males by the strong laterally compressed spine that occupies the upper portion of the segment, but that is touching neither anterior nor posterior margins of the sternite; short bristles simple, hair-like; male front vestiture developed mainly below upper margin of eyes.

Description. *Male:* body length 2.3–3.3 mm, 2.0 times as long as wide; color dark reddish brown. Front dark brown with shining surface. Front with weak transverse impression above epistoma, flat from there to upper level of eyes; surface aciculate from vertex to epistoma. Median line slightly below lower centre of front weakly elevated. Vestiture of abundant, long hair uniformly distributed, longer nearby frontal margins, median line without hairs. Antennal funiculus and scapus reddish brown. Club brown, covered with densely set golden hairs. Pronotum 1.0 times as long as wide, surface smooth, shining, punctures small, deep on base and disk, much larger on lateral margins of the apical area. Punctures at anterior margin of pronotum not confluent. Surface of pronotum glabrous, devoid of hairs. Prosternite separated from pronotum by well-developed acute lateral margin. Lateral sides of the prosternite (propleura) abundantly and evenly punctured by the punctures of equal size with the punctures at lateral margins of pronotum.

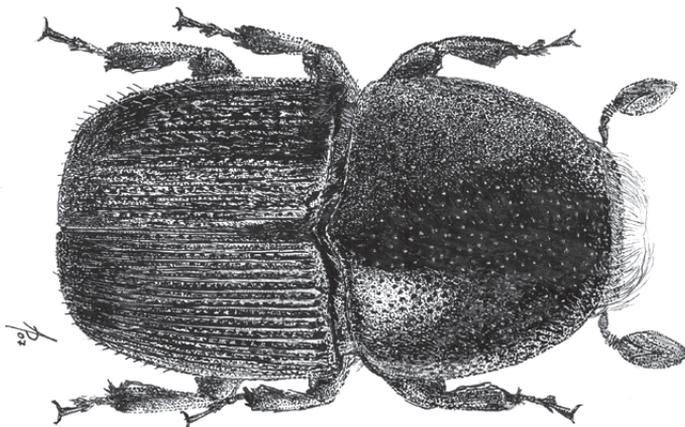


Figure 13. Habitus of *S. costellatus*, male

Scutellum triangular, set not deeply into scutellar impression.

Elytra 1.0–1.1 times as long as wide, 1.1 times as long as pronotum; striae impressed, first and second interstriae impressed from base of elytra, all other interstriae are impressed from basal third or from more distal part of elytra; punctures in striae and interstriae small, about equal in size, spaced by diameter of a puncture. Posterior elytral margin with inconspicuous rows of short erect hairs. Abdomen reddish-brown, its surface dull; second sternite subvertical, with a black median, laterally compressed carina, occupying central half of segment, carinate tubercle is evenly rounded at base, its highest point near posterior margin. Surface of second abdominal sternite with evenly placed circular punctures, punctures of other sternites lesser in size compared to punctures of second sternite; complete abdominal surface evenly covered by short erect hairs. Legs reddish-brown, covered by recumbent yellow hairs.

Female: similar to male except front much more strongly convex; frontal hairs are short and sparse, conspicuous only at epistoma; carina on second sternite smaller.

Host. liana

Biology. The species infests lianas that were mechanically damaged. Parental tunnels are biramous and transverse; the larval mines are longitudinal. Number of egg chambers varies from 15 to 45. Larval galleries are longitudinal, long. Complete cycle of development from the egg to teneral adults takes 45 – 56 days.

***Scolytus lindemani* sp. n.**

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Figs 14–15

Type locality. Peru, Loreto province, left bank of Amazon River, Itaya River S04.15.503 W073.28.035, 62 km SW from Iquitos.



Figure 14. Habitus, dorsal view of *S. lindemani*, female

Type material. Holotype ♀ (ZMM): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l. 3.02.2006 leg.. A.V. Petrov.

Diagnosis. Differs from *Scolytus spinidens* by the shape of the abdomen and by the armature of the second abdominal sternite.

Description. *Female:* body length 2.0 mm, 2.5 times as long as wide; color reddish brown. Front light brown, faintly shining, strongly convex from epistoma to vertex. Frontal surface evenly punctured by shallow sparse punctures from epistoma to vertex; vestiture very scanty, represented by sparse short pale hairs. Vertex with narrow dark median line. Antennae brown, club elliptical, covered by short golden hairs. Pronotum 1.0 times as long as wide. Maximal width of pronotum around midpoint, lateral sides parallel through most of their length, at apex with an evident constriction; surface is gently reticulated, faintly shining, at base and on disk with small shallow punctures, punctures larger but also shallow near sides of pronotum and in its apical portion. Pronotum is divided from propleura by the poorly developed elevated margin. Propleura smooth, non punctured. Very sparse hairs are concentrated in apical portion of pronotum.

Scutellum triangular, scutellar impression is not developed.

Elytra light brown in color, 1.3 times as long as wide, 1.3 times as long as pronotum; lateral sides of elytra nearly parallel up to posterior part, where rather suddenly narrowed towards sutural apex, with their sides forming an angle of 45°. Elytral suture is slightly raised. Elytral surface dull, covered with regular rows of punctures of medium size. Interstriae flat and smooth; second, fourth, sixth and eighth interstriae with very sparse punctures set far apart from the neighbours; first, third, fifth and seventh interstriae without puncturation. Sparse punctures of the interstriae carry one short scale-like pale hair each. Near elytral apex, hairs longer and more abundant. Abdomen light brown in colour. Second sternite set vertical, perpendicular to first sternite, junction between first and second abdominal sternites rounded, with no indication of a transverse carina, suture between first and second sternites poorly marked, blurred, practically invisible. Second sternite armed by 5 sharpened denticles: near the posterior margin, a conical, pointed median spine is located, which does not touch the posterior

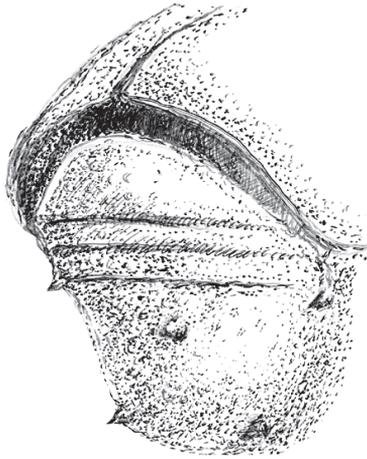


Figure 15. Sternites of abdomen of *S. lindemani*, female

margin of the sternite; lateral sides of second sternite with two sharp denticles; at lateral sides of the border between first and second sternites there are two additional sharp tubercles, these tubercles separated by $2/3$ of sternite length; the rest of sternites unarmed. Central portion of fifth sternites impressed, its posterior margin raised. Surface of sternites roughly punctured by multiple punctures. Abdomen covered by short pale scale-like hairs. Legs brown, covered with pale hairs.

Male: Unknown

Distribution. known only from the type locality.

Etymology. The new species is named in honor of the Russian forest entomologist G.V. Lindeman, who dedicated his life to studies of xylobiont insects.

***Scolytus excavatus* Wood, 2007**

Description is based on specimens collected in Peru and provided by Sarah Maria Smith.

Peru Madre de Dios, Los Amigos Biological Station, GPS: S12°34'9" W70°6'0.40", 19–25.V.2008 Smith & Hulcr Colls.

Description. *Male:* body length 5.5–6.4 mm, 1.8–2.0 times as long as wide; color red brown to black. Front concave eye to eye from epistoma to well above upper level to eyes, mandibles at base are strongly thickened and elevated, with blunt tubercles, with deep transverse furrows and rugosities, frontal margin above mandibles strongly incurved towards central portion of the front, center of front with small median carinate tubercle, front above this tubercle with the circular impression that occupies space up to upper level of eyes, bottom of the impression with the surface smooth, finely punctured. Sides of impression are covered with yellow erect bristles not forming dense brush, in the upper portion of front hair-like vestiture is sparse, in several specimens

represented by singular hairs only; antennae brown, club elliptical with evenly rounded apex, covered by short golden hairs. Pronotum 0.8–0.95 times as long as wide, its base with the median projection towards scutellum, lateral sides of pronotum are evenly narrowed from base to apical margin, without subapical constriction; pronotal surface faintly shining, nearly dull, covered by minute punctures, diameter of punctures at the sides of pronotum slightly larger than diameter of punctures in its centre, apical margin of pronotum with sparse hairs.

Scutellum very small, triangular, immersed deeply into scutellar impression.

Elytra 0.8–1.0 times as long as wide; striae impressed, striae punctures of moderate size, not confluent. Interstriae about three times as wide as striae, covered by small punctures with few scattered setiferous pores bearing one erect thick short bristle each. Posterior elytral margin with only sparse puncturation. Abdomen black, its surface dull, evenly punctured by punctures of moderate size, vestiture abundant, entire surfaces of abdominal sternites 2–4 covered by long yellow hairs, surface of the fifth sternite with sparse hair-like vestiture except on lateral sides of the fifth sternite base. Border between first and second sternites junction strongly projected backwards and also elevated, shape of the second sternite is cup-formed incurved, median part of second sternite anterior margin with the shark back fin-shaped denticle curved upwards; this denticle occupies the space from base of sternite and up to center of the sternite. Fifth abdominal sternum is medially impressed, its posterior margin is elevated.

Legs black, tarsi reddish-brown; femora are covered by short recumbent hairs, outer margin of meso- and metatibia with long erect yellow hairs

Female: Body length: 4.8–5.3 mm, 1.7–2.0 times as long as wide. Front concave eye to eye from epistoma to well above upper level to eyes, each mandible at the base bears processes with apices directed upwards and towards the apex of the process of adjoining mandible (in older beetles these processes may be broken off); center of the front with deep longitudinal impression continuing upwards up to upper level of eyes, lateral sides of the impression are densely covered with pale hairs. Lateral margins of front are elevated, curved near eyes, following the upper level of eyes line. Frontal surface smooth, gently punctured, at lateral sides of front pale hairs are set denser. From the vertex two symmetrically set fringes (forelocks) of long dark grayish-black hairs are directed towards center of the front. Pronotum: 0.74–0.96 times as long as wide, essentially as in male. Elytra: 0.8–1.2 times as long as wide and similar to elytra of male. Abdomen is covered by short yellow hairs, second sternite with basal margin rounded, subvertical, middle of segment with a large cylindrical spine. Apex of this spine is thickened and covered by short hairs, fifth sternite concave, its apical margin acute.

Host. *Pterocarpus robrii* (Fabaceae).

Biology. bigynous, each gallery is built by 2 – 4 females.

Notes. Male is described here for the first time. S.L. Wood erroneously treated female holotype as a male. Studies of a long series of *S. excavatus*, collected by Sarah M. Smith and Jiri Hulcr, allowed to remove this inaccuracy and to expand the description of the female of this unusual species.

***Scolytus mozolevskae* sp.n.**

urn:lsid:zoobank.org:act:288F4E7C-A481-42B4-92CD-C450D99BE8A3

Figs 16–18

Type locality. Peru, Loreto province, left bank of Amazon River, Itaya River, S04.15.503 W073.28.035.

Type material. Holotype ♂ (ZMM): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l., 4°11'S, 73°26'W 8.V.2009, leg.. A.V. Petrov. Paratypes 75♂♂, 51♀♀ (Petrov collection): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l., 73°26'W 4°11'S, 5–6.02.2005, leg.. A.V. Petrov (7♂♂, 3♀♀); same locality, but 2–10.02.2006, leg.. A.V. Petrov (29♂♂, 44♀♀), same locality, but 28.02.2006, leg.. A.V. Petrov (1♂), same locality, but 10.03.2006 (31♂♂, 1♀), same locality, but 3.02.2007 (4♂♂, 1♀), PERU: LORETO PROVINCE: 70 km SW from Iquitos to Nauta, 130 m a.s.l., 23.02.2008 (3♂♂, 1♀); same locality, but 27.02.2008, leg.. A.V. Petrov (1♀).

Diagnosis. New species is morphologically closely related to *Scolytus amazonicus* Schedl from which it differs by body size, by dark hair-like frontal vestiture, by strongly shining second abdominal sternite surface that is punctured by large punctures, by absence of raised callosities and impressed areas with punctures; by absence of lateral tubercles at sides of third abdominal sternite which are smooth.

Description. *Male:* body length 2.9 mm (paratypes length 2.6 – 3.2 mm), 2.2 times as long as wide; colour dark brown. Front dark, grayish brown with shining surface. Front weakly convex from eye to eye and from epistoma to vertex; surface aciculate from vertex to epistoma. Median line running from epistoma up to upper margin of front well-developed. Frontal surface covered by dense, closely set brown hairs, these hairs darker at base and lighter near apex, hairs above mandibles lighter than hairs at the upper portion of front. Hairs longer at lateral frontal sides, long hair apices directed towards centre of front. Vertex densely punctured by longitudinally elongated punctures. Antennae with reddish brown scapus and funiculus, club with narrow base, gradually widening towards apex, apex of club is evenly rounded. Pronotum black, its surface shining, punctured by sparse deep punctures, at lateral sides punctures larger, closely set compared to punctures of base, disk and apical portions of the pronotum. Apical pronotal area practically devoid of vestiture, with singular short, dark hairs. Pronotum separated from prothorax (propleura) by a clearly marked, sharply elevated pronotal margin. Lateral sides of prothorax (propleura) punctured by points of moderate size, but these punctures smaller compared to those at lateral sides of pronotum. Lateral sides of prothorax are covered by very short scale-like hairs and by sparse setae.

Scutellum triangular, deeply set in scutellar impression, covered by minute scale-like pale hairs.

Elytra dark grayish brown. Elytra 1.15 times as long as wide; 1.24 times as long as pronotum, striae distinctly, narrowly impressed, with round non-confluent punc-

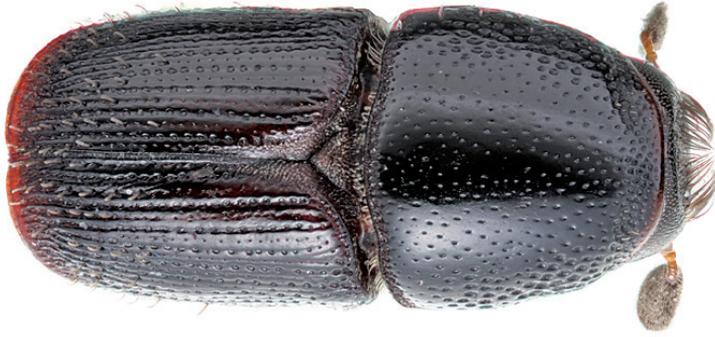


Figure 16. Habitus of *S. mozolevskae*, male

tures, interstriae flat and smooth with rows of small punctures with the diameter significantly smaller than in punctures of rows. At anterior part of elytra punctures are set densely and chaotically. Sparse pale hairs form rows at interstriae of the posterior third of elytral length and throughout complete length at sides of elytra. Abdomen black, its surface shining, uniformly covered by erect moderately long hairs. Second sternite subvertical, nearly perpendicularly set to first sternite, anterior margin slightly elevated, costate. Third, fourth and fifth sternites form a 45° angle with the first sternite. Lateral sides of sternites without tubercles. Second abdominal sternite roughly punctured by deep punctures from its middle and up to the posterior margin; sternite base with sparse punctures only. First, fourth and fifth sternites densely punctured by punctures of middle size. Points at second and third sternites grouped on separately set slightly impressed areas with the elevated surface without any puncturation between. Surface of first and second sternites dull, surface of third and fourth sternites glossy. Fifth sternite slightly impressed medially, its posterior margin elevated. Legs reddish brown, covered by short pale hairs.

Female: body length 2.5–3.1 mm, 2.15–2.2 times as long as wide; colour dark brown. Similar to male except differing in front and abdomen structures. Front broadly convex from eye to eye, from epistoma to vertex; surface aciculate from vertex to epistoma. Vestiture scant, hairs moderately long and sparse, mostly evident at lateral sides of front. Abdomen more convex compared to male abdomen due to slightly rounded first sternite posterior margin and slight decrease in size of second sternite.

Host. liana.

Biology. *S. mozolevskyi* infests damaged and irreversibly weakened lianas. Beetles infest the liana trunk throughout all its length. Density of galleries is very high, with up to five egg galleries per square decimeter. Parental tunnels are biramous and transverse; larval mines are longitudinal.

Distribution. Known only from the type locality.

Etymology. The new species is named in honor of the forest entomologist Dr. E.G. Mozolevskaya.



Figure 17. Habitus, lateral view of *S. mozolevskae*, male

***Scolytus neofacialis* Schedl, 1976**

Figs 19–20

Material examined. Brazil: Varginha, M. Gerais, II-1972, M. Alvarenga Holotype ♂, NHMW, Wien. Peru: 20 km NE from Iquitos, Momon river, Gen Gen vill. alt. 120 m, 6.02.2007, A.Petrov (1♀).

Diagnosis. Species differs from *S. bolivianus* Schedl by smaller punctures on pronotal disk, by shorter bristles at elytral interstriae and significantly more abundant hairs at female front (the latter species is known only by female holotype).

Description. *Male:* Body length 3.2–3,4 mm, 2.1 times as long as wide; colour dark brown, elytra reddish brown. Front faintly convex, strongly shining; center of front and epistoma with sparse longitudinal furrows, lateral sides of front densely aciculate from vertex to epistoma. Vestiture on lateral and dorsal pronotal margins of long, moderately abundant, incurved hair, vestiture in central area shorter, less abundant. Antenna brown, covered by short golden hairs, club elliptical, with apex evenly rounded. Pronotum 1.04 times as long as wide, reddish brown, with darker apical margin; surface smooth, shining, punctures small in disk, on lateral margins larger and subrugose on anterior area; lateral margins and anterior area of pronotum covered by thin, short yellow hairs; pronotum divided from prosternite by a well-developed acute lateral margin. Lateral sides of prosternite (propleura) roughly punctured by punctures of moderate size, these punctures smaller compared to punctures at lateral sides of pronotum.

Scutellum triangular, not deeply set in scutellar impression.

Elytra reddish brown, unicolorous, surface faintly shining, nearly dull. Elytra 1.2 times as long as wide, 1.2 times as long as pronotum, striae weakly impressed in base of elytra and narrowly, distinctly impressed on posterior half; interstriae on basal portion flat, smooth, not impressed, in posterior half impressed equally to striae, bristle-carrying interstitial punc-



Figure 18. Punctuation of second sternite of *S. mozolevskae*

tures larger compared to stria punctures, interstriae with rows of numerous erect golden bristles organized on the complete elytral surface in regular rows. Abdomen reddish brown, its surface faintly shining, nearly dull; second sternite subvertical, junction with first sternite abrupt, transversely subcostate, fifth sternite weakly concave, apical margin weakly elevated. All sternites abundantly covered by long yellow hairs, curved towards elytral apex.

Female: body length 3.2 mm, 2.1 times as long as wide; colour reddish brown, pronotum 1.04 times as long as wide, elytra 1.0 times as long as wide, 1.0 times as long as pronotum, morphology similar to male, except front and abdomen. Front convex with yellow moderately long hairs, curved towards center of the front, in the middle of the front hairs are shorter when compared to male; from upper frontal portion longer hairs go down, these hairs oriented towards front centre; abdomen more convex compared to male.

Notes. The holotype of *S. neofacialis* preserved in NHMW (Vienna) is a male. The female is here described for the first time.

The species is very similar to *Scolytus bolivianus* Schedl, from which it differs only by the body size. It is quite probable that *S. neofacialis* in the future will turn out to be a synonym of *S. bolivianus* which was described from one incompletely developed male. Further investigation of *S. bolivianus* will require a new series.

Scolytus peruensis Schedl, 1937

Material examined. Peru: Rio Toro, La Merdet Chanchamayo, NHMW, Wien (Lectotype ♂ and paratype ♀)

Diagnosis. Species can be distinguished from *S. barinensis* Wood by less strongly developed median frontal tubercle in males and also by significantly stronger developed frontal vestiture in males; by more gently punctured pronotum and by quite different elytral sculpture.

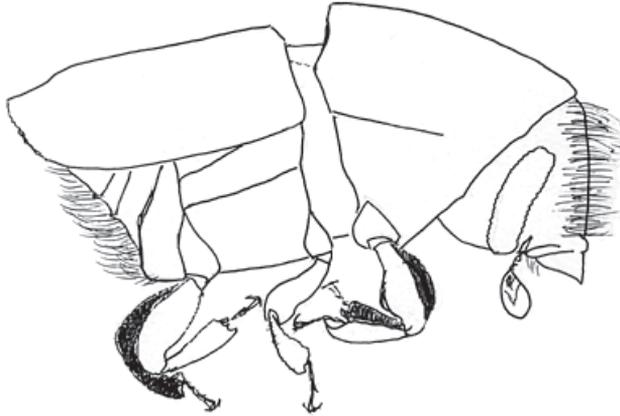


Figure 19. Habitus, lateral view of *S. neofacialis*

Description. *Male:* body length 3.2–3.4 mm, 1.9 times as long as wide; colour dark reddish brown, pronotum dark brown or black. Front with transverse impression above epistoma and with a conspicuous median tubercle above this impression. Front on upper two-thirds to vertex obscurely aciculate. Front covered by brown hairs more abundant at lateral sides. Antennal funculus and scapus reddish brown. Club grayish brown, ellipsoid in form, evenly rounded at apex and densely covered by short golden hairs. Pronotum 1.0 times as long as wide; lateral sides almost straight and parallel on basal half, arcuately converging toward broadly rounded anterior margin; surface smooth, shining. Pronotal puncturation uneven, punctures of anterolateral angles of pronotum several times larger compared to minute punctures on base and disk.. Apical portion of pronotum with few hairs.

Scutellum triangular, deeply set in scutellar impression.

Elytra 0.9 times as long as wide, 0.9 times as long as pronotum, elytral surface punctured, punctures forming rectilinear weakly impressed rows, punctures in striae of moderate size, not confluent, but rather set apart from their neighbors; interstriae almost four times as wide as striae, smooth, shining, punctures mostly minute; elytral apex with rows of short and sparse erect hairs; abdomen dark reddish brown, surface dull; second sternite subvertical, junction with first sternite abrupt, anterior margin not carinate, its surface rough, with sparse points of moderate size the posterior margin of second sternite; median short laterally compressed tubercle in center of second sternite; third – fifth sternites without denticles and tubercles, punctures at these sternites very small, moderately close. First sternite is covered by short recumbent hairs, vestiture of second – fifth sternites entirely abraded on type. Legs reddish brown, covered by short hairs.

Female: similar to male except details of front and abdomen. Female front more convex than male front, hairs on lateral sides of front shorter; two forelocks consisting of densely set dark brown hairs run from the vertex towards the centre of head. Median

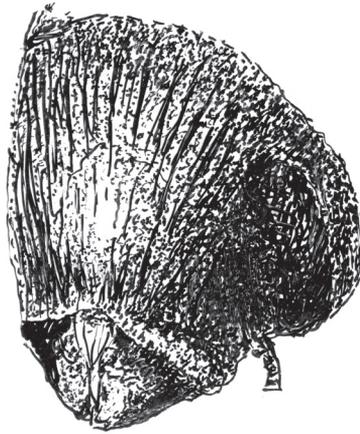


Figure 20. Head of *S. neofacialis*

spine on second sternite longer than wide, its apex narrowly rounded, spine apex is directed downwards from centre of sternite to its base.

Notes: The above treatment was based on the male (Holotype) and female (Paratype). It is possible that the holotype had traumas immediately after pupation, because its body morphology has numerous evident deviations including strongly shortened elytra with the abnormally curved apex and a shortened second sternite tubercle when compared to female. To confirm the species diagnosis, additional male specimens are required which were lacking at the time of our investigation.

Scolytus proximus Chapuis, 1869

Figs 22–23

Material examined. Peru: Loreto province, 20 km NE from Iquitos, Momon river, Gen Gen vill., 120 m a.s.l., 5–7.02.2007 A.Petrov (48♂♂, 24♀♀); 70 km SW from Iquitos to Nauta, 26–29.02.2008 A.Petrov (41♂♂, 37♀♀); 58 km SW from Iquitos to Nauta, Itaya river, 120 m a.s.l., 5–8.V.2009 A.Petrov (4♂♂, 2♀♀).

Diagnosis. Species differ from other species in genus by frontal vestiture in male and in female, by elytral puncturation and by form of second abdominal sternite spine that is alike in form to a shark dorsal fin.

Description. *Male:* body length 2.8–3.5 mm, 1.8–1.9 times as long as wide; colour dark brown black, surface shining. Front flattened on dorsal half, weakly transversely impressed in lower third, lateral areas on lower third somewhat aciculate-granulate, median line on impressed area is slightly elevated. Centre of front with callous-like tubercle slightly rising above impression; above tubercle frontal surface coarsely aciculate. Lateral sides of front slightly elevated, covered with dense brushes

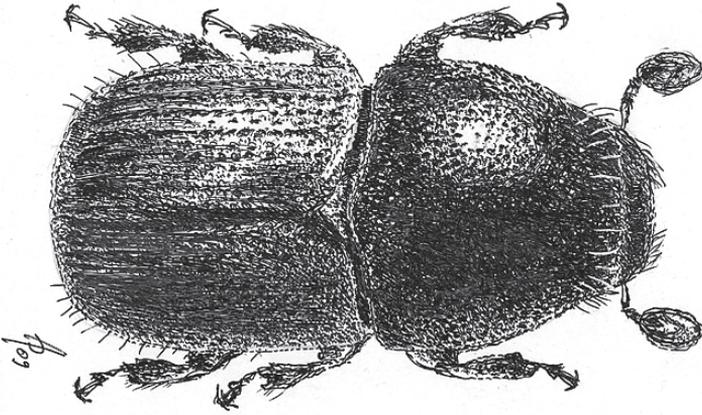


Figure 21. Habitus of *S. pinnatus*, female

of long brown hairs, hair apices curved towards centre of front. Centre of frontal area covered by recumbent hairs of moderate size. Antennal funiculus and scapus reddish brown. Club ellipsoid, grayish brown, densely covered with short golden hairs. Pronotum black, 0.8–0.88 times as long as wide, attains maximum width at the middle of its length; surface smooth, shining, puncturation very small and sparse on disk, more dense and of moderate size on apical margin and of large size at lateral sides of pronotum; surface with few inconspicuous hairs, nearly glabrous. Pronotum separated from prosternite (propleura) by well-developed acute lateral margin, lateral portions of prothorax (propleura) densely punctured by large punctures, surface with recumbent hairs.

Scutellum triangular, deeply set into scutellar impression.

Elytra 0.8–0.94 times as long as wide, 0.9–1.0 times as long as pronotum. First and second rows of punctures impressed from base to declivity, others not impressed or feebly impressed in base and evidently impressed from a middle to apical part of elytra. Punctures in striae of moderate size, sometimes size of punctures become larger from base towards posterior part of elytra. Interstriae three times as wide as striae, smooth, shining, weakly impressed in anterior part of elytra, punctured by small punctures, among which larger setiferous pores can be found in posterior elytral portion. Declivity short; first, third, fifth and seventh interstriae with pale sparse, erect, scale-like hairs forming rows from elytral center and up to apical elytral portion with strongly confused (obscure) puncturation; all other interstriae have only 1–2 short bristles nearby margin of declivity. Abdomen dark brown, surface faintly shining, nearly dull, punctured by small punctures, covered with short pale bristles, under bristles abdominal surface with plumose setae. Erect bristles on second sternite three times as long as on fifth sternite. Second sternite is vertical, with large laterally compressed spine; form of the spine is similar to a shark dorsal fin with its apex curved upwards towards third



Figure 22. Habitus of *S. proximus*, male

sternite; size and form of spine is strongly variable between specimens. Legs reddish brown, covered by short yellow hairs.

Female: similar to male except front has shorter hairs evenly covering frontal surface from middle to lateral margins, hairs in centre of front pale, on upper portion of front above upper level of eyes of front a dark fringe consisting of two bundles of dark-grayish brown bristle-like hairs running downwards; hair apices in fringe directed towards front centre.

Notes. Unfortunately, the authors were unable to study the type series of *S. proximus* and for material determination we used only the original description (Chapuis, 1869) and specimens from the collection of K. Schedl.

Biology. *Scolytus proximus* infests trunks and large branches of the fallen trees. Parental tunnels are biramous and transverse; the larval mines are longitudinal. Length of transverse tunnels is 20–35 mm.

Scolytus thoracicus Chapuis, 1869

Material examined. Peru: Loreto province, 20 km NNE from Iquitos, Momon river, Gen Gen vill., 8.02.2007 A.Petrov

Diagnosis. Species differs from its relatives by male frontal characters and by stepped median spine on sternite 2 in both sexes.

Description. *Male:* body length 3.0–4.3 mm, 1.9 times as long as wide; colour dark brown or black. Front flattened on dorsal half, strongly, transversely impressed in lower third, impression surface is roughly punctured, median line at impressed portion of front is slightly elevated. Center of front with transverse carina, strongly, dorsoventrally compressed, center of carina strongly thickened and overhanging frontal impression;



Figure 23. Habitus, lateral view of *S. proximus*, male

area above carina smooth and dull, gently shagreen and punctured by sparse minute punctures, devoid of hairs. Lateral parts of front slightly elevated, covered by dense brushes of long brown hairs, hair apices directed towards centre of front. Antennal funiculus and scapus reddish brown. Club grayish brown, of elongate form, 2.1 times as long as wide, abundantly covered by short golden hairs. Pronotum 1.0 times as long as wide, lateral sides almost straight and parallel on basal half, arcuately converging toward broadly rounded anterior margin; surface smooth, shining, punctures minute on disk, much larger on lateral margins of the apical area. Pronotum has an acute lateral margin dividing it from prosternite. Lateral sides of prothorax (propleura) are densely and evenly punctured by punctures that is larger compared to punctures at lateral sides of pronotum, towards apical margin with gentle pale hairs of moderate length.

Scutellum of moderate size, triangular, densely punctured by minute punctures, slightly deepened into scutellar impression.

Elytra 1.0 times as long as wide, 1.0 times as long as pronotum; rows of punctures weakly, narrowly impressed, punctures small, punctures in striae not confluent; interstriae smooth, shining, three times as wide as striae punctures, punctures very small. At the posterior elytral portion among minute punctures of interstriae are larger setiferous pores each bearing one short erect hair. Lateral sides of elytra with a row of yellow hairs of moderate length. Short elytral declivity with obscure puncturation. Abdomen black, its surface dull, evenly punctured by deep punctures of moderate size; second sternite vertical, armed by a median, laterally compressed spine, occupying sternite portion from its base to centre. Apex of tubercle with asymmetrically bifurcated apex, two-stepped. Lateral margins of second sternite with elevated blunt tubercles. Abdominal sternites and spine are covered by erect yellow hairs; longer hairs are located on border between first and second sternites, on lateral sides of sternites and on apex of fifth sternite. Legs dark grayish brown, femora covered with long brown hairs.

Female: similar to male except front convex, without tubercle; punctures fine, surface coarse aciculate; vestiture of fine, uniformly distributed hairs, extending upper level of eyes; spine in second sternite two-stepped as in male but much smaller.

Notes. The species is recorded for Peru for the first time. The male studied did not differ from male of *S. thoracicus* from Brazil.

***Scolytus vagabundus* sp. n.**

urn:lsid:zoobank.org:act:113AFEB7-9AB8-4E8A-8068-E0ECE0A00633

Figs 24–25

Type locality. Peru, Loreto province, left bank of Amazon River.

Type material. Holotype ♀ (ZMM): PERU: LORETO PROVINCE: left bank of Amazon River, 70 km SSW from Iquitos to Nauta, 130 m a.s.l., 1.03.2008, leg. A.V. Petrov.

Diagnosis. Species closely related to *S. carveli* and *S. pinnatus* Eggers, from which it can be distinguished by body size, by second sternite tubercle form and its position on sternite, by presence of tubercle on fifth sternite and by abdominal vestiture. From *S. pinnatus* new species can be distinguished also by absence of tubercles and denticles on fourth sternite.

Description. *Female*: body length 2.2 mm, 2.2 times as long as wide; colour dark brown. Head dark grayish-brown, nearly black. Frons convex from eye to eye from epistoma to vertex; surface aciculate from vertex to epistoma. Vestiture scant, hairs short and sparse, conspicuous in lateral parts of front. Antenna brown, densely covered by short golden hairs, club elliptical with evenly rounded apex. Pronotum 1.1 times as long as wide, its maximal width at the half of its length, from center to apex pronotum seems more elongated. Pronotal surface shining, punctured by deep points at base and in central part of disk; punctures of lateral sides of pronotum and its apical portion slightly larger. Apical portion of pronotum with few short dark hairs. Pronotum has a well defined acute lateral margin separating it from prothorax (propleura). Lateral sides of prothorax (propleura) are abundantly and evenly punctured by punctures of moderate size.

Scutellum triangular, deeply set in scutellar impression.

Elytra dark grayish brown with reddish brown declivity. Elytra 1.1 times as long as wide, 1.0 times as long as pronotum; lateral elytral margins slightly widened from base to middle of their length, these sides are evenly rounded then towards elytral declivity. Elytral surface shining, punctured with sparse punctures in striae. Striae and interstriae are deepened, interstriae with few and sparse punctures, evident only in posterior part of elytra. In the posterior part of elytra and on declivity, interstriae with rows of pale sparse erect hairs. Abdomen reddish brown. Second sternite set vertically, perpendicular to first sternite, anterior margin of second sternite weakly rounded, not costate, sternite two armed by a large, laterally compressed median spine, this spine basis runs through second sternite from its base and up to posterior margin. On dorsum of the spine a sharpened denticle directed by its apex downwards; this denticle located closer to base of second sternite. Lateral sides of second and third sternites with small sharp-

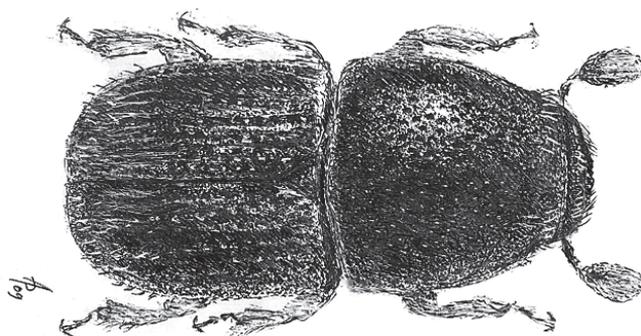


Figure 24. Habitus of *S. vagabundus*, female

ened denticles. Fifth sternite with a median tubercle. Surface of second sternite smooth and shining, without puncturation, other sternites with minute dense puncturation. Abdomen densely covered by yellow hairs of moderate length, hair apices directed toward tubercle of fifth sternite. Legs reddish brown, with golden hairs.

Male: Unknown.

Distribution. Known only from the type locality.

Etymology. Species name originates from the Hispan word “vagabundo” (vagabond).

***Scolytus woodi* sp. n.**

urn:lsid:zoobank.org:act:99DBFD74-8414-4F8A-B3A7-B89FDC4A605B

Figs 26–31

Type locality. Peru, Loreto province, left bank of Amazon River, Itaya River.

Type material. Holotype ♂ (ZMM): PERU: LORETO PROVINCE: right bank of Amazon River, 30 km S from Iquitos, Panquana camp., 120 m a.s.l., 30.01.1997, leg.. A.V. Petrov. **Paratype:** 1♀ (Petrov collection): PERU: LORETO PROVINCE: Itaya river, left bank of Amazon River, 58 km SSW from Iquitos to Nauta, 120 m a.s.l., 4°11'S 73°26'W 10.02.2007, leg.. A.V. Petrov (1♀).

Diagnosis. Species morphologically closely related to *Scolytus bispinatus* and *S. carveli*, from which can be distinguished with ease by form and position of second sternite tubercle and also by presence both in male and in female of small sharpened median tubercle at posterior margin of fourth sternite.

Description. *Male:* Body length 2.0 mm, 2.85 times as long as wide; colour reddish brown. Head dark grayish brown. Front flat with a small median elongate tubercle running from epistoma nearly up to center of front. Circular impression clearly seen in upper portion of front above upper level of eyes nearby margin with vertex. Frontal surface shining, longitudinally aciculate. Lateral parts of front cov-

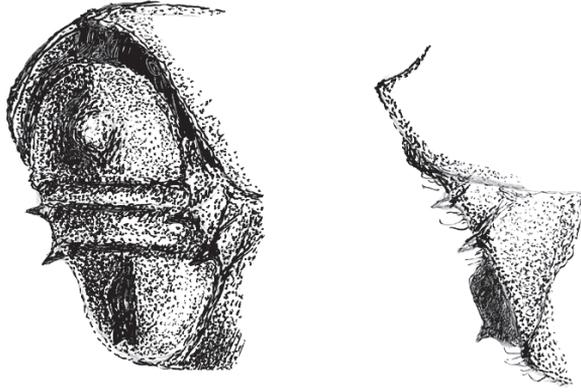


Figure 25. Sternites of abdomen of *S. vagabundus*, female

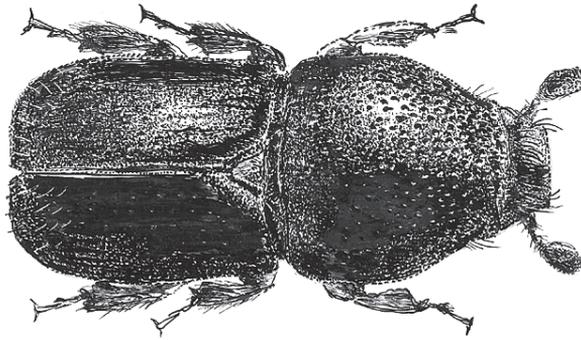


Figure 26. Habitus of *S. woodi*, male

ered by very sparse grey hairs of moderate length, their apices directed towards center of front. Antennae brown, covered by short golden hairs, club elliptical with evenly rounded apex. Pronotum 1.0 times as long as wide. Maximal width of pronotum at half of its length, lateral sides evenly rounded towards apex and base; towards apex, pronotum appears more elongate. Faintly elevated median line runs from centre of pronotum towards its apical portion. Pronotum grayish brown, its basis lighter, reddish-brown; surface shining, at basis and in central part of disk pronotum with small shallow punctures, punctures at lateral sides and in apical portion larger but also shallow. Sharply elevated lateral margin separates pronotum from other parts of prothorax (propleura). Lateral sides of prothorax (propleura) are abundantly and evenly punctured by punctures of moderate size. Scant pubescence limited to few hairs at apical portion of pronotum.

Scutellum triangular, deeply set in scutellar impression.

Elytra reddish-brown. Elytra 1.1 times as long as wide, 1.0 times as long as pronotum; lateral sides of elytra are nearly parallel up to declivity, from the begin-

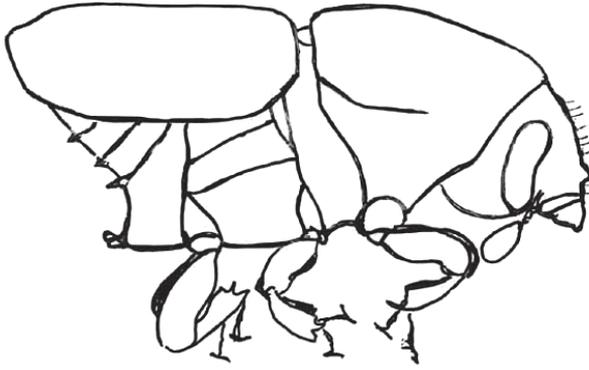


Figure 27. Habitus, lateral view of *S. woodi*, male

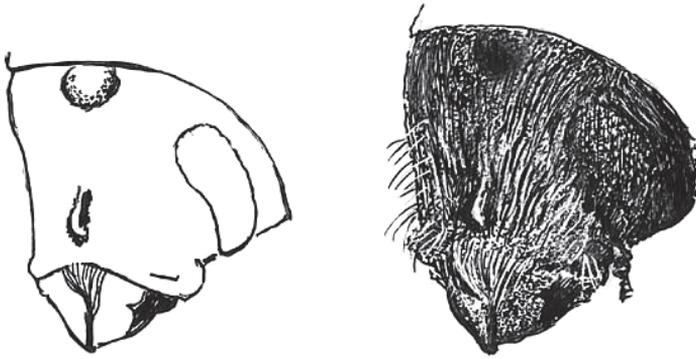


Figure 28. Head of *S. woodi*, male

ning of declivity and up to sutural apex elytra are evenly rounded. Elytral surface shining, with regular rows of small punctures. Interstriae flat and smooth, with sparse punctures, conspicuous only in posterior portion of elytra. In posterior portion of elytra, interstriae with rows of pale erect hairs. Abdomen reddish-brown. Second sternite is vertical, perpendicularly set in relation to first sternite, anterior margin of second sternite weakly elevated, costate. Second sternite base armed by a large, median spine. This spine has a very specific outline, its two rounded apices are directed into opposite sides from the same basis, so when looking from below tubercle has form of stylized heart (Fig. 28). Elevated median line runs from base of tubercle towards second sternite center. Posterior margin of fourth sternite with small median sharpened tubercle (Fig. 29). Lateral sides of second and third sternites with minute denticles, second sternite with sharpened denticles, third sternite with smaller denticles with blunt apices. Abdominal surface shining, punctured by minute punctures, covered with very sparse tiny erect hairs. Legs reddish brown, with golden hairs.



Figure 29. The central spine of second sternite of *S. woodi*, male

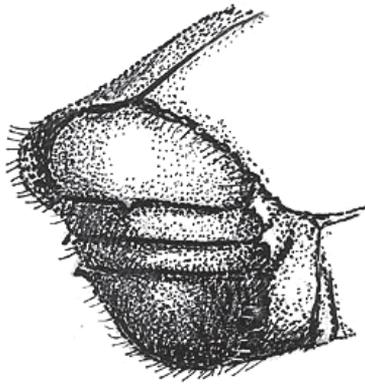


Figure 30. Sternites of abdomen of *S. woodi*, female

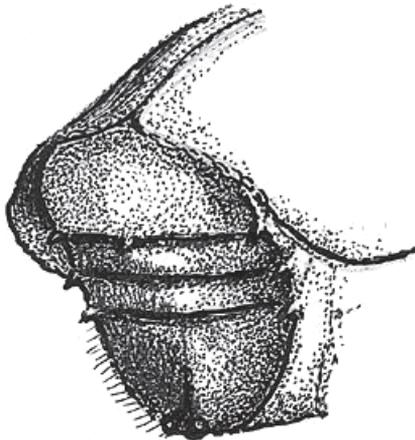


Figure 31. Sternites of abdomen of *S. woodi*, male

Female: similar to male except front more convex, vestiture less abundant and shorter, tubercle in anterior frontal portion of triangular form; second sternite unarmed. As in male, posterior margin of fourth sternite with small median sharpened tubercle at posterior margin, lateral sides of second and third sternites with denticles, but these denticles are extremely small.

Distribution. Known only from the type locality.

Etymology. This new species is named in honour of the eminent entomologist Professor Stephen L. Wood who dedicated his life to studies of Scolytidae and Platypodidae.

Key to Peruvian *Scolytus* Geoffroy, 1762 species.

- 1. Front without median tubercle or longitudinal carina **2**
- Front with median tubercle or longitudinal carina **17**
- 2(1). Antennal club very strongly elongated, its length is more than 2.5 times greater than its width and more than 3.0 times greater than the combined length of scapus and funiculus (Fig. 5); central portion of elytra with oblique central light band; in males second sternite not armed, fifth sternite with large median denticle; in females second sternite is armed by laterally compressed spine and fifth sternite has no denticles and tubercles; 1.9 –3.1 mm; Brazil and Peru ***S. antennatus* Schedl**
- Ratio between antennal length and width does not exceed 2.0; elytra without light oblique band..... **3**
- 3(2). Frontal surface aciculate..... **4**
- Frontal surface is punctured or upper and central portions of front are transversely rugose..... **13**
- 4(3). Scutellum is reduced, invisible when viewed from above; antennal club with narrowed and pointed apex; form of suture on club resembles Greek letter lambda ; base of pronotum with median projection; elytra are covered by short erect dark setae from base and up to apex; in male second sternite subvertical relative to first sternite, its anterior margin subacutely costate on median area, in female second sternite with costa absent, its base rounded, anterior margin with small bifurcated callus; 3.2–4.1 mm; Costa Rica to Brazil .. ***Scolytus costellatus* Chapuis**
- Scutellum normal, triangular in shape; antennal club with its apex rounded; base of pronotum without median projection **5**
- 5(4). Abdominal sternites with laterally compressed tubercle or with longitudinal carina..... **6**
- All sternites without median tubercles or longitudinal carina..... **11**
- 6(5). Sternites 4 and 5 with median tubercle or callous-like elevation..... **7**
- Sternites 4 and 5 without median tubercle or callous-like elevation..... **8**

- 7(6). Second sternite with median laterally compressed tubercle that occupies distance from sternite base and up to its center; fourth sternite with small sharpened tubercle at its posterior margin. Brazil ***Scolytus pinnatus* Eggers** (Fig. 21)
- Second sternite with median laterally compressed tubercle, that occupies the distance from the basal area and up to posterior sternite margin, nearby anterior margin of second sternite this tubercle has sharpened projection oriented downwards; fourth sternite has no tubercles; central portion of fifth sternite with high callous-like elevation; 2.2 mm, Peruvian Amazonia..... ***Scolytus vagabundus* sp. n.**
- 8(6). Lateral sides of second and third abdominal sternites without sharp denticles..... **9**
- Lateral sides of second and third abdominal sternites with sharp denticles ... **10**
- 9(8). Median carina of second abdominal sternite is rounded at its apex; striae and interstriae 1 and 2 impressed from base of elytra to declivity; 2.3–3.3 mm; Mexico to Peru ***Scolytus cristatus* Wood**
- Denticle at the second sternite is not rounded at apex, but longitudinally bifurcate (median spine stepped on sternite 2) 3.0–4.2 mm; Brazil to Peru... ***Scolytus thoracicus* Chapuis (female)**
- 10(9). Median tubercle on second abdominal sternite is of rectangular form, its height not greater than the half of tubercle length; elytral puncture rows are not deepened at base of elytra, in posterior third of elytral length rows of punctures are only slightly deepened, interstriae flat and smooth with only sparse punctures visible only in posterior portion of the elytra; laterally set tubercles of second sternite are evidently sharpened both in male and in female; female without median tubercle at second sternite; 1.9–2.1 mm Peruvian Amazonia..... ***S. carveli* sp. n.**
- Median tubercle of second abdominal sternite is laterally compressed, higher than basal width, its apex slightly curved dorsad; third and fourth abdominal sternites with very small tubercles; 2.0 mm; Brazil ***Scolytus elongatus* Schedl**
- 11(5). Lateral sides of second abdominal sternite without tubercles; the surface of second sternite shiny, covered from center and up to posterior margin by deep large punctures; base of second sternite with few sparse punctures, shining; base of antennal club is significantly narrower compared to its apical portion; in male lateral portions of front are covered by long dark hairs curving towards frontal centre, in female front is convex with short hairs, vertex without fringe; 2.7–3.3 mm; Peruvian Amazonia..... ***Scolytus mozolevskae* sp.n.**
- Lateral sides of second abdominal sternite with small tubercles **12**
- 12(9). Surface of second abdominal sternite is evenly covered with punctures of middle size, abdominal surface is evenly covered by dense yellow hairs; entire elytral surface is covered with rows of short pale hairs on interstriae; width of

- the antennal club at base and in apical portion is nearly the same. Male front is covered by the abundant long hairs, in female hairs in the central portion of front are shorter, from the vertex originates a fringe of longer but rather sparse hairs; 3.2–3.4 mm, Brazil and Peru (Amazonia).....
- ***Scolytus neofacialis* Schedl**
- Puncturation of second abdominal sternite is uneven, present only locally, punctures of second sternite are grouped only at distinct slightly deepened areas; around these areas is surface dull, slightly elevated, with no puncturation, vestiture sparse, only locally developed; elytral interstriae with rows of sparse hairs developed only posteriorly; base of antennal club is significantly narrower compared to its apical portion; in male lateral portions of front are evenly rounded and covered by long golden hairs, forming a brush; in female brush in center of front is shorter but the fringe of reddish-brown hairs originating from the vertex overhang upper portion of front; 4.0–4.5 mm; Brazil, Peru (Amazonia)..... ***Scolytus amazonicus* Schedl**
- 13(3). Front deeply transversely concave from eye to eye and longitudinally from epistoma to above upper level of eyes; base of each mandible with process (in older beetles these processes may be broken off); scutellum is very small; second abdominal sternite with the median long cylindrical tubercle which is thickened apically; 4.8–5.3mm; Peru to Bolivia.....
- ***Scolytus excavatus* Wood (female)**
- Front faintly or distinctly convex, mandibles without processes, scutellum of normal size..... **14**
- 14(13). Lateral sides of second abdominal sternites without sharpened tubercles; front with slightly elevated median line from epistoma up to center of front; from centre of frontal flat, shining, slightly impressed in its centre, area runs toward vertex; two orange fringes overhang this area symmetrically on both lateral sides; this fringes are formed by long hairs; hairs at lateral sides of front are short, with their apices directed towards centre of front; second sternite subvertical, its junction with first sternite abrupt; 2.2–3.6 mm; Brazil, Peru (Amazonia)..... ***Scolytus angustatus* Browne (female)**
- Lateral sides of the second abdominal sternite with sharpened tubercles ... **15**
- 15(14). Second abdominal sternite without median tubercle, in male central portion of first sternite apical margin and basis of second sternite are slightly projecting backwards; border between first and second sternites is blurred; base of second sternite with two unobvious callous-like tubercles, lateral sides of first sternite are narrowed; lateral denticles of second sternites with attenuated apices, conspicuous; in female border between first and second abdominal sternites is faintly rounded, without microscopic callous-like tubercles, lateral denticles of the second sternite are small, front with transverse rugosities above frontal center and up to vertex; 1.5–1.8 mm; Brazil to Peru.....
- ***Scolytus bicinctus* Schedl**
- Second abdominal sternite with small tubercle near posterior margin **16**

- 16(15). Second sternite without sharpened denticles on basal margin and on lateral sides of posterior margin; junction of first and second sternites is rounded; frontal surface with moderately long white hairs; 2.2 mm; Surinam.....
 *Scolytus spinidens* Schedl
- Lateral sides of second abdominal sternite basal margin with two small sharpened tubercles, lateral sides of second sternite posterior margin also with pair of sharpened tubercles; front is gently covered with small shallow punctures, frontal hairs short and sparse; 2.0 mm; Peru (Amazonia)
 *Scolytus lindemani* sp. n., female
- 17(1) Second sternite without median tubercle. Front is covered by small punctures; in male first abdominal sternite apex and second sternite basal area projecting backwards in the centre, anterior margin of second sternite very strongly carinate on median third of segment width, or lateral profile of abdomen is incurved from second sternite and up to fifth sternite apex; in female second sternite subvertical, without central curvature; in male lateral parts of second and third sternites with sharpened tubercles, in females these tubercles nearly indistinct; male front faintly convex, flat above frontal tubercle, covered by moderately long hairs; in female front with median elevated line, longitudinal impression in upper portion of front and with two orange fringes overhanging front from vertex; 2.2–3.6 mm; Brazil, Peru (Amazonia)
 *Scolytus angustatus* Browne
- Second sternite with median tubercle..... **18**
- 18(17). Front impressed from epistoma up to the upper level of front; lateral frontal surface gently punctured; frontal margin that is adjacent to mandibles is strongly incurved towards center of the front; center of the front with circular impression; mandibles with deep transverse furrows and rugosities; base of mandibles with blunt elevated tubercles; second abdominal sternite with a tubercle in a form of a shark back fin curved upwards; 5.5–6.4 mm; Bolivia to Peru)..... *Scolytus excavatus* Wood (male)
- Front not impressed, flat or convex; in the case of faint circular impression presence it is developed only on the upper portion of front at the border with vertex; front longitudinally aciculated, mandibles without transverse furrows and processes **19**
- 19(18). Posterior margin of fourth sternite with sharpened tubercle; lateral sides of second and third sternites carry tubercles that are of median size and with sharpened apices in male, minute and blunt-ended in female; second sternite base in male with tubercle bifurcated at apex, second sternite in female without tubercle; front in male with impression at the border between upper portion of front and vertex; 2.0–2.1 mm; Peru (Amazonia)
 *Scolytus woodi* sp. n.
- Posterior margin of fourth abdominal sternite without tubercle; head in male without impression at border between front and vertex..... **20**

- 20(19). Median tubercle is located near center or in posterior portion of second sternite, this tubercle is not laterally compressed.....**21**
 – Median tubercle is laterally compressed, it occupies the space from the basal portion of second sternite and up to its centre**22**
- 21(20). Tubercle is located in the centre of the second abdominal sternite; color dark reddish brown; 2.5 mm; Argentina to Brazil***Scolytus caudatus* Eggers**
 – Tubercle of the second sternite is very small, apically sharpened, located closer to the posterior sternite margin, but does not touch this margin; color black; 3.0–3.3 mm Brazil to Peru.....***Scolytus canellae* Wood (male)**
- 22(20). Median spine is longitudinally bifurcate at its apex; male front flattened on basal half, rather strongly, transversely impressed on lower third, median tubercle strongly, dorsoventrally compressed; vestiture very long; 3.0–4.2 mm; Brazil to Peru ***Scolytus thoracicus* Chapuis (male)**
 – Median tubercle at second abdominal sternites is not bifurcate; male front without transverse carina **22**
- 22(21). Apex of tubercle on second sternite is directed upwards; tubercle is shark back fin-shaped; vestiture of abdomen abundant with palmate and simple setae; male frontal hairs at center and at lateral sides are dark brown, in female hairs of front center are significantly paler in colour and there is a fringe above the upper level of eyes directed downwards which is formed by two fascicles of dark brown hair-like setae with their apices directed towards center of front; 2.8–3.5 mm; Venezuela, Colombia, Peru ***Scolytus proximus* Chapuis**
 – Apex of tubercle on second sternite is directed downwards; abdominal hairs short and sparse; in female median tubercle is longer than in male, rounded apically; in female front without fringe; 3.2 – 3.4 mm; Peru.....
 ***Scolytus peruensis* Schedl**

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Taxonomic changes in palaeotropical Xyleborini (Coleoptera, Curculionidae, Scolytinae)

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Abstract

Following the recent reclassification of the Palaeotropical xyleborine genera (Hulcr & Cognato 2010), additional species are transferred to correct genera or synonymized based on analysis of their morphological characters. The following species are given new combinations: *Debus amphicranoides* (Hagedorn), **comb. n.**, *Debus birmanus* (Eggers, 1930), **comb. n.**, *Debus dolosus* (Blandford, 1896), **comb. n.**, *Debus eximius* (Schedl, 1970), **comb. n.**, *Debus interponens* (Schedl, 1954), **comb. n.**, *Debus robustipennis* (Schedl, 1954), **comb. n.**, *Debus spinatus* (Eggers, 1923), **comb. n.**, *Microperus alpha* (Beeson, 1929), **comb. n.**, *Microperus corporaali* (Eggers), **comb. n.**, *Microperus eucalyptica* (Schedl, 1938), **comb. n.**, *Microperus nugax* (Schedl, 1939), **comb. n.**, *Pseudowebbia percorthylus* (Schedl, 1935), **comb. n.**, *Truncaudum circumcinctus* (Schedl, 1941), **comb. n.**

The following species are synonymized: *Arixyleborus hirtipennis* (Eggers), **syn. n.**, with *Arixyleborus puberulus* (Blandford); *Coptoborus palmeri* (Hopkins), **syn. n.**, with *Debus emarginatus* (Eichhoff); *Coptoborus terminaliae* (Hopkins), **syn. n.**, with *Debus emarginatus* (Eichhoff); *Cyclorhipidion polyodon* (Eggers), **syn. n.**, with *Truncaudum agnatum* (Eggers); *Euwallacea artelaevs* (Schedl), **syn. n.**, with *Planiculus bicolor* (Blandford); *Xyleborinus perminutissimus* (Schedl), **syn. n.**, with *Xyleborinus perpussillus* (Eggers); *Xyleborus exesus* Blandford, **syn. n.**, with *Debus emarginatus* (Eichhoff); *Xyleborus fulvulus* (Schedl), **syn. n.**, with *Microperus corporaali* (Eggers); *Xyleborus marginicollis* (Schedl), **syn. n.**, with *Diuncus justus* (Schedl); *Xyleborus shoreae* Stebbing, **syn. n.**, with *Debus fallax* (Eichhoff).

The following species are given new status: *Streptocranus superbus* (Schedl, 1951), **restored name**; *Webbia divisus* Browne, 1972, **restored name**; *Webbia penicillatus* (Hagedorn, 1910), **restored name**. Genus *Taphrodasus* Wood (1980) is declared not valid.

Keywords

ambrosia beetles, Debus, *Microperus*, reclassification

Introduction

Xyleborini are one the most species-rich groups of scolytine beetles, and one which produced many invasive pests. In spite of the economic concern, xyleborine beetles have received comparatively little attention by taxonomists. S. L. Wood (1989) made the first major attempt to organize the many hundreds of described species into a generic classification. This classification was subsequently adopted in the most comprehensive treatise on scolytine taxonomy, the Catalog of Scolytidae and Platypodidae (Wood and Bright 1992, Bright and Skidmore 1996, 2002, also on-line at: <http://www.scolytid.msu.edu>). This concept was later refined using morphological cladistics (Hulcr et al. 2007a, Hulcr and Cognato, 2009), and currently summarized by Alonzo-Zarazaga and Lyal (2009). Hulcr and Cognato (in press) provided further rearrangements of Palaearctic and Palaeotropical Xyleborini classification using a combination of morphological and molecular approaches. This work augments the latest classification with a series of transfers and synonyms. Majority of the species treated here occur in SE Asia or Melanesia.

List of abbreviations

- BMNH** Natural History Museum, London
FRI Forestry Research Institute, Dehra Dun, India
MCG Museo Civico Genova, Genova
MNB Museum fur Naturkunde der Humboldt University, Berlin, Germany
MSUC Michigan State University Arthropod Collection, East Lansing, MI, USA
NHMW Naturhistorisches Museum, Wien, Austria
RAB Roger A. Beaver's private collection, Chiang Mai, Thailand
SMTD Staatliches Museum fur Tierkunde, Dresden, Germany
UCD Bohart Museum, University of California-Davis, CA, USA
USNM United States National Museum, Smithsonian Institution, Washington, D.C., USA.

Taxonomic treatment

Arixyleborus puberulus (Blandford)

Xyleborus puberulus (Blandford, 1896)

Xyleborus hirtipennis Eggers, 1940, **syn. n.**

Arixyleborus hirtipennis (Eggers): Browne, 1955, **syn. n.**

Specimens examined. Indonesia, Java (*X. hirtipennis*, lectotype, USNM); Sarawak, Malaysia (*X. puberulus*, holotype, BMNH).

Comments. Lectotype of *Arixyleborus hirtipennis* bears all essential features of *A. puberulus*, only the declivital rugosities more organized into rows, shining area of elytra smaller, less clearly distinguished from rugose area. These are exceptionally plastic in *A. puberulus*, *A. hirtipennis* represents small deviation in the large range of variation of declivital surface in *A. puberulus*.

***Diuncus justus* (Schedl)**

Xyleborus justus Schedl, 1931

Diuncus justus (Schedl): Hulcr & Cognato, 2009

Xyleborus marginicollis (Schedl, 1936b), **syn. n.**

Specimens examined. Indonesia, Java, Buitenzorg (*D. justus*, holotype, NHMW); Philippines, Luzon, (*X. marginicollis*, holotype, NHMW).

Length. 1.5 mm.

Comments. Type specimen of *X. marginicollis* Schedl represents one end of a continuum of variation in *D. justus*: short (1.5 mm) but robust (most representatives of *D. justus* slightly longer and more slender). Diagnostic characters identical: surface of declivity devoid of vestiture, no elytral denticles, smooth impression across interstriae 2 and 3 (very shallow).

***Debus amphicranoides* (Hagedorn), comb. n.**

Xyleborus amphicranoides Hagedorn, 1908

Specimens examined. Malaysia, Sabah, Danum Valley (2, R.A. Beaver det., MSUC); Sumatra (USNM).

Comments. Prolonged large representative of *Debus*. Elytral declivity deeply excavated, edge of declivity with two pairs of long teeth, but only few tubercles. Declivital surface smooth.

Debus amphicranoides (Hagedorn) possibly senior synonym of the following (NHMW): *Debus birmanus* (Eggers), *Debus cyclopus* (Schedl), *Debus interponens* (Schedl), *Debus robustipennins* (Schedl). *D. birmanus* identical except slightly larger, with slightly longer declivital posterolateral processes, much smaller upper tooth on declivity. *D. interponens* similar except lacks constricted declivity and has shorter posterolateral declivital processes. Schedl (1954) considered *D.* (as *Xyleborus*) *interponens* possible altitudinal variation of *X. robustipennins*; the two essentially identical, origi-

nated from different elevations. *Debus cyclopus* similar except narrower elytral apical emargination. *Debus robustipennis* larger. Schedl (1954) mentioned that it only differed from *D. amphicranoides* in minor differences in declivital teeth shape.

***Debus birmanus* (Eggers), comb. n.**

Xyleborus birmanus Eggers, 1930

Specimens examined. Malaysia, Burma (2 indiv., BMNH).

Comments. Very similar to *D. amphicranoides*, possibly a synonym. Holotype at FRI not available.

***Debus dolosus* (Blandford), comb. n.**

Xyleborus dolosus Blandford, 1896

Specimens examined. Malaysia, Sarawak (holotype, BMNH); Malaysia, Sabah, Danum Valley (9 indiv., Hulcr det., MSUC.).

Diagnosis. Elytral declivity slightly with much higher number of declivital tubercles than other *Debus*. Declivity flat, not excavated, not emarginate at apex. Depth of emargination varies. Similar to *Debus pumilus*, but uniformly brown, with more and larger tubercles on the declivity. Significant intraspecific size variation.

Comments. Elytral declivity superficially different from other *Debus* spp, but its structure homologous. Few small or large tubercles in the interstriae 1 (usually 3 pairs), displaced by broadened interstriae 1 and positioned on first striae or on interstriae 2. Strial punctures greatly reduced on declivity, difficult to follow as interstria 1 broad, displacing other striae. No tubercles originating on second striae. Smaller tubercles on striae 3 and beyond, creating tuberculated area surrounding declivity. Other characters shared with *Debus* spp.: extended pronotal disc, triangular protibiae with large and long but sparse denticles (<7), inflated prosternal posterocoxal process, antennal club shape.

Xyleborus persimilis (Eggers) and *D. dolosus* (Blandford) probably synonyms. *X. persimilis* (lectotype, USNM) with slightly broader, more excavated declivity. Browne (1961) suggested that *X. subdolosus* is only a local variety of *D. dolosus*.

***Debus eximius* (Schedl), comb. n.**

Xyleborus eximius Schedl, 1970

Specimens examined. Indonesia, Kalimantan (2, holotype & allotype, NSMT); Indonesia, Kalimantan (2 paratypes, NHMW).

Comments. Elytral apex not emarginate, but all other diagnostic characters of *Debus* present: elongated pronotal disc, broad antennal club type 2, triangular protibiae, flat elytral declivity with tubercles on elevated lateral sulcus (appears as if formed by interstriae 2 through 4).

***Debus fallax* (Eichhoff)**

Xyleborus fallax Eichhoff, 1878

Debus fallax (Eichhoff): Hulcr & Cognato, 2010

Xyleborus shoreae Stebbing, 1909, **syn. n.**

(complete taxonomic history in Wood and Bright, 1992)

Specimens examined. *X. shoreae*: India, Kumaon, (2), Beeson det., BMNH); Malaysia, Kedah, (two labels: *X. shoreae*, Browne det., *X. fallax*, Schedl det., BMNH); Thailand, Pong Yaeng N. P., (Beaver det.); Borneo (Schedl det., BMNH); *D. fallax*: Malaysia, Sabah, Danum Valley (Hulcr det.); Malaysia, Sabah, Danum Valley (51, Hulcr det.); New Guinea, Morobe Province, Bulolo (Jordal det.); New Guinea (BBM, 5 indiv.); Sulawesi (Browne det., BMNH); Thailand, Pong Yaeng N. P. (2, Hulcr det.); PNG, Madang Prov. (36), Oro Prov. (66), West Sepik (123) (Hulcr coll, det.); Philippines, Luzon, Mt. Makiling (*X. amphicranulus* Egg. holotype, *X. fallax* syn., SMTD).

Comments. Holotype of *X. shoreae* in FRI, inaccessible, non-type specimens identified by several authorities available. Location of *X. fallax* holotype unclear. Wood and Bright (1992) indicated IRSNB as holotype depository, however museum personell reports that holotype has never been deposited there. *X. shoreae* is a variant of *D. fallax* (Eichhoff), declivital emargination shallower than in most *D. fallax*. All other characters identical to *D. fallax*: color uniformly brown to bicolored (light brown to orange pronotum), elytral denticles all small except the denticle in the middle of declivital face, which is slightly longer than others; declivity surface shining, most specimens with remnants of striae punctures, size 2.6 - 3.0 mm. Declivity emargination depth intermediate between *D. fallax* and *D. emarginatus*, most other characters (size, coloration, flat posterolateral processes) shared with *D. fallax*. Maiti and Saha (2004) had access to holotype, redescription and illustration fits *D. fallax*. Stebbing not consistent in distinguishing *X. shoreae* from *X. fallax*, assigned similar specimens to either species (Maiti and Saha 2004).

Biology and distribution: Reported from India and Thailand, and by Browne (1983) as imported from PNG to Japan. Despite the name “*shoreae*”, the species is a broad generalist (Wood and Bright, 1992).

***Debus interponens* (Schedl), comb. n.**

Xyleborus interponens Schedl, 1954

Specimens examined. Malaysia, Sarawak, Mt. Penrissen, 4500 ft. (lectotype, NHMW).

Comments. All diagnostic features of genus *Debus* present, including antennal club form, prolonged pronotum, emarginate declivity. Similar to *D. amphicranoides* (Hagedorn), but with less constricted declivity and longer posterolateral declivital processes. Schedl (1954) considered *D. interponens* altitudinal variant of *D. robustipennis*, the two are allegedly identical, only differing by their origins from different elevations.

***Debus robustipennis* (Schedl), comb. n.**

Xyleborus robustipennis Schedl, 1954

Specimens examined. Indonesia, Borneo (lectotype, NHMW).

Comments. All diagnostic features of *Debus* present, including antennal club form, prolonged pronotum, emarginate declivity.

Lectotype of *X. robustipennis* Schedl very similar to non-type specimens of *Debus amphicranoides* (Hagedorn) in USNM, only slightly larger. Schedl (1954) indicated that *X. robustipennis* differs from *X. amphicranoides* very little, merely by shallower and wider declivital emargination, having the lateral declivital costa between teeth 1 and 2 more elevated, and lateral declivital process shorter. Type of *D. amphicranoides* not available, thus synonymy could not be confirmed.

***Debus spinatus* (Eggers), comb. n.**

Xyleborus spinatus Eggers, 1923

Specimens examined. Malaysia (BMNH); Malaysia, Sabah, Danum Valley (3, Hulcr det.).

Diagnosis. An “elegant” form of *D. fallax*. Longer, smooth declivity, shallowly emarginate, no tubercles or granules on declivital sides except two pairs of slender teeth, one long, one short. Declivity shagreen when dry.

***Debus emarginatus* (Eichhoff)**

Xyleborus emarginatus Eichhoff, 1878

Debus emarginatus (Eichhoff): Hulcr & Cognato, 2010

Xyleborus terminaliea Hopkins, 1915, **syn. n.**

Coptoborus terminaliae (Hopkins) Wood and Bright, 1992, **syn. n.**

Xyleborus exesus Blandford, 1894, **syn. n.**

Xyleborus palmeri Hopkins, 1915, **syn. n.**

Coptoborus palmeri (Hopkins): Wood & Bright, 1992, **syn. n.**

(complete taxonomic history in Wood and Bright, 1992)

Specimens examined. *X. terminaliae*: Philippines, Pagbilao (holotype, USNM). *X. exesus*: Japan, (holotype, BMNH). *D. emarginatus*: Indonesia, Sumatra, Bandar Baroe (homotype, compared to type by Eggers, NHMW); Indonesia, Java, Bandjar (homotype, compared to type by Eggers, NHMW, 2 indiv.); Philippines, Laguna, Pangil (homotype, NHMW); Malaysia, Sabah, Danum Valley (17 indiv., Hulcr det., MSUC); New Guinea (BBM, 20 indiv.); New Guinea, Ambunti (4, BBM); New Guinea (FICB); New Guinea, Gulf Province, Ivimka (UCD); Thailand, Pong Yaeng N. P. (Hulcr det., MSUC); PNG, Madang Prov. (79, Hulcr coll.).

Comments. Holotypes of *X. exesus* Blandford, *X. palmeri* Hopkins, and *X. terminaliae* Hopkins share all diagnostic characters with homotype and large series of non-types of *Debus emarginatus* (Eichhoff). *X. exesus*: declivity with slightly less steep slope, less pronounced lateral tubercles (granules), dominant tubercle in middle of lateral sulcus slightly longer. Schedl (1973e) suggested synonymy of non-New Guinean *X. emarginatus* Schedl with *X. exesus* Blandford, based on shared shallow declivital emargination. Holotype of *X. exesus* damaged, missing elytron, fits range of *D. emarginatus* variation. *X. palmeri* Hopkins is larger variant of typical *D. emarginatus*.

***Microperus alpha* (Beeson), comb. n.**

Xyleborus alpha Beeson, 1929

Coptodryas alpha (Beeson) Wood & Bright, 1992

Specimens examined. India, Sunderbans Div. (holotype, BMNH).

Comments. All diagnostic features of *Microperus* present: small size, elytral punctures aligned in striae, and prolonged body shape (Hulcr and Cognato in press). Similar to *Microperus pomelianus*, but slightly longer, with distinctly elevated and long declivital costa.

***Microperus corporaali* (Eggers), comb. n.**

Xyleborus corporaali (Eggers, 1923)

Coptodryas corporaali (Eggers): Wood & Bright, 1992

Xyleborus fulvulus (Schedl, 1942b), **syn. n.**

Xyleborus fulvus (Schedl, 1939): *X. fulvulus* (Schedl, 1942), preoccupied (*Xyleborus fulvus* Murayama 1936), **syn. n.**

Specimens examined. *M. corporaali*: Indonesia, Kotangan an der Ostkusgte (lectotype, USNM); *X. fulvulus*: Indonesia, Sumatra (paratype, USNM).

Comments. *X. fulvulus* identical to *Microperus corporaali* (identical antennae, body shape, declivital surface and shape, posterolateral declivital costa, declivital vestiture as one row of erect setae per intrestria, backward-bent setae in strial punctures). Paratype not mentioned by Anderson and Anderson (1971).

***Microperus eucalyptica* (Schedl), comb. n.**

Xyleborus eucalyptica Schedl, 1938

Coptodryas eucalyptica (Schedl): Wood & Bright, 1992

Specimens examined. Australia, Queensland, Geagana (lectotype, NHMW).

Comments. All diagnostic features of *Microperus* present (elytral mycangia, absence of scutellum, small size, prolonged body shape, abundant vestiture). Similar to *M. intermedius*, but substantially longer, elytra often bicolored, usually without convexity on elytral disc.

***Microperus nugax* (Schedl), comb. n.**

Xyleborus nugax Schedl, 1939

Coptodryas nugax (Schedl): Wood & Bright, 1992

Specimens examined. Malaysia, Selangor (lectotype, BMNH); Malaysia, Selangor (Schedl det., BMNH); Malaysia, Sabah, Danum Valley, (13, Hulcr det., MSUC).

Diagnosis. Very similar to *Microperus diversicolor* (e.g., antennal club type 3), except pronotum bright yellow with brown patch, elytra black, declivity commencing closer to elytral base, declivital interstriae covered with many small sharp hooks (similar as in *M. parva*, but larger). Characteristic elytral disc: anterior portion inflated, convex, boundary between elytral disc and declivity slightly concave, impressed.

Comments. Schedl (1979) designated lectotype in NHMW, another unspecified “type” resides in BMNH. Possibly synonymous with *Coptodryas undulata* (Sampson) (as *X. leprosulus* Schedl, syn. Wood, 1989) (Schedl, 1939).

Biology. Creates irregularly branching galleries with transverse brood chambers (Beaver & Browne 1978).

***Planiculius bicolor* (Blandford)**

Xyleborus bicolor Blandford, 1894

Euwallacea bicolor (Blandford): Wood & Bright, 1992

Planiculius bicolor (Blandford): Hulcr & Cognato, 2010

Xyleborus artelaevius (Schedl, 1942a), syn. n.

Euwallacea artelaevius (Schedl): Beaver, 1998, syn. n.

Xyleborus rameus Schedl, 1940

Xyleborus bicolor (Schedl): Kalshoven, 1959

Specimens examined. *X. artelaevius*: Malaysia, Perak, (holotype, NHMW); New Guinea, Gulf Province, Ivimka, (R.A. Beaver det., UCD); Indonesia, Sulawesi (R. A. Beaver det., BMNH). *P. bicolor*: Nagasaki, Japan (syntype, BMNH); Fiji, Namosi (*X. rameus* (syn. *P. bicolor*) Schedl det., BMNH).

Comments. Holotype of *X. artelaevius* virtually identical to *Planiculius bicolor* (Blandford), except first segment of antennal club more convex. All other characters identical, including uniform granules in declivital interstriae 1, 2, and 3 (same size granules in interstriae 1–3 characteristic for *P. bicolor*). *X. artelaevius* holotype deteriorated, missing or damaged body parts including antennae.

***Pseudowebbia percorthylus* (Schedl), comb. n.**

Xyleborus percorthylus Schedl, 1935

Taphrodasus percorthylus (Schedl): Wood, 1980

Specimens examined. Malaysia, Peninsula (holotype, NHMW).

Comments. Diagnostic characters of *Pseudowebbia*: regular type of pronotum (not extremely prolonged and flat as in *Webbia*), circular antennal club (not broadened), triangular to broadly rounded protibia (not thin and sickle-like as in *Webbia*). Elytral declivity deeply excavated, surrounded by highly elevated circumdeclivital costa with no teeth.

Type species of *Taphrodasus* Wood, 1980. Morphological limits of *Taphrodasus* never specified. Characters listed by Wood (1980) are either autapomorphic to *T. percorthylus*, or present in other genera, mostly *Webbia*. *Taphrodasus* not a valid genus, see below.

***Streptocranus superbis* (Schedl), stat. n.: restored name**

Xyleborus superbis Schedl, 1951

Coptoborus superbis (Schedl): Wood & Bright, 1992

Xyleborus superbulus Schedl, 1958a, **unnecessary replacement name**

Coptoborus superbulus (Schedl, 1958a): Wood & Bright, 1992, **unnecessary replacement name**

Specimens examined. Indonesia, Java, Buitenzorg (holotype, NHMW).

Comments. *Xyleborus superbus* Schedl (1951) preoccupied by *Xyleborus superbus* Schedl (1942c). Renamed *X. superbulus* (Schedl, 1958a). *X. superbus* Schedl (1942c) later placed in *Coptoborus* (Wood and Bright 1992). Replacement name unnecessary, original name *S. superbus* (Schedl, 1951) restored.

Genus *Taphrodasus* Wood, stat. n.: invalid genus

Taphrodasus Wood (1980), monotypic, type species *Taphrodasus percorthylus* (Schedl, 1935): Wood, 1980. Later included in *Taphrodasus*: *Webbia divisus* Browne (1972), *Xyleborus penicillatus* Hagedorn (1910), *Xyleborus cuspidus* Schedl (1975). *T. percorthylus* transferred to *Pseudowebbia* (Hulcr and Cognato, this volume); *T. divisus* and *T. penicillatus* restored in *Webbia* (Hulcr and Cognato, this volume), *T. cuspidus* not related to any of the other three species (Hulcr and Cognato, *in prep.*).

***Truncaudum agnatum* (Eggers)**

Xyleborus agnatus Eggers, 1923

Cyclorhipidion agnatum (Eggers): Wood & Bright, 1992

Truncaudum agnatum (Eggers): Hulcr & Cognato, 2010

Xyleborus polyodon (Eggers, 1923), **syn. n.**

Cyclorhipidion polyodon (Eggers, 1923): Wood & Bright, 1992, **syn. n.**

(complete taxonomic history in Wood and Bright, 1992)

Specimens examined. *T. agnatum*: New Guinea, Hatam (cotype, MCG). *X. polyodon*: Philippines, Luzon, Mt. Makiling; (unspecified “type”, SMTD).

Comments. Type of *X. polyodon* similar to *T. agnatum*, except tubercles on and around declivity larger, pointed. Tubercles in homologous position. Eggers’s unspecified “type” in SMTD from the same collection series as lectotype at USNM (Anderson & Andreson, 1971).

***Truncaudum circumcinctus* (Schedl), comb. n.**

Premnobius circumcinctus Schedl, 1941

Premnobius circumcinctus (Schedl): Wood & Bright, 1992

Xyleborus circumcinctus (Schedl): Schedl, 1962b

Specimens examined. Uganda (*P. circumcinctus*, holotype, NHMW).

Comments. The only known African *Truncaudum*. *Truncaudum* synapomorphies: impressed submentum, antennal club type 1, curved outer edge of protibiae, complete denticulated circumdeclivital costa. Very similar to *Truncaudum impexus* [(Schedl):

Hulcr and Cognato (in press)], except declivity slightly convex (mostly flat in *Truncaudum* spp.), antenna type 1, several adjacent denticles on each stria on the upper edge of circumdeclivital costa (mostly a single flat tubercle in *Truncaudum* spp.). Otherwise remarkably similar to Asian relatives. Length: 2.8 mm.

Described as *Premnobius* by Schedl (1941), later treated as *Xyleborus* (Schedl, 1962b), but combination never officially published.

***Webbia divisus* Browne, stat. n.: restored name**

Webbia divisus Browne (1972)

Taphrodasus divisus (Browne): Wood & Bright, 1992

Specimens examined. Malaysia, Perak (holotype, BMNH).

Comments. Transferred to *Taphrodasus* (Wood and Bright, 1992) without discussion of characters. *Webbia* synapomorphies: dorsal aspect of pronotum long and quadrangular, pronotal disc long and flat, frontal slope of pronotum short, scutellum suppressed, costate and setose elytral bases. Differs from most *Webbia* spp. by densely pubescent and excavated declivity and elongated body shape. Length: 2.4 mm. Characters shared with *Pseudowebbia percorthylus* [(Schedl, 1935): Hulcr and Cognato, this volume] (type species of *Taphrodasus*) limited to excavated declivity with dense setae, genus-level characters different.

***Webbia penicillatus* (Hagedorn), stat. n.: restored name**

Xyleborus penicillatus Hagedorn 1910

Prowebbia penicillatus (Hagedorn): Browne 1963

Webbia penicillatus (Hagedorn): Bright 2000

Taphrodasus penicillatus (Hagedorn): Wood & Bright, 1992

Specimens examined. Malaysia, N.S. Triang (homotype, NHMW); Malaysia, Perak (BMNH); Malaysia, Borneo (BMNH).

Comments. Type in Hamburg museum lost (Wood and Bright 1992). Most features characteristic of *Webbia* (elongated pronotum, suppressed scutellum), unrelated to type species of *Taphrodasus*: *Pseudowebbia percorthylus* ((Schedl, 1935): Hulcr & Cognato, this volume). Similar to *W. divisus*, except declivity with long, dense, erect setae, not scales.

***Xyleborinus perpusillus* (Eggers)**

Xyleborus perpusillus Eggers, 1927

Xyleborinus perpusillus (Eggers): Wood & Bright, 1992

Xyleborinus perminutissimus (Schedl, 1934) **syn. n.**

Specimens examined. *X. perminutissimus*: Indonesia, Java, Mt. Gede (lectotype, NHMW). *X. perpusillus*: Indonesia, Sumatra (holotype, USNM); Malaysia, Sarawak, Gunung Buda (R.A. Beaver det., MSUC); Malaysia, Sabah, Danum Vallery (29 indiv., Hulcr coll.); New Guinea, Oro Province, Kanga (5 indiv, Hulcr coll.).

Comments. Lectotype of *Xyleborinus perminutissimus* (Schedl, 1934d) virtually identical to holotype of *Xyleborinus perpusillus* (Eggers). Slightly smaller tubercles in some declivital interstriae, but pattern identical: tubercles missing from interstriae 2.

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The external morphology of *Austroplatypus incompertus* (Schedl) (Coleoptera, Curculionidae, Platypodinae)

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Abstract

Previous descriptions of adult *Austroplatypus incompertus* (Schedl) are completed by the addition of descriptions and illustrations of the adults and, in particular, their maxillary palps. I describe and illustrate the non-adult phases of the life cycle and provide a key to the larval instars. The sexual dimorphism of *A. incompertus* is atypical and includes a latitudinal cline which obeys Bergmann's rule. The taxonomic position of the genus within the Platypodinae is clarified. *Platypus incostatus* Schedl is recognised as the male of the species, and hence a new synonym of *A. incompertus*.

Keywords

Curculionidae, Platypodinae, *Austroplatypus*, Australia, external morphology, larvae, sexual dimorphism, latitudinal cline

Introduction

Studying and accurately describing the external morphology of insects is important because it is the external details that characterise and give indications of the animals' biology, ecology and social behaviour. In addition, insects are often identified solely by external adult morphology and this is reflected in the formal taxonomic descriptions of most species.

Studies of the external morphology of platypodines have generally concentrated on taxonomic research and consequently have mainly dealt with descriptions of specific parts of the external morphology of adults. In contrast, relatively few papers (Hogan 1948, Browne 1961, Roberts 1962, Santoro 1957, 1965, Candy 1990) have described all the developmental stages of a particular species.

The lack of comprehensive morphological descriptions within the platypodines is typified by *Austroplatypus incompertus* (Schedl). This species was discovered in the early 1950s and named in 1968. Describing and identifying it has been problematic as specimens are unusually difficult to collect. Adult beetles are not attracted to light and the only way to obtain all developmental stages is to cut them from living trees. Consequently there has been a dearth of material for description or comparison. In fact, until the current study, no well-documented collection of both adult and larval *A. incompertus* material had been made. This has no doubt contributed to the small number of papers dealing with the taxonomy and biology of *A. incompertus* (Schedl 1968, Campbell 1969, Browne 1971, Harris et al. 1973, 1976). There are even fewer studies of the immature stages. No descriptions exist of the eggs or pupae, and although it is generally accepted that there are five larval instars (Harris et al. 1973, Wright and Harris 1974; Harris et al. 1976), only the final instar has been described (Browne 1972). There are no records of any morphological differences between instars or any measurements of head capsule widths, an important method for differentiating instars.

The research reported in this paper had two broad aims. The first was to verify and complement existing descriptions of the external morphology of *A. incompertus*. This necessitated descriptions of the egg, larval instars and the pupa as well as a description of adult sexual dimorphism and the adult maxillary palps. In addition immature stages and adults were illustrated with line drawings and scanning electron micrographs.

An integral part of these descriptions were measurements such as head capsule widths and adult body lengths. However, such measurements are problematic if variation exists among populations. The increase in mature larval head capsule width of *Platypus subgranosus* Schedl from north to south (Candy 1990) illustrates the need to take measurements over a wide geographical range where possible. Thus, size variation was also examined for a number of factors, viz. geographical location for larvae and adults and sex and host tree species for adults.

The second aim was to integrate the new material presented here with existing taxonomic descriptions and discuss the current taxonomic position of *A. incompertus*.

Material and methods

The source materials for this paper were voucher specimens collected during the study as well as material already held in the Forestry Commission of NSW Insect Collection (FCNI). In their entirety these specimens encompassed the currently known geographical and host tree species range of *A. incompertus* (Kent 2008a). Type material of

both *A. incompertus* (National Museum of Victoria) and *P. incostatus* (British Museum) was also examined.

Collections examined

AM	Australian Museum
ANIC	Australian National Insect Collection
BM	The Natural History Museum, London
FCNI	Forestry Commission of NSW Insect Collection
NMV	National Museum of Victoria
SAM	South Australian Museum.

Material examined

Unless otherwise noted all specimens mentioned below are part of FCNI.

Austroplatypus incompertus (Schedl)

Holotype female: New South Wales: Eden, 23.x.1953 (NMV), LH Bryant. Ex. *Eucalyptus sieberana* F. Muell. (= *E. sieberi* L. Johnson).

Paratypes: Victoria: Woodhouse Creek, N of Omeo, xi.1964 (1♀ NMV); near Omeo, xi.1965 (2♀ NMV). (Note: the distribution of the paratypes examined at NMV does not agree with Schedl (1968) which lists 2 paratypes from Woodhouse Creek and 1 near Omeo).

Other material examined: New South Wales: Dorrigo, 23.iii.1954 (1♀) [Note: same information as Holotype of *Platypus incostatus*]; Styx River State Forest, 24.ix.1992 (11♀), 16.x.1992 (7♀); 20.i.1993 (1♀,1♂); Mt Boss State Forest, 27.iii.1958 (2♀), Bellangry State Forest, 12.xi.1965 (5♀); 7.xii.1988 (13♀); Bellangry Timber Mill, Wauchope, 9.xii.1988 (1♀); Manning River National Forest, Taree, 10.viii.1965 (5♀), 8.ix.1965 (2♀), 9.ix.1965 (1♀), 19.vi.1967 (3♂); Cooperook State Forest, 11.viii.1965 (1♀); Ourimbah State Forest, Wyong, 20.xi.1984 (1♀), 18.iii.1988 (6♀,5♂), 13.x.1988 (1♀), 22.xi.1988 (22♀), 17.i.1989 (1♀), 24.ii.1989 (3♀,1♂), 16.vi.1989 (11♀,1♂); Mt Wilson, Blue Mtns, iv.1986 (3♂ AM); Banshea State Forest, near Oberon, 7.x.1965 (5♀), 18.iii.1970 (3♀,1♂); Cumberland National Forest, West Pennant Hills, 19.viii.1965 (1♀), 30.viii.1965 (1♀), 30.ix.1965 (1♀), 28.x.1965 (3♀), 12.iv.1967 (1♀), 19.iv.1967 (1♀,1♂), 26.ix.1967 (1♀), 6.xii.1967 (1♀); iii-v.1968 (1♀,6♂), 8.iv.1969 (1♀,4♂), 30.iii.1988 (1♂), 5.iv.1988 (1♀), 8.iv.1988 (2♀), 14.iv.1988 (15♀,1♂), 19.iv.1988 (1♀), 20.iv.1988 (1♀), 21.iv.1988 (1♂), 13.xii.1988 (2♀), 23.ii.1989 (1♀), 1.iii.1989 (1♀), 30.iii.1989 (23♂), 3.iv.1989 (11♀,2♂), 4.iv.1989 (1♀,4♂), 5.iv.1989 (1♀,1♂), 10–12.iv.1989 (9♀,8♂), 11.iv.1989 (1♀), 2.iv-6.v.1990 (75♀,55♂), 14.vi.1990 (4♀), 25.x.1990 (3♀), 18–19.iv.1991 (1♂), 20–21.iv.1991 (1♀,1♂); 4–14.iv.1991 (3♂), 4–24.iv.1991 (24♀,13♂), 30.iv-1.v.1991 (1♀), 4–5.iv.1992 (1♂), 6.iv.1992 (1♂), 7.iv.1992 (2♀,6♂), 6–7.iv.1992

(3♀,11♂), 7–8.iv.1992 (2♂), 11–12.iv.1992 (4♀,11♂), 13.iv.1992 (17♀, 38♂), 14.iv.1992 (19♀,1♂), 15.iv.1992 (6♀,7♂), 15–18.iv.1992 (9♀), 18.iv.1992 (3♀,2♂), 18–21.iv.1992 (2♀,1♂), 24.iv.1992 (1♂), 25–28.iv.1992 (9♀,4♂), 29.iv.1992 (1♀), 30.iv.1992 (4♀,1♂), 1–11.v.1992 (12♀,1♂), 6–8.v.1992 (1♀); Broughton's Lookout, 15 kms S of Wombeyan Caves, 27.viii.1979, (1♂ AM); Nullica State Forest, Eden, 19.xi.1991 (1♀); Nalbaugh State Forest, Bombala, 21.xi.1991 (7♀); Bondi State Forest, Bombala, 21.x.1965 (4♀); Bombala, 13.iii.1991 (3♀,6♂); Eden, 23.x.1953 (1♀) [Note: same information as Holotype], 25.vii.1989 (4♀); Naghi State Forest, Eden, 20.x.1965 (4♀).

Victoria: Lightning Creek, N of Omeo, viii.1965 (1♂ NMV); Woodhouse Creek, near Omeo, viii.1965 (2♀, NMV); Swifts Creek, 20 miles (32 km) S of Omeo, 1966 (2♀ NMV; 2♀ SAM; 1♀ ANIC), 14.iv.1967 (3♀,1♂).

Platypus incostatus Schedl

Holotype male: New South Wales: Dorrigo, 23.iii.1954 (BM), J Cartwright. Ex. *Eucalyptus laevopinea* R.T. Baker.

Specimen preparation – General

All specimens of immature life stages were fixed to preserve their shape and size and thus ensure that descriptions and measurements were accurate and comparable. Eggs, larvae and pupae were fixed in KAA [kerosene (7%), glacial acetic acid (16%) and 95% ethanol (77%)] for 5–30 minutes depending on size and developmental stage; eggs and small larvae required the shortest fixing period and the fifth instar and pupae the longest. The fixed specimens were then passed through immersion stages of several hours each in 90% and 85% ethanol before eventual permanent storage in 80% ethanol. Adults were killed either by freezing or by immersion in 80% ethanol and then air-dried and mounted on card points.

Specimen preparation - Scanning electron microscopy

For scanning electron microscopy, specimens were fixed in 2% glutaraldehyde in phosphate buffer (pH 6.9) for 24 hours, transferred through a series of increasing ethanol concentrations and then stored in absolute ethanol until coating. Just before coating, the specimens were placed in either ethyl acetate or acetone and then critical-point dried, after which they were sputter-coated with platinum or gold.

Observations

Observations of all life cycle stages of the beetle were made using stereo-dissecting and compound microscopes and a Cambridge S120 scanning electron microscope with a Robinson detector. These observations formed the basis for the descriptions of the external structures. The morphological terminology for larval descriptions follows that used by Browne (1961, 1972) and Roberts (1962).

Sex determination of adults

Adult beetles were sexed based on external morphological differences (Kent 2001): females by the presence of mycangia and a spined elytral declivity; males by the absence of mycangia and presence of simple rounded elytral apices.

Measurements

Both adult and larval measurements were made using a stereo-dissecting microscope fitted with a scaled graticule. One measurement was recorded for larvae: the width of the head capsule at its widest point. Three measurements were recorded for adults: dorsal prothorax length (measured along middle of the prothorax) and width (measured at its widest point, the posterior edge of the femoral emargination), and elytral length. Although total length is commonly reported in taxonomic descriptions, this measurement proved to be unreliable due to post-mortem head deflection and was therefore not recorded. Some adult beetles could not be measured because of their position on the card mounts.

Statistical analysis

Analysis of variance (ANOVA) was carried out on the measurements of the fifth instar larval head widths to determine whether there was a difference in specimens from different localities (the localities from which study material was derived fell naturally into three well separated latitudinal groups - Fig. 1). Similarly, measurements of adult beetles were analysed using ANOVA to determine whether there were differences between sexes, or between adult females from different localities or different host species (there being too few males from the range of localities and hosts to permit analysis). The analyses of females were restricted to prothorax length, as this was the most repeatable measurement. Where appropriate, *Post hoc* Tukey Honest Significant Difference (HSD) multiple comparison tests were performed to determine which means differed significantly.

Results

Descriptions

Egg ($n = 40$) length $0.70 \text{ mm} \pm 0.06$, width $0.45 \text{ mm} \pm 0.04$ (SD). Elongate, translucent white, shiny, without obvious sculpturing.

First instar larva (Figs 2, 3a, b) length $1.183 \text{ mm} \pm 0.2$ (SD) ($n = 5$), maximum body diameter much smaller than that of gallery. Maximum width on 5th abdominal segment. Body hyaline, white, shape ovoid and hump-backed dorsally. Head exerted, width of head capsule $0.303 \text{ mm} \pm 0.012$ ($n = 10$), wider than long, greatest width over bulbous antero-lateral margins. Head setae prominent, 1 posteriorly to each antero-lateral margin, nearly twice as long as any other. Antennae small, one each side of epicranium in unpigmented portion between mandibular condyles (Fig. 3a). Mandibles lightly sclerotised and with comb-like teeth (Fig. 3a). Maxillary palpi 1-segmented;

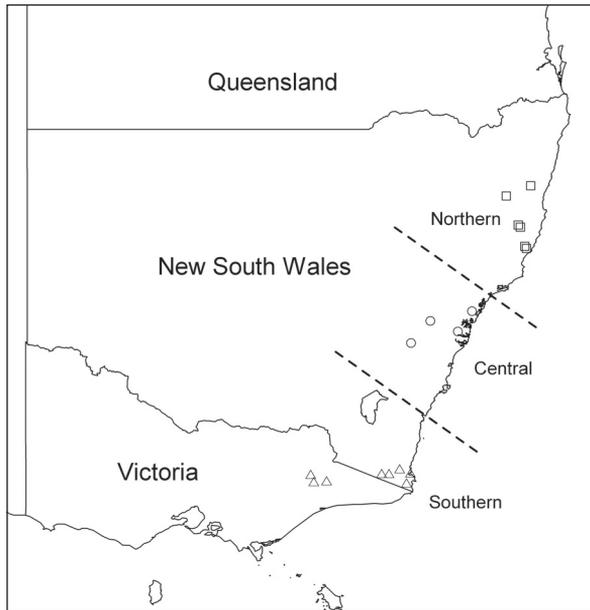


Figure 1. Latitudinal distribution of adults and larvae from which measurements were taken.

labial palpi 1-segmented (Fig. 3b). Meso- and metathoracic segments each enlarged into pseudopods. All thoracic segments bearing a single prominent lateral seta on each side. Abdominal tergites 6 and 7 each bear a single prominent seta on a dorsolateral protuberance on each side. All sternites with lateral protuberances, each bearing two setae, those of segments 5–9 enlarged into pseudopods (Fig. 2). Only two pairs of spiracles, one on prothorax and the second on abdominal segment eight.

Second instar larva (Fig. 4) slightly larger than first instar, but same general form. Head more elliptical, less angular than first instar. Head capsule width $0.353 \text{ mm} \pm 0.028 \text{ (SD)}$ ($n = 11$). Mandibles similar. The main difference between the first two instars is the presence of nine pairs of spiracles, one each on the prothorax and one each on eight abdominal segments.

Third instar larva (Fig. 5a, b) slightly larger than the second instar, but still smaller than gallery diameter. Head capsule width $0.581 \text{ mm} \pm 0.077 \text{ (SD)}$ ($n = 32$). Body still hump-backed but more flattened ventrally and not as translucent as first two instars. Head distinctly narrower than prothorax and more rounded in shape in comparison to the first two instars. Pseudopods no longer as prominent. Spiracles as in second instar. Mouthparts as in Fig. 5a, b.

Fourth instar larva (Fig. 6) body stout, more or less closely fitting the galleries. Head clearly narrower than width of pronotum. Pseudopods not evident. Head capsule slightly wider than long, width $0.868 \text{ mm} \pm 0.071 \text{ (SD)}$ ($n = 49$). Labrum and mandibles as in Fig. 6. Mandibles similar to third instar, only slightly chitinized and still bearing small teeth along apical and subapical edges. Pronotum lacking any chitinized pattern of ridges (see below).

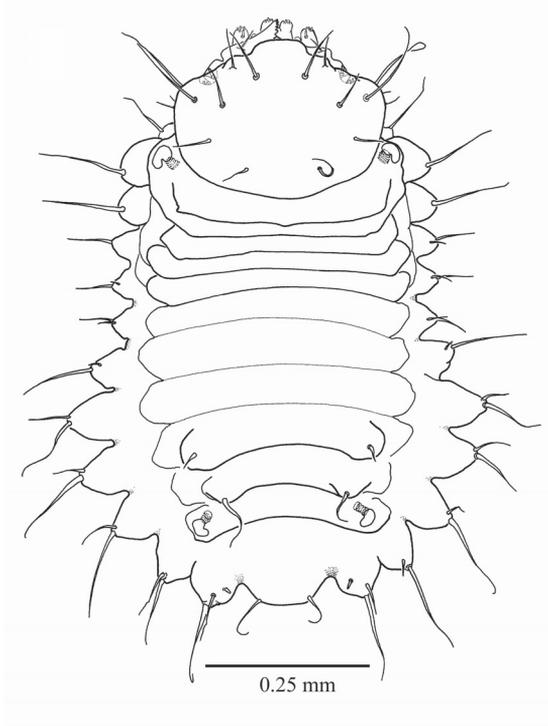


Figure 2. First instar larva, habitus, dorsal.

Fifth instar larva (Figs 7, 8, 9a, b, c, 10, 11) see Browne (1972) for detailed description. The following is supplementary to Browne's description. Head capsule width $1.121 \text{ mm} \pm 0.086 \text{ (SD)}$ ($n = 547$). Figures 8 and 9a, b, c illustrate head with details of labrum, mandible and labium, respectively. Mandibles heavily chitinized, bluntly pointed and lacking teeth. Pronotum pattern with two pairs of setae, the lateral seta of each pair socketed and surrounded by irregular chitinized ridges, the medial seta surrounded by lighter chitinized irregular ridges (Fig. 10). Spiracles (Fig. 11) ovate with single, short, dorsally directed air tube; peritreme surrounded by cuticular wrinkles. Thoracic spiracles larger than abdominal ones.

Five distinct larval instars are morphologically discernible using the following key

1. Body ovoid, trapezoidal, rhomboidal, hump-backed dorsally; body width distinctly less than diameter of gallery (Figs 2, 4) **2**
- Body elongate, not markedly hump-backed; body width almost the same as that of the gallery (Fig. 7) **4**
2. Prominent pseudopods on meso- and meta-thoracic segments and on abdominal segments 5–8, head broader than long (Figs 2, 4) **3**
- Pseudopods not very prominent on any body segment, head more round.....
..... **third instar**

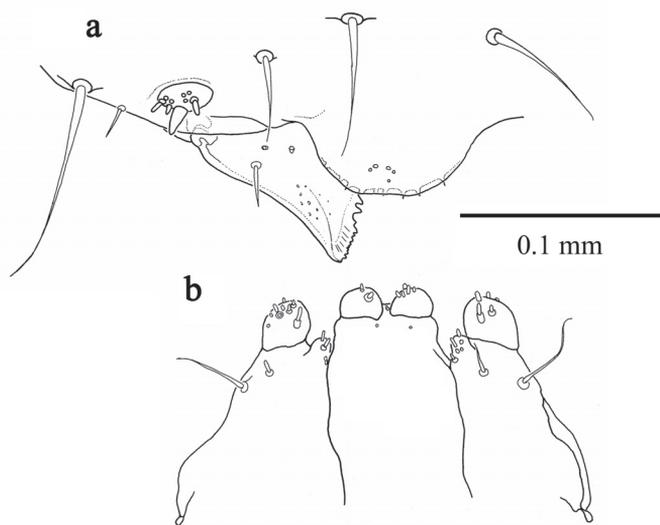


Figure 3. First instar larva **a** antenna, labrum and mandible, dorsal **b** maxillae and labium, dorsal.

3. Only two pairs of spiracles, both the same size, one pair on prothorax and one on abdominal segment 8, head very broad, transversely oblong (Fig. 2) **first instar**
- Nine pairs of spiracles, one pair on prothorax and one pair on each side of first eight abdominal segments, head more elliptical (Fig. 4) **second instar**
4. Pronotum lacking any brown chitinized pattern; mandibles slightly chitinized with teeth on cutting margin (Fig. 6) **fourth instar**
- Pronotum with brownish chitinized patterned consisting of two pairs setae, surrounded by irregular ridges (Fig. 10); mandibles heavily chitinized, apex bluntly pointed and free of small teeth (Fig. 9b) **fifth instar**

Pupa (Fig. 12) cuticle white and glabrous, setae coarse, arising laterally from an armed tubercle (Fig. 13), larger and more numerous on head and prothorax than on abdomen. Rostrum not reaching fore coxae. Antennal club smooth. Sex indeterminate until the darkening of the cuticle of the young adult appears through the pupal skin. At this point females can be identified by the appearance of mycangia in the centre of the prothorax.

Adults (Fig. 14a, b, c, d) have the typical elongate cylindrical form of platypodines, with a length of approximately 6 mm and a diameter of approximately 2 mm. All types examined at NMV were females. This is in contradiction to Schedl's tentative assignment of them as all male (Schedl 1968).

Schedl (1972b) described *P. incostatus* as a new species closely allied to *A. incompertus*, from a single specimen of unspecified sex from Dorrigo, N.S.W., collected on 23 March

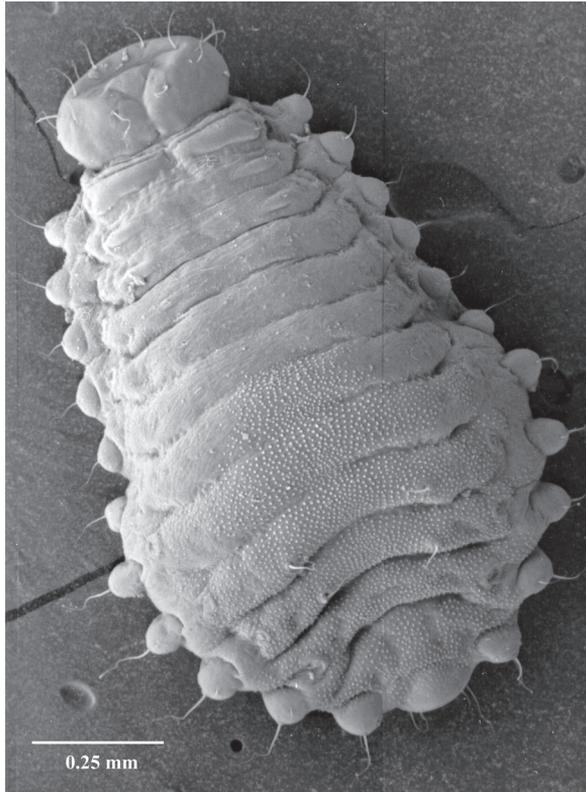


Figure 4. Second instar larva, habitus, dorsal.

1954. Following the suggestion of R.A. Beaver (pers. comm.) that the holotype of *P. incostatus* described by Schedl might in fact be a male *A. incompertus* I examined the holotype (held by the Natural History Museum, London) and confirmed that it is a male *A. incompertus*. Interestingly, the FCNI collection contains a single female *A. incompertus* collected from the same locality on the same day, but Schedl evidently never saw this specimen. As the name *P. incompertus* predates that of *P. incostatus*, the latter becomes a synonym.

Provided one is aware of these problems Schedl's 1968 and 1972b descriptions of adult beetles are fairly complete. Since they have already been published do not require repeating in this paper. Inadequacies in the original description of the adult head (Schedl 1968) were remedied by Browne (1971). In addition the mycangia in female *A. incompertus* are described in detail and illustrated in Kent (2008b).

Maxillary palps (Fig. 15a, b, c) of adult *A. incompertus* are three segmented. This is in contrast to a previous report that they have four segments (Browne 1971). Browne's error appears to have resulted from mistaking part of the palpiger as an additional segment (Zimmerman 1994, Kuschel 1995, pers. obs.). Because of the importance this misidentification has played in the taxonomic debate regarding whether platypodines and scolytines should be placed within or outside of Curculionidae (Wood 1973), the palp is illustrated here in detail for the first time. This figure shows the palp in a se-

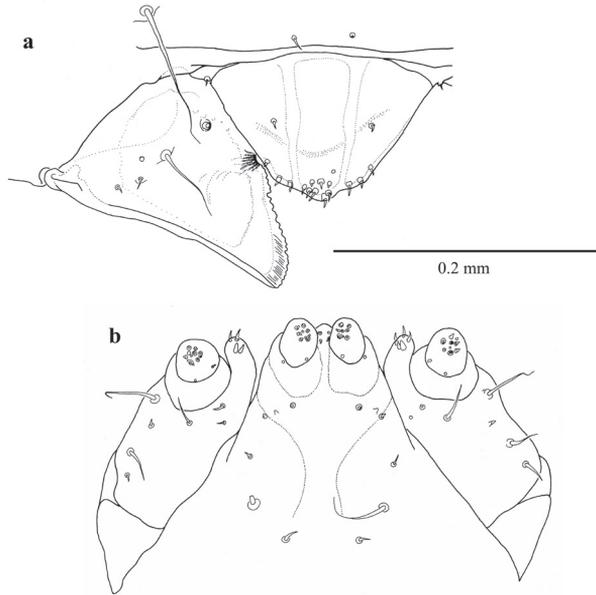


Figure 5. Third instar larva **a** mandible, labrum and epistoma, dorsal **b** maxillae and labium, ventral.

quence of views, the ventral one showing a superficial resemblance to a four segmented condition. This resemblance disappears when the palp is rotated to the dorsal view.

Sexual dimorphism

The sexes are dimorphic in *A. incompertus* with the most obvious difference being the shape and sculpturing of the elytra. In the female the elytral declivity is abrupt and armed with prominent spines, while in the male the elytral apices are more rounded with only very small spines. This difference between the sexes is easily discernible with the naked eye and can be used to sex individuals in the field. Additional differences between the sexes can be seen using a stereo-dissecting microscope:

- The presence in the female of mycangia in the centre of the prothorax (Fig. 16) and their absence in the male;
- The presence in the female of a series of ridges at the base of the elytra (Fig. 17) and their absence in the male. The ridges are located between the 3rd and 4th interstices and form a series of backwardly directed ridges, twice as wide at the anterior edge (straddling both the 4th and 3rd interstices) and tapering to half that (just the 3rd) for approximately a sixth of the total length of the elytra.

Size differences

Larvae

Only fifth instar larvae were present in sufficient numbers to allow analysis of variance. There were highly significant differences in head capsule width among the

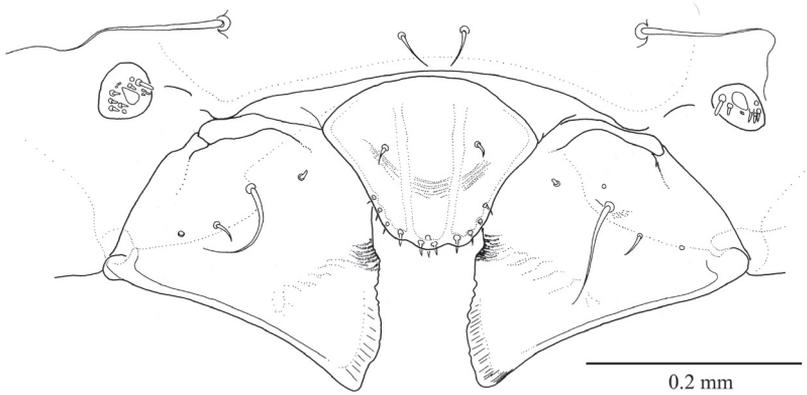


Figure 6. Fourth instar larva, antennae, mandibles, labrum and epistoma, dorsal.

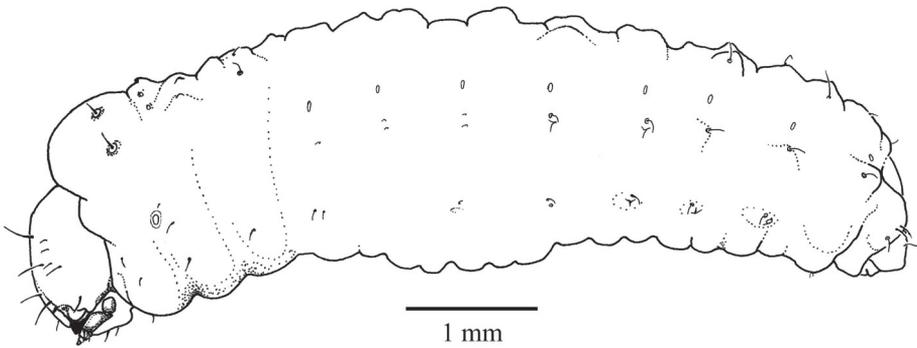


Figure 7. Fifth instar larva, habitus, lateral.

different latitudinal groups [$P < 0.001$, $DF = (2, 543)$] with the width increasing from north to south (Table 1).

Adults

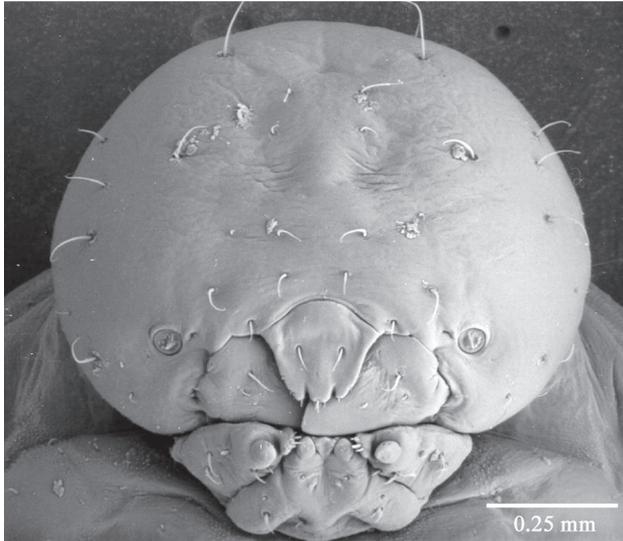
Between sexes. Although both the prothorax and the elytra were measured, the prothorax proved to be better suited to regular measurement because of its flatness, especially along its length. Measurements based on the prothorax were also less likely to be subject to error, compared to elytral length, as the latter can be difficult to measure if the elytra are opened after the death of the specimen. Even so, the results of the analysis of the three different measurements pooled across all hosts and localities showed that all were highly significantly different between the sexes [prothorax length $P < 0.001$, $DF = (1, 604)$; prothorax width $P < 0.001$, $DF = (1, 603)$ and elytral length $P < 0.001$, $DF = (1, 604)$], with males being smaller than females.

Because all three measurements were significantly different between the sexes but prothorax length was the most suitable and reliable measurement, subsequent analyses

Table 1. Head capsule width of fifth instar for different latitudinal groups.

Latitudinal group	n	Mean head capsule width (mm)
Northern	84	1.015 ^a
Central	292	1.087 ^b
Southern	171	1.230 ^c

Assignment of different superscript letters indicate a highly significant difference ($P < 0.001$) between means.

**Figure 8.** Fifth instar larva, head, ventral.

were restricted to this variable. Males were present in too few numbers across all localities and hosts to permit analysis.

Between localities. There was a highly significant size difference between female beetles from the different latitudinal groups [$P < 0.001$, $DF = (2, 428)$] with prothorax length increasing from north to south (Table 2).

Between hosts. There was also a highly significant difference between beetles from the different host tree species [$P < 0.001$, $DF = (8, 418)$], and *Post hoc* Tukey HSD multiple comparisons placed the hosts into three groups (Table 3).

Discussion

Immature stages

Five distinct larval instars could be distinguished on the basis of their morphology and their head capsule widths, as is the case with other platypodines (Browne 1961, 1972, Hogan 1948, Roberts 1960, 1962, 1968, Candy 1990). The external morphology of the fifth instar larval stage of *A. incompertus* is characterised by the design of the

Table 2. Mean prothorax length of *A. incompertus* females for each of the three latitudinal groups.

Latitudinal group	n	Prothorax length (mm)
Northern	70	1.621 ^a
Central	314	1.745 ^b
Southern	47	1.872 ^c

Assignment of different superscript letters indicate a highly significant difference ($P < 0.001$) between means.

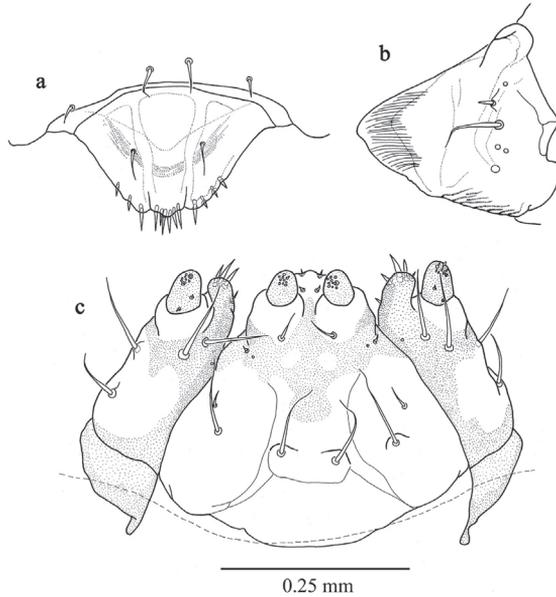


Figure 9. Fifth instar larva **a** labrum and epistoma, dorsal **b** mandible, dorsal **c** maxillae and labium, ventral.

prothorax pattern which separates it from the larva of *Dendroplatypus*, which it most closely resembles (Brown 1972). Brown (1972) also split *Austroplatypus* from the majority of platypodines based on his observation that the anterior notches of the labrum are shallow. This study found that the notches in fifth instar larvae were not shallow as illustrated by Browne (1972) but more deeply and narrowly notched (Fig. 8). This level of detail is only seen in scanning electron micrographs. Preserved specimens and slide preparations show the labrum with shallow notches because these preparation methods appear to result in the closure of the gaps between the notches (Fig. 9a).

Sexual dimorphism

Sexual dimorphism in *A. incompertus* is reversed, compared with the situation in other platypodines. Males are significantly smaller than females, females have elytral modifications, in the form of an elytral declivity modified for both cleaning and defence, which males do not, and only females possess mycangia. In most platypodines,

Table 3. Mean prothorax length of *A. incompertus* females for each of the host tree *Eucalyptus* species.

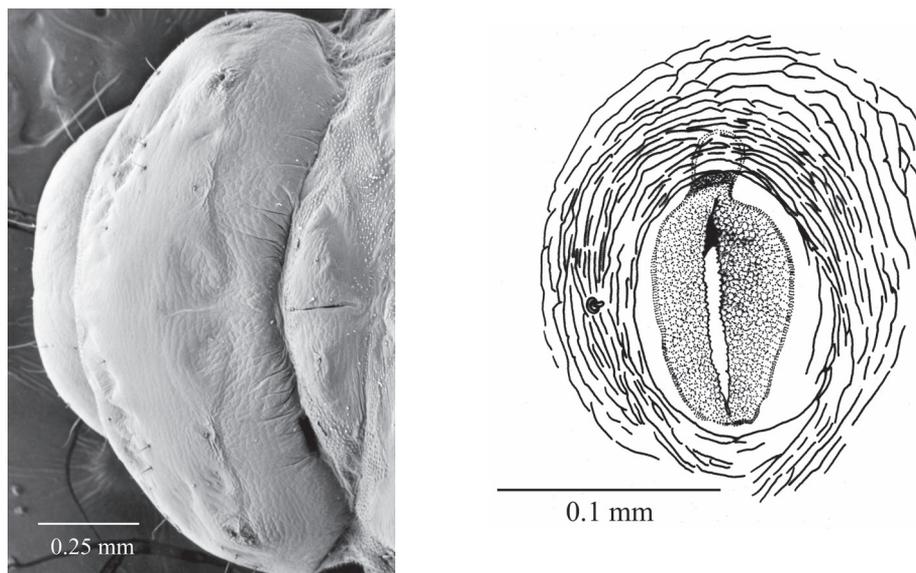
Host species	n	Prothorax length (mm)	Host distribution
<i>E. andrewsii</i>	16	1.533 ^a	Northern tablelands of NSW & adjacent areas of Queensland
<i>E. cameroni</i>	2	1.630 ^{ab}	Northern tablelands & ranges of NSW
<i>E. laevopinea</i>	15	1.681 ^b	Central & northern tablelands of NSW and immediately adjacent areas of Queensland
<i>E. pilularis</i>	300	1.723 ^b	Coastal NSW and southeast Queensland
<i>E. obliqua</i>	33	1.811 ^c	Northern tablelands & south coast of NSW, coast & ranges Victoria, Mt Lofty Ranges South Australia and Tasmania.
<i>E. agglomerata</i>	36	1.817 ^c	Central & southern coast of NSW and adjacent areas of Victoria
<i>E. fastigata</i>	6	1.856 ^c	Tablelands, ranges & coastal escarpments of NSW and adjacent parts of Victoria
<i>E. sieberi</i>	16	1.879 ^c	Tablelands & coast of NSW and eastern Victoria
<i>E. delegatensis</i>	3	1.914 ^c	Southern ranges of NSW and eastern Victoria

Assignment of the same superscript letter indicates no significant difference between species, different superscript letters indicate a highly significant difference ($P < 0.001$)

the sexes are similar in size or the male is only slightly smaller, males alone possess elytral modifications or modifications are much more strongly developed in males, and males either have no mycangia or a reduction in the number of mycangia compared with females (Chapius 1865, Strohmeier 1914, Hogan 1948, Milligan 1979, Roberts 1960, Wood 1993, Beaver and Liu 2007). Wood (1993) linked these external modifications, or lack of them, to the typical Platypodinae monogynous mating system and male initiated gallery system. This is consistent with the situation in *A. incompertus* where the reversal in elytral modifications reflects the different roles undertaken by the sexes in gallery systems with only females initiating the gallery systems and carrying out defence and maintenance activities (Kent 2001).

Size differences

Fifth instar larval head capsule widths and all three adult body measurements of *A. incompertus* display a size variation consistent with Bergmann's rule which states that body size increases at higher latitudes (Blanckenhorn and Demont 2004). Latitudinal clines in body size have been observed in a number of ectotherms (Reeve et al. 2000), including arthropods (Blanckenhorn and Demont 2004). Whilst several authors (Shaw and Groeters 1998, Reeve et al. 2000) have suggested possible mechanisms for the evolution of such clines, research in this field is still in its infancy and no theory has gained ascendancy. As a result of the latitudinal cline observed in *A. incompertus*, measurements for this species should be treated with caution in taxonomic works.



Figures 10, 11. 10 Fifth instar larva, pronotum, dorsal 11 Fifth instar larva, thoracic spiracle.

Taxonomy and phylogeny

Austroplatypus incompertus (Schedl)

Platypus incompertus, Schedl 1968, Memoirs Natural History Museum, Victoria. 28, 15.

Austroplatypus incompertus, Browne 1971, Commonwealth Forestry Review. 50, 49;

Schedl, 1972a; Wood 1973, 1993; Zimmerman 1992, 1994; Kuschel 1995.

Platypus incostatus, Schedl, 1972b, Papua New Guinea Agricultural Journal. 23, 68, **syn. n.**

Platypus incompertus was described from six specimens, which Schedl thought to be male. An examination of the type material of *A. incompertus* (held in the National Museum of Victoria) revealed that it consisted of females only. *P. incompertus* was subsequently placed in a new genus, *Austroplatypus*, by Browne (1971). His paper contains a generic description for *A. incompertus* and a detailed description of its antenna, maxilla and labial palps. Browne's miscount of the segments of the maxillary palps (four instead of three) caused problems in the taxonomic placement of platypodines within the Curculionoidea (Wood 1973, Kuschel 1995).

Armed with the knowledge that *A. incompertus* displays atypical sexual dimorphism, the discrepancy between the original descriptions of both *A. incompertus* (Schedl 1968) and *P. incostatus* (Schedl 1972b) may be explained. The presence of mycangia, which in platypodines are usually more developed in females than males, should have suggested to Schedl that his original six specimens were females. However, he may have decided (incorrectly) that his six specimens were males based on the structure of their elytra. Subsequent taxonomic and descriptive work (Campbell

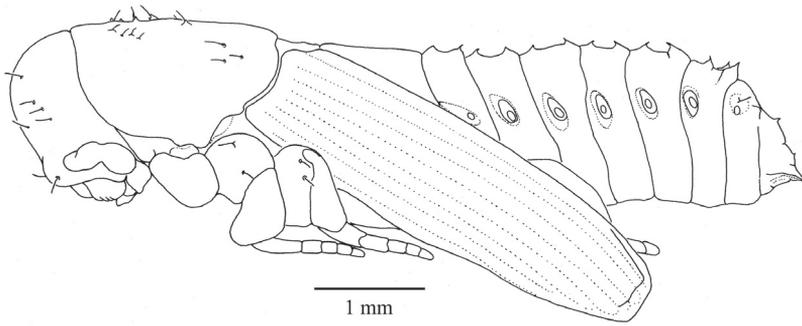


Figure 12. Pupa, habitus, lateral.

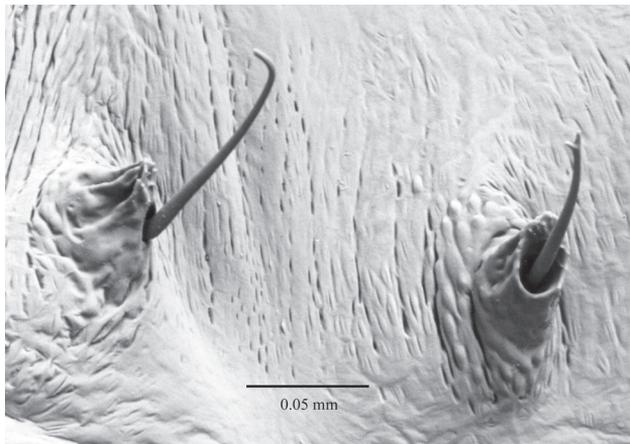


Figure 13. Pupa, thoracic setae, dorsal.

1969, Browne 1971, Schedl 1972a, Harris et al. 1973, 1976) correctly assigned descriptions to the sexes.

Schedl (1972b) unfortunately erred again when he described *P. incostatus* as a new species closely allied to *A. incompertus*. Schedl distinguished this new species from *A. incompertus* based mainly on the distinctly smaller size, the absence of mycangia and the reduced elytral modifications, all of which are manifestations of the atypical sexual dimorphism in this species. He was also unwilling to assign the specimen a sex.

Because the sexes in most platypodines are either similar in size or the female is slightly larger the distinctly smaller size of the single *P. incostatus* specimen described by Schedl probably convinced him that he was dealing with two different species. However, the current study has shown that not only is there a significant size difference between the sexes, but also a significant size difference between beetles from different parts of their distributional range. The original type material that was used to describe *A. incompertus* came from the southern part of the distribution (Eden, NSW and Woodhouse Creek north of Omeo and near Omeo Victoria), whereas the single type specimen of *P. incostatus* is from the most northern part of the distribu-

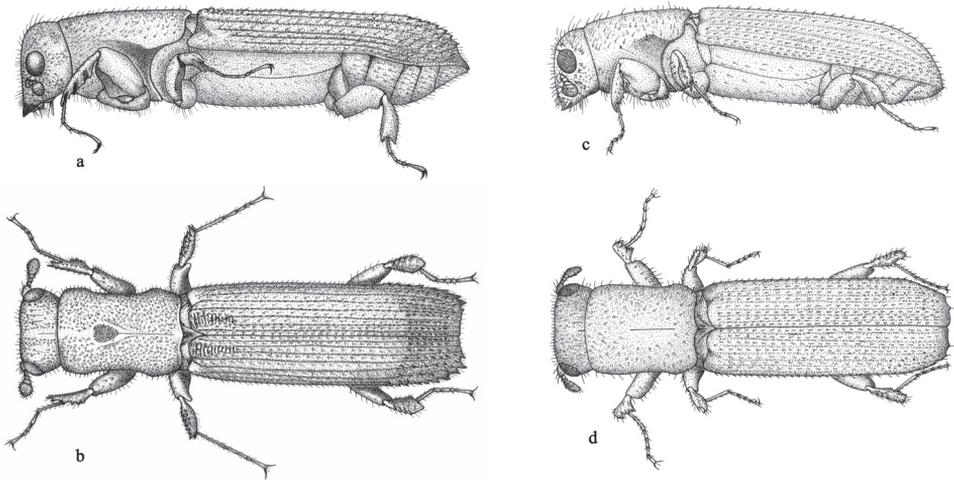


Figure 14. Adult female (a&b) and male (c&d) (lateral and dorsal respectively).

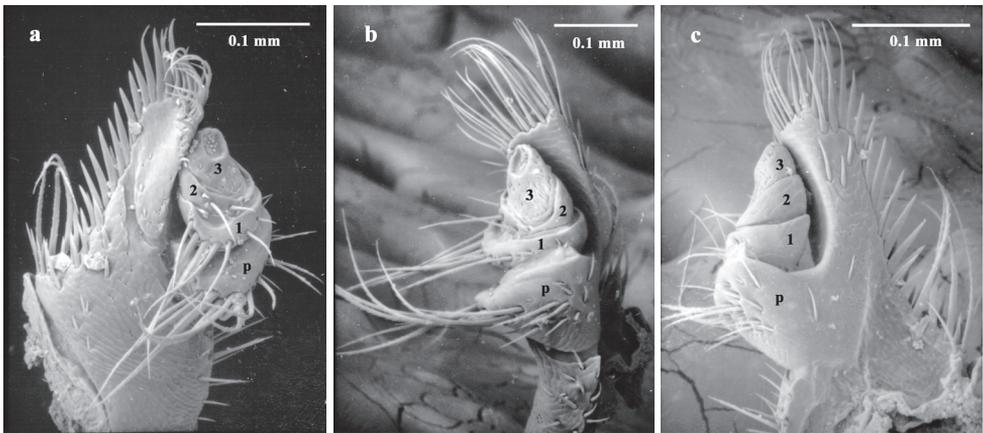


Figure 15. Adult maxillary palp **a** ventral **b** lateral **c** dorsal (segments numbered 1–3 and palpiger – p).

tion (Dorrigo, NSW). Thus, Schedl would have been looking at a male specimen from the smallest end of the size range, compared with female specimens from the larger end of the range. This situation would have suggested to him that he was dealing with two species.

Position of Austroplatypus within Platypodinae

The position of *A. incompertus* in the family Platypodinae is still unclear. Browne (1971) placed it in the tribe Platypodini near *Dendroplatypus* Browne, while Schedl (1972a) assigned it to the subfamily Platytarsilinae together with the monotypic Australian genus *Notoplatypus* Lea and the Malaysian genus *Platytarsulus* Schedl. *Austroplatypus* does not fit within Schedl's Platytarsilinae, since it does not possess the distin-

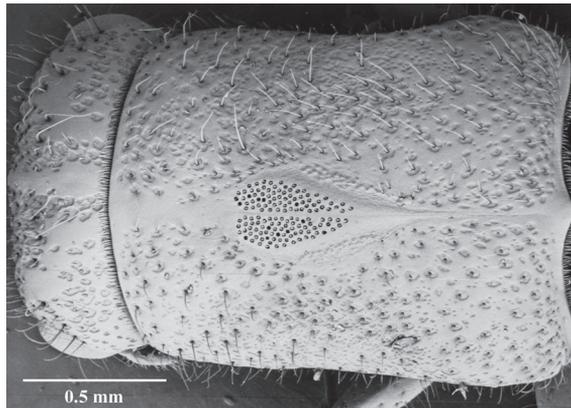


Figure 16. Mycangia of female.

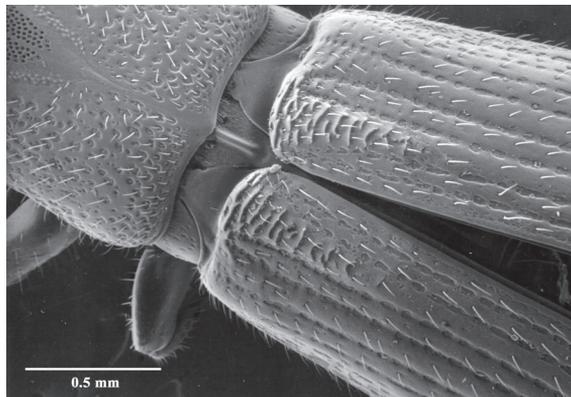


Figure 17. Elytral ridges of female.

guishing characteristics of very slender elongate body form and the proboscis-like head shape. In addition, both of the other two genera have reduced antennal segments while *Austroplatypus* has the four antennal segments characteristic of the rest of the platypodines (Schedl 1972a). Wood (1993) synonymised *Austroplatypus* under *Platypus* Herbst and thus also placed it in the Platypodini. He gave no reasons for this action but had possibly detected Browne's (1971) error with respect to the number of maxillary palp segments. If so, it is strange that he did not also synonymise *Dendroplatypus* under *Platypus*, as Browne (1955) had similarly miscounted its maxillary palp as having four segments. Zimmerman (1992, 1994) and Kuschel (1995) noted Browne's miscount of the maxillary palp segments of *Austroplatypus* and treated it as a valid genus, but did not comment on its classificatory position. In his review of the genus *Platyarsulus* Beaver (1998) also agreed that *Austroplatypus* was a valid genus. Since *A. incompertus* differs from *Platypus* not only in its atypical sexual dimorphism, but also in its uniquely modified life-history strategies of mating and reproduction (Kent and Simpson 1992, Kirkendall et al. 1997), its placement in a separate genus within the Platypodini appears justified.

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Revision of the genus *Phloeoditica* Schedl - with description of two new genera and two new species in Phloeosinini (Coleoptera, Curculionidae, Scolytinae)

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Abstract

The genus *Phloeoditica* Schedl currently includes four species from Southeast Asia. These species vary substantially in important morphological characters and indicate the existence of multiple genera for these species. A revision based on morphological and in part molecular data resulted in the transfer of *Phloeoditica setosa* to *Pseudoxylechinus*, the erection of a new genus *Asiophilus* for *Phloeoditica phloeosinoides* and a new species *A. macropunctatus* from Vietnam. Another new genus with affinities to *Phloeoditica* is described based on the new species *Microditica uniseriata* from Thailand. The new genera are included in a revised key to the tribe Phloeosinini.

Keywords

Phloeoditica, *Pseudoxylechinus*, *Asiophilus*, *Microditica*, Phloeosinini, South-East Asia

Introduction

Schedl (1962, 1963) described the genus *Phloeoditica* based on the species *Kissophagus curtus* Eggers (1925). In the same publication he also transferred *K. setosus* Eggers (1939) to the same genus and described two new species, *P. elegans* and *P. obscura*.

Browne (1966) added a fifth species, *P. phloeosinoides*, which he with some hesitation placed in *Phloeoditica*. *P. obscura* Schedl was later transferred to *Pseudodiamerus* by Wood (1988). The doubts expressed by Browne and the uncritical inclusion of *K. setosus* and *P. obscura* in *Phloeoditica* by Schedl indicate a heterogeneous taxonomic history and a current uncertainty in the assembly of *Phloeoditica* species. Recent collections from Vietnam and Thailand have furthermore revealed two additional undescribed species with affiliations to some of the species currently included in the genus. A revision is therefore needed.

Material and methods

Measurements follow the protocol by Wood (1982) and Jordal (1998). Four of the revised species were represented by only a single specimen in a condition which prevented genitalia and proventriculus preparations. Long series were available for the type species of *Phloeoditica* and one undescribed species in a closely related genus, which allowed dissections and DNA extraction. PCR amplification followed primers and protocols given in Jordal and Hewitt (2004).

Type material and other material are deposited in collections indicated by the following abbreviations:

- CMNO Canadian Museum of Nature, Ottawa
- NHCB Natural History Collections, Bergen Museum, Bergen
- NHMW Natural History Museum, Vienna
- NHRS National Museum of Natural History (Riksmuseet), Stockholm
- ZMUC Zoological Museum, Copenhagen

Results and discussion

Phloeoditica Schedl

Phloeoditica Schedl, 1963: 260

Phloeoditica: Schedl, 1962: 189 (Alonso-Zarazaga and Lyal, 2009: unavailable name)

Type species: *Kissophagus curtus* Eggers

Diagnosis. Typical phloeosinine having a 5-segmented funicle and flattened club with oblique sutures and broadly separated pro- and mesocoxae. Readily recognised by a unique pair of long denticles at the outer apical margin of protibiae, and an unusually long and laterally curved inner uncus.

Description. Size range 1.7–2.5 mm. Frons convex to moderately flattened in both sexes; antennal funicle 5-segmented, large club with two oblique sutures, the first marked by a septum, the second suture only marked by setae. Pronotum smooth, densely punctured, with short bristle-like setae. Scutellum not visible from above. Elytra with interstrial ground vestiture consisting of hair-like or scale-like setae; mesal groove immediately behind scutellum without interlocking nodules and cavities. Metepisternum clothed by plumose scales; sclerolepidia present, small and hair-like. Postnotum fused to metanotum; scutoscutellar suture parallel to scutellar groove for less than one-third of its length, then gradually curved laterally. Pleural suture nearly straight. Procoxae and metacoxae broadly separated. Outer apical angle of protibiae with a pair of projecting long socketed denticles, mostly embedded in cuticle; inner mucro extended into a large uncus curved towards outer margin.

Comments: The name *Phloeoditica* is feminine as documented by Alonso-Zarazaga and Lyal (2009).

Taxa included: *P. curta* (Eggers, 1925), *P. elegans* Schedl (1963). **Taxa excluded:** *P. phloeosinoides* Browne (1966) to *Asiophilus*, *P. setosa* (Eggers, 1939) to *Pseudoxylechinus*, *P. obscura* Schedl, 1963, to *Pseudodiamerus* (by Wood 1988).

Phloeoditica curta (Eggers, 1925)

Figs 1a, 4a, 5a, 6a, 7a

Kissophagus curtus Eggers, 1925: 155

Phloeoditica curtus (Eggers); Schedl 1962: 189

Type material examined. Lectotype: Burma with the following label data - “*Kissophagus curtus* n.sp. cotype, Eggers det 1924 / Mus. Pragense, Tenasserim, coll. Helfer / Cotype/ Dauerpräparat nr 2696 Fuehler, coll. Schedl” (NHMW) - current designation. **Other material examined:** Bangladesh, Khulna, Sunderbaans, Katka, ex *Pongamia pinnata*, 27 Feb. 1997, L. R. Kirkendall, leg (6 specimens, NHCB); Vietnam, with the following label: “Hoa-Binh (Tonkin) (A. de Cooman). Coll. J. Clermont” (1 specimen, NHMW). The locality in Hoa-Binh is located west of Hanoi in Vietnam, and not the island of Tonkin as incorrectly inferred by Wood and Bright (1992). Tonkin was the old colonial name of Vietnam.

Diagnosis: Interstriae broad and strongly elevated, with about three irregular rows of rounded scales and one median row of longer bristles separated on average by their length. Apex of metatibiae truncated and slightly excavated, surrounded by 4–5 proximally pointing small spines and a larger inner mucro. It is readily distinguished from *P. elegans* by the rounded scales on the interstriae. DNA sequences in Genbank: COI, GQ470889; EF1a, AF308402.

Description: **Length** 2.1–2.5 mm, 1.9–2.1 times longer than wide. Colour dark brown, with yellow setae. **Head.** Frons slightly convex, transversely impressed above epistoma, a weaker and more narrow impressed area in central area, sometimes with a



Figure 1. Dorsal and frontal view of *Phloeoditica curta* (A), *Phloeoditica elegans* (B), *Pseudoxylechinus setosus* (C, D).

narrow and shallow median longitudinal groove towards upper level of eyes. Frons finely pubescent, setae coarse and slightly longer in impressed area, a few longer setae along epistomal margin. Eyes three times longer (dorso-ventrally) than wide, separated above by 2.2 times their width. Antennal club large, one oblique suture indicated by weak septum and a second false suture indicated by setae. Funiculus 5-segmented, scapus about three quarter length of funiculus and club combined. **Pronotum** 0.85 times as long as wide, constricted on anterior fourth, anterior margin and notum smooth, shiny, punctures separated by half their diameter; short bristle-like setae from each puncture. **Elytra** 1.4–1.5 times longer than wide, 1.9–2.0 times longer than pronotum, sides parallel on anterior two-thirds, apex subacuminate due to elevated interstriae 1 and 3. Base of elytra moderately procurved and elevated by a complete row of crenulations. Striae deeply impressed, punctures large, subquadrate, separated by half the length of a puncture and formed by transverse ridges. Interstriae as wide as striae, strongly elevated, interstriae 2 and 4 less elevated on declivity, punctures obscure, small granules of variable size mainly on declivity. Interstriae 10 not elevated, reaches level of metacoxae. Vestiture consisting of 2–3 irregular interstitial rows of densely placed rounded scales and one central row of longer bristles, each separated on average by their length. **Hind wing** with weakly pigmented veins, stigmal patch without apical tubercles or setae, six short setae along costal margin of stigma, cluster of five longer and softer costal setae at junction between R and

SC-C. **Sclerolepidia** present along entire margin of metepisternum, small and hair-like; metepisternum with densely placed plumose scales. **Legs.** Procoxae separated by two-thirds the width of one coxa. Precoxal ridges very short, sharp. Mesocoxae separated by the width of one procoxa, mesocoxal process slightly proclinate. Metacoxae broadly separated. Protibiae armed by a long inner uncus curved towards outer margin and three socketed teeth embedded in cuticle along the outer lateral margin, the lower two close together and of similar size (type) or the inner tooth shorter (Bangladesh series). Mesotibiae armed by 4 lateral, socketed teeth. Metatibiae armed by 2 small lateral socketed teeth close to apex and 4–5 additional small apical spines along the outer and inner apical margin forming a semi-closed corbel-like structure. **Proventriculus** with apical plate about one-third as long as proventriculus, without median suture, with about 7 transverse and blunt ridges; femoral teeth small, irregularly placed; closing teeth few, long and soft; mastigatory brush rather weakly developed. **Aedeagus** about 5 times longer than wide, narrowly rounded at apex; apophyses about 2.5 times longer than aedeagal body (not clearly demarcated); a pair of short and narrow terminal plates present at apex; long inflated internal sac reaching half way between the apophyses, lightly sclerotised at apex. Tegmen a closed simple ring. Spiculum gastrale robust and L-shaped, with a tiny knob at posterior angle, about 0.8 as long as aedeagus. **Female rectum** with loop.

Comments. The type locality in Tenasserim is most likely in the province Tanintharyi of Myanmar (Burma). A designation of a lectotype is necessary because syntypes are mixed with specimens from different localities. The series examined from Bangladesh differ marginally from the type series collected in Myanmar and Vietnam by the smaller inner tooth at the protibial apex.

Phloeoditica elegans Schedl, 1962

Figs 1b, 4b, 5b

Phloeoditica elegans Schedl, 1962: 190

Type material examined. 2 paratypes: Vietnam with the following label data - "Tonkin, reg. de Hoa-Binh, A. de Cooman / Dauerpräparat nr 2081 Fuehler, coll. Schedl" and "Museum Paris, Tonkin, reg de Hoa-Binh, A. de Cooman 1929 / Dauerpräparat nr 2356 Fuehler, coll. Schedl" (NHMW).

Diagnosis: Distinguished from *P. curta* by the smaller size and the less elevated interstriae having a single row of erect hair-like bristles on interstria 1 and irregular rows of hair-like bristles on the remaining interstriae. The first suture of the antennal club has a more distinct septum visible without preparation.

Description: **Length** 1.7–2.0 mm, 2.0–2.2 times longer than wide. Colour dark brown, with yellow setae. **Head.** Frons convex, transversely impressed on lower half, especially just above epistoma. Short bristle-like setae evenly distributed from upper level of eyes to epistoma. Eyes three times longer (dorso-ventrally) than wide, separated above by 2.2 times their width. Antennal club large, one oblique suture indicated by a distinct

septum and a second false suture indicated by setae only. Funiculus 5-segmented, scapus about three quarter length of funiculus and club combined. **Pronotum** 0.9 times as long as wide, weakly constricted on anterior third, anterior margin and notum smooth, shiny, punctures deep, subconfluent; short spatula-shaped setae from each puncture. **Elytra** 1.5 times longer than wide, 1.9 times longer than pronotum, sides slightly diverging posteriorly, rounded behind. Base of elytra moderately procurved and elevated by a complete row of crenulations. Striae slightly impressed, punctures large, deep, transversely oval, separated by half the length of a puncture. Interstriae slightly wider than striae, slightly elevated, punctures at base of erect setae obscure. Interstriae 10 sharply elevated, reaches level of metacoxae. Vestiture consisting of 2–3 irregular interstitial rows of recumbent bristle-like setae slightly longer than distance between them and one central row of longer erect bristles each separated on average by 2–3 times their length. **Sclerolepida** present along entire margin of metepisternum, small and hair-like; metepisternum with densely placed plumose scales. **Legs**. Procoxae separated by one-third the width of one coxa. Precoxal ridges very short, sharp. Mesocoxae separated by the width of one procoxa, mesocoxal process proclinate. Protibiae armed by a long inner uncus curved laterally and three socketed teeth embedded in cuticle along the outer lateral margin, the lower two of similar size and closer together, much larger. Mesotibiae armed by 4 lateral, socketed teeth. Metatibiae armed by 3 lateral socketed teeth close to apex.

Comments. Types were mounted on cardboard which prevented examination of posterior ventral body parts. Types were not dissected for internal characters.

***Pseudoxylechinus setosus* (Eggers, 1939), comb. n.**

Figs 1c, d, 4c

Kissophagus setosus Eggers, 1939: 3

Phloeoditica setosa (Eggers); Schedl, 1962: 188

Type material examined. Holotype: Burma with the following label data - “N. E. Burma, Kambaiti, 7000ft., 1.5.1934, R. Malaise/ Typus [red paper]/ *Kissophagus setosus* n. sp. Type Eggers det 1938 / 301 65” (NHRS). **Other material examined:** 1 specimen with the same data as holotype, status of specimen not specified (NHMW).

Diagnosis. Distinguished from all genera in Phloeosinini by the strongly concave frons and further from *Phloeoditica* and *Microditica* genus nov. by the visible large and dome shaped scutellum, and by the gradually rounded lateral margin of the protibia having socketed teeth. It is distinguished from other *Pseudoxylechinus* species except *P. indicus* Wood by the strongly concave frons and hair-like ground vestiture, and further from *P. indicus* by the more obtusely rounded lower lateral margin of the impressed frons, by the broader pronotum, and by the broader interstriae.

Description: Length 2.7 mm, 2.1 times longer than wide. Colour dark brown with yellow setae. **Head.** Frons deeply concave between eyes from epistoma to upper level of eyes, upper half of impressed area reticulate with minute granules, shin-

ing below. Vestiture consisting of moderately long coarse setae over impressed area, slightly longer setae along lateral margin, sparse, minute setae above eyes. Eyes three times longer (dorso-ventrally) than wide, separated above by 3 times their width. Antennal club flattened, with one septate suture; funiculus possibly 6-segmented. **Pronotum** 0.8 times as long as wide, constricted on anterior third, anterior margin and notum lightly rugose, reticulate, punctures shallow, confluent; vestiture consisting of dense hair-like setae interspersed by a smaller number of longer and coarser bristles. **Elytra** 1.5 times longer than wide, 2.1 times longer than pronotum, sides subparallel on anterior two-thirds, rounded behind. Base of elytra procurved and elevated by a complete row of crenulations. Striae weakly impressed, punctures small, shallow, separated on average by less than their diameter. Interstriae three times wider than striae, weakly elevated, feebly granulated, punctures obscure. Interstria 10 not elevated, short, reaching beginning of metepisternum. Vestiture consisting of 4–5 irregular interstitial rows of hair-like setae (ground vestiture) and one central row of longer bristles each separated on average by their length. **Sclerolepidia** present along entire margin of metepisternum as small plumose scales; metepisternum with densely placed plumose scales. **Legs**. Procoxae separated by about half the width of one coxa (covered in glue). Precoxal ridges very short, sharp. Protibiae armed by six socketed teeth along the lateral and apical margin, the uppermost teeth half way and the remaining five close to the apical margin, inner uncus distinctly curved caudally. Mesotibiae armed by 4 lateral, socketed teeth. Metatibiae armed by 3 small lateral socketed teeth close to apex.

Comments. The holotype has lost both antennae and only a badly preserved microscope slide of the non-type specimen was available, indicating most likely a 6-segmented funicle. However, the similarity in other characters to the species of *Pseudoxylechinus* Wood and Huang (1986) is striking and the species undoubtedly belongs here. Some authors have noted that *Pseudoxylechinus* may be a synonym of the recently resurrected genus *Longulus* Krivolutskaya, but the two genera remained separate in the absence of sufficient type material (Mandelstam et al., 2007). Most species of *Pseudoxylechinus* are nevertheless distinguished from *Longulus* by having a distinctly impressed lower male frons, particularly so in *P. indicus* and *P. setosus* (see Wood 1986).

The distribution of the genus ranges from Japan in the east, via Yunnan and Tibet to Darjeeling in the west (Wood 1986). Consequently *P. setosus* fits well within this geographical pattern.

Asiophilus Jordal, gen. n.

urn:lsid:zoobank.org:act:936D10AE-DBA2-4ABB-9021-442FB0904F76

Type species: *Phloeoditica phloeosinoides* Browne, 1966, by current designation.

Diagnosis: A typical phloeosinine genus with 5-segmented funicle, flattened club with two oblique sutures and widely separated pro- and mesocoxae. It is readily distin-

guished from *Phloeosinus* by the entire eye and less produced outer apical margin of the protibiae, and by the ascending venter.

Description: Body length 1.5–1.65 mm. Frons convex; eyes entire, distance between eyes 2.7–2.9 their width; funicle 5-segmented, antennal club large and moderately flattened, with two oblique sutures. Pronotum and elytra roughly punctured, with a pair of medial closely set erect setae. Scutellum large, flat, slightly sunken with a small depression in elytra around scutellum; elytral base procurved, raised with a single complete row of crenulations. Metepisternal setae hair-like or bifid. All coxae widely separated; protibiae with 5–6 lateral and apical socketed teeth. Venter ascending to meet elytral apex.

Etymology. From the Greek word *philos* (having affinity for) and Asia, referring to the type localities in Vietnam and Philippines.

Comments. Browne (1966) placed *Phloeoditica phloeosinoides* in *Phloeoditica* with much hesitation and referred to several characters that deviate from *P. curta* and *P. elegans*, e.g. the larger and dorsally visible scutellum, the scant vestiture, and two real sutures in the antennal club. Species of this genus bear some superficial resemblance to the hylesinine genus *Ficicis*, but is readily distinguished by the 5-segmented funicle and the lack of pronotal asperities. **Taxa included:** *A. phloeosinoides* (Browne) and *A. macropunctatus* Jordal, sp. n.

***Asiophilus phloeosinoides* (Browne, 1966), comb. n.**

Figs 2a–c, 4d, 5c

Asiophilus phloeosinoides Browne, 1966: 243.

Type material examined. Holotype: “Philippines, Tawi Tawi, Tarawakan, north of Batu Batu, 21. Oct 1961, Noona Dan Exp. 61–62 / Caught by mercury-light 18.30–00.30”. The holotype is pinned on a minuten-pin.

Diagnosis. Distinguished from *A. macropunctatus* by the more sparsely punctured frons, by the less asperate interstriae, by the scant elytral vestiture, and by the protibiae bearing 5 and not 6 lateral socketed teeth.

Description: Length 1.5 mm, 2.0 times longer than wide. Colour dark reddish-brown. **Head.** Frons weakly convex above to flattened below, transversely impressed just above epistoma; punctures few, small and shallow. Vestiture consisting of 5–6 setae along epistomal margin, and almost invisible fine setae above. Eyes three times longer (dorso-ventrally) than wide, separated above by 2.7 times their width. Antennal club large, moderately flattened and oval, with two regularly spaced oblique sutures, finely pubescent. Funiculus 5-segmented, scapus about 0.8 times as long as the length of funiculus and club combined. **Pronotum** 0.85 times as long as wide, distinctly constricted on anterior third, notum roughly punctured, weakly granulated along anterior-lateral areas, punctures irregularly separated by about half their diameter; vestiture consisting of scant minute setae in punctures and a pair of medially placed longer

erect setae. **Elytra** 1.3 times longer than wide, 1.7 times longer than pronotum, sides subparallel on anterior half, apex rounded. Base of elytra procurved and elevated by a complete row of crenulations. Striae impressed, punctures variably large, deep, subconfluent. Interstriae as wide as striae, slightly elevated, rugose, shining, with punctures about half the size of striae punctures and more widely spaced. Interstriae 10 reaching level of metacoxae. Vestiture consisting of interstitial rows of tiny recumbent setae. **Sclerolepidia** present along entire margin of metepisternum, very small; metepisternum almost glabrous, with scant minute setae. **Legs.** Procoxae separated by width of one coxa. Precoxal ridges short, distinct. Mesocoxae separated by slightly more than the width of procoxa, mesocoxal process vertical. Protibiae armed by 5 socketed teeth along the lateral and apical margin and one lightly curved inner mucro. Mesotibiae armed by 5 lateral, socketed teeth. Metatibiae armed by 4 lateral socketed teeth on apical half.

Comments. This species is only known from the unique type specimen. The type locality Tawi Tawi is a small island just east of Sabah.

Asiophilus macropunctatus Jordal, sp. n.

urn:lsid:zoobank.org:act:C7E42DF9-B578-4296-ABC1-4C0B1E293DA9

Figs 2d–f, 4e, 5d

Type material. Holotype: “Vietnam: Lao Cai, ca. 12km along road from Sapa to Lai Chau, 1950m, 22°20'58"N 103°46'15"E, 1–12.V.1999, B. Hubley, pan traps (yellow), margin of 6m wide stream, edge of bamboo/2° forest”.

Diagnosis. Distinguished from *A. phloeosinoides* by the more coarsely punctured frons and pronotum, by the elytral vestiture consisting of bristle-like interstitial setae, and by the protibiae bearing 6 lateral socketed teeth.

Description: Length 1.65 mm, 2.0 times longer than wide. Colour dark brown or black. **Head.** Frons weakly convex, transversely impressed just above epistoma, punctures large, nearly confluent. Scant minute setae in punctures, about 12 longer setae along the epistomal margin. Eyes three times longer (dorso-ventrally) than wide, separated above by 2.9 times their width. Antennal club large, moderately flattened and oval, with two regularly spaced oblique sutures, finely pubescent. Funiculus 5-segmented, scapus about 0.8 times as long as the length of funiculus and club combined. **Pronotum** 0.8 times as long as wide, distinctly constricted on anterior third, notum roughly and densely punctured, punctures subconfluent; vestiture consisting of scant minute setae in punctures and a pair of median longer erect setae. **Elytra** 1.3 times longer than wide, 1.9 times longer than pronotum, sides subparallel on anterior two-thirds, apex rounded. Base of elytra strongly procurved and elevated by a complete row of crenulations. Striae impressed, punctures large, deep, separated by about one-quarter their diameter. Interstriae as wide as striae, slightly elevated, rugose, shining, with irregularly sized and more widely spaced punctures about half the size of striae punctures. Interstriae 8 and 9 on posterior half more elevated and sharply

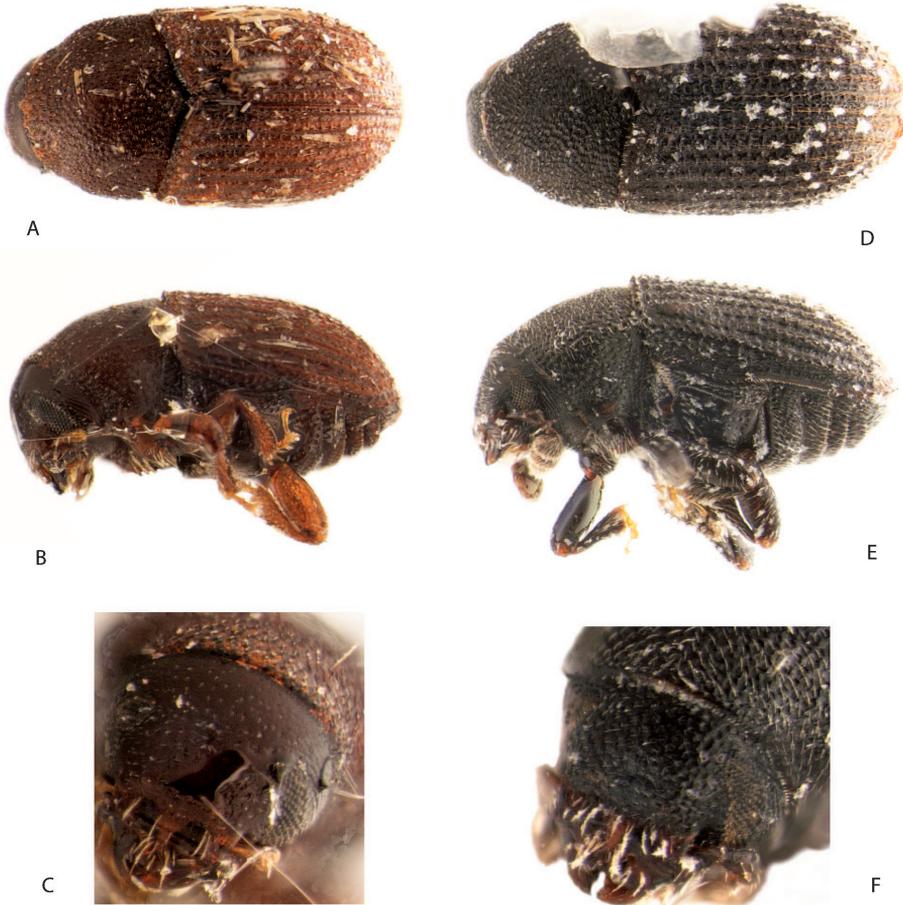


Figure 2. Dorsal, sinistral and front view of *Asiophilus phloeosinoides* (A–C) and *Asiophilus macropunctatus* (D–F).

crenulated; interstriae 10 reaching level of metacoxae. Vestiture on disk consisting of interstitial rows of recumbent hair-like setae separated by less than their length, striae setae minute; on declivity interstitial setae in two confused rows. **Sclerolepidia** present along entire margin of metepisternum, very small; metepisternum with scant bifid setae, densely clothed closer to endosternum. **Legs.** Procoxae separated by width of one coxa. Precoxal ridges short, distinct. Mesocoxae separated by slightly more than the width of procoxa, mesocoxal process vertical. Protibiae armed by 6 socketed teeth along the lateral and apical margin and one lightly curved inner mucro. Mesotibiae armed by 6 lateral, socketed teeth. Metatibiae armed by 5 lateral socketed teeth on apical half.

Comments. Only known by the unique type specimen from high altitude in Northern Vietnam.



Figure 3. Dorsal and sinistral view of *Microditica uniseriatus*.

***Microditica* Jordal, gen. n.**

urn:lsid:zoobank.org:act:284A0489-1042-4083-AB27-3BF7E41B399F

Type species: *Microditica uniseriata* Jordal, sp. n., monotypic.

Diagnosis. Typical phloeosinine genus with a 5-segmented funicle, barely visible scutellum and the broadly separated pro- and mesocoxae. The genus is diagnosed by the unique long and laterally curved inner uncus (mucro) of the protibiae, by the deeply grooved antennal club, and by the short crenulations at the elytral base reaching only to interstriae 5.

Description: Frons convex and nearly glabrous in both sexes; eyes entire; funicle 5-segmented, antennal club large, with deeply grooved sutures. Pronotum smooth and shiny. Scutellum very small, flush with elytra and mainly visible on anterior slope. Elytral base nearly straight, with a single row of crenulations from scutellum to interstriae 5. Metepisternal setae scale-like; sclerolepidia distinct, small. Protibiae with the inner uncus very large and curved laterally, lateral teeth apparently unsocketed. Hind wings with four setae along costal margin at stigmal patch, hind margin from base to tip with long setae. All coxae widely separated, mesosternal process vertical. Postnotum fused to metanotum, scutoscutellar suture parallel to sutural groove for two-third of its length, then curves relatively abruptly laterally. Proventriculus simple, without apical sutural teeth or posterior mastigatory brush. Male aedeagus weakly sclerotised, spiculum gastrale weakly forked and tegmen a simple ring.

Etymology. The Greek name *micro* (small) refers to the small size of a bark boring beetle; *ditica* is a Latinised form of the Greek feminine adjective *dytiké* (that likes to penetrate) (Alonso-Zarazaga and Lyal 2009).

Comments: This genus shares most characteristics with *Phloeoditica* but is readily distinguished by the differently shaped protibia, the incomplete row of crenulations at the base of elytra, by the lack of ground vestiture, by the number and position of setae on the front and hind margin of the hind wings, and by the scutoscutellar suture following the scutellar groove much longer posteriad. The long setae along the hind margin are typical for small sized beetles (Kuschel 2000) and may not be of significant

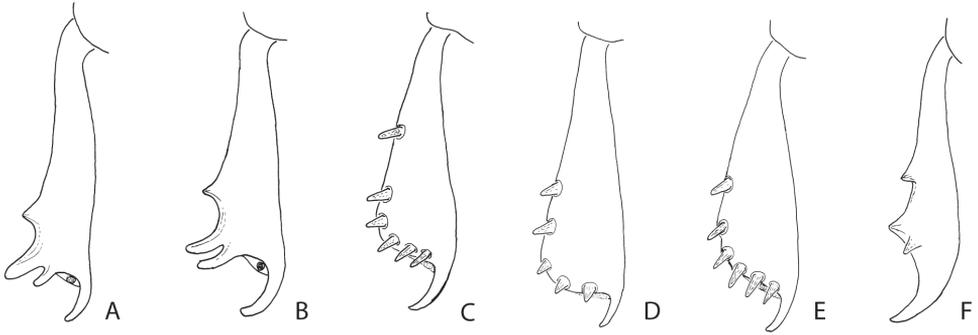


Figure 4. Posterior face of the left protibia of *Phloeoditica curta* (A), *Phloeoditica elegans* (B), *Pseudoxylechinus setosus* (C), *Asiophilus phloeosinoides* (D), *Asiophilus macropunctatus* (E), *Microditica uniseriatus* (F).

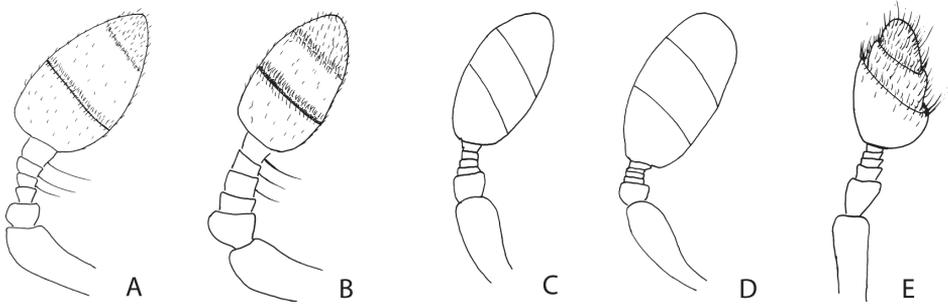


Figure 5. Antennal club and funicle of *Phloeoditica curta* (A), *Phloeoditica elegans* (B), *Asiophilus phloeosinoides* (C), *Asiophilus macropunctatus* (D), *Microditica uniseriatus* (E).

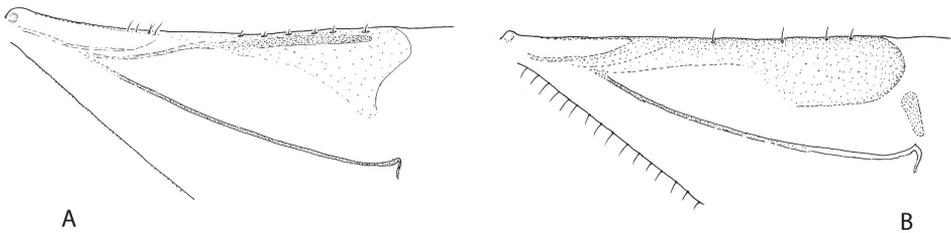


Figure 6. Basal part of hind wings in *Phloeoditica curta* (A) and *Microditica uniseriata* (B).

phylogenetic value. Phylogenetic analyses of combined COI and EF-1 α nucleotide data show that *Microditica* and *Phloeoditica* are quite unrelated and do not necessarily form a monophyletic group (unpublished data). This taxon share a few characters with other tribes such as Phloeotribini (semiarticulated antennal club) and Hypoborini (interrupted row of crenulations at base of elytra), but is readily distinguished from all taxa in those tribes by the broadly separated coxae.

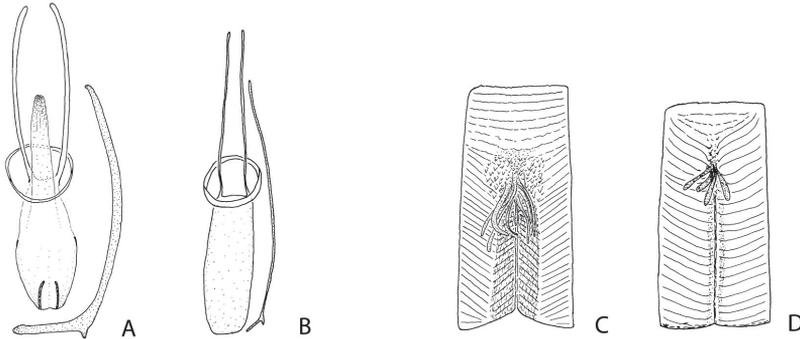


Figure 7. Male genitalia with spiculum gastrale (**A–B**) and proventriculus (**C–D**) in *Phloeoditica curta* (**A, C**) and *Microditica uniseriata* (**B, D**).

***Microditica uniseriata* Jordal, sp. n.**

urn:lsid:zoobank.org:act:F4626599-BD94-43CF-B48C-24B13035E8C3

Figs 3, 4f, 5e, 6b, 7b, d

Type material. Holotype: Thailand, Railay Beach - Krabi, 8.014N 98.840E, 21 Nov. 1999 K. Harketstad, leg. (NHCB). **Paratypes:** Same locality as holotype (8 specimens, NHCB).

Diagnosis. Very small body size; frons convex and shining in both sexes; large club with two deep grooves; protibiae with large inner uncus directed laterad; base of elytra with a single row of crenulations between scutellum and interstriae 5; uniseriate rows of interstitial spatulate bristles. DNA sequences in Genbank: COI, GQ470890; EF1a, GQ470891)

Description. **Length** 0.85–0.95 mm, 2.0–2.1 times longer than wide. Colour light brown. **Head.** Frons convex, shiny, sparsely dotted by small shallow punctures separated by 2–4 times their diameter. Vestiture consisting of sparse minute hair-like setae, a few longer setae close to epistoma. Eyes 2.5 times longer (dorso-ventrally) than wide, separated above by 2.4 times their width. Antennal club large, two segments clearly marked by deep grooves, almost articulated; funiculus 5-segmented; scapus about 0.7 times as long as funiculus and club combined. **Pronotum** 0.95 times as long as wide, broadly rounded anteriorly, constriction on anterior fourth vaguely indicated. Disk smooth, shiny, with small and shallow punctures variably separated by 1–3 times their diameter. Vestiture consisting of scant minute hair-like setae and two median pairs and two anterior pairs of longer setae. **Elytra** 1.2 times longer than wide, 1.6 times longer than pronotum. Sides subparallel on anterior half, apex rounded. Base of elytra straight, with a single row of raised crenulations between scutellum and interstriae 5. Striae lightly impressed, punctures large, deep, separated by half their diameter. Interstriae smooth, punctures obscure, with a single row of small granules mainly on declivity and associated with the base of setae. Interstriae 10 not elevated, reaching level of metacoxae. Vestiture consisting of interstitial rows of erect spatulate

bristles, each separated on average by their length. **Sclerolepidia** present along entire metepisternal suture, sparse metepisternal scale-like setae. **Legs.** Procoxae separated by width of 1 coxa; precoxal ridges very short but distinct. Mesocoxae 1.2 times wider than one procoxa; mesocoxal process vertical. Metacoxae broadly separated. Protibiae with two lateral unsocketed teeth, a third tooth just mesal to the second tooth, then gently curved to meet a large and laterally curved inner uncus. Mesotibiae and metatibiae each armed by 4 lateral socketed teeth. **Proventriculus** simple, apical plate short, about one-quarter of total length, with 3–4 transverse blunt ridges or rugae; femoral teeth weakly developed at base of 4–5 closing teeth. Mastigatory brushes not developed. **Aedeagus** weakly sclerotised, about 6–7 times longer than wide, apophyses very thin, longer than aedeagal body; tegmen a simple ring. Spiculum gastrale slightly shorter than aedeagus, weakly forked in the caudal end.

Etymology. The specific epithet *uniseriata* refers to the uniseriate rows of interstitial bristles.

Comments. *M. uniseriata* has been collected only from the type locality and was taken from the bark of an unknown dead shrub together with *Hypothenemus birmanus* (Eichhoff).

Key to the genera of Phloeosinini of the World

1. Eye entire..... **2**
- Eye emarginate or divided..... **10**
2. Protibiae slender, armed by three apparently unsocketed teeth (denticles largely embedded in cuticle), inner uncus very large and long, curved towards outer margin (Figs 4a–b, f) **3**
- Protibiae broader, armed by at least four lateral socketed teeth of equal size, inner uncus/mucro shorter, directed caudally or nearly straight (Figs 4c–e)..... **4**
3. Protibiae armed on outer apical angle by two closely set projecting teeth and a smaller tooth on lateral margin (figs 4a–b); crenulations at elytral bases reaching humeral angles; interstitial ground vestiture consisting of hair-like setae or scales (Figs 1a) ***Phloeoditica***
- Protibia armed by two lateral teeth of equal size, and one mesal smaller tooth (Fig 4f); crenulations at elytral bases reaching interstriae 5; ground vestiture absent (Fig 3)..... ***Microditica***
4. Funicle 5-segmented **5**
- Funicle 6- or 7-segmented **7**
5. Antennal club symmetrical (Figs 5c–d); crenulations at elytral base a single row (Fig. 2)..... ***Asiophilus***
- Antennal club strongly asymmetrical; additional elytral crenulations close to scutellum **6**
6. Antennal club without sutures ***Chramesus***
- Antennal club with two strongly procurved sutures ***Pseudochramesus***

7.	Funicle 7-segmented	8
–	Funicle 6-segmented	9
8.	Scutellum visible; base of elytra strongly procurved; procoxa broadly separated	<i>Dendrosinus</i>
–	Scutellum not visible, base of elytra weakly procurved, procoxae contiguous	<i>Hyleops</i>
9.	Body slender, about 2.1 times longer than wide; antennal club symmetrical.....	<i>Carphotoreus</i>
–	Body stout, about 1.6 times longer than wide; club strongly asymmetrical ...	<i>Catenophorus</i>
10.	Procoxa contiguous; antennal club subglobular; funicle 5- or 6-segmented...	<i>Cladoctonus</i>
–	Procoxa separated; antennal club elongated; funicle 5-segmented	11
11.	Interstriae 10 extended to level of ventrite 3; humeral angles of elytra extended anteriorly, with largest crenulations	<i>Phloeocranus</i>
–	Interstriae 10 reaching level of metacoxae; elytral bases moderately procurved, with a single row of equally sized crenulations	12
12.	Pronotum finely asperate; antennal club with transverse sutures; eyes broadly emarginate	<i>Phloeosinopsoides</i>
–	Pronotum smooth; club with oblique sutures; eyes deeply emarginated or divided.....	13
13.	Eyes divided or nearly so; tarsal segment 3 slender	<i>Hyledius</i>
–	Eyes deeply emarginated; tarsal segment 3 broad and emarginate.....	<i>Phloeosinus</i>

Acknowledgments

R. Beaver suggested that *Microditica* is a member of Phloeosinini, close to *Phloeoditica*. I would furthermore like to thank the curators H. Schönmann, F. Genier, A. Solodovnikov and B. Viklund for preparing the loan of type material for this study. Finally, I would like to thank M. Knížek for providing pictures of a *Pseudoxylechinus setosus* specimen in NHMW.

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Taxonomic notes on the afrotropical genera *Hapalogenius* Hagedorn, *Hylesinopsis* Eggers, and *Rhopalopselion* Hagedorn (Coleoptera, Curculionidae, Scolytinae)

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Abstract

Taxonomic confusion among the afrotropical scolytine genera *Hapalogenius* Hagedorn, *Hylesinopsis* Eggers and *Rhopalopselion* Hagedorn, and their synonyms is discussed with especial reference to the catalogues of Wood and Bright (1992), and Alonso-Zarazaga and Lyal (2009). A key is given to separate the three genera recognised, and the species considered to be included in each genus are listed. *Hylesinopsis* is resurrected from synonymy with *Hapalogenius*, and shown not to be closely related to it. *Chilodendron* Schedl is considered to be a synonym of *Hylesinopsis* and not of *Xylechinus* Chapuis. The following new synonymy is proposed at specific level: *Hapalogenius africanus* (Eggers) (= *Hapalogenius lesnei* Eggers, = *Metahylesinus brincki* Schedl); *Hapalogenius fuscipennis* (Chapuis) (= *Hapalogenius bimaculatus* Eggers); *Hapalogenius oblongus* (Eggers) (= *Metahylesinus striatus* Schedl); *Hylesinopsis fasciata* (Hagedorn) (= *Kissophagus punctatus* Eggers); *Phrixosoma niger* Eggers (= *Hapalogenius niger* Schedl). The following species are returned to *Hylesinopsis* from *Hapalogenius* to which they were transferred by Alonso-Zarazaga and Lyal (2009): *Hylesinopsis alluaudi* (Lepesme), *H. angolensis* (Schedl), *H. arabiae* (Schedl), *H. atra* (Nunberg), *H. confusa* (Eggers), *H. decellei* (Nunberg), *H. dubia* Eggers, *H. emarginata* (Nunberg), *H. fasciata* (Hagedorn), *H. ficus* (Schedl), *H. granulata* (Lepesme), *H. hirsuta* (Schedl), *H. joveri* (Schedl), *H. pauliani* (Lepesme), *H. punctata* (Eggers), *H. saudiarabiae* (Schedl). The following new combination is given: *Hylesinopsis leprosula* (Browne) from *Cryphalus* Erichson. New distributional records are given for some species.

Keywords

Afrotropical region, Curculionidae, *Hapalogenius*, *Hylesinopsis*, *Rhopalopselion*, Scolytinae, new synonymy, new combination

Introduction

There has been considerable confusion in the literature about the relationships and limits of the scolytine genera *Hapalogenius* Hagedorn, *Hylesinopsis* Eggers, *Rhopalopselion* Hagedorn, and some other scolytine nominal genera from the Afrotropical region. In this paper, I attempt to resolve some of this confusion, and give some resultant taxonomic changes. The conclusions are based on the study of type material and other specimens from the following institutions: Deutsches Entomologisches Institut, Müncheberg (DEI), Hungarian Natural History Museum, Budapest (NHMB), Musée Royale de l'Afrique Centrale, Tervuren (MRAC), Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw (MIZW), Museum für Naturkunde der Humboldt Universität, Berlin (MNB), National Collection of Insects, Pretoria (NCIP), Natural History Museum, London (NHML), Naturhistorisches Museum, Wien (NMW), Transvaal Museum, Pretoria (TMP), Zoological Museum of Lund University (ZMLU), supplemented by specimens sent for identification by B. Jordal (University of Bergen, Norway), and in my own collection (RAB).

The genus *Rhopalopselion* was described by Hagedorn (1909) with *R. bituberculatum* Hagedorn the only included species. The genus *Hapalogenius* was described by Hagedorn (1912) with *H. globosus* the only included species. The genus *Hylesinopsis* was described by Eggers (1920b) with *H. dubius* the only included species. Schedl (1951) considered that *Rhopalopselion* and *Hapalogenius* (together with a third genus, *Pseudophloeotribus* Eggers) were synonymous, an opinion that he later retracted (Schedl 1963a). In fact, Schedl (1963a) placed *Rhopalopselion*, *Hapalogenius* and *Hylesinopsis* in three different tribes, Strombophorini, Hypoborini and Phloeosini [*sic*] respectively, within his subfamily Hylesinae [*sic*]. Wood (1978, 1986) continued to consider *Hapalogenius* as a synonym of *Rhopalopselion*, and included it and *Hylesinopsis* in the tribe Hylesinini. Between 1983 and 1988, Wood synonymised with *Hylesinopsis* the following genera: *Trypographus* Schedl, *Chilodendron* Schedl (Wood 1983); *Metahylesinus* Eggers (a replacement name for *Pseudohylesinus* Eggers nec Swaine), *Hapalophloeus* Schedl, *Hemihylesinus* Schedl (Wood 1984); *Glochicopterus* Schedl, a genus synonymised with *Metahylesinus* by Wood (1983); and *Aridiamerus* Schedl (Wood 1988a,b). In addition, Schedl (1957a) had already synonymised *Pseudophloeotribus* Eggers with *Metahylesinus*, a synonymy accepted by Wood (1986). Wood and Bright (1992) in their catalogue of Scolytidae maintain this position, and give further references to the genera and species mentioned.

Recently, Alonso-Zarazaga and Lyal (2009) recognised that Wood and Bright (1992) had placed the type species of *Hapalogenius* in synonymy with *Hylesinopsis fuscipennis*

(Chapuis), and consequently reinstated *Hapalogenius* as the valid name for the genus *Hylesinopsis*. This resulted in a large number (38) of recombinations of species transferred from *Hapalogenius* to *Hylesinopsis*. Alonso-Zarazaga and Lyal (2009) retain *Rhopalopselion* as a valid genus, with the same twenty-four species included by Wood and Bright (1992).

Wood (1986) has suggested that *Hylesinopsis sensu* Wood and *Rhopalopselion sensu* Wood are rapidly evolving genera, and that they could either be amalgamated into a single, large genus, or split up into a number of small genera. I believe that the most satisfactory solution at present is to distinguish three genera, based on morphological and biological criteria: *Rhopalopselion*, *Hapalogenius* and *Hylesinopsis*. The first two of these genera are closely related, the third, *Hylesinopsis*, is quite distinct from them. Figures 1–3 illustrate a representative species of each genus. The three genera may be distinguished using the following key, which also serves to diagnose the genera:

1. Antennal funicle 7-segmented, club rounded to ovate with several annuli of closely-placed hairs. Pronotum almost quadrate, without a subapical constriction, the anterior angles prominently spinulose with strong asperities. Scutellum rather large, quadrate. Fifth abdominal ventrite with a median, approximately triangular process. Protibia with closely placed socketed teeth, and a well-developed tarsal groove on the anterior side. Large or moderately sized, stoutly-built, black species, 2.5 mm or more long. Xylophagous.....
.....***Rhopalopselion* Hagedorn**
- Antennal funicle 6- or 7-segmented, club sometimes more elongate, with or without more rows of setae than segments. Pronotum trapezoidal, narrowed anteriorly, usually with a subapical constriction, the anterior angles less prominently or not spinulose, the asperities often weakly developed. Scutellum small or not visible. Fifth abdominal ventrite without a median process. Protibia with or without socketed teeth; tarsal groove strongly or weakly developed. Smaller, less robust, usually brown or ferruginous species, usually less than 2.5 mm long. Phloeophagous, except *Hapalogenius horridus* (Eggers), which is reportedly xylophagous..... **2**
2. Antennal club oblong-oval or egg-shaped, apex rounded, sometimes septate, usually with 4–7 annuli of closely placed hairs not corresponding to the sutures. Funicle 6- or 7-segmented, at least the last 1–2 segments much more strongly transverse than the more basal segments, symmetrically inserted into club. Eye usually shallowly emarginate. Costate ridge extends from procoxa to anteroventral margin of pronotum. Apical half of protibia widened, with convex outer margin rounded to apex and bearing 5–9 small, closely placed socketed teeth. Anterior face of protibia with well-developed, glabrous tarsal groove, anterior tarsi retractile into groove ***Hapalogenius* Hagedorn**
- Antennal club elongate, apex somewhat pointed, basal suture usually partly or completely septate, with no more than 3 rows of setae on outer face. Funicle always 6-segmented, the apical segments not strongly transverse, usually only slightly wider than more basal segments, more or less asymmetrically inserted

into club. Eye entire. Costate ridge between procoxa and anteroventral margin of pronotum absent. Outer margin of protibia not convexly rounded in apical half, without a series of small socketed teeth, extended apically into a backwardly-pointing spine, at most 3 smaller spines basal to it on the outer margin, apical margin truncate, with 1–3 similar spines. Anterior face of protibia with a very short tarsal groove, tarsi not retractile
*Hylesinopsis* Eggers

Systematics

Hapalogenius Hagedorn

Fig. 1

Hapalogenius Hagedorn, 1912: 352. (Type species: *Hapalogenius globosus* Hagedorn, monobasic).

Pseudohylesinus Eggers, 1920a: 234. (Type species: *Pseudohylesinus togonus* Eggers, monobasic, preoccupied by Swaine 1917: 11).

Metahylesinus Eggers, 1922: 165. (Type species: *Pseudohylesinus togonus* Eggers, automatic, replacement name for *Pseudohylesinus* Eggers nec Swaine).

Pseudophloeotribus Eggers, 1933: 18. (Type species: *Pseudophloeotribus africanus* Eggers, original designation). (The subsequent designation by Schedl 1960: 75 was unnecessary.).

Glochicopterus Schedl, 1954: 75. (Type species: *Glochicopterus baphiae* Schedl, monobasic).

Hapalophloeus Schedl, 1966: 363. (Type species: *Metahylesinus brincki* Schedl, original designation).

Hemihylesinus Schedl, 1967: 224. (Type species: *Hemihylesinus endroedyi* Schedl, monobasic).

Aridiamerus Schedl, 1982: 284. (Type species: *Aridiamerus angolensis* Schedl, monobasic). (*Hylesinopsis angolana* Wood 1988a: 32 is an unnecessary replacement name.)

Eggers (1927), having compared the types of *Phloeotribus fuscipennis* (Chapuis, 1869) and *Hapalogenius globosus*, concluded that the species were identical. Chapuis' name had priority, but the species did not belong in *Phloeotribus* and was transferred to *Hapalogenius*. This conclusion was accepted by Schedl (1963a). Wood and Bright (1992: 94) placed *P. fuscipennis* and its synonym *H. globosus* in *Hylesinopsis*, overlooking the fact that *Hapalogenius* has priority, but they also (Wood and Bright 1992: 96) cited *Hapalogenius*, with its type species, *H. globosus*, as a synonym of *Rhopalopselion*. As noted above, Alonso-Zarazaga and Lyal (2009) reinstated *Hapalogenius* as the correct name for the species treated by Wood and Bright (1992) under *Hylesinopsis*. I consider that *Hapalogenius* is a valid genus, but that it is distinguished from *Rhopalopselion* and *Hylesinopsis* by the characters given in the key above, and with the synonymy given. I have examined the type species of all the genera involved. In addition to the type species listed above, the following 30 nominal species



Figure 1. *Hapalogenius oblongus* (Eggers), dorsal, **A** and lateral, **B**.

can be assigned to the genus: *Hapalogenius acaciae* Schedl*, *H. congonus* Schedl, *H. immaturus* Schedl*, *H. lesnei* Eggers, *H. lonchocarpae* Schedl*, *H. maculatus* Schedl*, *H. occidentalis* Schedl*, *H. primus* Schedl, *H. rufus* Schedl*, *H. senegambiensis* Schedl, *H. subseriatus* Schedl*, *H. suturalis* Schedl*, *Hylesinopsis kenyae* Wood, *H. ugandae* Wood*, *Hylesinus horridus* Eggers, *H. pusillus* Gerstaecker, *Metahylesinus brincki* Schedl*, *M. dimorphus* Schedl, *M. hispidus* Eggers, *M. orientalis* Eggers*, *M. quadrituberculatus* Schedl, *M. striatus* Schedl*, *M. sulcatus* Eggers*, *Pseudophloeotribus africanus* Eggers*, *P. oblongus* Eggers*, *P. rhodesianus* Eggers*, *P. seriatus* Eggers, *P. squamosus* Eggers*, *P. variegatus* Eggers*, *Rhopalopselion atakorae* Schedl* (* - type(s) examined). The genus clearly belongs in the tribe Hylesinini *sensu* Wood (1986a), but this tribe seems likely to be paraphyletic (e.g. Farrell et al. 2001, Jordal et al. 2008, McKenna et al. 2009), and may need to be redefined.

New synonymy in *Hapalogenius*

***Hapalogenius africanus* (Eggers)**

Pseudophloeotribus africanus Eggers 1933:19.

Rhopalopselion africanus (Eggers): Schedl 1951: 1104.

Metahylesinus africanus (Eggers): Schedl 1960: 76.

- Hylesinopsis africanus* (Eggers): Wood 1986: 39.
Hapalogenius africanus (Eggers): Alonso-Zarazaga & Lyal 2009: 69.
Hapalogenius lesnei Eggers 1943: 73, **syn. n.**
Rhopalopselion lesnei (Eggers): Wood & Bright 1992: 97.
Metahylesinus brincki Schedl 1957b: 323, **syn. n.**
Glochicopterus brincki (Schedl): Schedl 1963b: 262.
Hapalophloeus brincki (Schedl): Schedl 1966: 363.
Hylesinopsis brincki (Schedl): Wood 1984: 225; Wood & Bright 1992: 93.

I have examined the female holotype of *Pseudophloeotribus africanus* (NHML) from Zambia, and other specimens from Zimbabwe (NHML), and compared them with syntypes of *Hapalogenius lesnei* (NMW), and with specimens of *M. brincki* from Namibia which had earlier been compared with syntypes of this species in ZMLU. I have also examined specimens from Angola, Botswana, Namibia, and South Africa (NICP, TMP, RAB). Only a single species is represented, which varies in length from 1.5–2.2 mm, and in size-related characters, such as the number of teeth (6 or 8) on the anterior margin of the pronotum, and the detailed arrangement of the setae on the elytra.

It may be noted that Eggers (1933) described the genus *Pseudophloeotribus* as having seven funicular segments. The genus *Hapalophloeus* was separated from *Metahylesinus* because its type species (*M. brincki*) had only six funicular segments (Schedl 1966). I can confirm that the latter figure is correct. A seventh segment appears to have become fused to the base of the antennal club. The number of funicular segments is normally constant within a species in the Hylesinini.

H. africanus is quite widely distributed in southern Africa. In addition to the distribution given by Wood and Bright (1992), it is known from Angola, Botswana and Mozambique. However, no host plants have been recorded. Specimen labels indicate that the species has been collected mostly at light.

***Hapalogenius fuscipennis* (Chapuis)**

- Phloeotribus fuscipennis* Chapuis 1869: 44.
Hapalogenius fuscipennis (Chapuis): Eggers 1927: 196.
Hylesinopsis fuscipennis (Chapuis): Wood & Bright 1992: 94.
Hapalogenius globosus Hagedorn 1912: 352; Eggers 1927: 196 (Synonymy).
Hapalogenius bimaculatus Eggers 1933: 22, **syn. n.**

Eggers (1933) distinguished his new species *H. bimaculatus* from *H. fuscipennis* by the presence of two flecks of dark setae on the posterior third of the elytra among the pale setae of the remainder of the elytra. I have compared the holotype of *H. bimaculatus* (NHML) with a series of specimens of *H. fuscipennis* from South Africa (NICP, TMP). The series includes specimens in which the elytral setae are wholly pale, intermediates

resembling *H. bimaculatus*, and specimens in which the setae are almost entirely dark. In the absence of any other distinguishing characters, I conclude that *H. bimaculatus* is a synonym of *H. fuscipennis*. The shape of the median row of setae on the elytral interstriae varies from almost circular to somewhat elongate and truncate in different individuals. The species is known only from South Africa and Mozambique. Wood and Bright (1992) give Zimbabwe, but this appears to be in error for Mozambique. The only hosts recorded are *Millettia grandis* ('Umzimbiti' of Hagedorn 1912) (Leguminosae), and an unidentified tree 'sandalo'. Hagedorn (1912) briefly described and illustrated the gallery system under bark.

***Hapalogenius oblongus* (Eggers)**

Pseudophloeotribus oblongus Eggers 1935: 299.

Metahylesinus oblongus (Eggers): Schedl 1960: 80.

Hylesinopsis oblongus (Eggers): Wood and Bright 1992: 95.

Hapalogenius oblongus (Eggers): Alonso-Zarazaga and Lyal 2009: 69.

Metahylesinus striatus Schedl 1957: 865, **syn. n.**

The holotypes of both *oblongus* and *striatus* are in NHML. They have been directly compared, and I consider that they represent a single species, with minor variation in the density of the vestiture. I have also examined a series collected by Dr. B. Valentine in Kenya, and compared them with the holotype of *H. oblongus*. The species is recorded from Kenya, Uganda and Tanzania, and from the host tree genera: *Acacia* (Leguminosae), *Croton* (Euphorbiaceae) and *Eucalyptus* (Myrtaceae). This suggests that it is a polyphagous species.

***Phrixosoma nigra* (Eggers)**

Bothryperus niger Eggers 1933: 21

Phrixosoma nigra (Eggers): Wood & Bright, 1992: 190

Hapalogenius niger Schedl 1952: 7, **syn. n.**

Metahylesinus niger (Schedl): Schedl, 1960: 79

I have examined the holotype of *Phrixosoma nigra* (NHML), and the two syntypes of *Hapalogenius niger* and a further specimen standing under this name in the Schedl collection (NMW). Both species were described from Uganda, from the same host species (*Harungana madagascariensis* (Clusiaceae)), and are clearly synonymous. Schedl (1952) appears not to have noticed that the eyes of his species are bipartite, and that the antennal club is asymmetrical with a partly septate first segment – characteristics of *Phrixosoma* and not of *Hapalogenius*. Schedl (1963a) briefly describes the biology of the species, and illustrates the gallery system (as *Bothryperus niger*).



Figure 2. *Hylesinopsis dubius* Eggers, dorsal, **A** and lateral, **B**.

***Hylesinopsis* Eggers, stat. res.**

Fig. 2

Hylesinopsis Eggers, 1920b: 40. (Type species: *Hylesinopsis dubia* Eggers, monobasic).
Trypographus Schedl, 1950: 213. (Type species: *Trypographus joveri* Schedl, monobasic).
Chilodendron Schedl, 1953: 74. (Type species: *Chilodendron planicolle* Schedl, monobasic).

These genera share the type of eye, antenna and protibia given in the key above. *Trypographus* and *Chilodendron* were synonymised with *Hylesinopsis* by Wood (1983). Wood and Bright (1992: 92) give *Chilodendron* as a synonym of *Hylesinopsis*, but its type species, *C. planicolle*, is also listed on page 118 under the genus *Xylechinus* Chapuis, with a note that the transfer of the species was to be published by Wood in a paper in press in 1992. However, this paper was apparently never published. Alonso-Zarazaga and Lyal (2009), apparently basing their decision on the notes in Wood and Bright (1992), synonymise *Chilodendron* with *Xylechinus*. I have examined a syntype of *C. planicolle* (NMW), and find that the synonymy given by Alonso-Zarazaga and Lyal (2009) appears to be excluded by the 6-segmented funicle (always 5-segmented in *Xylechinus*), entire eye (always emarginate in *Xylechinus*),

fore tibia without socketed teeth, and plumose metepisternal setae (scalelike in *Xylechinus*), even though the pronotum lacks asperities (as in some *Xylechinus*) (Wood 1982, 1986). Until further detailed studies are made of the species here included in *Hylesinopsis*, I prefer to leave *Chilodendron*, and its single included species, as a synonym of that genus.

The lack of close relationship of this genus to *Hapalogenius*, based on morphology, seems to be corroborated by some analyses based on molecular data. In the phylogenetic tree of Farrell et al. (2001: Fig. 6), the single species of *Hylesinopsis* studied (*H. dubia*) is widely separated from the two species of *Hapalogenius* included (*H. oblonga*, *H. seriata*) (both labelled as *Hylesinopsis* sp. in Farrell et al. 2001). In the phylogenetic tree of McKenna et al. (2009: Fig.2), the same species of *Hylesinopsis* (*H. dubia*) (McKenna, pers. comm. 2009) is widely separated from the two genera (*Alniphagus*, *Hylesinus*) currently included in the tribe Hylesinini. In both cases, *Hylesinopsis* seems to be more closely related to genera included in the subfamily Scolytinae *sensu* Wood by Wood (1986) and Wood and Bright (1992). One phylogenetic tree (Jordal et al. 2008, Fig. 4) suggests a closer relationship between *Hylesinopsis dubia*, *Hapalogenius seriata*, and *Hylesinus varius* (F.), but in other analyses the relationship between these species is unresolved (Jordal et al. 2008). The tribal classification of the Scolytinae *sensu* Alonso-Zarazaga and Lyal needs revision (e.g. Jordal et al. 2008, Alonso-Zarazaga and Lyal 2009), and no attempt to place *Hylesinopsis* in an existing tribe is made here.

In addition to the type species, *H. dubia*, and the type species of *Trypographus* (*T. joveri*), the following nominal species must be removed from *Hapalogenius* to which they were transferred by Alonso-Zarazaga and Lyal (2009) and returned to *Hylesinopsis* in which they are listed by Wood and Bright (1992): *Chilodendron saudiarabiae* Schedl, *Hylesinopsis angolensis* Schedl, *H. arabiae* Schedl, *Kissophagus alluaudi* Lepesme, *K. confusus* Eggers*, *K. fasciatus* Hagedorn*, *K. ficus* Schedl*, *K. granulatus* Lepesme, *K. pauliani* Lepesme, *K. punctatus* Eggers, *Trypographus ater* Nunberg, *T. decellei* Nunberg, *T. emarginatus* Nunberg, *T. hirsutus* Schedl*. (* - type(s) examined). In addition, the following species belongs to the genus: *Cryphalus leprosululus* Browne* (see below). References to all these species can be found in Wood and Bright (1992).

The species are normally associated with trees of the family Moraceae (*Ficus*, *Morus*, *Bosqueia*, *Treculia*). There are only three records from other families, one each from Anacardiaceae, Meliaceae and Rosaceae. This narrow host range contrasts with the wide host range of *Hapalogenius* and *Rhopalopselion*.

On the basis of the limited distributional data available, nearly 50% (8 ex 17) of the species appear to be confined to montane habitats above 1500m. This includes the following species: *alluaudi*, *confusa*, *emarginata*, *fasciata*, *granulata*, *pauliani*, *punctata*, *saudiarabiae*. Eight species appear to be more lowland species: *angolensis*, *arabiae*, *atra*, *decellei*, *dubia*, *ficus*, *joveri*, *leprosulula*. *H. planicolle* was described from Mt. d'Ambre in Madagascar, but no altitude is given.

Taxonomic changes in *Hylesinopsis*

Hylesinopsis fasciata (Hagedorn)

Kissophagus fasciatus Hagedorn, 1909: 737

Hylesinopsis fasciatus (Hagedorn): Wood & Bright 1992: 94.

Chilodendron fasciatus (Hagedorn): Schedl 1963b: 261

Kissophagus punctatus Eggers, 1932: 28, **syn. n.**

I have compared two specimens of *K. punctatus* (NMW), which had been compared with the damaged holotype by Eggers and Schedl respectively, with a series of specimens of *H. fasciata* in my own collection from Tanzania and Nigeria. The latter had earlier been compared to a syntype of that species, and other specimens from East Africa in NHML. Eggers (1932) distinguished the two species by the more elongate shape, stronger shine, more distinct puncturation, and the presence of granules on the basal part of the elytra. Comparisons suggest that *K. punctatus* lies at one end of the range of variation found in *H. fasciata*. The small differences noted by Eggers (1932) are insufficient to separate *K. punctatus* as a separate species, and the latter is, therefore, placed in synonymy. Wood and Bright (1992) cite a holotype for *H. fasciata*. However, Hagedorn described the species from “compluria specimina”, indicating that he had a series of syntypes before him.

Hylesinopsis leprosula (Browne), **comb. n.**

Cryphalus leprosulus Browne 1980: 774.

I have examined the holotype (MRAC), and twenty-one paratypes (MRAC, NHML). It is not clear why Browne (1980) assigned this species to the genus *Cryphalus* Erichson. Such an assignment within the tribe Cryphalini is ruled out by the six-segmented funicle, the elongate eyes, the lack of a visible scutellum, the raised and crenulate basal margin of the elytra, and other characters. The species is here removed from *Cryphalus* and transferred to *Hylesinopsis*.

Rhopalopselion Hagedorn

Fig. 3

When the species described in *Hapalogenius* are omitted, the remaining eleven species included in *Rhopalopselion* in Wood and Bright (1992) form a cluster of closely related species distinguished by the quadrate pronotum with strong asperities at the antero-lateral corners, and the large quadrate scutellum. The apical visible sternite

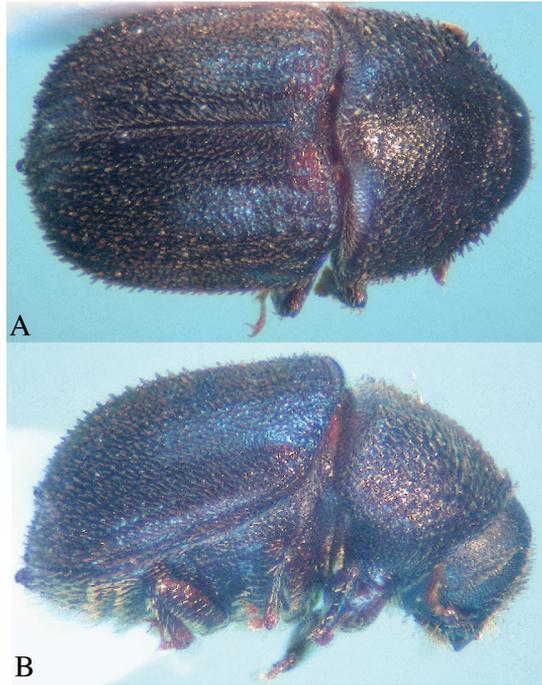


Figure 3. *Rhopalopselion thompsoni* Schedl, dorsal, **A** and lateral, **B**.

has a triangular, median projection. The beetles are strongly built, black in colour, and 2.5–4.5 mm long. All those with known habits are xylophagous (Schedl 1960, Browne 1963). Like *Hapalogenius*, the genus belongs in the tribe Hylesinini *sensu* Wood (1986a)

In addition to the type species, *Rhopalopselion bituberculatum* Hagedorn*, I consider the following species to belong in the genus: *R. atrum* Eggers, *R. confusum* Eggers, *R. conjungens* Schedl*, *R. dentatum* Nunberg*, *R. grande* Schedl, *R. immune* Eggers*, *R. intermedium* Schedl, *R. nitidum* Schedl, *R. orientale* Schedl*, *R. thompsoni* Schedl*. (* - type(s) examined). The remaining species listed under the genus by Wood & Bright (1992) belong in the genus *Hapalogenius* (see above) in which almost all were originally described. It may be noted here that the holotype of *R. bituberculatum* is in DEI and not MNB as stated by Wood and Bright (1992).

New records of *Hapalogenius* and *Hylesinopsis*

The following new records extend the known geographical distribution of the species.

Hapalogenius atakorae (Schedl). GHANA: Northern Reg., Nakpanduri escarp., 10°38'N, 0°12'W, 19.vi.1971, under tree bark (*Endrödy-Younga*) (37exx.) (TMP, RAB).

Hapalogenius pusillus (Gerstaecker). SOUTH AFRICA, West Cape, Knysna, Gouna, 6.xi.2006, ex *Virgilia oroboides* (*B.Jordal*) (4exx.) (RAB) (Further specimens in B.Jordal's collection).

Hapalogenius sulcatus (Eggers). NAMIBIA: East Caprivi, Katima, Mulilo, 17°29'S, 24°17'E, 3–8.iii.1992 (*M.Uhlig*) (1 ex.); Kavango, Kaudom Camp, 18°21'S, 20°43'E, 22–25.ii.1992, lux (*M.Uhlig*) (1 ex.); Kavango, Mahango Game Res., 20.i.1993 (*F.Koch*) (ZMB); SOUTH AFRICA: E.Transvaal, Berlin, 300m below, 25°33'S, 30°43'E, 4.ii.1987, UV light (E-Y:2416) (1 ex.); N.Transvaal, Entabeni – L.Trich., c.23°05'S, 30°12'E, airplankton (E-Y:1138) (1 ex.); Tvl., Nelshoogte, gallery for. below St., 25°51'S, 30°53'E, 4.xii.1987, UV light (E-Y:2354) (1ex.); Tvl., Nelspruit Nat.Res., dry valley, 25°29'S. 30°55'E, 8.ii.1987, UV light, top valley (E-Y:2432) (4 exx.) (all coll. *Endrödy-Younga*) (TMP, RAB); ZIMBABWE: Chipinga, 1.ii.1990 (*C.R.Owen*) (1 ex.) (TMP); Kyle Recr. Park at Lake Mutirikwi, 20°13'S, 31°00'E, 1–5.xii.1993, lux (*M.Uhlig*) (1 ex.) (ZMB).

Hylesinopsis dubia Eggers. GUINEA: Sereidou, 4.iv.1975, lux (*Zott*) (1 ex.) (ZMB).

Hylesinopsis fasciata (Hagedorn). SOUTH AFRICA : S.Natal, Weza, Bangeni Forest, 30°38'S, 29°39'E, 21.xi.1989, beating in forest (*Endrödy & Klimaszew*) (E-Y:2708) (1 ex.); as previous except: 30°32'S, 29°41'E, 23.xi.1989 (E-Y: 2716) (1 ex.) (TMP).

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Scolytus stephensi sp. n. - a new species of bark-beetle (Coleoptera, Curculionidae, Scolytinae) from Northern India with a key to Indian *Scolytus* Geoffroy, 1762 species

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Abstract

A new species of bark-beetle from Kashmir, *Scolytus stephensi* sp. n., dedicated to the late Professor Emeritus Stephen Lane Wood, is described and figured. Key to Indian *Scolytus* Geoffroy, 1762 species is provided.

Keywords

Scolytus, Scolytinae, Curculionidae, new species, India, Stephen Lane Wood

Introduction

In the recently published monograph by Maiti and Saha (2009) only three species from the genus *Scolytus*, namely *S. major* Stebbing, 1903, *S. kashmirensis* Schedl, 1957 and *S. chelogaster* Schedl, 1957 are mentioned as occurring in India. Schedl's paper about Indian bark and timber beetles (1957) also lists *S. nitidus* Schedl, 1936,

S. scolytus (Fabricius, 1775) from India and *S. rugulosus* (Müller, 1818) var. *baluchistani*, n.var. and *S. amygdali* Guérin, 1847 as Scolytines native to the Indian subcontinent. As we have demonstrated, *S. scolytus* was wrongly recorded from India and in fact the records of this species refer to the newly described species *S. stepheni* sp. n. Although *S. rugulosus* and *S. amygdali* were recorded from Pakistan, we found it desirable to include these species into the key to the Indian *Scolytus* species provided below.

The two specimens considered in the current paper were labeled by K. Schedl and cited by him (Schedl 1957) as *Scolytus scolytus* (Fabricius, 1775), despite clearly different frontal vestiture, and abdominal armature in the male. The species was mentioned by Beeson (1941) as *Scolytus himal-ulmi* but without any description (Schedl 1957). We have considered the status of the new species with Carolus Holzschuh who first labeled the species as new, and he agreed that the present authors should describe the new species. *S. scolytus* should be excluded from the Indian Scolytinae fauna.

Systematics

Scolytus stepheni sp. n.

urn:lsid:zoobank.org:act:951F18E6-5F12-4AE2-B233-3AB0C1609E05

Figs 1, 3, 4

Type material. Holotype (male) (NHMW) bears the following labels: 1.Pahlgam, 7000 ft, Lidar valley, Kashmir. 7.VI.1928 C.F.C. Beeson. (on reverse side t.№193) // 2. Male sign // 3. under bark *Ulmus wallichiana* // 96.

Allotype (female) (NHMW) bears the following labels: Pahlgam, 7000 ft, Lidar valley, Kashmir. 7.VI.1928 C.F.C. Beeson // Female sign // under bark *Ulmus wallichiana* // *Scolytus scolytus* Geoff. [Sic!] det. K.E.Schedl 1953 // n.sp. det. C. Holzschuh.

Description. Holotype. *Male*. Body length 4.6 mm, 2.1 times as long as wide

Head black, faintly shining. Frons flat, longitudinally aciculate, its surface with fine pale hair-like setae; lateral parts of frons near eyes covered by denser and longer hair-like setae. Vertex deeply punctured. Antennae brown, antennal club nearly elliptical, its surface with short golden hair-like setae.

Pronotum reddish-brown, nearly as long as wide, wider than its length. Sides of pronotum parallel for most of their length; gently rounded towards pronotal apex; constriction in apical portion of pronotum only weakly developed. Surface punctured, with punctures larger in frontal portion than in center of pronotal disk. Anterolateral angles of pronotum bear sparse long light hair-like setae.

Elytra reddish-brown, faintly shining, as wide as pronotal base and 1.5 times as long as pronotum. Elytral base slightly elevated; scutellum triangular; impression near scutellum only poorly developed. Striae slightly impressed, strial punctures circular, closely placed; interstriae flat with smaller punctures than in striae and less closely placed. Subapical elytral constriction distinct. Prior to apex (in subapical constricted

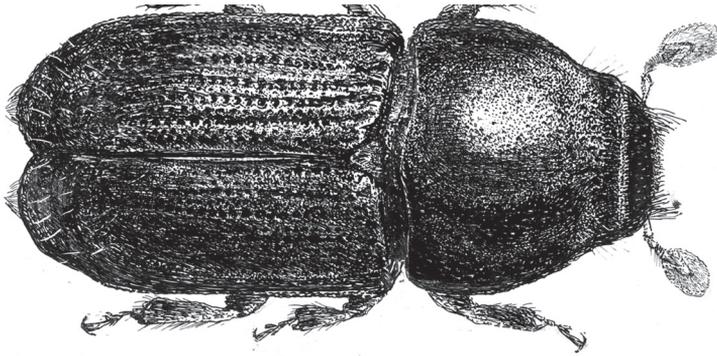


Figure 1. *Scolytus stepheni* sp. n. male dorsal view.

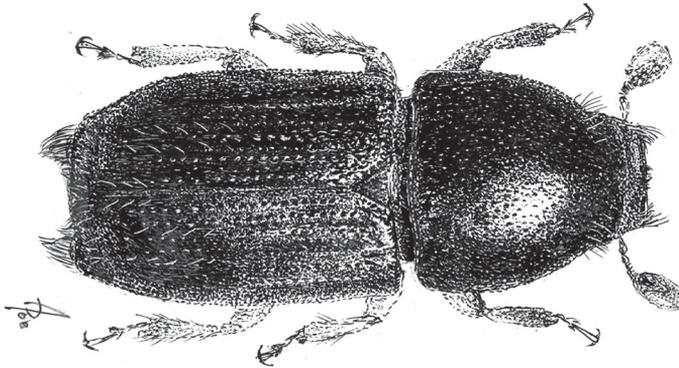


Figure 2. *Scolytus daburicus* Chapuis, 1869 male dorsal view.

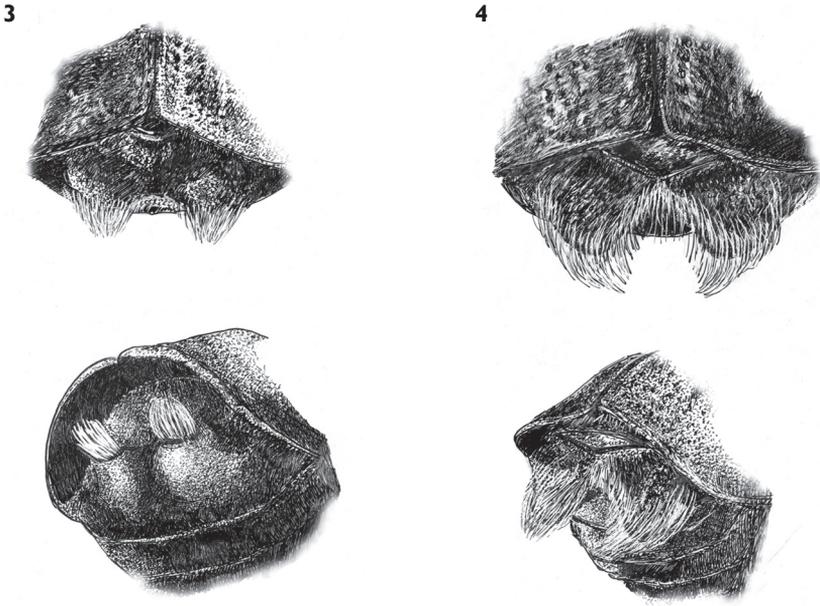
part) elytra with faint impression with irregularly set punctures. Pale sparse erect hair-like setae only visible near elytral apex.

Abdomen reddish-brown, dull. First and second sternites darker than third, fourth and fifth sternites. All sternites with densely set round punctures. Posterior margins of third and fourth sternites with minute median tubercles. Lateral sides of fifth sternite clearly thickened on posterior margin and with carinate apex. Two strong tubercles developed on fifth sternite, their apices with brushes of densely set golden hair-like setae, the brushes not confluent at glabrous apical margin of abdomen.

Legs reddish-brown, covered by golden hair-like setae.

Female. Similar to male but can be distinguished by the larger size (4.9 mm), more convex frons and by less strongly developed “callous-like elevations” at 5-th sternite without hair-like brushes of setae.

Diagnosis. The new species is more closely related to *S. daburicus* (Fig. 2) than to any other Indian *Scolytus* species. From *S. daburicus* it is distinguished by the broader



Figures 3, 4. 3 *S. stepheni* male, abdominal apex 4 *S. daburicus* male, abdominal apex.

body, by the flat elytral interstriae without any transverse rugosities or furrows. In the new species, the hair-like setae at the lateral parts of the frons are shorter and sparser. The clearest difference from *S. daburicus* is seen in the form of the tubercles on the fifth abdominal segment and in their vestiture. In *S. daburicus* long hair-like setae, forming tufts attain the apical margin of the fifth sternite where the two tufts are confluent, and intergrade. The tubercles of the fifth sternite in *S. daburicus* are spatuliform, blade-like whereas in *S. stepheni* these tubercles have the form of truncated cones. The tubercles in *S. stepheni* are set closer to the median line of the fifth sternite, whereas in *S. daburicus* the tubercles occupy the whole space from center to lateral sides of sternite. The distance from the tubercle apices to the posterior margin of the fifth sternite is significantly greater in *S. stepheni* compared to the relevant distance in *S. daburicus*.

Etymology. Professor Stephen Lane Wood worked extensively on collections of Scolytinae preserved in Indian museums, and described a number of new Scolytinae species from India. In this paper we describe one more new bark-beetle species from India kept in the Natural History Museum in Vienna (NHMW) and dedicate this species to the late Professor Stephen Lane Wood.

Discussion

The new species is closely related to *Scolytus daburicus* Chapuis, 1869, but differs in many details. Body length 4.6 mm, 2.1 times as long as wide (in *S. daburicus* body is

2.3–2.6 as long as wide). Other features to distinguish new species from *S. dahuricus* are given in the section Description and Diagnosis. To help researchers to deal with Indian *Scolytus* species we add below the key to species that is absent in Maiti and Saha (2009) monograph.

Key to the Indian *Scolytus* Geoffroy, 1762 species

1. Abdomen unarmed in both sexes, bearing no processes or tubercles on the second sternite or high-elevated callosities on the 5-th sternite, these callosities with or without brushes of hair-like setae..... **2**
- Abdomen is modified in both sexes, bearing either process or tubercle(s) on the second sternite, or highly elevated callosities on the 5-th sternite, these callosities with or without brushes of hair-like setae **4**
- 2(1). Punctures nearby anterior and lateral margins of the pronotum are elongate and significantly denser than on the pronotal disk; these punctures nearby anterior and lateral margins fuse with neighboring punctures, forming longitudinal rugosities. Pronotum in middle part with distinct, strong puncturation. Beetles small, usually 1.4–2.4 mm, rarely up to 3 mm in length.....
..... ***Scolytus rugulosus* (Müller, 1818)**
- Pronotal punctures nearby anterior and lateral margins of the pronotum set denser than on the pronotal disk, but even at margins punctures are clearly divided from neighbors, never fuse and do not form longitudinal rugosities. Beetles usually of larger size **3**
- 3(2). Punctures in elytral striae and interstriae of approximately the same size. Pronotal disc puncturation consists of minute and sparse elongate punctures; in the middle of pronotum punctures are separated greater than by 5 times the width of an individual puncture as in European *Scolytus mali*. Both sexes with median frontal tubercle above epistoma. Frons is convex in both sexes, covered by granules, not aciculate even in the upper portion. Elytra unicolorous, dark brown, with the rows of erect interstitial hair-like setae evident from base of the elytra and up to their apex. Abdomen is ascending gradually, second sternite is convex. Body 2.8–6.0 mm in length. On Conifers.....
..... ***Scolytus major* Stebbing, 1903**
(= *S. minor* Stebbing, 1903; = *S. deodara* Stebbing, 1903)
- Punctures in elytral striae evidently larger than punctures of interstriae. Pronotal disc puncturation consists of elongate punctures, not forming longitudinal rows; in the middle of pronotum punctures are separated by 2–3 times the width of an individual puncture essentially as in European *S. laevis*. Frons longitudinally aciculate. Relatively pale elytra usually with a dark transverse band near middle. Beetles of smaller size, 2.0–3.0 mm in length. Mainly on Rosaceae ***S. amygdali* Guérin, 1847**

- 4(1). Fifth abdominal sternum with two adjacent conical processes, each process with a bundle of at least 15 golden hair-likesetae. These processes are set a bit apart from the posterior margin of the 5 th sternite. Body length 4.6 mm
..... ***S. stepheni* sp. n., male**
- Fifth abdominal sternum without conical processes bearing bundles of hair-likesetae, it may have at most highly elevated callosities separated by the longitudinal sulcus..... **5**
- 5(4). Fifth abdominal sternum with two callous-like elevations separated by the longitudinal impression. These callous-like elevations do not touch the posterior margin of the 5 th sternite. Frons uniformly punctured, evenly covered with short hairs that are far not so dense as in European *S. scolytus* (Fabricius, 1775) and somehow longer. Body length 4.9 mm.....
..... ***S. stepheni* sp. n., female**
- Fifth sternite not modified, it may have only slight impression encircled by the elevated posterior margin of the sternite..... **6**
- 6(5). Tubercle of the second abdominal sternite is small, conical and sharp; this tubercle is set nearby the posterior margin of the second sternite, but not at the posterior margin itself. This tubercle is slightly larger in male than in female. Second abdominal sternite strongly ascending. Pronotum with small and widely separated punctures essentially as in European *S. mali*. Scutellum and scutellar impression are covered by white elongate hair-like setae in unabraded specimens. Punctures of elytral striae are large, round and shallow, only slightly larger compared to interstrial punctures which are also round and shallow. Frons in male is flattened, aciculated, each side of the frons has a row of long golden hair-like setae sloping from vertex to epistoma, each seta exceeding half of the frontal width. In females frons is in rather dense long hair-like setae throughout the whole surface, the individual hair-like setae are less than 1/3 of the frontal width. Body length 2.9–3.4 mm***Scolytus nitidus* Schedl, 1936**
- Second abdominal sternite with the tubercle or process in the anterior third of sternite length. Second abdominal sternite subvertical **7**
- 7(6). Posterior margin of the second abdominal sternite unmodified. Second abdominal sternite with the long process in the anterior third. In males this process is long, horizontal, suddenly and sharply curved upwards at its apex; in female the process is sword-like, more short and more gently curved upwards at its apex. Puncturation of pronotum resembles European *S. laevis* and not *S. mali*, pronotal points are distinct and rather large. Elytra are brown with the black central portion, forming an obscure dark band nearby middle. Scutellum is deeply set in scutellar impression, glabrous. Elytral interstriae each with one row of regularly set minute punctures, much smaller compared to points of striae. In male frons impressed in the middle, shining, with deep punctures and deeply, but not densely longitudinally aciculate. Hair-like setae of the upper portion of the frons form two brushes at the border with vertex;

besides at the interior margin of each eye there is a bundle of enormously long hair-like setae in number of 9; these setae are incurved and nearly equal the width of the frons, at least exceeding 2/3 of its width. Female frontal vestiture is not preserved in available specimen. Body length 3.5 mm.....

..... ***S. chelogaster* Schedl, 1957**

- Posterior margin of the 2nd abdominal sternite is modified. In females it is carrying two sharp denticles set one fifth of sternite width apart from sternite lateral margin and in males there are two strong conical denticles set at the posterior sternite margin at one fourth of sternite width apart from it lateral margin. Central portion of second sternite posterior suture is thickened in females and in males this portion of sternite forms a triangular elevation projecting backwards and overhanging the third sternite. Besides, in males there is a button-like tubercle in the middle of the anterior third of second sternite; in females this tubercle is larger and is laterally compressed. Punctuation of the central part of the pronotum is minute, essentially as in *S. mali*. Anterior 2/3 of pronotum is black, posterior part of the pronotum and elytra completely are light brown in colour. Scutellum set deeply in scutellar impression and is covered with elongated scale-like white setae. Elytral stria and interstria punctures are large, round and shallow, nearly equal in size. Posterior portion of elytra, base of the second abdominal sternite, fifth abdominal sternite and hind legs are covered by the very long hair-like setae not forming tufts anywhere. Male frons at sides with two parallel rows of long setae, individual setae equal to one half of the frontal width; there are no bundles of long setae at interior margin of the eyes. In female frons is covered by sparse erect hair-like setae throughout all frontal surface. Body length 3.6 in the male and 4.1 mm in the female..... ***S. kashmirensis* Schedl, 1957**

Acknowledgments

Dr. Heinrich Schönmann is thanked for help during the authors' work with the collection of Scolytinae in the Natural History Museum of Vienna (NHMW), and Dr. Carolus Holzschuh (Villach) is thanked for his comments on the new species and for the courtesy of allowing us to describe the new species. Special thanks are due to Dr. Roger Beaver and to Dr. Miloš Knížek for helpful comments on the manuscript draft and correcting the language.

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Description of new *Dryocoetes* (Coleoptera, Curculionidae, Scolytinae) species from Afghanistan and Northern India and redescription of *Scolytoplatypus kunala* Strohm

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Abstract

A new bark beetle species, *Dryocoetes browni* from Northern India and Afghanistan, is described as a new to science and redescription of *Scolytoplatypus kunala* Strohmeyer, 1908, previously known only from the female holotype, is provided.

Keywords

Curculionidae, Scolytinae, *Dryocoetes*, *Scolytoplatypus*, Afghanistan, Northern India, new species

Introduction

One more new species of Scolytinae in the genus *Dryocoetes* was discovered during study of materials kept in Natural History Museum, London (NHML), and several more examples of this species were found in the O.N. Kabakov collection from Afghanistan.

Oriental *Scolytoplatypus* species were recently reviewed by Beaver and Gebhardt (2006). This paper gave new insights into the taxonomy of the genus and has helped researchers to describe new species from the region. However, treatment of *Scolytoplatypus kunala* Strohmeier, 1908 in most papers, including the cited one, is doubtful or erroneous. Schedl (1973) considered *S. kunala* to be a senior synonym of *S. darjeelingi* Stebbing, 1914, but Beaver and Gebhardt (2006) treated *S. kunala* as a junior synonym of *S. daimio* Blandford, 1893 and *S. siomio* Blandford, 1893, but as a distinct species from *S. darjeelingi*. Importantly, all *Scolytoplatypus* species known from Himalaya, besides *S. kunala*, were recorded only in Eastern Himalaya, whereas *S. kunala* was discovered in Kashmir Province, Western Himalaya (Strohmeier, 1908). We have found three males and two females of *Scolytoplatypus* species collected by O.N. Kabakov in Afghanistan in Russian collections. After comparison of these specimens with the female holotype of *S. kunala* we consider these specimens from Afghanistan to be conspecific with *S. kunala* and provide redescription of both male and female of this poorly known species. *S. kunala* is reinstated here as separate good species. So far we extend the geographical range of Oriental *Scolytoplatypus* to the west and consider *S. kunala* to be the most “western” *Scolytoplatypus* species from Asia.

Systematics

Dryocoetes brownei, Mandelshtam & Petrov, sp. n.

urn:lsid:zoobank.org:act:6510C1A7-5D09-45D5-A994-2AD2CAE8522F

Description. Male. Holotype (NHML) body length 5.1 mm, width 2.0 mm, other specimens (four female paratypes) 4.8–5.0 mm in length. Body reddish brown, essentially as in *Dryocoetes autographus* Ratz. All five studied specimens appear to be mature, not teneral.

Frons is rather densely but not coarsely, uniformly punctured, with an enlarged puncture in center forming a small fovea. Frontal surface shining, without reticulation. Vertex more sparsely punctured and with smaller punctures. A median longitudinal black line (sulcus) on vertex probably indicates internal strengthening of the head. Frons with rather long, fairly sparse, yellowish hair-like setae, not forming tufts typical of females of *Dryocoetes* species. Hair-like setae significantly longer at lateral sides of pubescent frontal area. Epistoma with long dense yellowish setae directed downwards. Eyes rather large, emarginate anteriorly. Antennae typical for genus: funiculus 5-segmented and club obliquely truncate with recurved sutures on anterior face, and one suture near apex on posterior face.

Pronotum slightly longer than wide (1.9 vs. 1.8 mm); sides subparallel in basal three fourth and apex simply rounded, without teeth on anterior margin. Pronotal surface generally granulate, more coarsely anteriorly, punctured area very small and restricted to central portion of pronotal base around impunctate median line extending approximately one fifth of pronotal length only. Pronotal surface between granules

shining, without any reticulation. Sides and anterior margin of pronotum with long, curved, yellow hair-like setae.

Scutellum large, flat, flush with elytral surface, of same reddish color as elytra.

Elytra slightly wider (2.0 vs. 1.9 mm) than pronotum, nearly cylindrical, only slightly widened towards apex, 3.2 mm long. Elytra extremely coarsely punctured on the disk, especially on striae 1–3 (Fig. 1). Juxtastatural stria not impressed both on disk and on declivity, its punctures nearly as deep and as large as punctures of second stria. Interstriae in central part of disk narrow, 1.5–2.0 times narrower than striae, rather convex and shining, with minute punctures nearly 5 times smaller in diameter than stria punctures, in one irregular row on each interstria; minute tubercles present on interstriae on disk, but not on declivity.

Declivity slightly flattened, convex, not steep, dull. Ventrolateral sides of declivity not armed and lacking minute tubercles on declivital surface. First and second interstriae are widened at declivity. Strial punctures of first and second interstriae on declivity larger than punctures of other striae, but more than two times smaller than on disk. First and second striae slightly divergent towards elytral apex. Suture appearing only slightly convex on declivity because juxtastatural striae are not deepened. Elytra with rather long yellow interstitial hair-like setae, longer laterally and on the declivity; stria hair-like setae recumbent and approximately 5 times shorter than interstitial setae.

Legs typical for the genus, protibia with 5 socketed teeth on outer surface, meso- and metatibiae each with 5 spines on outer margin.

Underside of body reddish brown, abdomen covered with rather long setae on posterior margin of ventrites.

Female. Similar to male, but the frons with a dense tuft of long yellow hair-like setae.

Etymology. The new species is dedicated to the eminent British coleopterologist F.G. Browne, who first labeled the holotype as a possible new species.

Type material. Holotype (male) is deposited in NHML. Labels of the holotype are as follows: Kashmir: Gulmarg. vi – 1931. Dr. M.Cameron. B.M. 931–452.// *Dryocoetes* sp.n. det. F.G.B. 1967 (in black ink, in F.G. Browne's handwriting)// Possibly one of Beeson's undescr. spp. – *deobanos himalahinorum* [sic!] (in black ink, in F.G. Browne's handwriting). Paratypes (4 females) (including female allotype): Afghan[istan], Nur-estan N.Waygal 2500 m., 10.VII.1972, Kabakov [leg.], 1 spec. in Zoological Institute, St.Petersburg (ZISP) and 3 spec. in A.V. Petrov private collection.

Diagnosis and comparison with other Indian *Dryocoetes* species. A new bark-beetle is described from Northern India that differs from all other Indian species of the genus *Dryocoetes* by the exceptionally large punctures of the elytral discal striae and by the large size of the body.

In India, four species of genus *Dryocoetes* were previously reported to occur, namely *D. hewetti* Stebbing, 1908, *D. himalayensis* Strohmeyer, 1908, *D. quadrisulcatus* Strohmeyer, 1908 and *D. indicus* Stebbing, 1914. We were able to study all these four species in the Zoological Museum of Moscow University (ZMMU). The first of them has a spatulate antennal club, and extremely long declivital pubescence, and was correctly transferred to the genus *Taphrorychus* (Wood and Bright, 1992). *D. himalayensis* and *D. quadrisulcatus* differ from both *D. indicus* and *D. brownei* by the much smaller body size



Figure 1. *Dryocoetes brownei*, HT, male, dorsal view.

and by the strongly deepened first striae on the disk and the declivity. Although this feature is more evident in males of these species, it is also developed in the females. *D. indicus* is also smaller in size (4.0 mm vs 5.1 mm) than *D. brownei*, has equally punctured striae and interstriae on the disk, and minute but evident tubercles on the declivity.

Scolytoplatypus kunala Strohmeyer, 1908

Material examined: Holotype (female): Kashmir, Pir Panjal, Rost [leg.] // Female sign // Type // *Spongocerus kunala* Strohm. Determ. Strohmeyer // Coll. Strohmeyer // Holotypus (on red paper). Holotype is deposited in Senckenberg Deutsches Entomologisches Institut (SDEI). Additional material examined: 2 males, Afghan[istan], Nur-estan, N. Waygal, 2750 m., 9.7.1972, Kabakov [leg.] (Zoological Museum of Moscow University and A.V.Petrov private collection); 1 more male and 2 females with labels: Afghan[istan] Nurestan N. Waygal 3500 m. 2.7.1972 Kabakov [leg.] (A.V. Petrov private collection).

Description. Male. Length 2.7 mm, body stout, 2.1 times as long as wide (Figs 2, 3). General colour pale brown, elytra with only slightly darkened suture, lateral margins and apices; each elytron with a large yellow spot extending from anterior margin up to two thirds of elytral length. Legs and antennae yellowish brown.

Frons concave, uniformly shagreened, minutely, uniformly punctured. Vestiture of whole frontal surface consists of very fine erect and relatively long hairlike setae visible from lateral and dorsal view (not from frontal view). Upper and lateral edges of frons with long hairlike setae; those on upper part until middle of eyes very long and curved towards center of frons. Longest setae convergent in middle of frons, not extending beyond middle of frons; those on lateral edges of flattened lower frontal part become shorter ventrad and are not so curved (Fig. 4); frons is quite different from *S. daimio* with frontal tufts of hairs attaining epistomal margin (Fig. 5).



Figure 2. *Scolytoplatypus kunala*, male, dorsal view.

Pronotum wide and short, 0.8 times as long as wide (1.9 mm vs 2.3 mm), widest in anterior third, vestiture of fine and short hair-like setae denser at anterior margin. Pronotal surface shining, minutely punctured, punctures very shallow and set 3–4 diameters apart from each other. Surface between punctures minutely reticulated. Posterior part of pronotum more lightly coloured than anterolateral angles. Lateral margins of pronotum sharply elevated and propleura strongly concave.

Prosternum weakly convex, with an obscure triangular elevation between procoxae, its indistinct pointed apex oriented backwards, and base of triangle forming anterior prosternal margin. This margin is armed with two divergent translucent processes set far apart (Figs 6, 7).

Scutellum small, triangular, flush with elytral surface.

Elytra 1.38 times as long as wide, 2.0 times as long as pronotum, clearly widened posteriorly. Elytral surface minutely punctured, shining, without signs of reticulation. Elytral punctures not organized in rows and interstriae invisible besides at declivity where all interstriae with exception of the first one are finely carinate. First declivital interstriae at declivity are broadly elevated, not carinate and bear 9–10 tubercles of median size, towards elytral apex evidently divergent. Carina on all other interstriae very low and devoid of tubercles. Elytral declivity convex, not impressed. Posterior dark carinate portion of elytra has yellowish and dense recumbent hair-like setae, anterior light portion of elytra is glabrous.

Underside of beetle is uniformly light yellow. Fourth and fifth abdominal sterna with abundant long yellowish hair-like setae protruding beyond abdominal apex.

Front femora without tooth above apex. Front tibiae with three widely set spines at lateral edge and with apical mucro. Tarsi long, third segment not bilobed, fifth segment as long as all previous combined.



Figure 3. *Scolytoplatypus kunala*, male, lateral view.

Female. Similar to male, but frons is not impressed and long pubescence at lateral and upper edges of frons is not developed (Fig. 8). Pronotum has a median mycangial pore in its centre.

Length 2.8 mm (HT – 2.96 mm), body stout, 2.15 times as long as wide. Body pale brown, elytral colour pattern essentially as in male, body surface faintly shining.

Head brown, darker compared to other body parts. Frons faintly convex, dull. Frontal surface gently shagreened. Lateral frontal parts near eyes faintly shining. Middle part of frons with a sickle-shaped faintly shining impression above mandibles, upper part of impression near center of the frons with two symmetrically placed small tubercles that are seen with difficulty. Slightly elevated dark median line continues from vertex down to epistomal impression. Frontal surface covered by shallow round punctures. Median part of frons covered by sparse, short erect hair-like setae, with somewhat higher density in middle of frons. Short recumbent hair-like setae are concentrated around eyes. Vertex is covered with round shallow punctures, glabrous. Antennae brown with sand-coloured triangular flat club.

Pronotum subquadrate, surface faintly shining, covered by microscopic round punctures, with faintly developed flattened tubercles laterally from pronotum center. Slightly anteriorly to pronotum middle a well-developed mycangial pore with a bunch of pale fine hair-like setae is developed. Posterior part of pronotum up to the central pore is covered by pale microscopic hair-like setae; anteriorly to the pore, pronotum with more long pale erect hair-like setae. Lateral pronotal margin as in all *Scolytoplatypus* is acute. Prothorax has an impression for protibiae. Intercostal piece flat, its lateral margins near apex with bunches of long golden hair-like setae.

Scutellum as in male.

Elytra light brown, faintly shining. Elytral base 1.2 times as wide as pronotum base. Maximal elytral width at beginning of declivity. Declivital margins not evenly rounded toward elytral apex, elytral apex somewhat angular. Dorsum of declivity evenly arched towards apex. Elytra 1.4 times as long as wide. Elytral surface with circular punctures.



Figure 4, 5. 4 *Scolytoplatypus kunala*, male, frontal vestiture 5 *Scolytoplatypus daimio*, male, frontal vestiture.

Strial punctures not deepened and of similar size to interstitial punctures, so that striae are obscure, not clearly seen. Interstriae slightly elevated on declivity, first interstriae with minute tubercles, seen with difficulty. Elytral surface covered with microscopic light hair-like setae.

Metasternum light brown, covered by short pale hair-like setae. Metacoxal cavities with clearly marked raised margin.

Abdomen light brown. Sternites covered by minute shallow round punctures and pale hair-like setae; these setae clearly longer on 3-rd, 4-th and 5-th sternites than on 1-st and 2-nd sternites.

Legs light yellow. Denticles on outer lateral protibial surface rather strong in the specimen described, but probably intraspecifically variable.

Diagnosis. In habitus the species resembles specimens of *S. daimio*, but smaller in size and has another color pattern on elytra (with only poorly developed light dark pattern). Frontal pubescence essentially as in *S. zahradniki* Knížek, 2008 or *S. tycon* Blandford, 1893. Rather short frontal vestiture easily distinguishes the male *S. kunala* from *S. daimio* and *S. darjeelingi* males in which the longest setae extend in a brush from the upper frontal parts up to the epistoma (Fig. 5). Based on the habitus and details of the male prosternum morphology, *S. kunala* is most closely related to *S. daimio* and *S. darjeelingi*, differing from both species in the presence of rather short frontal vestiture in the male. The last feature is present not only in *S. kunala* but also in *S. tycon*, however in the latter, the male prosternum is differently developed and the body is much stouter. The pale area of the elytra is surrounded only by slightly darker zone formed by brown elytral apices and elytral margins, not black as in *S. darjeelingi* Strohmeier, 1914. All other Oriental species can be easily distinguished by the features given in the modified key of Beaver and Gebhardt (2006) (see below). In the recently described *Scolytoplatypus zahradniki* Knížek, 2008 with similar frontal pubescence the male prosternum does possess two processes anteriorly, but they are closely set and not wide apart as in *S. kunala*. A similar prosternum to *S. kunala* is seen in *S. daimio*,



Figure 6. *Scolytoplatypus kunala*, male, prosternum.



Figure 7. *Scolytoplatypus kunala* male prosternum organ, enlarged.

but not in *S. zahradniki*, which possesses closely set translucent processes at anterior margin of pronotum and a distinct type of pronotal elevation with a sharp keel protruding forwards and backwards. The *S. zahradniki* males can also be distinguished by the clearly carinate elytral interstriae which are only slightly elevated on the *S. kunala* declivity (Knížek 2008). The female of *S. kunala* can be distinguished from the females of *S. daimio* and *S. zahradniki* by the smaller body size and by presence of declivital tubercles only on the 1 – st elytral interstria, by very faint striae on the apical part of the elytral declivity.

Unfortunately, the recently published key to Indian *Scolytoplatypus* by Maiti and Saha (2009) ignores the paper by Beaver and Gebhardt (2006) and uses quite another

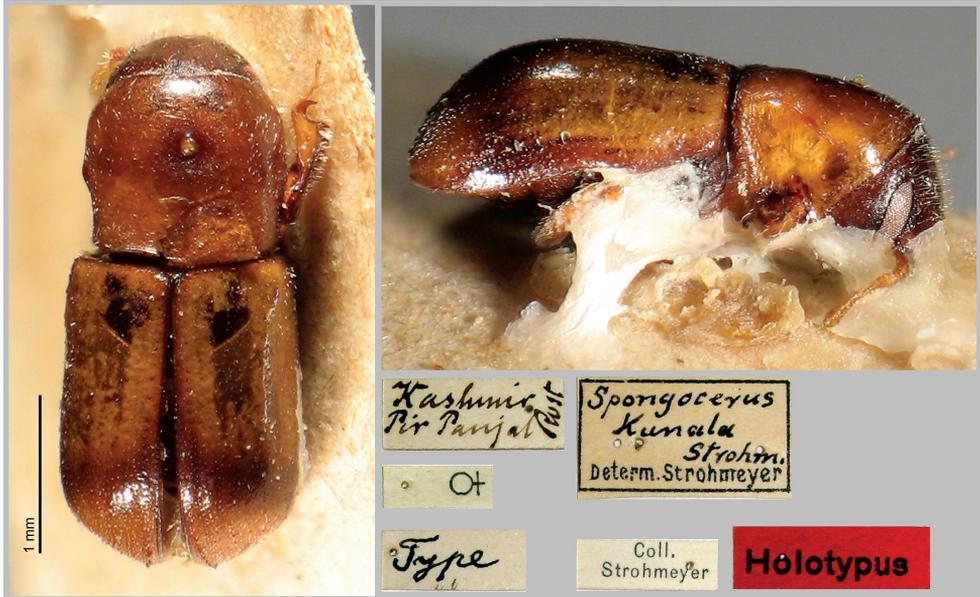


Figure 8. *Scolytoplatypus kunala*, Holotype, female.

set of features to distinguish species. Importantly, it does not use the male prosternum structure to provide principal features to identify species groups. Three new species were described as new by Maiti and Saha (2008), namely *S. gardneri*, *S. lopchuensis* and *S. samsinghensis*; however use of another set of features to distinguish species does not allow the inclusion of these three species into the key by Beaver and Gebhardt (2006). *S. samsinghensis* differs from *S. kunala* by the much larger size (3.75–3.80 mm versus 2.70–3.00 mm), by the uniformly dark reddish brown to blackish brown body color, by the presence of conspicuous interstitial ridges on the elytral disk both in males and in females and also by the very short frontal pubescence both in male and in female. Besides, sparse long, erect declivital hair-like setae present in *S. samsinghensis* male are absent in *S. kunala*. Both *S. lopchuensis* and *S. gardneri* are slightly smaller in size compared to *S. kunala* (2.55–2.60 mm vs. 2.70–3.00 mm). The female of *S. lopchuensis* differs from that of *S. kunala* by the absence of the mycetangium pore in the centre of the pronotum, and the female of *S. gardneri* is unknown. Males of both species, *S. lopchuensis* and *S. gardneri*, are different from *S. kunala* in having even frontal vestiture without a fringe of hair-like setae on the upper frontal rim with their apices converging towards the centre of the frons. *S. kunala* is very closely related to *S. darjeelingi* Stebbing sensu Maiti and Saha, 2009; however, in contrast to Maiti and Saha's description, *S. darjeelingi* has very long tufts of hair-like setae originating from the upper part of the frons (Stebbing 1914, Beaver and Gebhardt 2006) and extending to the epistoma near the mandibles.

Discussion. The key to Oriental *Scolytoplatypus* species males by Beaver and Gebhardt (2006) can be easily modified to include both redescribed *S. kunala* and recently described *S. zhradniki*.

The key to males will be changed from couplet 19

19. Prosternum with a pair of widely separated, translucent, divergent anteriorly processes. Rows of punctures on elytral dorsum not impressed, usually indistinct..... **19A**
- Prosternum with a pair of closely set translucent processes, with an asymmetrical translucent process, or without translucent processes..... **19B**
- 19A. Frons with a rather sparse fringe of hair-like setae on each side curving inwardly, convergent to the center of frons but not extending to lower half of frons. 2.7 mm..... ***Scolytoplatypus kunala* Strohmeyer**
- The incurved brushes of hair-like setae denser and longer, extending beyond middle of frons and usually attaining epistomal margin **22 (species *S. shogun*, *S. daimio* and *S. darjeelingi*)**
- 19B. Prosternum raised in middle in a triangle, the apex anterior or posterior.... **20**
- Prosternum flat or weakly convex, not raised in a triangle. Prosternum without translucent processes at the anterior margin. 3.5–4.5 mm ***S. tycon* Blandford**
20. Apex of prosternal triangle posterior, anterior margin projecting in two rounded lobes, slightly asymmetrical, and with a translucent process on the right side only. 2.8–3.0 mm long ***S. ruficauda* Eggers**
- Apex of prosternal triangle anterior, with two symmetrical, divergent, triangular, closely set translucent processes **21**
21. Posterior margin of raised prosternal triangle has a sharp elevation directed posteriorly in the center, apex of prosternal triangle anterior without a pointed tubercle directed downwards. 2.6–3.3 mm..... ***S. zabradniki* Knížek**
- Apex of prosternal triangle anterior with a single pointed tubercle directed downwards. 3.1–3.3 mm long ***S. blandfordi* Gebhardt**

The key to Oriental *Scolytoplatypus* species females by Beaver and Gebhardt (2006) can also be modified to include the redescribed species, *Scolytoplatypus daimio*, and recently described *Scolytoplatypus zabradniki* Knížek.

The key to females will be changed from couplet 15.

15. Basal angles of pronotum triangularly produced laterally, acute apically (species *S. mikado*, *S. raja*)..... **16**
- Basal angles of pronotum not strongly produced laterally, approximately rectangular **17**
17. Elytral interstriae carinate in the posterior two thirds of elytra 2.8–3.5 mm ...
..... ***S. zabradniki* Knížek**
- Elytral interstria not carinate, with rows of tubercles or striae weakly impressed before declivity or not impressed at all; if carinate than size less than 2.8 mm..... **17A**

- 17A. Elytral striae weakly impressed before declivity; elytral disc with fine hair-like setae on both striae and interstriae. Body length 3.8–4.5 mm ***S. tycon* Blandford**
- Elytral striae not impressed before declivity, or if impressed, then length less than 2 mm **18**
18. Elytral declivity with dense vestiture of long, yellowish hair-like setae **19 (species *S. blandfordi*, *S. darjeelingi*, *S. pubescens*)**
- Elytral vestiture of very short hair-like setae or elytra glabrous **21**
21. More elongate species, the elytra 1.7–1.9 times as long as pronotum **22 (species *S. shogun*, *S. daimio*)**
- Less elongate species, the elytra at most 1.5 times as long as pronotum **23**
23. Apex of interstriae 2 with a small acutely pointed tooth **24 (species *S. carinatus*, *S. nitidus*)**
- Apex of interstriae 2 without a tooth **24A**
- 24A. Larger species, body length 2.8–3.0 mm. Interstriae at the declivity with minute tubercles, clearly seen only at the first interstriae, obscure and seen with difficulty at all other interstriae ***S. kunala* Strohmeyer**
- Smaller species 1.2–1.8 mm long **25 (species *S. nanus*, *S. minimus*, *S. pusillus*)**

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Five new species of *Triotemnus* (Coleoptera, Curculionidae, Scolytinae) from Morocco and Yemen

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Abstract

Five new species of the genus *Triotemnus* from Morocco and Yemen are described. *Triotemnus* is a new genus of Scolytinae for the Yemen region. External morphology of the new species and all morphologically related species of the genus were studied. While the new species from Morocco are morphologically similar to the known species from the corresponding region, all three newly described species from Yemen, mainly two of them living in Socotra, are morphologically very different from all other known species of the genus. Geographical distribution and the probability of endemism are discussed.

Keywords

Bark beetles, Dryocoetini, Palearctic region, Morocco, Yemen, Socotra

Introduction

The genus *Triotemnus* Wollaston, 1864, comprises 11 species distributed in the Palearctic, Afrotropical and Oriental regions (Wood and Bright 1992, Bright and Skidmore 1997, 2002; Gatti and Pennacchio 2004). In total, 7 species are known from the

Palaeartic region. From these, only two species, *T. subretusus* Wollaston, 1864 and *T. ulianai* Gatti & Pennacchio, 2004, occur in Europe, and five species are known from North Africa – *T. antoinei* Peyerimhoff, 1949, *T. lepineyi* Balachowsky, 1949 and *T. longicollis* Peyerimhoff, 1925 from Morocco, *T. grangeri* Peyerimhoff, 1919 from Algeria and *T. subretusus* Wollaston, 1864 from the Canary Islands. Only one species is known from Palaeartic part of India – *T. scrofa* Schedl, 1975, from Uttar Pradesh. This species, together with *T. pilicornis* Wood, 1992, occur in Oriental region (India, and *T. scrofa* also in Sri Lanka). Other species of the genus – *T. aethiopicus* Eggers, 1936, *T. striatus* Eggers, 1936 and *T. villiersi* Schedl, 1958 live in Afrotropical region. Interestingly, all the species were described in separate publications (Balachowsky 1949b; Eggers 1936a; Eggers 1936b; Gatti and Pennacchio 2004; Peyerimhoff 1919; Peyerimhoff 1925; Peyerimhoff 1949; Schedl 1958; Schedl 1975; Wollaston 1864 and Wood 1992). That fact, as well as the rather scarce literature on species and genus level, reflects the relative rareness of all the species. Some species are also rare in museum collections and are very seldom collected by entomologists. Collecting of these species in the field is apparently difficult, but many specimens can nevertheless be obtained by rearing when infested parts of the host plants are collected.

Even though the fauna and flora of Socotra shows high endemism, there are in some cases affinities to the Ethiopian and Indian fauna, perhaps due to a common geological history of these areas. Socotran species of *Triotemnus* differ distinctly from all other species of the genus. Including the information about their biology, these species are suggested as endemic and the possibility for occurring elsewhere is very unlikely. On the contrary, the new species from Morocco are morphologically very similar to known species from that region. Because of the morphological uniformity, one may suggest that species from this region diversified rather recently, and have had little time for morphological differentiation (see e.g. Jordal and Hewitt 2004; Jordal et al. 2004, for similar examples). Even though the new species were always collected from just one location, the broader distribution of their host plants makes occurrence in other areas likely (all known species of *Triotemnus* are living in “small” shrubs, like *Euphorbia* spp. and *Bupleurum* spp.). On the other hand makes the geographical conditions, such as deep valleys and the meteorological conditions of high mountains, relatively suitable for long term separation of local populations.

Methods

Newly discovered species were compared to all known species in the genus, except *T. ulianai* Gatti & Pennacchio, 2004, which was not available for the study. The significance of morphological differences was affirmed by examining long series of specimens. Descriptions use the terminology from e.g. Wood 1986, Wood 1992 and/or Jordal 2009. Specimens were collected from their host plants directly in the field, and by rearing in the lab. When possible, the gallery system was also studied by dissecting host plant tissue. Internal characters of the beetles were not studied.

Descriptions of the new species

Triotemnus Wollaston

Cladoctoporcus Schedl, 1975. Type species *Cladoctoporcus scrofa* Schedl, 1975

Type species. *Triotemnus subretusus* Wollaston, 1864

Note. The position of the genus *Triotemnus* Wollaston within the higher systematics of bark beetles has changed frequently since its origin. The very first attempt to range the genus within the higher systematics was made by Ferrari 1867, who recognized 6 groups of scolytids and *Triotemnus* was placed into Group 5 – Tomicides. Later, many different authors placed the *Triotemnus* in different tribes, but three main transfers were particularly important. Hagedorn 1908 suggested that the genus belongs to the family Crypturgidae, followed by Hopkins 1915, which ranked it at subfamily level. This was followed by Schedl 1932, which placed it into the tribe Crypturgini LeConte, 1876. Later it was transferred to the tribe Thamnurgini Nüsslin, 1911 by Balachowsky 1949a and afterwards into Dryocoetini Lindemann, 1876 by Wood 1986, in which it is remaining in the most modern system and the most important recent papers until now, with one exception of Pfeffer 1995, which followed Balachowsky 1949a. There is only one synonymy at the generic level, the monobasic genus *Cladoctoporcus* Schedl, 1975 was synonymized by Wood in 1984. All other species currently included in the genus were originally described in *Triotemnus*, except *Triotemnus grangeri* (Peyerimhoff, 1919), which was originally described under the genus *Lymantor* Løvendal, 1889 and was transferred to *Triotemnus* by Peyerimhoff in 1949.

Diagnosis. Length 1.2 – 2.3 mm, slender, cylindrical body form, reddish to dark brown, antennae and legs lighter. Male frons flattened to concave. Eyes emarginate on anterior margin around the antennal insertion. Each mandible with short or long pointed tooth-like process directed upward. Antennal funicle 4- or 5-segmented (3-segmented in *T. scrofa*), antennal club longitudinally oval, usually with two sutures in apical part on anterior side. Pronotum oval or cylindrical, longer than wide, feebly declivous anteriorly, distinctly punctured, usually with impunctate median longitudinal area, not armed on basal margin. Scutellum visible, rather small, flush with elytra. Elytra cylindrical, sometimes widened or narrowed posteriorly, more or less deeply punctured in striae, finely punctured in interstriae, interstriae flat, usually smooth or minutely granulate, elytral declivity regularly rounded or flattened, sometimes with distinct lateral edges. Vestiture usually of long erected hair-like setae, these setae may be longer anteriorly, laterally and posteriorly. Procoxae contiguous, lateral margin of protibia armed by 4–5 socketed teeth. Female similar to male, except frons slightly convex, mandibles without the tooth-like processes.

Triotemnus Wollaston, 1864 differs from closely related genera (e.g. *Thamnurgus* Eichhoff, 1864, *Xylocleptes* Ferrari, 1867 and *Lymantor* Løvendal, 1889) mainly by modified frons in males with tooth-like processes on mandibles, feebly if at all de-

clivous pronotum, which is unarmed on anterior margin. *Tiarophorus* Schreiner, 1882 has much longer pronotum and strongly, but differently modified frons in males and 6-segmented antennal funicle. Some species ranged in *Tiarophorus* (Wood and Bright 1992) are recently considered under *Pseudothamnurgus* Eggers, 1912 (e.g. Pfeffer 1995). Solving the relationship of this genus/species with *Triotemnus* remains for the future study. *Taphronurgus* Reitter, 1913 has no tooth-like processes on mandibles in males. The most similar *Cynanchophagus* Aksent'ev, 1987 has much longer pronotum and 7–9 socketed protibial teeth (Mandelstam et al. 2006).

***Triotemnus pseudolepineyi* Knížek, sp. n.**

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Figs 1, 2

Type material. Holotype male, pinned, with labels as follows: “Morocco, 31. 5. 1999/ High Atlas, Toubkal massif/ Chamharouch/ Jan Batelka lgt.“ 31°5'35"N 7°54'22"W. Allotype female, pinned: the same data as the holotype. Paratypes: 125 males, 113 females: the same data as the holotype.

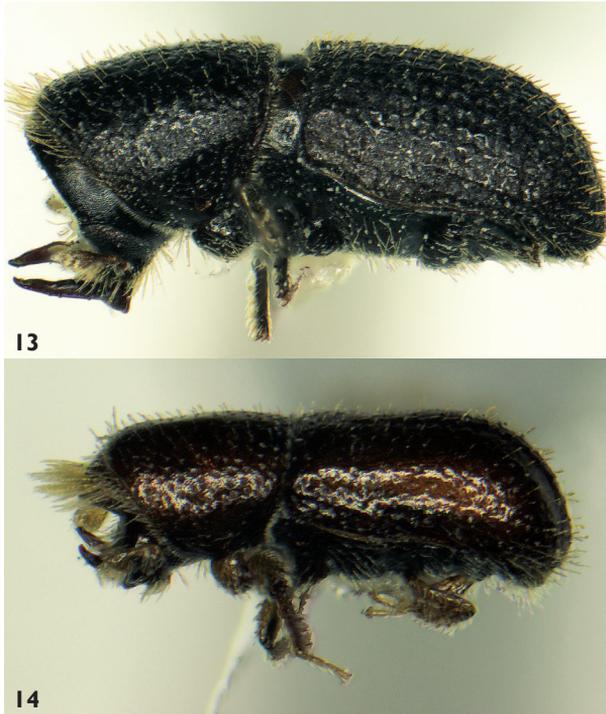
Holotype and Allotype deposited in the collection of National Museum in Prague, 190 paratypes in the author's collection, 4 paratypes in Naturhistorisches Museum, Wien, 4 paratypes in Muséum d'Histoire Naturelle, Genève, 40 paratypes in coll. J. Batelka (Praha).

Diagnosis. This species is morphologically distinct from all other species of the genus due to the strongly developed callous-like lateral edges of elytral declivity. It is the most closely related to *T. lepineyi* Balachowsky, from which it differs also by the more elevated lateral edges on elytral declivity, which are clearly higher than slightly elevated suture and by which the elytra appear deeply bisulcate. Elytra are also more narrowly rounded on posterior quarter in *T. pseudolepineyi*. The elevated callous-like longitudinal process on the lateral margin terminated before reaching the posterior margin of elytra from lateral view.

Description. Male. Length 1.30–1.80 mm (1.72 mm in holotype), 2.50–2.69 times longer than wide (2.61 in holotype). Colour brown to dark brown if fully coloured. **Head.** Frons concave, excavated, concavity may differ from deep excavation up the level just above upper edge of the eyes, which is smooth, strongly shining, very finely and sparsely punctured, uniformly shagreened, to rather shallow, densely and rather deeply punctate, excavation divided from vertex by semi-carinate costa, this elevated in the middle forming wide-based tubercle-like process; vertex shining, deeply and rather densely punctured; vestiture of very long sparse erected gold hair-like setae situated on the lateral edges of the frontal excavation mainly. Eyes emarginate on anterior margin around the antennal insertion, rather small. Each mandible with short, strong and pointed tooth-like process directed upward, reaching just the lower level of frontal excavation. Antennae light brown, antennal funicle 4-segmented, antennal club longitudinally oval, anterior side with one transverse suture just above the middle, second suture slightly marked in apical half by row of setae, basal half corneous, posterior side without sutures.



Figures 1–12. Dorsal view. **1** *T. pseudolepinei* – male **2** *T. pseudolepinei* – female **3** *T. lepinei* – male **4** *T. lepinei* – female **5** *T. batelkai* – male **6** *T. batelkai* – female **7** *T. grangeri* – male **8** *T. grangeri* – female **9** *T. socotraensis* – male **10** *T. socotraensis* – female **11** *T. kabateki* – male **12** *T. yemenensis* – female.



Figures 13–14. Lateral view. **13** *T. socotraensis* – male **14** *T. kabateki* – male

Pronotum 1.08–1.15 times longer than wide (1.12 in holotype), sub-oval, widest in the middle of its length, weakly declivous in front, summit not clearly marked, punctato-granulate on anterior declivity, frontal edge rounded, basal angles broadly rounded, posterior margin rounded, disk shining, strongly and rather densely punctate on disk and lateral areas, interspaces very finely shagreened, median longitudinal area impunctate; vestiture of sparse hair-like setae, becoming very long anteriorly and posteriorly. **Elytra** 1.43–1.51 times longer than wide (1.50 in holotype), 1.42–1.56 times longer than pronotum (1.42 in holotype), sub-parallel on basal three-fourths, widest in posterior part where are slightly wider than pronotum, then converging to rounded apex; basal edge rounded, not armed; scutellum visible, very small, smooth and shining, flush with elytra; first striae slightly impressed on the whole length of the elytral disc, other striae not impressed; elytral striae deeply punctured, interspaces slightly larger than the diameter of the punctures; interstriae less densely and less deeply punctured, shining. Elytral declivity regularly rounded and elevated at suture, bisulcate, lateral edges strongly elevated, fourth interstriae developed into a large callous-like longitudinal and slightly undulated process, elevation not reaching the posterior margin, lateral elevated edges much higher than slightly elevated suture, interspace between the suture and elevated lateral edges depressed, smooth, shining, very finely and sparsely punctate at the striae, and impunctate on interstriae. Elytral vestiture consisting of sparse hair-like semi-erected setae on disk, each about 1.5 times longer than the distance between strial punctures, much

longer (approximately twice) hair-like setae on lateral and posterior margins; sulcate part of the elytral declivity without setae except short oblique setae along the suture (often abraded). **Legs** brown. Procoxae subcontiguous, prosternal process very narrow, long and sharply pointed; mesocoxae separated by the width of scapus, mesoventral process descending, narrow and bluntly pointed; metacoxae separated slightly more than mesocoxae. Pro-, meso- and metatibiae on outer lateral margin usually with 6 socketed teeth, mesotibiae sometimes with 5 socketed teeth, variable between specimens within series.

Female. **Length** 1.26–1.85 mm (1.56 mm in allotype), 2.58–2.70 times longer than wide (2.63 in allotype). **Head** similar to male, but mandibulae not armed by tooth-like processes, frons convex, slightly flattened just above the epistoma, dull, very densely punctato-ganulate, becoming less pronounced in the flattened area, on vertex with a wide tubercle-like process; vestiture of very fine, short, erect yellowish hair-like setae directed forward, becoming denser toward epistomal margin. Antennal club different from male, short and oval. **Elytra** with lateral parts of declivity less strongly developed, but higher than elytral suture.

Etymology. Name of this new species is derived from the morphologically nearest species named and described as “lepineyi” by Balachowsky (1949b) and using of the Greek term “*pseudos*” – pretended.

Biology. Specimens were collected from wilting shrubs of *Bupleurum spinosum* (Apiaceae). The species is phloeophagous. Maternal galleries were not clearly visible due to the full consumption of phloem and sapwood by the larvae. Before pupation the larvae bore into the sapwood forming up to one centimetre long internal pupation galleries. Larval galleries were generally filled with yellow frass in their whole length.

Distribution. Morocco (High Atlas), endemic. Even though the species is suggested as endemic here, it is possible that it may be found in other areas, mainly within Morocco and Algeria, because the host plant is found in neighbouring areas.

***Triotemnus batelkai* Knížek, sp. n.**

urn:lsid:zoobank.org:act:3A52C4BA-3D76-4ED1-A881-97CDEE161230

Figs 5, 6

Type material. Holotype male, pinned, with labels as follows: “Morocco, 2260–2350m/ Tizi-n-Tichka pass, 30.VI-1.VII.1998, ex larva VIII. 1999/ J. Batelka & H. Batelková lgt. “ 31°24'58"N 7°23'34"W. Allotype female, pinned: the same data as the holotype. Paratypes: 23 males, 63 females: the same data as the holotype.

Holotype and Allotype deposited in the collection of National Museum in Prague, 62 paratypes in the author's collection, 2 paratypes in Naturhistorisches Museum, Wien, 2 paratypes in Muséum d'Histoire Naturelle, Genève, 20 paratypes in coll. J. Batelka (Praha).

Diagnosis. The species is morphologically distinct from the most closely related species *T. grangeri* (Peyerimhoff), which in *T. grangeri* has the lateral edges of elytral declivity more strongly developed, the declivital flattened area is much wider, the vesti-

ture on frontal edge of pronotum and lateral and posterior margins of elytra is slightly longer, and the uniseriate setae along the suture on the elytral declivity are much more stout and longer.

Description. Male. Length 1.43–2.00 mm (1.63 mm in holotype), 2.55–2.86 times longer than wide (2.76 in holotype). Ferruginous to dark brown if fully coloured. **Head.** Frons shallowly concave up to the level just above upper edge of the eyes, concavity rather deeply punctured except very finely punctured, nearly impunctate area above epistoma, shining, very finely shagreened, excavation divided from vertex by rounded costa elevated in the middle forming a short transversely rounded keel; vertex semi-shining, deeply and rather densely punctured; vestiture of very long, erected, golden hair-like setae situated on the lateral edges of the frontal excavation mainly, these on concavity of about half length. Eyes emarginate on anterior margin around the antennal insertion, rather small. Each mandible with a short and strong (wide based) pointed tooth-like process directed upward, reaching just the lower level of frontal excavation. Antennae yellowish, antennal funicle 4-segmented, antennal club longitudinally oval, anterior side with one transverse suture just above the middle, apical half covered by dense setae, basal half corneous, posterior side without sutures. **Pronotum** 1.14–1.21 times longer than wide (1.20 in holotype), sub-oval, widest in the middle of its length, frontal edge rounded, basal angles broadly rounded, posterior margin rounded; anterior disk weakly declivous, summit not clearly marked, approximately in the frontal third, disk shining, strongly and densely punctate along an impunctate and smooth median longitudinal area, punctato-granulate on the remaining disk, granulation becoming stronger laterally and frontally mainly, interspaces finely rugose; vestiture of sparse semi-erect hair-like setae directed towards impunctate medial line, setae becoming much longer anteriorly. **Elytra** 1.39–1.64 times longer than wide (1.51 in holotype), 1.32–1.35 times longer than pronotum (1.33 in holotype), sub-parallel on basal three-fourths, widest in posterior half, then converging to broadly rounded (sub-straight) apical margin; base of elytrae rounded, not armed; scutellum visible, but very small, smooth and shining, flush with elytra; elytral striae rather deeply sparsely and regularly punctured, not impressed, interspaces slightly larger than the diameter of the punctures; interstriae less densely and less deeply punctured; elytral suture slightly elevated on nearly its entire length except on the basal fifth of elytra. Elytral declivity regularly rounded at suture, otherwise flattened up to the clearly defined lateral edges which are armed by a narrow and regularly elevated ridge, the costate ridge slightly undulated by a small blunt tubercles, lateral elevated edges slightly higher than slightly elevated suture, declivital disc smooth, shining, impunctate except distinctly punctate in continuation of striae 1 and 2; elytral apex broadly round (nearly straight from dorsal view), armed by a slightly elevated costa. Elytral vestiture of two types, sparse and very long (more than two times longer than distance between the striae punctures) hair-like erected setae and semi-erect half long hair-like setae, setae becoming much longer (approximately double length) and dense laterally and posteriorly and on lateral margins of the declivity; disk of the elytral declivity without setae except sparse uniseriate short stout

oblique setae along the suture, these directed toward the declivital margins (these setae often abraded). **Legs** light brown. Procoxae contiguous, prosternal process narrow, sharply pointed; mesocoxae narrowly separated by distance less than width of scapus, mesoventral process descending, narrow and bluntly pointed; metacoxae separated by twice the width between mesocoxae. Number of tibial socketed teeth on outer lateral margin varying between the specimens: protibiae with 5–7 socketed teeth, mostly 6, meso- and metatibiae with 6 socketed teeth.

Female. **Length** 1.43–1.92 mm (1.70 mm in allotype), 2.60–2.87 times longer than wide (2.62 in allotype). **Head** similar to male, but mandibulae not armed by tooth like processes, frons convex, slightly flattened just above the epistoma, semi-matt, very densely punctato-ganulate, this sculpture becoming more fine on the flattened area, vestiture of golden, rather dense, long, erected hair-like setae becoming gradually longer towards the epistomal margin. Antennal club oval, but shorter than in male. **Elytra** with lateral margins of the elytral declivity slightly less sharply developed.

Etymology. The new species is dedicated to my colleague Jan Batelka, who collected the specimens. Jan Batelka is the leading scientist in taxonomy of the beetle family Rhipiphoridae.

Biology. Specimens were collected from wilting shrubs of *Bupleurum spinosum*, additional specimens were obtained by rearing in the lab. The newly described species is phloeophagous. The gallery system was not studied.

Distribution. Morocco (High Atlas), endemic. Even though the species is suggested as endemic here, it is possible that it may be found in other areas, mainly within Morocco and Algeria, because of the host plant occurrence in neighbouring areas.

***Triotemnus socotraensis* Knížek, sp. n.**

urn:lsid:zoobank.org:act:76EB4C08-A10F-43BF-A279-AEA3C652C85F

Figs 9, 10, 13

Type material. Holotype male, pinned, with labels as follows: “Yemen, Soqotra Is., 10 km W HADIBOH/ 23.xi.-11.xii.2003, 10–70 m [GPS]/ leg. P. Kabátek, ex larve“, 12°39'N 53°57'E; “YEMEN-SOQOTRA/ 2003; Expedition: Jan Farkač, Petr Kabátek & David Král“; “Host plant: *Euphorbia arbuscula*“. Allotype female, pinned: the same data as the holotype. Paratypes: 69 males, 70 females: the same data as the holotype; 7 males, 5 females: “Yemen, Soqotra Is., SUQ E/ env. sand dune, 22.XI.2003, N 12°40'02" E 54°03'45", 20–170 m [GPS]/ leg. P. Kabátek, ex larve“; “YEMEN-SOQOTRA/ 2003; Expedition: Jan Farkač, Petr Kabátek & David Král“; “Host plant: *Acacia pennivenia*“.

Holotype and Allotype deposited in the collection of National Museum in Prague, 147 paratypes in the author's collection, 2 paratypes in Naturhistorisches Museum, Wien, 2 paratypes in Muséum d'Histoire Naturelle, Genève.

Diagnosis. *T. socotraensis* is morphologically very distinct from all other species of the genus due to the very stout body and morphology of elytra. There is no other

known species with such strongly punctate elytral striae and granulato-punctate interstriae. It is also unique by the uniformly dark, nearly black, colour.

Description. Male. Length 1.41–1.89 mm (1.76 mm in holotype), 2.23–3.28 times longer than wide (2.38 in holotype), short and cylindrical, very stout, colour dark brown to black. **Head.** Frons broadly concave up to vertex, slightly flattened transversely above the epistoma, matt, concavity shallowly, but very distinctly and rather densely punctured, whole surface including inside and between punctures strongly shagreened, excavation separated from vertex by a well defined transverse costal ridge, which is somehow undulated due minute blunt tubercles, vertex shagreened; vestiture of sparse, short, semi-erect, golden hair-like setae, these becoming more dense and longer around the insertion of antennae. Eyes rather deeply emarginate on anterior margin, their fronto-dorsal margin slightly protuberant above the costal ridge of excavation of frons. Each mandible with a very long sabre-shaped process directed anteriorly and curved inward, length of each of these processes roughly equal to the length of the antenna. Antennae reddish, antennal funicle 3-segmented, antennal club oval, flattened, anterior side clearly marked by two procurved sutures, basal segment corneous, posterior side marked by two obscure rows of setae displaced apically. **Pronotum** 1.05–1.51 times longer than wide (1.05 in holotype), sub-quadrate, lateral, anterior and posterior margins slightly rounded from dorsal view, widest in the middle of its length, weakly declivous in front, summit not clearly marked, situated approximately in the middle, with a second summit just before the anterior margin, disk matt, of the same appearance as frons, shallowly, but very distinctly and rather densely punctured, punctuation becoming stronger towards pronotal base, granulated between punctures, surface strongly shagreened, impunctate median longitudinal area missing; vestiture of sparse, short semi-erected hair-like setae mixed with two times longer erected hair-like setae, the later becoming more dense and longer towards anterior margin. **Elytra** 1.31–1.91 times longer than wide (1.32 in holotype), 1.25–1.39 times longer than pronotum (1.26 in holotype), parallel on basal three-fourths, than converging to broadly rounded apical margin; base of elytrae rounded, not armed, sometimes a few blunt tubercles present as continuation of interstitial tubercles; scutellum visible, rather small, flush with elytra; elytral striae slightly impressed on elytral disk, deeply and densely punctured, punctures separated by less than the diameter of a puncture, interstriae narrower than striae, punctated and granulated, elytral suture very slightly elevated on the base of elytral declivity. Elytral declivity regularly rounded, of the same appearance as the elytral disk, except striae punctures and interstitial tubercles slightly larger, apical margin not armed, rounded. Elytral vestiture of semi-erect or erect, short, stout, sparse, uniseriate interstitial hair-like setae on the disk and declivity of elytra, their length is shorter than the distance between striae punctures, these setae becoming up to three times longer laterally and posteriorly. **Legs** dark brown. Procoxae subcontiguous, prosternal process narrow, sharply pointed, apically curved downward; mesocoxae broadly separated by distance of twice width of scapus, mesoventral process descending, broad and transversely truncated apically; metacoxae separated by similar distance as mesocoxae. Number of tibial socketed teeth on outer lateral margin varying

between the specimens and between the right and left side. Protibiae with 4–5 socketed teeth, mesotibiae with 5–6 and metatibiae with 5 socketed teeth.

Female. **Length** 1.33–1.89 mm (1.74 mm in allotype), 2.31–2.38 times longer than wide (2.35 in allotype). **Head** similar to male, but mandibulae not armed by tooth-like processes, frons convex, slightly flattened just above the epistoma, semi-matt, sparsely and finely punctate in the middle, punctuation getting very dense near epistoma on flattened area, nearly impunctate on vertex, whole surface shagreened; vestiture of gold, very sparse to missing short hair-like setae on vertex and becoming rather dense and long towards epistoma, anterior side of antennal club marked by two more strongly procurved sutures. **Pronotum** with lateral margins more narrowly converging anteriorly, punctuation of pronotum less distinct, tuberculation stronger.

Etymology. Name of the new species is derived from Socotra – the island of its origin.

Biology. Specimens were collected from wilting shrubs of *Euphorbia arbuscula* (Euphorbiaceae) in Hadiboh and *Acacia pennivenia* (Fabaceae) in Suq, additional specimens were obtained by rearing in the lab. Both host plants are endemic to Socotra. The newly described species is phloeophagous. The gallery system was not studied.

Distribution. Yemen - Socotra, endemic.

***Triotemnus kabateki* Knížek, sp. n.**

urn:lsid:zoobank.org:act:2BDB6B50-80BB-4767-B6A8-99C5F763B37A

Figs 11, 14

Type material. Holotype male, pinned, with labels as follows: “Yemen, Soqotra Is., LAHAS/ (pass), 28.xi.2003, N 12°13'46" E 54°05'26", 69 m [GPS]/ leg. P. Kabátek, ex larva”; “YEMEN-SOQOTRA/ 2003/ Expedition: Jan Farkač, Pter Kabátek & David Král”; “Host plant: *Euphorbia arbuscula*”. Allotype female, pinned: the same data as the holotype. Paratypes: 30 males, 31 females: the same data as the holotype.

Holotype and Allotype deposited in the collection of National Museum in Prague, 57 paratypes in the author’s collection, 2 paratypes in Naturhistorisches Museum, Wien, 2 paratypes in Muséum d’Histoire Naturelle, Genève.

Diagnosis. *T. kabateki* is morphologically distinct from all other species of the genus due to the unique male frons, slim body and small size in both sexes. The most closely related species is *T. pilicornis* Wood, 1992, which also has a conspicuous median spine on vertex. But the spine in *T. pilicornis* is dorso-ventrally flattened and the frons is not squeezed laterally. These species do not overlap in size (*T. pilicornis* is 1.5–2.2 mm long).

Description. Male. **Length** 0.96–1.22 mm (1.15 mm in holotype), 2.74–2.77 times longer than wide (2.67 in holotype), very slim and tiny species. Colour light to dark brown when fully coloured. **Head.** Frons strongly modified, deeply concave vertically, laterally squeezed, shining, smooth, impunctate and without any granules, on the median part of vertex with conspicuous, protuberant, large, pointed horn-like process; vertex semi-shining dorsally, shagreened and rather strongly punctuated near horn-like

process, vestiture of frons of very sparse golden hair-like setae visible only from lateral view, horn-like structure on vertex hidden in long brush of hair-like setae directed straight forward and growing partly from the apex of the horn, but mainly on its dorso-lateral base. Eyes very small and triangle-shaped, placed on the latero-ventral margins of frons. Each mandible with rather long slim but strong sabre-shaped process directed anteriorly and curved in its last third inward, length of each of these processes roughly half of the length of the whole antenna. Epistoma and mandibles somehow protuberant, making the vertical excavation deeper from lateral view. Antennae yellowish, antennae funicle 3-segmented, antennal club oval, flattened, base on anterior side corneous, one transverse suture in the middle, apical half covered by dense setae, posterior side not marked by sutures. **Pronotum** 1.12–1.18 times longer than wide (1.12 in holotype), sub-cylindrical, widest in the middle of its length, lateral margins weakly rounded, frontal and posterior margins broadly rounded, pronotum moderately declivous on anterior third, summit approximately in the frontal third, disk shining, rather sparsely punctuated by coarse punctures, interspaces very finely shagreened, median longitudinal area impunctate; vestiture of sparse semi-erect hair-like setae, more fine than on elytra, becoming longer anteriorly. **Elytra** 1.59–1.63 times longer than wide (1.61 in holotype), 1.46–1.50 times longer than pronotum (1.50 in holotype), parallel on basal four fifths, then broadly rounded to apical margin; base of elytrae rounded, not armed, densely and deeply punctated; scutellum visible, very small, smooth and shining, flush with elytra; basal fifth of elytra very densely punctate and finely granulated, elytral striae not well defined, not impressed, whole elytra irregularly punctured, punctuation less deep than on pronotum, elytral suture very slightly elevated on the declivity. Elytral declivity regularly rounded, very slightly flattened in the continuation of second interstriae. Declivital disc of the same appearance as the elytral disk, but shagreened and semi-matt. Elytral vestiture of very sparse and minute, short, semi-erect, hair-like setae combined with slightly more abundant uniseriate, stout, hair-like erected setae that are approximately two times longer than the shorter setae, the longest becoming much longer postero-laterally, setae missing on the flattened second interstriae on the elytral declivity. **Legs** light brown. Procoxae separated by the width of scapus, prosternal process narrow, bluntly pointed; mesocoxae broadly separated by distance of twice the width of scapus, mesoventral process descending; metacoxae separated as mesocoxae. Number of tibial socketed teeth on outer lateral margin varying between the specimens. Protibiae with 4–5 socketed teeth, meso- and metatibiae with 5–6 socketed teeth.

Female. **Length** 1.00–1.22 mm (1.11 mm in allotype), 2.71–3.34 times longer than wide (2.71 in allotype). **Head** similar to male, but mandibulae not armed by tooth-like processes, frons convex, slightly flattened above the epistoma, shining, very densely punctated on upper part, very minutely punctated on the flattened area, not well defined blunt and shining tubercle-like elevation on vertex; vestiture of golden, sparse, rather long, semi-erect hair-like setae.

Etymology. The new species is named after my colleague Petr Kabátek, who collected the specimens. Among other, Petr Kabátek is the leading scientist in taxonomy and mainly biology of the beetle family Cerambycidae.

Biology. Initial specimens were collected from wilting shrubs of *Euphorbia arbuscula*, endemic plant to Socotra, additional specimens were obtained by rearing in the lab. The newly described species is phloeophagous. The gallery system was not clearly discernable and mined in all directions close to the epidermis.

Distribution. Yemen - Soqotra, endemic.

***Triotemnus yemenensis* Knížek, sp. n.**

urn:lsid:zoobank.org:act:C8251172-B6D1-4287-83C6-06C25D800091

Fig. 12

Type material. Holotype female, pinned, with labels as follows: “SW YEMEN, Wadi Zabid E/ Zabid, N14°09' E43°31' / 325 m, 22. III. 2007/ leg. Petr Kabátek, ex larva“. Paratypes: 1 male, 3 females: the same data as the Holotype.

Holotype deposited in the collection of National Museum in Prague, Paratypes in the author's collection.

Diagnosis. *T. yemenensis* is morphologically readily distinct from all other species of the genus due to the small and stout body form, the very small mandibular teeth in the males, the very shining and sparsely, but strongly punctured pronotum in both sex. It may resemble *T. subretusus* Wollaston, but the latter species is slightly larger, the mandibular teeth are longer, the frons is not clearly punctated in males and is flattened in females, the pronotum is mostly very finely shagreened. Another morphologically similar species, *T. scrofa* Schedl, differs in the same characters and it also has a 3-segmented antennal funicle.

Description. Female. Length 1.26–1.30 mm (1.30 mm in Holotype), 2.50–2.78 times longer than wide (2.50 in Holotype). **Head.** Frons convex, shining, very finely shagreened, densely punctato-ganulate, granulation becoming more fine and dense towards epistoma, vestiture of golden, rather dense, long, erect, hair-like setae becoming more dense towards the epistomal margin. Eyes emarginate on anterior margin around the antennal insertion, rather large. Mandibulae not armed by tooth like processes. Antennae light brown, antennal funicle 4-segmented, antennal club round, rather strongly flattened, anterior side clearly marked by two weakly recurved sutures on anterior half, basal segment mainly corneous, posterior side without visible sutures. **Pronotum** 1.16 times longer than wide, dark brown to black, sub-oval, widest in posterior half, weakly declivous in front, summit not clearly marked, approximately in the frontal third, lateral margins converging anteriorly, frontal and posterior margins rounded, basal angles rounded, disk shining, rather sparsely punctated by coarse punctures except in a smooth median longitudinal area, interspaces finely shagreened, vestiture of sparse, long, semi-erect, very fine, hair-like setae, becoming slightly longer anteriorly. **Elytra** 1.46 times longer than wide, 1.34 times longer than pronotum, light brown, nearly cylindrical, widest just before declivity, broadly, nearly transversely rounded posteriorly; base of elytra rounded, not armed; scutellum visible, very small, blackish, flush with elytra; elytral striae regularly, finely and sparsely punctate, not im-

pressed, interspaces slightly larger than the diameter of the strial punctures, interstriae very sparsely and less deeply punctated, smooth and finely shagreened; elytral declivity regularly rounded at suture, otherwise flattened in the space between suture and third striae up to the weakly defined lateral edges which are slightly elevated, elytral suture very slightly elevated, declivital disc smooth, shining, finely shagreened, microscopically punctate in continuation of the elytral striae. Elytral vestiture of uniseriate rows of two types, sparse and very long (approximately 1.5 times longer than distance between strial punctures) hair-like erect setae and semi-erect shorter (two thirds of the longer setae) hair-like setae, long setae becoming much longer posteriorly on the declivity. **Legs** light brown. Procoxae very narrowly separated, prosternal process short and sharply pointed; mesocoxae separated by slightly more than double width of scapus, mesoventral process broad and broadly rounded apically; metacoxae separated similarly to mesocoxae. Number of tibial socketed teeth on outer lateral margin varying between the specimens. Protibiae with 4–5 socketed teeth, mostly 4, meso- and metatibiae with 5–6 socketed teeth, mostly 5.

Male. Length 1.17 mm, 2.54 times longer than wide. **Head** similar to female, but frons very shallowly concave up to the level just above upper level of the eyes, concavity very finely and sparsely punctate, shining, very finely shagreened, excavation separated from vertex by a rounded and not well defined costa, marked on vertex in the middle by short transverse keel, vertex semi-shining, deeply and rather densely punctate; vestiture of frons of very short and fine semi-erect golden, hair-like setae, these apparently longer near epistoma and on the upper border of the frontal excavation. Each mandible with a very short, strong, wide-based, tooth-like process directed upward.

Etymology. Name of the new species is derived from Yemen – the country of its origin.

Biology. Specimens were collected on wilting shrubs of *Euphorbia* sp. The newly described species is phloeophagous. The gallery system was not studied.

Distribution. Yemen, perhaps endemic.

Acknowledgments

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The Banded Elm Bark Beetle, *Scolytus schevyrewi* Semenov (Coleoptera, Curculionidae, Scolytinae) in North America: a taxonomic review and modifications to the Wood (1982) key to the species of *Scolytus* Geoffroy in North and Central America

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Abstract

In 2003, an Asian bark beetle, *Scolytus schevyrewi* Semenov (Coleoptera: Curculionidae: Scolytinae), the banded elm bark beetle, was detected for the first time in North America. This paper modifies the Wood (1982) key to the species of *Scolytus* Geoffroy to enable identification of *S. schevyrewi* in North and Central America. Variation of diagnostic characters in *S. schevyrewi* is discussed.

Keywords

Scolytus schevyrewi, banded elm bark beetle, exotic species, Scolytinae

Introduction

A growing number of exotic wood boring or wood associated beetles have recently been found to be established in North America (e.g., Hoebeke 1994; Hoebeke 1999; Maier and Lemmon 2000; Vandenberg et al. 2000; Mudge et al. 2001; CFIA 2002; McCullough and Roberts 2002; LaBonte et al. 2005; Haack 2006; Lee et al. 2008). In response to this trend, a multiagency pilot project to detect exotic Scolytinae throughout

the United States was initiated in 2001. This program was initially designated the Exotic Forest Pest Early Detection and Rapid Response Program, but is now known as the Early Detection and Rapid Response program, or EDRR (Rabaglia et al. 2008). Since 2007, the EDRR program has been implemented on a national level under the auspices of the USDA Forest Service and, as of 2009, most states in the U.S. have been participants.

As the cooperating taxonomist for the western states participating in the 2003 EDRR program, specimens from Lindgren funnel traps used in this survey were sent to me for identification. Early samples from the Denver, Colorado, metropolitan area contained several specimens of a species of *Scolytus* Geoffroy unfamiliar to me and that I was unable to key to any species in Wood (1982). I consequently sent specimens to Dr. Stephen L. Wood (deceased), Dr. Donald E. Bright (emeritus, Colorado State University, Fort Collins, Colorado) and Dr. Natalia J. Vandenberg (U.S.D.A., Agricultural Research Service, Systematic Entomology Lab, Washington, DC). These taxonomic authorities determined the specimens to be *Scolytus schevyrewi* Semenov, an Asian species previously unknown from North America. Shortly thereafter, I found specimens of *S. schevyrewi* in samples from Ogden, Utah.

Subsequent trapping found this species to be abundant and clearly established in Denver and Ogden. These data stimulated extensive trapping surveys throughout Colorado and Utah, where it was found at most sites. The realization that *S. schevyrewi* was widely distributed in Colorado and Utah prompted several neighboring states to initiate surveys as well. At the end of 2003, *S. schevyrewi* had been detected in twelve additional states (Negron et al. 2005). By 2008, this supposedly new exotic species had been found from coast to coast in twenty-eight states (with the earliest records from 1994), as well as in southern Canada (Lee et al. 2009). As yet, there are no records of *S. schevyrewi* from Mexico.

Methods

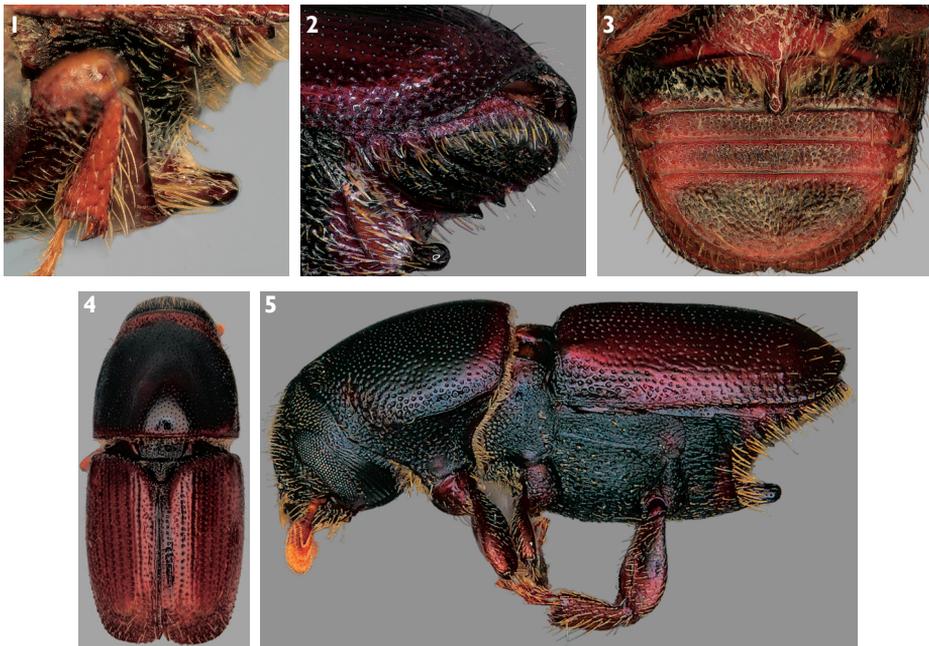
Existing taxonomic treatments for North American *Scolytus* (Bright 1975; Wood 1982; Furniss and Johnson 2002) do not include *S. schevyrewi* as it was unknown from this continent when those were published. Shortly after the detection of *S. schevyrewi* in Colorado and Utah, an image-based aid to the identification of this species was placed on the Purdue University NAPIS (National Agricultural Pest Information Site) website (LaBonte et al. 2003). This aid is more streamlined than the following modifications to the Wood (1982) key and emphasizes the differences between *S. schevyrewi* and *S. multistriatus* (Marsham) because the latter is much more apt to be encountered in surveys than is *S. piceae* (Swaine). However, this early treatment is incomplete as it does not include some diagnostic characters subsequently found nor was the range of variation of some characters recognized.

The diagnostic characters used to differentiate *S. schevyrewi* from other species of *Scolytus* are mainly based on specimens acquired via the EDRR project and a variety of wood boring insect surveillance programs, most funded via the USDA Cooperative Agricultural Pest Survey (CAPS) program. I have examined over 7,600 specimens of *S. schevyrewi* from these surveys.

Distinguishing *Scolytus schevyrewi* from other species of *Scolytus* in North and Central America

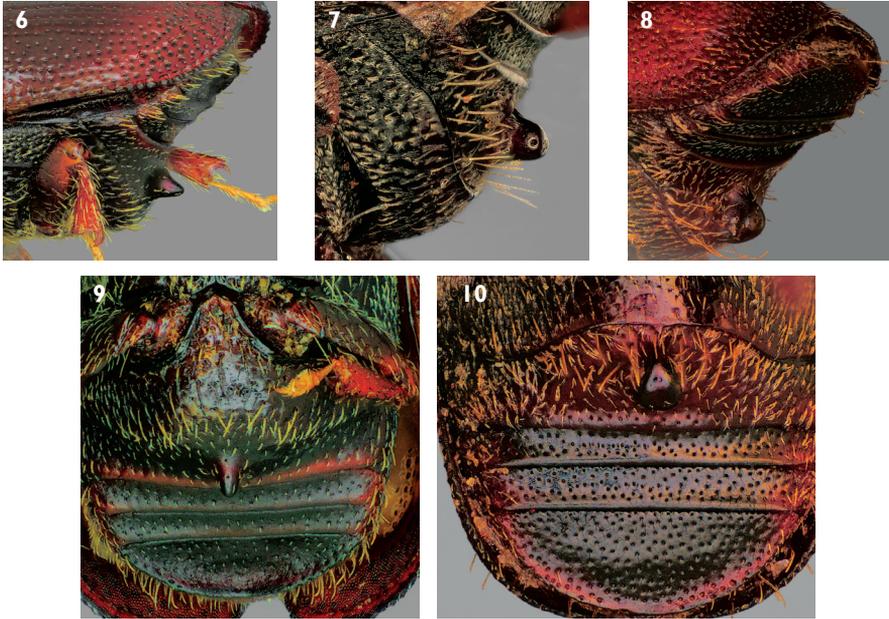
The following modifications to Wood’s (1982) key to the species of *Scolytus* in North and Central America will serve to identify typical specimens of *S. schevyrewi*. Very little of the text in his key remains in the couplets below, other than the distributions, hosts, and size ranges for species dealt with therein. Several characters used in his key to discriminate among these species are not used because they are unnecessary or lead to an unduly cumbersome key, are too variable, or cannot be accurately assessed without reliably identified reference specimens, a resource many users of this key will lack. These characters can include the relative sizes of interstrial and strial punctures, whether the elytral interstriae are impressed, and subtle differences in size among abdominal sternal punctures.

- 8(7). Sternum 2 with base of spine touching its anterior margin (Fig. 1); posterolateral margins of sterna 2–4 each bearing small, distinct, sharply pointed tubercles (those on sternum 4 often obscured by elytra) (Fig. 2); median posterior margin of sternum 1 convex (Fig. 3); elytra unicolorous brown (Fig. 4); British Columbia and Nova Scotia to California and Florida to California and Florida; *Ulmus*; 1.9–3.1 mm (dorsal habitus Fig. 4, lateral habitus Fig. 5)
*multistriatus* (Marsham)



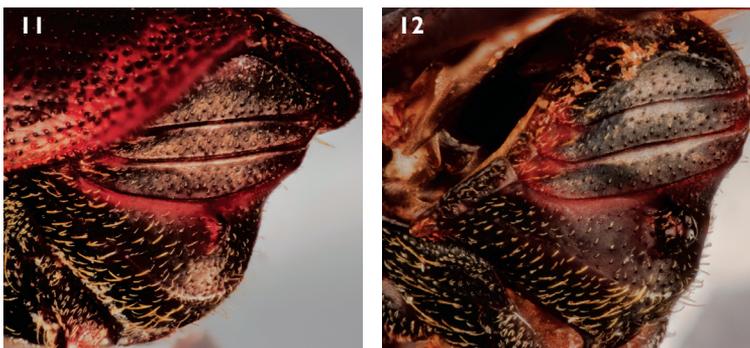
Figures 1–5. 1 Lateral view of spine on abdominal sternum 2 of *Scolytus multistriatus* 2 Lateral view of abdominal sterna of *Scolytus multistriatus*, showing lateral tubercles 3 Ventral view of abdominal sterna of *Scolytus multistriatus* 4 Dorsal habitus of *Scolytus multistriatus* 5 Lateral habitus of *Scolytus multistriatus*.

- Sternum 2 with base of spine remote from its anterior margin (Figs 6, 7); posterolateral margins of sterna 2–4 lacking tubercles (Figs 6, 8); median posterior margin of sternum 1 convex (Fig. 9) or concavely truncate (Fig. 10); in coniferous or deciduous hosts **9**



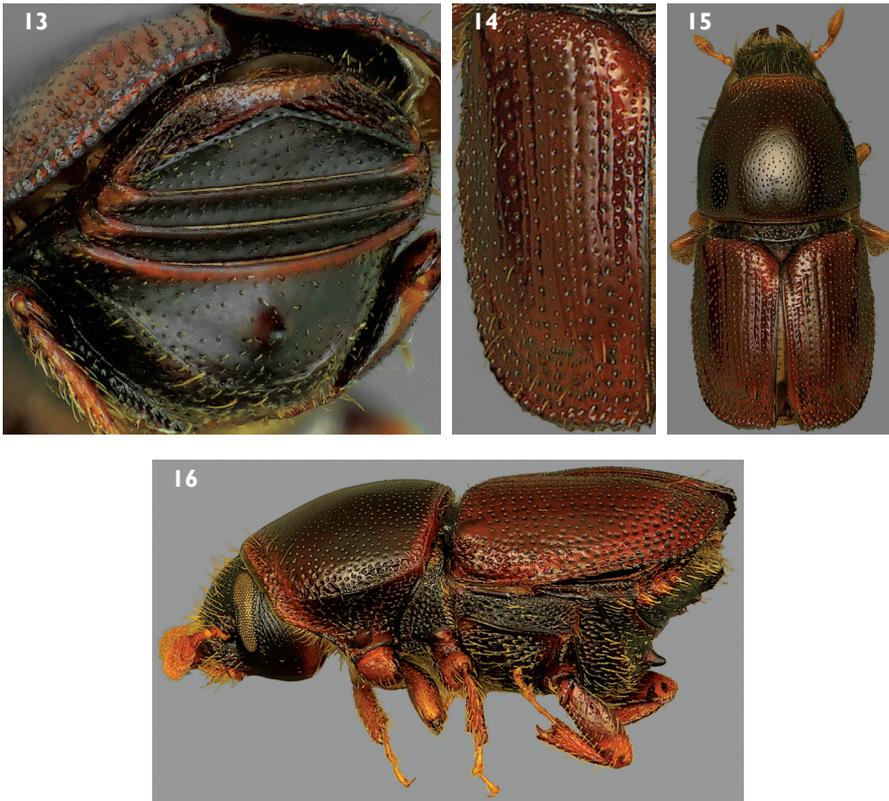
Figures 6–10. 6 Lateral view of abdominal sterna of *Scolytus piceae* 7 Lateral view of abdominal sterna of *Scolytus schevyrewi* 8 Oblique lateral view of abdominal sterna of *Scolytus schevyrewi* 9 Ventral view of abdominal sterna of *Scolytus piceae* 10 Ventral view of abdominal sterna of *Scolytus schevyrewi*.

- 9(8). Spine on sternum 2 with base remote from posterior margin of segment (Figs 6, 7) **9a**
- Spine on sternum 2 in contact with posterior margin of segment (Figs 11, 12)..... **10**



Figures 11–12. 11 Oblique lateral view of abdominal sterna of female *Scolytus unispinosus* LeConte 12 Oblique lateral view of abdominal sterna of male *Scolytus unispinosus* LeConte.

- 9a. Spine on sternum 2 narrowly conical and sometimes pointed at apex in lateral (Fig. 6), ventral (Fig. 9), and apical (Fig. 13) views; median posterior margin of sternum 1 convex (Fig. 9); last abdominal sternum with transverse carinae distant from apex (Fig. 13); elytra unicolorous brown (Figs 14, 15); interstriae not impressed and diameter of interstitial punctures less than those of striae (Fig. 14); pronotum dark with at most very narrow pale banding along anterior and posterior margins (Fig. 15); Alaska and Nova Scotia to California and New York; *Picea* and, rarely, *Larix*; 2.2–2.8 mm (dorsal habitus Fig. 15, lateral habitus Fig. 16)7. *piceae* (Swaine)



Figures 13–16. 13 Posterior view of abdominal sterna of *Scolytus piceae* 14 Dorsal view of left elytron of *Scolytus piceae* 15 Dorsal habitus of *Scolytus piceae* 16 Lateral habitus of *Scolytus piceae*.

- Spine on sternum 2 variable, from almost absent to strongly developed, but most often broadly conical and blunt at apex in lateral view (Figs 17–20), apex often broader than base in ventral view (Fig. 10) and flattened in apical view (Fig. 21); occasional aberrant specimens with a spine on sternum 2 and a second spine on sternum 3 (Figs 22, 23); median posterior margin of sternum 1 emarginate or truncate (Fig. 10); last abdominal sternum with transverse carinae very near apex (Fig. 21); elytra almost always with dark median band, with bases and apices pale (Figs 24, 25) although this band may

be indistinct (Fig. 26); interstriae often impressed and diameter of interstitial punctures subequal to those of striae (Fig. 27); pronotum generally with relatively extensive pale coloration (Figs 24–26); currently known from most of the coterminous states in the U.S.A. (except for the southeastern states) and from southern Canada; deciduous hosts (known only from *Ulmus* in North America); 2.7–4.3 mm (dorsal habitus Figs 24–26, lateral habitus Fig. 28) (not in Wood 1982)..... *schevyrewi* Semenov



Figures 17–27. 17–20 Variation in spine on abdominal sternum 2 of *Scolytus schevyrewi* 21 Posterior view of abdominal sterna of *Scolytus schevyrewi* 22 Lateral view of abdominal sterna of *Scolytus schevyrewi* with two abdominal spines 23 Posterior view of abdominal sterna of *Scolytus schevyrewi* with two abdominal spines 24–26 Dorsal habitus and variation in elytral and pronotal coloration of *Scolytus schevyrewi* 27 Dorsal view of left elytron of *Scolytus schevyrewi*.



Figure 28. Lateral habitus of *Scolytus schevyrewi*.

Diagnostic summary and character variation

Typical specimens of *S. schevyrewi* cannot be easily confused with any other species of *Scolytus* known from North America. The shape and position of the spine on sternum 2 (Figs 7–8, 10, 17–21), especially in males, and typical coloration (Figs 24–26) are unique relative to all other North American species. However, this is a highly variable species and it is advisable to use a suite of characters for its identification. The following elaboration on variation in *S. schevyrewi* is based upon the examination of thousands of specimens of that species and of *S. multistriatus*, the species most apt to be confused with *S. schevyrewi*.

There can be great variation in the shape and position of the spine on sternum 2. Males most often have the spine well developed, with a blunt apex that is broader than the base, appearing triangular in ventral view (Fig. 10). Especially with females, this feature can be variously reduced, becoming almost absent in the most extreme cases (Fig. 20). Reduction of the spine can lead to possible confusion with specimens of *S. multistriatus* that have malformed or broken spines, which are not uncommon in large series thereof. However, as indicated previously, in *S. schevyrewi*, the base of the spine on sternum 2 is remote from the anterior margin, almost at the center, whereas in *S. multistriatus* the base of the spine is in contact with the anterior margin. Some *S. schevyrewi*, especially those with larger spines, can have the base of the spine positioned anterior of the center of sternum 2, compounding the possibility of confusion with aberrant *S. multistriatus*. Inadequately cleaned *S. multistriatus* may have debris under the base of the spine, which can make its lateral appearance broader than is the case. An extreme example of abdominal spine variation in *S. schevyrewi* is exhibited in a male from California (courtesy of R.L. Penrose, California Department of Food and Agriculture) (Figs 22, 23). In this instance, a second, accessory, sharply conical spine is present on the third abdominal sternum. This spine is asymmetrically positioned (Fig. 23), leading to my conclusion that this specimen represents a developmental aberration.

tion rather than a different species. In all other respects, this specimen appears to be a typical *S. schevyrewi*.

The elytron of a normal *S. schevyrewi* is distinctively colored, with a variably developed median dark band and the base and apex distinctly pale (Figs 24, 25). This character enables rapid identification of this species as no other North American species has this color pattern. The dark median band is best observed in well dried specimens; it can be obscured in specimens still damp from collecting in liquid or storage in alcohol. However, there are occasional specimens with apparently unicolorous dark or pale elytra (Fig. 26). Some samples exhibited higher proportions of these unicolorous specimens, but probably less than 10%. The existence of individuals with concolorous elytra dictates caution in complete reliance upon color for identification of *S. schevyrewi*, as both *S. multistriatus* and *S. piceae* normally have concolorous elytra. Some *S. multistriatus* also have elytra with dark apices and bases, with pale median areas.

The pronotum of a typically colored *S. schevyrewi* is also distinctively colored, with relatively extensive areas of pale coloration (Figs 24–26). The extent of the pale areas is highly variable. The most common pattern is a fairly broad pale band along the posterior margin with a somewhat narrower pale band along the anterior margin (Figs 24, 25). Many specimens have the pale coloration extending from the posterior margin into the median area (Fig. 26). This pale coloration can sometimes cover almost the entire dorsum of the pronotum. On the other hand, in some specimens the pronotum is essentially completely dark, with only hints of anterior and posterior pale marginal banding. The extent of pale pronotal coloration appears independent of the size and extent of the median dark elytral band and the darkness of the ground color of the elytra. Several of the specimens of *S. multistriatus* I've examined have large, nebulously paler areas in the median area of the pronotum. As with elytral coloration, pronotal coloration should be used with some caution to distinguish *S. schevyrewi* from *S. multistriatus* and *S. piceae*.

As indicated in the key, specimens of *S. schevyrewi* average larger than either *S. multistriatus* or *S. piceae*. However, small *S. schevyrewi* fall within the size range of both of the other species. Furthermore, large *S. multistriatus* approach the size of average or even large *S. schevyrewi*.

Specimens of *S. multistriatus* have distinct, pointed tubercles or “teeth” on the posterior lateral margins of sterna 2–4 (Fig. 2). Specimens of *S. piceae* and *S. schevyrewi* lack this feature (Figs 6, 8). This character is occasionally obscured in specimens of *S. multistriatus* swollen with liquid preservatives, but it can normally be observed by examining the lateral margins of the sterna from an oblique perspective.

The posterior margin of sternum 2 is distinctly truncate or slightly emarginate in almost all *S. schevyrewi* examined (Fig. 10). On the other hand, in *S. multistriatus* (Fig. 3) and *S. piceae* (Fig. 9) the posterior margin of sternum 2 is normally slightly to pronouncedly convex and in *S. multistriatus* is often slightly produced at the base of the spine (Fig. 3).

The elytron of a *S. schevyrewi* specimen in good condition typically displays three rows of relatively stout, long, discal setae that are about twice as long as the width of

the elytral intervals (Figs 24–26). The elytra of most *S. multistriatus* lack distinct rows of discal setae, although there are generally setae at the elytral apices and there may be discal setae (Fig. 4). If discal setae are present, they are generally scattered, are less stout than those of *S. schevyrewi* and are shorter, about as long as the width of the elytral intervals. Of the small series of *S. piceae* examined, most lacked discal setae (Fig. 14). A few specimens had a row of 3 or 4 discal setae on interval 7, but these setae were short and fine, similar to those of *S. multistriatus*.

On visible abdominal sterna 3–5, the setae of *S. schevyrewi* are short and recumbent (Figs 8, 10). Those of *S. piceae* are even shorter, often difficult to discern, and are also recumbent (Figs 6, 9). In contrast, specimens of *S. multistriatus* often have long, semi-erect setae on these sterna, especially on sternum 5 (Figs 2, 3).

In summary, a suite of characters is best used to reliably identify *S. schevyrewi*. Especially with regard to *S. multistriatus*, these include (more or less in order of reliability and ease of assessment) the shape and position of the spine on sternum 2, normal elytral and pronotal coloration, the absence of lateral teeth on sterna 2–4, average size, the truncate or slightly emarginate posterior margin of sternum 2, relatively abundant and large discal elytral setae, and short, recumbent setae on sterna 3–5.

Discussion

The U.S. specimens collected prior to 2003, along with the extensive U.S. distribution of *S. schevyrewi* and its great abundance in many areas, provide ample evidence that this exotic species is not new to the U.S. but is instead a legacy species that has been present for decades. Such legacy species, e.g., *Xyleborinus alni* (Niisima) (Mudge et al. 2001; LaBonte et al. 2005; Hoebeke and Rabaglia 2007), are probably more often the norm for newly detected exotic wood boring insects than otherwise. This is a consequence of the current surveillance technology, the limited survey efforts of the past, and the limited taxonomic expertise available to deal with the many thousands of specimens generated by current surveys.

There are profound taxonomic challenges presented by the remaining pool of undetected legacy species, truly newly introduced exotics, and the onslaught of continued new introductions as a consequence of global trade. Almost all existing taxonomic works for scolytines in North America, let alone other taxa of wood boring or wood associated insects, quite reasonably treat only those species previously known from this continent. The taxonomic infrastructure available to support surveillance for a wide spectrum of exotic wood borers has been eroding for decades and may have declined below critical and self-sustaining levels. New technologies, such as extended depth of field macroscopy and LUCID™ go far to bridge this taxonomic impediment, e.g., a recent guide to the North American Siricidae (Schiff et al. 2006). Nonetheless, exotic wood boring insects, such as *S. s. schevyrewi*, will continue to evade recognition and detection unless substantial funds and resources are devoted to expanding our taxonomic base.

Acknowledgements

Stephen L. Wood identified the first EDRR specimens of *S. s. schevyrewi*. He was also very generous with his time with regard to identifications of other challenging scolytines. North American Scolytinae taxonomy would be unrecognizable without his contributions. I will sorely miss him.

Donald E. Bright, who has also contributed mightily to North American scolytine taxonomy, confirmed Dr. Wood's identification of the initial EDRR specimens of *S. schevyrewi*. I am very grateful to him for his generosity and taxonomic support. Natalia J. Vandenberg also confirmed Dr. Wood's initial identification.

My long-suffering friends and colleagues, E. Richard Hoebeke and Robert J. Ragaglia, reviewed many versions of this manuscript and offered much valuable advice to improve it, as well as relentless prodding me to complete it. Several of my ODA colleagues, especially Joshua A. Vlach, provided valuable insights as well.

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I could not have recognized the significant characters and intraspecific variability of *S. schevyrewi* without the extensive set of specimens provided to me through surveys supported through, and in many cases conducted by, USDA APHIS-PPQ and Forest Service. These surveys were also often conducted by colleagues in state agencies of agriculture and forestry, including many of my local colleagues of the Oregon Department of Agriculture.

Last, but certainly not least, my profound thanks to the Oregon Department of Agriculture for use of our wonderful extended depth of field imaging system and the exemplary talents of Steven A. Valley, who acquired the marvelous images used in this paper.

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First records of *Xyleborinus octiesdentatus* (Murayama) (Coleoptera, Curculionidae, Scolytinae) from North America

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Abstract

Xyleborinus octiesdentatus (Murayama), an ambrosia beetle native to Asia, is reported for the first time in North America based on specimens from Alabama and Louisiana. This is the twenty-first species of exotic Xyleborina documented in North America. A re-description of the female and a key to the four North American species of *Xyleborinus* are presented.

Keywords

Coleoptera, Curculionidae, Scolytidae, Xyleborina, *Xyleborinus octiesdentatus*, new North American record, exotic species

Introduction

In 1977, Steve Wood documented the introduced and exported North and Central American scolytines known at that time (Wood 1977). He also pointed out that many of the recent introductions into North America were species with sib-mating systems (Wood 1982). Since then there have been many papers citing the numerous species and increasing rate of introductions of non-native scolytines into North America. The

number of non-native scolytines known to be established in North America has more than doubled since 1977. Whereas more than half of the species reported prior to 1977 were in the twig and seed infesting genera *Hypothenemus* and *Coccotrypes*, most of the recently established species are ambrosia beetles (Hoebeke and Rabaglia 2008, Rabaglia et al. 2009).

Ambrosia beetles in the Xyleborina are commonly transported in dunnage and crating, and readily establish in new environments due to their cryptic nature and sib-mating behavior (Wood 1982, Atkinson et al. 1990, Brockerhoff et al. 2006). Since 1980, there have been 13 non-native xyleborines found to be established in North America. As of 2009, there were 42 species of Xyleborina known from north of Mexico, and 21 of these are non-native (Rabaglia et al. 2006; Hoebeke and Rabaglia, 2008; Rabaglia et al. 2009; Okins and Thomas 2010). This paper reports the first occurrence of the 22nd non-native xyleborine, *Xyleborinus octiesdentatus* (Murayama), documented from North America, provides a key and description for its identification, and presents recent collection and taxonomic data.

The USDA Forest Service has been pilot testing and later implementing on an operational basis, an early detection and rapid response (EDRR) project for bark and ambrosia beetles since 2001 (Rabaglia et al. 2008). This project utilizes Lindgren funnel traps (Lindgren 1983) and lures which target non-native scolytines that are at high risk of introduction into the United States. As part of this project, in 2008 a study was conducted on the Kisatchie National Forest near Winnfield, Louisiana to determine the effects of lure release rates on beetle response. On April 24, 2008 a sample containing an unidentified xyleborine ambrosia beetle was collected, and images were sent to RJR. The beetle was recognized as a new, non-native species and images were forwarded to MK who suggested it was identical with *Xyleborinus octiesdentatus* (Murayama, 1931). The identification was then confirmed by RJR after comparison with Murayama's type specimen of at the US National Museum. This was the first record of this species in North America. An additional specimen was collected on August 14, 2008 in Vance, Alabama also as part of the EDRR project. In 2009, WJ collected additional specimens on the Kisatchie National Forest as part of a delimiting survey in Louisiana. Further collection details are in the Distribution section below.

Systematics

The Xyleborina (Xyleborini *sensu* Wood and Bright, 1992) is a large and complex group containing more than 1,200 species. Until Wood's (1986) reclassification, most species in the tribe were placed in the polyphyletic genus *Xyleborus*. Recent molecular (Jordal 2002) and morphological (Hulcr et al. 2007) methods have helped create a more stable classification (Hulcr and Cognato 2009). The genus *Xyleborinus* was established by Reitter (1913), and has at times been considered a synonym of *Xyleborus*. Since Wood (1986), it has been recognized as a distinct genus. The main character used

to distinguish the two genera is the somewhat hidden, conical scutellum in *Xyleborinus* and the visible, flat scutellum in *Xyleborus*.

Most publications on *Xyleborinus octiesdentatus*, including the original description from Korea by Murayama (1931), placed it in *Xyleborus* (Murayama 1934, Yin et al. 1984, Nobuchi 1985, Wood and Bright 1992). A study by R. A. Beaver (pers. comm.) and MK of Murayama's type collection at the US National Museum in 2003 indicated that the species should be placed in *Xyleborinus* (Beaver et al. 2008)

***Xyleborinus octiesdentatus* (Murayama, 1931: 46)**

Figs 1, 2 and 3

Diagnosis. Specimens of *X. octiesdentatus* can be easily distinguished from other members of *Xyleborinus* occurring in North America by the sulcate shape of the elytral declivity, and the elevated lateral declivital margins which bear four pairs of long, narrow, sharply pointed spines, increasing in length approaching the posterior margin.

Revised Key to *Xyleborinus* in America north of Mexico

The following key, modified from the key to *Xyleborinus* in Rabaglia et al. (2006), will enable the identification of the five species of *Xyleborinus* known from America north of Mexico. It includes the recently established *X. andrewsi* in Florida (Okins and Thomas 2010).

- 1. Posterior margin of elytra strongly convergent ***X. andrewsi* (Blandford)**
- Posterior margin of elytra broadly rounded **2**
- 2(1). Declivital interstriae 1 with small granules, 1 and 3 equally, weakly elevated.. **3**
- Declivital interstriae 1 without granules and not elevated **4**
- 3(2). Granules on declivital interstriae 1 and 3 larger, those on 3 pointed, spine-like, slightly incurved; granules on ventrolateral area large, sharply pointed, spine-like, curved slightly downwards and to the suture; declivital interstriae 2 flattened; 2.5–2.8 mm ***X. alni* (Niisima)**
- Granules on declivital interstriae 1 and 3 smaller, obtusely pointed; granules on ventrolateral areas small, less pointed; declivital interstriae 2 slightly impressed; 2.0–2.4 mm..... ***X. saxesenii* (Ratzeburg)**
- 4(2). Declivity flattened, declivital interstriae 3 slightly elevated with 3 pairs of small denticles, the pair near the posterior margin largest and often blunt; 1.6–1.9 mm..... ***X. gracilis* Eichhoff**
- Declivity sulcate, declivital interstriae 3 strongly elevated with 4 pairs of long, narrow, pointed spines increasing in size approaching posterior margin, 2.1–2.4 mm..... ***X. octiesdentatus* Murayama**



Figure 1. Lateral view of *Xyleborinus octiesdentatus* adult female.

Description. The species was redescribed by Nunberg (1982)

Female. Length 2.1–2.4 mm (from anterior margin of pronotum to posterior margin of elytra, excluding spines), 2.5× as long as wide; color brown to dark brown, matt. Frons convex, strongly reticulate, with large, shallow, rather dense punctures. Antennal club round with two round sutures on its anterior side and one strongly apically displaced suture on posterior side. Pronotum cylindrical, 1.2× as long as wide, frontal edge broadly rounded bearing small tubercles as continuation of very fine asperities on anterior half, posterior half finely shagreened, with minute, shallow punctures. Scutellum typical for the genus, conical, visible between the emarginated bases of the elytra. Elytra cylindrical 1.5× as long as wide, 1.3× as long as pronotum, side straight on anterior half, narrowed on posterior half; striae on the disk very shallowly impressed, regularly and rather densely punctured; interstriae flat, finely and regularly punctured; interstriae 1, 2 and 3 with small tubercles just before the upper margin of the declivity. Elytral declivity long, nearly from the middle of elytra, sulcate, sutural interstriae weakly elevated on upper part, not elevated below, without granules; lateral edges formed by strongly elevated continuation of 3rd interstriae, which bears four pairs of long, narrow, posteriorly directed sharply pointed spines, which increase in length approaching posterior margin, the last two pair exceeding outline of the elytral edge; several small, fine spines on the lateral raised margin of declivity. Vestiture consisting of moderately long, fine setae in uniseriate rows on interstriae, longer on declivity. Legs yellowish, brown.

Male. Not examined.

Distribution. China, Japan, South Korea (Wood and Bright 1992). United States (all records new to North America, numbers of specimens collected at each location shown in parentheses.): ALABAMA, *Tuscaloosa County*: Vance, 14 August

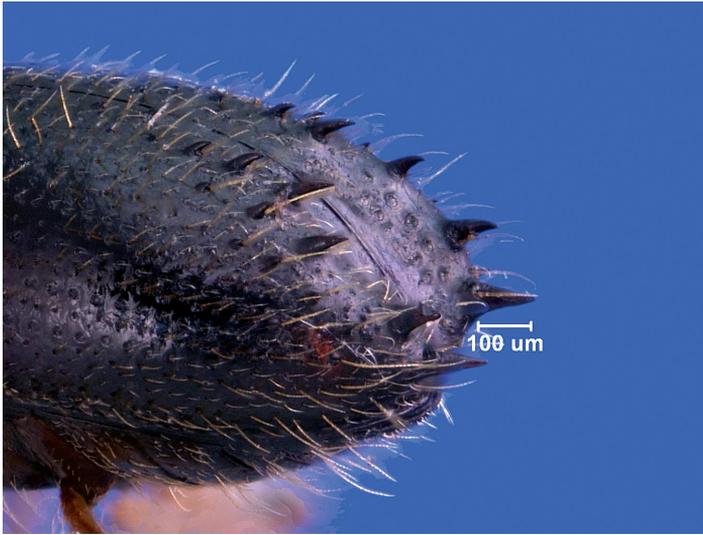


Figure 2. Declivity of *Xyleborinus octiesdentatus* adult female.

2008, ethanol-baited funnel trap (1); LOUISIANA, *Winn Parish*: Kisatchie National Forest, 6 miles w. of Winnfield, 24 April 2008, α - β -pinene (70:30) and ethanol-baited funnel trap (1); 23 March 2009, α - β -pinene (70:30) and ethanol-baited funnel trap (3), ethanol-baited funnel trap (3), phoebe oil-baited funnel trap (2) ; 9 April 2009, α - β -pinene (70:30) and ethanol-baited funnel trap (1); ethanol-baited funnel trap (2); 21 April 2009, α - β -pinene (70:30) and ethanol-baited funnel trap (7), ethanol-baited funnel trap (4); 29 April 2009, α - β -pinene (70:30) and ethanol-baited funnel trap (3), ethanol-baited funnel trap (6); phoebe oil-baited funnel trap (2); 21 May 2009,: α - β -pinene (70:30) and ethanol-baited funnel trap (1); 3 June 2009, trap on girdled yaupon (14); 9 June 2009,: trap on girdled yaupon (3); 15 June 2009, trap on girdled yaupon (3); 14 July 2009, trap on girdled yaupon (2); 4 August 2009,: trap on girdled yaupon (2). All specimens collected in North America are females.

Biology, habits, and host. In its native Asian range, the known hosts for *X. octiesdentatus* are *Carpinus laxiflora* (Siebold and Zuccarini) Blume (Corylaceae), *Cleyera* sp., *Eurya japonica* Thunberg (Theaceae) and *Illicium religiosum* Siebold (Illiciaceae) (Wood and Bright 1992), and *Illex rotunda* Thunberg (Aquifoliaceae) (Murayama 1934).

Although this species is certainly established in the Winnfield area of Louisiana (Winn Parish) and probably in Alabama (Tuscaloosa Co.), it has not been collected from any host trees. In May, 2009, on the Kisatchie National Forest, *Ilex vomitoria* Aiton (yaupon), *I. opaca* Aiton (American holly) (Aquifoliaceae) and *Carpinus caroliniana* Walter (ironwood) (Corylaceae) were girdled and a sticky band placed on the trees to act as attractant/trap trees for the beetle. These species were selected because known hosts of the beetles belonging to these genera occur in Asia. During the month following this treatment 27 specimens were collected on the sticky band on the girdled



Figure 3. Scutellum of *Xyleborinus octiesdentatus* adult female.

yaupon whereas no specimens were collected from the other species. No specimens of *X. octiesdentatus* were found boring into the yaupon tree.

The impact *X. octiesdentatus* will have in North America is still uncertain. All species of xyleborines carry symbiotic ambrosia fungi that are usually benign to hosts in their native range. However, as recently discovered with *Xyleborus glabratus* Eichhoff, 1877, another ambrosia beetle introduced from Asia, certain ambrosial fungi may prove to be very pathogenic on new, novel hosts in North America (Fraedrich et al. 2008). Future studies with *X. octiesdentatus* will attempt to identify fungal associates, and test their pathogenicity against North American host trees.

Acknowledgements

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Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe

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Abstract

Invasive bark beetles are posing a major threat to forest resources around the world. DAISIE's web-based and printed databases of invasive species in Europe provide an incomplete and misleading picture of the alien scolytines and platypodines. We present a review of the alien bark beetle fauna of Europe based on primary literature through 2009. We find that there are 18 Scolytinae and one Platypodinae species apparently established in Europe, from 14 different genera. Seventeen species are naturalized. We argue that *Trypodendron laeve*, commonly considered alien in Europe, is a native species; conversely, we hypothesize that *Xyleborus pfeilii*, which has always been treated as indigenous, is an alien species from Asia. We also point out the possibility that the Asian larch bark beetle *Ips subelongatus* is established in European Russia. We show that there has been a marked acceleration in the rate of new introductions to Europe, as is also happening in North America: seven alien species were first recorded in the last decade.

We present information on the biology, origins, and distributions of the alien species. All but four are polyphagous, and 11 are inbreeders: two traits which increase invasiveness. Eleven species are native to Asia, six to the Americas, and one is from the Canary Islands. The Mediterranean is especially favorable for invasives, hosting a large proportion of the aliens (9/19). Italy, France and Spain have the largest numbers of alien species (14, 10 and 7, respectively). We point out that the low numbers for at least some countries is likely due to under-reporting.

Finally, we discuss the difficulties associated with identifying newly invasive species. Lack of good illustrations and keys hinder identification, particularly for species coming from Asia and Oceania.

Keywords

Invasive species, ambrosia beetles, polyphagy, inbreeding, *Ambrosiodmus*, *Ambrosiophilus*, *Coccotrypes*, *Cyclorhipidion*, *Dactylotrypes*, *Dryocoetes*, *Gnathotrichus*, *Hypocryphalus*, *Hypothenemus*, *Phloeosinus*, *Phloeotribus*, *Megaplatypus*, *Monarthrum*, *Xyleborinus*, *Xyleborus*, *Xylosandrus*

Introduction

The great British ecologist Charles Elton presciently referred to the effect of invasive species as “one of the great historic convulsions in the world’s fauna and flora” (Elton 1958). Enormous damage is done by nonindigenous species to ecosystems and economies (e.g. Vitousek et al. 1997, Pimentel et al. 2005, Colautti et al. 2006, Asner et al. 2008), and introduced species are considered the biggest threat to biodiversity after habitat destruction (Wilson 1992). Though the ecological and economic effects of many immigrant species are minor, some immigrant species can significantly impact the functional properties of ecosystems, disrupt food webs, displace indigenous species, or threaten food and water supplies (Kenis et al. 2009). In some cases, it is the activities of the organism itself which have these effects, but in others, such as Dutch Elm Disease, it is the microorganisms they bear in or on them (e.g. Humble and Allen 2006).

Introduced wood-borers are a major concern to regions with significant forest resources. Around the world, dozens if not hundreds of alien phytophagous insects become established every decade, and wood-borers make up a significant proportion of these (Haack 2001, 2006, Work et al. 2005, Mattson et al. 2007). Steve Wood first drew attention to the accelerating rate of introductions of bark beetles and pinhole borers (Curculionidae: Scolytinae, Platypodinae) starting with a brief article in 1977 and subsequently re-visited the topic in each of his major synoptic works (Wood, 1977, Wood 1982, Wood and Bright 1992, Wood 2007). Supplements to the world catalog also express worries over the rapidly increasing list of established alien species (Bright and Skidmore 1997, 2002). In 1995, concerned about the growing problems with identifying exotic bark beetles, Robert Haack (USDA Forest Service) and European and Asian plant protection specialists finally convinced Steve (then six years retired!) to commence work on what would be his last great achievement, the monograph of the Scolytinae of South America (Wood 2007).

There has been over three decades of discussion of the problems posed by introduced bark beetles. Steve Wood’s 1977 paper was developed from a talk given at the XIVth International Congress of Entomology in 1972. Both this and the subsequent treatment of the topic in the introductory material of the 1982 monograph (pages 25–27) were from an American point of view: which species have been introduced to the Americas, and which North, Central or South American species have become established in Europe.

With respect to exotic wood-boring insects, for North America, much is known about which invasive species are present and where (Haack 2001, 2006). We know

much less about the numbers and distributions of alien species in Europe. In Wood's 1982 treatment, only *Gnathotrichus materiarius* had been introduced from the Nearctic to Europe, and a recent paper (Mattson et al. 2007) operated with only five species – less than a third of the total which we report here. There are no previous reviews on the topic, and databases which have been established specifically to inform the public and policy makers about alien species in Europe are riddled with errors and incomplete (at least with regard to Scolytinae and Platypodinae).

There are two sources of newcomers to a fauna: species originally from distant regions or other continents, and those from the same region or continent which are expanding or shifting their ranges. We consider here only established species immigrant to continental Europe. Within-Europe range expansions are of interest in themselves, but ecologically and evolutionarily are a distinct phenomenon from that of the establishment of truly exotic species. We will use the term 'alien species' here in the sense of alien to Europe, originating outside the bounds of continental Europe.

Methods

Terminology. The terminology of invasion biology is much disputed (e.g. Frank and McCoy 1990, Colautti and MacIsaac 2004, and their references), so we find it prudent to define ours. We use the terms *exotic*, *alien*, and *non-indigenous* interchangeably, to refer to species whose native distributions lie outside of continental Europe, our reference point. We use *invasive* broadly to refer to alien species which have established self-sustaining populations, irregardless of whether in natural or man-made habitats; we do not use it in the restricted sense of species having known ecological or economic effects. *Introduced* is sometimes used to refer to deliberate introductions (Frank and McCoy 1990), but we use it more broadly to indicate spread by human-mediated transport (regardless of intent), and we use *immigrant* and the collective term *adventive* synonymously. *Naturalized* refers to aliens with free-living, self-sustaining populations.

While we adopt the same definition of *Europe* used in DAISIE and Fauna Europaea, we exclude the Macaronesian islands, preferring to focus on continental Europe (including Ireland and the United Kingdom). Consequently, we consider the Canary Island endemic *Dactylotrypes longicollis* to be alien to Europe, and we do not treat the alien species found on the Azores (Bright 1987) but not elsewhere in Europe.

For brevity, in taxonomic contexts, we use *bark beetle* to include both Scolytinae and the closely related Platypodinae. *Ambrosia beetles* cultivate symbiotic fungi on the walls of their tunnel systems, which fungi are the sole food of larvae and adults. All Platypodinae are ambrosia beetles, as are many genera of Scolytinae.

Sources of data. Our starting point for listing alien bark beetles was the European database for alien organisms DAISIE (Delivering Alien Invasive Species Inventories for Europe). The DAISIE project encompasses over 11,000 species of all types of or-

ganisms, and is meant to be a central clearing house for information on biological invasions in Europe, and the database is continually updated. The geographic and taxonomic information in DAISIE is intended to play a key role in future national and international efforts to monitor and combat the spread of harmful non-native organisms. This information comes in two forms, the web-based database (DAISIE 2009a) and in lists in the recently published handbook of alien species (DAISIE 2009b).

In addition to the DAISIE website, we consulted NOBANIS (The North European and Baltic Network on Invasive Alien Species), a “Gateway to information on invasive alien species in North and Central Europe”. For further distributional data on scolytine and platypodine beetles in Europe we employed Fauna Europaea (Knížek 2004), the definitive database for scientific names of animals in Europe (native and non-native). These are the primary online resources available to the public, and likely the primary sources of information on European alien bark beetles outside of the scientific literature.

We also searched ISI Web of KnowledgeSM (and Internet more generally), but quickly found that almost none of the literature on alien bark beetles can be found by searching the web. The sources for the data in DAISIE are not given. To investigate the validity of the records available in the online databases, we searched the literature at our disposal, including the world catalog for bark beetles (Wood and Bright 1992), general works on the bark beetle fauna of Europe, country treatments, and papers with individual species records. We also availed ourselves of the generous advice and information from colleagues throughout Europe (see Acknowledgments), and of personal knowledge.

Treatments of data. We have attempted to classify the phase of establishment of each species (Table 1), given the collection localities and dates which are available in the literature. Phases range from Phase 1 (newly collected or intercepted, no evidence of establishment) to Phase 5 (apparently distributed throughout currently suitable habitat in Europe). (Since this paper focuses on aliens for which there is evidence of establishment, we do not treat species which are in Phase 1.) We did not feel that enough was known about alien bark beetle populations (in particular, about local abundances) to apply the Stages system of Colautti and MacIsaac (2004), but acknowledge its value.

Problems with data quality. As we quickly discovered to our dismay, literature documenting the discovery and spread of alien species is scattered and mostly published in obscure and difficult to obtain journals and newsletters, in a bewildering variety of languages: few of these publications are peer reviewed and almost none indexed in ISI Web of KnowledgeSM. Much of the knowledge of new discoveries seems to have been transmitted by word of mouth, in Europe.

Adding to the confusion is the fact that old names die hard. Much of the literature on introduced species promulgates names used in the original papers but which are no longer used. This is especially true of review papers and invasive species databases.

Many articles lack information on who identified the specimen(s) and what criteria were used. New locality records (even country records) seem to occasionally be based

Table 1. The population phases which we apply to alien species in Europe.

Stage	Population level in Europe	Examples of evidence (not exhaustive)
Phase 1	Interception, recently arrived (no evidence of establishment)	Collected from imported plant material; trapped at port or near imported logs; unique, old literature records
Phase 2	local colony persisting	One area: many specimens; repeated collections; collections in natural forests far from ports of entry
Phase 3	>1 colony, not spreading.	Disjunct populations, but no sign of expanding
Phase 4	more than one large colony, spreading	Disjunct populations: Well established in several areas and still spreading
Phase 5	established throughout suitable habitats	Distributed throughout region with currently suitable climate and host plants

on similarity with a species which is known to be in nearby countries, or based on old, incomplete keys; both methods can easily lead to mistakes in difficult taxa, such as *Hypothenemus* or *Coccotrypes*, which only experienced specialists can identify with any degree of confidence. Almost never is information on the deposition of voucher specimens stated; to confirm the identity of the species, one must try to find and contact an author in order to locate specimens.

Results and discussion

Which alien species are established in Europe?

The species present. There are 19 alien species established in continental Europe, according to our sources (Table 2). One of these, *Megaplatypus mutatus*, is a platypodine; the remainder are scolytines. Of these 19, we classify 14 as potentially expanding (Phases 2 – 4), 5 as probably currently spreading (Phases 3 – 4). All but one are considered naturalized: *X. morigerus* is not known to have established populations in the wild, but seems to have a permanent presence in European greenhouses.

Nine of our 19 species are not classified as established aliens in DAISIE. We explain their inclusion here briefly. Five on our list are classified by DAISIE as “status unknown”. In two, this is probably due to simple “coding errors”: there is no doubt that widely distributed species as (1) *C. bodoanum* and (2) *H. eruditus* are well-established aliens. That three more restricted species are established aliens is less widely known. (3) *Phloeosinus rudis* was collected in 1940 from *Thuja japonica* branches in St. Tropez (Hoffman 1942), suggesting that there was a breeding population in France at that time. The fate of this colony is not known, nor are there any subsequent records of the species from France. However, this species along with *P. aubei* (a Mediterranean species with similar biology) have recently been reported killing ornamental *Thuja occidentalis*, *Chamaecyparis* and *Juniperus chinensis* in the Netherlands (Moraal 2005, 2006). (4)

Table 2. The alien Scolytinae and Platypodinae of Europe, and the countries in which they are established. First: first record or first publication. Phase: phase of colonization, see Table 1.

Species	Established in countries	First	Phase	Notes, References
* <i>Ambrosiodmus rubricollis</i> (Eichhoff)	IT	2008	2	Faccoli et al. 2009.
* <i>Ambrosiophilus atratus</i> (Eichhoff)	IT	2007	2	Faccoli 2008, locally established.
<i>Coccotrypes dactyliperda</i> (Fabricius)	ES, FR, GR, HU (cultivated palms), IT, MA	1884	5	First mention is Eichhoff 1878 and 1881, also in Reitter 1913: from shops with imported dates and betelnut—no mention of established populations in Europe. ES, Garcia-Tejero 1955, definitely well established along coast. FR, Balachowsky 1949, common along coast. GR, Vasilaina-Alexopoulou et al. 1986, established. HU, György and Podlussány 2005, apparently in cultivated palms. IT, Targioni-Tozzetti 1884, established in Tuscany (earliest European record). MA, Mifsud and Knižek 2009. This species is widespread in N Africa.
* <i>Cyclorhipidion bodoanum</i> (Reitter)	BE, CH, DE, FR, IT, NE	1960	4	BE, Henin and Nageleisen 2005. DE, CH, Köhler 1992. DE, FR, Schott and Callot 1994, Bense and Schott 1995, Schott 2004 (as <i>Xyleborus peregrinus</i>). First record Alsace, 1960. IT, Audisio et al. 2008. NE, Vorst et al. 2008. AT: Knižek 2004 and DAISIE. But according to Hannes Krehan, Austrian Inst. for Forest Protection, there are no official records in AT.
<i>Dactylorhypes longicollis</i> (Wollaston)	CA, ES, FR, IT	1949	4	ES, Lombardero and Novoa 1994. FR, Balachowsky 1949, date seeds intercepted in New York, originating in “France”; Bovey (1987), 1 st France record 1955. IT, Sampò and Olmi 1975. CA, Whitehead et al. 2000. Spreading in Mediterranean, where it is probably currently confused with <i>C. dactyliperda</i> .
* <i>Dryocoetes himalayensis</i> Strohmeyer	CH, FR	2009	4	Knižek, unpub., CH & FR, established.

Species	Established in countries	First	Phase	Notes, References
<i>Gnathotrichus materiarius</i> (Fitch)	BE, CH, CZ, DE, ES, FI, FR, IT, NE, SE	1933	5	BE, Moucheron and Warzee 2006; CH, von Hirschheydt 1992 (1984). CZ, Knížek 2009. DE, Schedl 1966; Gladitsch 1969 (1964). ES, established, López et al. 2007 (2003). FI, Valkama et al. 1997 (1996). FR, Balachowsky 1949 (1933 was 1 st Eur record). IT, Faccoli 1998 (1998). NE, Schedl 1966; Doom 1967 (1965). SE, Gillerfors 1988. MA, Mifsud and Knížek 2009, in ornamental <i>Ficus</i> .
* <i>Hypocryphalus scabricollis</i> (Eichhoff)	MA	1991		
* <i>Hypothenemus eruditus</i> Westwood	ES, FR, IT, MA	1924	5	Eichhoff 1878, 1881, no mention of European populations. ES, Garcia-Tejero 1955, established. FR, Balachowsky 1949 (not widespread, then). IT, Ragusa 1924. MA, Mifsud and Knížek 2009. Balachowsky 1949 says it is in ES, IT. Pfeffer 1995, throughout the Mediterranean.
<i>Megaplatypus mutatus</i> (Chapuis) ^a	IT	2000	2	IT, Tremblay et al. 2000. Kills poplars.
* <i>Monarthrum mali</i> (Fitch)	IT	2008	2	IT, Kirkendall et al. 2008. Probably established, but only one collection.
* <i>Phloeosinus rudis</i> Blandford	FR, NE	1940	3	FR, Hoffman 1942 found many in branches of <i>Thuja japonica</i> , in Var, St. Tropez, in June 1940. Balachowsky cites this. No recent finds. NE, Moraal 2006 and email: apparently locally established, along with <i>Phloeosinus aubei</i> . Kills <i>Thuja occidentalis</i> , <i>Chamaecyparis</i> and <i>Juniperus chinensis</i> . At least <i>rudis</i> is probably established, <i>aubei</i> might be too.
<i>Phloeotribus liminaris</i> (Harris)	IT	2004	2	IT (only), Pennacchio et al. 2004.
<i>Xyleborinus attenuatus</i> (Blandford) ^b	AT, CH, CZ, DE, ES, NE, PL, SE, RU, SK, UN	1987	5	AT: Holzschuh 1990 (oldest specimen 1986). CH, not in Bovey 1987; Kenis et al. 2005 ("C. Besuchet, pers. comm."). CZ, Knížek 1988 (1 st Eur record). DE, Lohse 1991. ES, Lombardero 1998. NE, Vorst et al. 2008. PL, Lohse 1991. SE, Lindelöw et al. 2006. Western Russia, Ukraine, Nikulina et al. 2007. SK, Knížek 1988.

Species	Established in countries	First	Phase	Notes, References
<i>Xyleborus affinis</i> Eichhoff	AT	2006	3	HU: found in imported <i>Dracaena</i> , no recent records (Merkl Otto, email, Merkl and Tuszadi 1992). IT, regularly in imported <i>Dracaena</i> , e.g. Carrai 1992. AT, "rare", introd. 2006: AliensAustria 2007 (Holzer 2007, 1 in Malaise trap).
* <i>Xyleborus pfeilii</i> (Ratzeburg)	AT, BG, CH, CA, CZ, DE, ES, FR, HU, IT, PL, SI, SK, UN	1837	5	Infrequently collected, but widespread in Europe and N. Africa. AT & DE, "Gallia", Eichhoff 1878. BG, 1934 specimens seen by Lombardero (1996). CH, Bovey (1987), not reported since 1898. DE, described from DE by Ratzeburg 1837. ES, Lombardero 1996 did not find, but she cites Kleine 1913 for ES. More widespread in FR (Balachowsky 1949) and AT (Schedl 1980). HU, is in Endrödi 1959. IT, Francardi et al. 2006. PL, is in Nunberg 1954. ES, DE, AT, FR: Reitter 1916, Fauna Germanica. Almost all central and southern European countries, Knížek 2004. Pfeffer 1995: AT, DE, FR, CZ, PL, UN, HU, CA, SI, SK; given the wide distribution of the species, we treat these as records for establishment, though it is not clear if Pfeffer made this distinction. IT, Pennacchio et al. 2003.
<i>Xylosandrus crassiusculus</i> (Motschulsky)	IT	2003	2	
<i>Xylosandrus germanus</i> (Blandford)	AT, BE, CH, CZ, DE, ES, FR, IT, NE	1950	5	AT, Holzschuh 1993 (1 st record 1992). BE, Bruge 1995 (1994). CH, Bovey 1987 (1984). CZ, Knížek 2009. DE, Groschke 1953 (1950?). ES, established, López et al. 2007 (2003). FR, Schott 1994 (1984). IT, Stergulc et al. 1999 (1992). NE, Vorst et al. 2008.
<i>Xylosandrus morigerus</i> (Blandford)	AT, CZ, FR, IT, UK	1916	3	UK, FR, AT and CZ (Bohemia), Reitter 1916, as occurring in greenhouses on <i>Dendrobium</i> . FR, greenhouse orchids, Balachowsky 1949. UK (Kew Gardens), Rome, Wien (orchids) in greenhouses, Schedl 1980.

Country abbreviations: **AT** Austria; **BE** Belgium; **BG** Bulgaria; **CA** Croatia; **CH** Switzerland; **CZ** Czech Republic; **DE** Germany; **ES** Spain; **FI** Finland; **FR** France; **GR** Greece; **HU** Hungary; **IT** Italy; **MA** Malta; **NE** Netherland; **PL** Poland; **RU** Russia; **SE** Sweden; **SI** Slovenia; **SK** Slovakia; **UK** United Kingdom; **UN** Ukraine.
 *The only Platypodinae; treated as *Platypus sulcatus* or *P. mutatus* in most earlier literature. ^bTreated as *Xyleborinus almi* (Nijima, 1909) in most literature. *Species not treated as established extra-European aliens in DAISIE.

Dryocoetes himalayensis is known only from the Himalayas of India; it has been collected over the past few years from both France and Switzerland (Knížek in press and pers. comm.). (5) *Ambrosiophilus atratus* was collected at one village in northeastern Italy in 2007 and 2008 in alcohol-baited traps (Faccoli 2008). The beetles clearly had overwintered successfully.

Xyleborus affinis is tentatively included in our list, because of the Malaise trap catch in Austria (Holzer 2007). As long as they are not near piles of imported logs, trap catches are strong evidence of a local, established population, and are now the main source of information on alien species in many regions around the world. This species is also possibly established in nurseries in Italy, where its presence in imported *Draacaena* stems seems to be constant (Carrai 1992), but it is also possible that these beetles are continuously imported and do not form reproducing populations. If it is indeed established in nurseries, its status in Italy would resemble that of *Xylosandrus morigerus* in Europe, a species with a long history of reproducing populations in orchids in greenhouses and which also is probably regularly being imported (Table 2).

Two ambrosia beetles on our list but not in DAISIE are only recently discovered: *Ambrosiodmus rubricollis* (Faccoli et al. 2009), and *Monarthrum mali* (Kirkendall et al. 2008). Large numbers of the former were collected from a live horse chestnut (*Aesculus hippocastaneum*) in the botanical gardens of Padua (Apr. 2009), and from peach trees (*Prunus persicae*) close to Verona (Oct. 2009), both in northeastern Italy. A single *Monarthrum mali* was trapped in a nature reserve in northeastern Italy in 2007. Given that the species is not often trapped even where it is common and indigenous (in eastern North America), and the remote locality, this species is considered to be established (Kirkendall et al. 2008).

The last species on our list of alien species, *Xyleborus pfeilii*, is currently considered to be indigenous. This ambrosia beetle is considered rare but found in much of Europe as well as in northern Africa and Turkey (Wood and Bright 1992, Pfeffer 1995); it is also established in both eastern and western North America (Vandenberg et al. 2000, LaBonte et al. 2005). Morphologically, it apparently belongs to the *volvulus-perforans* group of species (most of which are probably Asian in origin); it is not similar to any of the species of *Xyleborus* native to Europe. Furthermore, unlike *Trypodendron laeve* (see below), it shows a clearly disjunct distribution, with what we consider to be the native populations being in southern China, Japan, and Korea (Wood and Bright 1992). We suggest that this species was introduced to Europe from trade with the Far East, and spread so widely that the earliest bark beetle specialists (e.g. Eichhoff 1878) assumed it was part of the native fauna.

Finally, there is one species which we did not include but which may have recently made its first inroads into Europe. The highly aggressive Asian larch bark beetle *Ips subelongatus* (Motschulsky) has long been considered synonymous with the European larch bark beetle *Ips cembrae* (Heer) (Wood and Bright 1992) but is geographically and genetically distinct and carries different strains of blue-stain fungus (Stauffer et al. 2001). The two can be distinguished morphologically by specialists familiar with both species. Both species breed normally in larch (*Larix*), but are occasionally

found breeding in alternative hosts. *Ips subelongatus* was intercepted in Finland in logs from Siberia and in Estonia in timber from Russia (Voolma et al. 2004). Larch bark beetles were taken from spruces around St. Petersburg and more recently have been collected from pines in the Murmansk province (Voolma et al. 2004), which is outside the natural range of larch. Given the regional trade patterns, it is possible that these are *Ips subelongatus*, but species identity has not been confirmed by taxonomists or DNA data.

Two species are listed by DAISIE (2009a) as established aliens which we classify differently. The record for *Xyleborus perforans* seems to be based on a one-time interception from imported logs, in Poland (Wojciech Solarz, pers. comm.). There is no evidence for Poland or elsewhere that this widespread tropical ambrosia beetle reproduces anywhere in Europe. *Trypodendron laeve* Eggers, on the other hand, we propose is actually native to Europe. This spruce-breeding ambrosia beetle is treated by DAISIE, NOBANIS, and in the recent forestry literature (e.g. Kenis 2005) as an alien species. The perception that it is exotic presumably arose because it was first described from Japan, and subsequently only known in the West from Norway, Sweden, and Austria (Pfeffer 1995). However, *T. laeve* is apparently rare; it remained unknown to science until 1939, when Eggers described it based on a five specimens from Japan, and only seven years later when Strand unknowingly described as *T. piceum* the same species from a single collection from near Oslo, Norway (Eggers 1939, Strand 1946). The accumulation of collection data reflected in DAISIE and Fauna Europaea (and in Knížek's upcoming Palaearctic Scolytinae catalog) reveals a species which has now been found throughout Europe and across Asia to Japan, much like more common conifer forest bark beetles such as *Ips typographus* or *Tomiscus piniperda*. We see no reason to continue to consider this species to be alien to Europe.

The written list of aliens (DAISIE 2009b) includes 20 Scolytinae and 3 Platypodinae. Unlike the web version, these records do not specify status, so all records are presumably considered to be established species, and treated such in DAISIE's many analyses of terrestrial invertebrate or insect invasions. Of these 23 species, 13 are on this list as established aliens to Europe; one (*Phloeotribus caucasicus* Reitter) is a spreading European species; seven are interceptions (no evidence of breeding populations in Europe); and one we argue here is a native species (*Trypodendron laeve*). The net result is that where DAISIE (2009b) would include 23 species of Scolytinae and Platypodinae in analyses of established alien insects in Europe, we propose there are ca 25% fewer (19, only 13 of which are, in fact, listed by DAISIE as established aliens).

The genera present. Clearly, a wide variety of bark beetles are capable being transported to Europe, and there is a surprisingly high diversity which have succeeded in colonizing the continent: the 18 alien species comprise 16 different genera (15 of Scolytinae, 1 of Platypodinae), of which only five are present in the native fauna. Only two genera, *Xylosandrus* and *Xyleborus*, are represented by more than one exotic species; the Xyleborini (these two, plus *Ambrosiodmus*, *Ambrosiophilus*, *Cyclorhipidion*, and *Xyleborinus*) make up half of all adventive species.

When did they arrive?

The precise date of arrival in Europe is not known for most species because the introductions of bark beetles (and of most animals) are unintentional, and up to several decades can go by before newly established exotics – especially those which are not pests – are noticed (Kenis et al. 2007, Mattson et al. 2007, Roques et al. 2009). The first reference to the presence of an alien scolytine in Europe is the description almost two centuries ago of the east Asian ambrosia beetle *Xyleborus pfeilii* as a European species (Ratzeburg 1837), followed by reports of the topical seed beetle *Coccotrypes dactyliperda* in Italy (Targioni-Tozzetti 1884). Only nine more new alien species were found in the next 115 years, though at least one of these (the tiny, highly polyphagous but harmless *H. eruditus* first recorded by Ragusa in 1924) could well have been present much longer. The successful establishment of exotics seems now be accelerating (Fig. 1), despite greater international awareness of the dangers posed by wood packing materials (FAO 2002) and stricter regulation of plant trade: fully 8/19 aliens have been reported in the last decade (Table 2). The establishment rate in Europe of new alien species of insects (and of terrestrial invertebrates generally) has increased markedly in the last thirty years (Hulme et al. 2009).

How were they transported?

Many wood-boring insects, particularly scolytine and platypodine beetles, are transported between continents. While the majority of introductions of alien insects to Europe is via trade in ornamental plants (Kenis et al. 2007, Roques et al. 2009), bark beetles mainly travel in wood and in wooden packing materials such as crating, dunnage and pallets (Haack 2001, Allen and Humble 2002, Colunga-Garcia et al. 2009, Haack and Petrice 2009). Only a few are likely to be transported in plants or plant parts. The cut stems of *Dracaena* which are shipped to Europe from Central America frequently are infested with tropical *Xyleborus* species, the seeds and nuts with *Coccotrypes*, *Dactylotrypes*, and *Hypothenemus*, and the orchids with *Xylosandrus morigerus*; *Hypocryphalus scabricollis* probably entered Malta with exotic *Ficus* trees from southern Asia (Mifsud and Knížek 2009).

Biology of Europe's alien bark beetles

Whether or not alien insects succeed in establishing breeding populations depends on a number of factors, including suitability of local climate and hosts, appropriate phenology, and the effects of potential competitors and natural enemies. Immigrants which are host generalists or which use host species which are abundant and widespread where they have arrived should have a good chance of establishing permanent populations, given appropriate climatic conditions.

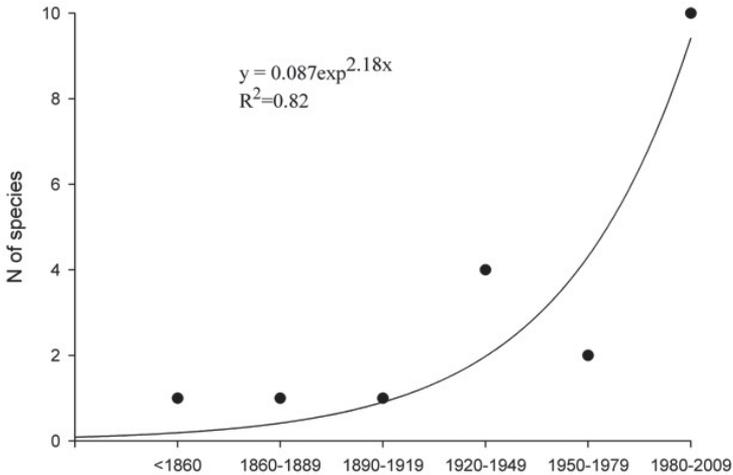


Figure 1. The accelerating rate of discovery of introduced Scolytinae and Platypodinae in Europe, shown as numbers of new species found in each 30-year period (data from Table 2).

Niche breadth. The vast majority of bark beetles (particularly phloeophagous species) are monophagous, breeding in one genus of host plants, or oligophagous, breeding in one family of host plants (Beaver 1979, Kirkendall 1983). These breed in one species of woody plant, several species in one genus, or in several related genera of hosts. Strikingly, all but four of the established aliens of mainland Europe are polyphagous (breeding in several to many families of woody plants). Two-thirds of the established alien Scolytinae and Platypodinae are ambrosia beetles, a much higher proportion than would be found in the source faunas of Asia or North America (Kirkendall 1993). Ambrosia beetles are most often polyphagous (Beaver 1979, Kirkendall 1983), and lack of host specificity is considered to be a major reason why they are so successful as invaders (Atkinson et al. 1990, Kirkendall et al. 2008). Of those species with more restricted diets, two breed in palm seeds, an abundant resource all around the Mediterranean, one in Fagaceae (a dominant family in much of Europe), and one in widely planted fruit trees (Table 3).

Importance of reproductive system. Particularly important to recently established, small populations are Allee effects, the acute demographic, ecological and genetic problems posed by low densities (Lande 1988, Courchamp et al. 2008). Single small populations are always at risk of extinction from random local disasters, and if they arose from large outbreeding populations they will usually suffer from inbreeding depression. Mate location can also lower the reproductive rate of small populations. Species which regularly mate by brother-sister mating, however, circumvent many of these problems: mating takes place among siblings, before dispersal, and regular inbreeders presumably suffer much less from inbreeding depression than do outbreeders (Jordal et al. 2001, Frankham et al. 2004, Kirkendall and Jordal 2006). Eleven (58%) of the immigrant species are inbreeders (Table 3), which is roughly twice as high as the

Table 3. Source and biology of alien bark beetles of Europe. Data from sources in Table 2, Wood (1982), Kirkendall (1983) and Wood and Bright (1992).

Species	Native to	Additional distribution	Zone	Feeds/Breeds	Host use
<i>Ambrosiodinus rubricollis</i>	east Asia	eastern North America, Australia	T	Xm/inbreeding	Polyphagous, broadleaf trees
<i>Ambrosiophilus atratus</i>	east Asia	North America	T	Xm/inbreeding	Polyphagous, broadleaf trees
<i>Coccotrypes dactyliperda</i>	? (Old World)	globally distributed, tropics & subtropics	M	Spm/inbreeding	Polyphagous, mainly palm seeds in Europe
<i>Cyclorhipidion bodoanum</i>	north Asia	North America	T	Xm/inbreeding	Oligophagous, Fagaceae
<i>Dactylotrypes longicollis</i>	Canary Islands	Madeira, North Africa	M	Spm/outbreeding	Oligophagous, palm seeds
<i>Dryocoetes himalayensis</i>	India		T	Phl/outbreeding	Polyphagous, <i>Juglans regia</i> , <i>Prunus lanata</i>
<i>Gnathotrichus materiarius</i>	eastern N. America		T	Xm/outbreeding	Polyphagous, conifers
<i>Hypocryphalus scabricollis</i>	east Asia		M	Phl/outbreeding	Polyphagous, broadleaf trees
<i>Hypothenemus eruditus</i>	American tropics?	globally distributed, tropics & subtropics	M	Phl/inbreeding	Polyphagous
<i>Megaplatypus mutatus</i>	South America		M	Xm/outbreeding	Polyphagous, broadleaf trees
<i>Monarthrum mali</i>	eastern N. America		T	Xm/outbreeding	Polyphagous, broadleaf trees
<i>Phloeosinus rudis</i>	east Asia		T	Phl/outbreeding	Oligophagous, Cupressaceae
<i>Phloeotribus liminaris</i>	eastern US		M	Phl/outbreeding	Monophagous, <i>Prunus</i>
<i>Xyleborinus attenuatus</i>	east Asia	North America	T	Xm/inbreeding	Polyphagous, broadleaf trees
<i>Xyleborus affinis</i>	Neotropics?	globally distributed, tropics & subtropics	M	Xm/inbreeding	Polyphagous
<i>Xyleborus pfeilii</i>	east Asia	North America	T,M	Xm/inbreeding	Polyphagous, broadleaf trees in Europe*
<i>Xylosandrus crassiusculus</i>	tropical & subtropical Asia	globally distributed, tropics & subtropics	M	Xm/inbreeding	Polyphagous
<i>Xylosandrus germanus</i>	east Asia	North America	T	Xm/inbreeding	Polyphagous
<i>Xylosandrus morigerus</i>	Asian tropics?	globally distributed, tropics	gh	Xm/inbreeding	Polyphagous; in Europe, greenhouse orchids

Additional distribution: other foreign regions in which a species is now established. Zone: **T**, temperate zone of Europe; **M**, Mediterranean zone; **B**, boreal zone; **gh**, greenhouse populations. *Feeds:* **Xm**, xylomycetophagous (ambrosia beetle); **Phl**, phloeophagous, breeding in bark; **Spm**, spermatophagous, breeding in seeds (terminology from Wood 1982). **X. pfeilii* is highly polyphagous in conifers and broadleaf trees in Japan (Mizuno and Kajimura 2002) though the few host records in Europe are from *Alnus* and *Betula* (e.g. Balachowsky 1949).

proportion of the European bark beetle fauna which inbreeds (Kirkendall 1993). Inbreeding is also clearly over-represented in adventive bark beetles in North America (Wood 1977, Atkinson et al. 1990, Haack 2001). Of the 50 exotic species established in North America by the year 2000, 37 (74%) are inbreeders (Haack 2001). And, of the 62 North and Central American species recorded as introduced to or exported from foreign countries (Wood 1977), 45 (73%) inbreed. Supporting the importance of inbreeding in colonization, it should be noted that islands almost always have much higher proportions of inbreeding species than their source populations (Kirkendall 1993, Jordal et al. 2001).

Both inbreeding and polyphagy should favor invasiveness. Interestingly, 10/15 polyphagous species are inbreeders, and 10/11 inbreeders are polyphagous (Table 4).

Biogeography: Where are alien species established, and where did they come from?

Climatic zones of Europe. Though smaller in area, the Mediterranean zone is disproportionately rich in alien bark beetles (Table 3). Mediterranean ecosystems are particularly rich in biodiversity (Underwood et al. 2009) and have milder winters than elsewhere in Europe, two factors which might favor the establishment of newly arrived species. Only the oldest established exotic, *Xyleborus pfeilii*, is currently established in two different zones (temperate and Mediterranean). In Europe, as far as is known, the tropical ambrosia beetle *Xylosandrus morigerus* is restricted to greenhouses where it is a pest of orchids.

Country records. Although 22 European countries recorded exotic species, large differences exist among the numbers of alien insects recorded per country (Fig. 2). Italy, France and Spain have the largest numbers of alien species (14, 10 and 7, respectively); for the former two countries, this corresponds to about 10% of their national bark beetle fauna (Balachowsky 1949, Abbazzi et al. 1995). Over half of these countries recorded only one or two alien scolytines and platypodines.

The great differences among countries could be due to several reasons. The number of alien insects is positively correlated with country surface area (Roques et al., 2009). Furthermore bark beetles show a latitudinal gradient in species richness: the number of alien scolytines and platypodines generally decreases with the increasing latitude (Kirkendall 1993), probably because of harsher winters and reduced host diversity. Besides having favorable temperatures, the southern countries (Italy, France and Spain) also have a wide variety of ecosystems, ranging from Mediterranean to mountain and alpine, and of climate regimes, leading to high diversity of woody plants and of ecological conditions.

Table 4. The relationship between feeding habits and reproductive systems, for alien Scolytinae and Platypodinae established in Europe. Data from Table 3.

Reproduction type	Polyphagous	Not polyphagous
Inbreeding	10	1
Outbreeding	5	3

While some of the differences between countries are real – Sweden does have fewer invasives than Switzerland – others are due to under-reporting at the country level; certainly, many of the differences among countries are due to differences in collecting effort and to the presence (or absence) of researchers with a special interest for Scolytinae and Platypodinae. Many sub-Scandinavia European countries are represented by zero or few records of alien bark beetle species but do have the requisite habitats. We found it particularly difficult to find detailed information on the bark beetle faunas of Portugal, eastern Europe, the Balkan countries, and countries of the eastern Mediterranean. Alien species doubtlessly can be found in these areas. The true ranges of alien bark beetles will not be known as long as there remain such gaps in our knowledge.

Unfortunately, here, too, the publicly available information on alien species in Europe is largely incorrect. Only for those recent arrivals established only in Italy are the country records in DAISIE accurate. Even species which have been established for over half a century and are well studied are not correctly reported in DAISIE: for both *Gnathotrichus materiarius* and *Xylosandrus germanus*, we can document at least three country occurrences missing from DAISIE.

The data in Fauna Europaea are similarly flawed. Three species are missing from the database, four country occurrences (for three species) cannot be verified, and country records are incomplete for most alien species, including for *G. materiarius* (2 missing) and *X. germanus* (3).

Where are the exotics from? By far, the vast majority of recent interceptions of non-indigenous plant pests in European countries are from Asia or from Europe, with an order of magnitude fewer interceptions originating in North America (Roques and Auger-Rozenberg 2006, Mattson et al. 2007). Established alien bark beetles are not as skewed with respect to geographic origin: the majority (12/19) are known or suspected to be native to Asia, but fully six are from the Americas. Of course, geographic origin and origin of immigrant populations can be two different things: five species are globally distributed, five Asian species are also established in North America, and the Canary Island endemic is well established on Madeira and in Morocco (Kirkendall, unpublished data). In most cases, whether Asian species were introduced from Asia or from invasive populations in the New World cannot easily be determined without detailed DNA studies.

The tropical affinities of one-third of the species (Table 3) might come as a surprise to some. However, all but *X. morigerus* range into temperate climes – and that one exception is only found in greenhouses, in Europe.

Taxonomy and invasives

Increasingly, governments at all levels realize the severity of threat posed by alien insects, and national and international programs have been set in motion throughout the world to address the problem (e.g. McNeely et al. 2001, DAISIE 2009a). However, though often not fully appreciated, correct identification of newly en-

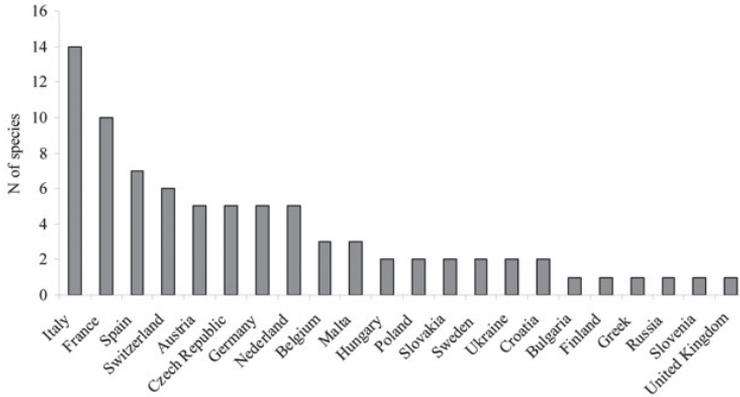


Figure 2. The numbers of alien bark beetles and pinhole borers per European country (data from Table 2).

countered exotic species bedevils many such efforts. As an example, the correct identification of the now well-established ambrosia beetle *Cyclorhipidion bodoanum* took over three decades and confounded bark beetle specialists on two continents simultaneously. In 1975, Steve Wood described *Xyleborus californicus* from specimens collected in northern California in 1944 (Wood 1975); he stated that this species was almost certainly exotic and probably from South America or southeastern Asia. The latter suggestion was supported when a specimen of *X. californicus* from China was intercepted in Vancouver (Vandenberg et al. 2000). That *Xyleborus californicus* might actually be *C. bodoanum* was suggested subsequently (M. Mandelshtam pers. comm., quoted in Rabaglia et al. 2006); the synonymy will be published by Knížek (pers. comm.) and has been independently verified by the senior author. Meanwhile, in Europe, an invasion by the same ambrosia beetle was initially misidentified as being *Xyleborus peregrinus* Eggers 1944 (which species actually is a synonym of *Xyleborinus saxesenii*); this later was corrected to *X. punctulatus* Kurentzov, which name was later shown to be a junior synonym of *X. bodoanus* (Mandelshtam 2001). That *X. bodoanus* is actually a *Cyclorhipidion* was recognized recently (Bussler 2006). Only now, over a half century since having invaded two continents, does this oriental species appear to be conclusively identified. As illustrated by this example, even specialists are often stymied when introduced species are from Asia, for which we generally lack the most basic tools for species-level identification (keys and high quality illustrations), and for where only a few working bark beetle taxonomists have access to representative material.

Taxonomy plays a fundamental but often underappreciated or overlooked role in strategies for monitoring, intercepting, and managing both exotic and indigenous organisms, including wood borers. Phytosanitary efforts to monitor or control new invasive species will fail without correct taxonomic and biogeographic information (and the latter is dependent on the former). Cryptic species often differ in key elements of their biology, such as in phenology, host preferences, pheromone behavior, susceptibil-

ity to natural enemies (including diseases), and in the species or strains of microorganisms which they carry with them. When such differences exist between look-alike species, control measures will often be ineffective if the species is misidentified. For example, similar appearing species may originate from different regions; incorrect identification in such an instance could lead to fruitless searches for key biological control agents. Occasionally, taxonomists themselves have overlooked minute morphological differences between sister species, but more often the incorrect identifications are by nonspecialists relying on published databases, keys, and illustrations rather than on consultation with taxonomic experts (Knížek 2007). On the other hand, experts are reluctant (or unable) to invest time in “routine identifications” involving thousands or tens of thousands of specimens of abundant pest species.

The taxonomic impediment is often three-fold: difficult access to taxonomic specialists; poor taxonomic knowledge of the group involved; lack of user-friendly keys and illustrations. Taxonomic specialists are few and overworked; quarantine agencies, foresters and other instances must compete with taxonomists’ own research projects (and more and more with specimen-rich biodiversity surveys). Taxonomic knowledge can be inadequate in several ways: many genera of wood-boring insects (including scolytines and platypodines) have not been recently revised (some, never so); for some regions of the world, the wood-boring fauna is poorly known; and for some species groups which are highly successful as colonists, species-boundaries and proper nomenclature are inadequately understood. Finally, even where the wood-borers are fairly well known and keys do exist (e.g. Central America), for many genera the keys can only be used by specialists with access to reference material; illustrations sufficient for species-level identification (drawings or high-resolution photographs) exist only for a very limited number of species groups or genera.

A way out of this impasse is two-fold: use of adequate photographic documentation of subtle morphological differences, especially when coupled with expert intelligence software for developing illustration-rich keys; and the development of inexpensive molecular methods (fragment profile- or sequence-based) for separating species difficult to identify by morphology (DNA barcoding). Fortunately, tools for both are becoming increasingly well known and more widely accessible, as are possibilities to publish new finds rapidly via highly accessible electronic journals. Consequently, we are already seeing that new discoveries are being documented, identified, illustrated and published much more rapidly.

In the future there will be more and more Asian wood-borers colonizing Europe and North America. Currently there are no modern resources for identifying bark beetles from Asia, the Orient, or Oceania. What is needed is the methodical, thorough monographic work which Steve Wood was so good at, preferably including DNA sequencing. Until we have monographs for China, Southeast Asia, and Oceania – and the young taxonomic talents capable of applying them – many future immigrants will long remain enigmas.

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Observations on sex ratio and behavior of males in *Xyleborinus saxesinii* Ratzeburg (Scolytinae, Coleoptera)

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Abstract

Strongly female-biased sex ratios are typical for the fungal feeding haplodiploid Xyleborini (Scolytinae, Coleoptera), and are a result of inbreeding and local mate competition (LMC). These ambrosia beetles are hardly ever found outside of trees, and thus male frequency and behavior have not been addressed in any empirical studies to date. In fact, for most species the males remain undescribed. Data on sex ratios and male behavior could, however, provide important insights into the Xyleborini's mating system and the evolution of inbreeding and LMC in general.

In this study, I used in vitro rearing methods to obtain the first observational data on sex ratio, male production, male and female dispersal, and mating behavior in a xyleborine ambrosia beetle. Females of *Xyleborinus saxesinii* Ratzeburg produced between 0 and 3 sons per brood, and the absence of males was relatively independent of the number of daughters to be fertilized and the maternal brood sex ratio. Both conformed to a strict LMC strategy with a relatively precise and constant number of males. If males were present they eclosed just before the first females dispersed, and stayed in the gallery until all female offspring had matured. They constantly wandered through the gallery system, presumably in search of unfertilized females, and attempted to mate with larvae, other males, and females of all ages. Copulations, however, only occurred with immature females. From galleries with males, nearly all females dispersed fertilized. Only a few left the natal gallery without being fertilized, and subsequently went on to produce large and solely male broods. If broods were male-less, dispersing females always failed to found new galleries.

Keywords

inbreeding, haplodiploidy, ambrosia beetles, all male broods, LMC, subsociality

Introduction

In panmictic (randomly mating) species, natural selection usually favors balanced sex ratios (Fisher 1930). In settings where male and female offspring are of unequal value to the mother, however, optimal sex ratios may be unbalanced. For example, in a non-randomly mating population or species with strictly local offspring reproduction, a mother will gain highest fitness by producing as many daughters as possible and just enough sons to ensure fertilization of all sisters in the brood (Hamilton 1967). This extreme economy in the production of males is common in small arthropods with regular brother-sister mating and local mate competition (LMC) between brothers (Hamilton 1967; Norris 1993). Usually it is associated with arrhenotokous haplodiploidy (Hamilton 1978 referred to arthropods exhibiting these characters as “the biofacies of extreme sex ratios and arrhenotoky”). Arrhenotoky potentially gives a mother precise control over the sex of each offspring, as she may choose to produce diploid daughters by fertilizing an egg, or haploid sons by leaving it unfertilized (Hamilton 1967; Charnov 1982). Hamilton (1978) suggested that the ancestral habitat for the aforementioned biofacies is situated under the bark of dead trees, even if the support for this quotation is weak and claims on the original habitat of ancient lineages are highly speculative (Normark et al. 1999).

A prominent group of beetles living under the bark is the weevil sub-family Scolytinae, that includes species with varying mating systems (Kirkendall 1983; 1993) and ploidy (diploid, functional haploid, haplodiploid; Kirkendall 1993; Brun et al. 1995; Normark et al. 1999). Both characters are selected to the extremes in all species belonging to the subtribe Xyleborini, which are a typical example for Hamilton’s biofacies since they are characterized by strong inbreeding, LMC and haplodiploidy. These so-called ambrosia beetles solely feed on a microbial complex (fungi, yeasts and bacteria; Haanstad and Norris 1985), which they grow on the walls of self-constructed tunnel systems (“galleries”) in the heart- or sapwood of trees. Until recently, this habitat has virtually been impossible to access and observe without destruction, which is why basic data on life histories, mating systems and behavior of most Xyleborini is still missing. The adaptation of an in vitro rearing technique (Norris and Baker 1967; Biedermann et al. 2009) finally may lead to the establishment of an excellent new model system for studying the independent evolution of inbreeding and haplodiploidy in a weevil lineage.

The few observational studies on Xyleborini that exist suggest that these beetles behave subsocially (Kirkendall et al. 1997; Mueller et al. 2005). Subsociality in *Xyleborinus saxesenii* Ratzeburg and other Xyleborini is indicated by the fact that mature female offspring maintain the natal gallery throughout a few days or even weeks at a time when they could already found their own nests (Kirkendall et al. 1997; Mueller et al. 2005; Biedermann 2007). Costs of independent breeding have been found to be high in this species due to risky dispersal and low founding success, which in former studies did not exceed 20% neither in the field nor when in vitro culturing was used (Biedermann et al. 2009). Therefore, it might pay for daughters to stay in productive

galleries, where they either reproduce themselves, or gain indirect fitness benefits by helping to produce more sisters (e.g. Peer and Taborsky 2007). The help of males (if there is) is assumed to be of minor importance to the family, given their tiny size (figures in Fischer 1954) and their underrepresentation in relation to females.

If males do not play an important role for gallery maintenance and protection, male numbers should be minimized in order to lower the cost of LMC. The optimal number should be affected by the maximum number of females one male is able to fertilize, the timing of male production, male survivorship and longevity, as well as male dispersal (see Kirkendall 1993 for a detailed review; Borsa and Kjellberg 1996). In Xyleborini males are outnumbered by females by a ratio of 1:5 to 1:30, depending on the species (e.g. Schedl 1962). Males supposedly hatch before females (observed in *Xyleborus affinis* Eichhoff; Roeper et al. 1980), but their life expectancy is unknown. As they lack functional flight wings, they are assumed to never leave the nest (Roeper et al. 1980; Kirkendall 1983; 1993), however, recent data suggests that males of *Xylosandrus germanus* Reiter sometimes leave their natal gallery to crawl on the host tree in search for outbreeding opportunities, i.e., disperse (Peer and Taborsky 2004).

The objective of this study was to observe males of *X. saxesenii* inside their galleries for the first time to report their number and hatching time relative to females, as well as to determine whether or not males disperse and if they share in gallery maintenance and protection. Furthermore, I aimed at clarifying the existence of all male broods, which has been remarked upon in several studies on Xyleborini (e.g. Fischer 1954; Norris and Baker 1967; Kirkendall 1993). Such broods are assumed to be produced by unfertilized females that later mate with one of their sons to subsequently produce “normal” mixed broods (Herfs 1959). Their existence was tested by following the fate of unfertilized females. All these studies were conducted by consecutively rearing several generations of *X. saxesenii* families in an artificial medium in glass tubes that allow for behavioral observations (Biedermann et al. 2009).

Methods

Study species

In the study species *Xyleborinus saxesenii* Ratzeburg, the ambrosial complex is typically dominated by the anamorphic fungus *Ambrosiella sulfurea* Batra (Batra 1967), and serves as the sole food for adults as well as the developing larvae. The latter feed xylo-mycetophagously (on fungus and wood; Schedl 1958), in this way digging out a single large brood chamber where individuals of all age classes live in close vicinity to each other and also to their fungal food source. Galleries are always founded by individual females that usually have been fertilized by a brother prior to their emergence from the natal nest. The first offspring mostly stay with their mother after reaching adulthood while the subsequent offspring generations develop (e.g. Kalshoven 1962; Schedl

1966; Bischoff 2004; Biedermann et al. 2009). Brood care and fungus tending in *X. saxesenii* are hitherto unknown, but expected to occur, because in case the foundress dies before the first brood has eclosed, the brood dies as well and the fungal garden degrades (Batra and Michie 1963; Norris 1979; 1993). Furthermore, gallery protection by blocking the entrance with the abdomen or a plug of frass and brood care behaviors have been observed in adult daughters of this as well as other xyleborine species (Kirkendall et al. 1997; Bischoff 2004; Biedermann 2007; personal observations).

Laboratory breeding and data collection

X. saxesenii beetles were bred in artificial agar-sawdust based “standard medium” in glass tubes (Biedermann et al. 2009). Single females were surface sterilized by submerging them first in ethanol (95%) and then in distilled water for a few seconds and subsequently put directly onto the medium. They usually started to excavate a tunnel system within two days and would not lay eggs until their mutualistic ambrosia fungus had started to grow. About 20% of the females started to lay eggs, which resembles the breeding success found in the field (Biedermann et al. 2009). The developing brood would subsequently enlarge the gallery system which was often constructed next to the tube wall, which facilitated the observations necessary for this study. Parts of the gallery inside the medium could not be accessed with this method, but as individuals move a lot, this should not have influenced my results.

Observations

I scanned the beetles in 70 observable galleries every second to third day and recorded male and female numbers, allocating the individuals to different developmental stages (eggs, larvae, male and female pupae, immature females, mature females, and males). Male and female pupae and adults were easy to differentiate because of their strong sexual dimorphism in size (Fig. 1, see figures in Fischer 1954). Immature females were identified by their light brown coloration that would turn black after maturation. As a result of sex specific mortality rates and siblicide, the so gained “secondary sex ratio” of the immature and mature offspring may differ from the mother’s optimal “primary sex ratio” of the eggs. Where I could witness male-female interactions, I recorded the age of the partners and whether it was a mating attempt or successful mating. Whenever possible, I determined the dates when the first egg was present ($N = 70$ galleries), when the first male and female offspring hatched ($N = 29$ galleries), when the first and last female matured ($N = 26$), and when the first male dispersed ($N = 13$). Dispersal was defined as emergence from the gallery, i.e., when individuals were found on the surface of the medium under the cap of the tube (Biedermann 2007). I stopped monitoring and dissected the galleries either when eclosion of new beetles ceased within about 3



Figure 1. Parts of a brood chamber of *Xyleborinus saxesenii* in artificial medium. 1st and 2nd/3rd instar larvae, several pupae, two immature females and a male are visible. The male is mounting an immature female.

months ($N = 41$ galleries), or when all adult females had dispersed ($N = 29$ galleries). In the latter case, galleries were used to monitor male dispersal.

I measured the breeding success (defined as the successful start of egg-laying within 40 days) and brood size of 311 daughters out of 33 families (*median* = 5 daughters/family, *range* = 1–41) to determine whether they differ between daughters of galleries with males and male-less ones. Subsequently, I correlated the secondary sex ratio of 62 daughter-families that had successfully produced a brood with the secondary sex ratio of their mothers' families to test whether secondary sex ratios might be heritable.

Additionally, I observed the behavior of eight males from different galleries for 10 min and calculated the proportion of time spent on different behaviors. I differentiated between shuffling (moving frass and feces with the legs under the body and with the abdomen), digging (excavating new tunnels), cannibalism (feeding on a larva, pupa, or adult beetle), courtship behavior (grooming an egg, larva, pupa, or adult beetle with maxillae and labium), walking, cropping (feeding on the fungal layer covering gallery walls), and mating attempt (mounting or copulating with a female) (Biedermann 2007).

Statistical analyses

The association between numbers of male and female offspring was explored using linear regression. The number of males within a brood of a given size should have

a binomial distribution under random sex determination. To test if this was the case, I compared the variance of the male numbers observed with that expected if the numbers of males were binomially distributed using a *Chi*²-test (Green et al. 1982). The same test was also used to analyze whether the number of males per family resembled a Poisson distribution. Male mating preference with either immature or adult females was analyzed using Fisher's exact test. Usually the data were not normally distributed (which was determined with Kolmogorov-Smirnov tests), consequently non-parametric statistics were conducted. The Mann-Whitney *U*-test for comparisons between two independent groups was applied to determine productivity differences between male and male-less broods, and to check for differences in the timing of male and female hatching and dispersal. The inheritance of sex ratios between mother and daughter galleries was analyzed with a Spearman's rank correlation. Analyses were performed with SPSS (Release 14.0; SPSS, Chicago, IL) and R (R Development Core Team 2008).

Results

Sex ratio and breeding success

Males were extremely scarce in *X. saxesenii* galleries (*mean* abundance per gallery = 0.96, SE = 0.09, *N* = 70; Fig. 2). Male production by mothers was not random, as their overall number did not resemble a Poisson distribution. They produced more one- and two-male broods, fewer male-less and three-male broods than expected, and no four-male brood, which suggests the optimal number is one or two males per brood. Nearly one third of the mothers produced no males (*N* = 21).

Families with males were significantly larger than families without males (Fig. 3). In accordance with this finding, males were absent from 50% of the galleries with only ten daughters or fewer, whereas only 8.3% of the galleries with more than ten daughters were male-less. However, overall the number of males per gallery was only weakly affected by the number of adult females (Linear regression: $F = 3.824$, $p = 0.055$, $DF = 1$, $N = 70$; Fig. 4). The residual mean squared error of the number of males (MSE = 0.597) was much smaller than the mean variance expected under binomial distribution (0.9398; *Chi*²-test: $\chi^2 = 43.2$, $DF = 68$, $p > 0.05$), which indicates that the production of males was not random, but relatively constant and precise (around one or two males per brood).

Breeding success (i.e., the likelihood to lay at least one egg within 40 days) of daughters per family ranged between 0% and 78% (*mean* = 15.2%, *median* = 0, *N* = 311 daughters from 33 families), and was 0% for all male-less broods. A statistical difference was however not detectable because of the high variation of breeding success across all families tested (*U*-test: $T = 77$, $p = 0.067$, $N = 26$ vs. 7).

The secondary sex ratios of the 62 successfully founded daughter-galleries did not correlate with the secondary sex ratios of their mothers galleries (Spearman's rank correlation: $r = 0.038$, $p = 0.771$, $N = 62$).

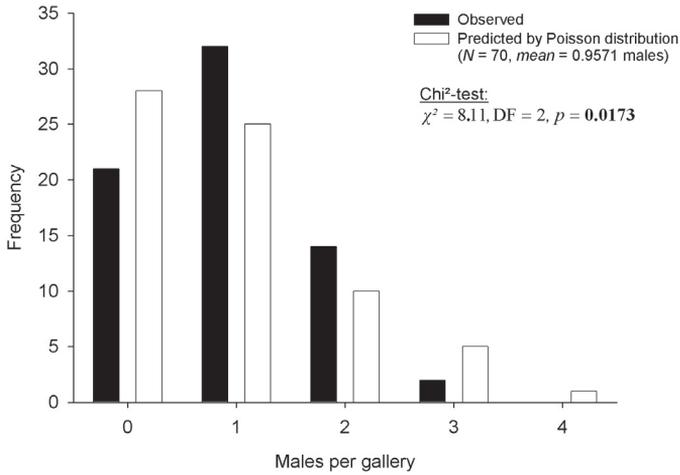


Figure 2. Occurrence of males in laboratory galleries of *Xyleborinus saxesenii*. The maximum number of males per gallery across the observation period is reported (N = 70 galleries). The data significantly differs from the expected Poisson distribution.

Male presence and behavior

The first male per gallery usually eclosed a few days after his first sister did so (Fig. 5), but before her maturation (N = 29 galleries). Following eclosion, males spent most of their time with cropping fungus and walking through the gallery system. When encountering a possible partner, the male started to courtship her, which resembles grooming the body of the female, and afterwards attempted to mate with her. Females seemed relatively reluctant, and thus mating attempts usually lasted several minutes and were rarely successful. Thirty mating attempts were observed, during which males mounted immature (N = 7 of 30 times) and mature females (N = 11 of 30 times) as well as pieces of wood, larvae, and other males (N = 12 of 30 times). Successful copulations, however, were only observed with three immature females, which hints towards a preference to mate with them (Fisher's exact test: $p = 0.09$, N = 21; Fig. 6). Only two females were found to emerge unfertilized from their galleries (indicated by the production of an exclusively male brood later on); they emerged from galleries with brood sex ratios of 2:16 and 1:86, respectively, which indicates that one male is capable of fertilizing up to 60 sisters on its own (no unfertilized females were detected in a gallery with a sex ratio of 1:60). Other male behaviors which were rarely exhibited included digging, cannibalism, and the shuffling of saw-dust and feces with the legs (all with median = 0%).

Although males are wingless, some of them (at least one male in 13 out of 29 galleries) dispersed, i.e., were found on the surface of the medium, when all offspring had matured and no new eggs were laid. Males did not disperse randomly together with

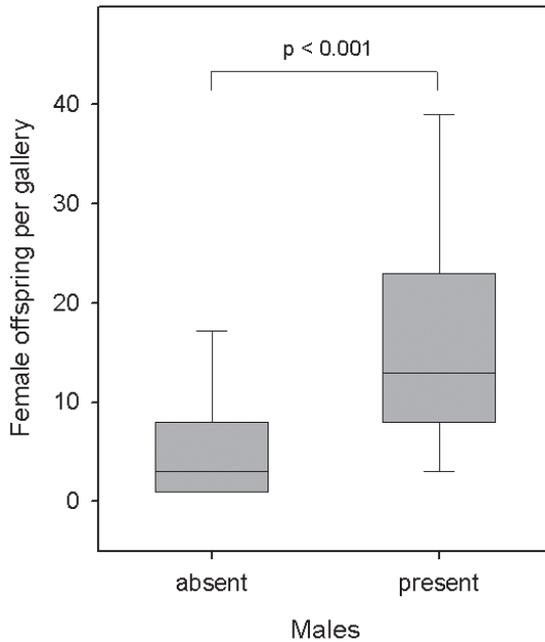


Figure 3. Presence of males in relation to the productivity of laboratory galleries of *Xyleborinus saxesenii*. Box-whisker plots with median, 90%, 75%, 25%, and 10% quartiles are shown. Mann-Whitney U -test: $T = 423$, $p < 0.001$, $N = 21 + 49$ galleries.

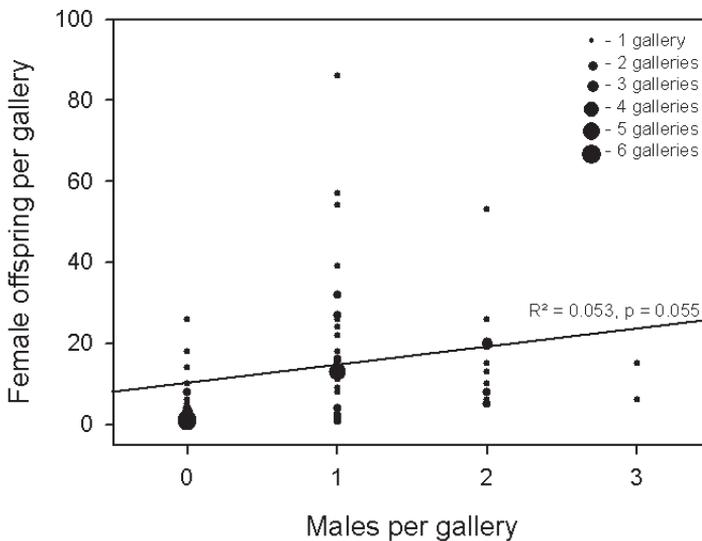


Figure 4. The number of males in relation to the number of females in laboratory galleries of *Xyleborinus saxesenii*. Each gallery is represented by one data point ($N = 70$). Linear regression ($males = 0.785 + (0.0119 * females)$): $F = 3.824$, $p = 0.055$, $DF = 1$.

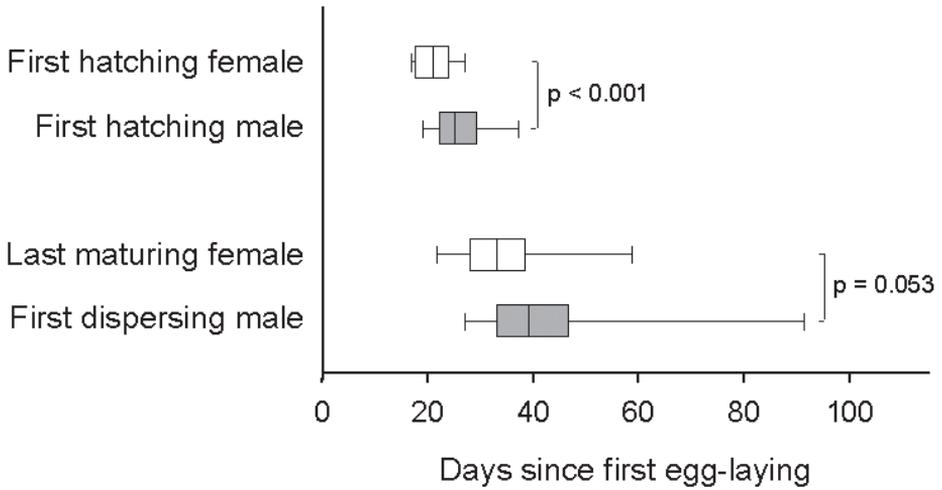


Figure 5. Timing of male and female hatching, maturation, and dispersal in laboratory galleries of *Xyleborinus saxesenii*. The correlation of the first male and female hatching from the pupal stage and the correlation between the last date a not-fully sclerotized female was seen, and the first male dispersal event ($N = 29$ galleries) were determined where possible and contributed one data point per gallery to this graph. Box-whisker plots with median, 90%, 75%, 25%, and 10% quartiles are shown. Mann-Whitney U -tests: $T = 1066$, $p < 0.001$, $N = 29 + 29$ galleries (female vs. male hatching); $T = 325.5$, $p = 0.053$, $N = 26 + 13$ galleries (female maturation vs. male dispersal).

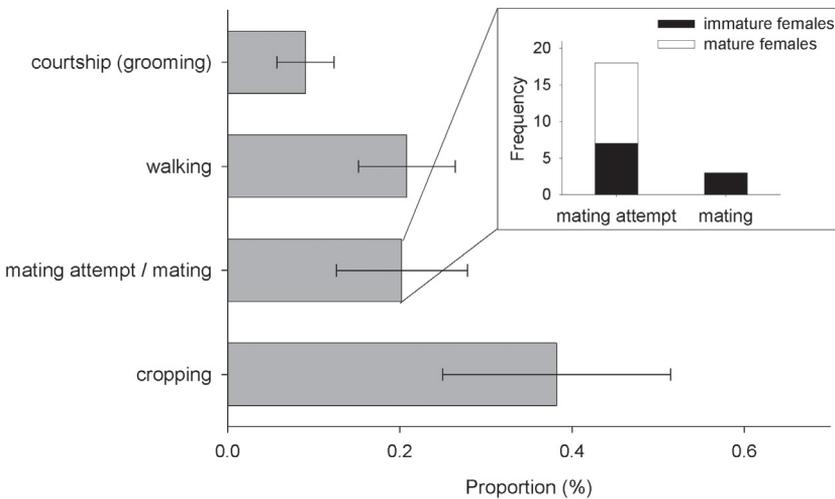


Figure 6. Behaviors of males in laboratory galleries of *Xyleborinus saxesenii*. Males ($N = 8$ galleries) were observed for 10 min and proportion of time spent with the different behaviors was calculated. The grey bars show the mean \pm SE for each behavior across all males. Male mating behaviors were further split into mating attempt and mating, and the age class of the female partner is reported.

their sisters throughout gallery life, but in most cases the first male dispersal occurred after the last female (in a gallery) had matured (Fig. 5).

Discussion

Under inbreeding conditions, natural selection should favor the production of that number of males that maximizes the mean number of inseminated females dispersing from a brood. Thus, in case males are able to inseminate only a limited number of females, the numbers of males and females should be correlated (e.g. Green et al. 1982; Borsa and Kjellberg 1996). In contrast to these predictions, male numbers in *X. saxesenii* families were relatively independent of the number of sisters to be fertilized, ranging from 0 to 3 males per 1 to 86 females, and also independent of maternal brood sex ratios. These facts conform to a strict LMC strategy (e.g. Hamilton 1967; Bernal et al. 2001) with a relatively precise and constant number of males per brood. Males were apparently extremely successful to locate all their unfertilized sister. Only ~3% (2 of 70 galleries) of the successfully breeding females turned out to be unfertilized (they produced solely male broods), which is approximately the same ratio found for *Xyleborus compactus* Eichhoff in the field (Brader 1964). Additionally, in a family with a sex ratio of 1:60 no unfertilized females were found during consecutive lab rearing. The success of males is probably explainable by the gallery morphology. Xyleborini in the genus *Xyleborinus* usually construct brood chambers (“caves”; Wood 1982; Roeper 1995) instead of branching tunnel systems as they are excavated by species of the genus *Xyleborus* (J. Hulcr personal communication), where males and females probably meet more regularly and thus fewer males may be sufficient to fertilize all sisters. In line with this idea, male and female numbers are correlated in the branching tunnel systems of *Xyleborus affinis* Eichhoff (Xyleborina, Scolytinae), as founder females lay eggs in clusters that always contain a male egg (Roeper et al. 1980).

At least one male per family should, however, be expected under the assumption of strict inbreeding. Contrary to that, 30% of all families were male-less; a proportion which is not untypical for Xyleborini (19% of all families in *Xylosandrus germanus* Reiter in the field; Peer and Taborsky 2004). As these measures were taken on adult offspring, the easiest explanation for that finding is that the secondary sex ratios reported, differ from the primary sex ratios allocated by the mother to the eggs, i.e., males had somehow been eliminated. Such secondary male killing could have been accomplished either by selectively cannibalizing offspring or by selecting mechanisms of the fungal cultivars (for attine ants; Mueller 2002) or of bacteria in the ovaries (Peleg and Norris 1972; Kawasaki et al. 2009). Given that both microbes are transmitted only from mothers to daughters, they would presumably profit from female biased broods (Dyson and Hurst 2004; Normark 2004). Studies on the primary sex ratio allocated by the mother to the eggs are therefore necessary to clarify the role of secondary sex ratio distorters as a cause for the high frequency of male-

less families in *Xyleborini*. If, however, it is assumed that there is no secondary male killing and that the absence of males is intended by the mother beetle from the very beginning, then either the chances for mating with foreign partners (and thus, outbreeding) must be higher than previously expected, or selection against male-less broods must be weak. Meeting and outbreeding with foreign mates is obviously possible, as males dispersed from nearly half of the galleries when brood production ceased and females sometimes produced all male broods, whose males also all emerged. It fits these data that *X. saxesenii* males can sometimes be seen outside their nests, occasionally walking on their natal host trees (personal field data). The idea that males disperse from their natal nest in search for outbreeding opportunities implies, however, that they are able to enter foreign galleries, what seems so be complicated by the fact that females or more rarely males (in the genera *Coptodryas* and *Cyclorhipidion*; J. Hulcr personal communication) block the gallery entrances (e.g. Kirkendall et al. 1997; personal observations). On the other hand, male-less families were always very small (equal to or less than 10 females; see similar results in *Hypothenemus hampei* Ferrari by Borsa and Kjellberg 1996), and in a previous study daughters of small families (less than 20 females) were found to contribute much less offspring to the next generation than the daughters from larger families, presumably because the latter are in better body condition and have a more productive complex of microbes to nourish them (Biedermann et al. 2009). Therefore, it is possible that these small male-less galleries would anyway not contribute much fitness to the next generation and hence selection against the absence of males within small broods is probably weak.

Relatively independent from the fact if secondary manipulations of the sex ratio occur, male numbers should be higher under conditions that allow outbreeding, as has been shown in *X. germanus* (Peer and Taborsky 2004). In case *X. saxesenii* mothers also allocate offspring sex according to outbreeding opportunities, then less males should have been found in my lab study compared to the field, where outbreeding opportunities can be expected to arise regularly. Contrary to these expectations, I found a sex ratio of 1:8 (m:f) on average, which is well below the average 1:20 sex ratio previously found in the field both in Australia (Hosking 1972) and Switzerland (personal observations). Although the methods for measuring sex ratios differed between lab and field studies, these strongly contradicting results are not explainable by methodological differences alone and may point to other (environmental) factors influencing sex allocation in *X. saxesenii*.

Males hatched significantly later than their first sisters did, which contrasts with findings in *X. affinis*, whose males hatch before females (Roepert et al. 1980). I hypothesize that in *X. saxesenii* fertilization of all females by their brothers was ensured because females need about ten days to fully develop (Biedermann et al. 2009), and males hatched on average 4 days after females. Furthermore, fertilization of all females was made possible by the high sexual activity of males that did not engage in social behaviors. Instead, they constantly wandered the gallery in search for virgin females, which they started to courtship (groom) upon encounter, followed

by mounting and copulation. Although rarely seen, these copulations occurred exclusively with immature females. Concordantly, males did not disperse as long as new immatures eclosed and could be fertilized, but tended to leave the natal nest as soon as eclosion ceased, presumably in search for outbreeding opportunities. This indicates that they try to fertilize as many sisters as possible, but search for outbreeding opportunities as soon as direct fitness maximization within the natal nest is no longer possible.

Unfertilized females produced solely male broods, but did not mate with their sons to subsequently produce “normal” mixed broods. This expectation was based on observations of *Coccotrypes dactyliperda* Fabricius (Scolytinae) females that do so (Herfs 1959). The behavioral difference between these two species is, however, plausible when one takes into account the extreme longevity and fertility of *C. dactyliperda* females, which raise up to five broods, in this way producing up to 144 individuals in total. In contrast, *X. saxesenii* females usually die soon after their first offspring matures (personal observations), which in case they mated with one of their sons would mean shortly after doing so. Even in case she was nevertheless able to lay a few fertilized eggs before her death, the brood would still be doomed as the mother’s presence and her brood care appears crucial for successful brood development (e.g. Norris 1993; Kirkendall et al. 1997; Biedermann 2007). Another fascinating explanation could be that male broods are intended by the females and represent an alternative reproductive tactic under certain conditions when fitness gains through outbreeding sons are higher than those that can be achieved with the production and maintenance of a mixed brood. Such a condition may, for example, be an environment with a lot of small and male-less broods (e.g., under high density), a situation in which selection would favor a few females to just produce sons that visit their male-less neighboring families.

My data shed light on the cryptic life and mating system of xyleborine ambrosia beetles within their galleries. In the future, molecular studies will be crucial for determining whether the observed inter- and intraspecific variance in sex ratios is an adaptation to outbreeding in some Xyleborini or a hint for the existence of sex ratio distorters, for example, their symbionts. My data provide a starting point for future studies dealing with factors that influence xyleborine sex ratios and the frequency of outbreeding events. Ambrosia beetles are one of the best model systems for studying the evolution of inbreeding, haplodiploidy, sociality and symbioses, but at the same time one of the least known. Before comparative studies on different species can be done to address the issues mentioned, further basic data on the behaviors of these beetles inside their galleries have to be collected.

Conclusion

My data suggest that males in *Xyleborinus saxesenii* Ratzeburg are extremely successful in locating and fertilizing all their sisters in the natal gallery. On average there is only

about one male per family relatively independent of the number of sisters and the maternal brood sex ratio. Apparently, this is sufficient to fertilize all females, probably because the morphology of the gallery system with a central “brood chamber” makes it easy for males to locate them. Only about 3% of the females from broods with males disperse unfertilized from the natal nest and subsequently produce all male broods, but do not mate with one of their sons to produce a mixed brood afterwards.

Despite the fact that males are not the first to hatch within a brood, they do so before the first females mature, and only disperse from the natal gallery once the last female has finished her development. They do not engage in gallery maintenance, gallery protection and brood care, but constantly wander the gallery, presumably in search of unfertilized females. Although males attempt to mate with all individuals independent of age and sex, they were observed to copulate only with immature females.

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Mitochondrial phylogenies in the light of pseudogenes and *Wolbachia*: re-assessment of a bark beetle dataset

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Abstract

Phylogenetic studies based on mtDNA become increasingly questioned because of potential pitfalls due to mitochondrial pseudogenes and mitochondrial selective sweeps. While the inclusion of nuclear markers should preferentially be considered for future studies, there is no need to abandon mtDNA as long as tests for the known mtDNA artefacts are performed. In this study we present additional data and test previous phylogeographical studies of *Pityogenes chalcographus*. We did not detect nuclear copies (numts) of the previously used mitochondrial markers by performing a combined long range/nested PCR of the COI gene and by an *in silico* analysis of the COI sequence data. This confirms the robustness of our previous phylogenetic study of *P. chalcographus*. Results of an *in-situ* hybridization of *Wolbachia* in *P. chalcographus* confirm the presence of this endosymbiont in this species. However, we did not detect a correlation between infection status, geographical region and mtDNA haplotypes. The hybridisation data also support a previous hypothesis that infections do not result from parasitoids or parasitic nematodes, insect surface or laboratory contaminations and are hence a true infection of *P. chalcographus*. We conclude that the deep structure found in mitochondrial populations of *P. chalcographus* indeed represents the evolutionary history of European populations.

Keywords

Wolbachia, Scolytinae, pseudogenes, numts, mtDNA, phylogeny, phylogeography

Introduction

In the last two decades several phylogeographic (e.g. Stauffer et al. 1999) and phylogenetic (e.g. Cognato and Sun 2007) studies on scolytines were presented and most of them used mitochondrial DNA (mtDNA) as one of, or the only genetic marker. Analyses of the mitochondrial genome pioneered the era of molecular ecology due to its small size, uniparental mode of inheritance, ease of isolation, and conserved simple structure, allowing the development of universal primers spanning several classes of Metazoa (e.g. Lunt et al. 1996). However, its potential for resolving the evolutionary history of organisms was gradually questioned when factors influencing the reliability of mtDNA derived phylogenies were identified, namely (i) nuclear non-functional copies of mitochondrial genes (e.g. Bensasson et al. 2001), (ii) maternally inherited endosymbionts (Hurst and Jiggins 2005), (iii) positive selection on mitochondrial genomes (Meiklejohn et al. 2007) and (iv) mitochondrial introgression as a consequence of hybridisation (Petit and Excoffier 2009).

Mitochondria originated from the endosymbiosis of α -proteobacteria in ancestral eukaryotic cells. Mitochondrial genomes contain fewer genes than those of free-living α -proteobacteria, due to a loss of genes during their evolutionary history. This gene loss is explained by (1) the functional redundancy of mitochondrial genes with pre-existing nuclear genes and (2) the functional transfer of mitochondrial genes to the nucleus. The transfer of mtDNA derived sequences to the nucleus is an ongoing process in eukaryotes and mitochondrial pseudogenes have been identified in the nuclear genome of many species (Timmis et al. 2004). Such nuclear mitochondrial (numt) pseudogenes can derive from any part of the mtDNA and occur typically as single copies at dispersed genomic locations. Numts are usually less than 1 kb in size (Richy and Leister 2004). Larger fragments as well as tandemly repeated numts have been reported in mammals (e.g. Bensasson et al. 2001). Phylogenies derived solely from mtDNA sequences may hence be erroneous due to numts being co-amplified by universal mitochondrial primers.

A set of strategies is available in order to avoid numt based errors, including *in silico* analysis of sequences to detect an eventual increased number of non-synonymous base substitutions, frameshifts, additional stop codons and reduced transition/transversion ratios (Bensasson et al. 2001). Positive results should raise doubt on the mitochondrial origin of the retrieved sequences. Furthermore, long PCR techniques can be utilized because most numt sequences are shorter than 1000 base pairs (Richy and Leister 2004).

A specific feature of mtDNA is its strict maternal inheritance in most insects. Due to this asymmetrical inheritance within a species the marker only reflects the female

part of the species' genealogy. Hence, mtDNA transmission will be influenced by any selection for maternally transmitted genes or other maternally selective traits. Several maternally transmitted endosymbionts are well known in invertebrates, with *Wolbachia* as the most prominent one (Werren et al. 2008). *Wolbachia* was also detected in *Ips typographus* (Stauffer et al. 1997), *Hypothenemus hamperi* (Vega et al. 2002), *Xylosandrus germanus* (Peer and Taborsky 2005) and *Coccotrypes dactyliperda* (Zchori-Fein et al. 2006). Recently, *P. chalcographus* was found infected with two *Wolbachia* strains *wCha1* and *wCha2* (Arthofer et al. 2009a). Both strains occur in low titre not accessible by conventional PCR detection methods.

While some *Wolbachia* infections do not alter host physiology and reproduction, such effects have been found in others. Reproductive fitness traits range from cytoplasmic incompatibility (CI) to male-killing, feminisation and the induction of thelytokous parthenogenesis (see Werren et al. 2008 for a review). In a population infected with CI-inducing *Wolbachia*, the mtDNA associated with the initially infected females will hitchhike through the population and replace the original haplotypes (Hurst and Jiggins 2005). From a phylogenetic point of view this selective sweep may easily be mistaken for a population bottleneck or a founder effect. On the other hand, old and established *Wolbachia* infections within a population might maintain mitochondrial isolation in spite of nuclear gene flow. In such cases, deep mtDNA structure may contradict homogenous nuclear phylogenies. Thus, the presence of *Wolbachia* must be checked when mtDNA based phylogenies and phylogeographies are established. This is usually done by conventional PCR using the *Wolbachia* specific primers for *wsp* (Zhou et al. 1998) or 16S rDNA (O'Neill et al. 1992). More sophisticated methods include high sensitivity detection (Arthofer et al. 2009a, b) or *in situ* hybridization which offers a possibility to detect *Wolbachia* directly in infected tissues (Chen et al. 2005). The latter method reduces the risk of false positive results due to contamination with infected parasitoids, parasitic nematodes or prey in the gut content of predators.

In this study we show that numts do not influence the phylogenetic pattern of *P. chalcographus* (Avtzis et al. 2008) by performing a combined long range/nested PCR of the COI gene and by an *in silico* analysis of the COI sequence data. Furthermore, we present results of an *in-situ* hybridization of *Wolbachia* in *P. chalcographus* confirming the presence of the endosymbiont in tissues of this species.

Material and methods

Numt search

Mitogenomic sequences of the coleopteran species *Pyrocoelia rufa* (Lampyridae), *Tribolium castaneum* (Tenebrionidae) and *Crioceris duodecimpunctata* (Chrysomelidae) were obtained from GeneBank (for accession numbers see table 1) and aligned using

Clustal X (Thompson et al. 1997). To facilitate identification of conserved regions sequences of *Apis mellifera* (Apidae), *Bombyx mori* (Bombycidae) and *Drosophila simulans* (Drosophilidae) were included in the alignment. Conserved regions were selected for primer design (Table 1). Occasional variable nucleotide positions within the conserved regions required the selection of primer sequences characteristic for coleopterans. Developed primers were Met/F 5' gctwhtgggttcataccc 3' located in the methionin tRNA region and CO2/R 5' caaatttctgaacattg 3' located in CO2. This primer pair amplifies a stretch of about 3463bp.

Fourteen DNA extracts of *P. chalcographus* representing all clades were selected for analysis. Thermocycling was performed in a Primus 25 advanced thermocycler (peqlab, Germany). Full length PCR was performed in 10 µl reactions using 0.4 µM of each Met/F and CO2/R primer, 6 mM magnesium sulphate, 200 µM dNTPs, 0.4 U *Taq* DNA polymerase (Sigma, USA), 0.01 U Sawady *Pwo* polymerase (peqlab) and 1 µl DNA template in the buffer provided with the *Pwo* polymerase. Cycling conditions were 3 min initial denaturation at 94° C followed by 32 cycles of 94° C (30 sec), 55° C (1 min) and 68° C (2.5 min) and a final extension step at 68° C (10 min). Products were diluted 1:10,000 with sterile distilled water and 1 µl diluted amplicon was used as template for the nested PCR. Dilution series were carried out to prove that the carry over of genomic DNA from the full length to the nested PCR reaction was small enough to avoid detectable amounts of amplicon. Nested PCR was done in 25 µl reactions containing 3.75 mM magnesium chloride, 125 µM dNTPs (Fermentas, Lithuania), 0.5 µM of each K698 (Caterino and Sperling 1999) and UEA10 (Lunt et al. 1996) primer and 1U *Taq* polymerase (Sigma, USA). Cycling conditions contained an initial denaturation step of 3 min at 94° C followed by 33 cycles of 94° C (30 sec), 48° C (60 sec) and 68° C (1.5 min) and a final extension step at 68° C (10 min).

Table 1. Primer sequences of Met/F and CO2/R for *Pityogenes chalcographus* amplifying 3463bp: alignments and GenBank accession numbers.

Met/F		5' gctwhtgggttcataccc 3'
<i>Crioceris duodecimpunctata</i>	NC_003372	...at.....
<i>Pyrocoelia rufa</i>	NC_003970	...tt.....
<i>Tribolium castaneum</i>	NC_003081	...at.a.....
<i>Apis mellifera ligustica</i>	NC_001566	...aaca.....
<i>Bombyx mori</i>	NC_002355	...at....c.....
<i>Drosophila simulans</i>	NC_005781	...ac.....
CO2/R		5' caaatttctgaacattg 3'
<i>Crioceris duodecimpunctata</i>	NC_003372
<i>Pyrocoelia rufa</i>	NC_003970	.g.....
<i>Tribolium castaneum</i>	NC_003081
<i>Apis mellifera ligustica</i>	NC_001566
<i>Bombyx mori</i>	NC_002355
<i>Drosophila simulans</i>	NC_005781

Amplicon size was checked by gel electrophoresis, products were purified with the QiaQuick PCR purification kit (Qiagen, USA) and Sanger sequencing was performed using nested PCR primers by a commercial provider.

An *in-silico* analysis was performed on 262 sequences of the original study (Avtzis et al. 2008) representing 58 European haplotypes of *P. chalcographus* (DQ515997-DQ516054) to identify non-synonymous base substitutions, additional stop codons, insertions and deletions, frameshifts and the transition:transversion ratio. Eleven molecular traits listed in table 2 were selected to discriminate numt and mtDNA which are extensively discussed in the results section.

Identification of *Wolbachia* infections by *in situ* hybridization

In situ hybridization followed a slightly modified protocol of Chen et al. (2005). Insects from locations with elevated *Wolbachia* prevalence were dissected under a stereo microscope using sterile forceps and scalpel blades. Ovarial tissue was recovered, transferred onto microscope slides, pre-fixed with a drop of methanol and air-dried over night. Final fixation was carried out in a drop of 0.4% formaldehyde at 4° C for

Table 2. *In silico* analysis of CO1 mutations of data presented in Avtzis et al. (2008). Total number and relative amount of mutational patterns observed in a 1557 bp stretch of n=262 individuals is compared with expected values for authentic mtDNA.

	Total	Relative (%)	Expected value for mtDNA ^a
Single base substitutions	125	100.0	-
1 st codon position substitutions	15	12.0	14.9 ± 9.4% ^b
2 nd codon position substitutions	2	1.6	4.5 ± 3.5% ^b
3 rd codon position substitutions	108	86.4	80.6 ± 21% ^b
Nonsynonymous substitutions	13	10.4	7.47 ± 5.4% ^c
C › T substitutions	25	20.0	-
GC › GT substitutions	3	12.0 ^d	25 ± 14.0% ^e
Insertions	0	0	none ^f
Deletions	0	0	none ^f
Additional stop-codons	0	0	none ^f
Transitions (3 rd codon position)	95	88.0 ^g	84.9% ± 18.1% ^h
Transversions (3 rd codon position)	13	12.0 ^g	15.1 ± 7.6% ^h
Transition-transversion ratio	7.31	-	-
GC content	-	34.6	28.66 ± 10.5% ⁱ

^a expected relative values as given in reference ± χ^2 confidence interval at $\alpha=0.05$ (Sachs 1999), ^b Blouin et al. (1998), ^c Shoemaker et al. (2004), data of *Drosophila subquinaria*, ^d percentage GC › GT substitutions of total C › T substitutions, ^e Bulmer (1986), Bensasson et al. (2001), ^f Zhang and Hewitt (1996), ^g percentage of total transitions/transversions on 3rd codon position, ^h Tamura (1992), ⁱ Lin and Danforth (2004), data for CO1 genes

5 min. Slides were washed twice by pipetting 2 ml buffer 1 (100 mM Tris.HCl, 150 mM sodium chloride, pH=7.4) on the tissue. The buffer was kept on the tissue for 30 sec and was then decanted. After 10 min air-drying 10 µl of a hybridization solution containing 1 ng/µl of a DIG-labelled *wsp* specific probe, 5% (w/v) dextrane sulphate, 2% (v/v) denatured salmon sperm, 1x SSC, 1x Denhart's reagent and 50% (v/v) formamide were placed on the slide under a cover slip. Tissue was denatured for 5 min at 96° C, cooled on ice and hybridized over night at 42° C in a humid chamber. The cover slip was removed and the slide washed two times 5 min with 2x SSC at room temperature and once 5 min with 0.1x SSC at 42° C. All subsequent steps were carried out at room temperature. The slide was exposed to buffer 2 (100 mM Tris.HCl, 150 mM sodium chloride, 0.5% (w/v) blocking reagent (Roche), pH=7.4) for 15 min, briefly washed with buffer 1 and air-dried for 10 min. 10 µl Anti-DIG antibody conjugated to alkaline phosphatase (Roche, 1:500 in buffer 2) were placed atop each tissue specimen and incubation was performed for one h in a humid chamber. Slides were washed two times 5 min in buffer 1 and equilibrated 5 min in buffer 3 (100 mM Tris.HCl, 150 mM sodium chloride, 1% (w/v) BSA, 0.3% (v/v) Triton X-100, pH=7.4). Staining was performed with 20 µl NBT/BCIP solution (Amresco, USA) in the dark under a cover slide. As soon as a purple colour became visible (30 min up to several h) the cover slip was removed, the sample washed briefly with distilled water, mounted, and microscopy was performed to detect cells infected with *Wolbachia*. For positive and negative control *Drosophila simulans* strains were used.

Results and discussion

Phylogeographic analysis of European *P. chalcographus* populations revealed a deep genetic structure between the most diverged haplotypes with three major clades and an estimated divergence time of 100,000 years before present (Avtzis et al. 2008). Recently, low titre infections of two *Wolbachia* strains were detected in more than 30% of the analysed specimens (Arthofer et al. 2009a). Thus, tests for integrity of the mtDNA based phylogeny in the light of numts and endosymbiont infection were mandatory. Here we present a data set demonstrating that the phylogeny of Avtzis et al. (2008) is not influenced by numt pseudogenes. Arthofer et al. (2009a) have detected *Wolbachia* in all major *P. chalcographus* clades in a pattern that is unlikely to be caused by CI inducing strains. Here we prove the presence of the endosymbiont directly in ovarial cells of the beetle, excluding positive *Wolbachia* detection by PCR due to contamination.

Long/nested PCR and in silico analysis for presence of numts

Alignment of mitochondrial genomes of three coleopteran and three non-coleopteran insect species resulted in six candidate primers (data not shown), of which one primer pair (Table 1), after extensive optimization of PCR conditions, amplified a clear band

from *P. chalcographus* DNA extracts. Dilution series of genomic DNA gave no visible bands in dilutions of more than 1:1,000, ensuring that all amplicons produced in the nested PCR originated solely from the full length PCR product and not from genomic carry-over (data not shown). After nested PCR extensive products of the expected size could be obtained from almost all haplotypes of *P. chalcographus* examined. Even templates without visible amplification in the full length PCR had formed enough product to be amplified in the subsequent nested reaction. Comparison of the NJ trees derived from direct PCR sequences (Avtzis et al. 2008) and from nested PCR sequences of 14 representative haplotypes of the major clades showed identical topologies (data not shown).

PCR conditions were chosen to remove any numt shorter than 3.4 kb, i.e. three times longer than the largest numts ever observed in insects. Both direct and long/nested PCR sequences were identical, and so were the phylogenetic trees. With our test, co-amplification of numts in the direct PCR approach would have led to discrepancies in tree topology between direct and long PCR sequences.

In order to extend numt screening to 262 individual sequences representing 58 different haplotypes, an *in silico* analysis was performed targeting characteristic differences between mtDNA and numt sequence composition. Eleven numerical traits were analyzed independently and all of them resulted in values within 5% confidence intervals for authentic mtDNA (Table 2). Thus, presence of numts in the analyzed populations of *P. chalcographus* can be excluded.

Several strategies to avoid numt co-amplifications are known. The purification of mtDNA by caesium chloride gradient centrifugation (Nishiguchi et al. 2002) prevents the isolation of numts but is inapplicable when the amounts of source DNA are limited. Beside this, the procedure is slow and laboursome and therefore not suitable for the screening of large populations. Other enrichment techniques provide a DNA that may still be contaminated with some nuclear sequences. In cases where the sequences of authentic mtDNA and the corresponding pseudogenes are known the development of target-specific primers may be recommended (Zhang and Hewitt 1996). The long PCR approach utilized in this study should exclude any amplicons derived from nuclear DNA. Furthermore, mtDNA shows some characteristics in base composition and mutational patterns that are different from the nuclear genome. Most obvious, mtDNA is strongly AT biased (Lewis et al. 1995) and evolves faster than single copy nuclear genes (Galtier et al. 2009). Most probably this fast evolution is explained by inefficient repair mechanisms at the mitochondrial replication complex. More recent studies have shown substantial rate heterogeneity between different species and mitochondrial genes (e.g. Mueller 2006). After transfer into the nucleus, a mitochondrial sequence will evolve with the typical patterns of a pseudogene. Compared to the authentic sequence which is under some selective constraint there will be less codon position bias and a higher proportion of nonsynonymous base replacements (Sunnucks and Hales 1996). Transition-transversion ratio is significantly higher in mtDNA than in corresponding pseudogenes (Arctander 1995). The GC dinucleotide is often methylated in nuclear DNA and 5-methylcytosine mutates abnormally often to T (Bird

1980). Therefore the rate of GC \rightarrow GT mutations among the four possible nC \rightarrow nT combinations is highly overrepresented in the nucleus but not in mtDNA where methylation does not occur (Bulmer 1986).

While we consider the long/nested PCR approach as very reliable to exclude any numt from a genetic analysis, it requires additional handling time, costs for PCR consumables and high quality DNA allowing the amplification of >3kb products. Especially the latter condition will not be given when long term stored specimens have to be analyzed that might have degraded DNA. The *in silico* approach presented here can be readily applied to individual haplotypes within any mtDNA alignment and does not require additional manipulations in the laboratory. It is thus suitable for a re-check of existing mtDNA based phylogenies.

Detection of *Wolbachia* by *in situ* hybridization

The principal functionality of a modified protocol for *Wolbachia* detection by *in situ* hybridization with DIG labelled probes was tested using ovarian tissue of *Wolbachia* free *D. simulans* STC and *D. simulans* flies infected with *w*Ri. Differences in colouration were clearly distinguishable between infected and uninfected *D. simulans* (Fig. 1 A, B).

Compared to *w*Ri in *D. simulans*, *Wolbachia* titre in *P. chalcographus* was low, and in average only 35.5% of the individuals were infected (Arthofer et al. 2009a). The ovarian tissue of several individuals analysed showed staining patterns at different intensities, comparable to the *D. simulans* positive controls (Fig. 1C).

Conclusion

Evidence of a range of selective forces on mtDNA markers make phylogenetic studies that are purely based on mtDNA less reliable. While the inclusion of nuclear markers like microsatellites or AFLP should preferentially be considered for future studies, there is no need to completely abandon mtDNA as long as tests for the potential manipulation of mtDNA sequences are performed. Such tests should also be included in ongoing efforts to barcode the tree of life based on mtDNA (Song et al. 2008). Here, we confirm that the data of the previous phylogeographic analysis by Avtzis et al. (2008) are not caused by numts. It can be concluded that the deep structure found in mtDNA populations of *P. chalcographus* indeed represents the evolutionary history at least of the female branch of European populations

Furthermore, we have detected *Wolbachia* in *P. chalcographus* cells in low titre by *in situ* hybridisation. Our results confirm earlier work that used a highly sensitive PCR method (Arthofer et al. 2009a). Such an approach can be prone to false positive results due to contamination, as it was found in one extract that carried a uniquely isolated *Wolbachia* sequence, that most likely derived from co-isolated DNA of a parasitoid (Arthofer et al. 2009a). The previous work showed that two strains are present in this

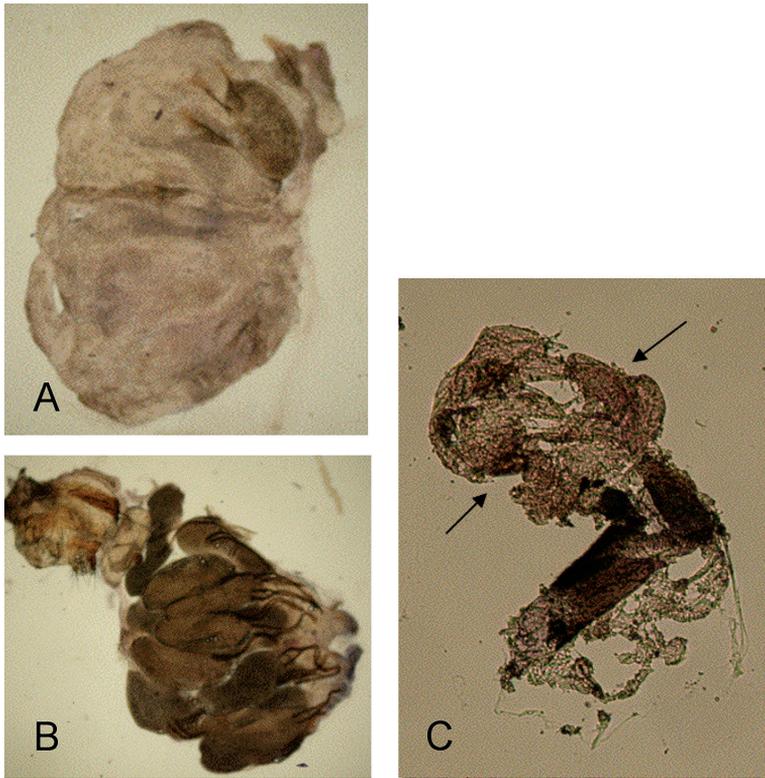


Figure 1. *in situ* hybridization with *wsp* specific probe and staining with NBT/BCIP solution on uninfected **A** and *Wolbachia* infected *Drosophila simulans* **B**. An accumulation of dark color is observed only in ovarioles of *Wolbachia* infected *D. simulans*. **C** Results of *in situ* hybridization of ovarian tissue excised from one *Pityogenes chalcographus* individual with accumulation of dark color (arrows). Three specimens were analysed. All pictures taken with 40-fold magnification.

beetle in low titre and low frequency, without any correlation between infection status, geographical region and mtDNA haplotype. Despite the inability to differentiate both strains with the presented hybridisation technique, the new data support that infections do not result from parasitoids, parasitic nematodes or laboratory contaminations and are hence true *Wolbachia* infections of *P. chalcographus*. In general, additional tests for presence of numts and endosymbionts are laborious and time consuming. However they are required for species that exhibit deep mtDNA divergences in order to exclude potential misinterpretation of mtDNA sequence data.

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