

THRIPS PALMI – POTENTIAL SURVIVAL AND POPULATION GROWTH IN NEW ZEALAND

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ABSTRACT

Thrips palmi Karny is a major pest of various crops in many countries. It does not occur in New Zealand but could be imported on ornamental plants or vegetables and is potentially a serious threat. Characterising the likely population growth and development of *T. palmi* under New Zealand conditions may assist with any eradication or long term management stemming from an incursion. In northern Asia, *T. palmi* over-winters in the field in warmer areas, while in cooler areas it over-winters in glasshouses, which act as a source of infestation each spring. A simple model was created using the DYMEX population modelling software and previously published parameters. It was modified to fit Japanese and Korean data before running simulations for locations in New Zealand. In New Zealand, *T. palmi* was predicted to be able to over-winter outdoors in warmer areas but, if greenhouse populations establish, these could give rise to outdoor populations during summer in almost all areas investigated.

Keywords: *Thrips palmi*, DYMEX, incursion management.

INTRODUCTION

Thrips palmi Karny is a major pest of various crops in many countries throughout the world. It is not present in New Zealand but, based on establishment in other temperate areas (Layland et al. 1994; Vierbergen 2001), is a potentially serious threat to New Zealand's horticultural industries. As such, the Ministry of Agriculture and Forestry (MAF 2005) has declared *T. palmi* to be a "regulated pest" on The Unwanted Organisms Register. *Thrips palmi* achieves pest status due to direct feeding damage and because it acts as a vector of plant diseases, such as groundnut bud necrosis toposvirus in India and watermelon silvery mottle toposvirus in Japan and Taiwan (CABI/EPPPO 1997).

European experience suggests that an incursion of *T. palmi* in New Zealand is likely. A total of 406 detections of *T. palmi* have been made (time frame not stated) in consignments of ornamental plants and vegetables imported into the USA and Europe, with the majority (79% for Europe and 85% for the USA) being on ornamental plants (Vierbergen 2001).

If *T. palmi* were found in New Zealand, it would be advantageous for MAF to be able to predict where populations could establish and persist, where only transient populations could establish, and population growth in both situations to determine where economic damage was likely to occur under New Zealand conditions. This information could be used to determine whether or not eradication would be necessary, should be attempted or is feasible and, if not, may assist growers to make decisions how best manage the pest. For example, an incursion in an area where the pest is unable to survive the winter outdoors may lead to a decision to allow the insect to die out passively while targeting greenhouses and other sources of summer infestation.

Dentener et al. (2002) determined using CLIMEX, predictive bioclimatic modelling software (Sutherst & Maywald 1999), that it was highly likely that *T. palmi* populations

would be able to survive outdoors through much of the northern North Island. Like most other risk analysis packages, CLIMEX gives only an indication of possible long-term survival of a population within an area. While long-term survival is ultimately more important, an indication of how the pest may behave in the short term has implications for immediate control decisions. The aim of this work was to model populations of *T. palmi* in areas of New Zealand using the modular modelling software DYMEX. DYMEX is a software package that allows the user to interactively build and run models of fluctuating populations of organisms in changing environments, and provides a means of quantitative risk assessment that can be applied in different geographical regions and over differing time scales (Sutherst et al. 2000).

Before running the model for New Zealand locations, it was necessary to know whether the model would accurately predict findings from other countries. Walker (1994) reported that *T. palmi* can over-winter in Okinawa, Japan, but in the southern part of Kyushu and further north, there is no evidence of over-wintering in the field and greenhouses serve as the foci of summer populations. Lee et al. (2001) reported that there is no evidence that *T. palmi* over-winters in the fields of Kumamoto and Okayama in Japan but they found that on Che-Ju Island in South Korea, *T. palmi* could over-winter in the field. To determine whether *T. palmi* was surviving the winter in the fields, Lee et al. (2001) recorded the adult population of *T. palmi* on the island throughout the winter. They found that the adult population was very high in December, decreased from January through April and then slightly increased from May. While they did not identify larval thrips to species level, larvae were seen together with aggregated *T. palmi* adults until late December. This information was used to verify the model.

METHODS

Software and weather data

Version 2 of DYMEX Builder (Maywald et al. 2004) and Simulator (Maywald et al. 2004) were used throughout model development. Weather data was sourced through Metbroker (Laurenson et al. 2002). New Zealand data originated from CliDB (NIWA), data for comparison from Korea came from the noaa database and from Japan, AmedAS.

Biological parameters used in model

The lifecycle of *T. palmi* consists of an egg, two larval instars, prepupa, pupa and adult stages. We included only four stages (egg, larva, pre-pupa/pupae and adult) in the DYMEX model as most of the literature does not provide separate information for first and second instars, or prepupal and pupal stages. Although females dominate *T. palmi* populations, males do occur. In order to account for this, populations in the model were assumed to be all female but the number of eggs laid per female was adjusted based on the assumption that 80.7% of individuals in real populations are female (Rosenheim et al. 1990). Parameter values were sourced from the available literature (Table 1 and below). Differences within parameters between sources were mainly due to differences in host plants and rearing techniques. In these cases, data from the different sources were combined to determine an "average" result unless there appeared good reason to favour one study over another.

Temperature was the only climatic variable considered in our model. There is no indication in the literature that rainfall or humidity are limiting factors for *T. palmi* development or survival. Rainfall data from the Japanese and Korean sites were analysed but no association between rainfall and *T. palmi* populations was detected.

To move the cohorts between stages and to remove the adults from the simulations, the step function was used with physiological age as the driving variable and both threshold and step height set to one, meaning all insects will move to the next cohort instantaneously when they reach a physiological age of 1. Potential fecundity was set at 200 eggs/female (Martin & Mau 1992) while daily progeny production was modelled to be temperature dependant. It was modelled using a linear above threshold function with the threshold set at 8.776°C and the slope of the function at 0.1574.

TABLE 1: Parameters used in the DYMEX model for each developmental stage of *T. palmi*.

	Egg	Larva	Pre/Pupa	Adult
Development ¹				
Driving variable		Daily temperature cycle		
Function shape		Linear above threshold		
Threshold	9.37	7.69	8.48	8.634
Slope	0.0112	0.0101	0.0125	0.0041
Cold mortality				
Driving variable		Minimum temperature		
Function shape		Linear below threshold		
Threshold	3	5	2	1
Slope	-0.5	-0.6	-0.6	-0.3
Daily mortality ²				
Driving variable		Days since start		
Constant	0.003	0.05	0.03	

¹Kawai 1985; Tsai et al. 1995; Wu et al. 1995; McDonald et al. 1999; Vijayalakshmi et al. 2000.

²Kawai & Kitamura 1987.

Validation of model using data from Japan and Korea

Iterations of the model were run for the Japanese sites, Kumamoto (32°70', 130°50') Okinawa, (26°00', 130°00') and Okayama (34°50' 133°30'), and Che-Ju Island (33°2', 126°20') in Korea using temperature data from 1996 to 2001 (initialisation date 1 June, initialised with 10 adults) to determine whether the model developed explained observations of the populations in these areas. Where the model failed to explain the observed data iterative adjustments were made.

New Zealand simulations

Survival and growth of *T. palmi* populations in New Zealand conditions were simulated using temperature data from 2000 to 2004 for six locations: Kerikeri (-35°11', 173°55.5'), Onehunga, Auckland (-36°56', 174°48'), Tauranga (-37°60', 176°12') and Napier (-39°28', 176°52') in the North Island and Nelson (-41°18', 173°14') and Christchurch (-43°32', 172°37') in the South Island. Model initialisations were started with 10 adults on 1 January, assuming that any incursion would consist of a small number of adults that evade detection and/or survive quarantine treatment. While the predicted timing of the initial population peak could vary with differing initialisation dates, the overall pattern of population growth and development remain similar.

RESULTS

Japanese and Korean simulations

The results from the areas in Japan and Korea (Fig. 1) from which the model was validated are broadly consistent with the descriptions of population dynamics given in the literature. In Okinawa, climate shows no regulatory effect and the population increases exponentially. The population in Che-Ju is able to increase exponentially until mid-winter when there is a levelling off but the population increases again during the spring, except in extreme years such as 2000-01 and 2002-03 (data not shown) where the population goes extinct. In Kumamoto and Okayama, the initial population build-up is slower but the population increases during spring, summer and early autumn. Numbers decrease rapidly with the onset of winter and population are unable to survive throughout the winter in Okayama and during most winters in Kumamoto. In Kumamoto, they may overwinter in very low numbers (not visible due to the scale used) in warm winters such as 1998-99 and 2001-02.

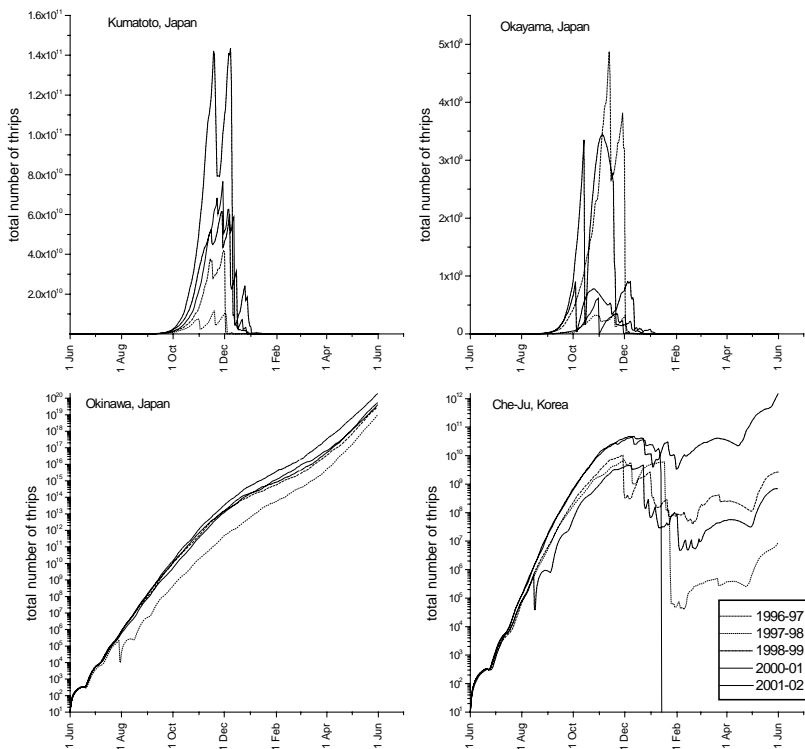


FIGURE 1: Population growth of *T. palmi* predicted by the Dymex model for four localities in Japan and Korea. Note differences in y-axis values.

New Zealand simulations

Thrips palmi appears likely to be able to establish outdoor populations in the northern North Island which will persist year round. However, it is likely to die out during the winter in other regions (Fig. 2). For the simulations at both Kerikeri and Onehunga, *T. palmi* populations showed a rapid increase in numbers immediately after arrival and continued to increase until mid-winter (1 July). In late winter there appeared to be a levelling off of numbers but this increased again during spring and into summer. The model suggests that at these sites, populations could continue to increase over time and that climate alone will have very little regulatory effect. At Napier, Nelson and Christchurch the predicted initial build up is slower but populations will be able to increase through late summer and autumn. With the onslaught of winter, numbers decrease rapidly and populations in these areas appear unlikely to be able to persist through the winter. The situation is similar for Tauranga but, although numbers decline markedly in winter, *T. palmi* can survive at low levels which allows populations to increase rapidly in spring. Predicted population numbers show substantial variation between years in all locations.

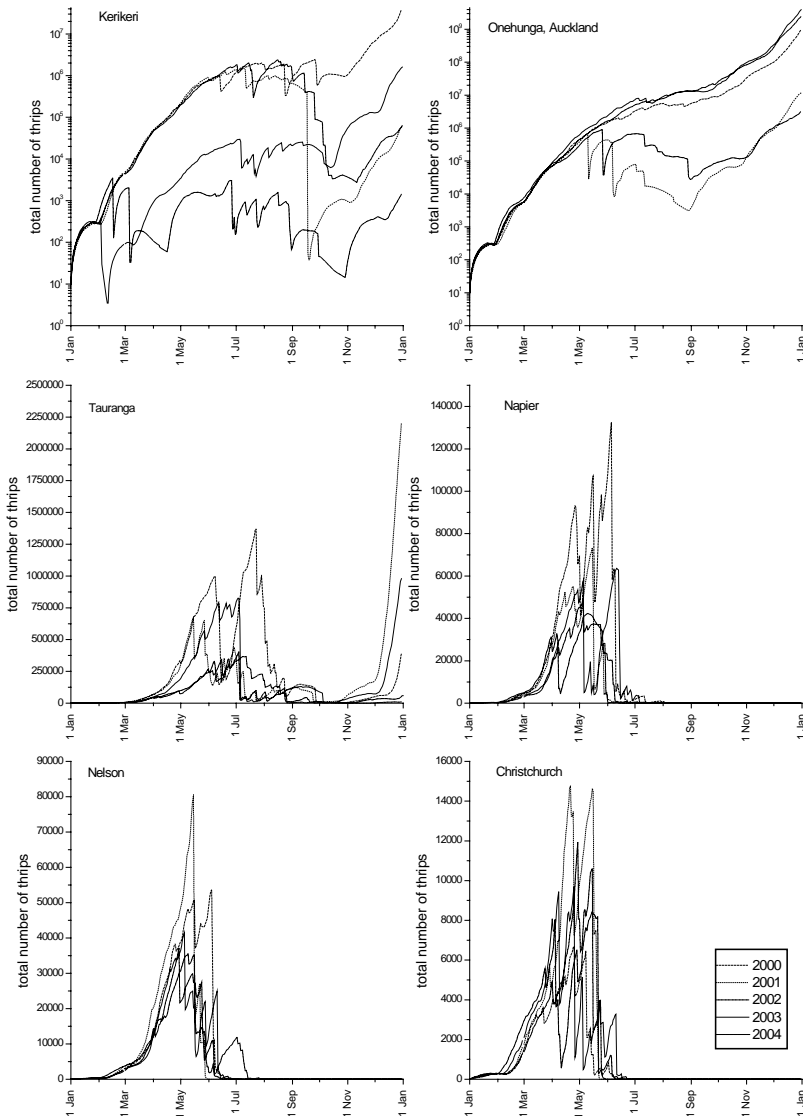


FIGURE 2: Population growth of *T. palmi* predicted by the Dymex model for six localities in New Zealand. Note differences in y-axis values.

DISCUSSION

The results presented here indicate that *T. palmi* would be likely to survive and establish populations if it were to arrive in New Zealand, at least in mid summer. The climate in warmer parts of the country, such as Onehunga (Auckland) and Kerikeri, is predicted to

enable it to survive and develop year round. In slightly cooler areas such as Tauranga, numbers are likely to be greatly reduced in winter but some *T. palmi* are predicted to survive and serve as nuclei of populations the following spring. The level of population growth and development may vary greatly from year to year. In colder regions such as Napier, Canterbury and Nelson, *T. palmi* is not predicted to establish long term field populations. However, if populations were to establish in greenhouses, these could be starting points for summer field populations as occurs in northern Japan. *Thrips palmi* is likely to be prevented from persisting in colder areas due to “cold mortality” during winter rather than a lack of thermal input during the summer. This is consistent with the suggestion that, in the UK, *T. palmi* is unlikely to be limited by an inability to complete its life cycle during favourable seasons (McDonald et al. 1999). New Zealand summers are predicted to be suitable for population growth and development.

If *T. palmi* arrives in New Zealand, the information deduced by the model can assist in developing strategies for control and/or eradication, appropriate to the area of infestation. In warmer areas where populations are likely to survive through winter, extensive control measures are likely to be needed, whereas in cooler areas a combination of greenhouse pest control and internal quarantine measures may be sufficient to eliminate populations. However cooler areas are likely to be vulnerable to persistent re-invasion from warmer areas if *T. palmi* establishes there.

The model is based on a single point location without the inclusion of density dependency. As such, it is difficult to determine what the modelled populations might mean in terms of damage. The build up of numbers from a starting point of 10 individuals in Japan and Korea is predicted to be more rapid than a similar situation in New Zealand and by implication the model predicts more rapid build up on a yearly basis in these countries but other differing influences will affect absolute numbers.

In general, this model agrees with the findings of Dentener et al. (2002). They conclude that *T. palmi* is likely to survive in the upper North Island (Northland, Auckland, Coromandel, Waikato and Bay of Plenty), which are areas that correspond to an Ecoclimatic Index (EI) >15 (EI gives an overall index of the suitability of an area for a species and is scaled from 0-100). In areas with an EI <15 (Nelson, Napier and Christchurch) both Dentener et al. (2002) and the model presented here suggest that low temperatures during winter will prevent *T. palmi* from establishing in these areas. While more research will develop the model further, these simulations indicate the effect of low temperatures as a limiting factor for population survival and have shown the potential for population outbreaks in some areas in New Zealand.

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