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Pest risk assessment of selected *Epitrix* species

Scientific Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment

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Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to answer the mandate. The project group consisted of four VKM members and a project leader from the VKM secretariat. Two external referees commented on and reviewed the opinion. The VKM Panel on Plant Health evaluated and approved the final opinion.

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Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

Epitrix is a taxonomically complex genus, with 162 described species all over the world, and most likely many more undescribed species. Due to taxonomic difficulties identifying the species, there is considerable uncertainty regarding which species that feed on cultivated crops. At least 13 *Epitrix* species are known to damage the tubers of potato, which is the crop of concern in northern Europe. At least five of those *Epitrix* species (*E. hirtipennis*, *E. fasciata*, *E. cucumeris*, *E. papa* and *E. pubescens*) have established themselves outside their native range, spurring concerns that they may spread further and potentially cause damage in new areas where potato is cultivated. It is unknown how most of these species have moved from country to country, but there have been several interceptions of unknown *Epitrix* species in shipments of ware potatoes.

We have identified three *Epitrix* species of potential phytosanitary concern for Norway: *E. cucumeris*, *E. hirtipennis*, and *E. papa*. These species currently have potential pathways into Norway and are able to damage potato tubers (especially *E. cucumeris* and *E. papa*). All three of these species are likely native to the Americas, although the origin of the newly described species *E. papa* is unknown. All three species have established themselves in southern Europe, in countries that export potato tubers to Norway. An unknown fraction of this import arrives unwashed in so called “big bags”. Unwashed potato is considered having the highest probability of conveying *Epitrix* species, since adult *Epitrix* beetles, eggs, larvae and pupae are all closely associated with the tuber itself or the surrounding soil. So far, however, none of these species have been found in or close to Norway.

While *E. cucumeris*, *E. hirtipennis*, and *E. papa* are of greatest current concern, we acknowledge that pathways for other *Epitrix* pests may open up in the future. Because the genus *Epitrix* is taxonomically difficult, and because the biology, risk profile, and management of *Epitrix* species are very similar, it makes sense at this point to treat all *Epitrix* species feeding on potato as a single species complex. Such an approach tentatively extends the current assessment of the threats posed by *E. cucumeris*, *E. hirtipennis*, and *E. papa* to future potential threats from other *Epitrix* species.

Although cultivated potato seems to be the most important host plant in Europe for the three *Epitrix* species, the beetles also utilize other plants, including cultivated aubergine, and tomato, as well as wild plants including European nightshade, jimsonweed, and several other wild solanaceous plants. Some of these wild plants are relatively common in parts of Norway.

We have only identified one pathway of importance for potato-feeding *Epitrix* into Norway, namely import of unwashed ware potatoes. The importation of concern mainly comes from areas with established *Epitrix* populations in southern Europe. As consignments are closed, and the beetles have limited capabilities to spread naturally, this means that the beetles have low chances to spread by themselves to Norwegian habitats with cultivated or wild hosts plants. Washing or brushing of potatoes before they enter into Norway is reportedly a very efficient phytosanitary approach that reduces risk considerably.

Tolerance to local climatic factors is generally the most important factor limiting immigration and establishment of insects in northern Europe. As part of the current assessment we have therefore carried out distribution modelling, based on reported occurrence data and several climatic predictors, to evaluate the potential distribution of the three selected *Epitrix* species in Norway. Based on the results of these models, the risk of the three *Epitrix* species establishing in Norway is believed to be low. However, a high degree of uncertainty should be stressed, because there is reason to believe that several of the reported *Epitrix* occurrences in international databases are identified as the wrong species.

If *Epitrix* beetles should establish in Norway and attack potato fields, larval feeding damage can reduce the economic value of the tubers. Curative pest control is possible with synthetic chemical products that are already approved for potato in Norway. Treatment with synthetic pesticides can reportedly be efficient in local plantations, although the beetles may find refuge in wild habitats, weeds, and untreated plantations. Preventive IPM actions are available but would probably need to be further developed to be effective in Norway.

We conclude that *Epitrix* presents a low risk for Norway. The probability of introduction, establishment and spread is low, but the probability may be increased in the future if more pathways open up, or as climatic conditions change. If *Epitrix* should establish and spread further in Norway, economic impact is assessed to be moderate. This conclusion, however, comes with some degree of uncertainty since there are many taxonomical issues and a high degree of uncertainty regarding distribution and hostplants. The single most efficient preventive method to stop *Epitrix* from entering Norway is to wash or brush all tubers before they enter into the country.

Key words: flea beetles, potato pest, biological invasions, invasive species, VKM, risk assessment, Norwegian Scientific Committee for Food and Environment, Norwegian Environment Agency

Sammendrag på norsk

Slekten *Epitrix* er en gruppe bladbiller i underfamilien bladlopper som er taksonomisk vanskelige å artsbestemme. Per i dag er det 162 beskrevne arter over hele verden, og sannsynligvis mange flere ubeskrevne arter. På grunn av utfordringene knyttet til artsbestemmelse er det betydelig usikkerhet rundt artenes utbredelse og hvilke vertsplanter de foretrekker. Minst ti *Epitrix*-arter er kjent for å gjøre skade på potet. Minst fem av disse (*E. hirtipennis*, *E. fasciata*, *E. cucumeris*, *E. papa* og *E. pubescens*) har etablert seg utenfor sine naturlige utbredelsesområder. Disse fem artene kan spre seg ytterligere og potensielt forårsake skade i nye områder hvor det dyrkes potet. Det er stort sett ukjent hvordan disse fem artene har flyttet seg fra land til land, men ukjente *Epitrix*-arter har vært påvist i eksportforsendelser med potet.

VKM har identifisert tre *Epitrix*-arter som kan utgjøre en potensiell risiko for Norge: *E. cucumeris*, *E. hirtipennis* og *E. papa*. Disse tre artene kan skade potet og kan komme til Norge med import av potet fra land hvor artene allerede forekommer. *Epitrix cucumeris* og *E. papa* gjør størst skade. Alle tre artene er trolig hjemmehørende i Nord- og Sør-Amerika, selv om opprinnelsen til den nylig beskrevne arten *E. papa* fremdeles er ukjent. De tre artene har alle etablert seg i land i Sør-Europa som eksporterer potet til Norge. En ukjent andel av denne eksporten består av uvaskete poteter i storsekk («big bags»). Import av uvasket potet anses å ha størst sannsynlighet for å introdusere *Epitrix*-arter til Norge, siden voksne biller, egg, larver og pupper alle kan finnes i potetene eller i jorda rundt potetene. Så langt er ikke *E. cucumeris*, *E. hirtipennis* eller *E. papa* funnet i Norge eller i våre naboland.

Den største risikoen for Norge i dag er innførsel av *E. cucumeris*, *E. hirtipennis* og *E. papa* med potet importert fra land i Europa der disse artene finnes. I tillegg kan det ikke utelukkes at disse og andre *Epitrix*-arter kan bli introdusert dersom Norge i fremtiden begynner å importere poteter fra land i Nord- og Sør-Amerika.

Fordi artene i *Epitrix*-slekten er taksonomisk vanskelig å bestemme, og fordi biologien, risikoprofilen og bekjempelsestiltakene er like for de forskjellige artene, er det fornuftig å behandle alle *Epitrix*-arter som skader potet som ett artskompleks. Med en slik tilnærming vil denne risikovurderingen også gjelde for andre *Epitrix*-arter enn de tre som per i dag er vurdert å utgjøre en risiko for Norge.

Den viktigste spredningsveien til Norge er funnet å være import av poteter, og da spesielt import av uvaskede poteter. Mesteparten av potetene som importeres til Norge kommer fra de områdene i Sør-Europa hvor populasjonstettheten av *Epitrix* er høyest. Poteter sendes i lukkede kontainere og oppbevares for det meste innendørs. Billene har derfor begrensede muligheter til å spre seg naturlig under transport. Det betyr at det er lav sannsynlighet for at billene sprer seg og etablerer seg i Norge. Å vaske potetene før de ankommer Norge anses å være det mest effektive tiltaket mot uønsket import av *Epitrix*.

Selv om potet ser ut til å være den viktigste vertsplanten for *Epitrix* i Europa benytter billene også andre vertsplanter. Det gjelder dyrket aubergine og tomat, samt viltvoksende arter i søtvierfamilien, som svartsøtvier, piggeple med flere.

Klima er en viktig begrensende faktor for spredning og etablering av insekter i Nord-Europa. Vi har derfor modellert potensiell utbredelse av *E. cucumeris*, *E. hirtipennis* og *E. papa* i Norge og Europa basert på klimatiske variabler og kjente forekomster av artene i Nord- og Sør-Amerika. Resultatene fra modellene indikerer at det er lav sannsynlighet for at disse tre artene skal etablere seg i Norge. Det understrekes at det er knyttet svært høy usikkerhet til disse resultatene. Det skyldes at forekomstdataene for *Epitrix* som er brukt i modellene trolig inneholder flere feil.

Dersom *Epitrix* skulle etablere seg i Norge og angripe potet kan det føre til skader som reduserer potetens økonomiske verdi. Det er mulig å bekjempe *Epitrix*-arter med syntetiske kjemiske plantevernmidler som er godkjente for potet i Norge. Slik behandling skal angivelig være effektiv i potetåkre, selv om billene kan finne tilflukt i ubehandlede områder og i ugress rundt åkrene. Forebyggende IPV-strategier (integrert plantevern) mot *Epitrix* finnes, men må trolig videreutvikles og tilpasses norske forhold for å være effektive.

Vi konkluderer med at *Epitrix* utgjør en lav risiko for Norge. Introduksjon, etablering og spredning er lite sannsynlig, men sannsynligheten kan øke i fremtiden hvis flere spredningsveier åpner seg, eller hvis de klimatiske forholdene endrer seg. Om *Epitrix*-arter skulle etablere seg og spre seg i Norge er skadepotensialet vurdert til å være moderat. Denne konklusjonen har en middels usikkerhet. Den mest effektive risikoreduserende tiltaket for å hindre *Epitrix* i å komme til Norge og etablere seg vil være å vaske all potet før den importeres.

Abbreviations and glossary

Table 1. Definition and explanation of terms used in the assessment. Definitions mainly follow the ISPM No.5 Glossary of phytosanitary terms by FAO (2019).

Definition and explanation of term	
Commodity	A type of plant, plant product, or other article being moved for trade or other purpose
Consignment	A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots)
EFSA	European Food Safety Authority
Endangered area	An area where ecological factors favor the establishment of a pest whose presence in the area will result in economically important loss
Entry	Movement of a pest into an area where it is not yet present, or present but not widely distributed
EPPO	European and Mediterranean Plant Protection Organization
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry
FAO	Food and Agricultural Organization
Introduction	The entry of a pest resulting in its establishment
Invasive species/ Invasive alien species	An invasive alien species is a non-native species that by its establishment or spread has become injurious to plants, or that by risk analysis is shown to be potentially injurious to plants
NFSA	The Norwegian Food Safety Authority
Pathway	Any means that allows the entry or spread of a pest
Pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products
Plants for planting	Plants intended to remain planted, to be planted or replanted

PRA	Pest Risk Analysis
PRA area	Area in relation to which a pest risk analysis is conducted
Spread	Expansion of the geographical distribution of a pest within an area
Tariff codes	Customs codes according to the World Customs Organization's internationally agreed Harmonized System.
VKM	The Norwegian Scientific Committee for Food and Environment

Background as provided by the Norwegian Food Safety Authority

Flea beetles of the genus *Epitrix* Foudras, 1860 (Coleoptera: Chrysomelidae: Alticinae) are small beetles that mainly feed on Solanaceae. Some *Epitrix* species are serious pests of potato, and the damage caused by larvae greatly decreases the commercial value of the potato tubers. Adults of some *Epitrix* species chew small circular holes in the leaves of potato plants. *Epitrix* can also feed on tomato, aubergine (eggplant), tobacco and other cultivated plants in Solanaceae. The genus *Epitrix* has a worldwide distribution and consists of over 160 species. Most of them are native to South and Central America, 13 species are native to Eurasia, 13 described species are native to North America, one species is native to the Canary Islands; the native range of one alien pest species detected in Portugal and Spain is unknown.

Some species of the genus have been introduced to areas outside their native range. In particular, *E. hirtipennis*, *E. fasciata* and *E. cucumeris* have been introduced from North America to the Palaearctic. Two distinct *Epitrix* species were discovered in mainland Portugal in 2008, *E. cucumeris* and *E. papa*. *Epitrix papa* is a new species of unknown origin and was first misidentified as *E. similaris* in Portugal and Spain in 2008 (Orlova-Bienkowskaja, 2015). *Epitrix pubescens* (Koch, 1803) has a Palearctic distribution; it is found in Denmark and Sweden, and probably is established in Norway as well. *Epitrix pubescens* was found in Hvaler, Østfold in 2016 (Artsobservasjoner.no, 2019), and may be spreading north into Norway from Sweden. *Epitrix pubescens* has also been intercepted in shipments of horticultural plants imported to Norway in 2006 (Staverløkk and Sæthre, 2007). Among the six naturally occurring *Epitrix* species present in Europe (*Epitrix abeillei*, *Epitrix atropae*, *Epitrix caucasica*, *Epitrix dieckmanni*, *Epitrix intermedia*, and *Epitrix pubescens*) none are damaging to potatoes (EPPO, 2017). *Epitrix* species are difficult to identify, and in some cases it is uncertain which species are damaging to which crops. It is therefore essential to update the current knowledge on taxonomy, distribution and host plants of *Epitrix* species that have the potential for negative ecological and economic impact in Norway.

The European and Mediterranean Plant Protection Organization (EPPO, 2012) conducted a PRA on *Epitrix* species damaging potato tubers in 2010-2011, and four *Epitrix* species are currently on the EPPO lists of pests recommended for regulation as quarantine pests; *E. papa* and *E. cucumeris* are on the EPPO A2 List (pests are locally present in the EPPO region) and *E. tuberis* and *E. subcrinita* are on the EPPO A1 List (pests are absent from the EPPO region). EPPO standard PM 9/22 recommends EPPO members on a national regulatory control system to prevent the introduction of these pests to the potato production system, and on measures to eradicate an outbreak, or for a containment strategy. In the EU, emergency measures to prevent the introduction and spread of these pests were established in 2012. None of the four above-mentioned *Epitrix* species are known to occur in Norway, nor are they on the Norwegian list of regulated pests.

Terms of reference as provided by the Norwegian Food Safety Authority

VKM is requested to carry out a pest risk analysis according to ISPM NO. 11. for selected *Epitrix* species for Norway. In their report, VKM is requested to include:

1. Identification of *Epitrix* species of potential phytosanitary concern for Norway and a summary of current knowledge about their taxonomy.

2. Information on the current distribution areas of the selected *Epitrix* species.

3. Identification of host plants for the selected *Epitrix* species and the current distribution area of the respective host plant species in Norway.

4. Assessment of possible pathways for entry of the selected *Epitrix* species and the potential for establishment and spread of the selected *Epitrix* species in Norway.

5. Assessment of the probability of the selected *Epitrix* species entering Norway from their current distribution areas by natural spread.

6. Assessment of the potential impacts in Norway (economic, environmental, social) if the selected *Epitrix* species are established.

7. Identification of relevant risk reduction measures and evaluation of their effectiveness and feasibility.

Pest risk assessment

1 Introduction

1.1 Purpose and scope

This document presents a scientific opinion prepared by the VKM Panel on Plant Health, in response to a request from the Norwegian Food Safety Authority. The opinion is a risk assessment of selected *Epitrix* species that may represent a potential phytosanitary concern for Norwegian potato production. Furthermore, the opinion identifies and evaluates risk reduction options in terms of their effectiveness in reducing the plant health risk posed by these pests.

The Pest Risk Assessment area (PRA-area) is Norway.

1.2 Method and information collection

As specified in the terms of reference, this pest risk analysis follows ISPM No. 11 Pest risk analysis for quarantine pests (FAO 2017).

Previous pest risk assessments and factsheets on *Epitrix* species:

- EPPO (2012) Pest Risk Analysis for *Epitrix* species damaging potato tubers.
- Malumphy et al., (2016). Potato flea beetles - *Epitrix* species, Plant Pest Factsheet, DEFRA.

1.3 Literature search strategy

Electronic searches were performed using the genus name "*Epitrix*" in various combinations with other relevant words, with default settings, in the following scientific databases: CAB direct (2019) Google Scholar (2019), JSTOR (2014), and ISI Web of Knowledge (2019). The reference lists in the sources that were found were screened for additional relevant publications.

1.4 Data collection

Data on import statistics for relevant commodities into Norway were downloaded from Statistics Norway (2019) using StatBank Open data API (Application Programming Interface) table 08801: external trade in goods, by commodity number (HS) and country. Data was downloaded using R (R Core Team, 2017) using the packages httr (Wickham, 2019) and rjstat (Schumacher and Malmedal, 2016).

1.5 Ratings of probabilities and uncertainties

The conclusions on probability of entry and establishment of the pests are presented and rated separately, following a fixed scale: very unlikely, unlikely, moderately likely, likely, very likely. The descriptors for these qualitative ratings are presented in Appendix I Table A1-1 and Table A1-2, respectively.

For the conclusions on entry and establishment, the levels of uncertainty are rated separately, following a fixed scale: low, medium, high. The descriptors for these qualitative ratings of uncertainty are presented in Appendix I Table A1-3.

2 Pest categorization

An initial pest categorization was performed on all *Epitrix* species known to attack potatoes. These pest categorizations are shown in Appendix II.

We used the following criteria to select *Epitrix* species to be included in the PRA:

1. A list of all *Epitrix* species (162 species) identified from literature, their known distribution areas, and host plants was gathered.
2. Species attacking potato were selected (10 species).
3. Individual pest categorizations were performed on the 13 selected *Epitrix* species.
4. Three species were selected for a full PRA based on climatic similarities between their known distribution area and Norway, and the volume and frequency of potato imports from these areas to Norway in the last 10 years.

Ten *Epitrix* species are documented feeding on potato: *E. pubescens* (no common name), *E. cucumeris* (potato flea beetle), *E. tuberis* (tuber flea beetle), *E. subcrinita* (western potato flea beetle), *E. papa* (no common name), *E. similaris* (no common name), *E. hirtipennis* (tobacco flea beetle), *E. yanazara* Bechyné (no common name), *E. ubaquensis* (Harold) (no common name), and *E. harilana rubia* Bechyné (no common name). Only the first five species have been demonstrated as capable of completing their life cycle on potato. Adults of *E. yanizara* are abundant on potato in Peru and can inflict considerable feeding damage, and *E. ubaquensis* and *E. harilana rubia* are also considered pests of potato in Peru (Kroschel and Cañedo 2009). Of the 10 species, at least *E. hirtipennis* is a threat to potato fields when appropriate solanaceous host plants are present nearby.

In the following, we assess the three species that are currently found in Europe: *E. cucumeris, E. papa,* and *E. hirtipennis*. These three species may be considered most likely to establish in Norway because of their geographical proximity and the existence of import pathways. However, as we argue in chapter 3, from a management perspective, *Epitrix* should be treated as a species complex. The reasons for this are that individual species are difficult to reliably identify; the potential for spread and economic damage is unknown for several species associated with potatoes, especially some species found in the Andes; and there are likely undescribed species that could be potato pests.

3 Pest taxonomy, biology, occurrence, hosts and regulatory status

3.1 Pest identification, name and taxonomic position

Table 2. Name and taxonomic position of the three *Epitrix* species included in this PRA.

	Epitrix cucumeris	*Epitrix hirtipennis*	*Epitrix papa*
Species name	*Epitrix cucumeris* (Harris, 1851)	*Epitrix hirtipennis* (Melsheimer, 1847)	*Epitrix papa* (Orlova-Bienkowskaja, 2015)
Synonyms	None	None	None
Common names	Potato flea beetle	Tobacco flea beetle	None
The pest is an arthropod	Class: Insecta, Order: Coleoptera, Family: Chrysomelidae, Genus: *Epitrix,* Species: *E. cucumeris*	Class: Insecta, Order: Coleoptera, Family: Chrysomelidae, Genus: *Epitrix,* Species: *E. hirtipennis*	Class: Insecta, Order: Coleoptera, Family: Chrysomelidae, Genus: *Epitrix,* Species: *E. papa*

3.2 Taxonomic information

The genus *Epitrix* is a member of the tribe Alticini, the flea beetles. Flea beetles have enlarged hind legs, which enable them to jump quickly when threatened, though they can also walk or fly. Like many flea beetles, species of *Epitrix* are small and are difficult for non-specialists to identify using morphological characters. In many cases, species are so similar in appearance that identification requires that male and female genitalia be extracted and examined (Bienkowski and Orlova-Bienkowskaja, 2016; Döberl, 2000; Orlova-Bienkowskaja, 2015). Although damaging species of *Epitrix* have been studied for well over a century (e.g. Chittenden 1898, cited in Glass 1940), identifying individuals to correct species using traditional methods remains a daunting task. While progress has been made in species identification via DNA sequencing (so-called DNA barcoding), only a few *Epitrix* species have been barcoded so far, and the initial work was rife with identification errors (Germain et al. 2013, Mouttet et al. 2017). As is frequently the case with economically important agricultural pest insects, published identifications may not be correct as they have often been carried out by agronomists, crop specialists, or agricultural entomologists who were not taxonomic experts. In addition, there is a strong geographical bias in the knowledge about *Epitrix* species. Most collecting and taxonomic research has been focused in North America, whereas the ancestral home is Central and South America for potato, tomato, and many wild *Solanum* host plants of *Epitrix*. Even in North America there are many undescribed species of *Epitrix* (Riley et al. 2002, Deczynski 2016), but it is especially problematic that little is known of the biology of the many Central and South American species (Döberl 2000, Bienkowski and Orlova-Bienkowskaja 2017, but see Kroschel and Canedo 2009). There are undoubtedly many undescribed species in Central and South America, an area with a rich *Epitrix* fauna. The majority of *Epitrix* species from this region that have been formally described are known from just one or a few collections. The few named *Epitrix* species from the Andes, for example, are mostly known from one or a few museum specimens, and there are undoubtedly undescribed species in the Andes which feed on Solanaceae. It is simply not known if Central and South American *Epitrix* species are potential pests of solanaceous crops grown in Norway.

3.2.1 Identifying species of *Epitrix*

The recent world catalog of *Epitrix* species lists 162 valid species and 11 subspecies (Bienkowski & Orlova-Bienkowskaya 2017). Species richness is highest in Central and South America, suggesting that this might be the center of origin of *Epitrix* (Döberl 2000, Bienkowski and Orlova-Bienkowskaja 2017). Only 13 species have been named from North America, from where 12 undescribed species are also known (Deczynski 2016). Another 13 species are native to Eurasia (Bienkowski & Orlova-Bienkowskaya 2016). Most *Epitrix* species are found in temperate climates, up to elevations of 2800 m.a.s.l. in Colombia (gbif.org) and possibly extending north of the 60th parallel in Canada (Bienkowski & Orlova-Bienkowskaya 2017). Though there is a world checklist for *Epitrix* (Bienkowski & Orlova-Bienkowskaya 2017), only North American and Palearctic species have been revised recently. Döberl (2000) treats Eurasian species, with a key (in German) and line drawings of external and internal morphological characters. This work has been superseded by the key to Holarctic species by Bienkowski & Orlova-Bienkowskaya (2016), which also presents species distributions, host plants, and a discussion of invasive species. The 2016 Masters degree thesis on North American *Epitrix* species by Anthony Deczynski is available online (Deczynski 2016) but is not to be considered a formal publication in the sense of the Zoological Code of Nomenclature Article 8.2. He illustrates all North American species, re-describes 14 known species and (though not formally) describes 12 new species. His key is the only available key which does not depend entirely or in part on genitalia. However, it should be noted that this is a thesis, and not a peer-reviewed paper, and the utility of the key remains to be critically tested.

3.2.2 The taxonomic challenge

We argue that potato-attacking species of *Epitrix* must be treated as a species complex rather than as selected individual species. While much is known about the biology of the species currently damaging potato (and other solanaceous crops), identifying intercepted or trapped foreign species is difficult both because judging differences among species requires considerable expertise and because there are many undescribed species in the genus.

In most cases, species of tiny beetles cannot be dependably identified by non-specialists, and *Epitrix* is no exception. Non-specialists sometimes simply apply a name to an unfamiliar pest species based on locality or host plant or both (e.g. Clark et al. 2004). But even when using taxonomic literature non-specialists can make serious mistakes, as clearly illustrated by the Portugal example (*E. papa*, detailed below). Identification is even more difficult when internal characters such as male or female genitalia must be examined, since this requires highly specialized techniques. Taxonomic specialists on a genus can compare specimens directly with authoritatively determined material, have published and unpublished identification tools at their disposal, and know exactly which morphological characters are informative. These taxonomic challenges are exemplified by *Epitrix*, where species identification usually requires both experience with morphological variation and mounting and studying male and female genitalia (Bienkowski & Orlova-Bienkowskaya 2016, EPPO 2017).

Applied research on *Epitrix* species began in the late 1800s (e.g. Chittenden 1898) and continues to this day. However, taxonomic knowledge has lagged behind, and modern knowledge of species limits has cast in doubt both the identities and host relationships of species reported in older literature. Some examples illustrate the problem. The damage to a variety of crop plants was ascribed to *Epitrix parvula* in earlier investigations (e.g. Glass 1940). We know now that many of these findings refer to *E. hirtipennis* (Clark et al. 2004). Conversely, we must combine older records of *E. fasciata* and true *E. parvula*, as these are now considered to all be *E. fasciata* (Bienkowski & Orlova-Bienkowskaya 2017). The very similar species *E. tuberis* and *E. similaris* are now known to be sympatric in California (Schenk et al. 2019), so damage to potato tubers in California that was ascribed by Gentner (1944) to *E. similaris* may have been caused by *E. tuberis*. There seems to be no recent evidence that *E. similaris* is a pest of potato. *Epitrix cucumeris* was initially believed to be a widespread potato pest occurring across North America; however Gentner (1944) separated them into an eastern species (true *E. cucumeris*) and described as new the western form (*E. tuberis*). This was not a trivial taxonomic correction since only *E. cucumeris* and *E. tuberis* damage potato tubers.

A way out of the taxonomic morass is to use DNA barcoding: sequencing of a standardized portion of the mitochondrial gene cytochrome c oxidase I (COI) (Germain et al. 2013, EPPO 2016). The advantages to DNA barcoding are that one cannot only identify adults of morphologically similar species but all life stages, and that no special entomological expertise is required. An important limitation of the method is that it is only as good as the taxonomic coverage of barcoded species (one can only identify species which have already been sequenced). A stark example of these barcoding weaknesses (as well as of the difficulty of identification based on morphology) is provided by the alien *Epitrix* species discovered in 2004 (EPPO, 2009) to be damaging potatoes in northern Portugal, and which by 2009 had spread into northern Spain. Details of this cautionary tale are in Orlova-Bienkowskaja (2015). In the above-mentioned barcoding study (Germain et al. 2013), collections from Portugal were identified as *Epitrix similaris*, apparently based on the earlier work by Boavida and Germain (2009). In the Boavida and Germain (2009) study, identifications were based on keys and drawings of male and female genitalia (Boavida and Germain *ibid.*: p. 502), and not on comparison with authoritatively identified material — and, it should be emphasized, were not made by a taxonomic expert. "*Epitrix similaris*" was subsequently listed as an A2 quarantine pest and threat to potato production in Europe (EPPO 2015). However, the source of the introduction to Portugal was most likely seed potatoes from northeastern Canada. But *E. similaris* is a rare species known only from California (western USA) and has never been collected outside of California, nor is it considered a pest. Subsequently, a Russian taxonomist, Marina J. Orlova-Bienskowskaja, established that the *Epitrix* species in Portugal is not only not *E. similaris*, but is a species new to science, one that she described as *Epitrix papa* (Orlova-Bienkowskaya 2015). This has later been confirmed by DNA barcoding the COI gene in specimens of *E. papa* from Portugal and *E. similaris* from California (Mouttet et al. 2016).

The barcoding study of Germain et al. (2013) was marred by several other misidentifications. Specimens from California claimed to be *E. subcrinita* were, in fact, *E. similaris*. Beetles from Kansas identified as *E. fasciata* turned out to be *E. brevis*. The sequence data deposited in Genbank have been corrected accordingly (Mouttet et al. 2016), but this taxonomic muddle should serve as an object lesson in the importance of involving taxonomic experts in molecular studies of this kind, particularly when taxa of economic concern are involved. But it also illustrates the necessity of treating *Epitrix* more broadly in the context of phytosanitary concerns, rather than restricting attention to a few species. One of the only three *Epitrix* potato pests established in Europe is a previously undescribed species whose home country and ecology are completely unknown. It would therefore be unjustifiable to restrict quarantine regulation to selected pestiferous *Epitrix* species when *E. papa* demonstrates the likelihood of introduction of species that are currently completely unknown.

Despite the problems detailed above, given that only a handful of taxonomists in the world can properly identify *Epitrix* species while any DNA laboratory can sequence the beetles, DNA barcoding will likely be the only reliable and readily available way to quickly ascertaining the identity of intercepted or field collected specimens, if the barcodes have been obtained from correctly identified specimens.

3.3 Biological information

All *Epitrix* species feed on plants, with varying degrees of diet breadth. Adults feed on leaves, stems and petals, while larvae feed on roots and tubers. Depending on temperature, the species described so far can have from one to four generations per year (Mason and Kuhar 2018, Boavida et al. 2019). In addition, the time spent at each developmental stage, i.e. egg, larva, pupa and adult, will depend on temperature, other biotic and abiotic factors and vary from species to species. Adult beetles overwinter in the soil, under crop debris or detritus. After emergence in the spring, adults lay eggs in the soil close to or directly on the host plant species. After the eggs hatch, the larvae feed primarily on roots or on the potato tubers, sometimes causing severe damage. Pupation takes place in the soil, before the adult beetles again emerge and start the cycle again, either the same year or the following year. Adult beetles may feed on foliage from a wide variety of plants, but these plants are not always true host plants that can support larval development.

3.4 Host plant species

As with most herbivorous insects, *Epitrix* flea beetles depend on certain plants to complete their life cycle and sustain viable populations. In this report the term 'host plant' is reserved for these plant species. Plant feeding insects may also be found resting or feeding on one or more non-host plants but cannot complete their larval development and sustain a population on those species. Because successful establishment of herbivorous beetles in new environments depends on the presence of host plants for development, it is important to determine which plant species are potential hosts in the new region and which are not.

There is little information on host plants for individual *Epitrix* species (but for examples see Glass 1940, Jones 1944, Eyre and Giltrap 2012, Boavida et al. 2013). *Epitrix* flea beetles are reported to feed on many plant genera, mainly in the Solanaceae (nightshades) family (Table 2). But although adults may feed on the foliage of many plant species, only a smaller subset of species can be used for egg laying and full larval development. The family Solanaceae includes important agricultural crops such as potato, tomato and aubergine, all of which belong to the genus *Solanum*, as well as peppers belonging to the genus *Capsicum*.

Epitrix and their primary host plants have their origin and main distribution area in the Americas. Solanaceae has a worldwide distribution, but the greatest diversity is in Central and South America. Also, most described (and probably also undescribed) *Epitrix* species are from the Americas (Döberl 2000, Bienkowski and Orlova-Bienkowskaja 2017).

In their review of host relationships of *Epitrix* and other leaf beetles Clark et al. (2004) highlighted two key problems with assigning host plants to individual *Epitrix* species. First, beetle species in older literature are sometimes clearly misidentified or possibly so, since the taxonomic understanding of the genus was poorer than it is today (see chapter 3.2.2). Second, published host lists usually do not distinguish between insects resting vs. feeding or breeding on the host in question, but simply report that “species *A* was found on plant *X*”. Often adult beetles collected from plants are reported to be “resting” on the plant. Some records are for adults that rest (or even feed) on non-host plants in early spring or late fall, when their main host plants are unavailable (Clark et al. 2004).

Only a small minority of the 162 valid species of *Epitrix* have host records. For those species that do, few field or lab studies have rigorously sorted out host from non-host plants. The very incomplete picture that we have currently is that some *Epitrix* species (and in particular the species treated in this report) regularly use economically important solanaceous plants as hosts, at least to the degree that they can cause noticeable feeding damage to foliage. Conversely, there are few reports identifying any non-solanaceous plants as critical hosts for *Epitrix* species. However, the fact that a herbivore has a limited host plant range in its native area does not preclude that new plant species can be included in its diet when it migrates to new areas (such as Norway), where previously unexplored food resources may be available.

Table 3. Reported host plants of *Epitrix* species, with taxonomic position, common names and Norwegian names.

Family	Genus	Species examples	Economically significant	Common name(s)	Norwegian name(s)
Solanaceae	*Capsicum*	*C. annuum*	Yes	Chili pepper, bell pepper, cayenne pepper, paprika, etc.	Chili, paprika
Solanaceae	*Capsicum*	*C. frutescens*	Yes	Chili pepper, piri piri, etc.	Chili
Solanaceae	*Datura*	*D. stramonium*	No	Devil's weed, jimsonweed	–
Solanaceae	*Hyoscyamus*	*H. niger*	Yes	Common henbane	–
Solanaceae	*Leucophysalis*	*L. nana*	No	Dwarf chamaesaracha	–
Solanaceae	*Lycium*	Several species	Yes	Matrimony vine, boxthorn, goji berry	Gojibær
Solanaceae	*Nicandra*	*N. physalodes*	Yes	Apple-of-Peru	Giftbær
Solanaceae	*Nicotiana*	*N. alata*	Yes	Jasmine tobacco sweet tobacco	–
Solanaceae	*Nicotiana*	*N. attenuata*	No	Wild tobacco coyote tobacco	Coyotetobakk
Solanaceae	*Physalis*	Several species	Yes	Ground cherry, physalis	Physalis
Solanaceae	*Solanum*	*S. lycopersicum*	Yes	Tomato	Tomat
Solanaceae	*Solanum*	*S. melongena*	Yes	Aubergine, eggplant	Aubergin
Solanaceae	*Solanum*	*S. nigrum*	No	European black nightshade	Svartsøtvier
Solanaceae	*Solanum*	*S. tuberosum*	Yes	Potato	Potet

3.4.1 Host plant species of *Epitrix cucumeris*

Adults of *E. cucumeris* have experimentally been shown to feed and reproduce on five plant species from two genera: aubergine, jimsonweed, tomato, potato and European black nightshade (Boavida et al. 2013; Table 2). Reproduction was found to be highest on European black nightshade and potato. In the same experiment, *E. cucumeris* did not reproduce on sweet pepper. In Spain, *E. cucumeris* was first reported on European black nightshade plants growing near potato plants (EPPO 2018). In addition, like many other *Epitrix* species, adults of *E. cucumeris* may feed on the foliage of a wide range of different plants that do not support beetle reproduction (Clark et al. 2004).

3.4.2 Host plant species of *Epitrix hirtipennis*

Understanding the range of hosts used by *E. hirtipennis* has been hampered by beetle misidentifications (section 3.2.2). In the US, *E. hirtipennis*, the tobacco flea beetle, is mainly considered a pest of tobacco and aubergine, though it is also associated with several other cultivated and wild Solanaceae (Glass 1940 (as *E. parvula*), Clark et al. 2004, Mason and Kuhar 2018). In France, *E. hirtipennis* was first discovered on aubergine in several locations in 2016 and 2017 (Mouttet 2017). In Italy, *E. hirtipennis* is reported to feed on potato and tobacco (EPPO 2017), but it has also been found on several wild indigenous Solanaceae species (Beenen 2005).

3.4.3 Host plant species of *Epitrix papa*

There is only one study of this newly described invasive species, and there is no information about where it came from or what its natural hosts might be. Adults of *E. papa* fed and reproduced on five different plant species tested by Boavida et. al. (2013) (who referred to it as *E. similaris*): aubergine, jimsonweed, tomato, potato, and European black nightshade. The species did not reproduce on sweet pepper. Reproduction was highest on European black nightshade and potato, and adults and larvae successfully fed on five different potato varieties (“Hermes”, “Agria”, “Picasso”, “Monalisa”, and “Asterix”).

3.5 Geographical distribution

The genus *Epitrix* has a near global distribution. It is reportedly present in more than 80 countries and occurs on all continents except Antarctica and Australia (Bienkowski and Orlova-Bienkowskaja 2017). Several *Epitrix* species have been introduced to areas outside their native range. Movements have in particular happened from North America to Europe and Asia, from Europe to North America, and from different continents to various Pacific islands (Bienkowski and Orlova-Bienkowskaja 2017). Because of the morphological similarity of many *Epitrix* species (chapter 3.2.2) it has historically been very difficult to distinguish between species, especially in the field. This means that identification to the species level rarely has been done or has been prone to result in misidentifications. Due to the difficulty of correct species identification, *Epitrix* species have often been considered as a pest complex and there can be errors in distribution data for individual species.

3.5.1 Geographic distribution of *Epitrix cucumeris*

Epitrix cucumeris has a broad geographic distribution stretching all the way from Peru to Canada, where it is registered in all provinces and territories. *Epitrix cucumeris* has also been introduced to Madeira and mainland Portugal (Figure 1).

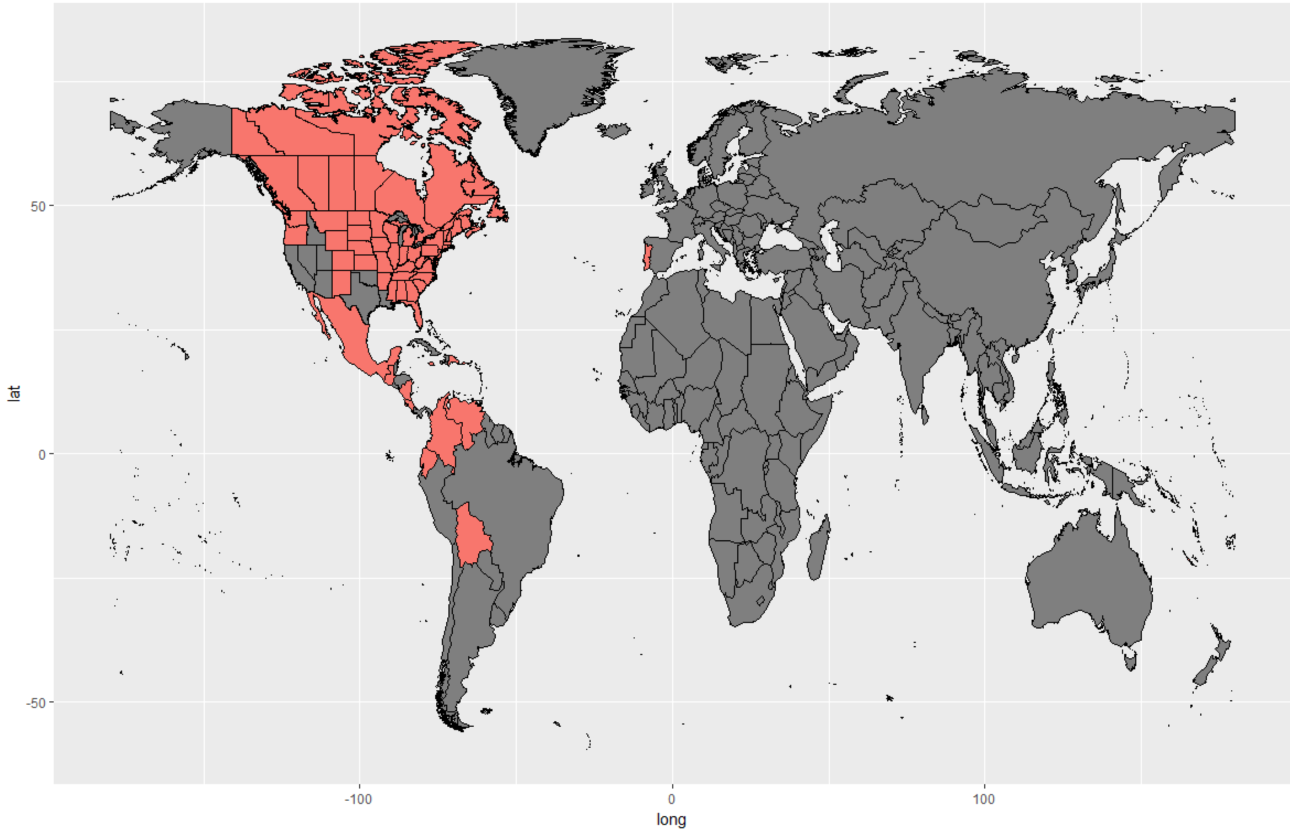

Figure 1. Known distribution of *Epitrix cucumeris* according to the world checklist by Bienkowski and Orlova-Bienkowskaja (2017). Red areas are countries, states, provinces and territories where *E. cucumeris* is registered.

3.5.2 Geographic distribution of *Epitrix hirtipennis*

Epitrix hirtipennis has a broad geographic distribution stretching from Brazil to Québec in Canada (Figure 2). Also, *E. hirtipennis* has been introduced to several countries outside the Americas, most notably Italy, Greece, Turkey, Spain, Macedonia, Bulgaria, Syria, Japan and Russia (Krasnodar Krai).

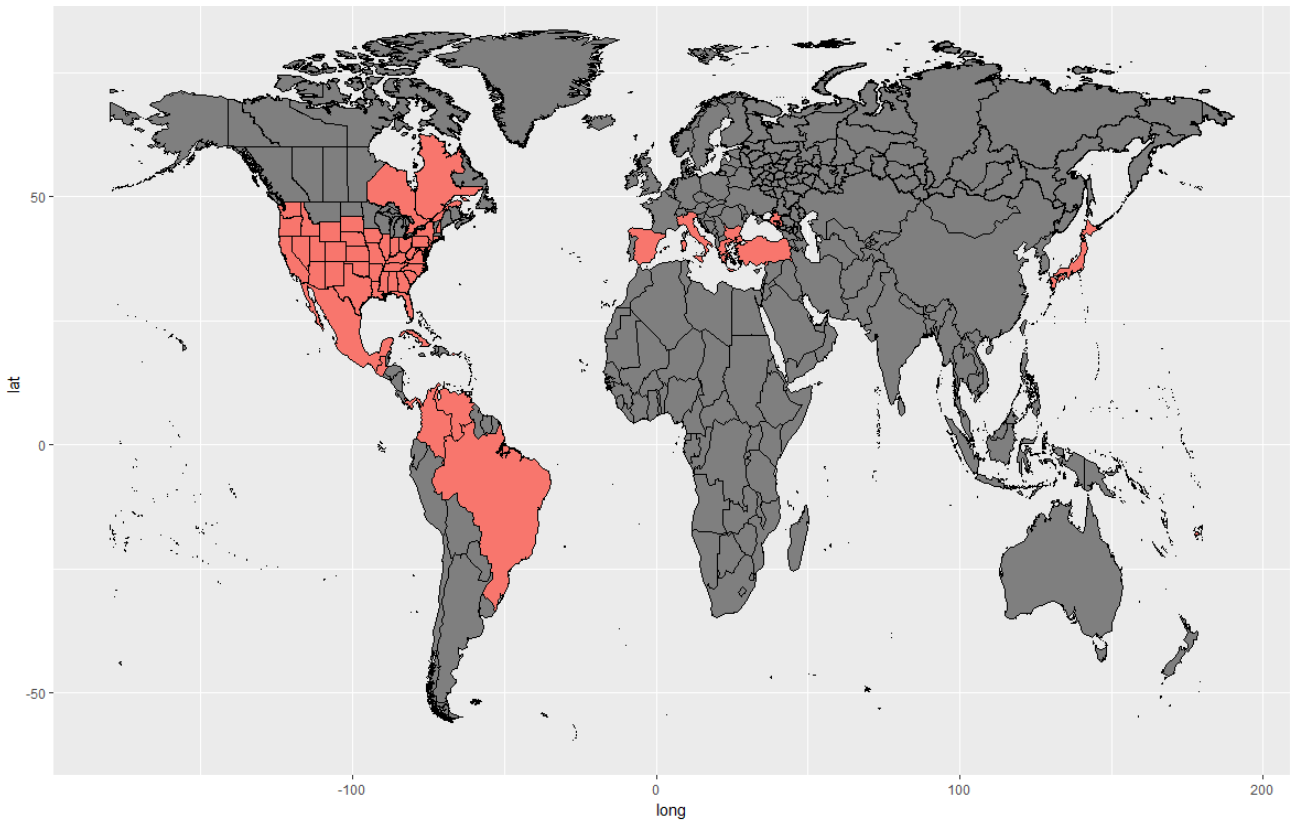

Figure 2. Known distribution of *Epitrix hirtipennis* according to the world checklist by Bienkowski and Orlova-Bienkowskaja (2017). Red areas are countries, states, provinces and territories where *E. hirtipennis* is registered.

3.5.3 Geographic distribution of *Epitrix papa*

Since it was first discovered in 2004, *E. papa* has spread throughout Portugal and into Spain along the Mediterranean and Atlantic coast (Figure 3). The native range and geographical origin of *E. papa* is still unknown.

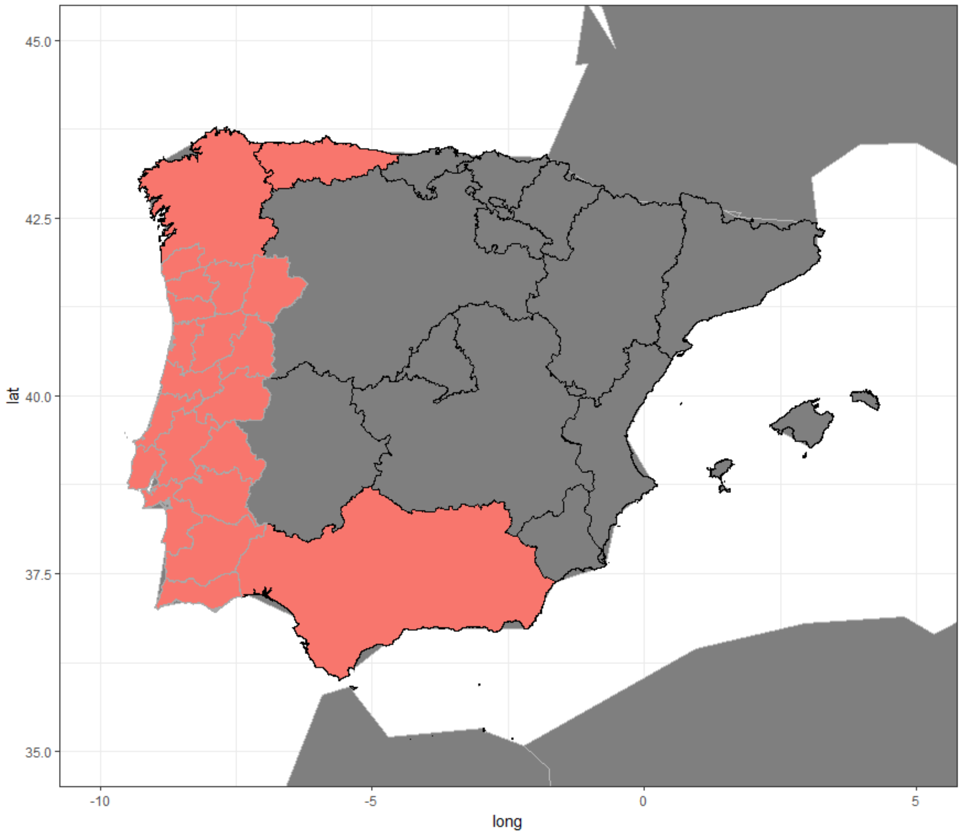

Figure 3. Known distribution *of Epitrix papa* in Portugal and Spain. Source: Direção Geral De Alimentação e Veterinária, Portugal.

3.6 Occurrence of the pests in the PRA area

Neither *E. cucumeris*, *E. hirtipennis* nor *E. papa* are known to occur in the PRA area. The only *Epitrix* species known to be present in the PRA area is *E. pubescens* (Artsobservasjoner.no, 2019).

3.7 Regulatory status

No *Epitrix* species are currently regulated in the PRA area. However *E. tuberis* and *E. subcrinita* are on the “EPPO A1 list of pests recommended for regulation as quarantine pests”, and *E. cucumeris* and *E. papa* are on the “EPPO A2 list of pests recommended for regulation as quarantine pests” (Table 4).

Table 4. Regulatory status of the four *Epitrix* species that are regulated in Europe. Abbreviations: EAEU – Eurasian Economic Union, EU – European Union, EPPO – European and Mediterranean Plant Protection Organization

Species	**Country/organization**	**List category**	**Year regulated**
Epitrix cucumeris	EAEU	A1 list	2016
	EPPO	A2 list	2016
	EU	Emergency measures	2016
Epitrix papa	EPPO	A2 list	2016
	EU	Emergency measures	2016
Epitrix tuberis	EPPO	A1 list	1987
	EU	Emergency measures	2012
	EAEU	A1 list	2016
Epitrix subcrinita	EPPO	A1 list	2010
	EU	Emergency measures	2012

4 Assessment of the probability of introduction and spread

4.1 Probability of entry of a pest

According to Bienkowski and Orlova-Bienkowskaja (2016), at least five *Epitrix* species have become established outside their native range; *E. hirtipennis*, *E. fasciata*, *E. cucumeris*, *E. papa* and *E. pubescens*. The precise movement pathway is unknown for these species, but there have been several interceptions of unknown *Epitrix* species in shipments of ware potatoes (two shipments from Spain to the United Kingdom (EPPO 2014, EPPO 2015), and two shipments from Spain to Belgium (EPPO 2016a, EPPO 2016b). Also, live *E. pubescens* has been intercepted in a shipment of plants for planting from the Netherlands to Norway (Staverløkk and Sæthre 2007). These examples show that *Epitrix* species are associated with both ware potatoes and plants for planting, and that several *Epitrix* species have survived in transport.

4.1.1 Identification of pathways of entry

The three commercial pathways that are relevant for *Epitrix* species and that have a significant import volume are imports of ware potatoes (i.e. potatoes destined for human consumption), tomatoes and aubergine (Table 5). In addition to these commercial pathways, the panel also considers natural spread. Unless stated otherwise, we do not distinguish between the three *Epitrix* species, given the similarities in their biology and host plants.

4.1.1.1 Natural spread

The probability of natural spread as an entry pathway into Norway is considered to be very unlikely, with a medium level of uncertainty.

For the reasons discussed below the panel assesses that *E. cucumeris*, *E. hirtipennis* and *E. papa* cannot be expected to spread naturally to Norway from their current distributions outside or within the EPPO area (the Azores, Portugal, Spain, Italy, Greece, Turkey, Macedonia and Bulgaria; see chapter 3.5) within the next decade.

'Natural spread' is defined as the coupling of dispersal with population growth. There is little published information on flight distances and dispersal ability of *Epitrix* species. However, according to EPPO (2005) "adults of *E. cucumeris* do not fly". Likewise, Elliot (2009) reported that *E. cucumeris* "seldom if ever fly". Nothing is known about the flight ability of *E. papa*. Like all other flea beetles, all *Epitrix* species have enlarged hind legs and can jump forcefully when they are threatened. However, jumping is not a mode of long-distance dispersal. Based on the available information it is reasonable to conclude that the probability of entry by natural spread is very low for *Epitrix* species.

Long distance spread of *Epitrix* species is thus only possible with movement of goods by humans. For example, *E. papa* spread several hundred kilometers in a few years in Portugal, presumably aided by the movement of infested plants, plant materials or equipment. *Epitrix papa* and other *Epitrix* species will probably not be able to spread from Portugal or Spain to Norway within the next 10 years without the help from humans.

4.1.1.2 Import of seed potato

The probability of entry of *E. cucumeris*, *E. hirtipennis* and *E. papa* to Norway with imports of seed potato is considered to be very unlikely, with a low level of uncertainty. It is prohibited by law to import seed potatoes or other propagating material of potato into Norway. The ban applies to seed potatoes from all countries (Lovdata.no 2019).

4.1.1.3 Import of ware potato

The probability of entry of *E. cucumeris*, *E. hirtipennis* and *E. papa* to Norway with imports of ware potatoes is considered to be moderately likely, with a medium level of uncertainty.

According to some Norwegian potato distributors, Norway imports both washed and unwashed potatoes. The ratio between washed and unwashed imports is unknown. Potatoes shipped in so called 'big bags' are not washed prior to arrival but are washed and packed in Norway.

The past 10 years Norway has imported 521,155 metric tons of potatoes from 30 different countries. Of this, 132,236 metric tons came from nine countries where *Epitrix* species are known to occur (Table 5). France is the largest and most frequent export country, with a total export of 117,804 metric tons. Potatoes from France constitute 89.1% of the total import volume to Norway from countries harboring *Epitrix*. The second largest exporter among these countries the past 10 years was Spain, with 13,937 metric tons (10.5% of the total import volume).

Prior to 2008 there was considerable import of potato from both the US and Canada, where several potato-infesting *Epitrix* species occur. Since there are no restrictions on import of potatoes from the US and Canada one may expect import also in the future. Potato import from these countries could increase the probability of entry of *E. cucumeris*, *E. hirtipennis, E. tuberis*, *E. subcrinita* and other *Epitrix* species from North America, especially if potatoes are imported unwashed in 'big bags'. Any increase in import of potatoes from Peru or Bolivia would be of special concern, since these countries probably harbor several potato-infesting *Epitrix* species.

Table 5. Import of potato to Norway (in metric tons) from countries where *Epitrix* species are known to occur. Data are from the past 10 years (2009-2018). N = number of years with export; sd = standard deviation.

Country	N	min	mean	max	sum	sd	percent
France	10	4.8	3020.6	12110.4	117803.6	4096.1	89.1
Spain	10	4.2	435.5	1407.9	13937.3	487.3	10.5
Italy	10	0.2	22.5	90.3	449.3	26.4	0.3
Brazil	2	0.1	4.6	13.6	13.8	7.8	< 0.1
Costa Rica	1	8.3	8.3	8.3	8.3	-	< 0.1
Peru	1	14.8	14.8	14.8	14.8	-	< 0.1
Greece	1	0.3	0.3	0.3	0.3	-	< 0.1
Portugal	2	1.0	1.5	2.0	3.0	0.7	< 0.1
Russia	1	5.7	5.6	5.6	5.6	-	< 0.1
Total					132236		100

4.1.1.4 Import of tomato

The probability of entry of *E. cucumeris*, *E. hirtipennis* and *E. papa* to Norway with imports of tomato is considered to be very unlikely, with a low level of uncertainty. Eggs and larvae of *Epitrix* are not present on tomato fruits. Tomato plants for planting with soil attached could be a potential pathway, but such plants are generally not traded.

The past 10 years Norway has imported a total of 529,985 metric tons of tomato from 74 different countries. Of this, 239,298 metric tons came from 18 countries where *Epitrix* species are known to occur, and 93% of this volume came from Spain.

4.1.1.5 Import of aubergine

The probability of entry of *E. cucumeris*, *E. hirtipennis* and *E. papa* to Norway with imports of aubergine is considered to be very unlikely, with a low level of uncertainty.

As with tomatoes, eggs and larvae are not present on aubergine fruit. Aubergine plants for planting with soil attached could be a potential pathway, but such plants are generally not traded. The past 10 years Norway has imported a total 13,325 metric tons of aubergine from 47 different countries. Of this, 6,758 metric tons came from 12 different countries where *Epitrix* species are known to occur, and 78% of this volume came from Spain.

4.1.2 Probability of the pest being associated with potatoes at origin of shipment

The overall probability of the pest being associated with the entry pathways at the origin of shipment is considered to be likely, with medium uncertainty.

There is extensive spatial overlap between the distribution areas of *Epitrix* species and the areas with the highest average potato yield throughout the world (Figure 4). *Epitrix* species will be closely associated with potato plants, potato tubers and the soil surrounding the potatoes. Most adult *Epitrix* feed on the leaves of different plants, while eggs are laid on the lower stem of a specific host such as potato. The larvae develop on the roots and can cause damage to the potato tubers. In some species, *Epitrix* larvae can tunnel up to 9 mm into the potatoes (Boavida et. al. 2013), making small black entrance holes and narrow black serpentine feeding tracks on or under the potato skin. *Epitrix* species complete one to four generations per year depending on local temperatures and may be prevalent in potato fields or their surroundings throughout the year. When potato is harvested, larvae and pupae may be present on the tubers or in any attached soil.

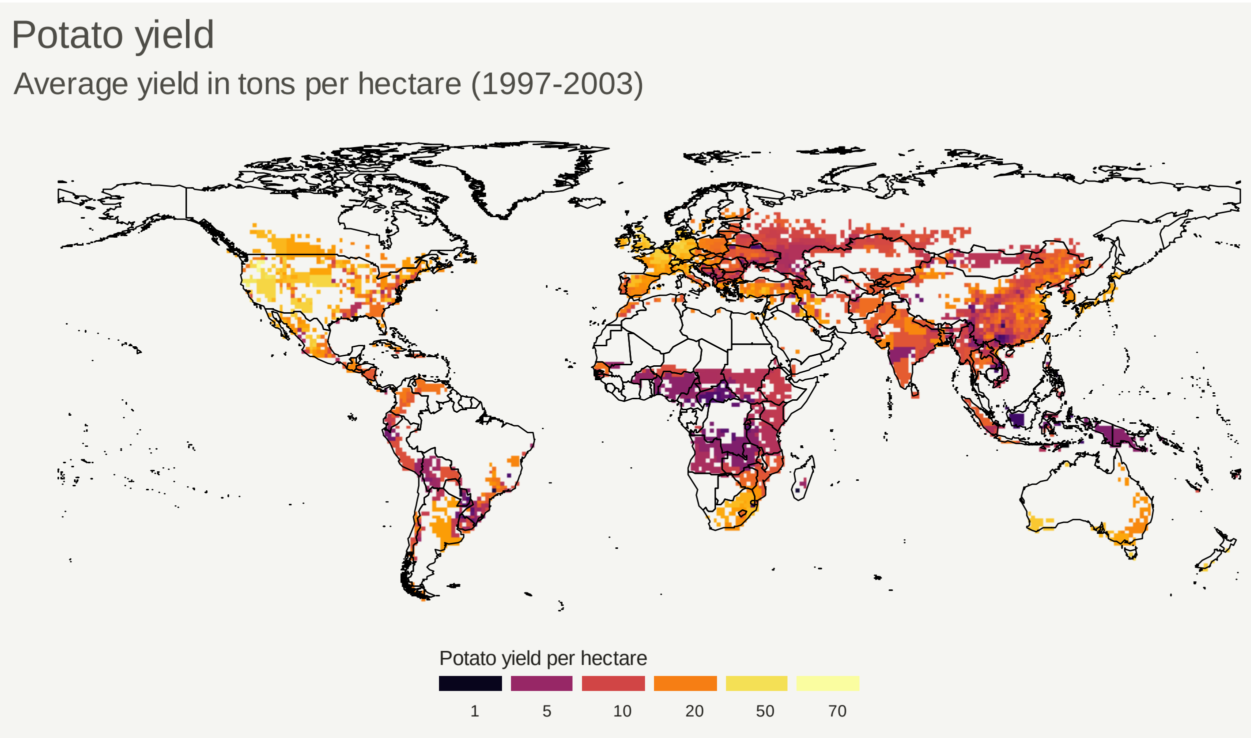

Figure 4. World potato production areas and yield. There is a high degree of spatial overlap between occurrence of *Epitrix* species (see Figure 1-3) and potato production, especially in Europe (Spain and Portugal) and America (United States, Canada, Bolivia and Peru) where several potato feeding *Epitrix* species occur (Data from Monfreda et. al. 2008).

4.1.3 Probability of survival during transport or storage

The overall probability of the pest to survive during transport and storage are considered to be very likely, with medium uncertainty.

Potatoes are transported both on ships and overland. Transport to Norway from Spain and France, the main export countries where *Epitrix* species are known to occur, is estimated to take maximum five days. Potatoes are transported at approximately 1–9 °C, and potatoes are stored indoors at approximately 4 °C. Transport and storage in dark and cool containers is favorable for the long term survival of *Epitrix* species. Ambient transport and storage temperatures of 1–9 °C are not low enough to kill *Epitrix* species but would simply halt development and activity.

4.1.4 Probability of pest surviving existing pest management procedures

The overall probability that the pest will go undetected during inspection of consignments or survive other existing phytosanitary procedures is considered to be likely, with low uncertainty.

All life stages of *Epitrix* are very small and hence difficult to detect during inspections. In addition, larvae can be hidden inside the potato tubers. It may therefore be easier to spot symptoms of *Epitrix* infestation than the pest itself. If they are cooled to an ambient temperature of 5–9 °C for several days, the beetles will probably be sedentary or dormant during inspections and consequently even more difficult to detect.

4.1.5 Probability of transfer to a suitable host

The overall probability of transfer of the pest to a suitable host is considered to be unlikely, with low uncertainty.

Potatoes are stored indoors most of the time, in trucks, containers or warehouses, before they are redistributed to shops and end users. *Epitrix* species are poor dispersers and are unable to fly long distances. Also, insect flight activity is usually highest at high temperatures (>20^{o} C) and the beetles' flight ability will probably be lower at the low temperatures experienced during transport and storage. The pest could be transferred to suitable hosts (such as weedy Solanaceae) if the soil that is washed off imported potatoes is disposed of near suitable hosts.

4.2 Probability of establishment

Establishment consists of survival, reproduction, and population growth. The main factors affecting establishment are (1) available resources, such as appropriate host plants, (2) the occurrence of natural enemies, and (3) a tolerable range of any constraining abiotic variables, such as temperature and precipitation. Potatoes are grown throughout Norway (Figure 10) and wild solanaceous plants are also widely distributed, so a lack of host plants is unlikely to limit the establishment of *Epitrix* in Norway. As to natural enemies, introduced species are often released from their native specialist enemies and therefore experience lower predation levels in new areas. The natural enemies of *Epitrix* are poorly studied, but we consider it unlikely that *Epitrix* species would be prevented from establishing themselves in Norway due to the presence of specialist enemies. Therefore, the focus of this section will be to investigate climatic suitability in Norway for the assessed *Epitrix* species. Unsuitable climatic conditions could increase mortality, extend development, decrease fecundity, and have other negative population effects.

4.2.1 Climatic suitability

Because there is little detailed information on the ecology and physiology of *Epitrix* species, distribution models are the best available tool for estimating the potential distribution of *Epitrix* in Norway. In order to use such models to estimate the environmental suitability of Norway to *Epitrix* we needed precise occurrence data for *E. cucumeris*, *E. hirtipennis* and *E. papa*, as well as climatic predictor variables.

Several databases were checked for species occurrence data in their native range: GBIF (2019), BISON (2019), inaturalist (2019) and Ecoengine (2019). We used the R program for statistical computing (R Core Team, 2019) and appropriate analysis packages (dismo (Hijmans et. al. 2017), tidyverse (Wickham 2017), spocc (Chamberlain 2018), scrubr (Chamberlain 2016), sdmpredictors (Bosch 2018), randomForest (Liaw and Wiener 2002), kernlab (Karatzoglou et. al. 2004), virtualspecies (Leroy t. al. 2015)). Additional occurrence data were found in Bieńkowski and Bienkowskaja (2018). Occurrence data in the form of precise coordinates were available for *E. cucumeris* (n = 1143) and *E. hirtipennis* (n = 927) (Figure 5), but no such data were found for the recently described *E. papa.* Several climatic predictors (at ~1 km^2 resolution) were downloaded from worldclim.org (Fick and Hijmans, 2017) and ENVIREM (Bemmels, 2018). In the end, only a few climatic predictors were used in the final model (Table 6). Climatic predictor variables were tested for autocorrelation, and highly autocorrelated variables were omitted from the analyses. For the remaining climatic predictors we extracted predictor values at each species occurrence point, and these values where used to fit multiple models to estimate potential distribution of *E. cucumeris* and *E. hirtipennis* in Europe. Different sets of occurrence data from North America were used as testing and training data, and all distribution predictions were made for Europe.

Several modelling algorithms were used and in total more than a thousand trial runs were made, but only a few models are presented here. For *E. cucumeris* and *E. hirtipennis,* we compare one ensemble model (combining a BIOCLIM model (Booth et al., 2014), a Random Forest model (Breiman, 2001), and a Support Vector Machine model (Vapnik, 1998)) with a Maxent model (Phillips et al., 2006). Maxent models have previously been found to outperform other distribution models (Elith et al., 2006).

There are several caveats when using occurrence data for *Epitrix* species. Firstly, there is the problem of possible species misidentification, as explained in chapter 2. Secondly, occurrence data are likely to be biased and not necessarily represent the true geographical distribution of the species. Therefore, predictions based on such data may not show the species' true potential distribution, but rather produce a pattern that reflects previous sampling efforts (Elith 2011). To reduce this problem we subsampled the data in an attempt to account for spatial bias. The presence records that were used in the distribution models are shown in Figure 5. Maxent has proven to perform well even with a small number of presence points (Elith et al., 2006). We therefore believe that the models we present provide valuable information on the potential distribution of *E. cucumeris* and *E. hirtipennis* in Norway. Still, the distribution models for Norway would probably have been more reliable if more occurrence data for e.g. *E. cucumeris* from northern Canada could have been included, such as data from north of the 60th parallel, which is the same longitude as Oslo, Norway.

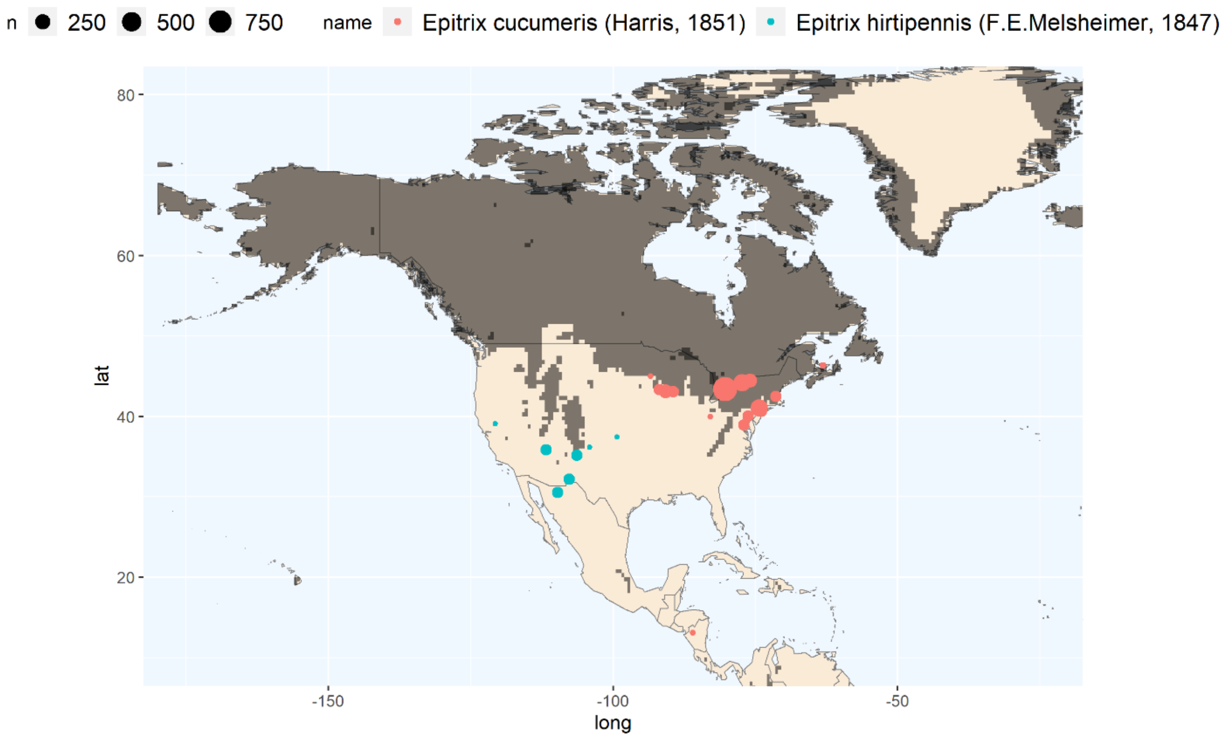

Figure 5. Location of presence records of *Epitrix cucumeris* (red dots) and *Epitrix hirtipennis* (green dots) used to model the species' potential distribution in Europe. N = number of occurrence points in each cluster of points. Dark areas are areas that have the same Köppen-Geiger climate classification as Norway.

Table 6. List of variables used in the species distribution models presented in Figure 6 and 7.

Variable name	Description of variables
bio2	Mean diurnal temperature range (mean of monthly temperature range (max temp - min temp)) i.e. continentality, in °C
bio5	Maximum temperature of the warmest month over a given time series, in °C
bio6	Minimum temperature of the coldest month over a given time series, in °C
bio13	Total mean precipitation of the wettest month, in millimetres
bio14	Total mean precipitation of the driest month, in millimetres
ER_growingDegDays5	Sum of mean monthly temperature for months with mean temperature greater than 5 °C multiplied by number of days, in °C
Koppen	Köppen-Geiger climate classification

4.2.1.1 **Potential distribution of *Epitrix cucumeris***

Rating of climate suitability: Unlikely

Rating of uncertainty: High

With the occurrence data currently available, neither the ensemble model nor the Maxent model included Norway in the potential distribution of *E. cucumeris* in Europe (Figure 6). The different models show the same general geographical pattern, with the highest probability of distribution in western and southern Europe, including Ireland, United Kingdom, France, Italy, Slovenia, Croatia and Bosnia. The Maxent model also predicted a high probability for distribution in coastal areas of Portugal, where *E. cucumeris* is already present. The ensemble model did not predict occurrence in the same area.

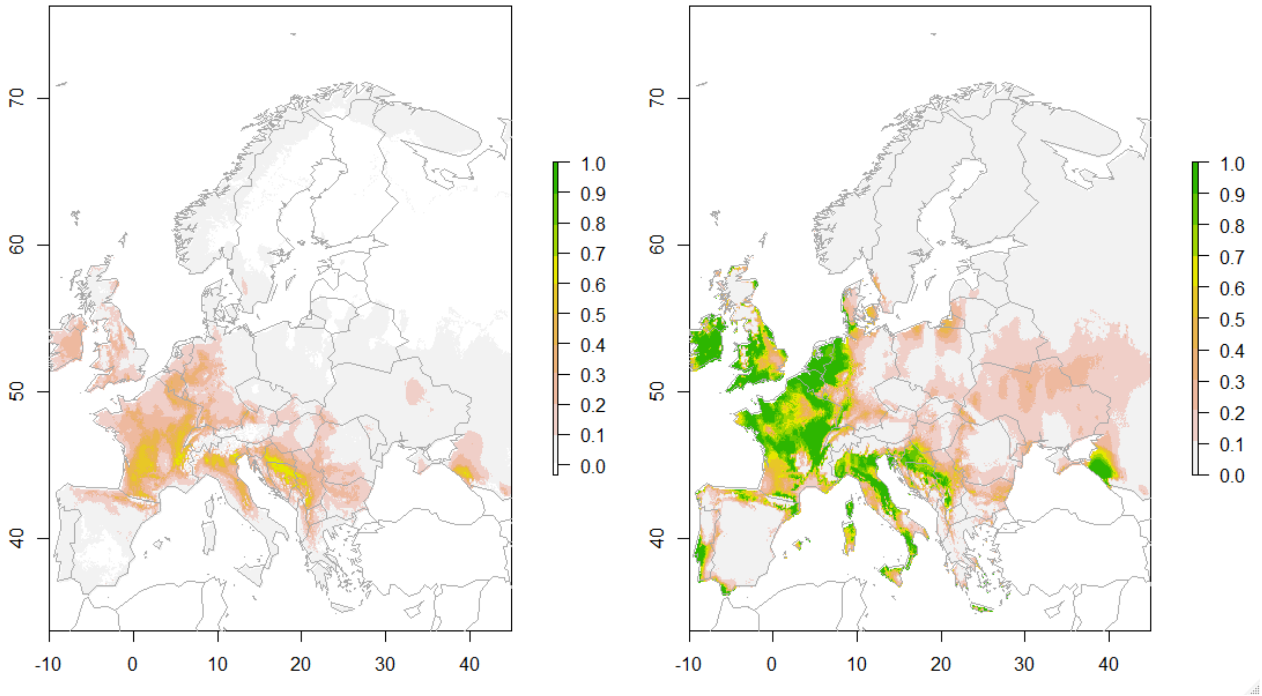

Figure 6. Different species distribution models for *Epitrix cucumeris* in Europe. To the left is the output of an ensemble model (weighted mean of three different models: BIOCLIM model, Random Forest model, Support Vector Machine model) and to the right is the output of a maximum entropy model. All models indicate a low probability of establishment of *E. cucumeris* in Norway. Legend shows the estimated probability of presence between zero (white) and one (green).

4.2.1.2 **Potential distribution of *Epitrix hirtipennis***

Rating of climate suitability: Unlikely

Rating of uncertainty: High

With the occurrence data currently available, neither the ensemble model nor the Maxent model included Norway in the potential distribution of *E. hirtipennis* in Europe (Figure 7). The models show the same general geographical pattern, with the highest probability of distribution along the Mediterranean Sea, where *E. hirtipennis* is already established.

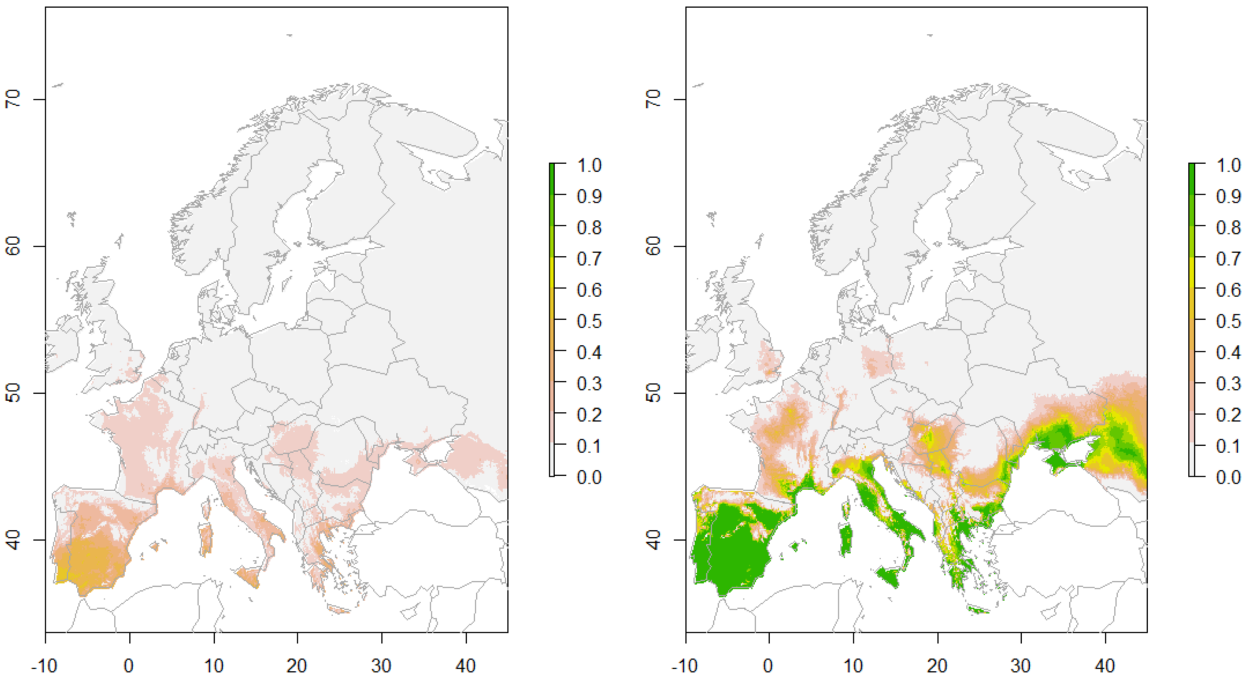

Figure 7. Different species distribution models for *Epitrix hirtipennis* in Europe. To the left is the output of an ensemble model (weighted mean of three different models: BIOCLIM model, Random Forest model, Support Vector Machine model) and to the right is the output of a maximum entropy model. All models indicate a low probability of establishment of *E. hirtipennis* in Norway. Legend shows the estimated probability of presence between zero (white) and one (green).

4.2.1.3 **Potential distribution of *Epitrix papa***

Rating of climate suitability: Likely

Rating of uncertainty: High

We were not able to model the potential distribution of *E. papa* in Europe due to the lack of precise occurrence data for this species. Therefore, we instead did a simpler comparison of the climate in Portugal and Spain with that in Norway to assess the degree of climatic similarity. According to the Köppen-Geiger climate classification (Beck et. al. 2018), Norway shares few climate classes with Spain and Portugal (Figure 8). Also, there are considerable differences in monthly mean temperatures between Norway and both Spain and Portugal, and the monthly mean precipitation in Norway is higher in the summer compared to Spain and Portugal. The large climatic differences between Norway and Spain/Portugal suggest that *E. papa* may not be able to establish in Norway. However, because *E. papa* currently is known only from Portugal and Spain but is not native to those countries it is impossible to reliably predict the potential distribution area of this species.

Recently, Boavida et al. (2019) published a laboratory study of developmental times of *E. papa* at different temperatures, including a model of developmental rates as a function of temperature with a lower developmental threshold of 8.1 °C. According to this model, the lower limit for completion of one *E. papa* generation is 625 degree-days above 8.1 °C. Because large areas in south-eastern Norway experience more than this during the summer the developmental data from Boavida et al. (2019) suggests that *E. papa* probably would be able to complete its development in parts of Norway (Figure 9). During warm summers (e.g. 2018) it may even be able to complete several generations, and thus reach higher population densities.

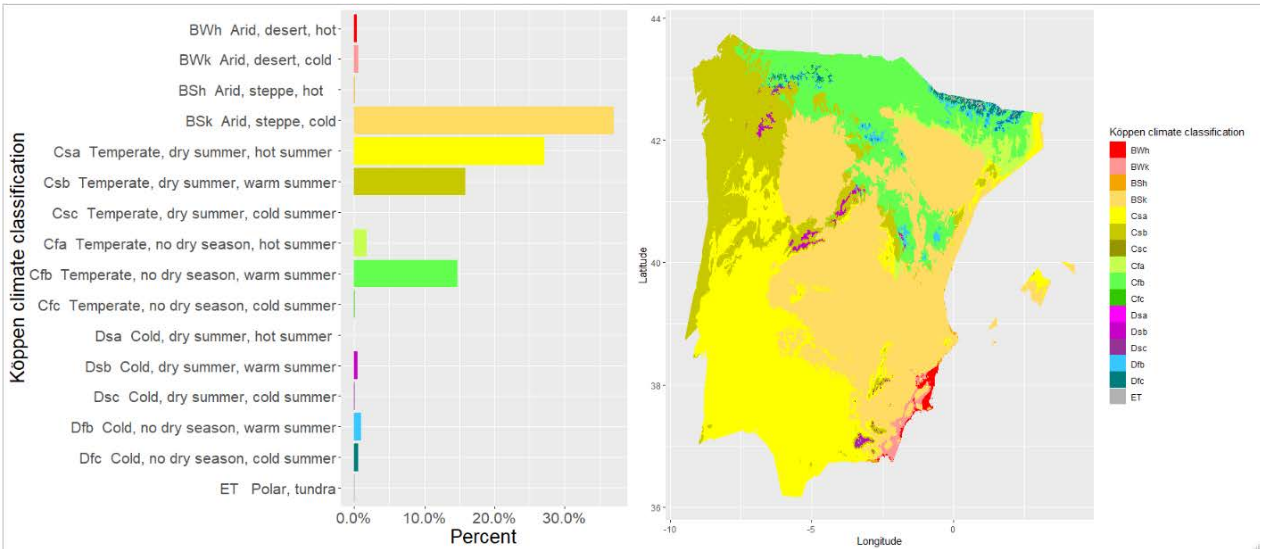

Figure 8. Köppen-Geiger climate classification map of Portugal and Spain at 1x1 km resolution and a bar plot showing the relative coverage of different climate classes. Climate classes that are shared between Norway and Spain/Portugal are: BSk (Arid, steppe, cold), Csb (Temperate, dry summer, warm summer), Cfb (Temperate, no dry season, warm summer), Cfc (Temperate, no dry season, cold summer), Dsb (Cold, dry summer, warm summer), Dfb (Cold, no dry season, warm summer), Dfc (Cold, no dry season, cold summer) and ET (Polar, tundra).

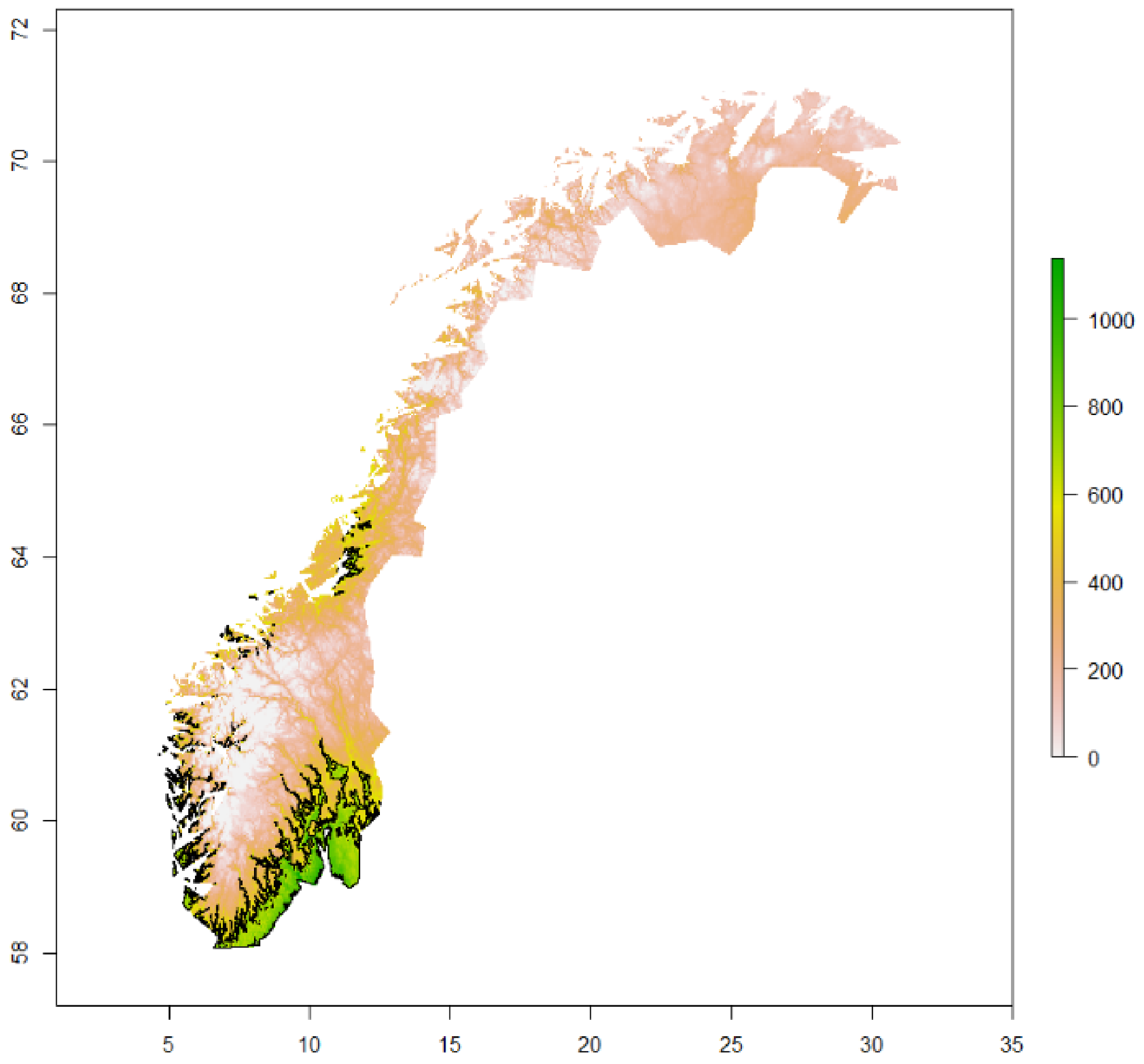

Figure 9. Map of Norway with growing degree days above a base temperature of 8.1 °C, the lower limit for development of *Epitrix papa* (Boavida et al 2019). Black polygons delimit areas with more than 625 degree-days above 8.1 °C, where *E. papa* probably would be able to complete its development according to Boavida et al. (2019).

4.2.2 Availability of suitable hosts, alternate hosts and vectors in the PRA area

Suitable host plants are present in the entire PRA area.

Epitrix species are associated with plants in the family Solanaceae and, as shown by Boavida et al. (2013), *E. cucumeris* and *E. papa* can reproduce on potato as well as certain wild relatives, such as *Solanum nigrum*, and species in the genus *Datura*. In addition, adults will feed on other plants, including non-Solanaceae species. Even though these non-hosts may not be suitable for development they could facilitate spread and short-term survival of *Epitrix* species in Norway.

4.2.2.1 Availability of potato in the PRA area

Potato is grown extensively throughout Norway, both commercially and privately (Figure 10).

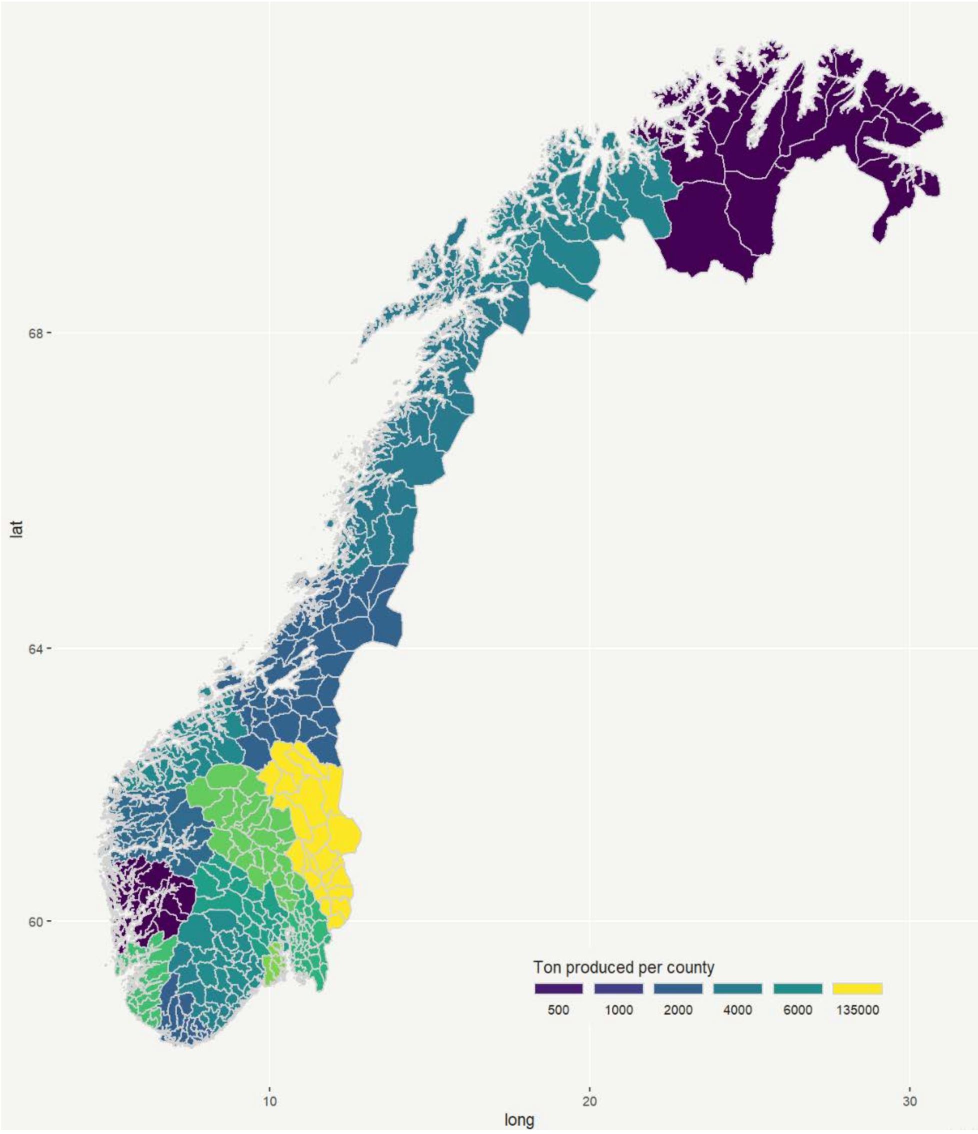

Figure 10. Mean annual potato production (in metric tons) in Norway the past 30 years.

4.2.2.2 Availability of other host plants in the PRA area

Tomatoes are grown commercially in Norway, mostly in greenhouses on the southwestern coast. In addition, tomatoes are grown privately indoors and in gardens all over the country.

Aubergine is not grown commercially in Norway and is imported mostly from Spain and The Netherlands.

Research on pestiferous *Epitrix* species has focused on their ecology with respect to crop plants. We know relatively little about which alternative plants can serve as reservoir hosts that may help sustain or augment *Epitrix* populations (but see Glass 1940, Jones 1944, Boavida et al. 2013). Wild host plants can act as reservoirs between crop plantings (e.g. between potato growing seasons), even if the wild plants are potentially only used for adult feeding. Long lists of solanaceous 'host plants' are given for most *Epitrix* species; some of these are records of adult feeding, but some are simply species on which adult beetles were sitting when collected, and in these lists these two situations cannot be disentangled (Clark et al. 2004). Nonetheless, there is a general consensus that feeding preferences are broad for pest species of *Epitrix* and that host usage (adult feeding or larval development) is nearly always possible on several different genera of Solanaceae (Glass 1940, Jones 1944, Boavida et al. 2013, and discussions in Clark et al. 2004).

We reviewed the information on the distribution of solanaceous plants in Norway in recent floras (Lid, 2005, Mossberg and Stenberg 2012), and checked *Epitrix* host plant data for the more widespread Norwegian species. Nine genera in the family Solanaceae occur in Norway, but few species of Solanaceae (the nightshade family) are listed in national floras (Lid, 2005, Mossberg and Stenberg 2012). Only one species is native, *Solanum dulcamara* ("slyngsøtvier" in Norwegian). This species has never been tested for suitability for *Epitrix,* but adults of *E. cucumeris* are frequently found on invasive *S. dulcamara* in South Carolina (A. Deczynski, pers. comm. Oct. 2019). All other species of nightshade are introduced to Norway. Only a few species are naturalized (that is, maintain continuous generations by their own reproduction), but some species are common because they are introduced continuously as contaminants of animal feed (including chicken feed) or are regularly planted as ornamentals (e.g. *Petunia* spp., *Nicandra physaloides*) or as medicinal plants. A few of the Solanaceae species that occur in Norway are potential reservoir hosts for *Epitrix*.

Solanum nigrum, black nightshade ("svartsøtvier" in Norwegian), is a weed in agriculture crops around the world as well as being widely cultivated for food or medicine. In Norway, it is common north to the counties of Hedmark and Oppland in eastern Norway and to Sogn and Fjordane in western Norway, where it is found in cropped fields, gardens, parks, along roadsides, and in various disturbed habitats (Lid, 2005). It is the only *Solanum* species that does well in Norway and is in fact a weed of potato fields. *Epitrix cucumeris* reproduces very well on this host plant, and *E. papa* can also reproduce on it (Boavida et al. 2013).

Solanum rostratum, buffalo-bur ("Kansassøtvier" in Norwegian), is not naturalized but is commonly found around agricultural fields and in pastures and meadows (Lid, 2005). It is frequently introduced with chicken feed. Its distribution is mainly coastal as far north as Nordland county, with scattered inland occurrences. *Epitrix cucumeris, E. hirtipennis, E. fuscula, E. subcrinita* and *E. tuberis* all are associated with *S. rostratum* in their native range (Clark et al. 2004).

Lycium barbarum (“bukketorn” in Norwegian) is fairly commonly encountered in eastern Norway. It is associated with *E. hirtipennis* in its native range (Clark et al. 2004).

Several varieties of *Datura stramonium*, jimsonweed (“piggeple” in Norwegian), can be found in Norway, where it occurs regularly as far north as northern Trøndelag county and occasionally as far north as Finnmark county. It is not naturalized but is frequently introduced as a garden plant and also enters the country with animal feed and bird seed (Lid, 2005). *Epitrix brevis, E. fasciata, E. hirtipennis, E. fuscula*, and *E. tuberis* are all recorded from jimsonweed (Clark et al. 2004). *Epitrix hirtipennis* at least feeds on this plant (Glass, 1940), and *E. cucumeris* and *E. papa* can reproduce on it (Boavida et al. 2013).

4.2.2.3 Probability of spread after establishment

Rating of probability of spread: Unlikely

Rating of uncertainty: Low

The process of continuous spread after establishment, i.e. the radial range expansion within the PRA-area, is expected to be very low for *Epitrix* species. However, human assisted spread, through long distance movement of goods such as potatoes and farming equipment, may aid the spread of *Epitrix*. The possibility for human assisted spread make the dispersal capacity of *Epitrix* highly unpredictable.

4.2.3 Conclusion on the probability of introduction and establishment and spread

Rating of probability of introduction and spread: Unlikely

Rating of uncertainty: Medium

Regarding introduction, the current global distribution of *Epitrix* species is thought to be very wide, but also largely unknown for most species due to taxonomical issues. The non-native *Epitrix* species in Europe have a southern distribution and are for the most part distributed around the Mediterranean Sea. *Epitrix* species have been shown to spread via trade with potato. Import of potato to Norway is relatively large from France, where *E. hirtipennis* is present. However, it is not known how much of this import that consists of unwashed potatoes, which is most likely to transport *Epitrix*. There has been no import of potato to Norway from North and South America the past 10 years, and this reduces the probability that *Epitrix* will be introduced. However, since there are no restrictions on potato import from America import volumes could change from year to year. The ability of *Epitrix* species to transfer to a suitable habitat after entering Norway with imported potato is consider to be low because of the pests’ limited dispersal ability, the closed transport systems for potato, and the low temperatures at potato handling facilities that impair spread.

Regarding establishment, the estimated potential distribution models for *Epitrix* in Norway suggest a low probability of establishment, but the models have high uncertainty due to taxonomic issues. Also, degree-day estimations of development of *E. papa* suggests that it can complete at least one generation in southern Norway. The main host plant for *Epitrix*, potato, is grown in the whole of Norway. If it was to establish in Norway *Epitrix* is believed to have a low rate of natural spread.

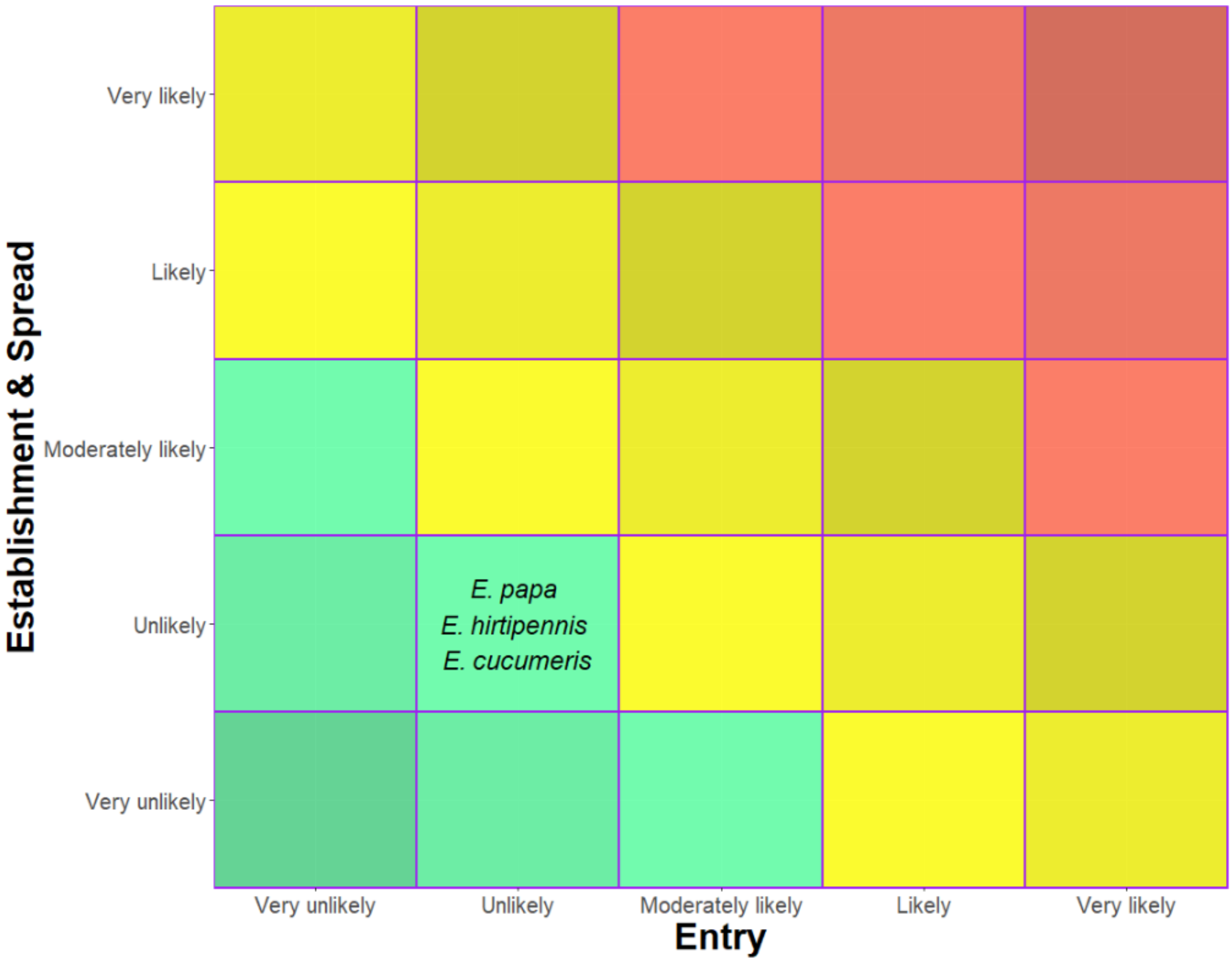

Figure 11. Summarized probability of invasion of the three assessed *Epitrix* species, as a combination of the probability of entry and the probability of establishment and spread.

5 Assessment of potential consequences

5.1 Direct pest effects

Rating of direct pest effect: Moderate

Rating of uncertainty: Medium

The most severe damage is made by *Epitrix* larvae feeding directly on tubers, leaving serpentine tracks in the tuber epidermis. This damage is in most cases only superficial and cosmetic, and does not prevent the tubers from being processed industrially. However, even minor cosmetic damage can make tubers unmarketable as ware potatoes, leading to substantial economic loss for farmers (Eyre 2013). *Epitrix papa* is considered to cause deeper and more severe damage to tubers, while *E. cucumeris* reportedly causes shallow damage only. Nevertheless, *E. cucumeris* was reported to cause yield losses of 43% in Canada (Eyre, 2013). Thus, the potential for economic loss may be high, but it is uncertain if the species' full destructive potential would be realized in Norway where it is predicted to suffer from climatic stress and to be able to complete at the most one generation per growing season (see establishment section). Available data on *E. hirtipennis* is inconclusive with regard to its ability to damage tubers directly, and it seems likely that it mainly damages other parts of the plant, causing indirect yield loss (described below) only.

The fact that *Epitrix* is predicted to be univoltine in Norway (as compared to multivoltine in the Iberian Peninsula), suggests that the beetles will not be able to build up high population densities as quickly (chapter 4.2). It will thus take longer time for the beetles to reach economically injurious levels, giving farmers substantially more time to identify the threat and take curative action (chapter 6). Therefore, the direct pest effects of *Epitrix* are likely to be lower in Norway as compared to the Iberian Peninsula, at least during “normal” summers. During exceptionally long and warm summers (e.g. 2018) the population growth, and damage levels, are likely to resemble Iberian levels.

5.2 Indirect pest effects

Rating of indirect pest effect: Moderate

Rating of uncertainty: Medium

In addition to tuber damage, *Epitrix* larvae can also feed on the roots and adults feed on the leaves. Damage to roots and leaves causes indirect yield loss through lower uptake of nutrients and water (root damage) and reduced photosynthesis (leaf damage). However, these indirect reductions of growth and yield are considered much less problematic than the quality reductions described in the previous paragraph.

Furthermore, wounds caused by *Epitrix* feeding can make potato and other crops susceptible to secondary pests and pathogens. Some secondary pathogens may even be vectored by *Epitrix* itself. For example, *Epitrix* has been reported to occasionally vector eggplant mosaic virus (Dale, 1954). *Epitrix* beetles can also carry *Verticillium* wilt and *Fusarium* (Bradshaw et al. 2007). However, vectoring of diseases is relatively unexplored for *Epitrix* and the indirect costs that may be inflicted by this are therefore unknown.

Finally, the indirect costs resulting from monitoring, integrated pest management, and chemical pesticides to control *Epitrix* (described in chapter 6) are potentially high but will vary greatly depending on which methods that are selected.

5.3 Conclusion of the pest risk assessment stage

VKM considers the three *Epitrix* species to represent a low risk for Norway. The probability of entry of *Epitrix* by natural spread is unlikely, mainly because of the geographical distance and sea barriers between Norway and the infested countries in Europe.

The probability of entry via potatoes (and mainly unwashed potatoes) is considered moderately likely, and should *Epitrix* enter Norway, establishment and spread are also unlikely.

The potential damage, should *Epitrix* be established, is considered to be moderate, since *Epitrix* most likely only will be able to complete one generation per year. Due to the difficulty of correct species identification and lack of knowledge regarding precise distribution and host plants, *Epitrix* species should be treated as a pest complex, with identical pest risk management for all *Epitrix* species.

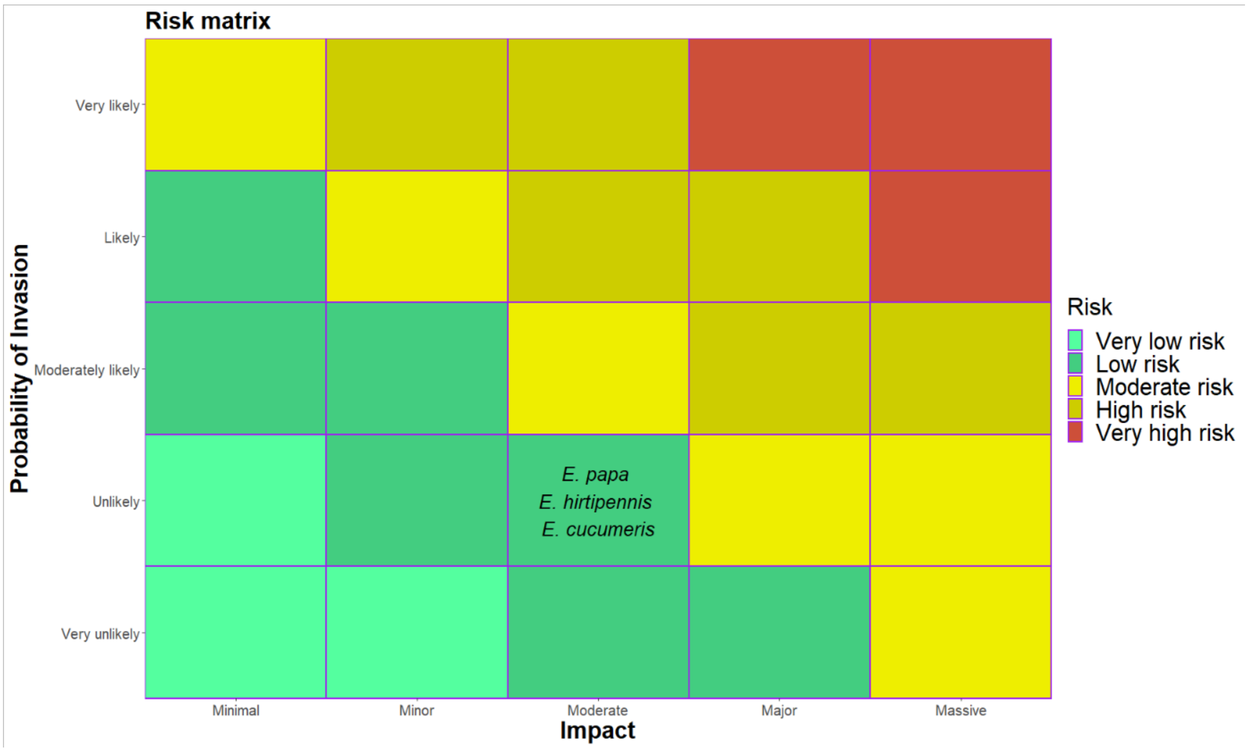

Figure 12. Summarized risk of *Epitrix* species, as a combination of the probability of invasion and the assessed impact. All three *Epitrix* species are considered to present a low risk for Norway.

6 Pest risk reduction options

6.1 Options for consignments

As import of seed potato is prohibited (see paragraph 4.1.1.2), the most important pathway remaining for introducing *Epitrix* into Norway is import of unwashed ware potato tubers from infected areas (see paragraph 4.1.1.3). Actions to detect *Epitrix* and decontaminate consignments along this pathway can be taken in the exporting country, and/or upon arrival of consignments to Norway.

6.1.1 Monitoring

All life stages (eggs, larvae, pupae, adults) of *Epitrix* can be transported in potato consignments. Eggs, larvae, and pupae can be found on or just inside the tuber surface, or in soil/debris attached to tubers. Adult beetles are independent from potato tubers and can be found on any part of the consignment, including containers and bags used for transportation. Unwashed potatoes shipped in 'big bags' represent a high risk of entry, and would be of key interest to monitor.

All life stages are small, and the eggs, larvae, and pupae are particularly difficult to detect by visual inspection as they are more or less immobile. Adult beetles are mobile, and hence easier to detect. However, as insects are ectothermal and tubers are transported and stored at low temperatures (see paragraph 4.1.3), adult activity will typically be very low in potato consignments. Thus, the possibility to detect adults during visual inspection of cool consignments is still low.

The most reliable method to detect *Epitrix* is to score damage symptoms on tubers (see chapter 5.1). The feeding larvae leave serpentine tracks on or under the potato skin. These tracks are relatively easy to detect and are not easily confused with symptoms of other pests or pathogens. However, reliable detection of these symptoms is difficult if soil or debris remain on the tubers. Thus, washing of tubers is a prerequisite for reliable detection of damage symptoms.

Although serpentine tracks indicate with high certainty that *Epitrix* individuals are, or were, present on the tubers, one cannot with certainty assume that the absence of symptoms indicates that the consignment is free of *Epitrix*. Eggs and adults do not cause any symptoms on tubers, and may thus go undetected. However, eggs hatch after 3-14 days (depending on temperature), and tubers that were harvested at least 14 days earlier should show at least some symptoms of larval feeding if *Epitrix* individuals are present.

Other monitoring methods include scoring of leaf damage inflicted by adults (see EFSA 2019), but such damage can easily be misidentified. Methods for monitoring adults by trapping has so far not been developed, but some semiochemicals that are attractive to *Epitrix* were recently identified by Boavida et al. (2019), suggesting that semiochemical-based traps for monitoring could soon be developed.

6.1.2 Preventive phytosanitary measures

Brushing or washing of potato tubers in the exporting country, or upon arrival to Norway, is not only a prerequisite for detection of symptoms, as stated in the previous paragraph. Washing is also a reliable method to remove all soil from tubers (Runia et al. 2009), and at the same time remove all eggs, larvae, pupae, and even adults. Washing is considered to be almost completely reliable, but dead or alive *Epitrix* individuals have still been detected a few times on washed potato consignments in Europe (see paragraph 4.1).

Although brushing or washing removes *Epitrix* from potato tubers it is still important to note that living individuals may remain in the washed-off soil and debris. Thus, this waste material may itself constitute a risk that needs proper handling.

One previous PRA (EPPO 2012) suggested that *Epitrix* individuals may escape before or during washing, if washing takes place within the importing country. Successful spread presumes that the insects survive the washing treatment, and that suitable host plants are available within a reachable distance. The escape risk can be eliminated completely if washing takes place outside of Norway (i.e. in the exporting country), or be reduced if the phytosanitary washing facility in Norway is isolated from suitable host plants. The risk would furthermore be reduced if washing is done relatively soon after arrival to Norway, to prevent any eggs, larvae, and pupae from developing into mobile adults. When washing takes place before consignments enter Norway, this also eliminates the need for disposing washed-off soil in Norway.

6.1.3 Curative phytosanitary measures

Curative actions may be taken if any life stage or damage symptoms of *Epitrix* are detected on potato tubers. Heat treatments and synthetic insecticides are conceivable actions, but may make the ware tubers unmarketable. Destruction of infested consignments, followed by proper disposal of the waste product, may be an acceptable solution. To make sure that all *Epitrix* individuals are killed it would also be necessary to disinfect containers, bags, and all parts that the consignment have been in contact with during transportation and storage.

6.1.4 Phytosanitary certificate

All potato consignments imported to Norway come with a phytosanitary certificate (“plantesunnhetssertifikat”). This states that the consignment has been controlled by relevant authorities in the exporting country and found to be free from pest species listed in the Norwegian Plant Health Regulation (“Forskrift om plantehelse”, attachments 1-2, and 4A). *Epitrix* is, however, not currently listed among these quarantine pests. Adding *Epitrix* to the list would allow Norwegian authorities to track the monitoring and phytosanitary measures that took place before the consignment entered Norway.

6.2 Options preventing or reducing infestation in the crop

If non-indigenous *Epitrix* individuals are found in Norwegian potato fields several actions can be taken to attempt to eradicate the population, as well as to limit its spread and prevent population build-up in new areas. All of these methods have weaknesses and are associated with uncertainties and costs.

6.2.1 Restrictions on potato cultivation

The most drastic preventive action would be to stop growing potato in the mildest parts of Norway where *Epitrix* may potentially find suitable climatic conditions. However, as suggested by our models of climatic suitability (paragraph 4.2.1) it is unlikely that suitable areas for *Epitrix* exist in Norway. Furthermore, even if open potato cultivation was prohibited, *Epitrix* might still be able to survive in other solanaceous plants in wild and semi-wild habitats (paragraph 4.2.2.2). Thus, even with a complete ban on potato cultivation one cannot guarantee that *Epitrix* would not be able to establish in the wild (provided that they tolerate the climate). The efficiency of cultivation restrictions is thus questionable.

Assuming that potato cultivation will still be allowed, there are several other options to limit population build-up of *Epitrix* at the field and landscape level. Two non-chemical methods are to use relatively resistant potato varieties (paragraph 6.2.2), and to promote natural enemies of *Epitrix* (co called “natural control”, or “conservation biological control”) (paragraph 6.2.3). These two methods cannot eradicate the pest, but are likely to be efficient tools to manage the pest and keep *Epitrix* populations below economically injurious levels. However, as discussed below, the uncertainty is high. If preventive actions fail to control *Epitrix* populations then chemical pesticides (paragraph 6.2.4) can be used as a curative option.

6.2.2 Using resistant varieties

Almost all plant species, including domesticated potato, show intraspecific variation in their resistance to herbivorous insects (Flanders et al. 1992; Frechette et al. 2010; Boavida et al. 2013). Some potato varieties are more resistant against *Epitrix* than others, but there is no variety that is completely resistant (Boavida et al. 2013). However, in areas where pests experience abiotic stress (as would be the case for *Epitrix* in Norway), even moderately resistant potato cultivars could probably be effective in limiting *Epitrix* population growth.

Potato breeding programs are ongoing in Norway (Graminor, 2019), but plant traits that promote resistance against *Epitrix* are currently not considered. Provided that genetic variation in relevant traits is available to breeders it would probably be possible to improve resistance against *Epitrix* in future Norwegian varieties, but this process would take several years. As discussed above, the use of resistant cultivars would probably be efficient in preventing *Epitrix* populations from reaching harmful levels.

From a breeding perspective it is intriguing that several wild relatives of potato are native or naturalized in Norway (see paragraph 3.4). In general, wild relatives of crop plants often provide rich genetic resources for plant resistance breeding. Indeed, some wild *Solanum* species have been shown to harbor genetic variation in anti-herbivore resistance against folivores including *Epitrix* (e.g. Wise and Rausher 2016). Modern methods to efficiently harness such resources from wild populations have been developed (Egan et al. 2018), and may potentially be used on future Norwegian potato varieties. However, such steps are not trivial, and may be dependent on further technological progress, as well as relaxed restrictions on gene editing.

6.2.3 Promoting natural enemies

Very little is known about natural enemies of *Epitrix* species in their native areas or in the new areas they have recently expanded into. In general, however, insect herbivores are often as strongly limited by their natural enemies as by plant resistance. In modern programs of integrated pest management, plant resistance and natural enemies are therefore combined to optimize preventive control (Stenberg 2017).

Biological control of insects often relies on specialist carnivores, like parasitoids. However, in a potential scenario with *Epitrix* spreading into Norway it is unlikely that coevolved specialist enemies will migrate along with them. On the contrary, key specialist enemies of for example American *Epitrix* species will probably not follow their prey to Europe, providing *Epitrix* with “enemy-free space” from specialist enemies in their new range. This enemy-free space may be one reason why invasive *Epitrix* populations can grow quickly and reach harmful population densities in the Iberian Peninsula. Thus, we presume that conservation biocontrol in Norway would have to rely on generalist predators that are native to Norway, and not coevolved with *Epitrix*. The ability of native natural enemies present in Norwegian potato fields to top-down control *Epitrix* is yet unknown, and needs to be experimentally investigated. Several methods are available to identify key predators (Birkhofer et al. 2017). As the natural enemies of *Epitrix* in Europe are understudied we are left with providing general guidelines for how to promote carnivores in agroecosystems. First of all, insect carnivores are sensitive to insecticides. Thus, frequent use of insecticides is likely going to leave all efforts to boost biocontrol with little or no effect. Cuthbertson (2015) suggested that spraying insecticides on potato fields should only be done early in the season when carnivore populations are low. Later in the season, when more carnivores have migrated into the fields, pest management should rely on other methods (Cuthbertson 2015). Fields with little or no insecticide use are more likely to support high predator populations that can help control pests, including *Epitrix*.

Within the framework of integrated pest management (IPM), several methods that promote insect predators have been developed. These methods include the continuous provision of shelter, nectar, alternative prey and pollen (Gurr et al. 2017). Habitat manipulations, including the planting of flower strips, are commonly used to provide these resources. It is not obvious, however, that such measures will be compatible with conventional potato production.

6.2.4 Chemical pesticides

Systemic insecticides have traditionally been used both as a preventive and curative action against insect pests in agriculture. However, the role of chemical insecticides has changed drastically in recent years, and many countries (including all EU countries) have decided that insecticides should only be allowed within the framework of IPM. Within IPM, insecticides should not be used preventively, but only curatively when other IPM actions (such as biocontrol) have failed to manage the pest below economic injurious levels (Stenberg 2017). Biddinger and Rajotte (2015) recently developed the IPM framework further, coining the concept *integrated pest and pollinator management* (IPPM) to explore how insecticides can be applied with minimal negative consequences for beneficial insects. In the case of quarantine pests, however, the goal may not be to manage the pests at low levels, but to eradicate them – and thus applying chemical pesticides immediately upon detection of the pest.

Systemic insecticides can be efficient tools to locally eradicate a quarantine pest, or at least prevent population build-up of the pest. Much testing has been done on the effects of different pesticides on various *Epitrix* species (reviewed by Cuthbertson 2015). Some of the systemic broad-spectrum insecticides that are approved for potato production in Norway (e.g. Biscaya OD 240, containing tiachoprid) can be used to efficiently combat *Epitrix,* but Cuthbertson (2015) specifically points out synthetic pyrethroids as the best option. This is because synthetic pyrethroids have a strong residual activity, thus requiring fewer applications. Three pyrethroid-based insecticides that are approved for potato in Norway are Decis Mega EW 50, Karate 54 CS, and Mavrik. These insecticides are currently used to combat aphids and leafhoppers in potato crops (NIBIO 2019). Thus, chemical control of aphids and leafhoppers using pyrethroid-based insecticides will at the same time target *Epitrix*. According to Cuthbertson (2015), in America the first spraying takes place immediately after adult *Epitrix* have been detected (i.e. when there are more than one adult feeding hole per 10 plants), and further sprayings continue throughout the season, or as long as needed. It should be pointed out that some of the most efficient insecticides (e.g. many new nicotine-like insecticides) are being phased out or prohibited in Europe due to environmental concerns.

Although synthetic insecticides can be quite effective to control *Epitrix*, pesticide application certainly also has some drawbacks that should be highlighted. First, many insecticides are harmful not only to pest insects, but also to beneficial insects such as pollinators and carnivores. Synthetic pyrethroids are reportedly less harmful than e.g. neonicotinoids, but severe negative effects of pyrethroids on bees and natural enemies have been reported (e.g. Ingram et al. 2015). Potato tuber production is not dependent on insect pollination, but pollinator health may still be considered important from a wider biodiversity perspective.

A second drawback of insecticides is that pests tend to evolve resistance against insecticides over time, making them less useful. Herbivorous insects with a broad diet (such as *Epitrix*) tend to be more prone to evolve resistance than specialists, presumably because their generalist lifestyle predisposes them to cope with various toxins present in their host plants (Hardy et al. 2018). Accordingly, much evidence suggest that *Epitrix* has evolved resistance against several insecticides. For example, *Epitrix* resistance against DDT was reported already in the 1950s

(Kring 1958). We note, however, that neonicotinoids and pyrethroids have different mechanisms of pest control, and their combined use may delay the evolution of resistance in pests.

In conclusion, if *Epitrix* becomes established in Norway we find it unlikely that any chemical treatment will be able to eradicate the pest completely. Because most *Epitrix* species feed on several host plants, and likely will have access to alternative host plants where they will find refuge from control, one can expect them to recolonize sprayed potato fields after some time. Some of the alternative host plants are weeds that grow in close proximity to potato fields, making recolonization likely, especially if *Epitrix* is not controlled on the weeds.

6.3 Options ensuring that the area, place or site of production or crop is free from the pest

Monitoring systems based on pheromones have yet to be developed for *Epitrix*. However, ongoing research on chemical attraction is a first step towards developing attractants for monitoring of *Epitrix* (Boavida et al. 2018). But at present, visual detection and monitoring is the only way to determine if the pest is present. Protocols for pest detection and monitoring could include scoring of the following symptoms (preferably for a combination of several symptoms):

1. Adult beetles on plants.
2. Shot holes on leaves.
3. Damage on tubers.
4. Adults or damage symptoms on alternative host plants.

To enable early detection, surveillance for *Epitrix* could be carried out at potential entry points, such as importers of ware potato.

6.4 Conclusion of pest risk reduction options

We conclude that introduction of new *Epitrix* species into Norway could (with relatively high certainty) be prevented by brushing or washing all imported ware potato. Although washing of imported tubers could be organized in Norway, the risk would be even further reduced if the washing is done in the exporting country before consignments are shipped Norway. If new *Epitrix* species become established in Norway they will be very difficult to eradicate completely, but their population build-up in potato fields could be reduced by using a combination of IPM tools (e.g. using resistant potato varieties and promoting natural enemies of the beetles). However, these IPM tools would need to be adapted for Norwegian conditions and this could take several years. Curative options exist, mainly in the form of systemic insecticides, but these options are associated with risks and uncertainties. Finally, we conclude that important knowledge gaps concerning the preventive and curative actions discussed in this paragraph could be filled by undertaking novel research on (1) breeding for anti-herbivore resistance in potato, (2) mapping natural enemies of *Epitrix,* and (3) exploring the beetles' proneness to evolve resistance against commonly used insecticides.

7 Conclusions (with answers to the terms of reference)

1. **Identification of *Epitrix* species of potential phytosanitary concern for Norway and a summary of current knowledge about their taxonomy**

   Several *Epitrix* species have the potential to reach high population densities and inflict damage to solanaceous crops (mainly potato). We have identified three species of potential phytosanitary concern for Norway, namely *E. cucumeris*, *E. hirtipennis*, and *E. papa*. Of these three species *E. papa* is the more serious pest. It was only recently discovered and identified in the Iberian Peninsula, but its origin is unknown. The other two species are native to the Americas and have spread into Europe. As *Epitrix* is a taxonomically complex genus, with more than 160 described species and several undescribed species that are difficult to identify for non-experts, *Epitrix* is commonly considered as a pest complex. This makes sense also from a pest risk and management perspective, as *Epitrix* species have very similar biology and risk profile, and require very similar monitoring and management actions.

2. **Information on the current distribution areas of the selected *Epitrix* species**

   The reported distribution of *E. cucumeris* and *E. hirtipennis* in the Americas stretches from Peru, and Brazil, respectively, in the south to Canada in the north. Introduced European populations are reported from Madeira to Portugal for *E. cucumeris*, and from several Mediterranean countries, as well as Japan and Russia for *E. hirtipennis*. Since *E. papa* was first discovered in 2004, it has spread throughout Portugal and into Spain along the Mediterranean and Atlantic coast. However, the true native and introduced distribution of all three species are uncertain due to uncertain species identifications and low sampling efforts in wild habitats. To date, no findings of the three species have been reported from Norway.

3. **Identification of host plants for the selected *Epitrix* species and the current distribution area of the respective host plant species in Norway**

   The three *Epitrix* species have overlapping host plant ranges, including potato, aubergine, and European nightshade. In addition, tomato, tobacco, jimsonweed, and several wild solanaceous plants can be utilized to various degrees. In addition to areas with cultivated potato, wild populations of jimsonweed and European nightshade are relatively common in southern and central Norway, but more scattered in the northern parts of the country.

4. Assessment of possible pathways for entry of the selected *Epitrix* species and the potential for establishment and spread of the selected *Epitrix* species in Norway

Only one commercial pathway of importance has been identified by the panel, namely import of unwashed ware potatoes from areas with established *Epitrix* populations. Beetles (of any life stage) that are transported in contaminated consignments can be expected to survive transport and enter Norway. However, as potato consignments are closed and the beetles rarely, or never, would have a chance to escape outdoors, the risk of establishment is low. Moreover, the climatic conditions in Norway are probably unfavourable for establishment and population growth of the assessed *Epitrix* species. However, this conclusion comes with a high degree of uncertainty due to low quality data on the current distribution of the species and their ability to tolerate low temperatures. If local populations were to establish in Norway, their natural spread is believed to be slow, at best, due to the limited flight capacities of *Epitrix*.

5. Assessment of the probability of the selected *Epitrix* species entering Norway from their current distribution areas by natural spread

The assessed *Epitrix* species reportedly have very poor flight capabilities, and disperse slowly. Natural spread from their current distribution into Norway would require crossing the Skagerrak strait, which the panel considers very unlikely.

6. Assessment of the potential impacts in Norway (economic, environmental, social) if the selected *Epitrix* species are established

The most severe damage is made by *Epitrix* larvae feeding directly on potato tubers. Although this damage is mostly cosmetic, it reduces the economic value of ware potatoes. In addition, damaged potato plants may be more susceptible to secondary pests and pathogens. Potential environmental and social impacts of *Epitrix* are considered to be moderate.

7. Identification of relevant risk reduction measures and evaluation of their effectiveness and feasibility

The risk of introducing new *Epitrix* species into Norway could be reduced by brushing or washing all imported ware potato, but washing may not always eliminate larvae from tubers (EPPO 2016). If new *Epitrix* species establish in Norway they will be very difficult to eradicate completely, but they can probably be locally managed in potato fields using a combination of curative and preventive actions. Synthetic pyrethroids and neonicotinoids are effective for curative control provided that they are not prohibited and the beetles do not evolve resistance to pesticides. Several semi-effective preventive integrated pest management actions are available, but would need further fine tuning for optimal use in Norway.

8 Data gaps

A thorough understanding of the threats to agriculture posed by non-native flea beetles would require a much better understanding of the taxonomy and host use of a wide range of *Epitrix* species, as well as more knowledge about which species could potentially thrive under current and future climate conditions in Norway. From a monitoring viewpoint, the most pressing need is to build up a much larger database of DNA barcodes than currently exists. However, this must be coupled with expert identification of specimens being sequenced, to avoid the difficulties that arose from the first barcoding study (Germain et al. 2013) where several pest species were misidentified (Mouttet et al. 2017). To build a DNA barcode database, we need targeted collecting and expert identification of *Epitrix* species from solanaceous crops being grown at higher altitudes in the Andes. To fill in gaps in our knowledge of host usage we need well-designed field experiments carried out at higher latitudes. Such research would reveal which species damage potato plant foliage or tubers, and which species can complete their life cycle in crop fields versus which species need weedy solanaceous hosts to thrive.

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Appendix I

Ratings and descriptors are based on Appendix 2 in VKMs Risk Assessment of cockspur grass (*Echinochloa crus-galli*).

Table A1-1; Rating of probability of entry.

Rating	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: • is not, or is only very rarely, associated with the pathway at the origin • no import volume, • may not survive during transport or storage • cannot survive the current pest management procedures existing in the risk assessment area • may not transfer to a suitable habitat in the risk assessment area
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin, • or very low import volume, • survives at a very low rate during transport or storage, • is strongly limited by the current pest management procedures existing in the risk assessment area, • has considerable limitations for transfer to a suitable habitat/crop in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin, • moderate import volume, • survives at a low rate during transport or storage, • is affected by the current pest management procedures existing in the risk assessment area, • has some limitations for transfer to a suitable habitat/crop in the risk assessment area.
Likely	The likelihood of entry would be high because the pest:

	• is regularly associated with the pathway at the origin, • high import volume, • mostly survives during transport or storage; • is partially affected by the current pest management procedures existing in the risk assessment area, • has very few limitations for transfer to a suitable habitat/crop in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin, • very high import volume, • survives during transport or storage; • is not affected by the current pest management procedures existing in the risk assessment area, • has no limitations for transfer to a suitable habitat/crop in the risk assessment area.

0 Table A1-2: Rating of the probability of establishment

Rating	Descriptors
Very unlikely	The likelihood of establishment would be very low because: • of the absence or very limited availability of suitable habitat/crop; • the unsuitable environmental conditions; • and the occurrence of other considerable obstacles preventing establishment.
Unlikely	The likelihood of establishment would be low because: • of the limited availability of suitable habitat/crop; • the unsuitable environmental conditions over the majority of the risk assessment area; • the occurrence of other obstacles preventing establishment
Moderately likely	The likelihood of establishment would be moderate because: • suitable habitats/crops are abundant in a few areas of the risk assessment area;

	• environmental conditions are suitable in a few areas of the risk assessment area; • no obstacles to establishment occur
Likely	The likelihood of establishment would be high because: • suitable habitats/crops are widely distributed in some areas of the risk assessment area; • environmental conditions are suitable in some areas of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in some areas of the risk assessment area
Very likely	The likelihood of establishment would be very high because: • hosts plants are widely distributed; • environmental conditions are suitable over the majority of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in the risk assessment area

Table A1-3: Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	No or little information is missing or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	Some information is missing or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.

Appendix II

Pest categorization – *Epitrix brevis*

Identity of pest

Scientific name: *Epitrix brevis* Schwarz, 1878

Synonyms: None

Common names: None

Hosts

Primary: potato (*Solanum tuberosum*)

Secondary domesticated hosts: peppers (*Capsium* spp.), tomato (*Lycopersicon esculentum*), beets (*Beta* spp.). *Epitrix brevis* is said to be associated with different Solanaceae species, but it is unknown if the larvae are able to complete their development on these hosts or if only the adults are feeding on them.

Epitrix brevis is also said to attack the following plants; jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple'), common groundcherry (*Physalis longifolia*) (Norwegian: 'ananaskirsebær'), American black nightshade (*Solanum americanum*) (Norwegian: 'adventivsøtvier'), eastern redbud (*Cercis canadensis*) (Norwegian: 'amerikajudastre'), Ethiopian eggplant *Solanum aethiopicum*), and Carolina horsenettle (*Solanum carolinense*).

Presence or absence in PRA area

Epitrix brevis is not present in Norway

Regulatory status

The species is not regulated in any countries

Potential for establishment and spread in PRA area

Climate

The natural distribution area of *Epitrix brevis* includes parts of Canada and USA, areas with a climate that is similar to the PRA area (Figure 1). *Epitrix brevis* hibernates as adult in the soil (Deczynski 2016). This could protect it against subzero temperatures, especially under snow cover.

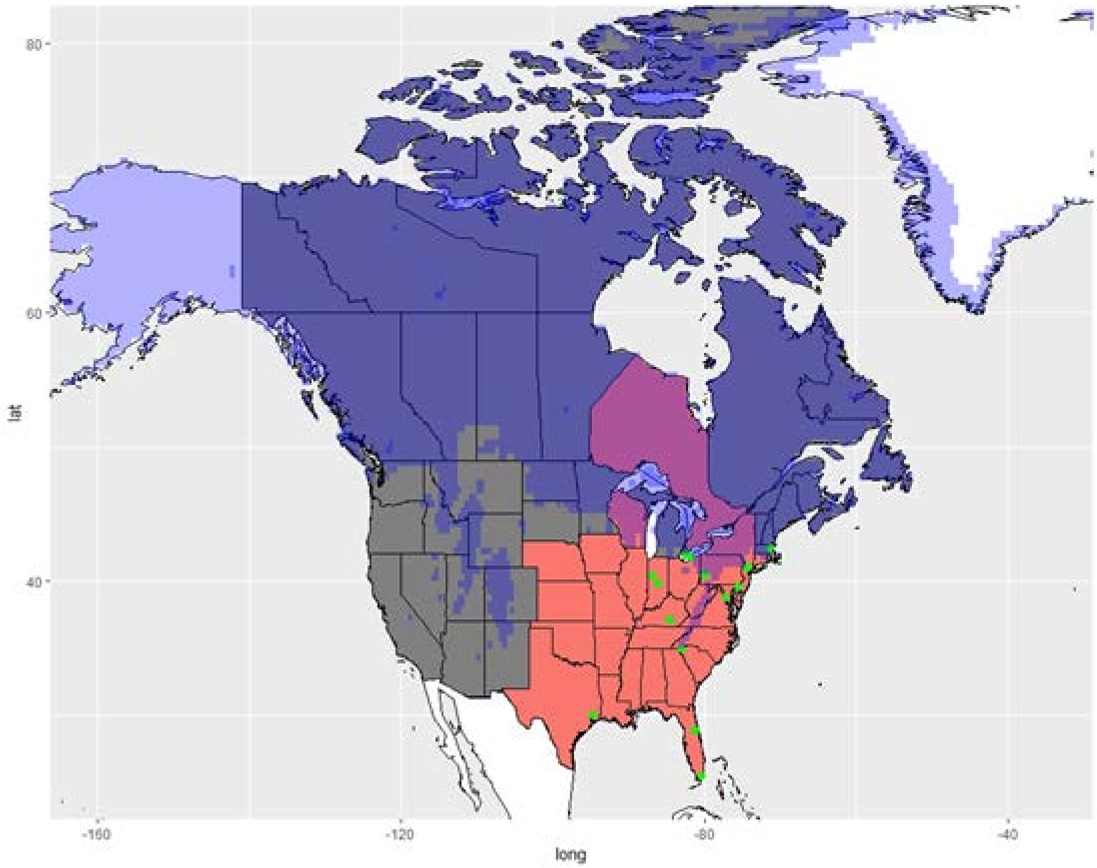

Figure 1. World map showing the known distribution of *Epitrix brevis*. Red and purple areas in the US and Canada are areas where *E. brevis* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

Distribution

In Canada, *E. brevis* is present in the province of Ontario (Bienkowski & Bienkowskaja 2017).

In the US, *E. brevis* is present in the states of Florida, Alabama, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia, Wisconsin, Delaware, and Pennsylvania (Bienkowski & Bienkowskaja 2017).

Pathway

The main pathway of concern would be import of potato. Norway has historically imported potatoes from Canada and the USA (Figure 2). However, the last import was in 2007.

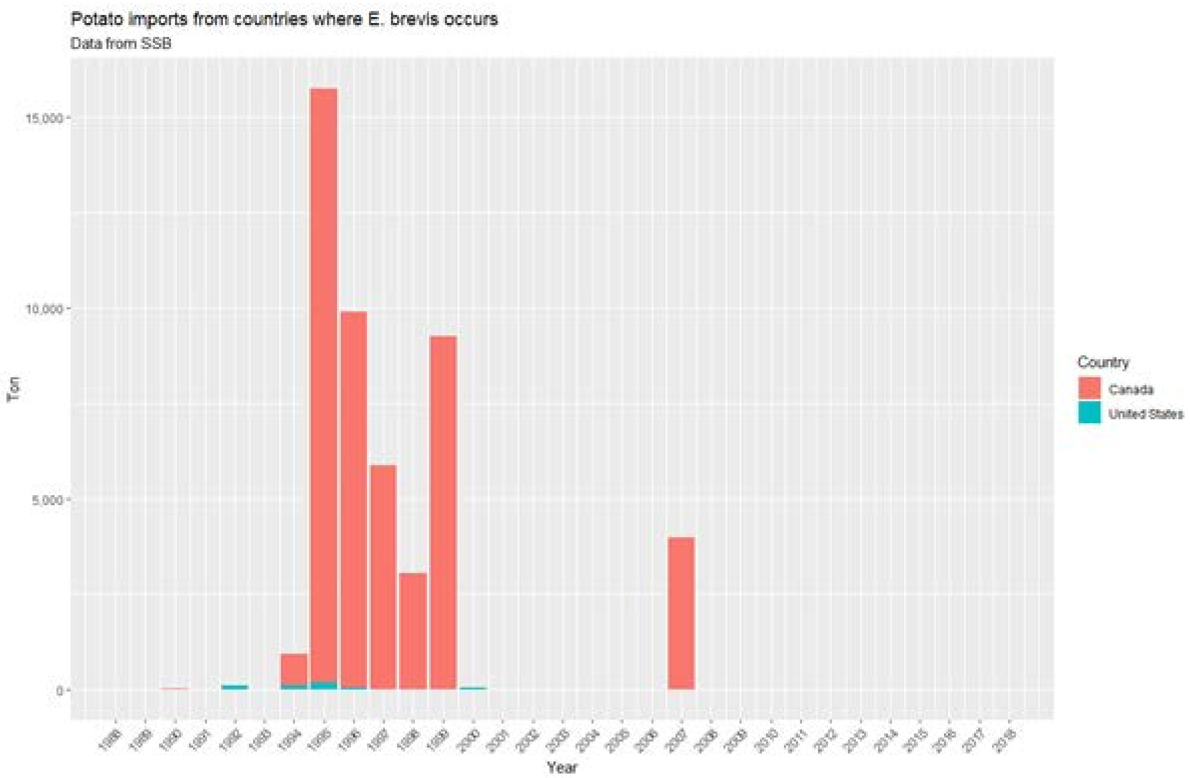

Figure 2. Potato imports (in metric tons) to Norway from Canada and USA, where *Epitrix brevis* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix brevis feeds on potato and cause yield losses. It could possibly also cause damage on peppers (*Capsium* spp.), tomato (*Lycopersicon esculentum*), and beets (*Beta* spp.)

Environmental impact in the PRA area:

Epitrix brevis could attack jimsonweed (*Datura stramonium*), American black nightshade (*Solanum americanum*), and Carolina horsenettle (*Solanum carolinense*)

Conclusion of pest categorization

Epitrix brevis does not appear to warrant categorization as a quarantine pest in Norway. It is not considered a serious pest in its native range and it is unlikely to enter Norway. *Epitrix brevis* is present in parts of Canada and USA that have a similar climate to Norway. It could thus thrive in Norway.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. (2017) World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540. DOI: 10.11646/zootaxa.4268.4.4.

Epitrix

Deczynski A.M. (2016) Morphological systematics of the nightshade flea beetles *Epitrix* Foudras and *Acallepitrix* Bechyné (Coleoptera: Chrysomelidae: Galerucinae: Alticini) in America north of Mexico, PhD thesis, Clemson University.

Pest categorization – *Epitrix cucumeris*

Identity of pest

Scientific name: *Epitrix cucumeris* (Harris, 1851)

Synonyms: None

Common names: Potato flea beetle

Hosts

Primary: Potato (*Solanum tuberosum*)

Secondary domesticated host plants: Eggplant (*Solanum melongena*), tomato (*Solanum lycopersicum*), and peppers (*Capsicum annuum*).

Secondary wild host plants: Black nightshade (*Solanum nigrum*) (Norwegian: 'svartsøtvier'), bittersweet nightshade (*Solanum d ulcamara*) (Norwegian: 'slyngsøtvier'), green nightshade (*Solanum physalifolium*) (Norwegian: 'begersøtvier'), and jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple')

Presence or absence in PRA area

Epitrix cucumeris is not present in Norway

Regulatory status

EPPO A2 list

Potential for establishment and spread in PRA area

Climate

Epitrix cucumeris' distribution in North America indicates that it could find suitable climatic conditions in Norway. As all other North American *Epitrix* species *E. cucumeris* hibernates as adult in the top soil. This could protect it against subzero temperatures, especially under snow cover.

Distribution

Epitrix cucumeris is widespread in Central and North America, including parts of Canada with similar climatic conditions as Norway (Figure 1). It recently appeared in Portugal (2004) and Spain (2017), but has rather limited distributions in the Iberian Peninsula (Boavida et al. 2013) and is under eradication.

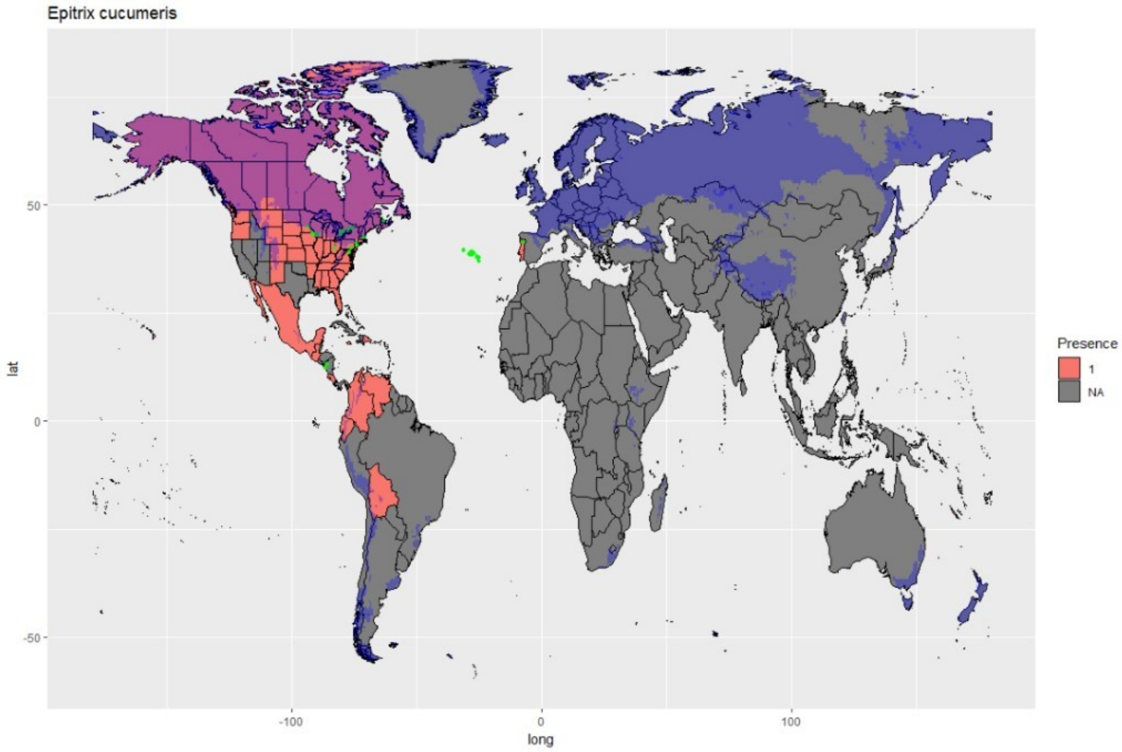

Figure 2. World map showing the known distribution of *Epitrix cucumeris*. Red and purple areas are areas where *E. cucumeris* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

Pathway

The most likely pathway is via imported unwashed seed potatoes and soil. Washing is commonly assumed to eliminate larvae from potato tubers (EPPO 2005), but new findings suggest that this may not always be the case (EPPO 2016). *Epitrix* beetles have been intercepted in ware potatoes from Spain to Belgium and the UK. Norway imports washed food potato from several countries where *E. cucumeris* occurs, but the last import was in 2007 (Figure 2).

In addition, import of rooted host plants belonging to other species (e.g. tomato) than potato could vector the beetle.

Natural dispersal between populations is by flying. The available literature is contradicting and inconclusive regarding the flight capacity of *Epitrix* species (see e.g. Fulton and Banham 1962 versus Elliott 2009). However, the distance to Norway from the closest population (Iberian Peninsula) is still too distant to allow immigration into Norway (at least in the short run).

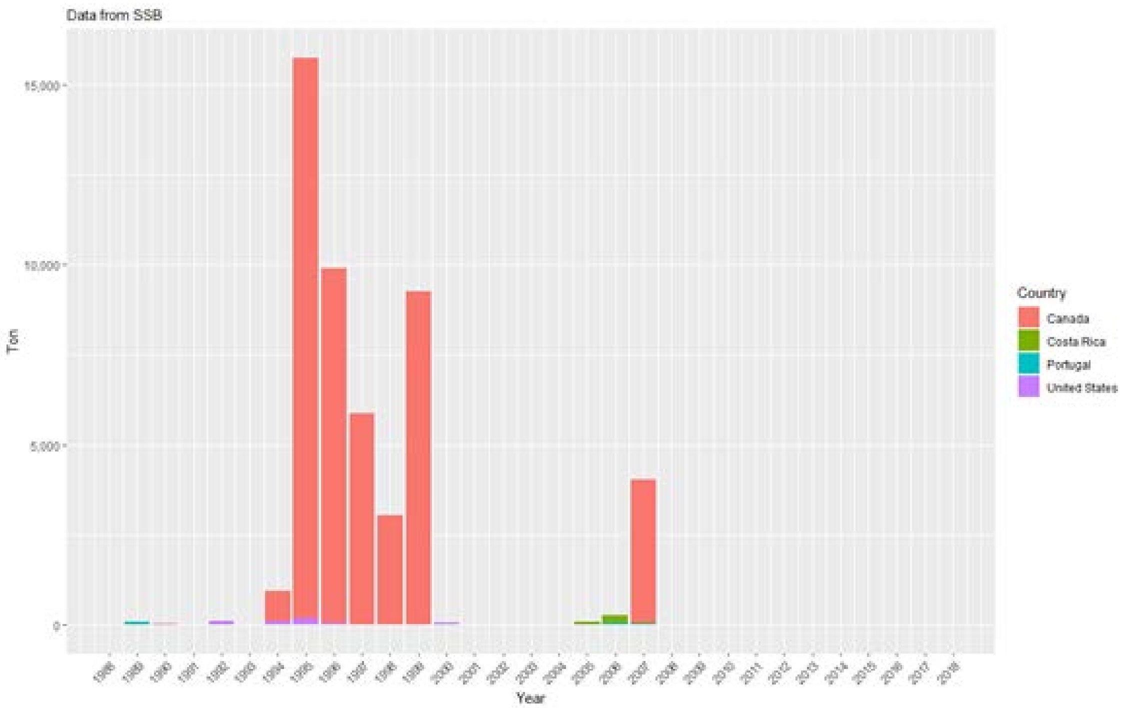

Figure 2. Potato imports (in metric tons) to Norway from countries where *Epitrix cucumeris* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

The economic impact of *E. cucumeris* in Norway is potentially high, but probably not as high as some other *Epitrix* species which cause more severe damage to potato tubers. Adults damage above-ground plant parts and in extreme cases this may reduce the plants' ability to photosynthesize and grow. Overall, however, above-ground damage is normally of minor importance for potato. The larvae feed on below-ground parts of their host plants, including direct damage to potato tubers. However, most tuber damage is reported to be superficial and of cosmetic importance only, with some deeper holes (Boavida et al. 2013).

Epitrix cucumeris can have up to three generations per summer and individual females lay up to 200 eggs (EPPO 2016). This shows that the pest is able to quickly build up large populations.

Epitrix cucumeris can also feed and reproduce on other domesticated plants in Norway, such as tomato and peppers. Potato and black nightshade are optimal host plants, allowing the beetles to reproduce quickly (Boavida et al. 2013).

Environmental impact in the PRA area:

Epitrix cucumeris can reproduce on several wild plant species that occur in Norway, but damage on wild plants has never been considered an environmental problem in other countries where *E. cucumeris* occurs.

Conclusion of pest categorization

Epitrix cucumeris probably warrants categorization as a quarantine pest in Norway. The species is included in the EPPO A2 list of pests recommended for regulation as quarantine pests.

References

Boavida, Giltrap, Cuthbertson, Northing. 2013. *Epitrix similaris* and *Epitrix cucumeris* in Portugal: damage patterns in potato and suitability of potential host plants for reproduction. *EPPO Bulletin* 43: 323-333.

Elliott. 2009. Flea beetle management. In: Guide to Commercial Potato Production on the Canadian Prairies. Western Potato Council, Portage la Prairie. https://www.gov.mb.ca/agriculture/crops/production/pubs/guide-to-commercial-potato-production.pdf

EPPO. 2005. Data sheets on quarantine pests. *Epitrix cucumeris*. EPPO Bulletin 35: 363-364.

EPPO. 2016. National regulatory control system for *Epitrix* species damaging potato tubers. EPPO Bulletin 46: 556-566.

Fulton and Banham. 1962. The tuber flea beetle in British Columbia. Canada Department of Agriculture. Publication No. 938. http://publications.gc.ca/pub?id=9.800647&sl=0

Pest categorization – *Epitrix fasciata*

Identity of pest

Scientific name: *Epitrix fasciata* Blatchley, 1918

Synonym: *Epitrix parvula*

Common name: Tobacco flea beetle, the banded Epitrix

Hosts

Primary: Potato (*Solanum tuberosum*) and tobacco (*Nicotiana* spp.). The literature does not specify which *Nicotiana* species that are attacked, but it possibly refers to cultivated tobacco, *Nicotiana tabacum.*

Secondary wild host plants: plants in the family Solanaceae (Glass 1940), jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple'), which is an alien species in Norway originating in North America.

Presence or absence in PRA area

Epitrix fasciata is not present in Norway

Regulatory status

The species is not regulated

Potential for establishment and spread in PRA area

Climate

Most of the *E. fasciata* distribution area is in tropical and subtropical areas. However, *E. fasciata* is said to be present in the province of Ontario, Canada. Parts of Ontario may have a climate that is similar to parts of the PRA-area (Figure 1).

Distribution

North America

In USA, *E. fasciata* is present in the states of Florida, Georgia, Louisiana, Maryland, Mississippi, South Carolina, Texas, West Virginia, Kansas, Delaware, and Virginia (Bienkowski & Bienkowskaja 2017; Figure 1). Additionally, *E. fasciata* is regarded as introduced to Hawaii (Bienkowski & Bienkowskaja 2017 and references therein).
In Canada, *E. fasciata* is present in the province of Ontario (Bienkowski & Bienkowskaja 2017).

South America

Epitrix fasciata is present in Mexico, Venezuela, Columbia, Brazil, Argentina, Cuba, Bahamas, Grenada, Puerto Rico, St. Vincent, Nicaragua, Peru, and Cayman Islands (Bienkowski & Bienkowskaja 2017; Figure 1). Additionally, it is regarded as introduced to Bermuda (Bienkowski & Bienkowskaja 2017 and references therein).

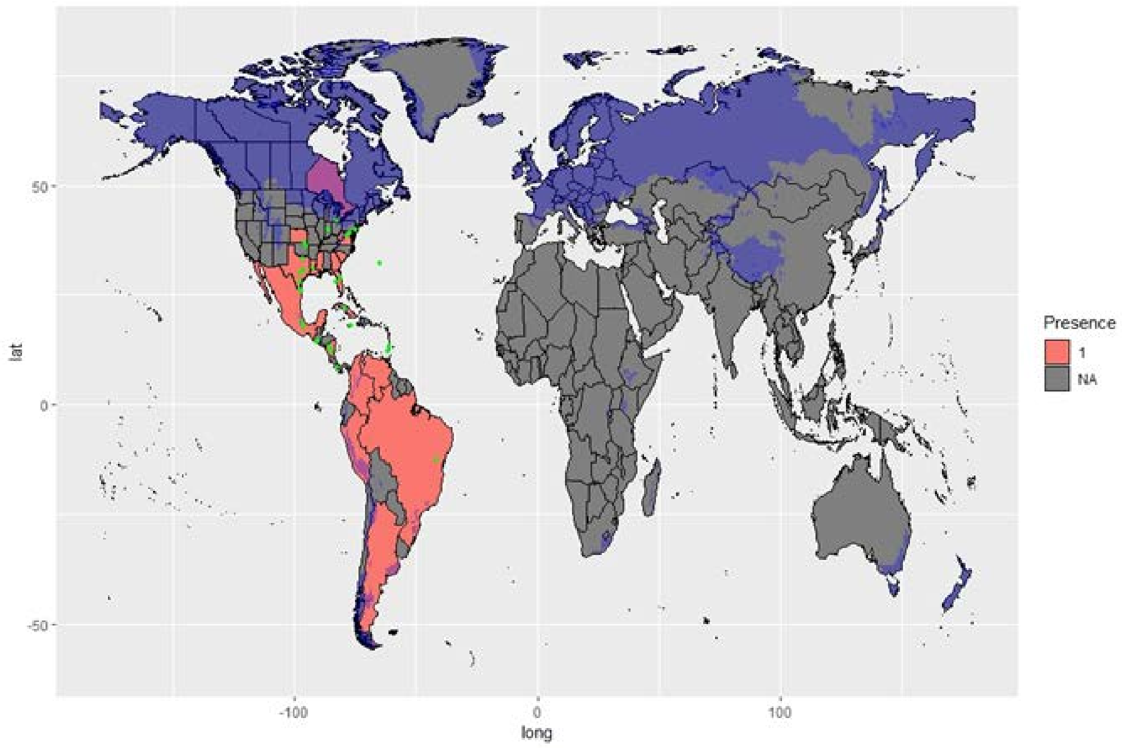

Figure 1. World map showing the known distribution of *Epitrix fasciata*. Red and purple areas are areas where *E. fasciata* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org

Pathway

The main pathway for *E. fasciata* would be import of potato. Norway has historically imported potatoes from several countries where *E. fasciata* occurs naturally, and the largest exporter has been Canada (Figure 2). However, the last import was in 2007.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Unknown

Environmental impact in the PRA area:

Unknown

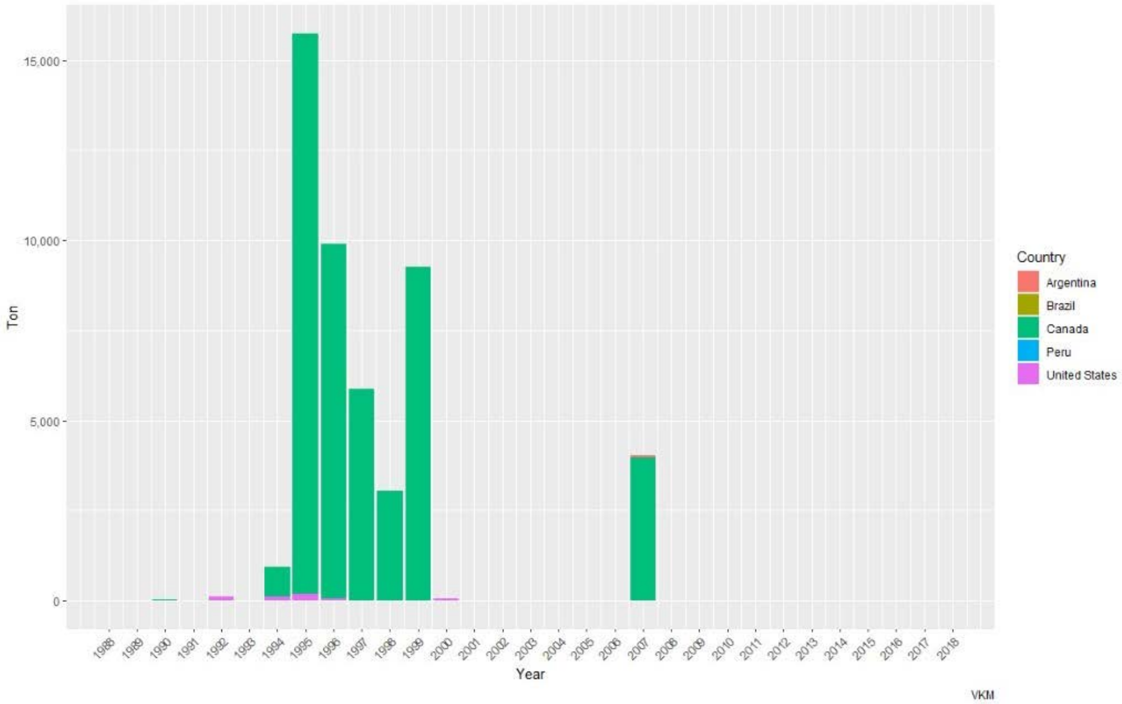

Figure 2. Potato imports (in metric tons) to Norway from countries in North and South America where *Epitrix brevis* occurs, the last 30 years.

Conclusion of pest categorization

Epitrix fasciata does not appear to warrant categorization as a quarantine pest in Norway since it is unlikely to enter the country. The climate in Norway might also not be suitable for *E. fasciata* , which has a predominantly tropical and subtropical distribution.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Glass E.H. 1940. Host plants of the tobacco flea beetle. Journal of Economic Entomology 33:467-470.

Pest categorization – *Epitrix fuscula*

Identity of pest

Scientific name: *Epitrix fuscula* Crotch, 1873

Synonyms: None

Common names: Eggplant flea beetle

Hosts

Primary: Potato (*Solanum tuberosum*) and eggplant (*Solanum melongena*)

Secondary wild host plants: weeds such as nettles (Urticaceae), belladonna or deadly nightshade (*Atropa belladonna*) (Norwegian: 'Belladonnaurt'), and jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple') (Mason & Kuhar 2018).

Presence or absence in PRA area

Epitrix fuscula is not present in Norway

Regulatory status

The pest is not regulated

Potential for establishment and spread in PRA area

Climate

Epitrix fuscula is reportedly present in Ontario, Canada where the climate is similar to Norway (Figure 1).

Distribution

Epitrix fuscula is found in Brazil, Venezuela, Mexico and USA (Figure 1). In the US it is said to be widely distributed across the country, except for the northern states (Mason & Kuhar 2018). However, according to Bienkowski & Orlova-Bienkowskaja (2017) the species is also found in Ontario, Canada.

Pathway

The main pathway for *E. fuscula* would be import of potato. Norway has historically imported potato from countries where occurs naturally, but only sporadically since 2003 (Figure 2). Since *E. fuscula* feeds on eggplant leaves and not the fruit itself import of eggplant is not an import pathway.

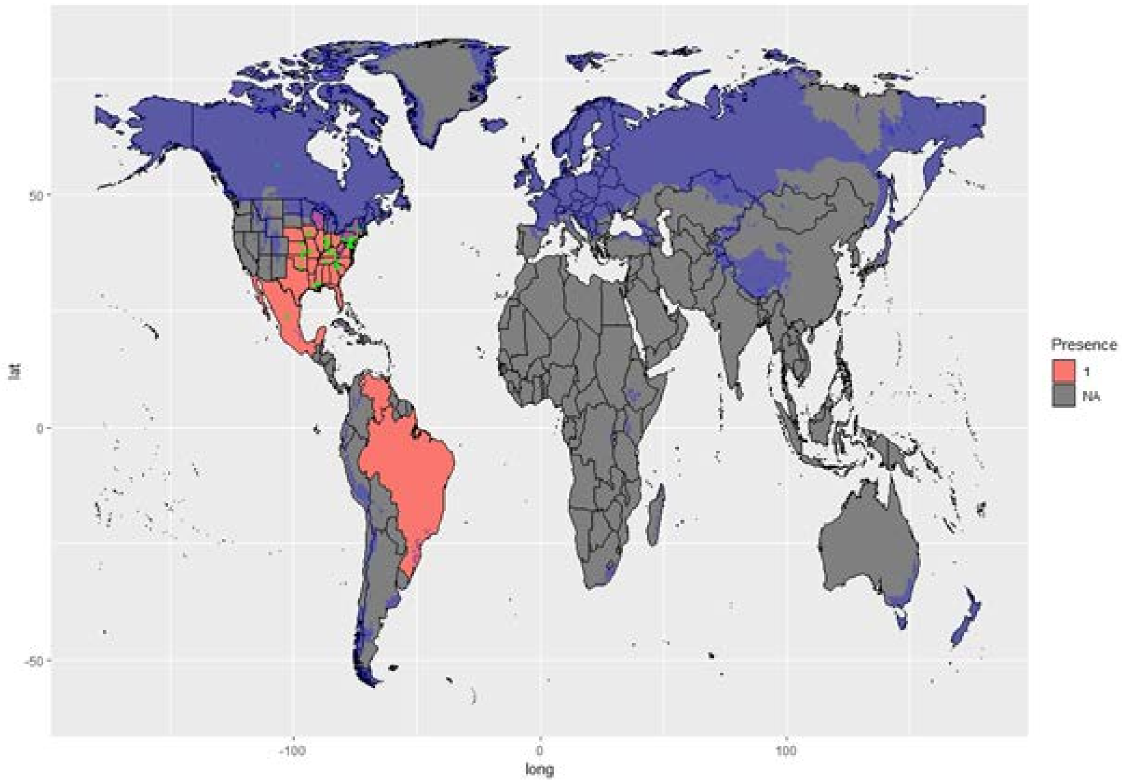

Figure 1. World map showing the known distribution of *Epitrix fuscula*. Red and purple areas are areas where *E. fuscula* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

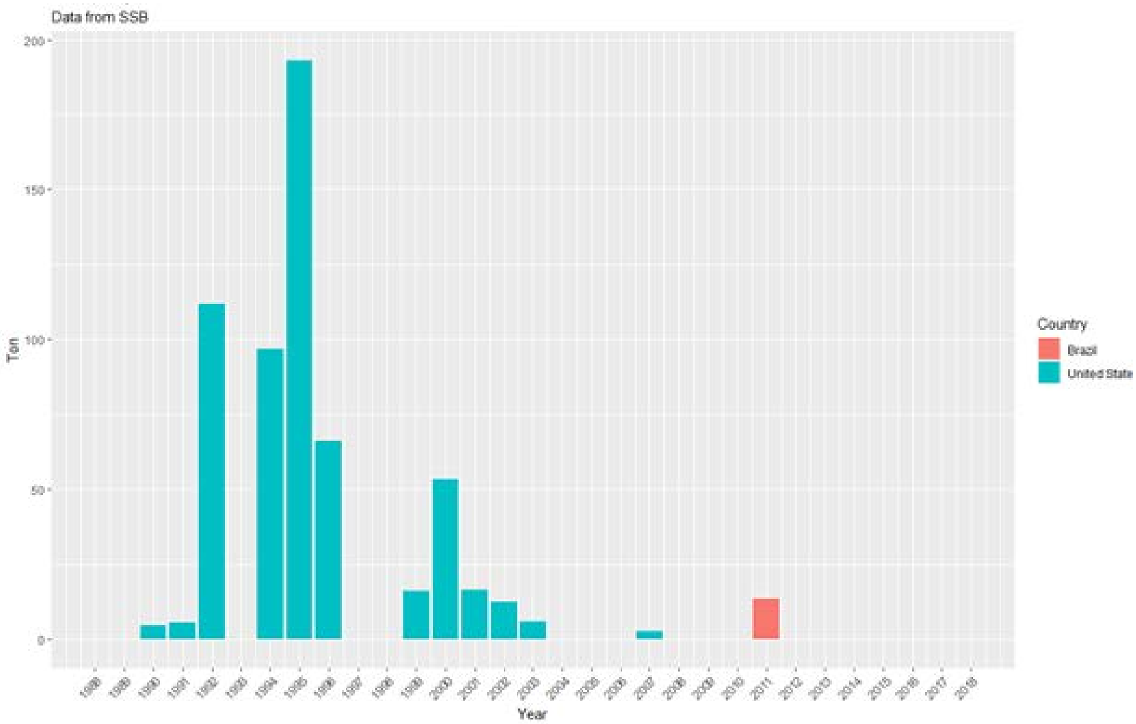

Figure 2. Potato imports (in metric tons) to Norway from Brazil and the US, where *Epitrix fuscula* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix fuscula may injure eggplant leaves and reduce their photosynthetic capability, leading in turn to reduced plant size, weight, and overall yield (Mason & Kuhar 2018). It also feeds on potato, but the economic impact is unknown.

Environmental impact in the PRA area:

Epitrix fuscula can reproduce on some wild plant species that also occur in Norway, but damage on wild plants has never been considered an environmental problem in the species' native range in America.

Conclusion of pest categorization

Epitrix fuscula does not appear to warrant categorization as a quarantine pest in Norway. The climate in Norway may not be suitable for *E. fuscula*, it is unlikely to enter the country, and it is not considered a serious pest on potato in its native range.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Mason J.A.C., Kuhar T.P. 2018. Flea beetles attacking eggplant in Virginia. Department of Entomology, Virginia Tech.

Pest categorization – *Epitrix harilana*

Identity of pest

Scientific name: *Epitrix harilana harilana* Bechyné, 1997 and *Epitrix harilana rubia* Bechyné, 1997

Synonyms: None

Common names: None

Hosts

Epitrix harilana is said to be associated with potato (*Solanum tuberosum*)

Presence or absence in PRA area

Epitrix harilana is not present in Norway

Regulatory status

The species is not regulated

Potential for establishment and spread in PRA area

Climate

Epitrix harilana is only known from Peru. Peru shares several climate types with Norway (Bsk, Csb, Cfb, Cfc and ET) (Figure 1).

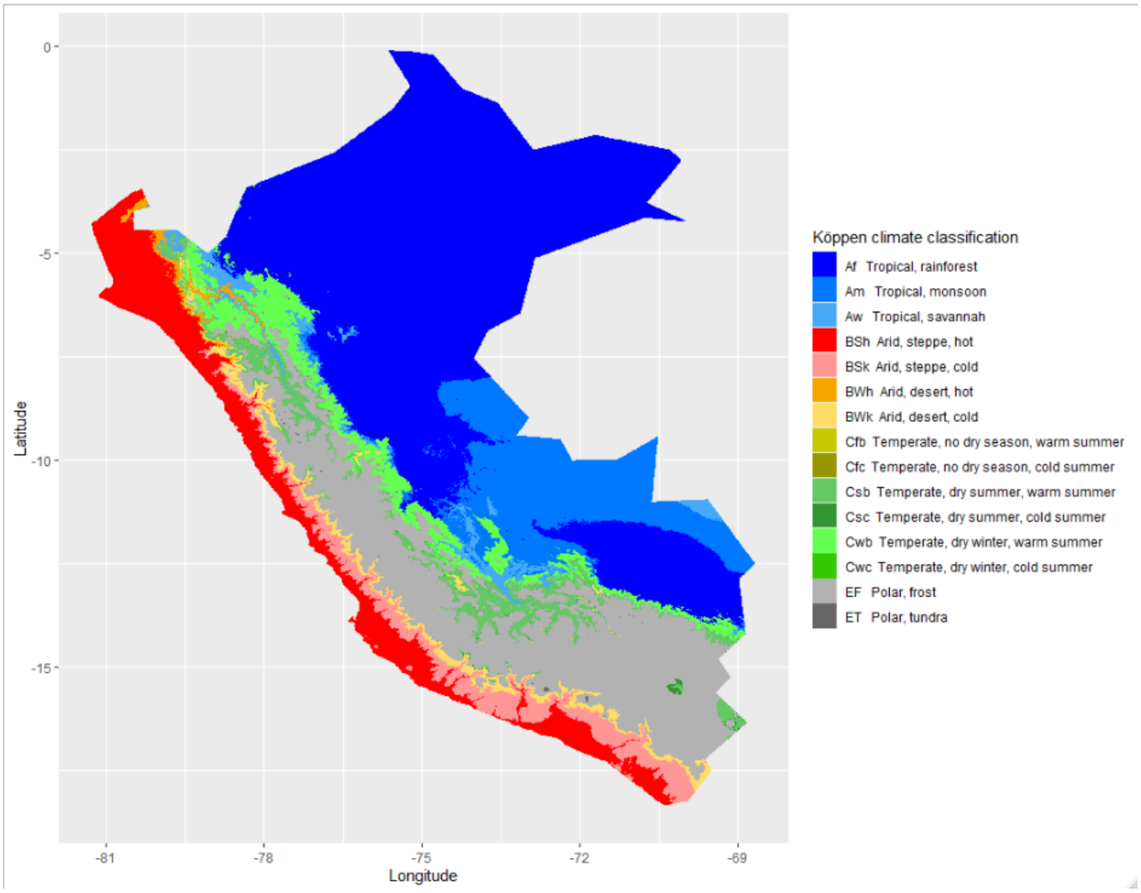

Figure 1. Map of Peru with detailed Köppen-Geiger climate classification. The climate zones Bsk, Csb, Cfb, Cfc and ET are shared between Peru and Norway.

Distribution

Epitrix harilana is known only from Peru (Kroschel Canedo 2015)

Pathway

The main pathway of concern would be import of potato. Norway has historically imported potatoes from Peru (Figure 2). However, the last import was in 2012.

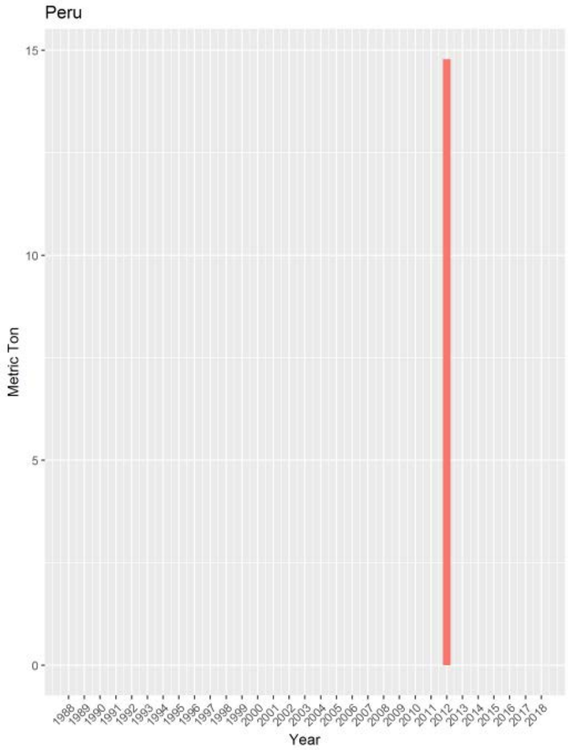

Figure 2. Potato imports (in metric tons) to Norway from Peru, where *Epitrix harilana* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix harilana feeds on potato and causes yield losses

Environmental impact in the PRA area:

Unknown

Conclusion of pest categorization

Epitrix fuscula does not appear to warrant categorization as a quarantine pest in Norway. It appears to have a limited distribution in Peru and there is little import of potato from Peru to Norway. However, there is very little documentation on the species' biology and for non-experts it would not be possible to separate *E. harilana* from other *Epitrix* species.

References

Kroschel J., Cañedo V. (2009) How do insecticides affect potato yield and ecosystem resilience to manage potato pests? An ecological assessment from the central highlands of Peru, CD Papers of 15th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC), International potato center, Peru.

Pest categorization – *Epitrix hirtipennis*

Identity of pest

Scientific names: *Epitrix hirtipennis* (Melsheimer, 1847)

Synonyms: None

Common names: Tobacco flea beetle

Hosts

Primary: Potato (*Solanum tuberosum*) and tobacco (*Nicotiana* spp.)

Secondary wild host plants: weeds such as nettles (family Urticaceae), nightshade, and jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple')

Presence or absence in PRA area

Epitrix hirtipennis is not present in Norway

Regulatory status

The species is not regulated

Potential for establishment and spread in PRA area

Climate

Epitrix hirtipennis is registered as far north as Ontario and Quebec, Canada where the climate is similar to Oslo, Norway (Figure 1). *Epitrix hirtipennis'* distribution in North America thus indicates that it could find suitable climatic conditions in Norway. As all other North American *Epitrix* species *E. hirtipennis* hibernates as adult in the top soil. This could protect it against subzero temperatures, especially under snow cover.

Distribution

Epitrix hirtipennis is native to mainland US and Canada (Figure 2). According to Mason & Kuhar (2018) *E. hirtipennis* is common in the southeast US and ranges as far north as Maryland, Michigan, Washington, New York and New Hampshire. According to Bienkowski & Orlova-Bienkowskaja (2017) *E. hirtipennis* is also found as far north as Ontario and Quebec in Canada (Figure 2).
Epitrix hirtipennis has also spread to several Mediterranean countries, Russia and Japan (Figure 2).

Pathway

The main pathway for *E. hirtipennis* to Norway would be import of unwashed potato. Norway has a large and consistent import of potato from countries where *E. hirtipennis* occurs (Figure 3).

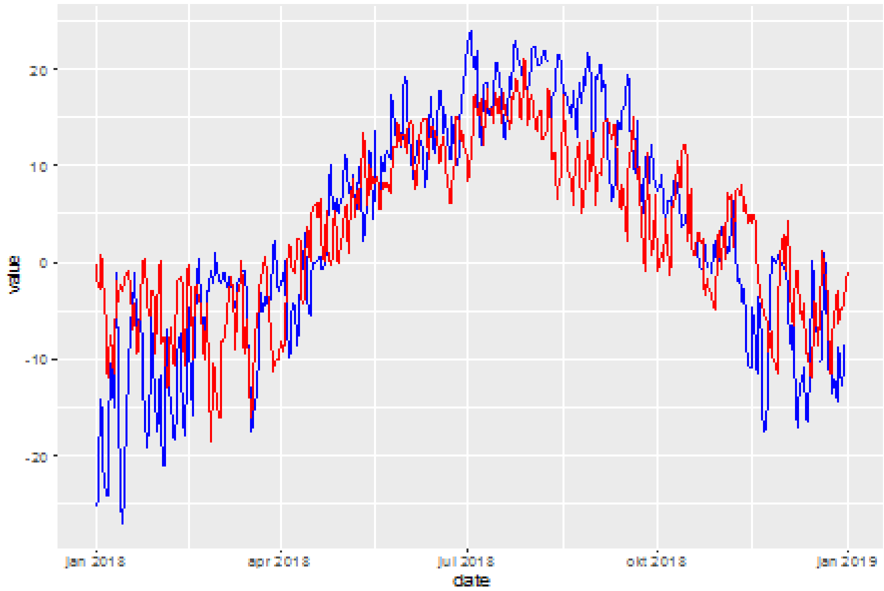

Figure 1. Daily minimum temperatures in Montreal (Quebec, Canada; blue line) and Oslo (Norway; red line) in 2018.

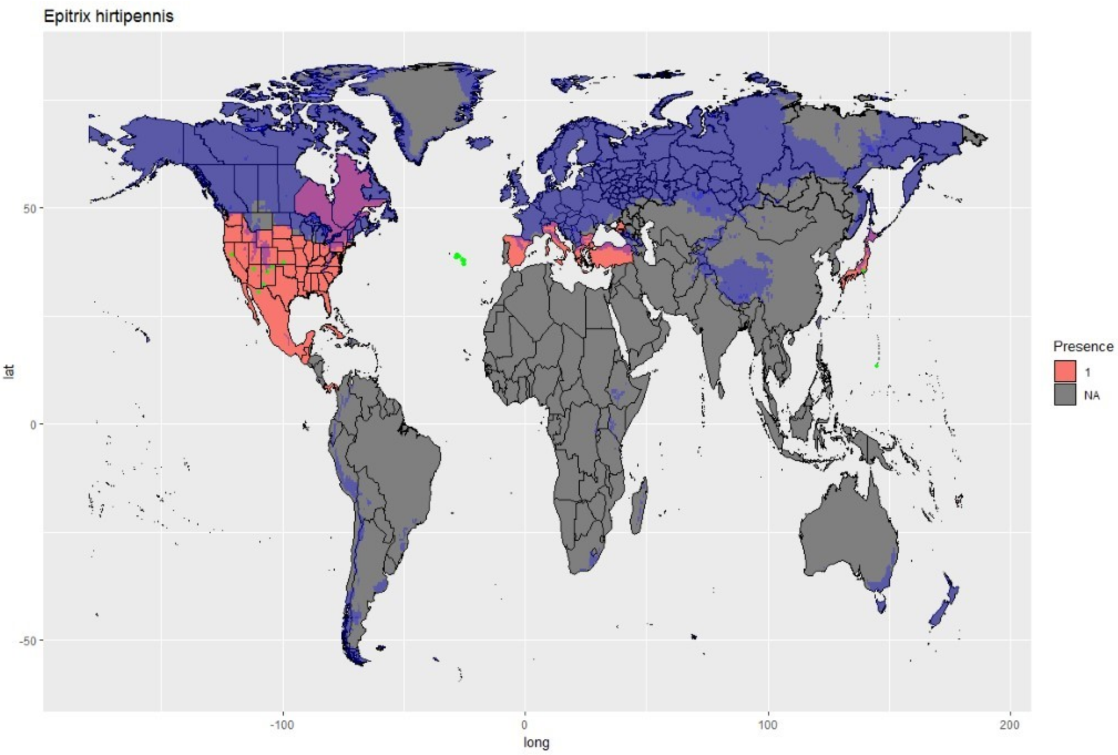

Figure 2. World map showing the known distribution of *Epitrix hirtipennis*. Red and purple areas are areas where *E. hirtipennis* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

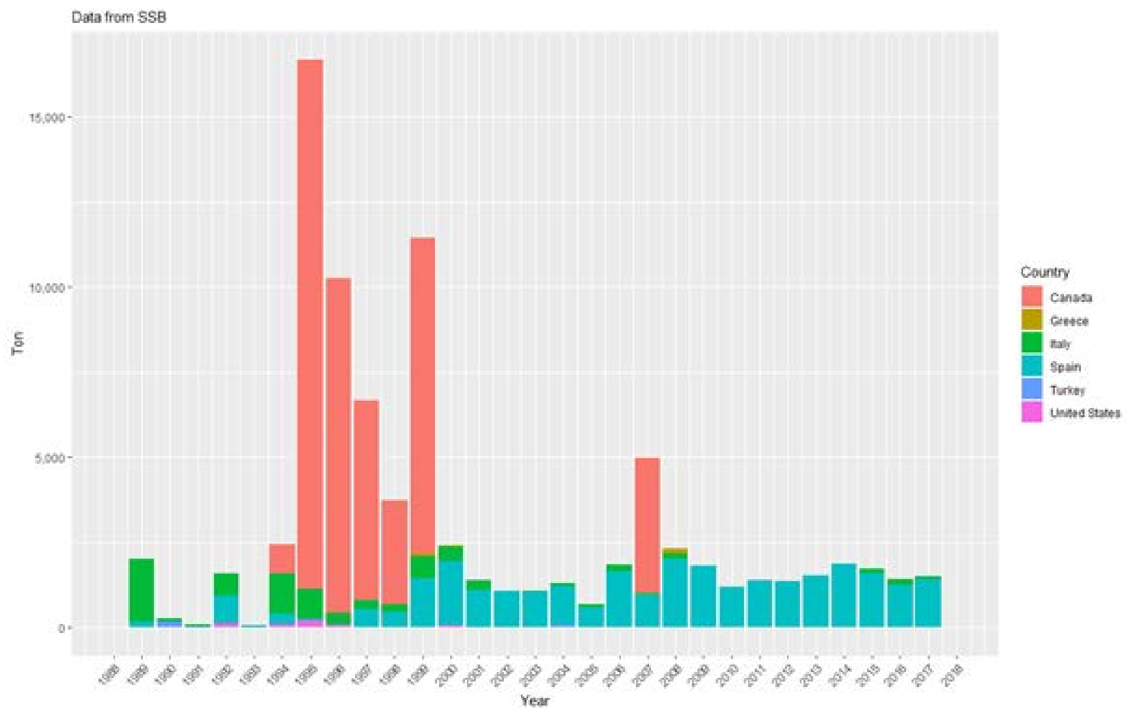

Figure 3. Potato imports (in metric tons) to Norway from countries where *Epitrix hirtipennis* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix hirtepennis feeds on potato and cause yield losses.

Environmental impact in the PRA area:

Epitrix hirtepennis feeds on many plants in the nightshade family and can also feed on common solanaceous weeds such as nettle, nightshade and jimsonweed (Mason & Kuhar 2018). However, damage on wild plants has never been considered an environmental problem in the species' native range in America.

Conclusion of pest categorization

Epitrix hirtipennis probably warrants categorization as a quarantine pest in Norway. It causes yield losses in potato and has the potential to enter the country with import of potato.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Mason J.A.C., Kuhar T.P. 2018. Flea beetles attacking eggplant in Virginia. Department of Entomology, Virginia Tech.

Pest categorization – *Epitrix papa*

Identity of pest

Scientific name: *Epitrix papa* (Orlova-Bienkowskaja, 2015)

Synonym: None (but previously mis-identified as *Epitrix similaris* in Europe)

Common names: None

Hosts

Primary domesticated host plant: *Solanum tuberosum* (potato)

Secondary domesticated host plants: Eggplant (*Solanum melongena*) and tomato (*Solanum lycopersicum*)

Secondary wild host plants: jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple') and black nightshade (*Solanum nigrum*) (Norwegian: 'svartsøtvier'). Black nightshade is more attractive than potato to *E. papa* (Cuthbertson et al. 2016).

Presence or absence in PRA area

Epitrix papa is not present in Norway

Regulatory status

The species is on the EPPO A2 list

Potential for establishment and spread in PRA area

Climate

It is unknown if *E. papa* is native to the Iberian Peninsula, or if it originated from another climate zone. Hence, it is not known if the current distribution of *E. papa* in Europe reflects its climate niche or if it could tolerate colder temperatures. As all *Epitrix* species it hibernates as adult in the top soil - a behavior that could protect it against subzero temperatures, especially under snow cover.

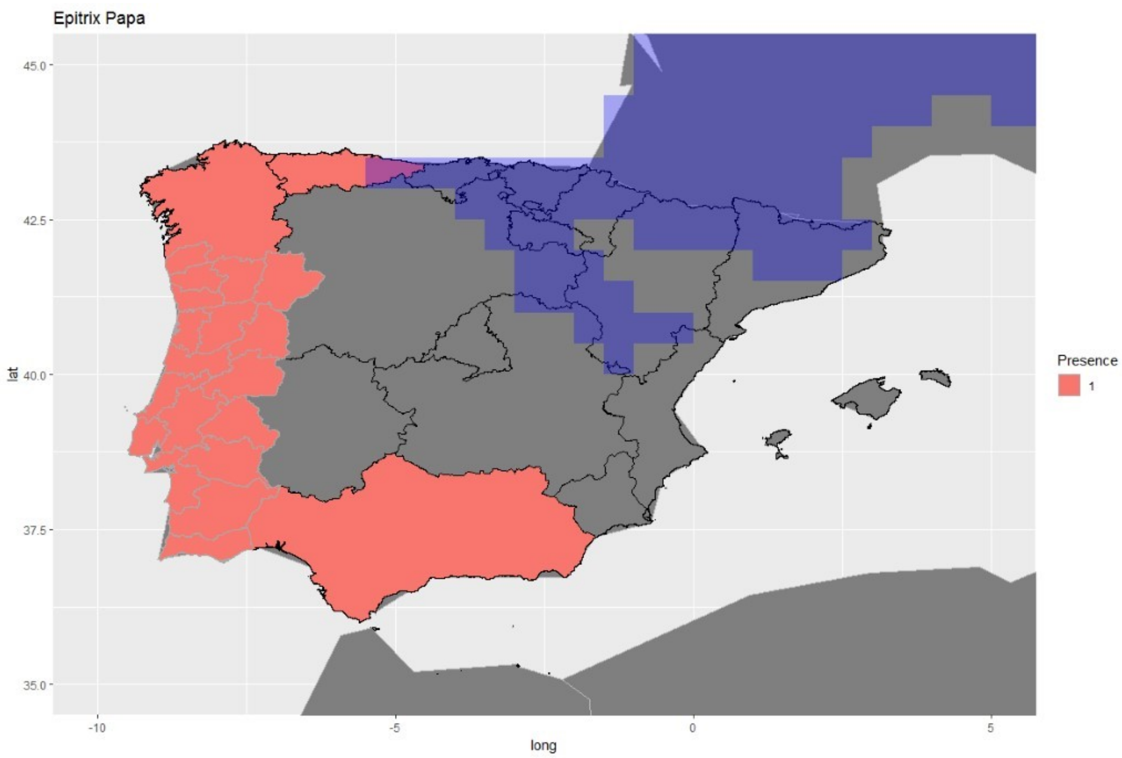

Figure 1. The distribution of *Epitrix papa* in Portugal and Spain. Red and purple areas are areas where *E. papa* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway.

Distribution

Epitrix papa was discovered in Portugal in 2008, and in northern Spain in 2009 (Boavida and Germain 2009; Eyre and Giltrap 2013). At first it was misidentified as *E. similaris* (Orlova-Bienkowskaja 2015; Mouttet et al. 2016). In 2017 it was discovered in several potato fields across Spain (Figure 1). A program has been initiated to eradicate *E. papa* from the Iberian Peninsula.

Although *E. papa* is not known from other areas, it might be native to the Americas. If so, one would presume that it is a very rare species there.

Pathway

The most likely pathway is via imported unwashed seed potatoes and soil. Norway imports potato from the Iberian Peninsula where *E. papa* occurs (Figure 2). Washing is commonly assumed to eliminate larvae from potato tubers (EPPO 2005), but new findings suggest that this may not always be the case (EPPO 2016). *Epitrix papa* has been intercepted in ware potatoes from Spain to Belgium and the UK.

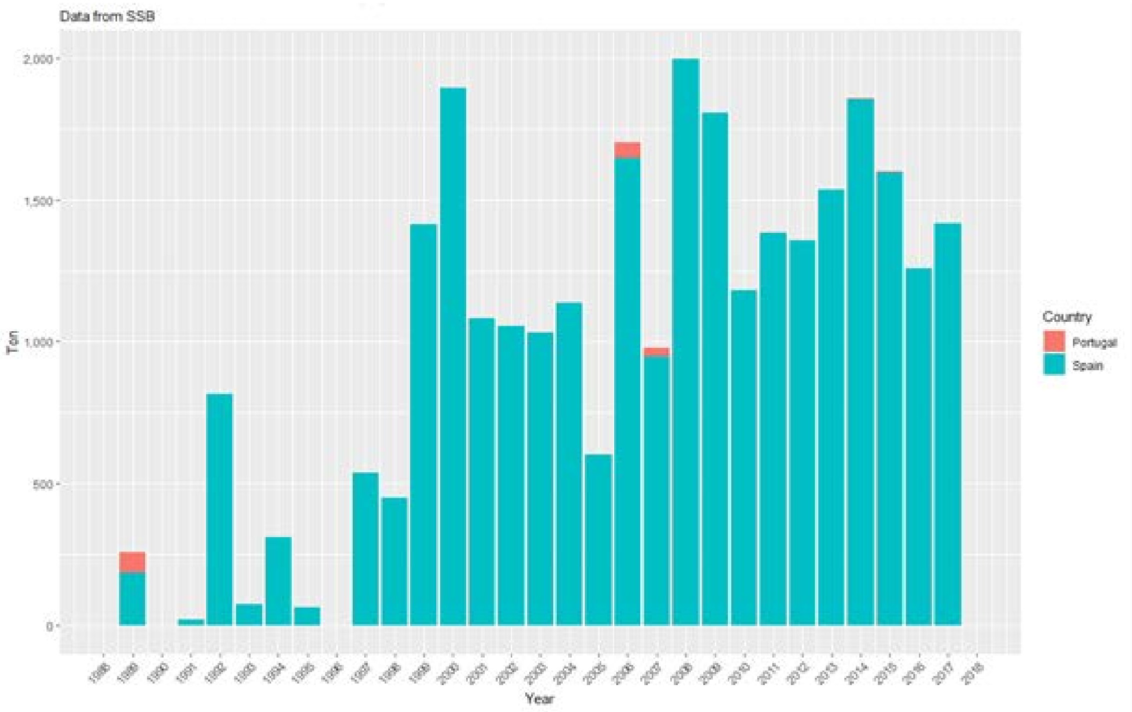

Figure 2. Potato imports (in metric tons) from Portugal and Spain, where *Epitrix papa* is known to occur, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

The economic consequences of *E. papa* in Norway are potentially high. Adults damage above-ground plant parts and in extreme cases this may reduce the plants' ability to photosynthesize and grow. Overall, however, above-ground damage is normally of minor importance for potato. The larvae feed on below-ground parts of their host plants, including severe direct damage to potato tubers (Boavida and Germain 2009). Damaged tubers are unmarketable.

Epitrix papa can have up to three generations per summer and individual females lay up to 200 eggs (EPPO 2016). This shows that the pest is able to quickly build up large populations.

Epitrix papa can also feed and reproduce on other domesticated plants in Norway, such as tomato. Potato and black nightshade are optimal host plants, allowing the beetles to reproduce quickly (Cuthbertson et al. 2016).

Environmental impact in the PRA area:

Epitrix papa can reproduce on a few wild plant species in Norway, but damage on wild plants has not been considered an environmental problem in the countries where *E. papa* occurs.

Conclusion of pest categorization

Epitrix papa probably warrants categorization as a quarantine pest in Norway. The species is included in the EPPO A2 list of pests recommended for regulation as quarantine pests.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Boavida and Germain. 2009. Identification and pest status of two exotic flea beetle species newly introduced in Portugal: *Epitrix similaris* Gentner and *Epitrix cucumeris* (Harris). EPPO Bulletin 39: 501–208.

Cuthbertson et al. 2016. *Epitrix* (flea beetle) species, life cycles and detection methods (*EPITRIX*). Euphresco Final Report.

EPPO. 2016. National regulatory control system for *Epitrix* species damaging potato tubers. EPPO Bulletin 46: 556-566.

Eyre and Giltrap. 2013. *Epitrix* flea beetles: new threats to potato production in Europe. Pest Management Science 69: 3–6.

Mouttet et al. 2016. Molecular evidence supports the recognition of *Epitrix papa* as a distinct species from *Epitrix similaris*. EPPO Bulletin 46: 583-587.

Orlova-Bienkowskaja. 2015. *Epitrix papa* sp. n. (Coleoptera: Chrysomelidae: Galerucinae: Alticini), previously misidentified as *Epitrix similaris*, is a threat to potato production in Europe. European Journal of Entomology 112: 824-830.

Pest categorization – *Epitrix setosella*

Identity of pest

Scientific name: *Epitrix setosella* (Fairmaire, 1888)

Synonym: *Epitrix wuorentausi* Kontkanen, 1950

Common name: None

Hosts

Primary: Potato (*Solanum tuberosum*)

Secondary: No available information

Presence or absence in PRA area

Epitrix setosella is not present in Norway

Regulatory status

The species is not regulated in any countries

Potential for establishment and spread in PRA area

Climate

No available information

Distribution

Russian Far East (Amur Region, Primorsky Krai); China (Fujian, Guangxi, Hebei, Jiangxi) (Döberl 2010) (Figure 1).

Pathway

The species' distribution in China and the Russian Far East suggest that it is unlikely to enter Norway, since Norway imports little potato from China and Russia (Figure 2).

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Unknown

Environmental impact in the PRA area:

Unknown

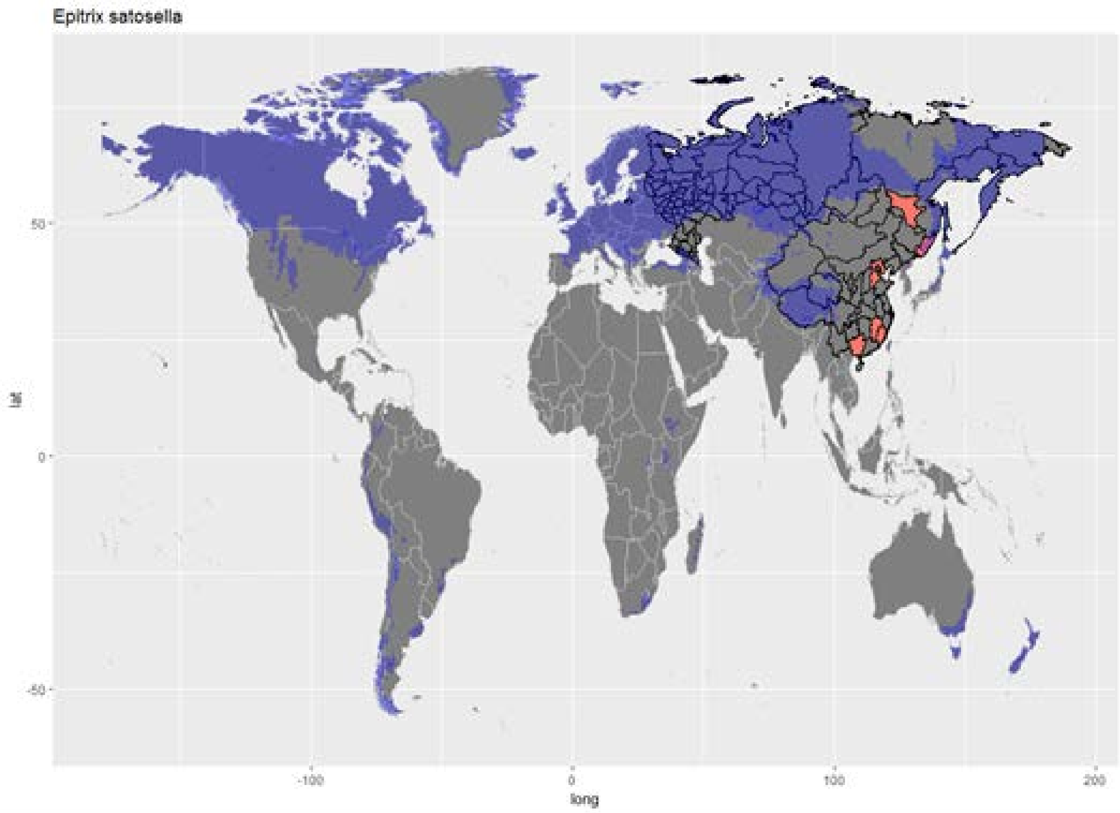

Figure 1. World map showing the known distribution of *Epitrix setosella*. Red areas in Russia and China are areas where *E. setosella* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue areas have the same Köppen-Geiger climate classification as Norway.

Conclusion of pest categorization

Epitrix setosella does not appear to warrant categorization as a quarantine pest in Norway since it is unlikely to enter the country. There is almost no published information about this species, except that it is listed in different taxonomic checklists etc.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. (2017) World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540. DOI: 10.11646/zootaxa.4268.4.4.

Döberl M. (2010) Subfamily Alticinae. In Löbl, I. & Smetana, A. (Eds.), Catalogue of Palaearctic Coleoptera: Chrysomeloidea. Vol. 6. Apollo Books, Stentrup, 491–563.

Epitrix

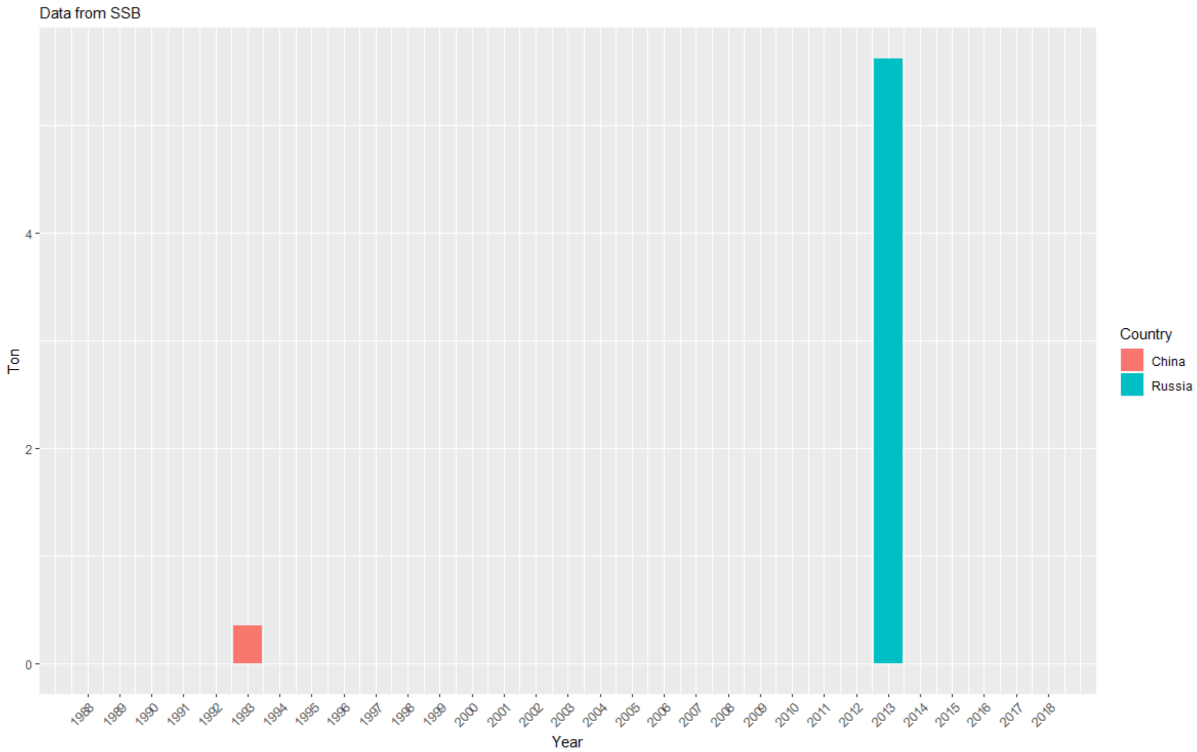

Figure 2. Potato imports (in metric tons) to Norway from China and Russia, where *Epitrix setosella* occurs, the last 30 years.

Pest categorization – *Epitrix tuberis*

Identity of pest

Scientific name: *Epitrix tuberis* Gentner, 1944

Synonym: None

Common name: Tuber flea beetle

Hosts

Primary host plant: potato (*Solanum tuberosum*).

Secondary domesticated host plants: tomato (*Solanum lycopersicum*), aubergine (*Solanum melongena*), peppers (*Capsicum* spp.).

Secondary wild host plants: black nightshade (*Solanum nigrum*) (Norwegian: 'svartsøtvier'), jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple'). It is not entirely clear from the literature if *E. tuberis* can complete its life cycle on the above-mentioned secondary host plants (EPPO 2010).

Presence or absence in PRA area

Epitrix tuberis is not present in Norway

Regulatory status

The species is listed on the EPPO A1 list of pests recommended for regulation as quarantine pests

Potential for establishment and spread in PRA area

Climate

The climate in the pest's native distribution area in Colorado and its more recently colonized range in southwestern Canada is similar to the climate in Norway (Figure 1). As all other North American *Epitrix* species *E. tuberis* hibernates as adult in the top soil. This could protect it against subzero temperatures, especially under snow cover.

Distribution

Epitrix tuberis is native to Colorado. It has spread to other areas in the western US (CABI 2018) and southwestern Canada that have a climate similar to the PRA area (Figure 1). The species is also present in parts of Central and South America.

Pathway

The most likely pathway is via imported unwashed seed potatoes and soil. Washing is commonly assumed to eliminate larvae from potato tubers (EPPO 2005), but new findings suggest that this may not always be the case (EPPO 2016). Norway has historically imported potatoes from countries where *E. tuberis* occurs (Figure 2). However, the last import was in 2007.

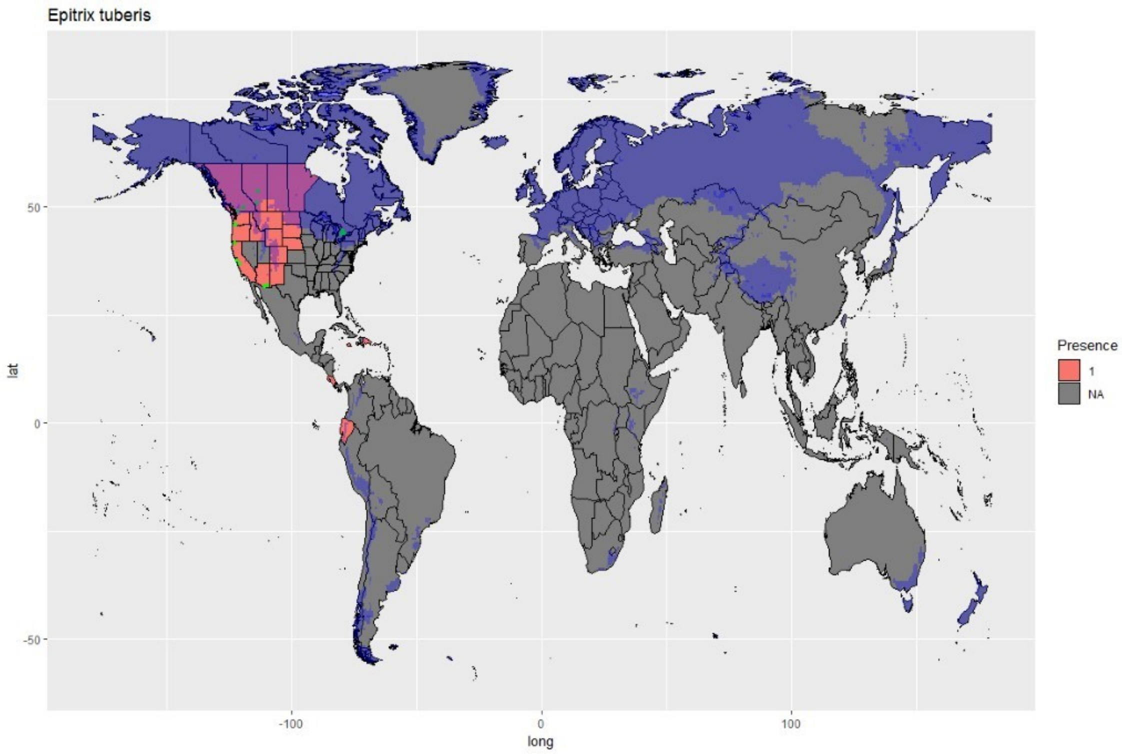

Figure 1. World map showing the known distribution of *Epitrix tuberis*. Red and purple areas are areas where *E. tuberis* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Taken together, the economic consequences of *E. tuberis* in Norway are potentially high. Adults damage aboveground plant parts and in extreme cases this may reduce the plants' ability to photosynthesize and grow. Overall, however, aboveground damage is usually of minor importance in potato. The larvae feed belowground and can inflict severe direct damage on potato tubers (Boavida and Germain 2009). Damaged tubers are unmarketable. *Epitrix tuberis* can complete up to three generations per summer and each female lays up to 200 eggs (EPPO 2016). This suggests that the pest quickly can build up large populations.

Environmental impact in the PRA area:

Although *E. tuberis* can feed on other plants than potato, it seems to discriminate more strongly against other plants than other *Epitrix* species. The available literature does not suggest that *E. tuberis* causes problems in unmanaged habitats.

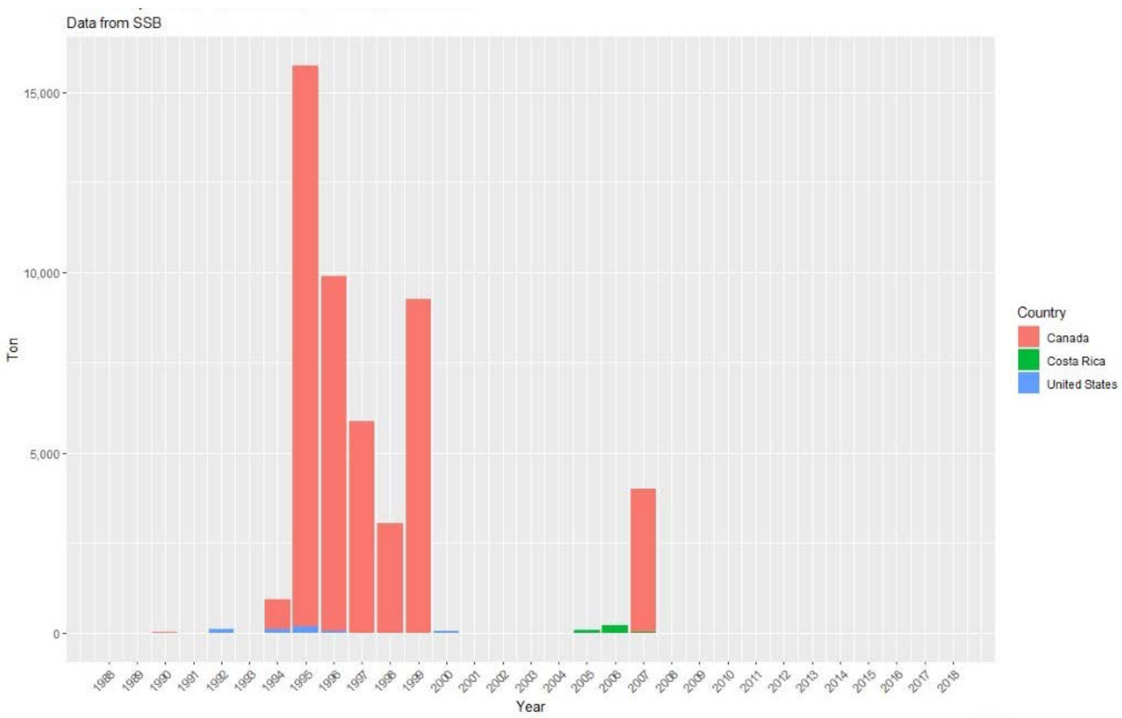

Figure 2. Potato imports (in metric tons) to Norway from Canada, USA and Costa Rica, where *Epitrix tuberis* occurs, the last 30 years.

Conclusion of pest categorization

Epitrix tuberis does not appear to warrant categorization as a quarantine pest in Norway since it is unlikely to enter Norway. *Epitrix tuberis* is present in parts of Canada and USA that have a similar climate to Norway. It could thus thrive in Norway.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Boavida C., Germain J.F. 2009. Identification and pest status of two exotic flea beetle species newly introduced in Portugal: *Epitrix similaris* Gentner and *Epitrix cucumeris* (Harris). EPPO Bulletin 39:501-508. DOI: 10.1111/j.1365-2338.2009.02339.x.

CABI. 2018. *Epitrix tuberis* (tuber flea beetle) datasheet. www.cabi.org/isc/datasheet/21555

EPPO. 2005. Data sheets on quarantine pests. *Epitrix cucumeris*. *EPPO Bulletin* 35: 363-364.
EPPO. 2010. Pest risk analysis for *Epitrix* species damaging potato tubers. Document 11-17790.

EPPO. 2016. National regulatory control system for *Epitrix* species damaging potato tubers. *EPPO Bulletin* 46: 556-566.

Pest categorization – *Epitrix similaris*

Identity of pest

Scientific name: *Epitrix similaris* Gentner, 1944

Synonym: None

Common name: Potato flea beetle

Hosts

Primary: Potato (*Solanum tuberosum*)

Secondary domesticated host plants: Tomato (*Lycopersicon esculentum*). Foliar damage has also been observed on aubergine (*Solanum melongena*).

Secondary wild host plants: jimsonweed (*Datura stramonium*) (Norwegian: 'piggeple'), black nightshade (*Solanum nigrum*) (Norwegian: 'svartsøtvier'), potato vine (*Solanum jasminoides*), and *Solanum trifolium* (EPPO 2012).

Presence or absence in PRA area

Epitrix similaris is not present in Norway

Regulatory status

The species is not regulated in Europe

Potential for establishment and spread in PRA area

Climate

Epitrix similaris' distribution in North America indicates that it could find suitable climatic conditions in Norway. As all other North American *Epitrix* species *E. similaris* hibernates as adult in the top soil. This could protect it against subzero temperatures, especially under snow cover.

Distribution

Epitrix similaris has a limited distribution in America and rarely undergoes outbreaks. Previous reports of *E. similaris* in the Iberian Peninsula are erroneous (Orlova-Bienkowskaja 2015; Mouttet et al. 2016). All previous literature on the distribution, behavior, and impact of *E. similaris* in Europe should thus be disregarded.

Pathway

The most likely pathway is via imported unwashed seed potatoes and soil. Washing is commonly assumed to eliminate larvae from potato tubers (EPPO 2005), but new findings suggest that this may not always be the case (EPPO 2016). Norway sporadically imports limited amounts of potato from the US (Figure 2), most of which is probably washed. The last import was in 2007.

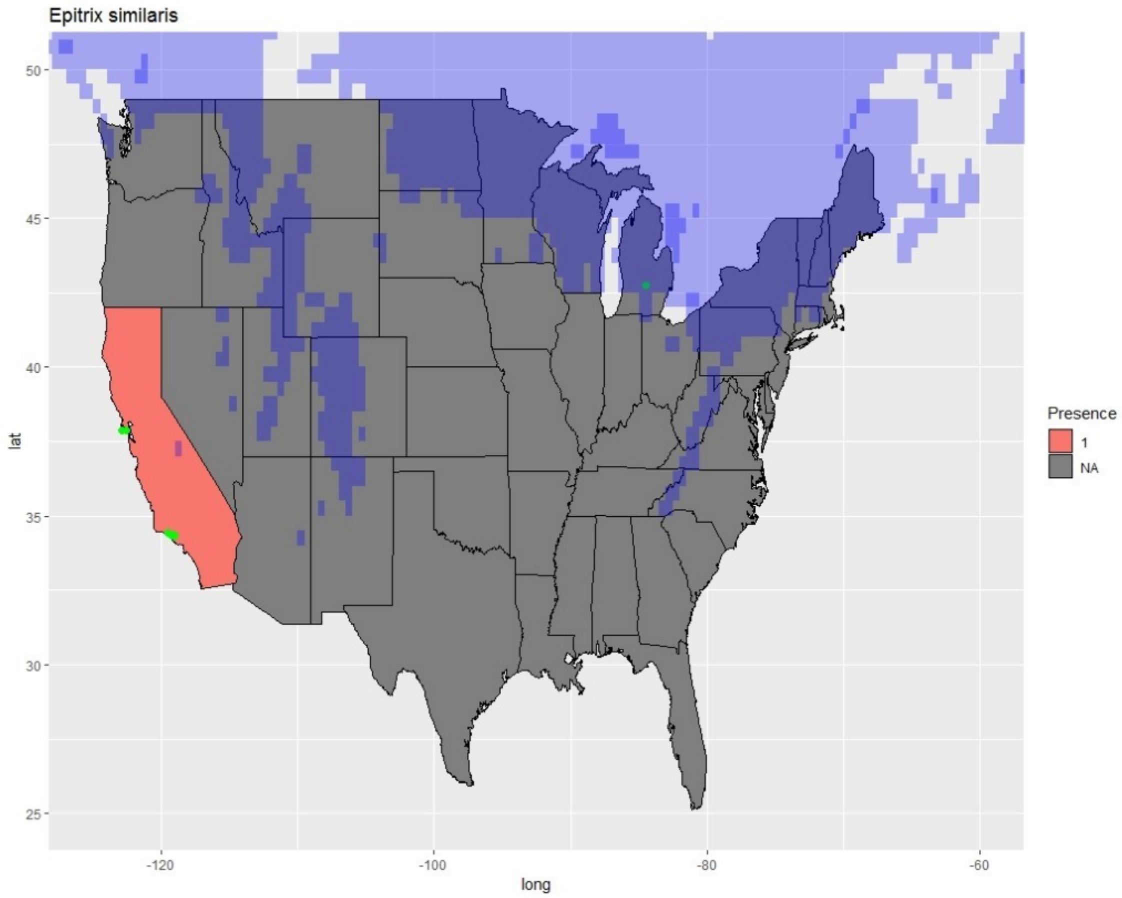

Figure 1. Map of the US showing the known distribution of *Epitrix similaris*. The red area is where *E. similaris* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix similaris can feed and reproduce on several wild and domesticated plants in Norway. Adults damage above-ground plant parts and in extreme cases this may reduce the plants' ability to photosynthesize and grow. Overall, however, above-ground damage is normally of minor importance for potato. The larvae feed on below-ground parts of their host plants, including direct damage to potato tubers.

Taken together, the economic consequences of *E. similaris* in Norway is potentially high.

Environmental impact in the PRA area:

Epitrix similaris can reproduce on some wild plant species that occur in Norway, but damage on wild plants has never been considered an environmental problem in the species' native range in America.

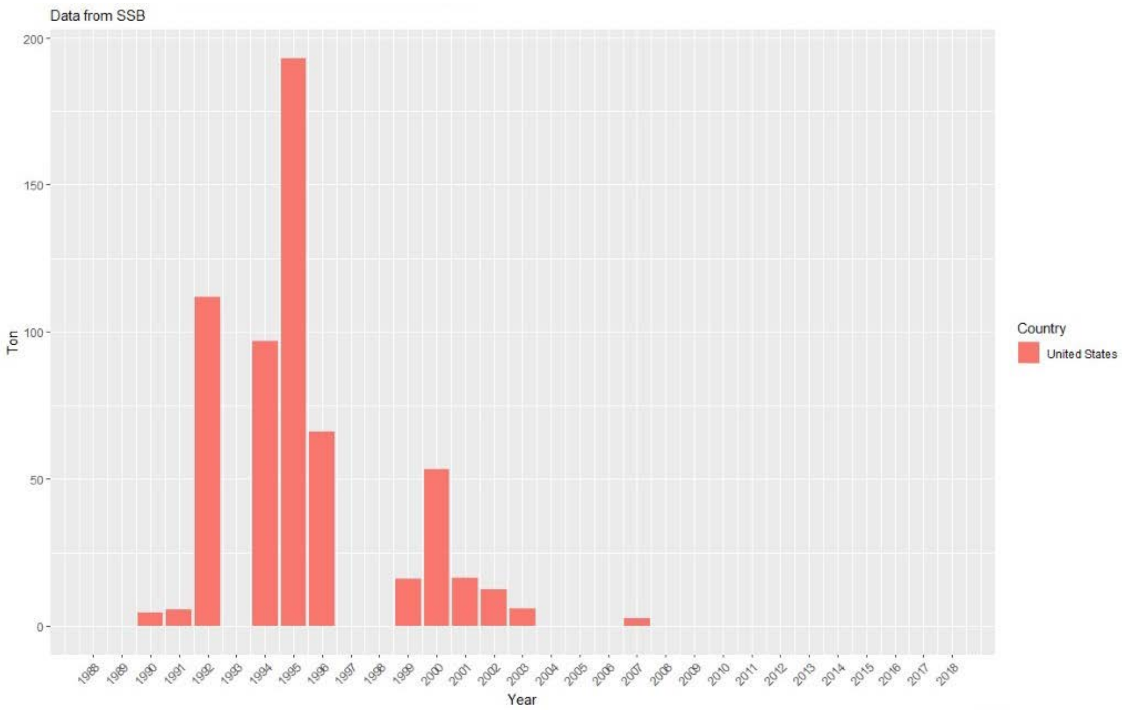

Figure 2. Potato imports (in metric tons) to Norway from the US, where *Epitrix tuberis* occurs, the last 30 years.

Conclusion of pest categorization

Epitrix similaris does not appear to warrant categorization as a quarantine pest in Norway. The species is unlikely to enter Norway because it has a limited distribution in the US and potato import from the US is low.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

EPPO. 2005. Data sheets on quarantine pests. *Epitrix cucumeris*. *EPPO Bulletin* 35: 363-364.

EPPO. 2012. Pest Risk Analysis for *Epitrix* species damaging potato tubers.

EPPO. 2016. National regulatory control system for *Epitrix* species damaging potato tubers. *EPPO Bulletin* 46: 556-566.

Orlova-Bienkowskaja. 2015. *Epitrix papa* sp. n. (Coleoptera: Chrysomelidae: Galerucinae: Alticini), previously misidentified as *Epitrix similaris*, is a threat to potato production in Europe. *European Journal of Entomology* 112: 824-830.

Mouttet et al. 2016. Molecular evidence supports the recognition of *Epitrix papa* as a distinct species from *Epitrix similaris*. *EPPO Bulletin* 46: 583-587.

Pest categorization – *Epitrix subcrinita*

Identity of pest

Scientific name: *Epitrix subcrinita* (LeConte, 1860)

Synonyms: *Epitrix subcarinata*

Common names: Western potato flea beetle

Hosts

Primary: Potato (*Solanum tuberosum*) (Jones 1944). The species develops successfully on potato plants but does not damage potato tubers (Jones 1944).

Secondary domesticated host plants: Recorded from many solanaceous crop plants, such as tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), chili pepper (*Capsicum* spp.), *Physalis* spp. and a variety of ornamentals (Clark et al. 2004).

Secondary wild host plants: Recorded from several introduced solanaceous weeds and wild solanaceous species (Clark et al. 2004). Collections from plants in other families probably do not represent true host records (Clark et al. 2004).

Presence or absence in PRA area

Epitrix subcrinita is not present in Norway

Regulatory status

EPPO A1 list; EU “emergency measures”

Potential for establishment and spread in PRA area

Climate

Epitrix subcrinita's distribution in North America indicates that it could find suitable climatic conditions in Norway. As all other North American *Epitrix* species *E. subcrinita* hibernates as adult in the top soil. This could protect it against subzero temperatures, especially under snow cover.

Distribution

North America

In the US, *E. subcrinita* has been found in the states of Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, New Mexico, and Wyoming (Figure 1).
In Canada, *E. subcrinita* is present in the provinces of Saskatchewan (Riley et al. 2003), Alberta and British Columbia. The species is also recorded from Mexico (Figure 1).

Central and South America

Epitrix subcrinita has been registered in Guatemala and Peru (Figure 1).

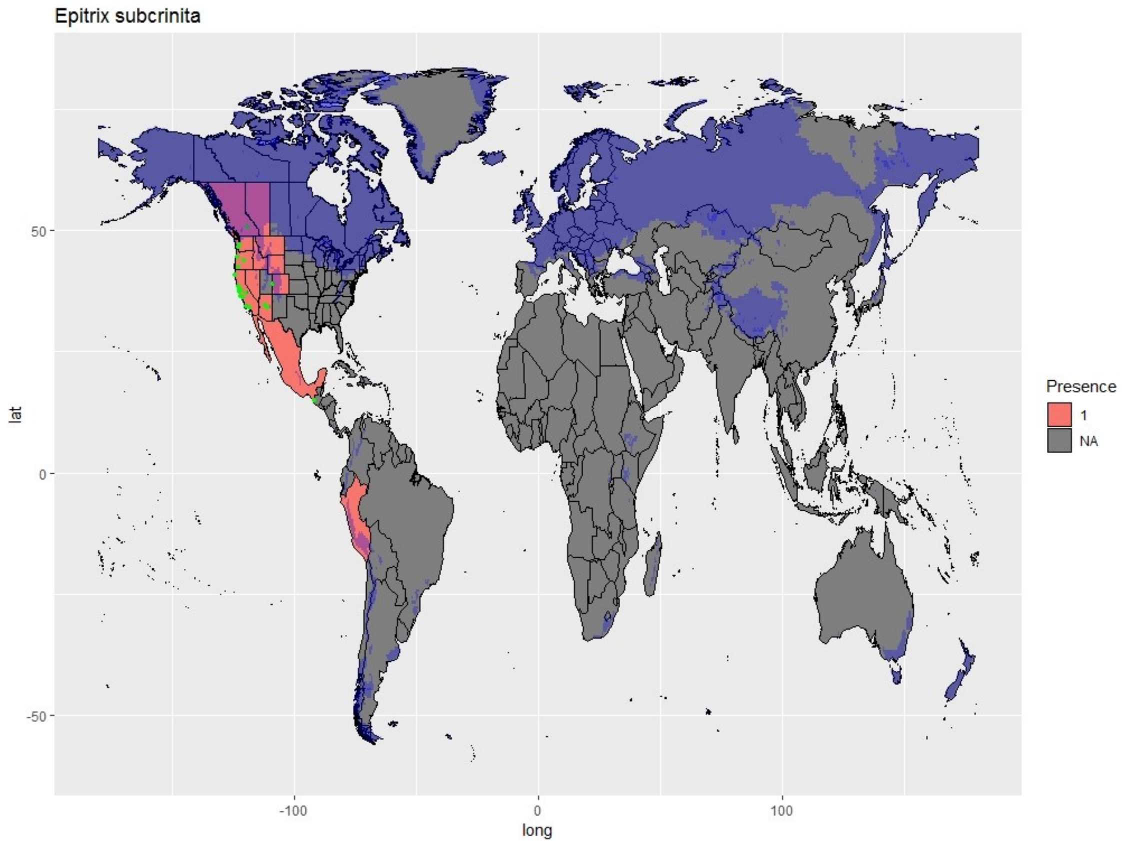

Figure 1. World map showing the known distribution of *Epitrix subcrinita*. Red and purple areas are areas where *E. subcrinita* is registered as present according to Bienkowski & Orlova-Bienkowskaja (2017). Blue and purple areas have the same Köppen-Geiger climate classification as Norway. Green points are presence records downloaded from gbif.org.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Unknown

Environmental impact in the PRA area:

Unknown

Conclusion of pest categorization

Epitrix subcrinita probably warrants categorization as a quarantine pest in Norway. The species is included in the EPPO A1 list of pests recommended for regulation as quarantine pests.

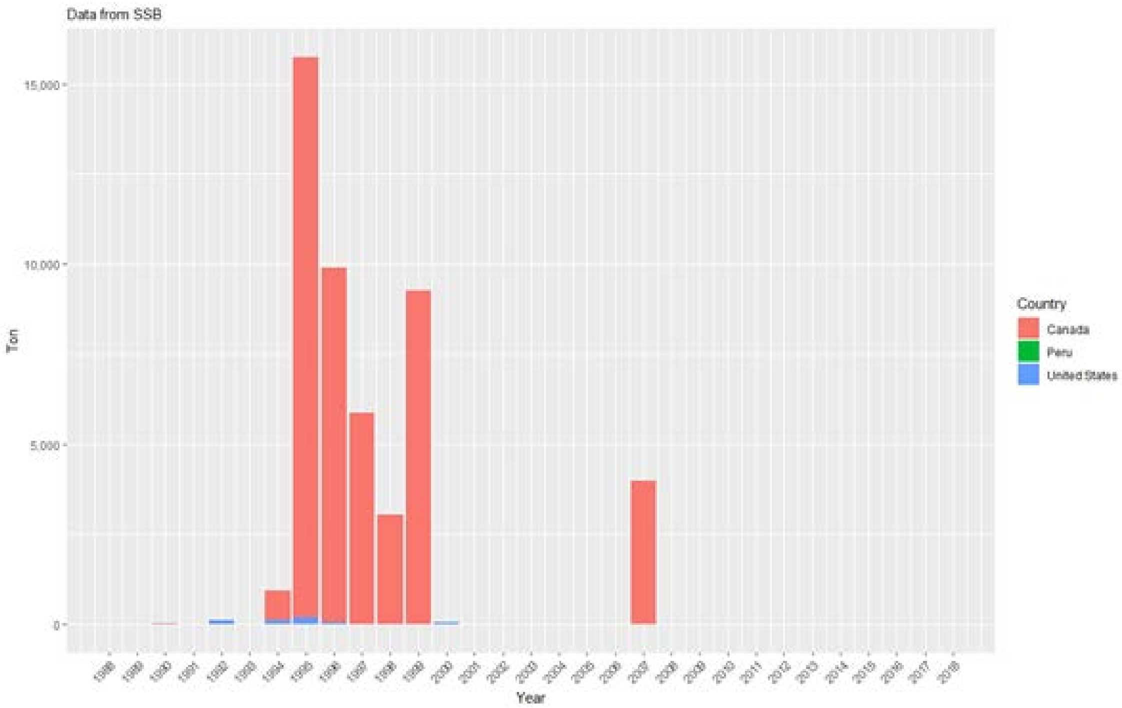

Figure 2. Potato imports (in metric tons) to Norway from Canada, Peru and the US, where *Epitrix subcrinita* occurs, the last 30 years.

References

Bienkowski A.O., Orlova-Bienkowskaja M.J. 2017. World checklist of flea-beetles of the genus *Epitrix* (Coleoptera: Chrysomelidae: Galerucinae: Alticini). Zootaxa 4268:523-540.

Clark S.M., LeDoux D.G., Seeno T.N., Riley E.G., Gilbert A.L., Sullivan J.M. 2004. Host plants of leaf beetle species occurring in the United States and Canada (Coleoptera: Megalopodidae, Orsodacnidae, Chrysomelidae, excluding Bruchinae). Coleopterists Society Special Publication no. 2:476.

Jones E.W. 1944 Biological studies of two potato flea beetles in eastern Washington. Journal of Economic Entomology 37:9-12.

Riley E.G., Clark S.M., Flowers R.W., Gilbert A.J. 2003. Chrysomelidae Latreille 1802, in: M. C. T. R. H. Arnett, P. E. Skelley and J. H. Frank (Ed.), American Beetles. Volume 2: Polyphaga: Scarabaeoidea through Curculionoidea. pp. 617-691.

Pest categorization – *Epitrix ubaquensis*

Identity of pest

Scientific name: *Epitrix ubaquensis ubaquensis* Harold, 1875
and *Epitrix ubaquensis venezuelensis* Jacoby, 1889

Synonyms: None

Common names: None

Hosts

Epitrix ubaquensis is said to be associated with potato (*Solanum tuberosum*)

Presence or absence in PRA area

Epitrix ubaquensis is not present in Norway

Regulatory status

The species is not regulated in any countries

Potential for establishment and spread in PRA area

Climate

Epitrix ubaquensis is only known from Peru. Peru shares several climate types with Norway (Bsk, Csb, Cfb, Cfc and ET) (Figure 1).

Distribution

Epitrix ubaquensis is known only from Peru (Kroschel Canedo 2015)

Pathway

The main pathway of concern would be import of potato. Norway has historically imported potatoes from Peru (Figure 2). However, the last import was in 2012.

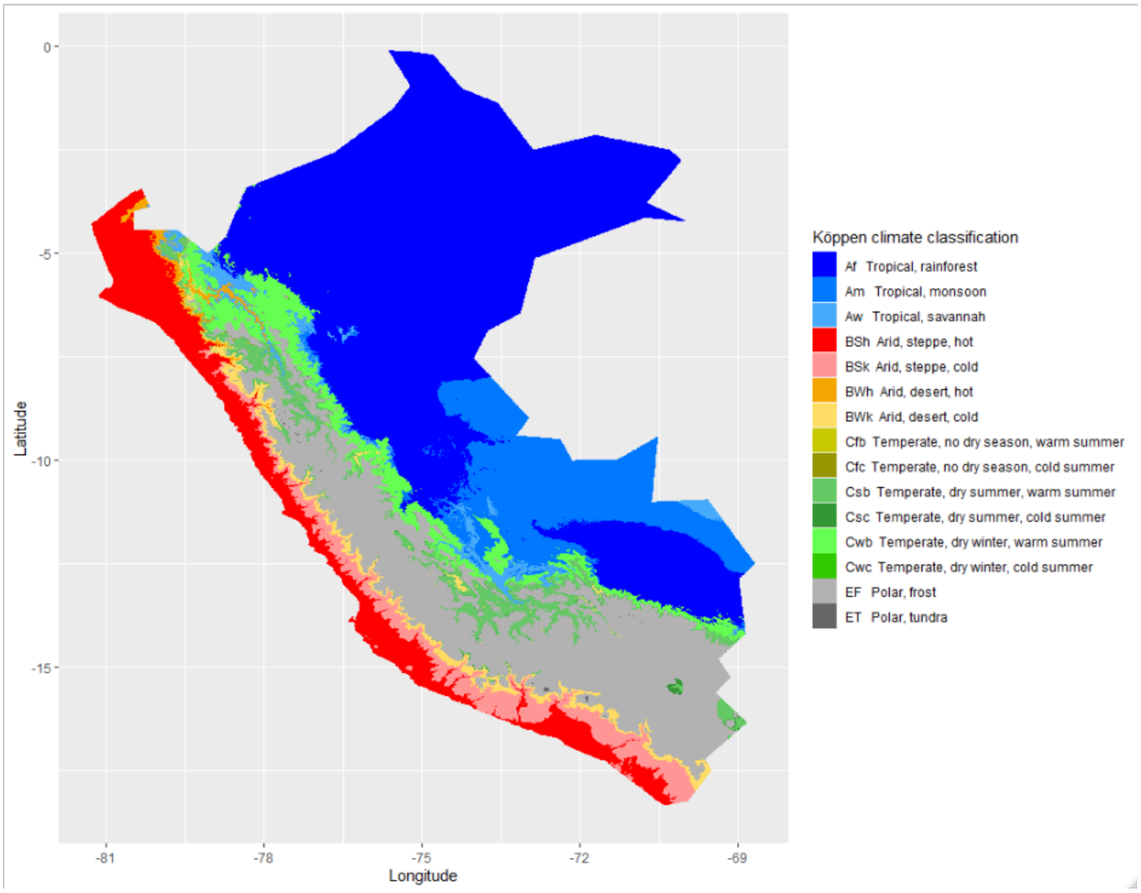

Figure 1. Map of Peru with detailed Köppen-Geiger climate classification. The climate zones Bsk, Csb, Cfb, Cfc and ET are shared between Peru and Norway.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix ubaquensis feeds on potato and causes yield losses

Environmental impact in the PRA area:

Unknown

Conclusion of pest categorization

Epitrix ubaquensis does not appear to warrant categorization as a quarantine pest in Norway. It appears to have a limited distribution in Peru and there is little import of potato from Peru to Norway. However, there is very little documentation on the species' biology and for non-experts it would not be possible to separate *E. ubaquensis* from other *Epitrix* species.

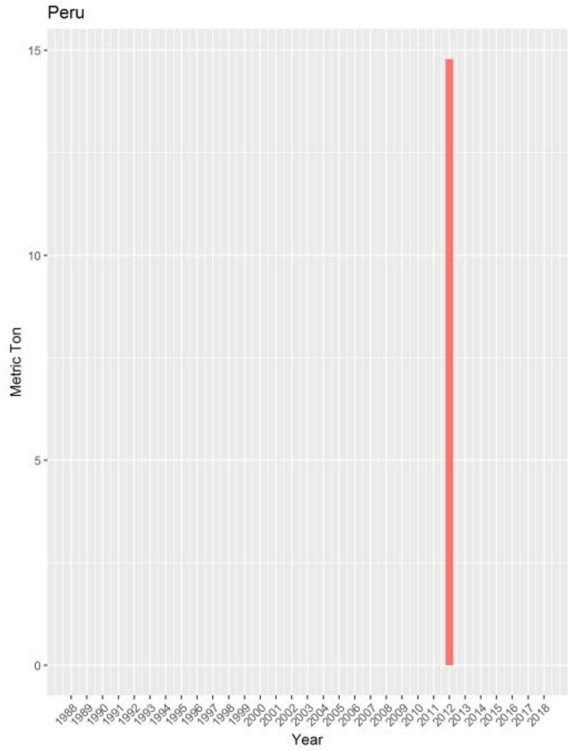

Figure 2. Potato imports (in metric tons) to Norway from Peru, where *Epitrix ubaquensis* occurs, the last 30 years.

References

Kroschel J., Cañedo V. (2009) How do insecticides affect potato yield and ecosystem resilience to manage potato pests? An ecological assessment from the central highlands of Peru, CD Papers of 15th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC), International potato center, Peru.

Pest categorization – *Epitrix yanazara*

Identity of pest

Scientific name: *Epitrix yanazara* Bechyné 1959b*.*

Synonyms: None

Common names: None

Hosts

Epitrix yanazara is said to be associated with potato

Presence or absence in PRA area

Epitrix yanazara is not present in Norway

Regulatory status

The species is not regulated in any countries

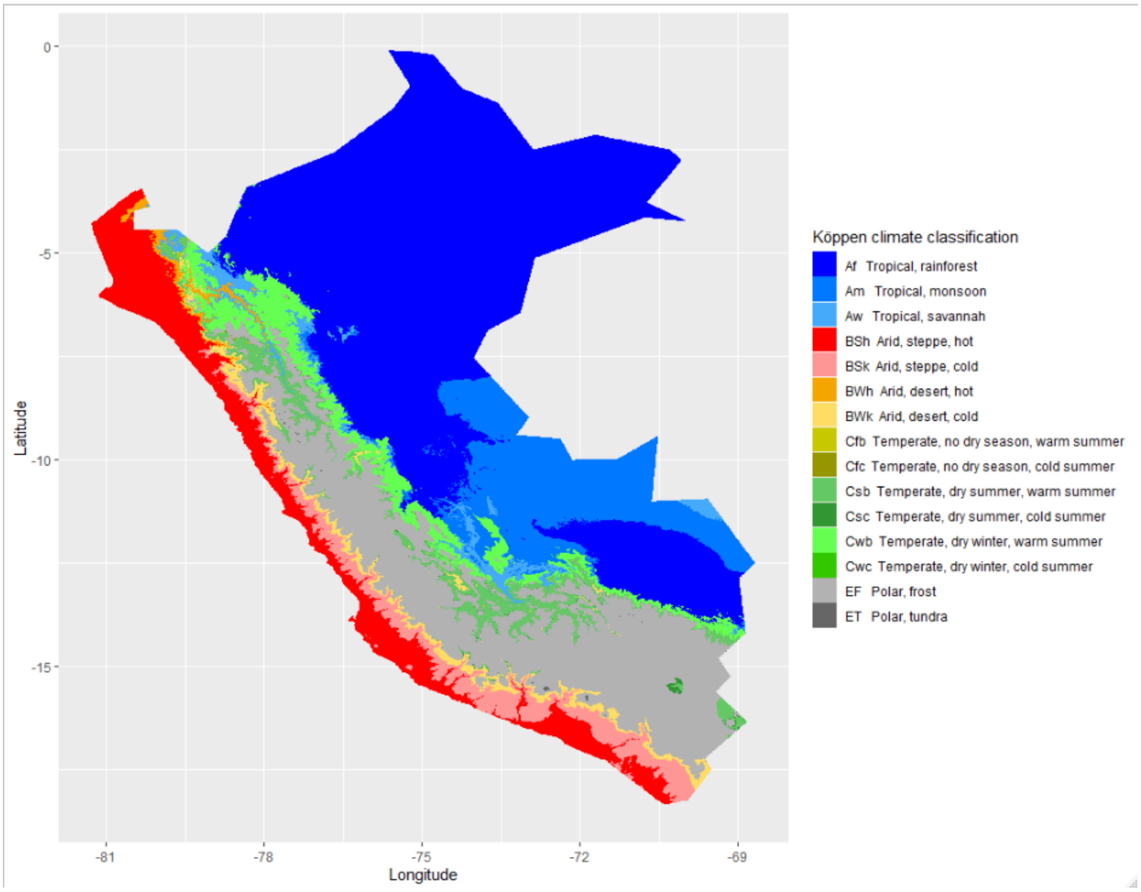

Figure 1. Map of Peru with detailed Köppen-Geiger climate classification. The climate zones Bsk, Csb, Cfb, Cfc and ET are shared between Peru and Norway.

Potential for establishment and spread in PRA area

Climate

Epitrix yanazara is only known from Peru. Peru shares several climate types with Norway (Bsk, Csb, Cfb, Cfc and ET) (Figure 1).

Distribution

Epitrix yanazara is known only from Peru (Kroschel Canedo 2015)

Pathway

The main pathway of concern would be import of potato. Norway has historically imported potatoes from Peru (Figure 2). However, the last import was in 2012.

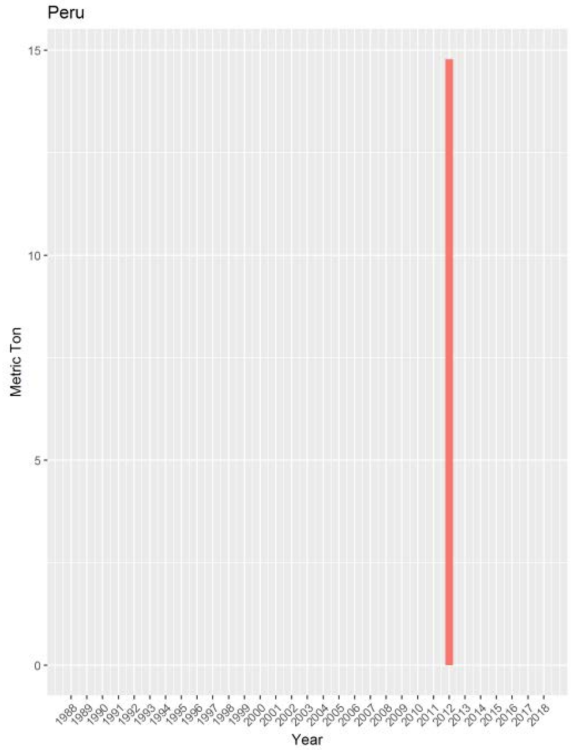

Figure 2. Potato imports (in metric tons) to Norway from Peru, where *Epitrix yanazara* occurs, the last 30 years.

Potential for economic consequences in PRA area

Economic impact in the PRA area:

Epitrix yanazara feeds on potato and cause yield losses.

Environmental impact in the PRA area:

Unknown

Conclusion of pest categorization

Epitrix yanazara does not appear to warrant categorization as a quarantine pest in Norway. It appears to have a limited distribution in Peru and there is little import of potato from Peru to Norway. However, there is very little documentation on the species' biology and for non-experts it would not be possible to separate *E. yanazara* from other *Epitrix* species.

References

Kroschel J., Cañedo V. (2009) How do insecticides affect potato yield and ecosystem resilience to manage potato pests? An ecological assessment from the central highlands of Peru, CD Papers of 15th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC), International potato center, Peru.