

Future Northland Pastures: 4. Northland arthropod pests and ‘sleepers’ that will increase in response to climate change

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Abstract

The distribution and abundance of some of the exotic invertebrates established in New Zealand will be altered by direct and indirect effects of climate change. Some of the invertebrates will become more active and subsequently their impact on pastoral systems will increase. A literature review focused on arthropod ‘sleepers’ in pastures in New Zealand was conducted. The results show that there are currently 12 arthropod pests that are likely to increase in numbers and/or distribution in Northland, becoming more damaging under future climate and habitat composition. Little is known about the current occurrence and abundance of these arthropods and their associated natural enemies in Northland. A monitoring programme for both the arthropod pests and the abundance of natural enemies throughout the year is needed. There is a need to develop a farmer-research partnership that allows for proactive creation of practical control solutions before serious outbreaks occur.

Keywords arthropod pest, climate change, natural enemies, sleeper pest

Background

At present there are more than 2,000 exotic invertebrates established in New Zealand (Brockerhoff et al. 2010). Many of these are pest species, ranging from minor to some of the most serious in the world, for example *Locusta migratoria*, the migratory locust. Some of these pest species, however, are currently ‘sleepers’, which do not cause problems because of limiting factors such as host plant availability and low temperatures. However, it is expected that many of them will become more active under climate change, and their potential impact on pastoral systems will increase (Gerard et al. 2013; Kean et al. 2015).

Climate change will alter the frequency and intensity of habitat disturbances such as wildfires, droughts, flooding, outbreaks of insect pests and diseases, and extreme wind events (Baker 1995; Turner et al. 1998). These may be more important than the direct impact of higher temperatures and elevated CO₂ on plant productivity (Dale et al. 2001). The changes may alter the distribution and abundance of arthropods already

having a pest status in an area, as well as enabling currently ‘sleeping’ arthropods to become active pests. It may also alter the timing and control efficacy of currently functioning biological control agents and integrated pest management (IPM) systems, enabling the pest to escape the control (Gerard et al. 2013; Schreven et al. 2017).

There are many *direct effects* of climate change on pest abundance and distribution. One of them is change in temperature, which may result in some cold-sensitive species being able to establish in new areas and/or develop throughout the year. For the northern North Island there will be a reduction in winter frosts, which will allow for the establishment of some cold/frost sensitive species and continuous development of other species throughout the year (Gerard et al. 2010). The frequency and intensity of pest outbreaks will increase as the climate becomes more variable and extreme and disrupts existing biological control systems (Stireman et al. 2005).

There are also *indirect effects* of climate change on pest abundance and distribution caused by changes in management options to optimise yield and/or economic returns in agricultural systems under climate change. One of the management options is to alter the timing, location, variety or species of pastoral plants planted to better match prevailing conditions and markets (Easterling et al. 2007). It is expected sub-tropical grasses with a C4 photosynthetic pathway will become more competitive and dominant over parts of the North Island (Field and Forde 1990). We may also see greater use of annual species as many high fertility dairy pastures will use annual or short-lived Italian and hybrid ryegrass (with endophyte) as the base of productive pastures with regular sowings every few years (McCahon et al. 2021). Already we have seen drought and heat tolerant forages increase in usage over the past decade, such as chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) (Caradus et al. 2013). Lucerne (*Medicago sativa*) (Ward 2008; Gerard et al. 2013) and more drought-tolerant red (*Trifolium pratense*) and white (*Trifolium repens*) clovers, or hybrids, are also likely to become more common throughout New Zealand (Williams et al. 2007). As the distribution and the composition of the pasture will

change in response to climate, so will the distribution of sleeper pests (Kean et al. 2015).

Approach

A literature search focused on arthropod ‘sleeper pests’ in pastures in New Zealand was conducted using Google Scholar. Further literature searches were done to find published scientific literature on sleeper pests in New Zealand. An independent search was done by a Knowledge Advisor at AgResearch to ensure no relevant literature had been missed. The species listed in Table 1 are arthropods identified from literature obtained in these searches, combined with new information gained from a recent paper by Mansfield et al. (2021).

Results and Discussion

A total of 12 arthropod pests, that are either considered to be sleeper pests or are current pests in New Zealand but that will increase in numbers and/or distribution in Northland in response to direct and indirect effects of climate change, were identified (Table 1). Some of these are significant pests overseas, such as the locust (Gupta 1983) and the tropical armyworm (*Spodoptera litura*) (Bragard et al. 2019) due to their sheer volume of consumption of a variety of host plants and their ability to rapidly build up in numbers (Gupta 1983; Bragard et al. 2019). The current cooler temperatures in New Zealand prevents the locust from swarming and the insect does not currently achieve pest status (McNeill and Hurst 2008). However, the locusts in New Zealand have retained their potential for swarming behaviour with a small swarm and the gregarious phenotype observed near Ahipara, Northland in the 1980s (Messenger 1988). The tropical armyworm can be found throughout many lowland North Island districts. However, it rarely displays epidemic outbreak populations, when caterpillars move ‘like an army’ through crops and pastures. Under climate change scenarios, including above average summer and autumn temperatures, the combination of events that precipitate outbreaks will become more common and additional generations will develop (Kean et al. 2015).

Aphids damage plants directly through feeding but also indirectly through their transmission of plant viruses (Minks and Harrewijn 1989). Climate change affects host plant distribution, growth rate, physiological status, and biochemistry. These changes influence the distribution and composition of aphid populations, which subsequently affects insect vector biology, feeding behaviour, and ultimately the spread of viral disease (van Munster 2020), as well as the virus transmission process itself (van Baaren et al. 2010). Little is known about blue oat mite(s) and red legged earth mites in New Zealand. For example, we do not know which (or how many) species of blue

oat mite we have in the country. Their distribution is currently localised and only occasionally reach pest status (Mansfield et al. 2021). However, in 1991 they were estimated to cost the sheep and beef industry AUD\$137-193M per annum (Ridsdill Smith 1991). Another arthropod for which little is known in New Zealand is the Flores weevil (*Atrichonotus sordidus*). The weevil is polyphagous, with the larvae feeding below ground (Mansfield et al. 2021). One of the main factors affecting Flores weevil distribution worldwide is the mean temperature of the driest quarter of the year (Lanteri et al. 2013) with a positive relationship between frequency and intensity of drought and the abundance of Flores weevil. However, the exact relationship between the two environmental factors is unclear (Mansfield et al. 2021).

Both the black beetle (*Heteronychus arator*) and the diamondback moth (*Plutella xylostella*) are expected to have more frequent population outbreaks in response to climate change. An increase in summer drought and associated shift in pasture composition and increased abundance of paspalum will favour black beetle abundance while for diamondback moths the winter mortality will decrease and development rate increase. When applying the CLIMEX model developed by Zalucki et al. (2012) to diamondback moth and New Zealand climate conditions, one additional generation per year is predicted by 2070, with more generations in the north than in the south (Mansfield et al. 2021).

Conclusions

We currently have more than 2,000 exotic arthropod species in New Zealand (Brockerhoff et al. 2010). Some of these will, under climate change, become more abundant and extend their distribution. This will affect their population dynamics in Northland, with the potential for them to cause more intense or more widespread damage to pasture and crop plants in the region (Stireman et al. 2005; Gerard et al. 2010; Gerard et al. 2013; Schreven et al. 2017; Mansfield et al. 2021). The arthropod species identified in Table 1 may increase in numbers and/or distribution in response to direct and indirect effects of climate change. These species may also escape their current control methods, further increasing the damage they cause to plants (Gerard et al. 2010; Schreven et al. 2017).

Little is known about the current occurrence and abundance in Northland of the arthropod pests listed in Table 1 or of the occurrence, population dynamics, composition and distribution of their natural enemies. A year-round monitoring programme for both arthropod pests and their natural enemies is needed in Northland to validate the species population dynamics and to inform the development of potential control strategies. Aligned with this is a need to develop damage thresholds for

some of these species.

For species such as Flores weevil, the plants the weevils will feed on in the field is still not well known so correlating an increase in abundance with an increase in damage of pasture plants is needed. For the blue oat mite, identification of the species currently in New Zealand is needed for evaluating potential effects and control methods.

Once we have improved understanding in these areas, farmers can be kept better informed around environmental and/or climatic and/or crop signs they should be alert to. Farmers need to be prepared for potential increases in a particular pest's abundance and the densities at which control methods need to be actioned. Consequently, a farmer-research partnership is needed to work proactively on control methods before serious outbreaks occur. As part of this, the development of resources such as a 'ute guide' or telephone app that could help them identify the signs of such infestations should be prioritised. It would be useful to collate in an accessible form, information relevant to Northland gained from research around plant pest-natural enemy population dynamics, species abundance, predation/parasitism rates, damage thresholds and host plant preference in response to direct and indirect effects of climate change. Understanding the economic cost and implications of these infestations would also help inform the quantum of further investment that should be directed towards this emerging issue.

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Table 1 The arthropod species identified as part of the literature review either as 'sleeper pests' or as current pests that will increase in numbers and/or distribution in response to direct and indirect effects of climate change in Northland.

| Common Name | Scientific name | Host plant consumption | Pest status | Distribution | Current natural enemy | Current control method | Key reference |
|-------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Tropical armyworm | <i>Spodoptera litura</i> (Lepidoptera: Noctuidae) | Wide range of broad-leaved species, including, but not limited to clovers and plantain | Sleeper pest * | Predominantly North Island, sporadic damage in Northland. | Parasitic wasp: <i>Meteorus pulchricornis</i> (Hymenoptera: Braconidae) and several unstudied ones. | Insecticides - alpha cypermethrin chlorpyrifos, diazinon, methomyl, methamidophos, and carbarlyl | (Gerard et al. 2011) |
| Black field cricket | <i>Teleoglyllus commodus</i> (Orthoptera: Gryllidae) | Mostly leaves and germinating seeds of grasses, especially ryegrass, but also legumes and weeds | Current ** | North Island and milder parts of South Island. Economically important in Northland, Auckland, Waikato, Bay of Plenty, Hawkes Bay, Taranaki and Manawatu. | Egg parasites: <i>Probraryconus dubius</i> and <i>Calliscelio teleoglylli</i> n.sp. (Hymenoptera: Scelionidae) | Grain baits coated with an insecticide (maldison) | (Blank 1990) |
| Tropical grass web worm | <i>Herpetogramma licarsalis</i> (Lepidoptera: Crambidae) | Various grasses including ryegrass, kikuyu and maize | Sleeper pest | Northern Northland | Virus: Granulosis virus, Nucleopolyhedrosis virus Parasitoids: <i>Lissopimpla excelsa</i> (Ichneumonidae) and <i>Meteorus pulchricornis</i> (Braconidae) <i>arrigera</i> (Tachinidae) noted as enemies in overseas literature and are found in NZ. | The insecticides Chlorpyrifos, diazinon, alphacypermethrin are noted in literature as effective | (Jensen & Cameron 2004) |
| Flores weevil | <i>Floresianus sordidus</i> (previously <i>Atrichonotus sordidus</i>) (Coleoptera: Curculionidae) | Polyphagous, including legumes. Somewhat unknown. <i>Medicago sativa</i> , Lotus, <i>Trifolium repens</i> , <i>T. pratense</i> , <i>Avena sativa</i> , <i>Phaseolus vulgaris</i> (Sommerfield 1977) | Sleeper pest | Hawkes Bay (Sommerfield 1977). Has been found throughout much of NZ but not from Otago or Southland. Distribution dependant on the mean temperature of the driest quarter (Lanteri et al. 2013). | Unknown | Incorporation of chlorpyrifos prior to sowing and fipronil seed treatment reported to provide effective control of lucerne weevil in canola. Weevils difficult to control with chemicals because larvae live in soil and are protected from exposure. Limited number of registered products. | (Mansfield et al. 2021) |

| Common Name | Scientific name | Host plant consumption | Pest status | Distribution | Current natural enemy | Current control method | Key reference |
|------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Blue oat mite(s) | <i>Pentthaleus</i> spp. (Arachnida: Pentthaleidae) Species not known for New Zealand | Differs between species. Hosts include grains (incl wheat), grasses, legumes, vegetables, ornamental flowers and weeds | Sleeper pest | Recorded from Waikato, Hawkes Bay, mid-Canterbury, Dunedin and Southland - probably widespread. | Predatory mites, probably susceptible to fungal pathogens | Insecticides - Organophosphates and synthetic pyrethroids | (Mansfield et al. 2021) |
| Red legged earth mite (RLEM) | <i>Halotydeus destructor</i> (Arachnida: Pentthaleidae) | Polyphagous – grasses, grains, weeds, vegetables, flowers | Sleeper pest | By 1975 present through much of the North Island but not the South Island. More abundant on annual pasture with high rainfall than with low rainfall. | Predatory mites Fungal pathogens: <i>Beauveria bassiana</i> and <i>Metarhizium anisopliae</i> are both pathogenic to RLEM <i>Neozygites acaracida</i> is reported to have little impact on populations. | Chemical controls – Organophosphates (but results somewhat variable and resistance reported in some populations in Australia). Resistance to synthetic pyrethroids also reported in Australia | (Ridsdill-Smith 1997; Mansfield et al. 2021) |
| Black beetle | <i>Heteronychus arator</i> (Coleoptera: Scarabaeidae) | Grasses including paspalum and ryegrasses, maize, sweet corn, potatoes, kumara and strawberries, cabbage, tomatoes, asparagus, grape vines, kiwifruit vines, pineapples, sugar cane, chestnuts, apples, pines, <i>Cryptomeria</i> | Current | Northern parts of the North Island – Northland, Waikato, Bay of Plenty and along the coast into northern Taranaki. | Endophytic fungi: <i>Epichloë</i> strains – some protection Pasture management methods: Break crop e.g. brassica, maize, legumes, chicory. Pathogens: Naturally occurring soil fungi <i>Beauveria</i> sp. Apicomplexan parasite <i>Adelina tenebrionis</i> (Sporozoa: Adeleidae) causing disease | Seed treatment e.g. imidacloprid. Organophosphate insecticides e.g. Chlorpyrifos, AR37 <i>Epichloë</i> endophyte in perennial, hybrid and Italian ryegrass, tall fescue and meadow fescue. | (Watson 1990; Mansfield et al. 2021) |

| Common Name | Scientific name | Host plant consumption | Pest status | Distribution | Current natural enemy | Current control method | Key reference |
|-----------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| Diamondback moth | <i>Plutella xylostella</i> (Lepidoptera: Noctuidae) | Brassicaceae e.g. broccoli, cabbage, kale | Current | Throughout NZ | Parasitic wasps: <i>Diadromus collaris</i> and <i>Diadegma semiclausum</i> (Ichneumonidae) Predators: Lacewing, <i>Micromus tasmaniae</i> (Neuroptera: Hemerobiidae) | Have developed resistance to many of the common pesticides and to Bt toxin. Intercropping and crop rotation can be helpful. Farmers often use frequent doses and insecticide mixtures. | (Mansfield et al. 2021) |
| Spotted alfalfa aphid | <i>Therioaphis trifolii</i> f. <i>maculata</i> (Hemiptera: Aphididae) | Lucerne, white clover and some medic species | Sleeper pest | From Auckland to the southern regions of Bay of Plenty in the North Island. | Predators: Lacewing (<i>Micromus tasmaniae</i>), Eleven spotted ladybird (<i>Coccinella undecimpunctata</i>) Hoverflies (<i>Melanostoma fasciatum</i> and <i>M. novaezelandiae</i>) Parasitic wasps: <i>Aphidius ervi</i> and <i>A. eadyi</i> (Braconidae) Fungus: <i>Entomophthora</i> spp. | Integrated pest management based on resistant cultivars, biological control agents, cultural practices and chemical control measures. Has developed resistance to most organophosphates | (Ridsdill-Smith 1997; Mansfield et al. 2021) |
| Blue green aphid | <i>Acyrtosiphon kondoi</i> (Hemiptera: Aphididae) | Lucerne, also found in white clover, red clover, <i>Lotus</i> spp, lentils and trefoils (Cameron & Walker 1989) | Current but may increase in response to climate change with potential for an additional generation during winter months. However, unsure for the Northland area | Throughout New Zealand (McSweeney & Dumbier 1978). | Predators: Lacewing, <i>Micromus tasmaniae</i> (Neuroptera: Hemerobiidae) Eleven spotted ladybird, <i>Coccinella undecimpunctata</i> (Coleoptera: Coccinellidae) Hoverflies, <i>Melanostoma fasciatum</i> and <i>M. novaezelandiae</i> (Diptera: Syrphidae) Parasitic wasps: <i>Aphidius ervi</i> and <i>A. eadyi</i> (Hymenoptera: Braconidae) Attempted to introduce spotted alfalfa aphid parasitoid <i>Trioxys complanatus</i> (Hymenoptera: Braconidae) in the North Island 1985 Fungus: <i>Entomophthora</i> spp. | Have developed resistance to many of the common pesticides and to Bt toxin. Intercropping and crop rotation can be helpful. Farmers often use frequent doses and insecticide mixtures. Resistant lucerne cultivars | (Mansfield et al. 2021) |

| Common Name | Scientific name | Host plant consumption | Pest status | Distribution | Current natural enemy | Current control method | Key reference |
|------------------|------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| Pea aphid | <i>Acyrtosiphon pisum</i> (Homoptera: Aphididae) | Lucerne, peas, broad beans, some clover vetches and trefoils | Current | Helensville, Auckland (Cameron et al. 1981), Northland, Waikato and the Bay of plenty (Archibald 1979). | Predators: Lacewing (<i>Micromus tasmaniae</i>), Eleven spotted ladybird (<i>Coccinella undecimpunctata</i>) Hoverflies (<i>Melanostoma fasciatum</i> and <i>M. novaezelandiae</i>) Parasitic wasp: <i>Aphidius ervi</i> and <i>A. eadyi</i> (Hymenoptera: Braconidae) Attempted to introduce spotted alfalfa aphid parasitoid <i>Trioxys complanatus</i> (Hymenoptera: Braconidae) in the North Island 1985 Fungus: <i>Ertomophthora</i> spp. At least 3 species | IPM: Resistant plant varieties, early cutting, crop rotation, biological control, insecticides e.g. chlorpyrifos, imadocloprid, neem oil | (Rohitha & Pottinger 1990) |
| Migratory locust | <i>Locusta migratoria</i> (Orthoptera: Acrididae) | Any plant material | Sleeper pest. Does not swarm due to temperatures being too low | North and South Island | Synthetic insecticides used overseas | | (Kean et al. 2015) |

* 'Sleepor pests' are referred to here as arthropods that are present in NZ but not currently considered a pest. Their abundance and distribution are limited by environmental and/or habitat variables but that may change under climate change, turning them into a pest.

** 'Current' pests are species currently considered a pest in New Zealand that will increase in number and/or distribution in response to climate change.