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Quick assessments of the potential for establishment in Sweden for the provisional quarantine pests *Chloridea virescens*, *Homona magnanima*, *Resseliella citrifrugis*, and *Spodoptera ornithogalli*

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Background

Following Article 30 of Regulation (EU) 2016/2031, plant pests provisionally qualifying as Union quarantine pests are subjected to specific measures. These pests are listed in Commission Implementing Regulation (EU) 2022/1941. Similarly to other Union quarantine pests, surveys for the Article 30 pests shall be carried out on a regular basis by the Member States according to the plant health regulation ((EU) 2016/2031). However, if it can be 'unequivocally concluded' that ecoclimatic conditions or the absence of hosts prevents the establishment or spread of the pest, surveys are not required.

Previously, quick assessments of the potential for establishment in Sweden were done for 82 quarantine pests for which there had been uncertainty about whether the ecoclimatic conditions and host availability allowed the establishment (Björklund and Boberg 2021; 2023). SLU Risk Assessment of Plant Pests was requested by the Swedish Board of Agriculture to apply the same methodology for conducting quick assessments for the following provisional quarantine pests: *Chloridea virescens* [HELIVI], *Homona magnanima* [HOMOMA], *Resseliella citrifrugis* [RESSCI] and *Spodoptera ornithogalli* [PRODOR], where the codes within brackets refer to EPPO codes (see EPPO Global Database, https://gd.eppo.int).

Method and definitions

The assessments were done following the format, method and definitions described in a previous report with the same objective (Björklund and Boberg 2021). For convenience, a brief description of the procedure and the scale used is quoted below (from Björklund and Boberg, 2023):

In short, the potential for establishment of the quarantine pests were assessed based on the likelihood of the pests to survive and reproduce in Sweden both outdoors and in protected cultivation in greenhouses. The degree to which conditions are suitable for establishment in Sweden was evaluated using the following scale:

- "Not suitable", i.e. the conditions does not support establishment.
- "Unlikely to be suitable", i.e. the conditions are unlikely to support establishment.
- "Likely to be suitable", i.e. the conditions are likely to support establishment.
- "Very likely to be suitable", i.e. the conditions are very likely to support establishment.

Based on an assessment for each pest the most likely option was selected and the uncertainty was provided as the plausible minimum and maximum options.

The assessments

Quick assessments were performed separately for each of the four provisional quarantine pest species to determine the degree to which conditions in Sweden are suitable for their establishment. In Table 1 the assessments are presented separately for conditions outdoors and in greenhouses. The rationale behind the assessments and the associated uncertainties (grey shading in Table 1) are provided separately for each species in the following subsections.

It should be noted that the assessments were performed very rapidly and for some of the species they were based on limited information which increase their uncertainty. Nevertheless, the available information was consistent enough for all assessed species to limit the maximum uncertainty-range to two steps on the assessment scale (Table 1).

Table 1. Assessments of the degree to which the conditions are suitable for the establishment of individual pests in Sweden outdoors and in greenhouses. For a description of the scale used for the assessments, see the section titled "Method and definitions". The assessment of the most likely scenario is denoted in the table with an X and the uncertainty (the range between the plausible minimum and maximum options) is depicted with a grey shade.

Pest	EPPO code	Organism	Environment	Not suitable	Unlikely to be suitable	Likely to be suitable	Very likely to be suitable
Chloridea virescens	HELIVI	Insect	Outdoors	X			
			In greenhouses		X		
Homona magnanima	HOMOMA	Insect	Outdoors	X			
			In greenhouses	X			
Resseliella citrifrugis	RESSCI	Insect	Outdoors	X			
			In greenhouses	X			
Spodoptera ornithogalli	PRODOR	Insect	Outdoors	X			
			In greenhouses	X			

Chloridea virescens [HELIVI]

Chloridea virescens is a species of moth in the family Noctuidae (*sv.* nattflyn) and known under the common name tobacco budworm (EPPO 2024a). It is reported to occur in large parts of North- and South America (EPPO 2024a). In Canada, the species is reported as present with a restricted distribution (i.e., Southern Ontario and Quebec; EPPO 2024a).

Major hosts are chickpea, soybean, cotton, tobacco, and tomato but *C. virescens* is a very polyphagous pest with more than 200 host plant species recorded (EPPO 2024a,b). The host list includes numerous plant species commonly found in Sweden, including field crops, greenhouse-grown crops, ornamental plants and wild species. It is thus assessed that the availability of hosts is unlikely to prevent establishment of the pest in Sweden.

Recently an EPPO PRA was performed for the pest (EPPO 2024b). The main points of the climate suitability analysis from the PRA, relevant to Swedish conditions, are summarized below:

- In the northern parts of the reported range (northern USA and southern Canada) populations are thought to primarily result from annual migration from the south (or repeatedly introduced with traded commodities). The northern limit for overwintering populations has been suggested to be 37°N, which approximately stretches from southern California in the west to North Carolina in the east (cf. Figure 3).
- In regions with established populations and cold climates, *C. virescens* overwinter as pupae in the soil. Low soil temperatures during winter may limit survival of the overwintering pupa. Areas in North America with minimum soil temperatures of the coldest month similar to those found in Sweden correspond to areas where the pest is not known to overwinter. This analysis was assessed as very uncertain since it is unknown i) what the exact temperature threshold for survival is and ii) whether other factors affect the survival.
- Köppen-Geiger climate types likely to favour establishment are found in southern Europe.
- An estimated 550 growing degree days above 12.6 °C is required to complete one generation. Based on temperature data for the time period 1987–2016 this threshold value is not reached in Sweden. Additionally, in areas with few generations per year, establishment would be less likely.
- Transient populations outdoors can occur in areas where the pest cannot overwinter.
- *Chloridea virescens* has been reported as a pest of tomato in protected conditions. The likelihood of establishment in protected conditions where host plants are present only part of the year was assessed as very unlikely in the EPPO PRA.

Based on the available information outlined above, we assess that the climate is not suitable for establishment of *C. virescens* outdoors in Sweden. The uncertainty of this assessment is low. However, if the pest establishes in more southern parts of Europe, transient populations may occur in Sweden due to the annual migration of adults or spread through, for example, host plants for planting.

Crop production in greenhouses are likely to provide more favourable conditions. However, in general, production in greenhouses in Sweden includes a crop-free period during the winter, and the growing medium is treated or replaced (see description in Appendix 1 in Björklund and Boberg 2021). This is likely to reduce the likelihood of establishment, but it is uncertain if this is sufficient to eliminate the pest since it can enter diapause and overwinter as pupae. In addition, some producers do cultivate hosts year round which may support a population of the pest year round. For example, short-term crops are cultivated during the winter break in organic vegetable production which also grow plants in soil. Such production is however performed to a limited extent. The conditions in greenhouses are assessed as unlikely to be suitable for establishment, with an uncertainty range spanning from "not suitable" to "unlikely to be suitable".

Assessment of the degree to which conditions are suitable for establishment in Sweden:

	Not suitable	Unlikely to be suitable	Likely to be suitable	Very likely to be suitable
Outdoors				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☐	☐	☐
In greenhouses				
Most likely	☐	☒	☐	☐
Uncertainty range	☒	☒	☐	☐

Homona magnanima [HOMOMA]

Homona magnanima is a species of moth belonging to the family Tortridae (*sv*. vecklare) and known under the common name oriental tea tortrix (EPPO 2024a). The pest is reported as present in China, Japan, North Korea, South Korea, Taiwan (CABI 2024) and Vietnam (Razowski 2008).

Homona magnanima is an important pest of tea (*Camellia sinensis*) in Japan but is very polyphagous and reported to attack a range of plant species representing 26–29 families (Schrader 2024). The very broad groups ‘ornamental plants’ and ‘plants in general’ are listed as hosts by DEFRA (2024). Examples of reported host plants that are known to grow in Sweden outdoors include *Malus domestica*, *Larix kaempferi*, *Paeonia*, *Prunus*, *Prunus avium*, *Pyrus*, *Rhododendron*, *Rosa*, *Salix* sp., *Vitis* and in greenhouses *Solanum melongena* (CABI 2024; Schrader 2024). It is thus assessed that the availability of hosts is unlikely to prevent establishment of the pest in Sweden, at least outdoors.

No detailed analysis of the climatic requirements of this pest was found in the literature. *Homona magnanima* is reported to occur in temperate to tropical climate (Sato and Oho 1980). In Japan the pest is present throughout the country, with the exception of the northernmost island, Hokkaido (Schrader 2024 citing Noguchi 1990). Focusing on the temperate Köppen-Geiger climate types found in the distribution area of the pest using the Köppen-Geiger maps of Beck et al. (2023; checking both the time period 1961–1990 and 1991–2020) the following was observed. In Japan, mainly Cfa and only small areas of Cfb are found. In the other countries where the pest is reported as present mainly the temperate climate types Cfa and Cwa are found but in Taiwan also the temperate climate type Cfb, which covers the mountainous regions. In Sweden, the climate zones are moving fast northwards and for the time period 1991–2020 the temperate climate type Cfb can be found along the coast of southern Sweden, and further north in a projected future climate (Beck et al. 2023; Figure 1). However, although the Cfb climate type occurs in Japan (small areas) and Taiwan (mountainous regions), no information was found regarding whether established populations are present in those areas.

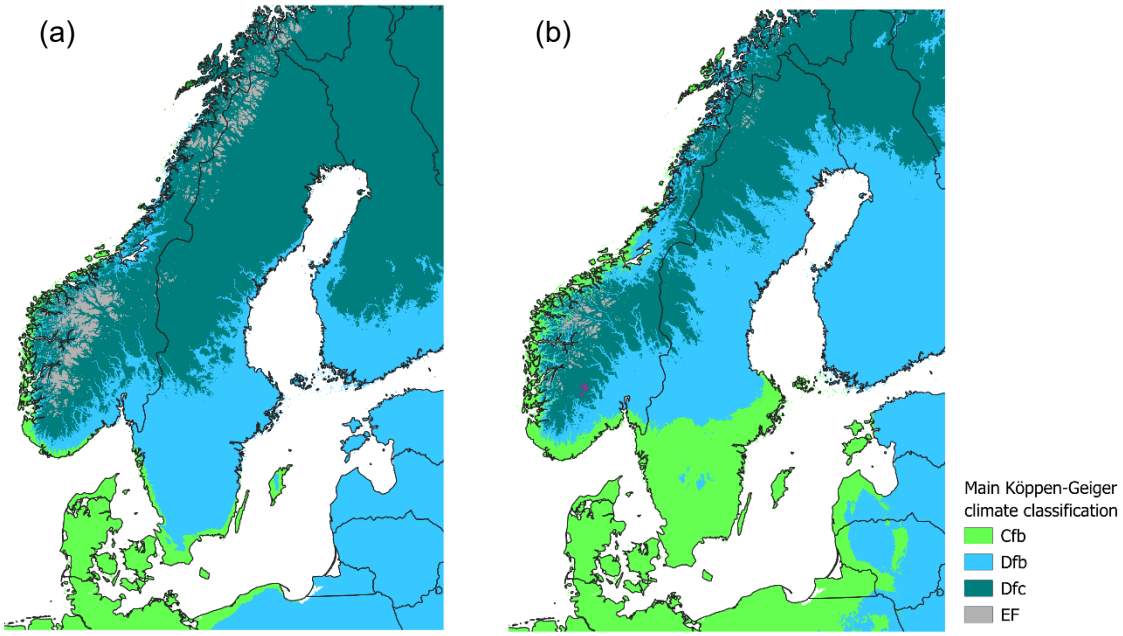

Figure 1. Köppen-Geiger climate classification in Sweden and surrounding areas based on the climate during (a) the time period 1991–2020 based on observed data and (b) the time period 2041– 2070 based on emission scenario SSP5-8.5 (high emission scenario). Maps are from Beck et al. 2023 (www.gloh2o.org/koppen; available under the CC BY 4.0 license). The current distribution of the climate zones is expected to be in between the historical- and the future distribution.

Homona magnanima has 3–5 generations in Japan (CABI 2024; Yasuda 1972). The temperature threshold for development has been estimated to 9.6–9.9°C depending on the life stages and in total 469 growing degree days were required for the development of egg to adult (Mao and Kunimi 1990). Considering a required pre-oviposition period, the accumulated temperature required to complete one generation was estimated by Mao and Kunimi (1990) to be 500

growing degree days above 10°C[1]. The area in Sweden where the growing degree day requirements were fulfilled for a threshold temperature of 10°C was mapped using temperature data for the time period 2003–2022 (Figure 2). Based on these data, the accumulated heat is sufficient for the development of one generation in large parts of Sweden. It should be noted that the map in Figure 2 provides an upper bound estimate since the threshold temperature used here is slightly higher than the threshold temperatures reported for the different life stages.

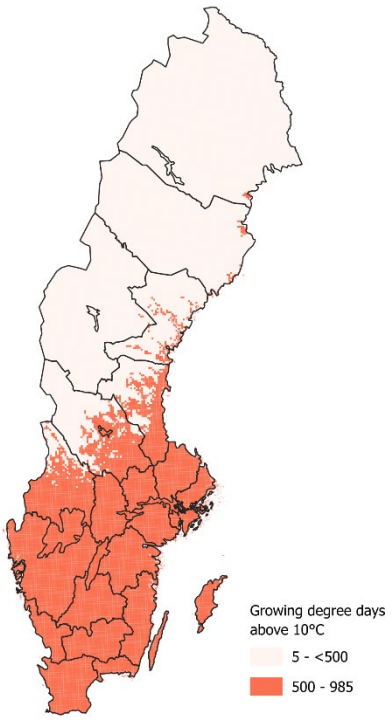

Figure 2. Mean annual growing degree days above 10°C with a threshold of 500 for the development of one generation of *Homona magnanima*. The growing degree days required for development was obtained from Mao and Kunimi (1990) and daily air temperature data from 2003–2022 at a resolution of 4 x 4 km were used (SMHI 2023). The calculation was done using Method 1 by McMaster and Wilhelm (1997) in R and maps were created with qGIS (R Core Team, 2024; QGIS Development Team, 2024). Map of the Swedish counties are from SCB (2020).

The pest overwinters as larvae but it appears to be unclear whether the species enters diapause (CABI 2024; Schrader 2024). The overwintering larvae are reported to not create any shelter and often feed during warm winter days (Yasuda 1972). No effect on developmental rates of larvae was observed for different photoperiod regimes in the lab which is consistent with a species without diapause (Mao and Kunimi 1990). Without a diapause and by overwintering as larvae rather than in a resilient stage (e.g., eggs or pupae), *H. magnanima* would rely on active feeding and development for survival. This would be impossible during the Swedish winter, where temperatures remain well below the developmental threshold of 10°C for long periods of time, expected to ultimately lead to their starvation before spring arrives. Furthermore, the low

[1] Based on a non-verified translation from Japanese to English.

temperatures during winter *per se* may be detrimental but no information about lethal low temperature thresholds for larvae was found.

Based on the available information the conditions outdoors in Sweden are likely not suitable for establishment mainly due to unsuitable environmental conditions for surviving the winter, but the assessment is uncertain. Protected conditions in greenhouses are likely to provide more suitable conditions, although no information was found indicating that *H. magnanima* is a pest in such production facilities in its current range. Although the host range is reported as very broad it appears that most hosts are woody plant species and it is uncertain whether suitable hosts are prevalent in commercial greenhouse production in Sweden. Aubergine is a reported host but commercial production in Sweden is limited to 0.4 ha (Swedish Board of Agriculture 2023).

Assessment of the degree to which conditions are suitable for establishment in Sweden:

	Not suitable	**Unlikely to be suitable**	**Likely to be suitable**	**Very likely to be suitable**
Outdoors				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☒	☐	☐
In greenhouses				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☒	☐	☐

Resseliella citrifrugis [RESSCI]

Resseliella citrifrugis is a species of gall midge (Family: Cecidomyiidae; *sv. gallmyggor*) known under the common name citrus fruit midge (EPPO 2024a). However, it should be noted that the taxonomic status of the species is uncertain and obscure (Xia et al. 2021; c.f. EFSA et al. 2021). The pest is only reported as present in China and limited to some southern and central provinces (EPPO 2024a).

Host plants are only found in the genus *Citrus* (EPPO 2024a). There are no established populations of citrus species in Sweden and none of the hosts are produced commercially (SLU Artdatabanken 2024; Widenfalk et al. 2022). Because the absence of hosts precludes establishment in Sweden, no analysis of climate suitability was conducted (but see EFSA et al. (2023)).

Resseliella citrifrugis is considered unable to establish outdoors due to the absence of suitable hosts. Furthermore, it is not known as a pest in greenhouses and there is no commercial production of citrus hosts in greenhouses and thus the conditions are not suitable for establishment in greenhouses either. These assessments have a low uncertainty.

Assessment of the degree to which conditions are suitable for establishment in Sweden:

	Not suitable	Unlikely to be suitable	Likely to be suitable	Very likely to be suitable
Outdoors				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☐	☐	☐
In greenhouses				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☐	☐	☐

Spodoptera ornithogalli [PRODOR]

Spodoptera ornithogalli is a species of moth in the family Noctuidae (*sv.* nattflyn) and known under the common name yellow-striped armyworm. The pest is reported to occur in large parts of North America and South America (EPPO 2024a). The species is reported as present with restricted distribution in Canada (reported as present in Southern Ontario and Quebec; EPPO 2024a).

Spodoptera ornithogalli is very polyphagous and more than 200 plant species are reported as hosts (EPPO 2023; 2024a). The host list includes common field crops, crops in greenhouses, ornamental and wild plant species growing in Sweden. Thus, we assess that the availability of hosts is unlikely to prevent establishment of the pest in Sweden.

Spodoptera ornithogalli has 3–4 generations per year and overwinters as pupae (Capinera 2001). In Northern America, distribution records are found across USA and up to southeastern Canada (up to, e.g., Newfoundland; Brito et al. 2018). However, the species only overwinter in the southern parts of USA. For example, while the pest is reported to migrate regularly to eastern Canada, it is unable to survive the winter in those regions (Pohl et al. 2018).

The northern limit of established populations in North America is uncertain. Kentucky and North Carolina is reported as the most northern states where the pest is established by van der Gaag and van der Straten (2017; citing Fleisher 2012). In extension material from University of Maryland, it is reported that *S. ornithogalli* has become an increasing problem in north-eastern

USA over the last 10 years since it appears to overwinter further north than before and thus invade fields in early summer (Brust 2008). According to the database 'Butterflies and Moths of North America' *S. ornithogalli* does overwinter further north but not north of Long Island (Lotts and Naberhaus 2024; Figure 3).

An EPPO PRA reports that *S. ornithogalli* is mainly established in areas with tropical and subtropical climate (EPPO 2023). Based on an assumed northern limit for established populations in Kentucky and North Carolina, the PRA conclude that the Köppen-Geiger climate types likely to be suitable for overwintering and establishment are found in southern Europe. Note that a northern limit set at Long Island (cf. previous paragraph) would not affect the conclusion from the Köppen-Geiger climate type comparison (Figure 3). Due to a lack of data on the thermal requirements of *S. ornithogalli*, a more precise area of potential establishment could not be identified in the EPPO PRA (2023).

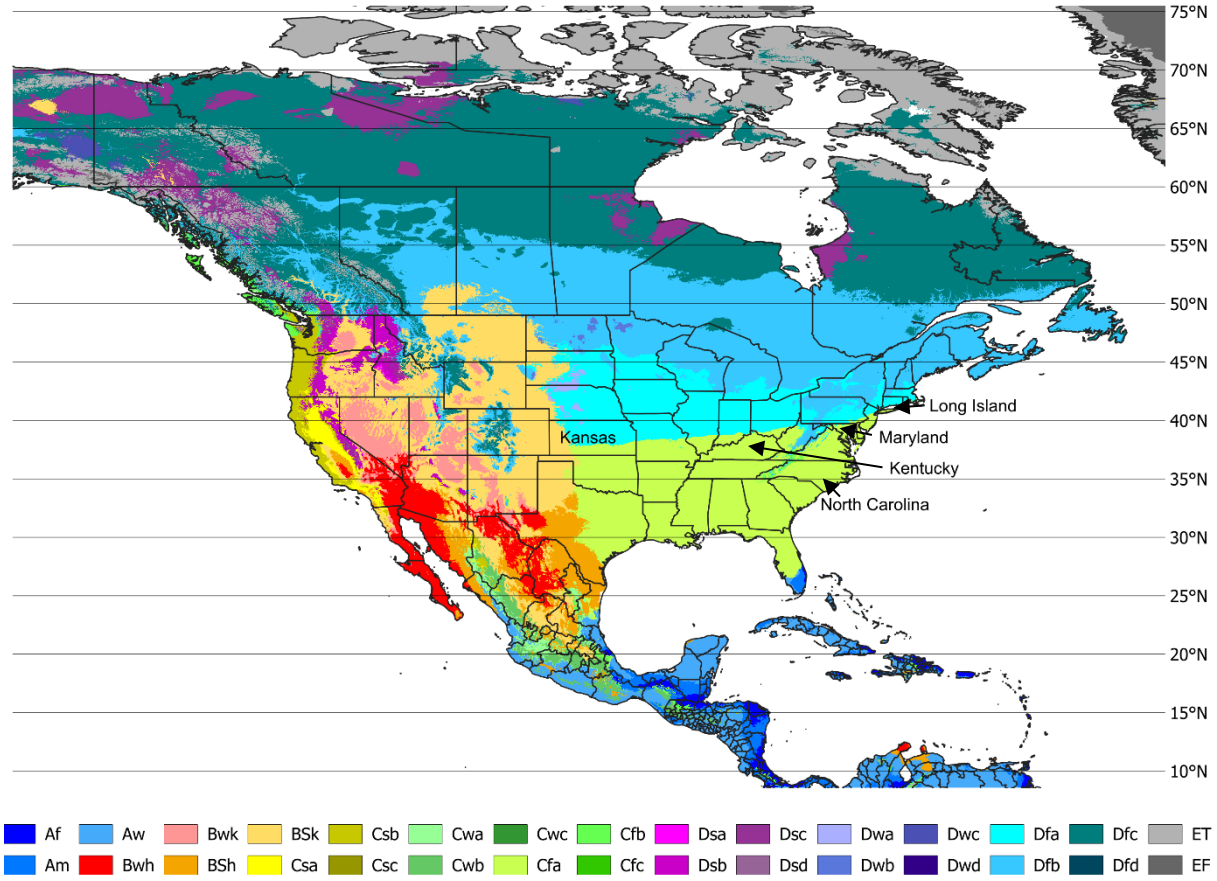

Figure 3. Köppen-Geiger climate classification in North America based on the climate during the time period 1991-2020 (map from Beck et al. 2023; www.gloh2o.org/koppen; available under the CC BY 4.0 license). States and locations mentioned in the assessment description of *Spodoptera ornithogalli* are indicated on the map.

EPPO (2023) assesses that transient populations (one generation per year with populations that do not survive the winter) may be possible as far north as southern Sweden. However, they also add that it is uncertain whether populations would be high enough in southern Europe (should it establish there) to induce migratory behaviour as observed in North America (EPPO 2023).

Spodoptera ornithogalli is reported as a pest of tomato and pepper in greenhouses (in Kansas; Cloyd 2018). However, according to van der Gaag and van der Straten (2017), the species (as part of the group American *Spodoptera* species) is not known as a significant pest in greenhouses in areas where it is unable to establish outdoors. It is not expected to establish in commercial greenhouses in such regions although outbreaks or transient populations may occur (van der Gaag and van der Straten 2017).

The conditions both outdoors and in greenhouses are assessed as not suitable for establishment of *S. ornithogalli*. The uncertainty is low for the assessment outdoors while it is higher for the assessment of conditions in greenhouses.

Assessment of the degree to which conditions are suitable for establishment in Sweden:

	Not suitable	**Unlikely to be suitable**	**Likely to be suitable**	**Very likely to be suitable**
Outdoors				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☐	☐	☐
In greenhouses				
Most likely	☒	☐	☐	☐
Uncertainty range	☒	☒	☐	☐

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