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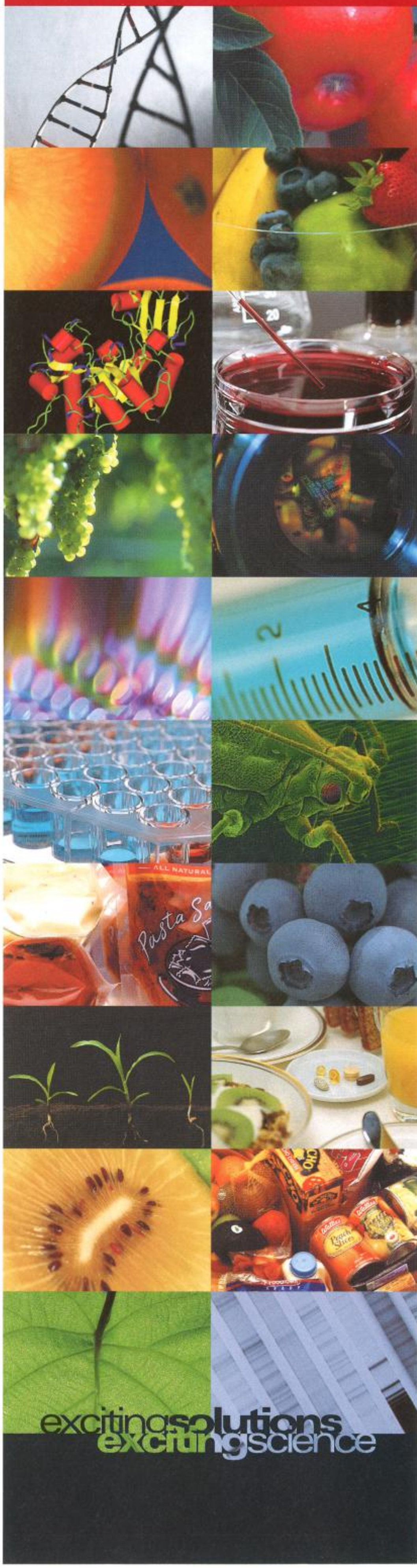

Temperature development rates of onion thrips
Final Report

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CONTENTS

Page

EXECUTIVE SUMMARY

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Objectives

To determine temperature development rates and lower temperature thresholds of onion thrips in New Zealand.

Methods

Thrips development was monitored daily from egg to adult on leek, onion leaf and onion bulb discs at 8, 12, 18, 21, 25, 30°C, and at variable ambient temperatures.

Key Results

There were no significant differences detected between temperature development rates of onion thrips when feeding on leeks, onion leaves or onion bulbs.

Survival of thrips was lower when feeding on onion bulbs compared with leek and onion leaf discs

Total developmental time (egg to adult) ranged from 51.1 days at 12°C to 10.3 days at 30°C.

Lower developmental temperature thresholds for each life stage ranged from 7.34°C for pupae to 9.06°C for eggs.

Thermal constants ranged from 63.61 degree-days for pupae to 78.78 degree-days for larvae.

Using the developmental model developed from the constant temperature data, the observed developmental times under variable conditions were predicted within 1 day.
Using the developmental model and temperature data from Pukekohe and Canterbury it was concluded that onion thrips populations were able to undergo two additional generations in 1998/99 season (a season when onions had very high thrips damage) when compared to 2004/05 season (a season when onion had low-moderate thrips damage) in both regions.

Onion thrips undergo 10-12 generations per year in Pukekohe compared with 6-8 generations per year in Canterbury, enabling thrips to reach more damaging levels in Pukekohe.

During a 6-week storage period, onion thrips could potentially go through two generations while in storage during February, March or April. However, due to the low survival and oviposition rates of onion thrips on onion bulbs the likelihood of onion thrips populations from field infestations increasing significantly on bulbs in storage is low.

Future Research

Confirm the developmental model under a range of variable temperature conditions.

Determine the damage potential of larval and adult onion thrips to onion bulbs.

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INTRODUCTION

A high incidence of onion thrips (*Thrips tabaci*) in export onion consignments has been a serious problem for the New Zealand onion industry since 1997. Feeding damage by thrips causes blemishes, shrivelling and skin separation, often resulting in a significant decrease in onion bulb quality. Consignments containing thrips not only lower the market value of the onions, but also infringe quarantine regulations of importing countries.

Understanding the relationship between insects and temperature is a critical component of pest management particularly in relation to the development of thrips on onion leaves in the field and bulbs in storage. Overseas research has examined the development of onion thrips under constant temperatures, however none of these studies have been carried out on onion bulbs. Overseas research has estimated lower thresholds ranging from about 4°C (Stacey and Fellowes 2002) to 11.5°C (Edelson and Magaro 1988). Geographic location and host plant nutritional quality have previously been highlighted as potentially important factors leading to these differences and emphasize the need for research on development with New Zealand strains and hosts.

Knowledge of thrips temperature development rates will:

- enable predictions of when the damaging later generations will occur in the field after the first adult thrips are detected through monitoring,
- assist with more appropriate timing of sprays in clusters,
- provide information about the intrinsic rate of increase of thrips on stored onion bulbs.

The objective of this study was to determine temperature development rates and lower temperature thresholds of onion thrips in New Zealand.

METHODS

Onion thrips used in the following trials were collected from a commercial crop in Puni on 2 February 2005 and reared by Crop and Food Research (Martin and Workman 2005).

Preliminary study

A preliminary bioassay was set-up to determine the number of thrips that we would be required for the main bioassay and to test if the bioassay procedures were appropriate.

Forty discs (18 mm diameter) of leek (sheath), onion leaves and onion bulbs were cut using a sharpened metal pipe. Discs were placed in petri dishes (50 mm diameter) lined with moist filter paper. Five female adults were place on each disc and the lid was secured. The thrips on discs were placed at 21°C, photoperiod 16:8 (L:D) for 24 h. Adults were then removed and discs were checked daily for the presence of thrips larvae. Once larvae had emerged individual thrips were relocated to a fresh leek, onion leaf or onion bulb disc and these were replaced every 2-4 days when required. Discs were kept for 30 days and the number that reached adult-hood was recorded.

Main bioassay

A total of 2100 female adult onion thrips were placed on 420 leek discs as described above. Only leek discs were used for oviposition because of problems with quality of onion leaves and onion discs in the preliminary trial. Discs were checked daily for larval emergence. On the day that a larva emerged it was transferred to a leek, onion leaf or onion bulb disc. Discs were placed at 8, 12, 18, 21, 25 or 30°C, photoperiod 16:8 h (L:D). An additional sample was placed outside at ambient variable temperature. Twenty leek discs and onion leaf discs with a single thrips larva were set up for each temperature. Due to low survival rates on onion bulb discs, 40 of these with and individual larva were set up. A total of 650 larvae were used for the trial. Discs were checked daily and the life-stage of each insect recorded.

Statistical analyses

The rate of development (1/time) was compared amongst temperatures and food sources using ANOVA using Genstat (Release 7.2). Least significant differences were calculated to separate treatments if the ANOVA resulted in a $P<0.05$.

The relationship between temperature and developmental rate for each life stage (egg larval and pupal) was calculated by linear regression analysis.

The developmental threshold temperature (t) and thermal constant (K) required for each life stage were derived from the regression equation y-a + bx, where y is the developmental rate at temperature x, a is the y-intercept and b is the slope. The developmental threshold and thermal constant values were calculated using the following formulae:

Developmental threshold $t = (y-a)/b$,
$t = (0-a)/b$.
y is set at 0, as we are attempting to determine the temperature at which development ceases (developmental rate zero).

Thermal constant is calculated by $K = 1/b$.

RESULTS AND DISCUSSION

Preliminary study

Sixty eggs were laid on the leek discs after 5-7 days. Female adults laid approximately 1.5 eggs per adult over the 24 h period. No larvae emerged from eggs laid on onion leaf or bulb discs. Both onion substrates were mouldy and/or rotten by day 7. In these experimental conditions, survival of thrips on onion bulbs was lower than on onion leaves or leeks (Table 1).

Table 1. Survival of larvae transferred to either leek, onion leaf or onion bulb discs.

Feeding substrate	No. neonate larvae transferred	No. individuals that survived to adult	Percentage that survived to adult
Leek	20	11	55
Onion leaf	20	15	75
Onion bulb	20	5	25

Main bioassay

Onion thrips eggs took 3.4-12.7 days to hatch on leek discs depending on temperature (Figure 1). None of the eggs placed at 8°C hatched.

There were no significant differences ($P > 0.05$) between the development times of larvae and pupae of onion thrips on leeks, leaves and bulbs (Figures 2 and 3, respectively).

Adults lived for a shorter amount of time on onion bulb discs compared with leek and onion leaf discs (Table 1). Survival to the pupal and adult stage was less on onion bulb discs when compared to leek and onion leaf discs.

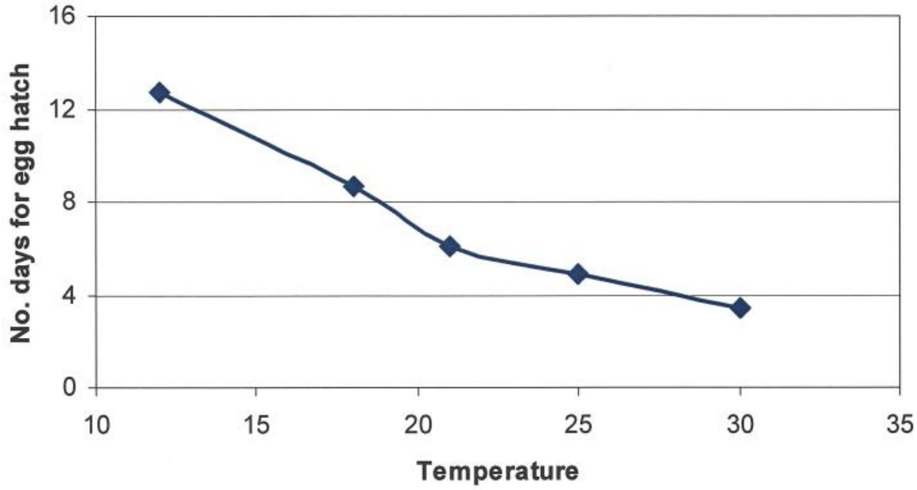


Figure 1: The average egg development time on leek discs at five constant temperatures.

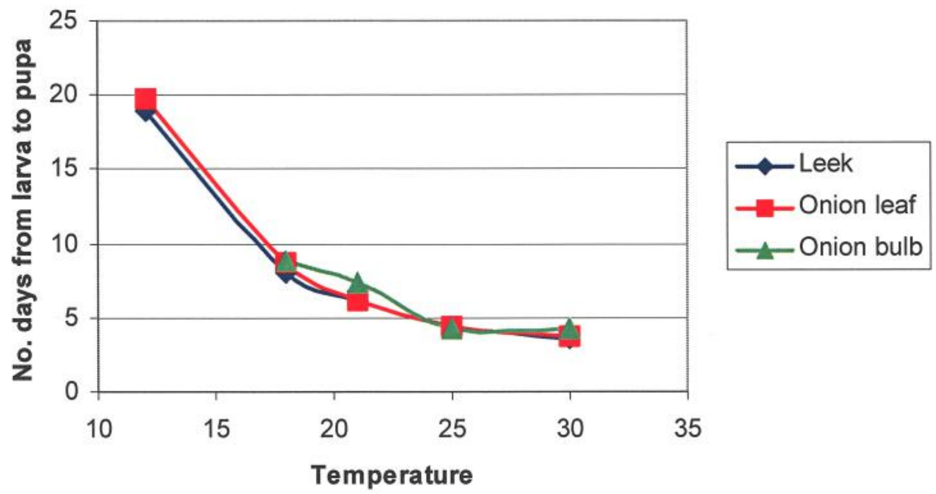


Figure 2: The average larval development time on leek, onion leaf and onion bulb discs at five temperatures.

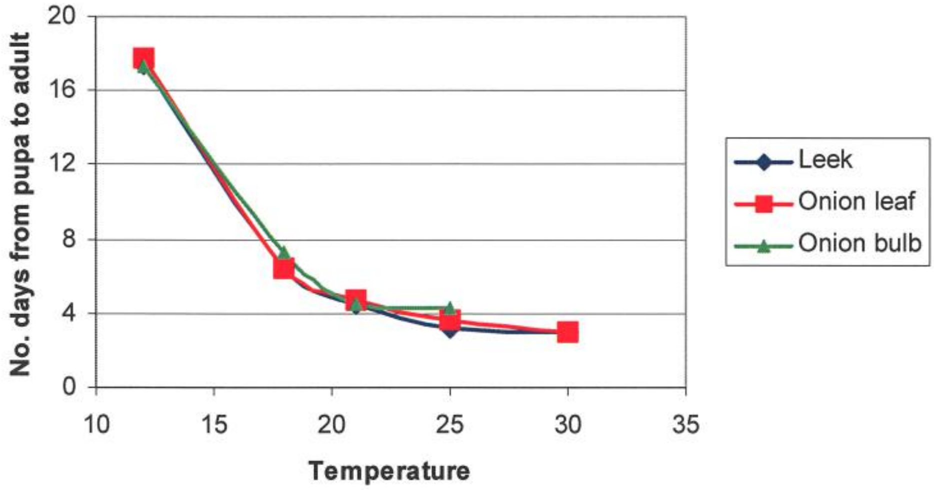


Figure 3: The average pupal development time on leek, onion leaf and onion bulb discs at five temperatures.

Table 1: The mean (SEM) adult longevity and percentage of thrips that survived to pupa or adult at each constant temperature. N.B. * = no survival though that life-stage.

Food source	Temperature	Adult longevity	Survival to pupa (%)	Survival to adult (%)
Leek	30	6.8 (2.3)	50	25
	25	5.8 (1.7)	40	25
	21	17.6 (2.9)	75	60
	18	20.0 (0.3)	70	70
	12	69.6 (14.7)[1]	50	42
Onion leaf	30	5.3 (0.9)	55	35
	25	6.8 (0.6)	50	45
	21	11.4 (1.0)	85	60
	18	16.7 (2.5)	60	50
	12	34.3 (20.7)	27	27
Onion bulb	30	*	10	0
	25	4.0 (2.1)	15	10
	21	1.5 (0.3)	15	7.5
	18	4.7 (2.0)	15	7.5
	12	*	8	0

[1] Adults thrips still alive on 18 July 2005.
* No survival to adult.

The average developmental times for each life stage of onion thrips at each of the constant temperatures are shown in Table 2. Total developmental time (egg to adult) ranged from 51.1 days at 12°C to 10.3 days at 30°C.

There was a linear trend of increasing developmental rate with increasing temperature for all life stages. The regression of developmental rate to temperature was significant for all life stage (R^2 values > 0.71), indicating a strong correlation between the two variables (Table 3).

There were significant differences in developmental times among the five constant temperature regimes (P-values < 0.001) for all of the life stages. Lower developmental thresholds for each life stage ranged from 7.34 for pupae to 9.06 for eggs and thermal constants ranged from 63.61 for pupae to 78.78 for larvae. Other studies have estimated the lower development thresholds ranging from 4°C (Stacey and Fellowes 2002) to 11.5°C (Edelson and Magaro 1988). Geographical location and nutritional quality of food source have previously been highlighted as potentially important factors leading to these differences. However in this study the nutritional quality of leek, onion leaves and onion bulbs did not have a significant influence on developmental rates. Nonetheless, food quality did affect survival and longevity of onion thrips. Murai (2000) estimated that 232.6 degree-days above a developmental threshold of 10.8°C were required to onion thrips to complete development from egg to adult on a diet of pollen and honey solution, while Edelson and Magaro (1988) estimated 191.1 degree days above threshold of 11.5°C.

Using the developmental model developed from the constant temperature data, the observed developmental times under variable conditions were predicted within one day (Table 4).

Table 2: Mean (SEM) developmental times (days) of onion thrips life stages.

Life stage	12°C	18°C	21°C	25°C	30°C
Egg	17.6 (0.2)	8.7 (0.1)	6.0 (0.2)	4.9 (0.1)	3.4 (0.1)
Larva	19.1 (0.6)	8.5 (0.2)	6.2 (0.2)	4.5 (0.2)	3.8 (0.1)
Pupa	13.8 (0.6)	6.6 (0.1)	4.7 (0.4)	3.7 (0.2)	3.0 (0.0)
Egg to adult	51.1 (0.6)	23.3 (0.2)	16.8 (0.5)	13.0 (0.4)	10.3 (0.2)

Table 3: Relationship between temperature and development of onion thrips and calculated lower development thresholds and thermal constants.

Life stage	Regression	n	R^2	P-value	Lower development threshold (t) (°C)	Thermal constant (K) (degree-days)
Eggs	y = -0.12496 + 0.013788x	356	0.87	<0.001	9.06	72.53
Larvae	y = -0.1047 + 0.012693x	134	0.81	<0.001	8.25	78.78
Pupae	y = -0.1154 + 0.01572x	93	0.71	<0.001	7.34	63.61
Total (egg to adult)						214.92

Table 4: Observed and predicted developmental times (days) of onion thrips eggs, larvae and pupae under variable conditions.

Life stage	Observed mean (SEM)	Predicted	Mean temperature during development (°C)
Eggs	7.2 (0.1)	6.8	19.71
Larvae	6.9 (0.2)	7.2	19.11
Pupae	5.5 (0.2)	4.9	20.22

The developmental thresholds and thermal constants were used to model the development times of each life stage using daily 9 am bulb temperature data from Pukekohe and

Canterbury during a high thrips season (1998/99) and a comparatively low thrips season (2004/05) (Figures 4-6). A pre-oviposition period of one day was included in the model based on previous observations by N. Martin. Higher temperatures in 1998/99 season resulted in faster development of all life stages compared with temperatures in 2004/05 season, particularly in the winter months. This resulted the thrips populations being able to undergo two additional generations in 1998/99 season when compared to 2004/05 season in both regions (Table 5, Figure 7). Onion thrips undergo 1.5-1.7 times more generations in Pukekohe compared with Canterbury, enabling thrips to reach more damaging levels in Pukekohe.

Using mean daily storage temperatures in onion bins collected from 27 January until 30 June 2005 (Figure 8), the developmental model was used to determine the development times of each onion thrips life stage (Figure 9) and number of generations that onion thrips would develop through (Figure 7). During a 6-week storage period, onion thrips could potentially go through two generations while in storage during February, March or April. However, due to the low survival rates of onion thrips on onion bulbs observed in this study (Table 1) and the low oviposition rates of onion thrips on onion bulbs observed in other studies (N. Martin pers. com.) the likelihood of onion thrips populations increasing significantly on bulbs in storage is low.

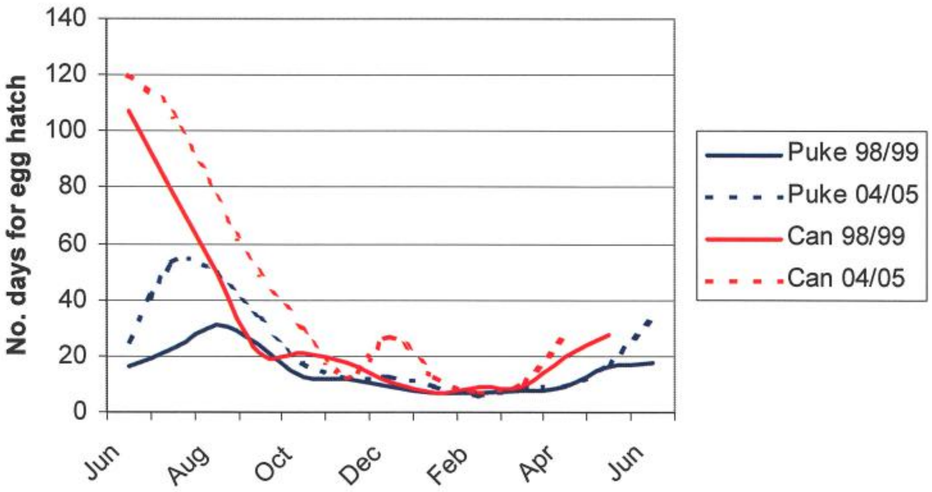


Figure 4: The number of days predicted for onion thrips egg development in Pukekohe and Canterbury onion field during the 1998/99 and 2004/05 seasons.

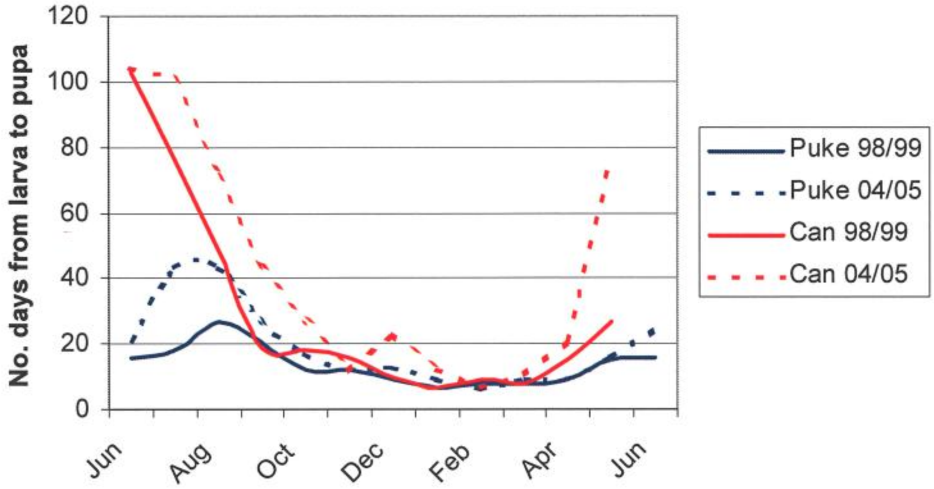


Figure 5: The number of days predicted for onion thrips larval development in Pukekohe and Canterbury onion field during the 1998/99 and 2004/05 seasons.

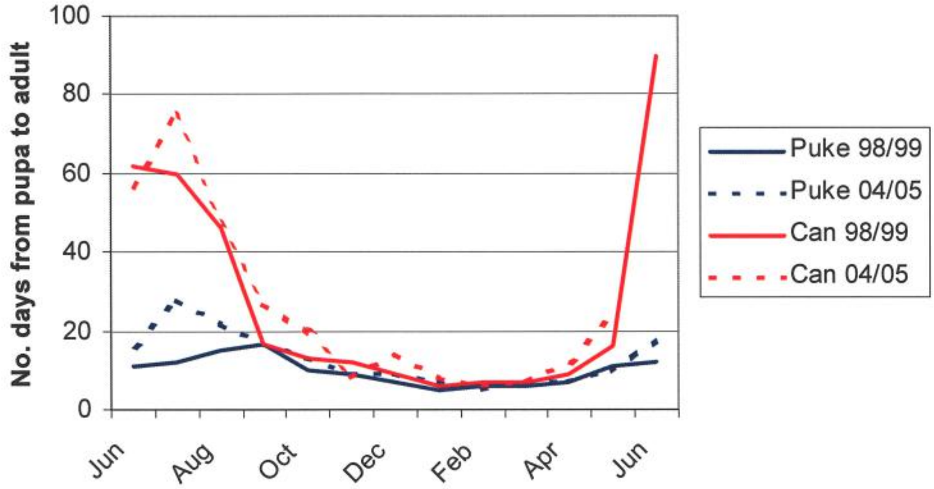
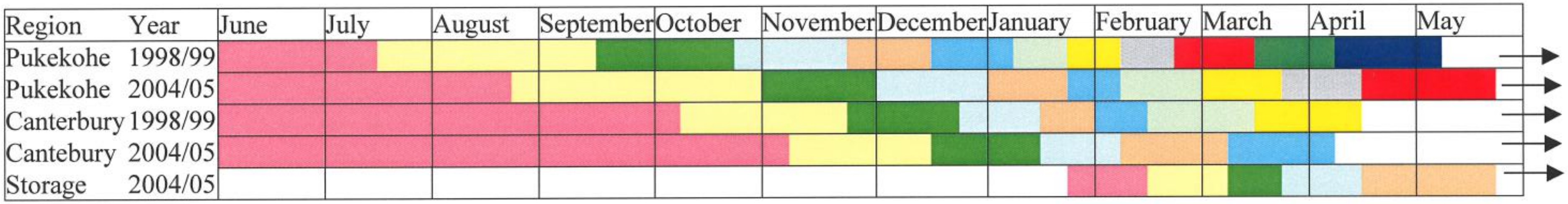


Figure 6: The number of days predicted for onion thrips pupal development in Pukekohe and Canterbury onion field during the 1998/99 and 2004.05 seasons.

Table 5: The predicted number of generations onion thrips went through in the field from June 1 until 31 May when comparing actual field bulb temperature data with the developmental model for Pukekohe and Canterbury 1998/99 and 2004/05 seasons.

Region	Season	No. of complete generations
Pukekohe	1998/99	12
Pukekohe	2004/05	10
Canterbury	1998/99	8
Canterbury	2004/05	6

Figure 7: The timing of each generation as predicted by the developmental model if eggs laid on the 1 June in the field or the 27 Jan in storage.



Each colour band represents a single generation (egg to adult) of onion thrips based temperature data collected in field (rows 1-4) and in storage (row 5).

Arrows indicate an incomplete generation.

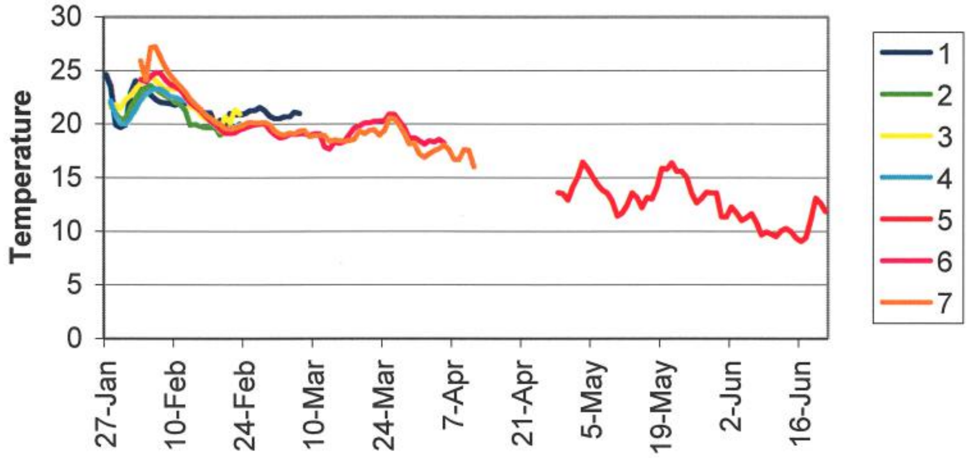


Figure 8: The average daily temperature in storage facilities in Pukekohe during the 2004.05 season.

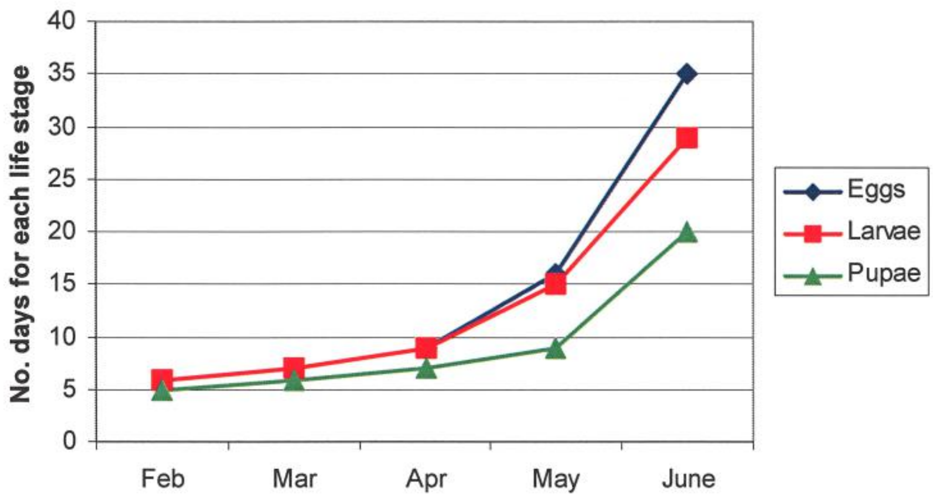


Figure 9: The number of days predicted for the development of each life stage in storage facilities in Pukekohe during the 2004/05 season.

CONCLUSIONS

There were no significant differences detected between temperature development rates of onion thrips when feeding on leeks, onion leaves or onion bulbs.

Survival of thrips was lower when feeding on onion bulbs compared with leek and onion leaf discs

Total developmental time (egg to adult) ranged from 51.1 days at 12°C to 10.3 days at 30°C.

Lower developmental temperature thresholds for each life stage ranged from 7.34°C for pupae to 9.06°C for eggs.

Thermal constants ranged from 63.61 degree-days for pupae to 78.78 degree-days for larvae.

Using the developmental model developed from the constant temperature data, the observed developmental times under variable conditions were predicted within one day.

Using the developmental model and temperature data from Pukekohe and Canterbury it was concluded that onion thrips populations were able to undergo two additional generations in 1998/99 season (a season when onions had very high thrips damage) when compared to 2004/05 season (a season when onion had low-moderate thrips damage) in both regions.

Onion thrips undergo 10-12 generations per year in Pukekohe compared with 6-8 generations per year in Canterbury, enabling thrips to reach more damaging levels in Pukekohe.

During a 6-week storage period, onion thrips could potentially go through two generations while in storage during February, March or April. However, due to the low survival and oviposition rates of onion thrips on onion bulbs the likelihood of onion thrips populations from field infestations increasing significantly on bulbs in storage is low.

Future Research

Confirm the developmental model under a range of variable temperature conditions.
Determine the damage potential of larval and adult onion thrips to onion bulbs.

ACKNOWLEDGEMENTS

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