NEWLY DETECTED EXOTIC SPECIES OF \textit{Xyleborus} (COLEOPTERA: 
Scoliidae) WITH A REVISED KEY TO SPECIES IN EASTERN NORTH AMERICA

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Abstract

Two exotic species of \textit{Xyleborus} (Coleoptera: Scoliidae) of Asian origin have recently 
been detected in the United States. \textit{Xyleborus pellicolus} Eichhoff has been collected 
in Pennsylvania and Maryland, and \textit{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 \textit{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 \textit{Xyleborus} (Coléoptère: Scoliidae) d'origine asiatique ont 
récemment été détectées aux États-Unis. \textit{Xyleborus pellicolus} Eichhoff a été capturé 
en Pennsylvanie et au Maryland, et \textit{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 \textit{Xyleborus} dans 
l'est de l'Amérique du 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 Scoliidae in institutional and private collections in preparation for 
a regional monograph of Scoliidae of the southeastern United States, it became apparent 
to the senior author that two species of ambrosia beetles of the genus \textit{Xyleborus}, not 
previously known from North America, were included. Independently, the second author 
was involved in an extensive collecting effort for Scoliidae in Maryland and collected 
both species. Both species were identified by the third author. These species are \textit{X. atratus} 
Eichhoff from Tennessee, Georgia, Maryland, Virginia, and West Virginia, and \textit{X. pellicolus} 
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: \textit{Amphissodes rubricollis} (Eichhoff), \textit{Xylosandrus germanus} Blandford, \textit{X. cras 
siusculus} (Motschulsky), \textit{X. compactus} (Eichhoff), and \textit{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 scoyltids that have been introduced into North America 
recently and observed that the majority of these reproduce by arrenotoky 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 \textit{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 clytral declivity, and the longer interstriae 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, uniseriate 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 interstriae 1 and 3 equal in height, interstriae 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 (MDAC, 1). Tennessee: Hamilton Co., east side of Chattanooga, Stonechenge Dr., 19-IV-87, mercuric 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 Philippines, Indonesia, and New Guinea and has been reported from *Morus* (Moraceae), *Alnus*, *Betula*, *Carpinus* (Betulaceae), *Ulmus* (Ulmaceae), *Quercus*, *Fagus*, *Castanopsis*, *Lithocarpus* (Fagaceae), *Cinnamomum*, *Litsea*, *Maclura* (=*Persea*) (Lauraceae), *Pinus* (Pinaceae), *Acacia*, *Albizia*, *Ormosia* (Fabaceae), *Prunus*, *Malus* (Rosaceae), *Acer* (Aceraceae), *Camellia*, *Cleyera*, *Stewartia* (Theaceae), *Styrax* (Styraceae), *Aralia* (Araliaceae), *Diospyros* (Ebenaceae), *Ternstroemia* (Ternstroemiaceae), and *Evolia* (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 interstitial 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 accipitate 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; interstitial punctures confused on disc and declivity, associated with abundant, confused setae; declivity steep, occupying posterior 15% of elytra. Face flattened, interstriae 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.


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 Prennothus, Xyleborinus, or Ambrosiodinus (Wood 1987, 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 (procurred in Prennothus), a large, flat scutellum (small and pointed in Xyleborinus), and with the posterior portion of the pronotum smooth (rugose in Ambrosiodinus).

This key is intended to facilitate identification. The arrangement of species in the key is not phylogenetic.
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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 cornaceous area ................................................................. 3

2 (1). Anterior margin of pronotum rounded; interstitial setae on disc and declivity abundant, confused; declivity convex (Figs. 3, 5). Asian exotic, Maryland, Pennsylvania. 3.2 mm
   Anterior margin of pronotum subquadrate (Fig. 6); interstitial 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); declival striae impressed, declival 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; declival interstriae at least twice as wide as striae. North-central United States and Canada. 2.3–2.6 mm .............................................. savi (Hopkins)

6 (5). Anterior margin of pronotum armed by 6–8 subequal serrations (Fig. 8); declivity flattened, interstitial 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 .................................................. dispers (F)
   Anterior margin of pronotum with weakly developed serrations (Fig. 2); declival interstriae 2 impressed, declivity slightly bisulate; interstitial 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 circumdeclival ring (Fig. 16). Eastern North America. 3.6–4.5 mm .................................................. celsius 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 .................................................. validus 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, apically 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 75–80% 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 striae 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 striae 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 1986b) have markedly fewer ambrosial species than nearby humid tropical areas (Atkinson and Equihua 1986a). 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 1986a). 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 semi-arid 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 saxesenii (Rauebug), 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 jerrugineus* [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 temperate eastern Asia (Choo 1983; Nobuchi 1986b). The 10th species, *Pemphobius 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 1986a, 1986b).

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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References


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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.
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 celatus, 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. solvulus, declivity; 19, X. xylographus, declivity (some 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.