I dedicate this disertation
to
my beloved mother and father

Interactions between *Anystis baccarum* (Acari: Anystidae), a generalist predatory mite, and larvae of *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae), a pest of apples

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ABSTRACT

A large numbers of Anystis baccarum (Acari: Anystidae) were discovered living alongside of Epiphyas postvittana (Lepidoptera: Tortricidae) larvae known as light brown apple moth (LBAM) in shelter belt of acacia, Acacia rewa (Leguminoseae: Sub family Mimosoidae). Few questions that needed to be answered were whether the mites actually feed on the LBAM larvae and what are their interactions. The objective of my study was to investigate the general characteristics of mite feeding on LBAM larvae, and to study the age, density, webs and defence behaviour of larvae as exogenous factors, and the effect of level of starvation and experience of mites as endogenous factors on foraging behaviour of A. baccarum.

Eleven experiments were conducted under laboratory conditions. At 20 c, the average daily consumption rate of A. baccarum was 11.5±2.68 neonate E. postvittana larvae of 1.484 mm in lenght and 0.231 mm in width. The predator spent 1106± 309 seconds mean feeding time, feeding on a neonate larvae of E. postvittana. A. baccarum is cannabalistic and survived 6.1±2.28 days totaly deprived of food and water.

Webs of E. postvittana larvae act as a physical barrier to attack of A. baccarum. When the webs were removed larvae upto eight days of age were consumed by A. baccarum, however survival from capture by mite increased with age. When the mite was given a choice between three different age groups of larvae, a higher number of neonate larvae were taken as the first choice, but the overall results showed the choice depends on random encounters between

the predator and prey and prey avoidence behaviour of larvae. Spinning was the most frequent avoidence behaviour of larvae without webs. Spinning response occured less frequently with increased age of the larvae. The most common response of larvae in webs was quick movement forwards or backwards.

Starvation for 24 hours did not significantly increase walking speed of A. baccarum over walking speed of non-starved mites, but walking speed was decreased at 48 hr and 72 hr starvation. However, starvation increased prey capture of A. baccarum compared to non starved condition. Starvation also had a significant effect on number of captures at first encounter.

A. baccarum with no experience of prey on apple shoots prefered to rest on branch of apple than leaf and fruit given that area of the branch is low, preference was even greater. On their search of alternative walking and resting periods, A. baccarum spent significantly more time walking than resting. When given experience of feeding a neonate larva of LBAM on branch, leaf or fruit, A. baccarum spent significantly more time walking on the location they were fed.

In conclusion, the larvae of E. postvittana includes in to the list of prey of A. baccarum. If encounterd during their dispersal phase after hatching, possibilities are high that neonate larvae of E. postvittana to be preyed by A. baccarum ocurring in large numbers in orchrd ecosystems in New Zealand. Studies on this predator-prey interaction opens new venues of research on generalised predator-prey interactions.

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CHAPTER 1

LITERATURE REVIEW OF MITES AS BIOLOGICAL CONTROL AGENTS

1.1 Introduction

In many parts of the world, predatory mites are currently being evaluated as control agents against leaf-feeding insects and mites. This interest in using predatory mites as biological control agents is fairly recent. Three decades ago most of the acarines now being considered as biological control agents against leaf-feeding insects had not even been identified. The first mite recognized for its ability to reduce pest populations (reviewed by Gerson and Smiley, 1990), was Hemisacroptes malus (Shimer), which feeds on the oyestershell scale, Lepidosaphes ulmi (L.), reported from America in 1868. They noted that the first international shipment of these mites as natural enemies was undertaken in 1873 following redocumentation of the importance of the mite by C.V. Riley in the same year. The project of transfering predatory mites to from eastern Canada to western Canada in 1917 control the same prey was rated as a successful biological control project by Turnbull and Chant (1961). The Bdellid mite, Bdellodes lapidaria Kramer, was discovered (Womersley,1933) as a predator of the lucerne flea, Smithurus viridis (L.), in Australia. Uchida and Miyazaki (1935) considered water mites as important enemies of mosquitoes. Thereafter many species of predatory mites were recognised as important biological control agents by scientists all over the world.

Although Acari were identified for their potential use against some pests from the beginning of the rise of biological control as a discipline, it was only from the 1950's onwards that the potential of the Phytoseiidae and other mites

was recognized and mites began to draw the attention they deserve as biocontrol agents. Table 1 summarises important mites which provide control of agricultural pests. Many applied studies including introductions of predatory mites to control different pests have also been done.

In 1982, the Berkeley Conference on biological control of pests by mites was held. The following recommendations were made by contributers to the conference (Gerson and Simley, 1990): (1) that further exploration for predaceous mites be undertaken as well as basic research on mite systematics and biology, (2) that mass rearing methods and quality control be developed, (3) that field experiments employing appropriate controls be conducted on promising candidates, (4) that better (and more uniform) evaluation procedures be devised, and (5) that means of integrating the emerging, promising acarine biocontrol agents into existing pest management programmes be developed.

1.2 Systematics of predatory mites

The Class Arachnida is comprised of eleven divisions. All but two of these are completely predaceous in habit, with representatives often displaying a variety of morphological characteristics well suited to a predatory existence (Krants,1975). In the subclass Araneae (spiders), the head and thorax are combined in a single unit, the cephalothorax, jointed to the abdomen by a slender pedicel. The subclass Acari includes the ticks and the mites. The acarine body (Krants,1975) is composed mainly of the idiosoma, while mouth-parts are borne on the gnathosoma, an anterior region more or less distinct from the idiosoma. All the acarine biological control agents belong to order Acariformes and order Parasitiformes. The important suborders to which they belong are Crytostigmata, Astigmata, Prostigmata, and Mesostigmata.

Table 1. Some mites which provide control of agricultural pests (source-Gerson and Smiley, 1990 p. 142, modified).

Mite Family	Natural enemy	Pest	Pest order	Habitat
Anystidae	Anystis spp	Earth mite	Prostigmata	Pastures
		Lucerne flea	Collembola	Pastures
Ascidae	Blattisocius	Ephestia	Lepidoptera	Stored products
Bdellidae	Bdellodes spp	Lucerne flea	Collembola	Pastures
Cheyletidae	Cheyletus spp	Acarids	Prostigmata	Stored products
Hemisarcoptes	Hemisarcoptes	Armoured scale insects	Homoptera	Orchards
Macrochelidae	Macrocheles	Bush flies	Diptera	Cowdung
Phytoseiidae*	Amblyseius fallacis	European red mite	Prostigmata	Orchards
		Two spotted spider mite	Prostigmata	Orchards
Phytoseiidae	Euseius	Citrus thrips	Thysanoptera	Orchards
Phytoseiidae	Phytoseiulus persimilis	Spider mites	Prostigmata	Green houses
Phytoseiidae*	Typhlodromus occidentalis	Two spotted spider mite	Prostigmata	Orchards
Phytoseiidae	Typhlodromus pyri	Spider mites	Prostigmata	Orchards
Stigmaeidae	Stigmaeids	Brevipalpus	Prostigmata	Tea

*(Early,1984)

Records on common predatory mites belonging to 29 acarine families were reviewed by Gerson and Smiley (1990) and are summarised in Table 2. Information on recently recorded predatory mites are included with the relevant references.

The literature on predatory mites is voluminous but it has recently been condensed (Gerson and Smiley, 1990) and largely concerns the usefulness of one family, the Phytoseidae, in the control of spider mites in horticultural crops. In the Canary islands, Pande et al. (1989) report of seven species of tetranychid mites together with data on 4 species of predatory phytoseiids associated with them. Kreiter et al. (1991) on the other hand reviewed the predatory mites which are found in viticulture and fruit tree culture.

1.2.1 Recent studies on biology

The study of the biology of predatory mites is a prerequisite for applied studies. Abou-Awad and Reda (1992), showed fecundity of frequently mated females of predatory mite Agistimus exsertus was greater than females mated only once. A positive relationship was noted between the number of progeny and sex ratio at different intervals of the reproductive period. Kreiter (1991) described the biology, morphology, behavior and occurence of 36 phytoseiid predators that occur in France.

Table 2. Common features of predatory mite families, predatory mites recorded, and their hosts.

Family	Common Features	Predatory mite species	Hosts
Acaridae	Whitish, slow moving, many species associated with arthropods, commonly occur in stored foods.	Tyrophagus putrescentiae	Arthropods in stored grain, cheese, fungus cultures.
		Rhizoglyphus echinopus	plant parasitic nematodes
Anystidae	Large, reddish, soft bodied, fast runners, carry few dorsal setae, possess a palpal thumb-claw complex, prey on mites and small insects,	Anystis agilis	Many pests infesting alfalfa, apple and citrus orchards, and vineyards
		Anystis baccarum	Spider mite
		Anystis salicinus	red-legged earth mite, lucerne flea
Arrenuridae	Heavily sclerotinised bodies	Arrenurus spp.	Mosquitoes

Family	Common Features	Predatory mite species	Hosts
Ascidae	Free living predator Commonly found in soils, on plants and in stored products	Blattisocius tarsalis	Stored product pest moth
		Arctoseius cetratus	Mushroom pests
		Platyseius spp.	Mosquito egg and larvae
		Cheiroseius spp.	Mosquito egg and larvae
		Lasioseius parberlesi	Mite pest of rice
		L. scapulatus	Nematodes
Bdellidae	Snout-like mouthparts, fairly large in size (4 mm), red-brown or greenish, active hunters.	Bdella depressa	Spider mites, spring tails
		B. longicornis	vine spider mite
		B. lapidaria	Lucerne flea

Family	Common Features	Predatory mite species	Hosts
Camerobiidae	Long legs, weak palpi.	Neophyllobius spp.	Armoured scale insects European fruit scale Eriopalpid mites Tenuipalpid mites
Cheyletidae	Slow moving, some are ectoparasites of birds, mammals or insects, some are free living predators.	Cheyletus eruditus	Mite pests of stored foods
		Hemicheyletia bakeri	Spider mites
		Cheletogenes ornatus	Armoured scale insect crawlers
Cunaxidae	3-5 segmented palpi, yellow, red or brown in colour, fast runners, indiscriminate feeders on small arthropods	Cunaxa capreolus	Book lice, oriental spider mite
		C. parvus	Oyster shell scale
		C. oliveri	Eriophyid gall mite

Family	Common Features	Predatory mite species	Hosts
Eriophyidae	Elongate, worm like bodies, two pairs of anteriorly placed legs, claw-less tarsi.	Aceria chondrillae	Skeleton weed
		Aceria app.	Russian knapweed
		A. convolvuli	Bind weed
		Eriophyes boycei	Rag weed
Erythraeidae	Large, reddish mite, larvae usually parasitize other arthropods, nymphs and adults are predators	Lasioerythraeus johnstoni	Tarnished plant bug
		Balaustium putmani	Many arthropods
		B. murorum	Egg predator of apple tortricid
Eupalosellidae	Very long palpi and chelicerae, yellow to orange coloured mites, usually occur on plants, often associated with armoured scale insects, a few species occur in the soil.	Saniosulus nudus	scale crawlers

Family	Common Features	Predatory mite species	Hosts
Galumnidae	Genital setae carry six setae on each plate.	Orthogalumna tetrabantis	Water hyacinth
		Pergalumna spp.	Nematodes
Hemisarcoptidae	Whitish, soft-bodied mites.	Hemisacroptes coccophagus	Armoured scale insects
		H. malus	Oyster shell scale
Hydryphantidae	Red, water mites with soft, papillate or lined integument	Hydraphantids (parasites)	Mosquitoes, black flies, biting midges, horse flies.

Family	Common Features	Predatory mite species	Hosts
Laelapidae	Blood-sucking parasites of birds and mammals and nest-inhabiting or free living predators of small invertebrates.	Androlaelaps	Western corn rootworms
		Stratiolaelaps	plant nematodes
		Hypoaspis aculeifer	
		Hypoaspis spp	Oryctes rhinoceros
		Haemogamasus pontiger	Acarid mites, wounded or weakly sclerotized insect larvae
Limnesiidae	weak integument	Tyrrellia circularis	Biting midges
		Limnesia jamurensis	Anopheles and culex mosquitoes

Family	Common Features	Predatory mite species	Hosts
Macrochelidae	Fast-moving, free- living predators common in habitats rich in decaying organic material.	Macrocheles muscaedomesticae	House fly, lesser housefly
		M.glaber	Australian bushfly
		M. peregrinus	Bushfly, buffalofly
Parasitidae	Common predators in the soil, often dispersed by beetles and flies.	Pergamasus quisquiliarum	garden symphylan
		Poecilochirus monospinosus	
		Pergamasus spp.	House fly Stored product pest mites

Family	Common Features	Predatory mite species	Hosts
Phytoseiidae	Entire dorsal shield with 20 pairs of setae, fast-running mites live on plants and in the soil, feed on small arthropods (including spider mites), on other available diets such as homopteran honey dew, pollen and rarely plant juices.	Phytoseiulus persimilis	Spider mites
		Typhlodromus occidentalis	Spider mites
		T.pyri	Spider mites
		Amblyseius spp.	Cyclamen mite
		A. victoriensis	Citrus eriophyids
		A. cucumeris	Thrips tabaci
Pionidae	Weak, smooth integument (parasitic)	Pionia larvae	Chironomidae
		Piona nodata	Mosquito larvae
		Piona spp	Small aquatic arthropods

Family	Common Features	Predatory mite species	Hosts
Padapolipidae	All members are parasites of insects	Lacustacarus spp.	Short horned grasshopper
		Padapolipiodes grassi	Migratory locust
		Chrysomelobia labidomerae	Chrysomelid beetle
		Coccipolipus epilachnae	Mexican bean beetle
Plarygosomatidae	Red, small-to mediun sized parasites of lizards, scorpions and various insects.	Pimeliaphilus plumifer	Blood sucking bugs
		Pimeliaphilus spp.	Cockroaches
Pseudocheylidae (van Dis and Ueckermann, 1991)	Predatory mites ocurring under tree barks, in litter and moss.	Pseudocheylus spp.	(Information not available)
		Neocheylus spp.	
		Anoplocheylus paraclavatus	
		A. tellustrus	
		A. reticulatus	

Family	Common Features	Predatory mite species	Hosts
Pyemotidae	Milky-white spindle shaped or rounded, segmented bodies (parasites)	Pyemotes herfsi	Caterpillars of the pink ball worm
		P.tritici	Stored food pest-Tribolium
Stigmaeidae	Red to yellow colour, ovoid or elongate shaped, live in the soil and on plants, usually predators of mites, a few prey on scale insects or parasitises flies	Agistemus spp. Zetzellia spp.	Eriophyid, tetranychid, tenuipalpid mites.
		Several stagmeids	Tenuipalpid
Tarsonemidae	Small mites with broad to elongated oval bodies, hard and shiny integument,	Iponemus spp. (parasite)	Bark beetle
	Feed on green plants, fungi, arthropods as parasites, predators or as undetermined relationship.	Acaronemus destructor	Phytophagous mite of Tenuipalpidae and Tetranychidae

Family	Common Features	Predatory mite species	Hosts
Tetranychidae	Needle-like chelicarae	Tetranychus desertotum	Prickly pear
		Tetranychus spp.	Water hyacynth
		T. lintearius	gorse
Trombidiidae	Large in size, usually red in colour, dense coat of setae.	Eutrombidium locustarum (parasites and predators)	Many acaridid, tettigonid grasshoppers.
		Allothrombium monspessulanum	Aphids
Tydeidae	Small, softbodied, with needle-like chelicerae, fast moving, commonly found in soil and plants, Tudeids play three seperate beneficial roles (1) prey certain pests, (11) serve as alternate food for other predators, (111) 'clean up' honey dew and reduce damage attributed by sooty-mould.	Homeopronematus anconai	Tomato russet mite, pollen, fungi, plant tissue.
		Other tydeids	Eriophyids, nematodes, other invertebrates

Family	Common Features	Predatory mite species	Hosts
Uriopodidae	Live in forest and other rich organic soils and in manure, many species disperse during their deutonymphal stage, when attach to insects by means of an anal pedicel.	Fuscuropoda vegetans	Nematodes, house fly, eggs of little house fly.