Weather associated with myrtle rust on the North Island east coast

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Introduction

The New Zealand native Myrtaceae species that so far appear most vulnerable to damaging myrtle rust (*Austropuccinia psidii*) attack are ramarama (*Lophomrytus bullata*), rōhutu (L. obcodata), natural hybrids between these two and pōhutukawa (*Metrosideros excelsa*). Recent observations of *L. bullata* severely impacted by myrtle rust near East Cape (Graeme Atkins, DOC and Roanne Sutherland, Scion) include observations of yellow *A. psidii* spores present during last winter (June-August 2020). The presence of spores during winter poses the question of whether *A. psidii* can continue to complete infection cycles through winter in the East Cape area. If infection cycles continue throughout winter, earlier and more rapid increase of myrtle rust is expected the following spring, resulting in more severe host damage. On the other hand, if the pathogen remains inactive (latent) through winter and seasonal multiplication only begins when temperatures rise in spring, disease increase in spring will be slower, resulting in a later and possibly less severe epidemic.

Modelling of latency and symptom development (Beresford et al. 2020) has shown that in cooler southern areas of New Zealand and at higher altitudes, temperatures below 12°C in winter (June to August) greatly extend the latent period (time from infection to new spores). The pathogen can remain latent and often symptomless for several months until temperatures rise again in spring (September to October). Conversely, in warmer northern areas *A. psidii* can continue its cycle of infection and spore production through winter, albeit it at a slow rate. As temperatures increase during spring (September-November) and summer (December-February) the latent period becomes much shorter (minimum 6-7 days) allowing more rapid multiplication and a rapid increase in host damage. Infection requires night time wetness/high humidity at temperatures above 10-12°C (Beresford et al. 2018). Because infection only occurs on new growth (including flowers and fruit), epidemics only develop on susceptible hosts that are actively growing.

The aim of this study was to use a modelling approach to examine winter temperatures in New Zealand, particularly on the east coast of the North Island, and to identify areas where temperatures are favourable for infection during winter and areas where the pathogen remains in the latent phase. Latent overwintering is considered to occur when the latent period takes at least one month (30 days) to complete, i.e., when one or fewer latent periods occur per month. If the latent period is less than one month (more than one latent period occurring per month), it is considered that the infection cycle continues through winter.

Methods

To answer the question about winter activity, the known relationship between air temperature and latent period for *Lophomyrtus* spp. (Figure 1) was used with daily temperature data to model the number of latent periods (infection cycles) able to be completed per month during the coldest months of June, July and August. This was done over three years for five localities in the North Island and upper South Island (Table 1).

Table 1. Weather stations in the HortPlus^{TM} weather data base used for modelling myrtle rust latent period and infection risk. No weather station data were available specifically for the East Cape area.

Name	Locality	Latitude (°S)	Longitude (°E)	Altitude (m)
Owairaka	Plant & Food Research campus, Auckland	36.89	174.73	40
Opotiki	Eastern Bay of Plenty	38.02	177.31	7
Rotorua	Rotorua Airport	38.11	176.32	285
Havelock North	Havelock North, Hawke's Bay	39.65	176.88	40
Riwaka	Motueka, Tasman	41.10	172.97	15

In addition to latent period, the daily infection risk was also investigated at the same sites using output from the infection sub-model of the Myrtle Rust Process Model (Beresford et al 2018). The infection sub-model predicts that if *A. psidii* spores and a susceptible host are present, substantial infection will occur on any day when the infection risk index is greater than 0.5 (based on humidity, temperature and solar radiation). If the index is less than 0.5 a minor amount of infection may occur, depending on inoculum (abundance of spores).

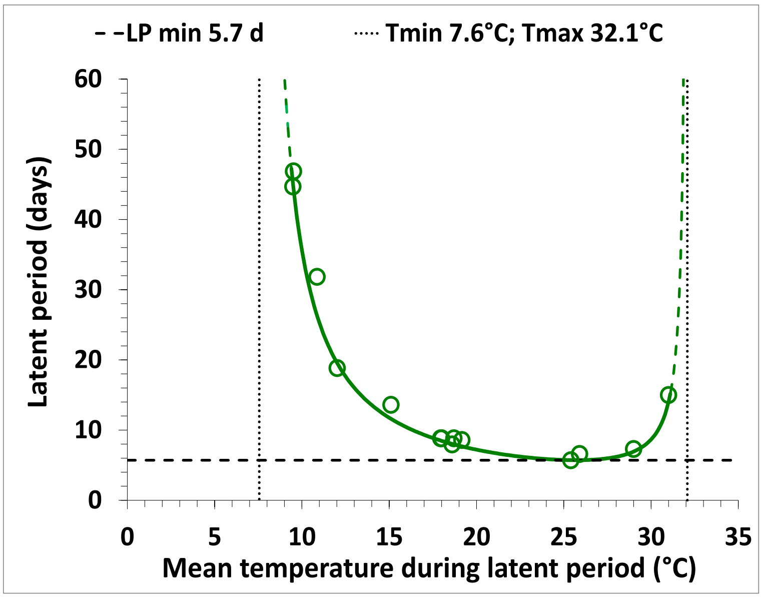

Figure 1. Relationship between *Austropuccinia psidii* latent period and mean temperature during the latent period for *Lophomyrtus* sp. From Beresford et al. (2020).

Each of the graphs below shows the following three myrtle rust predicted risk variables summarised monthly over nearly three years, from January 2018 to October 2020:

1. ***Number of latent periods per month***. In warm summer weather the latent period is very short (minimum 6-7 days) with 4-5 latent periods per month. In cool winter weather the latent period becomes much longer (e.g., 30-60 days) with one or fewer latent periods per month. In this case *A. psidii* is considered to be overwintering as latent infection. The blue dashed line in the graphs demarks one latent period per month, below which latent overwintering occurs and above which continued infection cycles occur.
2. ***Proportion of days per month with infection risk greater than 0.5***. This variable indicates the frequency with which temperature and humidity conditions are conducive to infection during a given month. During winter, cold temperatures are likely to limit infection, whereas during summer, low humidity may limit infection.
3. ***Overall relative risk***. This variable is the product of variables 1 and 2 and indicates how latent period and infection risk interact to determine the overall weather suitability for myrtle rust development in a given month. Variables 1 and 2 both tend to be greater at warmer temperatures and therefore overall relative risk tends tend to follow temperature seasonality. The numbers on the left hand Y-axis in the graphs apply to overall relative risk, with units of latent period – infection days per month.

Results

The graphs below show that during winter 2020, across all sites (Auckland to Motueka), a greater number of latent periods per month occurred in June and August 2020, especially further north, than during the winters of 2018 or 2019. This was driven by warmer winter temperatures during 2020. Going further south, the number of latent periods per month in the winter months generally decreased to 1 or fewer. At Rotorua, at an altitude of 285 m (Table 1), the number of latent periods per month in winter was similar to Riwaka in the upper South Island.

Of particular interest for the East Cape area is Opotiki, which had a relatively high number of latent periods per month during winter 2020. This suggests that *A. psidii* infection cycles could have continued in the East Cape area, particularly during the warm periods in June and August 2020. This fits with the observed yellow myrtle rust spores visible on ramarama near East Cape in July 2020. Once pustules containing the yellow spores appear on a host plant in winter they may continue producing spores for up to three months (Beresford et al. 2020), although this may be shortened by very rainy and windy weather.

The climatic risk maps below show latent period (in days) throughout New Zealand on a weekly basis from June to August 2020. These were produced by NIWA using the Myrtle Rust Process Model. The light and dark green areas are where predicted latent period is greater than 30 days (< 1 latent per month) and where latent overwintering of *A. psidii* is likely to occur. The beige, pink and red areas are where predicted latent period was less than 30 days and therefore where winter infection is likely to continue. Conditions were highly favourable for winter-time latent development and symptom appearance around East Cape in the week of 21-27 June and were moderately favourable in the weeks of 14-20 June, 19-25 July and 2-8, 16-22 and 23-29 August.

Therefore the unusually warm winter conditions in the East cape area in 2020 would have been favourable for continued winter activity of *A. psidii,* probably contributing to earlier spring build-up of myrtle rust on susceptible hosts in that area.

Elsewhere, continued latent development through winter 2020 occurred almost constantly in Northland and Auckland, occasionally in Waikato and Bay of Plenty, infrequently in coastal Taranaki and Whanganui and conditions were never suitable in the lower North Island and the whole of the South Island. These weekly-average latent period maps reflect how the suitability of weather for myrtle rust winter development fluctuates constantly in marginally-suitable areas as different weather systems cross New Zealand.

The overall relative risk variable showed highest values for the three years at all sites during summer 2017-18, generated by moist northerly wind flows, and lowest values during summer 2019-20 resulting from the very dry summer conditions that year.

Overall relative risk values shown in the Havelock graph suggests that the lack of reported myrtle rust in Hawke's Bay is not because of climatic unsuitability there and it is likely that rust has either not yet arrived in that region, or it has arrived but is as yet undetected. The same probably applies to other North Island east coast areas where myrtle rust has not yet been reported (e.g., Wairarapa).

Conclusions

Abnormally warm winter temperatures in the East Cape area in 2020 probably enabled *A. psidii* to remain active over winter, although conditions suitable for re-infection by any spores produced were often unsuitable during that time. However, the presence of uredinia before spring 2020 would have enabled an early start to spring myrtle rust infection and inoculum multiplication, probably exacerbating damage to ramarama trees that was already present in the East Cape area from earlier years.

This study highlights the important truth that areas with warm winters have greater myrtle rust risk because infection and sporulation can continue year round. Years when warmer winter conditions occur further south have a lengthened myrtle rust infection season and this increases the geographic range over which myrtle rust can develop. It follows, therefore, that climate warming will increase the threat posed by myrtle rust to susceptible Myrtaceae species in New Zealand.

Acknowledgement

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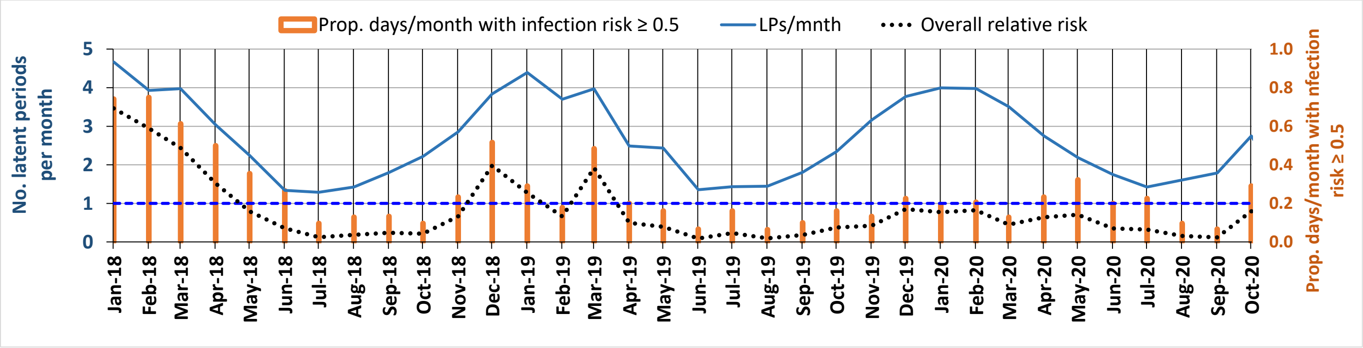
References

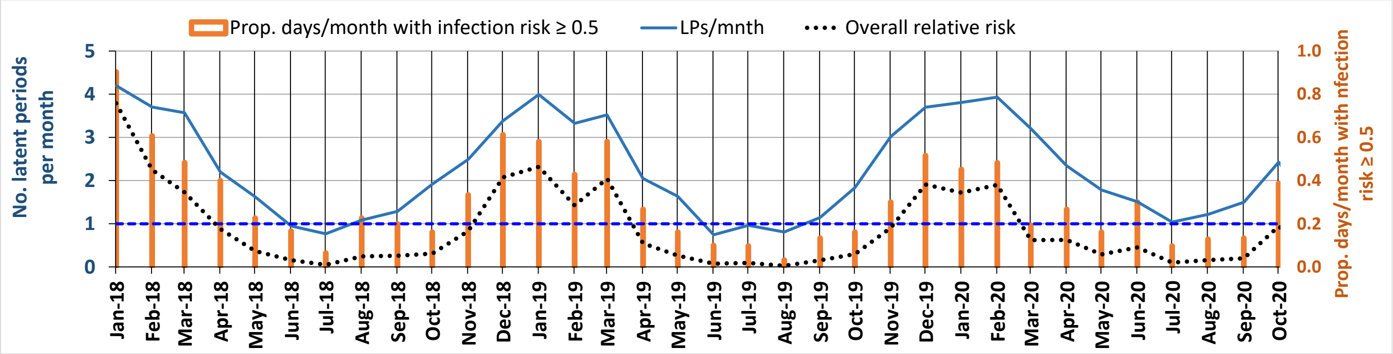
Beresford RM, Turner R, Tait A, Paul V, Macara G, Yu ZD, Lima L, Martin R 2018. Predicting the climatic risk of myrtle rust during its first year in New Zealand. *New Zealand Plant Protection* ***71***: 332-347.

Beresford RM, Shuey, LS, Pegg GS 2020. Symptom development and latent period of *Austropuccinia psidii* (myrtle rust) in relation to host species, temperature and ontogenic resistance. *Plant Pathology* ***69:*** 484–494. doi:10.1111/ppa.13145

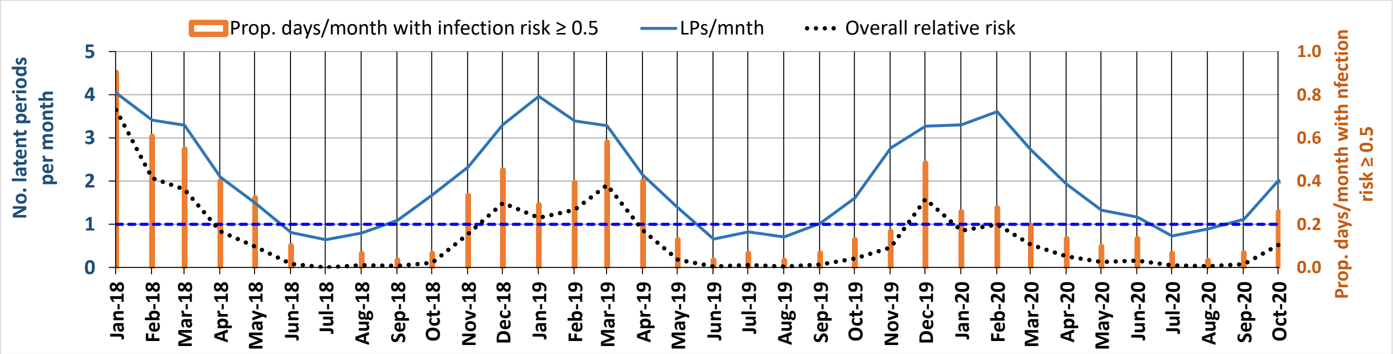
Owairaka



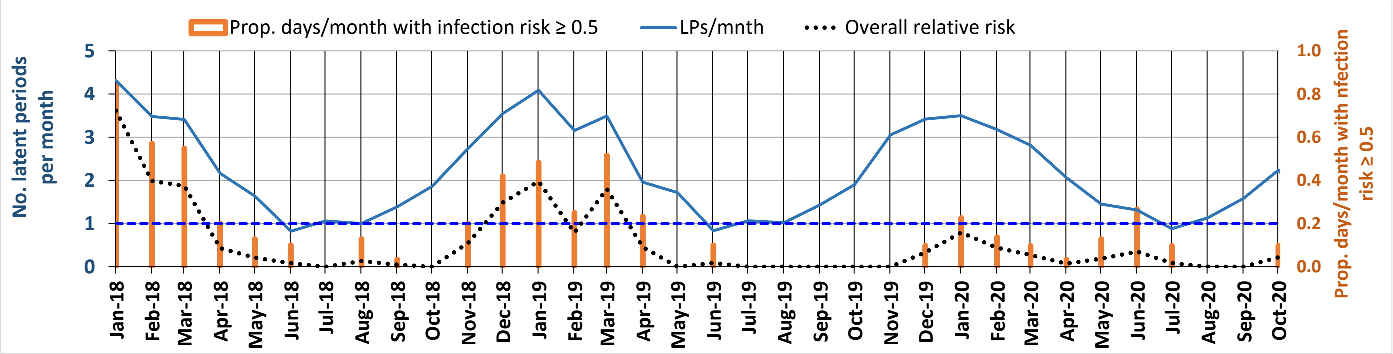
Opotiki



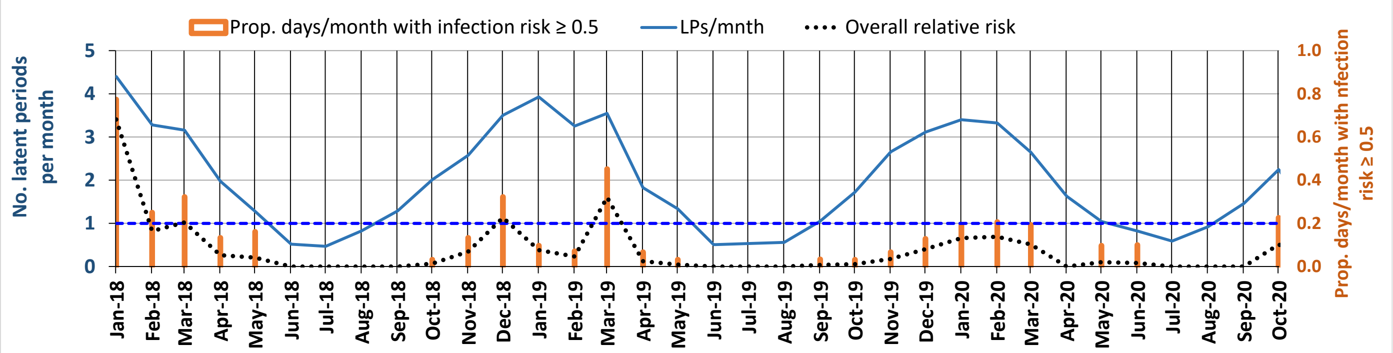
Rotorua

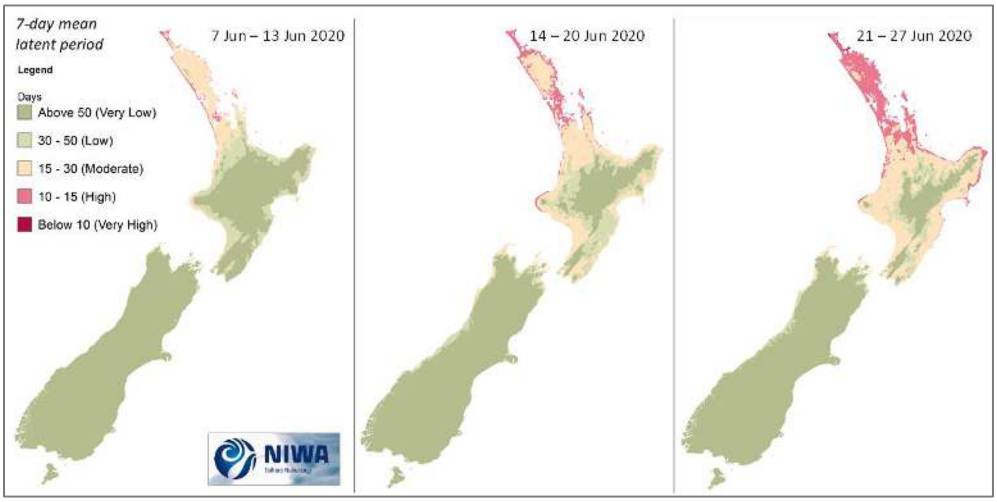


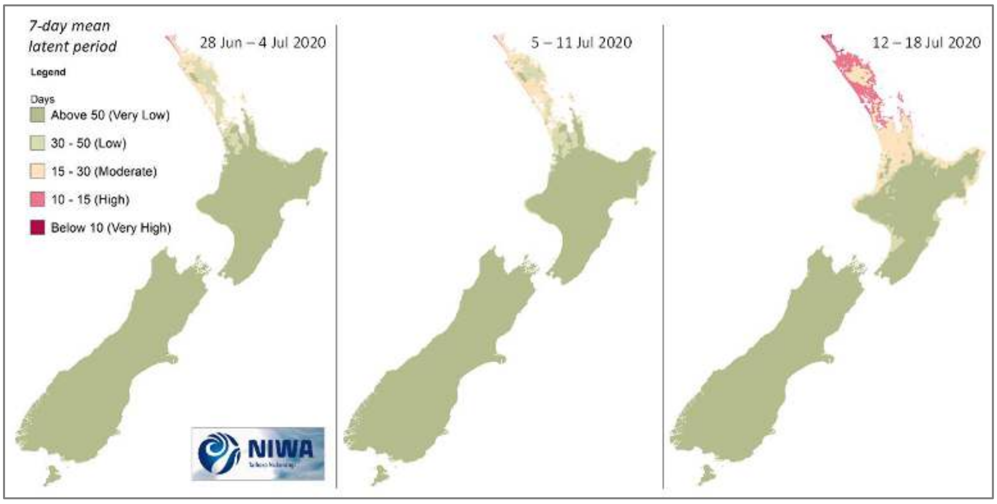
Havelock North

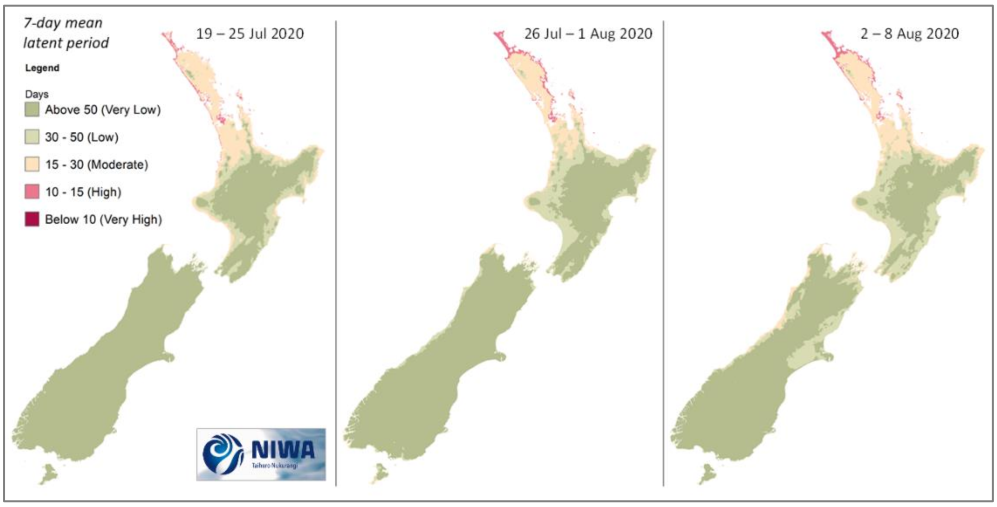


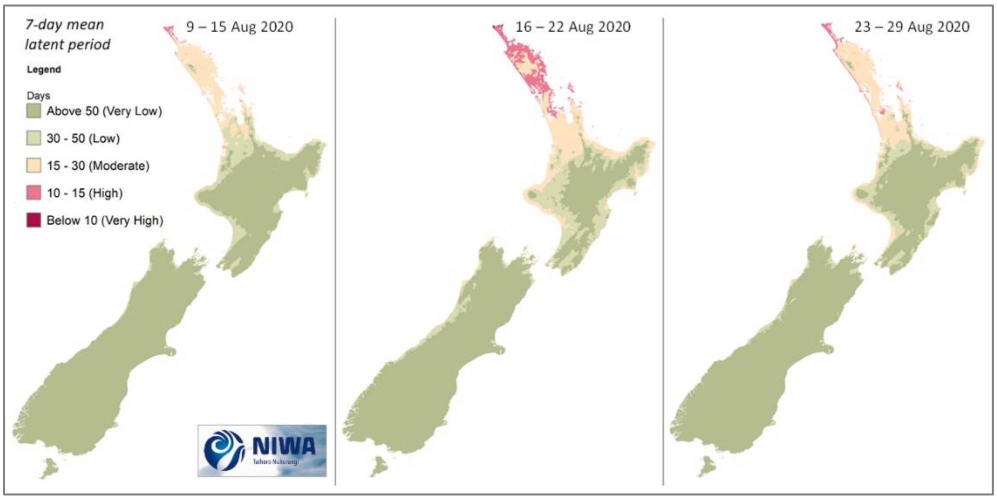
Riwaka




7-day mean
latent period
Legend
Days
Above 50 (Very Low)
30 - 50 (Low)
15 - 30 (Moderate)
10 - 15 (High)
Below 10 (Very High)
7 Jun – 13 Jun 2020
14 – 20 Jun 2020
21 – 27 Jun 2020
NIWA


7-day mean
latent period
Legend
Days
Above 50 (Very Low)
30 - 50 (Low)
15 - 30 (Moderate)
10 - 15 (High)
Below 10 (Very High)
28 Jun – 4 Jul 2020
5 – 11 Jul 2020
12 – 18 Jul 2020
NIWA


7-day mean
latent period
Legend
Days
Above 50 (Very Low)
30 - 50 (Low)
15 - 30 (Moderate)
10 - 15 (High)
Below 10 (Very High)
19 – 25 Jul 2020
26 Jul – 1 Aug 2020
2 – 8 Aug 2020
NIWA


7-day mean
latent period
Legend
Days
Above 50 (Very Low)
30 - 50 (Low)
15 - 30 (Moderate)
10 - 15 (High)
Below 10 (Very High)
9 – 15 Aug 2020
16 – 22 Aug 2020
23 – 29 Aug 2020
NIWA