PHENOLOGY OF *LISTRONOTUS BONARIENSIS* (KUSCHEL) (COLEOPTERA: CURCULIONIDAE) IN OTAGO

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**ABSTRACT**

Using adult phenology it was shown that *Listronotus bonariensis* populations in the Southern South Island of New Zealand were restricted to one full generation per year. This was associated with degree day accumulation above 10°C between spring and the onset of reproductive diapause in mid March. In some areas a partial second generation was observed but the influence of this appears minor, and predominantly first generation adults overwintered to lay eggs in spring. It is suggested that the lack of a second generation prevents *L. bonariensis* from commonly reaching damaging population densities in the southern South Island.

**Keywords:** Argentine stem weevil, *Listronotus bonariensis*, degree days

**INTRODUCTION**

*Listronotus bonariensis* (Kuschel) (Argentine stem weevil) is a major insect pest of pasture in New Zealand and causes losses of between $78 and $251 m annually (Prestidge _et al._ 1991). Although ubiquitous throughout New Zealand, in the southern South Island adult densities are considered low to medium in comparison with areas where it causes significant damage such as Canterbury and the Waikato (Ferguson _et al._ 1994). These authors suggested that this resulted from lower accumulation of degree days (DD) above 10 °C (the critical threshold temperature for development (Goldson _et al._ 1993) in the southern South Island than in the northern regions. Consequently only one complete generation, and in some areas an additional partial second generation, could occur. This compares with Canterbury where two generations occur (Goldson _et al._ 1993; Proffitt unpublished), and the North Island where three generations may be completed (Barker _et al._ 1988). *L. bonariensis* enters a state of reproductive diapause in autumn, probably induced by photoperiod (Goldson 1981) which coincides with the autumnal equinox.

This study investigated the relationship between adult weevil development with temperature and photoperiod in the southern South Island.

**METHODS**

*L. bonariensis* was collected at three (spring, summer and autumn) or six weekly (winter) intervals from pastures dominated by ryegrass and white clover at Ophir, in Central Otago, at Sutton, on the Strath Taieri and at Invermay, near Mosgiel on the Taieri Plain. At Ophir collections were made from March 1993 to March 1996 and at Sutton and Invermay from March 1995 to March 1996. Adult weevils were quantitatively sampled by digging turves 150 x 150 x 30 mm deep, at 5 m intervals along set transect lines, from the pastures. Weevils were heat extracted in modified Tulgren funnels for 7 days (Proffitt _et al._ 1993). At all the sites 20 samples were taken on each occasion but at Ophir each sample consisted of four turves (0.09 m²), at Sutton two turves (0.045 m²) and at Invermay three turves (0.068 m²). This sampling strategy was designed to overcome the large variation associated with weevil aggregation that occurs when weevil densities are low (Barlow _et al._ 1994) and kept the maximum standard error of the population means to within 20% of the means. The weevils extracted from the
turves were collected into, and stored in 70% ethanol until dissected to record the sex and reproductive condition of females. Reproductive maturity was indicated by the presence of sperm in the spermatheca and eggs in calyces. Weevils were identified as teneral if the dorsal integument under the elytra and wings was soft and unmelanised. Separate generations of adult weevils were defined by peaks in the percentage of teneral adults present in the samples.

Long term average temperature records (Anon. 1982) and recent records (National Institute of Water and Atmospheric Research, Kilburnie, computer data base) from Ophir and Invermay were used to calculate the number of DD/month above 10°C. This equalled (the mean of the average daily maximum temperature/month + the average daily minimum temperature/month) -10 °C x number of days/month). Temperature records were not available for Sutton. A figure of 360 DD (N. Barlow, pers comm. in Ferguson et al. 1994) was used to estimate generation times. Initiation of reproductive diapause was calculated from day length measurements obtained from The Directorate of Time, US Naval Observatory. Degree day estimates and photoperiods from Lincoln and Ruakura are presented for comparison.

RESULTS AND DISCUSSION

At the sites investigated in this study, overwintering female L. bonariensis generally became reproductive in September and remained so until December/January when the percentage of reproductive weevils declined rapidly (Figs.1 and 2). The main egg laying period (unpublished data) occurred in October/November and peak emergence of adults was recorded between January and March except at Ophir in 1994 when it extended into April (Figs.1 and 2). The rapid decline in the percentage of reproductive females at all sites in late summer (Figs. 1 and 2) indicated that generally newly emerged females weevils did not become reproductively mature until the following spring. At Ophir, however, some eggs were laid in February (unpublished data) and low numbers of teneral second generation weevils recorded in May (1993, 1995) and June (1994) (Fig. 2). This is at odds with the situation in Canterbury where frosts kill pre-adult stages and prevents winter emergence of adults (Goldson pers comm.). The emergence of weevils in May and June at Ophir therefore requires further investigation. Some weevils at Sutton also produced eggs in mid-February 1995 (unpublished data) but the fate of these is unknown. Low numbers of teneral adults were recorded in April 1995 but this is more likely to be extended emergence of first generation adults rather than emergence of second generation adults, as it is improbable that sufficient temperature accumulation occurred before early April to allow development of a second generation from egg to adult. A similar situation is likely to exist at Invermay where emerging first generation weevils can become reproductively mature in time to lay eggs before mid-March, but no evidence of a second generation of adults was detected. Larvae do not appear to survive the winter at any of the sites investigated as no teneral adults were found during spring sampling. The overwintering adults were, therefore, mainly first generation with low numbers of a second generation of adults at Ophir.

Based on a generation time from egg to adult of approximately 360 DD above 10°C, Ferguson et al. (1994) suggested that heat accumulation may limit stem weevil populations to one generation per year, and possibly a partial second generation in warmer parts of the southern South Island. While the long term average annual total DD calculated by Ferguson et al. (1994) for Invermay and Lauder (near Ophir) of 655 and 754 respectively reflects accumulated temperature available for egg and larval development, the totals up to mid-March (443 and 608 DD respectively), when females enter reproductive diapause, is a better reflection of the number of generations possible.

Long term averages, and recent data for DD accumulation over 10 °C (Table 1) indicate that in theory sufficient temperature accumulates to allow only one generation of L. bonariensis to occur at both Ophir and Invermay, compared with two at Lincoln and three at Ruakura, between spring when the average daily temperature allows weevil development to re-commence and when the reproductive diapause inducing
FIGURE 1: Percentage of reproductively mature adult female *L. bonariensis* (■) and percentage of teneral *L. bonariensis* (●) at Invermay (a) and Sutton (b). Adult *L. bonariensis* density at Invermay (c) and Sutton (d). Error bars are SEMs.

FIGURE 2: Percentage of reproductively mature adult female *L. bonariensis* (■) and percentage of teneral (●) Argentine stem weevil at Ophir (a). *L. bonariensis* adult density at Ophir (b). Error bars are SEMs.
photoperiod of 12.3 hours light : 11.7 hours dark (Goldson 1981) occurs. This is reached on 16 March at the Otago and Canterbury sites, and 14 March at Ruakura. This investigation demonstrated that at Invermay only a single generation did occur in 1995-96. At Ophir, however, given favourable micro-habitats or higher than average temperatures, it is possible that sufficient heat accumulation could occur to allow two generations with adults emerging during April and May as was recorded. Given that areas with higher temperatures than Ophir occur in Central Otago, it may not be uncommon for substantial proportions of some populations to develop to second generation adults prior to autumn. The climate at Sutton is intermediate between Invermay and Ophir. This and the single generation indicated by sampling at Sutton in 1995-6 suggests that only one generation will normally occur here.

**TABLE 1:** Cumulative monthly degree days over 10 °C (period covered by temperature records) at Invermay and Ophir. Lincoln and Ruakura estimates are included for comparison.

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1 indicates the month first theoretical generation adults appear.  
2 indicates the month second theoretical generation adults appear.  
3 indicates the month third theoretical generation adults appear.

The photoperiod threshold (12.3 hours light) recorded by Goldson (1981) to trigger reproductive diapause occurs between 14-17 March regardless of location within New Zealand because it corresponds closely with the autumn equinox. However, by the time diapause is induced, weevil populations in the Waikato have reached a stage where some of the second generation adults, which emerged in February, have produced eggs which, given sufficient heat accumulation, develop into a small third adult population (Barker *et al.* 1988). These adults overwinter with second generation adults which have not become reproductive before mid-March and lay eggs in the following spring with subsequent first generation adults peaking in early summer (Barker *et al.* 1988). In Waikato pastures the most damage occurs from second generation larval feeding (Barker and Pottinger 1982). In Canterbury eggs from overwintering adult weevils produce first generation adults peaking in December, some of which give rise to second generation adults in March (Proffitt unpublished). Canterbury’s second generation weevils overwinter, along with some first generation adults and produce eggs in spring. In Canterbury it is generally considered that the first generation larvae cause most damage (J. Proffitt pers. comm.).

*L. bonariensis* is well documented as a serious pasture pest in the North Island and Canterbury but high population densities (200-300/m²) are not commonly found in Otago. The results of this study suggest reduced temperature accumulation may be a factor limiting population increase. If this is so, by mapping the number of DD above 10 °C that occur between spring and mid-March, when reproductive diapause occurs, it should be possible to predict areas where *L. bonariensis* is likely to occur frequently at high population density, areas unlikely to experience high densities, and the intermediate areas where it will sometimes reach high densities. The effect of sub-zero
temperatures on *L. bonariensis* survival and phenology, however, should not be ignored and this needs to be investigated.

**CONCLUSION**

*L. bonariensis* populations are generally restricted to one full generation per year in the southern South Island. This is associated primarily with insufficient DD above 10 °C in most areas, between spring and the initiation of reproductive diapause, to allow weevils to develop through a second generation. Assuming multivoltinism is an important factor in determining population size it should be possible to identify a zone south of which *L. bonariensis* will not achieve significant pest status unless there is significant climate warming.

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**REFERENCES**


