NEWLY DETECTED EXOTIC SPECIES OF *XYLEBORUS* (COLEOPTERA: SCOLYTIDAE) WITH A REVISED KEY TO SPECIES IN EASTERN NORTH AMERICA

THOMAS H. ATKINSON
Entomology and Nematology Department, University of Florida, 1600 SW 23rd Drive, 0540-IFAS, Gainesville, Florida, USA 32611-0540

ROBERT J. RABAGLIA
Maryland Department of Agriculture, 50 Harry S. Truman Parkway, Annapolis, Maryland, USA 21401

and DONALD E. BRIGHT
Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario, Canada K1A 0C6

Abstract

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Two exotic species of *Xyleborus* (Coleoptera: Scolytidae) of Asian origin have recently been detected in the United States. *Xyleborus pelliculosus* Eichhoff has been collected in Pennsylvania and Maryland, and *X. atratus* Eichhoff from Tennessee, Georgia, Maryland, Virginia, and West Virginia. Descriptions of both species and a revised, illustrated key to members of the genus *Xyleborus* in eastern North America are presented. An explanation is proposed for the large numbers of recent introductions of exotic ambrosia beetles from eastern Asia into eastern North America.

Résumé

Deux espèces exotiques de *Xyleborus* (Coleoptera: Scolytidae) d'origine asiatique ont récemment été détectées aux États-Unis. *Xyleborus pelliculosus* Eichhoff a été capturée en Pennsylvanie et au Maryland, et *X. atratus* Eichhoff au Tennessee, en Georgie, au Maryland, en Virginie et en Virginie occidentale. Nous décrivons ici ces deux espèces et nous présentons une clé révisée et illustrée des membres du genre *Xyleborus* dans l'est de l'Amérique de Nord. Nous proposons une explication pour le grand nombre d'introductions récentes dans l'est de l'Amérique du Nord de scolytes du bois exotiques provenant de l'est de l'Asie.

Introduction

While reviewing Scolytidae in institutional and private collections in preparation for a regional monograph of Scolytidae of the southeastern United States, it became apparent to the senior author that two species of ambrosia beetles of the genus *Xyleborus*, not previously known from North America, were included. Independently, the second author was involved in an extensive collecting effort for Scolytidae in Maryland and collected both species. Both species were identified by the third author. These species are *X. atratus* Eichhoff from Tennessee, Georgia, Maryland, Virginia, and West Virginia, and *X. pelliculosus* Eichhoff from Maryland and Pennsylvania.

At least five exotic xyleborine ambrosia beetles have been introduced into eastern North America from Asia in this century, and some are significant pests. These are as follows: *Ambrosiodmus rubricollis* (Eichhoff), *Xylosandrus germanus* Blandford, *X. crassiusculus* (Motschulsky), *X. compactus* (Eichhoff), and *Xyleborus validus* Eichhoff (Wood 1977). The newly detected exotic species reported here raise this total to seven, a significant portion of the total fauna of ambrosia beetles of the region. Wood (1977) was the first to point out the large numbers of exotic scolytids that have been introduced into North America recently and observed that the majority of these reproduce by arrhenotoky and are highly inbred (consanguineous polygyny of Wood [1982]; inbred polygyny of Kirkendall [1983]). In these species newly matured females mate with siblings before emerging from the brood host and are thus able to establish new populations from a single individual.

Descriptions and illustrations of the two newly detected species and a revised, illustrated key to the species of *Xyleborus* in eastern North America are presented. Ecological and biogeographical trends in the Scolytidae are analyzed and an explanation for the large numbers introduced into eastern North America from Asia is proposed.

Abbreviations for collections cited in the text are as follows: FSCA, Florida State Collection of Arthropods, Gainesville, FL; MDAC, Maryland Department of Agriculture, Annapolis, MD; SLWC, S.L. Wood personal collection, Provo, UT; TAMU, Texas A & M University, College Station, TX; THAC, T.H. Atkinson personal collection, Gainesville, FL; UGCA, University of Georgia, Athens, GA; and WVDA, West Virginia Department of Agriculture, Charleston, WV. The scolytid holdings of the Canadian National Collection, U.S. National Museum, Museum of Comparative Zoology, and institutional collections in the southeastern United States were examined but did not contain North American specimens of these species.

Xyleborus atratus Eichhoff

Diagnosis (Figs. 2, 4). This species is most closely related to *Xyleborus dispar* (F.), also introduced into North America (found from western Europe to Japan). It can be distinguished by the more weakly developed serrations on the anterior margin of the pronotum, the more impressed, weakly bisulcate elytral declivity, and the longer interstrial setae on the declivity.

Female. Length 3.0 mm, 2.6 times as long as wide; mature color black.

Frons reticulate, with large dense punctures, especially on lateral areas.

Pronotum 1.1 mm long, 1.1 times as long as wide; anterior margin rounded, unarmed or weakly armed with small serrations; summit near middle, sides arcuate; disc faintly reticulate, sparsely, shallowly punctured.

Elytra 1.7 mm long, 1.5 times as long as wide; strial punctures on disc moderately large, close, spaced within row by diameter of punctures, not impressed, without setae; interstriae 3 times as wide as striae, uniseriately punctate-setose, length of setae equal to width of interstriae, longer posteriorly; punctures becoming granulate posteriorly and gradually increasing in size.

Declivity short, steep, occupying less than posterior 20% of elytra; declivity shallowly bisulcate with interstria 1 and 3 equal in height, interstria 2 impressed; uniseriate granules on all interstriae abundant, small, uniform in size; strial punctures larger than on disc, spaced by ½ diameter of puncture; interstriae 2 times as wide as striae.

Male. Not seen. Described and illustrated by Murayama (1933).

Material Seen. *Georgia*: Jackson Co., Commerce, 14-VII-88, *Pinus taeda*, A. Moreira (UGCA, 1). *Maryland*: Anne Arundel Co., Annapolis, 4–6-IV-88, R.J. Rabaglia, lindgren funnel trap with ethanol (MDAC, 1); Calvert Co., Battlecreek Cypress Swamp, 13-IV-89, 22-V-89, R.J. Rabaglia, lindgren funnel trap with ethanol (MDAC, 2); Montgomery Co., Potomac, R.J. Rabaglia, lindgren funnel trap with ethanol (MDAC, 1). *Tennessee*: Hamilton Co., east side of Chattanooga, Stonehenge Dr., 19-IV-87, mercury vapor and black light, E.G. Riley (FSCA, 1; TAMU, 1). *Virginia*: Albemarle Co., Ivy Creek Natural Area, 24-V to 14-VI-89, T. Tigner (FSCA, 1). *West Virginia*: Kanawha Co., Guthrie, 25-IV-88, M.C. Thomas (WVDA, 1); same data, 12-V-88 (THAC, 1). This species is apparently established over a large area in the eastern United States as it has been collected from widely separated localities.

This species is known from Korea, Japan, Taiwan, China, Burma, the Phillipines, Indonesia, and New Guinea and has been reported from *Morus* (Moraceae), *Alnus, Betula, Carpinus* (Betulaceae), *Ulmus* (Ulmaceae), *Quercus, Fagus, Castanopsis, Lithocarpus* (Fagaceae), *Cinnamonum, Litsea, Machilus* (=*Persea*) (Lauraceae), *Pinus* (Pinaceae), *Acacia, Albizzia, Ormosia* (Fabaceae), *Prunus, Malus* (Rosaceae), *Acer* (Aceraceae), *Camellia, Cleyera, Stewartia* (Theaceae), *Styrax* (Styracaceae), *Aralia* (Araliaceae), *Diospyros* (Ebenaceae), *Ternstroemia* (Ternstroemiaceae), and *Evodia* (Rutaceae) (Choo 1983).

Xyleborus pelliculosus Eichhoff

Diagnosis (Figs. 1, 3, 5). This species has sutures on the posterior face of the antennal club, a character not present in any native North American species of *Xyleborus*. It can be easily identified by the abundant, confused interstrial punctures and pubescence on the elytral disc and declivity.

Female. Length 3.2 mm, 2.8 times as long as wide; color dark brown.

Frons reticulate, with scattered small granules, faintly aciculate near epistomal margin; a weak longitudinal carina present from above upper level of eyes to epistoma, indistinct below; antenna with sutures and pubescence on apical 25% of club.

Pronotum 1.3 mm long, 1.1 times as long as wide; anterior margin rounded, unarmed; summit near middle; disc reticulate, shallowly punctate, with abundant, short setae, longer laterally.

Elytra 1.6 mm long, 1.45 times as long as wide; discal interstriae not impressed, punctures small, with short, inconspicuous, recumbent setae, becoming longer posteriorly; interstrial punctures confused on disc and declivity, associated with abundant, confused setae; declivity steep, occupying posterior 15% of elytra, face flattened, interstria 2 impressed; strial punctures much larger than on disc, adjacent punctures nearly touching; all interstriae sparsely granulate, granules larger on interstriae 1 and 3, confused setae on all interstriae.

Male. Not seen. Described by Murayama (1934).

Material Seen. *Maryland*: Harford Co., Susquehanna St. Park, 8-V-89, R.J. Rabaglia, lindgren trap with ethanol (THAC, 1; MDAC, 2); Montgomery Co., Potomac, 17-IV-89, R.J. Rabaglia, lindgren trap with ethanol (THAC, 1). *Pennsylvania*: Delaware Co., Chadds Ford, 25-V-87, J.E. Wappes (THAC, 1). Specimens from the United States were compared directly with two Japanese specimens in the Eggers collection at the U.S. National Museum which had been compared with Eichhoff's holotype by Eggers.

This species appears to be well established in eastern Maryland and adjacent Pennsylvania.

Key to Females of *Xyleborus* from Eastern North America

To facilitate identification of these newly reported exotics, a key to the species of *Xyleborus* from eastern North America is given below. Wood's (1982) key to the species of *Xyleborus* from North and Central America includes all but the newly detected exotics, but because a very large number of tropical species are also included it is difficult to use for eastern North America. All species found east of the Great Plains, from southern Texas to north-central Canada, are included.

Several species previously included in *Xyleborus* by Bright (1968) and Wood (1982) are now placed in *Premnobius, Xyleborinus*, or *Ambrosiodmus* (Wood 1982, 1986). Wood (1980, 1986) removed many generic names from synonymy from *Xyleborus* but indicated only the type species for each. According to Wood's (1986) generic key, *Xyleborus validus* would belong in the genus *Euwallacea* Hopkins and *X. pelliculosus* would be placed in the genus *Terminalinus* Hopkins. Because the species in the genera removed from synonymy by Wood (1980) have not been revised in any comprehensive way, we are conservatively treating the two species currently found in North America as *Xyleborus* until their taxonomic status has been clarified. The North American (north of Mexico) species of *Xyleborus*, as treated here, include those species with recurved sutures on the antennal club (procurved in *Premnobius*), a large, flat scutellum (small and pointed in *Xyleborinus*), and with the posterior portion of the pronotum smooth (rugose in *Ambrosiodmus*).

This key is intended to facilitate identification. The arrangement of species in the key is not phylogenetic.

1. Posterior face of antennal club with sutures on apical third (Fig. 1).................. 2

— Posterior face of antennal club without sutures (Fig. 15), apical margin formed by acute margin of basal corneous area 3

2 (1). Anterior margin of pronotum rounded; interstrial setae on disc and declivity abundant, confused; declivity convex (Figs. 3, 5). Asian exotic, Maryland, Pennsylvania. 3.2 mm .... *pelliculosus* Eichhoff

— Anterior margin of pronotum subquadrate (Fig. 6); interstrial setae on disc and declivity uniseriate; declivity flat (Fig. 7). Asian exotic, eastern United States south to Louisiana. 3.4–3.8 mm .... *validus* Eichhoff

3 (1). Anterior margin of pronotum usually armed by several coarse serrations (Fig. 8) (may be present in specimens of *atratus* [Fig. 2]); body stout, less than 2.2 times as long as wide; mature color black.. 4

— Anterior margin of pronotum unarmed by large serrations (Figs. 2, 10); body slender, greater than 2.5 times as long as wide; mature color usually yellowish or reddish brown 7

4 (3). Posterolateral costa on declivity armed by 3–5 distinct tubercles. North-central United States and Canada, south to Virginia. 2.8–3.5 mm................... *obesus* LeConte

— Posterolateral costa on declivity of uniform height, may appear slightly undulating, but without denticles (Fig. 9).. 5

5 (4). Anterior margin of pronotum armed by numerous small subequal serrations (Fig. 8); declivital striae impressed, declivital interstriae less than 2 times as wide as striae (Figs. 4, 9) 6

— Anterior margin of pronotum armed by 2–6 serrations, median pair conspicuously larger than others; declivital interstriae at least twice as wide as striae. North-central United States and Canada. 2.3–2.6 mm .... *sayi* (Hopkins)

6 (5). Anterior margin of pronotum armed by 6–8 subequal serrations (Fig. 8); declivity flattened, interstrial setae subequal in length to width of interstriae (Fig. 9). North-central United States and Canada, Pacific Northwest of United States and Canada. 2.8–3.5 mm .... *dispar* (F.)

— Anterior margin of pronotum with weakly developed serrations (Fig. 2); declivital interstriae 2 impressed, declivity slightly bisulcate; interstrial setae twice as long as width of interstriae (Fig. 4). Asian exotic, Tennessee, Georgia, Maryland, West Virginia. 3.0 mm.. *atratus* Eichhoff

7 (1). Declivity strongly concave with obtusely elevated margins on posterolateral areas (Fig. 14); sutural interstriae of declivity armed by 2–4 stout tubercles. Southern Texas to Central America. 3.8–4.2 mm .... *horridus* Eichhoff

— Declivity convex, flattened, or somewhat impressed near midline, but not concave ... 8

8 (7). Declivity flattened or slightly sulcate, denticles on some interstriae much larger than on others (Figs. 16, 17).. 9

— Declivity flattened or convex, denticles on all interstriae (where present) uniform in size (Figs. 18, 19, 20) 11

9 (8). Declivity steep, flat, surface dull; stria 1 on declivity strongly curved away from midline, with 2 large, pointed, widely spaced tubercles almost on striae; smaller granules on all interstriae only at base or lateral areas of declivity, not on face, forming a circumdeclivital ring (Fig. 16). Eastern North America. 3.6–4.5 mm .... *celsus* Eichhoff

— Declivity less steep, slightly impressed along midline, surface shining; interstriae 1 and 2 armed only at base by small tubercles; interstria 3 with 3 widely spaced denticles, the middle one conspicuously larger than others (Fig. 17)............................ 10

10 (9). Anterior portion of pronotum of female impressed, weakly sulcate. Southeastern United States 2.0–2.5 mm .... *viduus* Eichhoff

— Anterior portion of pronotum of female convex, normal (Figs. 10, 11), impressed and sulcate in males (Figs. 11, 13). Eastern North America, Neotropics. 2.0–2.3 mm .... *ferrugineus* (F.)

11 (8). Surface of declivity opaque, dull (Figs. 19, 20, 21)............................... 12

— Surface of declivity shining (Figs. 18, 22) 14

12(11). Declivity broadly sloping, occupying posterior 30–40% of elytra (Fig. 23), declivity slightly tapered posteriorly; tubercles of interstriae 1 and 3 small but conspicuous (Fig. 20). Eastern North America, Neotropics. 2.0–2.7 mm .... *affinis* Eichhoff

— Declivity steep, occupying posterior 15% of elytra, apex blunt, not tapered; tubercles of interstriae 1 and 3 very small (Fig. 19) 13

13(12). Anterior portion of pronotum of female impressed, weakly sulcate. Eastern North America. 2.3–2.4 mm .... *planicollis* Zimmermann

— Anterior portion of pronotum of female convex, normal (impressed and sulcate in males). Eastern North America. 2.3–2.7 mm .... *xylographus* (Say)

14(11). Declivity convex, posterolateral areas not subacutely margined (Figs. 22, 24) 15

— Declivity flattened, oblique, occupying posterior 25–30% of elytra; posterolateral margin subacutely margined (Fig. 18). Southern Florida, Texas, Neotropics. 2.1–2.8 mm...... .... *volvulus* (F.)

15(14). Discal interstriae 2 times as wide as striae; some declivital tubercles with height and basal width greater than the diameter of strial punctures. Western North America to Honduras, New York to Georgia. 2.2–2.7 mm .... *intrusus* Blandford

— Discal interstriae less than 1.5 times as wide as striae; some declivital tubercles with height and basal width less than the diameter of strial punctures (Fig. 22). Eastern North America. 2.3–2.7 mm .... *pubescens* Zimmermann

Why Are There So Many Asian Ambrosia Beetles in Eastern North America

The greatest diversity of ambrosia beetles occurs in humid tropical regions of the world (Browne 1961; Beaver 1977; Wood 1982). Warm temperatures, lack of extreme cold temperatures, or both, are apparently required by most species. High humidity is probably as important as high temperature for most ambrosial species. Within the tropics, areas with a pronounced dry season (Atkinson and Equihua 1986*b*) have markedly fewer ambrosial species than nearby humid tropical areas (Atkinson and Equihua 1986*a*). The ambrosial feeding habit has evolved independently many times within the scolytid–platypodid clade (Wood 1982), probably under humid tropical conditions in most cases (Beaver 1977; Atkinson and Equihua 1986*a*). The general trend on all continents is that ambrosia beetle diversity drops sharply with increasing distance from the equator. This trend is less pronounced along gradients where humid tropical environments change more-or-less smoothly toward moist temperate environments such as in eastern Asia and eastern North America. Both of these areas, especially the former, have rich ambrosia beetle faunas. Temperate areas separated from the humid tropics by regions of arid or semiarid climate such as western Europe and western North America have comparatively poor faunas.

The ambrosia beetle faunas (Scolytidae and Platypodidae) of eastern and western North America (north of Mexico) differ greatly both in richness and taxonomic composition. Taxonomic and biogeographic information on North American Scolytidae and Platypodidae are synthesized primarily from Bright (1968, 1976), Wood (1979, 1982), and unpublished data. Eastern North America by far has the richer fauna with 44 species (including 10 exotic species) whereas western North America has only 25 (including four exotic species). Several species cited by Wood (1977) as introduced from the Neotropics into North America are treated here as native as they are distributed continuously along the Gulf Coast through Mexico (*Ambrosiodmus obliquus* [LeConte]), or are found in Florida and nearby islands in the Caribbean, as well as in South and/or Central America (*Corthylus spinifer* Schwarz, *Xyleborinus gracilis* [Eichhoff], and *Xylosandrus zimmermanni* [Hopkins]).

The faunas of eastern and western North America are also taxonomically distinct, with only six species in common, two of them exotics. Three of the shared species, *Xyleborus dispar, X. intrusus*, and *Xyleborinus saxeseni* (Ratzeburg), have disjunct eastern and western ranges. The other three species, *Trypodendron betulae* Swaine, *T. retusum* (LeConte), and *T. lineatum* (Olivier), have essentially boreal–montane distributions, joined across central Canada. There are no species in common with continuous southern distributions. Several species found in eastern North America are also widely distributed in the Neotropics, including the Pacific Coast of Mexico, but have not been reported from the western United States (e.g. *Xyleborus ferrugineus* [F.], *X. affinis* Eichhoff, and *X. volvulus* [F.]). The ranges of most eastern species are limited on the west by the Great Plains (coinciding with decreased precipitation and the limits of the eastern deciduous forests). The distinctiveness of the faunas suggests that extant patterns of climate and vegetation in the central part of the continent have long been, and continue to be, effective in preventing natural exchange of ambrosial species between the two coasts. The lower number of species in the west, both native and introduced, implies that eastern North America is and has been a more favorable area for ambrosia beetles both in evolutionary and recent time. The large number of successful introductions in the east suggests that ecological saturation of ambrosial species has not occurred.

The most likely explanation for these data is the difference in rainfall and humidity between the two regions. Humidity is generally high over large regions in central and eastern North America. In western North America areas of high humidity and rainfall tend to be smaller, and intercalated into a complex mosaic of arid, semiarid, and montane areas. The greater diversity of hardwood species in the east is unlikely to be an important factor in the comparative richness of ambrosia beetles. Most native eastern species and all of the introduced species are not host-specific and will breed in a wide variety of tree species.

A closer analysis of the species of exotic ambrosial species from eastern North America shows that the bulk are native to Asia (seven of 10). Two other species that were probably introduced into North America from Europe (Wood 1977), *Xyleborus dispar* and *Xyleborinus saxeseni*, also occur in temperature eastern Asia (Choo 1983; Nobuchi 1986*b*). The 10th species, *Premnobius cavipennis* Eichhoff, is of tropical African origin and is apparently restricted to subtropical Florida, though widely distributed in the Neotropics. All of the exotic ambrosia beetles have inbred polygyny as their mating system, supporting Wood's observations (1977). Females of these species normally mate with siblings prior to emergence from the brood host and are able to establish new populations from a single individual (Wood 1977, 1982). Literature on the diverse scolytid and platypodid fauna of temperate eastern Asia is scattered, making it difficult to tabulate the richness of ambrosial species, which is quite high. Korea has 34 species (out of a total of 99 scolytids and platypodids) (Choo 1983), almost as many as eastern North America. Japan has 111 species of ambrosia beetles (total of 321 species of scolytids and platypodids) (Nobuchi 1986*a*, 1986*b*).

Taken together these observations suggest that a net transfer of ambrosial species probably will continue from temperate and subtropical Asia to eastern North America, and to western North America to a lesser extent. The rich, temperate-adapted ambrosia beetle fauna in Asia provides the source of new immigrants. Conditions for establishment are favorable in eastern North America. Inbred polygyny facilitates introduction, and increased trade between the United States and Canada and the far east provides the opportunity for transport.

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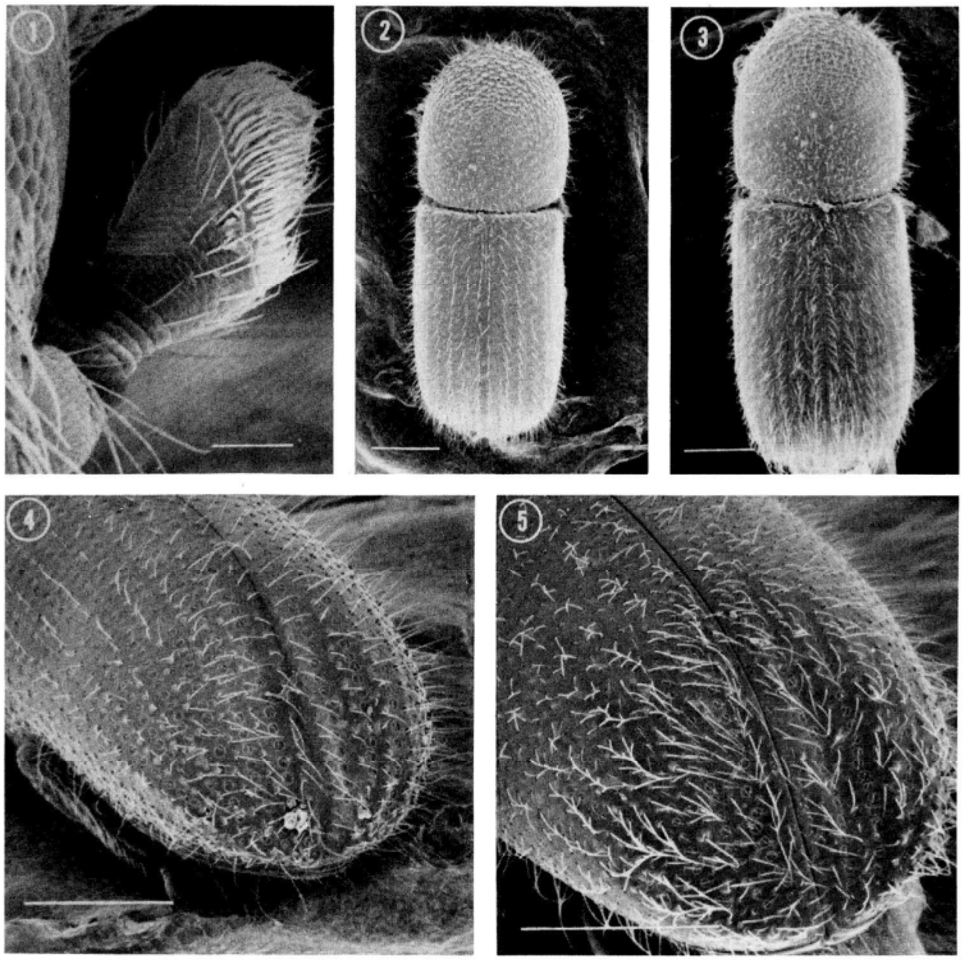
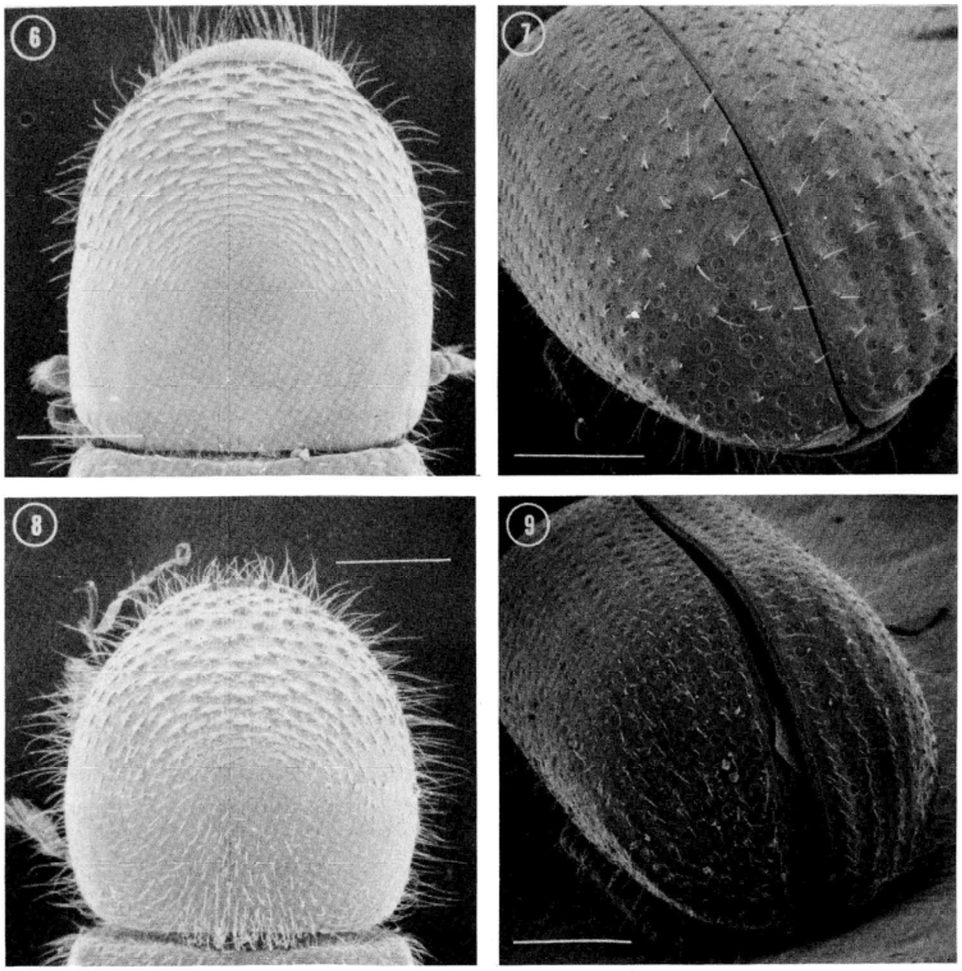
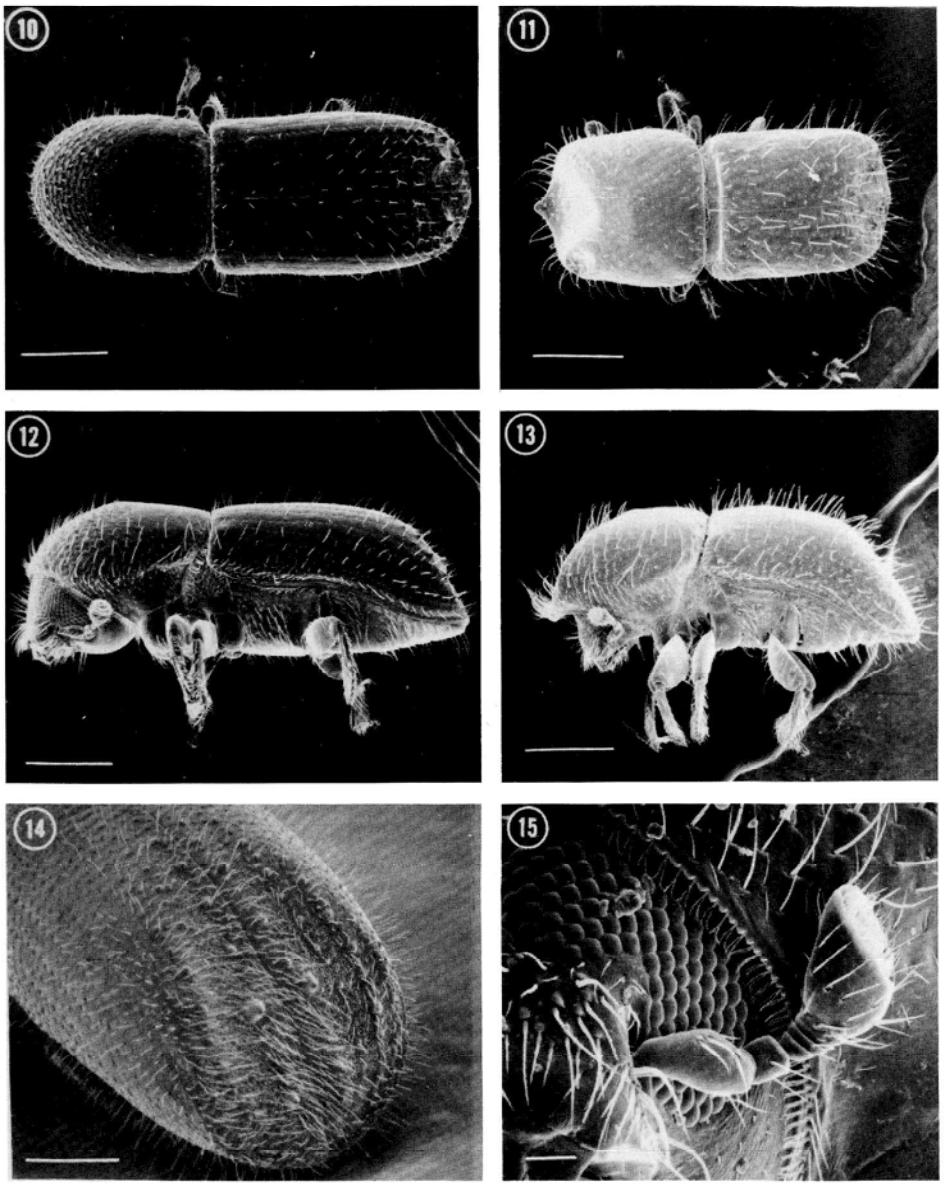


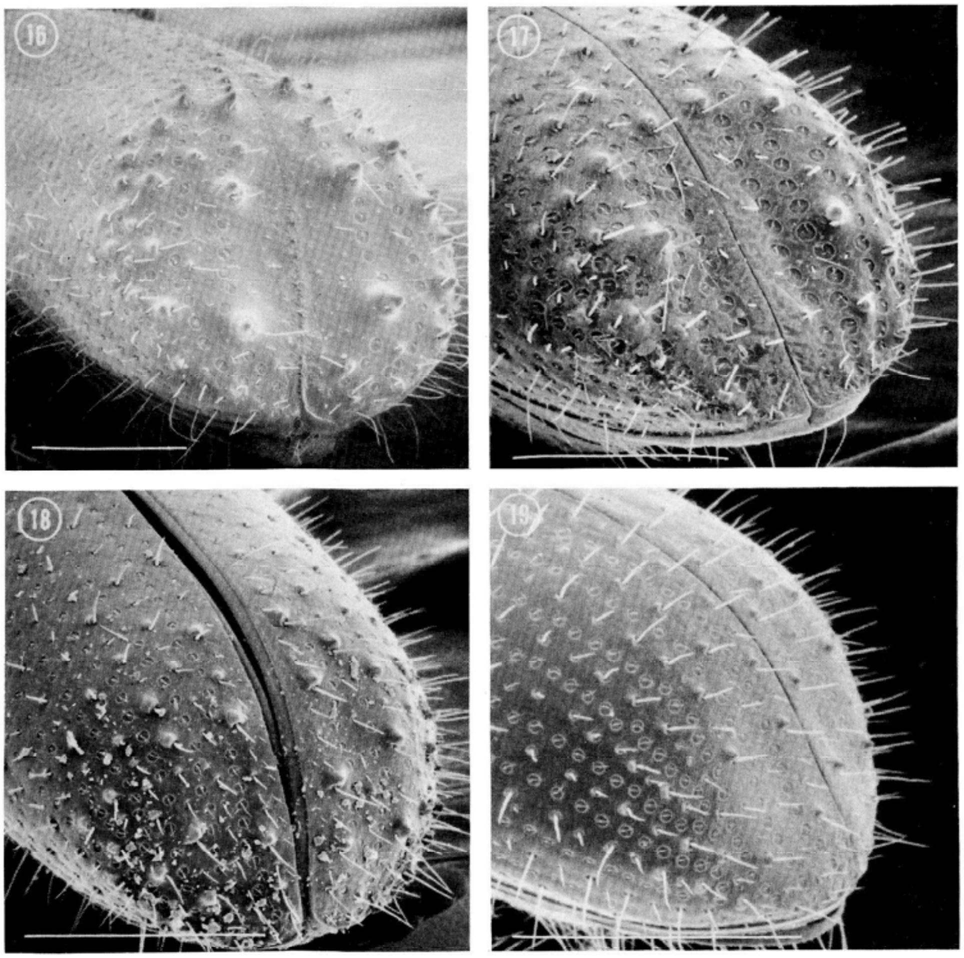
FIGS. 1–5. 1, *Xyleborus pelliculosus* antenna showing sutures on posterior face; 2, *X. atratus*, female, dorsal view; 3, *X. pelliculosus*, female, dorsal view; 4, *X. atratus*, female, declivity; 5, *X. pelliculosus*, female, declivity. White lines represent 0.05 mm in Figure 1, 0.5 mm in Figures 2–5.



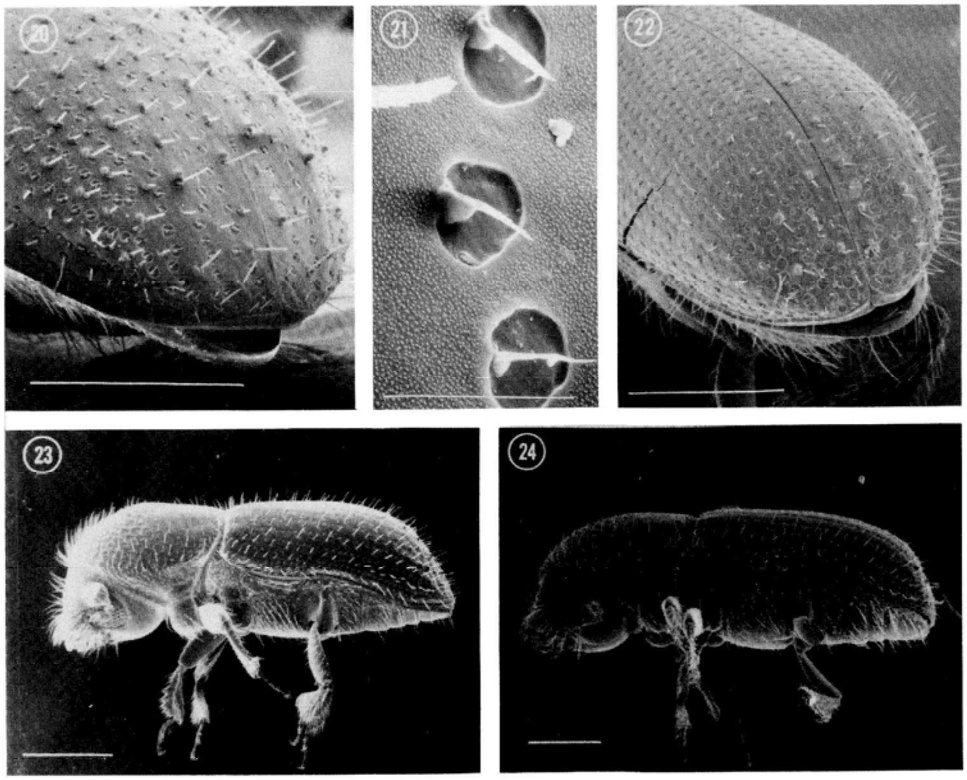
FIGS. 6–9. 6, *Xyleborus validus* pronotum; 7, *X. validus* declivity; 8, *X. dispar*, pronotum; 9, *X. dispar*, declivity. White lines represent 0.5 mm in all figures.



FIGS. 10–15. 10, *Xyleborus ferrugineus* female, dorsal view; 11, *X. ferrugineus* male, dorsal view; 12, *X. ferrugineus* female, lateral view; 13, *X. ferrugineus* male, lateral view; 14, *X. horridus*, declivity; 15, *X. pubescens* antenna. White lines represent 0.5 mm in Figures 10–14, 0.05 mm in Figure 15.



FIGS. 16–19. 16, *Xyleborus celsus*, declivity; 17, *X. ferrugineus*, declivity (declivital surface partially covered with an extraneous film in this specimen; normally the declivital surface of this species is shining); 18, *X. volvulus*, declivity; 19, *X. xylographus*, declivity (note faintly reticulate pattern on declivital surface). White lines represent 0.5 mm in all figures.



FIGS. 20–24. 20, *Xyleborus affinis*, declivity; 21, *X. affinis*, closeup of surface of declivital interstria 2 (note small superficial granules); 22, *X. pubescens*, declivity; 23, *X. affinis*, lateral view; 24, *X. pubescens*, lateral view. White lines represent 0.5 mm in Figures 20, 22–24, 0.05 mm in 21.