Environmental Protection Authority
Te Mana Rauhī Taiao

APPLICATION FORM

RELEASE

Application to import for release or to release from containment new organisms

under the Hazardous Substances and New Organisms Act 1996

Send by post to: Environmental Protection Authority, Private Bag 63002, Wellington 6140 OR email to: noinfo@epa.govt.nz

Application number

APP201254

Applicant

Tomatoes New Zealand

Key contact

Helen Barnes

Important

This application form is to seek approval to import for release or release from containment new organisms (including genetically modified organisms).

The application form is also to be used when applying to import for release or release from containment new organisms that are or are contained within a human or veterinary medicine.

Applications may undergo rapid assessment at the Authority's discretion if they fulfil specific criteria.

This application will be publicly notified unless the Authority undertakes a rapid assessment of the application.

This application form will be made publicly available so any confidential information must be collated in a separate labelled appendix.

The fee for this application can be found on our website at www.epa.govt.nz.

If you need help to complete this form, please look at our website (www.epa.govt.nz) or email us at noinfo@epa.govt.nz.

This form was approved on 1 May 2012.

1. Brief application description

Provide a short description (approximately 30 words) of what you are applying to do.

To import for release the organism *Macrolophus pygmaeus* (*M. pygmaeus*) as a biological control agent for the control of greenhouse whitefly and other pests of greenhouse tomatoes.

2. Summary of application

Provide a plain English, non-technical description of what you are applying to do and why you want to do it.

The greenhouse tomato industry which is represented by Tomatoes New Zealand (TNZ) wishes to utilise a biological control agent (BCA) to improve the effectiveness of Integrated Pest Management (IPM) of greenhouse whitefly *Trialeurodes vaporariorum* in New Zealand greenhouses. This application is to import and release into greenhouses the biological control agent *M. pygmaeus. Macrolophus pygmaeus* is a specialised whitefly predator in the mirid family.

- The first aim of the programme is to release the BCA for use as part of an integrated pest management (IPM) programme in commercial tomato greenhouses.
- The second aim is to reduce reliance on chemical sprays to control whitefly, which is the most significant pest of tomatoes, to improve plant health with a subsequent greater yield of better quality fruit, especially for export.
- The third aim is to improve compliance with export biosecurity requirements, for export through reduced pest pressures and thus reduced pest incursions on the fruit during grading and packing.

3. Describe the background and aims of the application

This section is intended to put the new organism(s) in perspective of how they will be used. You may use more technical language but please make sure that any technical words used are included in a glossary.

The Greenhouse Tomato Industry

Tomatoes New Zealand is an affiliated Product Group of Horticulture New Zealand and represents the interests of all commercial fresh tomato growers in New Zealand. There are about 150 growers who produce approximately 40,000 tonnes of standard loose fruit as well as the specialty fresh tomatoes including truss, plums, cherries and cocktail that together have a farm gate value of $110 million per annum including $10m in exports in 2012. The principle export market is Australia in summer although product is also exported to many Pacific Island and Pacific Rim countries. In New Zealand fresh tomatoes are predominantly grown in greenhouses but there are also 50,000 tonnes of tomatoes grown outdoors in Hawkes Bay & Gisborne specifically for processing and a small volume grown outdoors elsewhere for the fresh market. The greenhouse sector is in production all year round while the outdoor fresh tomato sector is seasonal, producing tomatoes in summer and early autumn.

The greenhouse fresh tomato industry is changing; grower numbers have decreased significantly in the last 10 years, but production is increasing. Large volumes of tomatoes are now being produced in high-technology greenhouses. To be able to plant a new crop for a quality yield sufficient to satisfy today's marketplace, the minimum capital investment, starting from bare land, requires approximately $1 - $2 million per hectare.

Growth in the industry and in consumption has all been based around the rapid rise in the popularity of the specialty tomatoes; i.e. vine ripened, on the vine, both standard size and smaller, and the plum and cherry types.

The range of varieties grown has increased dramatically through the specialty varieties and most are of Dutch origin. Some are traditional types, while others are vine ripened or long shelf life, cherry or cocktail tomatoes. The range of speciality and pre-packed tomatoes has increased dramatically in the last four to five years. Otherwise the main product is "standard round loose tomatoes".

Many growers are small, family-run partnerships that used to produce from older, timber framed greenhouses. However, these are fast disappearing as new housing subdivisions spread to the rural/urban fringe. Those who remain have upgraded to either modern twin skin plastic houses or Dutch-style glasshouses.

Most greenhouse growers use soil-less media, predominantly using cocopeat slabs but some are also planting into pumice or sawdust filled plastic bags or buckets, or in rock-wool slabs. These are all hydroponic or semi-hydroponic systems. However, a small number of growers are (still) growing in the soil, mainly to achieve the requirements for organic production. Some growers still only heat their greenhouses for frost protection but most now heat their greenhouses for total environment control to achieve increased yield, a reduction in disease issues, and to maintain consistent quality.

Most growers are committed to year round production, and utilise bumble bees (*Bombus terristus*), living in portable cardboard hives in the greenhouse that have a life of 6 – 8 weeks, for pollination. The bee pollination of the flowers is a ‘perfect’ activity for them and results in a consistent and ongoing quality fruit set. However, the bees are very susceptible to some of the chemical sprays growers are forced to use to control whitefly infestations hence the industry’s drive to achieve control by other more acceptable means; i.e.by predator insects.

Although the average operation is still relatively small in area, e.g. 4,000 square meters, there are now a number of large growing operations using the latest in overseas technology, ranging from 1 or 2 hectares through to 5 or more hectares. Two operations comprise 20 hectares of glass each.

Whitefly as a pest

<u>Host plants:</u> Greenhouse whitefly (*Trialeurodes vaporariorum*) is the species most commonly found on greenhouse tomato crops in New Zealand. However, it has a host range of several hundred plant species and can easily spread from one crop or weed species to another. Greenhouse crops attacked by greenhouse whitefly include eggplant (aubergine), cucumber, gerbera, sweet pepper, tomato and capsicum. They are also pests on pumpkins, and beans, especially during hot seasons. One New Zealand strain of greenhouse whitefly is now a major pest on tamarillo (Martin, 1989).

<u>Impacts</u>: Adult whitefly cause direct damage when they suck plant juices. As a result, infestations of whitefly can give tomato plants a yellow, mottled look, stunting their growth, causing wilting and defoliation and thereby

seriously reducing crop yield. Heavy feeding by whitefly can eventually kill plants. Indirect damage occurs when their sticky honeydew secretions grow sooty moulds that block photosynthesis. Any sooty mould on fruit renders the fruit unmarketable and has to be washed off before sale which is impractical.

Virus transmission: Adult whitefly also have the potential to cause crop losses indirectly by transmitting plant viruses. Overseas, greenhouse whitefly transmits tomato chlorosis virus, tomato infection chlorosis virus and strawberry virus (CPC, 2012). In New Zealand it has spread beet pseudo-yellow virus (BPYV) in cucumber crops (Smith, 2009a).

Biology: Whitefly can reproduce and disperse rapidly. The length of time for whitefly to complete its lifecycle from egg to adult depends on the temperature and host plant on which they are feeding. At 22°C (optimal temperature range is 20-25°C); egg-to-adult development on tomatoes takes about 28 days (Smith, 2009a). Whitefly may be present in greenhouses year round, but most growers report that infestations are worst in summer, especially when it is hot and dry, or sunny (Smith, 2009a). Greenhouse whitefly has no overwintering stage in New Zealand, and all stages may be found throughout the year (Martin, 1989). Adult whitefly are highly mobile and readily take to wing when disturbed by handling or brushing past plants.

Pesticide resistance: Whitefly also adapt to new host plant species and may rapidly develop insecticidal resistance if repeated spraying of insecticides from one chemical group occurs (Smith, 2009d; Walker et al., 2008).

Biological Control

Trialeurodes vaporariorum has been controlled successfully overseas by *M. pygmaeus* (Enkegaard et al., 2001). In New Zealand *T. vaporariorum* is currently controlled by a range of methods including the use of non-selective and selective chemical sprays and also to a limited degree, the biological control agent *Encarsia formosa.*

Encarsia formosa, a parasitic wasp, while successfully used overseas has not been as effective in New Zealand. Reasons for this include the whitefly staying active at lower temperatures than the wasp. On tomato, the average length of life cycle of whitefly ranges from 18-64 days at 28°C and 12°C respectively, compared to the wasp which prefers 20-28°C. Adult wasps are able to fly about 20 metres and disperse readily. A female wasp inserts her eggs into 3rd and 4th instar nymphs, often called the 'scale' stages, of greenhouse whitefly only (CPC, 2012; Perdikis et al. 2008). The egg hatches and the wasp's larva develop inside greenhouse whitefly nymph eventually killing it. After about 10 days, the greenhouse whitefly nymph will begin to turn black, and about 10 days later an adult wasp will emerge (CPC, 2012). This time-frame is quite long and any whitefly not parasitized will continue to reproduce. Consequently, the rate of parasitism of greenhouse whitefly by *E. formosa* will not provide sufficient control when greenhouse whitefly populations are far more abundant than the parasitoid. (Qui et al., 2004; Workman & Davidson, 2007).

If this application is approved, large numbers of insects will be reared by commercial operators and then released into greenhouses. This type of biological control is referred to as inundative or augmented (van Lenteren and Woets, 1988). This enables growers to achieve immediate control rather than waiting for sufficient populations of the BCA to build up in the greenhouse (Lex Dillon, NZ Hothouse, 2013, pers. comm.). This is quite different to the classical biological control approach where the control organism establishes over time and is able to maintain self-sustaining populations. This classical approach will not work in a greenhouse situation due to the rapid production manner in which greenhouse tomato crops are grown. The pest management programme for the BCA will likely require multiple introductions each season depending on pest pressure. It is expected that populations of the BCA will decline due to environmental conditions and food scarcity making it difficult for the BCAs to maintain self - sustaining populations through the winter period even in the greenhouse environment.

4. Information about the new organism(s)

- Provide a taxonomic description of the new organism(s) (if the organism is a genetically modified organism, provide a taxonomic description of the host organism(s) and details of the genetic modification).
- Describe the biology and main features of the organism including if it has inseparable organisms.
- Describe if the organism has affinities (e.g. close taxonomic relationships) with other organisms in New Zealand.
- Could the organism form an undesirable self-sustaining population? If not, why not?
- What is the ease with which the organism could be eradicated if it established an undesirable self-sustaining population?

4.1 Introduction

A full information sheet describing the biology of *M. pygmaeus* is contained in Appendix 9.3. A summary is provided for *M. pygmaeus* below. In this section we discuss the potential for *M. pygmaeus* to form self-sustaining populations within greenhouse environments and also the wider New Zealand environment. The undesirability of such populations is discussed in section 6.3.

4.2 *Macrolophus pygmaeus*

4.2.1 Taxonomy

Species:	*Macrolophus pygmaeus (Rambur, 1839)*
Order:	Hemiptera
Family:	Miridae
Genus:	Macrolophus
Synonyms	*Capsus nubilis, Phytocoris pygmaeus, Macrolophus nubilus, M. brevicornis, M. balcanicus, M. nubilis, M. insignis*

M. pygmaeus (Source: naturefg.com)

Notes on the revised taxonomy of this species;

The genus *Macrolophus* contains a small group of species with very simple and similar external morphology. The classification of these species has in the past been based on variable characters using morphological characteristics. In the last 20 years several authors have been discussing the proper identity of the species given the confusion caused by the inconsistency of the morphological characters that have been used to differentiate these species. Recent use of molecular tools to determine species identity has concluded that the commercial BCA labelled as *M. caliginosus* was in fact *M. pygmaeus* (Martinez-Cascales et al. 2006a, 2006b). These researchers also concluded that *M. pygmaeus* and *M. melanotoma* were two distinct species. *Macrolophus caliginosus* is classified as a junior synonym of *M. melanotoma* (Costa 1853). Martinez-Cascales et al. (2006b) described the phylogeny of *Macrolophus* based on the analysis of sequence variation of the cytochrome b fragment (Figure 1). In this analysis *M. pygmaeus* and *M. melanotoma* grouped in two separate clusters in the phylogenetic tree.

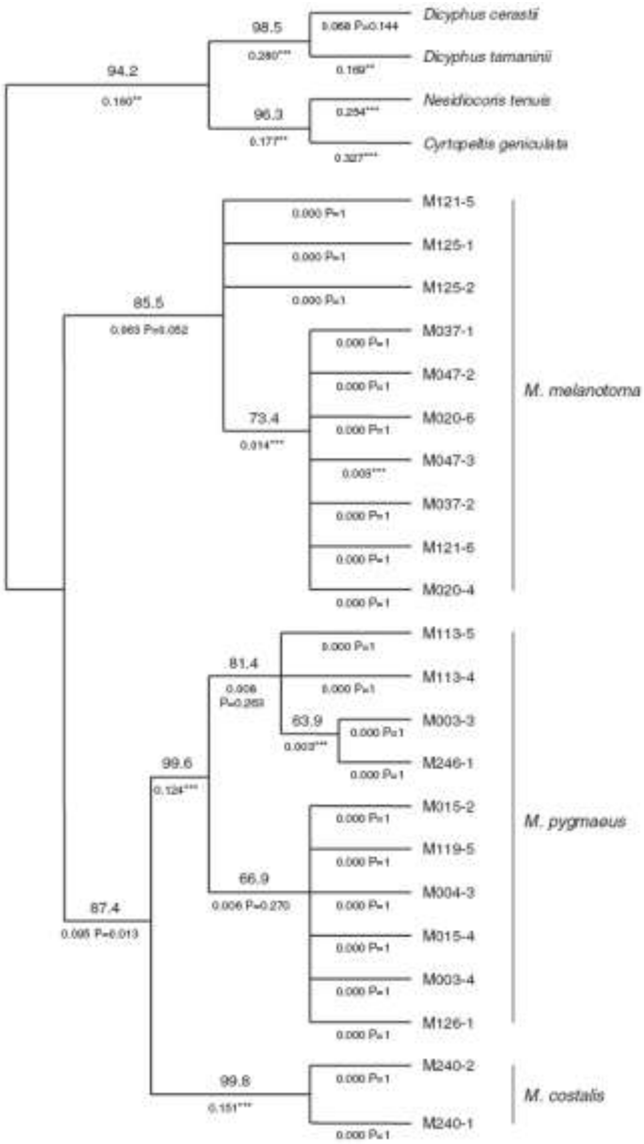

Figure 1. Phylogeny of *Macrolophus* species based on cytochrome b sequences. Note that *M. caliginosus* is a junior synonym of *M. melanotoma.* Sourced from Martinez-Cascales et al. (2006b).

Subsequent to these findings commercial suppliers of *Macrolophus* have now revised the naming of the species present in their biological control products from *M. caliginosus* to *M. pygmaeus* (Klapwijk, 2011). Much of the literature for *Macrolophus* as a BCA describes *M. caliginosus* (for example, Enkegaard et al. 2001; Hatherly et al. 2005; Workman and Davidson, 2007). However it is likely given this revision that much of the testing was conducted on *M. pygmaeus*. This issue still remains to be satisfactorily resolved in the commercial BCA literature.

4.2.2 Organism Affinities

The genus *Macrolophus* (Order: Hemiptera, Family: Miridae) is not present in New Zealand. In the Hemiptera order there are 43 families in New Zealand. In the Miridae family there are 9 tribes representing 115 species of which 12 are introduced (Larivière & Larochelle, 2004). *Macrolophus* is part of the Tribe Dicyphini of which there are two species present in New Zealand, one native and one introduced.

4.2.3 Biological Characteristics

Macrolophus pygmaeus is a predatory mirid from the Mediterranean. It is mainly found on solanaceous plants, particularly tomato and tobacco, but can also inhabit other crops (Malais & Ravensberg, 2003).

Macrolophus pygmaeus consumes all stages of whitefly (primarily *Trialeurodes* spp.) but prefers eggs and larvae. An adult can consume 30–40 eggs per day. This predator also eats aphids, two-spotted mite, insect eggs, caterpillars, thrips and leaf miner larvae (Enkegaard et al. 2001; Malais and Ravensberg, 2003). Like many mirids, *M. pygmaeus* also feeds on plant tissue and can cause damage to crops such as cucumber, gerbera and some cultivars of tomatoes, especially cherry tomatoes (Malais and Ravensberg, 2003). However, when used commercially the benefits of pest control outweigh the effects of plant damage. *Macrolophus* species *(M. pygmaeus, M. melantomata* (syn. *M. caliginosus*) have been used extensively in Europe for the past 15 years as biological control agents. *M. melantomata* (syn. *M. caliginosus*) was introduced into the UK in 1995 (Hatherly et al. 2005). It was subsequently detected outside of UK greenhouses, however no negative impacts have been documented (Castane et al. 2011; Hatherly et al. 2005; Hart et al. 2002). No specific mention was made in these reports of the actual distance from the greenhouse that this species was found.

Macrolophus pygmaeus females average 3.51 mm in length and the males 3.37mm (Martinez-Cascales et al. (2006b). The wings are a transparent green with brown markings on the hind parts. The adults are winged, so are able to disperse within the crop (Malais and Ravensberg, 2003). The eggs are laid on veins, leaf petiole and stem of the plant and are not visible to the naked eye (Malais and Ravensberg, 2003).

There are five nymphal instars (Malais and Ravensberg, 2003). Having no wings the nymphs are restricted to walking but they can move over the surface of the plant at great speeds.

4.2.4 CLIMEX and Habitat Suitability Modelling

To assist with understanding how *M. pygmaeus* might persist in the open New Zealand environment climate and habitat models were developed. A CLIMEX model consists of growth-related and stress related indices. Conditions that favour growth are grouped into dormancy/chilling, temperature, moisture and light indices. Limits to growth imposed by adverse climatic conditions are grouped into cold, hot, dry and wet stresses and combinations of two states (cold-wet, cold-dry, hot-wet and hot-dry). Ecoclimatic Index (EI) scores are the combination of growth indices based on temperature and moisture requirements and on stresses (temperature only in this case) and are scaled between 0 and 100. An EI score of 30 indicates that maximum growth has been achieved in at least 60% of the favourable season. Low EI scores can reflect suboptimal growth conditions and/or high stress conditions. An initial CLIMEX model for *M. pygmaeus* was constructed using published research for temperature-dependent development and for survival. Locality and country records from literature and internet data such as the Global Biodiversity Information Facility (http://www.gbif.org/) were mapped to verify model parameters. Localities where the BCAs occurred only in covered crops were excluded from verification maps. Parameters for models were iteratively adjusted until no further improvement of a match between model outputs and the known field distribution was considered to occur. The model was then applied to New Zealand and an interpretation was made of the likely persistence of populations outside greenhouses (Logan, 2012 – Appendix 9.5).

Further modelling using other methods was subsequently suggested by the EPA to clarify some of the uncertainty surrounding CLIMEX projections. In this subsequent analysis correlative-type habitat distribution models were used to infer environmental requirements for *M. pygmaeus* based on geographical collection records and to generate maps of suitable habitat within New Zealand. The models or algorithms used for this analysis were Maxent and seven different species distribution models for a combined multi-model or consensus approach. The multi-models were: logistic regression, classification and regression trees, conditional trees, naive Bayes, K-nearest neighbour, support vector machines, and artificial neural networks. The full report from this analysis is located in Appendix 9.6 (Logan et al. 2013).

CLIMEX and habitat suitability models were used to assess the ability to form self-sustaining populations of the BCA as described in the following section.

4.2.5 Ability to form Self Sustaining Populations

The response to climatic variables is reported by Hart et al. (2002) for *M. caliginosus*. The insects used in this study were commercially sourced and so are likely to have been *M. pygmaeus* and not *M. caliginosus* (Syngenta, 2012)[1]. It is likely that climatic responses are similar for all *Macrolophus* species due to their close phylogenetic relationship.

Macrolophus caliginosus is reported to perform best at temperatures between 20 to 25°C. The fecundity of *M. pygmaeus* was highest at 20°C (Perdikis and Lykouressis, 2002). The developmental threshold for *M. caliginosus* ranged from a minimum of 7.3 to 7.7°C (Hart et al. 2002; Hatherly et al. 2005) to a maximum of 40°C (Malais and Ravensberg, 2003). The lethal time (days) ($Ltime_{50}$) required to kill 50% of the population at 5°C was 32.4 days.

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[1] Syngenta (2012) Website information.
http://www.syngenta.com/global/Bioline/en/Technical_News/Pages/Macrolophuspygmeus.aspx, accessed June 2013.

There was a maximum field survival of 75 days for unfed nymphs and up to 200 days for fed nymphs (Hatherly et al. 2005) suggesting that temperature was not entirely limiting for *Macrolophus*, and that with the availability of prey, survival could span an entire UK winter (Hatherly et al. 2005). Average temperatures for NZ greenhouses range from 15°C to 25°C. *Macrolophus* will perform within this temperature range although lower night temperatures may affect performance.

Macrolophus has been detected outside of UK greenhouses (Hatherly et al. 2005) but its presence appears to be very rare (Rob Jacobson, UK consultant, 2013, pers. com.). Thermal biology testing also indicates the potential for *Macrolophus* to persist for extended periods outdoors in the winter in temperate climates (Bale, 2005). It was estimated that under outdoor conditions *Macrolophus* could complete two generations per year in the UK in summer (Hart et al. 2002). It does not enter diapause and is thought to actively seek shelter during the winter months (Hatherly et al. 2005).

Day length or photoperiod is also an important regulator of insect populations as many insect species regulate their biology in response to day length. Studies by Hamdan (2006) found that reducing day lengths from 16hr to 8hr or to continuous dark exposure had a significant effect on the development of *Macrolophus* embryos by causing embryo hatch rates to reduce under reduced daylight hours, or cease in the case of no light exposure.

CLIMEX models developed for *M. melanotoma* (syn. *M. caliginosus*) and *M. pygmaeus* (Logan, 2012) indicated that these species may persist outside greenhouses in Auckland, many areas of Northland, and on the east coast of the North Island particularly between Gisborne and Castlepoint. See full CLIMEX report (Appendix 9.5). Habitat suitability models (Logan et al. 2013, Appendix 9.6) (Maxent and multi-modelling) indicated a low likelihood that suitable climate for *M. pygmaeus* exists in New Zealand. The maxent model indicated that the climate suitability is poor, and the consensus multi-model indicated that only a small area of Kaitaia in Northland has suitable climate for *M. pygmaeus*.

Given the temperate climate in New Zealand and reported ability to survive outside of the greenhouse environment, this species could potentially survive the New Zealand winter in some limited areas. The reduced fecundity of *M. pygmaeus* in response to short day lengths suggests that under winter conditions with low mean daily temperatures and short daylight hours *M. pygmaues* is unlikely to successfully complete a reproductive cycle. This is supported by two of the three models used to assess climate suitability. These models suggest this survival would be restricted to a small area north of Kaitaia.

4.2.5 Dispersal Potential

The adults are winged, so are able to disperse within the crop (Malais and Ravensberg, 2003). Nymphs are restricted to walking and therefore the dispersal potential of this life stage is limited.

4.2.6 Conclusion

Taking into account the thermal biology requirements, CLIMEX and habitat modelling outcomes and day length impact on fecundity, it is expected that *M. pygmaeus* would be unable to establish self-sustaining populations outside of greenhouses in the South Island and in large areas of the North Island. CLIMEX modelling indicates that suitable climate conditions may exist particularly north of Auckland and the east coast but consensus multi-modelling indicated restricted climate suitability to a small area north of Kaitaia. Populations could potentially survive in some areas of the North Island for some parts of the year, however the reduced fecundity of *M. pygmaeus* in response to short day lengths suggests that under winter conditions of low mean daily temperatures and short daylight hours *M. pygmaeus* would be unlikely to successfully complete a reproductive cycle. This will further limit the ability of *M. pygmaeus* to develop a self-sustaining population.

The organism that is the subject of this application is also the subject of:

a. an innovative medicine application as defined in section 23A of the Medicines Act 1981. ☐ Yes X☐No

b. an innovative agricultural compound application as defined in Part 6 of the Agricultural Compounds and Veterinary Medicines Act 1997. ☐ Yes X☐ No

5. Detail of Māori engagement (if any)

Discuss any engagement or consultation with Māori undertaken and summarise the outcomes.

The applicant sought advice from the EPA on the most appropriate form of Maori engagement. Based on this advice the applicant undertook two levels of consultation.

The first was an information letter that was sent to members of the EPA's Maori consultation network. This network comprises approximately 200 representatives. The letter outlined the details of the application including purpose, proposed outcomes, a summary of the risks and benefits and an invitation to comment on the application. The applicant received four responses which are included in Appendix 9.9. In summary the respondents expressed a common theme of opposing any introduction of a new species to New Zealand.

The second level of Maori engagement involved meetings and discussion with an EPA Maori Reference Group (MRG) convened specifically for this application. Two meetings were held with this group. The first meeting involved a round table discussion where the applicant presented an overview of the application and answered questions from the group. At this meeting the MRG members requested more information on the application. A draft of the application was subsequently provided to the members.

The second meeting involved a visit by the MRG to the NZ Hothouse greenhouse facilities at Karaka near Auckland. The members were shown through two greenhouses and had the opportunity to view a commercial greenhouse in operation. The visit also included an opportunity for further discussion on the application. The MRG provided feedback in the form of a report which is included in Appendix 9.9. In summary the MRG noted that:

- Kaitiakitanga is a holistic approach to understanding and existing within the natural world. Māori have specific intergenerational obligations as kaitiaki to protect and enhance the mauri (life essence) of species and their surrounding environment

- Members understand and support the value and importance of an integrated pest management approach, though are cautious about the introduction of this species given the lack of information about the behaviour of the organisms outside of the glasshouse
- Without information on host range testing and potential impacts on native species, members consider it too difficult to determine whether the BCA will pose a risk of significant displacement of native species, deterioration of natural habitats or adversely affect New Zealand's inherent genetic diversity.
- Members noted that because of the industry's approach, the non-financial benefits from the application include a reduction in the use of chemicals and their subsequent effect on people (particularly staff) and the environment. Members also considered the industry's search for alternatives to chemicals to be responsible given the EPA's recent reassessment and removal or phase out of some organophosphates.
- Members suggested a range of controls that could be applied to the application to minimise any impacts of a BCA escaping from the greenhouse.

The applicant notes the range of controls suggested in the MRG report. Although the applicant is applying for a full release which does not allow controls to be imposed, the applicant would look favourably on developing a voluntary code of practice, to incorporate where feasible suggestions provided by the MRG should the application be approved.

Subsequent to completing Maori engagement, TNZ modified the application to only seek release approval for *M. pygmaeus.* The application originally discussed with the MRG sought approval for three BCAs. These were *Delphastus catalinae*, *M. pygmaeus, and Nesidiocoris tenuis.* As *M. pygmaeus* was included in the original application the applicant considers there to be no material change to the application in terms of information provided or potential impacts to Maori that the MRG has not already had the opportunity to comment on.

6. Identification and assessment of beneficial (positive) and adverse effects of the new organism(s)

Adverse effects include risks and costs. Beneficial or positive effects are benefits.

- Identification involves describing the potential effects that you are aware of (what might happen and how it might happen).
- Assessment involves considering the magnitude of the effect and the likelihood or probability of the effect being realised.

Consider the adverse or positive effects in the context of this application on the environment (e.g. could the organism cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause significant adverse effect to New Zealand's inherent genetic diversity, or is the organism likely to cause disease, be parasitic, or become a vector for animal or plant disease?), human health and safety, the relationship of Māori to the environment, the principles of the Treaty of Waitangi, society and the community, the market economy and New Zealand's international obligations.

6.1 Beneficial Effects - Economic

6.1.1 Integrated Pest Management

The key rationale for introducing new biological control agents is the crucial contribution they make to integrated pest management (IPM) in commercial vegetable production. IPM is an approach to pest management that uses a combination of compatible techniques to maintain pests at acceptable levels. It emphasises methods that are least harmful to the environment, the grower and the consumer, most specific to a particular pest, and aims to reduce reliance on one control method (often insecticides). It can be an economically sound approach that produces quality produce at minimum cost in a more sustainable manner. IPM does not emphasise pest eradication in most cases since this is often impossible to achieve and attempting to do so can be very costly and environmentally unsafe. An ‘acceptable level’ is usually a level at which economic loss is acceptable (Smith, 2009c). IPM programmes in general have the advantages of reduced dependence on chemicals, lower pesticide resistance, improved worker health and safety from reduced chemical exposure and reduced opportunities for residue contamination of fresh produce. In the greenhouse tomato industry the benefits of successful use of IPM is a vital step in ensuring the sustainability of greenhouse production in New Zealand. As reported by growers (Confidential appendix 9.7) IPM is an integral part of growers’ sales and marketing strategies. Consumers are increasingly becoming aware of food safety and are questioning where their food comes from and how it is grown. If the industry doesn’t maintain effective IPM programmes it runs the risk of alienating consumers.

The benefit of IPM programmes is perhaps more pronounced in export markets. In 2011 the industry exported 5,384 tonnes of tomatoes worth over $15 million. Key markets are Australia, New Caledonia, Japan and the emerging Canadian market. Growers note that international customers are increasingly focussed on where and how the product they import has been grown. This is demonstrated by the comprehensive residue testing required by overseas markets. For example Japanese tomato customers (supermarket buyers) require exporters to provide residue tests and spray diary copies for the three months prior to harvest before any product is sent to Japan. However success in export markets not only requires chemical residue compliance but that the product is pest free. Exporters note that large loose tomatoes can be grown anywhere globally, and do not really achieve a premium necessary to cover the cost of freight to the market. To achieve the required premium, New Zealand must be able to deliver fresh truss tomatoes, either large or smaller specialty product, into a northern Hemisphere winter. When crops are pest free, and have not been sprayed, the tomato has a clean, spot free surface; New Zealand truss tomatoes can achieve a premium price in USA and Hong Kong markets. This business is building each summer, from October to March. This is also New Zealand’s greatest pest pressure time. The industry is therefore focused on achieving IPM that delivers residue-free and pest-free tomatoes to enable this export opportunity to advance.

6.1.2 Control Costs and Production Savings

The economic benefits provided by the control of whitefly through the introduction of *M. pygmaeus* can be described in terms of reduced control costs, savings in yield and quality losses, and increased prices per kilogram achieved from more consistent production of premium fruit.

The current control programme for whitefly consists of a mix of the following elements:

- Biologicals - *Encarsia formosa*
- Yellow sticky rolls
- Soft chemistry – oils, soaps, seaweed products, Neem, Oberon, Admiral
- Entomopathogenic fungi (Biotelliga products)
- Non-selective chemistry (e.g. Lannate/ Attack- used as a clean-up treatments, seldom used during production)

The main impact of whitefly is that if left uncontrolled, it has a significant effect upon the health of the plants resulting in all of the issues that arise from that. These include:

- Infestations of whitefly can completely destroy a crop
- Lower yields (kgs/per square metre), therefore reduced economic viability
- Fruit is generally smaller in size and therefore of less value
- Having to use sprays for control also weakens the plants and makes them more susceptible to fungal disease due to increased humidity and “wetness”
- Fruit can be unsightly and marked as a result of spraying and fungal growth brought about by the whitefly

A fully functional (effective) IPM programme for greenhouse tomatoes would see a stronger emphasis on biological controls and reduced use of sprays and over time achieving a no spray pest control regime. The Dutch greenhouse tomato industry provides a good example of the successful use of biological control agents. Dutch tomato growers have access to several good beneficial insects for the control of whitefly and no longer have to use agri-chemicals for whitefly control. They are able to produce higher yields per square metre at lower cost. Assuming New Zealand growers could use BCAs with similar effectiveness to those utilised successfully by the Dutch greenhouse tomato industry then it is possible sprays for whitefly could be virtually eliminated within three years (Refer to confidential appendix 9.7).

Leading New Zealand growers and exporters provided information on production costs and losses attributable to whitefly and the estimated economic benefits of successful control through the use of *M. pygmaeus*. This information is provided in confidential appendix 9.7. In summary, industry figures indicate that current control costs (sprays, monitoring, labour, other BCA) for whitefly average approximately $23,000 per hectare per annum. In addition growers are facing yield losses of approximately $53,000 per hectare per annum. Quality losses (loss of marketable fruit and/or loss of premium fruit) have been estimated at approximately $19,500 per hectare per annum. Losses due to premium reduction occur because:

- The product cannot claim to be “spray free”
- It is not financially feasible to become a large scale registered organic producer
- In export markets:
    - New Zealand exporters cannot create a point of difference to competitors if they don’t have a biological (IPM) option

- New Zealand cannot get parity with other tomato producers within the category if competitors have a good biological (IPM) option.

Overall current costs of whitefly are approximately $95,000 per hectare per year.

Growers estimate that the successful use of this BCA will result in savings of around 54% in control costs alone, amounting to savings of approximately $12,400 per hectare per annum. Furthermore benefits from reducing yield losses and increasing marketable fruit volume is expected to provide further substantial savings of approximately $54,000 per hectare per year. Overall, financial benefits attributable to the successful use of *M. pygmaeus* are expected to be on average $66,000 per hectare per year (See Table 3, Confidential Appendix 9.7). The New Zealand greenhouse tomato industry has approximately 120 hectares under production (Source: Tomatoes NZ). This suggests that across the industry economic benefits amounting to approximately $8m per annum can be expected from the successful introduction of *M. pygmaeus.*

6.1.3 Maori involvement in the tomato greenhouse industry - Gourmet Mokai Limited

The greenhouse tomato industry employs over 1,000 staff directly involved in the growing and production system. Māori make up a good portion of the sector workers and also are involved as part owners of a significant greenhouse tomato production facility near Taupo.

Gourmet Mokai Ltd is the result of a joint venture between two Māori entities and a partner. The company operates a state of the art climate-controlled glasshouse over 5.5 hectares growing, harvesting and selling tomatoes and capsicums to New Zealand and export markets. Gourmet Mokai currently employs about 45–50 people full-time. The employees are primarily from the surrounding district and 80% of the workforce is Māori with the balance mainly being Pacific Islanders.

Tuaropaki was keen to diversify into a different land use, which is clean and green, environmentally friendly and produces no pollutants. Gourmet Mokai endeavours to run its business on a low chemical regime. The business relies on integrated pest management by using natural predators for pest control and bees for pollination. For example, predatory mites are used to control the main pests. The use of BCAs for effective IPM is consistent with the Gourmet Mokai philosophy.

6.2 Beneficial Effects – Human Health

The main indirect benefit to human health from increased use of biological control agents is reduced reliance on non-selective chemical sprays. While these sprays are generally only used as a clean-up procedure prior to harvest there is still the potential for worker exposure to these chemicals. Successful adoption of a low spray or no spray IPM programme would reduce the potential for adverse health effects in greenhouse workers.

Benefits Summary

The use of *M. pygmaeus* as a BCA's for greenhouse tomatoes provides the most sustainable and economically viable pest control option for this sector. The sector is committed to the use of BCA's as part of the integrated approach to pest management. The industry is experiencing increasing demands from supermarkets and consumers for high quality and residue free produce. These demands are most obvious in the sectors expanding export markets where food safety is increasing being used as a product differentiation tool.

The EPA has provided magnitude descriptors for beneficial and adverse effects (ERMA , 2004). Descriptors of beneficial effects are set out in Table 1. Overall we consider that taking into account the long term benefits of BCA to the tomato greenhouse sector, the most applicable descriptor of magnitude of potential beneficial effect as described by the EPA matrix would be "Medium term regional beneficial economic effects with some national implications, medium term job creation". We conclude the beneficial consequence of *M. pygmaeus* to be moderate based on the EPA risk descriptors (Table 1).

Table 1: Descriptors of beneficial effects

Descriptor	Examples of descriptions -BENEFICIAL
Minimal	Mild short term positive health effects to individuals in highly localised area Highly localised and contained environmental impact, affecting a few (less than ten) individuals members of communities of flora or fauna, no discernible ecosystem impact Local/regional short-term beneficial economic effects on small organisations (businesses, individuals), temporary job creation No social effect
Minor	Mild short term beneficial health effects to identified and isolated groups Localised and contained beneficial environmental impact, no discernible ecosystem impact Regional beneficial economic effects on small organisations (businesses, individuals) lasting less than six months, temporary job creation Minor localised community benefit
Moderate	Minor health benefits to individuals and/or medium term health impacts on larger (but surrounding) community and health status groups Measurable benefit to localised plant and animal communities expected to pertain to medium term Medium term (one to five years) regional beneficial economic effects with some national implications, medium term job creation Local community and some individuals beyond immediate community receive social benefit
Major	Significant beneficial health effects to localised community and specific groups in wider community Long term benefit to localised ecosystem(s) Measurable beneficial effect on GDP, some long term (more than five years) job creation Substantial social benefit to surrounding community, and individuals in wider community.
Massive	Significant long term beneficial health effects to the wider community Long term, wide spread benefits to species and/or ecosystems Significant on-going effect beneficial on GDP, long term job creation on a national basis Major social benefit affecting wider community

6.3 Adverse Effects - Environmental

6.3.1 Host range of *M. pygmaeus*

Macrolophus pygmaeus consumes all stages of whitefly and also eats aphids, two-spotted mite, insect eggs, caterpillars, thrips and leaf miner larvae (Malais and Ravensberg, 2003, Workman and Davidson, 2007). Table 2 summarises the host range for *M. pygmaeus* and available information on New Zealand native species (Malais and Ravensberg, 2003, Workman and Davidson, 2007). A review of the New Zealand native whitefly, aphid, mites, thrips and Lepidoptera species is detailed in Appendix 9.4.

Table 2: Summary of host range of *Macrolophus pygmaeus*

Biocontrol agent	Whitefly	Aphids	Mites	Lepidoptera	Thrips
Macrolophus pygmaeus	**Major**	minor	**Major**	minor	minor
Presence of native host species in NZ	9 native	13 native	12 genera, and 46 species of Tetranychidae (spider mites) present in New Zealand – not all native	1,582 native species of lepidoptera present in New Zealand	19 native

Like many mirids, *M. pygmaeus* also feeds on plant tissue, particularly when prey densities are low, and can cause damage to crops such as cucumber, gerbera and some cultivars of tomatoes, especially cherry tomatoes (Malais and Ravensberg, 2003). *Macrolophus pygmaeus* will preferentially feed on whitefly (*Trialeurodes* over *Bemisia*), but will predate aphids, mites, thrips and lepidoptera particularly when food supplies are scarce. Given this wide host range, there is the potential for *M. pygmaeus* to impact on native insect populations if it was able to form self sustaining populations outside the greenhouse.

The ability of *M. pygmaeus* to form self-sustaining populations in New Zealand was discussed in section 4.2.5. The conclusion was that survival of this species throughout a full season (including over winter) was likely to be restricted to some areas of the North Island of New Zealand if at all. CLIMEX modelling indicated that these species may persist outside greenhouses in Auckland, many areas of Northland, and on the East Coast of the North Island particularly between Gisborne and Castlepoint. However, restricted climate suitability and survival potential was indicated by maxent and consensus multi-modelling, where the models indicated a very low likelihood that suitable climate exists in New Zealand for *M. pygmaeus* except for possibly a small area north of Kaitaia in Northland. The reduced fecundity of *M. pygmaeus* in response to short day lengths suggests that under winter conditions of low mean daily temperatures and short daylight hours *M. pygmaeus* would be unlikely to successfully complete a reproductive cycle and will limit the ability of *M. pygmaeus* to develop as a self-sustaining population.

Macrolophus pygmaeus was illegally introduced to New Zealand during or prior to 2007. It appears not to have established outside greenhouses in New Zealand following its introduction. Original stocks were destroyed and no *M. pygmaeus* has been detected during monitoring at Pukekohe since 2009 (Logan, 2012). This supports the habitat modelling which indicates that survival would be restricted to a small area north of Kaitaia if at all. *M. pygmaeus* will only impact on native populations of host insects where it is able to form self-sustaining populations in habitats supporting native host species. Given that there are no tomato greenhouses in the area north of

Kaitaia, *M. pygmaeus* would need to spread naturally to this area and form self sustaining populations before any impact was likely.

6.3.2 Plant host preferences of *Macrolophus pygmaeus*

Macrolophus pygmaeus will feed on plant tissue, particularly when prey densities are low, and can cause damage to some crops. In the UK, *M. pygmaeus* is present in the natural environment and is not known to cause damage outside of the greenhouse but has been noted to cause damage to greenhouse tomato crops (Dr Philip Morey, British Tomato Growers Association, 2013, pers. comm.). Strategies to monitor and control *M. pygmaeus* populations in the greenhouse have been developed to avoid damage to tomato crops and *M. pygmaeus* is now considered to be very beneficial in the UK.

The potential for a polyphagous BCA such as *M. pygmaeus* to cause plant damage to crops or alternative plant hosts in the environment is potentially an adverse effect. However the ability of *M. pygmaeus* to survive on plant species (crop and non-crop) when the prey species is scarce or absent is viewed as a positive attribute for a BCA, as the plants can provide water and an alternative nutrition source (Ingegno et al. 2011).

Species of Macrolophus (Heteroptera: Miridae) belong to the subfamily Bryocorinae, tribe Dicyphini. Dicyphini show a preference for glandular and sticky plants such as tomatoes. In northwestern Italy species of Dicyphini have been collected on hairy plant species belonging to the Solanaceae, Lamiaceae and Geraniaceae (Ingegno et al. 2011). *Solanum nigrum* (European Black Nightshade) is reported as a major host plant for *M. pygmaeus* in Greece (Perdikis et al. 2011).

Overseas research on *M. pygmaeus* indicates that host plant selection has a substantial influence on survival and development, and that the benefits of particular host plants vary in the presence or absence of prey. When *M. pygmaeus* nymphs were provided with both plant and prey (*Ephestia kuehniella* - Mediterranean flour moth), they were able to complete development on all host plant species tested showing similar survival rates between plants, whereas without prey no *M. pygmaeus* nymphs reached adulthood in the same experimental conditions (Ingegno et al. 2011). This demonstrates the survival dependence of *M. pygmaeus* to both a suitable host plant and a suitable insect prey. While there may be some localised feeding on native plants, this will be a short term affect as *M. pygmaeus* requires both host plant and host prey to reproduce.

In terms of assessing the potential for *M. pygmaeus* to colonise (successfully oviposit) native plants in the New Zealand environment the plant host families reported overseas can be extrapolated to New Zealand. Overseas data records a few main plant hosts within the Solanaceae, Lamiaceae, and Geraniaceae, with a preference for plant species within these families that have glandular and hairy leaves. It is likely that there will be a similar preference for these exotic plant species in New Zealand.

In New Zealand the greatest proportion of potential plant hosts in these families are exotic species with a small number of New Zealand natives (Table 3). For example, there are 71 recorded plant species in the family Solanaceae present in New Zealand, of these only 4 are natives (poroporo species and a native flowering nightshade).

The suitability of these native plants species as host plants for *M. pygmaeus* is likely to be restricted due to the physical characteristics of the plant leaf surface. *Macrolophus pygmaeus* has a preference for hairy plant species; native poroporo is described as having leather-like, thick, tough leaves (NZ Plant Conservation Network: http://www.nzpcn.org.nz/) (Table 3). This suggests that due to these leaf features it would be less preferred as a plant host compared to exotic Solanaceae which are known hosts overseas. Consequently it is expected that only a small proportion of the native Solanaceae, Lamiaceae, and Geraniaceae will be suitable plant hosts as they do not have the preferred hairy leaf characteristics. This limited native plant host range will restrict the ability of *M. pygmaeus* to spread successfully into native habitats.

Table 3: Potential plant hosts for *Macrolophus pygmaeus* in New Zealand[1]

Recorded plant hosts (overseas). *(All recorded exotic plant hosts have hairy surfaces)*	**Present in New Zealand?**	**Native species in New Zealand?**	**Leaf features**	**Likely suitable host plant?**
Family: Solanaceae Species: *Solanum nigrum* (Black nightshade) *Lycopersicon esculentum* (tomato) *Capsicum annuum* (capsicum)	Yes (71 records of Solanaceae)	Yes (4 records): *Solanum aviculare* var. *aviculare* (poroporo) *Solanum aviculare* var. *latifolium* (poroporo) *Solanum laciniatum* (poroporo)	Poroporo species: leather-like, thick, rough and rigid leaves.	No
		Solanum nodiflorum (small flowered nightshade)	All parts glabrous (smooth, devoid of hairs)	No
Family: Lamiaceae Species: *Salvia officinalis* (Sage)	Yes (90 records of Lamiaceae)	Yes (5 records): *Plectranthus parviflorus* (Cockspur flower)	Short glandular leaf hairs	Yes
		Teucridium parvifolium (Teucridium)	Small leaved shrub	No
		Scutellaria novae-zelandiae (NZ skullcap)	Glabrous	No
		Mentha cunninghamii (NZ mint, Hihoi)	Glabrous	No
		Vitex lucens (Puriri)	Glabrous	No
Family: Geraniaceae Species: *Pelargonium* spp.	Yes (36 records of Geraniaceae)	Yes (9 records): *Geranium brevicaule* (Short-flowered cranesbill) *Geranium homeanum* *Geranium microphyllum* *Geranium potentilloides* *Geranium retrorsum* (turnip rooted geranium) *Geranium sessiliflorum* var. *arenarium* (Short-flowered cranesbill) *Geranium solanderi* (Turnip-rooted geranium) *Geranium traversii* (Chatham Island geranium)	All *Geranium* species have leaf hairs	Yes
		Pelargonium inodorum (Kopata)	soft hairy stems, leaf hairs	Yes

[1]New Zealand plant records were sourced from NZ Plant Conservation Network: http://www.nzpcn.org.nz/

6.3.3 Determining significance

The key decision making criteria are whether any effect resulting from the introduction of the BCA into greenhouse environments and escape from these, would result in significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause significant adverse effect to New Zealand's inherent genetic diversity. The EPA to our knowledge has not defined what "significant" means in terms of HSNO decision making but instead relies on a matrix of qualitative descriptors of risk combining likelihood and magnitude to get an overall assessment of risk (ERMA, 2004). There is no clear guidance on which one of these risk categories equates to "significant". The guidance suggests decision makers use descriptors of negligible, low, medium and high for decision making (ERMA, 2004). Perhaps the most useful guidance is the qualitative descriptors of environmental consequence adopted by the EPA. These are outlined in Table 4 below. In relation to these descriptors, the term significant is only used in describing major and massive impacts. It could be argued then that effects described as minimal to moderate would not be considered significant.

Table 4: Magnitude of adverse effect (risks and costs)

Descriptor	Examples of descriptions - ADVERSE
Minimal	Mild reversible short term adverse health effects to individuals in highly localised area Highly localised and contained environmental impact, affecting a few (less than ten) individuals members of communities of flora or fauna, no discernible ecosystem impact Local/regional short-term adverse economic effects on small organisations (businesses, individuals), temporary job losses No social disruption
Minor	Mild reversible short term adverse health effects to identified and isolated groups Localised and contained reversible environmental impact, some local plant or animal communities temporarily damaged, no discernible ecosystem impact or species damage Regional adverse economic effects on small organisations (businesses, individuals) lasting less than six months, temporary job losses Potential social disruption (community placed on alert)
Moderate	Minor irreversible health effects to individuals and/or reversible medium term adverse health effects to larger (but surrounding) community (requiring hospitalisation) Measurable long term damage to local plant and animal communities, but no obvious spread beyond defined boundaries, medium term individual ecosystem damage, no species damage Medium term (one to five years) regional adverse economic effects with some national implications, medium term job losses Some social disruption (e.g. people delayed)
Major	Significant irreversible adverse health effects affecting individuals and requiring hospitalisation and/or reversible adverse health effects reaching beyond the immediate community Long term/irreversible damage to localised ecosystem but no species loss Measurable adverse effect on GDP, some long term (more than five years) job losses Social disruption to surrounding community, including some evacuations
Massive	Significant irreversible adverse health effects reaching beyond the immediate community and/or deaths Extensive irreversible ecosystem damage, including species loss Significant on-going adverse effect on GDP, long term job losses on a national basis Major social disruption with entire surrounding area evacuated and impacts on wider community

These descriptors provide a means of establishing the significance of an effect of the release of the BCA. The descriptors have been referred to in previous decisions made by ERMA (e.g. 1080 reassessment report, 2007) but their use is noted as being for example purposes only. However similar descriptors of consequence are used by other regulatory agencies such as the Office of the Gene Technology Regulator (OGTR, 2009). Van Lenteren et al. (2003) attempted a semi quantitative risk assessment by calculating a risk index by combining values for establishment, dispersal, host range and direct and indirect effects. The qualitative descriptors used by van Lenteren (2003) are perhaps more useful than the indexing itself. In this work van Lenteren (2003) described direct environmental effects in terms of mortality, population suppression or local extinction of directly affected non target host organisms. For example, an estimate that the release of a BCA would result in less than 40% mortality of non-target organisms is considered as a minor impact.

6.3.4 Risk Assessment

Harm to the environment is normally considered on the level of population, species and ecosystem. Pests have seldom if ever been exterminated in more than 100 years of insect biological control (van Lenteren et al, 2003). In nature it is the rule rather than exception to find low densities of both herbivores and their natural enemies (van Lenteren et al. 2003). *M. pygmaeus* is polyphagous to a degree. It is therefore likely that subject to climate restrictions, should it be able to establish in New Zealand, it may have some effect on non-target species. The question is what is the likely level of effect and if the effect is significant. Finally it is necessary to consider the extent that the benefits outweigh the risks.

We have undertaken a qualitative assessment of the level of potential impact of *M. pygmaeus* against these factors as well as considering the sensitivity of the non-target hosts and environments (host plants). The magnitude is assessed taking into account the potential for establishment and dispersal. We have then assessed the overall risk by combining the likelihood of the impacts occurring and the magnitude of effect to get an overall assessment of environmental risk of the BCA.

The highly modified growing environments surrounding existing glasshouse production areas are not considered as habitats of national or regional significance. Due to transport (to market) and energy requirements of commercial glasshouse production, future glasshouse locations are highly likely to continue to be located in modified agricultural environments. Given the existing challenges experienced by commercial growers in establishing and maintaining effective populations of BCAs under temperature controlled glasshouse conditions, we consider it unlikely that this BCA will be able to be used successfully in home gardens or non-commercial tomato greenhouses. In order to spread from the initial greenhouse release sites to native habitats, populations would need to be self sustaining. Climate and habitat modelling suggests that there are limited areas of the North Island where populations could potentially form self sustaining populations. Therefore the risk of dispersal to and establishment in native habitat areas where commercial glasshouses do not exist is considered to be biologically difficult and unlikely to be successful.

There is the question of indirect effects occurring over time. However, the longer the time period for an affect to become apparent increases the potential for any observed species impact to be caused by factors not necessarily related to the BCA such as climate change and habitat loss. Because of this difficulty in ascribing long term effects to specific biological control agents we have not assessed indirect effects further.

Based on the biology of the organism and preferred plant host species for *M. pygmaeus* to lay its eggs on, it is unlikely that *M. pygmaeus* will naturally disperse into native valued habitats where its preferred exotic host plants (e.g. Solanaceae, Lamiaceae and Geraniaceae) are not widespread. *Macrolophus pygmaeus* requires both suitable prey and suitable host plants to successfully reproduce. These conditions exist in the highly modified agricultural and horticultural environments surrounding glasshouses. If *M. pygmaeus* spread outside the greenhouse it would likely remain in the most suitable habit with available food and plant host sources. There is no biological reason for *M. pygmaeus* to spread from a favourable to an unfavourable environment. The likelihood of *M. pygmaeus* spreading in this manner and establishing a self-sustaining population in natural valued habits is considered to be very unlikely. Therefore it is considered highly unlikely that *M. pygmaeus* would displace valued species from their native habitat. It is also unlikely that *M. pygmaeus* would displace native species from the highly modified agricultural and semi-rural environments that surround commercial greenhouse. Native species in these modified habits are unlikely to be abundant due to the pressures of normal agricultural and urban pest control activities.

Repeated introductions of *M. pygmaeus* into the greenhouse could increase the likelihood of insects moving out of the greenhouse environment. However normal predator-prey relationships dictate that as prey diminishes so too does the population of predators (van Lenteren and Woets, 1988). So predator populations inside the greenhouse are likely to fluctuate and new releases only required when pest pressure reaches action thresholds. Normal greenhouse practices also involve sanitisation of the greenhouse by removal of all plants and pesticide spraying between crop rotations. Under these conditions it is highly unlikely that residual populations of *M. pygmaeus* will survive throughout the full greenhouse growing cycle.

If *M. pygmaeus* were to move outside of the greenhouse, based on the biology of the organism and climate requirements, it could have local impacts limited to the site of the greenhouses releases. When considering results of habitat modelling, the impact of *M. pygmaeus* is highly likely to be limited to the top of the North Island. The reduced fecundity of *M. pygmaeus* in response to short day lengths suggests that under New Zealand winter conditions of low mean daily temperatures and short daylight hours *M. pygmaeus* would be unlikely to successfully complete a reproductive cycle (Hamdan, 2006) and would be unable to form a self sustaining population. This reproductive pressure taken together with the low likelihood of *M. pygmaeus* dispersing into natural habitats suggest that any long term spread out of greenhouses is likely to be into modified and urban environments where impacts on native habits and species would be expected to be minimal. Further, given habitat modelling results, any population development immediately outside of greenhouse sites is likely to be temporary.

Overall we consider that taking into account the biology, dispersal, host plant limitations, and reproductive constraints facing *M. pygmaeus* in the New Zealand environment, the most applicable descriptor of magnitude of potential effect as described by the EPA matrix would be “Localised and contained reversible environmental impact, some local plant or animal communities temporarily damaged, no discernible ecosystem impact or species damage”. Overall we conclude the environmental consequence of *M. pygmaeus* to be minor based on the EPA risk descriptors (Table 4).

6.4 Adverse Effects – Other

Macrolophus pygmaeus is not known to swarm, bite or cause a nuisance to humans so no adverse human health effects have been identified. No adverse effects to the market economy, communities and society have been identified or any implications on New Zealand's international obligations.

6.5 Concluding Comments

The applicant considers that the release of *M. pygmaeus* in commercial greenhouses poses minimal risk to the environment, people and communities, human health and Māori cultural considerations. We consider that the release of *M. pygmaeus* would not breach the minimum standards set out in the HSNO Act for the following reasons:

- *Macrolophus pygmaeus* is unlikely to cause significant displacement of any native species within natural habitats or cause any significant deterioration of natural habitats. This is because the climate and habitat modelling does not support widespread establishment of *M. pygmaeus* throughout New Zealand. Further, a number of factors when combined will place significant constraints on *M. pygmaeus* from causing undesirable impacts in natural and valued habitats. These factors include the organism biology, dispersal, host plant limitations, and reproductive constraints facing *M. pygmaeus* in the New Zealand environment. These factors support a conclusion that should *M. pygmaeus* populations escape from greenhouses they will most likely only survive temporarily in highly modified agricultural and semi-rural habits where host plant species are found.
- *Macrolophus pygmaeus* is not known to cause any significant adverse effects on human health and safety or cause disease, be parasitic, or become a vector for human, animal, or plant disease. As discussed above *M. pygmaeus* is unlikely to establish populations at the expense of New Zealand's inherent genetic diversity.

The benefits of the application are considered significant and relate to the long term viability of the New Zealand greenhouse tomato industry. The industry faces reduced chemical tools but more importantly, increasing customer demands for chemical-free produce. To maintain a viable sector into the future effective IPM is the only feasible option for this sector. BCAs such as *M. pygmaeus* are essential for implementing IPM systems in New Zealand. Growers' estimate that the use of successful BCA will result in savings of around 54% in control costs alone, amounting to savings of approximately $12,400 per hectare per annum. Furthermore benefits from reducing yield losses and increasing marketable fruit volume is expected to provide further substantial savings of approximately $54,000 per hectare per year. Overall, financial benefits attributable to the successful use of *M. pygmaeus* are expected to be on average $66,000 per hectare per year. The New Zealand greenhouse tomato industry has approximately 120 hectares under production. This suggests that across the industry economic benefits amounting to approximately $8m per annum can be expected from the successful introduction of *M. pygmaeus.*

On balance we consider that not only would the minimum standard thresholds be protected but that the benefits of releasing *M. pygmaeus* would outweigh any risks.

7. Could your organism(s) undergo rapid assessment?

If your application involves a new organism that is or is contained within a veterinary or human medicine, could your organism undergo rapid assessment (s38I of the HSNO Act)?

Describe the controls you propose to mitigate potential risks (if any). Discuss what controls may be imposed under the ACVM Act (for veterinary medicines) or the Medicines Act (for human medicines).

Discuss if it is highly improbable (after taking into account controls if any):

- the doses and routes of administration of the medicine would have significant adverse effects on the health of the public or any valued species; and
- the organism could form an undesirable self-sustaining population and have significant adverse effects on the health and safety of the public, any valued species, natural habitats or the environment.

Do not include effects of the medicine or new organism on the person or animal being treated with the medicine.

Not applicable

If your application involves a new organism (excluding genetically modified organisms), could your organism undergo rapid assessment (s35 of the HSNO Act)?

Discuss if your organism is an unwanted organism as defined in the Biosecurity Act 1993.

Discuss if it is highly improbable that the organism after release:

- could form self-sustaining populations anywhere in New Zealand (taking into account the ease of eradication)
- could displace or reduce a valued species
- could cause deterioration of natural habitats,
- will be disease-causing or be a parasite, or be a vector or reservoir for human, animal, or plant disease
- will have adverse effects on human health and safety or the environment.

Not applicable

8. Other information

Add here any further information you wish to include in this application including if there are any ethical considerations that you are aware of in relation to your application.

9. Appendices(s) and referenced material (if any) and glossary (if required)

Appendix 9.1: Literature cited

Appendix 9.2: Glossary of terms

Appendix 9.3: *Macrolophus pygmaeus* data sheet

Appendix 9.4: New Zealand Native Hosts

Appendix 9.5: CLIMEX modelling report

Appendix 9.6: Habitat suitability modelling report

Appendix 9.7: Economic assessment (confidential)

Appendix 9.8: Habitat suitability modelling maps and NZ tomato greenhouse locations

Appendix 9.9 Māori Consultation Feedback

10. Signature of applicant or person authorised to sign on behalf of applicant

x☐ I request the Authority to waive any legislative information requirements (i.e. concerning the information that shall be supplied in my application) that my application does not meet (tick if applicable).

I have completed this application to the best of my ability and, as far as I am aware, the information I have provided in this application form is correct.

15 November 2013

Signature	**Date**

Appendices

Appendix 9.1: Literature Cited

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Appendix 9.2: Glossary of terms

Collards	Various loose-leafed cultivars of Brassica oleracea (Acephala Group). Often termed collard greens.
Diapause	Dormancy – with specific initiating and inhibiting conditions e.g. temperature.
Fecundity	ability to reproduce
Glaborus	smooth, devoid of hairs
Polyphagous	feeding on many different kinds of food

Appendix 9.3: *Macrolophus pygmaeus* Data Sheet

DATASHEET: MACROLOPHUS PYGMAEUS

NAME

Species *Macrolophus pygmaeus* (Rambur, 1839)

Taxonomy Order: Hemiptera
Family: Miridae
Genus: *Macrolophus*

Synonyms *Capsus nubilis, Phytocoris pygmaeus, Macrolophus nubilus, M. brevicornis, M. balcanicus, M. nubilis, M. insignis*

Macrolophus pygmaeus (Rambur) has been separated from *M. melanotoma* by differences in morphology and mtDNA sequence (Martinez-Cascales et al. 2006, Perdikis et al. 2003). *Macrolophus caliginosus* (Wagner) is a junior synonym of *M. melanotoma* (Costa).

Martinez-Cascales et al. (2006) used molecular techniques to compare field collected *Macrolophus* with commercially available *Macrolophus*, labeled as *M. caliginosus*, and concluded that this was in fact *M. pygmaeus*. Perdikis et al. (2003) noted that the eggs of *M. melanotoma* miss the onelobed respiratory horn which is present in eggs of *M. pygmaeus*, this feature has been described for the commercially used *Macrolophus* as well. This information confirms that mirids marketed as biological control agents in Europe are in fact *M. pygmaeus* (Klapwijk, 2011).

M. pygmaeus (Source: naturefg.com)

Commercial use Widespread commercial use overseas for example: Koppert (Mirical), Syngenta Bioline in the USA, Canada, UK and Netherlands (Macroline p), Biobest.com (Macrolophus System).

ORGANISM BIOILOGY[2]

M. pygmaeus is a predatory mirid from the Mediterranean region. It is mainly found on solanaceous plants, particularly tomato and tobacco, but can also inhabit other crops (Malais & Ravensberg, 2003).

M. pygmaeus consumes all stages of whitefly (primarily *Trialeurodes* spp.) but prefers eggs and larvae. An adult can consume 30–40 eggs per day. This predator also eats aphids, two-spotted mite, insect eggs, caterpillars, thrips and leaf miner larvae (Enkegaard et al. 2001; Malais and Ravensberg, 2003). Like many mirids, *M. caliginosus* also feeds on plant tissue and can cause damage to crops such as cucumber, gerbera and some cultivars of tomatoes, especially cherry tomatoes (Malais and Ravensberg, 2003). *Macrolophus* species (*M. pygmaeus*, *M. melantomata* (syn. *M. caliginosus*) have been used extensively in Europe for the past 15 years as a biological control agents. *M. melantomata* (syn. *M. caliginosus*) was introduced into the UK in 1995 (Hatherly et al. 2005). It was subsequently detected outside of UK greenhouses, however no negative impacts have been documented (Castane et al. 2011; Hatherly et al. 2005; Hart et al. 2002).

Macrolophus pygmaeus females average 3.51 mm in length and the males 3.37mm (Martinez-Cascales et al. (2006b). The wings are a transparent green with brown markings on the hind parts. The adults are winged, so are able to disperse within the crop (Malais and Ravensberg, 2003). The eggs are laid on veins, leaf petiole and stem of the plant and are not visible to the naked eye (Malais and Ravensberg, 2003). There are five nymphal instars. (Malais and Ravensberg, 2003). Having no wings they are restricted to walking but they can move over the surface of the plant at great speeds.

DISTRIBUTION

Data on distribution is available for *M. caliginosus* in the Crop Protection Compendium. Due to the confusion over the identity of *Macrolophus* (refer to footnote 1) it is likely that *M. pygmaeus* distribution is very similar to that recorded for *M. caliginosus.*

M. caliginosus is listed by the CABI Crop Protection Compendium (2012) as present in the following countries:

EUROPE France, Italy, Netherlands, Spain

M. pygmaeus was illegally introduced to New Zealand around 2007 and its presence in Auckland, New Zealand is recorded by Eyles et al. (2008). Subsequent surveys have not found *M. pygmaeus*, suggesting that it may not have established outside of the glasshouse environment.

HOSTS*

Major Hosts (overseas experience)
M. pygmaeus consumes all stages of whitefly but prefers eggs and larvae. An adult can consume 30–40 eggs per day. This predator also eats aphids, two-spotted mite, insect eggs, caterpillars, thrips and leaf miner larvae (Malais and Ravensberg, 2003, Workmand and Davidson, 2007). Like many mirids, *M.*

[2] Commercial suppliers of *Macrolophus* have now revised the naming of the species present in their biological control products from *M. caliginosus* to *M. pygmaeus* (Klapwijk, 2011). Much of the literature for *Macrolophus* as a BCA describes *M. caliginosus* (for example, Enkegaard et al. 2001; Hatherly et al. 2005; Workman and Davidson, 2007). However it is likely given this revision that much of the testing was conducted on *M. pygmaeus*.

pygmaeus also feeds on plant tissue, particularly when prey densities are low, and can cause damage to crops such as cucumber, gerbera and some cultivars of tomatoes, especially cherry tomatoes (Malais and Ravensberg, 2003).

Host pests (targets for biocontrol overseas)
Trialeurodes vaporariorum (whitefly)
Bemisia tabaci (whitefly)
Ephestia kuehniella (lepidoptera)
Frankliniella occidentalis (thrips)
Macrosiphum euphorbiae (aphid)
Myzus persicae (aphid)
Tetranychus urticae (spider mite)

New Zealand native hosts (potential)
A review of the New Zealand endemic whitefly, aphid, mites, thrips and lepidoptera species is detailed in Appendix 9.4. *M. pygmaeus* will preferentially feed on whitefly (*Trialeurodes* over *Bemisia*) (Malais and Ravensberg, 2003, Workmand and Davidson, 2007), but will predate aphids, mites, thrips and lepidoptera particularly when food supplies are scarce. The table below summarises the host range for *M. pygmaeus* and available information on New Zealand native species (Malais and Ravensberg, 2003, Workmand and Davidson, 2007).

Summary of pest host range

Biocontrol agent	Whitefly	Aphids	Mites/Spider mites	Lepidoptera	Thrips
Macrolophus pygmaeus	**Major**	minor	**Major**	minor	minor
Presence of native host species in NZ	9 native	13 native	12 genera, and 46 species of Tetranychidae (spider mites) present in New Zealand – not all native	1,582 native species of lepidoptera	19 native

SPREAD & ESTABLISHMENT

Thermal requirements

M. pygmaeus is reported to perform best at temperatures between 20 to 25°C. The developmental threshold for *M. pygmaeus* range from a minimum of 7.3 to 7.7°C (Hart et al. 2002; Hatherly et al. 2005) to a maximum of 40°C (Malais and Ravensberg, 2003). The lethal time (days) ($Ltime_{50}$) required to kill 50% of the population at 5°C was 32.4 days, with a maximum field survival of 75 days for unfed nymphs and up to 200 days for fed nymphs (Hatherly et al. 2005) suggesting that temperature was not entirely limiting for *M. pygmaeus*, and that with the availability of prey, survival could span an entire UK winter (Hatherly et al. 2005).

Glasshouse assessment
Average temperatures for NZ glasshouses range from 15°C to 25°C. *M. pygmaeus* will perform within this temperature range although lower night temperatures may affect performance.

Environmental assessment
M. pygmaeus has been detected outside of UK glasshouses (the authors refer to *M. caliginosus*, refer to footnote 1) (Hatherly et al. 2005). Thermal biology testing also indicates the potential for *M. pygmaeus* to

persist for extended periods outdoors in the winter in temperate climates (Bale, 2005). It was estimated that under outdoor conditions *M. caliginosus* could complete two generations per year in the UK in summer (Hart et al. 2002). *M. pygmaeus* does not enter diapause and is thought to actively seek shelter during the winter months (Hatherly et al. 2005). Given the temperate climate in New Zealand and reported ability to survive outside of the glasshouse environment, this species could potentially survive the New Zealand winter.

CLIMEX modelling

CLIMEX models developed for *M. melanotoma* (syn. *M. caliginosus*) and *M. pygmaeus* (Logan, 2012) indicated that these species may persist outside glasshouses in Auckland, many areas of Northland, and on the east coast of the North Island particularly between Gisborne and Castlepoint.

Habitat suitability modelling

Maxent and muli-modelling of *M. pygmaeus* (Logan et al. 2013) indicated a low likelihood that suitable climate for *M. pygmaeus* exists in New Zealand. The maxent model indicated that the climate suitability is poor, and the consensus multi-model indicated that only a small area of Kaitaia in Northland has suitable climate for *M. pygmaeus*.

Spread potential

Adults are winged, so are able to disperse within the crop. *Macrolophus* naturally colonise tomato greenhouses in the Western Mediterranean area (Castane, 2004), therefore natural migration occurs in response to whitefly abundance. This demonstrates active dispersal and predatory activity of *Macrolophus* against host species.

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Appendix 9.4: New Zealand Native Hosts

1. Whitefly

Workman and Davidson (2007) list the following native whitefly of New Zealand and their host plants:

New Zealand Whitefly	Host plant
Aleyrodes fodiens (Maskell)	*Pseudwintera axillaris*
Aleyrodes winterae Takahashi	*Pseudwintera* species
Asterochiton aureus Maskell	*Melicytus* species (whiteywood)
Asterochiton cerata (Maskell)	*Nothofagus menziessii* (silver beech)
Asterochiton fagi (Maskell)	*Nothofagus menziessii* (silver beech)
Asterochiton pittospori (Dumbelton)	*Pittosporum eugenoides* (lemon wood)
Asterochiton simplex (Maskell)	*Pittosporum* and *Coprosma* species
Bemisia sp	*Melicytus* species (whiteywood)
Trialurodes asplenii	Ferns including *Asplenium*, *Blechnum*, and *Dicksonia* species
Bemisia flocculosa sp. n.	*Melicytus obovatus* (Violaceae) (Gill & Holder 2011)

Bemisia flocculosa was collected from six *Melicytus* species: *M. obovatus*; *M. alpinus*; *M. micranthus*; *M. lanceolatus*; *M. flexuosus*; *M. ramiflorus*; *M. aff. obovatus* (= sp. 1 and *M. obovatus*), and confirmed only from mid-Canterbury, New Zealand (Gill & Holder, 2011).

2. Aphids

Only a few native aphids are described from New Zealand (Eastop, 2011). Of the approximately 120 aphid species in New Zealand only about 13 are indigenous (Teulon et al. 2003). Only eight indigenous species of aphid have been fully described and named, and a further four species are being described. New Zealand native aphid species are listed below:

New Zealand aphids	Host plant	Notes (from Teulon et al. 2003)
Described species:		
Aphis coprosmae Laing ex Tillyard	*Coprosma* spp.	Only two-three populations have been recorded, and none since 1998.
Aphis cottieri Carver	*Muehlenbeckia* spp.	*Aphis cottieri* on Muehlenbeckia has been recorded from relatively few locations (Fiordland to Canterbury) but in appreciable numbers.
Aphis healyi Cottier	*Carmichaelia* spp.	Common. Populations recorded recently in Otago, Southland, Westland, and the central North Island.
Aphis nelsonensis Cottier	*Epilobium* sp.	*A. nelsonensis*, has not been recorded since 1965
Paradoxaphis aristoteliae Sunde	*Aristotelia* sp.	*Paradoxaphis aristoteliae* has been found at both ends of the South Island but, despite some effort, no further populations have been located.
Paradoxaphis plagianthi Eastop	*Plagianthus* sp.	*Paradoxaphis plagianthi* may be moderately abundant, but only in the Christchurch area.
Neophyllaphis totarae	*Podocarpus* spp.	Common. Widespread with sometimes high

New Zealand aphids	Host plant	Notes (from Teulon et al. 2003)
Cottier		local abundance.
Sensoriaphis nothofagi Cottier	*Nothofagus* spp.	Relatively widespread but populations seldom reach high levels.
Undescribed species:		
Aphis sp.	*Olearia* spp.	Limited information due to their recent discovery. Difficult to draw any definite conclusions on their relative abundance.
Casimira sp.	*Ozothamnus* sp.	*Casimira* species on *Ozothamnus* has only been found at one location, in the Catlins, Southland.
Euschizaphis sp.	*Aciphylla* spp.	Limited information due to their recent discovery. Difficult to draw any definite conclusions on their relative abundance.
Euschizaphis sp.	*Dracophyllum* spp.	Relatively widespread but populations seldom reach high levels.
Neophyllaphis sp.	*Podocarpus nivalis*	Limited information due to their recent discovery. Difficult to draw any definite conclusions on their relative abundance.

Teulon et al. (2003) note that native aphids appear to be predominantly host-specific, at least to host plant genera. The majority of New Zealand native aphids are scarce, having restricted range and low local abundance, however Teulon et al. (2003) note that this may reflect a lack of data. Only *A. healyi*, *Euschizaphis* (*Dracophyllum*), *N. totarae*, and *S. nothofagi* have been found in the North Island. The greater representation of nativespecies in the South Island may reflect the relative amount of sampling effort in each island (Teulon et al. 2003).

3. Lepidoptera

New Zealand Lepidoptera are extremely important globally for its high proportion of native taxa (about 90% of all species) (Landcare Research, 2012a). With over 1800 species, Lepidoptera form the third largest order of insects in New Zealand after beetles (Coleoptera) and flies (Diptera) (Dugdale, 1988). Lepidoptera occupy all biotopes except caves in New Zealand.

Although the New Zealand lepidoptera fauna is not diverse by world standards, and is especially poor in butterflies (only 13 native species currently recognised), it is extremely important globally for its high proportion of native taxa, and the presence of ancient, relictual groups, some rather richly represented (e.g. Micropterigidae with at least 16 species, and the native family Mnesarchaeidae with 14) (Landcare Research, 2012a).

New Zealand shares with Australia and New Caledonia an unusually high proportion of species with detritivorous larvae (i.e. larvae feeding on leaf-litter, dead wood and/or fungi). The second most diverse family of Lepidoptera in New Zealand is a group with detritivorous larvae, the Oecophoridae (nearly 250 species, compared to just 86 for the former USSR, a land area 80 times as large). Tineidae (over 100 species) and Psychidae (over 50 species) are also well represented. Such recyclers of nutrients in our forests and shrublands play an important ecosystem role, but these groups are among the most neglected and difficult taxonomically. Many detritivorous moths from overseas are well established in New Zealand and their effects on our native fauna (if any), such as through competitive interactions, are unknown (Landcare Research, 2012a).

4. Mites (Acari)/Spider Mites (Acari: Family Tetranychidae)

The Acari (mites and ticks) are a hyper-diverse group of minute arthropods. Some 50,000 species have been described worldwide, but there may be as many as half a million to one million species (Landcare Research, 2012b). In New Zealand, over 1,200 species (in 540 genera belonging to over 180 families) had been described by the year 2000. It is estimated some 90% of the New Zealand mite species are waiting to be discovered and described (Landcare Research, 2012b).

The family Tetranychidae (common name spider mites) belong to the mite order Prostigmata, which includes some 120 mite families. The family includes 2 subfamilies, over 70 genera and about 1,200 described species in the world. Fewer than 3% of these species are currently known in New Zealand (Zhang et al. 2002).

Mites of the Tetranychidae include some of the important pests in agriculture and forestry, and can be found feeding on many fruit trees, vines, berries, vegetables, and ornamental plants. Many spider mites naturally inhabit patchily distributed resources, such as weeds. The two-spotted spider mite, *Tetranychus urticae* Koch, is one of the major pests of ornamental plants and vegetable/fruit crops grown worldwide, and it is found on approximately 1200 described plant species in 70 genera. One species, *Tetranychus linterius*, is beneficial, and has been used as a biological control agent against gorse in New Zealand (Zhang et al. 2002).

Zhang et al. (2002) identified 2 subfamilies, 12 genera, and 46 species of Tetranychidae. Both subfamilies of the Tetranychidae (Bryobiinae, Tetranychinae) are represented in New Zealand. The Tetranychidae identified by Zhang et al. (2002) as present in New Zealand are not necessarily native. Three genera were newly recorded for New Zealand and 16 new species were described from this analysis (Zhang et al. 2002).

The following Tetranychidae were newly recorded only in New Zealand by Zhang et al. (2002):

Tetranychidae recorded only in New Zealand	**Notes on distribution** (from Zhang et al. 2002)
Subfamily Bryobiinae Berlese	
Bryobia annatensis Manson	New Zealand
Bryobia repensi Manson	New Zealand, wide distribution
Bryobia sp. *A nr repensi* from *Brachyglottis hectori* [as Senecio]	New Zealand. On *Brachyglottis hectori*, Mangarakau
Bryobia sp. *B nr repensi* from cucumber	New Zealand. On cucumber, Drury Auckland
Bryobia variabilis Manson	New Zealand. On broom, Christchurch, Palmerston North
Bryobia watersi Manson	New Zealand. On kiwifruit (Christchurch), cucumber (Levin)
Schizonobia sp. n. from *Spergula arvensis*	New Zealand, Auckland and Appleby
Petrobia (Petrobia) sp. nr *latens* (Ewing) from vegetation (Nelson)	New Zealand, Nelson
Petrobia (Petrobia) sp. n. from broom	New Zealand. On broom, Christchurch
Subfamily Tetranychinae	
Tribolonychus collyerae Zhang & Martin from *Nothofagus* sp. at Lake Rotoroa	New Zealand. Lake Rotoroa.
Tribolonychus sp. n. from *Nothofagus fusca* on Banks Peninsula	New Zealand. On *Nothofagus fusca*, Christchurch

Tetranychidae recorded only in New Zealand	**Notes on distribution** (from Zhang et al. 2002)
Schizotetranychus kaspari Manson	New Zealand
Schizotetranychus levinensis Manson	New Zealand. On grass, weeds Levin and Lincoln
Yezonychus brevipilus Zhang & Martin	New Zealand. On *Leionema nudum*, Waitakere, Huia
Yezonychus cornus (Baker & Pritchard)	New Zealand. On *Elaeocarpus dentatus*, Anawhata, Wauitakere, Kaueranga Valley, Akatarawa
Yezonychus falsicornus Zhang & Martin	New Zealand. Tapotupotu Bay, Waitakere, Little Huia, Otaki, Upper Pelorus, Banks Peninsular
Atetranychus sp. n. from Parsonsia	New Zealand, no other details
Sonotetranychus sp. n. from mountain beech	New Zealand. On mountain beech, Ngatimoti
Panonychus sp. A from mountain beech	New Zealand. On mountain beech, Ngatimoti
Panonychus sp. B from bush lawyer *Rubus cissoides*	New Zealand. On bush lawyer, Levin
Oligonychus sp. A nr bicolor from oak (WN)	New Zealand. On oak, Upper Hutt, Levin
Oligonychus sp. B nr bicolor from oak (AK)	New Zealand. On oak, Auckland
Tetranychus collyerae Manson	New Zealand, wide distribution
Tetranychus elsae Manson	New Zealand. On *Festuca*, Appleby
Tetranychus eyrewellensis Manson	New Zealand. On Carmichaelia australis, Eyrewell State Forest
Tetranychus moutensis Manson	New Zealand. On flax, Shannon and Paiaka
Tetranychus sp. nr *bambusae* from bamboo	New Zealand. On bamboo, Oratia, Titirangi, Wood Bay
Tetranychus sp. n. from cordyline	New Zealand. On cordyline, Lincoln
Tetranychus sp. nr elsae from *Coprosoma*	New Zealand. On *Coprosma rotundifolia*, Dunedin
Tetranychus sp. nr *lambi* from buttercup	New Zealand. On *Cucurbita* sp., buttercup & butternut pumpkins, Auckland

5. Thrips (Order Thysanoptera)

Worldwide over 5,000 species of thrips have been described. Thrips (Insecta: Thysanoptera) are grouped into two suborders, Terebrantia and Tubulifera, with most pests in the Terebrantia.

In New Zealand 52 species of Terebrantia in 26 genera have been recorded (Mound & Walker 1982). Nineteen species are indigenous to New Zealand, none of which are endangered. However, some native New Zealand thrips are considered to be ancient relict taxa (Mound & Walker 1982).

Of the 52 species of Terebrantia identified as present in New Zealand fifteen species are considered to have been introduced from Europe, and are found typically in pastures and gardens; 6 from the Old World tropics, usually found on non-native plants; 4 from the New World, and at least 7 from Australia (Mound and Walker, 1982). Of the 19 species known only from New Zealand, 6 show some relationship to the Australian fauna and 1 to that of New Caledonia, possibly introduced to New Zealand by wind or human movement. Adelphithrips with 3 species, a species-group of Thrips comprising 4 species, a subantarctic genus of 2 species, and 3 monobasic genera constitute the indigenous fauna. Adelphithzips is regarded as the sister-group of the world-wide Thrips genus-group. Pseudanaphothrips from New Zealand and south-eastern Australia is regarded as the sister-group of the world-wide *Frankliniella* genus-group (Mound and Walker, 1982).

Mound and Walker (1982) list the following Terebrantia as indigenous to New Zealand:

Terebrantia indigenous to New Zealand	**Notes** (from Mound and Walker, 1982)
Desmidothrips walkerae	
Adelphithrips cassiniae	
Adelphithrips dolus	
Adelphithrips nothofagi	
Anaphothrips zelandicus	Present only in New Zealand, including the Chatham Islands and Antipodes Islands, but closely related to Australian species.
Anaphrygmothrips otagensis	
Dichromothrips maori	Recorded from orchids in New Zealand, may prove to be the same species as *D. spiranthidis*, which was described from Australia
Dikrothrips diphyes	
Karphothrips dugdalei	
Lomatothrips paryphis	
Physemothrips chrysodermus	Genus *Physemothrips*, with two species in the subantarctic islands and extreme south of New Zealand, has no evident relationships with any other known genus.
Physemothrips hadrus	
Pseudanaphothrips annettae	
Scirtothrips pan	Only known from native forests in New Zealand. It may have come from Australia, because the most closely related species occur there and in the Philippines and Malaya.
Sigmothrips aotearoana	
Thrips austellus	These four native Thrips species form a distinctive species-group which may be of recent origin.
Thrips coprosmae	
Thrips obscuratus	
Thrips phormiicola	

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Appendix 9.5: CLIMEX Modelling

This is a report commissioned by Horticulture New Zealand (Tomatoes New Zealand), and carried out by Plant and Food Research Ltd.

At the time that this report was commissioned, Tomatoes New Zealand were evaluating 3 BCAs for whitefly control, *Nesidiocoris tenuis*, *Delphastus catlinae*, and *Macrolophus pygmaeus*. The report describes CLIMEX models for all 3 species.

Attached pdf file.

Logan, D. 2012. CLIMEX models for selected tomato BCAs. Prepared for Horticulture New Zealand. Plant and Food Research Ltd, Auckland. SPTS No. 6938. pp.16.

Appendix 9.6: Habitat suitability modelling

This is a report commissioned by Horticulture New Zealand (Tomatoes New Zealand), and carried out by Plant and Food Research Ltd.

At the time that this report was commissioned, Tomatoes New Zealand were evaluating 3 BCAs for whitefly control, *Nesidiocoris tenuis*, *Delphastus catlinae*, and *Macrolophus pygmaeus*. The report describes Habitat suitability models for all 3 species.

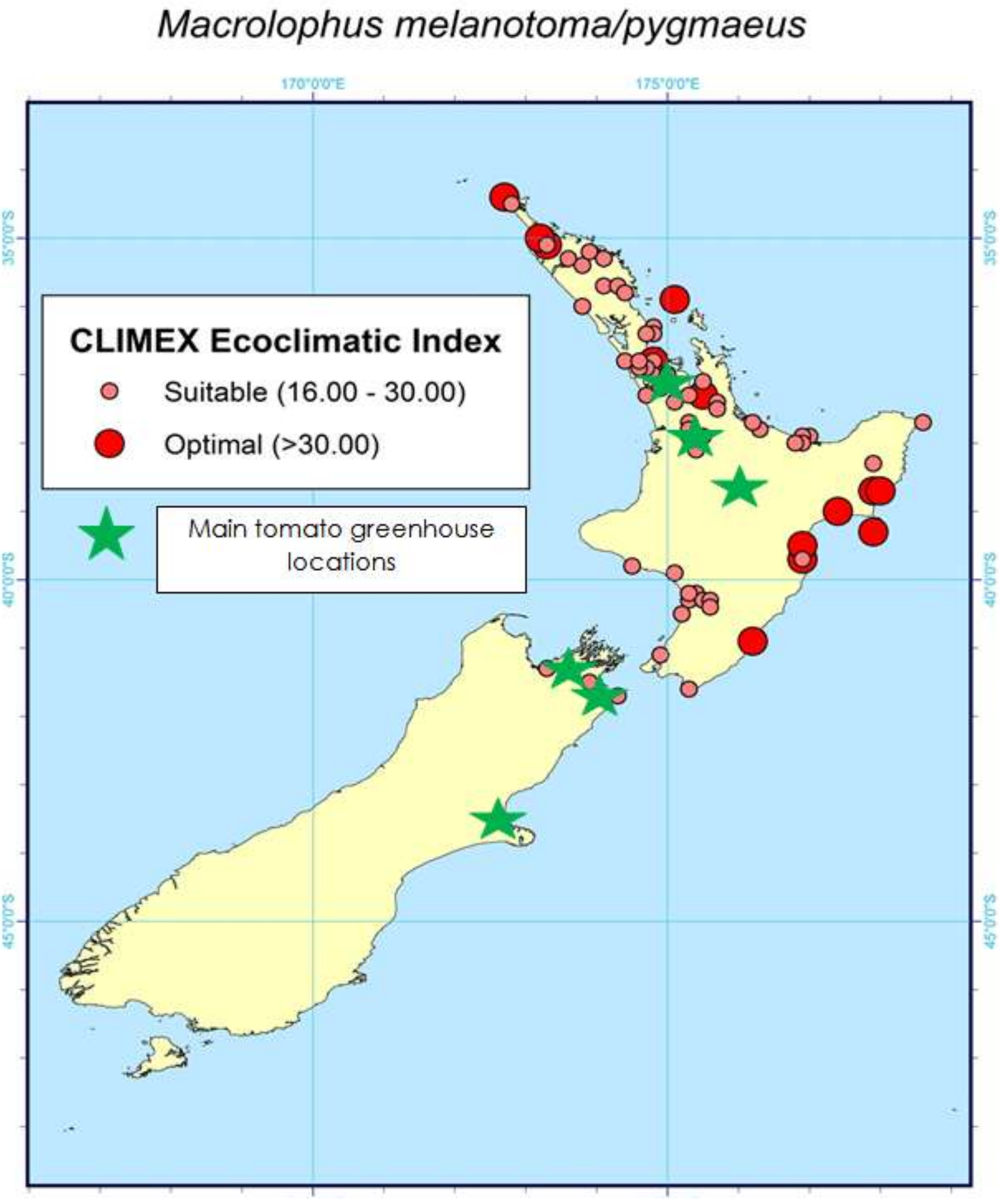
Attached pdf file.

Logan, D.P; Senay, S. D; Narouei Khandan, H. A. 2013. Habitat suitability predictions for selected glasshouse biological control agents using Maxent and Multi-modelling. Plant and Food Research Ltd, Auckland. SPTS No. 8061, 27p.

Appendix 9.7: Economic assessment (confidential)

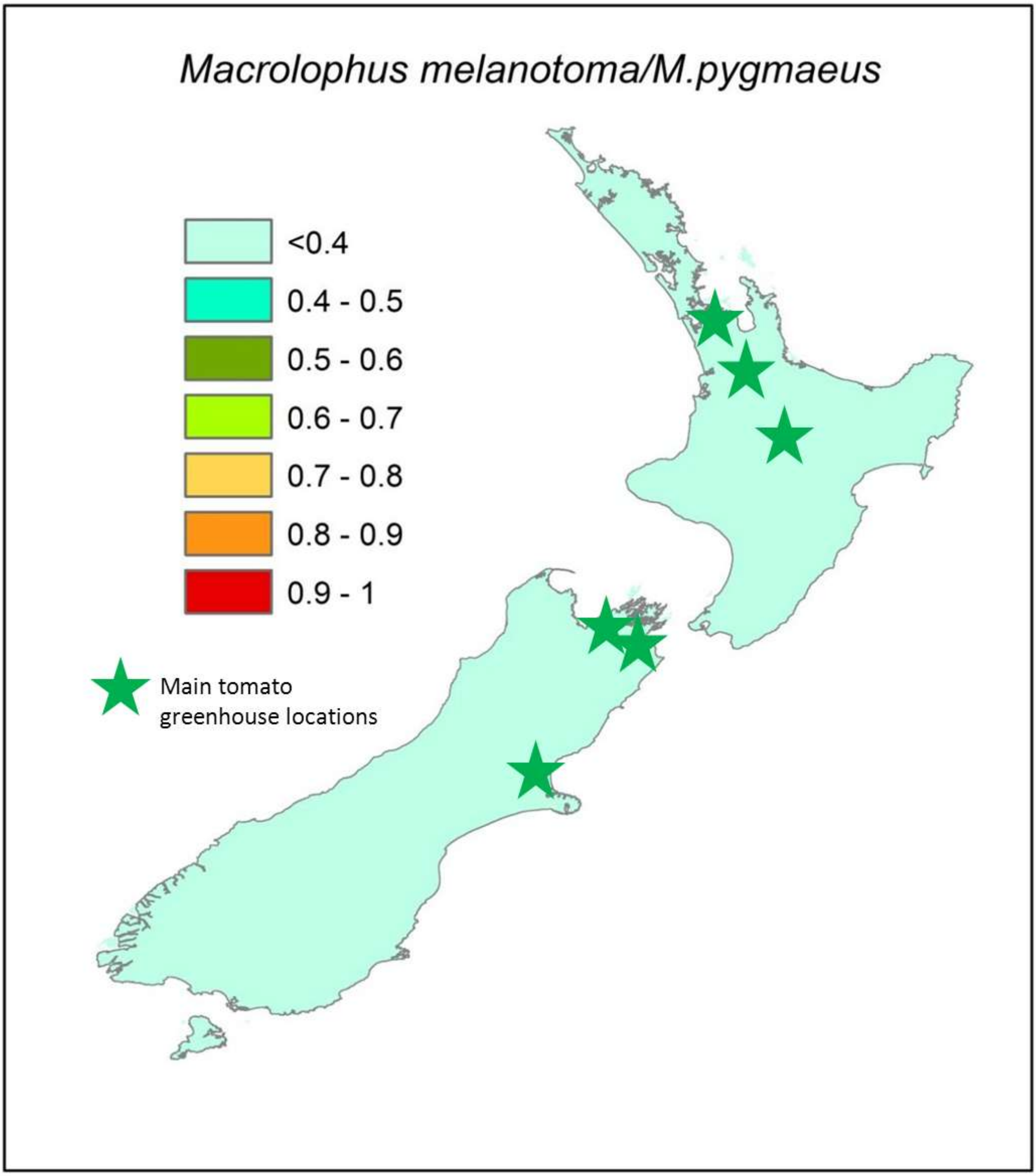
Appendix 9.8: CLIMEX and habitat suitability modelling maps and NZ tomato greenhouse locations

The following map was generated from CLIMEX modelling reported in Logan (2012) – Appendix 9.5. This map have been modified to show only optimal and suitable climate locations for *M. pygmaeus*. The locations of New Zealand's major tomato greenhouse operations are indicated.

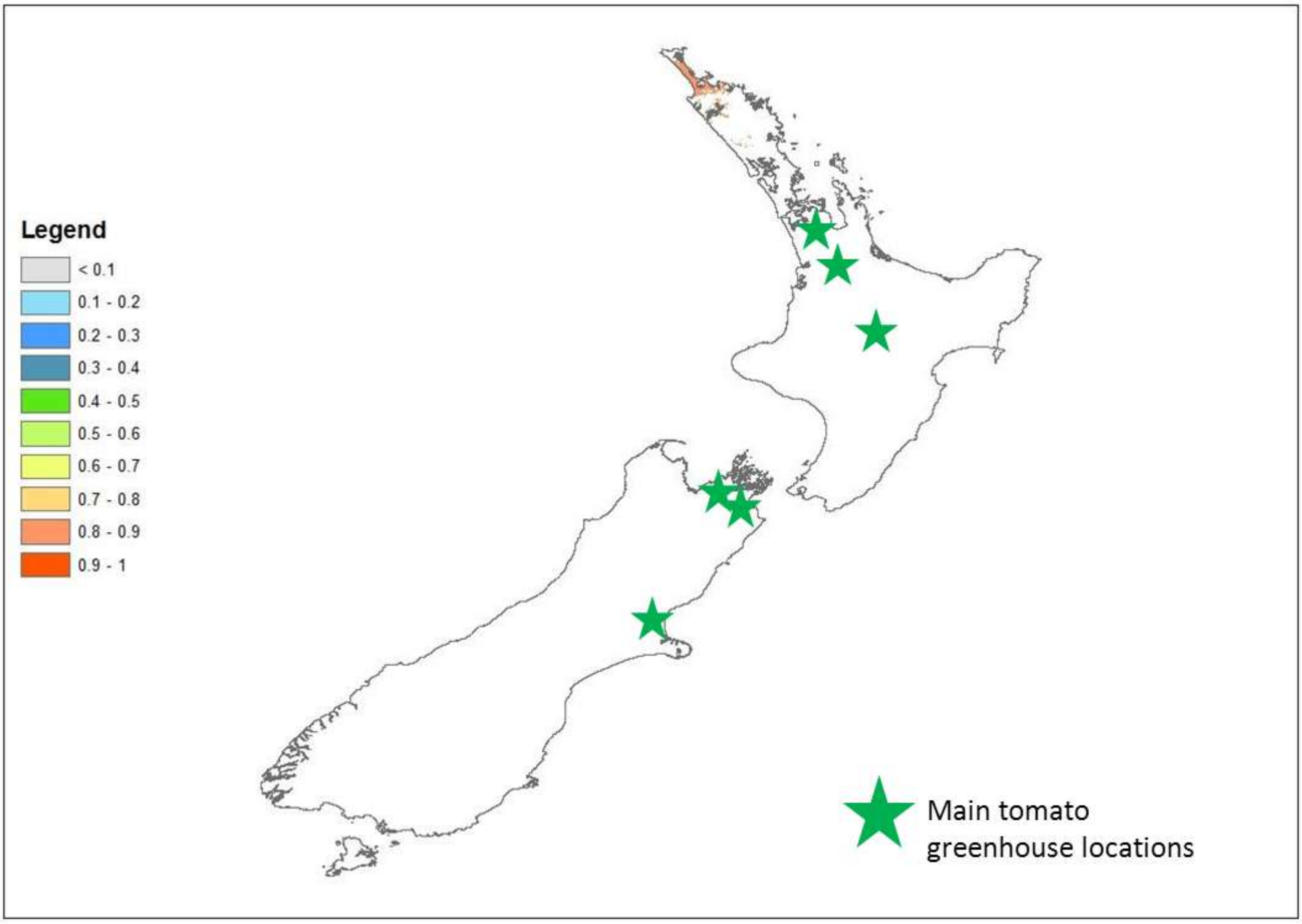


The following maps were generated from Habitat suitability modelling reported in Logan et al. (2013) – Appendix 9.6. The locations of New Zealand's major tomato greenhouse operations are indicated.

Maxent map of habitat suitability in New Zealand for *macrolophus pygmaeus.*



Consensus map of habitat suitability in New Zealand for Macrolophus pygmaeus. The map is a consensus of seven different algorithms (Logistic Regression, Naıve Bayes, Classification and Regression Trees, Conditional Trees, K-Nearest Neighbours, Support Vector Machines, and Artificial Neural Networks) weighted by their sensitivity scores.



Appendix 9.9: Māori Consultation Feedback

The Māori Reference Group Report for Tomatoes NZ

Proposed application to release the biological control agents (BCAs) Delphastus catalinae (Whitefly Lady Beetle), Macrolophus pygmaeus and Nesidiocoris tenuis (Tomato bug).

Purpose

The purpose of this report is to outline potential interests and issues identified by a Māori Reference Group (MRG) regarding the proposed application by Tomatoes NZ to release three BCA species. This application is to be submitted to the Environmental Protection Authority (EPA) under the Hazardous Substances and New Organisms Act.

Background

Tomatoes NZ undertook to work with an MRG in good faith to support its identification of potential adverse and beneficial effects arising from its application. Two meetings of the MRG were held, including a site visit to glasshouse and storage facilities. The draft application and technical reports were also provided to the MRG for review.

MRG members (members) were impressed at the commitment shown by the applicant and their consultants to this process of engagement.

Māori Interests & Issues Identified

The interests and issues identified by the members have been categorised as follows;

1. Ngā taha tūpato - tangible and intangible risks;
2. Ngā taha huanga – non-financial benefits;
3. Ngā taha ohanga: - economic benefits that accrue to Māori;
4. Ngā rāhuitanga - proposed management controls.

Members would like Tomatoes NZ to realise that these issues have been identified based on the information and discussion provided and are not representative of iwi or hapū views within specific tribal regions. Instead they are provided to inform the completion of the application and to highlight areas the applicant should be aware of, or might like to focus on through the application, the decision making process and beyond.

With this in mind, members also encourage Tomatoes NZ to continue to be open and accessible to meeting with and discussing the proposal and its outcome if and when approached by iwi or hapū. It would be a beneficial and enduring expression of the commitment and recognition of the organisation to the relationship Māori have with their environments.

1. Ngā taha tūpato - risks, both tangible and perceived

Kaitiakitanga is a holistic approach to understanding and existing within the natural world. Māori have specific intergenerational obligations as kaitiaki to protect and enhance the mauri (life essence) of species and their surrounding environment. On considering this application from a kaitiakitanga perspective, members were concerned to understand the broader pest and pest management context within which this proposed application sits. This approach is important when identifying potential effects and considers the cumulative impact of the release of the new organisms, particularly where the environment, native species and ecosystems are already under pressure from other sources.

Members understand and support the value and importance of an integrated pest management approach, though are cautious about the introduction of these species given the lack of information about the behaviour of the organisms outside of the glasshouse. The climate modelling indicates some risk of establishment of the species in certain regions. The lack of behavioural data alongside the climate modelling raises significant concern for members about the impact of the released BCA's to taonga species and their relationships within the wider environment.

This concern is heightened for Macrolophus pygmaeus given the information provided, particularly in relation to climate modelling and the likelihood of non-target effects. Climate modelling for Nesidiocoris tenuis, also raises significant concern in terms of the risk of establishing self-sustaining populations in Northland and the East Coast. Delphastus catalinae, was a more acceptable option for members given the information provided, though concern remains in terms of its ability to survive outside the glasshouse for up to 28 days.

Members acknowledge that these BCA's are used extensively in glasshouses around the world, and that no adverse effects to the surrounding environments had been recorded. However, members consider that the absence of such information should not be taken to mean the absence of adverse effects, and that testing in the New Zealand environment should be undertaken. Without this information members consider it too difficult to determine whether the BCA's will pose a risk of significant displacement of native species, deterioration of natural habitats or adversely affect New Zealand's inherent genetic diversity.

In this context members are keen to encourage the industry to consider and/or continue to progress research investigating native BCA options, and to outline more clearly in the application why indigenous alternatives are not viable. In particular members felt that the further development of the native species Drepenacrabinocular (hook tipped lacewing) and Amblydromalis limonicus (mite) should be seriously considered to avoid the level of uncertainty of effect possible with the imported BCA's.

In summary, members consider that the combination of climate modelling data and the absence of information about the potential for adverse effect from the three BCA species in the New Zealand environment sufficient to warrant an extremely cautious approach. Members feel that these information gaps should be addressed to provide assurance that native and valued species and ecosystems will not be threatened.

2. Ngā taha huanga – non-financial benefits

As noted briefly above, members acknowledge the importance of an integrated pest-management approach and are supportive of efforts to reduce the use of chemicals generally, but particularly on food crops. Members considered this approach to be broadly consistent with a kaitiakitanga approach, though noted that a key aspect of kaitiakitanga is the active management of balance in the relationships of all elements and species within the natural world (including people).

Members were impressed with the industry's efforts to reduce an unnecessary reliance on natural resources in their energy production, recycling, irrigation and waste management. Even their efforts around bumble bee production and pollination captured attention. These measures highlight good organisational and management practice, and provided some comfort in terms of the industry's respect for the environment within which they operate.

Members noted that because of the industry's approach, the non-financial benefits from the application include a reduction in the use of chemicals and their subsequent effect on people (particularly staff) and the environment. Members also considered the industry's search for alternatives to chemicals to be responsible given the EPA's recent reassessment and removal or phase out of some organophosphates.

3. Ngā taha ohanga - economic benefits specific to Māori

Members noted the high numbers of Māori employed by the glasshouse industry both in Auckland and around the country, and are also aware that at least one Māori organisation is a significant investor in the industry. Members felt that the application would benefit significantly from the inclusion of any data available on the Māori employment and investment figures to support the applicant's identification of economic benefits.

The recently launched Māori Economic Development Strategy and Action Plan, He Kai Kei Aku Ringa , provides a blueprint for a productive, innovative, and export-orientated Māori economy that would support better paying jobs and higher living standards. The report considers such an approach would boost Māori economic performance and benefit all New Zealanders. The new Māori Land Productivity Initiative within the strategy, Te Kōkiri mo te Whainga Hua o Ngā Whenua Māori is the private sector's response to the Māori Economic Development Panel's recommendation to raise the productivity of Māori land and currently unproductive land generally.

Members felt it would be good to see any available data about the involvement of Māori in the industry in the regions to understand the economic significance of the application to Māori communities. For example how many local Māori in Blenheim and other regions are employed in the industry and does an extrapolation of benefit by regional GDP help balance out the risk to benefits ratio of the application.

4. Ngā rāhuitanga - proposed controls

Having considered the information provided by the applicant and the points noted above, members are keen that Tomatoes NZ and their members consider adding the following conditions or management practices to their application and operations.

A. Due to the potential risk of Macrolophus pygmaeus discussed in the draft application and in this report, members are keen that management controls or practices for this BCA be commensurate with the level of risk posed by the organism.

B. That the release and use of the three BCA's is limited to those hothouses/glasshouses and breeding facilities meeting the highest industry standard.

C. Members would like the applicants to seriously consider staggering the release of the BCA's so that only one organism is released at a time and that a more stringent monitoring regime be undertaken. Further, more comprehensive releases would then follow dependant on the results of the monitoring data.

D. Members make the following suggestions in relation to such monitoring:

    a. Increase the number of bug scouts at the hothouses/glasshouses to include staff that monitor the exterior of the hothouses/glasshouses to ensure that there are no escapees.

    b. Implement the use of appropriate traps for monitoring outside of the hothouses, taking into consideration the behaviour of the organisms, and ensuring that the traps do not encourage the organisms to escape from the hothouses/glasshouses (e.g. pheromone traps placed too close to the hothouses/glasshouses which may encourage the organisms to leave the hothouses/glasshouses to congregate to them);

    c. Maintain integrated pest management systems that enhance monitoring of the organisms throughout the hothouses/glasshouses, and which restrict the potential movement of the BCA's into other buildings on the premises (e.g. the warehouses);

    d. Apply the measures above to all breeding facilities both on and off-site to monitor and ensure BCA's do not escape. This should also include strict monitoring regimes being implemented to secure the organisms in transit to the facilities where they will be released;

    e. Implement/maintain the 'bug-free' storage rooms (as observed at the Bombay facility), and where possible, implementing an appropriate holding period in those rooms prior to export both domestically and internationally, to ensure that there are no BCA escapees on products.

E. Restrict releases to a limited number of sites initially until the data/information obtained above can be assessed.

F. Seriously consider and progress the development of indigenous alternatives.

Members were also keen that Tomatoes NZ consider updating, or reporting back to, the EPA's Te Herenga (the National Māori Network) 12 and 24 months after release. It is often the case that Māori are "consulted" and then the applicants literally disappear with no follow up in relation to the concerns or issues raised. In addition, the provision of such update information can support the work of kaitiaki in the regions in their role and obligation for managing the balance of species in the native environment.

[1] http://www.tpk.govt.nz/_documents/medp/media-statement-private-sector-commits-to-action-to-improve-maori-land-productivity.pdf

Appendix 9.9b: Feedback From Information mail-out

From: Malcolm Paterson [mailto:Malcolm@ngatiwhatuaorakei.com]
Sent: Monday, 3 June 2013 10:11 a.m.
To: 'Graham Young'
Cc: Shaun Slattery; 'Patrick Gemmell'
Subject: RE: Tomatoes New Zealand letter of intent

Kia ora koutou

Ngāti Whātua Ōrākei is disturbed by applications such as these. We recognise the value of the tomato industry to NZ but the idea of introducing new foreign insect species to support a non-native plant to flourish is problematic. The information provided suggests that the species proposed to be introduced shouldn't have major negative impacts on native insect species but there is an acknowledgment that there may be some impacts. These haven't been (probably can't be) confidently and fully assessed and so a precautionary approach that first and foremost values our native ecology, biodiversity and species, would suggest that new insects with the capability to impact negatively on native species should not be introduced

Nāku nā

Malcolm Paterson

Kaiwhakahaere Matua (Senior Manager)
Toki Taiao (Ngāti Whātua Ōrākei Whai Maia Ltd heritage and resource management unit)

Email: malcolm@ngatiwhatuaorakei.com
Mobile: (021) 253 3930
Phone: (09) 336 1670
Fax: (09) 929 0002

Level 1
32-34 Māhuhu Cres
Waiariki
Auckland CBD

PO Box 42 045
Ōrākei
Auckland 1745

From: Graham Young [mailto:Graham.Young2@epa.govt.nz]
Sent: Monday, 27 May 2013 11:34 a.m.
To: abe@terarawa.co.nz
Subject: Tomatoes New Zealand letter of intent

Kia ora

Please see the attached letter from Tomatoes New Zealand with regards to their application to import three new biological control agents.

Kind regards

Graham Young
Applications Administrator
New Organisms

Environmental Protection Authority · Level 10 · 215 Lambton Quay · Private Bag 63002 · Wellington 6140 · New Zealand
Tel +64 4 916 2426 · Fax +64 4 914 0433 · DDI +64 4 474 5571 **www.epa.govt.nz**

From: Hayden Henry [mailto:hayden.henry@akonga.twoa.ac.nz]
Sent: Thursday, 30 May 2013 3:00 p.m.
To: Shaun Slattery
Subject: intergrated pest management

I sit on the maori forum advising EPA in regards of bringing in new pests to provide better management of your products (Tomatoes) I have concerns in regards of the effects that this Delphastus catalinae could have on our native insects, as expressed their are 18 species already introduced to NZ, This new species is being introduced in glass houses in a controlled warmer atmosphere, our summers have been warm of late therefore am concerned that if they got out of the green house what are the repercussions, has this been trailed overseas or anywhere else as we are not the only country that grows these vegatables and crops as the whitefly has already affected other crops and what data has been collated regarding this experiment. I would be interested in your containment management plan and risk plan if this pest escapes-it concerns me that we bring a new species into this country without trails and concrete evidence pertaining to the relaese of this species

P.O. Box 319
15/17 Roulston Street

PUKEKOHE
Telephone: 0-9 238 0250
Fax: 0-9 238 0259

Our Reference ……………..

Your Reference ……………

2nd June 2013

Tomatoes NZ
P O Box 10232
WELLINGTON 6143

Kia ora

APPLICATION TO IMPORT THREE NEW BIOLOGICAL CONTROL AGENTS

Thank you for providing the information for your proposed application.

Huakina is generally **opposed** to any introduction of new organisms to this country that could pose a threat to our native species.

Green House Location
There has been a huge growth in commercial greenhouses within our area. It is not easy to locate them away from natural habitats as it is an activity usually located in the rural area where natural habitats are the norm rather than the exception.

As several of the bugs can fly there would be ample opportunity to reach a 'natural habitat'.

Climate Tolerance
We note the low climate tolerance for the bugs that should limit their ability to spread and 'significantly' impact native populations.

Long term (should the predictions prove accurate) will this remain the same should climate change become a reality?

Taonga Species
As we do not know the potential harm your bugs could cause it is very difficult to say where the impacts could occur.

What we will say is that **all native species of this whenua are taonga**.

Email admin@huakina.co.nz
Website www.huakina.co.nz

Te Rūnanga o NGĀI TAHU

06 November 2013

TomatoesNZ
P O Box 10232
WELLINGTON, 6143

Email only: Shaun@solutionz.co.nz

Tēnā koe Shaun

Thank you for the pre-application letter "to import three new biological agents (BCAs) to improve the effectiveness of Integrated Pest Management". I apologise for the delay in responding to you.

A tikanga or values based framework for cultural risk assessment allows Te Rūnanga o Ngāi Tahu to make informed decisions about HSNO matters, knowing that the decisions will be consistent with cultural values. The process can be compared to a pōwhiri, whereby we bring manuhiri onto the marae through a process of lifting tapu that removes restrictions, to whakanoa them so that they are accessible and on the same level as tangata whenua. We can take HSNO matters through a similar process, guided by our values and tikanga. We take the new or unknown – what is tapu, and bring it to a state of better understanding and balance, or noa.

Several key values are used by Te Rūnanga o Ngāi Tahu to identify issues of importance and assess the effects of particular HSNO matters on Ngāi Tahu values and interests (i.e. environmental, cultural, health and well-being, economic and Treaty issues). These values are but not limited to: whakapapa, kaitiakitanga, and rangatiratanga.

- ***Whakapapa*** ensures cultural safety, by allowing us to determine whether an activity is natural or unnatural, appropriate or inappropriate. It ensures a holistic view of HSNO matters, recognising the interconnectedness, relatedness and relationships between all things. Whakapapa encourages us to think long term and recognise and provide for the intergenerational aspect of decision-making.

- ***Kaitiakitanga*** is about our responsibility as Te Rūnanga o Ngāi Tahu, both tribally and in our communities, to assess the cultural acceptability of a proposed activity. We are part of the landscape and therefore have a responsibility to ensure its sustenance for this generation and for those to come.

- ***Rangatiratanga*** is about our ability as Te Rūnanga o Ngāi Tahu to influence and participate in decision-making processes and ensure that our values and

Te Rūnanga o Ngāi Tahu
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Website: www.ngaitahu.iwi.nz

> perspectives are reflected in those processes. It is also about the customary authority of whānau and hapū within their own takiwā, the manawhenua of other iwi in their respective territories, and the role of Māori as Tangata Whenua under the Treaty of Waitangi.

The values of whakapapa, kaitiakitanga and rangatiratanga encompass numerous other values important to a tikanga based framework for cultural risk assessment. These include values such as mahinga kai, tapu, mana, and mauri.

Cultural values and principles provide benchmarks or 'tests' against which cultural risks and benefits can be evaluated. They ensure that we ask the right questions when assessing likelihood of risk and magnitude of impact. They also ensure that our responses to HSNO matters are consistent with our tribal vision: Mō tātou, ā, mō kā uri ā muri ake nei – For us and our children after us.

Please see the following link to the HSNO policy.

G:\TRONT\EXR- External Relationships\EXR 12 - Ext Iwi to Government Body\EXR 12-10 - ERMA\EXR 12-10-03 - HSNO\EXG 10-03-02 - Policy - Process Development\2008 - FINAL - HSNO Policy.pdf

Nāhaku nā, noa

Edward Ellison
Chair
HSNO Committee