Distribution, Host Plants, and Damage of the Black Twig Borer, *Xylosandrus compactus* (Eichhoff), in South Carolina

Juang-Horng Chong, Lauria Reid, and Margaret Williamson


**ABSTRACT** The black twig borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae: Scolytinae), is an exotic ambrosia beetle that can be a severe pest of ornamental trees and shrubs in the landscape of South Carolina. This paper reports on the beetle's distribution and host plants in South Carolina. Descriptive data on the severity of attacks in different locations and at specific heights of southern magnolia (*Magnolia grandiflora* L.) trees were also gathered. *Xylosandrus compactus* was trapped or observed in 18 counties in South Carolina, from the Atlantic Coast to the upper Piedmont regions. The recorded ornamental host plants of *X. compactus* in South Carolina include *Buxus sempervirens* L. (boxwood), *Cercis canadensis* L. (eastern redbud), *Cornus florida* L. (flowering dogwood), *Ficus carica* L. (common fig), *Gardenia jasminoides* J. Ellis (gardenia), *Hydrangea macrophylla* (Thunb.) Ser. (hydrangea), *Magnolia grandiflora*, *Morella cerifera* (L.) Small (wax myrtle), and *Pine* sp. (pine). On average, 47% of southern magnolia trees in seven neighborhoods of North Myrtle Beach, SC suffered attacks by *X. compactus*. Southern magnolia terminals at a height of 0–1 m (from soil surface) suffered the highest percentage of attacks (11.1%), followed by those at 1–2 m (7.2%). The percentage of terminals attacked was reduced to less than 4% at 3–6 m. The tendency for *X. compactus* to infest terminals at heights less than two meters suggests that preventive insecticide applications should target the lower branches to reduce damage.

**KEY WORDS** Ambrosia beetle, Curculionidae, Scolytinae, *Magnolia grandiflora*

Several species of exotic ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) are important pests of ornamental plants. *Xylosandrus crassiusculus* (Motschulsky) and *Xylosandrus germanus* (Blandford) are two of the most economically important ambrosia beetle species in the nursery production of the eastern United States (Hudson & Mizell 1999, Oliver & Mannion 2001, Reding et al. 2010). Recent introduction of the redbay ambrosia beetle, *Xyleborus glabratus*
Eichhoff, to the southeastern United States has the potential of significantly changing the biodiversity and sustainability of forestry (Hanula et al. 2008). The black twig borer, *Xylosandrus compactus* (Eichhoff), is an occasionally severe pest of landscape ornamentals in the southeastern Unites States (Ngoan et al. 1976, Mangold et al. 1977). The ambrosia beetle species mentioned above are believed to be of eastern Asian origin (Wood 1982, Rabaglia et al. 2006).

*Xylosandrus compactus* is distributed in parts of Africa, Asia, Pacific Islands, New Zealand, South America, and North America (Rabaglia et al. 2006). It was detected in Florida in 1941 (Wood 1982) and Hawaii in 1961 (Beardsley 1964). Currently, *X. compactus* is reported from Texas to North Carolina (Rabaglia et al. 2006). Although Rabaglia et al. (2006) did not report *X. compactus* in South Carolina, the beetle is known to be established in the state. Ethanol-baited trapping by Coyle et al. (2005) near Aiken, SC, captured a small number (n = 2 or 0.057% of total bark and ambrosia beetles captured) of *X. compactus* over a three-year period (2002–2004). A later survey by Miller & Rabaglia (2009), on the other hand, did not collect *X. compactus* at the Sumter National Forest near Union, SC. Both studies were conducted in pine or mixed pine-hardwood plantations. Our observations of damaged ornamental plants in both urban landscape and forests suggest that *X. compactus* is more abundant and widespread in South Carolina than previously reported (JHC & LR, personal observations).

Ngoan et al. (1976) and Hara & Beardsley (1979) reported the biology of *X. compactus*. In Florida, *X. compactus* overwinters as adults in twigs and small branches of suitable host plants and emerges in late February (Ngoan et al. 1976). The flight period peaks in March and adults are captured in sticky traps until September. Beetles of all developmental stages are present in the galleries from April to November. In the laboratory, *X. compactus* required about 28.5 days to complete development in flowering dogwood (*Cornus florida* L.) twigs at 25 ± 2°C (Ngoan et al. 1976). On average, 29 days overlap between the entry of parental females and the emergence of offspring from infested coffee (*Coffea arabica* L.) twigs kept between 23 and 27°C (Hara & Beardsley 1979). Ngoan et al. (1976) and Hara & Beardsley (1979) reported two larval instars within the galleries. Adult females remained in the galleries for 12–14 days and mate before emergence (Hara & Beardsley 1979). The male:female ratio was 1:9 in the field and 1:6 in laboratory colonies (Hara & Beardsley 1979). The longevity of females was 38.6 to 41.6 days (Hara & Beardsley 1979). Unmated females produced only male offspring and females that already have produced one brood do not excavate another gallery (Hara & Beardsley 1979).

More than 200 plant species are reported as host plants of *X. compactus* (Browne 1961, Ngoan et al. 1976 and references therein, Hara & Beardsley 1979, Samuelson 1981), with new host plant species added frequently (e.g., Sajap & Lee 1990, Oliveira et al. 2008). The host plant species of *X. compactus* in South Carolina have not been compiled. *Xylosandrus compactus* often attacks apparently healthy plants, resulting in wilting or flagging of infested terminals above the entry holes. Such attacks do not adversely affect the overall health of the infested trees. Nevertheless, the presence of wilting terminals significantly reduces the trees’ growth and esthetic appearance (Dixon & Woodruff 1982). Terminal wilting is caused by an ambrosia fungus, identified as *Fusarium solani* (Mart.) Synd. & Hans. by Ngoan et al. (1976) and Hara & Beardsley (1979). Ambrosia fungus is deposited by the adults and fed on by the larvae in the galleries.
The flagging of terminals associated with *X. compactus* infestation in ornamental trees and shrubs is a significant concern for homeowners and landscape care professionals. Currently, no management program is designed specifically against *X. compactus*. Based on experiences with *X. crassiusculus*, a preventive application of pyrethroids on trunks and branches during peak adult flight period is the only effective method of deterring attacks by the ambrosia beetles (Hudson & Mizell 1999, Mizell & Riddle 2004). Topical application of all branches on a mature shade tree may be logistically challenging. Therefore, it is important to determine the feasibility of limiting the application of preventive insecticides to an area or height that has the highest risk of attacks by *X. compactus*. To target insecticide application, we need to determine if terminal flagging associated with *X. compactus* attacks is related to plant height.

The objectives of this study were 1) determine the distribution of *X. compactus* in South Carolina, 2) compile a list of reported host plants of *X. compactus* in South Carolina, and 3) determine the vertical distribution of infested terminals on southern magnolia trees. This study will help us better understand the biology and ecology of *X. compactus*. In addition, the results will help to improve the management of *X. compactus* in the landscape and reduce pesticide use by accurately targeting insecticide applications to the most frequently affected areas of a tree.

**Materials and Methods**

Distribution data were extracted from three sources: 1) the Early Detection and Rapid Response (EDRR) Program for exotic wood boring beetles conducted by the South Carolina Forestry Commission, 2) a database of sample identifications maintained by the Clemson University Plant Problem Clinic (PPC), and 3) observations by the authors. Host plant data were compiled from the Clemson University Plant Problem Clinic database and observations by the authors. Classification of host plants was based on the USDA PLANTS Profile Database (USDA 2010).

Distribution data for *X. compactus* were obtained from the EDRR Program database for 2004, 2006, 2007, and 2010 maintained by the South Carolina Forestry Commission. During each survey year, Lindgren funnel traps were placed at selected locations throughout the state (Rabaglia et al. 2008). The funnel traps were each baited with ultra-high release ethanol, ultra-high release mixture of ethanol and α-pinene, and *Ips* lure (Biota Control Inc., Coquitlam, British Columbia, Canada; PheroTech Inc., Delta, British Columbia, Canada) and deployed in or near forests and urban woodlands. Bark beetles captured by the baited traps were killed in collection cups filled with antifreeze. The captured beetles were collected every two weeks from April to August of each year and brought back to the laboratory for identification to species level by trained entomologists. Sixteen counties were surveyed by the EDRR Program: Charleston, Laurens, and Richland in 2004; Colleton, Florence, Georgetown, Kershaw, Orangeburg, Richland, and Sumter in 2006; Anderson, Chesterfield, Dorchester, Laurens, Orangeburg, Spartanburg, and York in 2007; and Berkeley, Charleston, Chesterfield, Lexington, and York in 2010. One location was surveyed in each county per year.
Clemson University PPC is a multidisciplinary program that provides identification and management recommendation services for plant problems, insects, and diseases. Samples are submitted for identification by homeowners, county extension agents, farmers and growers, commercial landscape care providers, sports turf managers, and regulatory agency personnel. Insect specimens are identified by trained entomologists and management recommendations are provided by state extension specialists. A database of all submittals, including locality and host plant information, is maintained by the Clemson University PPC. Data on host plant and collection localities of X. compactus were obtained by searching the database.

Seventy-seven mature southern magnolia trees in seven communities at North Myrtle Beach, Horry County, SC were surveyed in February 2010 for damage by X. compactus. The communities were at least 1 km from each other. Southern magnolia was chosen as the host plant species because of its ubiquity in the landscapes, its apparent preference by X. compactus, and the easily detectable flagging of terminals. Often, no label or other documents were available on the selected southern magnolia trees to aid in the identification of cultivar. A southern magnolia tree was considered damaged when a wilted or flagged terminal was discovered at any height. The wilted terminal was collected by hand or with an extendable pruner and examined for ambrosia beetle entry holes. The terminal was then dissected and adult ambrosia beetles in the pith or within the gallery were collected and identified to confirm infestation. The percentage of southern magnolia trees that had suffered attacks from X. compactus in each neighborhood was calculated.

The tendency for X. compactus to attack terminals at specific heights was assessed in the landscape of a golf-residential neighborhood at North Myrtle Beach in February 2010. Twenty southern magnolia trees that were on average 4.4 ± 0.3 m (range: 2.3–6.2 m) in height and had received minimal maintenance or pruning were selected. The height of the selected trees was divided into six 1-m sections beginning from the soil line using a laser hypsometer (Insight™ 400 LH, Opti-Logic Corporation, Tullahoma, TN) while standing at about 15 m from the target trees. The healthy and wilted terminals within each height section were visually counted. A manlift was used to safely lift the surveyors to specific heights above 2 m. The percentage of wilted terminals within each height section was determined and compared among the six height sections with one-way ANOVA (SAS Institute 1999) at α = 0.05. The percentage of wilted terminals was arcsine-transformed before ANOVA analysis. Means were separated by Fisher’s Least Significant Difference (LSD) test when significant difference was detected.

Voucher specimens of X. compactus from the attack preference study were deposited in the Clemson University Arthropod Collection. Beetles collected by the EDRR Program were kept at the South Carolina Forestry Commission. Insect and plant specimens identified by taxonomists at the Clemson University PPC were not preserved.

Results and Discussion

Xylosandrus compactus was collected in 13 of the 16 counties surveyed by the EDRR Program: Berkeley, Charleston, Chesterfield, Colleton, Dorchester, Florence, Georgetown, Kershaw, Laurens, Orangeburg, Richland, Sumter, and
York. The beetle was not captured in Anderson, Lexington, and Spartanburg Counties. *Xylosandrus compactus* was also reported in five additional counties (Aiken, Beaufort, Darlington, Horry, and Pickens) based on records from the Clemson University PPC and observations by the authors (Fig. 1). Infested counties ranged from the Atlantic Coast to the Inner Piedmont. No sampling has been conducted to determine the establishment of *X. compactus* in the remaining 25 counties in South Carolina. We expect *X. compactus* to be distributed in the majority of the counties not surveyed by EDRR Program and other studies. The wide distribution of *X. compactus* in South Carolina disagrees with the suggestion that this ambrosia beetle species is found only along the Coastal Plain of the southeastern US (Dixon et al. 2005). *Xylosandrus compactus* is likely to have a wide distribution beyond the Coastal Plain of Alabama, Louisiana, Mississippi, North Carolina, and Texas. The actual distribution of *X. compactus*
in these southern states can be ascertained only by a more comprehensive survey and detection program.

After *X. compactus* was detected in Florida in 1941, it was reported in Alabama, Georgia, Louisiana, and Mississippi in the 1970s (Ngoan et al. 1976, Mangold et al. 1977), Texas in 1989 (Atkinson et al. 1991), and North Carolina in 2000 (Rabaglia et al. 2006). The earliest published report of *X. compactus* in South Carolina was based on trap catches in 2002 (Coley et al. 2005). According to records of the Clemson University PPC, the earliest sample of *X. compactus* was from dogwood trees in Horry County in 1987. In the next two decades, samples of infested plant materials and insects were submitted sporadically by South Carolina citizens and cooperative extension agents (Table 1). *Xylosandrus compactus* might have become established in South Carolina before 1987, but a lack of bark and ambrosia beetle surveys would have hindered an earlier detection. The beetle was not found during recent samplings in Maine and New Hampshire (Dobbs et al. 2010), Ohio (Ghandi et al. 2010), and Tennessee (Oliver & Mannion 2001).

Ten plant species in nine families were reported as host plants of *X. compactus* in South Carolina (Table 1). The most frequently submitted plant species were southern magnolia and flowering dogwood. Nearly all the host plants reported in this paper are popular landscape and ornamental trees and shrubs. The list of host plants presented in Table 1 was compiled from records of samples submitted to Clemson University PPC and represents only a limited and biased

<table>
<thead>
<tr>
<th>Host plant family</th>
<th>Host plant species</th>
<th>Collection year</th>
<th>Collection county</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buxaceae</td>
<td>Boxwood, <em>Buxus sempervirens</em> L.</td>
<td>2007</td>
<td>Beaufort</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Redbud, <em>Cercis canadensis</em> L.</td>
<td>1994</td>
<td>Colleton</td>
</tr>
<tr>
<td>Hydrangeaceae</td>
<td>Hydrangea, <em>Hydrangea macrophylla</em> (Thunb.) Ser.</td>
<td>2000</td>
<td>Aiken</td>
</tr>
<tr>
<td>Moraceae</td>
<td>Fig, <em>Ficus carica</em> L.</td>
<td>2000</td>
<td>Horry</td>
</tr>
<tr>
<td>Myricaceae</td>
<td>Wax myrtle, <em>Morella (= Myrica) cerifera</em> (L.) Small</td>
<td>1990</td>
<td>Beaufort</td>
</tr>
<tr>
<td>Pinaceae</td>
<td>Pine, <em>Pinus</em> sp.</td>
<td>2000</td>
<td>Beaufort</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Gardenia, <em>Gardenia jasminoides</em> J. Ellis</td>
<td>1995</td>
<td>Charleston</td>
</tr>
</tbody>
</table>

Table 1. Reported host plants of the black twig borer, *Xylosandrus compactus* (Eichhoff), in South Carolina. Data were extracted from insect identification database maintained by Clemson University's Plant Problem Clinic.
representation of the actual host range of X. compactus in the field. More than 200 plant species are recorded as hosts of X. compactus (Ngoan et al. 1976). Commonly attacked plant species in Florida include many shade and ornamental trees and shrubs: Acer spp. (maples; Aceraceae), Callicarpa americana L. (American beautyberry; Verbenaceae), two Caryophyllaceae, Cassia fistula L. (golden shower tree; Fabaceae), Cattleya skinneri Lindl. (Skinner’s cattleya; Orchidaceae), Celtis laevigata Willd. (sugarberry; Ulmaceae), Cinnamomum camphora (L.) Ness & Eberm. (camphor tree; Lauraceae), Dendrobium pulchellum Roxb. (charming dendrobium; Orchidaceae), Khaya nyasica Stapf. (mahogany; Meliaceae), Koelreuteria elegans (Seem.) A. C. Sm. (Chinese rain tree or flamegold; Sapindaceae), Liquidambar styraciflua L. (sweetgum; Hamamelidaceae), Macadamia ternifolia F.V. Muell. (macadamia; Proteaceae), Malus sieversii (= pumila) (Lede.) M. Roem. (wild apple; Rosaceae), Mangifera indica L. (mango; Anacardiaceae), Ostrya virginiana (Mills.) K. Koch (American hop hornbeam; Betulaceae), two Persea spp. (avocado; Lauraceae), Platanus occidentalis L. (sycamore; Platanaceae), two Quercus spp. (oaks; Fagaceae), Salix sp. (willow; Salicaceae), Sambucus nigra ssp. canadensis (L.) R. Bolli (S. simpsonii Rehder) (Florida elderberry; Caprifoliaceae), Symlocos tinctoria (L.) L’Her (yellowwood; Symlocaceae), redbud, southern magnolia, and flowering dogwood (Dixon et al. 2005). The Florida and South Carolina host lists share some common species (e.g., redbud, dogwood, and southern magnolia). Some species reported from Florida (e.g., maple, hickory, sweetgum, and oaks), although not reported from South Carolina, are also widely grown in South Carolina and may be susceptible to attacks by X. compactus. The most curious host record from Table 1 is pine. Pines are not known to be a common host of X. compactus, but because insect specimens associated with these records were not preserved, we cannot confirm the identification. We did not observe in this study any pitching of sap by the attacked plants in response to attacks by X. compactus.

Xylosandrus compactus showed a marked preference for terminals in the lower portions of southern magnolia, with 11.1% of terminals wilted at 0–1 m, followed by 7.2% at 1–2 m (Fig. 2). Only 1.3–3.7% of the terminals were attacked in sections higher than two meters. Bark and ambrosia beetles have been shown to fly close to the ground (~ 0.5 m) (Ulyshen & Hanula 2007). Reding et al. (2010) also showed that more X. crassiusculus were captured in ethanol-baited traps hung from 0.5 and 1.7 m than 3.0 m above ground, whereas more X. germanus were captured at 0.5 m than 1.7 and 3.0 m. In Ohio, 91% of attacks by X. germanus on the trunk of flowering dogwoods were concentrated below 1 m (Reding et al. 2010). Xylosandrus compactus might behave similarly because the ambrosia beetles often initiate attacks on the lower terminals of host trees. In contrast to Reding et al. (2010), Ulyshen & Hanula (2007) and this study, Abreu et al. (2001) reported no difference in the numbers of X. compactus captured in traps installed at various heights between 0–10 m in an Amazonian forest reserve.

Southern magnolia tree has a single-stem growth form with the widest canopy spread at the lowest height. Southern magnolia trees sampled in this study had the highest number of terminals (101.1) at 1–2 m height, although the counts were not significantly different from the sections at 0–1 and 1–2 m (Fig. 2). The lowest count of dead and live terminals (32.7) was at 5–6 m. The lower number of
terminals in the lowermost section was the result of branch senescence and maintenance or pruning practices. *Xylosandrus compactus* is known to attack small twigs less than 2 cm in diameter (Ngoan et al. 1976; Dixon et al. 2005). It was possible that a higher number of terminals with diameters suitable for attacks by *X. compactus* in the lower sections had contributed to the higher proportion of the terminals between attacked. Southern magnolia terminals attacked in this study were less than 1 cm in diameter. We did not record the diameter of healthy terminals; therefore, we could not compare the proportions of attacked terminals in each diameter classes and make a conclusion on the twig-diameter preference of *X. compactus*. Similar to other ambrosia beetles, *X. compactus* may be attracted to volatiles released by stressed trees (e.g., ethanol) (Ranger et al. 2010). However, it is not known if terminals shaded in the lower sections of a magnolia tree, or trees planted in urban landscape, were stressed and thus produced these attractive volatiles. The physiological and morphological cues that induce higher numbers of attacks on the lower sections of the southern magnolia trees warrant further investigations.

An understanding of the host range and the tendency for *X. compactus* to attack terminals below two meters may facilitate the development of an integrated management program. Affected homeowners, landscape care professionals and nursery growers should monitor for *X. compactus* attacks on some of the most frequently attacked plant species, most notably southern magnolia, flowering dogwood, and redbud. Monitoring also should focus on terminals lower than two meters. The only option currently available is a preventive treatment.
with pyrethroids in March to April during peak adult flight (Ngoan et al. 1976). If an application cannot be made to the entire mature tree, insecticides should be applied evenly and thoroughly to all terminals below two meters. This targeted application may help reduce the frequency and cost of insecticide applications, the amount of insecticides applied to the environment and the risks to human and environmental health, while significantly reducing the numbers of wilted or flagged terminals resulting from attacks by \textit{X. compactus}.

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