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SCIENTIFIC NOTE

First Records of *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae: Scolytinae) from South America, with Notes on its Distribution and Spread in the New World

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Xylosandrus crassiusculus (Motschulsky), the granulate ambrosia beetle, is presumably native to southern Asia. It has been introduced into tropical and subtropical areas of the World, including much of sub-Saharan Africa, parts of the New World (Anderson 1974; Wood 1982; Wood and Bright 1992; Kirkendall and Ødegaard 2007), and Europe (Kirkendall and Faccoli 2010). It was first detected in the New World in coastal South Carolina (Anderson 1974). It was reported from Costa Rica (1996) and Panama (2003) (Kirkendall and Ødegaard 2007) in what is most likely separate introduction events. The beetle is a serious economic pest in tree nurseries and transplanted orchard and ornamental trees wherever it is found (Browne 1961; Kovach and Gorsuch 1985; Atkinson *et al*. 1988; Ranger *et al*. 2015).

Recently, we have found significant range extensions for this species in Central and South America. The records included here mainly come from a survey of Brazilian bark and ambrosia beetles (Flechtmann and collaborators). Over a period of more than 20 years, the senior author (alone or with collaborators) has run trapping studies over 12-month periods at sites throughout Brazil (Fig. 1), mostly using ethanol-baited flight intercept traps. These previous studies are particularly valuable because they help document sites where other ambrosia beetles were trapped with similar methods but *X. crassiusculus* was not found, allowing us to have more confidence in bracketing the introduction(s) of this species into Brazil and any subsequent spread. Additional new distribution records from Central America come from the revision of collections by the second author. Specimens cited here are deposited in the Museu de Entomologia da FEIS/UNESP, Ilha Solteira, São Paulo, Brazil (MEFEIS) and in the Florida State Collection of Arthropods, Gainesville, Florida (FSCA).

New Country Records

GUATEMALA: Izabal; Green Bay Resort (Ramoncita, Sierra del Mico), 23-26-IX-2008, J.B. Hepner (FSCA, 1).

FRENCH GUIANA: Cayenne-Camopi, Reserve Naturelle des Nouragues (Saut Pararé), primary ombrophilous rainforest, 4°4′18″N 52°43′57″W, 88 m, unbaited window trap, 20-X-2009, S. Brülé (MEFEIS, 1).

BRAZIL: AMAPÁ: Macapá, IEPA; terra firme ombrohilous forest fragment, 0°2′18.8″S 51°5′36.6″W; 7 m, ethanol-baited FIT, 13-IX-2014, 25-VIII-2014, W.R. Silva (MEFEIS, 3).

PERNAMBUCO: Recife, Mata Brennand, lowland Atlantic forest fragment, 8°2′52.12″S 34°58′49.55″W, 75 m, ethanol-baited FIT, 29-XI-2014, 6-XII-2014, T.J.S. Alves (MEFEIS, 6).

RIO DE JANEIRO: Maciço do Gericinó/ Mendanha, secondary Montane Ombrophilous Dense forest in advanced stage of succession, 22°49′40.4″S 43°31′51.6″W, 480 m, ethanol-baited FIT, 6-XI-2012, 19-III-2013, 30-IV-2013, M.S. Santos (MEFEIS, 4); same except 22°49′22.8″S 43°31′47.1″W, 621 m, 6-XI-2012 (MEFEIS, 1).

SÃO PAULO: São Sebastião, Montane Ombrophilous Dense forest, ethanol-baited FIT, F.S. Zorzenon; Site 1:

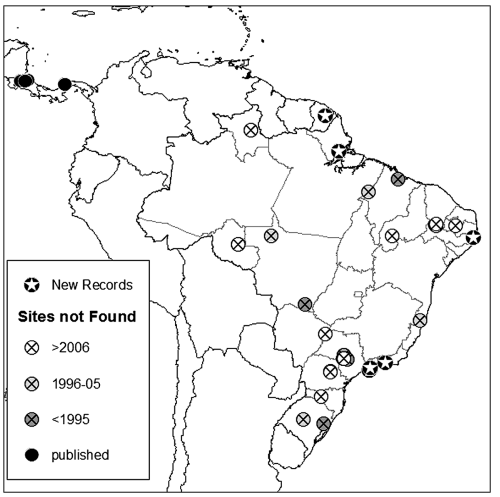

Fig. 1. Occurrence of *Xylosandrus crassiusculus* in Central and South America. Sites where flight intercept traps were deployed by the senior author and/or collaborators but no captures occurred are shown by circles with an X. Dates are the most recent years that traps were deployed at those localities.

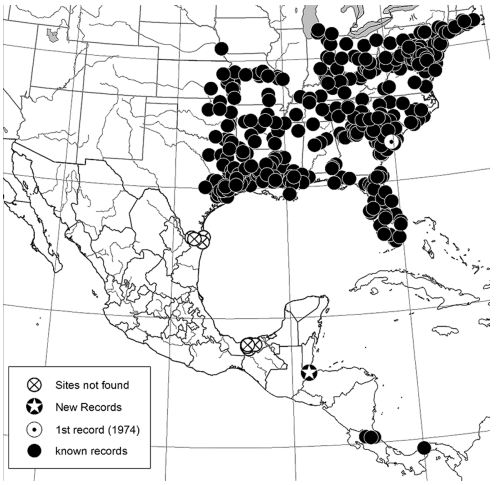

Fig. 2. Distribution of *Xylosandrus crassiusculus* in North and Central America. Recent trapping sites of E. G. Riley (South Texas, 2007–2008) and M. Pérez de la Cruz (Tabasco, 2007–2011) where beetle was not collected ("sites not found") are shown. See text for explanation.

Guaecá neighborhood, 23°49′03.3″S 45°27′46.6″W, 22 m, 16-VIII-24-X-2013 (MEFEIS, 45); Site 2: Guaecá Beach, 23°49′04.3″S 45°28′04.2″W, 22 m, 8-VIII- 25-X-2013 (MEFEIS, 68); Site 3: Toque-Toque Grande Beach, 23°49′51.7″S 45°30′08.7″W, 120 m, 8-VIII– 25-X-2013 (MEFEIS, 14); Site 4: Costão do Navio, 23°49′09.9″S 45°28′34.3″W, 180 m, 23-VIII– 25-X-2013 (MEFEIS, 6); Ilha Bela, urban area, Montane Ombrophilous Dense forest fragment, 23°44′39.43″S 45°20′49.76″W, 27 m, ethanol-baited FIT; 15-X-2013 (MEFEIS, 2); same data except 23°51′21.20″S 45°24′49.57″W, 24-X-2013 (MEFEIS, 2); Caraguatatuba, Parque Estadual da Serra do Mar, Montane Ombrophilous Dense forest, 23°35′06.98″S 45°25′56.03″W, 300 m, ethanol-baited FIT, 15-IV-2014, L.F.P.P.F. Salles (MEFEIS, 1).

All known localities for *X. crassiusculus* in the New World are shown in Figs. 1 and 2. New localities reported here are highlighted. The new records from northern and southeastern Brazil most likely represent one or more new introductions. Based on the material available, there is no way of knowing if it was introduced from its native range in Asia or whether it was secondarily introduced from a previous introduction in the New World. An analysis of DNA similar to that done by Cognato *et al.* (2015) with species of *Euwallacea* Hopkins would be needed to resolve this question. One of us (CAHF) has been working with local collaborators in numerous locations in Brazil (Fig. 3) using a common protocol of flight intercept traps baited with ethanol. These trapping programs have been conducted since the early 1980s. *Xylosandrus crassiusculus* responds to ethanol (Miller and Rabaglia 2009; Hulcr *et al.* 2011), so the lack of previous records despite a large and continuous sampling effort strongly supports the conclusion that the species has been absent from areas between southern Brazil and French Guiana until fairly recently.

The presence of *X. crassiusculus* in French Guiana may be due to unaided spread of the beetle from previously reported localities in Costa Rica and Panama. In particular, the French Guiana locality is in primary rainforest distant from the coast and major towns (Fig. 1). As noted by Kirkendall and Ødegaard (2007), this species is capable of establishing itself in relatively undisturbed habitats and primary forests. The collections in coastal regions of northern and southeastern Brazil suggest recent, human-aided introduction(s) within the last 10 years. The collection localities are near the coast and relatively close to major ports. The absence of historical collections in interior localities of Brazil implies that it that it has not spread evenly across northern Brazil, even though there are suitable habitats.

Xylosandrus crassiusculus was first detected in the US in 1974 (Anderson 1974). Additional records from eastern North America have been reported from numerous publications (Wood 1982; Chapin and Oliver 1986; Deyrup and Atkinson 1987; Atkinson *et al*. 1988, 1991; Oliver and Mannion 2001; Rabaglia 2003; Rabaglia and Valenti 2003;

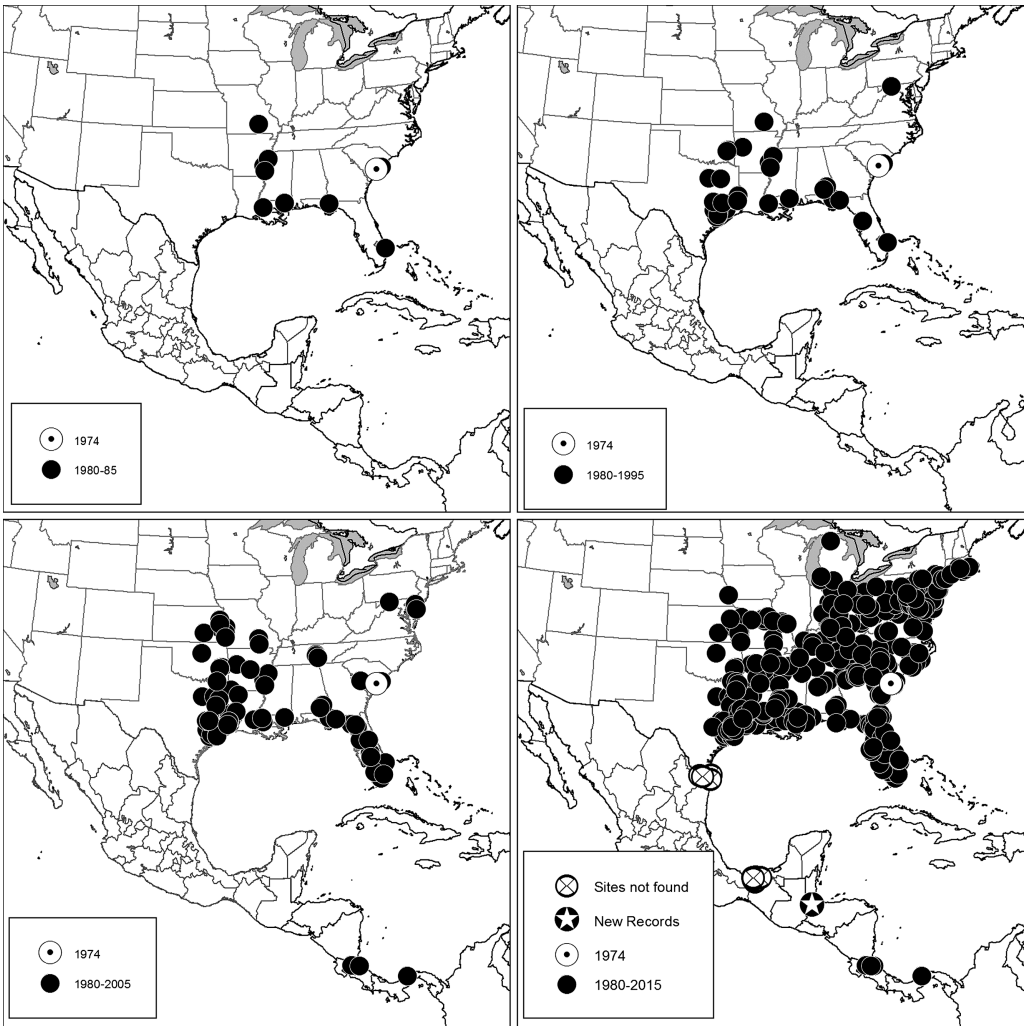

Fig. 3. Spread of *Xylosandrus crassiusculus* in the eastern United States and Central America. Note that *X. crassiusculus* reached its maximum southwestern extension in Texas by 1995 and has only spread slightly northwards since then.

Rabaglia *et al.* 2006; Lightle *et al.* 2007; Cognato *et al.* 2010; Reed and Muzika 2010; Werle *et al.* 2012; Atkinson and Riley 2013; Douglas *et al.* 2013). Additional North American records are taken from unpublished sources by Atkinson (2015), particularly from the US Forest Service Early Detection Rapid Response program (Rabaglia *et al.* 2008).

The distribution of *X. crassiusculus* over time in eastern North America is shown in Fig. 3. Within 40 years of its introduction, it is now distributed throughout the eastern states from southern Michigan and southern Ontario, Canada to the extremity of southern Florida. In the central US, its western limits correspond roughly to those of the eastern deciduous forests. The distribution of *X. crassiusculus* in this area is similar to that of the native ambrosia beetles *Xyleborus impressus* Eichhoff, *Xyleborus celsus* Eichhoff, *Xyleborus xylographus* (Say), *Monarthrum fasciatum* (Say), and *Monarthrum mali* (Fitch) (Atkinson 2015). Its southwestern limits appear to have been reached in central Texas by or before 1995 (Fig. 3), approximately 20 years from its original detection. In the subsequent 20 years, it has not spread any further to the south or west. In 2007–2008, a major trapping effort was undertaken in the lower Rio Grande Valley using Lindgren funnel traps and other types of flight intercept traps (Figs. 2, 3, E.G. Riley, personal communication). *Xylosandrus crassiusculus* was

not collected in this area, even though numerous other scolytine species were found (Atkinson and Riley 2013). It has also been absent from recent collections in the same region by the second author. It would appear that the dry climate of southern Texas and northeastern Mexico and associated scrub and grassland communities form a natural barrier to the unaided dispersal of this species. This area seems to form a similar barrier to much of the Scolytinae and Platypodinae of the southeastern US (Atkinson and Riley 2013).

Xylosandrus crassiusculus was reported from Costa Rica (1996) and Panama (2003) by Kirkendall and Ødegaard (2007). It is very likely that the presence of *X. crassiusculus* in Guatemala is due to unaided spread of the beetle from previously reported localities in Costa Rica and Panama. At present, this species is probably not yet in Mexico, based on the extensive trapping effort of Pérez de la Cruz and associates in the state of Tabasco (Fig. 2, 3), also using flight intercept traps baited with ethanol (Pérez De La Cruz *et al*. 2009a, b, 2011; Baños-Juárez *et al*. 2012). Nonetheless, the recent record from the Caribbean coast of Guatemala suggests that this species will likely expand from there into southeastern Mexico, rather than from the southeastern US.

Xylosandrus crassiusculus is possibly native to temperate and tropical Asia. It has been found as far north as Korea and Japan and also at relatively high elevations in the Himalayas in Bhutan and Tibet (Wood 1982; Wood and Bright 1992). In eastern North America, most collection localities are below 40° N latitude (Fig. 2). In South America, 40° S latitude includes all of Brazil, Uruguay, Paraguay, and central Argentina. The lack of spread beyond central Texas suggests that in the absence of human assistance, dry climates form a natural barrier to spread and that parts of northern Argentina and interior regions of northeaster Brazil might not be suitable. Records of this species in mountainous areas of Asia (Wood and Bright 1992) suggest that it may also establish at intermediate elevations in the Andes where humidity is sufficient.

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