Developing a landscape risk assessment for the redheaded cockchafer (*Adoryphorus couloni*) in dairy pastures using precision agriculture sensors

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Abstract

The redheaded cockchafer (*Adoryphorus couloni*) (Burmeister) (RHC) is an important pest of semi-improved and improved pastures of south-eastern Australia. The third instar larvae of the RHC feed on the organic and root matter found in the soil causing reduced pasture growth and in severe cases death of plants. The control of the RHC is complicated by its lifecycle which involves the insect spending the majority of its life underground with only a brief time as an adult beetle flying. The RHC is particularly hard to control as there are no insecticides registered for use against the pest or any effective cultural control methods. A pasture mix containing an endophyte believed to deter insect feeding will be commercially available in late 2014 and a biological control, an entomopathogenic nematode, are the only possible options to use against the RHC. However, the cost of the biological control is high at approximately \$6,500 ha^{-1} and therefore use is not practical in grazing enterprises. The most common method currently used by farmers to control this pest is to re-sow pasture in affected paddocks. This thesis aims to identify possible relationships between third instar RHC larvae with environmental variables which can be measured using precision agriculture sensors. This may allow farmers to identify areas of the landscape which are particularly susceptible to infestation based on soil, plant and topographic attributes. If these areas can be easily identified farmers could target control before an infestation becomes severe. This thesis begins by identifying the potential relationships between the RHC and environmental variables measured by proximal sensors; the soil electrical conductivity (soil ECa), normalised difference vegetation index (NDVI) and elevation. Relationships between these variables and third instar RHC larvae were established however they were not consistent and more research was required to determine if they remained stable over time and place. Next the relationships between the individual measurements taken by the CropCircle™ and EM38 were explored. It was determined that the red wavelength reflected, as opposed to the near infrared wavelength, from the CropCircle™ and the EM38 operated in the vertical dipole mode, rather than the horizontal dipole mode, had the strongest relationships with third instar RHC larvae. Further examination of the relationships found between the proximally sensed measurements and third instar RHC larvae allowed the development of univariate, bivariate and multivariate models which predict RHC population densities within a paddock. The bivariate model which used elevation and soil ECa ratio was the most useful predictor of third instar RHC larvae population densities. The NDVI was found not to be a strong predictor of third instar RHC larvae densities when used on its own in a model or in conjunction with elevation and soil ECa ratio. The next step was to further refine these models and used them to develop risk maps which delineate regions which are under different levels of threat from third instar RHC larvae damage. Three models were explored with the best risk map produced using both third instar RHC count and sensor derived environmental variable data based on the cross validation accuracy estimate. The risk maps produced may be able to be used by farmers to target the application of control techniques in areas where it is needed most and the economics of this were explored. The blanket sowing of an endophyte containing pasture thought to deter RHC feeding and site specific application of the biological control to areas at 'extreme' risk of infestation was found to be the most cost effective strategy. To encourage the use of these risk maps, a sampling strategy which outlines the minimum

number of samples required to detect a certain category of RHC infestation and their location based on proximally sensed environmental data was designed. It was determined that sample sites were correlated to 71m and 34 holes were required to be dug to detect an 'extreme' infestation. The cost of implementing the sampling strategy and using the risk maps to control third instar RHC infestations was examined. It was determined that savings up to \$18,337.44 could be made by the farmer on the 9 ha^{-1} study site if they were to sample for and control an 'extreme' RHC infestation through the blanket sowing of the endophyte containing pasture and site specific application of the biological control. Overall the research presented in this thesis contributes to the improved detection and management of the RHC in pastures using the relationships between third instar larvae infestations and environmental variables derived from precision agriculture sensors

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