Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

SLU Risk Assessment of Plant Pests

SLU ua 2020.2.6-1710

May 25, 2020

Potential establishment of the priority pest *Conotrachelus nenuphar* in Sweden

Background and terms of reference

The European Commission has established a list of 20 priority pests (Commission Delegated regulation (EU) 2019/1702). The pests have been selected among the Union quarantine pests as the pests for which the potential economic, environmental and social impact is assessed to be the most severe in the EU.

For each priority pest Member States shall carry out annual surveys (article 24 in EU regulation 2016/2031). However, the regulation further states that:

“The surveys shall not be required to be carried out for pests for which it is unequivocally concluded that they cannot become established or spread in the Member State concerned due to its ecoclimatic conditions or to the absence of the host species.”

For some of the priority pests it is currently uncertain whether the ecoclimatic conditions or host availability in Sweden allow their establishment in whole or part of the country.

The Swedish Board of Agriculture has requested SLU Risk Assessment of Plant Pests to assess whether certain priority pests are able to establish in Sweden and further, when relevant, identify the area of potential establishment. This report provides the assessment of the potential establishment of *Conotrachelus nenuphar* (EPPO code: CONHNE).

Short description of *Conotrachelus nenuphar*

The pest *Conotrachelus nenuphar* is a small weevil, ca 5-7 mm long as adults. The colloquial name is Plum curculio and it is a pest of different stone and pome fruits (Smith et al. 1996). Host plant species are mainly found in the family Rosaceae (Smith et al. 1996; EFSA, 2019a). The species is currently only reported from eastern North America, where the species is distributed from Florida to the southern parts of Canada (Vincent et al. 2004; EPPO, 2020).

Two different strains have been identified, one southern with several generations per year and one northern with one generation developing per year (Smith et al. 1996; EFSA, 2019a).

Obligate diapause is reported for the northern strain, for which diapause is a prerequisite for reproduction, whereas facultative diapause is reported for the southern strain (Smith and Flessel, 1968).

The species overwinters as adults in fallen leaves, in the orchards and in nearby woods, to emerge in spring to early summer (Lafleur et al. 1987; Racette et al. 1992). Maturation feeding is necessary before egg laying (Racette et al. 1992). Mating and oviposition occurs when fruits become available (Armstrong, 1958). The larvae develop within the fruit that often drop prematurely (Armstrong, 1958; EFSA, 2019a). The weevil pupates in the soil to later emerge and feed before overwintering as adults (Armstrong, 1958). No information was found that indicate overwintering of other life stages, i.e. there are no indications that a two year life cycle for the species would be possible.

Natural dispersal is generally by walking, or flying when temperatures are >20°C, but are generally limited in range (EFSA, 2019a and references therein). EFSA (2019a) estimated the spread rate to a maximum distance of 300 m expected per year.

Ecoclimatic conditions

Analysis based on the current distribution and Köppen-Geiger climate zones

The northern part of the distribution range of *C. nenuphar* in North America extends into the southern parts of the Canadian provinces (e.g. Vincent et al. 2004). The northern limit in Canada has been suggested to be approximately around latitude 50°N (Smith et al. 1996; Holt et al. 2016). Many of the observations reported from Canada are found in the Köppen-Geiger climate zone Dfb (Appendix 1), which corresponds to the type of climate found in southern parts of Sweden (more or less south of '*Limes norrlandicus*') (Figure 1). No records were found from the Köppen-Geiger climate zone Dfc which is found in the northern parts of Sweden. Future change in climate are projected to shift the distribution of the Köppen-Geiger climate zones northwards (Beck et al. 2018). The climate zone Dfb is then expected to cover most of the northern parts of Sweden, while the climate zone Cfb is expected to cover the southern parts (Beck et al. 2018; Figure 1b).

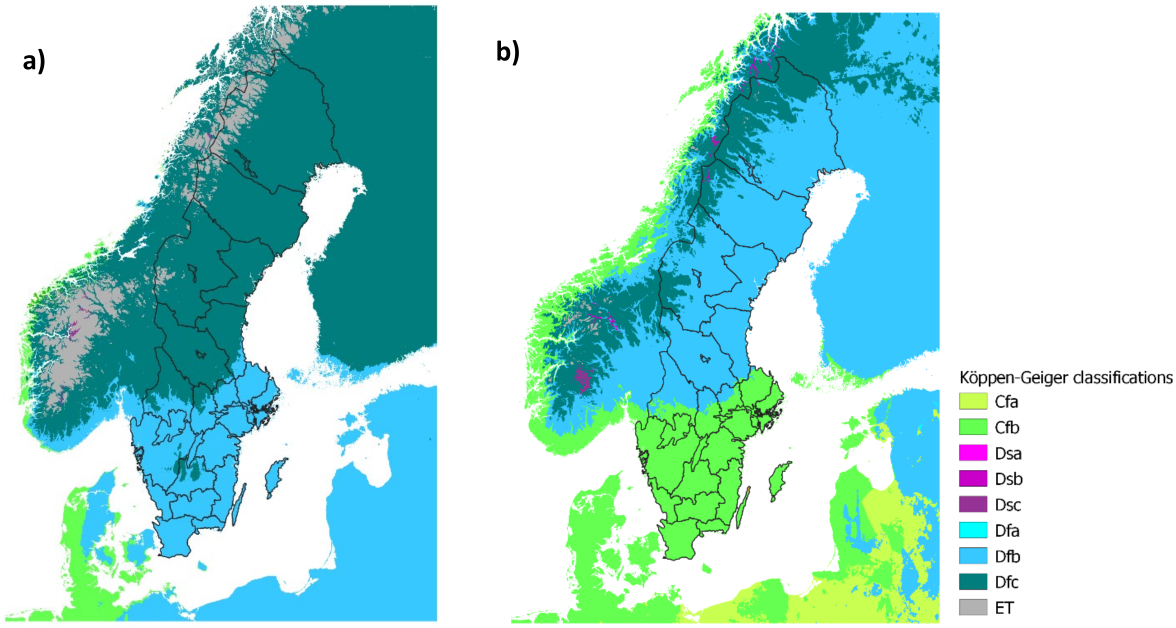

Figure 1. *Köppen-Geiger climate classifications in Sweden and surrounding areas based on a) the climate during the time period 1980-2016 and b) the predicted climate according to scenario RCP 8.5 for the time period 2071-2100 (modified maps from Beck et al. 2016;* http://www.gloh2o.org/koppen*; available under the CC BY-NC 4.0 license). The map of the counties in Sweden is from SCB (2020).*

Thermal requirement for development

Several studies have developed degree-day models to predict the emergence of *C. nenuphar*, often with the aim to determine optimal timing of control measures. Depending on the specific aim, location and crop the estimated thermal requirements reported from the different studies vary.

In a Pest Report for *C. nenuphar*, EFSA (2019a) considers that the main factors that determine the development and number of generations per year is temperature and degree-day (DD) accumulation. Using 250 DD above 10°C as thresholds (assumed values based on information in Akotsen-Mensah et al. 2011, EFSA, pers. comm., 6 April 2020), a *maximum* of one to three generations of the pest were estimated for EU based on climate data from JRC for the period 1998-2017 (EFSA, 2019b). However, whether the requirements for one generation are met in Sweden is not clear. In Akotsen-Mensah et al. (2011), seasonal peaks were used to develop a degree-day model for *C. nenuphar* in peach orchards in Alabama. Based on a biofix of January 1st, a first peak in trap captures were observed at 245 DD above 10°C followed by a second peak at 1105 DD and a potential third at 1758 DD. The species overwinters as adults and the first peak represents the trap catches of the overwintered individuals, and thus 245 DD is not enough for the development of one full generation. The second peak represents the trap catches of the first new generation produced during the year. Using data from one year, Akotsen-Mensah et al. (2011), estimated the accumulated DD required for complete development from first egg event to peak emergence of adults to 1018 DD. Using the degree day values obtained for the first and second peak emergence, one estimation of the degree days above 10°C required for one generation as adult to adult would be 860 DD. This is a very rough estimation since it is based on observations from presumably overlapping generations, but gives an indication of accumulated temperature needed for the development from adult to adult.

In addition, this estimation does not include any accumulated temperature required for maturation of overwintering adults. It is not clear whether all or parts of the first accumulated 245 DD represents a required maturation period and/or the timing when conditions for emergence are met. It is, however, necessary to add the DD accumulation during the maturation period to the adult to adult development time to obtain the DD accumulation requirement for the establishment of the pest in an area. Other estimations of degree-days corresponding to spring emergence of overwintering adults from more northern locations are also available. In apple orchards in Massachusetts, the start of immigration occurred after a calculated 109 DD base 6.1°C and the 50th percentiles of cumulative captures after 251 DD (Piñero and Prokopy, 2006). In apple and cherry orchards in Michigan, females mated after overwintering and 95% of females mated after 134 DD (base 10°C) (Hoffmann et al 2004). The spring emergence has been reported to coincide with for example mean daily temperatures of 10.8-15.6°C (Racette et al. (1992) citing other sources).

Other studies have been done on the thermal requirement for different stages of the weevils' development. Studies of populations belonging to the southern strain showed that the lower temperature threshold for larvae development was 11.1°C and that complete larvae development required 215.5 DD (at peak emergence) (Lan et al. 2004). The lower temperature threshold for pupal development was 8.7°C and 442.4 DD were required to complete the stage (to peak emergence)(Lan et al. 2004). A later study by Selby and Whalon (2014) on the northern strain using the temperature threshold values from Lan et al. (2004) found that the mean number of DD ranged between 203-368 for larvae development (incl. oviposition) and 365-442 DD for pupae development (first emergence) depending on rearing location and type of fruit. Thus, the thermal requirements appear to be highly variable making estimations difficult.

We calculated the mean number of degree-days based on the threshold of 10°C for Sweden using the R code by Korycinska (2020) and gridded MARS-AGRI4CAST temperature data for the time period 1999-2018 from JRC (JRC, 2020). The calculations were run in R (R Core Team, 2019) and maps were created with qGIS (QGIS Development Team, 2020). In the southern parts of Sweden corresponding to the Köppen-Geiger climate zone Dfb (Figure 1a) the mean number of degree days above 10°C was >600 but values >800 was only found in some parts (Figure 2a). The number of degree-days also differ across years and only small areas in the most southern part of Sweden consistently had ≥800 DD above 10°C during the time period 1999-2018 (Figure 2b). Although no specific threshold required for one generation could be identified, the assessment indicate that the region most likely to meet the thermal requirements are found in areas of southern Sweden with >800 DD above 10°C. Further analysis would be required in order to make better predictions of whether the temperature requirements for development of *C. nenuphar* is met in Sweden and if so in which parts.

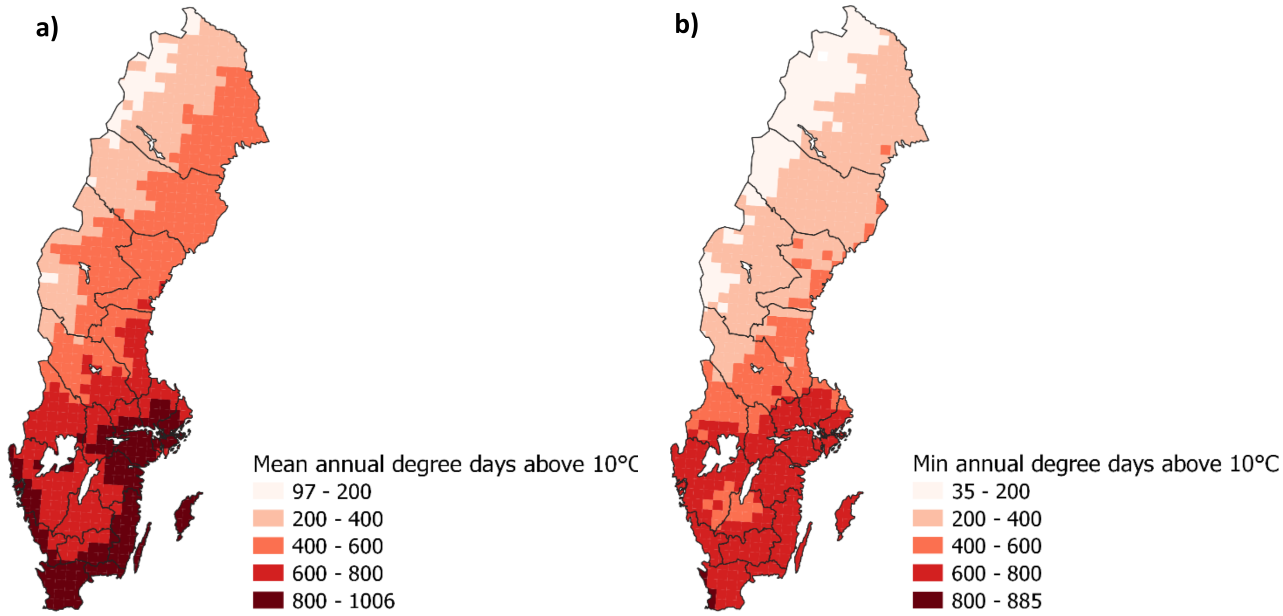

Figure 2. *Mean (a) and minimum (b) annual temperature accumulation (degree days) above a threshold of 10°C for the time period 1999-2018. Calculated using the R code by Korycinska (2020) and gridded MARS-AGRI4CAST temperature data from JRC (JRC, 2020). The map of the counties in Sweden is from SCB (2020).*

Presence and distribution of hosts

Main hosts include *Prunus* spp. (plommonsläktet), *Malus domestica* (äpple) and *Pyrus communis* (päron). *Prunus* hosts found in Sweden include *P. domestica* (plommon), *P. avium* (sötkörsbär), *P. cerasus* (surkörsbär) as well as minor occurrences of *P. armeniaca* (aprikos) and *P. persica* (persika). Other hosts listed by EFSA (2019a) that are found in Sweden, either cultivated and/or growing in the wider environment (Anderberg and Anderberg, 1996; SLU ArtDatabanken, 2020), are:

- *Amelanchier canadensis* (syn. *A. confusa*) (svensk häggmispel)
- *Crataegus* spp. (hagtornar)
- *Cydonia oblonga* (kvitten)
- *Fragaria ananassa* (jordgubbe)
- *Hemerocallis lilioasphodelus* (gul daglilja)
- *Sorbus aucuparia* (rönnbär)
- *Ribes* spp. (ripsar)
- *Vaccinium* spp. (odonsläktet)
- *Vitis* spp. (vinsläktet)

Considered together, host plants are thereby widely distributed in Sweden and found in production sites, private gardens and in the wider environment. Some host plant species or genera have a distribution that covers the whole of Sweden, e.g. *Sorbus aucuparia* and *Vaccinium* spp. (Räty et al. 2016; Anderberg and Anderberg, 1996).

Conclusion

Based on the information presented above our assessment is that *Conotrachelus nenuphar* would be able to establish in some parts of southern Sweden. Due to the rather limited data available to assess the potential establishment of the pest, the assessment is associated with a high uncertainty. The lack of reports from more northern regions in Canada suggests that the climatic conditions in the northern parts of Sweden, i.e. approximately north of *Limes Norrlandicus*, would not be suitable for the pest. The region most likely to meet the thermal requirements for the development of the pest is assessed as areas of southern Sweden with >800 DD above 10°C. Further analysis would be required to more precisely identify the area in southern Sweden where establishment is most likely to occur.

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Appendix 1. Distribution of *Conotrachelus nenuphar* in Canada

Conotrachelus nenuphar has been reported in most southern provinces in Canada (Bouchard, 2017). It should be noted that record(s) from British Columbia are reported as invalid by CABI (2020) and they are not included in EPPO GD (2020). Many records are found in the Köppen-Geiger climate zone Dfb (corresponding to southern Sweden) but no records were found from the Köppen-Geiger climate zone Dfc which is found in the northern parts of Sweden (Table 1).

Table 1. Sources consulted for the distribution of *Conotrachelus nenuphar* in different provinces of Canada.

Records of *Conotrachelus nenuphar*	**Reference**
Distribution of *C. nenuphar* in North America shown on a map including the southern regions of Saskatchewan, Manitoba, Ontario, Quebec as well as in New Brunswick, Prince Edwards Island and Nova Scotia.	Vincent et al. 2004
Reported as present in British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Foundland, New Brunswick, Nova Scotia, Prince Edwards Island No specific locations were provided.	Bouchard, 2017
Records from Ontario, Prince Edwards Island, New Brunswick, Quebec. Including many records in Köppen-Geiger zone Dfb but not from Dfc.	GBIF.org (15 maj 2020) GBIF Occurrence Download [Records were downloaded and mapped on the Köppen-Geiger climate zones according to Beck et al. (2018) using qGIS]
Records from Agriculture Canada Experimental orchard, Frelighsburg, Quebec.	Bostanian and Coulombe, 1986
Specimens collected in an orchard near Frelighsburg, Quebec	Racette et al. 1990
Records from Vineland, Ontario.	Hagley and Chiba, 1980
Distribution in Canada in eastern provinces to Manitoba to approximately latitude 50°N	Smith et al. 1996

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