PEST INFORMATION TO TEST THE CRITERIA FOR THE INTEGRATION OF EMERGING PESTS INTO POARS

(Document prepared by IPPC Secretariat)

[1] The POARS Steering Group (SG) has agreed on the criteria for incorporating emerging pests into POARS. The POARS SG has planned an evaluation to refine these criteria further. The following pests have been selected to test the criteria:

- *Agrilus planipennis* (emerald ash borer)
- *Bactrocera dorsalis*
- *Cactoblastis cactorum*
- *Nilaparvata lugens*
- *Tilletia indica* (Karnal bunt)
- *Tomato brown rugose fruit virus* (ToBRFV)
- *Tuta absoluta*

[2] The IPPC Secretariat has compiled relevant information for each pest in Appendix 1 to support the assessment and optimize time during the in-person meeting. This information is not exhaustive but serves as a summary of key sources. For a comprehensive understanding, the original sources should be consulted. Expert judgment is crucial, particularly for criteria where data is either unavailable or unclear.

[3] The POARS SG in invited to:

- *Consider* the information in Appendix 1 to test the criteria for integrating emerging pests into POARS and *consult* the original sources where relevant.
- *Provide* expert judgment to interpret the information and where data is unavailable or unclear.

Appendix 1

Compiled information

1. *Agrilus planipennis* Fairmaire

1. Pest identity	
1.1. Taxonomy	Order: Coleoptera Family: Buprestidae [1]
1.2. Common name	emerald ash borer [1]
1.3. Biology and Ecology	• The proportion of individuals completing their development in more than one year depends on when the eggs were laid during the summer months, the local climate, host condition, larval density in the tree. Time required to complete 1 generation [2]: - One year: adults begin to emerge in late spring or early summer → larvae develop in summer and autumn → the pest overwinters as fourth instar larvae or prepupae → pupation occurs in spring of the following year. The pest completes 1 generation in one year when frost free days are over 150 per year. - Two years: young larvae (first to third instars) overwinter in the cambial area and resume feeding in spring of the following year → these individuals overwinter a second time as fourth instars or prepupae, and then pupate and emerge as adults the next year. The pest completes one generation in two years when frost free days are below 150 per year. • In North America, *A. planipennis* typically has one generation per year, though some individuals may require 2 years to complete a generation. In Michigan, USA, adult emergence occurs in late May and early June, coinciding with the accumulation of 230-260 degree days, calculated on a base 10°C threshold. [1] • In China, it completes its cycle in 1 year in Tianjin Province, but it is usually semivoltine in the cooler climate. In a semivoltine cycle, mid-instar larvae overwinter in the cambium, resume feeding in April and complete development in late summer. [1] • After emergence, they walk to the crown of their host tree and feed on small amounts of ash foliage, continuing to feed throughout their life, about 3 to 6 weeks. Initial flight begins 3-4 h after first feeding. The adults are active from 06.00 to 17.00 h, especially on warm sunny days. [1] • Mating starts 5-7 days after emergence. Females feed for another 5-7 days before oviposition begins. [1] • Eggs are laid individually on the bark surface, inside bark cracks and crevices, mostly in late June to early July in Michigan. Each female lays an average of 50-90 eggs although one female reared in captivity laid 258 eggs. The eggs hatch in about 1-2 weeks. [1] • The larvae typically feed in the cambium of trees or in the stems of vines and small woody plants. First-instar larvae tunnel through the bark to the cambium, where they feed from mid-June to October-November. Larvae pass through four instars. In a univoltine cycle, the mature larvae

	overwinter in pupal cells about 1 cm deep in the sapwood or outer bark. [1] • Pupation occurs in April-May and adults emerge about 3 weeks later. [1] • The adults remain under the bark for 1-2 weeks and then emerge through 'D'-shaped exit holes that are about 3-4 mm wide on trunks and branches. [1] •
1.4. Host range	• *Chionanthus virginicus*, *Fraxinus* spp. (*F. americana*, *F. angustifolia*, *F. chinensis*, *F. excelsior*, *F. lanuginose*, *F. mandshurica*, *F. latifolia*, *F, lanuginose*, *F. ornus*, *F. nigra*, *F. nigra* x *mandshurica*, *F. pennsylvanica*, *F. profunda*, F. quadrangulate, F. rhynchophylla, *F. uhdei, F. mandshurica* var. *japonica, F. velutina*), *Juglans mandschurica* var. *sieboldiana*, *Juglans mandschurica*, *Juglans mandschurica* var. *sachalinensis*, Pterocarya rhoifolia and *Ulmus japonica* [*Ulmus davidiana* var. *japonica*] [1, 2] • *Olea europaea* subsp. *europaea* could become an alternative host where ash foliage is available nearby for adults to consume in order to complete sexual maturation. [2] • North American ash species are susceptible to EAB even when healthy, whereas Asian species (*F. chinensis*, *F. mandshurica*, *F. rhynchophylla*) are susceptible only when stressed. [2]
2. Geographical spread	
2.1. Pest outbreaks[4] (including incursions) are reported in new geographical areas, suggesting a significant expansion of the pest's range.	• *A. planipennis* is native to northeastern China the Korean peninsula, and Russian Far East. [1] • In 2002, it was introduced into North America, and now occurs locally in many US States, Ontario and Quebec and is rapidly expanding its range. As of October 2018, the North American range of emerald ash borer includes 35 US States and five Canadian provinces. [1] • It was detected in 2005 [2] and officially reported in 2007 from the region of Moscow, Russia. Unpublished observations and the extent of the outbreak in this Moscow region suggest that the beetle arrived there several years earlier. As of 2017, it spreaded to at least eleven regions of the European part of Russia. [1]
	Canada, China, Japan, North Korea, Norway, Russia, South Korea, Ukraine, the United States [1]
3. Population increase	
3.1. A documented and substantial increase in the pest population in an existing area	N/A

suggests an increased risk of spread and damage.	
4. Economic Impact	
• **Direct impacts** a. Types, amount and frequency of damage b. Crop losses, in yield and quality c. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses d. Abiotic factors (e.g. climate) affecting damage and losses e. Control measures (including existing measures), their efficacy and cost f. Cost of replanting g. Effect on existing production practices	• Trees attacked by *A. planipennis* are ultimately killed. [1] • The proportion (in %) of yield losses (mortality rate) the species could make in EU is estimated to be 75% (with a 95% uncertainty range of 51 - 96%) based on certain assumptions. [2] • The larvae make long serpentine galleries (up to 26-32 mm long) into the sapwood, which enlarge as they grow and are filled with brownish sawdust and frass. Callus tissue produced by the tree in response to larval feeding may cause vertical splits, 5-10 cm long, in the bark above a gallery. [1] • As the larvae damage the vascular system, attacks cause general yellowing and thinning of the foliage, dying of branches, crown dieback and eventually death of the tree after 2 to 3 years of infestation. After 1 to 2 years of infestation, the bark often falls off in pieces from damaged trees, exposing the insect galleries. [1] • In China and Russia, *A. planipennis* typically attacks weakened ash trees, particularly those that grow in open areas or at the edge of closed forests. Entire stands can be killed during outbreaks, but only when American ash species are planted. Attack densities are highest in the lower bole of host trees. [1] • In contrast, in North America, *A. planipennis* has infested and killed trees in both open settings and closed forests and the attacks begin in the upper bole and main branches of host trees. [1] • To date, it is estimated that *A. planipennis* has killed over 30 million trees over the past few years in North America, in particular *Fraxinus pennsylvanica, Fraxinus americana* and *Fraxinus nigra*, as well as several horticultural varieties of ash. [1] • *A. planipennis* can kill trees of various size and condition (small trees of 5 cm trunk diameter to large mature trees). Tree death usually occurs within 3 years following initial attack although heavier infestations can kill trees within 1 to 2 years. [1] • The spread of *A. planipennis* in North America is expected to continue, and the economic impact of the invasion is likely to become enormous. There are more than 8 billion ash trees in the USA alone, belonging to 16 native ash species, among which six are economically important. [1] • Ash wood is a high-quality material for various special uses albeit not produced on a plantation scale. The undiscounted compensatory values of forest and urban ash in the USA were estimated at US$282 billion and US$20-60 billion, respectively. [1]
• **Indirect impacts** a. The presence of the pest affects domestic and export markets,	• In the USA and Canada, eradication cuts have been carried out at outlier sites, consisting of the cutting and shipping of all ash trees within a certain distance of infested trees. [1] • In the USA and Canada, movement of ash material from infested areas is regulated by federal quarantine regulations. Prohibited material

including export market access, and the extent of phytosanitary measures imposed by importing countries b. Changes to producer costs or input demands, including control costs c. Changes to domestic or foreign consumer demand for a product resulting from quality changes d. Feasibility and cost of eradication or containment e. Capacity to act as a vector for other pests f. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides g. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides h. Increased human health	includes ash trees, limbs or cut firewood, ash logs and lumber, uncomposted ash wood chips and bark chips larger than 1 inch in diameter. [1] • In Michigan, sale or transport of ash nursery trees is prohibited state-wide, and transport of any non-coniferous firewood out of the quarantined counties is prohibited as well. [1] • The species is not known to vector any plant pathogens. [2]

costs associated to the use of synthetic pesticides i. Resources needed for additional research and advice	
5. Environmental Impact	
Direct impacts a. Reduction of keystone plant species b. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) c. Significant reduction, displacement or elimination of other plant species.	• With ash being an essential component of temperate forest ecosystems in North America and Europe, the invasion of EAB has severe ecological impacts. The decline of ash affects both species composition and forest structure, leading to changes in microenvironment and understory succession. Therefore, not only the tree genus itself, but also a variety of species dependent on ash are threatened by EAB. In North America alone, 282 species depend on ash, with 43 of them assumed to be threatened if ash should be lost. [3] • In Europe, it was found that 44 species (11 fungi, 29 invertebrates and four lichens) being 'obligate' and 62 species (six bryophytes, 19 fungi, 24 invertebrates and 13 lichens) being 'highly associated' with F. excelsior in the UK alone. Similarly, 536 lichen species (c. 30% of the national lichen flora) occur on F. excelsior stems in the UK, while in total, 953 ash-associated species were identified. Similar numbers of ash-dependent species are to be expected in other parts of Europe. [3] • In European Russia, the establishment of EAB has resulted in a cascade of ecological effects, such as outbreaks of other xylophagous beetles on EAB-infested trees. [3] • Several ash species will surely decline in North America, which, through cascading effects, may have consequences on other components of biodiversity. For example, at least 21 moth species feed exclusively on ash, among which several are vulnerable to extinction. [1]
• Indirect impacts a. Significant effects on plant communities b. Significant effects on designated	• Widespread ash dieback may negatively affect carbon flux and storage, and increase erosion. [3]

environmentally sensitive or protected areas c. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) d. Costs of environmental restoration	
6. Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism • Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	• Ashes are important park, garden and street trees. These trees have to be replaced and there are now fewer viable choices for their replacement. [1]
7. Likelihood of Entry into New Areas	

• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	• The spread of emerald ash borer is characterized by both short and long distance movement in a process called stratified dispersal. Dispersal can occur naturally through adult flight as well as through human-assisted accidental transportation of infested host material. [1] • Natural dispersal: Both laboratory and field observations suggest that adult flights are limited to a few kilometres per year. Mated females when they were allowed to feed between flight periods were capable of flying an average of 1.3 km per day for 4 days. The field observations suggested shorter distance of adult dispersal within 200 m of the origin in areas where ash trees are abundant. [1] • It is estimated that the maximum distance expected to be covered in one year by *A. planipennis* is approximately 1,600 m (with a 95% uncertainty range of 320 – 8,262 m) based on certain assumptions. [2] • Accidental introduction: Long-distance dispersal occurs through human-assisted movement of plants and wood products (including wood, wood packaging, wood chips and firewood) containing bark strips, moving in local and international trade. Hitchhiking of adult beetles on or inside vehicles is also considered to be a major means of long-distance dispersal. [1] • Pathway causes and vectors: Transport of fire wood, Forestry, Nursery trade, Timber trade, Containers and wood packaging, Plants or parts of plants, Wind, Land vehicles [1] • Plant parts liable to carry the pest: - Bark, Seedlings, Stems, Stems (above ground)/Shoots/Trunks/Branches (pest stage: eggs, larvae, nymphs, pupae, adults), - Wood (pest stage: larvae, pupae) [1] • Likelihood of entry/control: - Highly likely to be transported internationally accidentally - Difficult to identify/detect as a commodity contaminant - Difficult to identify/detect in the field - Difficult/costly to control [1]
8. Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest • Reproductive strategy of the pest • Method of pest survival	• The genus Fraxinus is distributed in Africa, Asia, Europe, North America, Oceania and South America. [1] • Tolerated climate: Steppe climate [1] • Preferred climate: Warm temperate climate (wet all year), Continental/Microthermal climate, Continental climate (wet all year), Continental climate with dry winter [1] • Latitude range: 52°N to 32°S [1] • Temperature: - Absolute minimum temperature: - 42 °C - Mean annual temperature: 2 to 17 °C - Mean maximum temperature of hottest month:23 to 33 °C - Mean minimum temperature of coldest month: -25 to 3 °C [1] • Rainfall:

• Cultural practices and control measures	- Dry season duration: 0 to 8 (number of consecutive months with <40 mm rainfall) - Mean annual rainfall: 400 to 1700 (mm; lower/upper limits) [1] • The wide distribution of *A. planipennis* covers most of the Köppen-Geiger climates present in the EU: large part of its life cycle is completed inside the trunk, where it is protected from extreme meteorological conditions, and can be extended over longer periods of time, in case of unfavourable conditions. [2] • Field observations identified the lethal temperature for larvae (−25°C on average) and laboratory studies for prepupae (−30°C on average). Adults are active in strong sunlight and at temperatures above 25°C. In experimental conditions, *A. planipennis* adults fly at room temperatures of 23°C and express their maximum flying capacity at 27.9 °C. [2] • Silvicultural Methods: In North America and Europe, *A. planipennis* attacks and kills healthy trees. Thus, the silvicultural methods to maintain or enhance tree vigour, which are usually applied to prevent the attack of most bark and wood-boring insects are of little value. To prevent the emergence of adults from dead or cut trees, mechanical destruction of infested trees through chipping, grinding or heat treatment is recommended. [1] • Chemical Control: Insecticides can be sprayed on cut logs to kill adults at emergence and sanitize infested logs. Cover sprays and trunk or soil injections of insecticides can also be used. No insecticide seems to provide 100% control, but ash trees can tolerate minor damage by the beetle. In woodland and forested areas, insecticidal control is neither economically viable nor environmentally desirable.[1] • As chemical control, injections or sprays are considered as valid methods to protect living and cut trees. Trunk or soil systemic injections or soil drenches could be used to prevent tree infestations (100% effective) or kill *A. planipennis* already present in trees though this is not 100% effective except for emamectin benzoate. [2] • Biological Control: - Three parasitoid species were collected in China, determined to have adequate specificity, and released in North America: but impacts of the parasitoids have not yet been determined. [1, 2] - The fungus Beauveria bassiana has been found to be highly virulent against *A. planipennis*, and demonstrated lethal effects in greenhouse and field trials when applied on emerging adults and larvae. Foliar and trunk applications in the field were also able to significantly reduce populations of *A. planipennis* both at newly colonised ash sites and at sites with established pest populations. [1] • It is estimated that the time in EU between the event of pest transfer to a suitable host and its detection is 10 years. [2]
Rate of spread after establishment in new areas	• The rate of the range expansion of EAB is largely dependent on a number of factors. In North America, recorded expansion rates are between 2.5 and 80 km/year in part due to human-assisted transport. [3] • In Russia, range expansion from Moscow to the north seems to have occurred at a slower rate (13 km/year) than to the south (30 km/year) and west (41 km/ year) between 2009 and 2013. [3]

	• Using a spatially explicit cellular model, it was estimated the expansion of the invasion front in North America from 1998 to 2006 to be about 20 km/year. Based on dendrochronological data from Michigan, it was found that from 1998 to 2003, new satellite populations of EAB formed at a rate of 7.4 per year, with average jump distances of 24.5 km. [3]
Scale of impacts in new areas	
References	[1] CABI, 2024. CABI Compendium. Wallingford, UK: CAB International. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.3780#sec-17. (Accessed Aug. 2024) [2] EFSA, Baker Richard, Gilioli Gianni, Behring Carsten, Candiani Denise, Gogin Andrey, Kaluski Tomasz, Kinkar Mart, Mosbach-Schulz Olaf, Neri Franco Maria, Preti Stefano, Rosace Maria Chiara, Siligato Riccardo, Stancanelli Giuseppe, & Tramontini Sara. (2019). *Agrilus planipennis*– Pest Report and Datasheet to support ranking of EU candidate priority pests [Data set]. Zenodo. https://doi.org/10.5281/zenodo.2784060 (Accessed Aug. 2024) [3] Valenta, V., D. Moser, S. Kapeller, and F. Essl. "A new forest pest in Europe: a review of Emerald ash borer (*Agrilus planipennis*) invasion." Journal of Applied Entomology 141, no. 7 (2017): 507-526.

2. *Bactrocera dorsalis*

1. Pest identity	
1.1. Taxonomy	*Bactrocera dorsalis* (Hendel, 1912) belongs to the Tephritidae family. It has several synonyms including *Bactrocera invadens*, *Bactrocera papayae*, and *Bactrocera philippinensis* (EPPO, 2023; Manrakhan, 2019, EFSA, 2019). Class: Insecta, Order: Diptera, Family: Tephritidae
1.2. Common name	Commonly known as the Oriental fruit fly (Manrakhan, 2019).
1.3. Biology and Ecology	*Bactrocera dorsalis* lays eggs under the skin of host fruits, and larvae feed on fruit flesh, causing decay. It can have multiple generations per year, particularly in tropical and subtropical climates (Manrakhan, 2019).
1.4. Host range	Known hosts include over 270 species such as mango, papaya, citrus, banana, and guava (EPPO, 2023; CABI, 2019).
2. Geographical spread	
2.1. Pest outbreaks[4] (including incursions) are reported in new geographical areas, suggesting a	*Bactrocera dorsalis* is native to Southeast Asia and has since spread to over 65 countries across Africa, the Americas, and Oceania due to global trade and climate changes (Manrakhan, 2019; EPPO, 2023). The species has spread to almost the entire sub-Saharan region since its first appearance in Kenya in 2003. Regular captures occur in the USA, particularly Florida and California(EFSA 2019).

significant expansion of the pest's range.	
3. Population increase	
3.1. A documented and substantial increase in the pest population in an existing area suggests an increased risk of spread and damage.	The species shows rapid population growth in tropical and subtropical regions, where it can complete up to 10 generations per year (Manrakhan, 2019).
4. Economic Impact	
• **Direct impacts** h. Types, amount and frequency of damage i. Crop losses, in yield and quality j. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses k. Abiotic factors (e.g. climate) affecting damage and losses l. Control measures (including existing measures), their efficacy and cost m. Cost of replanting	The economic impact of *B. dorsalis* is significant, particularly in agriculture, due to fruit damage and increased control costs. Infestation leads to fruit loss, reduced yields, and increased pesticide use. Damage caused by larvae can affect up to 100% of unprotected fruit, leading to significant losses in yield and quality. The cost of managing *Bactrocera dorsalis* can be high due to quarantine measures and eradication programs (CABI, 2019). In Hawaii, the economic losses due to *Bactrocera dorsalis* are estimated to exceed $3 million annually (CABI, 2019).

n. Effect on existing production practices	
• **Indirect impacts** j. The presence of the pest affects domestic and export markets, including export market access, and the extent of phytosanitary measures imposed by importing countries k. Changes to producer costs or input demands, including control costs l. Changes to domestic or foreign consumer demand for a product resulting from quality changes m. Feasibility and cost of eradication or containment n. Capacity to act as a vector for other pests o. Effects of new control measures such as secondary pest outbreaks from the use of	The presence of the pest restricts market access due to the imposition of phytosanitary regulations by importing countries (CABI, 2019; EPPO, 2023). (EFSA, 2019) Additional control costs and reduced consumer demand due to quality degradation further impact producers

wide spectrum pesticides p. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides q. Increased human health costs associated to the use of synthetic pesticides r. Resources needed for additional research and advice	
5. Environmental Impact	
Direct impacts d. Reduction of keystone plant species e. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) f. Significant reduction,	*Bactrocera dorsalis* competes with native fruit flies, potentially displacing them. The application of chemical controls, necessary to manage the pest, can harm non-target species, including pollinators and beneficial insects (CABI, 2019). *Bactrocera dorsalis* poses a threat to keystone plant species, especially in regions where it invades(EFSA, 2019). b. It can reduce plant biodiversity by displacing native species, particularly in tropical and subtropical ecosystems(EFSA, 2019).

displacement or elimination of other plant species.	
• **Indirect impacts** e. Significant effects on plant communities f. Significant effects on designated environmentally sensitive or protected areas g. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) h. Costs of environmental restoration	Chemical interventions aimed at controlling the pest may lead to long-term environmental degradation, particularly in ecologically sensitive regions (EPPO, 2023) The presence of the pest may cause changes to plant communities and affect sensitive ecosystems by altering ecological processes (EFSA, 2019)
6. Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism	Loss of jobs in agriculture and social unrest in affected regions due to the economic consequences of pest control efforts. Public health may also be at risk due to increased pesticide use (CABI, 2019). Potential social unrest in areas dependent on affected crops, as interventions to control the pest may disrupt local communities (EFSA, 2019) Tourism and public/private gardens may suffer due to the pest's spread, affecting ornamental and food plants of national importance(EFSA,

• Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	2019). d. Risks to food security arise from reduced crop yields and increased reliance on synthetic pesticides(EFSA. 2019).
7. Likelihood of Entry into New Areas	
• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	*Bactrocera dorsalis* can spread through international trade, especially via the transport of infested fruits. The pest can survive through various transport methods, such as in luggage, mail, and cargo (EPPO, 2023; CABI, 2019).
8. Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest	The pest can adapt to new environments as long as suitable hosts are present. Its reproductive capacity and ability to survive under diverse climatic conditions contribute to its likelihood of establishing in new areas (Manrakhan, 2019). Although *B. dorsalis* thrives in tropical regions, climate models suggest its potential to establish in Mediterranean climates. Temperature and humidity play a crucial role in its lifecycle, and continuous fruit availability makes the Mediterranean region

• Reproductive strategy of the pest • Method of pest survival • Cultural practices and control measures	susceptible to its establishment. Moreover, climatic changes could expand its range in Southern Europe (Stephens et al., 2007 and Vargas et al., 2010 in EFSA 2019).
9. Rate of spread after establishment in new areas	•
10. Scale of impacts in new areas	
11. References	CABI. (2019). *Bactrocera dorsalis* (Oriental fruit fly) datasheet. CABI Compendium. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.17685 EFSA (European Food Safety Authority), Loomans A, Diakaki M, Kinkar M, Schenk M and Vos S, 2019. Pest survey card on Bactrocera dorsalis. EFSA supporting publication 2019:EN-1714. 24 pp. doi:10.2903/sp.efsa.2019.EN-1714 EPPO. (2023). *Bactrocera dorsalis* Express Pest Risk Analysis. European and Mediterranean Plant Protection Organization. https://pra.eppo.int/pra/f91a8915-3464-42d5-ab36-c172ade88c96 Manrakhan, A. (2019). *Bactrocera dorsalis* (Oriental fruit fly). CABI Compendium. https://doi.org/10.1079/cabicompendium.17685

3. *Cactoblastis cactorum*

2. Pest identity	
8.1. Taxonomy	☐ **Order**: Lepidoptera ☐ **Family**: Pyralidae ☐ **Subfamily**: Phycitinae ☐ **Genus**: Cactoblastis ☐ **Species**: Cactoblastis cactorum (Berg, 1885) ☐ **Synonyms**: Zophodia cactorum
8.2. Common name	Cactus moth, prickly pear moth
8.3. Biology and Ecology	The cactus moth, *Cactoblastis cactorum*, is native to northern Argentina, parts of Peru, and Paraguay. It feeds on prickly pear cacti (Opuntia species), primarily consuming the contents of cactus pads. Larvae live and feed inside cactus pads, hollowing them out and causing decay and plant death. This species

	exhibits a multi-voltine life cycle with 2 to 3 generations per year, depending on environmental conditions. Adult moths are nocturnal, and females lay eggs in clusters that resemble cactus spines. Larvae gregariously feed on cactus cladodes, and the damage they cause is exacerbated by secondary bacterial infections (Simonson, 2005).
8.4. Host range	The cactus moth primarily feeds on species within the Opuntia genus, but it can also affect other cacti species. At least 30 species of Opuntia are known to be hosts, with varying degrees of susceptibility. Some species from other plant families, such as Solanaceae (tomatoes) and Cucurbitaceae (melons, pumpkins), have experienced spill-over damage when cactus moth populations were high (Simonson, 2005).
9. Geographical spread	
9.1. Pest outbreaks[4] (including incursions) are reported in new geographical areas, suggesting a significant expansion of the pest's range.	*Cactoblastis cactorum* is native to northern Argentina, Peru, and Paraguay. It was introduced to Australia in the 1920s as a biological control agent for invasive Opuntia species. Since then, it has spread globally. The pest was introduced to the Caribbean in the 1960s and reached the United States in 1989, first detected in Florida. By 2003, the moth had spread to Georgia and South Carolina. It is now expanding westward, with documented populations in Alabama and Texas (Simonson, 2005). n the U.S., the cactus moth threatens the ecosystems of the southwestern states, particularly Texas, New Mexico, Arizona, and California, where native and cultivated Opuntia species are abundant. It also poses a significant risk to Mexico, where Opuntia species are economically and culturally important. Predictions suggest that the moth will continue to expand westward, potentially affecting large areas of both the U.S. and Mexico (Simonson, 2005). The species has also spread to South Africa, Hawaii, Mauritius, and other areas where Opuntia cacti are present. In Mexico, although the moth has not yet been widely detected, there have been interceptions at border crossings, such as an infested fruit intercepted at the Laredo, Texas airport from Mexico in 1995. The pest's ability to spread quickly and establish in new areas through natural and human-aided dispersal poses a high risk for further geographical expansion (Simonson, 2005).
10. Population increase	
10.1. A documented and substantial increase in the	In the southeastern United States, *Cactoblastis cactorum* has shown a significant increase in its population and spread. Between 1989 and 1999, the cactus moth's spread was estimated at 50-75 km per year. However, in the early 2000s,

pest population in an existing area suggests an increased risk of spread and damage.	this rate increased to 158 km per year. The moth's ability to establish rapidly in new environments, especially in the U.S. and Caribbean islands, is concerning (Simonson, 2005). Florida and its surrounding regions have experienced increased population densities of the cactus moth, with overlapping generations in some warmer areas like the Florida Keys, where moths are present year-round. This population increase is not only due to favorable environmental conditions but also because the moth's life cycle allows for multiple generations annually, contributing to its invasive potential (Simonson, 2005).
11. Economic Impact	
• **Direct impacts** o. Types, amount and frequency of damage p. Crop losses, in yield and quality q. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses r. Abiotic factors (e.g. climate) affecting damage and losses s. Control measures (including existing measures), their efficacy and cost t. Cost of replanting u. Effect on existing production practices	The larvae of *Cactoblastis cactorum* feed internally on cactus pads, hollowing them out and causing plants to collapse. This type of damage leads to significant plant mortality and the reduction of plant size and health. Opuntia species are economically significant for food (nopales, tunas) and fodder, especially in Mexico and the southwestern U.S. *Cactoblastis cactorum* threatens to reduce crop yields by damaging the plants and making them more susceptible to bacterial infections. In South Africa, entire plantations of *Opuntia ficus-indica* and *Opuntia robusta* have been destroyed by the moth. The cactus moth has a high adaptability to various climates and Opuntia species, which increases the pest's virulence in new environments. Warmer climates favor multiple generations of the cactus moth, allowing for higher reproduction rates and population growth. This leads to a more significant impact on Opuntia species in regions with mild winters. Current control measures include pheromone traps for monitoring, mechanical removal of infected plants, and the area-wide application of the sterile insect technique (SIT). Chemical pesticides have shown limited effectiveness. The cost of these control methods can be high, especially when implemented over large areas.
• **Indirect impacts** s. The presence of the pest affects domestic and export markets, including export	In Mexico, where Opuntia is a major agricultural product, the spread of *Cactoblastis cactorum* could severely impact exports of edible cactus products to the U.S. and other countries. Phytosanitary restrictions could be imposed by importing nations, reducing market access.

market access, and the extent of phytosanitary measures imposed by importing countries t. Changes to producer costs or input demands, including control costs u. Changes to domestic or foreign consumer demand for a product resulting from quality changes v. Feasibility and cost of eradication or containment w. Capacity to act as a vector for other pests x. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides y. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides z. Increased human health costs associated to the use of synthetic pesticides aa. Resources needed for additional research and advice	Producers may face increased costs for controlling the moth through trapping, monitoring, and other pest management techniques. If damage from the moth significantly reduces the quality of Opuntia crops, consumer demand could decline, both domestically and internationally. Complete eradication of *Cactoblastis cactorum* is unlikely due to its rapid spread and establishment in wild and cultivated cactus populations. Containment strategies could be expensive and challenging to implement over large areas. Wide-spectrum pesticides could result in secondary pest outbreaks or reductions in beneficial insects, such as pollinators.
12. Environmental Impact	
Direct impacts g. Reduction of keystone plant species	The cactus moth poses a significant threat to *Opuntia* species, which are keystone plants in many ecosystems, particularly in arid and semi-arid regions. *Opuntia* plants provide food and habitat for a wide variety of species, and their decline would have cascading effects on ecosystems.

h. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) i. Significant reduction, displacement or elimination of other plant species.	In regions like Mexico and the southwestern United States, *Opuntia* species are major components of the landscape. The cactus moth threatens over 80 species of *Opuntia*, including rare and endangered species, such as *Opuntia corallicola* in Florida. A reduction in these species would disrupt local ecosystems, leading to a loss of biodiversity. As *Opuntia* species decline, other plant species could be affected through changes in competitive dynamics, water availability, and soil stability. In areas where *Opuntia* species dominate, their loss could result in significant shifts in plant community composition.
• **Indirect impacts** i. Significant effects on plant communities j. Significant effects on designated environmentally sensitive or protected areas k. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) l. Costs of environmental restoration	The reduction of *Opuntia* species could result in shifts in plant community structure, allowing invasive or non-native species to take over, further altering ecosystems. The cactus moth poses a particular threat to protected areas where *Opuntia* species play a crucial ecological role. These areas could experience significant environmental degradation, affecting not only plant species but also the wildlife that depends on *Opuntia*. The loss of *Opuntia* species could lead to soil erosion, changes in water tables, increased fire hazards, and disruptions in nutrient cycling. These changes would have long-term impacts on the stability and functioning of ecosystems, particularly in desert and semi-desert regions. Efforts to restore ecosystems impacted by the cactus moth would be costly and challenging, particularly in areas where *Opuntia* species have been significantly reduced or eliminated.
13. Social Impact	
• Loss of jobs	The decline in *Opuntia* production, particularly in Mexico, would lead to job losses, as many rural communities depend on

• Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism • Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	*Opuntia* farming for their livelihoods. This could affect producers, harvesters, and workers in related industries. The implementation of containment and eradication strategies, such as the use of pesticides or the removal of infected plants, could lead to unrest in affected communities, particularly if these measures disrupt local economies or traditions. The loss of *Opuntia* species in natural landscapes, particularly in areas like national parks and protected regions, could negatively affect tourism. Visitors come to these areas to experience the unique flora, and the decline of *Opuntia* could reduce the attractiveness of these destinations. The cactus moth could impact ornamental cactus species used in private and public gardens, particularly in xeriscaping projects in arid regions like the southwestern United States. This could lead to increased costs for homeowners and public entities to manage or replace damaged plants. In Mexico, *Opuntia* species hold cultural and national significance, even appearing on the national flag. The loss or decline of these species due to the cactus moth could have symbolic and cultural repercussions. *Opuntia* species are a staple food in many regions, particularly in Mexico. A significant decline in *Opuntia* production due to the cactus moth could threaten food security, particularly for subsistence farmers and rural communities that rely on *Opuntia* for both food and income.
14. Likelihood of Entry into New Areas	
• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	The cactus moth has multiple pathways for entry into new areas, including natural dispersal by wind and water, as well as human-assisted transportation through infested plants or plant parts in the horticultural trade. *Cactoblastis cactorum* larvae can easily be transported on *Opuntia* plants or plant products, particularly those used for ornamental purposes. Infested cactus pads are often difficult to detect, increasing the likelihood of accidental introduction. The larvae of the cactus moth are well-protected inside the cactus pads, giving them a high probability of surviving transport or storage, particularly when environmental conditions are favorable.

	Existing pest management procedures, such as inspections and quarantines, have not been entirely effective in preventing the spread of the cactus moth. The species has continued to expand its range despite efforts to control its movement. Potential undocumented pathways include the movement of infested ornamental cacti in domestic and international trade, as well as informal biological control efforts where individuals may transport the moth intentionally to control invasive *Opuntia* species in new areas.
15. Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest • Reproductive strategy of the pest • Method of pest survival • Cultural practices and control measures	The cactus moth thrives in warm climates, particularly those with mild winters. *Cactoblastis cactorum* has shown a high capacity for adaptation, particularly in areas with suitable host plants and climates. Its ability to produce multiple generations per year increases its invasive potential. The moth's reproductive strategy includes laying egg clusters (egg-sticks) containing hundreds of eggs, with larvae feeding gregariously inside the cactus pads. This reproductive strategy supports rapid population growth. The larvae of the cactus moth are protected inside the cactus pads, making them less vulnerable to environmental stress and predators. Pupation occurs in plant debris or soil near the host plant, ensuring the species can survive adverse conditions.
Rate of spread after establishment in new areas	The cactus moth has shown a rapid rate of spread once established in new areas. In the southeastern United States, the moth has spread at rates of up to 158 kilometers per year, suggesting that its spread in new regions could be swift, particularly in areas with abundant *Opuntia* species and favorable climates.
Scale of impacts in new areas	The scale of impacts in new areas could be significant, with potential consequences for agriculture, ecosystems, and local economies. In Mexico and the southwestern United States, where *Opuntia* species are of both economic and cultural importance, the cactus moth's spread could lead to widespread losses in cactus production, environmental degradation, and negative social impacts.
References	Simonson, S. E., Stohlgren, T. J., Tyler, L., Gregg, W. P., Muir, R., & Garrett, L. J. (2005). Preliminary assessment of the potential impacts and risks of the invasive cactus moth, *Cactoblastis cactorum* Berg, in the U.S. and Mexico. Final Report to the International Atomic Energy Agency.

4. *Nilaparvata lugens* Stål

1. Pest identity	
1.1 Taxonomy	Order: Hemiptera Suborder: Auchenorrhyncha Family: Delphacidae [1]
1.2 Common name	brown planthopper [1]
1.3 Biology and Ecology	• Adult *N. lugens* are dimorphic, with winged (macropterous) and short-winged (brachypterous) forms. Macropters migrate into ricefields shortly after transplanting. The subsequent generation consists primarily of brachypterous females and macropterous males. Later development of macropterous females can be stimulated by a number of factors, including nymphal crowding, decreasing host-plant quality, short daylength and low temperatures. [1] • It cannot overwinter in temperate and subtropical regions. [2] • It is capable of long-distance migration, and recolonizes temperate areas each year in June or July. In September, some brown planthoppers are carried back to the tropics when winds are favourable. [1, 2] • *N. lugens* shows distinctive generational peaks in temperate rice because of the synchrony of immigration. Both overlapping generations and distinctive generational peaks have been observed in the tropics, depending on the local pattern of rice cultivation. [1] • There are generally three generations per crop on improved rice varieties in the tropics, up to six generations per crop may occur on late-maturing varieties. [1] • It can complete 12 generations in a single year in tropical areas, where it resides year-round, and fewer generations in temperate areas, where it is a migratory pest. [2] • Biological attributes such as size, developmental time, fecundity and longevity are highly influenced by temperature, and the nutritional status and resistance of the host plants. [1] • Under optimal conditions (on healthy, susceptible hosts at temperatures of 25-30°C), brachypterous females typically lay 300-400 eggs, but fecundities of over 1000 eggs per female have been recorded. Macropterous females generally lay about 100 eggs. [1] • Eggs are laid in groups of 2-12, most often in the leaf sheaths but occasionally in the leaf midribs; they hatch in 6-9 days. [1] • There are five nymphal instars, each of which may last 2-4 days. Adult longevity is typically in the range of 10-20 days. *N. lugens* harbours eukaryotic endosymbionts that have a nutritional role and are necessary for normal growth. [1]
1.4 Host range	Oryza sativa, some wild Oryza species in Asia, Zizania sp. [1]
2 Geographical Spread	
Pest outbreaks (including incursions) are reported in new geographical areas, suggesting a	• *N. lugens* is widely distributed in south and South-East Asia, Australia (only in tropical areas), Oceania and some Pacific Islands. [1] • Several outbreaks have occurred in China, South Korea, the Philippines, Solomon Islands, Thailand, Sri Lanka, Vietnam, India, Malaysia and Indonesia. [1]

significant expansion of the pest's range.	• Distribution: Australia, Bangladesh, Brunei, Cambodia, China, Federated States of Micronesia, Fiji, Guam, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, New Caledonia, North Korea, Northern Mariana Islands, Pakistan, Palau, Papua New Guinea, Philippines, Singapore, Solomon Islands, South Korea, Sri Lanka, Taiwan, Thailand, Vietnam [1]
3 Population Increase	
A documented and substantial increase in the pest population in an existing area suggests an increased risk of spread and damage.	
4 Economic Impact	
Direct impacts v. Types, amount and frequency of damage w. Crop losses, in yield and quality x. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses y. Abiotic factors (e.g. climate) affecting damage and losses z. Control measures (including existing measures), their efficacy and cost aa. Cost of replanting bb. Effect on existing production practices	• Both nymphs and adults feed on leaf sheaths at the base of the plant. On plants grown closely together, some insects may move upwards to the leaves. [1] • In the Philippines, *N. lugens* damaged at least 80,000 ha in 1973-74. [1] • An estimate of losses caused by *N. lugens* in Malaysia was M$ 10 million. [1] • The yield loss due to *N. lugens* in India was 1.1-32.5%. [1] • It is reported that yield losses in West Malaysia attributable to *N. lugens* in years with and without outbreaks of this hopper. In an outbreak year such as 1977, as much as 25% (870 kg/ha) of the yield was lost, compared with ca 1% (or 34 kg/ha) in the 1976-77 season. Though the yield losses are a consequence of the planthopper outbreak, the application of large quantities of insecticides for control resulted in an upsurge of *Chilo polychrysus* that caused heavy damage. [1] • It is reported that serious yield losses of rice were caused by outbreaks of *N. lugens* throughout China. One report described an outbreak of *N. lugens* in rice growing areas in China in which yield losses reached 30% in 19.8% of the area and 100% in an area of 4000 mu (1 mu = 0. 067 ha). [1] • It is summarized that some damage has been reported from Bangladesh, Brunei, China, Fiji, Korea, Malaysia, Papua New Guinea, the Solomon Islands, Sri Lanka, Thailand and Vietnam, but extensive losses from the insect and from grassy stunt disease have occurred in India (estimated at US$ 20 million), Indonesia ($100 million) and the Philippines ($26 million). Losses from the insect alone are $100 million in Japan and $50 million in Taiwan. The estimated losses due to *N. lugens* and grassy stunt virus disease total more than $300 million. [1] • In a field study of Korean cultivars, some resistant cultivars supported low populations of *N. lugens*, were undamaged without insecticide and fungicide protection, and had a relatively low yield increase, when insecticides were used. Other some cultivars, however, had considerable hopper populations despite their resistance gene and showed some

	hopperburn later than japonica cultivars, among which there were no resistant cultivars. [1] • It is showed that yield losses varied significantly with growth stage attacked and pest density, and were greater earlier in the season and at greater pest densities. [1] • Based on the assessment of yield losses, a control threshold of 20-25 planthoppers/hill has been tentatively suggested for tropical countries; however, the critical economic injury level may be as low as 2-5 planthoppers/hill. [1] • The use of IPM against *N. lugens* in India is reported successful in 1983-85. As a result the average yield of rice in the area increased from 3438 to 4667 kg/ha, an increase of 36%. [1] • In an insecticide trial against *N. lugens* it was found that in untreated fields the yield was 4485 kg/ha while in the most effective treatment it was 6121 kg/ha. [1] • There are reports of *N. lugens* occurring with other pests such as *Sogetella furcifera* and sheath blight, causing mixed damage and combined losses. [1] • A sequential sampling plan for *N. lugens* was developed in the Philippines and decisions to apply insecticides to plots with threshold levels of plant hoppers resulted in significant yield increases. [1] • More than two rice crops per year, lack of a rice-free period, staggered planting and injudicious use of fertilizer are factors favouring *N. lugens* build up and subsequent damage. [1] • Existing species and levels of natural enemies in Asian rice areas are currently regarded as the key to *N. lugens* management; *Anagrus* spp. and *Oligosita* spp. (egg parasitoids), the mirid *Cyrtorhinus lividipennis* (egg predator), and the beetles *Micraspis* and *Coccinella*, the bug *Microvelia*, and the spider *Lycosa pseudoannulata* (predators of nymphs and adults). [1] • Host-plant resistance became a major control method for *N. lugens*. Numerous host-plant resistance genes have been identified and incorporated in most breeding lines. [1] • Pesticides accelerate the rate at which *N. lugens* adapts to novel varieties, as fecundity and the ability to survive are enhanced by reduced natural enemy pressure. 'Preventive' and calendar-based pesticide controls should be avoided in rice due to the possibility of *N. lugens* resurgence. [1]
Indirect impacts bb. The presence of the pest affects domestic and export markets, including export market access, and the extent of phytosanitary measures imposed by	• *N. lugens* is the vector for rice grassy stunt tenuivirus and rice ragged stunt oryzavirus. [1] • The viruses vectored by *N. lugens* (rice grassy stunt virus and rice ragged stunt virus) are not regulated in the EU, while they are both quarantine in the USA. [2]

importing countries cc. Changes to producer costs or input demands, including control costs dd. Changes to domestic or foreign consumer demand for a product resulting from quality changes ee. Feasibility and cost of eradication or containment ff. Capacity to act as a vector for other pests gg. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides hh. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides ii. Increased human health costs associated to the use of synthetic pesticides jj. Resources needed for additional research and advice	
5 Environmental Impact	

Direct impacts j. Reduction of keystone plant species k. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) l. Significant reduction, displacement or elimination of other plant species.	
Indirect impacts m. Significant effects on plant communities n. Significant effects on designated environmentally sensitive or protected areas o. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant	• Organophosphate and pyrethroid pesticides are known to be toxic to most natural enemies. Other pesticides, including fungicides, are also known to be highly toxic to natural enemies and are suspected of increasing *N. lugens* resurgence. [1]

species, erosion, water table changes, increased fire hazard, nutrient cycling) p. Costs of environmental restoration	
6 Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism • Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	
7 Likelihood of Entry into New Areas	
• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	• The brown planthopper is a long-distance migratory insect known to migrate passively with prevailing winds. The pest could also spread by movement of plants for planting and freshly cut host plants. [2] • Hypothetical pathways: Freshly cut host plants (pest stage: eggs, nymphs, adults), Hitchhiking (pest stage: nymphs, adults). However, there is no evidence that hosts are traded as growing or cut plants. Immature and adult planthoppers are highly mobile, departing plants when disturbed and are likely to hop off plants at origin and so not be transported on traded plants. [2] • Planthoppers in general are infrequently intercepted relative to other families in Hemiptera. [2] • Most rice seedlings are directly drilled and seed does not provide a mechanism for spread for this insect. [2]

8 Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest • Reproductive strategy of the pest • Method of pest survival • Cultural practices and control measures	• In most rice ecosystems, no classical or indundative biological control is necessary for *N. lugens* because the naturally occurring predators and parasites are sufficient for economic control in almost all cases. [1] • It cannot overwinter in temperate and subtropical regions. [2] • The most favourable temperatures for the survival and reproduction of *N. lugens* ranges from 25°C to 30°C. [2]
9. Rate of spread after establishment in new areas	
10. Scale of impacts in new areas	
References	[1] CABI, 2024. CABI Compendium. Wallingford, UK: CAB International. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.36301#sec-11. (Accessed Aug. 2024) [2] EFSA Panel on Plant Health (PLH), Claude Bragard, Paula Baptista, Elisavet Chatzivassiliou, Francesco Di Serio, Paolo Gonthier, Josep Anton Jaques Miret et al. "Pest categorisation of *Nilaparvata lugens*." EFSA Journal 21, no. 5 (2023): e07999.

4. *Tilletia indica* Mitra

1. Pest identity	
Taxonomy	Order: Tilletiales Family: Tilletiaceae [1]
Common name	Karnal bunt of wheat [1]
Biology and Ecology	• *T. indica* survives in the soil. Teliospores germinate at or near the soil surface in response to temperature and moisture, normally at temperatures between 20 and 25°C. Survival and spread of the fungus can occur by transport of infested and infected seed. [1] • Sporidia are dispersed by wind or rainsplash to the wheat ears and act as the primary source of infection. Germ tubes arise from secondary sporidia and grow towards stomatal openings of the glume, lemma or palea, where they enter. [1]

	• The hyphae grow intercellularly within the glume, lemma, palea and possibly rachis, leading to infection of the seed, which is normally limited to the pericarp. [1] • Spread of the pathogen then appears to take place systemically from primary infection sites to adjacent spikelet and florets. [1] • Sporidia also develops on leaves and other plant parts. [1] • Temperatures of 8-20°C and high humidity associated with light rain showers and cloudy weather are most favourable for infection of the ears. Environmental conditions are considered to play a decisive role in infection, with dry weather, high temperatures (20-25°C) and bright sunlight being unfavourable. [1] • Secondary sporidia were able to germinate and multiply on surface-sterilized leaves, soil and so on, thus providing a large inoculum for airborne infection. These secondary sporidia have been shown to be very durable and can remain dormant and then regenerate very rapidly under conditions conducive for the disease. [1] • There is no direct evidence that *T. indica* can be transmitted from planted seeds to the plants grown from the seed. However, teliospores that heavily contaminate seeds do survive and germinate in the soil and are considered to be an important inoculum source of the pathogen. [1] • Histological studies of the infection of wheat seeds indicate that *T. indica* is restricted to the pericarp. [1] • Germination of teliospores occurred on the soil surface over a temperature range of 10 to 25°C and at 5-40% soil moisture content. They also germinate on glumes of wheat and infect the plants. [1]
Host range	• The main host of *T. indica* is wheat (*Triticum* spp.); durum wheat and triticale are less susceptible. [1] • The main host species identified from the literature are *Triticum aestivum* (bread wheat), *Triticum durum* (durum wheat) and Triticosecale (triticale). [2] • In inoculation experiments *Aegilops* spp., *Bromus* spp., *Lolium* spp. And *Oryzopsis* showed varying degrees of susceptibility. [1] • It is reported that the wild wheat species *Aegilops geniculata*, *A. sharonensis*, *A. peregrina* var. *peregrina* and "*Triticum scerrit*" are potential hosts of *T. indica*, without specifying whether the infections were observed under natural conditions. [2] • The following species have been reported to cause infection by artificial inoculation: *Oryzopsis miliacea* (synonym of *Piptatherum miliaceum*), Bromus ciliatus, *B. tectorum*, *Lolium canariense*, *L. multiflorum, L. perenne*, *T. monoccocum*, *T. tauschii*, *T. timopheevi*, *Aegilops bicornis, A. caudata* (currently *A. markgrafii*), *A. columnaris*, *A. comosa*, *A. cylindrica*, *A. mutica*, *A. searsii*, *A. sharonensis*, *A. tauschii*, *A. triaristata* (currently *A. neglecta*) and *A. triuncialis*. [2]
2. Geographical Spread	
3. Pest outbreaks4 (including incursions) are reported in new geographical	• The first report of a new bunt disease in wheat came from Pakistan in 1909. This was presumably Karnal bunt, which was first formally recorded in 1930 near the north Indian city of Karnal. Within India the pathogen spread and can now be considered widespread in northern and central India. [1]

areas, suggesting a significant expansion of the pest's range.	• The first report of Karnal bunt from a non-Asian country came from Mexico in 1972. [1] • Isolated outbreaks have been found in south-western USA since its first reported occurrence there in 1996. [1] • In 2000, Karnal bunt was reported in South Africa. [1] • Distribution: Afghanistan, India, Iran, Iraq, Mexico, Nepal, Pakistan, South Africa, the United States [1]
4. Population Increase	
A documented and substantial increase in the pest population in an existing area suggests an increased risk of spread and damage.	• In 1972 in Mexico, the disease was restricted to the Yaqui and Mayo valleys in Sonora and was found in only trace amounts in farmers' fields. However, in the early 1980s, disease surveys in these valleys found Karnal bunt on 64 % of the farms. [3]
5. Economic Impact	
Direct impacts cc. Types, amount and frequency of damage dd. Crop losses, in yield and quality ee. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses ff. Abiotic factors (e.g. climate) affecting damage and losses gg. Control measures (including existing measures), their efficacy and cost hh. Cost of replanting ii. Effect on existing	• In India, until 1970, outbreaks occurred every 2-3 years, with a disease incidence of 0.1-10% and annual yield losses of about 0.2%. When infection is severe, yield, seed quality and germination are adversely affected. Food grain is unacceptable when infection exceeds 3%. The disease is controlled using resistant cultivars in infested areas so that high levels of infection are seldom reached at present. [1] • In Mexico, direct losses are not very significant and do not exceed 1%. [1] • It is estimated that the economic impact of *T. indica* introduction into Western Australia could range from 8 to 24% of the total value of wheat production. [4] • A single 50,000 ha outbreak with phytosanitary controls in the EU was estimated to cost potentially €454 million over 10 years from the time of detection. [4] •

production practices	
Indirect impacts kk. The presence of the pest affects domestic and export markets, including export market access, and the extent of phytosanitary measures imposed by importing countries ll. Changes to producer costs or input demands, including control costs mm. Changes to domestic or foreign consumer demand for a product resulting from quality changes nn. Feasibility and cost of eradication or containment oo. Capacity to act as a vector for other pests pp. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides qq. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides	• In Mexico, indirect costs to the economy are more significant due to quarantine measures which have to be applied for grain exports. In addition, the presence of Karnal bunt in Mexico has created a need for considerable extra precautions in the dispatch of cereal germplasm material by the International Maize and Wheat Improvement Center (CIMMYT). [1] • CIMMYT uses the following procedures for germplasm material sent to other continents: production in areas free from *T. indica*; propiconazole sprays of seed-production plots; treatment of seed batches in a sodium hypochlorite bath; seed treatment with carboxin, captan and chlorothalonil. [1] • For Europe and Australia, seeds of host plants should come from a pest-free area. Grain should come from a pest-free area or from a pest-free place of production (with testing of the harvested grain). New Zealand requires similar measures. [1, 4] • Karnal bunt is not toxic to humans, but infection by *T. indica* can affect the appearance and smell of grain products. *T. indica* infection increased the prolamine and decreased the albumin and globulin protein content of the seed. The decreased level of glutelins lowered the gluten quality in diseased compared with healthy grain. [1] • The species is not known to vector any plant pathogens. [2] • Once introduced, the pathogen would be almost impossible to eradicate because of the likely lag period before detection and the fact that the spores can remain viable in the soil for 5 years or more. [4]

rr. Increased human health costs associated to the use of synthetic pesticides ss. Resources needed for additional research and advice	
6. Environmental Impact	
Direct impacts m. Reduction of keystone plant species n. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) o. Significant reduction, displacement or elimination of other plant species.	• *T. indica* mainly attacks an annual crop (wheat). It does not affect other species in the natural environment. Its economic impact on cereal growing is not such as modifying land use. Accordingly, the environmental impact of this pest is nil. [1]
Indirect impacts q. Significant effects on plant communities r. Significant effects on designated environmentally sensitive or protected areas	

s. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) t. Costs of environmental restoration	
7. Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism • Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	• Karnal bunt is not toxic to humans, but infection by *T. indica* can affect the appearance and smell of grain products. [1] • The species is not known to be related to problems caused by mycotoxins. [2]
8. Likelihood of Entry into New Areas	
• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing	• Direct visual observation for Karnal bunt (dry seed inspection) is regarded as insufficient for quarantine purposes because low levels of infection might pass undetected and even minimal seed infections can substantially contaminate healthy seed lots. [1] • True seeds (inc. grain) are liable to carry the pest both internally and externally (pest stages: fungi and spores), and the pest or symptoms are usually invisible during trade/transport. [1] • The main potential pathway of entry of *T. indica* into New Zealand is through imports of infected or contaminated grain intended for sowing. Infected or contaminated grain intended for processing in areas where

pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	wheat or triticale is grown, or even for transport through such areas, also poses a risk. [4]
9. Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest • Reproductive strategy of the pest • Method of pest survival • Cultural practices and control measures	• Being a non-systemic pathogen, it generally produces not more than four or five bunted kernels in each spike. Detection in the field is very unlikely and the first year of an outbreak usually goes undetected. For instance, in USA in 1996, it had taken at least 4 years for the pathogen to be detected. [1] • EFSA considered that all the area of production of *Triticum aestivum* (bread wheat) and *Triticum durum* (durum wheat) in the EU is suitable for *T. indica*. [2] • Cultural control: High nitrogen applications and excessive irrigation favour the disease. To prevent the spread of *T. indica* into previously unaffected areas, the use of disease-free seed is essential. The movement of farm machinery and soil from contaminated fields may also be restricted. [1] • Chemical control: Bleach of seeds, in combination with heat treatment, is effective. Carboxin + thiram, and chlorothalonil have been used as seed treatments in the USA and Mexico. Foliar sprays of fungicides may be used to control the airborne inoculum of primary and secondary sporidia. [1] • Resistant cultivars of bread wheat are available. [1] • In EU areas of host production, fungicides applications on bread and durum wheat are currently used against other pathogens. Most of them are considered to be effective, for a.i. and for treatment time, against *T. indica*. [2]
10. Rate of spread after establishment in new areas	
11. Scale of impacts in new areas	• Based on certain assumption, EFSA estimated that the percentage yield loss for bread wheat and durum wheat is 0.05% (with a 95% uncertainty range of 0.007 – 0.37%) and the percentage quality losses for bread and durum wheat is 2% (with a 95% uncertainty range of 0.1 – 9.5%). [2] • When a single outbreak occurs in an area of 50,000 ha, it is estimated that the total cost will be 454 million euros in 10 years due to the costs mentioned above and phytosanitary controls. If plant health official controls are less implemented and national spread, it is expected to cost 548 million euros. In such a case, if the disease spreads across the EU, then it is foreseen that the cost should be increased by 10 times for 10 years. [5]

	• It stated that the economic loss to occur when *T. indica* entered in Australia was 55 ADB dollars per ton. In this case, it is noted that the smallest share in financial loss will be caused by the loss of yield. [5] • It was estimated that reaction and control costs would constitute 99.5% of the total economic cost of the outbreak of KB in the United Kingdom. Reaction expenditures include the measures to be taken in the product infected with the disease, their costs, and the expenses for their management. [5]
References	[1] CABI, 2024. CABI Compendium. Wallingford, UK: CAB International. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.36168#sec-25. (Accessed Sep. 2024) [2] Baker, R., G. Gilioli, C. Behring, D. Candiani, A. Gogin, T. Kaluski, M. Kinkar et al. "*Tilletia indica* Pest Report to support ranking of EU candidate priority pests." [3] EFSA Panel on Plant Health (PLH). "Scientific opinion on a quantitative pathway analysis of the likelihood of *Tilletia indica* M. introduction into EU with importation of US wheat." EFSA Journal 8, no. 6 (2010): 1621. [4] Marroni, M. V., H. Brown, and S. L. H. Viljanen-Rollinson. "Potential for entry and establishment in New Zealand of *Tilletia indica* the cause of Karnal bunt of wheat." New Zealand Plant Protection 67 (2014): 18-25. [5] Turgay, Emine Burcu, Arzu Çelik Oğuz, and Fatih Ölmez. "Karnal bunt (*Tilletia indica*) in wheat." In Climate Change and Food Security with Emphasis on Wheat, pp. 229-241. Academic Press, 2020.

5. *Tomato brown rugose fruit virus (ToBRFV)*

1. Pest identity	
Taxonomy	Family: Virgoviridae Genus: Tobamovirus [1]
Common name	Tomato brown rugose fruit virus [1]
Biology and Ecology	• Being an obligatory symbiont that does not have an extracellular cycle, the habitat of ToBRFV is that of its main hosts, pepper and tomato. [1] • ToBRFV can be transmitted mechanically through contact, such as by contaminated tools, direct plant-to-plant contact, and propagation materials. The virus is easily spread in greenhouses via common cultural practices (thinning, transplanting etc). [1, 2] • ToBRFV infects the host plants systemically, so all plant tissues contain the virus and can be sources of inoculum for further crops. [1] • The virus can survive in contaminated soils, crop debris and on implements for years. Contaminated soils, irrigation water and nutrient solutions are also potential sources of the virus. [1] • ToBRFV could be carried by bumblebees (*Bombus terrestris*) and mechanically transmitted to healthy tomato plants during pollination and consequently could contribute to disease spread in tomato in glasshouses. On the other hand, transmission of ToBRFV by specific vectors has not been reported. [1, 2] • As for other tobamoviruses, seed transmission of ToBRFV is strongly suspected but has not been confirmed. Contamination of seeds by

	tobamoviruses is mostly external (on the seed surface) and transmission from seed to seedling is low. [1, 2]
11.1. Host range	• So far, the only natural infections officially reported are on tomato (*Solanum lycopersicum*) and pepper (*Capsicum annuum*) crops. The only natural infections of pepper are reported from Mexico, Palestine and Jordan in a mixed infection with Tobacco mild green mosaic virus. [1] • Some symptomless infections are reported on potential weed species present in the same environment as pepper and tomato crops, e.g. *Solanum nigrum* [*S. americanum*] and *Chenopodium murale*, but these reports are from host range inoculation. [1]
12. Geographical Spread	
Pest outbreaks4 (including incursions) are reported in new geographical areas, suggesting a significant expansion of the pest's range.	• The virus was first reported in 2016 from tomato plants grown in greenhouses in Jordan in 2015 [2], then subsequently reported in Israel, Mexico, California (eradicated), Arizona (eradicated), New Jersey, Germany, China, Palestine, Turkey and Italy (Sardinia, Sicily). [1] • As specific detection tests are only recent and considering the interceptions on infected seed in international trade, the pest may be present in countries where it has not been reported yet.[2] • Distribution: Albania, Argentina, Australia, Austria, Belgium, Bulgaria, Canada, China, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, India, Iran, Italy, Jordan, Latvia, Lebanon, Lithuania, Malta, Mexico, Morocco, Netherlands, Norway, Palestine, Poland, Portugal, Saudi Arabia, Slovakia, Slovenia, Spain, Switzerland, Syria, Turkey, UK, US, Uzbekistan, Western Sahara. [1, 2] • The virus in some countries in Europe is under eradication. [1]
13. Population Increase	
A documented and substantial increase in the pest population in an existing area suggests an increased risk of spread and damage.	
14. Economic Impact	
Direct impacts jj. Types, amount and frequency of damage kk. Crop losses, in yield and quality ll. Biotic factors (e.g. adaptability and virulence of the pest)	• The virus can infect up to 100% of the plants in a crop and cause 30-70% loss of tomato yield on plants. Infection can also significantly reduce plant vigour thereby reducing the length of the production period during which tomato fruits are harvested.[2] • Due to the symptoms, the fruits of infected plants lose market value or are unmarketable. Infections may also on occasion lead to premature death of the plant.[2] • Although there are no specific data on the damage caused by ToBRFV, its economic impact (direct and indirect) could be very high because only preventive measures can be applied and there are no curative approaches other than rouguing after the virus has been detected in a specific field/greenhouse. [1]

affecting damage and losses mm. Abiotic factors (e.g. climate) affecting damage and losses nn. Control measures (including existing measures), their efficacy and cost oo. Cost of replanting pp. Effect on existing production practices	• No resistance genes are currently available for tomato (*Solanum lycopersicum*) hybrids and cultivars. [1] • It is not possible to differentiate ToBRFV from other tobamoviruses that infect tomato (*Solanum lycopersicum*) on the basis of symptoms in leaves and fruits, as the symptoms are similar and can be subjective. [1] • ToBRFV-infected plants and propagative parts (seed, cuttings, etc.) can be identified by different methods including biological (local lesion assay), serological and molecular assays. [1] • In addition to direct crop losses, the economic impact is due to the cost of applying hygiene measures, and to the loss of export market for seed and plantlets. [2]
Indirect impacts tt. The presence of the pest affects domestic and export markets, including export market access, and the extent of phytosanitary measures imposed by importing countries uu. Changes to producer costs or input demands, including control costs vv. Changes to domestic or foreign consumer demand for a product resulting from quality changes ww. Feasibility and cost of	• ToBRFV was added to the EPPO Alert List in 2019 and to the EPPO A2 List of pests recommended for regulation as quarantine pests in 2020. It is a quarantine pest for the European Union and other EPPO member countries. [1, 2] • In 2019, the Australian government implemented new emergency measures for imported tomato and pepper seeds. [1] • In 2019, United States Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) issued a Federal Order restricting the importation of tomato and pepper by requiring imported plants, propagative materials and plant products to be free of evidence of ToBRFV infection. [1] • The following aspects contribute to the economic impact of ToBRFV: - Tomato is a high value crop, particularly when grown in greenhouses, in high input, intensive, hydroponic crops, where the economic investment is very high. - ToBRFV causes damage to the plant and fruit. - Higher costs for virus testing and general hygienic measures. - Detection of the virus in new areas may demand an attempt at eradication. - Alternatives to insect pollinators in greenhouses are not economically feasible. - Higher cost for tomato seed production. - After eradication, the best practice would be avoiding re-planting tomatoes however alternative crops may not be as economically rewarding as tomato. [1] • Successful eradication attempts have been reported for the German introduction and the northern Italian introduction. Eradication is feasible for greenhouse crops, and should include:

eradication or containment xx. Capacity to act as a vector for other pests yy. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides zz. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides aaa. Increased human health costs associated to the use of synthetic pesticides bbb. Resources needed for additional research and advice	- destruction of all crop residues, organic substrate, ropes, mulches, by fire (when feasible). - decontamination of all the surfaces with high pressure water with a virus inactivating agent. - decontamination of the hydroponic system with a number of physical and chemical measures. - rotation with non-host plants to break the re-infection cycle from residues. [1] • Eradication is only considered possible if the outbreak is detected early and strict measures are taken. [2]
15. Environmental Impact	
Direct impacts p. Reduction of keystone plant species q. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level	

where there is evidence of such effects being significant) r. Significant reduction, displacement or elimination of other plant species.	
Indirect impacts u. Significant effects on plant communities v. Significant effects on designated environmentally sensitive or protected areas w. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) x. Costs of environmental restoration	
16. Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism	

• Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	
17. Likelihood of Entry into New Areas	
• Number of pathways • Probability of being associated with a pathway • Probability of survival during transport or storage • Probability of pest surviving existing pest management procedures • Probability of transfer to a suitable host • Potential pathways not documented should also be assessed	• Likelihood of entry: Highly likely to be transported internationally accidentally / deliberately [1] • Local spread and entry from countries where the virus occurs will mainly be linked to human assisted mechanical transmission of the pathogen and the movement of infected tomato and pepper plants (seeds, plants for planting and fresh fruits). Containers used to transport infected fruits (even when empty) moved between countries, and persons working in places producing host plants or fixing greenhouses travelling internationally are other possible pathways.[2] • It is assumed that natural dispersal (e.g. with water, pollinating insects and birds) of ToBRFV will generally remain within the same production area, where suitable hosts are available. [2] • ToBRFV can establish in the whole EPPO region wherever tomato and pepper are grown and is likely to cause economic impact at least in crops in protected conditions. [2]
18. Likelihood of Establishment in New Territories	
• Availability, quantity and distribution of hosts • Environmental climatic suitability • Potential for adaptation of the pest • Reproductive strategy of the pest • Method of pest survival • Cultural practices and control measures	• Likelihood of control: Difficult to identify/detect as a commodity contaminant, Difficult to identify/detect in fields, Difficult/costly to control [1] • No chemical treatment can be used to cure infected plants. [1, 2] • All the measures that can be implemented are preventive and can be against the primary infection, or the secondary spread. Primary infection mostly derives from seed or soil contamination therefore the following measures can help in breaking the infection cycle: - Specific instructions for the production of seedlings to certify the absence of the virus. - Disposal of infested plant lots, associated plant debris and other material. - Use of ToBRFV free planting material. - Restriction of access to the production site. - Avoidance of handling and packing tomato fruits in locations that are close to tomato production sites.

	- Restricting the entry of host plants from countries where the virus is present. - Removal of (bumble) beehives. [1, 2]
19. Rate of spread after establishment in new areas	• It has been shown that under experimental greenhouse conditions, only two ToBRFV-infected tomato plants were necessary to quickly spread the infection to almost all plants in a greenhouse (0.05 ha), where 1.45%, 80%, and up to 100% of the tomato plants were infected after 1 month, 4 months, and 8 months (the end of the cultivation period), respectively. [3] • In another study, the maximum incidence of ToBRFV (100%) was reached in 4 months under commercial greenhouse conditions, where cultural practices were carried out more frequently, favoring the mechanical transmission of ToBRFV. [3]
20. Scale of impacts in new areas	
References	[1] CABI, 2024. CABI Compendium. Wallingford, UK: CAB International. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.88757522. (Accessed Sep. 2024) [2] EPPO (2024) EPPO Global Database. https://gd.eppo.int (Accessed Sep. 2024) [3] Salem, Nida'M., Ahmad Jewehan, Miguel A. Aranda, and Adrian Fox. "Tomato brown rugose fruit virus pandemic." Annual review of phytopathology 61, no. 1 (2023): 137-164.

6. *Tuta absoluta* (Meyrick)

2. Pest identity	
20.1. Taxonomy	Order: Lepidoptera Family: Gelechiidae [1]
20.2. Common name	tomato borer, South American tomato moth, tomato leaf miner, South American tomato pinworm [1]
20.3. Biology and Ecology	• The duration of the different life stages are: - Eggs – 6 days - 4 larval stages – total 20 days - Pupa – 10 days - Adult moth – 7 to 8 days [2] • The larval stages penetrate into leaves, stems and tomato fruits and create conspicuous mines and galleries. All stages of the tomato plant can be attacked. The 3rd and 4th larval stage is very mobile and can also be found outside mines. [2] • *T. absoluta* can feed on aerial parts of potato. Tubers of potato are not affected. [2] • In South America, *T. absoluta* has a neotropical distribution. Development stops between 6-9 °C. *T. absoluta* is generally considered to not occur in colder climates, e.g. in the Andes not above 1000m. However, findings have been made at higher altitudes than this, the holotype having being taken in Peru at 3500m. [2] • No data are known on minimum temperatures. [2]

	• In greenhouses with tomato production *T. absoluta* can have 9 generations. [2]
20.4. Host range	• *Amaranthus spinosus, Beta vulgaris, Blitum bonus-henricus, Citrullus lanatus, Datura ferox, D. stramonium, Jatropha curcas, Lycium chilense, Medicago sativa, Nicotiana glauca, Oxybasis rubra, Phaseolus vulgaris, Solanum aethiopicum, S. arcanum, S. coagulans, S. elaeagnifolium, S. habrochaites, S. lycopersicum, S. lyratum, S. melongena, S. muricatum, S. nigrum, S. peruvianum, S. pimpinellifolium, S. sarrachoides, S. tuberosum, Spinacia oleracea, Xanthium strumarium* [1] • Main host plant of *T. absoluta* is tomato, but the pest has also been reported on above ground parts of potato, aubergine and several Solanaceae weeds. [2]
21. Geographical Spread	
Pest outbreaks4 (including incursions) are reported in new geographical areas, suggesting a significant expansion of the pest's range.	• In 2008 Spain reported several outbreaks of *T. absoluta* on tomato plants in some regions, and further outbreaks have since been reported in the Mediterranean region. [2] • Distribution: Africa – Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Democratic Republic of the Congo, Cote d'Ivoire, Egypt, Equatorial Guinea, Ethiopia, Ghana, Kenya, Lesotho, Libya, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome & Principe, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe America – Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Haiti, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela Asia – Afghanistan, Bangladesh, China, India, Iran, Iraq, Israel, Jordan, Kazakhstan, Kyrgyzstan, Myanmar, Nepal, Pakistan, Qatar, Saudi Arabia, Syria, Tajikistan, Thailand, Turkmenistan, United Arab Emirates, Uzbekistan, Yemen Europe – Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, France, Georgia, Germany (Transient), Greece, Guernsey, Hungary, Italy, Lithuania, Malta, Moldova, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Switzerland, Türkiye, UK, Ukraine [1]
22. Population Increase	
A documented and substantial increase in the pest population in an existing area suggests an increased risk of spread and damage.	• The tomato pinworm is a multivoltine species, showing high reproductive potential because of its adaptability which allows the pest population to increase very quickly. [3]
23. Economic Impact	
Direct impacts qq. Types, amount and frequency of damage	• *T. absoluta* is the most important pest of tomato in South America, both in the field and in greenhouses. Without any control measure the potential damage may be 100%, especially at high population densities at the end of the

rr. Crop losses, in yield and quality ss. Biotic factors (e.g. adaptability and virulence of the pest) affecting damage and losses tt. Abiotic factors (e.g. climate) affecting damage and losses uu. Control measures (including existing measures), their efficacy and cost vv. Cost of replanting ww. Effect on existing production practices	growing season. Both yield and fruit quality can be significantly reduced and crop losses up to 100% have been reported. Also in Spain, crop losses up to 100% have been reported in 2008. [2] • In areas where the emergency measures were applied the damage levels were considerably lower and integrated crop management (biological control and pollination) was not disrupted. [2] • *T. absoluta* has several qualities that render the species difficult to control. It has a short generation time, it is very flexible in pupation site, and larvae mine inside plant tissues, including fruits. The mining habit will probably decrease the efficacy of insecticide application since the insecticides will not hit larvae that mine in fruits. [2] • It is expected that insecticidal control of *T. absoluta* will disrupt ICM practice, because the insecticides that are probably needed to control the pest negatively affect biological control agents and bumble bees. As a consequence, growers will have to revert to labour intensive mechanical pollination and will also have to control other pests using insecticides instead of biological control agents. [2] • As control measures, monitoring/trapping/mating disruption using pheromone lures, chemical/bio pesticides, biological control are available. [4]
Indirect impacts ccc. The presence of the pest affects domestic and export markets, including export market access, and the extent of phytosanitary measures imposed by importing countries ddd. Changes to producer costs or input demands, including control costs eee. Changes to domestic or foreign consumer demand for a product resulting from quality changes fff. Feasibility and cost of eradication or containment ggg. Capacity to act as a vector for other pests hhh. Effects of new control measures such as secondary pest outbreaks from the use of wide spectrum pesticides iii. Effects on crop yields due to reduction of pollinators from the use of wide spectrum insecticides	• Unacceptable levels of cosmetic fruit damage may occur in fresh market tomato production due to the mining habit of the organism. [2] • The introduction of *T. absoluta* is expected to lead to an increased use of chemical pesticides. [2] • In a worstcase scenario that all greenhouses would become infested, it is estimated that 13 - 15 extra insecticide treatments are necessary to fully control *T. absoluta* in a Dutch greenhouse. The estimated costs of these extra insecticide treatments are € 4 million per year for the NL. [2] • The success of eradication depends on how widely the pest is distributed when it is found for the first time. Eradication seems impossible when the pest is able to survive outdoors on weedy host plants. Successful eradication of incidental outbreaks in greenhouses is probably possible, with strict insecticidal control and/or crop removal. There is no information available on examples of successful eradication in greenhouses. [2] • Application of insecticides, Steward (indoxacarb) and Tracer (spinosad), will partly disrupt existing integrated crop management systems. Disruption of the integrated crop management system will have serious economic impact, because (a) bumblebees cannot be applied for pollination during a period of about 3 days after application and companies have to revert to labour intensive mechanical pollination during this period, and (b) biological control is

jjj. Increased human health costs associated to the use of synthetic pesticides kkk. Resources needed for additional research and advice	disrupted and pesticides have to be applied against pests which are usually controlled biologically. [2] • Pollinators are also the unintentional targets of pesticide use in tomatoes, where pollination enhances fruit production and pesticide use can compromise such economic and environmental service. [3]
24. Environmental Impact	
Direct impacts s. Reduction of keystone plant species t. Reduction of plant species that are major components of ecosystems (in terms of abundance or size), and endangered native plant species (including effects below species level where there is evidence of such effects being significant) u. Significant reduction, displacement or elimination of other plant species.	
Indirect impacts y. Significant effects on plant communities z. Significant effects on designated environmentally sensitive or protected areas aa. Significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling) bb. Costs of environmental restoration	
25. Social Impact	
• Loss of jobs • Social unrest due to necessary interventions to contain and eradicate the emerging pest • Tourism • Public and private gardens • Plants of national importance • Recreation (e.g., fishing) • Risks to food safety or food security	•

<table>
<tr><td>26. Likelihood of Entry into New Areas</td><td></td></tr>
<tr><td>• Number of pathways
• Probability of being associated with a pathway
• Probability of survival during transport or storage
• Probability of pest surviving existing pest management procedures
• Probability of transfer to a suitable host
• Potential pathways not documented should also be assessed</td><td>• Identified pathways and probability of entry
- Fruits imported from regions where the pest is present: high
- Packaging material and transportation vehicles: Medium
- Plants for planting of tomato or aubergine: Very low
- Plants for planting of ornamental Solanaceae: Low/Medium (highly uncertain)
- Passenger luggage: Very low [2]
• In case of fruits imported from regions the pest is present, the probability of arrival of infested consignments is high, especially for vine tomatoes.
• Tomato consignments are present for several days to weeks at packing stations before being fully processed. If the organism arrives in a late larval stage or as pupa it can develop into a moth at a packing station and escape. Escaped moths may find tomato greenhouses in the neighbourhood of the packing station. [2]
• The probability that the organism escapes from fresh market tomatoes in trade and successfully transfers to tomato production places is medium in cases where these companies are separated and medium - high in cases where these activities are done by the same company.[2]
• The susceptibility of insecticides has been monitored over the past few years in Europe, and subsequent intensification of resistance to different active ingredients. In Italy, after less than 5 years of the T. absoluta arrival, the pest population was more than 1000-fold resistant to chlorantraniliprole and flubendiamide, as well as showing cross resistance to both compounds. [3]</td></tr>
<tr><td>27. Likelihood of Establishment in New Territories</td><td></td></tr>
<tr><td>• Availability, quantity and distribution of hosts
• Environmental climatic suitability
• Potential for adaptation of the pest
• Reproductive strategy of the pest
• Method of pest survival
• Cultural practices and control measures</td><td>• In greenhouses with tomato production T. absoluta can have 9 generations. [2]
• Threshold temperatures and temperature sums needed for development of different life stages of T. absoluta (DD = Day Degree) [2]:
<table>
<tr><th></th><th colspan="2">Research A</th><th colspan="2">Research B</th></tr>
<tr><td>Egg</td><td>9.7 °C</td><td>72 DD</td><td>6.9 °C</td><td>104 DD</td></tr>
<tr><td>Larva</td><td>6.0 °C</td><td>267 DD</td><td>7.6 °C</td><td>239 DD</td></tr>
<tr><td>Pupa</td><td>9.1 °C</td><td>131 DD</td><td>9.2 °C</td><td>117 DD</td></tr>
<tr><td>Egg-Adult</td><td></td><td></td><td>8.1 °C</td><td>460 DD</td></tr>
</table></td></tr>
<tr><td>28. Rate of spread after establishment in new areas</td><td>• The current environmental suitability model predicts suitable conditions exist in South and Central America, southern</td></tr>
</table>

	Europe, and parts of Australia and East Africa (Figure 6). The simulations suggest the potential worldwide spread of *T. absoluta* to all key tomato growing regions. [4] • *T. absoluta* moths have been trapped in some areas with few or no tomato crops, and urban environments. This suggests high mobility of moth populations and capacity to survive in harsh environments, and to persist on alternative host plants. [4] • When first reported in North Africa, *T. absoluta* has spread at an average speed of 800 km per year both eastward and southward to increasing numbers of sub-Saharan countries, where it has become a major pest of tomato and other Solanaceae. [4]
29. Scale of impacts in new areas	• The economic consequences of establishment of the organism for the Netherland tomato sector can be high: € 5-25 million/year due to crop losses and € 4 million/year due to pest management in a worst-case scenario. [2]
References	[1] EPPO (2024) EPPO Global Database. https://gd.eppo.int (Accessed Sep. 2024) [2] Potting, R.P.J. , D. J. van der Gaag, A. Loomans, M. van der Straten, H. Anderson, A. MacLeod, J. M. G. Castrillón, and G. V. Cambra. (2013). *Tuta absoluta*, Tomato leaf miner moth or South American tomato moth. Ministry of Agriculture, Nature and Food Quality, Plant Protection Service of the Netherlands. [3] Campos, Mateus R., Antonio Biondi, Abhijin Adiga, Raul NC Guedes, and Nicolas Desneux. "From the Western Palaearctic region to beyond: *Tuta absoluta* 10 years after invading Europe." Journal of Pest Science 90 (2017): 787-796. [4] Rwomushana, Ivan, Tim Beale, Gilson Chipabika, Roger Day, Pablo Gonzalez-Moreno, Julien Lamontagne-Godwin, Fernadis Makale, Corin Pratt, and Justice Tambo. "Tomato leafminer (*Tuta absoluta*): impacts and coping strategies for Africa." (2019): 56-pp.