Report of a Pest Risk Analysis

agriculture, nature
and food quality

Pest: CNIDOCAMPA FLAVESCENS

PRA area: The Netherlands

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Fig. 1. Moth of *C. flavescens*


Fig. 2. Larva of *C. flavescens*

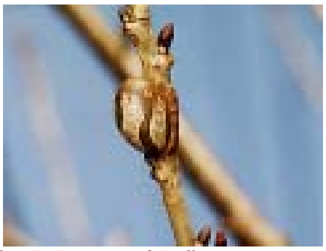
Fig. 3. Cocoon of *C. flavescens*

December 2004

1. INITIATION

1.1 Reason for doing PRA

During a number of years, the Plant Protection Service intercepted *Cnidocampa flavescens* several times in consignments *Acer* and *Zelkova* plants originating from Asian countries. A preliminary (short) risk assessment indicated that this oriental moth was a potentially harmful organism for the Netherlands. However, a more extended pest risk assessment was needed to study the level of risk in more detail.

1.2. Taxonomic position of pest

Order: Lepidoptera
  Family: Limacodidae
    Genus: Cnidocampa Dyar, 1905 (Monema Walker, 1855)
      Species: flavescens Walker, 1855

Common name: Oriental moth

2. PROBABILITY OF INTRODUCTION

2.1 Entry

2.1.1 Geographical distribution

Parts of China, Japan, Korea, Taiwan, USA and Russia

It is believed that Asia is the area of origin of *C. flavescens.* The current most likely area of distribution of *Cnidocampa flavescens* is: parts of China, Japan, Korea, Taiwan, USA and Eastern Siberia, Russia (Claussen, 1978; CAB International, 2003; Tang ZhiXiang and Tang, 2001; Claussen, 1978; Dowden, 1946). The oriental moth established near Boston in 1906, outside its area of origin (*Dowden, 1946; Clausen 1978*). In the years after 1906, it became clear that the species had established successfully in the State of Massachusetts (Claussen, 1978; Dowden, 1946). In Japan, the species is present and common throughout the country (*Yamada 2004, Insect Ecology Lab, Faculty of Bioresources Mie University, Japan, personal communication to W. Lammers*). Little is known about its distribution in other parts of the current area of distribution.

There are no records of introductions elsewhere.

2.1.2 Major host plants

Several major (fruit) tree species

A large number of tree species is reported as host plant species for *C. flavescens* (Table 1). Several of these trees are common and widespread in the Netherlands.

Table 1. Common and scientific names of species recorded as hosts of *C. flavescens*

Name	Scientific name	Reference
Norway Maple	*Acer platanoides*	*Collins, 1933; Dowden, 1946 ; Zhang 1994*
Sycamore Maple	*A. pseudoplatanus*	*Dowden, 1946*
Aspen	*Populus spp.*	*Hofacker, 2003 (personal comm.)*
Black Birch	*Betula nigra*	*Dowden, 1946*
Sweet Birch	*Betula lenta*	*Wildwnc.org*
Cherry (wild and cultivated)	*Prunus spp.*	*Clausen, 1978; Dowden, 1946; Togashi and Ishikawa, 1994*
Apple	*Malus spp.*	*Clausen, 1978; Togashi and Ishikawa, 1994*
Pear	*Pyrus spp.*	*Clausen, 1978; Dowden, 1946; Togashi and Ishikawa, 1994*
Plum	*Prunus spp.*	*Clausen, 1978; Dowden, 1946; Togashi and*

		Ishikawa, 1994
Willow	*Salix spp.*	*Yamada, 1992; CAB International, 2003*
	Salix chaenomeloides	*CAB International, 2003*
Malabar ebony	*Diospyros malabarica*	*CAB International, 2003*
Chestnut	*Castanea spp.*	*Togashi and Ishikawa, 1994; CAB International, 2003*
Walnut	*Juglans spp.*	*Jia-Xi You, 2001; CAB International, 2003*
(Japanese) Persimmon	*Diospyros spp.*	*Tao. et al. 1997 ; Clausen 1992; Togashi and Ishikawa, 1994*
Zelkova tree	*Zelkova*	*Togashi and Ishikawa, 1994*
Citrus	*Citrus reticulata*	*Anonymous, 2002*
Jujube	*Ziziphus sp*	*Canadian Food Inspection Agency, 2004*

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

Imported host tree species originating from the current area of distribution.

In The Netherlands, *Cnidocampa flavescens* has been intercepted several times in bonsai plants (*Zelkova*) and Acer trees for planting during import inspections and post-import inspections, indicating that the pest is able to survive existing commercial practices. The cocoon was always the intercepted (observed) life-stage. In Canada, *C. flavescens* was intercepted once in *Ziziphus sp*. originating from China (*Canadian Food Inspection Agency, 2004*).

Also other host plant trees could act as a pathway, but *Prunus spp, Malus spp* and *Pyrus spp* are not allowed to be imported in the EU from the Asian region. Import inspection data from the Dutch PPO are presented in table 2. This indicates that *Acer spp* and *Zelkova* represent the highest entry risk.

Table 2. Import inspection data (NL) for imported host plants from the countries where *C. flavescens* is present (November 2002 – October 2004)

Latin name	Country of origin	Number of imported plants
Acer spp.	China	2,357,654
	Japan	121,322
	USA	Unreliable data
	South Korea	1,834,855
Acer spp TOTAL		***> 4,3 Million plants***
Zelkova	China	616,434
	Japan	24
Zelkova TOTAL		***616,458***
Salix spp.	China	20,000
	Taiwan	240
Salix spp TOTAL		***20,240***

Betula spp.	China	490
	Japan	16,000
	USA	52
Betula spp TOTAL		***16,542***
Diospyros spp.	China	6
	Thailand	16
	South Korea	3
Diospyros spp TOTAL		***25***
Castanea spp	Total area of distribution	0
Juglans spp	Total area of distribution	0
Populus spp	Total area of distribution	0
Citrus spp	Total area of distribution	0
Prunus spp	Total area of distribution	0
Malus spp	Total area of distribution	0
Pyrus spp	Total area of distribution	0

Council Directive 2000/29/EC does not require any specific obligatory phytosanitary measures for *Acer, Betula, Salix, Diospyros and Juglans* plants. Certain phytosanitary requirements – non-specific for *C. flavescens* – are in force for the other host plants and bonsai plants in general, but some *C. flavescens* specimens have been intercepted in the past. During phytosanitary inspections, cocoons could remain undetected because they are camouflaged quit well. The larvae of the oriental moth, however, are very distinctive.

2.2 Establishment

2.2.1 Crops at risk in the Netherlands

Several (fruit) tree species

Many of the listed host plants (Table 1) are present in the NL, either commercially grown and / or in nature and alongside roads. Plant species like cherry, apple, pear, poplar, walnut and willow are common and widespread in the NL. Transfer from the pathway to ´natural host plants´ is very likely, and consequently these host plants can play a significant role in dispersing and maintaining *C. flavescens.*

2.2.2 Climatic similarity of present distribution with the Netherlands

A climate match carried out with the CLIMEX program (Suthurst and Maywald, 1985) indicates that the Netherlands have climatic conditions comparable to those in the known area of distribution, especially Japan and Boston. Factors included in the study are minimum and maximum temperature and air humidity. Dubatolov (*2004, Siberian Zoological Museum, Institute of Animal Systematics and Ecology, Novosibirsk, Russia, personal communication to W. Lammers*) and Yamada (*2004, Insect Ecology Lab, Faculty of Bioresources Mie University, Japan, personal communication to W. Lammers*) also assume that the climatic conditions in the Netherlands are suitable for establishment of *C. flavescens*.

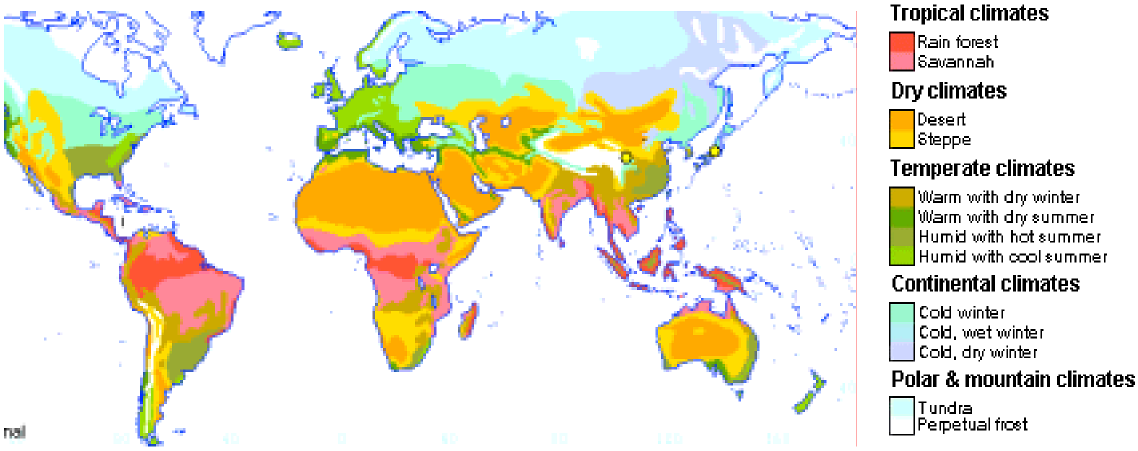

Fig 4. World climate zones (Köppen-system)

Cnidocampa flavescens seems to be able to survive under a wide temperature range (cold winters in Siberia and Japan and warm summers in Central China), which can be an indication for its wide potential area of distribution (Fig 4).

2.2.3 Aspects of the pest's biology that would favour establishment

Cocoons are well camouflaged and females lay many eggs.

The cocoons of *C. flavescens* are very well camouflaged and may remain unnoticed until emergence of the moths. Additionally, if present, moths could fly away immediately after opening a container and find a suitable host plant (in nature). As stated before, several host plants are common and widespread, both in nature and in cultivated landscapes in nature (willow, apple, pear etc.).

Looking at the life-cycle of *C. flavescens* in the current area of distribution (Fig 5), there are only one or two generations to be expected in The Netherlands (*Yamada, 1987, 1992; Tang-ZhiXiang; Dowden, 1946; Clausen, 1978* and *Tang, 2001*). A mated female, however, may lay 500 – 1,000 eggs (*Clausen, 1978*).

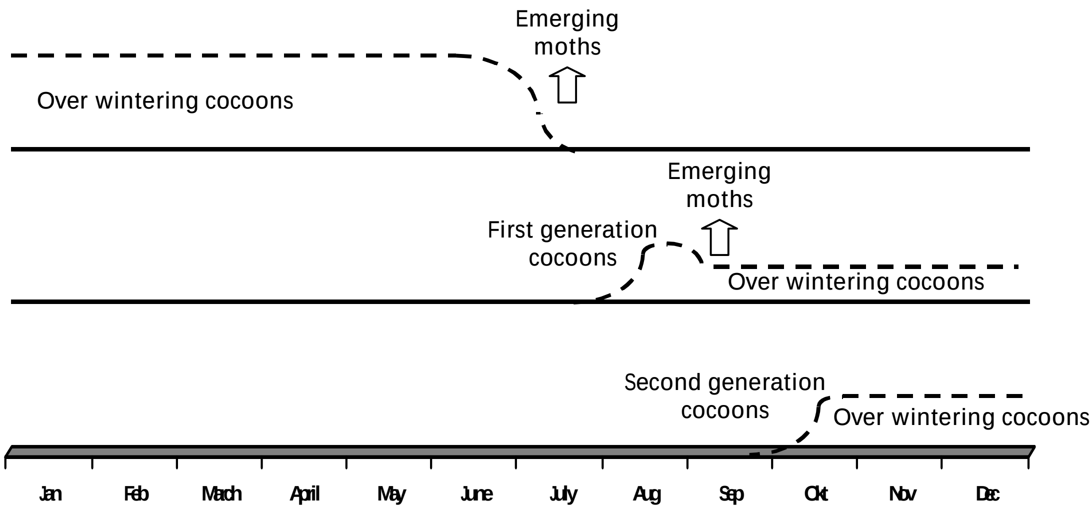

Fig 5. Schematic representation of the life-cycle of *Cnidocampa flavescens* (*Yamada, 1987*)

In general, low densities in populations are subject to the *Allee-effect*, which may reduce the rate at which the invader moves into a new environment (*Lewis & Kareiva, 1993*). One frequent cause of Allee effects is a scarcity of reproductive opportunities at low densities. For example, in some insect populations, difficulty in locating conspecific mates will reduce the likelihood that individuals in the next generation will produce offspring. However, in 1906 the oriental moth was able to establish in the state of Massachusetts (USA), but the circumstances are unknown. It is important to realise that whatever the impact of the *Allee-effect* on establishment and spread might be, it does not completely minimize the establishment risk of small numbers of introduced specimens. Especially the entry of mated females represents a high risk.

2.2.4 Other characteristics that might favour establishment

Absence of natural enemies

It is believed that all known parasitic species are not present in the Netherlands. If, theoretically speaking, parasitoids are already present in the Netherlands, they might decrease population levels but most likely will not prevent establishment. In Japan, several parasitoids of the oriental moth are present: *Praestochrysis (= Chrysis) shanghaiensis*, *Eurytoma monemae* and *Chaetexorista eutachinoides,* (*Togashi and Ishikawa, 1994*; *Yamada, 1987*). Zheng *et al* (1992) stated that the insect *Arma custos* (Fabricius) preys on 40 species, with a preference for the larvae of *Cnidocampa flavescens*. Other known natural enemies are *Chaetexorista atripalpis,* and *Chaetexorista javana* (*Clausen, 1978; Dowden, 1946*), all attacking larvae from *Cnidocampa flavescens*. However, Yamada (1992) suggests that some ant and bird species might have a regulatory effect on the oriental moths population also, due to predation. Also Fuester (*2004, Beneficial Insect Lab. University of Delaware, Newark USA, personal communication to W. Lammers*) assumes that there are a number of generalist natural enemies, like *Chaetexorista javana,* that attack the oriental moth in addition to the known specific parasitoids*.*

Another factor that favours establishment is the intended use of the imported host plants: many of these host plants are used for planting in the open. Therefore, transfer from the pathway to host plants in nature or on commercial sites could occur, finally resulting in establishment. Natural host plants would probably play an important role in establishment of the species. In general, there are no control measures used in nature that could prevent establishment of the oriental moth.

Although it is uncertain if *C. flavescens* really needs specific abiotic factors for survival and establishment, it is likely that such essential ´abiotic conditions´ for *C. flavescens* are also present in the Netherlands because the oriental moth is present in the entire country of Japan (*Yamada, 2004, Insect Ecology Lab, Faculty of Bioresources Mie University, Japan, personal communication to W. Lammers*).

2.2.5 Which part of the Netherlands is the endangered area?

It is very likely that *C. flavescens* can establish and survive throughout the Netherlands. Especially solitary host plant trees and orchards are probably the endangered area. These are the places where *C. flavescens* appears mostly in Japan. It appears much less frequent in forests or groups of trees, which might be due to the high predation pressure in such habitats and the moth's low oviposition on shaded trees. (*Yamada*, *2004, Insect Ecology Lab, Faculty of Bioresources Mie University, Japan, personal communication to W. Lammers*).

3. ECONOMIC IMPACT ASSESSMENT

3.1 How much economic impact does the pest have in its current distribution area?

The damaging effect of *C. flavescens* consists of the young larvae feeding upon surface tissues of the underside of the leaves (where the eggs are laid), while the older larvae consume the entire leaf except the midrib and main veins (*Clausen, 1978*).

Japan

Yamada (*2004, Insect Ecology Lab, Faculty of Bioresources Mie University, Japan, personal communication to W. Lammers*) indicates that the oriental moth appears frequently in open fields and sometimes damages its host plants. The species does not cause problems in forests or a group of trees. This might be due to the high predation pressure in such habitats and the moth's low oviposition on shaded trees. Preliminary experiments carried out by Dr Yamada indicated that some ant species are egg predators as well.

At this moment, a parasitoid of the oriental moth is present in Japan (*Praestochrysis (= Chrysis) shanghaiensis*). It is assumed that the damage levels caused by the moth were higher during the time this parasitoid was absent compared to the current time when *Cnidocampa flavecens* causes defoliation only very rarely. It is impossible to assess the total damage in Japan before and after the introduction of the parasitoid because there is data available.

Russia

Dubatolov (*2004, Siberian Zoological Museum, Institute of Animal Systematics and Ecology, Novosibirsk, Russia, personal communication to W. Lammers*) has not observed much damage in nature in Eastern Siberia, but sometimes the oriental moth was recorded as a pest species in gardens and tree nurseries in the Russian Far East (Primorskii Krai territory). The damage levels in Eastern Siberia are most likely influenced by the presence of predators as well.

USA

C. flavescens established in the USA in 1906 and spread slowly (*Clausen, 1978*). In 1906, 3 square miles was determined as infested, in 1916 about 12 square miles were known to be infested and in 1942, the infested area was approximately 300 square miles in size (*Dowden, 1946*). *Cnidocampa flavescens* is still present in Massachusetts at this moment (*Carlson, 2003, System Entomology Laboratory. Smithsonian Institution, Washington DC, personal communication to W. Lammers*).

Dowden (1946) made a precise description of the damage caused by the oriental moth: larvae feed on the foliage of a wide variety of trees. Norway maple is preferred, but pear, apple, cherry, plum, black birch and sycamore maple are often fed on extensively. Infested trees are only slightly injured, because defoliation does not usually occur before late September. However, the larvae are a considerable nuisance, because their spines cause a nettle-like poisoning or irritation when the come in contact with a person's skin. *C. flavescens* attracted little attention from 1906 until 1921 in Boston area. In 1921, considerable defoliation was observed in the Roxbury and Dorchester sections of Boston. Heavy infestations persisted in this area until 1929, when there was noticeable decrease and since then no feeding was observed in this region (=until 1946, no data for the period after 1946). In 1923, some feeding occurred north of Boston, and, although only a few trees were involved, the number of defoliated trees increased steadily through 1932. Decrease and increase of the number of defoliated trees was observed until 1938. From 1938 – 1946, light to medium infestations persisted in small, isolated localities throughout the infested area.

Dowden (1946) indicates that the introduced parasitoid *Chaetexorista javana* probably played an important role in the fluctuations of population (and damage) levels, but the fluctuations cannot be explained totally by the presence of this species. He also states that the dispersion of *C. flavescens* has been surprisingly slow in the Boston area. Its ability to develop on a great variety of common plants and its tolerance to wide variations in climate indicate a larger potential distribution area in the USA.

Since 1946, no reports could be found on damage caused by *C. flavescens* in this area. According to Hofacker (2003, Forest Health Protection, USDA Forest Service, personal communication), it is clear that at this moment *Cnidocampa flavescens* does not cause much trouble in the USA since there is hardly any knowledge on the damaging effect of the species.

In summary, *Cnidocampa flavescens* seems to cause damage to its host plants in the current area of distribution occasionally, but there is little evidence (literature) to verify this. Also, the frequency and scale of damage is unknown. Natural enemies most likely influence the damage levels in the area of origin. In the *newly* infested area around Boston, damage was observed from 1921 until 1946 as described by Dowden (1946). An introduced parasitoid most likely caused fluctuations in population levels of *C. flavescens*. Defoliation occurs in September, and therefore trees do not suffer much. There are no reports indicating (significant) economic losses on commercially grown crops (fruit trees, walnut). XiYou *et al* (2001) refer to *Cnidocampa flavescens* as one of the main pests of walnut in the Lulong county (Hebei Province). However, there is no indication of what the phrase '*main pest*' means quantitatively.

The larvae are considered a nuisance to humans (*Dowden, 1947; Clausen, 1978; Dubatolov, 2003, Siberian Zoological Museum, Institute of Animal Systematics and Ecology, Novosibirsk, Russia,* *personal communication to W. Lammers*). The allergic reaction can be compared with the reaction after touching a stinging nettle plant (*Urtica dioica*).

3.2 How much economic impact would the pest have in the Netherlands?

In 1906, the oriental moth was observed on 3 square miles near Boston in the state of Massachusetts. In 1916, about 12 square miles were infested and in 1942, the infested area was approximately 300 square miles in size (*Dowden, 1946*). This could be an indication for the slow natural spread of the species. Lewis and Kareiva (1993) state that, in general, low population densities are subject to the *Allee-effect*, which may substantially reduce the rate at which the invader moves into a new environment. However, the PRA area (NL) is a small area. Therefore, large parts of the Netherlands could become infested in a rather short period, especially if we consider that natural enemies are absent in the Netherlands.

In the current area of distribution, defoliation caused by the larvae of *Cnidocampa flavescens* is observed sometimes on its host plants. The expected minimum impact scenario in the Netherlands is a scenario that is comparable to the damage observed in the current area of distribution: occasional aesthetic damage (defoliation) occurring mainly in solitary trees in nature or alongside roads. This impact should be rated ‘low’. However, natural enemies most likely influence the damage levels. Considering the absence of natural enemies in the Netherlands, somewhat higher population (and damage) levels might be expected in the first years after establishment.

Defoliation occurs in September, and consequently trees do not suffer much. In general, defoliation of fruit trees results in lower yields and in reduced numbers and sizes of fruits (*Baufeld and Freier, 1991; Peterson et al, 1996*). Some plant species are be able to withstand high levels of defoliation, without resulting into yield losses. An example is cotton, which seems to be able to withstand defoliation levels up to 57% without showing significant yield loss (*Mascarenhas et al, 1999*).

Some people will react allergic to the hairs of the larvae. The allergic reaction can be compared with the reaction after touching a stinging nettle plant (*Urtica dioica*). An allergic reaction only occurs of the larvae are being touched. This is different from the situation with oak procession caterpillars (*Thaumetopoea processionea*), whose hairs are being spread by the wind from infested (oak) trees.

4. Pest Risk Management

Probably, eradication or containment in nature will be impossible, because many host plants are present within the Netherlands and control measures aside from biological control are unknown at this moment. Measures in public green would be nearly impossible to carry out. Control of the oriental moth might be hampered by the fact that several life-cycle stages are present at the same time; In Japan, the moths emerge from the over-wintered cocoons from late June to early July. These adults lay eggs, resulting in larvae and the so-called 'first generation cocoons' appear from late July to early August. The story repeats itself one more time and the 'second generation cocoons' appear from October through November (*Yamada, 1987*). Suppression of population levels below the economic (environmental) threshold might be achieved with natural enemies, which are currently absent in the PRA region.

On the 'farm-level', it is more likely that containment or eradication could be achieved if effective (non-) chemical measures are available. Fuester (*2003, Beneficial Insect Lab. University of Delaware, Newark USA, personal communication to W. Lammers*) assumes that spray schedules in orchards eliminate infestations.

5. CONCLUSIONS OF PRA

5.2 Estimate the probability of entry

Cnidocampa flavescens is able to enter the Netherlands. Interceptions in this country and Canada on several host plant species originating from Asia indicate that this is possible. The entry risk is different for each of the identified pathways because of the varying volume of imported host plants: during the past two years, more than 4 Million *Acer* plants (bonsai and *regular* plants) were traded to the Netherlands from countries where *C. flavescens* is present at this moment. Other host plants that were imported from the current area of distribution on a large scale during the past two years are *Zelkova* (bonsais; 616,000), *Salix* (20,000) and *Betula* (16,000). *Castanea spp., Juglans spp., Populus, spp., Citrus spp., Prunus spp., Malus spp.* and *Pyrus spp.* were not traded to the Netherlands from the *C. flavescens* current area of distribution, partly because of import restrictions (Council Directive 2000/29/EC).
The trading of host plants is considered the only likely pathway for introduction of the oriental moth in the EU.

ENTRY RISK: **MEDIUM - HIGH**

5.3 Estimate the probability of establishment

After entry in the EU, *C. flavescens* is likely to be able to establish and survive. Host plant species such as willow, apple, pear, cherry, walnut and poplar are commonly present in nature as well as in orchards and tree nurseries throughout The Netherlands. Therefore, the species is likely to be able to migrate from the host plant, which acted as a pathway, to other host plants. Moreover, the climatic conditions in The Netherlands are comparable to parts of the species' current area of distribution. Low numbers of introduced specimens might have scarce reproductive opportunities because of the low population densities (Allee effect)

ESTABLISHMENT RISK: **HIGH**

5.4 Estimate the potential economic impact

According to several experts, the oriental moth incidentally causes damage in its native area (Asia), especially on solitary trees and in orchards. Damage in forests does not seem to occur or at least less often. However, there is no (scientific) information known on the damage levels and the frequency of observed damage. The only indication that *Cnidocampa flavescens* should be treated seriously comes from indirect information in a few scientific articles stating that the oriental moth is '*a serious pest*' or is regarded as '*one of the main pests*' in a certain area.

The vicinity of Boston, state of Massachusetts (USA) became infested with *Cnidocampa flavescens* in 1906. In the following 40 years, varying degrees of defoliation were observed and described. Defoliation occurs in late September in the USA, consequently resulting in only slightly injured host trees. Although the species is still present in Massachusetts, there are no recent reports of minor or major damage occurring in this *newly* infested area. A parasitoid that was introduced shortly after introduction is likely to have a reducing effect on population and damage levels. If the species causes significant damage in the USA at this moment, there would be more information available on this subject. In comparison, outbreaks of the gypsy moth in the USA also resulted in the introduction of natural enemies by man during the same period as the oriental moth (1920's). However, there are many sources of recent and up-to-date information available for the gypsy moth (18,400 Google hits), while the oriental moth is virtually un-described in literature and unknown to scientists in the USA (80 Google hits). Higher population and damage levels might be expected in The Netherlands because natural enemies are absent, but it is impossible to estimate these levels.

An unwanted side effect of *C. flavescens* is that some people are allergic to the hairs of the larvae, comparable to the reaction after touching a stinging nettle plant.

ECONOMIC IMPACT IN ABSENCE OF NATURAL ENEMIES: **LOW – MEDIUM**
ECONOMIC IMPACT IN PRESENCE OF NATURAL ENEMIES: **LOW**

5.5 Conclusion of the pest risk management options

Several parasitoids are known to have a suppressing effect on *C. flavescens* populations, but these species are not present in the Netherlands. Perhaps there are some other unknown generalist parasites attacking *C. flavescens*. If *C. flavescens* would establish in nature, eradication of the species cannot be achieved by phytosanitary measures because host plants are extensively present in nature in the Netherlands. On the farm-level (fruit orchards, tree nurseries), eradication or control of the species probably will be less difficult. However, there is no clear information about the effect of chemical and non-chemical measures besides natural enemies.

5.6 Final conclusions

C. flavescens, a species that is able to enter and most likely able to establish in the Netherlands, is expected to cause damage by defoliating host trees that are common in nature, along roads on fruit companies and tree nurseries. In its current area of distribution *C. flavescens* is not very damaging, but we should bare in mind that parasitoids, which have a suppressing effect on population levels, are present in those areas and absent in the Netherlands. Therefore, higher population and damage levels might be expected in The Netherlands until the moment natural enemies are present. Defoliation will most likely occur from late September onwards, resulting in a low impact on the trees. *C. flavescens* presents a minor risk for human health as well: people will consider this species a nuisance because they react allergic to the hairs of the larvae.

Considering all the presented information, *Cnidocampa flavescens* should not be listed as a quarantine pest. The main reason for this conclusion is the lack of information on significant damage levels and the fact that defoliation is only expected from September onwards.

Plant Protection Service, Wageningen (NL)
December 2004

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