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ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

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Report of a Pest Risk Analysis for

Spodoptera ornithogalli and *Spodoptera praefica*

Courtesy: Tom van Noort, NVWA (NL) – EPPO Global Database (EPPO Code: PRODOR)

This summary is based on an assessment of the potential impact of twelve *Spodoptera* species of the Americas for the EU territory, prepared by the NPPO of the Netherlands (Van der Gaag and Van der Straten, 2017) called later NPPO-NL-RA. *Spodoptera ornithogalli* (Guenée) and *Spodoptera praefica* (Grote) are two species for which the probability of establishment and potential impact was assessed for the EU region. The NPPO-NL-RA did not assess the pathways of introduction and spread. However, given that *Spodoptera* species have in general a similar biology, information on possible pathways of introduction and spread were derived from pest categorizations and risk assessments of *Spodoptera* species prepared by EFSA (*S. littoralis* (EFSA, 2015), *S. frugiperda* (EFSA, 2017; 2018), *S. litura* (EFSA, 2019) and *S. eridania* (EFSA, 2020)). Additional literature searches have been conducted to make it more representative to the whole EPPO region.

Pests: *Spodoptera ornithogalli* (Guenée)*; Spodoptera praefica* (Grote)
PRA area: EPPO region
Assessors: Roel Potting, Dirk Jan van der Gaag, Marja van Straten, Tom van Noort (NPPO, The Netherlands) and subsequent discussions in the EPPO Panel on Phytosanitary Measures

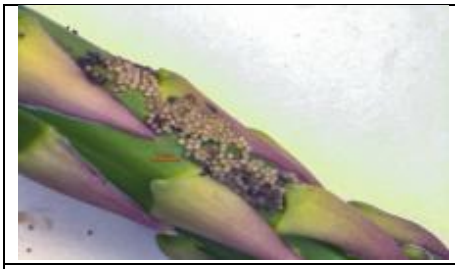
Date: NPPO-NL-RA was published in 2017. The Panel on Phytosanitary Measures discussed the document in 2021-09, 2022-03 and 2022-10
EPPO Working Party on Phytosanitary Regulations and Council agreed that *Spodoptera ornithogalli* and *S. praefica* should be added to the EPPO A1 List of pests recommended for regulation as quarantine pests in 2023.

Cite this document as:

EPPO (2023) Report of a pest risk analysis for *Spodoptera ornithogalli* and *S. praefica*. EPPO, Paris. Available at https://gd.eppo.int/taxon/PRODOR/documents and https://gd.eppo.int/taxon/PRODPR/documents

Based on this PRA report, measures for above-ground fresh plant parts of hosts and host plants for planting (except seeds, tissue cultures and pollen) are recommended.

STAGE 1: INITIATION	
Reason for doing PRA:	Many *Spodoptera* species (Noctuidae; armyworms) are important polyphagous pests of cultivated crops primarily in the tropical and subtropical regions. Currently, four *Spodoptera* species have a quarantine status in the EPPO region (*S. eridania, S. frugiperda, S. litura* and *S. littoralis*). The NPPO-NL-RA was performed because of interceptions of several non-regulated *Spodoptera* species (including *S. ornithogalli*) in the Netherlands on plants and plant products originating in the Americas. *S. ornithogalli* and *S. praefica* are the only two species identified in this risk assessment to be of potential economic importance for the EU, in addition to *S. eridania* (EPPO A1) and *S. frugiperda* (EPPO A2).
Taxonomic position of pests:	*Spodoptera ornithogalli* (Guenée) Lepidoptera, Noctuidae. Common name: yellow-striped armyworm EPPO code: PRODOR Other scientific names: *Prodenia marima* Schaus; *Prodenia ornithogalli* (Guenée); *Spodoptera marima* (Schaus) *Spodoptera praefica* (Grote); Lepidoptera, Noctuidae, Common name: western yellow-striped armyworm EPPO code: PRODPR Other scientific names: *Prodenia praefica* (Grote) Note: *Spodoptera marima* (Schaus, 1904) and *Spodoptera ornithogalli* (Guenée, 1852) were considered cryptic species based on differences in morphological characters. The species are allopatric (see geographical distribution). Recently, Brito *et al*. (2019) revised the taxonomic status of these two *Spodoptera* species and concluded that *S. marima* should be considered as a new junior synonym of *S. ornithogalli*.

		
Egg batch of *S. ornithogalli* on Asparagus. Courtesy: Tom van Noort, NVWA, the Netherlands	larva of the yellowstriped armyworm, *S. ornithogalli*. Photograph by Lyle J. Buss, University of Florida.	Adult yellowstriped armyworm, *S. ornithogalli*. Photograph by Lyle J. Buss, University of Florida

A datasheet for *S. ornithogalli* is available at
https://entnemdept.ufl.edu/creatures/veg/leaf/yellowstriped_armyworm.htm

An Alert list datasheet for *S. praefica* is available at
https://www.eppo.int/ACTIVITIES/plant_quarantine/alert_list_insects/spodoptera_praefica
A mini datasheet prepared in the framework of the EPPO Study on Pest Risks Associated with the Import of Tomato Fruit is available at*: https://gd.eppo.int/download/doc/457_minids_PRODPR.pdf*

STAGE 2: PEST RISK ASSESSMENT

PROBABILITY OF INTRODUCTION

Entry

Geographical distribution:

S. ornithogalli is present in South, Central and North America (Figure 1)[1]. A full list of the countries where *S. ornithogalli* is present can be found in the EPPO Global Database: https://gd.eppo.int/taxon/PRODOR/distribution

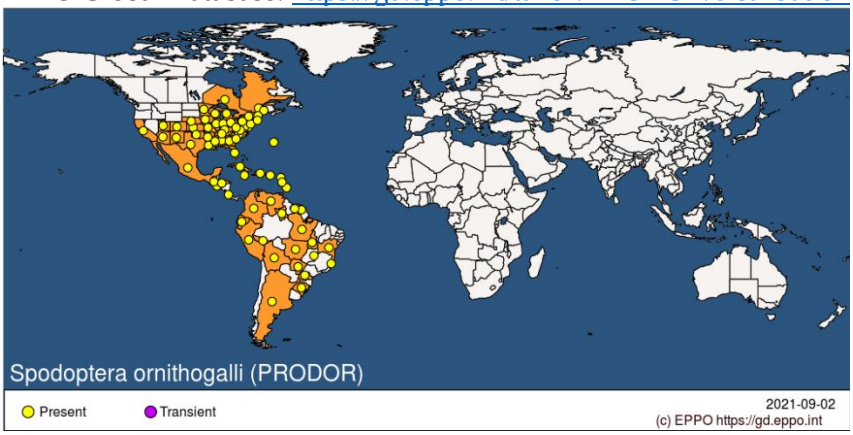


Figure 1. Geographical distribution of *S. ornithogalli*

S. praefica is present in western part of the USA and southern parts of Alberta and British Columbia in Canada (Figure 2). A full list of the countries where *S. praefica* is present can be found in the EPPO Global Database: https://gd.eppo.int/taxon/PRODPR/distribution

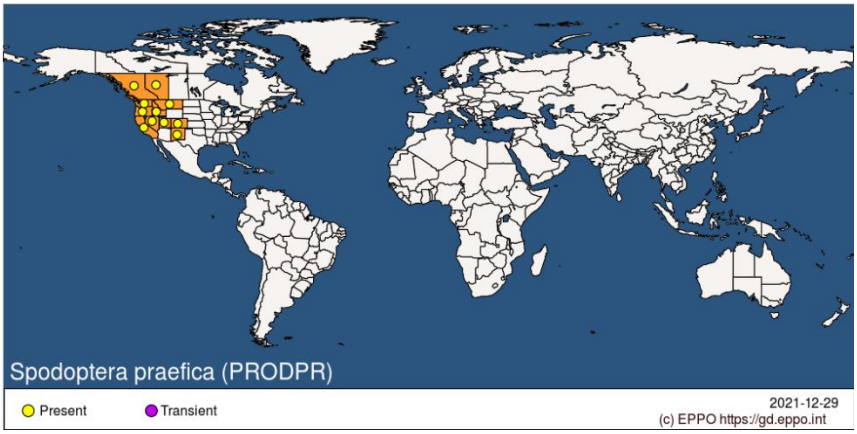


Figure 2. Geographical distribution of *S. praefica*

Major host plants:

In the NPPO-NL RA, the focus was on host plant records that were relevant for the assessment of the potential impact of the different *Spodoptera* species for the EU. The aim was not to make a full list of all known host plants.
A full list of host plants for *S. ornithogalli* and *S. praefica* can be found in the EPPO Global Database (https://gd.eppo.int/taxon/PRODOR/hosts and https://gd.eppo.int/taxon/PRODPR/hosts).

S. ornithogalli is polyphagous and larvae are reported to feed on at least 209 plant taxa belonging to 76 botanical families, with 23% of the records belonging to Asteraceae (Brito *et al*., 2019). In addition, *S. ornithogalli* was intercepted on the following plants: leaves of *Xanthosoma sagittifolium* and

[1] In this PRA report *S. marima* and *S. ornithogalli* are considered as one species (*S. ornithogalli)* and the geographic distribution is updated according to the information provided in Brito *et al*. (2019).

fruits of *Rubus fruticosus* (unpublished records of interception by NPPO NL). In the United States vegetable crops damaged are asparagus, bean, beet, cabbage, cantaloupe, carrot, corn, cucumber, lettuce, onion, pea, potato, rhubarb, rutabaga, salsify, sweet potato, tomato, turnip, and watermelon. Other crops damaged include alfalfa, blackberry, cotton, clover, grape, lentil, peach, rape, raspberry, sorghum, soybean, sugarbeet, sweetclover, sunflower, tobacco, wheat, and several flower crops. Some of the weed species known to be suitable hosts are castor bean, *Ricinus communis*; dock, *Rumex* sp.; gumweed, *Grindelia* sp.; horse nettle, *Solanum carolinense*; horseweed, *Erigeron canadensis*; jimsonweed, *Datura* sp.; lambsquarters, *Chenopodium album*; morningglory, *Ipomoea* sp.; plantain, *Plantago lanceolata*; prickly lettuce, *Lactuca serriola* (synonyme: *L. scariola*); and redroot pigweed, *Amaranthus retroflexus*. In many cases, *S. ornithogalli* develops first on weed or rangeland plants, with subsequent generations affecting crops (Capinera, 2017).

S. praefica is a polyphagous species and larvae are reported to feed on forage crops, '*fruit and vegetables*', ornamentals, and weeds. More than 60 plant species or genera have been recorded as hosts. In the western USA it is known as a pest on various crops including tomato, lupin, rice, lucerne and lentil.

Which pathway(s) is the pest likely to be introduced on:

A pathway analysis was not part of the NPPO-NL-RA. In general, *S. ornithogalli* and *S. praefica* are defoliators. Given the highly polyphagous behaviour of *S. ornithogalli* and *S. praefica* there are many species of cut flowers, cut foliage, leafy vegetables and plants for planting which could provide potential pathways for entry. However, there are uncertainties on the probability of association of the pest with the traded commodities (products are likely to be discarded before export) apart from recent interceptions of consignments (mainly of *Asparagus* infested by *S. ornithogalli*) showing that the pest can enter the EPPO region.
An assessment of potential pathways for *S. ornithogalli* and *S. praefica* is given in ANNEX 1.
Based on the biology and the main pathways identified for other *Spodoptera* (see Annex 1) the pathways for *S. ornithogalli* and *S. praefica* (based on the EPPO pathway categories, see guidance PM 5/5) are:

- Above-ground fresh plant parts (cut flowers, cut foliage, and leafy vegetables (incl. herbs and stem vegetables))
- Plants for planting (except seeds, pollen and tissue culture) with soil/growing medium attached
- Plants for planting (except seeds) without soil/growing medium attached

Remark: Although vegetables belong either to the categories fruit, above-ground fresh plant parts, or underground plant parts, the denomination '*fruit and vegetables*' has been maintained at several places in this PRA report for practicality.

These pests may also feed on fruits when leaves are not available. Similarly, *S. ornithogalli* may be occasionally present in the harvested underground parts of onion, potato and sweet potato. For *S. praefica*, no information is available if it attacks underground plant parts.
The volume of cut flowers as well as '*fruits and vegetables*' of hosts imported in the EPPO region from countries where *S. ornithogalli* occurs is high, but relatively lower for *S. praefica* because it is only present in some western states of the USA and Canada (see table x2 and x3 in ANNEX 1). The import data should be seen as a general indicator for possible pathways.

The likelihood of transfer is considered low for host '*fruits and vegetables*' and cut flowers (see Annex 1 pathway analysis).

The volume of plants for planting of hosts from areas where *S. ornithogalli* and *S. praefica* are present is low, the probability of association also seems low but the probability of transfer is assessed to be high for this pathway, in particular when growing media is attached.

Establishment

Plants at risk in the PRA area:

S. ornithogalli and *S. praefica* use many plant species as a host (see section Major Host Plants) and many of these plant species are widely present both outdoors and in protected cultivation in the EPPO region. Among the vegetable crops present in the EPPO region known to be damaged by *S. ornithogalli* in their current area of distribution are asparagus, bean, beet, cabbage, carrot, corn, cucumber, lettuce, onion, pea, potato and tomato; and lentil, lucerne, lupin, rice and tomato by *S. praefica*.

Climatic similarity of present distribution with PRA area (or parts thereof):

S. ornithogalli and *S. praefica* overwinter outdoors in more northern areas than most of the other *Spodoptera* species that are present in North America. There are similarities between the climate in the parts of North America where *S. ornithogalli* and *S. praefica* are present and large parts of the EPPO region.

Characteristics (other than climatic) of the PRA area that would favour establishment:	None.
Which part of the PRA area is the area of potential establishment:	*S. ornithogalli* and *S. praefica* are polyphagous pests and there are many hosts available throughout the EPPO region in agricultural fields, in protected cultivation and as wild species. There is uncertainty regarding establishment under protected cultivation (both species are not known as greenhouse pests). Since the availability of host plants is not a limiting factor, the area of potential establishment corresponds to areas where climatic conditions are suitable to sustain populations throughout the year (i.e. overwintering pupae). A comparison of the three Köppen-Geiger climate types that occur in countries where the two *Spodoptera* species have been reported and the climate types that occur in the EPPO region suggest that these two pests can establish (and overwinter) in the southern parts of the EPPO region (see Figure 3 and Annex 2 for more information). Transient populations (i.e. at least one generation /year) are estimated to be possible up to south Sweden.

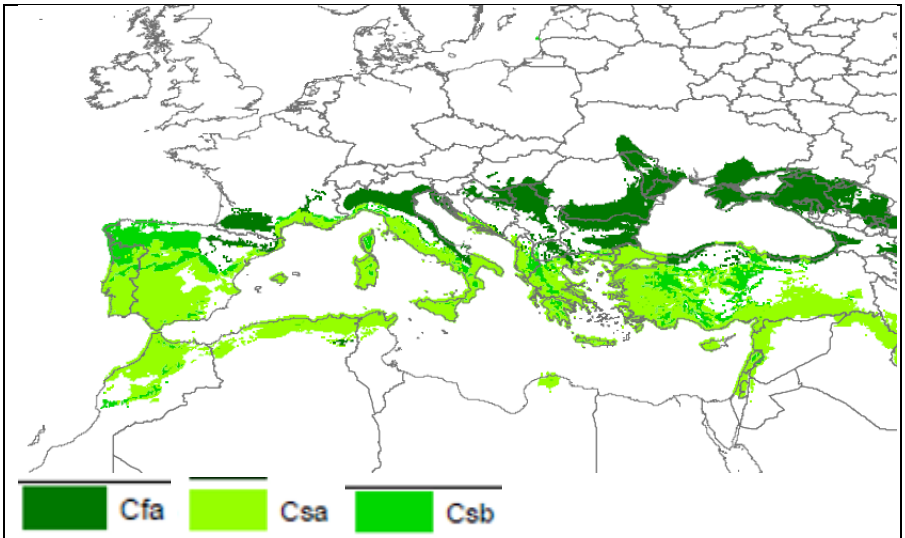


Figure 3. Distribution of Köppen-Geiger climate types Csa (dry hot summer), Csb (dry warm winter) and Cfa (humid sub-tropical) suitable for permanent establishment of *S. ornithogalli* in the EPPO region. For *S. praefica*, Csa and Csb are considered suitable.

Spread	Human assisted spread is possible with the trade of infested cut flowers, '*fruits and vegetables*' and plants for planting. Many *Spodoptera* species engage in migratory behaviour and with the aid of suitable winds can migrate hundreds of kilometers (Johnson, 1987). According to Brito *et al*. (2019), *S. ornithogalli* has great dispersal capabilities including migration (Ferguson *et al*. (1991) cited in Brito *et al*., 2019). *S. praefica* is also described as a migratory species that spreads northwards from the southwest of North America each year (PNW Moths, 2017). If *S. ornithogalli* and *S. praefica* establish in the southern areas of the EPPO region, they could spread in the summer northwards and transient populations could damage field and protected crops in more northern areas. It is uncertain if population build up in the southern EPPO region will be sufficient to induce migratory behavior to the northern regions.

POTENTIAL ECONOMIC CONSEQUENCES

How much economic impact does the pest have in its present distribution:

Damage is caused by the larvae, principally by consumption of foliage. The small, gregarious larvae tend to skeletonize foliage but as the larvae grow and disperse, they consume irregular patches of foliage or entire leaves. Mature larvae can bore into fruit (e.g. tomato). When stressed by lack of food, larvae can eat apical portions of branches, bore into stem tissue and attack tubers close to the soil surface (e.g. potato).

The importance of damage reported varies considerably across the geographic distribution range and vegetable type. *S. ornithogalli* is a pest of economic importance on several vegetable crops in southeast of the USA (Capinera, 2017). In South America (e.g. Brazil) *S. ornithogalli* (formerly known as *S. marima*) is not reported as a vegetable pest. In California *S. ornithogalli* is not an important pest, whereas in Kentucky it is a transient pest on tomato and recently potato (website Pennsylvania, 2020).

	
Young larvae of *S. ornithogalli* feeding on tomato leaves. University of Kentucky	Mature larvae of *S. ornithogalli* feeding on tomato fruit. University of Kentucky

	
S. ornithogalli causing field scale defoliation and damage in potatoes, August 28, 2020. Photo: Bob Leiby, Penn State Extension	

https://extension.psu.edu/pennsylvania-insect-alert-for-september-2-2020-yellow-striped-armyworm-outbreak

In its native range, *S. praefica* is considered to be a pest of various crops including tomato and forage crops (e.g. alfalfa). In California, *S. praefica* is considered more important than *S. ornithogalli* (Capinera, 2017).

Describe damage to potential hosts in PRA area:

S. ornithogalli and *S. praefica* are primarily foliage feeders and can seriously damage young plants in the early season, later in the season it can also damage tomato and pepper fruits as well as foliage. Cosmetic damage on ornamentals can also be expected (e.g. on Asteracea, Dendrathema and Draceana).

Hosts grown in the EPPO region include crops such as *Asparagus*, beans (*Phaseolus*), Cole (*Brassica* spp.), eggplant (*Solanum melongena*), maize (*Zea mays*), onion (*Allium cepa*), potatoes (*Solanum tuberosum*), sugarbeet (*Beta vulgaris* subsp. *vulgaris*), tomatoes (*Solanum lycopersicum*) and sweet pepper (*Capsicum annuum*). Host plants are grown outdoors and in greenhouses.

How much economic impact would the pest have in the PRA area:

S. ornithogalli and *S. praefica* have the potential to cause damage on many economically important vegetable crops (Table 1) in the southern regions of the EPPO region. According to the NPPO-NL-RA the potential economic impact of the species is assessed to be generally 'medium' meaning that targeted measures are necessary to keep yield and and/or quality losses low and crop protection costs are average. Locally or occasionally, 'major' impacts may occur ('major impact': frequent or expensive measures are needed to keep losses limited; significant increase in crop protection costs). In the EPPO region, insecticides are often used to suppress *Spodoptera* populations from reaching the economic threshold level. Pest management is targeted at the early larval stages to keep the population level of medium and large larvae below the economic threshold level (0.7 larvae per 4 plants; Pernezny *et al*. 1996 as cited in Liburd *et al*., 2000).

The impact will vary among the different crops depending on their respective IPM programs (basically whether insecticides used against other pests in the crop are also effective against the two species). IPM programs will need to be adjusted to incorporate the two species.

Impacts may, however, increase if insecticides to control Lepidopteran pests would no longer be effective or registered. Due to the increasing resistance of *Spodoptera* species to chemical insecticides (Hilliou *et al*., 2021) repeated applications are often needed to prevent losses from fruit injuries and reductions in total marketable yields (Meinke and Ware, 1978; Zhangxin, 1984; Brewer and Trumble 1994; all cited in Liburd *et al*., 2000). Biological insecticides, such as *Bacillus thuringiensis* products containing the endotoxin CryIC protein have demonstrated high levels of efficacy against *Spodoptera* species. Moar *et al*. (1995) have shown that there is the potential for *S. exigua* larvae to develop resistance to this protein. Chaufaux *et al*. (1997) documented resistance to the CryIC protein in the related *S. littoralis*.

Table 1. Harvested area of EU 28 member states (2019, including UK) of some crops that are hosts of *S. ornithogalli*. Crops in bold are also hosts of *S. praefica)*. Derived from EUROSTAT dataset Crop production in EU standard humidity [APRO_CPSH1].

Crop	**EU28 harvested area (x1000 ha), 2019**
Potatoes (including seed potatoes)	1751
Brassicas	290
Asparagus	61
Tomatoes	235
Cucumbers	34
Eggplants	21
Courgettes and marrows	42

Watermelons	75
Peppers (capsicum)	60
Carrots	120
Onions	187
Rice	419
Sweet lupins	174

There is uncertainty about the pest population levels that are likely to develop across production areas and host types given the variability occurring within the pest's current distribution range.
Proximity of crops to rangeland containing weed hosts, or to alfalfa, may be important factors predisposing vegetable crops to injury. At high densities, especially if alfalfa hay is mowed, larvae will sometime disperse simultaneously and invade nearby vegetable fields. Physical barriers such as trenches can be used to limit such dispersal.
Both pests have not been reported as greenhouse pests; however, in areas where outdoors populations are present the pests may enter greenhouses and potentially cause damage.
The establishment of *S. ornithogalli* and *S. praefica* in the EPPO area can have an impact on trade, because the pest has a quarantine status in East and South Africa.

The potential environmental impact is rated as low based on the fact that *Spodoptera* species seem mainly or only a problem in agricultural areas.

CONCLUSIONS OF PEST RISK ASSESSMENT

Summarize the major factors that influence the acceptability of the risk from this pest:

Estimate the probability of entry:

Given the polyphagous behaviour of the two species and the large variability in the prevalence on the different host species throughout their distribution area in the Americas there is a high uncertainty what the most important potential pathways are.

The volume of '*fruits and vegetables*' and cut flowers of host plants from areas where *S. ornithogalli* is present is high but there are uncertainties on the probability of association of the pest with the traded commodity and the probability of transfer is considered low for these commodities.
The volume of host plants for planting from areas where *S. ornithogalli* is present is low but the probability of transfer is considered high for these commodities, in particular for plants with growing media attached. During the last ten years no interceptions of *S. ornithogalli* and *S. praefica* have been notified on plants for planting in the EPPO region.
Overall, the probability of entry is assessed to be moderate with a high uncertainty.

Estimate the probability of establishment:

Given the availability of suitable hosts and the climatic suitability of large parts the EPPO region, the likelihood of establishment of *S. ornithogalli* and *S. praefica* is considered to be high with low uncertainty in southern parts of EPPO region outdoors. *S. praefica* may be able to overwinter in more northern areas of the EPPO region, based on the more northern current distribution compared to *S. ornithogalli*. However, there is no difference in climate type for these regions. Due to the lack of data on the thermal requirements of *S. ornithogalli* and *S. praefica* there is uncertainty about the exact area of potential establishment.

Estimate the probability of spread:	The main pathway for spread is natural spread including long distance migratory behaviour. It is uncertain if, after entry, the environmental conditions in the EPPO region would trigger significant migratory behaviour to other areas. Human assisted spread is possible with trade in vegetable host plants and host plants for planting (other than seeds and pollen). The rate of spread is estimated to be high with a low uncertainty.
Estimate the potential economic impact:	*S. ornithogalli* and *S. praefica* have many hosts that are major crops in the EPPO region. The introduction of these species is likely to cause significant losses in various crops, especially in southern parts of the EPPO region. Specific IPM programmes will likely have to be established if *S. ornithogalli* or *S. praefica* were to be introduced. The impact of *S. ornithogalli* or *S. praefica* is expected to be moderate on several vegetable crops cultivated in the EPPO region with a high uncertainty due to a lack of quantitative data on yield losses.
Degree of uncertainty	*S. ornithogalli* is highly polyphagous and has many potential pathways and it is uncertain what the most important pathways are. There is a large variability in the prevalence of *S. ornithogalli* on the different host species throughout its distribution area in the Americas. Similar uncertainties exist for *S. praefica*. There is uncertainty related to the size of the endangered area due to lacking data on climatic requirements for the pests. There is uncertainty about the potential economic impact in the EPPO region considering the large variation of impact in their current distribution area and lack of quantitative data on yield losses. There is uncertainty about the pest population levels that are likely to develop in the southern regions of the EPPO region that could be a source of migration to the more northern parts of the EPPO region.
OVERALL CONCLUSIONS	*S. ornithogalli* and *S. praefica* meet all the criteria to qualify as a quarantine pest. In particular, these polyphagous pests are absent in the EPPO region and could cause significant damage on several crops if it were to be introduced. *S. ornithogalli* and *S. praefica* pose a risk to the EPPO region and risk management options should be considered.

STAGE 3: PEST RISK MANAGEMENT

IDENTIFICATION OF THE PATHWAYS

Due to their polyphagous behaviour *S. ornithogalli* and *S. praefica* can potentially be present on many species of imported cut flowers, cut foliage, leafy vegetables and plants for planting from areas where the pest is present. However, there is a large variability in their prevalence (especially for *S. ornithogalli*) on the different host species throughout their distribution area in the Americas. Therefore, there is uncertainty what the most important host species are in terms of pathways. As far as known, *S. ornithogalli* has been intercepted in the EU only on fruits and vegetables of *Asparagus*, *Xanthosoma*, *Momordica* and *Rubus*; but, because of the high uncertainty, risk management measures are recommended for all the host plants.

Pathways studied in the pest risk management

The most important identified pathways for the introduction of *S. ornithogalli* and *S. praefica* are:

- Above-ground fresh plant parts of hosts (cut flowers, cut foliage, and leafy vegetables (incl. herbs and stem vegetables))
- Host plants for planting (except seeds) with soil/growing medium attached
- Host plants for planting (except seeds) without soil/growing medium attached

The pathways with a very low likelihood of entry (i.e. host fruits, underground plant parts of host plants, soil/growing medium as such) are not further considered. Regarding fruits, although there is a high uncertainty for the likelihood of entry with such commodity (see detailed assessment of this pathway in Annex 1), countries may decide to regulate specific host fruit species on which there is evidence of association with fruits from the Americas (e.g. reported interceptions) to achieve a higher level of protection. Although transfer is regarded as unlikely for fruits, it may occur when imported fruits are stored or repacked at destination in facilities that also grow host fruits.

IDENTIFICATION OF POSSIBLE MEASURES

The pest is relatively easy to detect (egg masses and gregariously feeding larvae) and visual inspection of consignments could be very effective.

Possible measures for all pathways

Pest free area (PFA)

Pest free place/site of production established according to EPPO Standard PM 5/8 *Guidelines on the phytosanitary measure 'Plants grown under physical isolation'*

Systems approach combining measures related to the place/site of production (no signs observed, treatment) and measures related to the consignment (inspection) (only for above-ground fresh plant parts)

Post-harvest treatment (only for above-ground fresh plant parts)

Post-entry quarantine (only for plants for planting)

Import for processing or direct consumption.

EVALUATION OF THE MEASURES IDENTIFIED IN RELATION TO THE RISKS PRESENTED BY THE PATHWAYS

The trade in the commodities from outside the EPPO region is huge so impact on trade could be major. However, potential impact may be significant, and the pest would be difficult to eradicate or contain if introduced.

Degree of uncertainty Uncertainties in the management part are:
There is a large variability in the prevalence of *S. ornithogalli and S. praefica* on the different host species throughout their distribution areas in the Americas. Therefore, there is high uncertainty what the most important pathways for introduction are.

IDENTIFICATION OF POSSIBLE MEASURES

Pathway	Measures identified for the exporting country

Above-ground fresh plant parts of hosts (cut flowers, cut foliage, and leafy vegetables (incl. herbs and stem vegetables))	Pest free area (PFA) (ISPM 4, ISPM 29) (see requirements below) OR Pest-free production site for the specified pest, established according to EPPO Standard PM 5/8 *Guidelines on the phytosanitary measure 'Plants grown under physical isolation'* OR System approach combining: - No signs of *Spodoptera* spp. observed at the place/site[1] of production during the last 3 months prior to export, and - Appropriate treatment (treatment of the place/site of production) to ensure freedom from the specified pest, and - Inspection of the lot prior to export and absence of the specified pest OR Appropriate post-harvest treatment OR Import for processing or direct consumption at specific time of the year (in the framework of a bilateral agreement)
Host plants for planting (except seeds, tissue cultures and pollen)	Pest free area (PFA) (ISPM 4, ISPM 29) (see requirements below) OR Pest-free production site for the specified pest, established according to EPPO Standard PM 5/8 *Guidelines on the phytosanitary measure 'Plants grown under physical isolation'* OR Plants without soil or growing media attached, and without leaves OR Post-entry quarantine (in the framework of a bilateral agreement)

[1]*: The choice between pest free place of production and pest free production site is a decision to be taken by the NPPO based on the operational capacities of the producers and biological elements.*

Countries may decide to regulate specific host fruit species on which there is evidence of association with fruits from the Americas (e.g. reported interceptions) to achieve a higher level of protection. The measures could be similar with the ones recommended for above-ground fresh plant parts of hosts.

Requirements for establishing a PFA:
Because of the migratory behaviour of the *Spodoptera* species, PFA is not considered applicable for the states/countries where the pest is present.

- To establish and maintain the PFA, a general surveillance in the area in the three years prior to establishment of the PFA and continued every year may be sufficient. Specific surveys should also be carried out in the zone between the PFA and known infestation to demonstrate pest freedom. The surveys should be targeted for the pest and should be based on appropriate combination of trapping, and visual examination of host plants.
- There should be restrictions on the movement of host material (originating from areas where the pest is known to be present) into the PFA, and into the area surrounding the PFA, especially the area between the PFA and the closest area of known infestation.

ANNEX 1. PATHWAY ANALYSIS

The biology of *S. ornithogalli* and *S. praefica* is similar to that of other *Spodoptera* species. Eggs are deposited in clusters on leaves. Larvae are known as defoliators and generally feed on the leaves of plants, When stressed by lack of food, larvae can eat apical portions of branches, bore into stem tissue, feed on fruits if present (e.g. tomato). *S. ornithogalli* has been reported attacking tubers close to the soil surface, including potato tubers. Pupation takes place in the soil. Egg batches, larvae and pupae can be present on plants in trade.
Based on the biology and the main pathways identified for other *Spodoptera* species (EFSA-PLH panel, 2015, 2017,2018, 2019, 2020) the main pathways for *S. ornithogalli* are listed in bold below. Other pathways were considered very unlikely for the reasons that are stated:

- **Above-ground fresh plant parts of hosts (cut flowers, cut foliage, and leafy vegetables (incl. herbs and stem vegetables))**
- **Host plants for planting (except seeds) with soil/growing medium attached**
- **Host plants for planting (except seeds) without soil/growing medium attached**
- Host fruits
- Underground plant parts of hosts
- Soil/growing medium as such

For the scientific names of hosts please consult EPPO Global database.

Pathway	**Above-ground fresh plant parts of hosts (cut flowers, cut foliage, and leafy vegetables (incl. herbs and stem vegetables))**
Coverage	Above-ground fresh plant parts of hosts moving in trade from host species where the pest occurs. The pathway covers cut flowers, cut foliage, and leafy vegetables (including herbs as well as stem vegetables such as green asparagus, celery and rhubarb).
Pathway prohibited in the PRA area?	In general, no prohibition.
Pathway subject to a plant health inspection at import?	In several EPPO countries e.g. in the European Union, most of the plant products are subject to a plant health inspection at import since 14 December 2019 (Regulation (EU) 2016/2031).
Pest already intercepted?	Yes. Analysis of EUROPHYT interception data (table X1) indicates that most interceptions of *Spodoptera* species occur on '*cut flowers and branches*' and '*leaves*' (n=499 for 2009-2019, Europhyt); and on '*fruit and vegetables'* (n=348 for 2009-2019, Europhyt) which includes leafy vegetables. There are no records of interception of *S. ornithogalli* or *S. preafica* in Europhyt. However, the NPPO of the Netherlands has intercepted *S. ornithogalli* on *Asparagus officinalis* from Mexico (n=21), and *Xanthosoma sagittifolium* (n=1) from Suriname (2010-2020, NVWA unpublished data). The life stages of *S. ornithogalli* intercepted were egg batches and young instar larvae. Also, Takahashi (2002) reported interceptions of *S. ornithogalli* on *Asparagus* vegetables from the Americas.
Plants concerned	Given the highly polyphagous behaviour of *S. ornithogalli* and wide geographic distribution there are many species of cut flowers, cut foliage and leafy vegetables which could provide potential pathways for entry. In the USA the pest is a regular pest in asparagus, cabbage, lettuce and rhubarb. Other crops damaged include sunflower, and several flower crops. Asparagus is the only commodity for which regular interceptions have been reported. *S. preafica* has a relatively limited distribution of occurrence compared to *S. ornithogalli.* The reported host plants and crops for *S. praefica* include mint, prickly lettuce, sunflower and several flower crops.
Most likely stages that may be associated	Eggs and larvae are the stages most likely to be associated with cut flowers, cut foliage and leafy vegetables. Adults: it is unlikely that adults will remain on the plants due to the disturbance of packing.
Important factors for association with the pathway	There is a large variability in the host plant use of *S. ornithogalli* across its geographic distribution (Brito *et al*., 2019). Therefore, it is difficult to predict if *S. ornithogalli* can be associated with a particular harvested commodity from a specific region. In general, *S. ornithogalli* and *S. praefica* are defoliating pests what favour association with this pathway.

	Pest control may be in place to protect the product to be harvested. The pest is relatively easy to detect (egg batches, feeding larvae, large last instars) and damaged plant parts may be graded at harvest and sorting.
Survival during transport and storage	Cut flowers, cut foliage and leafy vegetables in international trade are commonly transported under controlled conditions (lower temperature and/or controlled atmosphere). Given the temperature conditions (e.g. 10 ºC), the development of the life stage present on the commodity (eggs or larvae) may be halted during the trade process. However, eggs and larvae were alive when intercepted on leafy vegetables at import (data from NPPO NL).
Trade	Given its wide host plant range and large distribution range there is a large trade volume of potential pathways of leafy vegetables (lactuca, brassica) and cut flowers from South, Central and Northern American countries where the pest occurs into the EPPO region. To assess the pathway, it was checked if the host plant genus had a specific EUROSTAT code. For the respective custom codes EUROSTAT was consulted to retrieve the import volume of potential commodities for all the 27 EU member states (+ UK) from export countries were *S. ornithogalli* is present. Not all leafy vegetables have a specific code (for example no code available for the intercepted commodity *Xanthosoma*). Only codes for which a unique EUROSTAT code was available were included in the table below. The results are presented in table X2 and X3, together with data for fruits and other vegetables. Data for the import of host plant cut flowers from countries where *S. ornithogalli* is present are presented in table X3 (based on data from the import database of NPPO of NL).
Transfer to a host	Hosts are widespread in the EPPO region. However, as these commodities are imported for consumption or processing, transfer from cut flowers, cut foliage and leafy vegetables directly provided to the consumer or used for processing is generally considered unlikely (Van der Gaag *et al*., 2019). The shelf life of these commodities is usually short and the pest has to develop to the adult stage, find a mate and find a patch of suitable host plants. It is likely that the pest will be destroyed during processing or discarded by the final consumer in a closed waste bin. Therefore, waste management is important in determining the probabilty of transfer.
Likelihood of entry and uncertainty	Low with high uncertainty Although the imported volume of potential commodity pathways is large the evidence for association of *S. ornithogalli* with the pathway in exported commodities is low. Among the numerous potential pathways, *Asparagus* is the only commodity for which regular interceptions are reported. There is a large uncertainty on the possible association with cut flowers, and some leafy vegetables from the Americas due to the large variability in host plant use across its geographic distribution range.

Pathway	Host plants for planting
Coverage	Plants for planting, with or without growing media, with leaves Plants with bare roots, cuttings. Seeds tissue culture and pollen are excluded because the pest is not associated with these pathways.
Pathway prohibited in the PRA area?	Yes, in part, in some countries: e.g. the import of all plant genera included in the family Solanaceae is prohibited from American countries where the pest occurs into EU countries. This includes plants for planting of *Capsicum* and *Solanum.* In several EPPO countries (e.g. in EU countries), growing medium attached to plants imported from third countries (other than Switzerland) should follow special requirements (e.g. free from soil and new, subject to fumigation and heat treatment, etc.) which should ensure freedom of pests (Annex VII.1 of Regulation 2019/2072).
Pathway subject to a plant health inspection at import?	Yes, in many EPPO countries
Pest already intercepted?	No. There is no evidence that *S. ornithogalli* or *S. praefica* have been intercepted on plants for planting from countries where the pest is known to occur.
Plants concerned	Given the highly polyphagous behaviour of *S. ornithogalli* and *S. praefica* there are many species of plants for planting which could provide potential pathways for entry. However, the trade of host plants for planting from areas where *S. ornithogalli* is present seems rather limited (see below).
Most likely stages that may be associated	Eggs and feeding larvae may potentially be associated with the aboveground parts of host plants for planting. Adults: it is unlikely that adults will remain on the plants due to the disturbance of packing. Pupae: pupae may be associated with the growing media (very unlikely to be associated with bare rooted plants) It is very unlikely that eggs, larvae or adults are present when plants are traded without leaves.
Important factors for association with the pathway	The pest may be present in nurseries if those are located in infested areas. There is a large variability in the host plant use of *S. ornithogalli* across its geographic distribution (Brito *et al*., 2019). Therefore, it is difficult to assess if *S. ornithogalli* can be associated with a particular harvested commodity from a specific region. The pest is relatively easy to detect (egg batches, feeding larvae, large last instars) and pest control may be in place to protect the plants. *Dracaena, Schefflera, Ficus, Yucca* and *Peperomia* are reported as hosts of *S. ornithogalli* however there is uncertainty regarding association with these hosts (no reports of damage on these genera).
Survival during transport and storage	Plants for planting in international trade are commonly transported under controlled conditions (lower temperature and/or controlled atmosphere). Given the temperature conditions (e.g. 10 ºC), the development of the life stage present on the commodity (eggs or larvae) may be halted during the trade process.
Trade	There is trade of host plants for planting from countries where *S. ornithogalli* and *S. praefica* are present into the EPPO region. The Netherlands is an important importer of plants for planting and the host plant genera *Dracaena, Schefflera, Ficus, Yucca* and *Peperomia* are regularly imported from countries where *S. ornithogalli* is present (see table X4 for more details).
Transfer to a host	Plants for planting will generally be planted in favourable conditions for their development and these may also be favourable for pest development, for example if used in a greenhouse or planted outside in the southern parts of the EPPO region. The probability of transfer from infested imported plants for planting is assessed to be generally high.

Likelihood of entry and uncertainty	**Host plants for planting (except seeds) without soil/growing medium attached:** Low to moderate with high uncertainty (probability of association, practices before export) **Host plants for planting (except seeds) with soil/growing medium attached:** Moderate with a high uncertainty (probability of association, practices before export).

Pathway	Host fruits
Coverage	Host fruits (in the botanical sense) moving in trade from host species where the pest occurs.
Pathway prohibited in the PRA area?	In general, no prohibition.
Pathway subject to a plant health inspection at import?	In several EPPO Countries, e.g. in the European Union most of the plant products are subject to a plant health inspection at import since 14 December 2019 (Regulation (EU) 2016/2031).
Pest already intercepted?	Yes. Analysis of EUROPHYT interception data (table X1) indicates that several interceptions of *Spodoptera* species occur on '*fruits and vegetables*' (n=348 for 2009-2019, Europhyt) which includes leafy vegetables. There are no records of interception of *S. ornithogalli* or *S. praefica* in Europhyt. However, the NPPO of the Netherlands has intercepted *S. ornithogalli* on fruit of *Rubus fruticosus* (n=1) and *Momordica*, (2010-2020, NVWA unpublished data).
Plants concerned	Given the highly polyphagous behaviour of *S. ornithogalli* and wide geographic distribution there are many species of fruit which could provide potential pathways for entry. In the USA the pest is a regular pest in bean, cantaloupe, corn, cucumber, pea, tomato, and watermelon. Other crops damaged include blackberry, cotton, grape, peach, rape and raspberry. *S. praefica* has a relatively limited distribution of occurrence compared to *S. ornithogalli*. The reported host plants and crops for *S. praefica* include apple, bean, blackberry, cucurbits, cotton, melon, pea, peach, pear and tomato.
Most likely stages that may be associated	Larvae is the stage most likely to be associated with fruits. Adults: it is unlikely that adults will remain on the plants due to the disturbance of packing. Eggs are not reported to be laid on fruits (the female lay egg masses on the foliage).
Important factors for association with the pathway	There is a large variability in the host plant use of *S. ornithogalli* across its geographic distribution (Brito *et al*., 2019). Therefore, it is difficult to predict if *S. ornithogalli* can be associated with a particular harvested commodity from a specific region. In general, *S. ornithogalli* is a defoliator and may therefore only be occasionally present in harvested fruit. Pest control may be in place to protect the product to be harvested. The pest is relatively easy to detect (feeding larvae, large last instars) and damaged fruits may be sorted out at harvest or later.
Survival during transport and storage	Fruits in international trade are commonly transported under controlled conditions (lower temperature and/or controlled atmosphere). Given the temperature conditions (e.g. 10 ºC), the development of the life stage present on the commodity (eggs or larvae) may be halted during the trade process.
Trade	Given its wide host plant range and large distribution range there is a large trade volume of potential pathways of fruit from South, Central and Northern American countries where the pest occurs into the EPPO region. To assess the potential fruit pathways, same process as for above ground fresh plant parts has been followed. The results are presented in table X2 and X3, together with data for other vegetables.
Transfer to a host	Hosts are widespread in the EPPO region. However, as these commodities are imported for consumption or processing, transfer with fruits directly provided to the consumer or used for processing is generally considered unlikely (Van der Gaag *et al*., 2019). The shelf life of these commodities is usually short and the pest has to develop to the adult stage, find a mate and find a patch of suitable host plants. It is likely that the pest will be destroyed during processing or discarded by the final consumer in a closed waste bin. Therefore, waste management is important in determining the probability of transfer.
Likelihood of entry and uncertainty	Very low with high uncertainty Although the imported volume of potential commodity pathways is large the evidence for association of *S. ornithogalli* with the pathway in exported commodities is low.

	There is uncertainty on the possible association with fruit from the Americas due to the large variability in host plant use across its geographic distribution range. The likelihood is lower than for above ground fresh plant parts because the pest is mainly a defoliator.

Underground plant parts of host plants

This pathway covers bulbs, corms, tubers, rhizomes and roots, including ware potatoes; for consumption or processing, but not for planting.

The pest may occasionally attack tubers (e.g. larvae of *S. ornithogalli* on potato). There is no report of *S. praefica* feeding on underground plant parts.

In the USA, *S. ornithogalli* is a regular foliage feeding pest in beet, carrot, onion, potato, rutabaga, salsify, sweet potato and turnip. Sugarbeet is also reported to be damaged. Underground plant parts may be possibly accompanied by green parts, but it is assumed it would mainly be for local market, and not for import from America.

As pupation takes place in the soil, pupae could be present in the soil attached to underground plant parts of host plants, but it is unlikely pupae will survive the harvest and packing process.

Likelihood of entry and uncertainty: very low with moderate uncertainty

Soil/growing medium as such

This pathway covers soil/growing medium as a commodity. Soil/growing medium associated with other pathways is covered under those (e.g. plants for planting, underground plant parts). As pupation takes place in the soil, pupae could be present. The import of soil and growing media is usually regulated in the EPPO region (e.g. soil and growing media as such from all third countries other than Switzerland, cannot be imported in the EU according to Annex VI point 19 and 20 of Commission Implementing Regulation (EU) 2019/2072). If soil or growing media in which infested plants were previously grown is imported, it may be a pathway for entry of the pest. However, this is considered unlikely for growing media for professional use.

Likelihood of entry and uncertainty: very low with low uncertainty

Table X1 Overview of notifications of interception of Spodoptera species. EUROPHYT 2009-2019.

Europhyt commodity type (Class Name)	**Total number of notifications**
INTENDED FOR PLANTING : ! OTHERS	1
INTENDED FOR PLANTING : ALREADY PLANTED	5
INTENDED FOR PLANTING : AQUATIC PLANTS	1
INTENDED FOR PLANTING : CUTTINGS	17
INTENDED FOR PLANTING : NOT YET PLANTED	22
INTENDED FOR PLANTING : PLANT TISSUE CULTURE	1
OTHER LIVING PLANTS : ! OTHERS	2
OTHER LIVING PLANTS : CUT FLOWERS AND BRANCHES WITH FOLIAGE	495
OTHER LIVING PLANTS : CUT TREES RETAINING FOLIAGE	1
OTHER LIVING PLANTS : FRUIT & VEGETABLES	348
OTHER LIVING PLANTS : LEAVES	4
OTHER LIVING PLANTS: CUT BRANCHES WITHOUT FOLIAGE	1
OTHERS(!)	1
Total	**899**

TABLE X2

Summary of import of E28 countries of potential fruit and vegetable commodities from countries where *S. ornithogalli* is present (EUROSTAT data, total for all 28 EU countries (including UK) 2015-2019, volume indicated as x100 KG). Relevant export countries for *S. praefica* are highlighted.

GN-Code and description of commodity	Plant Genus	Volume (x100 KG)	Top 3 countries

071420_SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	9630971	UNITED STATES, HONDURAS, BRAZIL
080711_FRESH WATERMELONS	Citrullus	5440961	BRAZIL, COSTA RICA, GUATEMALA
070920_FRESH OR CHILLED ASPARAGUS	Asparagus	1858752	PERU, MEXICO, UNITED STATES
070310_FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	1675717	PERU, MEXICO, UNITED STATES
070810_FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	639248	GUATEMALA, PERU, UNITED STATES
070820_FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	158340	GUATEMALA, DOMINICAN REPUBLIC, SURINAME
070610_FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	137986	UNITED STATES, MEXICO, COSTA RICA
070200_TOMATOES, FRESH OR CHILLED	Lycopersicon	99844	DOMINICAN REPUBLIC, COSTA RICA, COLOMBIA
071040_SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea	37627	PERU, UNITED STATES, MEXICO
070511_FRESH OR CHILLED CABBAGE LETTUCE	Brassica	25980	UNITED STATES, MEXICO
070890_FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna	15106	GUATEMALA, PERU, CANADA
070519_FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca	14758	UNITED STATES, CANADA, MEXICO
070490_FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica	6506	MEXICO, COSTA RICA, UNITED STATES
070700_CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis	464	DOMINICAN REPUBLIC, SURINAME, COSTA RICA

TABLE X3. Detailed data of import of E28 countries of potential fruit and vegetable commodities from countries where *S. ornthogalli* is present (EUROSTAT data, total for all 28 EU countries (including UK) 2015-2019, volume indicated as x100 KG). (*) Relevant export countries and commodities for *S. praefica* are indicated by an asterisk and highlighted.

Export Country where *S. ornithogalli* is present	**Imported product (label)**	**Genus**	**2015**	**2016**	**2017**	**2018**	**2019**
ARGENTINA	FRESH OR CHILLED ASPARAGUS	Asparagus	23		53	16	
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus					24
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	235	1422	722	210	18866
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	1200	7	10		96
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	33		6		1901
BARBADOS	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	11	39		98	77
BOLIVIA	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	280	274	207	288	373
BRAZIL	FRESH OR CHILLED ASPARAGUS	Asparagus	20	6		12	
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus		80	211		49
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus		4	3		6
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca				1	
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	423	37	257		

	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	140	1			
	FRESH WATERMELONS	Citrullus	487360	607206	689787	760438	830975
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	12702	14143	20414	21803	39223
	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea			14	33	47
	TOMATOES, FRESH OR CHILLED	Lycopersicon			28		
CANADA *	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis	9	22			
	FRESH OR CHILLED ASPARAGUS	Asparagus	6				
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus				30	
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna	1051	867		108	
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca					149
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium		2602	5		9
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum			238	9	
	FRESH WATERMELONS	Citrullus					219
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	163	360	1302		

	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea				204	2
	TOMATOES, FRESH OR CHILLED	Lycopersicon	9				
COLOMBIA	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis					1
	FRESH OR CHILLED ASPARAGUS	Asparagus	60	17			
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	1	27			
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca					2
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum		6		2	3
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea		197	168		325
	TOMATOES, FRESH OR CHILLED	Lycopersicon	11				2829
COSTA RICA	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis			40		
	FRESH OR CHILLED ASPARAGUS	Asparagus			18		
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica	816	393		46	440
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	5058	5069	2703	7646	3247
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	10	13		23	14
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	155			483	

	FRESH WATERMELONS	Citrullus	300832	357957	394157	435545	558868
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	1354	2331	1107	1444	3623
	TOMATOES, FRESH OR CHILLED	Lycopersicon	3008	1324	3069	1227	344
DOMINICA	FRESH WATERMELONS	Citrullus			2		
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea		13			
DOMINICAN REPUBLIC	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis	126	3	14	40	39
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	5638	5317	5195	4635	3187
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica	154	151	174	80	94
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna		6		65	105
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca				17	
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium					42
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum			1	29	
	FRESH WATERMELONS	Citrullus	180	206	326	245	993

	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	718	805	1073	988	513
	TOMATOES, FRESH OR CHILLED	Lycopersicon	10847	19551	21840	19688	15921
ECUADOR	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis	4	5	6	5	6
	FRESH OR CHILLED ASPARAGUS	Asparagus	974	973	1405	1192	2068
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus			20		60
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica	2	1	1	2	
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	3456				40
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	100	54	149		
	FRESH WATERMELONS	Citrullus	200				
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	198	736	1	48	
	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea				125	
EL SALVADOR	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea				129	
GUATEMALA	FRESH OR CHILLED ASPARAGUS	Asparagus	118	220	4		

	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	26200	27514	25851	26453	21272
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica				413	276
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	566	967	479	2259	1612
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna	628	1385	2965	1239	106
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	60	161	52	35	116
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	92392	86389	83648	94900	87528
	FRESH WATERMELONS	Citrullus					7016
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea			1951	10214	24682
HONDURAS	FRESH OR CHILLED ASPARAGUS	Asparagus		138			180
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus			1	11	32
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica		28			

	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna		9			
	FRESH WATERMELONS	Citrullus	763	26	421	754	4189
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	100129	127318	141150	109085	129410
JAMAICA	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis			5		
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica		3			8
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum			19	58	
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	9812	4339	1436	2725	4092
MEXICO	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis		7			
	FRESH OR CHILLED ASPARAGUS	Asparagus	29436	57708	63932	63399	78743
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	237	72	209	256	829
	FRESH OR CHILLED CABBAGE LETTUCE	Brassica			106		
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS,	Brassica	9				2300

	HEADED BROCCOLI AND BRUSSELS SPROUTS)						
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	7042	4978	6301	3498	7190
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna				58	12
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca			40		
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	78361	71493	65037	78300	57258
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	33	559	24	92	252
	FRESH WATERMELONS	Citrullus			209		
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea				5	
	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea	357		330	578	549
	TOMATOES, FRESH OR CHILLED	Lycopersicon	2				
PERU	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis					2
	FRESH OR CHILLED ASPARAGUS	Asparagus	306362	301797	278775	326802	335229
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	130	1347	247	443	118
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	3		1	6	
	FRESH OR CHILLED LEGUMINOUS VEGETABLES,	Vigna	1834	2821	1028	422	

	SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')						
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	117828	176088	210987	318251	406122
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	21675	30874	30955	37341	47453
	FRESH WATERMELONS	Citrullus	967	884	209	1	
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	7172	2868	4588	4138	10980
	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea	4507	5105	7705	7714	8236
	TOMATOES, FRESH OR CHILLED	Lycopersicon		1			
SURINAME (ex DUTCH GUIANA)	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis	63	7	36	3	10
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	237	493	615	422	864
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica			4		
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna	40	83	76	77	70

	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	422	262	385	278	125
	FRESH WATERMELONS	Citrullus					23
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	163	617	158	144	288
	TOMATOES, FRESH OR CHILLED	Lycopersicon	33	35	32	42	2
UNITED STATES *	CUCUMBERS AND GHERKINS, FRESH OR CHILLED	Cucumis			10		1
	FRESH OR CHILLED ASPARAGUS	Asparagus	6085	516	1276	887	302
	FRESH OR CHILLED BEANS 'VIGNA SPP., PHASEOLUS SPP.', SHELLED OR UNSHELLED	Phaseolus	1		5	7	
	FRESH OR CHILLED CABBAGE LETTUCE	Brassica		1003	19488	5383	
	FRESH OR CHILLED CABBAGES, KOHLRABI, KALE AND SIMILAR EDIBLE BRASSICAS (EXCL. CAULIFLOWERS, HEADED BROCCOLI AND BRUSSELS SPROUTS)	Brassica	540	481	25	28	37
	FRESH OR CHILLED CARROTS AND TURNIPS	Daucus	20883	17785	21702	13426	5552
	FRESH OR CHILLED LEGUMINOUS VEGETABLES, SHELLED OR UNSHELLED (EXCL. PEAS 'PISUM SATIVUM' AND BEANS 'VIGNA SPP., PHASEOLUS SPP.')	Vigna	19	14	9	9	
	FRESH OR CHILLED LETTUCE (EXCL. CABBAGE LETTUCE)	Lactuca	854	1975	10940	692	88
	FRESH OR CHILLED ONIONS AND SHALLOTS	Allium	299	2013	1143	2356	59899
	FRESH OR CHILLED PEAS 'PISUM SATIVUM', SHELLED OR UNSHELLED	Pisum	5867	4330	5717	4036	2423

	FRESH WATERMELONS	Citrullus					3
	SWEET POTATOES, FRESH, CHILLED, FROZEN OR DRIED, WHETHER OR NOT SLICED OR IN THE FORM OF PELLETS	Ipomoea	1270021	1769693	2039632	2043169	1681524
	SWEETCORN, UNCOOKED OR COOKED BY STEAMING OR BY BOILING IN WATER, FROZEN	Zea	162	510	1163	261	25
	TOMATOES, FRESH OR CHILLED	Lycopersicon	1				
United States (incl. Navassa Island (part of 'UM') from 1995 -> 2000)	Sugar beet, fresh, chilled, frozen or dried, whether or not ground(1988-2500)	Beta	3				
Total			2949883	3727141	4175807	4417624	4471808

Table X4. Import by the Netherlands of host plants of cut flowers and plants for Planting from countries where *S. ornthogalli* is present in 2019 and 2020 (indicated as number of imported lots, NVWA import database)

Commodity	2019	2020	Total
CUT FLOWERS			
ROSA	19561	18913	38474
DIANTHUS	7280	6401	13681
SOLIDAGO	140	260	400
ASTER	143	191	334
ZANTEDESCHIA		2	2
CATTLEYA		1	1
HELIANTHUS		1	1
LIVING PLANTS			
DRACAENA	2067	1940	4007
SCHEFFLERA	393	417	810
FICUS	365	284	649
YUCCA	296	288	584
PEPEROMIA	201	202	403
PHILODENDRON	119	145	264
SEDUM	125	121	246
CRASSULA	130	103	233
BEGONIA	99	71	170
DAHLIA	85	67	152
TRADESCANTIA	68	70	138
DIANTHUS	57	65	122
ASTER	61	56	117
EPIPREMNUM	39	57	96
PILEA	48	28	76

PORTULACA	39	26	65
OENOTHERA	32	23	55
SOLIDAGO	20	31	51
COLOCASIA	18	30	48
VIOLA	23	19	42
PORTULACARIA	24	14	38
DENDRANTHEMA	22	15	37
SYNGONIUM	16	20	36
DIGITALIS	14	19	33
ZANTEDESCHIA	20	4	24
SAXIFRAGA	10	13	23
IPOMOEA	8	11	19
COSMOS	10	7	17
FRAGARIA	8	5	13
HIBISCUS	9	3	12
RUBUS	6	6	12
PELARGONIUM	9	2	11
HELIANTHUS	1	10	11
ALLIUM	6	4	10
JATROPHA	6	2	8
CALENDULA	4	2	6
RHODODENDRON	3	2	5
MONSTERA		5	5
HELICONIA		5	5
TAGETES		5	5
PINUS	2	3	5
GERANIUM	2	3	5
THUNBERGIA	4		4
XANTHOSOMA	2	1	3
IXORA	2	1	3
CATTLEYA		3	3
HEDERA	1	2	3
BRASSICA	1	2	3
GARDENIA	2	1	3
VERNONIA	1	1	2
SYZYGIUM		2	2
PETUNIA	1	1	2
ROSA	1	1	2
CALATHEA	1	1	2
LITCHI	2		2
MANIHOT	2		2
CELOSIA		2	2
ASPARAGUS	1		1
BOMBAX	1		1
LACTUCA		1	1
MUSA		1	1
ALTERNANTHERA	1		1

THEOBROMA		1	1
POTENTILLA	1		1
CALADIUM		1	1
ZINNIA	1		1
CYPERUS		1	1
CUCURBITA	1		1
Eindtotaal	31615	29995	61610

ANNEX 2. Additional data on climate suitability

In the risk assessment (Van der Gaag and Van der Straten, 2017), it was assessed that *S. ornithogalli* can at least establish in the southernmost parts of the EU but can probably also have a more northerly distribution because it is present in US states with relatively cold winters (plant hardiness zones 6-7). However, these states also have warm summers.

The Köppen-Geiger climate classification system is widely used in pest categorization and pest risk assessment (MacLeod and Korycinska, 2019). *S. ornithogalli* is mostly established in areas of the Americas where tropical and subtropical climate types occur. In the USA *S. ornithogalli* occurs in the Köppen-Geiger climate types Csa (dry hot summer), Csb (dry warm winter) and Cfa (humid sub-tropical) (Figure X1). The most northern states where *S. ornithogalli* is established are Kentucky and North Carolina. These states have Köppen-Geiger climate type Cfa (humid subtropical, dark green). In comparison with *S. ornithogalli, S praefica* is reported in more northern states, such as Oregon, Washington, and British Colombia (CA). These reports are mainly based on moth sightings (ref to Moth Photographers Group), and therefore it is uncertain if these reported moths are migrants or can also originate from overwintering pupae in these states. In recent years serious larval feeding damage by *S. praefica* to alfalfa has been reported in the west of British Columbia (Min. Agr. Canada & British Columbia, 2019), but there is no information on the origin of these populations (i.e. if it can overwinter in British Columbia or not).

The climate types of Oregon, Washington, and British Colombia (CA) include the climate types Csa and Csb that occur in the EPPO region (see Figure X1) and are similar to *S. ornithogalli*. It also includes climate type Cfa and Cfb (temperate oceanic climate), but in a very limited way. Therefore, there is a high uncertainty as to whether *S. praefica* can establish on these types of climate in the EPPO region.

Figure 3 in the main text gives an overview in which regions these climate types occur in the EPPO region, using data from MacLeod and Korycinska (2019). It indicates that the southern area of the EPPO region is suitable for establishment of both *S. ornithogalli* and *S. praefica*.

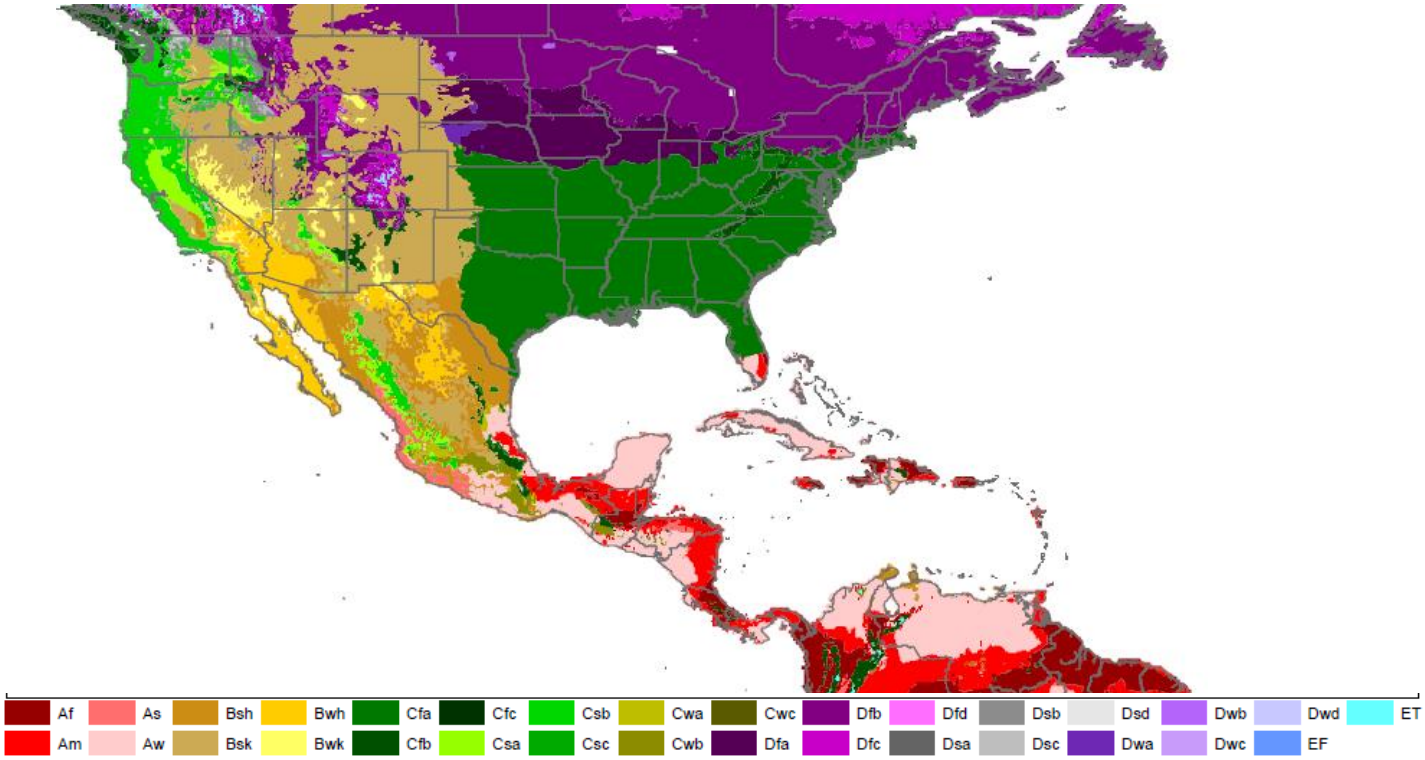


Figure X1. Köppen-Geiger climate types in North and Central America

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