EPPO Datasheet: *Diabrotica undecimpunctata howardi*

Last updated: 2021-09-09

IDENTITY

Preferred name: *Diabrotica undecimpunctata howardi*
Authority: Barber
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Coleoptera: Chrysomelidae
Other scientific names: *Crioceris sexpunctata* Fabricius, *Diabrotica duodecimpunctata* (Fabricius), *Diabrotica sexpunctata* (Fabricius)
Common names: southern corn rootworm, spotted cucumber beetle, twelve-spotted cucumber beetle
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EPPO Categorization: A1 list
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EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: DIABUH



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Notes on taxonomy and nomenclature

Before the adoption by Michelbacher *et al.* (1941) of the name *D. undecimpuctata* Mannerheim, the species had been known as *Diabrotica soror* LeConte (Tubbs, 1991). Then Barber (1947) divided *D. undecimpunctata* into four subspecies: the nominal one corresponds to subspecies *soror* LeConte, the subspecies *howardi* Barber (the holotype of *Crioceris sexpunctata* Fabricius is a specimen of this subspecies) and the two other subspecies *tenella* and *duodecimnotata*. *D. undecimpunctata* is closely related to the major pests *Diabrotica barberi* and *Diabrotica virgifera virgifera* (the northern and the western corn rootworms) (EPPO/CABI, 1997a). The subspecies *D. undecimpunctata howardi* is frequently cited as *D. duodecimpunctata* (Fabricius) in earlier literature (Clark *et al.*, 2004).

HOSTS

Adults of *D. undecimpunctata howardi* are reported on a wide range of wild or cultivated plants and have been found on the leaves, stems and ?owers of members of about 50 different botanical families. A list is available in Clark *et al.* (2004) and is also reproduced in tabular format by EFSA PLH (2020). Among cultivated plants, adults attack in particular *Cucurbitaceae* (e.g. *Cucumis sativus, Cucumis melo, Cucurbita pepo, Citrullus lanatus*) but also groundnut (*Arachis hypogea*), soybean (*Glycine max*), *Phaseolus vulgaris* and other legumes, maize (*Zea mays*) and sweet potato (*Ipomoea batatas*). If flowers are available, adults will feed on them rather than the leaves causing reductions in fruit yield. If flowers are not available, adults prefer the foliage of cucurbits to other crops.

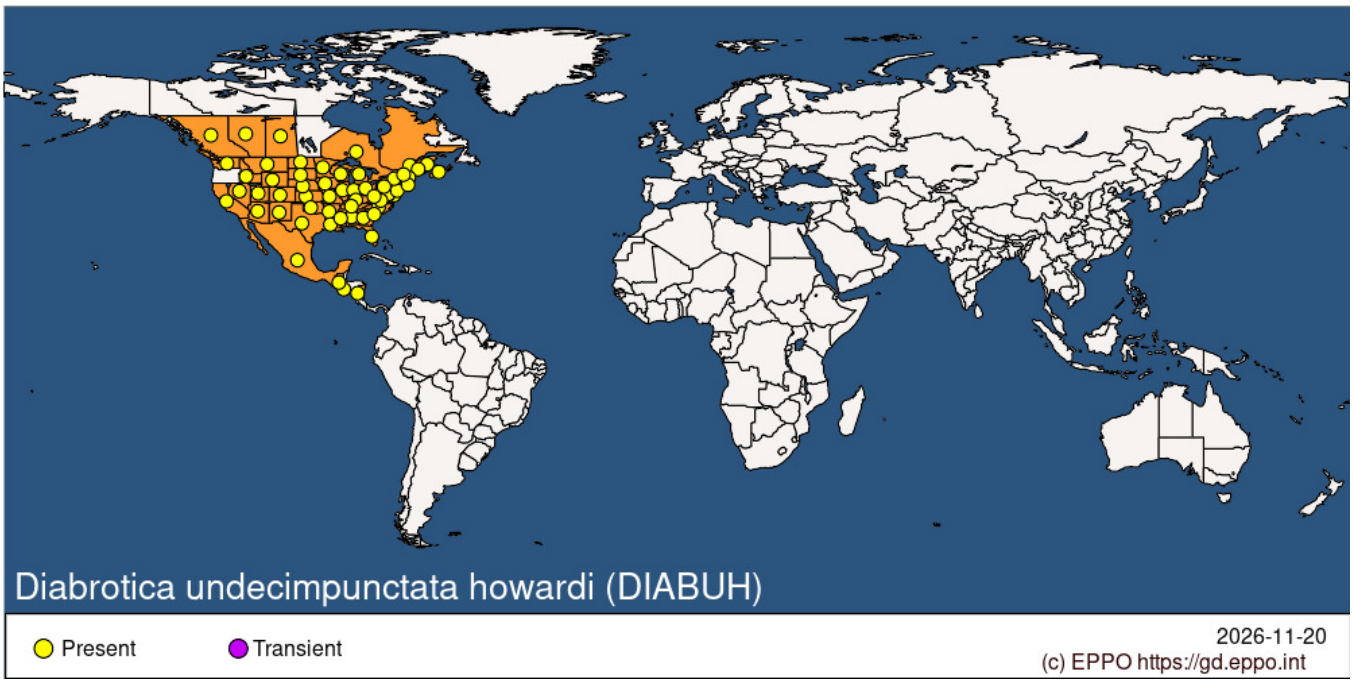
The larvae feed mainly on maize roots but also feed on various other plant roots (e.g. cucurbits, legumes, sweet potato, weeds). Larvae of *D. undecimpunctata howardi* differ in this behavior from the larvae of the closely associated striped cucumber beetle *Acalymma vittata*, which feed exclusively on the same cucurbit host species as the adults.

Host list: *Amorpha canescens, Amorpha fruticosa, Arachis hypogaea, Artemisia californica, Atropa belladonna, Avena sativa, Baccharis halimifolia, Baccharis neglecta, Baccharis salicifolia, Beta vulgaris, Bidens aristosa, Bidens laevis, Boltonia asteroides, Bouteloua eriopoda, Bromus catharticus, Calendula sp., Callistephus chinensis, Capsicum frutescens, Cenchrus americanus, Cercis canadensis, Chenopodium album, Cirsium horridulum, Citrullus colocynthis, Citrullus lanatus, Cosmos sp., Cucumis anguria, Cucumis melo, Cucumis sativus, Cucurbita argyrosperma, Cucurbita cylindrata, Cucurbita digitata, Cucurbita ecuadorensis, Cucurbita ficifolia, Cucurbita foetidissima, Cucurbita lundelliana, Cucurbita martinezii, Cucurbita maxima, Cucurbita melopepo, Cucurbita moschata, Cucurbita okeechobeensis, Cucurbita palmata, Cucurbita pedatifolia, Cucurbita pepo, Cucurbita radicans, Cucurbita texana, Cynodon dactylon, Dahlia pinnata, Dalea purpurea, Datura stramonium, Digitaria sanguinalis*

, Echinacea pallida, Echinochloa crus-galli, Echinocystis lobata, Erigeron philadelphicus, Eriogonum sp., Erythrina herbacea, Eupatorium serotinum, Fagopyrum sp., Festuca sp., Flourensia cernua, Galinsoga quadriradiata, Glycine max, Gutierrezia microcephala, Gutierrezia sarothrae, Helianthus annuus, Helianthus grosseserratus, Hordeum vulgare, Ionactis linariifolia, Ipomoea batatas, Krigia biflora, Lactuca sativa, Lagenaria siceraria, Lathyrus hirsutus , Lathyrus odoratus, Lathyrus sativus, Lathyrus tingitanus, Leucanthemum maximum, Medicago arabica, Medicago polymorpha, Medicago sativa, Neltuma chilensis, Neltuma glandulosa, Nicotiana tabacum, Oryza sativa, Panicum dichotomiflorum, Panicum miliaceum, Parthenium argentatum, Parthenium integrifolium, Persicaria perfoliata, Phaseolus lunatus, Phaseolus vulgaris, Phleum sp., Physalis pubescens, Pisum sativum, Rheum rhabarbarum, Robinia pseudoacacia, Rudbeckia hirta, Saccharum officinarum, Secale cereale, Senecio sp., Sesbania longifolia, Sicyos angulatus, Solanum carolinense, Solanum elaeagnifolium, Solanum lycopersicum, Solanum melongena, Solanum tuberosum, Solidago altissima, Solidago canadensis, Solidago missouriensis, Solidago rigida, Sorghum bicolor, Sorghum halepense, Sorghum x drummondii, Spinacia oleracea, Symphyotrichum cordifolium, Symphyotrichum ericoides, Symphyotrichum praealtum, Symphyotrichum turbinellum, Taraxacum officinale, Trifolium incarnatum, Trifolium pratense, Trifolium repens, Trigonella foenum-graecum, Triticum aestivum subsp. aestivum, Vernonia baldwinii var. interior, Vicia benghalensis, Vicia cracca, Vicia faba, Vicia hirsuta, Vicia monantha, Vicia sativa, Vicia villosa subsp. varia, Vicia villosa, Vigna unguiculata subsp. unguiculata , Vigna unguiculata, Wisteria sp., Zea mays, Zinnia sp.

GEOGRAPHICAL DISTRIBUTION

The older literature did not distinguish the two subspecies (*D. undecimpunctata* subsp. *undecimpunctata* Mannerheim and *D. undecimpunctata* subsp. *howardi* Barber). In the distribution given below, the records of *D. undecimpunctata* subsp. *howardi* are believed to be reliable and show its presence in most states of the USA. It is possible that some of the records in western North America for *D. undecimpunctata* subsp. *howardi* in fact refer to *D. undecimpunctata* subsp. *undecimpunctata* (or both).



North America: Canada (Alberta, British Columbia, New Brunswick, Nova Scotia, Ontario, Québec, Saskatchewan), Mexico, United States of America (Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming)
Central America and Caribbean: El Salvador, Guatemala, Nicaragua

BIOLOGY

The two main subspecies of *D. undecimpunctata*, subspecies *undecimpunctata* and *howardi* have very similar biology (Metcalf and Metcalf, 1993).

D. undecimpunctata subsp. *howardi* overwinter in the adult stage near agricultural fields and do not hibernate. Most beetles are found under leaves and straw, in grass near the base of the plants (Hays and Morgan, 1965) or under debris. Overwintered adults become most active in the spring (normally late March) when temperatures reach 21° C (Metcalf and Metcalf 1993). They start feeding on the flowers and foliage of many different host plants. They also show the capacity for significant migration in early spring and throughout the summer months as highlighted by several authors (Arant, 1929; Pereira *et al.*, 2017). Females oviposit from late April to early June on newly - emerged maize (*Zea mays*) (Brust and House, 1990) but also on many other hosts and apparently prefer (as shown in laboratory studies) to oviposit in a moist or wet substratum (Campbell and Emery, 1967) in organic or clay soils. Oviposition increased with an increase in relative humidity (RH). The optimum temperature for oviposition is about 29°C (Campbell and Emery, 1967). Females lay from 200 to 1200 eggs singly in the soil, close to the bases of larval host plants. They produce twice as many eggs as *Diabrotica virgifera* under laboratory rearing conditions (Jackson, 1986). The survival of newly laid eggs depends on there being sufficient soil moisture for survival within the first 24 to 72 h (Krysan, 1976). Eggs failed to hatch when the RH was maintained below 75%, and egg hatch is best when the RH is 85% or above (Campbell and Emery, 1967). Depending on temperature, eggs incubate for 7 to 10 days before hatching. Then larvae feed for 2-4 weeks, passing through three instars. During the latter part of the third instar, the larvae leave the host plants, burrow into the soil and enter the inactive or prepupal stage of the larval period which usually lasts 6-8 days. Pupation takes place in an earthen shell and lasts 6-12 days (Arant, 1929). First generations emerge from late June to early July. There is no difference in the rate of adult survival at temperatures between 7°C and 29°C. All adults died within 2 weeks when held at 35°C. Longevity is best at 18°C (Campbell and Emery, 1967). Adults of the new generation often move from one host to another, e.g. starting on the larval host maize (silks) or groundnut and moving onto the cucurbit hosts in mid-summer, and finally onto subsidiary hosts, such as chrysanthemum, in the autumn (Hays and Morgan, 1965). Later in the year, the adults may feed on winter legumes. A complete life cycle requires at least 6-9 weeks. In southern North America two or three generations per year may occur; the second-generation adults are prevalent from September to November. But in northern North America, there is only one generation per year (Campbell *et al.*, 1989) and the beetles form transient (non-overwintering) populations. These areas are recolonized annually from areas with mild winters. Continuously overlapping generations can occur in subtropical and tropical regions (Metcalf & Metcalf, 1993). The beetles feed until the reduction in temperatures makes them become inactive. Mating occurs before the winter and before the onset of a reproductive diapause in response to a reduced daylength of 13 hours or less (Elsey, 1988). It should be noted that *D. undecimpunctata* overwinters as adults, in contrast to *D. virgifera*, which overwinters as eggs. Populations of the latter species are accordingly concentrated in fields of the larval host (maize), whereas *D. undecimpunctata* tends to be more associated with the host plants of the adults (cucurbits).

DETECTION AND IDENTIFICATION

Symptoms

Adults feed on many plants (see host list) but the literature generally describes symptoms on cucurbits. Infested cucurbits show adult feeding holes in the leaves plus scars on runners and young fruits resulting in wilting and reduced yield. Scarring in the crown of the plant is also typical of adult damage. The beetles damage crops by causing scarring on fruits, decreasing their market value. Fruit of smooth-skinned melons is more susceptible to damage by beetles before the skin becomes too hard to penetrate (Capinera, 2008).

Larvae feed on roots and tunnel through the stems. They can cause occasional injury to the surface or rind of cucurbit fruits which come into contact with the soil. Feeding by larvae may increase the incidence of Fusarium wilt disease. Infested maize plants usually show the effect of larval infestation of the roots when they are 20-50 cm tall; plants grow poorly, becoming stunted and yellow, but may survive and still produce grain. If the stem is attacked, internal drilling causes the bud to wither and die. The plant may be killed outright (Arant, 1929).

Morphology

Eggs

Eggs are generally oval, 0.7 x 0.5 mm, light yellow when first oviposited, but become darker yellow as they age. It has been noted by Atyeo *et al.* (1964) that the surface of the egg of rootworm pests is covered primarily with polygons and then secondary ridges which are useful for specific identification using a scanning electron microscope (SEM). The subspecies of *Diabrotica undecimpunctata* are indistinguishable but are readily distinguished from *D. virgifera* subsp. *virgifera* and *D. virgifera* subsp. *zeae* by the presence of pits within the polygons, and from *D. barberi* by the presence of 14 to 20 pits per polygon (compared to 6 to 12 per polygon for *D. barberi*).

Larva

Larvae have a yellowish white, wrinkled body, 12-19 mm long, with six very small legs, and a greyish-brown head. Mendoza and Peters (1964) have provided morphological criteria to differentiate *Diabrotica undecimpunctata*, *D. virgifera* and *D. barberi*. But *D. undecimpunctata* subsp. *undecimpunctata* and *D. undecimpunctata* subsp. *howardi* are not distinguishable at the larval stage.

Pupa

Length about 6.3 mm, width about 3 mm. White becoming yellow with age. The tip of the abdomen bears a pair of stout spines, and smaller spines are found dorsally on the remaining abdominal segments. There is a sexual dimorphism at the pupae stage, female pupae bearing a pair of distinctive papillae on the venter near the apex of the abdomen while males have no papillae (Krysan and Miller, 1986).

Adult

Length 5.2-7.5 mm long. Elytra green, yellow or rufous, maculate with 12 round black maculae, black head with filiform antennae bi- or tricolored, pronotum yellow, subquadrate, bifoveate, scutellum black. Abdomen fully yellow. Tibiae and femora bicolored: yellow, from 1/2 to 2/3 is darkened with black or brown. *D. undecimpunctata* subsp. *howardi* can be separated from *D. undecimpunctata* subsp. *undecimpunctata* and *D. undecimpunctata* subsp. *duodecimnotata* by the colour of the abdomen and by spots on the elytra in *D. undecimpunctata* subsp. *howardi* that are smaller than in *D. undecimpunctata* subsp. *undecimpunctata*, but larger than in *D. undecimpunctata* subsp. *duodecimnotata* and *D. undecimpunctata* subsp. *tenella*. The adult *D. undecimpunctata* subsp. *howardi* is larger and more robust than *D. undecimpunctata* subsp. *tenella*. A full description of the adult is available in Derunkov *et al.* (2013).

Detection and inspection methods

Visual examination of imported commodities and soil or washing the roots and sifting soil to recover hidden stages (i.e. larvae or pupae) is possible, but the effectiveness of these methods is quite uncertain, especially in cases of very low levels of infestation. A method to distinguish the larvae of the three species of corn rootworm using morphological characteristics is reported by Mendoza and Peters (1964).

Yellow sticky traps baited with a chemical kairomone attractant (Hongtrakul, 1997) and cucurbitacin-baited traps could be used for the monitoring of production sites (Jackson *et al.*, 2005; Luna, 2006; Alston and Worwood, 2012). However, the effectiveness of this trapping for the detection of very low populations has yet to be proven. Adults of *D. undecimpuncta* subsp. *howardi* can be identified using the diagnostic protocol for *Diabrotica virgifera* subsp. *virgifera* which includes a key to the adults of 13 *Diabrotica* species which occur in US agriculture (EPPO, 2017).

PATHWAYS FOR MOVEMENT

The EFSA Panel on Plant Health performed a pest categorization of *D. undecimpunctata* subsp. *howardi* including a full investigation of potential pathways (EFSA PLH, 2020). This subspecies occurs in North and Central America where adults feed on a wide range of plants from about 50 different botanical families. However, adults only feed on

young fruits not ready for harvest and in addition, fly away quickly when disturbed. The probability of their remaining on the foliage or fruit during handling is thus considered very low.

The adults are strong fliers, travelling readily from field to field during the summer. But their flight potential is not sufficient to spread from North America to the EPPO region. Hitchhiking behaviour could occur, as has been observed with *Diabrotica virgifera* in Europe.

EFSA (2020) noted that *D. undecimpunctata* subsp. *howardi* is more likely to move through international trade as immature stages (eggs, larvae or pupae) in soil and growing media (with or without host plants) than as adults. However, the survival rate of immature stages on roots of true host plants, or in soil (either as a commodity on its own, or when accompanying plants for planting in international trade), is not known. But considering that the rearing of *Diabrotica* species in laboratory facilities requires experience and attentiveness of the operator and also a good knowledge of the ecological needs of the insect to promote the growth and development of the insect (Jackson, 1986), the survival rate is probably very low.

It is worth noting that *D. undecimpunctata* subsp. *howardi* does not seem to show any propensity to travel via international trade: Europhyt records of pest interceptions from 1995 to 2020 do not report any interceptions of this species in the EU (EFSA PLH, 2020).

PEST SIGNIFICANCE

Economic impact

The larval stage of *D. undecimpunctata* subsp. *howardi*, by feeding on the roots of plants, has the greatest impact. Severe damage may result in discolored and stunted plants; plant death occurs when larvae burrow into the stem. Adult beetles damage leaves, flowers or fruits and may cause wilting and reduced yield.

In Canada, Beirne (1971) reported a 100% loss of watermelon seedlings as a result of attack by adults of *D. undecimpunctata* subsp. *howardi*. Attacks on more mature plants result in a general leaf desiccation. Attacked fruits of cucumber and pumpkin have a characteristic pinhole appearance that can reduce their market value (Beirne, 1971). *D. undecimpunctata* subsp. *howardi* has been reported to attack glasshouse-grown cucumbers after moving from field-grown cucumber plants (Beirne, 1971). *D. undecimpunctata* is cited as an important pest of cucurbits in Missouri (Necibi *et al*., 1991) and is a key pest of peanuts in south-eastern Virginia (Lummus *et al.*, 1983), North Carolina (Campbell and Emery, 1967) and Georgia (Hays and Morgan, 1965).

D. undecimpunctata subsp. *howardi* is also a root pest of maize, but is of lesser importance on this crop than the related *D. virgifera* and *D. barberi* because oviposition of migrating adults is spread over a number of hosts, meaning that the emergence rate from maize field is often low relative to other *Diabrotica* species (Meinke, personal observation cited by Pereira *et al*, 2017). However, it is considered as a significant pest of maize in the Gulf Coast region of Texas (Porter *et al.*, 2006). Fleming and Reed (2010) suggest, based on laboratory trials, that larvae could be an economic pest of sweet potatoes. Damage by *D. undecimpunctata* subsp. *howardi* occurs most often on heavy clay soils or soils high in organic content. During periods of very wet weather, it may cause damage on any soil type, even sandy soils (French, 1978). The geographical range of *D. undecimpunctata* subsp. *howardi* almost completely matches the recorded range of *D. barberi* (EPPO, 2021), and it is not clear whether the damage caused specifically by southern corn rootworm is generally distinguished from that attributable to its northern sister species.

D. undecimpunctata howardi is considered as one of the prominent chrysomelid beetle vectors. Adults or larvae transmit eight viruses in three genera (Tolin *et al.*, 2016). For example, the larvae are vectors of maize chlorotic mottle virus (MCMV) (Jensen, 1985) and the adults are able to transmit one Carmovirus (BMMV) and six Comoviruses (BPMV, CPMV, CPSMV, QPMV, RaMV and SqMV).

Control

The incidence of corn rootworms can be limited by rotation of maize with other non-host crops (in North America, typically soybean) but crop rotation will not provide adequate control of *D. undecimpunctata* subsp. *howardi* because it deposits eggs in soil after the corn has reached the seedling stage (Porter *et al.*, 2010). Control techniques

used in North America include: soil treatment with granular insecticides such as terbufos, isofenphos, carbofuran or tefluthrin at the time of planting (Sutter *et al.*, 1990; Porter *et al.*, 2010), late planting into land that has been ploughed earlier in the spring to remove vegetation and discourage egg laying; application of granular baits containing cucurbitacin arrestants which control adults when applied just before egg laying. Some strains of *Bacillus thuringiensis* (Bt) are toxic to larvae of the southern corn rootworm (Rupar *et al.*, 1991) and commercial transgenic maize hybrids designed to protect the root system of corn from larval feeding damage have been introduced since 2003 in the USA and are effective against *D. undecimpunctata* subsp. *howardi*. These hybrids were created with a Cry3Bb1 gene from a *Bacillus thuringiensis* variant (Vaughn *et al.*, 2005) but currently, expression of Vip1/Vip2 genes also showed activity against *Diabrotica* spp. and are highly toxic against *D. undecimpunctata* (Domínguez-Arrizabalaga *et al.*, 2020).

Control of adult *D. undecimpunctata* forms part of integrated pest management schemes for cucurbits, groundnut, beans etc. in USA. In addition to early ploughing, transparent screens can be used to exclude the beetles from cucurbit crops. The presence of black plastic mulch does appear to limit the number of immature beetles found at the shallower soil depths (0-5 cm). The mulch limits the adult female beetle's access to the soil around the plant (Necibi *et al.*, 1992). Early trap plantings of cucurbits can be used to attract adults, which are then destroyed with insecticides. Various benzenoid attractants are used to monitor populations and to provide some control (formulated as baits) (Lampman *et al.*, 1987).

The use of resistant varieties is probably the most important control strategy. For example, varietal resistance is sought in cucurbits, the seedlings of several commercial varieties are resistant to spotted cucumber beetles as well as having resistant foliage later in the season (Sorensen *et al.*, 2003). Despite these possibilities, chemical insecticides very commonly have to be used against spotted cucumber beetle, mainly to protect plants at the cotyledon stage to allow a good stand to establish, but also as foliar applications to prevent transmission of bacteria and viruses.

Phytosanitary risk

The predicted distribution of *D. undecimpunctata* subsp. *howardi* was estimated by Marchioro and Krechemer (2018) using a machine-learning algorithm (MaxEnt) with ten predictors (Environmental variables). The minimum temperature of the coldest month has the highest percentage of contribution of all bioclimatic variables for the model developed for this species. The predicted optimal climatic areas with hosts include a large portion of the EPPO region, from Western Europe to Eastern Russia and Northern Africa.

Existing experience of the spread of *D. virgifera* in Eastern and Western Europe as well as the availability of suitable climatic conditions and of susceptible hosts strongly suggest that, if it entered into the EPPO region, *D. undecimpunctata* subsp. *howardi* would establish, rapidly spread and be damaging in large parts of the region. Economic impact is anticipated by EFSA PLH (2020) in maize and outdoor cucurbit production.

PHYTOSANITARY MEASURES

Considering that adults actively ?y and are unlikely to remain on the plants during harvesting or transatlantic trade, phytosanitary measures at import should focus on true host plants with roots and soil where immature stages could be present.

Requirements for the production of host plants with roots and soil could be based on the production in pest free areas (EFSA PLH, 2020) or in a pest free place/site of production (e.g. under complete physical isolation). In particular, a number of EPPO countries already require that plants for planting should be accompanied by a phytosanitary certificate to enter their territory, indicating that these plants have been inspected and are free from quarantine pests prior to entry (EU, 2019). In case of entry on such plants, the following additional measures could be ordered: chemical treatments of consignments, processing under specified conditions or storage in a modified atmosphere.

Relevant management measures could also include the prohibition of the introduction of soils and growing media as such into the EPPO region. Such import from North and Central America is already prohibited by a number of EPPO countries (EU, 2019).

Even though current national regulations in the EPPO region may not cover the true host range of *D. undecimpunctata howardi*, phytosanitary measures are widely applied to all plants for planting and soil and the entry

pathways can be considered as partially closed.

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ACKNOWLEDGEMENTS

This datasheet was extensively revised in 2021 by Philippe Reynaud. His valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2026) *Diabrotica undecimpunctata howardi*. EPPO datasheets on pests recommended for regulation. Available online. https://gd.eppo.int

Datasheet history

This datasheet was first published in the EPPO Bulletin in 1999 and is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

EPPO (1999) EPPO Data sheets on quarantine pests - *Diabrotica undecimpunctata*. *EPPO Bulletin* **29**(4), 477-482. https://doi.org/10.1111/j.1365-2338.1999.tb01422.x



Co-funded by the
European Union