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First Report of the European Oak Borer, *Agrilus sulcicollis* (Coleoptera: Buprestidae), in the United States

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Abstract

Agrilus sulcicollis Lacordaire was first reported in North America from Ontario, Canada in 2008; specimens were collected in the field on red oak (*Quercus rubra* L.), on sticky traps, and also found in insect collections that dated from 1995. After hearing of this discovery in Ontario, unidentified *Agrilus* specimens that had been collected in Michigan during recent field studies of the emerald ash borer, *Agrilus planipennis* Fairmaire, were examined. As a result, *A. sulcicollis* specimens were identified that had been collected in four Michigan counties during 2003 to 2008: Ingham, Oakland, Saint Clair, and Washtenaw. All Michigan specimens had been collected from sticky traps or reared from English oak, *Q. robur* L. This is the first establishment record of *A. sulcicollis* in the United States. In addition, *A. sulcicollis* adults were collected on sticky traps in Monroe and Orleans counties, New York, during surveys in 2009 that targeted *A. planipennis*. In Europe, *A. sulcicollis* infests primarily oak. Information is provided on U.S. collection records, U.S. port interception records, and basic life history data of *A. sulcicollis*.

The European oak borer, *Agrilus sulcicollis* Lacordaire (Coleoptera: Buprestidae), was first reported as established in North America in Canada by Jendek and Grebennikov (2009). After identifying the initial Canadian specimen in 2008, which had been collected in 2006 on a sticky trap near London, Ontario, E. Jendek and V. V. Grebennikov went to southern Ontario in 2008 to look for additional specimens in the field as well as in private and university insect collections. They found several specimens that had been collected from multiple sites in Ontario from 1995 to 2008 (Jendek and Grebennikov 2009). After hearing of this discovery in late 2008, we examined unidentified *Agrilus* specimens that we had collected in Michigan during previous field studies of the emerald ash borer (EAB), *Agrilus planipennis* Fairmaire. As detailed below, some of our unknown *Agrilus* specimens were subsequently identified as *A. sulcicollis*. In this paper, we provide details of the first reported collections of *A. sulcicollis* in the United States, *Agrilus* interception records at U.S. ports of entry, and information on the life history of *A. sulcicollis*.

Michigan collections of *A. sulcicollis*. After the discovery of EAB in southeastern Michigan in 2002 (Haack et al. 2002), we conducted several EAB field studies in southern Michigan each year starting in 2003. In most of these field studies, we used either purple panel traps (Champion Box Co., Cedaredge, CO), girdled ash trees, or freshly cut ash logs along with sticky traps to catch EAB adults during their major flight season (June-August). We applied Pestick (Phytotronics Inc., Earth City, MO) directly to the purple panel traps while

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Tanglefoot (Tanglefoot Company, Grand Rapids, MI) was applied to stretch wrap (JC Parry and Sons, Baltimore MD) after we had wrapped a band about 30-cm-high around the circumference of the girdled trees and ash logs. In most cases, we collected only the EAB adults that were captured on the sticky traps, but occasionally we collected all *Agrilus* specimens. Therefore, our selection of field sites in these particular studies was based on the presence of EAB and its host tree (ash, *Fraxinus* spp.), rather than sites that would have been more promising for collection of *A. sulcicollis*, i.e., sites with an abundance of its major host - oak, *Quercus* spp.

Overall, we collected specimens of *A. sulcicollis* from four Michigan counties as of December 2008 (Ingham, Oakland, Saint Clair and Washtenaw), with the earliest collections from three counties in 2003, which was the first year of our EAB field work. Because collections from sticky traps were made at irregular time periods, exact collection dates cannot be provided. Therefore, we present either a range of dates that covers each particular trapping period or a single date that reflects the day on which the collection was made. At first only males were positively identified based on genitalia (Bilý 1982, Zabloutny 2009). Initial identifications were made by James E. Zabloutny (USDA APHIS, Romulus, MI), with final confirmation made by Natalia J. Vandenberg [USDA ARS Systematic Entomology Laboratory (SEL), Washington, DC] and Richard L. Westcott (SEL taxonomic specialist in Buprestidae, Salem, OR). The specimens listed below are currently located at the USDA APHIS office in Romulus, MI.

Efforts to collect *A. sulcicollis* in additional U.S. states in 2009.

Following the initial discovery of *A. sulcicollis* in the United States in early 2009, sticky-trap collections from the national EAB survey efforts in Iowa, Minnesota, New York, and Tennessee were examined for *A. sulcicollis* and other exotic buprestid species. *Agrilus sulcicollis* was found only in samples from New York. Details are given below.

New United States records in chronological order. Michigan: Washtenaw Co., 1 ♂, 3 ♀, Northfield Twp., Lat 42.35 N, Long -83.73 W, 15-30 May 2003, sticky trap on 50-cm-long freshly cut ash bolt suspended vertically near ground for use in EAB dispersal study, Toby R. Petrice collector. This specimen was tentatively identified as *A. sulcicollis* by J. E. Zabloutny on 6 February 2009, and later confirmed as *A. sulcicollis* by N. J. Vandenberg and R. L. Westcott on 23 February 2009.

Oakland Co., 3 ♂, 5 ♀, Kensington Metro Park, Lat 42.53 N, Long -83.65W, 4-23 June 2003, sticky trap on 1-m-long freshly cut ash log suspended vertically near ground for use in EAB dispersal study, Toby R. Petrice collector.

Saint Clair Co., 1 ♀, 42.90 N, Long -82.85 W, 12-24 June 2003, collected on sticky band trap on trunk of a girdled ash tree, Toby R. Petrice collector.

Ingham Co., 19 ♂, 25 ♀, 3 undetermined sex, Michigan State University Tree Research Center, Lat 42.67 N, Long -84.47 W, multiple dates from June 2005 to July 2006, reared in the laboratory from trunk and branch sections of naturally infested English oak, *Quercus robur* L., trees, Leah S. Bauer and Deborah L. Miller, collectors.

Ingham Co., 1 ♂, 17 ♀, Lansing, Washington Park, Lat 42.71 N, Long -84.56 W, Crego Park, Lat 42.72 N, Long -84.52, 29 May - 30 July 2007; 3 ♂, 49 ♀, 1 undetermined sex, Lansing, Washington Park and Crego Park, 9 June - 30 July 2008, collected on sticky purple panel traps used in EAB surveys, Tina M. Ciaramitaro and Therese M. Poland, collectors.

In addition, during surveys conducted in southern Michigan in 2009, *A. sulcicollis* was again collected in Ingham and Oakland Counties. Collection details are provided below.

Ingham Co., 1 ♂, 4 ♀, Michigan State University Tree Research Center, Lat 42.67 N, Long -84.47 W, 29 May - 12 June 2009, trapped on yellow sticky cards (15 × 30 cm) placed on branches with live foliage in lower canopy of *Q. robur* trees, Toby R. Petrice collector.

Oakland Co., 1 ♂, 1 ♀, Kensington Metro Park, Lat 43.54 N, Long -83.66 W, 5-21 May 2009, sweep net collection beneath oak tree, Brian B. Sullivan collector (James R. Manor, USDA APHIS, personal communication).

New York: Monroe Co., 2 ♀, along Redman Road, Brockport, Lat 43.20 N, Long -77.97 W, 22 June 2009, purple panel trap, part of 2009 EAB survey, collected by Forecon Inc. staff. This specimen was tentatively identified by J. E. Zabloutny as *A. sulcicollis* on 13 August 2009 and later confirmed on 12 November 2009 by N. J. Vandenberg. One specimen retained at the U.S. National Museum.

Orleans Co., 1 ♀, along Center Rd., near Kendall, Lat 43.30 N, Long -78.06 W, 22 June 2009, purple panel trap, part of 2009 EAB survey, collected by Forecon Inc. staff. J. E. Zabloutny provided the final identification on 13 November 2009.

U.S. interception history. USDA APHIS (Animal and Plant Health Inspection Service) has maintained an electronic database (PESTID, formerly named PIN or Port Information Network) of pest interceptions at U.S. ports-of-entry since 1984 (Haack 2006). From 1984 through 2008 there were 35 interceptions of borers identified to the genus *Agrilus* that were found in wood packaging materials (mostly crating and dunnage, which is often used to brace cargo) associated with imports. Given that most wood borers are usually intercepted in the larval stage, identification is often made only to the family or genus level (Haack 2006). Identification to the species level was made for only 1 of the 35 interceptions and those individuals were identified as *A. sulcicollis*. On that occasion three live adults and one live larva were intercepted in California on dunnage from Belgium in 1986. The 35 *Agrilus* interceptions originated from at least 11 countries: most originated from Belgium (15), followed by Germany (5), Italy (3), China (2), and France (2). The *Agrilus* interceptions were made in 13 U.S. states. Most interceptions of *Agrilus* occurred in Ohio (9), followed by California (7), Alabama (5), and Texas (4). We do not know the country of origin of the *A. sulcicollis* populations now established in North America, where they first became established, or by what pathway they entered North America, however infested wood packaging material is suspected.

Description. A detailed description of *A. sulcicollis* was presented by Bílý (1982) and Jendek and Grebennikov (2009). Color photos of the adults are presented in Bílý (2002), Jendek and Grebennikov (2009), and Zabloutny (2009), with line drawings of the adults and male genitalia in Bílý (1982), and a description and drawing of the larva in Palm (1962). Briefly, adults are 5 - 9 mm long, elongate, variable in color with the dorsal portion being shades of metallic bronze, green, violet, and blue. Most Michigan specimens are blue to blue green (Zabloutny 2009).

Diagnosis. Another non-native *Agrilus* species that is common in much of eastern North America is *A. cyanescens* Ratzeburg. The blue form of *A. sulcicollis* is very similar in appearance to *A. cyanescens* (Jendek and Grebennikov 2009, Zabloutny 2009). Adults of the two species are similar in length with both having an incised or emarginate apex on the last abdominal sternite (= ventrite). In profile, *A. sulcicollis* is more elongate than *A. cyanescens*. In adult males, the medial portion of the venter is densely pubescent in *A. sulcicollis* but glabrous in *A. cyanescens*, and the second visible abdominal ventrite is tuberculate in *A. sulcicollis* but not in *A. cyanescens* (Jendek and Grebennikov 2009). Similarly, the medial portion of the prosternum in adult males is densely pubescent in *A. sulcicollis* but glabrous or weakly pubescent in *A. cyanescens* (Zabloutny 2009).

Males of *A. sulcicollis* have a strongly asymmetrical aedeagus, but the aedeagus is symmetrical in *A. cyanescens* (Bílý 1982, Jendek and Grebennikov 2009, Zabloutny 2009). In addition, Zabloutny (2009) lists additional morphological differences, including (a) a shallow groove on the vertex and frons of *A. cyanescens* that is absent from the vertex and frons of *A. sulcicollis*, and (b) short prehumeral carinae and a wide medial depression on the pronotum of *A. sulcicollis*, while in *A. cyanescens* the prehumeral carinae and medial depression are usually absent or not distinct.

Common Name. The common name “European oak borer” was approved as the English common name for *A. sulcicollis* by the Entomological Society of Canada in January 2009 (Jendek and Grebennikov 2009). The same common name was submitted by the first author to the Common Names Committee of the Entomological Society of America in 2009.

Range. The native range of *A. sulcicollis* encompasses nearly all of Europe: from Scandinavia to Italy and Spain to Russia. In Europe, *A. sulcicollis* expanded its range recently, being first reported in the United Kingdom in 1992 (Alexander 2003). A range map is shown in Jendek and Grebennikov (2009) and on the Fauna Europaea webpage: <<http://www.faunaeur.org/>>. In North America, *A. sulcicollis* has been reported in Ontario, Canada (Jendek and Grebennikov 2009) and most recently Michigan and New York (this paper) (Fig. 1). It is likely that *A. sulcicollis* is already present in other parts of North America and will continue to spread.

Principal hosts. In Europe, *A. sulcicollis* utilizes species of oak (*Quercus*) as its primary hosts, including *Q. cerris* L., *Q. frainetto* Ten., *Q. petraea* (Matuschka) Liebl., *Q. pubescens* Willd., *Q. robur*, and *Q. suber* L. (Bílý 2002, Jendek and Grebennikov 2009). In addition, in Europe, *A. sulcicollis* has occasionally been reported to infest species of *Carpinus*, *Castanea*, and *Fagus* (Bílý 2002, Jendek and Grebennikov 2009). Although *A. sulcicollis* has apparently been reared from non-oak hosts, it has been reported as an oak specialist in Sweden (Hedin et al. 2008) and Switzerland (Moretti and Barbalat 2004). In Canada, adults that apparently had died as they emerged through the bark were dissected from the lower trunk of a red oak, *Quercus rubra* L., tree (Jendek and Grebennikov 2009). In Michigan, several specimens were reared in 2005 and 2006 from trunk and branch sections cut from English oak, *Q. robur*, trees that were growing in an experimental planting at Michigan State University, East Lansing, MI.

Biology. *Agilus sulcicollis* usually has a 1-year life cycle in central Europe, but a 2-year life cycle occurs further north, e.g., Sweden (Palm 1962, Bílý 1982, 2002, Jendek and Grebennikov 2009). Adult flight occurs primarily during May through July in Europe. Adults feed on foliage of host plants and lay eggs singly on the bark surface usually in bark cracks along the trunk and major branches. Oviposition is most common on sun-exposed portions of trees and recently cut logs (Kappes and Topp 2004, Bouget 2005, Hedin et al. 2008, Lindhe et al. 2005, Vodka et al. 2009). Larvae tunnel in the cambial region at the sapwood-phloem interface as well as in the bark itself, especially when the bark is thick (Bílý 1982, 2002). Larvae construct pupal cells in the outer sapwood or in the outer bark. Pupation usually occurs in May and June. The sex ratio likely approaches 1:1. For example, of 47 *A. sulcicollis* specimens reared from *Q. robur* in Ingham County, MI, 19 were male, 25 were female, and 3 could not be determined.

Impact. Little is known about the impact of *A. sulcicollis* in North America. Given that collection records of *A. sulcicollis* are known from as early as 1995 in Canada and 2003 in the United States, with no associated reports of widespread oak mortality in either country, suggests that *A. sulcicollis* will be far less lethal to oaks than EAB has been to ash in North America (Poland and McCullough 2006). However, in Europe, *A. sulcicollis*, along with *A. biguttatus*

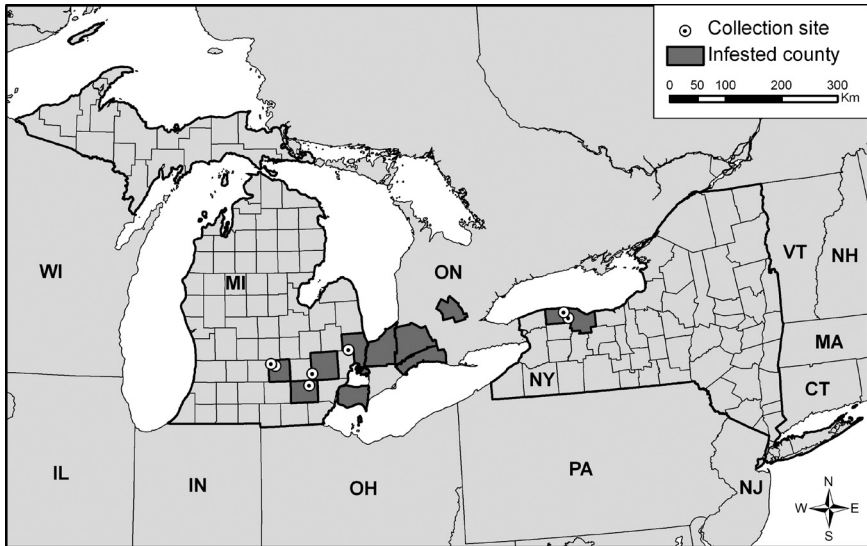


Fig. 1. Known distribution of *Agrilus sulcicollis* in North America as of December 2009, showing infested counties (shaded) in Michigan and New York (based on data in the present paper) and Ontario [based on Jendek and Grebennikov (2009)]. The four positive Michigan counties were (west to east; Ingham, Washtenaw, Oakland, and Saint Clair). The two positive New York counties were (west to east; Orleans and Monroe). Circles within the infested U.S. counties represent approximate locations where *A. sulcicollis* collections were made. Abbreviations are: CT = Connecticut, IL = Illinois, IN = Indiana, MA = Massachusetts, MI = Michigan, NH = New Hampshire, NJ = New Jersey, NY = New York, OH = Ohio, ON = Ontario, PA = Pennsylvania, VT = Vermont, and WI = Wisconsin.

(Fab.) and *A. angustulus* (Illiger), is commonly associated with oak mortality, especially in forests stressed by factors such as drought (Moraal and Hilszczanski 2000, Evans et al. 2004, Hilszczanski and Sierpinski 2006, Vansteenkiste et al. 2004).

In eastern North America, the twolined chestnut borer, *Agrilus bilineatus* (Weber), is the most lethal native *Agrilus* species infesting oaks, especially when the oak trees are stressed (Haack and Benjamin 1982, Dunn et al. 1986). It is interesting to note that in addition to rearing *A. sulcicollis* from *Quercus robur* trees in 2005 and 2006 in Michigan, we also reared *A. bilineatus* from the same trees. Unfortunately, given that we were not aware of *A. sulcicollis* at that time, we did not record any details on the frequency at which both *A. bilineatus* and *A. sulcicollis* occurred in the same logs and which species appeared to have attacked first based on the pattern of their larval galleries.

There are at least 42 native species of *Agrilus* that utilize oaks as hosts throughout the United States (Nelson et al. 2008), and at least 9 of these species occur in Michigan (Wellso et al. 1976). Perhaps the impact of *A. sulcicollis* in North America will be limited by this broad diversity of native oak-infesting *Agrilus* species, both through direct competition when infesting the same oak tree as well as the likely coevolved defenses that North American oaks have developed against *Agrilus* borers. However, it is still early in the invasion

process to declare with any certainty what the final impact of *A. sulcicollis* will be in North America.

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Note Added in Proof

We recently learned that an additional 20 adult specimens of *A. sulcicollis* were collected from sticky traps at multiple locations in Michigan in 2003-2004. Of the 20 specimens, 2 males (collected on 11 June 2003) and 3 females (collected on 16 June 2003, 20 June 2003, and 3 July 2003) were from Wayne County, MI, near Canton, and represent a new county record for Michigan. This survey was conducted by Jason B. Oliver of Tennessee State University (TSU) and was part of a cooperative agreement with USDA APHIS Otis Methods Laboratory to trap emerald ash borer, *A. planipennis*. The *A. sulcicollis* adults were identified by Joshua P. Basham (TSU) and confirmed by Ted C. MacRae and Richard L. Westcott. The specimens are housed in the TSU insect collection at the Otis L. Floyd Nursery Research Center in McMinnville, TN. One of the male specimens from Wayne County, MI, is pictured on-line at <<http://bugguide.net/node/view/359113/bgpage>>.

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