PLANT PROTECTION CENTRE

February 1996

Pest Risk Assessment (PRA) for Woolly Aphid *Eriosoma lanigerum*

Commissioned by the Norwegian
Agricultural Inspection Service

Professor Torgeir Edland and
Technician Ingrid Helleland
Department of Entomology and
Nematology,
The Norwegian Crop Research Institute
Plant Protection Centre, Fellesbygget,
N-1432 Ås, Norway

Plante forsk
Norsk institutt for planteforsking

Pest Risk Assessment (PRA) for woolly aphid *Eriosoma lanigerum*

Torgeir Edland & Ingrid Helleland
Department of Entomology and Nematology
Plant Protection Centre
The Norwegian Crop Research Institute
Fellesbygget
N-1432 Ås, Norway

1. Endangered area

The Pest Risk Assessment (PRA) area is Norway.

2. Name and taxonomic status

Eriosoma lanigerum (Hausmann 1802).
Insecta: Hemiptera: Homoptera: Pemphigidae.

Common names:
USA: Woolly apple aphid
GB: Woolly aphid
D: Blutlaus
F: Puceron lanigère
E: Pulgon lanigero del manzano
NL: Appelbloedluis
N: Blodlus

No longer EPPO A2 list.

3. Regulatory criteria

Quarantine pest

According to EPPO a quarantine pest is "a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled".

E. lanigerum is absent from the PRA area (Norway) and therefore satisfies this aspect of the definition of a quarantine pest.

4. Methods for identification/detection

Macroscopic and microscopic examination.

4.1 Morphological distinguishing marks of the pest

4.1.1 Adult: 1.5-3 mm long, reddish or purplish brown in colour, and nearly hidden under masses of bluish white woolly wax which is exuded by the insect. Thus, colonies of this aphid are easily recognisable by the masses of whitish woolly wax produced (EPPO 1979). Body with numerous wax plates; antenna short; siphunculi short and pore-like, appearing as elevated rings; cauda short and rounded.

4.2 Symptoms of damage

The aphid feeds on sap in the woody tissues and on young shoots (but never on apple leaves), inducing swollen, cankerous tumours which may reach the size of a nut. The galling may seriously disfigure the plants. "Water shoots" arising from the trunk or main branches are especially liable to be attacked. The disorganisation of the vascular system which results and the continual feeding on sap lead to a rapid wilting of attacked branches. Secondary pests invade the weakened tissues. Infestation of superficial roots leads to distortion and inhibition of normal functioning.

4.3 Possible confusions

No other aphid species, feeding on apple, is covered with masses of white, woolly wax, lacks external siphunculi, and produces gall-like tumours on infested bark. Therefore, it is unlikely that *E. lanigerum* might be confused with other pests.

5. Establishment potential

5.1 Biological information of the pest

E. lanigerum is a common and important apple pest in many countries. The aphid was first described from Germany in 1802, shortly after introduction of the species.

5.1.1 Life cycle

The life cycle of *E. lanigerum* has been described by Börner & Heinze (1957), Kotte (1958), EPPO (1979), Alford (1984), MAFF/ADAS 1992, and others.

In the USA, (especially in the eastern part), eggs are normally deposited in cracks or protected places on the bark of elm trees in the autumn. The eggs hatch early in spring and the emerging aphids, which are wingless, feed on the elm buds and leaves during May and June. They then produce a winged form, which migrates to apple, hawthorn and mountain ash and feeds, to some extent, in wounds on the trunk and branches and may invade the trunk below the surface of the ground. During summer, the aphids reproduce by giving birth to living young. In autumn, wingless males appear and mate with wingless females, each female laying a single egg in the situations described above. Some winged females are present during the entire summer.

In Europe, but also in some western states of USA (Flint 1991), the woolly aphid infests and reproduces only on apple. It overwinters as naked (wax-less) nymphs, sheltering in cracks or

under loose bark or bark flakes on apple trees. In cold climates, the winter may be passed under ground on roots to a depth of about 10 cm. In warmer climate, also egg-lying females may overwinter on trunks and branches.

The reproductive capacity of *E. lanigerum* is huge: beginning in March-April, there are 10-12 generations annually, each viviparous female producing up to 130 nymphs parthenogenetically. The duration of the first nymphal instar varies considerably at different temperatures, being 2-5 days at 26°C and 5-12 days at 17°C. The duration of the second, third and fourth instars varies much less, from 5-6 days at 26°C and 11-15 days at 17°C.

In spring and summer, only wingless parthenogenetic females are found but, towards autumn, winged forms are produced; these include parthenogenetic females, which continue to reproduce on apple, and non-parthenogenetic females and males. In the absence of elm, the latter two are unable to mate and reproduce, and thus, in Europe, a complete part of the life cycle is omitted.

5.1.2 Migration, dispersal and transport

Normally, a few winged woolly aphids are produced in July. These may inoculate other apple trees, but most natural spread is by young, wingless nymphs which often crawl, or are blown by wind from tree to tree.

Individual aphids adhere readily to clothing and implements, and spread is, therefore, rapid. Birds and animals may disperse the aphid over large areas. The far most important way of dispersal, however, is the spread of infested nursery plants.

5.1.3 Host plants

Beside *Malus* (especially dwarf varieties)which is considered the most important host of *E. lanigurum*, EPPO (1979) includes *Pyrus*, *Cotoneaster* and *Cydonia* as principal hosts.

Other, but more sporadic host plants are *Amelanchier*, *Chaenomeles*, *Crataegus*, *Pyracantha* and *Sorbus* (Alford 1984). In America, *Ulmus americana*, is a major host plant, on which *E. lanigerum* is hibernating (Davidson & Lyon 1979).

Wild host plants in Norway

The following species are growing wild in Norway: *Malus sylvestris*, *Cotoneaster integerrimus* and *C. niger*, *Crataegus monogyna* and *C. calycina* as well as the none native *C. laevigata*. Also the none-native *Amelanchier spicata* is often wild growing in the PRA area. Beside mountain ash, *Sorbus aucuparia*, which are growing all over the country, 11 other species of the same genus are wild growing in many different areas (Lid 1987).

Cultivated host plants in Norway

Cultivated apple (*Malus domestica*) and pear (*Pyrus c. cult.*) are grown commercially as far north as Valldal, Møre og Romsdal, at 62° 18'N latitude. However, the main areas of fruit growing are located along the Oslo-fjord and around some lakes in the eastern part and in the fjord districts of the western part of the PRA area (Edland 1996).

Various ornamental species of all genera listed above are grown in home gardens all over the country.

5.2 Geographical distribution

5.2.1 World wide distribution

The woolly aphid originated in the eastern part of North America. It was first noticed in Europe (England) in 1787, on nursery trees introduced from America, and the species became widely distributed on the continent during the 1800's. In Sweden this scale has been established since 1930, and now it occurs in most countries where apples are grown.

According to EPPO (1979) *E. lanigerum* is distributed in the following countries:

EPPO region: Widespread in Austria, Belgium, France, Germany, Italy, Luxenbourg, Netherlands, Portugal, Spain, Switzerland, Turkey and the United Kingdom; locally established in Algeria, Bulgaria, Cyprus, Czechoslovakia, Denmark, Greece, Hungary, Ireland, Jersey, Malta, Morocco, Poland, Romania, Soviet Union, Sweden, Tunisia and Yugoslavia; has been reported from Norway but is not established there.

Asia: Bangladesh, Burma, China, India, Iran, Iraq, Israel, Jammu and Kashmir, Japan, Jordan, Korea, Lebanon, Nepal, Pakistan, Ryukyu Islands, Saudi Arabia, Sikkim, Sri Lanka, Syria, Yemeni Arab Republic.
Africa: Angola, Egypt, Ethiopia, Kenya, Libya, Madagascar, Réunion, Rhodesia, South Africa.
Australasia: Australia, Hawaiian Islands, New Zealand.
North America: Widespread in Canada, Mexico, USA.
Central and South America: Costa Rica, West Indies, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela.

The distribution map of pests (CIE 1975, No 17) gives a world-wide review of the distribution of woolly aphid (Fig. 1).

5.2.2 Reports on E. lanigerum from Denmark and Sweden

The situation in Denmark was discussed by Bovien & Thomsen (1950). To southern Jutland the woolly aphid arrived already in 1885, but it was not permanently established in Denmark until around 1920. Today the species is widely distributed in this country.

In Sweden, Borg (1949) studied the distribution of the aphid. It was probably introduced into the southern part by 1920, but the first valid record was made in 1930, in an orchard in Malmö. Since that time the woolly aphid has spread from Skåne and Öland in south to Götaland and Dalsland in north (Freytag-Loringhoven 1992). The county Dalsland has borderline common with southern part of Østfold, Norway. In Finland the woolly aphid is absent. A table showing the distribution of *E. lanigerum* in the Nordic countries is presented by Heie 1980.

COMMONWEALTH INSTITUTE OF ENTOMOLOGY

DISTRIBUTION MAPS OF PESTS

Series A (Agricultural), Map No. 17 (revised), December 1975

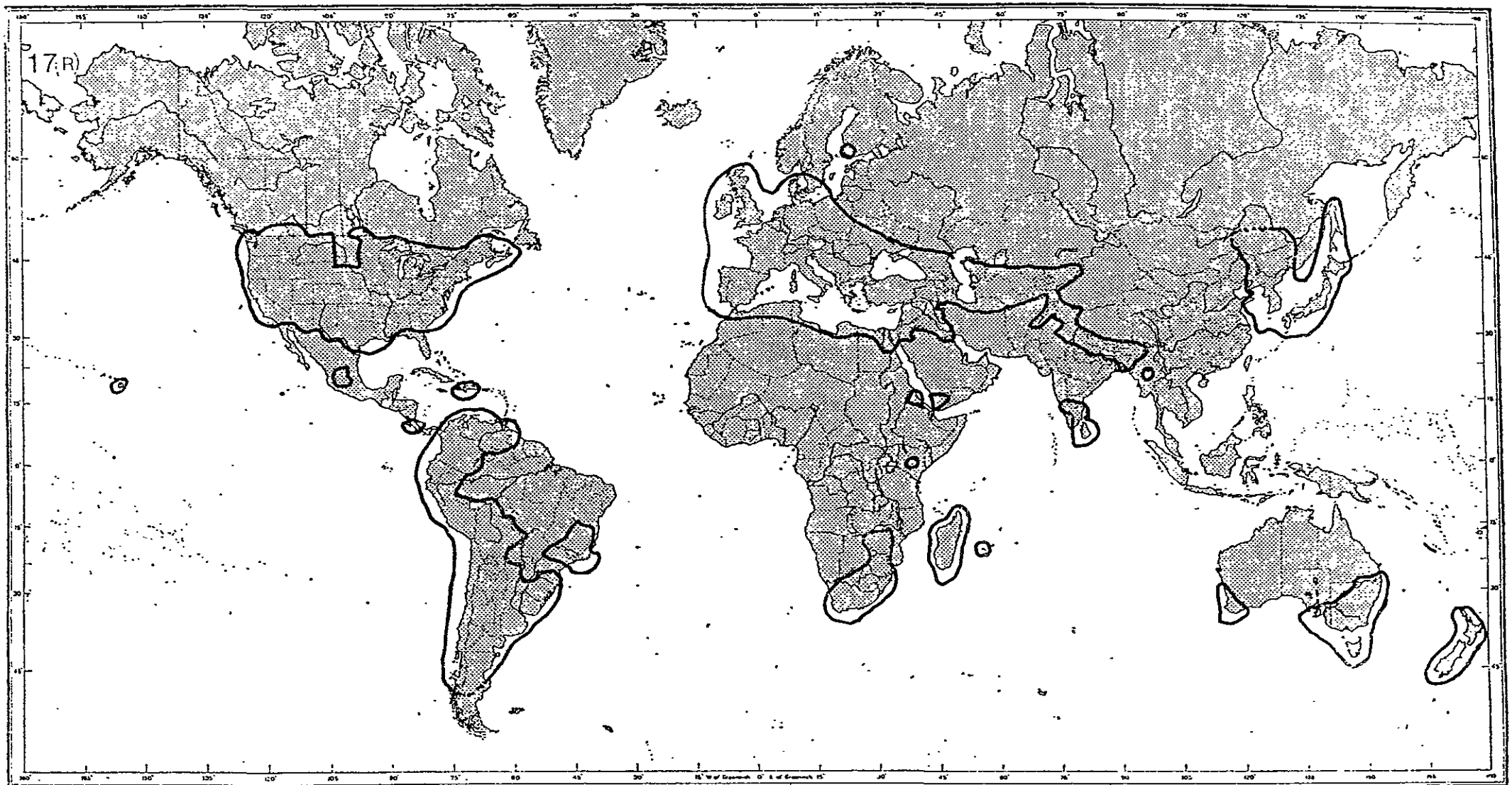
Published at:—56 Queen's Gate, London, SW7 5JR

Pest: *Eriosoma lanigerum* (Hsm.)

(Hem., Aphididae) (Woolly Apple Aphis, American Blight)

Host Plants: Apple, pear, *Cotoneaster*.

Fig. 1



For list of countries in which this pest is known to occur, see overleaf

5.2.3 Establishment of E. lanigerum in the PRA area

The woolly aphid has been temporarily established four times in Norway (Edland 1990)

1. 1894-95 on apple, Arendal (Aust-Agder)
2. 1949-51 on apple root stocks and grafted trees, Hareid (Møre og Romsdal)
3. 1951-52 on fruit trees, Sandnes (Rogaland)
4. 1974 on *Malus purpurea* 'Elevi', Halden (Østfold)

In the last three cases all the records were from young trees, imported from European nurseries. In the field of Hareid the aphids became active in April, proving that *E. lanigerum* is able to overwinter as far north as 62.3° N. altitude (Fjelddalen 1964).

All the above mentioned infestations were efficiently eradicated, partly by burning the infested trees, and partly by use of different insecticides (tar oil or organophosphorous compounds).

In addition to these temporary establishments, *E. lanigerum* has a few times been intercepted on imported apple fruits. Thus, in 1989 and 1990, this aphid occurred mainly on the fruit stalk and in the calyx of apples imported from Washington State, USA. Our identification of *E. lanigerum* was verified by experts at ADAS, Ministry of Agriculture Harpenden, and British Museum, London in letter dated 17.01.90

5.3 Environmental suitability in the PRA area

5.3.1 Climatic conditions for development

The optimum temperature for development of *E. lanigerum* is according to EPPO (1979) 20°C. Börner & Heinze (1957) discuss the climatic influences on this aphid in detail. The lowest temperature for development is found to be between 4.2 and 7°C, the highest somewhere between 30 and 37°C. Soil temperatures of 29.5-37.8°C are unfavourable and result in high mortality.

In laboratory experiments, the females reproduced at the highest rate at temperatures around 16°C. The apterous forms living on apple, became mature at a moderate temperature of 21°C within 14-16 days, at 26.5°C within 11 days. The first larval stage needed longer developmental time than later stages.

Long lasting winter frost may reduce the populations severely. The critical temperature lays between -25 and -27°C. When the temperature remains so low for some hours, most of the aphids are killed.

Moderate air humidity is most favourable for *E. lanigerum*. The optimum conditions at 16-20°C is found to be between 50 and 70 % relative humidity.

In Europe, it has been suggested that *E. lanigerum* can survive successfully in areas with a January isotherm of -3°C.

5.3.2 The situation in the PRA area

According to climatic maps (Aune 1993), showing the monthly temperature for the PRA area, the warmest area on an annual basis is the coastal zone of Southern Norway from Østfold to Trøndelag. This zone has a normal annual temperature (i.e. the average of all monthly temperatures in the period 1 January 1961-31 December 1990) of 6-8°C. In the western part of this zone the monthly temperatures do not fall below 0°C even in the coldest winter periods. In eastern Norway, all the commercial fruitgrowing is located in the zone with a normal monthly temperature of -6°C or higher in January-February. Near the coast of this area, where a large part of our fruit production takes place, the average temperature in January is -2°C. Thus, since this area has a January isotherm above -3°C, it is unlikely that *E. lanigerum* should not be able to survive the winters in our fruit areas.

In Denmark, the populations of *E. lanigerum* were drastically reduced during the extreme coldness which occurred in three subsequent winters 1939-42, but the aphid was nowhere eradicated by the frost. In fact, the infestation became very severe in many orchards already in 1943 (Bovien & Thomsen 1959).

In Norway, snow covers will protect the hibernating aphids on the lower part of the trunks. Furthermore, it is seldom that the minimum temperature reaches below -25°C in areas of commercial fruit growing.

The summer temperatures in Norway are favourable for development of *E. lanigerum*. The climatic maps by Aune (1993) show that the zone with an average monthly temperature of 12-16°C in June, July and August, covers all areas of commercial fruit production in the country.

5.3.3 Conclusion for establishment potential for E. lanigerum in the PRA area

It is concluded that *E. lanigerum* has potential for establishment in all districts of commercial fruit growing in Norway.

5.4 Spread potential after establishment

5.4.1 The spread potential within the PRA area

Once *E. lanigerum* is established in a Norwegian locality, winged aphids may disperse to other host plants, and nymphs can be blown by wind from tree to tree. Moreover, it may be spread by birds and animals over large areas, and especially by passive transportation of infested plant materials along the coast in its potential area of establishment.

5.4.2 Occurrence of host plants in the PRA area

The wild growing mountain ash (*Sorbus aucuparia*) is distributed all over the country, where apple and other fruit trees are grown. Also many ornamental trees, being listed as hosts for *E. lanigerum* are commonly distributed in all our fruit areas. Thus, the spread potential for a permanent establishment of this pest in Norway is high.

5.5 Natural enemies

5.5.1 Natural enemies of E. lanigerum in other countries

Many predators and parasitoids are natural enemies of *E. lanigerum*. Börner & Heinze (1957) list a range of various lacewings (Neuroptera), mirids (Heteroptera), lady birds (Coleoptera) and syrphids (Diptera) which prey on this aphid, some parasitic wasps (Hymenoptera) and a few fungi, which live on *E. lanigerum*. Although some of them may locally reduce the populations of *E. lanigerum* and its damage significantly, most of them seem to be of minor importance. In England and other European countries, earwigs e.g. *Forficula auricularia* L. is considered important predators of fruit pests, and pesticide use which kill these predators may lead to an increase in number of *E. lanigerum* (MAFF/ADAS 1992).

In France, Bonnemaison (1976) claims that only one species of parasitoids, the exotic aphelinid *Aphelinus mali* (Haldeman), is commonly occurring on apple trees. This well-known endoparasite of *E. lanigerum* on apple and pear trees was deliberately introduced into France in 1920, and to other European countries in the subsequent years. It has been used frequently as a biocontrol agent against this aphid and still survives in many orchards.

The adults of *A. mail* are 0.7 - 1.0 mm long and mainly black, with antennae, each hind femura and the base of the abdomen yellow. They are very active, running about in the close vicinity of host colonies. Attacked aphids cease to produce wax so that blackish, naked parasitized individuals soon became obviously. There are several generation each year, individuals overwintring inside dead host mummies as larvae or pupae (Alford 1984).

In the Paris-area *A. mali* develop 7-8 annual generations, in Sweden 5 generations in favourable years. The adults emerge in medio April and the last generation enter diapause in August-October in France. In Denmark it emerges in May, but enter diapause so early that its host often increase drastically in number before hibernation, and therefore often occurs numerous both in the autumn and also in the early spring (Bovien & Thomsen 1950).

The efficiency of *A. mali*, as a natural enemy of *E. lanigerum*, is highly dependent on the ecological conditions. In warm climate, such as in Italy, it is a very successful parasitoid, whereas in colder and wet areas, the reproduction of *A. mali* is often insufficient. Thus, as stated by van Lenteren (1995), *A. mali* successfully controls the aphid in southern countries, but, "The parasitoid also established in Holland, but is not able to reduce populations of aphids sufficiently, supposedly because of adverse climatological conditions". This fate was also the case in Denmark, where *A. mali* cannot replace chemical control measures (Bovien & Thomsen 1950).

5.5.2 Natural enemies of E. lanigerum in the PRA area

Several species of the predators mentioned above are distributed in Norway. The fauna of insect parasitoids, however, is poorly investigated. Yet, it is unlikely that important natural enemies of *E. lanigerum* are distributed in Norwegian orchards.

Since *A. mali* is not an efficient natural enemy of *E. lanigerum* in the Netherlands, probably due to cool and wet climate, it is most improbable that it could be a significant parasitoid in our country.

6 Control

6.1 Control methods in regular use

Both biological and chemical control measures are used for *E. lanigerum*.

According to MAFF/ADAS (1992) the introduced parasitoid *A. mali* "is widely established in south-east England and in some western districts. Although it does not thrive here as well as in warmer, drier climates, in some years it can make a useful contribution to woolly aphid control. However, this control is pointless where broad-spectrum pesticides are to be applied in the summer of control of codling moth, tortrix moth or red spider mites, because these chemicals kill the parasite".

Many different insecticides are being recommended for this aphid control. Alford (1984) mentions the following materials as appropriate insecticides: chlorpyrifos, demeton-S-methyl, dimethoate, heptenophos, malathion, mevinphos, nicotine, oxydemeton-methyl, pirimicarb, thiometon, vamidothion and NDOC. Vamidothion is one of the most effective materials and in lightly infested orchards spraying every other year should be adequate.

In Denmark, control of *E. lanigerum* has been tested using late spring/summer applications of 0.04 % methidathion, 0.05 % propoxur, 0.075 % fenitrothion, and 0.625% pyrethrum. In Yugoslavia, autumn treatments with endosulfan in oil or parathion gave near 100 % mortality of the aphid (EPPO 1979).

EPPO (1990) lists 20 different compounds being used/recommended in 1978 in four European countries: Denmark, Poland, Switzerland and Portugal. In addition to 13 of the compounds mentioned above, this list covers: azinphos-ethyl, azinphos-methyl, ethiofencarb, etrimfos, lindane, omethoate, and phosalone. Pirimicarb was the only material which was recommended in all four countries, while each of the remaining compounds were recommended only in one or two countries. In Portugal alone, 14 different insecticides were listed for woolly aphid control. Denmark, Poland and Switzerland recommended 5,4 and 3 compounds respectively. The number of annual applications being used varied. In one country 2 sprays of azinphos-ethyl and 5 sprays of methidathion could be applied as maximum per year.

In western USA (Washington State) Beers (1990) recommends 5 insecticides to be used for moderate to heavy infestations of *E. lanigerum*. Endosulfan, dimethoate and chlorpyrifos provide excellent control, while diazinon and methyl-parathion are acceptable against the pest in low pressure situation. In this part of USA, however, endosulfan should not be applied more than tree times during fruiting period.

In Sweden, where *E. lanigerum* is a serious pest on apple, the control is regarded as difficult. When this pest has been established in an orchard, it is almost impossible to eradicate it. Satisfactory control depends of efficient wetting and good distribution of the spray. High-volume spraying is preferred, as the spray has to penetrate the protective woolly covering of the aphids and reach colonies living in cracks on the underside of branches. Therefore, high quantities of water (e.g. at least 2000 l spray mixture per ha) should be used. Pirimicarb, the fast acting selective contact carbamate insecticide with fumigant activity is recommended in

Sweden, always at full dosage, but in order to achieve sufficient fumigant effect, the spraying should be performed in calm and warm weather (Freytag - Loringhaven 1992).

6.2 Control potential of *E. lanigerum* in the PRA area

As discussed above, biological control of the woolly aphid has a small potential in Norway, because of the absence of important native natural enemies, and because introduced exotic predators and parasitoids e.g. *Aphelimus mali* would probably be unsatisfactory biocontrol agents, due to adverse climatic conditions (cf. van Lenteren 1995).

Among the above mentioned 28 insecticides being recommended/used for woolly aphid control in Europe and USA in recent time, only 6 compounds are registered on the Norwegian market for use in fruit orchards (Svendsen 1995). These are azinphos-methyl, demeton-S-methyl, dimethoate, diazinon, ethiofencarb and pirimicarb. Used at normally recommended dosages, the former four compounds, being broad spectrum organophosphorus insecticides, are very harmful to most natural enemies occurring in our fruit orchards. Therefore, azinphos-methyl, demeton-S-methyl and diazinon are not allowed to be used in integrated fruit production in Norway without restrictions, whereas dimethoate is forbidden for use in such production. It should be noticed that dimethoate, which is most harmful of many important natural enemies, is the only available insecticide, among those listed in USA as compounds with excellent effect against *E. lanigerum*.

Ethiofencarb and pirimicarb, are widely used aphicides in Norway, and have proved to control present occurring aphids very efficiently when used at a rate of 1/10 - 1/30 of the normally recommended dosages.

Among the 28 insecticides, which were applied for woolly aphid control in Europe and USA during recent years, 13 compounds were on the Norwegian marked some years ago. They were all abandoned, either because of undesirable toxicological qualities (e.g. endosulfan and parathion), or because the manufacturers found our market too small for selling them. This seems to be an increasing problem for small countries. Several manufacturers/distributors have made it clear that special chemicals, like fenoxycarb, petroleum oil, and other selective compounds, which are suitable for IPM in fruit orchards and other minor crops, are not to be sold on our small market in future. Thus, it is likely to assume that effective insecticides against *E. lanigerum*, such as chlorpyrifos, endosulfan, parathion and vamidothion, shall not be registered for use in the Norwegian agriculture.

Therefore it may be concluded that in Norway the control potential of *E. lanigerum* is rather poor.

7. Economic importance

7.1 Pest significance

According to EPPO (1979) the woolly aphid has for many years been a well known and injurious pest of apple trees in nurseries and of young trees in the orchard in both the USA and Europe. After its introduction into South Africa, it spread rapidly, even to relatively isolated farms. Many reports have noted with alarm the increased incidence of *E. lanigerum* in orchards

sprayed with broad-spectrum insecticides for control of codling moth and other pests. This increase has often been attributed to the killing of natural enemies of the aphid.

In the EPPO region at present, *E. lanigerum* is of great economic importance in Germany, Luxembourg and Portugal, and of some importance in other countries where it is established.

The aphid does little direct harm to mature trees, but galls are often produced on infested wood. These spoil the appearance of nursery stock and reduce its value. Severe damage, which occurs on the roots and woody aerial tissues, may make the trees unfit for sale (EPPO 1979).

Moreover, the galls caused by *E. lanigerum* often split open and may then provide a point of entry for diseases, such as *Gloesporium* spp and apple canker, *Nectria galligena* Bres. The sticky masses of 'wool' produced by this aphid may contaminate foliage and developing fruits, and they are often a nuisance at harvest time (Alford 1984).

In some parts of USA, the perennial canker fungus *Pezicula* (*Neofabraea*) *malicorticis* (Jacks.) Nannf. attacks injured apple tree, causing dead areas on limbs and "Bull's-eye rots on apple and pear fruits. It is known that *E. lanigerum* is attracted to this canker, and also contributes to the spread of this disease (Flint 1991). Therefore, an effective control of woolly aphid is important, although its control should limit canker extension to only one year (Grove 1990).

7.2 Potential economic importance in the PRA area

Severe infestation of *E. lanigerum* can result in serious consequences for the Norwegian fruit growing.

As discussed above, attacks of *E. lanigerum* may contribute to infestation of various diseases on fruit trees. The perennial canker *P. malicorticis* has been recorded in Norway (Gjærum et al. 1967), and establishment of woolly aphid may therefore result in further spread of this fungus, and to extended pesticide use. Significant increases in plant protection costs, may force fruit growers to abandon their production.

According to Kvåle (1995), the area of commercial orchards in Norway is approximately 3,300 ha. The annual fruit production, including the crops produced in private garden, is estimated to about 51,100 tons, with apples as the most important fruit crop (65 %). During recent years the production in commercial orchards has been 9,000 - 13,000 tons of apples (first class) per year.

In 1989, the total number of farms possessing more than 1000 fruit trees, was nearly 500. Many of these farms are situated in hilly areas, too steep for other agricultural crops. Therefore, although small, the Norwegian fruit production is still important, since there are very few, if any, alternative possibilities for employment (Edland 1996).

Thus, the economic consequences of severe infestation of *E. lanigerum* in all our apple and pear producing areas, could be the loss of several hundreds of man-labour years, and a loss of production valued at 100 mill NOK annually (Kvåle 1996, per.comm.)

An alternative strategy is to apply insecticides profylactically to control woolly aphid and to prevent its spread in the PRA area.

7.4 Effects on ongoing Integrated Pest Management (IPM) programmes in the PRA area

Since the beginning of the 1970's, great success in developing efficient IPM programmes has been achieved in Norway. In 1988 the average use of insecticides and acaricides was 1.1 sprays and of fungicides 3.5 sprays, for the whole season in many orchards, without significant damage to the crop (Edland 1995). This is less than 20 % of what is being used in integrated fruit production in some other European countries (Prinoth, 1990).

A recent survey (Kvåle & Hovland 1995) has shown that the majority of Norwegian fruit growers are using IPM with success, and it is estimated that their average use of insecticides and acaricides is equal to 2 normal dosage application/year. This is, as outlined by Edland (1996), a reduction of 70-75 % during the past 25 years. In order to maintain this low level of pesticide use, the introduction and establishment of new pests must be avoided.

Introduction and establishment of *E. lanigerum* in our orchards, would most probably result in profylactic sprays in an attempt to prevent severe damage. These additional sprays, will not only increase the costs of applications significantly, but they will also have severe detrimental impact on natural enemies, which at present are keeping other pests at a very low level. Thus, introduction of a new pest can easily create new problems by native pests, and increase the control expenses so much that many growers are forced to abandon their fruit production.

7.5 Environmental damage

In Norway various pesticides have been intercepted in soil and in ground and surface water. Several research and monitoring programmes are going on, including research projects at the Plant Protection Centre. The present minimum use of pesticides in Norwegian fruit orchards, however, contributes little, if any, to such pollution.

7.6 Conclusion

One or several annual insecticide applications against *E. lanigerum* in Norwegian orchards, will greatly increase the pesticide use in our fruit production, and cause severe detrimental impacts on the environment and the foundation of IPM programmes. Research work concerning different plant protection problems in Norway, is trying to minimize the pesticide use as much as possible. The present strategy used in our IPM programmes, developed for fruit orchards, has clearly demonstrated that this goal has been achieved.

8. Introduction potential

8.1 Entry

8.1.1 Import of fruits to Norway

According to Kvåle (1995) the average annual import of the main fruit types during the period 1987-90 were as follows: 59 700 tons citrus fruits, 49 300 t. bananas, 46 000 t. apples, 11 900 t. pears and 18 300 tons grapes.

Norwegian statistics (Frukt- og grønsakgrossistenes servicekontor, 1996) shows that the total amount of fresh fruits, which has been imported to Norway during recent years, varies from approximately 190.000 to 304. 000 tons per year (Table 4).

Table 4 Import of various fruits to Norway in the period 1986-95. Quantity in tons per year of the various groups. (Frukt- og grønnsakgrossistenes service kontor, 1996)

Group of fruits	Amount in tons per product per year							
	1986	1987	1988	1989	1990	1991	1992	1993
Bananas	44.593	43.335	45.715	51.090	48.486	53.498	61.195	60.826
Citrus fruits	57.133	41.508	59.164	57.211	62.833	56.272	61.960	60.638
Grapes	20.166	19.423	17.942	16.026	15.376	16.362	118.629	18.822
Apples	47.327	44.947	45.490	40.202	41.475	37.822	35.903	38.666
Pears	16.343	13.821	11.947	13.832	10.322	11.858	11.449	13.965
Peaches + nectarines	3.424	3.832	3.775	4.328	4.034	3.344	4.961	4.088
Other fruits incl. tinned f.	28.346	30.464	10.531	9.986	8.869	33.115	10.175	34.131
Total	217.332	197.330	194.564	192.675	191.395	212.271	304.272	231.136

In addition to the annual amount, Table 5 also shows the number of countries from where the various groups of fresh fruits came from in 1994 and 1995, as well as the value of the fruits in mill NOK. All the consignments of fresh fruit were imported from a total of 36 countries. The great majority of shipments in 1994-1995, were imported from countries in southern Europe, Africa, Asia and America, where *E. lanigerum* is known as an established pest in the fruit orchards.

Table 5 Import of fresh fruit to Norway in 1994 and 1995. No. of exporting countries for each groups, quantity in tons and value in million NOK are given (Frukt- og grønnsak-grossistenes servicekontor, 1996).

Group of fresh fruits	No. of exporting countries	1994		1995	
		Tons	Mill NOK	Tons	Mill NOK
Bananas	5	59.484	263.544	59.549	262.401
Citrus fruits	15	60.257	297.516	61.067	347.989
Grapes	9	17.510	157.026	14.968	150.921
Apples	11	38.843	207.775	37.188	204.810
Pears	6	15.663	85.890	13.147	79.773
Stone fruits	7	7.874	63.728	5.391	57.812
Berries	7	1.527	41.216	2.332	54.247
Other fresh fruits	17	21.305	292.552	20.763	263.184
Total	36	222.463	1409.247	214.405	1421.137

8.1.2 Survival of the E. lanigerum under the environmental conditions of transport

Individuals of *E. lanigerum* can survive transportion on both nursery plants and on fruits. Under inspection carried out in 1989 and 1990 of infested apples from USA, living nymphs and adults of this aphid were detected.

8.1.3 Detection of the E. lanigerum at entry inspection

The Norwegian Agricultural Inspection Service and the Custom Service are responsible for the supervision of the import of plants and parts thereof to Norway. The Inspection Service may demand that a consignment of commodities is being kept back by the Customs Authorities, so that inspection of the goods can be undertaken. Also, the Inspection Service may for the same purpose demand that a consignment of commodities, which has passed through the customs can be held back in the importer's ware house.

Importer or distributor of a commodity must bring the goods to and from the place found most suitable by the Inspection Service for sufficient inspection work. The Inspection Service may, free of charge, take samples for further examination.

8.1.3.A Import prohibitions

According to the Ministry of Agriculture (1983) it is prohibited to import into the country:

a. All developing stages of living nematodes, insects and mites, cultures of viruses, bacteria and fungi and other damaging plant pests and diseases.

b. Plants and plant products infected or infested with the pests and diseases listed in Appendix 1, A (which includes *E. lanigrum*).

8.1.3.B Import on special conditions

A. Plant and parts of plants for cultivation's and propagation.

1. Supervision in the period of growth: The plants must have been under official phytosanitary supervision during the period of growth for the season previous to import, and must have been found free from the plant pests and diseases mentioned in Appendix 1, A, (which includes *E. lanigerum*).

2. Plants which are considered as host plants for Fire Blight (see Appendix 3) cannot be imported from countries where this disease occurs. (Appendix 3, includes *Chaenomeles, Cotoneaster, Crataegus, Cydonia, Malus, Pyracantha, Pyrus and Sorbus*, which are all listed as host plants of *E. lanigerum*.

3. The plants or parts of plants shall not more than 15 days prior to depatch, be examined by the exporting counytry's official plant inspection service, which by issuing a plant health certificate confirms that the consignment fulfils the requirements of these regulations, including that the plants or parts of plants are found free from the pests and diseases mentioned in Appendix 1 A (which includes *E. lanigerum*).

4. Delivery of consignments subject to part A above, must not be made before the Norwegian Plant Inspection Service has checked and accepted the certificates.

B. Plants and parts of plants which are not intendent for cultivation or propagation.

1. Fresh (not tinned) fruit and berries: Apricots, raspberries, apples, peaches, strawberries, cherries (including morellos), plums, pears, red currants, black currants, gooseberries, grapes, citrus fruits and melons.

2. The plants or plant products shall not more than 15 days prior to despatch be examined by the exporting country's official plant inspection service, and found free from the pests and diseases mentioned in Appendix 1 A (which includes *E. lanigerum*).

Every consignment shall be accompanied by a certificate of health issued by the official plant inspection service of the exporting country.

Requirements for valid phytosanitary certificates, and decisions concerning plant consignments which fail to observe the necessary requirements are given in detail by the Ministry of Agriculture (1983).

8.1.4 Movement into the PRA area by natural means

There is a certain, though small, chance of natural spread of *E. lanigerum* by wind or by birds and animals, from infested areas in Sweden into the PRA area of Norway.

9. Conclusion

The conclusion of the pest risk assessment for *E. lanigerum* is that this pest has sufficient economic importance and potential for establishment, and that the risk is sufficient for phytosanitary measures to be justified.

REFERENCES

Alford, D.V. 1984. A colour atlas of fruit pests, their recognition, biology and control. Wolfe Publishing Ltd. London. 320 pp.

Aune, B. 1993. Det norske meteorologiske institutt. Månedstemperatur 1:7 mill. Nasjonalatlas for Norge, karblad 3.1.6. Statens Kartverk (In Norwegian).

Beers, E.H. 1990. 1990-Spray guide for tree fruits in eastern Washington. Washington State University, College of agriculture and Home Economics, USA. 96 pp.

Bonnemaison, L. 1976. Zehrwespen. Nützlinge in Apfelanlagen. IOBC/WPRS Broschüre Nr. 3: 87-88.

Borg, Å. 1949. Blodlusinventeringen i Skåne 1945-1948 (Eng. Summary). Statens Växtskyddsanstalt. Medd. Nr. 53. 42 pp. (In Swedish).

Bovien, P. & M. Thomsen 1950. Haveplanternes skadedyr, og deres bekæmpelse. August Bang Forlag, København. 346 pp. (In Danish).

Börner, C. & K. Heinze 1957. Aphidina - Aphidoidea, Pemphigidae *In* Handbuch der Pflanzenkrankheiten. 5. Band, 2. Teil. P. 281-289.

CIE 1975. Distribution maps of pests. *Eriosoma lanigerum* Haumann Series A. Map No. 17 (revised). CAB International Institute of Entomology, London, UK.

Davidson, R. H. & W. F. Lyon 1979. Insect pests of farm, garden and orchard. John Wiley & Sons, New York. 596 pp.

Edland, T. 1990. Utanlandske skadedyr (4), Blodlus *Eriosoma lanigerum* Hausmann, - ein vanleg, men farleg skadegjerar i dei fleste land. Gartneryrket 80 (10): 16-18 (In Norwegian).

Edland, T. 1995. Integrated pest management (IPM) in fruit orchards. P. 44-50. *In* Hokkanen, H.M.T. & J.M. Lynch (Eds.) Biological control: Benefits and risks. Cambridge Univ. Press, Cambridge. 304 pp.

Edland, T. 1996. Benefits of minimum pesticide use in insect and mite control in orchards. *In* Pimentel, D. (Ed.) Techniques for reducing pesticide use: Economic and environmental benefits. John Wiley & Sons, Ltd. London (In print).

EPPO 1979. *Eriosoma lanigerum* Hausmann. Homoptera: Aphididae. Data sheets on quarantine organisms. Paris. 5 pp.

EPPO 1990. Good agricultural practice in use of plant protection products on apple. EPPO Tecnical Documents No. 1003: 62-63.

Fjelddalen, J. 1964. Aphids recorded on cultivated plants in Norway 1946-62. Norsk Entomologisk Tidsskrift 12 (5-8): 259-295.

Flint, M.L. 1991 (Ed.). Integrated pest management for apples and pears. Univ. Calif. Div. Agric. and Nat. Res. Publications No. 3340: 130-133.

Freytag-Loringhoven, B. von, 1992. Blodlus - Faktablad om växtskydd - Trädgård - 164T. SLU Info/Växter - Växtskydd. 2 pp. (In Swedish).

Frukt- og grønsakgrossistenes servicekontor 1996. Statistikk over importen til Norge av frukt og grønnsaker i tonn og 1.000 kroner. Norges Frukt- og Grønnsakgrossisters Forbund. (In Norwegian).

Gjærum, H.B., R. Landfald & A. Hirvonen-Semb 1967. Sopper, nye eller lite kjente som årsak til råter i norske epler. Forskning og forsøk i landbruket 18: 115-121. (English summary).

Grove, G.G 1990. 1990-Spray guide for tree fruits in eastern Washington. Washington State University, College of Agriculture and Home Economics, USA. 96. pp.

Heie, O.E. 1980. The Aphidoidea (Hemiptera) of Fennoscandia and Denmark I. Fauna Entomologica Scandinavica 9: 118-121 + 208-211.

Kotte, W. 1958. Krankheiten und Schädlinge im Obstbau und ihre Bekämpfung. Paul Parey, Berlin/Hamburg. 519 pp.

Kvåle, A. 1995. Fruktdyrking. Landbruksforlaget, Oslo. 208 pp. (In Norwegian).

Kvåle, A. & B. Hovland 1996. Usage of pesticides in Norwegian apple production. Abstract: The International Conference on Integrated Fruit Production. Cedzyna, Poland. P. 66.

van Lenteren, J.C. 1995. Frequency and consequences of insect invasions. P 30-43 *In* Hokkanen H.M.T. & J.M. Lynch (Eds.). Biological Control: Benefits and Risks. Cambridge Univ. Press, Cambridge. 304 pp.

Lid, J. 1987. Norsk, svensk, finsk flora. Det Norske Samlaget, Oslo, 837 pp. (In Norwegian).

MAFF/ADAS 1992. Woolly aphid. *In* Crop pests in the UK (Ed. M. Gratwick). Chapman & Hall London - New York. P. 78-81.

Ministry of Agriculture 1983. Regulations for the import of plants and parts thereof etc., to Norway. 23 pp.

Prinoth, H. 1990. Auswertung von Betriebsheften auf Planzenschutzmassnahmen. Obstbau Weinbau 27: 184-185.

Svendsen, S. 1995. Plantevern. Kjemiske og biologiske midler 1995-1996. Planteforsk, Plantevernet/Landbruksforlaget. 239 pp. (In Norwegian).