PEST RISK ANALYSIS FOR *DIASPIDIOTUS PERNICIOSUS*

STAGE 1: PRA INITIATION

1. What is the name of the pest?

Diaspidiotus perniciosus (Comstock) Cockerell, 1899 San José scale

Notes on taxonomy and synonyms

This organism has at least 15 synonyms and taxonomists disagree about the genus to which it should be assigned (*Diaspidiotus* or *Quadraspidiotus*). CABI (2009) provides a comprehensive list of synonyms and accepts *Diaspidiotus perniciosus* as the valid name, whilst EPPO uses *Quadraspidiotus perniciosus* as the valid name.

2. What is the reason for the PRA?

San José scale (as *Q. pernicious*) was first regulated across Europe through a European Control Directive (69/466/EEC) that was published in 1969 (Anon., 1969). Subsequently the San José Scale directive (69/466/EEC) was substantially amended and in the interests of clarity and rationality it was codified in 2006 as Council Directive 2006/91/EC on control of San José Scale (Anon., 2006), repealing the 1969 directive (69/466 EEC). The 2006 Directive described the minimum measures to be taken within EU MS to control San José Scale and to prevent it from spreading. However, given the widespread distribution of the organism within the EU already and the understanding that the organism would not be of significance in northern Europe if it were to spread, a working party of Agricultural Attachés has considered repealing the 2006 Directive. A PRA is required to inform policy discussions and inform the UK decision as to whether to support repeal of 2006/91/EC.

A PRA to assess San José Scale for the UK was previously conducted in 1981 (Baker, 1981). The current PRA draws from the earlier document.

3. What is the PRA area?

Since this organism occurs elsewhere in Europe, this PRA focuses on the UK as the PRA area.

STAGE 2: PEST RISK ASSESSMENT

4. Does the pest occur in the PRA area or does it arrive regularly as a natural migrant?

No. *D. perniciosus* does not occur in the UK and does not arrive regularly as a natural migrant. *D. perniciosus* is incorrectly recorded as present in the UK by

ScaleNet a database and resource commonly used by scale experts around the world (www.sel.barc.usda.gov/SCALENET/SCALENET.HTM).

5. Is there any other reason to suspect that the pest is already established in the PRA area?
No. There is no reason to suspect that *D. perniciosus* is already established in the PRA area.

6. What is the pest's status in the Plant Health Directive (Council Directive 2000/29/EC[1]) ?
Neither *Diaspidiotus perniciosus* nor the synonym *Quadraspidiotus perniciosus* appears in 2000/29/EC.

As noted in **2.** above, San José scale was first regulated across Europe in 1969. It was not included in the Plant Health Directive 77/93/EEC (Anon., 1976) although 77/93/EEC did amend 69/466/EEC so that measures were not needed on "slightly contaminated consignments of fresh fruit." The 1969 directive (69/466/EEC) was codified in 2006 as 2006/91/EC. San José scale is also covered by an EC Marketing Directive 93/48/ECC, (Anon., 1993) which is the implementing directive of 92/34/EEC (Anon., 1992) (see **9.** below).

7. What is the quarantine status of the pest in the lists of the European and Mediterranean Plant Protection Organisation (EPPO)? www.eppo.org

EPPO List:	A1 regulated pest list		A2 regulated pest list	✓	Action list		Alert list	

D. perniciosus (named as Q. *perniciosus*) is an A2 quarantine pest for EPPO (EPPO, 2007). There has been some discussion within EPPO as to whether international quarantine measures need to be maintained against *D. perniciosus*, or whether internal measures would suffice. The conclusion in 1983 was that the species should remain on the EPPO quarantine list mainly to protect regions and countries in central western Europe, where the species was absent or had a limited distribution e.g. France and Switzerland (Smith *et al*., 1997).

8. What are the pests' host plants?
Diaspidiotus perniciosus is highly polyphagous with CABI (2009) listing seven genera (*Malus*, *Morus*, *Prunus*, *Pyrus*, *Ribes*, *Rubus* and *Vaccinium*) as major hosts and over 170 genera as minor hosts. The host range could be much wider. The importance of each host varies across the world.

[1] http://europa.eu.int/eur-lex/en/consleg/pdf/2000/en_2000L0029_do_001.pdf

9. What hosts are of economic and/or environmental importance in the PRA area?

Generally *D. perniciosus* is most serious on deciduous fruit trees including apple, pear, peach, plum, currants and some woody ornamental plants (Konstantinova, 1976; APPC, 1987; Davidson & Miller, 1990; Kozár 1990; Kosztarab, 1996). In the EC Marketing Directive 93/48/EEC, *Q. perniciosus* is listed as a harmful organism specifically affecting the quality of *Corylus avellana* (hazel), *Pyrus communis* (pear), *Juglans regia* (walnut), *Malus* (apple), *Prunus domestica* (plum, bullace, damson, gage), *Prunus salicina* (Chinese / Japanese plum), *Prunus persica* (peach & nectarine) and *Prunus cerasus* (morello cherry). The organism affects the whole plant, including fruits, leaves, stems and post-harvest fruit.

10. If the pest needs a vector, is it present in the PRA area?

No vector is required. This is a free living organism.

11. What is the pest's present geographical distribution?

D. perniciosus originated in Eastern Asia and has spread to many parts of the world (Kozár, 1990). It now occurs widely in North and South America, Europe, southern Africa, Asia and Oceania. Maps of the global distribution of *D. perniciosus* are provided in CABI (2009) and EPPO (1998).

Table 1: Distribution of San José scale (*Diaspidiotus perniciosus*)

North America:	Canada (eastern and western provinces), Mexico, USA (eastern and western states)
Central America:	Cuba
South America:	Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay, Venezuela
Europe:	Within the EU (Austria, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Italy, Poland, Portugal (including Madeira), Romania, Slovakia, Slovenia, Spain (including Canary Islands)) Other European countries (Albania, Croatia, Moldova, Russian Federation, Serbia and Montenegro, Switzerland, Ukraine).
Africa:	Algeria, Angola, Congo, Democratic Republic of the Congo, Morocco, South Africa, Tunisia, Zimbabwe
Asia:	Afghanistan, Armenia, Azerbaijan, Bangladesh, Bhutan, Brunei Darussalam, China, Georgia (Republic), India, Iran, Iraq, Japan, Kazakstan, Korea, Nepal, Pakistan, Tajikistan, Thailand, Turkey, Uzbekistan, Vietnam.
Oceania:	Australia, New Zealand

Sources: CABI (2009) and EPPO (1998).

12. How likely is the pest to enter the PRA area[2]?

very Unlikely	Unlikely	Moderate likelihood	Likely	very Likely
✓				

Between November 1996 and April 2009, *Diaspidiotus perniciosus* was intercepted 11 times, always on fruit. Nine of the 11 interceptions were on *Prunus*, one was on *Malus* and one on *Pyrus.* Thus there is a route for the organism to reach the UK, but transfer from fruit to a suitable growing host plant is very unlikely. The role of infested fruit in spreading this organism has been much disputed. It is likely that spread from fruit could occur only if a fruit on which crawlers were present was actually placed in contact with the bark of a suitable preferred host (Baker, 1981).

Table 2: Details of *Diaspidiotus perniciosus* interceptions 1996 - 2009

Date	Host (produce)	Origin
04-Nov-96	*Prunus*	Unknown
08-Nov-96	*Prunus*	South Africa
20-Nov-96	*Malus*	South Africa
27-Oct-97	*Prunus*	USA
04-Nov-97	*Prunus*	Netherlands
13-Nov-98	*Prunus*	USA
03-Mar-04	*Prunus*	Argentina
28-Apr-06	*Pyrus communis*	South Africa
17-May-06	*Prunus domestica*	Australia
30-Jan-07	*Prunus domestica*	South Africa
12-Apr-07	*Prunus domestica*	Chile

Between 1935 and 1992, there are records of 13 other interceptions (11 on plums, 2 on pears) mainly from Italy and Spain (C. Malumphy, pers comm.).

The main, if not the only, means of international spread of *D. perniciosus* is on nursery stock. A search of an interceptions database showed that there are no records of *D. perniciosus* being intercepted on nursery stock, or any growing plants in England & Wales UK between January 1996 and April 2009.

13. How likely is the pest to establish outdoors in the PRA area?

very Unlikely	Unlikely	Moderate likelihood	Likely	very Likely
		✓		

If San Jose scale did enter the UK, establishment outdoors (in southern England) would be possible (moderately).

D. perniciosus occurs, or has been shown to survive, in several areas of the world whose climates are broadly similar to those in the UK e.g. in Denmark & Netherlands, Sakhalin (Russia), Hokkaido (Japan), Nova Scotia, British Columbia (Vancouver Island), Tasmania, and the South Island of New

[2] Pest entry includes an assessment of the likelihood of transfer to a suitable host (ISPM No. 11, FAO, Rome)

Zealand (Baker, 1981). However, in all these places the climates tend to be more continental with wider annual ranges of temperature (warmer summers and cooler winters). *D. perniciosus* can clearly survive and overwinter in countries with much more severe winters than the UK, so one may think that it is probably the cooler summers of the UK that is presently limiting its ability to establish.

The thermal biology and phenology of *D. perniciosus* has been repeatedly studied. As such there are some contradicting data. Baker (1981) calculated a threshold of 7.0°C and thermal sum of 813 Day-Degrees (DD) was required for a complete generation. Gentile & Summers calculated a threshold of 10.5°C and thermal sum of 584 DD. Smith *et al*. (1997) refer to a threshold of 7.3°C and a thermal sum of 500 DD for the first generation and a thermal sum of 770 DD for a second generation in central Europe. Based on the duration of the life cycle at fixed temperatures (Table 3) the threshold temperature for development can be calculated as 9.2°C with a thermal sum of approximately 670 DD required for a complete generation. Based on such data alone, and using a computer simulation model derived from a University of Michigan phenology model (Welch *et al*., 1978) one generation of *D. perniciosus* may be is possible in southern Britain in most years, with two in exceptionally hot years, such as 1976 and 1995 (Baker, 1981)

Table 3: Duration of *Diaspidiotus perniciosus* life cycle at fixed temperatures

Temperature	Days to complete life cycle
20-21°C	60
25-26°C	42
31-32°C	30

However, in the summer and autumn, when temperatures fall below approximately 23°C, a small proportion of first instar larva begin to enter diapause. At approximately 14°C all first instar larva will be in diapause (Huba, 1962). There is a linear relationship between temperature and proportion of the population in diapause, thus 50% of the crawlers will be in diapause at 13.5°C. Winter mortality of larvae can be high, e.g. 44% – 73% along the Mediterranean coast (Benassy *et al*., 1958). Crawlers, both mobile and newly-settled are killed by heavy rain which washes them off hosts (Gentile & Summers, 1958).

In the UK, there would usually be sufficient thermal energy each year to enable a single generation of *D. perniciosus* to be completed. However, populations are unlikely to reach pest proportions (see **16.**).

14. How likely is the pest to establish in protected environments in the PRA area?

very Unlikely		Unlikely		Moderate likelihood	✓	Likely		very Likely	

Although not generally regarded as a pest of plants grown in protection, it would be likely that if an infested host were grown in protection, such as an

ornamental botanic garden glasshouse, *D. perniciosus* would be able to establish.

15. How quickly could the pest spread within the PRA area?

very Slowly		Slowly	✓	Moderate pace		Quickly		very Quickly	

Local spread is likely to be slow given that only the first instar larvae are mobile and move less than 1m (Kirichenko, 1937; Mathys, 1953), or perhaps a few metres at most (Skorkin, 1937 (in Baker, 1981)). Wind currents could also disperse the organism locally. Longer distance spread would occur via distribution of infested host plants.

16. What is the pest's potential to cause economic and/or environmental damage in the PRA area?

very Small	✓	Small		Medium		Large		very Large	

San José scale is an extremely important indirect pest of apples, pears, peaches, and plums. It is a sucking insect that injects a toxin into the plant as it feeds causing localized discolorations. The presence of reddish blemishes on fruit at harvest indicates potentially damaging numbers on the trees. Local outbreaks have been observed in different parts of the world on fruit trees and ornamental plants, e.g. in Hungary (Kozár & Drozdjak, 1988), Switzerland (Kozár *et al*., 1994; Mani *et al*., 1995), the European part of Russia (Kozár & Konstantinova, 1981), Australia (Baker, 1977) and Canada (Ker & Sears, 1986). Left uncontrolled and with suitable environmental conditions for multiple generations per year, *D. perniciosus* can kill an entire young tree in two to three years (Bessin, 2004). However, the impact of an uncontrolled infestation varies on a regional basis being most severe in the warmer areas where 4 or 5 generations per year are possible, although with 2 or more generations per year impacts can still be significant (Huba, 1962, 1963).

In southern Europe there can be 3 or 4 generations per year (Popova, 1938; Gambaro, 1957), in central Europe (Switzerland) there are two complete generations and one partial generation each year. In apple and pear orchards in Spain (Lerida) two generations occur each year (Fernandez Sanchez de la Nieta *et al*., 1973). In northern continental Europe there is one generation per year. As such it is not likely to cause much damage, as its reproductive potential and development are much reduced at low temperatures (Gentile & Summers, 1958). In the Far East, where *D. perniciosus* is indigenous and only has one generation per year it causes little harm (Smith *et al*., 1997).

A number of parasitoids, e.g. *Anagrus atomus*, *Thomsonisca typica* and predators e.g. *Chilocorus renipustualatus, Chilocorus similis, Cocconella septempunctata, Cybocephalus fodori* and *Rhyzobius lophanthae,* that are

natural enemies of *D. perniciosus,* occur in the UK. Natural enemies can be efficient regulators of *D. perniciosus*, and can keep population densities down in natural habitats (CABI, 2009).

If *D. perniciosus* were to establish in southern England, the annual national cost of living with the organism is likely to be small since the unsuitable climatic conditions are unlikely to allow populations to grow to economically damaging levels, hence would prevent it from becoming a pest (Baker, 1981).

Nevertheless there might be local losses in "hot spots" where climate was atypical and where there were a diminished number of natural enemies, such as in urban environments.

17. What is the pest's potential as a vector of plant pathogens?
Although *D. perniciosus* injects a plant toxin whilst feeding, it is not a vector of a plant pathogen.

STAGE 3: PEST RISK MANAGEMENT

18. How likely is the pest to continue to be excluded from the PRA area?

	very Likely	Likely	Moderate likelihood	Unlikely	very Unlikely
Outdoors:	☐	✓	☐	☐	☐

There is no evidence that *D. perniciosus* arrives in the UK on nursery planting stock. As long as this situation continues, it is likely that the UK will remain free from *D. perniciosus*.

	very Llikely	Likely	Moderate likelihood	Unlikely	very Unlikely
In protection	☐	✓	☐	☐	☐

There is no evidence that *D. perniciosus* arrives in the UK on protected nursery planting stock e.g. for use in glasshouses. As long as this situation continues, it is likely that the UK will remain free from *D. perniciosus*.

19. How likely are outbreaks to be eradicated?

very Likely	Likely	Moderate likelihood	Unlikely	very Unlikely
☐	☐	✓	☐	☐

If necessary, infested parts of plants could be cut off and bark cleaned using water sprays e.g. to simulate heavy rain. Chemical fogs or sprays that are used in orchards could be used (check chemical according to host).

20. What management options are available for containment and control?

In regions where San José scale can be an orchard pest, monitoring and control programmes have been developed e.g. in Hungary (Kozar, 1976) and California (Rice at al., 1982). Biological control, e.g. using *Encarsia perniciosi*, which has been very successful elsewhere could be used.

Further work that would reduce uncertainties

Area of PRA	Uncertainties	Further work that would reduce uncertainty
Taxonomy	Confusion caused by EPPO and EU not using the accepted valid name.	EPPO and EU recognise and use the genus *Diaspidiotus*
Pathway	Spread via nursery stock.	Analysis of EU inspections and interceptions. Link this with historical spread.
Distribution	Detailed distribution in Central Europe.	Contact individual NPPOs and seek advice from experts working with *D. perniciosus*.
Establishment	Ability to complete a generation in UK without entering diapause too soon. Impact of climate change on ability to establish.	Detailed modelling and integration of thermal biology and phenology. Use climate change scenarios to model future likelihood of establishment.
Spread	Rate of spread if it were to establish in UK	Detailed analysis of historical spread data.
Impact	Impact given climate change.	(Linked to establishment)
Management		

21. Summary

San José scale is apparently native to northern China and has spread widely in all temperate regions. It is highly polyphagous and is recorded from hosts belonging to at least 240 genera in 81 plant families, but favours the Rosaceae. In many regions of the world it is considered a major pest of deciduous fruit trees (apple, pear, peach, plum), currants (red currant and gooseberry), and woody ornamentals. It is increasing its geographical range in central Asia (Konstantinova *et al*., 1984) and is likely to do so in Europe in association with climate change.

Since 1996 there have been few interceptions of *D. perniciosus* on fruit, notably *Prunus*, but there are no records of it on live plants, the major conduit for its international spread. Nevertheless if it were able to enter the UK it is likely to be able to establish in the UK (southern England) but not to reach

high population densities that would cause economic damage to commercial orchards and amenity plants, except during a period of sustained unusually warm years. A complex of natural enemies already present in the UK would help suppress population densities.

22. Conclusions

Although *D. perniciosus* is not well suited to UK environmental conditions, it is likely to be able to establish in southern England if it entered on nursery stock. However, damage would not be expected in most years since only one generation is likely to be possible, and economic damage is only reported in regions with multiple generations per year.

Given that the organism is widely distributed elsewhere in Europe I would support repeal of 2006/91/EC to allow plant health resources to focus on pests of more immediate concern.

REFERENCES

Anon. (1969) Council Directive of 8 December 1969 on the control of San Jose Scale (69/466/EEC)

Anon. (1976) Council Directive 77/93/EEC of 21 December 1976 on protective measures against the introduction into the Member States of harmful organisms of plants or plant products *Official Journal L 026,* 31/01/1977 p. 0020 – 0054

Anon. (1992) Council Directive 92/34/EEC of 28 April 1992 on the marketing of fruit plant propagating material and fruit plants intended for fruit production *Official Journal L 157, 10.6.1992, p. 10–18*

Anon. (1993) Commission Directive 93/48/EEC of 23 June 1993 setting out the schedule indicating the conditions to be met by fruit plant propagating material and fruit plants intended for fruit production, pursuant to Council Directive 92/34/EEC Official Journal L 250 , 07/10/1993 p. 1 – 8

Anon. (2006) Council Directive 2006/91/EC on control of San José Scale *Official Journal L 312, 11.11.2006 p 42-44.*

APPC (1987) Asia and Pacific Plant Protection Commission, 1987. Insect pests of economic significance affecting major crops of the countries in Asia and the Pacific region. Technical Document No. 135. Regional FAO Office for Asia and the Pacific (RAPA), Bangkok, Thailand. 56 pp.

Baker, CRB. (1981) San Jose scale, *Comstockaspis perniciosa* (Comstock), assessment of potential in Britain. In: Pest Biology Database, *Comstockaspis perniciosa* datasheet 1165, CSL.

Bessin, R. (2004). San Jose Scale, Entomology fact sheet, University of Kentucky College of Agriculture http://www.uky.edu/Ag/Entomology/entfacts/fruit/ef204.htm

CABI Crop Protection Compendium (2009). *Quadraspidiotus perniciosus*. Datasheet http://www.cabi.org/compendia/cpc/

Davidson, J.A. and D.R. Miller, (1990). Ornamental plants. In: D. Rosen (ed.), Armoured scale insects, their biology, natural enemies and control. Vol. 4B. Elsevier, Amsterdam, the Netherlands: 603-632.

EPPO (1998). Distribution maps of quarantine pests for Europe, *Quadraspidiotus perniciousus*, Map 131. CABI Wallingford.

Fernandez Sanchez de la Nieta, J. M., Camino Germa, I., Fernandez Sanchez de la Nieta, J. I., Franco Garreta, I. & Soldevila Baneres, J. (1973). Life-cycle of

the San Jose scale (*Quadraspidiotus perniciosus* Comst.). *Boletin Informativo de Plagas*. **111**, 7-10.

Huba, A. (1962). The prognosis of the spread and harmfulness of the San Jose scale (*Quadraspidiotus perniciosus* Comst.) in Europe (In Czech). *Polnohospodarstvo* **9** (5-6), 415-421.

Huba, A. (1963). The ecology of Quadraspidiotus perniciosus. *EPPO Publications Series A*. 34 pp 64-72.

Ker, K.W., Sears, M.K. (1986). Effectiveness of superior oil applied to apple for control of the San José scale, *Quadraspidiotus perniciosus*, and the European fruit scale, *Quadraspidiotus ostreaeformis* (Homoptera: Diaspididae). *Proceedings of the Entomological Society of Ontario* **117**, 45-48.

Kirichenko, A.N. (1937). The San Jose Scale in conditions of USSR. Works of quarantine laboratories (In Russian) 272 pp.

Konstantinova, G.M., (1976). Coccids - pests of apple. *Zashchita Rastenii* **12**: 49-50.

Konstantinova, G.M., Kozár, R., Yasnosh, V.A., Matesova, G., Tereznikova, E.M., Bazarov, B., Benke, G., Gummel, E, Gura, N.A. and V.J. Knyazatova, (1984). Scale insects on deciduous fruit trees in eastern parts of USSR. In: Z. Kaszab (ed), Proceedings of the 10th International Symposium of Central European Entomofaunistics, Budapest, 15-20 August 1983. Verhandlungen des Zehnten Internationalen Symposiums über Entomofaunistik Mitteleuropas (SIEEC): 350-352.

Kosztarab, M., (1996). Scale insects of north-eastern North America. Identification, biology, and distribution. Virginia Museum of Natural History, Martinsville, Virginia, USA. 650 pp.

Kozár, F. (1976). A comparison of forecasting methods for San Jose scale (*Quadraspidiotus perniciosus* Comst., Homoptera: Coccoidea) from the practical point of view. XXIIIrd Plant Protection Conference: Forecasting in Plant Protection, Budapest, March 30-31, 1976, 245-247. [in Hungarian]

Kozár, F., (1990). 1.1.5 Zoogeographical considerations. In: D. Rosen (ed.), Armoured scale insects, their biology, natural enemies and control. Vol. 4A. World Crop Pests. Elsevier, Amsterdam, the Netherlands: 135-148.

Mathys, G. (1953). Observations sur la mobilite des larves neonates de Quadraspidiotusperniciosus Comst. et sur leur transport par le vent. Landw. Jb. Schweiz.67 (6): 981-984.

Rice, R.E., Flaherty, D.L. & Jones, R.A. (1982). Monitoring and modeling San Jose scale. *California Agriculture*. **36** (1/2), 13-14.

Schaub, L., Bloesch, B., Hippe, C., Keimer, C., Schmid, A., Brunetti, R. (1999). Validation of a phenology model for San Jose scale. *Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture*. **31** (5), 253-257.

Smith, I.M., McNamara, D.G., Scott, P.R. & Holderness, M. (1997) *Quarantine Pests for Europe*, 2nd Edn., CABI / EPPO, Wallingford, 1425pp.

Additional comprehensive information is also available at:
http://nlbif.eti.uva.nl/bis/diaspididae.php?selected=beschrijving&menuentry=soorten&id=108

Name of Pest Risk Analyst: Alan MacLeod
Address: The Food and Environment Research Agency,
Sand Hutton, York, YO41 1LZ, UK
Date: April 2009