Pest categorisation of *Diabrotica barberi*

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Abstract

The EFSA Panel on Plant Health performed a pest categorisation of *Diabrotica barberi* (Coleoptera: Chrysomelidae), the northern corn rootworm, for the EU. *D. barberi* is a univoltine species occurring in mid-western and eastern USA and Canada, where it reproduces on maize (*Zea mays*), the preferred larval host. A small proportion of individuals can develop to a lesser extent on spelt (*Triticum spelta*), rice (*Oryza sativa*), millet (*Panicum miliaceum*) and a few North American wild grasses. Eggs are laid in the soil of maize fields, where they overwinter and can enter a diapause which can extend for more than one winter. Larvae hatch in late spring and early summer. Adult emergence peaks in the summer to feed on maize tassels, silks and ear tips. Adults abandon maize fields looking for other feeding hosts and return to maize for oviposition during late summer and autumn. *D. barberi* is considered a key pest of maize, together with other rootworm species of the same genus. *D. barberi* is regulated in the EU by Directive 2000/29/EC (Annex IAI). Within this Directive, a general prohibition of soil from most third countries prevents the entry of *D. barberi* larvae. However, adults carried on sweetcorn or green maize are potential pathways for entry into the EU. Climatic conditions and the wide availability of maize provide conditions to support establishment in the EU. Following establishment, impact on maize yields is anticipated. Phytosanitary measures are available to inhibit entry of this pest. *D. barberi* satisfies the criteria, which are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest. *D. barberi* does not meet the criteria of occurring in the EU nor plants for planting being the principal means of spread for it to be regarded as a potential Union regulated non-quarantine pest.

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

Council Directive 2000/29/EC\(^1\) on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community establishes the present European Union plant health regime. The Directive lays down the phytosanitary provisions and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union. In the Directive’s 2000/29/EC annexes, the list of harmful organisms (pests) whose introduction into or spread within the Union is prohibited, is detailed together with specific requirements for import or internal movement.

Following the evaluation of the plant health regime, the new basic plant health law, Regulation (EU) 2016/2031\(^2\) on protective measures against pests of plants, was adopted on 26 October 2016 and will apply from 14 December 2019 onwards, repealing Directive 2000/29/EC. In line with the principles of the above mentioned legislation and the follow-up work of the secondary legislation for the listing of EU regulated pests, EFSA is requested to provide pest categorisations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/pest categorisation is not available.

1.1.2. Terms of reference

EFSA is requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002\(^3\), to provide scientific opinion in the field of plant health.

EFSA is requested to prepare and deliver a pest categorisation (step 1 analysis) for each of the regulated pests included in the appendices of the annex to this mandate. The methodology and template of pest categorisation have already been developed in past mandates for the organisms listed in Annex II Part A Section II of Directive 2000/29/EC. The same methodology and outcome is expected for this work as well.

The list of the harmful organisms included in the annex to this mandate comprises 133 harmful organisms or groups. A pest categorisation is expected for these 133 pests or groups and the delivery of the work would be stepwise at regular intervals through the year as detailed below. First priority covers the harmful organisms included in Appendix 1, comprising pests from Annex II Part A Section I and Annex II Part B of Directive 2000/29/EC. The delivery of all pest categorisations for the pests included in Appendix 1 is June 2018. The second priority is the pests included in Appendix 2, comprising the group of Cicadellidae (non-EU) known to be vector of Pierce’s disease (caused by Xylella fastidiosa), the group of Tephritidae (non-EU), the group of potato viruses and virus-like organisms, the group of viruses and virus-like organisms of Cydonia Mill., Fragaria L., Malus Mill., Prunus L., Pyrus L., Ribes L., Rubus L. and Vitis L.. and the group of Margarodes (non-EU species). The delivery of all pest categorisations for the pests included in Appendix 2 is end 2019. The pests included in Appendix 3 cover pests of Annex I part A section I and all pests categorisations should be delivered by end 2020.

For the above mentioned groups, each covering a large number of pests, the pest categorisation will be performed for the group and not the individual harmful organisms listed under “such as” notation in the Annexes of the Directive 2000/29/EC. The criteria to be taken particularly under consideration for these cases, is the analysis of host pest combination, investigation of pathways, the damages occurring and the relevant impact.

Finally, as indicated in the text above, all references to ‘non-European’ should be avoided and replaced by ‘non-EU’ and refer to all territories with exception of the Union territories as defined in Article 1 point 3 of Regulation (EU) 2016/2031.

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\(^1\) Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1-112.

\(^2\) Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants. OJ L 317, 23.11.2016, p. 4-104.

\(^3\) Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31/1, 1.2.2002, p. 1-24.
1.1.2.1. Terms of Reference: Appendix 1

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

**Annex IIAI**

(a) Insects, mites and nematodes, at all stages of their development

*Aleurocanthus spp.*
*Anthonomus bissignifer* (Schenkling)
*Anthonomus signatus* (Say)
*Aschistonyx eppoi* Inouye
*Carposina niponensis* Walsingham
*Enarmonia packardi* (Zeller)
*Enarmonia prunivora* Walsh
*Grapholita inopinata* Heinrich
*Hisomonos phycitis*
*Leucaspis japonica* Ckll.
*Listronotus bonariensis* (Kuschel)

(b) Bacteria

Citrus variegated chlorosis
*Erwinia stewartii* (Smith) Dye

(c) Fungi

*Alternaria alternata* (Fr.) Keissler (non-EU pathogenic isolates)
*Anisogromma anomala* (Peck) E. Müller
*Apiosporina morbosa* (Schwein.) v. Arx
*Ceratocystis virescens* (Davidson) Moreau
*Cercoseptoria pini-densiflorae* (Hori and Nambu) Deighton
*Cercospora angolensis* Carv. and Mendes

(d) Virus and virus-like organisms

Beet curly top virus (non-EU isolates)
Black raspberry latent virus
Blight and blight-like
Cadang-Cadang viroid
Palm lethal yellowing mycoplasm
Satsuma dwarf virus

**Annex IIB**

(a) Insect mites and nematodes, at all stages of their development

*Anthonomus grandis* (Boh.)
*Cephalcia lariiciphila* (Klug)
*Dendroctonus micans* Kugelan
*Gilphinia hercyniae* (Hartig)
*Goniapterus scutellatus* Gyll.
*Ips amitinus* Eichhof

*Numonia pyrivorella* (Matsumura)
*Oligonychus perditus* Pritchard and Baker
*Pissodes spp.* (non-EU)
*Scirtothrips aurantii* Faure
*Scirtothrips citri* (Moultex)
*Scolytidae spp.* (non-EU)
*Scrobipalopsis solanivora* Povolny
*Tachypterellus quadrigibbus* Say
*Toxoptera citricida* Kirk.
*Unaspi citri* Comstock

*Xanthomonas campestris* pv. *oryzae* (Ishiyama)
*Dye and pv. oryzicola* (Fang. et al.) Dye

*Elsinoe* spp. Bitanc. and Jenk. Mendes
*Fusarium oxysporum* f. sp. *albedinis* (Kilian and Maire) Gordon
*Guignardia piricola* (Nosa) Yamamoto
*Puccinia pittieriana* Hennings
*Stegophora ulmea* (Schweinitz: Fries) Sydow & Sydow
*Venturia nashicola* Tanaka and Yamamoto

*Citrus tristeza virus* (non-EU isolates)
*Leprosis*
*Little cherry pathogen* (non-EU isolates)
*Naturally spreading psorosis*
*Tatter leaf virus*
*Witches’ broom* (MLO)
(b) Bacteria

*Curtobacterium flaccumfaciens pv. flaccumfaciens* (Hedges) Collins and Jones

(c) Fungi

*Glomerella gossypii* Edgerton

*Hypoxylon mammatum* (Wahl.) J. Miller

*Gremmeniella abietina* (Lag.) Morelet

1.1.2.2. Terms of Reference: Appendix 2

List of harmful organisms for which pest categorisation is requested per group. The list below follows the categorisation included in the annexes of Directive 2000/29/EC.

**Annex IAI**

(a) Insects, mites and nematodes, at all stages of their development

Group of Cicadellidae (non-EU) known to be vector of Pierce’s disease (caused by *Xylella fastidiosa*), such as:

1) *Carneocephala fulgida* Nottingham
2) *Draeculacephala minerva* Ball

Group of Tephritidae (non-EU) such as:

1) *Anastrepha fraterculus* (Wiedemann)
2) *Anastrepha ludens* (Loew)
3) *Anastrepha obliqua* Macquart
4) *Anastrepha suspensa* (Loew)
5) *Dacus ciliatus* Loew
6) *Dacus curcurbitae* Coquillett
7) *Dacus dorsalis* Hendel
8) *Dacus tryoni* (Froggatt)
9) *Dacus tsuneonis* Miyake
10) *Dacus zonatus* Saund.
11) *Epocha canadensis* (Loew)

(c) Viruses and virus-like organisms

Group of potato viruses and virus-like organisms such as:

1) Andean potato latent virus
2) Andean potato mottle virus
3) Arracacha virus B, oca strain
4) Potato black ringspot virus
5) Potato virus T
6) non-EU isolates of potato viruses A, M, S, V, X and Y (including Yo, Yn and Yc) and potato leafroll virus

Group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L., such as:

1) Blueberry leaf mottle virus
2) Cherry rasp leaf virus (American)
3) Peach mosaic virus (American)
4) Peach phony rickettsia
5) Peach rosette mosaic virus
6) Peach rosette mycoplasm
7) Peach X-disease mycoplasm
8) Peach yellows mycoplasm
9) Plum line pattern virus (American)
10) Raspberry leaf curl virus (American)
11) Strawberry witches’ broom mycoplasm
12) Non-EU viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L.
Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Group of *Margarodes* (non-EU species) such as:

1) *Margarodes vitis* (Phillipi)  
2) *Margarodes vredendalensis* de Klerk  
3) *Margarodes prieskaensis* Jakubski

1.1.2.3. Terms of Reference: Appendix 3

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IAI

(a) Insects, mites and nematodes, at all stages of their development

| Insects | Mites | Nematodes |
|---------|-------|-----------|
| Acleris spp. (non-EU) | Longidorus diadecturus | Eveleigh and Allen |
| Amauromyza maculosa (Malloch) | Monochamus spp. (non-EU) | |
| Anomala orientalis Waterhouse | Myndus crudus | Van Duzee |
| Arrhenodes minutus Drury | Nacobbus aberrans (Thorne) Thorne and Allen |
| Choristoneura spp. (non-EU) | Naupactus leucoloma Boheman |
| Conotrachelus nenuphar (Herbst) | Premnotypes spp. (non-EU) |
| Dendrolimus sibiricus Tschetterikov | Pseudopityophthorus minutissimus (Zimmermann) |
| Diabrotica barberi Smith and Lawrence | Pseudopityophthorus pruinosus (Eichhoff) |
| Diabrotica undecimpunctata howardi Barber | Scaphioidea luteolus (Van Duzee) |
| Diabrotica undecimpunctata undecimpunctata Mannerheim | Spodoptera eridania (Cramer) |
| Diabrotica virgifera zeae Krsyan & Smith | Spodoptera frugiperda (Smith) |
| Diaphorina citri Kuwait | Spodoptera litura (Fabricius) |
| Heliothis zea (Boddie) | Thrips palmi Karny |
| Hirschmanniella spp., other than | Xiphinema americanum Cobb sensu lato (non-EU populations) |
| Hirschmanniella gracilis (de Man) Luc and Goodey | Xiphinema californicum Lamberti and Bleve-Zacheo |
| Liriomyza sativae Blanchard |

(b) Fungi

| Fungi |
|-------|
| Ceratocystis fagacearum (Bretz) Hunt | Mycosphaerella larici-leptolepis Ito et al. |
| Chrysomyxa arctostaphyli Dietel | Mycosphaerella populorum G. E. Thompson |
| Cronartium spp. (non-EU) | Phoma andina Turkensteen |
| Endocronartium spp. (non-EU) | Phyllosticta solitaria Ell. and Ev. |
| Guignardia laricina (Saw.) Yamamoto and Ito | Septoria lycopersici Spec. var. malagutii Ciccarone and Boerema |
| Gymnosporangium spp. (non-EU) | Thecaphora solani Barrus |
| Inonotus weirii (Murril) Kotlaba and Pouzar | Trechispora brinkmannii (Bresad.) Rogers |
| Melampsora farlowii (Arthur) Davis |

(c) Viruses and virus-like organisms

| Viruses and Virus-like Organisms |
|---------------------------------|
| Tobacco ringspot virus | Pepper mild tigré virus |
| Tomato ring spot virus | Squash leaf curl virus |
| Bean golden mosaic virus | Euphorbia mosaic virus |
| Cowpea mild mottle virus | Florida tomato virus |
| Lettuce infectious yellows virus |
(d) Parasitic plants

*Arceuthobium* spp. (non-EU)

**Annex I AII**

(a) Insects, mites and nematodes, at all stages of their development

*Meloidogyne fallax* Karssen  
*Popillia japonica* Newman

(b) Bacteria

*Clavibacter michiganensis* (Smith) Davis et al.  
*Ralstonia solanacearum* (Smith) Yabuuchi et al.

(c) Fungi

*Melampsora medusae* Thümen  
*Synchytrium endobioticum* (Schilbersky) Percival

**Annex I B**

(a) Insects, mites and nematodes, at all stages of their development

*Leptinotarsa decemlineata* Say  
*Liriomyza bryoniae* (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.2. Interpretation of the Terms of Reference

*Diabrotica barberi* is one of a number of pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a quarantine pest or those of a regulated non-quarantine pest for the area of the European Union (EU) excluding Ceuta, Melilla and the outermost regions of Member States (MSs) referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on *Diabrotica barberi* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as search term. Relevant papers were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature.

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, 2019) and relevant publications.

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTE) of the European Commission, and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications...
of plant pests detected in the territory of the MS and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *D. barberi*, following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018) and in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

This work was initiated following an evaluation of the EU plant health regime. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a Union quarantine pest and for a Union regulated non-quarantine pest in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required in accordance with the specific ToR received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as a regulated non-quarantine pest. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as a regulated non-quarantine pest that needs to be addressed in the opinion. For the pests regulated in the protected zones only, the scope of the categorisation is the territory of the protected zone; thus, the criteria refer to the protected zone instead of the EU territory.

It should be noted that the Panel’s conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms, whereas addressing social impacts is outside the remit of the Panel.

Table 1: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

| Criterion of pest categorisation | Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest |
|---------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Identity of the pest (Section 3.1) | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? |
| Absence/presence of the pest in the EU territory (Section 3.2) | Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly! | Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism. | Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest. (A regulated non-quarantine pest must be present in the risk assessment area). |
| Regulatory status (Section 3.3) | If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future. | The protected zone system aligns with the pest-free area system under the International Plant Protection Convention (IPPC). The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone). | Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked? |
The Panel will not indicate in its conclusions of the pest categorisation whether to continue the risk assessment process, but following the agreed two-step approach, will continue only if requested by the risk managers. However, during the categorisation process, experts may identify key elements and knowledge gaps that could contribute significant uncertainty to a future assessment of risk. It would be useful to identify and highlight such gaps so that potential future requests can specifically target the major elements of uncertainty, perhaps suggesting specific scenarios to examine.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?

Yes, the identity of *D. barberi* is established and taxonomic keys are available for its identification to species level.
The northern corn rootworm, *D. barberi* Smith & Lawrence 1967 (Coleoptera: Chrysomelidae: Galerucinae) is a well-defined species occurring in Northern America. The species was originally described by Say in 1824 as *Gelleruca longicornis* (Chiang, 1973). The genus *Diabrotica* includes about 100 species native of the New World (Krysan, 1986; Derunkov et al., 2013). *D. barberi* had been considered a subspecies of *Diabrotica longicornis* (Say) 1823 (i.e. *D. longicornis barberi* Smith & Lawrence). However, the taxon was elevated to species level based on laboratory and field studies, including the examination of more than 3,500 museum specimens (Krysan et al., 1983).

### 3.1.2. Biology of the pest

*Diabrotica barberi* is a univoltine species. Larvae hatch by late spring and early summer and develop on the roots of maize (Branson and Krysan, 1981; Hesler, 1993), where they have three instars (Hammack et al., 2003). Males emerge earlier than females (Naranjo and Sawyer, 1988). Upon emergence from the soil, adults feed on maize tassels, silks and ear tips. Adult populations peak in the fields while maize is flowering (Lance et al., 1989). Maize leaves are not the preferred food of adult *D. barberi* (Ludwig and Hill, 1975; Hesler, 1993) and feeding on flower parts such as tassels and silks provides higher fecundity and longevity (Lance and Fisher, 1987). As the floral structures of maize dry and deteriorate, female *D. barberi* abandon maize fields (Lance et al., 1989) and become increasingly abundant on the flowers of weeds, prairie forbs and crops other than maize within the families Asteraceae, Cucurbitaceae, Fabaceae and Poaceae (Clark et al., 2004). Adult *D. barberi* also feed on apple fruits, especially where the skin has been broken by other insects (Hesler, 1993). Egg-laden *D. barberi* adult females actively seek maize when searching for oviposition sites during late summer and autumn (Lance et al., 1989). Eggs are laid in clutches of 25–31 eggs (Naranjo and Sawyer, 1988) in the soil of maize fields, where they overwinter and can enter a diapause which can extend for more than one cold season (Krysan et al., 1984; Fisher et al., 1994). Temperatures in the range 6–15°C foster diapause development. Maximum egg hatch was observed for eggs exposed to 8–12°C for 160–205 days (Fisher et al., 1994). Hatching of eggs maintained at 0°C ranged from 20% to 6.3% for 15 and 135 days, respectively, and reached 8% after 180 days of exposure to this temperature (Fisher et al., 1994). Laboratory studies (Jackson and Elliott, 1988; Woodson and Jackson, 1996) showed that development from egg to adult can be completed at temperatures in the range 15–31.5°C. Survival was lower at 15 and 31.5°C for both males and females, with optimal temperature for growth between 18 and 30°C. A development threshold of 10.2°C and a thermal constant of 525 and 865 DD from either egg hatch or oviposition to adult emergence, respectively, were calculated. According to Naranjo and Sawyer (1988), mean female and male longevity were similar, ranging from ca. 90 days at 17.5°C to 42 days at 30°C. During this time, females may lay an egg clutch every 6–7 days with a total fecundity of 118–274 eggs.

*Diabrotica barberi* and the closely related *D. virgifera virgifera* LeConte are sympatric and can be found in the same maize fields in mixed infestations. However, *D. virgifera virgifera* has displaced *D. barberi*, or at least reduced its abundance, in some areas (Capinera, 2001). This displacement has been attributed to greater insecticide resistance and higher reproductive rate of *D. virgifera virgifera* relative to *D. barberi* (Capinera, 2001).

### 3.1.3. Intraspecific diversity

Based on the genetic variation of mitochondrial DNA (mtDNA) and the nuclear ribosomal internal transcribed spacer, ITS1, found in specimens collected in 10 states of the USA (extending from Pennsylvania to the Great Plains), two distinct clades have been identified. They can be described as the eastern population and the western population (Roehrdanz et al., 2003). However, these authors did not present any evidence for differences in pest status of these populations, which will be dealt with together in this categorisation.

### 3.1.4. Detection and identification of the pest

**Are detection and identification methods available for the pest?**

**Yes**, detection and identification methods for *D. barberi* are available.
Detection

Symptoms:

According to Smith et al. (1997), 'larval feeding on the roots causes root pruning. As a result, the force needed to pull the plant from the soil decreases (this can serve as an index of damage), and the plants have a greater tendency to lodge. The older larvae burrow in the cortical parenchyma of the roots, and then dig channels in the central vascular tissue. Tunnels in maize roots are thus a characteristic symptom, though they may be due to other species. Adult feeding does not cause any particularly characteristic symptom.'

Pheromone trapping:

Yellow sticky traps have been used to monitor this species. Their attractiveness could be enhanced by use of some semiochemicals (Capinera, 2001). The 2R,8R stereoisomers of 8-methyl-2-decyl propanoate proved attractive for *D. barberi* when tested in South Dakota (Guss et al., 1985). Furthermore, cucurbitacin and a few additional chemicals isolated from Cucurbitaceae (i.e. eugenol, isoeugenol, 2-methoxy-4-propylphenol, cinnamyl alcohol) could also be used (Capinera, 2001).

Identification:

Immature stages:

Smith et al. (1997) report that ‘larvae are small, wrinkled, yellowish-white, with a brown head capsule, reaching 10–18 mm in length’. However, attempts to distinguish larvae belonging to the genus *Diabrotica* using external characters have proven to be difficult (Krysan, 1986). Mendoza and Peters (1964) devised a key to differentiate mature larvae of the economically important *D. undecimpunctata howardi* Barber, *D. v. virgifera* and *D. barberi*.

Adult morphology:

According to Derunkov et al. (2013), body length and width are 4.8–5.6 and 2.0–2.5 mm, respectively (*Diabrotica* ID, online). Head basic colour is yellow. Antennae are filiform, bi- or tricolored, with antennomere 1 yellow, testaceous or greenish brown and antennomeres 2-11, Brussels brown. The pronotum is Paris green, green or yellow. The scutellum is yellow. Elytra are green, with five distinct sinuate sulci. Elytral epipleura are green. The abdomen is yellow, pale olivine or green. Tarsi are black, amber brown or chestnut. Tibiae are bicoloured yellow. Femora are uniform yellow or olive other. The aedeagus is symmetric, with four internal sac sclerites. According to the same authors, ‘*D. barberi* is similar to *D. longicornis* and *D. virgifera*. They can be separated by the following features: in *D. barberi* the head, tibia and tarsi are paler than in *D. longicornis*; femora unicolourous green or flavous in *D. barberi*, while femora of *D. virgifera* as a rule bicoloured, with outer edges dark, chestnut or piceous; distance from apex to ventral flange of aedeagus in *D. virgifera* is 1.5–2.0 times that of *D. barberi*. The shapes of the internal sac sclerites (especially sclerite 4B) differentiates all three species very well.’

Molecular methods:

Szalanski and Powers (1996) developed a PCR-RFLP-based diagnostic method for adults and larvae of *Diabrotica* species including, *D. barberi*. Other authors have focused on using molecular markers to establish the phylogeny of the genus *Diabrotica* (e.g. Clark et al., 2001a,b). These studies could also be used for diagnostic purposes.

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

*D. barberi* is present in the Nearctic region only (Figure 1 from the Great Plains region to North Dakota and Oklahoma, and east to the Atlantic Ocean, and Canada (Manitoba, New Brunswick, Ontario and Quebec) (EPPO, online, accessed 04/06/2019). This species is native to this region. It was first discovered attacking maize in Colorado and has since spread eastward, mostly to the maize-growing region in the mid-western states. This range expansion is primarily attributed to a change in crop production practices: continuous monoculture of maize in the same fields (Capinera, 2008).
3.2.2. Pest distribution in the EU

D. barberi is not known to be present in the EU. The NPPO of Slovenia informed EPPO that D. barberi is not present there due to no pest records (EPPO global database, 2019).

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

D. barberi is listed in Council Directive 2000/29/EC in Annex IAI. Details are presented in Tables 2 and 3.

**Table 2: Diabrotica barberi in Council Directive 2000/29/EC**

| Annex I Part A | Harmful organisms whose introduction into, and spread within, all member states shall be banned |
|----------------|-----------------------------------------------------------------------------------------------|
| Section I (a)  | Harmful organisms not known to occur in any part of the community and relevant for the entire community |
| (a)            | Insects, mites and nematodes, at all stages of their development                             |
| 10.1           | *Diabrotica barberi* Smith and Lawrence                                                     |
3.3.2. Legislation addressing the hosts of *Diabrotica barberi*

**Table 3:** Regulated hosts and commodities that may involve *Diabrotica barberi* in Annexes III, IV and V of Council Directive 2000/29/EC

| Annex III Part A | Plants, plant products and other objects the introduction of which shall be prohibited in all member states |
|------------------|--------------------------------------------------------------------------------------------------|
| Description | Country of origin |
| 14 | Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat | Turkey, Belarus, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe, other than the following: Egypt, Israel, Libya, Morocco, Tunisia |

| Annex IV Part A | Special requirements which must be laid down by all member states for the introduction and movement of plants, plant products and other objects into and within all member states |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------|
| Section I | Plants, plant products and other objects originating outside the community |
| Description | Special requirements |
| Seeds of *Zea mays* L. | Official statement that: (a) the seeds originate in areas known to be free from *Erwinia stewartii* (Smith) Dye; or (b) a representative sample of the seeds has been tested and found free from *Erwinia stewartii* (Smith) Dye in this test. |

| Annex V Part A | Plants, plant products and other objects which must be subject to a plant health inspection (…) in the country of origin or the consignor country, if originating outside the community before being permitted to enter the community |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------|
| Part A | Plants, plant products and other objects originating in the community |
| Part B | Plants, plant products and other objects originating in territories, other than those territories referred to in part A |
| Section I | Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community |
| 1 | Plants, intended for planting, other than seeds but including seeds of *Zea mays* L. |

3.3.3. Legislation addressing the organisms vectored by *Diabrotica barberi* (Directive 2000/29/EC)

*Diabrotica barberi* is an efficient vector of the Squash mosaic virus (SqMV, Secoviridae) in the field, with transmission percentages up to 16.7 % (Langham et al., 1997). This virus is present in Greece, Italy and The Netherlands (EPPO, online, accessed 14/06/2019) but is not considered as a quarantine pest in the EU or the EPPO region (EPPO, online).

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

A distinction between breeding and adult feeding hosts has to be made. Larvae are stenophagous and mostly feed on maize roots. Adults are polyphagous and can feed on maize flowers and leaves but also on different hosts belonging to different botanical families (Clark et al., 2004) and come back to maize for oviposition (Ludwig and Hill, 1975). Although maize is the only crop regularly attacked by *D. barberi*, development can also occur to a lesser extent on millet (*Panicum miliaceum* L.), rice (*Oryza sativa* L.) and spelt (*Triticum spelta* L.). Moreover, some survival occurs on some rangeland forage grasses and in some cases, adults from larvae reared on these hosts can lay viable eggs (Chiang, 1973; Capinera, 2001).

- Breeding hosts: maize (main host), millet, rice, spelt.
- Adult feeding hosts: Asteraceae, Cucurbitaceae, Fabaceae and Poaceae (including maize).
3.4.2. Entry

**Is the pest able to enter into the EU territory?**

Yes, soil/growing media; forage / green maize and maize cobs could provide potential pathways.

- soil/growing media: Closed due to legislation (2000/29 EC, Annex III, A 14.).
- fresh maize cobs (sweetcorn): Open pathway
- forage/green maize: Open pathway

Adults could be carried on consignments of fresh sweetcorn (corn cobs) and forage/green maize (Smith et al., 1997). These pathways are not specifically regulated although as an Annex I/AI pest the entry of *D. barberi* into the EU is prohibited regardless of the commodity where they are found. Other plants on which adults feed on pollen could provide potential pathways if transported when in flower. However, pollen hosts are generally wild plants and weeds and are not judged to provide a realistic pathway.

In future, following the implementation of the Plant Health Regulation (EC 2016/2031), consignments of almost all fruits and vegetables, including sweetcorn, will require a phytosanitary certificate indicating that it has been inspected and is free from harmful organisms prior to entry into the EU.

There are no data in Eurostat for the import of fresh or chilled sweetcorn (CN 0709 9060) prior to 2000 or after 2011. Figure 2 shows the amount of fresh or chilled sweetcorn imported from USA between 2000 and 2011. Eurostat reports imports of sweetcorn from Canada in 2000 (20 tonnes) and in 2008 (4 tonnes). However, 99.95% of sweetcorn imports from either USA or Canada were from USA between 2000 and 2011.

![Figure 2: EU 28 annual import of fresh or chilled sweetcorn (CN 0709 9060) 2000–2011](image)

**Figure 2:** EU 28 annual import of fresh or chilled sweetcorn (CN 0709 9060) 2000–2011

Import code CN 2308 0090 is described as 'Maize stalks, maize leaves, fruit peel and other vegetable materials, waste, residues and by-products for animal feeding, whether or not in the form of pellets, n.e.s. (excl. acorns, horse-chestnuts and pomace or marc of fruit)’. It is unknown whether or not maize stalk and leaves with the potential to convey adult *D. barberi* would form a proportion of this category. Nevertheless, import volumes are shown in Figure 3.
Regarding plants for planting, maize seed for planting is not considered a possible pathway (Smith et al., 1997). While in principle growing maize plants could have adults on aerial parts and immature stages associated with the roots, and in growing media, and so could provide a pathway, maize plants for planting are traded as seed, not as growing plants. In addition, soil and growing media are prohibited, other than from specified countries, as noted above (Table 3).

Europhyt records of pest interceptions from 1994 to 4 June 2019 were searched. There were no reports of interception of *D. barberi*.

### 3.4.3. Establishment

*Is the pest able to become established in the EU territory?*

**Yes**, biotic and abiotic conditions are conducive for establishment of *D. barberi* in large parts of the EU where maize is cultivated.

#### 3.4.3.1. EU distribution of main host plants

The main host of *D. barberi*, *Z. mays*, occurs in large parts of the EU in cultivated areas (Table 6). Maize, grown as grain or sweetcorn and as green maize (forage) occurs widely across the EU in many member states (Appendix A). Table 4 shows the EU maize area 2014–2018.

**Table 4:** EU 28 area of grain and green maize (cultivation/harvested/production 1,000 ha) (EUROSTAT, accessed 29 June 2019)

|                | 2014    | 2015    | 2016    | 2017    | 2018    |
|----------------|---------|---------|---------|---------|---------|
| Grain maize and corn-cob-mix (Eurostat code C1500) | 9,610.16 | 9,255.56 | 8,563.21 | 8,271.64 | 8,286.69 |
| Green maize (Eurostat code G3000)                   | 6,147.80 | 6,267.95 | 6,256.88 | 6,183.30 | 6,363.05 |
| Sum                                                     | 15,757.96 | 15,523.51 | 14,820.09 | 14,454.94 | 14,649.74 |

#### 3.4.3.2. Climatic conditions affecting establishment

*D. barberi* is distributed across mid and eastern North America (Figure 1) within a variety of Köppen–Geiger climate zones. The global Köppen–Geiger climate zones (Kottek et al., 2006) describe terrestrial climate in terms of average minimum winter temperatures and summer maxima, amount of precipitation and seasonality (rainfall pattern). In North America, *D. barberi* occurs in, e.g. climate zone Cfa (warm temperate climate, fully humid, hot summer) which also occurs in the EU in Bulgaria,
Romania, southern France, Spain and Italy. *D. barberi* also occurs in climate zone Dfb (snow climate, fully humid, warm summer) which occurs in the EU, e.g. in Austria, Czech Republic, Germany, Poland, Romania, Slovakia and other eastern EU MS (MacLeod and Korycinska, 2019) where large areas of maize are also grown. See Appendix B.

Recognising that *D. barberi* occurs across a range of climatic zones, the pest exhibits some adaptability to environmental conditions. It is possible that if *D. barberi* were to be introduced into the EU, it could adapt to other EU climates closely related to those in its native range. In addition, the distribution of *D. barberi* in USA overlaps with the related maize pest *D. virgifera virgifera* which, following its introduction into Europe in the early 1990s (Kiss et al., 2005; Ciosi et al., 2008), has spread widely (Carrasco et al., 2010) and is now well established across much of Europe and the EU (see EPPO GD, 2019). Were *D. barberi* to be introduced, it could do the same. As *D. virgifera virgifera* has displaced *D. barberi*, or at least reduced its abundance, in some areas of the USA (Capinera, 2008), competition between these species in the EU could occur as well.

We assume that climatic conditions in the EU will not limit the ability of *D. barberi* to establish.

### 3.4.4. Spread

**Is the pest able to spread within the EU territory following establishment?**

Yes, adults can fly and typically abandon maize fields to feed on other plant species and return to maize to oviposit. Adult flight would be the major means of spread.

**RNQPs: Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?**

No, spread is mainly natural

While larvae of *D. barberi* move relatively little, adults typically abandon maize fields to feed on other plant species, and return to lay eggs (Chiang, 1973; Ludwig and Hill, 1975). Although, adults of the genus *Diabrotica* can migrate over long distances, moving with weather features such as cold fronts Smith et al. (1997), a study on aldrin resistance in *D. barberi* populations in the USA (Patel & Apple, 1966) showed that beetles are not expected to move more than 3/4 mile against prevailing winds.

### 3.5. Impacts

**Would the pests’ introduction have an economic or environmental impact on the EU territory?**

Yes, the introduction of *D. barberi* would most probably have an economic impact in the EU through reduction of maize yields.

**RNQPs: Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?**

Maize plants for planting are not anticipated to be a pathway for spread. Nevertheless, should *D. barberi* be present on other plants for planting, an economic impact on the intended use of the plants would be expected.

In maize, an average yield reduction of around 0.9% per *D. barberi* larva per root mass has been observed (Chiang, 1973). Taking also into account the extent of lodging due to *D. barberi* injury to the roots, a yield reduction of 4.64 % for every adjusted root damage rating unit on a 1–6 scale was established (Hills and Peters, 1971). The annual impact of the three most relevant maize rootworm species in the USA, *D. v. virgifera*, *D. barberi* and *D. undecimpunctata howardi* Barber, was estimated in the range of $1.0 to 1.2 billion in terms of costs of control and yield loss to American maize producers (Metcalf, 1986; Sappington et al., 2006).

Lodging makes harvest more difficult and can result in yield losses.

If *D. barberi* was introduced in the EU impact could also be expected as a result of the infection and spread of Squash mosaic virus (SqMV: Secoviridae) which it vectors.

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4 See Section 2.1 on what falls outside EFSA’s remit.
3.6. Availability and limits of mitigation measures

Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?
Yes, the existing measures (see Section 3.3) can mitigate the risks of entry via soil, within the EU. Fresh maize cobs (sweetcorn) and foliage/green maize remain an open pathway and additional measures are available (see 3.6.1). Plants other than maize on which adults feed on pollen could provide potential pathways if transported when in flower. However, pollen hosts are generally wild plants and weeds and are not judged to provide a realistic pathway.

RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?
Yes, sourcing plants and plant parts including sweetcorn and green maize from PFA would mitigate the risk.

3.6.1. Identification of additional measures

Phytosanitary measures are currently applied to soil and Z. mays plants for planting. However, the maize cobs and green maize pathways are not regulated (see Section 3.3).

3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 5.

Table 5: Selected control measures (a full list is available in EFSA PLH Panel, 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance.

| Information sheet title (with hyperlink to information sheet if available) | Control measure summary                                                                                                                                                                                                 | Risk component (entry/establishment/spread/impact) |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| **Chemical treatments on consignments during processing**                  | Use of chemical compounds that may be applied to plants or to plant products (i.e. maize combs, green maize) after harvest, during process or packaging operations and storage (i.e. spraying/dipping pesticides) | Entry                                              |
| **Controlled atmosphere**                                                 | Treatment of plants (i.e. maize combs, green maize) by storage in a modified atmosphere (including modified humidity, O₂, CO₂, temperature, pressure)                                                                 | Entry                                              |
| **Crop rotation, associations and density, weed/volunteer control**       | Cropping practices can affect *D. barberi* biology:
  - Crop rotation, e.g. with soybean, which normally results in destruction of rootworms, remains a preferred management practice for this beetle (Capinera, 2001)
  - Crop rotation has selected for *D. barberi* individuals that have an extended egg diapause and can overwinter 2 or more years (Krysan et al., 1984; Krysan and Miller, 1986). The occurrence of prolonged diapause in *D. barberi* eggs helps account for larval root damage observed in first-year maize fields (Chiang, 1973; Krysan et al., 1984, 1986; French and Hammack, 2010; French et al., 2014) | Establishment & spread                            |
| **Chemical treatments on crops including reproductive material**          | Soil/seed-applied systemic insecticides have been applied to protect maize crops from rootworm larvae. Adult control is occasionally needed to protect maize silks and ear tips from injury (Capinera, 2001; French et al., 2014) | Establishment & spread                            |
3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 6.

Table 6: Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance

| Information sheet title (with hyperlink to information sheet if available) | Supporting measure summary | Risk component (entry/establishment/spread/impact) |
|---|---|---|
| **Use of resistant and tolerant plant species/varieties** | • Some maize cultivars are tolerant to *D. barberi* damage as they can regenerate a root system after damage (Chiang, 1973)  
• Seed companies have developed maize hybrids containing genes from the soil bacterium *Bacillus thuringiensis* Berliner (Bt) that code for production of insecticidal proteins that have high levels of antibiosis to neonates of the rootworm complex. Several Bt toxins registered in the United States are active against *Diabrotica* species and are produced either singly or in pyramids (Oyediran et al., 2016) | Establishment & spread |
| **Timing of planting and harvesting** | Cropping practices can affect *D. barberi* biology:  
• Late planting of maize does not require insecticide applications but may result in heavier infestations the following year | Establishment & spread |
| **Biological control and behavioural manipulation** | Although a revision performed in 2009 found 290 publications on natural enemy–subtribe Diabroticina associations in the New World (Toepfer et al., 2009), research is still needed to properly exploit these natural enemies for biological control of *D. barberi* | Establishment & spread |
No major issues with the present regulations in place

No major issues with the present regulations in place

By its very nature of being a rapid process, uncertainty is high in a categorisation. However, the uncertainties in this case are insufficient to affect the conclusions of the categorisation.

Diabrotica barberi satisfies the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest. D. barberi does not meet the criteria of occurring in the EU nor plants for planting being the principal means of spread for it to be regarded as a potential Union regulated non-quarantine pest (Table 7).

Table 7: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)
| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|---------------------------------|-----------------------------------------------|-------------------------------------------------|------------------|
| Absence/presence of the pest in the EU territory (Section 3.2) | *D. barberi* is not known to be present in the EU. | *D. barberi* is not known to be present in the EU. Therefore, it does not fulfill this criterion to be regulated as a regulated non-quarantine pest (RNQP) | |
| Regulatory status (Section 3.3) | The pest is currently listed in Annex IAI of 2000/29 EC | There are no grounds to consider its status as a quarantine pest is to be revoked | |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | The pest could enter into, become established in, and spread within, the EU territory. The main pathways are:  
- Soil  
- Maize combs (sweetcorn)  
- Green maize  
- Plants for planting excluding seeds imported from infested areas | Adults can fly and typically abandon maize fields to feed on other plant species and return to oviposit. This could be the major means of spread | Details of pollen hosts as possible pathways unknown  
Pathway volumes unknown |
| Potential for consequences in the EU territory (Section 3.5) | The pests’ introduction would most probably have an economic impact in the EU | Should *D. barberi* be present on plants for planting, an economic impact on its intended use would be expected | |
| Available measures (Section 3.6) | There are measures available to prevent the entry into, establishment within or spread of the pest within the EU (i.e. sourcing plants from PFA) | There are measures available to prevent pest presence on plants for planting (i.e. sourcing plants from PFA, PFPP). However, maize is not planted but seeded | |
| Conclusion on pest categorisation (Section 4) | All criteria assessed by EFSA above for consideration as a potential quarantine pest are met with no uncertainties | The criterion of the pest being present in the EU territory, which is a prerequisite for consideration as a potential regulated non-quarantine, is not met. The criterion of plants for planting the main means of spread is not met either | |
| Aspects of assessment to focus on/scenarios to address in future if appropriate | | | |
References

Branson TF and Krysan JL, 1981. Feeding and oviposition behavior and life cycle strategies of Diabrotica: an evolutionary view with implications for pest management. Environmental Entomology, 10, 820–825.

Capinera JL, 2001. Handbook of Vegetable Pests. Academic Press, San Diego, 729 pp. Available online: https://books.google.es/books?id=ca&illg=8j7kOlaLhSwc8oi=finder&pg=PP1&ots=NRpCyAlm86g=yPt3w9WvYq9tn IzxfrVjg2VrP4&rredir_esc=y#v=onepage&q&f=false

Capinera JL, 2008. Northern Corn Rootworm, Diabrotica barberi Smith and Lawrence (Coleoptera: Chrysomelidae).

In: Capinera JL (eds.). Encyclopedia of Entomology. Springer, Dordrecht. pp. 2016–2018. https://doi.org/10.1007/978-1-4020-6359-6_2242

Carrasco LR, Harwood TD, Toepfer S, MacLeod A, Levay N, Kiss J, Baker RHA, Mumford JD and Knight JD, 2010. Dispersal kernels of the invasive alien western corn rootworm and the effectiveness of buffer zones in eradication programmes in Europe. Annals of Applied Biology, 156(1), 63–77.

Chiang HC, 1973. Bionomics of the northern and western corn rootworms. Annual Review of Entomology, 18, 47–72. http://doi.org/10.1146/annurev.en.18.010173.000403

Ciosi M, Miller NJ, Kim KS, Giordano R, Estoup A, and Guillemaud T, 2008. Invasion of Europe by the western corn rootworm, Diabrotica virgifera virgifera: multiple transatlantic introductions with various reductions of genetic diversity. Molecular Ecology, 17(16), 3614–3627.

Clark TL, Meinke LJ and Foster JE, 2001a. Molecular phylogeny of Diabrotica beetles (Coleoptera: Chrysomelidae) inferred from analysis of combined mitochondrial and nuclear DNA sequences. Insect Molecular Biology, 10(4), 303–314.

Clark TL, Meinke LJ and Foster JE, 2001b. PCR-RFLP of the mitochondrial cytochrome oxidase (subunit I) gene provides diagnostic markers for selected Diabrotica species (Coleoptera: Chrysomelidae). Bulletin of Entomological Research, 91(6), 419–427.

Clark SM, LeDoux DG, Seeno TS, Riley EG, Gilbert AJ and Sullivan JM, 2004. Host plants of leaf beetle species occurring in the United States and Canada (Coleoptera: Megalopodidae, Orsodacnidae, Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication No. 2. Sacramento, CA. 476 pp.

Derunkov A, Konstantinov A, Tishechkin A, Hartje L and Redford AJ, 2013. Diabrotica ID: Identification of Diabrotica species (Coleoptera: Chrysomelidae) from North and Central America. USDA APHIS PPQ Center for Plant Health Science and Technology, USDA Agricultural Research Service, University of Maryland, and Louisiana State University. Available online: https://idtools.org/id/beetles/diabrotica/ [Accessed: 03 June 2019].

Diabrotica ID, online. Available online: https://idtools.org/id/beetles/diabrotica/factsheet.php?name=6740

EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Cafiero M, Dehnen-Schmutz K, Gregoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting S and Gilioli G, 2018. Guidance on quantitative pest risk assessment. EFSA Journal 2018;16(8):5350, 86 pp. Available online: https://doi.org/10.2903/j.efsa.2018.5350

EPPO (European and Mediterranean Plant Protection Organization), online. EPPO Global Database. Available online: https://www.eppo.int/ (09/01/2019) [Accessed: 4 June 2019].

FAO (Food and Agriculture Organization of the United Nations), 1995. ISPM (International standards for phytosanitary measures) No 4. Requirements for the establishment of pest free areas. Available online: https://www.ippc.int/en/publications/614/

FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM (International Standards for Phytosanitary Measures) 21—Pest risk analysis of regulated non-quarantine pests. FAO, Rome, 30 pp. Available online: https://www.ippc.int/sites/default/files/documents/1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf

FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International Standards for Phytosanitary Measures) 11—Pest risk analysis for quarantine pests. FAO, Rome, 36 pp. Available online: https://www.ippc.int/sites/default/files/documents/20140512/ispm_11_2013_en_2014-04-30_201405121523-494.65%20KB.pdf

FAO (Food and Agriculture Organization of the United Nations), 2017. ISPM (International standards for phytosanitary measures) No 5. Glossary of phytosanitary terms. Available online: https://www.ippc.int/en/publications/622/

Fisher JR, Jackson JJ and Lew AC, 1994. Temperature and diapause development in the egg of Diabrotica barberi (Coleoptera: Chrysomelidae). Environmental Entomology, 23, 464–471. https://doi.org/10.1093/ee/23.2.464

French BW and Hammack L, 2010. Reproductive traits of northern corn rootworm (Coleoptera: Chrysomelidae) in relation to female and male body size. Annals of the Entomological Society of America, 103, 688–694. https://doi.org/10.1603/AN09174

French BW, Coates BS and Sappington TW, 2014. Inheritance of an extended diapause trait in the northern corn rootworm, Diabrotica barberi (Coleoptera: Chrysomelidae). Journal of Applied Entomology, 138, 213–221. https://doi.org/10.1111/j.1439-0418.2012.01751.x
Ludwig KA and Hill RE, 1975. Comparison of gut contents of adult western and northern corn rootworms in Langham MAC, Gallenberg DJ and Gergerich RC, 1997. Occurrence of squash mosaic comovirus infecting summer... lance DR, Eliott NC and Hein GL, 1989. Flight activity of Diabrotica... lance DR and Fisher JR, 1987. Food quality of various plant tissues for adults of the northern corn rootworm... Krysan JL, Jackson JJ and Lew AC, 1984. Field termination of egg diapause in Diabrotica... Krysan JL and Miller TA, 1986. Methods for the study of pest Diabrotica. Springer Series in Experimental Entomology. Springer, New York, NY. pp. 1–23. Krysan JL and Miller TA, 1986. Methods for the study of pest Diabrotica. Springer-Verlag, New York, USA. Krysan JL, Smith RF and Guss PL, 1983. Diabrotica barberi (Coleoptera: Chrysomelidae) elevated to species rank based on behavior, habitat choice, morphometrics, and geographical variation of color. Annals of the Entomological Society of America, 76(2), 197–204. https://doi.org/10.1093/aesa/76.2.197 Krysan JL, Jackson JJ and Lew AC, 1984. Flight activity of egg diapause in Diabrotica with new evidence of extended diapause in D. barberi (Coleoptera: Chrysomelidae). Environmental Entomology, 13(5), 1237–1240. https://doi.org/10.1093/ee/13.5.1237 Krysan JL, Foster DE, Branson TF, Ostlie KR and Cranshaw WS, 1986. Two years before the hatch: rootworms adapt to crop rotation. Bulletin of the Entomological Society of America, 32, 250–253. Lance DR and Fisher JR, 1987. Food quality of various plant tissues for adults of the northern corn rootworm (Coleoptera: Chrysomelidae). Journal of the Kansas Entomological Society, 60, 462–466. Lance DR, Elliott NC and Hein GL, 1989. Flight activity of Diabrotica spp. at the borders of cornfields and its relation to ovarian stage in D. barberi. Entomologia Experimentalis et Applicata, 50, https://doi.org/10.1111/j.1570-7458.1989.tb02315.x Langham MAC, Gallenberg DJ and Gergerich RC, 1997. Occurrence of squash mosaic comovirus infecting summer squash (Cucurbita pepo) in South Dakota and transmission by Diabrotica barberi. Plant Disease, 81, 696. Ludwig KA and Hill RE, 1975. Comparison of gut contents of adult western and northern corn rootworms in northeast Nebraska. Environmental Entomology, 4, 435–438. MacLeod A and Korycinska A, 2019. Detailing Koppen-Geiger climate zones at a country and regional level: a resource for pest risk analysis. EPPO Bulletin, 49, 73–82. Mendoza CE and Peters DC, 1964. Species differentiation among mature larvae of Diabrotica undecimpunctata howardi, Diabrotica virgifera, and D. longicornis. Journal of the Kansas Entomological Society, 37, 123–125. Metcalf CL, Flint WP and Flint RL, 1962. Destructive and Useful Insects. 4th Edition. McGraw-Hill, New York. Metcalf RL, 1986. Foreword. In: TA. Miller (ed.) Springer Series in Experimental Entomology. Springer-Verlag New York Inc. pp. VII–XV. https://link.springer.com/content/pdf/bfm%3A978-1-4612-4686-2%2F1.pdf Narango SE and Sawyer AJ, 1988. Impact of host plant phyology on the population dynamics and oviposition of northern corn rootworms, Diabrotica barberi (Coleoptera: Chrysomelidae) in Field Corn. Environmental Entomology, 17, 508–521. https://doi.org/10.1093/ee/17.3.508 Oyediran IO, Matthews P, Palekar N, French W, Convile J and Burd T, 2016. Susceptibility of northern corn rootworm Diabrotica barberi (Coleoptera: Chrysomelidae) to mCry3A and eCry3.1Ab Bacillus thuringiensis proteins. Insect Science, 23, 913–917. https://doi.org/10.1111/1744-7917.12249 Patel KK and Apple JW, 1966. Chlorinated hydrocarbon resistant northern corn rootworm in Wisconsin. J Econ Entomol, 59, 522–525. Roehrdanz RL, Szalanski AL and Levine E, 2003. Mitochondrial DNA and Its1 differentiation in geographical populations of northern corn rootworm, Diabrotica barberi (Coleoptera: Chrysomelidae): identification of distinct genetic populations. Annals of the Entomological Society of America, 96(6), 901–913. https://doi.org/10.1603/0013-8746(2003)096[0901:MADAJ2.0.CO;2] Sappington TW, Siegfried BD and Guillemaud T, 2006. Coordinated Diabrotica genetics research: accelerating progress on an urgent insect pest problem. American Entomologist, 52, 90–97. Smith IM, McNamara DG, Scott PR and Holderness M (eds.), 1997. Diabrotica barberi and Diabrotica virgifera. In: Quarantine Pests for Europe. 2nd Edition. CAB/EPPO, Wallingford, 1425 pp.
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Szalanski AL and Powers TO, 1996. Molecular diagnostics of three Diabrotica (Coleoptera: Chrysomelidae) pest species. Journal of the Kansas Entomological Society, 69(3), 260–266.
Toepfer S, Haye T, Erlandson M, Goettel M, Lundgren JG, Kleespies RG, Weber DC, Cabrera G, Peters A, Ehlers R-U, Strasser H, Moore D, Keller S, Vidal S and Kuhlmann U, 2009. A review of the natural enemies of beetles in the subtribe Diabroticina (Coleoptera: Chrysomelidae): implications for sustainable pest management. Biocontrol Science and Technology, 19:1, 1–65. https://doi.org/10.1080/09583150802524727
Woodson WD and Jackson JJ, 1996. Development rate as a function of temperature in northern corn rootworm (Coleoptera: Chrysomelidae). Annals of the Entomological Society of America, 89(2), 226–230.

Glossary

Containment (of a pest) Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)
Control (of a pest) Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest) Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)
Eradication (of a pest) Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)
Establishment (of a pest) Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest) The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest) The entry of a pest resulting in its establishment (FAO, 2017)
Measures Control (of a pest) is defined in ISPM 5 (FAO 1995) as ‘Suppression, containment or eradication of a pest population’ (FAO, 1995). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate Risk Reduction Options that do not directly affect pest abundance.
Pathway Any means that allows the entry or spread of a pest (FAO, 2017)
Phytosanitary measures Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)
Protected zones (PZ) A protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union.
Quarantine pest A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)
Regulated non-quarantine pest A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)
Risk reduction option (RRO) A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager
Spread (of a pest) Expansion of the geographical distribution of a pest within an area (FAO, 2017)
Sympatric Organisms occurring within the same or overlapping geographic areas.
Univoltine Producing one brood in a season and especially a single brood of eggs capable of overwintering
Abbreviations

EPPO  European and Mediterranean Plant Protection Organization
FAO  Food and Agriculture Organization
IPPC  International Plant Protection Convention
ISPM  International Standards for Phytosanitary Measures
MS  Member State
PLH  EFSA Panel on Plant Health
PZ  Protected Zone
RNQP  Regulated non-quarantine pest
TFEU  Treaty on the Functioning of the European Union
ToR  Terms of Reference
## Appendix A – Detailed area of maize in EU member states

### Area of grain maize and corn-cob-mix cultivation/harvested/production (Eurostat code C1500) in EU member states 2014–2018 (1,000 ha)

|          | 2014  | 2015  | 2016  | 2017  | 2018  | 5 year mean | % of 5 year mean |
|----------|-------|-------|-------|-------|-------|-------------|------------------|
| EU 28    | 9,610.16 | 9,255.56 | 8,563.21 | 8,271.64 | 8,286.69 | 8797.452 | 100.0            |
| Romania  | 2,513.56 | 2,608.06 | 2,584.22 | 2,405.24 | 2,415.25 | 2505.266 | 28.5             |
| France   | 1,848.07 | 1,639.49 | 1,458.32 | 1,435.70 | 1,423.92 | 1561.1 | 17.7            |
| Hungary  | 1,191.42 | 1,146.13 | 1,011.56 | 988.82 | 943.98 | 1056.382 | 12.0             |
| Italy    | 869.95 | 727.37 | 660.73 | 645.74 | 614.31 | 703.62 | 8.0             |
| Poland   | 678.25 | 670.30 | 593.50 | 562.11 | 645.41 | 629.914 | 7.2             |
| Germany  | 481.30 | 455.50 | 416.30 | 432.00 | 410.90 | 439.2 | 5.0             |
| Bulgaria | 408.40 | 498.64 | 406.94 | 398.15 | 444.50 | 431.326 | 4.9             |
| Spain    | 418.55 | 398.26 | 359.28 | 333.63 | 326.60 | 367.264 | 4.2             |
| Croatia  | 252.57 | 263.97 | 252.07 | 247.12 | 235.00 | 250.146 | 2.8             |
| Austria  | 216.32 | 188.73 | 195.25 | 209.48 | 209.90 | 203.936 | 2.3             |
| Slovakia | 216.19 | 191.44 | 184.81 | 187.81 | 178.56 | 191.762 | 2.2             |
| Greece   | 159.78 | 152.05 | 139.48 | 132.49 | 133.37 | 143.434 | 1.6             |
| Portugal | 107.64 | 97.91 | 88.61 | 86.52 | 90.46 | 94.228 | 1.1             |
| Czech Republic | 98.75 | 79.97 | 86.41 | 86.00 | 81.85 | 86.596 | 1.0             |
| Belgium  | 62.83 | 58.40 | 52.10 | 49.00 | 53.99 | 55.264 | 0.6             |
| Slovenia | 38.33 | 37.74 | 36.39 | 38.29 | 36.75 | 37.5 | 0.4             |
| Netherlands | 18.00 | 15.80 | 12.27 | 12.25 | 13.77 | 14.418 | 0.2             |
| Lithuania | 19.00 | 11.71 | 12.43 | 9.93 | 13.39 | 13.292 | 0.2             |
| Denmark  | 10.10 | 9.00 | 5.70 | 5.10 | 6.30 | 7.24 | 0.1             |
| UK      | 0.00 | 4.00 | 5.00 | 5.00 | 7.20 | 4.24 | 0.0             |
| Sweden  | 0.95 | 1.33 | 1.71 | 1.19 | 1.17 | 1.27 | 0.0             |
| Luxembourg | 0.22 | 0.14 | 0.13 | 0.08 | 0.09 | 0.132 | 0.0             |

### Area of green maize (forage maize) cultivation/harvested/production (Eurostat code G3000) in EU member states 2014–2018 (1,000 ha)

|          | 2014  | 2015  | 2016  | 2017  | 2018  | 5 year mean | % of 5 year mean |
|----------|-------|-------|-------|-------|-------|-------------|------------------|
| EU 28    | 6,147.80 | 6,267.95 | 6,256.88 | 6,183.30 | 6,363.05 | 6243.796 | 100.0            |
| Germany  | 2,092.60 | 2,100.40 | 2,137.60 | 2,095.90 | 2,195.90 | 2124.48 | 34.0             |
### Diabrotica barberi: Pest categorisation

| Country      | 2014  | 2015  | 2016  | 2017  | 2018  | 5 year mean | % of 5 year mean |
|--------------|-------|-------|-------|-------|-------|-------------|------------------|
| France       | 1,411.80 | 1,475.23 | 1,433.16 | 1,406.01 | 1,422.20 | 1429.68     | 22.9             |
| Poland       | 541.21  | 555.20  | 597.00  | 596.01  | 601.58  | 578.2       | 9.3              |
| Italy        | 342.74  | 336.93  | 325.04  | 342.10  | 355.33  | 340.428     | 5.5              |
| Czech Republic | 237.24 | 244.96  | 234.40  | 223.21  | 224.11  | 232.784     | 3.7              |
| Netherlands  | 226.00  | 223.86  | 203.81  | 203.51  | 203.25  | 212.086     | 3.4              |
| UK           | 171.00  | 179.00  | 186.00  | 197.40  | 224.00  | 191.48      | 3.1              |
| Denmark      | 178.20  | 182.40  | 182.40  | 166.70  | 179.60  | 177.86      | 2.8              |
| Belgium      | 178.12  | 173.34  | 168.74  | 171.28  | 179.74  | 174.244     | 2.8              |
| Greece       | 82.84   | 90.18   | 118.69  | 125.55  | 125.83  | 108.618     | 1.7              |
| Spain        | 112.97  | 107.92  | 106.24  | 107.36  | 107.42  | 108.382     | 1.7              |
| Austria      | 83.46   | 91.99   | 84.64   | 82.19   | 83.35   | 85.126      | 1.4              |
| Slovakia     | 85.79   | 89.52   | 78.05   | 81.44   | 73.11   | 81.582      | 1.3              |
| Portugal     | 85.39   | 80.78   | 80.26   | 78.43   | 79.03   | 80.778      | 1.3              |
| Hungary      | 85.08   | 89.98   | 76.41   | 69.05   | 64.22   | 76.948      | 1.2              |
| Romania      | 48.27   | 46.34   | 51.42   | 50.10   | 47.06   | 48.638      | 0.8              |
| Slovenia     | 29.49   | 28.73   | 28.69   | 29.19   | 29.82   | 29.184      | 0.5              |
| Croatia      | 28.79   | 32.60   | 30.98   | 28.29   | 25.00   | 29.132      | 0.5              |
| Bulgaria     | 25.13   | 26.56   | 31.10   | 29.93   | 27.24   | 27.992      | 0.4              |
| Lithuania    | 28.50   | 29.25   | 26.59   | 24.34   | 28.25   | 27.386      | 0.4              |
| Latvia       | 21.20   | 25.40   | 25.90   | 22.10   | 25.50   | 24.02       | 0.4              |
| Sweden       | 15.67   | 15.65   | 15.74   | 16.80   | 17.17   | 16.206      | 0.3              |
| Luxembourg   | 14.75   | 14.45   | 14.94   | 15.19   | 15.87   | 15.04       | 0.2              |
| Ireland      | 13.87   | 12.85   | 10.92   | 11.88   | 17.76   | 13.456      | 0.2              |
| Estonia      | 7.40    | 8.50    | 7.96    | 9.18    | 10.55   | 8.718       | 0.1              |
| Cyprus       | 0.31    | 0.30    | 0.20    | 0.17    | 0.16    | 0.228       | 0.0              |
Appendix B – Distribution of EU climates in North America in which *Diabrotica barberi* occurs

| Climate classification | Climate description (Kottek et al., 2006) |
|------------------------|------------------------------------------|
| Cfa                    | Warm temperate climate, fully humid, hot summer |
| Cfb                    | Warm temperate climate, fully humid, warm summer |
| Dfb                    | Snow climate, fully humid, warm summer |

Source: map derived from data in MacLeod and Korycinska (2019).