
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

BRIEF COMMUNICATION: Hot years in history and facial eczema

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Keywords: climate change; facial eczema; *Pithomyces chartarum*: sporidesmin toxin

Introduction

Facial Eczema (FE) is caused by grazing animals ingesting the toxin sporidesmin which is produced by spores of the fungus *Pithomyces chartarum*. In order for the fungus to sporulate, a series of weather and environmental events must occur, with warm, moist, humid conditions and leaf dead-matter at the pasture base required (Brook 1969). In New Zealand, the combination of required conditions has historically been confined to summer and autumn months in temperate parts of New Zealand as illustrated in a map published by di Menna et al. (2009).

There is a large body of research that concludes that the world is in a period of climate change, characterised by increasing temperatures and extreme weather events (Ministry of Environment NZ, 2008) with the temperature increases predicted to incrementally increase into the future. Using climate change predictions, modelling work reported by di Menna et al. (2009) and Dennis et al. (2014) demonstrated that into the future the geographical regions in New Zealand affected by FE would increase, as temperature increases would result in more areas achieving the minimum temperatures required for sporulation.

Through using published literature and media articles prior to 2016, the worst years for FE in New Zealands history were 1938 and 1999. Indeed the outbreak in 1938 was what led to the establishment of the Ruakura Research Centre (now AgResearch) in an attempt to understand the cause and control of the then-unknown disease that had resulted in photosensitivity, liver damage, production losses and death in affected animals (di Menna et al. 2009).

The purpose of this paper is to report on the FE outbreak of 2016 and to draw temperature parallels to the outbreaks of 1938 and 1999 using weather data from the Ruakura Weather Station.

Materials and methods

Data generated at the Ruakura weather station and sourced from the National Institute of Weather and Atmosphere (NIWA) National Climate Database (CliFlo, 2017) was used in the analysis. The average minimum and monthly air temperatures, average humidity and total monthly rainfall for each calendar month dating from 1922 was available. For the summer and autumn periods (December-May) the values for minimum and monthly air temperatures were averaged per year, and across all years to give the historical average. The historical average values were subtracted from yearly values to provide an estimate of the yearly summer/autumn temperature deviation from the historical average.

Using published literature and published spore counts, where possible, a categorisation of the severity of the FE outbreak in the Waikato region for each year was collated, and for years when specific Waikato reports were not available, national estimates were used. When spore count data was available, categories were assigned as "Bad" years when greater than 60% of farms tested had spore counts which exceeded 30,000 spores/g of leaves; "Moderate" when between 40% and 60% of farms exceeded the threshold, and "Low" when less than 40% of farms exceeded the threshold, and "Very Low" when less than 20% of farms exceeded the threshold. Spore count data was not available prior to 1975 and from 2000 to 2005, so published literature was used to assign the level of outbreak. The years 1938, 1999 and 2016 were categorised as the "Top Three Worst" years, based on literature and personal communications, although the exact order within those has not been confirmed.

The data was analysed in SAS using the general linear model procedure, with category fitted as a fixed effect, and mean deviation within summer and autumn for both the minimum and maximum values together with a sum of deviations fitted as the dependent variable (SAS, 2011). The temperature deviations were plotted by year, and the plot coded to represent the level of FE outbreak observed in that year (Very Low, Low, Moderate, Bad and Top Three).

Results and discussion

The year 2016 was an extreme year for the proliferation of the *Pithomyces chartarum* fungus throughout a wide geographical spread in New Zealand, as interpreted by sporidesmin spore counts reported by Gribbles Veterinary Laboratories (Gribbles Veterinary, 2016). The threshold for treatment is considered to be 20,000 spores/g of leaves. In mid-March 2016, the levels of spores reported for the Waikato region were in excess of 2,500,000 spores/g of leaves (Gribbles Veterinary, 2016), levels not previously observed. Spore counts also remained high over an extended period with more than 40% of farms measured exhibiting spore counts greater than 30,000 spores/g of leaves from early February through until mid-May (Gribbles Veterinary, 2016). The result of these elevated levels was high levels of clinical FE observed throughout the North Island, and the top and upper west coast of the South Island. Within farming circles parallels have been drawn between the severity of the 2016 outbreak and those previously observed in 1999 and 1938, which, as discussed in the introduction, have previously been identified as the worst years for FE in New Zealand's history. The map published by di Menna et al. (2009) predicting where FE could occur if 3°C climate warming was to occur, was an accurate representation of areas affected by FE for the North Island, top and upper west coast of the South Island. The map does predict hot-spot areas in the south and east of the South Island, but these areas were unaffected in 2016.

The year 2016 was also an extreme year for air temperatures in New Zealand, with the NIWA documenting 2016 to be New Zealand's hottest on record, particularly for the summer and autumn period (NIWA, 2017). They also reported that the only years in history that had parallel extremes for the first six months of the year were 1999 and 1938 (NIWA, 2016).

Whilst it is known that the perfect climatic conditions for proliferation of the fungus require elevated temperatures, moisture and humidity; within the Waikato region, in the majority of years, humidity remains relatively high throughout the summer and early autumn, and, with the exception of drought years, sufficient levels of moisture are received. As such the remaining variable that does exhibit considerable between year variation is the air temperature. Using the data from the Ruakura Weather station collected from 1922 to 2016, the average Summer/Autumn temperature was 15.96°C, with a range of 14.08 to 17.93°C. Table 1 considers the level of deviation for the categorised FE outbreak data. This supports the findings that 1938, 2009 and 2016 were significantly warmer years when compared to even the bad years for the minimum and total deviations. And that the trend of increasing temperatures with increasing categories was observed, although the differences between consecutive categories were not always significantly different.

Whilst more detailed modelling of the data could be carried out to include the effects of humidity and rainfall, the data presented does demonstrate that throughout history there has been a consistent intrinsic relationship between air temperature and, in particular, minimum air temperature and *P. chartarum* proliferation. Whilst such a relationship has long been reported (Brook, 1963), this relationship has not been documented in decades.

From Figure 1 there are several key points of note. Firstly, that as reported by NIWA for the national data, the hottest three years are 2016, 1938 and 1999 in that order for this data set based on Ruakura data, which are also the "Top Three" worst years for FE in New Zealands history. Secondly, that although not a perfect correlation, where information was available, the years that were warmer than the historical average tended to be the years in which moderate to bad outbreaks were observed. The relationship is not perfect; for example, in 2009 the relationship between the colder temperature and moderate number of farms with elevated spore counts does not fit this trend. However, 2009 was a year in which there was a significant early elevation in spore counts that was not sustained, as the late summer and autumn months turned cooler leading to an overall low temperature deviation. Thirdly, that as the years progressed, there were an increasing proportion of years with above-average temperatures. Specifically, five of the top 20 years for highest summer/autumn deviations for the Ruakura weather station have occurred since 2010.

The year 2016 ranks alongside the years 1938 and 1999 in terms of high temperature extremes in the summer and autumn months, and also being regarded as the top three years for severity of FE outbreaks in New Zealand. The impact of climate change is being observed on New Zealand's temperature, with five years of the last six ranking in the top twenty hottest years recorded since 1922. Given the intrinsic relationship between temperature and *Pithomyces chartarum* proliferation, the pattern of increased moderate to bad FE outbreaks as observed over the last six years will likely continue, with increased geographical spread in the areas affected. As such there needs to be increased education and extension of the known methods to minimise the impact of sporidesmin on production animals (Beef + Lamb NZ, 2016).

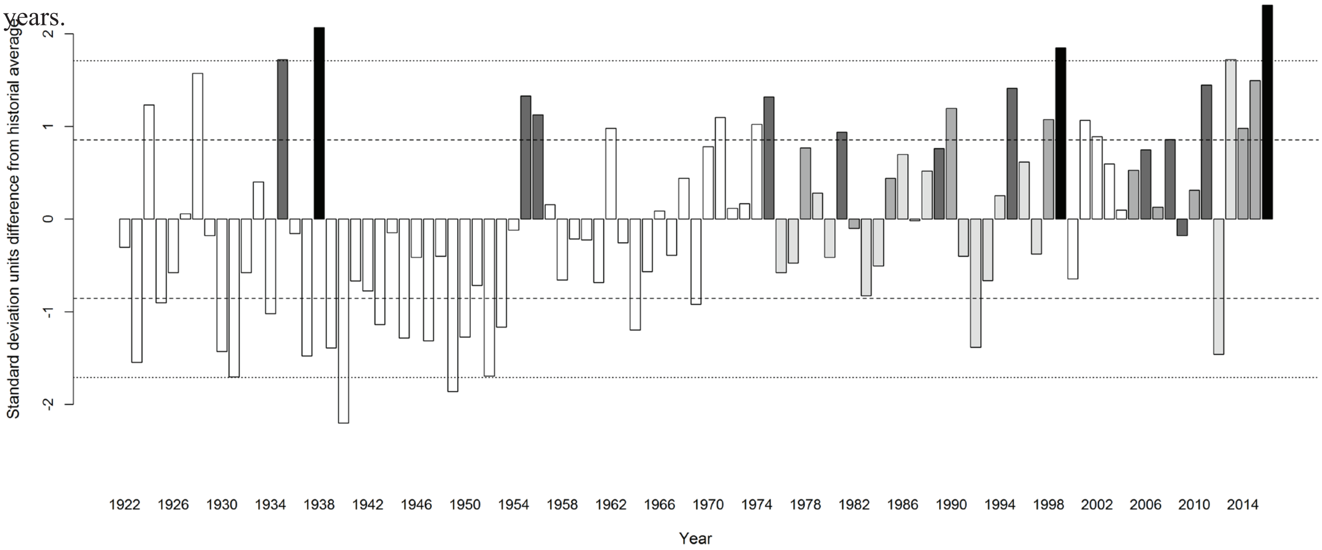
Table 1 Relationship between deviation from historical temperature averages and facial eczema outbreaks in the Waikato based on weather data collected from the Ruakura Weather Station

	Facial Eczema Outbreak Category[1,2]				
Temperature Deviation	Very Low	Low	Moderate	Bad	Top 3 Worst
Summer Min Average.(°C)	0.23 ± 0.41[a]	0.25 ± 0.23[ab]	0.53 ± 0.26[a]	1.3 ± 0.25[b]	1.8 ± 0.48[b]
Autumn Min Average (°C)	-0.4 ± 0.42[a]	0.14 ± 0.23[ab]	0.7 ± 0.26[bc]	0.8 ± 0.25[bc]	2.1 ± 0.48[d]
Summer Max Average (°C)	-0.5 ± 0.52[a]	-0.4 ± 0.20[a]	0.4 ± 0.33[ab]	0.9 ± 0.31[b]	1.6 ± 0.60[b]
Autumn Max Average (°C)	-1.2 ± 0.44[a]	-0.2 ± 0.25[a]	0.67 ± 0.28[b]	0.5 ± 0.27[b]	1.6 ± 0.51[b]
Sum of Deviations (°C)	-1.9 ± 1.08[a]	-0.2 ± 0.06[b]	2.3 ± 0.68[b]	3.6 ± 0.65[b]	7.1 ± 1.25[c]

[1]When spore count data was available categories were assigned as years "Bad" when greater than 60% of farms tested had spore counts which exceeded 30,000 spores/g; "Moderate" when between 40% and 60% of farms exceeded the threshold and "Low" when less than 40% of farms exceeded threshold and "Very Low" when less than 20% of farms exceeded the threshold. Literature reports were also used to categorise years. The three worst years in history – 1938, 2009 and 2016 were assigned "Top 3 Worst".

[2]Means with the same letter are not significantly different at $P<0.05$.

Figure 1 Temperature deviation from average for December-May by year from historical average for data collected from the Ruakura weather station Hamilton. The colours are coded to according to the severity of the facial eczema outbreak in those years: Black – "Top 3 Worst" years; Dark-Grey –"Bad" outbreak; Mid-Grey – "Moderate" outbreak; Light-Grey – "Low" outbreak; White – indicates that no information or data was available to make inferences about the level of outbreak in those years.



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