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Pest risk assessment of the South American Leafminer (*Liriomyza huidobrensis)* in Norway

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Pest risk assessment of the South American Leafminer (*Liriomyza huidobrensis*) in Norway

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SUMMARY

Liriomyza huidobrensis (Blanchard, 1926) is a pest species that originates from Central and South America, but since the 1990s it has spread with plants to many parts of the world. In the tropics, subtropics and warmer parts of the temperate zone it has been established in the field, while in a colder climate it can develop as a pest only in greenhouses. The pest has a wide host plant range. In Europe the pest has been reported in most countries, Norway included, predominantly on ornamental plants in greenhouses, but also outside greenhouses in gardens and semi-natural environment.

The pest risk assessment was initiated by the Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) Panel on Plant Health.

The VKM Panel on Plant health gives the following main conclusions of the risk assessment: 1) *L. huidobrensis* has been spread to Norwegian greenhouses on a number of occasions, but each time it has been eradicated. It is not present in Norway today. 2) The overall probability of entry of *L. huidobrensis* into Norway and the overall probability of establishment in greenhouses of *L. huidobrensis* in Norway are both rated as high with low levels of uncertainty. 3) In the absence of statutory control the probability for *L. huidobrensis* to be spread quickly in greenhouses in the PRA area by trade of host plants is rated as high. The uncertainty of this assessment is low. 4) *L. huidobrensis* has been spread outdoors in the field around infested greenhouses during the summer, but it can not overwinter in the field in Norway. The level of uncertainty of this assessment is low. 5) The part of the PRA area where presence of *L. huidobrensis* might result in economically important losses (the endangered area) in greenhouses is assessed to be all of Norway. 6) *L. huidobrensis* is likely to have moderate economic impact in the greenhouses in the PRA area with current phytosanitary measures. Without any such regulations *L. huidobrensis* is likely to have major economic impact on the greenhouse industry of the PRA area. The levels of uncertainty of these assessments are low. 7) The non-commercial consequences to natural environments in the PRA area are likely to be low. The level of uncertainty of this assessment is low.

CONTRIBUTORS

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

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ASSESSED BY

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1. BACKGROUND

Among the three polyphagous *Liriomyza*-species that are quarantine pests in Norway (*L. huidobrensis*, *L. sativae* and *L. trifolii*), *L. huidobrensis* has the lowest temperature preferences. It has been established in many tropical, subtropical and warmer parts of the temperate areas all over the world (except Australia). In addition there are regular outbreaks in greenhouses in most parts of the world. The larvae of *L. huidobrensis* are highly polyphagous, being able to develop inside the leaves of plants in many plant families, including cultivated plants like many vegetables, ornamentals and cotton. Under climatically favorable conditions generations follow in quick succession, and serious damage has been reported in many agricultural and ornamental crops.

What was earlier treated as the species *L. huidobrensis* has recently been subdivided into the two species *L. huidobrensis* and *L. langei* (Scheffer & Lewis 2001). However, so far all investigated specimens outside California, Mexico and Hawaii have been confirmed to belong to *L. huidobrensis*.

The global distribution of *L. huidobrensis* (Appendix 1) has changed considerably since the last PRA was made for the pest in Norway (Sæthre 1996). Due to the recent spread of the species in many parts of the world, it has probably been established in more tropical and subtropical countries than is presently documented in international literature, especially in Africa and Asia, and it will probably reach new countries in the near future. In Europe the pest has been reported in many countries, predominantly on ornamental plants in greenhouses, but also outside greenhouses in gardens and semi-natural environments. Due to different levels of investigation and policies in different countries, the current distribution map of the species in Europe and the rest of the world (EPPO 2006) is not well documented, and the information must be used with caution.

In Norway there have been several imports of the pest into greenhouses since 1995, but so far the pest has always been eradicated. In two cases in recent years the species was spread to some extent in the field during the summer. In both cases the populations died out during the following winter, but this situation has made the Norwegian Food Safety Authority on the alert concerning the species.

The report from the *ad hoc* group has been initiated, evaluated and approved by VKM Panel on Plant Health. The pest risk assessment was adopted by the panel at December 10th 2009.

Be aware that the current document is a pest risk assessment, and not a Pest Risk Analysis (PRA). A PRA consists of both a risk assessment and a risk management part. VKM performs purely the risk assessment, whereas the Norwegian Food Safety Authority is responsible for the risk management. However, since this pest risk assessment is part of a PRA process, the current document refers to the PRA term in several contexts, like the identification of the PRA area and referrals to former PRAs. This is in accordance with the international standard ISPM No. 11 (FAO 2004).

2. INITIATION

2.1. Initiation points

2.1.1. PRA initiated by the identification of a pest

Initiated by the Norwegian Scientific Committee for Food Safety, a previous Norwegian PRA is being re-evaluated. The pest has been established in many countries all over the world in recent years, and it has been spread to Norway several times. Also, the taxonomy of the pest has recently been revised. Consequently, the timing of the PRA initiation is due to repeated incidents in Norwegian greenhouses in recent years, and to new knowledge about the pest.

2.2. Identification of PRA area

The PRA area is Norway.

2.3. Information

Information sources utilised for this pest risk assessment are published material available in international scientific journals, books and reports, as well as personal communications with persons involved in the area, geographical data, unpublished results, and information from the Norwegian Food Safety Authority that have been made available to the risk assessors. Where these information sources have been used, this is indicated in the text by references enclosed in brackets.

The current pest risk assessment is made according to the international standard ISPM No. 11 (FAO 2004).

2.3.1. Previous PRAs

Commissioned by the former Norwegian Agricultural Inspection Service, the former Norwegian Crop Research Institute (Planteforsk) in 1996 did a PRA on *Liriomyza huidobrensis* (Sæthre 1996). The PRA referred to the first three outbreaks of the pest in Norwegian greenhouses in 1995. The biology of the species was given, and available control measures and the potential economic importance were evaluated.

The PRA was followed up by an investigation of possible *Liriomyza* species being present in greenhouses and the field in Norway in 1996 (Sæthre 1997).

Following an infestation of *L. huidobrensis* in 2002 that spread to 32 greenhouses all over the country, two investigations were performed in 2003-2005 (Johansen *et al.* 2004, 2006).

Important information is also found in the two EPPO documents “EPPO Data Sheet on Quarantine Pests. *Liriomyza huidobrensis*” (EPPO 1997) and “EPPO Diagnostic. *Liriomyza* spp.” (EPPO 2005).

In the Netherlands, a report evaluating whether *L. huidobrensis* should be regarded as a quarantine pest or not was delivered in 2005 (Westerman *et al.* 2005).

2.4. Conclusion of initiation

The pest of concern is the dipterous pest *Liriomyza huidobrensis*. The work was initiated by the Norwegian Scientific Committee for Food Safety, and the initiation point for the pest risk assessment is the re-evaluation of a previous PRA for Norway. The PRA area is Norway.

3. Pest risk assessment

3.1 Pest categorization

3.1.1. Identity of pest

3.1.1.1 Scientific name

Liriomyza huidobrensis Blanchard, 1926

3.1.1.2 Synonyms

Agromyza huidobrensis Blanchard, 1926

Liriomyza cucumifoliae Blanchard, 1938

Liriomyza dianthi Frick 1958

3.1.1.3 Common names

South American Leafminer

Pea Leafminer

Chrysanthemum Leafminer

3.1.1.4 Taxonomic position

Class: Insecta; Order: Diptera; Family: Agromyzidae; genus: *Liriomyza*.

Recent molecular research found evidence of a cryptic species within the species previously known as *Liriomyza huidobrensis* (Scheffer 2000). For this new species the old name *L. langei* Frick was resurrected (Scheffer & Lewis 2001). For the time being, the two species can only be separated by molecular characters (Scheffer *et al*. 2001), but work has started to find morphological measures that can be used to separate the two species (Takano *et al*. 2005). At present *L. langei* has been confirmed only from California and Mexico in North America, and Hawaii (Scheffer & Lewis 2001, Scheffer *et al*. 2001), while *L. huidobrensis* has been confirmed from Argentina, Canada, Columbia, Guatemala and Peru in America, and China, Israel, Japan, Korea Sri Lanka, Taiwan and West Java in Asia (Scheffer & Lewis 2001, Scheffer *et a*l. 2001, He *et al*. 2002, Takano *et al*. 2005). Due to these reports, in the present PRA document *L. huidobrensis* reported from all parts of the world except California, Mexico and Hawaii are treated as *L. huidobrensis*, although it is possible that future work will show that some of these belong to the cryptic species *L. langei*.

Two taxonomically closely related species occur naturally in Norway:

Tomato leafminer *Liriomyza bryoniae* (Kaltenbach, 1858) is a highly polyphagous pest in several agricultural crops in Southern Europe. It is sometimes occurring on tomatoes grown in greenhouses in Norway. Only a few records have been done in the field in southern Norway (Spencer 1976, Arild Andersen unpublished data).

Liriomyza strigata (Meigen, 1830) is a highly polyphagous species, and common in most parts of Norway, but it has not been reported as a pest in agricultural crops (Spencer 1976).

As a conclusion, due to the difficult taxonomy of the species and several very closely related species, all information concerning *L. huidobrensis* has to be evaluated with caution.

3.1.2 Presence or absence in PRA area

L. huidobrensis has been discovered at the Norwegian border at least twice during the last five years (Table 1), and the infested plants have been rejected. It has been intercepted at least 13 times in trade of greenhouse plants in the PRA area during 1995-2009 (Table 2). However, all interceptions into greenhouses in Norway have been eradicated, and all populations detected in the field have died out during the first winter (Sæthre 1997, Johansen *et al*. 2004). It should be mentioned that the outdoor surveys of *L. huidobrensis* in Norway have not been conducted systematically. Only local and regional surveys were conducted around infested greenhouses after the incidents in 1995 (40 samples, Sæthre 1997) and 2002 (Johansen *et al*. 2004, 2006). *L. huidobrensis* has been found outdoors in Norway at six occasions, always close to infested greenhouses (see paragraph 4.2.2.2).

Table 1. Imports to Norway the last five years stopped due to records of *Liriomyza* spp. by import control (Norwegian Food Safety Authority).

Year	**Pest species**	**Plant species**	**Country of origin**
2004 – 2007: no records			
2008	*Liriomyza* sp.	*Exacum* sp.	Denmark
	L. huidobrensis	*Exacum* sp.	Denmark
	L. huidobrensis	*Exacum* sp.	Denmark
	Liriomyza sp.	*Solidago* sp.	Zimbabwe
	Liriomyza sp.	*Verbena* sp.	The Netherlands
2009: no records			

Table 2. Imports of *Liriomyza huidobrensis* into Norwegian greenhouses and garden centres (Norwegian Food Safety Authority and Norwegian Institute for Agricultural and Environmental Research).

Year	**Number of imports**	**Number of infested greenhouses and garden centres**	**Host plant**	**Country of origin**
1995	1	3	*Gypsophila* sp.	Israel, Netherlands?
1996 - 2001	0	-	-	-
2002	1	37	*Chrysanthemum* sp.	Netherlands
2003	4	4	*Exacum* sp., *Chrysanthemum* sp., *Verbena* sp.	Denmark, Kenya?
2004	1*	1	*Osteospermum* sp.	USA
2007	3	3	*Chrysanthemum* sp.	Brazil
2008	2	4	*Exacum* sp.	Denmark
2009	1	1	*Diascia* sp.	?

*The current pest risk assessment concludes that the species is possibly *L. langei* (see paragraph 4.1.1.4).

3.1.3 Regulatory status

In Norway *L. huidobrensis* is currently treated as a quarantine pest.

3.1.4 Potential for establishment and spread in PRA area

According to EPPO reports on notifications of non-compliance for *L. huidobrensis* for the years 2002-2009 (EPPO Reporting Service 2002 – September 2009), it is obvious that there is a high probability that plants containing *L. huidobrensis* now and then is sought imported into Norway. The occurrence of *L. huidobrensis* is most common in cut flowers from South America and Africa to the Netherlands (Appendix 2). Due to the availability of relevant host species and favourable climatic conditions, there is a potential for establishment and spread of *L. huidobrensis* all year round in greenhouses in the PRA area. The entries of *L. huidobrensis* are presented in chapter 4.1.2. If not eradicated, the species would be able to exist in greenhouses all year round, but outdoors in the field it would only survive during the summer. Kang *et al*. (2009) suggest an overwintering range limit under natural conditions in China to be the -5 °C isotherm of the minimum mean temperature in January. In that case, data from Aune (1993) and three meteorological stations in Norway (Table 3) should indicate that *L. huidobrensis* would be able to overwinter in the coastal areas of Southern Norway. However, the latitude they suggest in China is 35° N, which correspond to Crete and Cyprus in Europe and Syria in Asia, far south of Norway. This large difference can be explained by the more Atlantic climate in Europe compared to the continental climate in China. Furthermore, Chen

& Kang (2004) reported that the LT_{50} [1] of pupae of *L. huidobrensis* was only 5 days at -5 °C and 5 hours at -10 °C, which would make it very unlikely that *L. huidobrensis* would survive during winter even in the mildest parts of Norway.

The mean temperature along the coast of Southern Norway in May – August is around 15 °C, as shown by the mean temperature for three meteorological stations during 1995-2009 (Ås near Oslo in South-Eastern Norway, Særheim near Stavanger in South-Western Norway and Kvithamar near Trondheim in Middle Norway) in Table 3. During 3 months (90 days) at 15 °C, *L. huidobrensis* should be able to go through two full generations. The development time at 15 °C is 47.5 days according to He *et al*. (2000). An overview of the development zero and day-degrees for the different stages of *L. huidobrensis* are given in Table 4.

Table 3. Monthly mean temperatures (°C) for the years 1995 – 2009 at three sites in coastal Southern Norway (Landbruksmeteorologisk tjeneste (LMT), Bioforsk).

	Jan	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**June-Aug**
Særheim	2.4	6.4	9.4	12.3	14.7	15.3	12.5	8.7	14.1
Ås	-2.8	5.0	10.0	14.0	16.1	15.7	11.3	6.1	15.3
Kvithamar	-0.8	5.2	9.1	12.7	15.1	14.8	10.9	6.3	14.2

Table 4. Development zero and day-degrees for the different stages of *Liriomyza huidobrensis* (He *et al*. 2000).

Stages	Egg	Larva 1st instar	Larva 2nd instar	Larva 3rd instar	Pupa
Development zero (°C)	11.5	7.6	8.8	10.3	5.3
Day-degrees (D°C)	40.0	45.5	29.4	21.6	169.9

The entry of *L. huidobrensis* into greenhouses at one locality in Østfold County in the spring of 2002 can be treated as a "worst case" in Norway. The species was established in greenhouses at one farm, and secondary infestation was confirmed in 32 greenhouses all over the country. Possible local presence was monitored outdoors around five infested greenhouses during the summer. Around the primary infested greenhouses *L. huidobrensis* was detected on wild flowers in the field at least 500 m away, partly in large populations. However, around the four greenhouses with secondary infestation, only single specimens of the species were detected. Emergence traps were used around the primary infested greenhouses the following year (2003), when no specimens of *L. huidobrensis* were found (Johansen *et al*. 2004). Also in connection with the entries in 1995, no specimens were found outside the greenhouses the

[1] LT_{50} = Lethal Time: the period of time required for 50% of a population to die.

following year (Sæthre 1997). In conclusion, *L. huidobrensis* can be established in greenhouses in the PRA area. The pest can also spread locally in the field around infested greenhouses during the summer and develop into large populations, but the species will not survive the winter in the field.

3.1.5 Potential for economic consequences in PRA area

Yield losses of the three New World *Liriomyza* spp. (*L. huidobrensis*, *L. sativae* and *L. trifolii*) can be significant, and the three species are regarded as serious pests of numerous ornamental and agricultural pests (Parrella 1987, Murphy & La Salle 1999).

Unlike the other two species, *L. huidobrensis*, makes mines in the chloroplast-containing mesophyll layers, and is potentially more damaging (Weintraub & Horowitz 1995). Yield reductions of 30-75 % of potatoes have been observed in several countries, e.g. in Israel (Weintraub & Horowitz (1996) and Indonesia (Shepard *et al*. 1998), and in European greenhouses entire crops of vegetables have been lost, e.g. in Germany (Leuprecht 1992).

3.1.6 Conclusion of pest categorization

L. huidobrensis is present in the PRA area only after occasional entries. So far, the pest has been eradicated after every entry.

Due to the availability of hosts and a suitable climate, there is a potential for establishment and spread of *L. huidobrensis* in greenhouses in the PRA area. All evidence indicates that the species is able to exist and multiply in the field in the summer, but can not survive the winter.

The pest could cause significant loss or damage to plants in greenhouses in the PRA area. Thus, the current pest risk assessment is continued.

3.2. Assessment of the probability of introduction and spread

3.2.1 Probability of entry of the pest

3.2.1.1 Identification of pathways

Pathway A. Import of host plants with eggs, larvae or pupae

L. huidobrensis might be imported into the PRA area with host plants originating from infested areas. This is shown by the previous history of the pest, especially the high number of infestations detected in cut flowers at European borders (Appendix 2). This pathway is rated as the most likely pathway for entry of *L. huidobrensis* into the PRA area.

Adults of *L. huidobrensis* copulate on the host plants, and the females make so-called pinholes by inserting their ovipositor into the leaves to feed on the plant fluids that run from the wounds. Later they lay eggs inside the leaf in some of the pinholes. Larvae hatch from the eggs and create a so-called mine by eating tissue inside the leaf. When fully grown, the larvae leave the mine and pupate either on the outside of the leaf or drop to the ground before they pupate. The next generation of flies emerges from the pupae. Thus, the plant host species offers *L. huidobrensis* all it needs concerning environment and development. A small infestation can be difficult to discover, since it often can consist only of pinholes, eggs and possibly some larvae in small mines. Also, sometimes the mines are easy to spot from only one side of the leaf, and can easily be overlooked.

The full range of natural host species to date is reported in Appendix 3. *Chrysanthemum* sp. and *Exacum* sp. have been the imported plant to Norway most commonly infested with *L. huidobrensis* (Tables 1 and 2).

The global distribution of *L. huidobrensis* is shown in Appendix 1.

Pathway B. Import of soil/growing media with pupae

L. huidobrensis might be imported into the PRA area with soil/growing media_originating from infested areas. *L. huidobrensis* has the potential to contaminate soil and growing medium as pupae, and the pest has a potential to survive significant periods of time in potting media. The developmental time for pupae depends on the temperature, and varies from 8.2 days at 25 °C to 14.2 days at 15 °C (Lanzoni *et al*. 2002).

Pathway C. Natural spread of adult flies from other European countries by air.

L. huidobrensis might enter the PRA area by natural spread of adult flies by air from infested areas in other European countries. Wind-borne migration has been shown to exist in many insect taxa, including Diptera species (Gatehouse 1997).

3.2.1.2 Probability of the pest being associated with the pathway at origin

The ratings of probabilities and uncertainties for *L. huidobrensis* being associated with the pathways at origin are given for each pathway in Table 5. The probabilities varies according to factors like

- prevalence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with commodities, containers, or conveyances
- volume and frequency of movement along the pathway
- seasonal timing
- pest management
- cultural and commercial procedures applied at the place of origin

Table 5. Estimates of the probability of *Liriomyza huidobrensis* being associated with each pathway at origin in relation to geographical source. The probability of the pest is ranked according to the following scheme: Very unlikely; Unlikely; Moderately likely; Likely; Very likely. Uncertainty for each estimate is given in brackets, and is ranked according to the following scheme: Low; Medium; High.

	Pathway	**Europe (EU/Switzerland)**	**USA and Canada**	**South and central America**	**Africa**	**Asia**
A	Import of host plants with eggs, larvae, pupae or adult flies	Moderately likely (low uncertainty)	Unlikely (low uncertainty)	Moderately likely (medium uncertainty)	Moderately likely (low uncertainty)	Moderately likely (medium uncertainty)
B	Import of soil/growing media with pupae	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)
C	Natural spread of adult flies by air	Unlikely (medium uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)	Very unlikely (low uncertainty)

Pathway A. Import of host plants with eggs, larvae or pupae

Generally this is considered as the most probable pathway of entry of *L. huidobrensis* into the PRA area. Due to low import of infested host plants to Norway from USA and Canada, the probability of entry from these countries is rated as lower than from the rest of the world.

Depending on the geographical origin of the host plants, import of host plants encompasses both the potential to import *L. huidobrensis* and the closely related species *L. langei*. However, import of plants from North America into the PRA area is low, so the probability of importing *L. langei* is also low. The only possible exception we know of is *Liriomyza* spp. detected on *Osteospermum* sp. plants imported from USA in November 2004 (Table 2).

Since the first discovery of *L. huidobrensis* in Norway in 1995, the pest has been stopped twice at the border as interceptions on host plants for planting imported from American, European and Asian countries (Table 1), and 13 times it has been established for short periods of time in greenhouses in the PRA area before it has been eradicated (Table 2).

Pathway B. Import of soil/growing media with pupae

The import of soil and organic growing media into the PRA area is prohibited from countries outside Europe (Landbruks- og matdepartementet 2000). Import of growing media (except *Sphagnum*) from European countries needs to be followed by a Phytosanitary Certificate. Therefore, the probability for the pest being associated with this pathway at origin is considered as very unlikely from all parts of the world.

Pathway C. Natural spread of adult flies from other European countries by air.

Natural spread of *L. huidobrensis* by aerial dissemination of adult flies is possible, as strong winds could potentially move the pest over great distances from other European countries like Sweden, Denmark, Germany and Poland into the PRA area. Such weather events occur sometimes when there are strong southern or south-eastern winds in Northern Europe

However, the probability for the pest being associated with this pathway is considered as unlikely from Europe and very unlikely from other parts of the world. This is due to the fact that the following two unusual situations must coincide: a relatively high population density of *L. huidobrensis* must have been established in the field in a nearby country, and the weather conditions in the area must favor a spread of the population to Norway. This situation could change if *L. huidobrensis* is established in the field in other countries in Northern Europe.

Pathway C is only possible from Northern Europe.

3.2.1.3 Probability of survival and multiplying during transport or storage

There is a high probability for *L. huidobrensis* to survive and multiply during transport or storage of host plants (pathway A). This is due to the fact that all the developmental stages of the pest (eggs, larvae, pupae and adult flies) will be able to utilize the host plant for their successful development, and the temperature need of the plants is suitable also for all stages of the pest. The level of uncertainty in this assessment is low.

There is a low probability for *L. huidobrensis* to survive and multiply during transport or storage of soil or growing media (pathway B). This is due to the fact that pupae can survive periods of approximately 1-2 weeks in soil, away from their host plants. The level of uncertainty in these assessments is low.

3.2.1.4 Probability of pest surviving existing pest management procedures

The likelihood of the pest to survive existing pest management procedures will vary from very unlikely to very likely depending on the commodity and the phytosanitary measures applied. For all pathways and all geographical origins the ability for the pest to remain undetected will be affected by the method of inspection by the exporting country's NPPO and if required by the Norwegian regulations. Similarly, the likelihood of the pest surviving any phytosanitary measures required by Norwegian legislation will depend on the effectiveness of their application and their efficacy. For each pathway ratings of the probability for survival, and uncertainties of the ratings, are given below. So far the Norwegian authorities are of the opinion that *L. huidobrensis* does not exist in Norway.

Pathway A. Import of host plants with eggs, larvae or pupae

It is moderately likely that *L. huidobrensis* will survive existing pest management procedures given by Landbruks- og matdepartementet (2000). The known entries into Norway are presented in Table 2. The pest may be present on plants even if the plants originate from an area in which there is an official statement that *L. huidobrensis* does not occur. It is also moderately likely that the pest will remain undetected on plants that are inspected and tested prior to export to the PRA area from greenhouses in areas where the pest occurs. The uncertainties of these assessments are low.

Pathway B. Import of soil/growing media with pupae

If *L. huidobrensis* is present in soil or growing media it is very unlikely to be detected and there is a high probability to survive existing pest management procedures. The uncertainties of these assessments are low.

Pathway C. Natural spread of adult flies by air

Free movement of insects with wind is impossible to control. Consequently, there is a possibility that *L. huidobrensis* might be wind-borne into the country if the species has an outbreak in a nearby country, or if the species in the future is established in greenhouses or the field in nearby countries. The uncertainty of this assessment is low.

3.2.1.5 Probability of transfer to a suitable host

Due to the polyphagy of *L. huidobrensis*, the probability of transfer to a suitable host after arrival in the PRA area is high, whatever the pathway of entry. Regarding the host plants, the pest is already present on a suitable host. It is very likely that the pest would be transferred to other hosts in Norwegian greenhouses and garden centres. The conditions in greenhouses and garden centers with close spacing of plants favour the dispersal of the pest. Furthermore, *L. huidobrensis* is very likely to transfer to a suitable environment, when sold to the consumer. The environments of parks and private gardens, at least along the coast of Norway, are very likely to support the pest during summer.

It is highly likely that *L. huidobrensis* could be transferred from plants in greenhouses to host plants in natural environments during the summer**.** This has been documented at least twice in connection with entries into Norway.

3.2.1.6 Summarised probability of entry for each pathway

Pathway A. Import of host plants with eggs, larvae or pupae

The likelihood of *L. huidobrensis* to be imported into the PRA area with host plants is rated as high, with low level of uncertainty. This is rated as the most likely pathway for entry of *L. huidobrensis* into the PRA area.

Pathway B. Import of soil/growing media with pupae

The likelihood of *L. huidobrensis* to be imported into the PRA area with contaminated soil is rated as low, with a high level of uncertainty.

Pathway C. Natural spread of adult flies from other European countries by air.

The likelihood of *L. huidobrensis* to enter the PRA area by natural spread is considered as low, with a high level of uncertainty. However, if the species is established in nearby countries like Germany, Poland, Denmark or Sweden in the future, such entries will be much more probable.

3.2.2 Probability of establishment

The probability of establishment of *L. huidobrensis* in the PRA area will vary with the availability of suitable hosts, suitability of the environment, biological characteristics of the pest, and the effects of existing pest management practices. The significance and the uncertainty for each of these topics are addressed in the following paragraphs (4.2.2.1 – 4.2.2.4).

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

L. huidobrensis has a very broad host range across a wide range of plant genera, and there is an abundant availability of suitable hosts in the PRA area. The uncertainty surrounding this data is low. *Chrysanthemum* sp. and *Exacum* sp. have been the imported plants most commonly infested with *L. huidobrensis* (Tables 1 and 2). Under natural conditions the pest has infested at least 104 plant species in 88 plant genera worldwide (Appendix 3), representing over 27 plant families (Table 5). Of these, many grow naturally or in greenhouses in Norway. Wild plants growing in Norway that has been confirmed infested in other countries are among others chickweed (*Stellaria media*), yarrow (*Achillea millefolium*), buttercups (*Ranunculus acris*), and sow thistles (*Sonchus arvensis*), although the topic has not been systematically investigated.

Table 6. Plant families that contain host species for *L. huidobrensis* (Spencer 1990, Sæthre 1996, Andersen *et al*. 2002, 2008, EPPO Reporting Service 2002 – September 2009, EPPO databases on quarantine pests, and unpublished material in the Norwegian Institute for Agricultural and Environmental Research).

Scientific name	**Scientific name**	**Scientific name**	**Scientific name**
Acanthaceae	*Campanulaceae*	*Gesneriaceae*	*Primulaceae*
Alliaceae	*Cannabaceae*	*Goodeniaceae*	*Ranunculaceae*
Alstroemeriaceae	*Caryophyllaceae*	*Lamiaceae*	*Scrophulariaceae*
Amaranthaceae	*Chenopodiaceae*	*Linaceae*	*Solanaceae*
Apiaceae	*Cucurbitaceae*	*Oxalidaceae*	*Verbenaceae*
Asteraceae	*Fabaceae*	*Papaveraceae*	*Violaceae*
Brassicaceae	*Gentianaceae*	*Polemoniaceae*	

3.2.2.2 Suitability of environment

The environmental conditions in greenhouses in the PRA area are considered to be suitable for *L. huidobrensis* all year round, with a low level of uncertainty. Outdoors, the environmental conditions are considered to be suitable for *L. huidobrensis* during the summer in some parts of the PRA area, with a low level of uncertainty. The assessments behind these conclusions are given below.

Climate is an important factor that affects establishment of *L. huidobrensis*, and climate suitability of the PRA area is therefore analysed in this section. The global distribution of the pest according to EPPO is shown in Appendix 1.

The monthly mean temperature in most parts of coastal Southern Norway in October – April (exemplified by Særheim, Ås and Kvithamar, Table 3) is lower than the lowest developmental temperature of *L. huidobrensis* of about 8 °C (Lanzoni *et al*. 2002). Consequently, *L. huidobrensis* could develop in the field only during five months each summer, but would have to stay in the pupal stage for the remaining seven months each winter.

L. huidobrensis was found in the field after incidents in Norwegian greenhouses in 1995, 2002 and 2003. In 1995 a single specimen was found outside the greenhouses in Rogaland County. In the growing season of 2002 the species was present in high numbers in the field around the primary infested greenhouses (see paragraph 4.1.4), and single specimens were

found outside four secondary infested greenhouses in the counties of Østfold, Buskerud and Akershus. Also in 2003 a single specimen was found outside an infested greenhouse in Østfold County. After the infestations in 1995 and 2002, field investigations the following year concluded that the species had not been able to overwinter in the field (Sæthre 1997, Johansen *et al*. 2004).

The present distributions show that the polyphagous quarantine *Liriomyza* species cannot successfully overwinter under natural conditions in the temperate areas. However, *Liriomyza* species have dispersed far beyond their apparent overwintering range limit, and in much higher-latitude regions with severe winter conditions, by opportunistic exploitation of protected microhabitats (Kang *et al.* 2009). The climatic conditions necessary for the development of *L. huidobrensis* has been investigated both in Asia, Europe and North America during the quick spread of the species towards the north in recent years, and is reported below.

In North America *L. huidobrensis* has been established in the field in Southern Ontario, Canada (Martin *et al.* 2005). The investigation by Scheffer *et al*. (2001) confirms that this is not *L. langei*, present further south in North America. In this area, at the same latitude (45° N) as Southern France and Northern Italy in Europe, the species cannot overwinter in the field (Martin *et al.* 2005). In Asia Chen & Kang (2004) has suggested that *L. huidobrensis* can overwinter in the field north to a latitude of approximately 35° N, with an isotherm of minus 5 °C in January. North of 35° N the species will have to overwinter in greenhouses and infest the fields each year. The species has also been established several places in Japan north to Hokkaido, at a latitude of approximately 45° N (Takano *et al.* 2008).

L. huidobrensis was found in field crops in Mecklenburg-Vorpommern in Northeastern Germany during the summer 1995. During the following winter, mean monthly temperatures of minus 3.4 – 3.9 °C were measured, with single days down to minus 15 °C. *L. huidobrensis* was not able to overwinter in the field under these circumstances (Kuhnke *et al*. 1998). An overwintering experiment was set up in the Netherlands during the winters 1990/1991 and 1991/1992. From pupae of *L. huidobrensis* stored in the field from November to March, experiencing 30 frost days and the lowest minimum of -11.5 °C, a mean of 9.1 % survived (van der Linden 1993).

In Portugal *L. huidobrensis* has been established as an important pest species, and due to the use of so-called open Mediterranean greenhouses, the pest can easily switch between greenhouses and the open field according to preferred temperatures at different times of the year (Godinho & Mexia 2000). These conditions are expected to be similar in other European countries along the Mediterranean, like Spain and Italy.

In Crete, Greece, *L. huidobrensis* has since 1992 been a serious pest species on several winter-grown cultures at temperatures fluctuating mainly between 10-20 °C (Roditakis & Golfinopopoulou 1997). Also in Israel the species has been an important pest species in field crops since 1995 (Weintraub 2001).

The lower threshold temperature for development of the different larval stages and the pupal stage in different *L. huidobrensis* populations were found to be 5.3 – 10.3 °C by He *et al.* (2000), 5.35 – 6.3 °C by Head *et al*. (2002), and 7.3-8.1 °C by Lanzoni *et al*. (2002). Taking into account the mean temperatures in coastal Norway in the period October – April (Table 5), this means that there will be almost no development of the species in the field during these seven months.

In conclusion, all scientific data suggest that *L. huidobrensis* will not be able to overwinter in the field even in the mildest areas of Norway. However, if growing host plants continuously

in greenhouses, the species will be able to develop large populations. The number of generations will vary with the temperature. At 20 °C the life-cycle takes 22.5 days, and 16 generations would develop per year, while at 25 °C the life-cycle is 16.1 days (Lanzoni *et al*. 2002), and 22 generations would develop per year.

3.2.2.3 Cultural practices and control measures

After establishment in greenhouses in the PRA area, the pest will be sought eradicated. In all situations so far this policy has been successful, so it is unlikely that the pest will be established in greenhouses over long periods of time.

Also the managed environment outside greenhouses in parts of the PRA area is favourable for establishment of *L. huidobrensis* during the summer months. It is unlikely that existing pest management practice in the PRA area will prevent spread of the pest in greenhouses or in the field. *L. huidobrensis* also has many host plants among commonly grown vegetables in Norway. Thus, if infested greenhouses are in the vicinity of agricultural fields, *L. huidobrensis* could become spread into the fields. However, so far such a situation has not been reported. Based on biological characteristics, it is likely that the pest during summer could survive pest management practices in the field in Norway. The uncertainty surrounding these questions is low.

Likelihood of the existing pest control management practice to prevent establishment of the pest in greenhouses

In Norway, dimethoate, thiacloprid, abamectin, spinosad and several pyrethroids are recommended pesticides against *L. huidobrensis* and other leafmining flies (Mattilsynet 2009). In addition, two parasitic wasp species and one nematode species are on the current list of biological agents against leafmining flies in Norway. Since eradication has been the chosen strategy by all incidents of *L. huidobrensis* into the PRA area, the effectiveness of these pest control methods has not been tested. However, due to the experience from control programs in other countries (e.g. Weintraub & Horowitz 1998, Weintraub 2001, Head *et al*. 2000, Civelek *et al*. 2004), we find it unlikely, with low uncertainty, that these pest management practises currently available in greenhouses, garden centres, parks, private gardens and fields in the PRA area would prevent establishment of *L. huidobrensis.*

Likelihood to survive eradication programs in the PRA area, based on the biological characteristics of the pest.

So far, eradication has been the chosen strategy by all incidents of *L. huidobrensis* into the PRA area. Important parts of the eradication program have been full sanitation of infested greenhouses (immediate destruction of all plant material, and heat treatment of the soil) and no growing of potential host plant species for a certain period of time. Due to the successful eradications of *L. huidobrensis* after all incidents in the PRA area, we find it unlikely that the pest could survive eradication programs in greenhouses in the PRA area. The uncertainty is low. In the field it is highly unlikely that *L. huidobrensis* can be eradicated by any means during the summer, but during the following winter it will die out.

Suitability of the managed environment in the PRA area for pest establishment

The managed environment around Norwegian greenhouses, garden centres, private gardens and public greens are all favourable to spread of *L. huidobrensis* during summer. The

uncertainty is low. In greenhouses and garden centres, host plants are abundantly available. Trade networks, which are common between Norwegian greenhouses and garden centres, favour a wider establishment of the pest. In parks, private gardens and natural areas, the environment is also considered favourable due to availability of hosts and conduct climate. Mutual use of equipments at different sites, are examples of management practises that will support the spread and establishment of *L. huidobrensis.* Once entered into the environment, spread is favoured by the short generation time and the ready availability of host plants.

3.2.2.4 Other characteristics of the pest affecting the probability of establishment

It is likely that the reproductive strategy of the pest and duration of its life cycle could aid establishment, and it is likely that a population could become spread in the field during the summer months. The pest is highly adaptable and has been introduced into many new areas outside its area of origin. In parts of the temperate zone *L. huidobrensis* infests crops in the field in summer even if it cannot overwinter outside greenhouses. This is due to repeated colonization from infested greenhouses every spring. The uncertainty is low for these assessments.

Probability of the reproductive strategy of the pest and the duration of its life cycle to aid establishment

L. huidobrensis has a reproduction strategy that most likely would favour quick spread in the field during summer, and all year round in greenhouses. In greenhouses, at 20 °C the life-cycle takes 22.5 days, and theoretically 16 generations could develop per year, while at 25 °C the life-cycle is 16.1 days (Lanzoni *et al*. 2002), and 22 generations could develop per year. This rapid development of successive generations is part of the explanation for the quick build-up of huge population. Another important factor both in the greenhouses and in the field is the wide host plant range that makes it probable for the pest to find host plants everywhere and the development of resistance to many insecticides in many populations. The uncertainty of this assessment is low.

3.2.3 Probability of spread after establishment

There is a high probability for *L. huidobrensis* to be spread quickly in the PRA area by trade of host plants. The uncertainty of this assessment is low. Planting of infested plants will bring the pest from the greenhouses into the environment.

Spread by natural means

L. huidobrensis has the opportunity for natural spread in the PRA area during the summer, and it is highly likely that this spread would be rapid. In Norway, natural spread of the pest has only been observed during the summer in areas around infested greenhouses along the southwestern and southeastern coast of the country. The situation around the primary greenhouses infested in 2002 demonstrated that *L. huidobrensis* in the field in Norway could spread in an area with a diameter of at least 1 km during the three summer months.

Long-distance dispersal by natural means includes movement by aerial dissemination of adult flies during major weather events such as wind driven rain and turbulent air. So far this has not been observed in Norway.

Spread by human assistance

There are very high probabilities for *L. huidobrensis* to be spread quickly by human-mediated means in the PRA area, most significantly through the commercial movement of infested plants for planting. The uncertainty of this assessment is low.

The potentially rapid spread within Norway by trade of infested host plants (even under statutory control) is confirmed by the situation that developed in 2002.

3.2.4 Conclusion on the probability of introduction and spread

Probability of entry

The overall probability of entry of *L. huidobrensis* into the PRA area is rated as high, with a low level of uncertainty. This assessment is based upon identification of pathways, import volume, the probability of the pest being associated with the pathway at origin, the probability of survival and multiplying during transport or storage and the probability of transfer to a suitable host after arrival.

Probability of establishment

The overall probability of establishment in greenhouses of *L. huidobrensis* in the PRA area is rated as high, with a low level of uncertainty. This assessment is based on an abundant availability of suitable hosts, suitability of the environment, biological characteristics of the pest, and the effects of existing pest management practices.

The overall probability of spread of *L. huidobrensis* outdoors in the PRA area is rated as moderate, with a low level of uncertainty. This assessment is based on the experience during the situation in 2002 (cf. 4.1.4.).

Probability of spread after establishment

The probability for *L. huidobrensis* to be spread quickly in the PRA area by trade of host plants for planting is rated as high. The uncertainty of this assessment is low. Planting of infested plants will bring the pest from the greenhouses into the environment. This can also happen if adult flies escape from the greenhouses through doors or windows. In parts of the PRA area where climate events are favourable, and where there is an abundance of continuous hosts, natural spread is likely to be high during the summer months. During the winter, all out-door populations will die out in the PRA area.

3.3. Assessment of potential economic consequences

3.3.1 Pest effects

3.3.1.1 Direct pest effects

The direct effects by *L. huidobrensis* include both the biological and aesthetical injury to the plants, cf. 4.1.5. Since *L. hudiobrensis* is listed as a quarantine pets in Norway, all specimens observed have been immediately eradicated. Large infestations have never been observed in Norwegian greenhouses with one exception in 2002. However, the economical consequences of this infestation event were largely due to an indirect pest effect as several commercial greenhouses were instructed to eradicate all host plants (cf. 4.3.1.2).

3.3.1.2 Indirect pest effects

The only large spread and infestation of a species in the genus *Liriomyza* which has been observed in Norway took place in 2002. That year *L. huidobrensis* was detected in greenhouses in Østfold, and during the next 3-4 weeks *L. huidobrensis* spread rapidly and was recorded from 26 garden centres or flower shops all over Norway. In addition 140 greenhouses and garden centres were checked. Two more records were done at garden centres and two more on imported plants at wholesale dealers (Willumsen 2002).

At all production units where *L. huidobrensis* was observed, the Norwegian Food Safety Authority (former Landbrukstilsynet) instructed all sales of plants to be stopped and that all infested plant material should be destroyed. No host plants should be introduced until the enterprise was declared free from the leafminer, and the Norwegian Food Safety Authority had to approve when such a declaration could be issued. Other sales units where *L. huidobrensis* observed were also instructed to destroy all plant material, and no host plants were allowed to be introduced until one month after the destruction and cleaning took place (Willumsen 2002).

3.3.2 Analysis of economic consequences

3.3.2.1 Analysis of commercial consequences

The leafminer *L. huidobrensis* is likely to have significant economic impact in Norwegian greenhouses without current phytosanitary measures. The present regulations with *L. huidobrensis* as a quarantine pest will initiate immediately destruction of plant material within parts or the complete greenhouse area. The economical consequences will depend on the amount and the total value of plant material destructed in each case.

The total economical consequences for Norwegian greenhouses due to the infestation of *L. huidobrensis* in 2002 was estimated to 40-50 million NOK (Miljøverndepartementet 2007).

3.3.2.2 Non-commercial and environmental consequences

Appearance of *L. huidobrensis* in natural areas in the PRA area could be a local threat to closely related species, mainly *L. bryoniae* and *L. strigata*, by competing over host plants. In addition it would cause locally high infestations in host plants. However, since the species will be eradicated during the winter, the threat to the environment, both plants and animals, is valuated as low.

3.3.3 Conclusion of the assessment of economic consequences

It is concluded that *L. huidobrensis* can cause significant damage to plants, both vegetables and ornamentals, in Norwegian greenhouses. In addition to the directs crop losses, *L. huidobrensis* will cause indirect economic consequences as the Norwegian Food Safety Authority will instruct that all plant material in an infested unit should be destructed. The significances of direct and indirect losses depend on how fast an infestation is observed and how fast a potential spreading by trade is stopped.

3.3.3.1 Endangered area

The PRA area where presence of *L. huidobrensis* might result in economically important losses is identified as Norwegian greenhouses and garden centres.

4. CONCLUSION OF THE PEST RISK ASSESSMENT

Pest status of the PRA area

The pest of concern in this pest risk assessment is the Agromyzid fly *Liriomyza huidobrensis*. The PRA area is Norway. *L. huidobrensis* is not present, and the pest is a quarantine species in the PRA area. It has been imported several times, but each time it has been eradicated.

Probability of introduction and spread

The overall probability of entry of *L. huidobrensis* into the PRA area is rated as high. This assessment is based upon identification of pathways, import volume, the probability of the pest being associated with the pathway at origin, the probability of survival and multiplying during transport or storage and the probability of transfer to a suitable host after arrival.

The overall probability of establishment of *L. huidobrensis* in greenhouses in the PRA area is rated as high. The probability of establishment in the field is rated as high during the summer months, but its ability to overwinter in the field in the PRA area is evaluated as very low. This assessment is based on an abundant availability of suitable hosts, suitability of the environment in at least parts of the PRA area, and biological characteristics of the pest.

The level of uncertainty of these assessments is low.

Conclusion regarding endangered areas

The part of the PRA area where presence of *L. huidobrensis* in greenhouses and nurseries might result in economically important losses (the endangered area) is assessed to be all of the country of Norway. This area must be regarded as a maximum estimate for the endangered area. In the field, the species would need a summer temperature of at least 15 °C to develop populations of a certain size to become a pest. This could happen in coastal areas of Southern and Middle Norway.

Conclusion of the assessment of economic consequences

The pest *L. huidobrensis* is likely to have moderate economic impact on the greenhouses in the PRA area with current phytosanitary measures. Without any such regulations *L. huidobrensis* would likely have major economic impact on the greenhouse industry of the PRA area.

L. huidobrensis is likely to have a low economic impact on outdoor crops in the PRA area.

The non-commercial consequences to natural environments in the PRA area are likely to be low.

The level of uncertainty of these assessments is low.

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Appendix 1

Appendix 1. Global distribution of *Liriomyza huidobrensis* (EPPO 2009, Bahlai *et al*. 2006)

Country	Widespread	Limited distribution	Few records	No details
Europe				
Cyprus	X			
Greece	X			
Spain	X			
Austria		X		
Belgium		X		
Croatia		X		
France		X		
Italy		X		
Malta		X		
Netherlands		X		
Poland		X		
Portugal		X		
Turkey		X		
United Kingdom		X		
Czechia			X	
Finland			X	
Germany			X	
Hungary			X	
Norway			X	
Bulgaria				X
Montenegro				X
Serbia				X
Switzerland				X
Asia				
Phillippines	X			
Taiwan	X			
China		X		

India		X		
Indonesia		X		
Israel		X		
Japan		X		
Sri Lanka		X		
Vietnam		X		
Korea			X	
Jordan				X
Lebanon				X
Malaysia				X
Singapore				X
Syria				X
Thailand				X
Africa				
Morocco		X		
South Africa		X		
Comoros				X
Mauritius				X
Reunion				X
Seychelles				X
America				
Chile	X			
Argentina		X		
Brazil		X		
Canada		X		
Colombia		X		
Dominican Republic		X		
USA		X		
Venezuela		X		
Peru		X		
Belize				X
Costa Rica				X

Equador				X
El Salvador				X
French Guiana				X
Guadeloupe				X
Guatemala				X
Honduras				X
Nicaragua				X
Panama				X
Uruguay				X
Oceania				
Guam			X	

Appendix 2

Appendix 2. EPPO report on notifications of non-compliance for *Liriomyza huidobrensis* (records of *Liriomyza* spp. are not included) (EPPO Reporting Service 2002 – September 2009)

Year	Consignment	Type of commodity	Country of origin	Destination
2009	*Eustoma grandiflorum*	Cut flowers	Kenya	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila paniculata	Cut flowers	Kenya	France
	Molucella	Cut flowers	Israel	Ireland
	Eryngium	Cut flowers	Kenya	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands
	Trachelium	Cut flowers	Ecuador	Netherlands
	Chrysathemum	Cut flowers	Columbia	Netherlands
	Chrysanthemum	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands
	Solidago	Cut flowers	Kenya	Netherlands
2008	*Aster*	Cut flowers	Ecuador	Netherlands
	Aster, Trachelium	Cut flowers	Ecuador	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands
	Eryngium alpinum	Cut flowers	Kenya	Netherlands
	Gysophila	Cut flowers	Ecuador	Netherlands

	Trachelium	Cut flowers	Ecuador	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Trachelium	Cut flowers	Ecuador	Netherlands
	Aster	Cut flowers	Zimbabwe	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands
	Eustoma	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Columbia	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands
	Lisianthus	Cut flowers	Kenya	Netherlands
	Molucella	Cut flowers	Israel	Ireland
	Eustoma	Cut flowers	Kenya	Netherlands
	Exacum affine	Plants for planting	Denmark	Norway
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Trachelium	Cut flowers	Ecuador	Netherlands
	Carthamus	Cut flowers	Netherlands	Ireland
	Chrysanthemum	Cuttings	Tanzania	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Eryngium	Cut flowers	Zimbabwe	United Kingdom
	Gypsophila	Cut flowers	Ecuador	Austria
	Gypsophila	Cut flowers	Ecuador	Italy
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Ecuador	United Kingdom
2007	*Chrysanthemum*	Cut flowers	Ecuador	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Chrysanthemum	Cut flowers	Costa Rica	Netherlands
	Eryngium	Cut flowers	Kenya	Netherlands

	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Eustoma	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Eryngium foetidum	Vegetables (leaves)	Zimbabwe	Netherlands
	Gypsophila	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands
	Molucella	Cut flowers	Israel	Ireland
	Unspecified	Vegetables (leaves)	Netherlands	United Kingdom
2006	*Eryngium*	Cut flowers	Zimbabwe	Netherlands
	Gypsophila	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands
	Molucella	Cut flowers	Israel	Ireland
	Unspecified	Leaves	Netherlands	United Kingdom
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Ecuador	Sweden
	Molucella	Cut flowers	Israel	Ireland
	Pisum	Vegetables	Kenya	United Kingdom
	Unspecified	Unspecified	Kenya	United Kingdom
	Chrysanthemum	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Ecuador	Sweden
	Gypsophila	Cut flowers	Israel	Netherlands
	Gypsophila paniculata	Cut flowers	Ecuador	Sweden
	Gypsophila paniculata	Cut flowers	Kenya	Netherlands

	Leucanthemum	Cuttings	Kenya	United Kingdom
	Moluccella	Cut flowers	Israel	Ireland
	Ocimum basilicum	Vegetables	Thailand	France
	Pisum	Vegetables	Kenya	United Kingdom
	Solidago	Cut flowers	Zimbabwe	Netherlands
2005	*Aster*	Cut flowers	Zimbabwe	Netherlands
	Dendranthema	Cut flowers	Costa Rica	Netherlands
	Eryngium	Cut flowers	Zimbabwe	Netherlands
	Eustoma	Cut flowers	Ecuador	Netherlands
	Eustoma	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Israel	Ireland
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Argyranthemum	Plants for planting	Germany	Finland
	Argyranthemum	Cuttings	Kenya	Finland
	Argyranthemum, Osteospermum	Plants for planting	Germany	Finland
	Dahlia	Plants for planting	Netherlands	United Kingdom
	Diascia	Cuttings	Kenya	United Kingdom
	Eryngium	Cut flowers	Ecuador	Netherlands
	Eryngium	Cut flowers	Israel	Ireland
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	United Kingdom
	Lisianthus	Cut flowers	Kenya	United Kingdom
	Petunia	Cuttings	Israel	United Kingdom
	Solidago	Cut flowers	Israel	Ireland
	Verbena	Cuttings	Ecuador	United Kingdom

	Verbena	Cuttings	Kenya	United Kingdom
	Verbena	Plants for planting	Netherlands	United Kingdom
	Lisianthus	Cut flowers	Brazil	Netherlands
	Gypsophila	Cut flowers	Israel	Netherlands
	Dendranthema	Cut flowers	Costa Rica	Netherlands
	Eryngium alpinum	Cut flowers	Kenya	Netherlands
	Gerbera	Plants for planting	Netherlands	Germany
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Netherlands	Ireland
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Lisianthus	Cut flowers	Brazil	Netherlands
	Ocimum basilicum	Vegetables	Israel	Ireland
	Ocimum basilicum	Vegetables	Thailand	Ireland
2004	*Aster*	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Netherlands	Ireland
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Phaseolus vulgaris	Vegetables	Guatemala	Ireland
	Phaseolus vulgaris	Vegetables	Kenya	Ireland
	Trachelium	Cut flowers	Ecuador	Netherlands
	Trachelium	Cut flowers	Ecuador	Netherlands
	Coriandrum savitum	Vegetables	Thailand	Ireland
	Dendranthema morifolium	Cut flowers	South Africa	Netherlands
	Dianthus	Cut flowers	Ecuador	Netherlands
	Eustoma	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Israel	Netherlands
	Lisianthus russelianus	Cut flowers	Columbia	United Kingdom
	Ocimum basilicum	Vegetables	Cyprus	Ireland

	Ocimum basilicum	Vegetables	Thailand	Ireland
	Scaevola aemula	Plants for planting	Denmark	Finland
	Aster	Cut flowers	South Africa	Netherlands
	Dendranthema morifolium	Plants for planting	Brazil	United Kingdom
	Eryngium	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Italy	Slovenia
2003	*Carthamus*	Cut flowers	Kenya	United Kingdom
	Eryngium alpinum	Cut flowers	Kenya	United Kingdom
	Gypsophila	Cut flowers	Netherlands	Ireland
	Gypsophila perfecta	Cut flowers	Netherlands	United Kingdom
	Molucella	Cut flowers	Netherlands	United Kingdom
	Allium cepa	Vegetables	USA	United kingdom
	Argyranthemum frutescens	Cutting	Germany	Finland
	Exacum affine	Pot flowers	Belgium	United Kingdom
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Israel	Ireland
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Netherlands	Ireland
	Pisum savitum	Vegetables	Kenya	Netherlands
	Pisum savitum	Vegetables	Zambia	United Kingdom
	Primula elatior	Plants for planting	Netherlands	United Kingdom
	Trachelium	Cut flowers	South Africa	Netherlands
	Dendranthema morifolium	Cut flowers	Netherlands	United Kingdom
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Gypsophila	Cut flowers	Israel	Ireland

	Gypsophila	Cut flowers	Israel	Netherlands
	Gypsophila	Cut flowers	Kenya	Netherlands
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Lisianthus	Cut flowers	Ecuador	Netherlands
	Pisum sativum	Vegetables	Kenya	Netherlands
	Trachelium	Cut flowers	South Africa	Netherlands
	Pisum sativum	Vegetables	Zambia	United Kingdom
	Gypsophila, Rosa	Cut flowers	Israel	Netherlands
	Allium fistulosum	Vegetables	Kenya	United Kingdom
	Bupleurum, Molucella laevis	Cut flowers	Netherlands	United Kingdom
	Carthamus	Cut flowers	Israel	United kingdom
	Dendranthema	Cut flowers	Netherlands	Ireland
	Dianthus	Plants for planting	Netherlands Antilles	United Kingdom
	Gypsophila	Cut flowers	Ecuador	Netherlands
	Gypsophila	Cut flowers	Israel	Ireland
	Gypsophila	Cut flowers	Israel	Netherlands
	Gypsophila paniculata	Cut flowers	Netherlands	United Kingdom
	Lamium	Cuttings	Portugal	United Kingdom
	Lisianthus	Cut flowers	Netherlands	United Kingdom
	Phaseolus vulgaris	Vegetables	Kenya	Ireland
	Thunbergia alata	Plants for planting	Netherlands	Finland
	Verbena	Plants for planting	Netherlands	Finland
	Pisum	Vegetables	Kenya	United Kingdom
	Pisum sativum	Vegetables	Kenya	Netherlands
	Pisum sativum	Vegetables	Kenya	United Kingdom
	Trigonella	Vegetables	Cyprus	United

	foenum-graecum			Kingdom
	Verbena	Cuttings	Kenya	United Kingdom
	Pisum	Vegetables	Kenya	United Kingdom
	Carthamus	Cut flowers	Netherlands	United Kingdom
	Chrysanthemum	Plants for planting	Netherlands	United Kingdom
	Chrysanthemum morifolium	Cut flowers	South Africa	Netherlands
	Eruca	Vegetables	Lebanon	France
	Eruca vesicaria	Vegetables	Cyprus	United Kingdom
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Gypsophila paniculata	Cut flowers	Israel	United Kingdom
	Moluccela laevis	Cut flowers	Israel	United Kingdom
	Pisum	Vegetables	Kenya	United Kingdom
	Pisum	Vegetables	Zambia	United Kingdom
	Pisum sativum	Vegetables	Kenya	Netherlands
	Pisum sativum	Vegetables	Kenya	United Kingdom
	Pisum sativum	Vegetables	Zimbabwe	United Kingdom
	Pisum sativum	Vegetables	South Africa	United Kingdom
	Pisum sativum	Vegetables	Zambia	United Kingdom
	Dendranthema hybrids	Cuttings	Kenya	Finland
	Gypsophila	Cut flowers	Israel	France
	Pisum sativum	Vegetables	Kenya	Netherlands

	Pisum sativum	Vegetables	Zambia	Netherlands
	Pisum sativum	Vegetables	Zimbabwe	Netherlands
2002	*Dendranthema*	Pot plants	Netherlands	Norway
	Gypsophila	Cut flowers	Netherlands	United Kingdom
	Pisum sativum	Vegetables	Zambia	Netherlands
	Zinnia augustifolia	Plants for planting	Netherlands	United Kingdom
	Bupleurum	Cut flowers	Kenya	United Kingdom
	Bupleurum griffithii	Cut flowers	Israel	United Kingdom
	Centaurea	Cut flowers	Italy	United Kingdom
	Dahlia	Plants for planting	Netherlands	United Kingdom
	Dianthus	Cut flowers	Turkey	Netherlands
	Gypsophila	Cut flowers	Israel	Germany
	Pisum sativum	Vegetables	Kenya	Netherlands
	Cucumis sativus	Plants for planting	Netherlands	United Kingdom
	Cineraria	Plants for planting	Italy	United Kingdom
	Ocimum basilicum	Vegetables	Israel	Ireland
	Osteospermum	Cuttings	Italy	United Kingdom
	Pisum sativum	Vegetables	Kenya	Netherlands
	Pisum sativum	Vegetables	Kenya	United Kingdom
	Beta vulgaris, Trigonella foenum-graecum	Vegetables	Cyprus	
	Coriandrum sativum	Vegetables	Cyprus	United Kingdom
	Coriandrum sativum	Vegetables	Thailand	Ireland
	Dendranthema	Cut flowers	Netherlands	Estonia
	Dendranthema	Cut flowers	South Africa	Netherlands
	Pisum sativum	Vegetables	Kenya	United

				Kingdom
	Pisum sativum	Vegetables	Zimbabwe	United Kingdom
	Trigonella foenum-graecum	Vegetables	Cyprus	United Kingdom
	Pisum sativum	Vegetables	Kenya	United Kingdom

Appendix 3

Appendix 3. Host plants for *Liriomyza huidobrensis* (Sæthre 1996, Andersen *et al*. 2002, 2008, EPPO Reporting Service 2002 – September 2009, EPPO databases on quarantine pests, and unpublished material in the Norwegian Crop Research Institute).

Host species	**Major host = A; Minor host or not classified = B**
Achillea sp.	B
Allium ampeloprasum	B
A. cepa	A
A. fistulosum	B
A. sativum	A
Alstromeria sp.	B
Amaranthus sp.	B
Anemone sp.	B
Anthirrhinum sp.	B
Apium graveolens	A
Argyranthemum frutescens	B
Argyranthemum sp.	B
Aster sp.	A
Bellis sp.	B
Beta vulgaris	A
Brassica campestris	B
B. juncea	A
B. oleracea	B
B. rapa	B
Bupleurum griffithii	B
Bupleurum sp.	B
Calendula sp.	B
Callistephus chinensis	B
Cannabis sativa	B
Capsicum annuum	A
Carduus sp.	A
Carthamus sp.	B
Centaurea sp.	B

Chrysanthemum frutescens	A
C. morifolium	A
Cichorium endivia	B
Cineraria sp.	B
Cirsium arvense	B
Coriandrum savitum	B
Cucumis melo	A
C. sativus	A
Cucurbita pepo	B
Dahlia pinnata	B
Dahlia sp.	B
Datura sp.	B
Daucus carota	B
Dendrathema moripholium	B
Dendrathema sp.	B
Dianthus barbatus	B
D. caryophyllus	B
D. chinensis	B
Dianthus sp.	B
Diascia sp.	B
Eruca vesicaria	B
Eruca sp.	B
Eryngium alpinum	B
E. foetidum	B
Eryngium sp.	B
Eustoma grandiflorum	B
Eustoma sp. (syn. *Lisianthius*)	B
Exacum affine	B
Exacum sp.	B
Galinsoga sp.	B
Gazania sp.	B
Gerbera sp.	B
Glechoma hederacea	B
Gypsophila paniculata	A

G. perfecta	B
Gypsophila sp.	B
Lactuca sativa	A
Lamium sp.	B
Lathyrus sp.	B
Leucanthemum	B
Liatris sp.	B
Linum sp.	B
Lobelia sp.	B
Matricaria sp.	B
Matthiola incana	B
Medicago sativa	B
Molucella laevis	B
Molucella sp.	B
Nicotina alata	B
Ocimum basilicum	B
Oxalis sp.	B
Petasites hybridus	B
Petroselinum crispum	B
Petunia hybrids	B
Phaseolus vulgaris	A
Phlox drummondii	B
Pisum sativum	A
Pisum sp.	B
Primula elatior	B
P. obconica	B
P. polyantha	B
Ranunculus sp.	B
Raphanus sativus	B
Saponaria sp.	B
Scaevola aemula	B
Senecio vulgaris	B
Solanum lycopersicum	B
S. melongena	B

S. nigrum	B
S. tuberosum	A
Solidago sp.	B
Solidaster sp.	B
Sonchus sp.	B
Spinacia oleracea	A
Stellaria sp.	B
Tagetes erecta hybrids	B
Thunbergia alata	B
Trachelium sp.	B
Trigonella foenum-graecum	B
Tropaelum majus	B
Verbena hybrids	A
Vicia faba	B
Vigna radiata	B
Viola sp.	B
Zinnia augustifolia	B
Zinnia sp.	B