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FINAL IMPORT RISK ANALYSIS OF THE NEW ZEALAND REQUEST FOR THE ACCESS OF APPLES (*Malus pumila* Miller var. *domestica* Schneider) INTO AUSTRALIA

DECEMBER 1998

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It is my determination that the importation of apple fruit (*Malus pumila* Miller var. *domestica* Schneider) from New Zealand will not be permitted under the conditions proposed by New Zealand which contend that mature apple fruit free of trash are not a vector of the bacterial disease *Erwinia amylovora* (fire blight). This determination is consistent with Australia's appropriate level of protection for this disease and is in accord with Australia's international rights and obligations under the Agreement on Application of Sanitary and Phytosanitary Measures.

Paul Hickey
Executive Director

December 1998

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SUMMARY

An application for access into Australia for apples had been received from New Zealand. The major quarantine risk is the possibility that the importation of apples from New Zealand could lead to the establishment of fire blight disease in Australia. Fire blight is a bacterial disease absent from Australia but present in New Zealand. The New Zealand proposal is based on the contention that mature apple fruit free of trash are not a vector for fire blight.

The available scientific literature, submissions from interested parties and state specialists, and research work done by New Zealand were considered in analysing the proposal and preparing this import risk analysis document.

The major findings of the risk analysis are:

- The research data on the absence of *E. amylovora* on mature and immature apples provided by New Zealand is not directly relevant to the New Zealand proposal to source apples free from trash from any area of New Zealand.
- The impact of fire blight in Australia is likely to be very high.
- Apples sourced under the New Zealand proposal could carry fire blight bacteria.
- There are significant areas of scientific uncertainty about certain steps in the possible pathway of disease establishment via trade in apples.
- The New Zealand claim that apples cannot act as a vector for fire blight is not supported by an analysis of the scientific literature and other available information.
- The New Zealand proposal does not provide an equivalent degree of risk mitigation as Australia requires for other high risk products.
- There do not appear to be practical risk mitigation measures that could be implemented in Australia to reduce the risk to an acceptable level.

AQIS does not consider that on the basis of available evidence the New Zealand claim that mature apple fruit free of trash are not a vector of fire blight is adequately demonstrated or that the proposal provides an equivalent level of protection required for other products imported into Australia that could carry high impact pests. The New Zealand proposal would not be consistent with Australia's appropriate level of protection and therefore cannot be accepted.

AQIS considers that with the current state of knowledge and the unresolved uncertainty about the possibility of apple fruit acting as a vector for fire blight, any risk management measures should be based on arrangements that provide, with a high degree of confidence, that imported apples are not carrying *E. amylovora*.

1. INTRODUCTION

An application for access into Australia for apples was received from New Zealand in late 1995 (Appendix 1). This application contained a pest list for New Zealand apples and details of New Zealand research work on fire blight disease, the major quarantine concern for Australia.

2. SCOPE OF THE IMPORT RISK ANALYSIS

The New Zealand proposal for apple access is based on the contention that mature apple fruit free of trash are not a vector for fire blight establishment. This claim is based upon the available scientific literature and additional research work done by New Zealand.

The New Zealand proposal claims that: *"**the export of mature apples produced under New Zealand conditions (regardless of the fire blight (disease) status of the orchard) will not be a viable pathway for the introduction of E. amylovora into Australia**."*, (Appendix 1).

Under the proposal apples could be sourced from trees with active fire blight as long as they were mature and free of trash when packed. No other risk management measures were proposed by New Zealand in the original request. The issues paper (AQIS, 1996) highlighted the fact that the research included in the New Zealand proposal was based on orchards that had been inspected and found free of fire blight. AQIS considered that this should form the basis of any risk management measures that could be developed based on the New Zealand submission. However, New Zealand consistently asserted that apples were not a vector for fire blight and did not propose any alternative risk management measures during the consultation phases of the risk analysis. Therefore the scope of this import risk analysis is an assessment of the risks of importing apples from any area of New Zealand provided they are mature and free of trash. The analysis also considers any possible risk management measures that could be used in Australia.

3. IMPORT RISK ANALYSIS PROCESS

AQIS released an issues paper in July 1996 (AQIS, 1996) that contained full details of the New Zealand proposal. The paper also identified the pests of quarantine concern and provided background information on the disease fire blight. A paper from the Australian Bureau of Agricultural and Resource Economics (Bhati and Rees, 1996) on the costs of fire blight disease was also distributed by AQIS with the issues paper.

Stakeholders were asked to provide relevant comments directly to AQIS within 60 days of release. At industry request an extension of time was provided for comment so the final consultation period was approximately 4 months.

Submissions were received from the State departments of agriculture, industry and interested parties. All of these submissions concentrated on fire blight disease but some submissions also commented on other quarantine pests of concern.

During the risk analysis process AQIS reviewed the available scientific literature, sought opinion from outside experts, discussed the proposal with State Government pathologists and interested parties and considered the material provided during the consultation process. The risk analysis followed the International Standard of Phytosanitary Measures, Guidelines for Pest Risk Analysis (IPPC, 1996a).

A draft Pest Risk Analysis was released in April 1997 (AQIS, 1997). Comments were sought within 60 days. However, before the expiry of the comment period fire blight was reported in the Royal Botanic Gardens, Melbourne. As fire blight was the most significant quarantine pest further consideration of the New Zealand proposal was suspended. Subsequent survey work has found no evidence of fire blight in Australia. A summary of the eradication action and the national survey program was released by AQIS on 9 March, 1998. (AQIS, 1998a).

AQIS announced on 9 March 1998 that consideration of the New Zealand proposal was recommencing and called for any further submissions on the draft Pest Risk Analysis by the end of April.

The risk analysis of the New Zealand proposal was substantially complete before the new risk analysis process developed in response to the Nairn review into quarantine was announced, (Australian Quarantine - A shared responsibility - The Government Response, 1997). Therefore there was no justification for restarting at the beginning of the new procedures.

A major principle of the new process is the provision of adequate opportunities for consultation with stakeholders. Three formal periods of consultation have been provided for in the assessment of the New Zealand proposal. This is comparable to the opportunities required under the new consultation process outlined in the handbook (AQIS, 1998).

In order to allow stakeholders to identify differences between this document and the Draft Pest Risk Analysis (AQIS, 1997) the original format has been retained.

4. QUARANTINE PESTS

Tables 1 and 2 list the diseases and pests likely to occur on apple fruit grown in New Zealand and AQIS's assessment of their quarantine significance for Australia.

The quarantine significance has been assessed under the International Plant Protection Convention definition of a quarantine pest:

> "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".

Of the diseases listed only two, fire blight and *Nectria* canker have been assessed as being of quarantine significance to all areas of Australia. In addition there are three diseases present in Australia but of quarantine concern for Western Australia because they are either absent or

present but under official control in that State. Apple fruit from the eastern Australian States are not permitted entry to Western Australia due to these and other pests. Any conditions for entry of New Zealand apples would need to take into account the different pest status of Western Australia.

Of the arthropod and gastropod pests, Apple blister mite (*Eriophyes mali*), Apple leafcurling midge (*Dasyneura mali*) and Garden featherfoot (*Stathmopoda* sp. (*skelloni*)) warrant special mention because they are considered to pose a significant risk for entry with fruit. European red mite (*Panonychus ulmi*), Codling moth (*Cydia pomonella*) and Oriental fruit moth (*Grapholita molesta*) are absent from or under official control in Western Australia. Exotic pests primarily associated with damage to leaves but with the capability of entry with fruit as eggs or larvae are the leafrollers *Planotortrix excessana, P. octo, Cnephasia jactatana, Ctenopseustis herana* and *C. obliquana* and possibly adult Bronze beetle (*Eucolaspis brunnea*).

Other quarantine pests of concern are mentioned because they may be associated with apple fruit but are not primarily pests of apple. These are seed bugs (*Nysius huttoni, Rhypodes* spp. and *Plinthisus* sp.), *Thrips obscuratus*, and the snail *Vallonia excentrica*. Where only generic names have been provided by New Zealand they are assumed to be quarantine pests but they may eventually be identified as a species already present in Australia (mealybug, *Carpophilus* sp., Lyonetiidae).

Numerous quarantine pests on the New Zealand apple pest list are listed because circumstance could lead them to be associated with apples, not because of the pest's preference for apple. Many would be controlled by management practices in orchards and packing houses.

AQIS considers that satisfactory risk management measures based on field controls, orchard inspection and packing house inspections could be used to manage these pests. These measures would be directly equivalent to those applied by AQIS to other products coming from New Zealand and other countries for the same range of pests. For example the conditions developed for trade in pears and apples from a number of countries in Asia are directly relevant to the New Zealand situation. Operational details of risk management measures would need to be finalised as part of the process of developing specific conditions for trade.

New Zealand have provided additional information about *Venturia asperata.* This organism has been recorded on three separate occasions from one site on dead fallen overwintered leaves and is considered to be a saprophyte on fallen leaves. It has never been detected on apple fruit. AQIS will accept this organism as non-quarantinable subject to confirmation by New Zealand that survey work which has been conducted would have been likely to have found the organism on apple fruit if it was present.

However, given the potential impact of fire blight and Australia's long standing policy on the import of fire blight host material including fruit, the risks associated with fire blight disease required further detailed analysis. This paper presents the results of this analysis.

5. FIRE BLIGHT DISEASE

Fire blight is a serious disease of pome fruit caused by the bacterium *E. amylovora*. The disease was first described in North America in 1780. In 1996 it had been reported in 34 countries (Van der Zwet, 1996). The disease was first detected in New Zealand in 1919 and despite initial attempts to limit spread the disease established throughout the country.

Until the report of fire blight in Melbourne, Australia was considered free of fire blight. Evidence for disease freedom included active surveys for symptoms in some areas and the fact that fire blight had never been found despite the presence of highly susceptible hosts and disease conducive conditions throughout Australia. Evidence from the recent national surveys supports the claim that the eradication program has been successful and fire blight is not present in Australia (AQIS, 1998). Since early this century Australia has had strict quarantine controls on the entry of host material that could introduce the disease. Host fruit has only been sourced on the basis of country or area freedom for fire blight.

The major economic hosts of fire blight are apples and pears but it is also a serious disease of cotoneasters, pyracanthas and many other species of rosaceous plants (Van der Zwet & Keil, 1979). Table 3 shows the major host genera that are present in Australia. This table also includes plant genera which contain species that are occasionally recorded as hosts when artificially inoculated or under unusual environmental conditions.

Control of fire blight is a difficult problem. Antibiotic sprays can be effective but are not always permitted for use. No antibiotics are currently registered for control of plant pests in Australia. Resistance to antibiotic sprays has developed in some countries including the USA and New Zealand. Copper based sprays can also be used but can cause fruit damage if applied at certain growth stages. Removal of blighted branches to prevent disease progress through the tree and reduce the inoculum available for disease spread is a common control strategy but over time this can result in a substantial reduction in the productive capacity of the tree.

5.1 IMPACT OF DISEASE

Apple and pear industry

The biological impact of the disease is highly dependent on environmental conditions. In some countries such as New Zealand the disease is rarely a significant agricultural production problem while in other areas such as California it can be so severe as to make the production of pears uneconomic (Reil *et al*, 1979).

Certain pear varieties including the major varieties grown in Australia are particularly susceptible to the disease. Many of the apple varieties grown in Australia are also susceptible.

Several studies (Wimalajeewa, 1988; Penrose *et al*, 1988; Roberts, 1991) have attempted to predict the severity of fire blight disease on apples and pears under Australian conditions using models developed for disease control overseas. All these studies agree that it could have a substantial impact if it established in Australia. For example, Roberts (1991) predicted that fire blight could be severe in most seasons in most apple and pear growing areas. Estimates for fruit production losses ranged up to 50% for pears and up to 20% for apples where fire blight was severe in all Australian orchards. Experience in countries with fire blight shows that the severity of the disease is very variable depending on the season and location with even adjacent orchards recording significantly different levels of fire blight. Therefore this magnitude of loss probably represents the worst case situation with the disease being severe in all areas. Nevertheless, all the data supports the view that fire blight would be a very significant disease under Australian conditions with some areas such as the Goulburn Valley region, with its highly susceptible pear varieties and conducive conditions for disease, being likely to suffer severely if fire blight were to establish.

The gross value of the Australian apple and pear industry in 1994-95 was $346 million and in 1995-96 $396 million. Several studies attempted to translate the biological impacts into economic impacts. For example, the ABARE study (Bhati & Rees, 1996, Appendix 3) suggested that losses could be $125M per year if the disease was present in all regions and a study commissioned by the Australian Apple and Pear Growers Association (AAPGA, 1997) suggested that the Australian pear industry may not be viable if fire blight was present. This study estimated losses of $827 million to growers over the period 1997-2002 if fire blight was widespread. A similar study on the Granite Belt region of Queensland for the Queensland Fruit and Vegetable Growers (QFVG, 1996a) estimated that losses could amount to $20.9 million per year if fire blight was present.

Environmental and other impacts

The work on the impact of fire blight should it establish in Australia is all based on effects on commercial apple and pear crops. There are a number of other host plants of fire blight grown in Australia that could be affected by the disease in areas where climatic conditions suggest that fire blight would a significant problem. Table 2 includes a number of hosts that are common in Australia in parks and home gardens. Establishment of fire blight in Australia would substantially reduce the amenity value of these plants as well as directly affect the nursery trade supplying these plants.

Australia has a few native rosaceous plants in the genera Rubus, Geum, Aphanes and Acaena. These are widespread in Australia with every state having some native rosaceous plants. There is no information about the susceptibility of native species to fire blight but of these genera only Rubus is listed as having species susceptible to fire blight.

The Tasmanian Beekeeper's Association, through the Department of Primary Industries and Fisheries, Tasmania (DPIF, 1996) raised the possible impact of fire blight on the honey industry. Insect (including bee) control is one of the measures that is sometimes used to prevent spread of fire blight and it is possible that honey production could be affected by disease control measures if fire blight were to establish in Australia.

5.2 ANALYSIS OF THE PATHWAY FOR FIRE BLIGHT ESTABLISHMENT VIA TRADE IN APPLES

A complex chain of events needs to occur for fire blight to establish in Australia from the import of apples. Any absolute breaks in this chain would mean that fire blight would not establish. Alternatively if the probability of a complete chain of events being completed is sufficiently low then there is little risk that the disease will establish via this pathway. An analysis of key events in this chain is given below.

Fire blight being active in the district sourcing apples during the growing season

Fire blight established in New Zealand in 1919. Except for a brief period soon after disease establishment there have been no restrictions on the movement of infected host material. Therefore the distribution of fire blight bacteria in New Zealand reflects environmental limitations and the presence of host material. No commercial apple producing areas are known to be free of the disease organism.

The significance and the intensity of the disease in New Zealand varies from season to season and therefore the chance of apples becoming contaminated with bacteria also varies significantly. However, even in years or districts where the level of disease in apple orchards is low there could be other sources of active fire blight. For example, many orchard areas are located near towns and settlements and it is known that other hosts such as cotoneaster and pears can have active fire blight in seasons where there is little fire blight evident in apple orchards. This is confirmed by the significant number of registered orchards that failed to meet the conditions for export to Japan because of the presence of fire blight symptoms on plants in the buffer areas surrounding the apple orchards (see Appendix 2, Question 9).

Notwithstanding the significant seasonal variation in the severity of fire blight, under the New Zealand proposal to source apples from any district of New Zealand and in any season it has to be assumed that active fire blight will be present in one or more districts sourcing apples for export.

Fire blight bacteria being transferred to apples from an active source and being present on healthy apples harvested for export

<u>New Zealand data</u>

New Zealand has presented data (Appendix 1) which show that apples taken from orchards that are inspected and shown to be free of fire blight symptoms do not carry fire blight bacteria at the level of detection (100 bacteria/apple). In their submission New Zealand stated that 81,715 apples had been tested using the DNA technique and fire blight was not detected. New Zealand has indicated, (Appendix 2, Question 7), that in trials the DNA technique could reliably detect apples carrying 100 bacteria and could detect approximately 50% of apples carrying 10 bacteria. The DNA probe hybridised with each of 41 strains of *E. amylovora*

isolated in New Zealand (Appendix 2, Question 3) and 69 of 76 *E. amylovora* strains held on the International Collections of Micro-organisms from Plants (ICMP).

New Zealand provided a statistical analysis of the apple sampling work involving 81,715 apples and concluded that based on the sampling intensity no more than 469 apples/20 million could carry fire blight above the detectable limit (Appendix 1). Statistical advice provided by the Bureau of Resource Sciences indicates that the value obtained is sensitive to the type of analysis used and the assumptions made. AQIS has normally used the approach outlined in Canon and Roe (1982). This type of analysis gave a slightly higher value of 733 apples/20 million that could carry fire blight above the detectable limit. However, irrespective of which value is accepted the proportion of apples that could be carrying bacteria above the level of detection in the population of apples tested by New Zealand is very small.

Clarification from New Zealand on the fruit sampling program indicates that these tests were not done under conditions that are directly equivalent to the New Zealand proposal to export "mature apples produced under New Zealand conditions (regardless of the fire blight (disease) status of the orchard". Most of the tests were done on immature apples approximately 2.5cm diameter (Appendix 2, Question 6). Approximately 60,000 tests are included in work that has been published (Clark *et al*. 1993). New Zealand has stated that the remaining tests are from further samplings in 1992 and 1993 and fruit taken from trials to determine the spread of *E. amylovora* from inoculation sites.

Most of the tested fruit was immature and drawn from orchards that had been carefully inspected for the absence of disease symptoms (Clark *et al*, 1993). In addition in many cases the orchards were within buffer zones that were free of fire blight hosts immediately surrounding the orchard and free of symptoms on any hosts within 500 metres of the orchard. These conditions are quite different to the New Zealand proposal to source apples from any area of New Zealand regardless of the fire blight status of the orchard and with no buffer zones surrounding the orchard. Under the New Zealand proposal apples could be sourced from trees with active fire blight, as long as the fruit was mature and packed free from trash.

Although New Zealand has not proposed inspection as a risk management measure evidence from research work suggests that inspection is not a completely reliable method for ensuring that bacteria are absent from apples. For example, Clark *et al* (1993) reported that bacteria were detected on fruit from one orchard that had been visually inspected earlier and found free of symptoms. Subsequent inspection revealed a low level of symptoms that had been missed the first time. Although not evident from the Clark *et al* paper (1993), the New Zealand submission states that this orchard was not subject to "official MAF inspection" implying that official inspection would have detected these symptoms. However, New Zealand has not proposed any "official MAF inspection".

It is not clear why positive findings of *E. amylovora* bacteria on apple fruit from orchards where symptoms were not evident have been excluded from the results presented with the New Zealand proposal. They are directly relevant to the proposal to source apples from any area of New Zealand with no risk management measures. In fact, they are typical of the situation that appears to prevail normally in New Zealand, with a low level of fire blight being

common in many commercial orchards in most seasons with occasional severe seasons. These data clearly indicate that fruit from orchards with very low levels of symptom expression do carry fire blight bacteria.

In summary, AQIS considers that the results of fruit testing are not directly relevant to the proposal by New Zealand and cannot be reliably used to indicate the status of fruit that would be harvested under the New Zealand proposal. This problem was identified in the issues paper released by AQIS (AQIS, 1996). The New Zealand response indicated that this data was generated in support of a previous application. AQIS is aware of this and acknowledges that this data shows that inspection of orchards could be a useful risk reduction measure.

There are also other reports from New Zealand of bacteria on fruit. Hale *et al* (1987) found that the proportion of fruit carrying fire blight bacteria from a severely infected orchard declined from 50% in early season to 3% at harvest. Under the current New Zealand proposal for unrestricted access this orchard and these apples would meet the conditions for export. These tests on mature fruit from an infected orchard provide a better estimate of the proportion of fruit at harvest that could carry bacteria under the New Zealand proposal than the data provided in the New Zealand proposal on testing of immature fruit from inspected orchards within buffer zones.

New Zealand also provided the results of experiments on the spread of *E. amylovora* from inoculated fruit, blossom and apple fruit. Seasonal conditions and the replication used are given in Appendix 2, Questions 1, 4 and 5. No detectable spread was observed. These experiments provide an indication of the risk of contamination of fruit from active fire blight under conditions which may generally prevail in New Zealand. However, given the possible volume of trade and the other evidence that apples can carry *E. amylovora*, more extensive replication over a variety of seasonal conditions would be required if these data were to contribute significantly to the quarantine decision. Similar data were provided by Clark *et al*, (1993) who also commented that the possibility that the lack of blossom spread of fire blight may have been due the size of the sample and "a season not conducive to natural spread of the disease".

Data from other countries

There is evidence from other countries that fire blight bacteria could occur on apple fruit under some conditions. For example, Van der Zwet (1990) found that a few apple fruit of susceptible cultivars harvested from apparently healthy trees developed a storage rot involving *E. amylovora* indicating that the apples must have been carrying fire blight bacterial when placed in storage. However, he was unable to recover *E. amylovora* from fruit of resistant cultivars and frequently could not recover fire blight from fruit collected from trees with disease. Scholberg *et al* (1988) were able to isolate bacteria from mature apple fruit on trees adjacent to blighted pear trees. More recently McManus and Jones (1996) were able to show the presence of fire blight bacteria in 75% of calyxes from mature fruit taken from symptomless trees in a severely blighted orchard. However, although the DNA technique used by them was very sensitive it does not distinguish living from dead bacteria and it is possible that the DNA of *E. amylovora* detected was from bacteria that were dead

(McManus, personal communication). In other tests by McManus and Jones (1996) 27% of fruit were positive for fire blight bacteria using a less sensitive test with a limit of detection of 20 bacteria. This contrasts with findings from New Zealand that recorded up to 3% apples positive using a test with a detection limit of 100 bacteria and suggests that the New Zealand work may have underestimated the number of apples that could be carrying *E. amylovora* .

Roberts *et al* (1998) reviewed the literature on the presence of *E. amylovora* on apple fruit in Canada, USA and New Zealand and provided an average value of 4.9% of fruit infested for apples drawn from orchards with active fire blight, and an average value of 0.35% fruit infested for apples drawn from orchards without any consideration of the fire blight status of the orchard. This lower value reflects the fact that only a proportion of orchards are likely to have active fire blight at any one time.

The possible presence of bacteria on fruit was also a key issue identified by a number of respondents who highlighted the problem with the relevancy of the New Zealand fruit testing work.

AQIS considers that the available literature including work from New Zealand clearly indicates that, depending on sourcing orchard and seasonal conditions, significant numbers of apples could carry *E. amylovora* under the New Zealand proposal.

Significant numbers of bacteria surviving during the picking, packing, transportation and distribution phases to the end consumer in Australia

There is evidence that *E. amylovora* does not survive when exposed to warmer temperatures, dry conditions and light (see for example, Maas Geesteranus & de Vries, 1984). However, bacteria in the calyx of the apple would be protected to some extent and are likely to survive for longer periods than when exposed. Cool storage is also likely to prolong the survival of bacteria on fruit. For example, Scholberg *et al* (1988) found that *E. amylovora* survived in cold storage for many months. The capacity of *E. amylovora* to survive on apples is also illustrated by the report of soft-rot of apples in storage (Van der Zwet, 1990) that appears to have involved *E. amylovora*. In addition, transport times from New Zealand to Australia are short and therefore New Zealand apples could be distributed in Australia with little delay after picking.

AQIS considers that cool storage and short transport times for apples from New Zealand are unlikely to lead to a substantial reduction in the numbers of apples carrying *E. amylovora* or the number of bacteria present on those apples.

Significant numbers of bacteria surviving on the core/peelings or discarded apples after use

The chance that fire blight would survive the use and disposal of the apple depends very much on how the apple is consumed.

Fire blight is not likely to survive on residues of apples that are processed to produce juice or other products, but this may be expected to be a fairly minor use of imported apples. The major use is expected to be for direct sale and consumption.

The data available in the literature (Hale *et al*, 1987) suggests that the calyx area appears to be the most likely site for survival of bacteria. The core including the calyx is the most likely part of the apple to be discarded after eating. Apple cores that are discarded into domestic rubbish collections are unlikely to constitute a risk for the survival and subsequent spread of *E. amylovora*. However, apple cores discarded directly into the environment are possible sources of inoculum. AQIS is unaware of any data on the survival of *E. amylovora* in the calyx of discarded apples or any data available on the proportion of apples that would be discarded directly into the domestic rubbish collection compared to apples discarded directly into the environment. However, the presence of apple trees along roadsides suggests that significant numbers do get discarded directly into the environment.

The evidence on survival of *E. amylovora* on exposure to light and under different temperatures and the evidence that *E. amylovora* is often overgrown with other bacteria when isolations are done from organic material suggests that *E. amylovora* does not have a high probability of surviving and multiplying for a long period on discarded apple cores. However, short term survival for a few days to weeks is likely.

There are other suggested scenarios for survival and multiplication of bacteria on apples. If a rot developed in New Zealand apples in cool store in Australia that involved *E. amylovora* then very high levels of bacterial inoculum could be produced and contaminate clean fruit stored and handled in the same facility. One possibility that has been suggested is that as spoilt fruit at metropolitan markets is sometimes returned to growers in bins this could directly expose Australian orchards to high levels of inoculum if the spoilage of this fruit involved *E. amylovora*.

AQIS requested information from New Zealand on post-harvest rots involving *E. amylovora*. New Zealand stated that such rots had never been reported in New Zealand and provided data on apples that had been inoculated, cool stored for 1-4 months then incubated at 20°C. No rots were seen in any of the inoculated fruit (Appendix 2, Question 10).

In summary, the mode of consumption and disposal of apples significantly reduces the chances that apples carrying *E. amylovora* would be available to act as inoculum but there are a possible scenarios that would allow survival of bacteria.

Apple material being discarded in an area where there are hosts of fire blight

Known hosts of fire blight are widely distributed in Australia but to be a vector of fire blight an apple or apple core would need to be discarded very close to a suitable host.

The presence of volunteer apple plants confirms that apples and apple cores are often discarded in gardens or parks where hosts could be present in a receptive state for infection. Often spoiled or rotting apples would be discarded in home compost heaps close to host

plants. Composting and recycling of organic material has been strongly encouraged in Australia over recent years therefore increasing the possibilities for apples to be discarded close to fire blight hosts in home gardens.

The density of fire blight host varies greatly. In some towns and cities, particularly in southern Australia, almost every garden would contain host plants while in many of the northern areas hosts may be present but at a much lower density. The QFVG (QFVG, 1996b) provided actual distribution and predicted distribution (using BIOCLIM) of key fire blight hosts in Queensland. This work suggested that hosts are present or could establish along much of the eastern coastal strip of Queensland up into Cape York.

The majority of Australia's population lives in areas conducive for fire blight disease and in areas where hosts of fire blight form a significant part of the home garden, public park and naturalised flora. These areas are also likely to have the greatest consumption of imported apples (in absolute terms) given the higher population. These conditions ensure that lack of hosts is unlikely to be a major limiting factor in the establishment of fire blight.

Host plants being at a receptive stage (such as flowering) for infection by fire blight

The flower is considered to be the most receptive stage for initiation of new infections although under some circumstances wounds such as those caused by hail or other mechanical damage can also be entry points.

Given that there are a number of host species widespread in Australia across a range of ecoclimatic regions it is likely that the receptive stage for infection will be present in some parts of Australia for a significant proportion of the year.

Apples can be stored for a considerable period of time. This may extend the period of availability of New Zealand apples and therefore increase the probability that fire blight hosts in Australia in a receptive stage for disease initiation could be exposed to any *E. amylovora* carried on New Zealand apples.

Environmental conditions being suitable for survival and multiplication of fire blight bacteria

Fire blight bacteria require relatively high temperatures and humidity to multiply although survival can occur at lower temperatures. Epidemic disease development typically takes place in warm (greater than 18.5^{o}C) and moist conditions (Van der Zwet & Keil, 1979). These conditions are present in many areas of Australia. For example, Roberts (1991) found that almost all major apple and pear production areas would be rated a severe risk for disease occurrence in most seasons. Dry, hot summers are not likely to be conducive to survival and multiplication except where irrigation systems maintain humidity at high levels. Such systems are common in horticultural areas in Australia.

The majority of the population lives along the moister coastal strip of Australia where environmental conditions are likely to be even more conducive for infection than commercial

fruit producing areas. Therefore, it is likely that suitable conditions for infection would be available for a substantial period of the year, particularly in the areas of maximum apple consumption.

A mechanism for transfer of bacteria from the apple to a new host being present and sufficient bacteria being transferred from the discarded material to the new host to start infection

E. amylovora does not have any specific vector or mechanism to allow transmission from an apple to a suitable host. Fire blight is not seed transmitted so germination of seeds in discarded apples does not present a risk. The most likely mechanism for transfer from discarded apples is that a browsing insect or an ant will incidentally pick up *E. amylovora* when visiting an apple and subsequently transfer these bacteria to a receptive flower.

Van der Zwet, 1979, lists 77 genera of arthropods that have been associated with the transmission of fire blight, and insects are considered one of the main vectors for short to medium range spread of the disease. These observations have been recorded from situations where large quantities of bacterial ooze or infected flower clusters are present. This is different to the situation where a comparatively small number of bacteria may be present in the calyx of an apple and if infection is to occur then all or almost all of these bacteria need to be transferred to a specific area of a suitable host plant. However, many of the arthropods listed by Van der Zwet are crawling species that could potentially move from an infected piece of fruit to a suitable flower. The AAPGA submission (AAPGA, 1996) provided a list of 27 insects (drawn from the list of Van der Zwet) which have been implicated in fire blight spread overseas that have the same genus or species present in Australia.

Other data on possible insect transmission was provided by Biocontrol Ltd (1996). This submission also raised the possibility of transmission from rotting fruit to a suitable host by fruit flies. Fruit flies are often bacterial feeders and will feed on rotting fruit. Australia has a diverse range of fruit fly species throughout much of the area where fire blight hosts are present. The New Zealand submission has argued that the biology of the tephritid flies is such as to preclude them acting as vectors for fruit flies and Van der Zwet (1979) does not list any tephritid fly species as being associated with fire blight spread. However, Van der Zwet does list one species of vinegar fly (sometimes referred to as fruit flies) as being associated with dissemination of fire blight. Vinegar flies are attracted to rotting fruit and are present in Australia in significant numbers and widely dispersed.

Another possible mechanism for transfer is mechanical transfer by objects accidentally contaminated by contact with rotting fruit with high levels of *E. amylovora* (see above discussion on fruit rot). Infection could be initiated in the absence of flowers if mechanical transfer involved wounding of a host plant. Problems experienced with disease transmission by pruning tools in areas where the disease is present show that mechanical transmission of fire blight can occur (Van der Zwet and Keil, 1979). If fruit bins and equipment were contaminated by handling apples carrying *E. amylovora* and subsequently used in a situation where host plants were present, then there would be some possibility of disease transmission occurring.

New Zealand has conducted research on the number of bacteria that are needed to start an infection. Apple and cotoneaster flowers were individually inoculated with known numbers of bacteria and subsequent symptom development monitored.

For apples, fire blight symptoms were only detected when at least 10^7 colony forming units (cfu) of bacteria were inoculated although browning was observed with 10^5 cfu. At inoculation levels of 10^0 to 10^4 cfu no symptoms developed and bacteria could not be re-isolated from the flowers.

The results with cotoneaster were similar with no symptoms observed on inoculation with 10^2 to 10^4 but symptoms were observed at high levels of inoculation. At this inoculation level no bacteria could be isolated from flowers. Cotoneaster is a highly susceptible host of fire blight and Hale *et al* (Appendix 1*)* suggest that this indicates that there is a threshold for the number of bacteria needed to start infection in these hosts.

Van der Zwet *et al* (1994), found that 5 bacteria were sufficient to result in a significant number of apple blossoms developing fire blight in one season but that this was dependent on bacterial strains used. In another season a minimum number of 5000 bacteria per blossom were needed for fire blight development.

The differences between the New Zealand work and other results reported in the literature may reflect differences in the environmental conditions. New Zealand has provided some weather data that indicates that conditions were not highly conducive for disease initiation and spread at the time the New Zealand research was conducted (Appendix 2, Question 1).

The AAPGA submission (AAPGA, 1996) also identified earlier work (Hildebrand, 1937) that indicate that one bacterium could be sufficient to start infection under some conditions. Although this work involved controlled inoculations of a range of host material it does indicate that under some conditions a single bacterium can be sufficient to initiate infection. These low numbers presumably reflect the ability of the bacteria to multiply very rapidly under suitable conditions and build up to infective levels.

Van der Zwet (1994) lists the "best documented principal means of dissemination" of fire blight. Of the 7 cases referred to, two were associated with trade in host fruit (apple cases-England and Bartlett pears-Hawaii). The others were attributed to budwood (2), birds (1) and wind (2). Roberts *et al* (1998) have reviewed the literature on this point and quote a number of opinions that fire blight is unlikely to have established in England because of contaminated fruit cases. This point was also made in the New Zealand and USA submissions. However, the Roberts *et al* (1998) paper and both the New Zealand submission and the USA submission on the draft PRA do not make any mention of the Hawaii case. The paper quoted by Van der Zwet (1994) on this case (Anon, 1966) mentions that significant quantities of pears exported to Hawaii developed fire blight lesions when placed at ripening temperatures. Although it is not clear if these imports led to the establishment of fire blight these data provide circumstantial evidence of a possible pathway of dissemination that involves trade in fruit.

In summary from a review of the available information there do appear to be plausible mechanisms for transfer of *E. amylovora* from fruit to a suitable host at a sufficient concentration to initiate disease. Under conditions conducive to bacterial multiplication the number needed to start an infection could be very small suggesting that the presence of even low numbers of fire blight bacteria on apples presents some risk. There is also some evidence that links trade in fruit with spread of fire blight to a new area.

Environmental conditions being suitable for transmission and establishment of secondary infections from the primary infection

Disease modelling work based on Australian weather conditions (Roberts, 1991) suggests that many apple and pear production areas have suitable conditions for spread of fire blight in spring and early summer but at other times of the year conditions are generally unsuitable. This suggests that if primary infections occurred outside these times or did not spread when first established there may be a period of time when the infection is confined to a discrete area. However, the warmer more humid coastal areas are likely to have conducive conditions for disease spread for longer periods. Depending on where the primary infection occurred environmental conditions may not be a limiting factor to further spread.

The New Zealand submission (New Zealand, 1998) has suggested that the detection of *E. amylovora* in the Royal Botanic Gardens, Melbourne indicates that the probable rate of spread of fire blight in Australia has been overestimated. However, given the uncertainties surrounding the time the organism may have been in the Gardens, the lack of data on the mode of entry of the organism and the controlled nature of this site the detection in Melbourne does not appear to outweigh other work that indicates that conditions in much of Australia would be conducive for establishment and rapid spread of fire blight.

The disease outbreak not being detected early enough to allow eradication

Given the capacity for *E. amylovora* to establish epiphytically (Van der Zwet *et al*., 1994) and the fact that the visible expression of fire blight symptoms is strongly dependant on environmental conditions, there is a high possibility that a low level of infection would not be noticed until spread had occurred and symptoms were widespread. Problems of early detection would be exacerbated by the diversity and distribution of hosts that would need to be monitored and the fact that many of the hosts would be in home gardens in cities and towns and not subject to regular commercial management and, therefore, symptoms might not be reported for some time. Problems of early detection are illustrated by outbreaks overseas. For example, by the time Israel detected the disease in 1985 it had established in two areas 200 kilometres apart (Shabi and Zutra, 1987).

The experience of other countries in eradicating fire blight is also relevant. The disease has only been successfully eradicated where outbreaks were very limited and conditions were unfavourable for spread. In most cases eradication campaigns have been ineffective. For example, despite extensive efforts soon after detection New Zealand was not able to prevent the spread of the disease. It is unlikely that an outbreak in Australia could be eradicated or

even contained in one area unless it was very limited and detected very quickly after establishment. These factors were critical to the success of the eradication program in the Royal Botanic Gardens, Melbourne, where the disease was detected in only a few plants in a controlled area within a city.

Volume of trade

The risk of establishment of a plant pest via trade is related to the probability of a commodity introducing the pest via this pathway and the number of times the importing country is exposed to this pathway. It is difficult to estimate the volume of apples that could be imported from New Zealand as it will be highly dependent on pricing, quality and availability. The AAPGA (AAPGA, 1996) submission suggests that there could be 10 shipments per year, each of 3600 tonnes. This represent approximately 24% of Australia's fresh apple consumption. Queensland Department of Primary Industry (QDPI, 1996) based their calculations on 5% of Australia's fresh apple consumption. Given the arrangements between Australia and New Zealand that allow free trade except where valid technical reasons exist such as quarantine it has to be assumed that a substantial volume of fruit could be sourced from New Zealand and any risk management measures need to take this into account.

Other Issues

Risk of trash being a vector for disease transmission

The New Zealand proposal requires that apples be free of trash in order to reduce the possibility that *E. amylovora* could be present in a shipment . McManus and Jones (1996) reported that *E. amylovora* could be detected in 100% of asymptomatic leaf tissue, 80% of asymptomatic axillary buds and 75% of asymptomatic fruit from a severely diseased orchard. Other work (see for example Van der Zwet and Buskirk, 1984) also indicates that *E. amylovora* is common on leaf material. These data suggest the probability that trash or apple fruit could carry *E. amylovora* may be approximately the same for any one orchard; therefore occasional small amounts of trash in shipments are unlikely to a pose a significant additional risk.

Risk of packing materials being a vector for disease transmission

Transmission on apple crates has been suggested as the mechanism for fire blight establishment in England (Van der Zwet, 1994). There is also evidence (Keck *et al*, 1996) that under a variety of laboratory conditions *E. amylovora* could survive on wood and plastic for a least 4 months. Given the New Zealand proposal to source from any area irrespective of disease symptoms, arrangements would be needed to ensure that contamination of packing materials with *E. amylovora* did not occur.

5.3 OVERALL ASSESSMENT OF PATHWAY RISK

5.3.1. Quantitative risk assessment

The analysis above indicates that no single step in the pathway provides a complete and unarguable break in the chain of events that needs to occur for fire blight to enter and establish. In the absence of this break, the risk analysis has to consider the overall probability of each of the events occurring together in an unbroken sequence leading to the establishment of disease.

A number of submissions attempted to address this point in actual probability terms. For example the QDPI (QDPI, 1996) submission suggested that the probability of disease establishment each year was 0.98. It would be expected that if the probability of fire blight establishment from apples was this high then it would be comparatively easy to obtain research data linking trade in apple fruit with the establishment of fire blight in other areas of the world. However, this is not the case.

The AAPGA submission (AAPGA, 1996) also provided a numerical analysis of the probability that trade in apples could lead to the establishment of fire blight. This study presents a range of values. The highest value is that fire blight would establish after only 0.04 years (approximately 14 days) trade in apples. As with the QDPI submission it is difficult to place any credibility on this value. The lowest value given in this study is that it would take 110 years of trade in apples for fire blight to establish. There is a 2750 fold difference between the low and the high probability estimate.

This wide spread of values serves to call into question the value of this type of analysis for complex pathways, where there is comparatively little data on key steps.

Roberts *et al* (1998), have published a review of the potential spread of fire blight via trade in apples. This paper reviews the existing literature and provides a quantitative analysis of the probability of introduction and establishment of fire blight via apple fruit. Although this review concentrates on circumstances surrounding the trade in apples from the USA and New Zealand to Japan it is also relevant to the New Zealand proposal for access to Australia. This paper has been referred to in both the New Zealand (New Zealand, 1998) and USA submissions (USA, 1998) and is therefore examined in detail below.

The analysis is similar to those provided by the AAPGA and QDPI. It uses a simple model based on the volume of trade and the probability of various events in the infection/establishment chain to calculate the probability of fire blight establishing via apple trade.

Three scenarios are modelled with differing risk management measures applied in the producing country. As no specific risk management measures were proposed by New Zealand only model S3 ("no phytosanitary requirement implemented for *E. amylovora*") is relevant. For the Japanese trade the model gives the probability of outbreaks occurring from once in 1,136 years (worst case) to once in 113,640 years (best case) for this scenario. The hundredfold variation is due to the spread of values used for the probability of transfer from apples to a new host.

The individual elements of this model are deal with below and the model applied to the New Zealand proposal for apple access to Australia.

F(1) Number of apple fruit shipped from exporting source per year.

Roberts *et al* (1998) chose a figure of 20 million fruit per year based on past experience of the USA in exporting apples to Japan. The situation for New Zealand apple exports to Australia is likely to be very much different. It has been estimated that New Zealand apples could capture over 20% of the Australian market (see above). A figure of 200 million fruit per year would be a more realistic choice for trade in apples between New Zealand and Australia.

P(1) Probability the fruit is infected or contaminated with *E. amylovora*.

In setting this figure Roberts *et al* (1998), use the proportion of orchards that may have fire blight compared with those that do not to calculate an average figure for the whole year's trade. In the case of the their S3 scenario the assumption has been made that for the USA, only 5% of apples would be sourced from orchards with significant fire blight with the balance of the volume coming from orchards that had a higher health status. This assumption in effect imposes a requirement that this condition be met if the analysis is to be valid. However, New Zealand has not proposed any conditions that would meet this requirement. Under the New Zealand proposal the total trade could come from orchards with active fire blight. In practice this is unlikely to happen every season but occasionally apple production areas experience severe fire blight and therefore there is the possibility that in some seasons significant numbers of apples could be sourced from orchards with active fire blight disease. The New Zealand apple production area is much less geographically spread than the USA and therefore more uniform in environment. It is likely that if fire blight was significant in a particular season then more than 5% of orchards would be affected. Given this possibility a more robust calculation that allows for this situation needs to be used and a figure based on sourcing apples from 50% of orchards with active fire blight has been used. This results in a probability for this factor of 0.025 compared to the figure of 0.003502 used by Roberts *et al*.

P(2) Probability *E. amylovora* survives storage, transport and discard conditions.

A "subjective" estimate of 0.1 was given by Roberts et al for this parameter. Given the very short transport times between New Zealand and Australia the probability of survival of bacteria present on or in apples is likely to be significantly higher.
A figure of 0.5 has been used in this analysis.

P(3) Probability fruit is discarded or placed near host.

It is very difficult to estimate a value for this probability. The Roberts *et al* paper used a value of 0.0025 for their calculations based on anecdotal evidence from USA officials who have visited to Japan. In Australia there is considerable promotion of the value of composting waste vegetable matter and many people would just discard apple cores directly in an area of the garden. Given the popularity of hosts of fire blight as garden plants these cores could be very close to host plants. A figure of 0.005 (double the Roberts *et al* value) has been used.

P(4) Probability host is at receptive state (e.g. flowering).

Roberts *et al* do not provide any specific data to justify their choice of 0.05 for this value which represents a "window" of host suitability of 18.5 days at any one point. A detailed analysis of the flowering times for the full range of hosts could be used to provide a better estimate but the value proposed seems to be a reasonable estimate and this value is used in the calculations given below.

P(5) Probability *E. amylovora* transferred to new host and infection takes place.

Expressed on an individual apple basis transfer of *E. amylovora* from an apple to a suitable host is the lowest probability event in the infection chain and therefore is one of the most critical probabilities. It is also the most difficult to research given the low probability. Roberts *et al* use a range of values covering two orders of magnitude and these values are used in the analysis given below.

The following table summarises the values used.

Table 4. Probability values modified for the New Zealand proposal

	Factor	Probability/value
F1	Number of apple fruit shipped from exporting source per year	200 million
P1	Probability the fruit is infected or contaminated	0.025
P2	Probability E. amylovora survives storage, transport and discard conditions	0.5
P3	Probability fruit is discarded or placed near host	0.005
P4	Probability host is at a receptive stage	0.05
P5	Probability E. amylovora transferred to new host and infection takes place	0.001- 0.00001
F2	Calculated frequency of outbreaks	0.625 - 0.00625 outbreaks per year

Based on the values given in table 4 the frequency of outbreaks falls in the range of 0.625 to 0.00625 per year or one outbreak every 1.6 to 160 years. If these values are correct then the risk posed by the New Zealand proposal is unacceptable.

Even if the probabilities proposed in the original Roberts *et al* analysis are accepted when the likely volume of trade to Australia is taken into account the analysis provides a range of calculated risks from one outbreak in 114 years to one outbreak in 11422 years. Given the uncertainties in determining probabilities for the different events in the infection pathway AQIS does not consider that the lower limit provides an adequate safety margin to cover uncertainties. Uncertainties in the choice of probabilities were clearly evident in the Roberts *et*

al analysis and are also highlighted by the preceding discussion of the key steps in the infection chain described above.

AQIS does not consider that the quantitative risk analysis is sufficiently robust to provide a sound basis for quarantine decision making as the outcomes are risk estimates that cover the range from an extremely high level of risk to a low level of risk. For a number of key events in the infection pathway there is very little objective data that is directly relevant. This problem with a quantitative analysis was also identified in the QFVG submission (QFVG, 1996b). Although numerical probability analysis of risk is a desirable aim in pest risk analysis in that it provides a direct objective measurement of the risks it is rare that adequate information is available to achieve this.

The lack of good data on the probability of key steps was evident at a workshop convened by AQIS of State and industry specialists. Although a quantitative risk analysis is appropriate where sufficient information is available, AQIS considers that a qualitative analysis is also a valid approach to quarantine decision making. This view is strongly supported by the recent review of quarantine (Australian Quarantine: A shared responsibility, 1996) and also provided for in the International Standard on Phytosanitary Measures, Guidelines for Pest Risk Analysis (FAO, 1996).

5.3.2 Qualitative risk assessment

Qualitative risk assessment seeks to analyse the problem using a variety of non-quantitative methods such as comparison to other situations which are relevant to the proposal being considered. This allows for a consistent approach to decision making. The following analysis examines trade by other countries in apples, other possible pathways for disease entry and conditions established for other products entering Australia.

Trade in apples by other countries

Although there is no International Standard for Phytosanitary Measures that is specifically applicable to the movement of host material from countries with fire blight to countries free of fire blight, a possible precedent for the consideration of the New Zealand proposal is the action taken by other fire blight free countries when importing apples.

A number of countries that are currently free of fire blight import apples from countries with fire blight, and have done so for a number of years. These imports occur under a range of conditions. For example, New Zealand and the USA send apples to Japan on the basis of a protocol that involves buffer zones, inspection of orchards and inspection at packing. The volumes imported are believed to be small. In the first two years New Zealand has had access to Japan only 218 and 190 tonnes have been sent. South Africa accepts apples from fire blight countries on the basis of certification that the apples do not come from orchards with fire blight. AQIS understands that only a small volume of fruit may have been imported under these conditions. China is believed to allow imports under conditions that require testing of a sample of each shipment from the USA for the presence of *E. amylovora*. AQIS is not aware that any shipments have been rejected. Recently Switzerland has imported apples on

the basis that they are sourced from orchards without symptoms although for a number of years it allowed imports without specific conditions. Other countries that are known to take measures to minimise the probability of establishment of fire blight via trade in fruit include Argentina, Brazil and Chile which have a requirement for a chlorine dip and the Slovak Republic which requires a form of area freedom.

Early this century Australia imported apples from the USA and Canada without any specific conditions or the requirement that they be free from trash although it is not known if the fruit was drawn from areas with fire blight. For example, in 1916-17 the value of apple imports from Canada and the USA was 61,662 pounds**.**

It is significant that in contrast to the New Zealand proposal for free access none of the countries discussed above allow the import of fruit without some measures to reduce the possibility that *E. amylovora* could be present. Clearly these countries consider that there must be some degree of risk associated with the import of host fruit carrying *E. amylovora*.

New Zealand has highlighted the fact that there is a range of countries without fire blight that import apples from countries with fire blight without any specific risk management measures. These countries include, Member States of the European Union, India, Korea, Pakistan, Sri Lanka, Taiwan and Zimbabwe. However, the existence of differences in risk acceptance by countries does not in itself imply that the more stringent measures are not justified. Every country has the sovereign right to choose an appropriate level of protection (ALOP) and take appropriate measures to meet this. Differing ALOP, differing environmental conditions and differing conditions within countries will inevitably result in variations in measures taken by different countries for the same pest.

Comparison with other pathways of entry

An analysis of alternative pathways for pest establishment can provide a useful measure of the risk faced from other pathways. For example, if there were other pathways for fire blight with substantially greater risks than the proposed trade then it may be difficult to justify restricting trade unless these other risks are addressed.

Other possible pathways of entry of fire blight into Australia include propagating material brought through the legal channels, illegal entry of propagating material, illegal entry of host material such as apples and pears and accidental bacterial contamination of people or objects.

The legal introduction of propagating material requires three seasons observation by qualified plant pathologists in post-entry quarantine before release. The AAPGA has provided a probability analysis that indicates that the risk from this pathway is very small. AQIS has general reservations about the AAPGA quantitative analysis (see discussion above) but agrees that the risk of fire blight establishment via the legal entry of propagating material is low. This system has permitted the safe import of a large number of hosts from countries where fire blight occurs.

An analysis of the establishment of a number of exotic pests in Australia indicates that a substantial proportion is likely to be due to illegal introduction of host material or perhaps incidental introduction with other objects or people. For example, citrus canker, severe tristeza virus, stripe rust and papaya fruit fly are just some of the exotic pests that probably established by such mechanisms. AQIS undertakes a wide range of activities intended to reduce the risks of entry of quarantine pests. These include a range of border inspection procedures at airports and ports and surveillance and monitoring activities directed at high risk areas. In recent years the resources for these activities have been increased significantly.

The AAPGA report suggests that the risk of establishment via carriage on inert material or people is no greater than 1 in 39,000 years and the chance of the unwitting carriage on illegal material brought through the quarantine barrier as 1 in 663 years. Given the experience with other pests, the fact that *E. amylovora* can survive on surfaces and systemically in some host material and the short travel times between Australia and fire blight countries AQIS considers that these probabilities have been underestimated but does not consider that the probabilities of establishment by these pathways is high.

The USA submission (USA, 1998) suggested that the recent reports of fire blight in the Royal Botanic Gardens, Melbourne indicate that there are more significant pathways for fire blight introduction than trade in apples. However, given the difficulties in drawing any firm conclusions about the mode of entry of the disease and the time the disease had been present in the Gardens it is impossible to draw any conclusions relevant to consideration of the New Zealand apple proposal.

While the preceding discussion indicates that there may be other risk pathways for fire blight AQIS does not consider that the risks from these pathways are so large that they would negate the necessity to seek a high level of risk mitigation in the development of any protocol for commercial trade in apples.

Comparison with other products/pests

Australia has an obligation under the Sanitary and Phytosanitary Agreement to avoid arbitrary or unjustified distinctions in the levels of phytosanitary protection it considers appropriate in different situations if such distinctions result in discrimination or disguised restrictions on international trade. In broad terms this means that Australia must manage risk in a consistent manner. Therefore a comparison of the assessed risks of a specific proposal against other related quarantine decisions is an important part of the risk assessment.

This section compares the New Zealand proposal against other cases where the impact of pest introduction is considered comparable to the impact of fire blight.

Import of pears from Japan

Australia has allowed imports of nashi type pears from Japan for some years. Recently the re-occurrence of a bacterial disease bacterial shoot blight was reported in Japan on the island of Hokkaido (Kim *et al*, 1996). This disease is similar to fire blight disease and therefore AQIS

immediately suspended imports until the situation could be assessed and adequate arrangements implemented to manage any risks.

Trade was re-established on the basis of area freedom from the disease for the exporting area. This area freedom is based on orchard inspection, fruit testing, quarantines on movement of host material from the diseased area, an active eradication campaign and pre-clearance fruit inspection. In addition, the exporting area is geographically remote from the disease outbreak area.

Trade in pears from Japan is broadly comparable to the New Zealand proposal in that it involves trade in a susceptible host product from a country with a disease similar to fire blight. It differs from the New Zealand proposal in that it involves only a very low volume of fruit, risk management is based on a robust area freedom arrangement and there is a stringent eradication program for the disease in place.

The New Zealand proposal does not offer an equivalent level of protection to the protocol in place for trade with Japan

Fruit fly hosts

Australia generally accepts fruit fly host material on the basis of area freedom established to the international standard (IPPC, 1996b) or on the basis of a disinfestation treatment that achieves approximately Probit 9 efficacy. The statistical sampling used to determine Probit 9 efficacy means that no more than 32 larvae per 1 million larvae could survive the treatment. This treatment is in addition to the normal field controls and practices that ensure that there is a low probability that fruit could be infested with fruit fly.

From the New Zealand fruit testing the maximum number of fruit that could carry bacteria is approximately 37 per one million. Therefore, these tests provide approximately the same protection as a Probit 9 treatment for fruit fly, assuming fruit is sourced under conditions comparable to these tests and it is accepted that the test sensitivity is adequate. However, as discussed above AQIS has significant reservations about the applicability of these tests to the New Zealand proposal and the level of infected fruit may be very much higher. For example, Roberts et al (1998), suggested that fruit drawn from orchards with fire blight could have up to 4.9% infected with fire blight.

Although there are other risk modifying factors for both fruit fly hosts and New Zealand apples it must be concluded that the New Zealand proposal appears to offer a lower overall level of protection than Australia is prepared to accept for fruit fly host material.

The New Zealand submission has carried out an analysis of the imports of fruit fly host material from Australia using a similar approach to the Roberts *et al* model suggesting that this "*may provide worthwhile guidance for the development of appropriate phytosanitary measures*". The New Zealand analysis suggests that one outbreak of fruit fly could be expected every 1538 years of trade from Australia. The New Zealand submission claims that " *The level of risk accepted by New Zealand for Queensland fruit fly host material is*

therefore far greater than Australia would be exposed to in accepting apple fruit from any area of New Zealand". It is questionable if the New Zealand policy on risk acceptance for fruit fly host material is relevant to Australia's policy on risk acceptance for fire blight. However, it is significant that based on the Roberts *et al* (1998) model, (adjusted only for the possible volume of fruit), the risk to Australia from trade in apples from New Zealand is one outbreak in 114 years for the worst case analysis. This is over ten times higher than the risk that New Zealand claims to face from fruit fly host material from Australia.

Cereal diseases

Wheat is generally prohibited entry to Australia because of concerns about a number of serious cereal diseases that are absent from Australia.

In addition, AQIS imposes a nil tolerance for wheat contamination in other products if there is a possibility that the wheat contamination could come from areas with diseases of concern. For example, all fertiliser shipments are inspected and rejected or required to be cleaned if wheat contamination is found.

The cereal industry in Australia is significant and like the apple and pear industry any entry of exotic pests and diseases is likely to have a substantial impact and therefore a very conservative position is taken on quarantine.

Although it is difficult to directly compare the chances of establishment of a disease from imported wheat grain versus the chances of establishment of fire blight from apples they are probably in the same order. For example, neither has a specific vector, both require germination and growth of the host commodity or the close proximity of another host and both would be dependent on specific environmental conditions for disease establishment. In addition, it could be argued that the chance of disease establishment from a single infected seed or apple is low but the volume of imports is potentially high, and it is not practical to adequately sample and assay for disease on a routine operational basis.

The New Zealand proposal does not appear to offer an equivalent level of protection to the level of protection Australia expects for cereal pests.

Citrus imports

Australia is currently examining a proposal to import citrus from Florida. One of the concerns is the possibility that citrus fruit could transmit citrus canker. In general terms citrus canker is similar to fire blight. They are both bacterial diseases, neither has a highly specific mechanism for transfer from the host fruit, both are dependent on specific environmental conditions for establishment and spread, both require the close proximity of host material at a suitable stage for establishment and both would have a high industry impact if they were to establish in Australia.

AQIS is developing a risk management approach based on area freedom. This will require geographical separation of the producing area and the disease outbreak area, adequate

ongoing inspection of the export areas to confirm absence of the disease and an active eradication program.

The New Zealand proposal does not appear to offer an equivalent level of protection as the area freedom approach being developed for citrus canker.

5.4. CONSIDERATION OF POSSIBLE RISK MANAGEMENT MEASURES

There are a variety of possible risk management options that could be considered in seeking to develop measures to manage the risk of introduction of fire blight disease via trade in apples. These are considered below.

Offshore:

Although the submission accompanying the New Zealand proposal provided information based on surveys and fruit testing the original proposal and later submissions by New Zealand have consistently maintained that mature apples free of trash are not a vector for fire blight. No other New Zealand based risk management measures have been suggested or offered by New Zealand. Therefore this risk analysis has not considered risk management measures that could be implemented in New Zealand.

Onshore:

Although Australia's stated quarantine policy is to prefer offshore management of quarantine risk given our responsibilities to our trading partners it is important to also consider onshore methods of risk management. Given that the analysis indicates that imported apples could carry fire blight bacteria these methods would need to be based on the principle of reducing exposure of fire blight host material to New Zealand apples.

1. Geographical restrictions in distribution and sale of New Zealand apples.

There are areas of Australia that do not have significant numbers of fire blight hosts and limiting distribution and sale of apples to these areas would minimise the risks. However, there are few internal restrictions on movement of apple fruit within Australia and in practice it would be difficult to prevent movement of New Zealand apples from an area without significant hosts to areas with significant hosts.

2. Time or seasonal restrictions on sales.

The susceptibility of fire blight host material in Australia varies depending on the environmental conditions in different areas of Australia. In theory time restrictions on distribution and sales of apples to areas where host material was not currently susceptible could reduce the risks. In practice, because fire blight hosts are widely distributed in Australia and the susceptible period varies from area to area it would not be feasible to apply effective controls.

3. Separate handling facilities for New Zealand apples.

One possible risk identified was the possibility that *E. amylovora* could be involved in post harvest rots of apples in the storage and distribution cycle in Australia. This could result in the build up of very large numbers of *E. amylovora* and could lead to contamination of fruit handling equipment and storage facilities. Separate storage and handling facilities could reduce this risk but in practical terms given the diversity and deregulated nature of the fruit industry in Australia it would be difficult to provide these facilities and ensure that sufficient controls were enforced.

5.5. MAJOR CONCLUSIONS OF THE PEST RISK ANALYSIS

1. The research data on the absence of *E. amylovora* on mature and immature apples provided by New Zealand is not directly relevant to the New Zealand proposal to source apples free from trash from any area of New Zealand.

2. The impact of fire blight in Australia is likely to be very high.

3. Apples sourced under the New Zealand proposal could carry fire blight bacteria.

4. There are significant areas of scientific uncertainty about certain steps in the possible pathway of disease establishment via trade in apples.

5. The New Zealand claim that apples cannot act as a vector for fire blight is not supported by an analysis of the scientific literature and other available information.

6. The New Zealand proposal does not provide an equivalent degree of risk mitigation as Australia requires for other high risk products.

7. There do not appear to be practical risk mitigation measures that could be implemented in Australia to reduce the risk to an acceptable level.

6. AQIS'S POSITION

AQIS does not consider that on the basis of available evidence the New Zealand claim that mature apple fruit free of trash are not a vector of fire blight is adequately demonstrated or that the proposal provides an equivalent level of protection required for other products imported into Australia that could carry high impact pests. In this respect the New Zealand proposal would not be consistent with Australia's appropriate level of protection and therefore cannot be accepted.

In regard to other quarantine pests AQIS considers that satisfactory risk management measures based on field controls, orchard inspection and packing house inspections could be used to manage these pests to achieve adequate quarantine protection. These measures would

be directly equivalent to those applied by AQIS to other products coming from New Zealand and other countries for the same range of pests.

AQIS considers that with the current state of knowledge and the unresolved uncertainty about the possibility of apple fruit acting as a vector for fire blight, any risk management measures should be based on arrangements that provide, to a high degree of certainty, that imported apples are not carrying *E. amylovora*.

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Table 1 Diseases likely to occur on apple fruit grown in New Zealand and their quarantine significance for Australia

Pathogen	Disease	Occurrence in Australia*	Comments	Status**
Bacteria				
Erwinia amylovora (Burrill) Winslow	Fire blight		**Economically significant pathogen of apple, pear and other host plant species. It has never been recorded in Australia.**	**Q**
Pseudomonas syringae pv. *syringae* van Hall	Bacterial blister bark	NSW, SA, Vic., WA		NQ
Fungi				
Alternaria alternata (Fr.) Keissl.	*Alternaria* rot, fruit rot	NSW, SA, Tas., Vic., WA		NQ
Botryosphaeria dothidea (Moug. *et* Fr.) Ces. & De Not.	White rot		Recorded in Australia on other hosts.	NQ
Botryosphaeria obtusa (Schwein.) Shoemaker	Black rot	NSW, Qld, SA, Tas., WA		NQ
Botryosphaeria parva Pennycook & Samuels	Ripe rot		Recorded in Australia on other hosts. Previously assessed as a non-quarantine pathogen for imports of kiwifruit from NZ into Australia.	NQ
Botryosphaeria spp.	Fruit rot		*B.* sp. recorded in Australia on apple.	NQ
Botryosphaeria stevensii Shoemaker	*Diplodia* canker	Vic.		NQ
Botrytis cinerea Pers.	Grey mould, dry eye rot	NSW, SA, Tas., Vic., WA		NQ
Colletotrichum acutatum Simmonds	Anthracnose	NSW, Qld		NQ
Diaporthe actinidiae Sommer & Beraha	*Phomopsis* rot		Recorded in Australia on other hosts. Previously assessed as a non-quarantine pathogen for imports of kiwifruit from NZ into Australia.	NQ
Diaporthe perniciosa Marchal	*Phomopsis* canker; post harvest rot	NSW, SA, Qld	Recorded as *Phomopsis mali* Roberts (anamorph) in Australia	NQ
Diaporthe sp.	*Phomopsis* rot			NQ
Elsinoe piri (Woronichin) Jenk.	*Elsinoe* spot, anthracnose, scab	NSW, Qld		NQ

Table 1 Diseases likely to occur on apple fruit grown in New Zealand and their quarantine significance for Australia

Pathogen	Disease	Occurrence in Australia*	Comments	Status**
Fusicoccum luteum Pennycook & Samuels	Ripe fruit rot		This pathogen is probably a strain of *B. dothidea*, which occurs in Australia. It has been recorded in NZ on apple, pear and kiwifruit. It has previously been assessed as a non-quarantine pathogen for imports of kiwifruit from NZ into Australia.	NQ
Gibberella baccata (Wallr.) Sacc.	Fruit rot		Recorded in Australia on other hosts.	NQ
Gloeodes pomigena (Schwein.) Colby	Sooty blotch	NSW, Qld, Tas., WA		NQ
Glomerella cingulata (Stonem.) Spauld. & Schrenk	Bitter rot		Recorded in Australia on other hosts.	NQ
Leptothyrium pomi (Mont. & Fr.) Sacc.	Fly speck	NSW, WA		NQ
Monilinia fructicola (Wint.) Honey	Brown rot	NSW, Qld, SA, Tas., Vic.	**Not recorded in WA and subject to interstate restrictions.**	**Q(WA)**
Monilinia laxa (Aderhold & Ruhland) Honey	Brown rot		**Recorded in Australia on other hosts and pathogenicity to apple shown by artificial inoculations. Not recorded in WA and subject to interstate restrictions.**	**Q(WA)**
Nectria galligena Bres.	Nectria canker, European canker, eye rot		**Eradicated in Tasmania.**	**Q**
Penicillium expansum Link	Blue mould	NSW, Qld, SA, Tas., Vic., WA		NQ
Penicillium spp.	*Penicillium* mould		*P.* sp. recorded in Australia on apples.	NQ
Pezicula alba Guthrie	Ripe rot	Qld, Tas., Vic., WA	*P.* sp. recorded in Australia on apples.	NQ
Pezicula malicorticis (H. Jacks.) Nannf.	Ripe rot	NSW, Vic., WA	Tas. ?, Minor disease, not under official control.	NQ
Phoma pomorum Thüm.	*Phoma* fruit spot	SA, Vic.		NQ
Phomopsis spp.	*Phomopsis* rot		*P. mali* recorded on apple in NSW, SA and Qld. A *Phomopsis* sp. recorded on apple in Vic. and WA.	NQ
Phytophthora cactorum (Lebert & Cohn) Schröt.	*Phytophthora* fruit rot	NSW, SA, Tas., Vic., WA		NQ
Pleospora herbarum	Leaf spot, leaf rot	SA, Tas., WA	Primarily a saprophytic organism.	NQ

Table 1 Diseases likely to occur on apple fruit grown in New Zealand and their quarantine significance for Australia

Pathogen	Disease	Occurrence in Australia*	Comments	Status**
Podosphaera leucotricha (Ellis & Everh.) Salmon	Powdery mildew	NSW, Qld., SA?, Tas., Vic., WA		NQ
Rhizopus stolonifer (Ehrenb.) Vuill.	*Rhizopus* rot	Tas., Vic.		NQ
Sclerotinia sclerotiorum (Lib.) De Bary	Calyx end rot		Recorded in Australia on other hosts.	NQ
Sphaerotheca pannosa (Wallr. ex Fr.) Lev.	Powdery mildew		Recorded in Australia on other hosts.	NQ
Trichothecium roseum (Pers.) Link	Pink rot	SA, Vic.		NQ
Valsa leucostoma (Pers.) Fr.	Valsa canker		Recorded in Australia on other hosts. *Valsa* sp. reported in Australia on apple.	NQ
Venturia inaequalis (Cooke) Wint.	Black spot, apple scab	NSW, Qld, SA, Tas., Vic., WA	**Being officially controlled in WA and interstate restrictions apply.**	**Q(WA)**
Venturia asperata	?		**New Zealand considers this is a saprophytic organism on dead leaves and is not present on apple fruit. Provided survey methods would be expected to detect this organism on fruit AQIS will accept this organism as non-quarantinable.**	**?**

* Occurrence in Australia in the States as indicated NSW = New South Wales; Qld = Queensland; SA = South Australia; Tas. = Tasmania; Vic. = Victoria; WA = Western Australia. There are no apple disease records for the Northern Territory as apple is grown there. The Australian Capital Territory would have similar diseases as NSW but information for this region is not available.

** Proposed quarantine status; NQ = Non-quarantine disease for Australia; Q = Quarantine disease for Australia; Q(WA) = Quarantine disease for Western Australia alone.

Note: Quarantine diseases and those which require further investigations in order to assess their quarantine status for Australia are printed in bold letters.

Table 2 ARTHROPOD AND GASTROPOD PESTS ON APPLE (*Malus pumila* var *domestica*) FRUIT IN NEW ZEALAND

SPECIES	COMMON NAME	OCCURRENCE IN AUSTRALIA	COMMENTS	STATUS
ACARINA (ERIOPHYIDAE)				
Eriophyes mali (BURTS)	APPLE BLISTER MITE		**Exotic, economic on apple**	**Q**
ACARINA (PHYTOSEIIDAE)				
Typhlodromus pyri SCHEUTEN	PREDATORY MITE	Introduced purposefully	Biocontrol agent	NQ
ACARINA (TETRANYCHIDAE)				
Bryobia rubrioculus (SCHEUTEN)	BRYOBIA MITE	NSW; QLD; SA; TAS; VIC; WA	Economic pest	NQ
Panonychus ulmi (KOCH)	EUROPEAN RED MITE	NSW; QLD; SA; TAS; VIC	**Under official control WA**	**Q(WA)**
Tetranychus urticae KOCH	TWO-SPOTTED SPIDER MITE	NSW, WA and other States	Economic pest	NQ
ACARINA (TYDEIDAE)				
Tydeus sp.	MITE	SA	Only *T. californicus* known. Not economic	NQ
ARANEIDA (SALTICIDAE)				
Trite sp.	JUMPING SPIDER	Genus present	**Exotic. Predator**	**Q**
BLATTODEA (BLATTELLIDAE)				
Blattella germanica (LINNAEUS)	GERMAN COCKROACH	Widespread	Economic pest	NQ
COLEOPTERA (ANTHICIDAE)				
Anthicus floralis LINNAEUS	NARROWNECKED GRAIN BEETLE		Low economic importance	NQ
COLEOPTERA (ANTHRIBIDAE)				
Araecerus palmaris (PASCOE)	DRIEDAPPLE BEETLE	NSW	Ecological impact	NQ
COLEOPTERA (CARABIDAE)				
Agonum sp.	GROUND BEETLE		**Exotic? Predator (ecological impact)**	**Q**
Anchomenus sp.	GROUND BEETLE		**Exotic? Predator (ecological impact)**	**Q**
Harpalinae (sub. Fam.)	PREDATORY GROUND BEETLE		**Exotic? Predator (ecological impact)**	**Q**
Notagonum submetallicum (WHITE)	SUBMETALLIC GROUND BEETLE		**Exotic? Predator (ecological impact)**	**Q**
COLEOPTERA (CERAMBYCIDAE)				
Arhopalus ferus (MULSANT)	BURNT PINE LONGHORN BEETLE		**Exotic. Economic on pine**	**Q**
COLEOPTERA (CHRYSOMELIDAE)				
Alticinae/halticinae (sub. Fam.)	FLEA BEETLE		**Exotic? Economic on apple**	**Q**
Eucolaspis brunnea (FABRICIUS)	BRONZE BEETLE		**Exotic. Economic pest on apple**	**Q**
Longitarsus fuliginosus (BROUN)	NATIVE CHRYSOMELID (NZ)		**Exotic. Environmental pest**	**Q**
COLEOPTERA (COCCINELLIDAE)				
Coccinella undecimpunctata LINNAEUS	ELEVENSPOTTED LADYBIRD	TAS	Beneficial in Australia	NQ
Stethorus bifidus KAPUR	APPLE SPIDER MITE LADYBIRD		Exotic. Beneficial	NQ
COLEOPTERA (CRYPTOPHAGIDAE)				
Cryptophagus sp.	FUNGUS BEETLE		**Exotic? No economic impact**	**Q**
Micrambina rutila (BROUN)	FUNGUS BEETLE ; PLASTER BEETLE		**Exotic. No economic impact**	**Q**

Table 2 ARTHROPOD AND GASTROPOD PESTS ON APPLE (*Malus pumila* var *domestica*) FRUIT IN NEW ZEALAND

SPECIES	COMMON NAME	OCCURRENCE IN AUSTRALIA	COMMENTS	STATUS
COLEOPTERA (CURCULIONIDAE)				
Asynonychus cervinus (BOHEMAN)	FULLERS ROSE WEEVIL	NSW; VIC, QLD, SA, TAS	Economic pest	NQ
Gonipterus scutellatus (GYLLENHAL)	EUCALYPTUS WEEVIL		Native to Australia	NQ
Gymnetron pascuorum (GYLLENHALL)	WEEVIL		**Exotic. Low impact (plantain weed)**	**Q**
Listroderes difficilis GERMAIN	VEGETABLE WEEVIL	NSW, QLD, SA, WA, VIC, TAS	Economic pest	NQ
Listronotus bonariensis (KUSCHEL)	ARGENTINE STEM WEEVIL	NSW, WA, TAS	Economic pest	NQ
Mitrastethus baridioides REDTENBACHER	NATIVE KAURI WEEVIL		**Exotic. Not economic**	**Q**
Phlyctinus callosus BOHEMAN	GARDEN WEEVIL	VIC, WA	Economic pest	NQ
Sitona disciodeus GYLLENHAL	SITONA WEEVIL	SA, TAS, VIC, NSW	Pest of legumes (lucerne, medics)	NQ
COLEOPTERA (DERMESTIDAE)				
Dermestes maculatus DE GEER	HIDE & SKIN BEETLE	Widespread	Animal product pest	NQ
COLEOPTERA (ELATERIDAE)				
Agrypnus variabilis (CANDEZE)	VARIABLE WIREWORM	TAS	Pest of grasses	NQ
Conoderus exsul (SHARP)	PASTURE WIREWORM		Pasture pest	NQ
COLEOPTERA (LAEMOPHLOEIDAE (=				
Cryptolestes sp.	FLAT GRAIN BEETLE		**Exotic? Economic in stored grain**	**Q**
COLEOPTERA (LATHRIDIIDAE)				
Aridius bifasciatus (REITTER)	MINUTE BROWN SCAVENGER	Present	No economic significance	NQ
Aridius nodifer (WESTWOOD)	FUNGUS BEETLE	Present	No economic significance	NQ
Cartodere sp.	FUNGUS BEETLE		**Exotic? Fungal feeder**	**Q**
Corticaria pubescens (GYLLENHALL)	FUNGUS BEETLE		**Exotic. Fungal feeder**	**Q**
Corticaria serrata (PAYKULL)	FUNGUS BEETLE		**Exotic. Fungal feeder**	**Q**
Cortinicara sp.	FUNGUS BEETLE		**Exotic? Fungal feeder**	**Q**
COLEOPTERA (NITIDULIDAE)				
Carpophilus davidsoni DOBSON	FRUIT BEETLE	NSW	Nuisance pest	NQ
Carpophilus gaveni DOBSON	FRUIT BEETLE	Present acco to Scott, 1984	Nuisance pest	NQ
Carpophilus sp.	DRIEDFRUIT BEETLES		**Exotic? Nuisance pest**	**Q**
COLEOPTERA (SCARABAEIDAE)				
Costelytra zealandica (WHITE)	GRASS GRUB		**Exotic. Economic pasture pest**	**Q**
COLEOPTERA (SCOLYTIDAE)				
Hylastes ater (PAYKULL)	BLACK PINE BARK BEETLE	Present	Economic pest of forest trees	NQ
COLEOPTERA (SILVANIDAE)				
Ahasverus advena (WALTL)	FOREIGN GRAIN BEETLE	Cosmopolitan	Not economic. Mould feeder	NQ
COLEOPTERA (STAPHYLINIDAE)				
	ROVE BEETLE		**Exotic? Ecological significance.**	**Q**

Table 2 ARTHROPOD AND GASTROPOD PESTS ON APPLE (*Malus pumila* var *domestica*) FRUIT IN NEW ZEALAND

SPECIES	COMMON NAME	OCCURRENCE IN AUSTRALIA	COMMENTS	STATUS
DERMAPTERA (FORFICULIDAE)				
Forficula auricularia LINNAEUS	EUROPEAN EARWIG	NSW, SA, TAS, VIC	Economic pest of vegetables	NQ
DIPTERA (CECIDOMYIIDAE)				
Dasyneura mali KEIFFER	APPLE LEAFCURLING MIDGE		**Exotic. Economic on apple**	**Q**
DIPTERA (MYCETOPHILIDAE)				
Mycetophila sp.	FUNGUS GNATS		**Exotic? Very low impact ecologically**	**Q**
DIPTERA (PHORIDAE)				
Antipodiphora tonnoiri (SCHMITZ)	PHORID FLY (NZ)		**Exotic.Mushr'm pest,vector (Megaselia)**	**Q**
DIPTERA (SYRPHIDAE)				
	HOVER FLIES		**Exotic. Inc. economic pests of bulbs**	**Q**
GASTROPODA (HELICIDAE)				
Helix aspersa MULLER	COMMON GARDEN SNAIL	WA, SA, VIC, TAS, NSW, QLD	Important economic plant pest	NQ
GASTROPODA (VALLONIDAE)				
Vallonia excentrica	SNAIL		**Exotic. Phytophagous**	**Q**
HEMIPTERA (APHIDIDAE)				
Aphis gossypii GLOVER	COTTON APHID	NSW, VIC, WA, QLD, NT, TAS	Economic as a pest and vector	NQ
HEMIPTERA (CICADELLIDAE)				
Typhlocyba froggatti BAKER	APPLE LEAFHOPPER	SA. TAS, VIC	Economic pest	NQ
HEMIPTERA (DIASPIDIDAE)				
Aonidiella aurantii (MASKELL)	RED SCALE	QLD, NSW, VIC, SA, WA	Economic pest of citrus	NQ
Aspidiotus nerii BOUCHE	IVY SCALE	QLD, NSW, SA	Economic pest	NQ
Hemiberlesia rapax (COMSTOCK)	GREEDY SCALE	SA	Economic pest	NQ
Lepidosaphes ulmi (LINNAEUS)	APPLE MUSSEL SCALE	NSW, SA, TAS, VIC, WA	Economic pest	NQ
Quadraspidiotus ostreaeformis (CURTIS)	OYSTERSHELL SCALE	SA, TAS, VIC	Economic pest	NQ
Quadraspidiotus perniciosus (COMSTOCK)	SAN JOSE SCALE	WA, All States except TAS	Economic pest	NQ
HEMIPTERA (LYGAEIDAE)				
Brentiscerus putoni (F.B.WHITE)	LYGAEID BUG	Widespread	Ecological impact	NQ
Dieuches notatus (DALLAS)	-			NQ
Nysius huttoni F B WHITE	WHEAT BUG		**Exotic. Economic on wheat**	**Q**
Pachybrachius inornatus (WALKER)	WEED SEED BUG	TAS	Ecological impact	NQ
Plinthisus sp.	SEED BUG		**Exotic? (1 common sp.). Ecologic**	**Q**
Rhypodes clavicornis FABRICIUS	LYGAEID BUG		**Exotic. Ecologically significant.**	**Q**
Rhypodes serricatus USINGER	SEED BUG		**Exotic. Ecologically significant.**	**Q**
HEMIPTERA (MIRIDAE)				
Sidnia kinbergi STAL	AUSTRALIAN CROP MIRID	VIC, TAS	Economic pest	NQ

Table 2 ARTHROPOD AND GASTROPOD PESTS ON APPLE (*Malus pumila* var *domestica*) FRUIT IN NEW ZEALAND

SPECIES	COMMON NAME	OCCURRENCE IN AUSTRALIA	COMMENTS	STATUS
HEMIPTERA (PENTATOMIDAE)				
Dictyotus caenosus (WESTWOOD)	BROWN SHIELD BUG		Economic pest	NQ
HEMIPTERA (PSEUDOCOCCIDAE)				
	MEALYBUG		**Exotic? Economic pest**	**Q**
Pseudococcus affinis (MASKELL)	TUBER MEALYBUG	NSW, QLD	Economic pest of tubers	NQ
Pseudococcus calceolariae (MASKELL)	CITROPHILOUS MEALYBUG	NSW, QLD	Economic pest	NQ
Pseudococcus longispinus (TARGIONI-	LONGTAILED MEALYBUG	VIC, NSW, QLD, SA	Economic pest	NQ
Pseudococcus similans (LIDGETT)	MEALYBUG		Economic pest	NQ
HYMENOPTERA (BRACONIDAE)				
Apanteles tasmanicus CAMERON	LEAFROLLER PARASITE	TAS	Native biocontrol agent	NQ
HYMENOPTERA (FORMICIDAE)				
Chelaner antarcticum (WHITE)	SOUTHERN ANT		**Exotic. Nuisance pest**	**Q**
LEPIDOPTERA (CRAMBIDAE)				
Hygraula nitens (BUTLER)	PYRALID WATER MOTH	QLD, VIC, NSW, SA, WA, TAS	Native on water weed	NQ
LEPIDOPTERA (GEOMETRIDAE)				
Helastia cryptica CRAW	NATIVE GEOMETRID		**Exotic. Litter fauna. Not economic**	**Q**
LEPIDOPTERA (LYONETIIDAE)				
	-			**Q**
LEPIDOPTERA (NOCTUIDAE)				
Agrotis ipsilon aneituma (WALKER)	GREASY CUTWORM	Migrates widely, resident tropics/subtropics	Native economic pest	NQ
Graphania mutans (WALKER)	CUTWORM		**Exotic. Economic pest**	**Q**
Helicoverpa armigera (HUBNER)	CORN EARWORM	WA, NT, QLD, NSW, rarely south.	Economic pest	NQ
LEPIDOPTERA (OECOPHORIDAE)				
Endrosis sarcitrella (LINNAEUS)	WHITESHOULDERED HOUSE MOTH	Widespread	Nonliving plant/animal product pest	NQ
Parocystola acroxantha MEYRICK	OECOPHORID MOTH	TAS		NQ
Tingena sp.	NATIVE LITTER FEEDING MOTH		**Exotic, ecological impact**	**Q**
LEPIDOPTERA (PYRALIDAE)				
Ephestia elutella (HUBNER)	TOBACCO MOTH	Widespread	Economic stored product pest	NQ
Eudonia paltomacha (MEYRICK)	SOD WEBWORM		**Exotic. Ecological impact**	**Q**
Eudonia psammitis (MEYRICK)	SOD WEBWORM		**Exotic. Ecological impact**	**Q**
Orocrambus sp.	GRASS AND MOSS MOTHS		**Exotic. Ecological impact**	**Q**
Scoparia sp.	SOD WEBWORMS		**Exotic. Ecological impact**	**Q**
LEPIDOPTERA (TINEIDAE)				
Opogona omoscopa (MEYRICK)	DETRITUS MOTH	Widespread	Ecological effects	NQ
Tineola bisselliella (HUMMEL)	COMMON CLOTHES MOTH	Widespread	Economic (Wool/animal fibre) pest	NQ

Table 2 ARTHROPOD AND GASTROPOD PESTS ON APPLE (*Malus pumila* var *domestica*) FRUIT IN NEW ZEALAND

SPECIES	COMMON NAME	OCCURRENCE IN AUSTRALIA	COMMENTS	STATUS
LEPIDOPTERA (TORTRICIDAE)				
	LEAFROLLER		**Exotic?**	**Q**
Cnephasia jactatana (WALKER)	BLACK-LYRE LEAFROLLER		**Exotic economic pest of apple**	**Q**
Ctenopseustis herana FELDER & ROGENHOFER	BROWNHEADED LEAFROLLER		**Exotic economic pest of apple**	**Q**
Ctenopseustis obliquana (WALKER)	BROWN HEADED LEAFROLLER		**Exotic economic pest of apple**	**Q**
Cydia molesta (BUSCK)	ORIENTAL FRUIT MOTH	VIC, TAS, NSW	Economic pest of apple	NQ
Cydia pomonella (LINNAEUS)	CODLING MOTH	NSW, QLD, SA, TAS, VIC	**Under official control in WA**	**Q(WA)**
Epiphyas postvittana (WALKER)	LIGHTBROWN APPLE MOTH	NSW, QLD, SA, TAS, VIC, WA	Economic pest	NQ
Planotortrix excessana (WALKER)	GREEN HEADED LEAFROLLER		**Exotic economic pest of apple**	**Q**
Planotortrix octo DUGDALE	GREENHEADED LEAFROLLER		**Exotic economic pest of apple**	**Q**
Strepsicrates macropetana (MEYRICK)	EUCALYPTUS LEAFROLLER	NSW	Ecological impact	NQ
NEUROPTERA (HEMEROBIIDAE)				
Micromus tasmaniae (WALKER)	TASMANIAN LACEWING	TAS	Native predator	NQ
PSOCOPTERA (ECTOPSOCIDAE)				
Ectopsocus sp.	BOOKLOUSE		Exotic? No economic significance	NQ
PSOCOPTERA				
	BOOKLICE		Exotic? No economic significance	NQ
THYSANOPTERA (THRIPIDAE)				
Heliothrips haemorrhoidalis (BOUCHE)	GREENHOUSE THRIPS	VIC, WA, NSW, QLD, SA	Economic pest	NQ
Thrips obscuratus (CRAWFORD)	NEW ZEALAND FLOWER THRIPS		**Exotic. Economic pest**	**Q**
ADDITIONAL PESTS NOT ON NZ LIST				
LEPIDOPTERA: OECOPHORIDAE				
Stathmopoda sp. (*skelloni* auct. nec. BUTLER)	GARDEN FEATHERFOOT		**Exotic. economic pest**	**Q**
HEMIPTERA (APHIDIDAE)				
Eriosoma lanigerum (HAUSMANN)	WOOLLY APPLE APHID	WA, NSW, QLD, SA, TAS, VIC	Economic pest	NQ
LEPIDOPTERA (HEPIALIDAE)				
Aenetus virescens (DOUBLEDAY)	PURIRI MOTH		**Exotic. Wood borer**	**Q**

* Occurrence in Australia in the States as indicated NSW = New South Wales; Qld = Queensland; SA = South Australia; Tas. = Tasmania; Vic. = Victoria; WA = Western Australia.

** Proposed quarantine status; NQ = Non-quarantine pest for Australia; Q = Quarantine pest for Australia; Q(WA) = Quarantine pest for Western Australia alone.

Note: Quarantine pest and those which require further investigations in order to assess their quarantine status for Australia are printed in bold letters.

Table 3 - Occurrence of fire blight host genera in Australia

Table 3a - Major host genera

Genus	*Number of species present in Australia
Amelanchier	6
Aronia	3
Chaenomeles	5
Cotoneaster	30
Crataegus	19
Cydonia	3
Eriobotrya	1
Heteromeles	1
Malus	17
Mespilus	1
Photonia	4
Pyracantha	8
Pyrus	9
Raphiolepis	2
Sorbus	23
Stranvaesia	2

Table 3b - Genera recorded as hosts under unusual conditions

Genus	*Number of species present in Australia
Aruncus	1
Fragaria	3
Prunus	36
Rosa	28
Rubus	33
Spiraea	12

* Based on:

Hnatiuk R.J. (1991) *Census of Australian Vascular Plants.* Australian Flora and Fauna Series No 11. AGPS Publishing .

Lazarides M and Hince B. (1993) CSIRO Handbook of economic plants of Australia. CSIRO

Bodkin F. (1986) Encyclopedia Botanica. Cornstalk Publishing.

APPENDICES

MINISTRY OF AGRICULTURE NEW ZEALAND
TE MANATU AHUWHENUA AOTEAROA

Ref. 1012-AUS-205-1

19 December 1995

Dr W Roberts
Head, Quarantine Policy Branch
Australian Quarantine and Inspection Service
Department of Primary Industries and Energy
GPO Box 858
Canberra ACT 2601
AUSTRALIA

Dear Dr Roberts

REQUEST FOR THE ACCESS OF NEW ZEALAND APPLES INTO AUSTRALIA

As you are aware, the New Zealand Ministry of Agriculture has for some time now been co-ordinating apple research and systems development with the view of being able to meet the Australian apple access requirement for New Zealand fruit, i.e. being produced in an area free from *Erwinia amylovora*. Recently completed New Zealand research (Attachment 1) shows that the export of mature apples produced under New Zealand conditions (regardless of the fire blight (disease) status of the orchard) will not be a viable pathway for the introduction of *E. amylovora* into Australia. Accordingly, I request that the export of mature New Zealand apples, free from trash, be considered equivalent to exporting apples from an area considered free from *E. amylovora* and that the access for New Zealand apples be granted on this basis.

You may recall from earlier access proposals, concern was expressed by Australian scientists as to the lack of correlation between research results and the likelihood of introduction of *E. amylovora* via the export fruit pathway. A statistical analysis (Attachment 2) has been undertaken on the results of earlier works by Hale *et al*. A total of 81 700 apples sourced from orchards free from fire blight (i.e. the disease caused by *E. amylovora*), were tested for the presence of the pathogen, using a DNA probe (with a limit of detection of 10^2 colony forming units), over a period of at least three seasons and there were no instances where *E. amylovora* was detected. The statistical analysis models the number of fruit (sourced from symptomless orchards) that may be "infested" with *E.amylovora* at a detectable level, in consignment sizes of 2 million and 20 million. For a consignment, of 20 million fruit, at p=0.95, this may be up to 469 individual fruit. That is, 469 fruit could be present that were infested with sufficient numbers of colony forming units detectable by the DNA probe. The limit of detection of the DNA probe is 10^2 colony forming units and therefore this figure of 469 must be considered to be a very conservative (over) estimate.

MAF Regulatory Authority
ASB Bank House, 101-103 The Terrace, PO Box 2526, Wellington, New Zealand,
Telephone (64-4)-474 4100, Facsimile (64-4)-474 4240.

Hale's paper demonstrates that for symptom expression, Stigmas had to be inoculated with concentrations of greater than 10^4 colony forming units. Using current techniques, it is not possible to determine the likelihood of any of the 469 fruit being infested with sufficient colony forming units (i.e. greater than 10^4), that would enable possible infection of a susceptible host. Nor is there sufficient information available to us to determine the likelihood of any such apple, that entered Australia, being in the situation (susceptible host/suitable environmental conditions) where this could occur. The likelihood of such an event occurring is extremely low and would in fact be far lower than for those pathways that already exist (e.g. legal and illegal introduction of propagation material) for the introduction of *E. amylovora* into Australia.

The above supports the view of the European and Mediterranean Plant Protection Organisation that apple fruit are not a pathway for the introduction of *E. amylovora* and that any phytosanitary measures imposed on the import of apple fruit to prevent the introduction of *E. amylovora* are not justified.

To assist with your commodity risk assessment, I have enclosed a list of the organisms (includes possible hitchhikers) associated with New Zealand apples and have indicated those that we are aware are present in Australia (i.e. non-quarantine pests). *Erwinia amylovora* has been included, albeit research supports the exclusion of mature fruit as a pathway for introduction.

As the New Zealand apple season is rapidly progressing, I would appreciate your earliest consideration of my request that the export of mature New Zealand apples, free from trash, be considered equivalent to:

"(a) that the disease known as "Fire Blight" or "Pear Blight' (*Erwinia amylovora* (Burrill) Winslow et al.) does not exist in the said district;"
[Quarantine (Plants) Regulations, Apples from New Zealand, D.(1)]

and that access for New Zealand apples be granted on this basis.

Yours sincerely

R J lvess
Chief Plants Officer

ECOLOGY AND EPIDEMIOLOGY OF FIRE BLIGHT IN NEW ZEALAND

C.N. Hale, R.K. Taylor and R.G. Clark.
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Mt Albert Research Centre
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New Zealand

Abstract

Fire blight symptoms were only seen in apple and cotoneaster flowers and in developing fruitlets when stigmas of individual blossoms were inoculated with concentrations of *Erwinia amylovora* providing $>10^4$ colony forming units. Using a sensitive DNA hybridisation method (^{32}P-labelled probe) *Erwinia amylovora* was detected in the flower parts of those blossoms showing fire blight symptoms. *Erwinia amylovora* was not detected in symptomless blossoms and developing fruitlets.

The DNA probe was used to determine the spread of *Erwinia amylovora* from inoculated blight sources (apple blossoms) showing fire blight symptoms. *Erwinia amylovora* was not detected in calyxes of immature and mature fruit or on the surfaces of mature fruit even from within 5 cm of these blight sources. The weather was conducive to the spread of the disease over flowering but all inoculated blossoms and those showing symptoms in adjacent blossom clusters either aborted as flowers or as developing fruitlets.

The results provide evidence to support the view of the European Plant Protection Organisation that no regulatory measures should be taken for fruit with respect to fire blight as mature, healthy export fruit are unlikely to be a vector for *Erwinia amylovora*.

1. Introduction

Fire blight, caused by *Erwinia amylovora* (Burrell) Winslow *et al* is of little significance in apple *(Malus X domestica* Borkh.) production but occasionally causes loss of flowers in some areas of New Zealand. Because of reports that *Erwinia amylovora* may occasionally survive epiphytically on immature fruit of apple (Thomson and Hale, 1987), (Hale *et al* 1987) in orchards which are severely infected (75 strikes/tree) with fire blight, it has been assumed that the bacteria may also survive epiphytically on mature fruit. However, where only occasional shoot tip infection occurred (1-2 strikes/tree) *Erwinia amylovora* was only isolated from immature fruit. Hale *et al (1993)* have since shown that there was a close correlation between results of field inspections in New Zealand and the results of DNA testina of c.60000 fruit over 3 seasons and this provides confidence that inspections predict that fruit from orchards without disease symptoms are not infested with *Erwinia amylovora* and consequently highly unlikely to disseminate fire blight when exported.

Van der Zwet *et al* (1990), in US, using plate isolation methods, showed that *Erwinia amylovora* was recovered from apple fruit located within 30 cm of heavily blighted shoots but that there was no recovery of *Erwinia amylovora* from fruit 100 cm from these same shoots. It was also found that the bacterium is not usually present on the surface or internal parts of apple fruit collected from orchards without symptoms of fire blight and this is in agreement with Roberts *et al.* (1989) who were unable to detect the bacterium in fruit harvested from blighted trees. Similarly Hale *et al.* (1933) in New Zealand, reported that, using a sensitive DNA hybridisation method, *Erwinia amylovora* was not detected in calyxes of either immature or mature apple fruit**,** even from within 20 cm of inoculated blight sources, in seasons not conducive to the spread of the disease over flowering. Although small populations (<l00 *Erwinia amylovora* per apple calyx) may have escaped detection, such populations would still have to be exposed to optimum conditions for disease development in order to reach proper infection courts to cause disease.

In this paper we provide the results from trials to determine the inoculum levels required for infection not only of a susceptible cultivator of apple (cv Gala), but also of an extremely susceptible alternative host *(Cotoneaster salicifolius* Franchet). We also report on the spread of *Erwinia amylovora* from inoculated blight sources in apple trees to fruit calyxes in an orchard.

2. Methods

2.1. Inoculum levels required for infection

An apple orchard and a cotoneaster planting at the Mt Albert Research Centre, The Horticulture and Food Research Institute. Auckland, were used for the inoculation studies.

2. 1. 1. Inoculations

Apple blossom clusters (cv Gala) were, enclosed in polyethylene chambers and stigmas of individual blossoms where inoculated through a micropipette dispenser with 20µl of suspensions of various concentrations of *Erwinia amylovora* in bacteriological saline (0.85% w/v sodium chloride), adjusted spectrophotometrically to provide 10^0-10^9 colony forming units (cfu). Symptom expression was monitored in detail in the inoculated blossoms and in blossoms adjacent to the inoculation sites during the period up to petal fall. Cotoneaster flowers were similarly enclosed in polyethylene chambers and inoculated with concentrations of *Erwinia amylovora* providing 10^0-10^9 cfu to each open flower Controls on apple and cotoneaster flowers involved inoculation with 20µl of bacteriological saline.

2.1.2. Sampling

Flower parts, with and without fire blight symptoms, were removed from the blossom clusters and tested for the presence of *Erwinia amylovora* using a ^{32}p_ labelled DNA probe prepared to total DNA, as described by Hale and Clark (1990), from the type culture of *Erwinia amylovora,* ICMP* 1540. The DNA was extracted from bacterial growth on nylon membranes (Hybond+, Amersham, UK)

supported on modified MS medium (Miller and Schroth, 1972). The MS medium was modified by removing sodium taurocholate, nitriloacetate acid, and thallium nitrate and reducing the agar concentration to 0.75%. The modifications enhanced the growth of *Erwinia amylovora* and slowed the growth of other microorganisms which were present on the blossom tissues. Any DNA hybridising with the ^{32}P-labelled DNA from the type culture was considered to originate from *Erwinia amylovora* in the blossom tissue. Replicate hybridisation's were made for each of the flower parts. Confirmation of the identity of the bacteria on imprints from the original membranes was completed using the polymerase chain reaction (PCR) method involving amplification of a low copy number 187-bp DNA fragment obtained using either DNA or intact bacteria as template (Guilford et *al.* presented at 7th International Workshop on Fire Blight).

2.2. Spread of *Erwinia amylovora* from inoculum sources

An apple orchard at the Mt Albert Research Centre, The Horticulture and Food Research Institute, Auckland, containing apple cultivars Gala, Gravenstein and Granny Smith at 70-80% flowering was used for the trials.

2.2. 1. Inoculations

Erwinia amylovora ICMP 1501 was used to inoculate blossoms. Selected blossom clusters were mist inoculated with bacteriological saline suspensions of *Erwinia amylovora* containing 10^8 cfu/ml. Controls consisted of blossom clusters sprayed with bacteriological saline. The bacterial suspension was confined to the selected blossom cluster by enclosing the cluster in a polyethylene bag. The bags were secured around the blossom clusters after inoculation to maintain a high relative humidity left overnight to enhance the probability of infection, and removed after 16h. Inoculations were carried out on 24 October 1994 and the weather was warm, fine and calm. After inoculation there were 3 days of conditions conducive to infection with a mean daily temperature >15^0C.

Calyxes of 15 mature stored apples (cv Gala) were inoculated with 100µl of suspensions of *Erwinia amylovora,* in bacteriological saline, containing either 10^3 or 10^9 cfu/ml. Fifteen apple fruit were surface inoculated by dipping in *Erwinia amylovora* suspensions containing 10^2 or 10^8 cfu/ml. Inoculated apples were either enclosed in individual net bags and hung in each of 5 trees, or secured with tape, as close as possible to blossom clusters containing open flowers. There were 3 apples per tree.

2.2.2. Sampling

After inoculation of blossom clusters with *Erwinia amylovora* fruit were sampled from as close as possible to, and at measured distances from, the inoculation sites on each tree. There were 4 separate sampling times during the season *(5* December 1994, 21 December 1994, 16 January 1995 and 8 February 1995).

*ICMP - International Collection of Micro-organisms from Plants, Landcare/Manaaki When Research New Zealand Ltd, Auckland, New Zealand.

At each sampling time individual apples were collected and tested for calyx infestation with *Erwinia amylovora* using the DNA hybridisation method described by Hale and Clark (1990). At the last 2 sampling times surface infestation with *Erwinia amylovora* was also tested by washing individual apples in 5 ml bacteriological saline for 1 minute in polyethylene bags. Surface washings were streaked on membranes and treated as described for calyx infestation tests. Replicate hybridisation's were made for each of the apples sampled.

3. Results

3.1. Inoculum levels required for infection

The results for disease symptom expression and detection of *Erwinia amylovora* in apple and cotoneaster blossoms and flowers are shown in Table 1. Severe symptoms, including blackening of flower parts, were seen in apple blossoms inoculated with 10^7 and 10^8 cfu per blossom, and *Erwinia amylovora* was detected in these blossoms using the DNA hybridisation test and confirmed using PCR. When inoculated with 10^5 cfu there was some slight browning of the apple pedicels but *Erwinia amylovora* was not detected in the tissues. When blossoms were inoculated with 10^0-10^4 cfu there were no disease symptoms and in no case was *Erwinia amylovora* detected in the blossoms. No disease symptoms were seen in the controls and *Erwinia amylovora* was not detected in any of the blossoms.

Severe symptoms, including blackening of flower parts and some tissue breakdown were seen in cotoneaster flowers inoculated with 10^5-10^8 cfu, and in each case *Erwinia amylovora* was detected in the symptomatic tissue. When inoculated with 102-10' cfu then there were no disease symptoms and *Erwinia amylovora* was not detected in the flowers. No disease symptoms were seen in controls and *Erwinia amylovora* was not detected in any of the flowers.

3.2. Spread of *Erwinia amylovora* from. inoculum sources

Two weeks after inoculation symptoms of fire blight were seen in the blossom clusters on all trees which had been inoculated with suspensions of *Erwinia amylovora* containing 10^8 cfu/ml. Very few of the blossoms in the inoculated clusters developed into fruitlets.

The results of fruit testing for *Erwinia amylovora* throughout the season are presented in Table 2. Five weeks after blossom inoculation (5 December 1994) occasional infected flowers were seen in the Gala and Gravenstein trees adjacent to the inoculated blossoms but not in the Granny Smith trees. No symptoms were seen in any of the trees with calyx inoculated fruit and surface inoculated fruit either hanging or taped close to blossom clusters with open flowers. Of the 207 fruitlets tested for calyx infestation, 4 did produce slight hybridisation with the DNA probe. However, when further checked on King's medium B (King et *al* 1954) the colonies were found to be either fluorescent pseudomonads or yellow bacteria not characteristic of *Erwinia amylovora*. When checked on CCT medium (Ishimaru and Klos, 1984) none of the colonies were characteristic of *Erwinia amylovora*. Further checks using PCR confirmed the colonies were not *Erwinia amylovora*.

Erwinia amylovora was not detected in any of the calyxes of 150 fruit tested two months after inoculation (21 December 1994). Three months after inoculation (16 January 1995) *Erwinia amylovora* was not detected either in calyxes or on surfaces of any of the 153 fruit tested. At harvest, approximately 4 months after blossom, calyx and surface inoculation (8 February 1995), 1733 fruit were tested and *Erwinia amylovora* was not detected either in the calyxes or on the surfaces. Although a few of the isolates gave slight hybridisation with the DNA probe, none was confirmed as *Erwinia amylovora* after checking on selective media and using PCR.

Data on the distance from the inoculation sites from which samples were taken are combined for the 4 sampling dates and presented in Table 3. *Erwinia amylovora* was not detected in calyxes or on surfaces of any of the immature or mature fruit even from those fruit sampled from within 5 cm of the inoculation sites, whether they were blossom, calyx or fruit surface inoculated.

4. Discussion

Symptoms of fire blight were seen, and *Erwinia amylovora* was detected, only in apple and cotoneaster flowers and developing apple fruitlets when the stigmas of individual flowers were inoculated with concentrations of *Erwinia amylovora* providing $>10^4$ cfu. These results are in agreement with those reported by van der Zwet *et al.* (1994) in which similar inoculum concentrations were required for infection of blossoms of apple cv Jonathon. The similar level of *Erwinia amylovora* required to infect flowers of the extremely susceptible alternative host, cotoneaster, is surprising and suggests that an infection threshold exists for these hosts.

It is interesting to note that calyxes of none of the immature fruitlets and mature fruit, even from within 5 cm of inoculation sites, were infested with *Erwinia amylovora* even after heavy inoculation of open flowers in adjacent blossom clusters. It was expected that *Erwinia amylovora* would be detected in some of the immature fruitlets on the first sampling occasion but in this season, which was conducive to infection, most of the flowers in the inoculated blossom clusters aborted and those fruitlets which did form did not survive until the first sampling. Infected flowers, in clusters adjacent to the inoculated clusters, also tended to abort soon after symptoms were apparent. Hale *et al* (1993) reported that there was no detectable spread of *Erwinia amylovora* from inoculum sources to fruit within 20 cm of the inoculation sites in a year which was unseasonably cool over the flowering period. However, in the present study the climatic conditions were conducive to infection, but again there was no detectable spread of *Erwinia amylovora* from the inoculated blossom clusters to the surviving immature fruitlets at the first sampling time and the mature fruit at harvest.

There was no spread of *Erwinia amylovora* from either calyxes or surfaces of fruit, which had been heavily inoculated, to any of the immature or mature fruit sampled. No symptoms were seen in any blossom clusters even when the inoculated fruit were in the immediate vicinity of the open flowers. This suggest that it is highly unlikely that infested fruit could be sources of infection either for pipfruit orchards or for alternative hosts.

Hale *et al.* (1993)) earlier reported a close correlation between orchard inspections for fire blight symptoms and DNA testing for the presence of *Erwinia amylovora* in large scale fruit sampling from these orchards. This provided confidence that inspections do, in fact, predict that fruit from orchards without disease symptoms are unlikely to be infested with *Erwinia amylovora*. The results presented here, together with those reported elsewhere (Roberts *et al*. 1989; van der Zwet *et al*. 1990; Hale *et al*. 1993) provide strong support for the European Plant Protection Organisation view that no regulatory measures should be taken for fruit with respect to fire blight (van der Zwet, 1994) as mature, healthy apple, fruit from orchards without fire blight symptoms are unlikely to be a vector for *Erwinia amylovora*. If undetectable populations of *Erwinia amylovora* are present in calyxes of apple fruit, the levels are extremely low and even if climatic conditions are conducive to infection and the infested fruit are in close contact with hosts at flowering, it is highly unlikely that such small populations will result in disease being expressed in apple orchards and plantings of alternative hosts.

5. References

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Table 1 Disease symptoms and detection of *Erwinia amylovora* in apple blossoms and cotoneaster flowers inoculated with different numbers of bacteria.

Apple

Inoculum concentration cfu/blossom	Symptoms *	*Erwinia amylovora*** detected in blossoms
Control	-	No
10^0	-	No
10^1	-	No
10^2	-	No
10^3	-	No
10^4	-	No
10^5	+	No
10^7	+++	Yes
10^8	+++	Yes

* Symptoms
+++ blackening of flower parts
\+ slight browning of pedicels
\- no symptoms in flowers

** Identifications confirmed by DNA hybridisation and isolations checked by PCR.

Cotoneaster

Inoculum concentration cfu/flower	Symptoms *	*Erwinia amylovora*** detected in flowers
Control	-	No
10^2	-	No
10^3	-	No
10^4	-	No
10^5	++	Yes
10^6	+++	Yes
10^8	+++	Yes

* Symptoms
+++ blackening of flower parts with complete breakdown of tissues
++ blackening of flower parts
\- no symptoms in flowers

** Identifications confirmed by DNA hybridisation and isolations checked by PCR.

Table 2 Number of positive detection's of *Erwinia amylovora* in calyxes and surfaces of fruit samples from inoculated trees.

Sampling date	Inoculation method	No. of fruit tested	No. Of fruit with *Erwinia amylovora*
5 December	Blossom	127	0
	Calyx	40	0
	Surface	40	0
21 December	Blossom	120	0
	Calyx	15	0
	Surface	15	0
16 January*	Blossom	103	0
	Calyx	25	0
	Surface	25	0
8 February*	Blossom	113	0
	Calyx	30	0
	Surface	30	0

* Calyx and surface of each fruit tested.

Table 3 Numbers of positive detection's of *Erwinia amylovora in* calyxes and on surfaces of fruit samples at various distances from inoculation sites (combined sampling dates).

Distance from inoc.sites (cm)	No. of fruit tested	No. Of fruit with *Erwinia amylovora*
0-5	103	0
6-10	76	0
11-20	142	0
21-30	154	0
31-50	138	0
51-100	64	0
>100	6	0

FIREBLIGHT SIMULATION Attachment 2

The probability to be estimated is the probability that fireblight is present. This is given by

p.present = p_d/p

where

p = probability that fireblight is detected in the lab trial

and

p_d = probability that fireblight is detected and present in the field trial

Results :-

A 5-95% Bayesian posterior interval of between 2.0 x 10^-8 and 2.4 x 10^-5 for p.present was obtained. A 1-99% posterior interval of between 9.1 x 10^-10 and 4.2 x 10^-5 was also obtained.

A 5-95% Bayesian posterior interval of between 0 and 48 was obtained for the number of fruit that might be infected in a sample of size 2 million. The mean and median for the distribution were 12 and 5 respectively. (See graph).

A 5-95% Bayesian posterior interval of between 0 and 470, was obtained for the number of fruit that might be infected in a sample of size 20million. The mean and median for the distribution were 123 and 55 respectively. (See graph).

Calculation method

A beta prior distribution beta(1/2,1/2) was given to each of the unknown probabilities p,pd. This is a non-informative prior, that is to say we have little or no prior indication of the value of the probability, and the information present in the prior is equivalent to one observation.

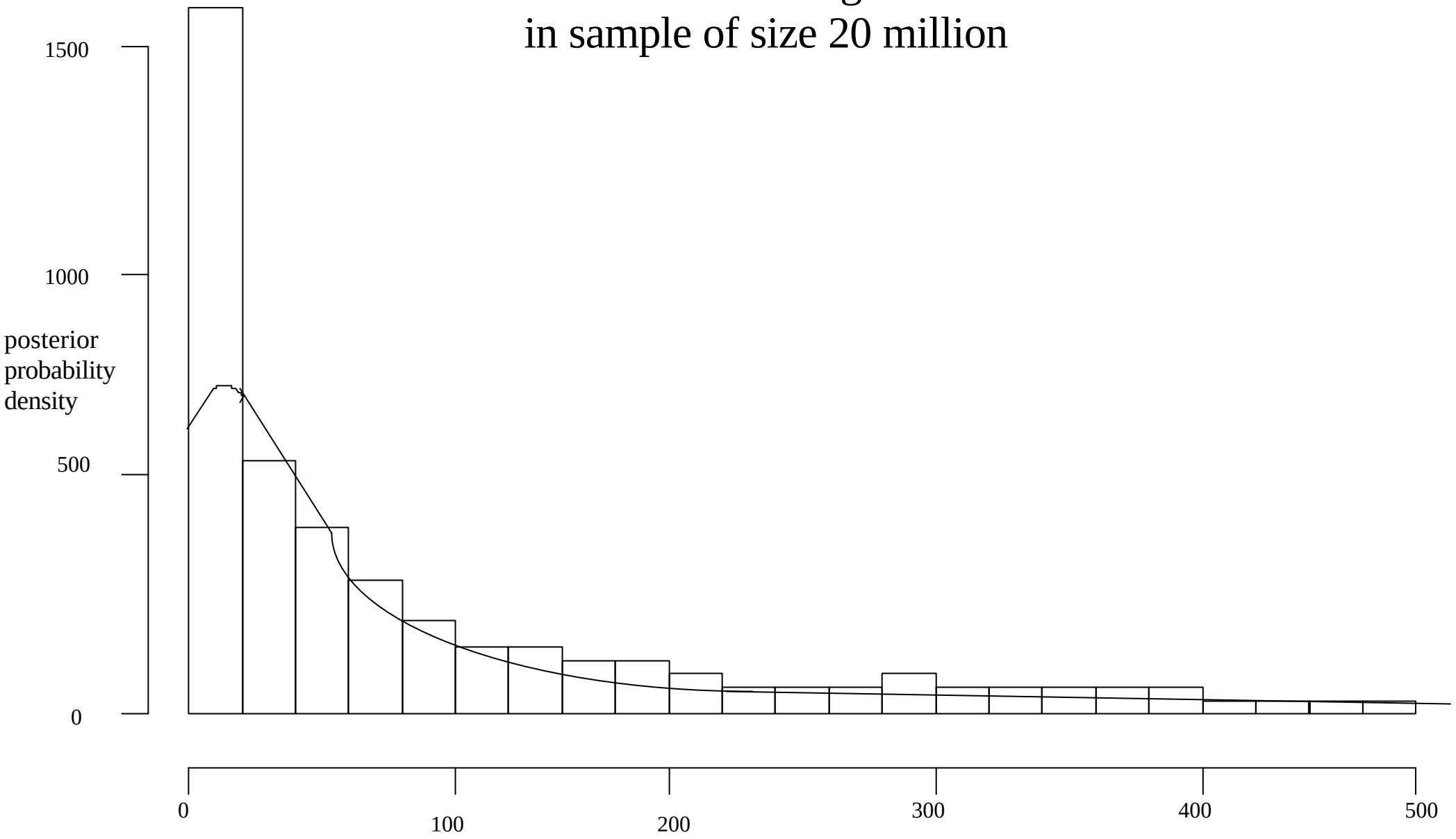
This is the Jefferies non-informative prior for a probability, a natural prior to use when there is no prior information about a binomial probability. It has the probability of invariance under transformations. Other priors could be used. for example if a beta (1/n,1/n) prior is used and we have no either no successes or no failures as in the present situation. however as n->infinity the posterior probabilities concentrate at the end points. Our analysis is somewhat conservative, effectively considering that the next observation may be the opposite of what has occurred.

Using this prior, values were simulated from the posterior distributions which are beta distributions beta (1 /2+0, 1/2+81/00) and beta (1/2+111, 1/2+0) for p-d and p and the ratios p-d/p calculated from the simulations.

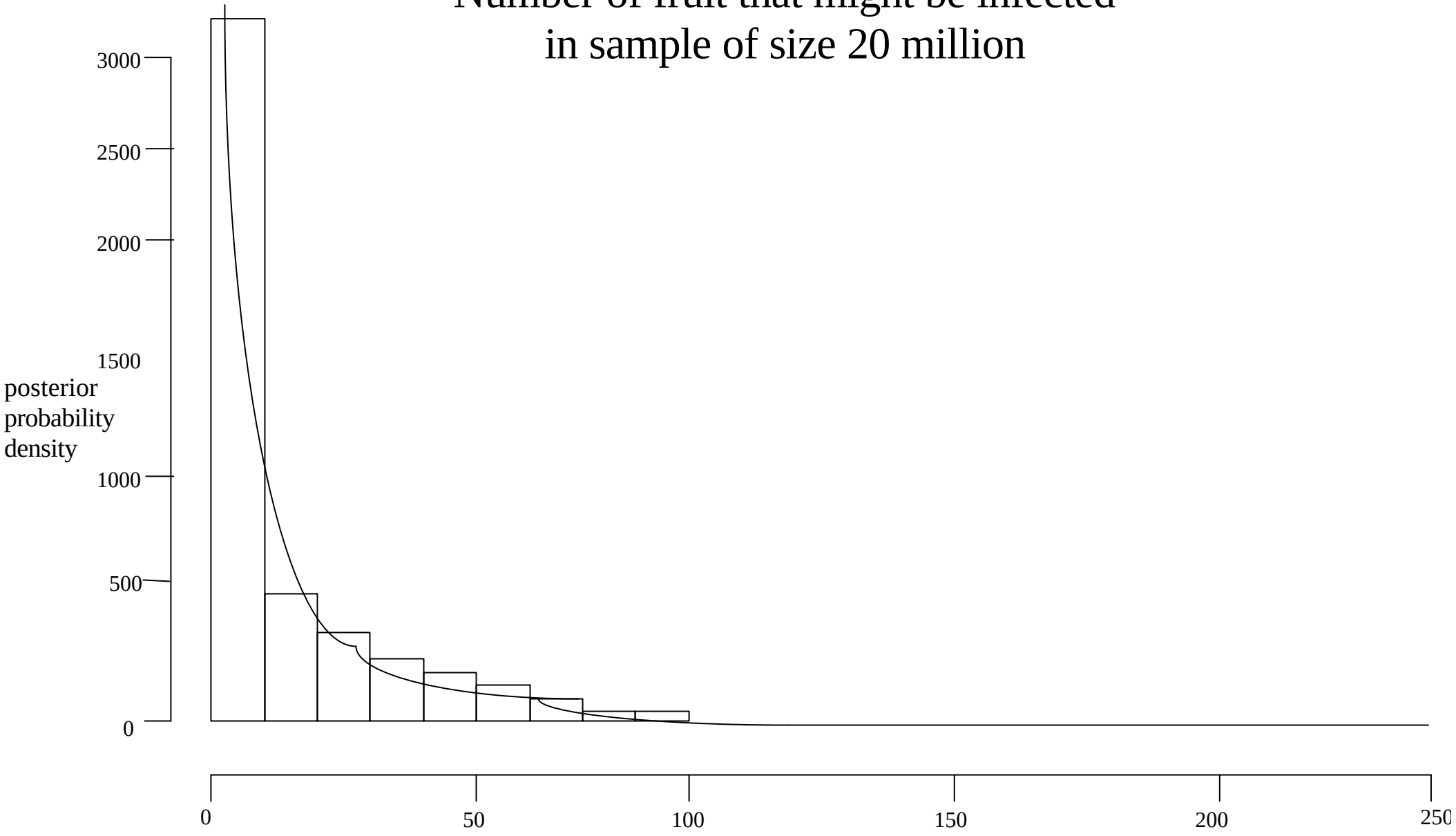
```
##############################################################################

#  simulation for bounds on probability of presence of fireblight
#  P(pres) = Pr (detected & present) /Pr (detected/present) = p_d/p
#  p-d estimated by m = 81700 field samples (none detected)
#  p estimated by n = 111 (all detected)
```

```
> N-5000;

S- PLUS : Copyright (c) 1988, 1995 MathSoft, Inc.
S : Copyright AT&T.
Version 3.3 Release 1 for Sun SPARC, SunOS 5.3 : 1995
Working data will be in home/rod/.Data
> a1_b1_a2_b2_1/2



> N = 5000; prior_rbeta (n, a1, b1)
> (n, a1, b1, 81700); den_rbeta (N, a2+111, b2+0)
> quantile (den, c (0.01.0.05, 0.25, 0.5, 0.75, 0.95, 0.99))  #p
        1%         5%        25%        50%        75%        95%        99%
0.9703441  0.9827324  0.9943665  0.9980341  0.9995477  0.9999816  0.9999994

> quantile (num, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))
        1%         5%        25%        50%        75%        95%        99%
9.030165e-10 1.995501e-08 5.592538e-07 2.732385e-06 8.063005e-06 2.339832e-05 4.205393e-
05

> quantile (num/den, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))
        1%         5%        25%        50%        75%        95%        99%
 9.085668e-10 2.019482e-08 5.624679e-07 2.740298e-06 8.095336e-06 2.352998e-05 4.233212e-
05


> ### Number of fruit that might be infected in sample of size 2 million
> quantile (x2, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))
1%  5%  25%  50%  75%  95%  99%
 0   0    1    5   16   48  84.01

> table (cut (x2, breaks = c (0, 2, 5, 10, 20, 50, 100, 1000))
   0+ thru       2       2+ thru       5       5+  thru      10      10+  thru      20      20+  thru      50
          820                   697                   710                   743                   785
50+  thru     100     100+  thru    1000
               195                    27

> ### Number of fruit that might be infected in sample of size 20 million
> quantile (x20, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))
1%  5%  25%  50%  75%  95%  99%
 0   0   12   55  163 469.05 858.02

> table (cut (x2, breaks = c (0, 2, 5, 10, 20, 50, 100, 200, 1000))
  0+ thru       2       2+ thru       5       5+  thru      10      10+  thru      20      20+  thru      50
          269                   265                   303                   440                   777
50+  thru     100     100+  thru     200+  thru     1000
               813                   775             982

#  a look at the prior distribution
> table (cut (prior, breaks=seq (from=0, to=1, by= .05)))
0.00+  thru  0.05  0.05+  thru  0.10  0.10+  thru  0.15  0.15+  thru  0.20
              255                 248          263                 226
0.20+  thru  0.25  0.25+  thru  0.30  0.30+  thru  0.35  0.35+  thru  0.40
              275                 248          250                 260
0.40+  thru  0.45  0.45+  thru  0.50  0.50+  thru  0.55  0.55+  thru  0.60
              248                 238          247                 231
0.60+  thru  0.65  0.65+  thru  0.70  0.70+  thru  0.75  0.75+  thru  0.80
              253                 244                237                 259
0.80+  thru  0.85  0.85+  thru  0.90  0.90+  thru  0.95  0.95+  thru  1.00
              259                 260          248                 251

### re-analysis using a beta (1,1) prior
```

```
> num_rbeta (N, 1, 1+81700) ; den_rbeta (N, 1+111, 1+0
> quantile (den, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))   #p
        1%         5%        25%        50%        75%        95%        99%
0.9607049  0.9739218  0.9878343   0.993896  0.9975887  0.9995578  0.9999146

> quantile (num, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))   #p_d
        1%         5%        25%        50%        75%        95%        99%
1.48971e-07 6.769603e-07 3.486803e-06 8.556425e-06 1.670294e-05 3.714983e-03 5.547984e-05

> quantile (num/den, c ( 0.01, 0.05, 0.25, 0.5, 0.75, 0.95, 0.99))
        1%         5%        25%        50%        75%        95%        99%
 1.507055e-07 6.802064e-07 3.514336e-06 8.649797e-06 1.679861e-05 3.763719e-05
5.605669e-05
```


Number of fruit that might be infected
in sample of size 20 million
1500
1000
posterior
probability
density
500
0
0
100
200
300
400
500
Number of fruit infected (Pr(x20>500=0.04)

Number of fruit that might be infected in sample of size 20 million



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The list of organisms recorded in New Zealand associated with apple **fruit** (*Malus pumila*) as categorised by **AUSTRALIA**

Species	Family	Order/Group	Common Name	Comments	References	Previous Categorisation* /Present in Australia	Confirmed Categorisation
Insects:							
Agonum spp.	Carabidae	Coleoptera	Ground beetle	orchard or packhouse contaminant (adult life stage), adult & larvae predatory in soil	Bucher & Emberson 1981		
Agrotis ipsilon aneituma (Walker)	Noctuidae	Lepidoptera	Greasy cutworm	orchard or packhouse contaminant (adult life stage), larvae feed on herbaceous hosts	Scott, 1984	P	
Agrypnus variabilis (Candeze)	Elateridae	Coleoptera	Variable wireworm	orchard or packhouse contaminant (adult life stage), larvae feed in soil on herbaceous	Scott, 1984		
Ahasverus advena (Walt.)	Silvanidae	Coleoptera	Foreign grain beetle	orchard or packhouse contaminant (adult life stage), larvae are secondary feeders on dried plant material	Scott, 1984		
Alticinae/Halticinae	Chrysomelidae	Coleoptera	Flea beetle	adult contaminant on fruit, larvae can be primary posts on foliage	Insects of Australia, 1970		
Anchomenus spp.	Carabidae	Coleoptera	Ground beetle	orchard or packhouse contaminant (adult life stage), adult & larvae predatory In soil	Hudson, 1934		
Anthicus floralis L	Anthicidae	Coleoptera	Narrownecked grain beetle	orchard or packhouse contaminant (adult life stage), larvae are secondary feeders on decaying plant material	Kuschel, 1990		
Antipodiphora tonnoiri (Schmitz)	Phoridae	Diptera	Native phorid fly	orchard or packhouse contaminant (adult life stage), larvae are secondary feeders on decaying plant material	Insects of Australia, 1970	P	
Aonidiella aurantii (Maskell)	Diaspididae	Herniptera	California red scale	primary, (occasional) on apple fruit/foliage, stems. Main host is Citrus	Scott, 1984	NA	
Apanteles tasmanicus Carneron	Braconidae	Hymenoptera	Leafroller parasite	orchard or packhouse contaminant (adult life stage), larvae are leafroller parasites	Scott, 1984		
Aphis gossypii Glover	Aphididae	Hemiptera	Melon aphid	primary pest (occasional) on foliage and rarely fruit	Scott, 1984	P	
Araecerus palmaris (Pascoe)	Anthribidae	Coleoptera	Fungus weevil	secondary feeder, larvae normally feed in mummified fruit only	Holloway, 1982		
Arhopalus ferus (Mulsant)	Cerambycidae	Coleoptera	Burnt pine longhorn beetle	orchard or packhouse contaminant (adult life stage), larvae are woodboring posts of pine trees	Scott, 1984	A	
Aridius bifasciatus (Reitter)	Lathridiidae	Coleoptera	Minute brown scavenger beetle	orchard or packhouse contaminant (adult life stage), secondary feeder on decaying plant material	Watt, 1969	NA	
Aridius nodifer (West.)	Lathridiidae	Coleoptera	Minute brown scavenger beetle	orchard or packhouse contaminant (adult life stage), secondary feeder on decaying plant material	Watt, 1969	NA	

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Aspidiotus nerii Bouche[1]	Diaspididae	Hemiptera	Oleander scale	primary (occasional) on apple fruit, foliage, stems	Williams & Watson, 1988	NA	
Asynonychus cervinus (Boheman)	Curculionidae	Coleoptera	Fuller's rose weevil	orchard or packhouse contaminant (adult life stage) adults may feed on foliage (occasional)	Scott, 1984	NA	
Blatella germanica (L)	Blattidae	Balltodea	German cockroach	orchard or packhouse contaminant (adult life stage) general scavenger on organic material	Scott, 1984		
Brentiscerus putoni (F.B. White)	Lygaeidae	Hemiptera	Lygaeid beetle	orchard or packhouse contaminant, normally seed-feeder on native hosts	Myers, 1926		
Carpophilus spp.	Nitidulidae	Coleoptera	Dried fruit beetle	contaminant/secondary on fruit (adults, larvae attracted to ripe fruit)	Scott, 1984		
Carpophilus davidsoni (Dobson)	Nitidulidae	Coleoptera	Dried fruit beetle	contaminant/secondary on fruit (adults, larvae attracted to ripe fruit)	Scott, 1984	NA	
Carpophilus gaveni Dobson	Nitidulidae	Coleoptera	Dried fruit beetle	contaminant/secondary on fruit (adults, larvae attracted to ripe fruit)	Scott, 1984	NA	
Cartodere spp.	Lathridiidae	Coleoptera	Fungus beetle	contaminant/secondary feeder on decaying plant material	Watt, 1969; Hinton, 1945		
Chelaner antarcticum (White)	Formicidae	Hyemenoptera	Southern ant	orchard or packhouse contaminant (adult life stage) contaminant/general scavanger	Brown, 1958		
Cnephasia jactatana (Walker)	Tortricidae	Lepidoptera	Black lyre moth	Larvae primary (occasional) on foilage, ?fruit	Gaskin, 1966	A	
Coccinella undecimpunctata L	Coccinellidae	Coleoptera	Elevenspotted ladybird	orchard or packhouse contaminant (adult life stage) predator	Scott, 1984		
Conoderus exsul Sharp	Elateridae	Coleoptera	Wireworm	orchard or packhouse contaminant (adult life stage) larvae primary pest in soil on herbaceous hosts	Scott, 1984		
Corticaria pubescens (Gyllenhall)	Lathridiidae	Coleoptera	Fungus beetle	orchard or packhouse contaminant (adult life stage) secondary feeder on decaying plant material	Watt, 1969		
Corticaria spp.	Lathridiidae	Coleoptera	Fungus beetle	orchard or packhouse contaminant (adult life stage) secondary feeder on decaying plant material	Watt, 1969		

Corticaria serrata (Paykull)	Lathridiidae	Coleoptera	Fungus beetle	orchard or packhouse contaminant (adult life stage) secondary feeder on decaying plant material	Watt, 1969		
Cortinicara spp.	Lathridiidae	Coleoptera	Fungus beetle	orchard or packhouse contaminant (adult life stage) secondary feeder on decaying plant material	Watt, 1969		

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Costelytra zealandica (White)	Scarabaeidae	Coleoptera	Grass Grub	Orchard or packhouse contaminant (adult life stage) polyphagous; adult defoliate, larvae are root feeders	Scott, 1984	A	
Cryptolestes spp.	Cucujidae	Coleoptera	Flat grain beetle	orchard or packhouse contaminant (adult life stage), secondary feeders on decaying/ dried plant material	Scott, 1984		
Cryptophagus spp.	Cryptophagidae	Coleoptera	Cryptophagid fungus beetle	orchard or packhouse contaminant (adult life stage), secondary feeder on decaying plant material	Busvine, 1980		
Ctenopseustis herana (Feld. & Rogen.)	Tortricidae	Lepidoptera	Brownheaded leafroller	larvae are primary pests on apple fruit, foliage	Dugdale, 1990	A	
Ctenopseustis obliquana (Walker)	Tortricidae	Lepidoptera	Brownheaded leafroller	larvae are primary pests on apple fruit, foliage	Scott, 1984	A	
Cydia molesta Busck	Tortricidae	Lepidoptera	Oriental fruit moth	larvae primary posts on fruit (occasional); usual hosts are Prunus spp.	Scott, 1984	NA	
Cydia pomonella (L)	Tortricidae	Lepidoptera	Codling moth	larvae primary pest in fruit	Scott, 1984	NA	
Dasyneura mali Keiffer	Cecidomyiidae	Diptera	Apple leafcurling midge	larvae tire primary post on foliage; larvae pupate on fruit-t (occasional)	Scott, 1984		
Dermestes maculatus Do Geer	Dermestidae	Coleoptera	Hide beetle	orchard or packhouse contaminant (adult life stage), larvae feed on dried animal material	Scott, 1984		
Diasernia grammalis Doubleday	Crambidae	Lepidoptera		orchard or packhouse contaminant (adult life stage), larvae feed on native grasses/herbaceous spp.	Husdson, 1928		

Dictyolus caenosus (Westwood)	Pentatomidae	Hermiptera	Brown shield bug	primary pests (occasional) on foliage, fruit buds, ?fruit	Scott, 1984		
Dieuches notatus (Dallas)	Lygacidae	Hermiptera	Lygaeid bug	orchard or packhouse contaminant (adult life stage), primary feeders on water cress in water courses	May, 1963		
Ectopsocus spp.	Ectopsocidae	Psocoptera	psocid/book lice	secondary feeders on decaying plant material	Smithers, 1969		
Endrosis sarcitrella (L)	Oecophoridae	Lepidoptera	White shouldered house moth	orchard or packhouse contaminant (adult life stage) scavengers on wool and animal products	Scott, 1984		
Ephestia elutella (Hubner)	Pyralidae	Lepidoptera	Tobacco moth	orchard or packhouse contaminant (adult life stage), larvae feed on dried foodstuffs of plant origin	Busvine, 1980		
Epiphyas postvittana (Walker)	Tortricidae	Lepidoptera	Lightbrown apple moth	primary pest on fruit and foliage	Scott, 1984	NA	

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Eucolaspis brunnea (F)	Chrysomelidae	Coleoptera	Bronze beetle	orchard or packhouse contaminant (adult life stage), feed on apple foliage (occasional)	Scott, 1984	A	
Eudonia paltomacha (Meyrick)	Pyralidae	Lepidoptera	Sod webworm	orchard or packhouse contaminant (adult life stage), larvae feed on grasses and herbaceous hosts	Hudson, 1928		
Eudonia psammitis (Meyrick)	Pyralidae	Lepidoptera	Sod webworm	orchard or packhouse contaminant (adult life stage), larvae feed on grasses and herbaceous hosts	Hudson, 1928		
Forficula auricularia L	Forficulidae	Dermaptera	European earwig	orchard or packhouse contaminant (adult life stage), feed on flowers/ general scavenger	Scott, 1984	NA	
Gonipterus scutellatus Gyllenhall	Curculionidae	Coleoptera	Gum tree weevil	orchard or packhouse contaminant (adult life stage), pests on Eucalyptus spp.	Scott, 1984	P	

Graphania mutans (Walker)	Noctuidae	Lepidoptera	Cutworm	orchard or packhouse contaminant (adult life stage), larvae feed on grasses & herbaceous hosts	Gaskin, 1966	A	
Gymnetron pascuorum (Gyllenhall)	Curculionidae	Coleoptera	"native weevil"	orchard or packhouse contaminant (adult life stage), larvae feed on Plantago spp. (weeds)	Kuschel, 1990; May, 1993		
Harpalinae	Carabidae	Coleoptera	Predatory ground beetle	adult contaminant on fruit, larvae predatory in soil	Insects of Australia 1970	P	
Helastia cryptica Craw	Geometridae	Lepidoptera		orchard or packhouse contaminant (adult life stage), larvae feed on dead leaves	Craw, 1987		
Helicoverpa armigera Hubner	Noctuidae	Lepidoptera	Tomato fruitwrom	doubtful record, recorded only once feeding on foliage and immature apple fruit, not normally a post of apple	Scott, 1984	P	
Heliothrips haemorrhoidalis (Bouche)	Thripidae	Thysanoptera	Greenhouse thrips	primary contaminant on fruit & foliage (occasioned), polyphagous	Scott, 1984	NA	
Hemiberlesia rapax (Comstock)	Diaspididae	Hemiptera	Greedy scale	primary (occasional) on fruit, foliage; found on a wide host range of woody plants	Scott, 1984	NA	
Hygraula nitens Butler	Crambidae	Lepidoptera	Pyralid water moth	orchard or packhouse contaminant (adult life stage) native, feeding habits of larvae not known	Hudson, 1928		
Hylastes ater Paykull	Scolytidae	Coleoptera	Black pine bark beetle	orchard or packhouse contaminant (adult life stage), adults/larvae feed on pine logs	Scott, 1984		
Lepidosaphes ulmi (L)	Diaspididae	Hemiptera	Apple mussel scale	primary pest of fruit	Scott, 1984	NA	
Listroderes difficilis Germain (was L. obliquus Klug)	Curculionidae	Coleoptera	Vegetable weevil	orchard or packhouse contaminant (adult life stage), larvae feed on herbaceous hosts	Scott, 1984	P	
Listronotus bonariensis (Kuschel)	Curculionidae	Coleoptera	Argentine stem weevil	orchard contaminant (adult life stage) larvae feed on grasses/cereals	Scott, 1984		

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Longitarsus fuliginosus (Broun)	Chrysomelidae	Coleoptera	“native chrysomelid"	orchard contaminant (adult life stage), native, ? feed on grasses	Kuschel, 1990		
Lyonetiidae	Lyonetiidae	Lepidoptera		adult contaminant on fruit; larvae can be primary on other hosts, mostly saphrophytic	Insects of Australia, 1970	P	
Micrambina rutila (Broun)	Cryptophagidae	Coleoptera	Plaster beetle	orchard or packhouse contaminant (adult life stage), secondary feeders on dead leaf & stem material	Kuschel, 1990		
Micromus tasmaniae (Walker)	Hemerobiidae	Neuroptera	Tasmanian lacewing	orchard contaminant (adult life stage), predator on aphids	Scott, 1984		
Mitrastethus baridioides Redtenbacher	Curculionidae	Coleoptera	Kauri weevil	orchard or packhouse contaminant (adult life stage), larvae feed on damp pine logs	Hosking, 1978		
Mycetophila sp.	Mycetophilidae	Diptera	Fungus gnats	orchard or packhouse contaminant (adult life stage), secondary feeder on decaying plant material	Insects of Australia, 1970	P	
Notogonum m submetallicum (White)	Carabidae	Coleoptera	Submetallic ground beetle	orchard or packhouse contaminant (adult life stage), larvae primary pests in soil on herbaceous hosts	Kuschel, 1990		
Nysius huttoni White	Lygaeidae	Hemiptera	Wheat bug	orchard or packhouse contaminant (adult life stage), seed feeder on grasses & herbaceous hosts	Scott, 1984	A	
Opogona omoscopa (Meyrick)	Tineidae	Lepidoptera	Tineid moth	orchard or packhouse contaminant (adult life stage) larvae feed on dead foliage & stems	Wise, 1953	P	
Orocrambus spp.	Pyralidae	Lepidoptera	Grass and moss moths	orchard or packhouse contaminant (adult life stage), adult contaminant on fruit, larvae primary on grasses	Gaskin, 1966		
Pachybrachius inornatus (Walker)	Lygaeidae	Hemiptera	Weed seed bug	orchard or packhouse contaminant (adult life stage), seed feeder on herbaceous hosts	Cumber, 1959		
Parocystole acroxantha Meyrick	Oecophoridae	Lepidoptera	Oecophorid moth	orchard or packhouse contaminant (adult life stage), larvae feed on dead foliage & stems	Dugdale, 1987		
Phlyctinus callosus Boheman	Curculionidae	Coleoptera	Garden weevil	orchard or packhouse contaminant (adult life stage), larvae am primary on roots of herbaceous species	Scott, 1984	NA	
Planotortrix excessana (Walker)	Tortricidae	Lepidoptera	Greenheaded leafroller	primary pest of fruit and foliage	Scott, 1984	A	
Planotortrix octo Dugdale	Tortricidae	Lepidoptera	Greenheaded leafroller	primary pest of fruit and foliage	Dugdale, 1990	A	
Plinthisus spp.	Lygaeidae	Lepidoptera	Seed bug	orchard or packhouse contaminant (adult life stage), seed feeder on herbaceous hosts	Insects of Australia, 1970	P	

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Pseudococcidae, species of	Pseudococcidae	Hemiptera	Mealybug	primary on fruit and foliage	Insects of Australia 1970		
Pseudococcus affinis (Maskell)	Pseudococcidae	Hemiptera	Obscure mealybug	primary on fruit and foliage	Cox, 1987	NA	
Pseudococcus calceolariae (Maskell)	Pseudococcidae	Hemiptera	Citrophilus mealybug	primary on fruit and foliage	Cox, 1987	NA	
Pseudococcus longispinus (Targioni-Tozzetti)	Pseudococcidae	Hemiptera	Longtailed mealybug	primary on fruit and foliage	Scott, 1984	NA	
Pseudococcus similans (Lidgett)	Pseudococcidae	Hemiptera	Mealybug	primary on fruit and foliage	Cox, 1987		
Psocoptera	Pscoptera indet	Pscoptera	psocid/book lice	contaminant/secondary, associated with decaying plant material	Insects of Australia 1970		
Quadraspidiotus ostreacformis (Curtis)	Diaspididae	Hemiptera	Oystershell scale	primary on fruit and foliage	Scott, 1984	P	
Quadraspidiotus perniciosus (Comstock)	Diaspididae	Hemiptera	San Jose scale	primary on fruit and foliage	Scott, 1984	NA	
Rhypodes clavicornis (F)	Lygacidae	Hemiptera	Seed bug	orchard or packhouse contaminant (adult life stage), seeds feeder on herbaceous hosts	Myers, 1926	A	
Rhypodes serricatus Usinger	Lygacidae	Hemiptera	Seed bug	orchard or packhouse contaminant (adult life stage), seeds feeder on herbaceous hosts	Usinger, 1942		
Scoparia spp.	Pyralidae	Lepidoptera	Sod webworms	orchard or packhouse contaminant (adult life stage), seeds feeder on herbaceous / grass hosts	Gaskin, 1966		
Sidnia kinbergi Stal	Miridae	Hemiptera	Australian crop mirid	orchard or packhouse contaminant (adult life stage), seeds feeder on lucerne / legumes hosts	Scott, 1984	P	
Staphylinidae indet	Staphylinidae	Coleoptera	Rove beetle	orchard contaminant (adult life stage) contaminant on fruit, predator / scavenger	Insects of Australia, 1970		
Sitona discoideus Gyllenhall	Curculionidae	Coleoptera	Sitona weevil	orchard or packhouse contaminant (adult life stage), pest of lucerne	Scott, 1984	P	
Stepsicrates macropetana Meyrick	Tortricidae	Lepidoptera	Eucalyptus leafroller	orchard or packhouse contaminant (adult lift stage), larva pests on eucalyptus spp.	Nuttall, 1983		
Stethorus befidus Kapur	Coccinellidae	Coleoptera	Ladybird	orchard or packhouse contaminant (adult life stage), predator on mites	Scott, 1984	NA	
Syrphidae	Syrphidae	Diptera	hoverflies	orchard or packhouse contaminant (adult life stage), predator on aphids	Insects of Australia, 1970		
Thrips obscuratus (Crawford)	Thripidae	Thysanoptera	New Zealand flower thrips	primary on fruit and foliage	Mound & Walker, 1982	A	
Tineola bissellicita (Hummel)	Tineidae	Lepidoptera	Clothes moth	orchard or packhouse contaminant (adult life stage), primary pest on woollen fabrics	Scott, 1984		

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Tinegena spp.	Oecophoridae	Lepidoptera	Native litter feeding moth	orchard or packhouse contaminant (adult life stage), native, feeding habits not known	Dugdale, 1988; Hudson, 1928		
Tortricinae, species of	Torticidae	Lepidoptera	leafrollers	primary (occasional)	Insects of Australia, 1970		
Typhlocyba froggatti baker	Cicadellidae	Hemiptera	Froggatt's apple leafhopper	primary on foliage, occasional on fruit	Scott, 1984	P	
Mites:							
Bryobia rubrioculus (Scheuten)	Tetranychidae	Acari	Brown mite	primary on fruit and foliage	Scott, 1984	NA	
Eriophyes mali (Burts)	Eriophyidae	Acari	Apple blister mite	primary on foliage, occasional on fruit	Manson, 1987		
Panonychus ulmi (Koch)	Tetranychidae	Acari	European mite	primary on fruit and foliage	Scott, 1984	NA (E.States)	
Tetranychus urticae Koch	Tetranychidae	Acari	Two spotted mite	primary on fruit and foliage	Scott, 1984	NA	
Tydeus spp.	Tydeidae	Acari	Tydeid mite	secondary on honeydew, fungi, ?sap feeders (occasional)	Charles, 1984	NA	
Typhlodromus pyri (Scheuten)	Phytoseiidae	Acari	Predatory mite	predator on pest mites	Scott, 1984	NA	
Araneae (Spiders):							
Trite spp.	Salticidae		Jumping spider	orchard or packhouse contaminant, predator	Forster & Forster, 1973		
Gastropoda (slugs/snails):							
Helix aspersa (Muller)	Helicidae	Stylommatophora Brown	garden snail	orchard or packhouse contaminant polyphagous foliage feeder	Scott, 1984	NA	
Vallonia excentrica	Vallonidae	Stylommatophora	snail	orchard or packhouse contaminant, polyphagous foliage feeder	Cameron & Redfern, 1976		
Fungi							
Alternaria alternata (Fries) Keissler (1912)		Hyphomycetes	Fruit rot	secondary pathogen of stored fruit	Jones & Aldwinkle, 1990	NA	

Botryosphaeria dothidea (Mougeot ex Fries) Cesati & de Notaris (1863)		Botryospaeriacea e	Black rot	primary fruit rot, not common	Jones & Aldwinkle, 1990**	NA	
Botryosphaeria obtusa (Schweinitz) Shoemaker (1964)		Botryospaeriacea e	Black rot	primary fruit rot, occurs in wetter areas	Jones & Aldwinkle, 1990; Snowdon, 1990		

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Botryosphaeria parva Pennycook & Samuels (1985)		Botryosphaeriacea e	Ripe spot	primary fruit rot, distribution uncertain	Jones & Aldwinkle, 1990	P	
Botryosphaeria spp.		Botryosphaeriacea e	Fruit rot	primary fruit rot	Jones & Aldwinkle, 1990		
Botryosphaeria stevensii Shoemaker (1964)		Botryosphaeriacea e	Diplodia canker	primary fruit rot, distribution uncertain	Jones & Aldwinkle, 1990	NA	
Botrytis cinerea Persoon (1797)		Hyphomycetes	Grey mould (dry eye rot)	primary fruit rot, common fungus. troublesome in wet seasons	Snowden, 1990	NA	
Colletotrichurn acutatum Simmonds ex Simmonds (1968)		Coelomycetes	Anthracnose	primary fruit rot, wide distribution	Snowden, 1990	NA	
Diaporthe actinidiae Sommer & Beraha (1975)		Valsaceac	Phomopsis rot	secondary, distribution uncertain	Snowden, 1990	NA	
Diaporthe perniciosa Marchal (1921)		Valsaceac	Phomopsis canker	secondary fruit rot	Jones & Aldwinkle, 1990	NA	
Diaporthe sp.		Valsaceac	Phomopsis rot	secondary rot	Jones & Aldwinkle, 1990	NA	
Elsinoe pyri (Vorornikhin) Jenkins (1932)		Myriangiaceae	Anthracuose/scab	primary, minor economic importance	Atkinson, 1971		
Fusicoccum luteum Pennycook & Samuels (1983)		Coelomycetes	Ripe spot	primary fruit rot, distribution uncertain	Jones & Aldwinkle, 1990	NA	
Gibberella baccata (Wallroth) Saccardo (1883)		Hypocreaceae	Fruit rot	secondary wound pathogen, minor importance	no technical refernce available	NA	

Gloeodes pomigena (Schweinitz) Colby (1920)		Coelomycetes	Sooty blotch	primary, widespread, but of minor economic importance	Jones & Aldwinkle, 1990		
Glomerella cingulata (Stoneman) Spaulding & Schrenk (1903)		Phyllachoraceae	Bitter rot	primary fruit rot, common in wetter areas	Jones & Aldwinkle, 1990	NA	
Leptothyrium porni (Montagne & Fries) Secardo (1880)		Coelomycetes	Fly speck	primary, rare, in wetter areas	Atkinson, 1971		
Monilinia fructicola (Winter) Honey (1928)		Sclerotiniaceae	Brown rot	secondary fruit rot	Jones & Aldwinkle, 1990	NA	
Monilinia laxa (Aderhold & Rubland) Honey ex Whetzel (1945)		Sclerotiniaceae	Brown rot	secondary fruit rot	Jones & Aldwinkle, 1990	NA	
Nectria galligena Bresadola (1901)		Hypocreaceae	Eye rot	primary tmit spot, uncommon symptorn in NZ	Jones & Aldwinkle, 1990		
Penicillium expansurn Link (1809)		Hyphomycetes	Blue mould	primary fruit storage rot	Jones & Aldwinkle, 1990	NA	
Penicillium spp.		Hyphomycetes	Penicillium mould	primary fruit storage rot	Jones & Aldwinkle, 1990		

The list of organisms recorded in New Zealand associated with apple **fruit** (*Malus pumila*) as categorised by **AUSTRALIA**

Species	**Family**	**Order/Group**	**Common Name**	**Comments**	**References**	**Previous Categorisation*/ Present in Australia**	**Confirmed Categorisation**
Pezicula alba Guthrie (1959)		Dermateaceae	Ripe spot	primary fruit rot	Snowdon, 1990		
Pezicula malicorticis (Jackson) Nannfeldt (1932)		Dermateaceae	Ripe spot	primary fruit rot	Snowdon, 1990		
Phoma pomorum Thuemen (1879)		Coclomycetes	Phoma fruit spot	primary leaf rot	Jones & Aldwinkle, 1990	NA	
Phomopsis spp.		Coelomycetes	Phomopsis rot	secondary fruit rot	Snowdon, 1990	NA	
Phytophthora cactorum (Lebert & Cohn) Schroeter (1886)		Pythiaceae	Phytophthora fruit rot	primary fruit rot, uncommon symptom in NZ	Jones & Aldwinkle, 1990		
Podosphaera leucotricha (Ellis & Everhart) Salmon (1900)		Erysiphaceae	Powdery mildew	primary, causes a fruit blemish	Jones & Aldwinkle, 1990; Snowdon, 1990		
Rhizopus stolonifer (Ehrenberg) Vuillemin (1902)		Mucoraceae	Rhizopus rot	primary storage rot	Jones & Aldwinkle, 1990	NA	

Sclerotinia scleroliorum (Libert) de Bary (1884)		Sclerotiniaceae	Calyx end rot	primary fruit rot, rare	Jones & Aldwinkle, 1990	NA	
Sphaerotheca, pannosa (Wallroth) Leveille (1851)		Erysiphaceae	Powdery mildew	primary, causes a fruit blemish	Persley, 1993	NA	
Trichothecium roseurn (Persoon) Link (1809)		Hyphomycetes	Pink rot	primary, fruit decay, rare	Snowdon, 1990		
Valsa leucostoma (Persoon) Fries (1849)		Valsaceae	Valsa canker	secondary/contaminant. not usually a pathogen of fruit	Jones & Aldwinkle, 1990	NA	
Venturia inacqualis (Cooke) Winter (1875)		Venturiaceae	Apple scab (+black spot)	primary fruit spot, common	Jones & Aldwinkle, 1990		
Bacteria:							
Erwinia amylovora (Burrill) Winslow et al		Enterbacteriaceae	Fire blight	fruit blight. inumiture fruit shrivel and abort, mature fruit are not a pathway for introduction	CABI, 1992		
Pseudomonas syringae pv. syringae van Hall (1902)		Pseudomonadaceae	Blast/blister spot	primary fruit spot, more common in wetter areas	Snowdon, 1990	NA	

** Fusicoccum luteum and Botryosphaeria parva have similar lifecycles. The reference for these two species is that for Botryosphaeria dothidea (teleomorph of Fusicoccum luteum)

Definitions of terms used:

Primary: organism feeds directly on host and causes significant damage
Secondary: organism feeds on fungal/bacterial decay on hosts but may cause indirect damage to host.
Contaminant: organism does not damage host, and is present accidentally or for a short time only
Occasional: organism irregularly causes primary damage to apples
A = Actionable post
NA = Non-Actionable organism, no action taken on interception
P = Present in Australia

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References: (Pathology)

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APPENDIX 2

ADDITIONAL INFORMATION PROVIDED BY NEW ZEALAND

Question 1

It is stated that the weather was conducive for fire blight during this research.

Can you supply weather records for this period?

Answer 1

Weather records for period of inoculation and infection are as follows:

Date/Month	Day	Rainfall mm	Mean Temp °C	Relative Humidity %
October	24	13.8	15.0	86
	25	9.5	16.9	93
	26		15.9	77
	27		17.0	70
	28	0.2	15.1	77
	29		15.0	96
	30		16.2	88
	31	26.7	16.0	83
November	1		15.8	80
	2		13.6	78
	3		14.1	80
	4		14.2	78
	5		15.5	60
	6	4.4	17.8	82
	7	0.1	19.8	95
	8	13.2	20.0	72
	9	2.0	16.3	90
	10		15.5	65
	11		15.4	83
	12	0.7	15.3	62
	13		17.4	75
	14		16.9	63
	15	1.1	19.0	84
	16	6.6	17.2	92
	17		14.3	75
	18	1.0	14.5	72
	19		14.1	55
	20		12.1	57
	21	0.3	13.8	70
	22	12.0	16.5	87
	23		14.2	72
	24		13.8	64
	25		15.3	67

	26		13.5	76

Comment:

. Inoculation dates: 24-26 October

. Sampling time (inoculation thresholds): 13-15 November

. After inoculation, a number of likely infection periods occurred with mean daily temperatures above 16^0C. That weather was conducive to infection and establishment was evidenced by the symptom expression in inoculated clusters and some adjacent flowers.

. Although temperatures were not recorded within the chambers in 1994, data collected for the 1995 season show that temperatures in the chambers are approximately 2^0C above the outside temperatures during the inoculation period.

Question 2

The strain used for inoculation was ICMP 1501. It is claimed that this is not listed in the ICMP catalogue. Can you supply data on this train?

Answer 2

The strain ICMP 1501 used for inoculation is listed in the ICMP Catalogue on page 10.

Details are as follows:

The culture was isolated from blossom of apple *(Malus x domestica)* cv. Ballarat. The isolation was made by D W Dye and the culture is also deposited as NCPPB 2084 at Harpenden, UK. The isolate is pathogenic to apple, pear, and nashi seedlings.

Question 3

Do you have any data on the strain specificity of the testing procedures (DNA test). How good is it at detecting other strains?

Answer 3

The 76 strains deposited as *Erwinia amylovora* and listed in the ICMP Catalogue from 10 plant species in 5 countries were tested, using DNA hybridisation, to determine the relationship of each isolate to the Type Culture of *Erwinia amylovora* (ICMP 1540). Of these isolates, 41 were from New Zealand.

The DNA hybridisation analyses were performed using ^{32}P-labelled total DNA of the *Erwinia amylovora* Type Culture (ICMP 1540) in colony hybridisation tests.

Sixty nine strains hybridised to the labelled DNA probe, indicating a close relationship with the Type Culture, including all the 41 strains of *Erwinia amylovora* isolated from various hosts in New Zealand.

Seven strains failed to hybridise, 2 from *Rubus* sp., 2 from *Onobrychis viciaefolia* (deposited as an *Erwinia amylovora* - like bacterium), 2 from pear and 1 from apple.

Isolates of other species of *Erwinia* eg *herbicola*, *E. atroseptica*, *E. carotovora*, and *E chrysanthemi* did not hybridise with the *Erwinia amylovora* probe.

Isolates of *Pseudomonas* species, *Agrobacterium tumefaciens*, *Clavibacter michiganense*, and *Xanthomonas campestris* did not hybridise with the *Erwinia amylovora* probe.

Pathogenicity

All the 41 strains of *Erwinia amylovora* isolated from various hosts in New Zealand were pathogenic on apple, pear and nashi.

None of the 7 strains failing to hybridise with the labelled probe caused a pathogenic response on apple, pear and nashi seedlings.

Question 4

Hale paper - Section 2.1.1 Can you supply any detail on the replication used?

Answer 4

There are 10 replicate blossom clusters for each inoculum concentration. The stigmas of 10 individual flowers in each blossom cluster were inoculated.

Question 5

Hale paper - Section 2.1.2 Can you supply information about when sample was done?

Answer 5

The 10 inoculated flowers in each cluster were sampled and tested for the presence of *Erwinia amylovora* by DNA hybridisation.

Question 6

Your letter of 19 December 1995 indicates that 81,700 fruit were tested yet the attached paper by Hale and a quick count of the data available in the literature only gets to approximately 60,000 apples assayed. Can you provide information on the source and circumstance of the other 20,000 apples tested? Were all of the fruit tested mature or does this include immature fruit?

Answer 6

The 60,000 fruit referred to in the paper were from testing done up to 1991. Further testing was done in 1992 and 1993, with the same results. Most of the fruit tested were immature (approx 2.5 cm diam.) taken from inspected orchards found to be free of fire blight symptoms.

[Included in the 81,715 are results from tests on healthy fruit taken from trials to determine the spread of *Erwinia amylovora* from inoculation sites].

Immature fruit were used for testing as in the original discussions with AQIS and Australian scientists these fruit were considered more likely than mature fruit to yield *Erwinia amylovora*. The paper by Hale, McRae and Thomson showed that *Erwinia amylovora* was detected in calyxes of 57% of immature fruit from a heavily infected orchard block (75 strikes/tree). However, *Erwinia amylovora* was only detected in calyxes of 3% of mature fruit from the same orchard block.

Question 7

Can you provide data that indicates that the DNA technique is reliable at the indicated limits for the detection of other strains of *Erwinia amylovora*'

Answer 7

The DNA hybridisation technique was checked for effectiveness in detecting a range of *Erwinia amylovora* strains from New Zealand inoculated into immature apple fruits.

Calyxes of immature apple cv. Braeburn fruit (25 per concentration of *Erwinia amylovora*) were inoculated with approx $10^{1,}$ $10^{2,}$ 10^{3} or 10^{4} colony forming units (cfu). Calyxes of inoculated apples were removed and tested for the presence of *Erwinia amylovora* using the DNA hybridisation method. DNA on membranes which hybridised with DNA from the Type Culture was considered to originate from *Erwinia amylovora* in the calyx tissue.

The DNA hybridisation method detected *Erwinia amylovora* in the calyx of each apple fruit inoculated with 10^{2}, 10^{3} or 10^{4} cfu *Erwinia amylovora* was detected in approx 50% of the fruit inoculated with approx 10^{1} bacteria.

The DNA prepared to the Type Culture of *Erwinia amylovora* hybridised with each of the 8 strains of *Erwinia amylovora* tested from apples in New Zealand.

Question 8

Can you provide data that indicates that the seasons in which this data was gathered covers conditions where fire blight would be expected to be severe in NZ

Answer 8

No, because fire blight is rarely "severe" anywhere in New Zealand. The data was collected mainly from fruit from orchards which had been inspected and found to be free of fire blight symptoms.

[It is highly unlikely that the orchard blocks were subjected to conditions which promoted fire blight over flowering. However, as the season progressed, there would have been many fire blight periods encountered].

Question 9

There are reports that a substantial number of shipments and or orchards have been rejected by Japan because of concerns about fire blight. A figure of 65% of fruit (or orchards?) is often raised in submissions to us. Can you clarify these reports?

Answer 9

Orchards (and 500 m buffer zones) are inspected on three occasions prior to harvest for fire blight. Should fire blight be detected in the orchard or buffer zone that orchard is removed from the program. In the 1995/96 season, 162 designated export areas were inspected. Of these, 49 were withdrawn because of the presence of fire blight. Of these 49, fire blight was detected in 10 (6%) of the designated areas.

Apples are not inspected/tested for *Erwinia amylovora* following harvest.

Question 10

It has been suggested that apples could develop post-harvest rot involving fire blight on arrival in Australia. This could build up high numbers and therefore increase the risk. Does NZ have any data on the incidence of or the varietal susceptibility of NZ apples to post-harvest rot involving fire blight?

Answer 10

There is no evidence that New Zealand apples develop post harvest rot involving fire blight.

Research in the past two seasons using inoculated apples cv. Gala, cool stored for 1-4 months at $0^{o}C$ - $0.5^{o}C$, and then incubated at $20^{o}C$ for two weeks has shown that *Erwinia amylovora* does not readily survive this treatment, even when calyxes were inoculated with

10^5 colony forming units of the pathogen. No rotting was seen in any of the inoculated fruit after storage and incubation.

[*Erwinia amylovora* was detected in approx 5% of apple calyxes cvs. Gala, Gravenstein and Granny Smith, sampled from a heavily inoculated orchard prior to storage. However, after either 25 days cool storage at 0°C - 0.5°C, or cool storage followed by incubation at 20°C for two weeks, *Erwinia amylovora* was not detected in any of the fruit. None of the fruit showed any rots.]

We have no evidence of the incidence of varietal susceptibility of New Zealand apples to postharvest rot involving fire blight. No postharvest rot due to fire blight has been recorded in New Zealand.

Question 11

It has been stated that NZ does not produce pears because of concerns about fire blight. Is this correct?

Answer 11

This is not correct. The New Zealand horticultural industry is market oriented and producers grow produce for which they have competitive advantages. Large scale (ie cf apple, kiwifruit) pear growing is not as profitable as various other crops and so there has been a movement away from the production of this fruit. Reasons are economic and market related as opposed to problems with production due to infection by *Erwinia amylovora*.

Question 12

In the statistical analysis how was the assumption of a beta (1/2, 1/2) prior distribution made? If this assumption is not made the figure of 469 increases to around 700 individual fruit per 20 million.

Answer 12

The fire blight simulation provided by John Maindonald (now University of Newcastle, NSW) and Rod Ball clearly states why the beta (1/2, 1/2) prior was used. It is a non-informative prior ie we have little or no prior information of the value of the probability, and the information present in the prior is equivalent to one observation.

This is the Jeffries non-informative prior for a probability, a natural prior to use when there is no prior information about a binomial probability. It has the probability of invariance under transformations. Other priors could be used eg if a beta (1/n, 1/n) prior is used we have either no successes or no failures as in the present situation. However, as n approaches infinity, the posterior probabilities concentrate at the end-points. Our analysis is somewhat conservative, effectively considering that the next observation maybe the opposite to what has occurred.

APPENDIX 3

Fire blight: a cost analysis of importing apples from New Zealand

For the Australian Quarantine and Inspection Service

U.N. Bhati and Catherine Rees

July 1996


ABARE

FIRE BLIGHT

Summary

Fire blight *(Erwinia amylovora) is* a bacterial disease of plants of the *Rosaceae* family, which includes apples, pears and some other fruit and ornamental plants. The disease has the potential to cause a significant loss of yield of fruit - up to 20 per cent for apples and 50 per cent for pears in Australia. Furthermore, control of the disease may be difficult and eradication is unlikely. Australia is free of this exotic disease, and restricts imports of host fruits and plant material from countries such as New Zealand where the disease is prevalent to maintain its disease free status.

In the late 1980s, New Zealand requested that Australia lift restrictions on imports of fresh apples from New Zealand. The request was rejected by Australia in 1990 on the grounds that the New Zealand submission did not have sufficient technical information to prove that its apples would not bring fire blight into Australia. Based on new research, New Zealand has again requested access to the Australian domestic fresh apple market.

The Australian Quarantine and Inspection Service - (AQIS) is evaluating the latest New Zealand submission. As a part of the evaluation, AQIS has requested that ABARE provide an analysis of the costs that could arise solely as a result of fire blight disease.

To provide this analysis, this study uses the latest economic and scientific information. It also uses partial equilibrium analysis and adopts a national viewpoint.

A change in quarantine restrictions that allows imports of fresh apples into Australia from New Zealand has the potential to impose costs through an outbreak of fire blight. If the disease occurs in all regions, the cost is estimated at $125.7 million, or 37.5 per cent of the gross value of annual apple and pear production in Australia. Given the uncertainty about the probability of a fire blight infestation resulting from fresh apple imports, estimates of costs were made using a range of probabilities. The range of probabilities used is not based on any scientific information, rather it is purely arbitrary. As examples, if the probability of a fire blight infestation occurring is 5 per cent and the disease is confined to one region, the expected value of the cost to the industry ranges between $20 000 and $2.4 million a year. If the disease spreads to all growing regions, the expected value of the cost to the industry is $200 000, if the probability of infestation occurring is 0.2 per cent, or $5.1 million, if a 5 per cent probability is assumed. The estimate of $5.1 million represents 1.5 per cent of the annual gross value of apple and pear production in Australia.