EPPO Datasheet: *Spodoptera frugiperda*

Last updated: 2020-06-25

IDENTITY

Preferred name: *Spodoptera frugiperda*
Authority: (Smith)
Taxonomic position: Animalia: Arthropoda: Hexapoda: Insecta: Lepidoptera: Noctuidae
Other scientific names: *Laphygma frugiperda* (Smith)
Common names: corn leaf worm (US), fall armyworm (US), grass worm, southern grass worm
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EPPO Categorization: A2 list
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EU Categorization: Emergency measures, A1 Quarantine pest (Annex II A)
EPPO Code: LAPHFR

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Notes on taxonomy and nomenclature

The species was first described in 1797 as *Phalaena frugiperda*, in 1852 it was assigned to the genus *Laphygma* (Luginbill, 1928), finally, in 1958 the genus *Laphygma* and *Spodoptera* were synonymized and since then, the valid name is *Spodoptera frugiperda*.

HOSTS

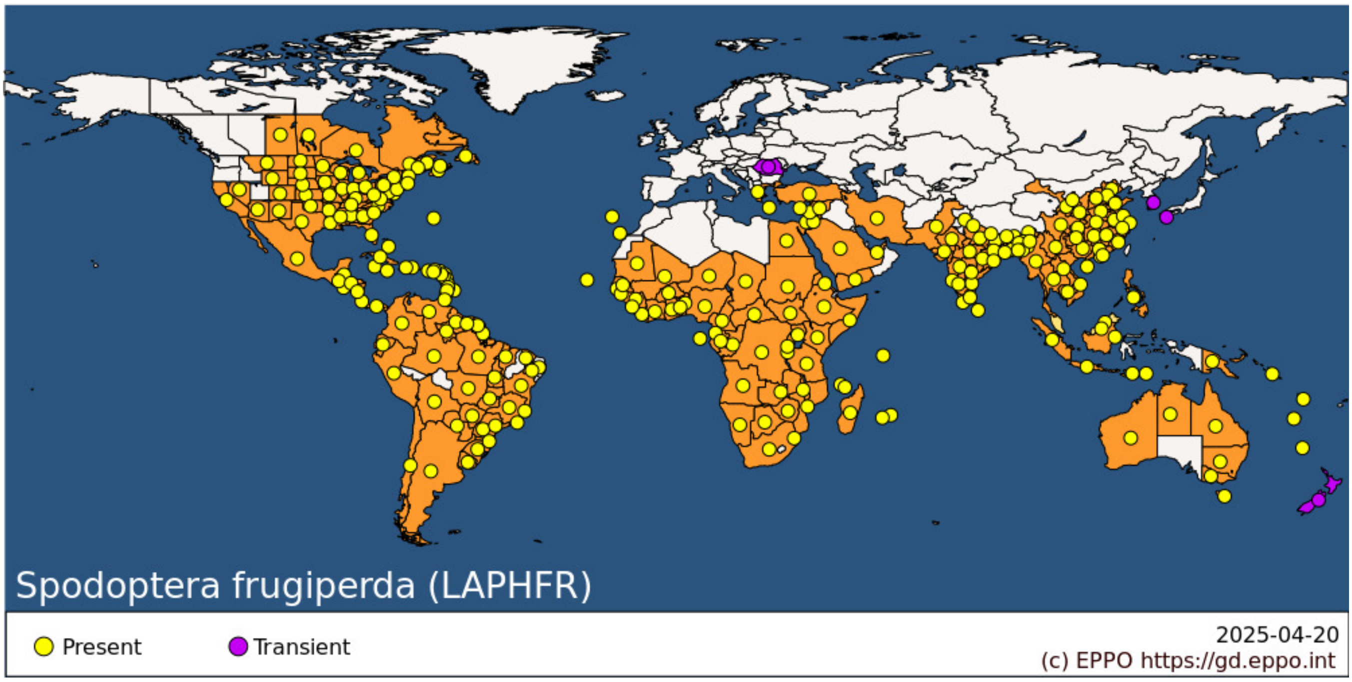
Spodoptera frugiperda is a polyphagous pest with a host range (observed in the Americas) of 353 plants belonging to 76 families, mainly Poaceae, Asteraceae and Fabaceae (Montezano *et al*., 2018). The greatest damage is observed in grasses, particularly maize and sorghum, which are the main hosts, along with other crops, such as rice, cotton and soybean (Casmuz *et al.*, 2010; Montezano *et al.*, 2018). In addition to crop species the pest also attacks ornamental plants (such as chrysanthemums, carnations, geraniums) and weeds (Montezano *et al*., 2018). Non-crop species are particularly important as they maintain pest populations in the environment during the non-cropping season and outside the cropping areas (Montezano *et al*., 2018). In recently invaded countries in Africa and Asia the pest damages mainly maize and, to a lesser degree, sorghum, sugarcane, and other crops (Vennila *et al*., 2019).

Host list: *Abelmoschus esculentus*, *Acacia mearnsii*, *Acalypha sp.*, *Acanthospermum hispidum*, *Ageratum conyzoides*, *Agrostis gigantea*, *Agrostis hyemalis*, *Agrostis stolonifera*, *Alcea rosea*, *Allium cepa*, *Allium fistulosum*, *Allium sativum*, *Aloe vera*, *Alternanthera ficoidea*, *Amaranthus dubius*, *Amaranthus hybridus*, *Amaranthus quitensis*, *Amaranthus spinosus*, *Amaranthus viridis*, *Andropogon leucostachyus*, *Andropogon virginicus*, *Arachis hypogaea*, *Arachis pintoi*, *Asclepias sp.*, *Asparagus officinalis*, *Asplenium nidus*, *Aster sp.*, *Atropa belladonna*, *Avena byzantina*, *Avena sativa*, *Avena strigosa*, *Axonopus compressus*, *Axonopus fissifolius*, *Baccharis dracunculifolia*, *Baccharis neglecta*, *Begonia rex*, *Beta vulgaris subsp. vulgaris var. cicla*, *Beta vulgaris*, *Bidens alba*, *Bidens pilosa*, *Boerhavia erecta*, *Bothriochloa pertusa*, *Brachiaria plantaginea*, *Brachiaria platyphylla*, *Brassica napus*, *Brassica oleracea var. botrytis*, *Brassica oleracea var. capitata*, *Brassica oleracea var. italica*, *Brassica oleracea var. viridis*, *Brassica rapa subsp. chinensis*, *Brassica rapa*, *Briza lamarckiana*, *Briza minor*, *Bromus catharticus*, *Brugmansia x candida*, *Cajanus cajan*, *Calendula officinalis*, *Campanula sp.*, *Canavalia ensiformis*, *Capsicum annuum*, *Carduus sp.*, *Carex sp.*, *Carica papaya*, *Carissa sp.*, *Carthamus tinctorius*, *Carya illinoinensis*, *Celosia argentea*, *Celtis iguanaea*, *Cenchrus americanus*, *Cenchrus clandestinus*, *Cenchrus echinatus*, *Cenchrus purpureus*, *Cenchrus spinifex*, *Cenchrus tribuloides*, *Cereus hildmannianus*, *Chamaerops humilis*, *Chenopodium album*, *Chenopodium quinoa*, *Chloris barbata*, *Chloris gayana*, *Chrysanthemum x morifolium*, *Chusquea lorentziana*, *Cicer arietinum*, *Cichorium endivia*, *Cichorium intybus*, *Cipura campanulata*, *Citrullus lanatus*, *Citrus reticulata*, *Citrus x aurantium var. paradisi*, *Citrus x aurantium var. sinensis*, *Citrus x aurantium var. unshiu*, *Citrus x aurantium*, *Citrus x limon*, *Cocos nucifera*, *Codiaeum variegatum*, *Coffea arabica*, *Commelina benghalensis*, *Commelina diffusa*, *Commelina erecta*

, *Convolvulus arvensis*, *Corchorus capsularis*, *Corchorus olitorius*, *Coriandrum sativum*, *Cortaderia selloana*, *Crotalaria breviflora*, *Crotalaria juncea*, *Crotalaria spectabilis*, *Croton capitatus*, *Cucumis melo*, *Cucumis sativus*, *Cucurbita argyrosperma*, *Cucurbita maxima*, *Cucurbita pepo*, *Cydonia oblonga*, *Cynara cardunculus*, *Cynara scolymus*, *Cynodon dactylon*, *Cynodon nlemfuensis*, *Cynodon plectostachyus*, *Cyperus compressus*, *Cyperus esculentus*, *Cyperus papyrus*, *Cyperus retrorsus*, *Cyperus rotundus*, *Cyperus sesquiflorus*, *Dactyloctenium aegyptium*, *Dahlia pinnata*, *Daucus carota*, *Daucus pusillus*, *Desmodium adscendens*, *Dianthus caryophyllus*, *Dichanthium aristatum*, *Digitaria aequiglumis*, *Digitaria ciliaris*, *Digitaria connivens*, *Digitaria didactyla*, *Digitaria eriantha*, *Digitaria horizontalis*, *Digitaria ischaemum*, *Digitaria pseudodiagonalis*, *Digitaria sanguinalis*, *Diospyros kaki*, *Echinochloa colonum*, *Echinochloa crus-galli*, *Elaeis guineensis*, *Eleusine coracana*, *Eleusine indica*, *Eleusine tristachya*, *Elymus repens*, *Eragrostis airoides*, *Erechtites hieraciifolius*, *Erechtites valerianifolius*, *Eremochloa ophiuroides*, *Erigeron canadensis*, *Eriochloa polystachya*, *Eryngium foetidum*, *Eryngium horridum*, *Eryngium megapotamicum*, *Eucalyptus camaldulensis*, *Eucalyptus robusta*, *Eucalyptus urophylla*, *Eustachys distichophylla*, *Fagopyrum esculentum*, *Festuca arvernensis*, *Fevillea cordifolia*, *Ficus carica*, *Fimbristylis littoralis*, *Fragaria chiloensis*, *Fragaria vesca*, *Fragaria x ananassa*, *Geranium sp.*, *Gerbera jamesonii*, *Gladiolus x gandavensis*, *Glycine max*, *Gossypium hirsutum*, *Helianthus annuus*, *Hemarthria altissima*, *Hevea brasiliensis*, *Hibiscus cannabinus*, *Hordeum vulgare*, *Ilex paraguariensis*, *Impatiens walleriana*, *Ipomoea aquatica*, *Ipomoea batatas*, *Ipomoea grandiflora*, *Ipomoea purpurea*, *Ipomoea triloba*, *Jatropha curcas*, *Juglans regia*, *Kummerowia striata*, *Lactuca sativa*, *Lagerstroemia*, *Leea coccinea*, *Leonurus japonicus*, *Lepidium didymum*, *Leptochloa mucronata*, *Lespedeza bicolor*, *Lespedeza thunbergii*, *Linum usitatissimum*, *Lolium arundinaceum*, *Lolium multiflorum*, *Luffa aegyptiaca*, *Lupinus albus*, *Malpighia glabra*, *Malus domestica*, *Mangifera indica*, *Manihot esculenta*, *Maranta arundinacea*, *Maranta leuconeura*, *Medicago sativa*, *Megathyrsus maximus*, *Melicoccus bijugatus*, *Melilotus officinalis*, *Melinis minutiflora*, *Melinis repens*, *Melissa officinalis*, *Mirabilis jalapa*, *Miscanthus x giganteus*, *Mitracarpus hirtus*, *Mucuna deeringiana*, *Muehlenbeckia sagittifolia*, *Musa sp.*, *Musa x paradisiaca*, *Nicotiana tabacum*, *Ocimum basilicum*, *Onosmodium virginianum*, *Oryza latifolia*, *Oryza sativa*, *Oxalis divaricata*, *Oxalis eriocarpa*, *Pandanus sp.*, *Panicum dichotomiflorum*, *Panicum laxum*, *Panicum miliaceum*, *Panicum virgatum*, *Pascalia glauca*, *Paspalum conjugatum*, *Paspalum cromyorhizon*, *Paspalum dilatatum*, *Paspalum distichum*, *Paspalum exaltatum*, *Paspalum fimbriatum*, *Paspalum notatum*, *Paspalum pumilum*, *Paspalum stellatum*, *Paspalum urvillei*, *Paspalum vaginatum*, *Passiflora alata*, *Passiflora edulis*, *Passiflora laurifolia*, *Pavonia cancellata*, *Pelargonium x hortorum*, *Persea americana*, *Phalaris angusta*, *Phalaris canariensis*, *Phaseolus lunatus*, *Phaseolus vulgaris*, *Philodendron cordatum*, *Phleum pratense*, *Phoenix roebelenii*, *Phytolacca sp.*, *Pinus caribaea*, *Piper sp.*, *Pisum sativum*, *Pittosporum tobira*, *Plantago tomentosa*, *Platanus occidentalis*, *Plumeria rubra*, *Poa annua*, *Poa pratensis*, *Pontederia crassipes*, *Portulaca oleracea*, *Prunus persica*, *Psidium guajava*, *Pueraria montana var. lobata*, *Pyrus communis*, *Raphanus raphanistrum*, *Raphanus sativus*, *Richardia grandiflora*, *Ricinus communis*, *Rosa sp.*, *Rumex crispus*, *Saccharum angustifolium*, *Saccharum officinarum*, *Schizachyrium tenerum*, *Secale cereale*, *Sechium edule*, *Senecio brasiliensis*, *Senna obtusifolia*, *Sesamum indicum*, *Setaria italica*, *Setaria parviflora*, *Setaria viridis*, *Sida cordifolia*, *Sida rhombifolia*, *Sidastrum paniculatum*, *Solanum aethiopicum*, *Solanum dulcamara*, *Solanum lycopersicum*, *Solanum macrocarpon*, *Solanum melongena*, *Solanum sisymbriifolium*, *Solanum tuberosum*, *Sonchus oleraceus*, *Sorghum arundinaceum*, *Sorghum bicolor*, *Sorghum halepense*, *Sorghum x drummondii*, *Spathoglottis plicata*, *Spermacoce latifolia*, *Spinacia oleracea*, *Sporobolus indicus*, *Stachytarpheta cayennensis*, *Stenotaphrum secundatum*, *Stylosanthes guianensis*, *Talinum paniculatum*, *Tanacetum cinerariifolium*, *Taraxacum officinale*, *Terminalia catappa*, *Thalia geniculata*, *Theobroma cacao*, *Tradescantia pallida*, *Tradescantia zebrina var. zebrina*, *Tragopogon porrifolius*, *Trianthema portulacastrum*, *Trifolium incarnatum*, *Trifolium polymorphum*, *Trifolium pratense*, *Trifolium repens*, *Triticum aestivum*, *Urera aurantiaca*, *Urochloa arrecta*, *Urochloa brizantha*, *Urochloa eminii*, *Urochloa fusca*, *Urochloa mutica*, *Urochloa ramosa*, *Urochloa texana*, *Vaccinium corymbosum*, *Vaccinium macrocarpon*, *Vaccinium oxycoccos*, *Verbascum virgatum*, *Vernicia fordii*, *Vicia faba*, *Vigna unguiculata subsp. sesquipedalis*, *Vigna unguiculata subsp. unguiculata*, *Vigna unguiculata*, *Viola sp.*, *Vitis vinifera*, *Wisteria sinensis*, *Xanthium orientale subsp. italicum*, *Yucca gigantea*, *Zea luxurians*, *Zea mays*, *Zea mexicana*, *Zingiber officinale*, *Zoysia sp.*

GEOGRAPHICAL DISTRIBUTION

S. frugiperda is native to tropical-subtropical areas of the Americas and during summer it migrates into southern and northern temperate American regions (Sparks, 1979). The pest was first reported in West Africa in 2016 (IITA, 2016), and over the next two years it spread throughout sub-Saharan Africa, and then reached Egypt in 2019 (Vennila *et al.*, 2019). In 2018, *S. frugiperda* was reported in India, rapidly spreading all over the country with the exception of the northernmost provinces (Repalle *et al.*, 2020). In the same year it was also reported in Yemen, Bangladesh, Myanmar, Sri Lanka, Thailand, and more recently (2019), in China, South Korea, Japan (Vennila *et al.*, 2019), Pakistan (Naeem-Ullah *et al.*, 2019), Laos (FAO, 2019), Philippines (IPPC, 2019), Indonesia (EPPO, 2019), and Vietnam (USDA GAIN report, 2019). During the first months of 2020 it was captured in traps from the islands of Saibai and Erub in Torres Strait (IPPC, 2020) and in mainland Australia (Queensland Government, 2020).



EPPO Region: Cyprus, Greece (mainland, Kriti), Israel, Jordan, Portugal (Madeira), Romania, Spain (Islas Canárias), Türkiye
Africa: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Congo, The Democratic Republic of the, Cote d'Ivoire, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, United Republic of, Togo, Uganda, Zambia, Zimbabwe
Asia: Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China (Anhui, Aomen (Macau), Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Ningxia, Shaanxi, Shandong, Shanghai, Shanxi, Sichuan, Xianggang (Hong Kong), Yunnan, Zhejiang), East Timor, India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Jharkand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tamil Nadu, Telangana, Tripura, Uttarakhand, Uttar Pradesh, West Bengal), Indonesia (Java, Kalimantan, Nusa Tenggara, Sumatra), Iran, Islamic Republic of, Israel, Japan (Kyushu), Jordan, Korea, Republic of, Lao People's Democratic Republic, Lebanon, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Syrian Arab Republic, Thailand, United Arab Emirates, Vietnam, Yemen
North America: Canada (Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan), Mexico, United States of America (Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, Wisconsin, Wyoming)
Central America and Caribbean: Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Virgin Islands (British), Virgin Islands (US)
South America: Argentina, Bolivia, Brazil (Amapa, Amazonas, Bahia, Ceara, Espirito Santo, Goias, Maranhao, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Para, Paraiba, Parana, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Roraima, Santa Catarina, Sao Paulo, Tocantins), Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay,

Peru, Suriname, Uruguay, Venezuela
Oceania: Australia (New South Wales, Northern Territory, Queensland, Tasmania, Victoria, Western Australia), New Caledonia, New Zealand, Norfolk Island, Papua New Guinea, Solomon Islands, Vanuatu

BIOLOGY

S. frugiperda is a highly fecund species, 900-1000 eggs can be laid by each female in tight clusters of 100-300 usually covered with a protective layer of abdominal bristles (Johnson, 1987). Usually egg-masses are stuck on the underside of leaves, however, at high population densities almost any surface can be used (Sparks, 1979). On maize, the young larvae feed together deep in the whorl, causing a characteristic skeletonizing or 'windowing' effect. In following instars larval behaviour changes, larvae become cannibalistic (Chapman *et al*., 1999) and disperse onto neighbouring plants, thus only very few older larvae per plant are typically found (Pannuti *et al.*, 2016). After six (or five) larval instars, larvae pupate inside a loose cocoon in an earthen cell, or rarely between leaves on the host plant. Adults emerge at night, and they can fly for many kilometres before laying eggs, sometimes migrating for long distances (Cock *et al*., 2017). The development period from egg to adult depends on host species (Silva *et al*., 2017) and temperatures, ranging from 71 days at 18°C to 20 days at 32°C on maize (Du Plessis *et al.*, 2020). *S. frugiperda* is a tropical species, adapted to warmer climates and not able to enter diapause (Barfield & Ashley, 1987), hence, its geographic distribution is closely dependent on climate conditions (Garcia *et al*., 2018). Its optimal temperature range for egg-to-adult development is between 26 and 30°C, with a minimum threshold of about 12 °C (Du Plessis *et al*., 2020) and an upper temperature threshold of 38-40°C (Barfield & Ashley, 1987). In areas where winter temperatures as low as 10 °C are rare, *S. frugiperda* can breed year round, with four to six generations per year, while in colder regions only one to two generations occur and populations migrate to overwinter in warmer and mild areas (Westbrook *et al.*, 2016; Jeger *et al*., 2017).

Two strains of *S. frugiperda*, distinguishable only by molecular methods, are known: the maize and rice strains (Pashley *et al.*, 1985). These strains are widely distributed in the native range (Ríos-Díez *et al*., 2012), where they show different host plant preference (rice strain: grasses and rice; maize strain: maize, sorghum, and cotton), as well as, different dispersal patterns and different susceptibility to pesticides (Pashley, 1988; Pashley *et al.*, 1992; Ríos-Díez *et al*., 2012). In Africa, India, Myanmar, and China both strains are reported (Ramasamy *et al*., 2018; Swamy *et al*., 2018; Assefa, 2019; Nagoshi, 2019; Liu *et al*., 2019), and the presence of an inter-strain hybrid has recently been suggested (Nagoshi *et al.*, 2019; 2020).

DETECTION AND IDENTIFICATION

Symptoms

Maize leaves are eaten and the whorl (funnel) may be a mass of holes, ragged edges and larval frass. Young larvae skeletonize the leaf lamina. Plants up to 30 days old can be cut through at the base by large larvae. Older plants may have the cobs attacked by larvae boring through the kernels. On tomato plants, buds and growing points may be eaten and fruits pierced. At high densities, large larvae disperse in swarms, but they often remain on wild grasses, if available (CABI, 2020).

Morphology

Eggs

Subspherical in shape (0.45 x 0.35 mm), stuck on the underside of leaves in groups of 100-300, sometimes in two layers. The egg mass is usually covered with a protective, felt-like layer of grey-pink scales (setae) from the female abdomen. Up to 1000 eggs may be laid by each female.

Larva

On hatching they are green with black lines and spots, and as they grow, they either remain green or become buff-brown and have black dorsal and spiracular lines. If crowded (by a high population density and food shortage) the final instar can be almost black in its armyworm phase. Fully grown larvae are 35-40 mm in length. Large larvae are characterized by an inverted Y-shape in yellow on the head, black dorsal pinaculae with long primary setae (two each side of each segment within the pale dorsal zone) and four black spots arranged in a square on the last abdominal segment. There are usually six larval instars, occasionally five. A full description of the larvae is given in Crumb (1956). Diagnostic features are given by Levy & Habeck (1976), and good pictures are available in the EPPO Diagnostic protocol PM 7/124 (EPPO, 2015).

Pupa

A typical brown, shiny noctuid pupa, 18-20 mm in length.

Adult

A sturdy grey-brown moth with a wing-span of 32-38 mm; the forewings are grey to grey-brown in the female, but in the male they are darker with dark markings and pale streaks; the hindwings are white. Adults of *S. frugiperda* might be confused with those of *S. exempta* and *S. littoralis*. In *S. frugiperda* the veins of the hindwing are brown and distinct, and in the male forewing the pale orbicular stigma has a pronounced pale 'tail' distally. In the male genitalia the valve is almost rectangular and there is no marginal notch at the position of the tip of the harpe; the female bursa lacks a signum. Details of the African species of *Spodoptera* are given by Brown & Dewhurst (1975), and keys to moths of the genus *Spodoptera* in the Western Hemisphere are given by Todd & Poole (1980), and, more recently, a world revision of the genus was made by Pogue (2002; 2011).

Detection and inspection methods

Symptoms caused by the larvae are similar for most leaf-eating Lepidoptera. All stages of the pest can be detected visually, specimens can be collected directly from infested plants or with the aid of light traps and pheromone baited traps.

The species can be identified both morphologically and molecularly. A reliable morphological identification is best carried out on adult stages. Morphological identification is less time-consuming than molecular identification, and in addition it can be done with relatively simple equipment and very few chemicals. For morphological and molecular identification see the EPPO Diagnostic protocol PM 7/124 (EPPO, 2015).

PATHWAYS FOR MOVEMENT

This species has a strong flight capacity, adults were reported to fly 100 km per night (Johnson, 1987). the species is a regular annual migrant in the Americas, dispersing throughout the USA and flying up into southern Canada virtually every summer (Westbrook *et al*., 2016). The use of the pre-oviposition (maturation) period for widespread dispersal seems to be very effective.

Larvae and pupae of *S. frugiperda* can be accidentally transported as contaminants of traded commodities, especially in parts of plants. In fact, larvae were intercepted in various occasions in Europe on vegetables or fruit from the Americas by air; and sometimes on herbaceous ornamentals (Seymour *et al*., 1985; Cock *et al*., 2017). In addition, the pest (adults or eggs) can travel as a stowaway on international flights. This is confirmed by the interceptions of *S. frugiperda* egg masses found in various parts of aircrafts coming from Central and South America (Cock *et al*., 2017).

PEST SIGNIFICANCE

Economic impact

Damage results from leaf-eating, and healthy plants usually recover quite quickly, but a large pest population can cause defoliation; the larvae then migrate to adjacent areas. Large larvae can cause extensive destruction of seedlings and young plants by cutting the stem. On larger plants the ears of maize may be attacked by larvae boring through the kernels; similarly, tomato fruits may be bored.

In the Americas the pest is considered an economically important pest of cultivated crops (Ellis, 2005), particularly maize, rice, sorghum, and sugarcane (Jeger *et al*., 2017): in the south-eastern states of the USA, during the period 1975-1983 it caused annual average yield loss of 60 million USD (Sparks, 1986) and in Brazil it is considered the most important pest of maize (IITA, 2016). In Kenya, losses of about a third of the annual maize production were estimated (De Groote *et al.*, 2020). Recently *S. frugiperda* has been considered by FAO as a potential food chain threat for Africa, Asia and Oceania (FAO, 2020). Concerning the EPPO region, the area most suitable for the pest establishment is the far south of Spain, Portugal, Italy and Greece and Cyprus, where it has been estimated that if the pest were to establish it could have four generations per year. In these areas, *S. frugiperda* could cause yield and quality losses in crops such as maize and rice (Jeger *et al*., 2017).

Control

On maize, if 5% of seedling plants are cut or 20% whorls of small plants (during the first 30 days) infested, insecticide application is recommended (King & Saunders, 1984); on sorghum the pest threshold level is regarded as one (or two) larvae per leaf whorl and two per head (Pitre, 1985). In some areas resistance to insecticides may be widespread and control can be difficult, therefore, rotation of pesticides with different modes of action is recommended to reduce risk of resistance development (Pitre, 1985; Abrahams *et al.*, 2017; Kanno *et al*., 2020).

A large number of parasitic Hymenoptera, as larval parasitoids, have been reared from *S. frugiperda*, and many predators are recorded; thus it appears that natural control is usually of considerable importance. Natural levels of larval parasitism are often very high (20-70%), mostly involving braconid wasps and to a lesser degree pathogens (Wheeler *et al*., 1989; Rios-Velasco *et al.*, 2011). In South America, egg parasitoids for *S. frugiperda* control are produced commercially, among them the egg parasitoid, *Telenomus remus*, seems the most promising for classical biological control (Abrahams *et al*., 2017). Virus-based biopesticides effective against the pest are available in the United States of America and Brazil (Abrahams *et al*., 2017).

Maize is being successfully bred for resistance to a wide range of pests, including *S. frugiperda* (Prasanna *et al*., 2018). Resistance has also been studied in other crops (Costa *et al*., 2019). Transgenic maize containing genes encoding delta-endotoxins from *Bacillus thuringiensis* var. *kurstaki* have been used effectively for control of the pest in the Americas, however, the evolution of insect resistance is a major concern (Prasanna *et al*. 2018). Various botanical extracts have shown insecticidal properties against the pest, particularly *Azadirachta indica* extract (Sisay *et al*., 2019).

Several types of cultural control can be applied to help minimize pest populations. Cultural aspects can be important since vigorous plants will recover after partial defoliation, and various basic techniques can help to minimize damage and aid plant recovery. Cultural methods do not provide adequate control alone but play an important role in integrated control (Abrahams *et al*., 2017).

Phytosanitary risk

Due to its polyphagy the species can be found on almost all types of plant commodities, therefore, it could be introduced by plant trade to the EPPO region. In the past it was intercepted occasionally in Europe on imported plant material (Seymour *et al.,* 1985), however, more recently an increase of its interceptions occurred; for example, 54% more interceptions were recorded in 2018 than in 2017 (DG for Health and Food Safety, 2019). Due to the strong flight capacity of *S. frugiperda*, this pest could further spread via natural dispersal from sub-Saharan Africa. In addition, *S. frugiperda* has a high reproductive potential, and it has proven to be highly adaptable to different environments.

PHYTOSANITARY MEASURES

S. frugiperda could enter the EPPO region through international trade. Being a polyphagous pest, it could arrive on several host plant products, however, pathway models indicate that peppers (*Capsicum* spp.) are the most likely, although they are not preferred hosts. Being that pepper is regulated and inspected upon entry into many countries (e.g. in the EU), further regulation is estimated to have a marginal effect. As regards the likelihood of entry of the pest by natural dispersal, if *S. frugiperda* continues to spread to North Africa, it could relatively easily enter southern

European countries (particularly the Andalusia region in Spain and Sicily in Italy) through migration. There is no possibility to prevent entry via natural dispersal, the likelihood of entry via this pathway could only be mitigated through pest control in Africa (Jeger *et al*., 2018). In December 2019, the FAO launched the "Global Action for Fall Armyworm Control" (http://www.fao.org/fall-armyworm/en/) to ensure a coordinated global approach, favouring a combination of monitoring, early warning systems, as well as, sustainable pest control methods.

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