Sveriges lantbruksuniversitet
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Unit for Risk Assessment of Plant Pests

SLU ua 2017.2.6-3393

Date and version number

2017-05-31, Version 1

Rapid Pest Risk Analysis
Xylosandrus germanus

This rapid pest risk analysis (PRA) provides a quick assessment of the risks posed by the pest to Sweden, which is the PRA area being assessed. The format is an adapted version of the EPPO Express PRA scheme (EPPO 2012). Definition of terms used as well as the rating scheme and assessments are done in line with the guidance given in EPPO CAPRA system (EPPO 2011). The likelihood of entry and establishment are assessed considering the current phytosanitary regulation in place with respect to the EU legislation (Council Directive 2000/29/EC). The definition of a quarantine pest follows the regulation (EU) 2016/2031.

Summary

Presence

Xylosandrus germanus is established, and in many countries highly abundant, in large parts of the European Union. However, *X. germanus* cannot be considered established in Sweden.

Entry, establishment and spread

The likelihood of entry of *Xylosandrus germanus* into Sweden is assessed to be very likely. In fact, the species have already been trapped at two different occasions in Sweden. The main pathways are “Wood and wood products” and “Natural spread”. The likelihood of natural spread to Sweden has increased since *X. germanus* recently established in Denmark. Also the likelihood of establishment is assessed to be very likely since suitable host are widely distributed, the climate is suitable and the species have a track record of being able to establish in different environments. If established, the rate of spread is assessed to be high based on the species high flight capacity and the high likelihood of spread through transportation of colonized material.

Impact

The economic impact was assessed to be medium based on a combination of i) that the species have been established in Europe for 65 years with few reports of economic impact and ii) that there is a risk for a similar shift towards increased impact as have been recorded in North America. From an environmental point of view the main concern is that *X. germanus* have become one of the most common scolytids in several areas where it has established. But, there are no reports that it has caused any local extinction of native species. Therefore the environmental impact was assessed to be small.

Management options

It is assessed to be difficult to prevent the introduction of *X. germanus* to Sweden, especially the risk of introduction due to natural spread. Once established there are several management options available in high value plantations, e.g. ornamental plant nurseries and apple orchards. For example, suitable breeding material, such as dead or dying hosts, may be removed in order to avoid population build-up. The main option to prevent damage to stored logs in the forest is “just-in-time felling”.

Assessment in relation to the definition of quarantine pests

The results presented in this rapid PRA shows that *Xylosandrus germanus* does not fulfil all of the criteria for a union quarantine pest, e.g. it is widely distributed within the EU territory. In addition, it indicates that *X. germanus* does not fulfil all criteria for a protected zone quarantine pest for Sweden, e.g. due to limited possibilities to prevent natural spread from Denmark.

Key uncertainties and further investigation needed

There is currently not enough support to claim that *X. germanus* is established in Sweden. However, there is a high risk that established populations remain undetected, due to reasons specified in this rapid PRA. Targeted surveys would decrease the uncertainty whether *X. germanus* is established in Sweden or not. Such surveys would also be a tool for early detection of all invasive scolytids that are attracted to ethanol baited traps. For example, a Citizen Science approach may be used for large-scale monitoring of invasive bark and ambrosia beetles (Steininger et al. 2015; www.backyardbarkbeetles.org/). It would also be desirable if the development of *X. germanus*, both nationally and internationally, is followed to detect any shift towards increased impact.

A key uncertainty of this PRA is related to the assessment of the magnitude of impact should this species become established in Sweden. A full systematic review, especially of the grey literature, may decrease this uncertainty.

Pest risk assessment

1 Name of the pest

Latin name: *Xylosandrus germanus* (Blandford)

***Synonyms*:** *Xyleborus orbatus* (Blandford) and *Xyleborus germanus* Blandford

***Common names*:** Japanischer Nutzholzborkenkäfer [DE], Schwarzer Nutzholzborkenkäfer [DE], Borkenkaefer, Japanischer Nutzholz [DE], Borkenkaefer, Schwarzer Nutzholz [DE], Smaller alder bark beetle [EN], Small alder bark beetle [EN], Black timber bark beetle [EN], Black stem borer [EN], Petit scolyte noir du Japon [FR], Xylébore germanique [FR], Xylebore japonique [FR], Han-no-kikuimusi [JA], Hannoki-kikuimushi [JA].

***Taxonomic position*:** Domain: Eukaryota, Kingdom: Metazoa, Phylum: Arthropoda, Subphylum: Uniramia, Class: Insecta, Order: Coleoptera, Family: Scolytidae, Genus*: Xylosandrus,* Species: *Xylosandrus germanus*.

2 Reason for performing the rapid PRA

In 2016, *Xylosandrus germanus* was trapped in a monitoring program administrated by the Swedish Board of Agriculture.

3 Does a relevant earlier PRA exist?

A Rapid PRA of *Xylosandrus germanus* was performed in 2014 for the UK by The Forest Research (Inward 2014). In summary it was concluded that for the UK the likelihood of entry and the likelihood of establishment were both high, the potential spread moderate to rapid and the potential economic, environmental and social impact was expected to be small to medium. With regard to risk management it was stated that options for control/management of an outbreak are limited since, for example, containment by restricting movement of wood would not be efficient due to the pest's good dispersal abilities and polyphagous nature. However, the risk of damage may be reduced by good silvicultural management. It was concluded that better knowledge of the species distribution was needed and targeted trapping was performed. The known distribution in UK in April 2017 is still in accordance with the description under the heading "Current area of distribution point" below (D. Inward, personal communication).

According to the UK Plant Health Risk Register there is no statutory actions against findings of this insect in the UK. It should, however, be noted that *X. germanus* was already known to be established in the UK when their Rapid PRA was performed.

The Rapid PRA for the UK is to a large extent relevant also for Sweden but the current Rapid PRA was considered necessary to perform since i) it would provide an assessment in relation to the conditions in Sweden, ii) it would add new information about the species published after 2014 and iii) an in depth analysis about the abundance of *X. germanus* in different European countries was needed.

4 Regulatory status of the pest

Xylosandrus germanus is not listed in the EC Plant Health Directive (Council Directive 2000/29/EC) nor in the lists of EPPO. This may be due to that *X. germanus* has been established in Europe for such a long time, i.e. it established in Germany already in 1954 (Wichmann 1955). Accordingly, *X. germanus* is listed in EPPOs list of pests which should not appear in EPPO Quarantine lists (EPPO 1992). Species are added to this list due to their “wide distribution, their status as 'quality pests' or their unimportance” (EPPO 1992).

5 Current area of distribution

Xylosandrus germanus is present in large parts of Europe as well as in several countries in North America and Asia. The list provided by CABI (2015) and EPPO Global Database (2016) of where the pest is present are in general agreement. For Europe they list the following countries: Austria, Belgium, Croatia, Czech Republic, France, Germany, Hungary, Italy, Netherlands, Poland, Russian Federation (Russian Far East and Southern Russia), Slovenia, Spain and Switzerland. However, *X. germanus* is also established in Denmark (Hansen and Jørum 2014), United Kingdom (Allen et al. 2016; Inward 2015) Romania (Olenici et al. 2014) and Ukraine (Nazarenko and Gontarenko 2014). Interestingly, *X. germanus* was also found in Kaliningrad in 2015 (Mandelshtam, M. Y. personal communication). It should be noted that there is a high risk that the presence of this species remain unnoticed in a country for many years due to its concealed mode of life and its preference for hosts that are already stressed, dying or dead, as well as that detection requires specialist identification skills.

For many European countries, where the presence of *X. germanus* has been reported, there is convincing empirical data showing that it is very abundant but there are also many countries for which enough information to determine its abundance was not found. A summary of the abundance of *X. germanus* in different European countries is listed below:

- Austria: In 1992, *X. germanus* was trapped in two locations in the western part of Austria, i.e. in Feldkirch and Rankweil (three individuals in total; Holzschuh 1993). In 1994, close to Salzburg, 11 and 16 individuals were found in two different trees (Geiser and Geiser 2000). In 2012, in a large monitoring project of saproxylic beetles in the Biosphärenparks Wienerwald, close to Vienna, *X. germanus* was the most abundant species (21 500 individuals, 70% of the total number; Holzinger et al. 2014).

- Belgium: In the Forêt de Soignes, in the south-eastern edge of Brussels, *X. germanus* was found to be the most abundant scolytid (Grégoire et al. 2001). During June to July in 2001, 9655 individuals of *X. germanus* were caught in 18 traps and *X. germanus* constituted 80% of all trapped scolytids (Grégoire et al. 2001). During the period July to August another 3963 individuals were caught in 100 traps where *X. germanus* constituted 84% of all trapped scolytids (Grégoire et al. 2001). In another study in 2002 eight traps were installed in two stands and 93 and 70 individuals of *X. germanus* were caught, i.e. 37% and 47%, respectively, of all trapped scolytids (Henin and Versteirt 2004). *X. germanus* has also been observed in 29 other stands in Belgium (Henin and Versteirt 2004). In six of these stands several tens of individuals were present in the captures. In a study where an experimental approach was used to evaluate if frost increases beech susceptibility to scolytine ambrosia beetles *X. germanus* was caught in landing traps at all 15 experimental trees (in total 1234 beetles were trapped) (La Spina et al. 2013).

- Croatia: In a study where traps were set up in oak stands in Jastrebarsko in Zagreb county and in Otok near Vinkovci *X. germanus* was the second most frequent species in the traps. In total, 1 466 individuals of *X. germanus* were trapped and they thereby constituted 8% of all trapped ambrosia beetles (Franjevic et al. 2016).

- Denmark: In 2012 *X. germanus* was found in Keldskov, on the island Lolland, where one individual was observed walking on an ash stem (Hansen and Jørum 2014). In 2013 *X. germanus* was found in Broby Overdrev, 80 km south west of Copenhagen, where three individuals were caught in a trap hinged in an old sun exposed weakened oak tree (Hansen and Jørum 2014). The species is considered to be spreading in Denmark and in 2014 it was trapped in window traps in four locations in Gribskov, 50 km north of Copenhagen, and in 2015 it was found on ash both in Jægersborg Dyrehave, 15 km north of Copenhagen, and in Keldskov (Palle Jørum, personal communication).

- France: In a study including traps from 50 sites in northern France *X. germanus* dominated the communities constituting about 45% of the trapped individuals (in total 10 729 *X. germanus* were trapped; Bouget and Noblecourt 2005).

- Germany: A survey showed that already in 1954 *X. germanus* was present in at least 24 sites in Germany (Wichmann 1955). *X. germanus* is considered to be very abundant in Rheinland-Pfalz and Nordrhein-Westfalen in western Germany (Henin and Versteirt 2004 who cites other sources). The species has also been shown to be present in three out of eight “Natural Forest Reserves” of the Bavarian Forest in south eastern

Germany (in total 79 individuals were trapped; Blaschke and Bussler 2012). In a study of emergence of Coleoptera from beech logs in a managed broadleaved forest *X. germanus* was one of the two most common scolytids (Kappes and Topp 2004). The emergence of *X. germanus* varied between 0 – 1000 individuals/m^2.

- Italy: In a study located in north-eastern Italy, *X. germanus* was trapped in 24 out of 25 forests (in total 1219 individual were trapped; Rassati et al. 2016). In a study in Bosco della Fontana, where window flight traps were set up around artificially killed red oaks (*Quercus rubra*) in a nature reserve in northern Italy, *X. germanus* constituted 16% of the trapped ambrosia beetles (in total 24 532 individuals were trapped; Faccoli and Rukalski 2004).

- Netherlands: *X. germanus* has been observed in 10 places distributed over a large part of the Netherlands (Vorst et al. 2008).

- Poland: *X. germanus* has been found in eleven sites across a large part of Poland (Mokrzycki and Grodzki 2014; Mokrzycki 2016). In several of these sites the populations seems to have increased recently, e.g. in one site, one individual were trapped in 2013 and in 2015 210 individuals were trapped (Mokrzycki 2016).

- Romania: In Voievodeasa Forest Reserve in northern Romania 20 traps were set out in 2011 and 2012 and *X. germanus* were caught in all traps both years (except in two traps in 2011; Olenici et al. 2014). In total, 71 individuals were trapped 2011 and 97 in 2012. According to Olenici et al. (2015) *X. germanus* has also been found in three other places in Romania, i.e. in Arad, Cacica and Leaota.

- Russia: In a mixed coniferous–broadleaf forest near Vladivostok in the Russian Far East *X. germanus* was trapped in all eight ethanol baited (Sweeney et al. 2016). In total 60 individual of *X. germanus* was trapped, i.e. 3 % of all Scolytinae species.

- Slovakia: In Duchonka in west Slovakia 19, 40, and 77 individuals of *X. germanus* were caught in 2010, 2011, and 2012 respectively (Galko 2013).

- Slovenia: *X. germanus* has been found in three locations in Slovenia. In the north-western part (Sabotin/Nova Gorica), in south-eastern part (Arnova sela pri Brezicah) and in the central part (close to Ljubljana) (EPPO Global Database; Jurc 2010; Jurc and Repe 2012).

- Spain: In 2003, four individuals of *X. germanus* were trapped in northern Spain (López et al. 2007). In 2011-2012 it was found in four new locations in northern Spain (29, 9, 3 and 2 individuals; Goldarazena et al. 2014; Goldarazena, personal communication).

- Switzerland: In 1995, 20 000 m^3 of debarked round wood of spruce (*Picea abies*) and fir (*Abies alba*) were attacked by *X. germanus* (Graf and Manser, 2000). In 1996, seven traps were set out in the same region and on average 365 *X. germanus* were caught per trap (Graf and Manser, 2000). In 1997, four traps were set out and 140 *X. germanus* were caught per trap and in 1998 six traps were set out and 47 *X. germanus* were caught per trap. There is also a report from Switzerland of large scale mass attacks on logs of beech (*Fagus sylvatica*) stored in the forest (According to the abstract of Maksymov (1987)). In the same study attacks were also recorded on oak (*Quercus robu*r) and spruce (*Picea abies*).

- UK: In a saproxylic survey in an area close to London, 18 traps were set out in 2008 and *X. germanus* was trapped in all of them (in total 883 individuals; Allen et al. 2016). Surprisingly, *X. germanus* was not trapped again in that area in subsequent studies with the exception of 2012 when it was trapped in all 10 traps used (in total 193 individuals). In West Sussex, 34 individuals were caught in 2010 and 2 individuals in 2011. In 2014, a number of individuals were found in South Hampshire. According to Inward (2015) it has also been trapped in moderate numbers (25+ individuals) in 2012 and 2013 in North Hampshire.

6 Is the pest present and is it widely distributed[1] in Sweden?

Xylosandrus germanus has been trapped twice in Sweden and in both cases close to potentially colonized imported wood material. In 1996, one individual was caught in a window trap in Nybro inside the flooring manufacturer Kährs area where for example oak from Germany was stored (Lundberg 1996). In 2016, one individual was caught in the harbor in Kalmar in one of the baited traps used in the monitoring program administrated by the Swedish Board of Agriculture (Lindelöw 2017 unpublished report to SJV). Based on these two observations, *X. germanus* cannot be considered established or widely distributed in Sweden. However, there is a high risk that the presence of this species remains unnoticed in a country for a long time due to its concealed mode of life and and its preference for hosts that are already stressed, dying or dead. In addition, specialist identification skills are required to determine if a found beetle is *X. germanus*. Further monitoring would decrease the uncertainty about whether this species is established in Sweden or not.

[1] Definition can be found in ISPM 5, Supplement 1.

7 Host plants and their occurrence in Sweden

cabi has a very wide host range and it may be able to attack almost any woody plant stem (CABI 2015). The beetle does not feed on the plant material but uses the hosts as a medium for growing the symbiotic ambrosia fungi it feeds on. It seems to only require a woody material with suitable density and moisture content. Thus, it appears as if this species is more limited by finding hosts in a suitable condition (e.g. stressed or recently dead) than on finding specific host plant species.

Examples of hosts of importance for Sweden are *Abies alba, Alnus glutinosa, Betula pendula, Fagus sylvatica, Malus domestica, Picea abies, Pinus sylvestris, Quercus robur and Tilia* spp. Thus, available hosts are present in almost the whole of Sweden.

8 Is the pest a vector?

☐ No

☒ Yes

X. germanus is closely associated with symbiotic ambrosia fungi, such as *Ambrosiella hartigii* (Weber and McPherson 1984) and *Ambrosiella grosmanniae* (Mayers et al. 2015). The fungus is transported in special spore carrying structures in the beetles (i.e. mycangium) and introduced into the gallery system by the females before oviposition begins (Beaver 1989). The fungal cultures subsequently produced in the wood are used as an exclusive source of food for both adults and larvae. The *Ambrosiella* fungi may cause staining of the wood around the galleries but is not regarded as pathogenic (CABI 2015).

X. germanus may also act as a vector for pathogenic fungi and the beetle has mainly been associated with different *Fusarium* spp. that may cause dieback, wilting and cankers on affected trees. This association has been observed in for example walnut (*Juglans* spp.; Frigimelica et al. 1999; Kessler 1974). Although not considered an important vector, *X. germanus* has also been shown to be able to transmit the Dutch Elm disease (Buchanan 1940).

9 Is a vector needed?

☒ No

☐ Yes

10 Pathways and likelihood of entry into Sweden

Wood and wood products: Wood and wood products are considered to be the most likely pathway for *X. germanus*. The beetle reside within the wood and are thereby both protected from adverse climatic conditions during transportation and become difficult to detect at points of entry (Rassati et al. 2016). It has for example been found in wood packing material such as dunnage, pallets and containers (USDA 2011). *X. germanus* is present in large parts of Europe as well as in several countries in North America and Asia and large volumes of potentially infested material is imported to Sweden from these countries. The two individuals of *X. germanus* that has been trapped in Sweden (Lundberg 1996; Lindelöw 2017 unpublished report to SJV) most likely entered through this pathway.

Plants for planting: Woody plant stems with almost any diameter (0.9 - 50 cm in diameter) can be colonized by *X. germanus* (Reed et al. 2015) and plants for planting is therefore considered a potential pathway. Plant for planting is however judged to be a less important pathway than “Wood and wood products” due to the much smaller volumes of suitable hosts material that is transported within this pathway and because attacked living plants frequently shows symptoms that makes it easier to detect colonized material. This pathway is assessed to be unlikely but with a high uncertainty and further investigation are needed to reduce this uncertainty.

Natural spread: *X. germanus* can fly at least 2 km (Grégoire et al. 2001). The high spread capacity of *X. germanus* is also supported by i) that its initial spread was several tens of kilometres per year both in Germany and in USA (Henin and Versteirt 2004), ii) in France it spread from one to 51 (out of 101) “Départements” during 30 years (Nageleisen et al. 2016), and iii) it is generally believed that it has spread from the population that first established in Germany to 18 other European countries (e.g. Lakatos and Kajimura, 2007). However, these observations of spread rates have probably been a result of a combination of natural spread and human assisted spread. The likelihood of entry into Sweden through natural spread is assessed to be likely based on the species high spread capacity and the fact that it has recently established in a neighboring country, i.e. in Denmark (Hansen and Jørum 2014).

Rating of the likelihood of entry

Pathway	Very unlikely	Unlikely	Moderately likely	Likely	Very likely	Uncertainty rating[a]
Wood and wood products	☐	☐	☐	☐	☒	Low
Natural spread	☐	☐	☐	☒	☐	Medium
Plants for planting	☐	☒	☐	☐	☐	High

[a)]Low/medium/high

11 Likelihood of establishment outdoors and under protected cultivation in Sweden

The likelihood that *Xylosandrus germanus* can establish outdoors in Sweden is assessed to be very likely since:

- *X. germanus* is highly polyphagous and suitable hosts are widely distributed in Sweden.
- Sweden share Köppen-Geiger climate type with areas where *X. germanus* is present, e.g. at Latitude, 49.2501, Longitude 84.4998 in Quebec (CABI 2015; Peel et al 2007). In some European countries, however, the species has not been found at higher altitudes, e.g. in Romania it was found up to 900 m a.s.l. (Olenici et al. 2014 and reference therein). *X. germanus* is still expanding its range northward in Europe, thus there is some uncertainty whether the climate in the northern areas, and in areas at high altitudes, in Sweden is suitable.
- The sibling mating behavior of *X. germanus*, leading to that adult females are already fertilized when they disperse, increases the likelihood of establishment.

The likelihood that *Xylosandrus germanus* will establish on plants grown under protected cultivation is assessed to be very unlikely since there does not seem to be any reports of that.

Rating of the likelihood of establishment

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely	Uncertainty rating[a]
Outdoors	☐	☐	☐	☐	☒	Low
Protected cultivation	☒	☐	☐	☐	☐	Low

[a)] *Low/medium/high*

12 Potential spread after introduction

Xylosandrus germanus can fly at least 2 km (Grégoire et al. 2001). According to Henin and Versteirt (2004) the initial spread of *X. germanus* was several tens of kilometres per year both in Germany and in USA. Even more relevant is a mapping of the estimated spread year by year in France from the first observation in 1984 until it had been observed in 51 out of 101 “Départements” in 2014 (Nageleisen et al. 2016). These spread rates was likely a combination of natural spread and spread due to transport of colonized material. It is assessed that the spread rate in Sweden after an introduction would be somewhat lower since cut trees nowadays are stored in the forest for a shorter time which decreases the risk that the trees become colonized before they are transported away. Mainly due to that it is not known in the studies cited above whether it is one population that has spread or whether new introductions have contributed to the expansion of the area occupied the uncertainty was assessed to be medium.

Rating of the magnitude of spread within Sweden

	Very low	Low	Moderate rate	High	Very high	Uncertainty rating[a]
Spread rate	☐	☐	☐	☒	☐	Medium

[a])Low/medium/high

13 Economic, environmental and social impact

Previous expert opinions on the potential impact of *Xylosandrus germanus* differ substantially. According to CABI (2015), representing a global perspective, *X. germanus* should be considered a high-risk quarantine pest. According to Ranger and Reding (2008) it has emerged as a key pest of nursery stock in the United States. According to Jurc and Repe (2012) the influence to Slovenian forest could be major. According to Mokrzycki and Grodzki (2014) it may become a serious pest in Central Europe, including Poland. According to Bouget and Noblecourt (2005) the species does not currently appear to be a major threat in Western Europe but based on recent reports the impact is likely to increase in the region. According to Inward (2014) the economic, environmental and social impact in UK is expected to be small to medium. According to Latakos and Kajimura (2007) it is a major invasive species in North America but in Europe it should still be considered a secondary pest which cause no remarkable damage.

X. germanus lives in a symbiotic relationship with its associated ambrosia fungi which may cause staining of the wood and the beetle may also vector pathogenic fungi such as *Fusarium* spp. (Frigimelica et al. 1999; Kessler 1974). The impact assessed in this rapid PRA is the impact of this beetle-fungi complex.

A key question for assessing the impact of *X. germanus* is whether it kills healthy plants. There are several reports of *X. germanus* attacks on apparently healthy trees, e.g. walnut trees (Weber and McPherson 1984), young oak trees (Heidenreich 1960) and chest nut trees (Oliver and Mannion 20019). However, according to a recent review apparently healthy trees under attack by *X. germanus* are likely to be, or have been, physiologically stressed (Ranger et al. 2016). In conclusion it is unclear whether *X. germanus* sometimes kill healthy plants but in most cases it attacks hosts that are stressed, dying or recently dead (Ranger et al. 2016).

As specified under the heading “Current area of distribution” above, *X. germanus* have become one of the most common scolytid in many forested areas where it has established. This has implications for both the economic, environmental and social impact.

Economic impact

In North America, *X. germanus* is one of the economically most important ambrosia beetles in nurseries (Ranger and Reding 2008; Ranger et al. 2010; USDA 2011). The host range is extremely wide and the list of attacked plants in nurseries includes dogwood (*Cornus* spp.), honeylocust (*Gleditsia triacanthos* L.), Japanese snowbell (*Styrax japonicus* S. et Z.), magnolia (*Magnolia* spp.), maple (*Acer* spp.), oak (*Quercus* spp.), and redbud (*Cercis* spp.) (Ranger et al. 2016). Attacks do not always kill the trees but in such cases the aesthetic value and tree growth may be seriously reduced (Ranger et al. 2016; Weber 1982). Severe damage has also recently been recorded in apple orchards in New York where tree losses of up to 30% have been reported (Agnello et al. 2015, 2016).

In Europe, the economic impact of *X. germanus* seem to be less severe than in North America, still there are reports of damage on *Fagus* spp., *Quercus* spp., *Juglans regia*, *Picea abies*, *Pinus sylvestris* and *Abies alba* (according to Henin and Versteirt (2004) who cites other sources). In 1995 *X. germanus* colonized 20 000 m^3 of round timber of Norway spruce and fir in the Swiss Central Plateau and in the Jura-region (Graf and Manser 2000). The economic impact of colonization of timber is a result of both the direct excavation of galleries and the wood staining caused by the ambrosia fungus which in this case caused an estimated loss of value of 1 million Swiss Francs (Graf and Manser 2000).

Environmental impact

Xylosandrus germanus is considered to have the potential to have a negative impact on the diversity of scolytid communities (Henin and Versteirt 2004; Bouget and Noblecourt 2005). This is supported by a study in Belgium indicating that *X. germanus* had a niche overlap with several native species (Henin and Versteirt 2004). Despite that some of the native species were specialists on a particular type of substrate, e.g. *Ernopocerus fagi* which only colonizes branches less than 8 cm in diameter, *X. germanus* could be found on all types of substrates, e.g. stumps, small branches, limbs and logs (Henin and Versteirt 2004). However, there seems to be no reports that *X. germanus* have caused any local extinction of native species despite i) the apparent niche overlap with native species, ii) the very high population densities and iii) the fact that *X. germanus* have been established both in Europe and North America for a very long time (65 and 85 years, respectively). Based on this limited information, and the lack of reports of any other environmental impact caused by *X. germanus*, the potential environmental impact within Sweden is assessed to be small but with a high uncertainty.

Social impact
Despite that *Xylosandrus germanus* has a long history as an invasive species and is very common in many of the areas where it has established there seems to be no reports on social impact. Therefore the potential social impact within Sweden is assessed to be very small.

Uncertainty
There are many examples of beetle-fungus symbioses that has shifted from colonizing dead trees to colonizing live trees in their introduced ranges (Hulcr and Dunn 2011). Typically this is a shift from being a secondary pest on a wide range of host to becoming a primary pest on a narrow range of hosts. One example is the redbay ambrosia beetle *Xyleborus glabratus*, and its fungal partner *Raffaelea* spp. This symbiosis has started to kill trees of the family Lauraceae within its new range and has eradicated mature redbay (*Persea borbonia*) along the southern Atlantic coast of North America and is now threating the avocado-growing regions (Hulcr and Dunn 2011). Such shifts may already have occurred for *X. germanus* in some regions, e.g. *X. germanus* had been in the apple growing regions in New York for a long time but it only recently began to kill the trees and now hundreds of trees are killed annually in this region (Agnello et al. 2015, 2016). Such shifts are hard to predict and increase the uncertainty in all the impact assessments made.

Rating of the magnitude of potential impact within Sweden

	Very small	Small	Medium	Large	Very large	Uncertainty rating[a]
Economic	☐	☐	☒	☐	☐	High
Environmental	☐	☒	☐	☐	☐	High
Social	☒	☐	☐	☐	☐	Medium

[a)] *Low/medium/high*

14 Risk management options

Management to prevent introduction
The main pathway for *X. germanus* is wood and wood products. Detection of infested wood is difficult since *X. germanus* makes its galleries in the sapwood and the entrance holes are just one millimeter in diameter. The polyphagous nature of the species also means that the pathway is not limited to wood and wood products from certain host species. *X. germanus* has also been found in wood packing material (USDA 2011) and monitoring and management of this pathway is difficult since packing material may become widely distributed before the beetles emerge from the wood.

The efficiency of the different treatments currently used to prevent the entry of pest species in wood varies when it comes to *X. germanus*. Debarking will not remove the beetles from already colonized material as they are situated in the sapwood nor will it prevent the colonization of wood (Graf and Manser, 2000; Haack and Petrice, 2009). A heat treatment of 56°C for 30 min (e.g. ISPM 15) is sufficient to kill a range of insect (IPPC, 2017; USDA, 2016). In an experiment where wood was experimentally infested with adults of *X. germanus* 100% were killed at 52˚C by hot water treatments and at 58˚C by microwave irradiation (according to the abstract in Suh (2014)). However, such treatments do not prevent the wood from being recolonized with *X. germanus* should the conducive environmental conditions be fulfilled (Haack and Petrice, 2009). Some fumigant, like methylbromide appear to successfully kill *X. germanus* in wood (Based on the abstract of Oogita et al., (1998)).

For the pathway “plants for planting” detection and management is easier than for the pathway “wood and wood material” mainly due to that infested plants frequently show signs of poor health. Sometimes infestations can also be detected based on the characteristic “frass tooth picks” which are created when the beetles excavate their galleries. These signs of attacks are however frequently short lived as they are easily destroyed. Management option for this pathway may for example include preventative contact insecticide treatments, inspections and destruction of infested material.

Natural spread of *X. germanus* from e.g. Denmark is considered likely and surveys, and eradication measures if the pest is detected, may be performed in an attempt to prevent establishment through this pathway. The effectiveness of this approach is hampered by the difficulties to detect this species early enough to prevent establishment and there appears to be no records in the literature of attempts to stop the natural spread of this species.

In conclusion it is assessed to be difficult to prevent the introduction of *Xylosandrus germanus* to Sweden.

Management after introduction

If *X. germanus* is detected early enough it may be possible to eradicate the founder populations. Such early detection may be achieved by, for example, using a Citizen Science approach to conduct large-scale monitoring of invasive bark and ambrosia beetles (Steininger et al. 2015; http://www.backyardbarkbeetles.org/).

Healthy plants are seldom attacked by *X. germanus*. Thus, maintaining healthy plants should be the foundation of any integrated pest management program against this pest (Ranger et al. 2016).

For detection and monitoring of *X. germanus* ethanol baited traps are frequently used. Ethanol has been shown to be the most attractive stress-related volatile for this species (Ranger et al. 2010). However, it should be noted that *X. germanus* is significantly less attracted to ethanol baited traps than other ambrosia beetles, e.g.

in one study *X. germanus* was the dominant species attacking the trees but they only constituted 1.7 % of the total trap catches (Oliver and Mannion 2001; Ranger et al. 2010). Thus, the abundance of *X. germanus* in an area may be underestimated in relation to other ambrosia beetles when ethanol baited traps are used for monitoring.

Monitoring the flight is a key element in the management of *X. germanus* in high value plantations such as ornamental plant nurseries, apple orchards etc. It is considered difficult to control *X. germanus* with insecticides and the monitoring is used to time the application of insecticides with the time of the attacks. Once the beetles have entered the trees there is no effective management method to control them (Frank et al. 2013). To be effective contact insecticides has to be applied repeatedly until the flight period is over (Frank et al. 2013; Oliver and Manion 2001). Whether the insecticides approved in Sweden are effective against *X. germanus* remains to be investigated.

Other management options in high value plantations includes sanitation, where suitable breeding material such as cut branches and brush piles surrounding nurseries are removed to avoid a populations build up (Hulcr and Stelinski 2017). An alternative is to use this breeding material as traps, i.e. to remove the material after it has been attacked but before the offspring has emerged. Traps may also be created by injecting ethanol into selected trees or stem sections (Ranger et al. 2010; Reding et al. 2016). Recent research also shows that it may be possible to use biological control fungi in the future to control *X. germanus* (Castrillo et al. 2016). The need for control is increased when the plants becomes stressed, e.g. after flooding, including excessive irrigation, or late frost (Hulcr and Stelinski 2017).

To prevent the damage caused by *X. germanus* to stored logs in the forest Graf and Manser (2000) suggest “just-in-time felling”. In Sweden “just-in-time felling” is already practiced to a high degree. This is partly due to that conifer logs left in the forest are frequently attacked by *Ips typographus*, and *Tomicus minor* as well as the ambrosia beetle *Trypodendron lineatum*. In Sweden the maximum amount of fresh spruce and pine allowed to be left in the forest is also regulated by the forestry act § 29 which, a bit simplified, states that the amount that *exceeds* five cubic meter should be removed within a particular time frame. These current practices in Sweden would probably not prevent high population levels, since *X. germanus* can breed in stumps and branches etc., but it should considerably reduce the potential impact of *X. germanus* since logs of spruce and pine are available for a shorter period in the forest. However, the economic impact may become significant in situations where large volumes of suitable host materials becomes available, e.g. after extensive storm fellings. As mentioned previously, it is difficult to control *X. germanus* with insecticides and the insecticides used in some countries against the ambrosia beetle *Trypodendrum lineatum* , i.e. Chlorpyrifos, Alfa-Cypermethrin, Cypermethrin, Deltamethrin, Permethrin and Endosulfan, does not provide sufficient protection against *X. germanus* (Graf and Manser 2000).

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References

Agnello, A, Breth, D, Davis, A. and Tee, E. Ambrosia beetle (*Xylosandrus germanus*) infestations and management trials in high-density apple orchards. Report, Dept. of Entomology, Cornell University. Online at http://bit.ly/2oyPPqh

Allen, A.J., Hammond, P. M. and Telfer, M.G. (2015) *Xylosandrus germanus* (Blandford, 1984) (Curculionidae: Scolytinae) in Britain. The Coleopterist 24(2): 72-75.

Beaver R.A. (1989) Insect-Fungus Relationships in the Bark and Ambrosia Beetles. In: Wilding N., Collins N.M., Hammond P.M., Webber J.F., editors. Insect-Fungus Interactions. Academic Press; London, UK, pp. 121–143.

Blaschke, M. and Bussler, H. (2012). Borkenkäfer und baumschädigende Holzpilze in einem Höhengradienten des Bayerischen Waldes. Bezirksforstinspektionen in Österreich, 54, 10-15.

Buchanan, W.D (1940) Ambrosia beetle *Xylosandrus germanus* transmits Dutch elm disease under controlled conditions. Journal of Economic Entomology, 33:819-820.

Bouget, C., and Noblecourt, T. (2005). Short-term development of ambrosia and bark beetle assemblages following a windstorm in French broadleaved temperate forests. Journal of applied entomology, 129(6), 300-310.

Bussler, H., and Immler, T. (2007). Neue Borkenkäferarten in Bayern. *Forstschutz Aktuell*, 38, 5-8.

CABI (2015) *Xylosandrus germanus* (black timber bark beetle), Data sheet. Online at http://www.cabi.org/isc/datasheet/57237 (accessed 10 April 2017))

Castrillo, L. A., Griggs, M. H., and Vandenberg, J. D. (2016). Competition between biological control fungi and fungal symbionts of ambrosia beetles *Xylosandrus crassiusculus* and *X. germanus* (Coleoptera: Curculionidae): Mycelial interactions and impact on beetle brood production. Biological Control, 103, 138-146.

Dodds, K. J., and Miller, D. R. (2010). Test of nonhost angiosperm volatiles and verbenone to protect trap trees for *Sirex noctilio* (Hymenoptera: Siricidae) from attacks by bark beetles (Coleoptera: Scolytidae) in the northeastern United States. Journal of economic entomology, 103(6), 2094-2099.

Franjević, M., Poršinsky, T., and Đuka, A. (2016). Integrated Oak Timber Protection from Ambrosia Bark Beetles: Economic and Ecological Importance in Harvesting Operations. Croatian journal of forest engineering, 37(2), 353-364.

Frigimelica, G., Stergulc, F., Zandigiacomo, P., Faccoli, M., and Battisti, A. (1999). *Xylosandrus germanus* and walnut disease: an association new to Europe. In Proceedings of the second workshop of the IUFRO working party (Vol. 7, No. 10, pp. 98-101). Web page http://www.wsl.ch/dienstleistungen/publikationen/pdf/3484.pdf

EPPO (1992) Pests which should not appear in EPPO Quarantine lists. EPPO Reporting Service no. 01 - 1992 Num. article: 1992/0, Working Party 1981/1985 web page: https://gd.eppo.int/reporting/article-5039

EPPO (2011). EPPO Decision-support scheme for quarantine pests. EPPO Standard PM 5/3(5). http://archives.eppo.int/EPPOStandards/PM5_PRA/PRA_scheme_2011.pdf *[accessed on 20 March 2017]*.

EPPO (2011). CAPRA Network. http://capra.eppo.org/ [*accessed on 20 March 2017*].

EPPO (2012). Decision-support scheme for an Express Pest Risk Analysis. EPPO Bulletin 42, 457–462.

EPPO Global Database 2016 *Xylosandrus germanus* https://gd.eppo.int/taxon/XYLBGE/distribution [accessed on 10 April 2017]

Faccoli, M., and Rukalski, J. P. (2004). Attractiveness of artificially killed red oaks (*Quercus rubra*) to ambrosia beetles (Coleoptera, Scolytidae). Invertebrati di una foresta della Pianura Padana, Bosco della Fontana–Secondo contributo. Conservazione Habitat Invertebrati, 3, 171-179.

Frank, S. D., Klingeman, W. E., White, S. A., and Fulcher, A. (2013). Biology, injury, and management of maple tree pests in nurseries and urban landscapes. Journal of Integrated Pest Management, 4(1), B1-B14.

Galko, J. (2013). First record of the ambrosia beetle, *Xylosandrus germanus* (Blandford, 1894)(Coleoptera: Curculionidae, Scolytinae) in Slovakia. Forestry Journal, 58(4).

Geiser, E., and Geiser, R. (2000). Erstnachweise und Wiederfunde von Alt-und Totholzkäfern in der Stadt Salzburg. Koleopterologische Rundschau, 70, 209-222.

Goldarazena, A., Bright, D. E., Hishinuma, S. M., López, S., and Seybold, S. J. (2014). First record of *Pityophthorus solus* (Blackman,) in Europe. EPPO bulletin, 44(1), 65-69.

Graf, E., and Manser, P. (2000). The imported Japanese scolytid beetle *Xylosandrus germanus*: Biology and damage potential for stored round timber compared to *Xyloterus lineatus* and *Hylecoetus dermestoides*. *Schweizerische Zeitschrift fur Forstwesen*, 151(8), 271-281.

Grégoire, J. C., Piel, F., De Proft, M., and Gilbert, M. (2001). Spatial distribution of ambrosia-beetle catches: a possibly useful knowledge to improve mass-trapping. Integrated pest management reviews, 6(3-4), 237-242.

Haack, R. A., & Petrice, T. R. (2009). Bark-and wood-borer colonization of logs and lumber after heat treatment to ISPM 15 specifications: the role of residual bark. Journal of Economic Entomology, 102(3), 1075-1084.

Hansen, M., and Jørum, P. (2014). Records of beetles from Denmark, 2012 and 2013 (Coleoptera). *Entomologiske Meddelelser*, 82(2), 113-168.

Heidenreich, E. (1960). Primärbefall durch *Xylosandrus germanus* an Jungeichen. Anzeiger für Schädlingskunde, 33(1), 5-10.

Henin JM, Versteirt (2004) Abundance and distribution of *Xylosandrus germanus* (Blandford 1894) (Coleoptera, Scolytidae) in Belgium: new observations and an attempt to outline its range. Journal of Pest Science 77, 57-63.

Holzinger, W. E., Frieß, T., Holzer, E., and Mehlmauer, P. (2014) Xylobionte Käfer (Insecta: Coleoptera part.) in Wäldern des Biosphärenparks Wienerwald (Österreich: Niederösterreich, Wien). Wissenschaftliche Mitteilungen des Niederösterreichischen Landesmuseums, St. Pölten, 25: 331-362.

Holzschuh C, 1993. Erster Nachweis des Schwarzen Nutzholzborkenkäfers (*Xylosandrus germanus*) in Österreich. Forstschutz Aktuell, (12-13):10.

Hulcr, J., and Dunn, R. R. (2011). The sudden emergence of pathogenicity in insect–fungus symbioses threatens naive forest ecosystems. Proceedings of the Royal Society of London B: Biological Sciences, 278(1720), 2866-2873.

Hulcr, J., and Stelinski, L. L. (2017). The ambrosia symbiosis: From evolutionary ecology to practical management. Annual Review of Entomology, 62, 285–303.

Inward, D. J. G. (2015) Rapid pest risk analysis for *Xylosandrus germanus* (Coleoptera: Scolytinae). Report. Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH.

IPPC (2017) Explanatory document for ISPM 15 (Regulation of wood packaging material in international trade). https://www.ippc.int/en/core-activities/standards-setting/explanatory-documents-international-standards-phytosanitary-measures/

Jurc, M. (2010). Some harmful native and non-native insects in the forests of the Ljubljana area. Gozdarski Vestnik, 68(5/6), 321-329 (in Slovenian).

Jurc, M and Repe, A. (2012) Some new immigrant phytophagous insects on woody plants in Slovenia Forstschutz Aktuell 55, 32-33.

Kaneko, T. (1967). Shot-hole borer of tea plant in Japan. Jap Agric Res Quart, 22, 19-21.

Kappes, H., and Topp, W. (2004). Emergence of Coleoptera from deadwood in a managed broadleaved forest in central Europe. Biodiversity and Conservation, 13(10), 1905-1924.

Kessler Jr, K. J. (1974). An apparent symbiosis between *Fusarium* fungi and ambrosia beetles causes canker on black walnut stems. Plant Dis. Rep, 58, 1044-1047.

Kirkendall LR, Faccoli M (2010) Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe. ZooKeys 56:227–251.

Lakatos, F., and Kajimura, H. (2007). Occurrence of the introduced *Xylosandrus germanus* (Blandford, 1894) in Hungary–a genetic evidence (Coleoptera: Scolytidae). Folia Entomol. Hung, 68, 97-104.

La Spina, S., De Cannière, C., Dekri, A., and Grégoire, J. C. (2013). Frost increases beech susceptibility to scolytine ambrosia beetles. Agricultural and forest entomology, 15(2), 157-167.

López, S., Iturrondobeitia, J. C., and Goldarazena, A. (2007). Primera cita en la Península Ibérica de *Gnathotrichus materiarius* (Fitch, 1858) y *Xylosandrus germanus* (Blandford, 1894)(Coleoptera: Scolytinae). Boletín de la Sociedad Entomológica Aragonesa, 40, 527-532.

Lundberg, S. (2006). Nytillkomna och strukna skalbaggsarter sedan 1995 års Catalogus Coleopterorum Sueciae. *Entomologisk Tidskrift*, 127(3), 101-111.

Maksymov, J. K. (1987). Erstmaliger Massenbefall des schwarzen Nutzholzborkenkäfer *Xylosandrus germanus* Blandf., in der Schweiz (First mass attack of the ambrosia beetle *Xylosandrus germanus in Switzerland*). Schweizerische Zeitschrift für Forstwesen, 138(3), 215-227. Abstract https://www.cabdirect.org/cabdirect/abstract/19890633465

Mayers, C.G, McNew, D.L, Harrington, T.C, Roeper, R.A, Fraedrich, S.W, Biedermann, P.H.W., Castrillo, LA, Reed, R.E. (2015) Three genera in the Ceratocystidaceae are the respective symbionts of three independent lineages of ambrosia beetles with large, complex mycangia. Fungal Biology, 119:1075-1092.

Mokrzycki, T. (2016). Obce gatunki korników (Coleoptera, Curculionidae, Scolytinae) w faunie Polski i potencjalne zagrożenia dla drzewostanów. Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej, 18(1 [46]).

Mokrzycki, T., and Grodzki, W. (2014). Drzewotocz japoński *Xylosandrus germanus* (Bldf.)(Coleoptera: Curculionidae, Scolytinae) w Polsce. Sylwan, 158(8), 590-594.

Nageleisen, L.-M., Bouget, C., Noblecourt, T. (2015) Les Scolytes du genre Xylosandrus de France (Coleoptera Curculionidae Scolytinae). L'Entomologiste, tome 71, 2015, n° 4: 267 – 271.

Nazarenko, V. Yu and Gontarenko, A. V. (2014) The First Record of *Xylosandrus germanus* (Coleoptera, Curculionidae) in Ukraine. Vestnik zoologii, 48(6): 569–570, DOI: 10.2478/vzoo-2014-0068

Olenici, N., Duduman, M. L., and Tomescu, R. (2015) *Xylosandrus germanus* (Coleoptera, Curculionidae, Scolytinae)–un potențial dăunător al pădurilor, livezilor şi viilor din România. Bucov. For. 5(2): 207-216.

Olenici, N., Knízek, M., Olenici, V., and Duduman, M. L. (2014). First report of three scolytid species (Coleoptera: Curculionidae, Scolytinae) in Romania. *Annals of Forest Research*, *57*(1), 87.

Oliver, J. B., and Mannion, C. M. (2001). Ambrosia beetle (Coleoptera: Scolytidae) species attacking chestnut and captured in ethanol-baited traps in middle Tennessee. Environmental Entomology, 30(5), 909-918.

Oogita, T., Naito, H., Soma, Y., Kawakami, F. (1998). Effect of low dose methyl bromide on forest insect pests. Research Bulletin of the Plant Protection Service, Japan, 34, 37-39.

Peel, M. C., Finlayson, B. L., and McMahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. *Hydrology and earth system sciences discussions*, 4(2), 439-473.

Ranger, C. M., Reding, M. E., Persad, A. B., and Herms, D. A. (2010). Ability of stress-related volatiles to attract and induce attacks by *Xylosandrus* *germanus* and other ambrosia beetles. Agricultural and Forest Entomology, 12(2), 177-185.

Ranger, C. M., Reding, M. E., Schultz, P. B., Oliver, J. B., Frank, S. D., Addesso, K. M., ... and Krause, C. (2016). Biology, ecology, and management of nonnative ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) in ornamental plant nurseries. *Journal of Integrated Pest Management*, 7(1), 9.

Rassati, D., Faccoli, M., Battisti, A., and Marini, L. (2016). Habitat and climatic preferences drive invasions of non-native ambrosia beetles in deciduous temperate forests. Biological Invasions, 18(10), 2809-2821.

Reding, M. E., Ranger, C. M., Oliver, J. B., Schultz, P. B., Youssef, N. N., and Bray, A. M. (2017). Ethanol-injection induces attacks by ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) on a variety of tree species. Agricultural and Forest Entomology, 19(1), 34-41.

Reed, S. E., Juzwik, J., English, J. T., and Ginzel, M. D. (2015). Colonization of artificially stressed black walnut trees by ambrosia beetle, bark beetle, and other weevil species (Coleoptera: Curculionidae) in Indiana and Missouri. Environmental entomology, 44(6), 1455–1464.

Steininger, M. S., Hulcr, J., Šigut, M., and Lucky, A. (2015). Simple and efficient trap for bark and ambrosia beetles (Coleoptera: Curculionidae) to facilitate invasive species monitoring and citizen involvement. Journal of economic entomology, 108(3), 1115-1123.

Suh, S. J. (2014). Lethal temperature for the black timber bark beetle, *Xylosandrus germanus* (Coleoptera: Scolytidae) in infested wood using microwave energy. Current Research on Agriculture and Life Sciences, 32(3), 131-134.

Sweeney, J. D., Silk, P., Grebennikov, V., and Mandelshtam, M. (2016). Efficacy of semiochemical-baited traps for detection of Scolytinae species (Coleoptera: Curculionidae) in the Russian Far East. European Journal of Entomology, 113, 84.

UK Plant Health Risk Register, website https://secure.fera.defra.gov.uk/phiw/riskRegister/viewPestRisks.cfm?cslref=22313mandelriskId=27331 Accessed: 15 February 2017.

USDA (2011) Risk assessment for the movement of domestic wood packaging material within the United States. USDA APHIS: pp36. Online at http://www.aphis.usda.gov/plant_health/plant_pest_info/downloads/RiskAssessment-WPM.pdf

USDA (2016) Survival of woodboring insects in heat-treated wood. Webpage https://www.nrs.fs.fed.us/disturbance/invasive_species/firewood_treatment/

Vorst O, Heijerman T, van Nunen F and van Wielink P (2008) Several bark beetles new to the Dutch fauna (Coleoptera: Curculionidae: Scolytinae). Nederlandse Faunistische Mededelinggen 29, 61-74 (in Dutch).

Weber, B. C., and McPherson, J. E. (1984). Notes: Attack on black walnut trees by the ambrosia beetle *Xylosandrus germanus* (Coleoptera: Scolytidae). Forest Science, 30(4), 864-870.

Weber, B., and McPherson, J. (1984). The ambrosia fungus of *Xylosandrus germanu*s (Coleoptora: Scolytidae). The Canadian Entomologist, 116(2), 281-283.

Wichmann HE (1955) Zur derzeitigen Verbreitung des Japanischen Nutzholzborkenkäfers *Xylosandrus germanus* Blandf. im Bundesgebiete. Journal of Applied Entomology 37(2), 250-258.

Wichmann, H. E. (1957). Einschleppungsgeschichte und Verbreitung des *Xylosandrus germanus* Blandf. in Westdeutschland. Journal of Applied Entomology, 40(1), 82-99.