IMPACT OF *EXAPION ULICIS* (FÖRSTER) (COLEOPTERA: APIONIDAE) ON GORSE SEED VIABILITY

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ABSTRACT

As part of a study of gorse (*Ulex europaeus* L.) biocontrol, the effectiveness of the gorse seed weevil (*Exapion ulicis* (Förster)) in controlling the amount of viable seed was investigated. Some seed attacked by gorse seed weevil still germinated, with mean germination for lightly damaged seed being 18% and mean germination for heavily damaged seed being 4%. Undamaged seed from damaged pods had high germination (mean 71%), while undamaged seed from undamaged pods had a mean germination of 77%. Many damaged seeds, as well as undamaged seeds from damaged pods, were infested by fungi (*Fusarium* spp. and *Cladosporium cladosporioides*), which affected the ability of the seeds to germinate. There were no differences ($P=0.84$) in the number of viable undamaged and damaged gorse seeds between the three sites sampled even though there were climatic differences and different soil types.

Keywords: *Ulex europaeus*, gorse, *Exapion ulicis*, gorse seed weevil, viability.

INTRODUCTION

Gorse (*Ulex europaeus* L.) has been a noxious weed throughout New Zealand for a long time. Early practices aimed to minimise its spread rather than to eradicate it because of its beneficial aspects. The gorse seed weevil (*Exapion ulicis* (Förster)) was introduced and liberated in Nelson and Alexandra in February 1931 with the aim of destroying gorse seed, and is now widespread and common in both islands (Kuschel 1971).

A female gorse seed weevil lays eggs through a hole in the side of an immature gorse pod. This hole closes and hatching weevil larvae may destroy seeds within the pod (Hill et al. 1991). The weevil can destroy a high percentage of gorse seed formed each spring in most areas of New Zealand (Miller 1970). However, the average rate of infestation of spring pods is only 60-70%. A significant amount of seed is set in autumn and winter (Miller 1970), and this seed escapes predation because the weevil is reproductively active only during spring (MacCarter & Gaynor 1980; Cowley 1983).

There has been little research on the effectiveness of *E. ulicis* in New Zealand. Studies by Cowley (1983) and Hoddle (1991) completed near Auckland, showed the weevil reduced the number of viable seeds from around 3 seeds/pod to 1 seed/4 pods. However, annual seed production was only reduced by 36% (Cowley 1983). In a third study, the effect of the weevil on gorse seed production was measured at three sites, two in Canterbury and one in Auckland, over three years. In the spring, weevils oviposited and infested up to 90% of immature pods. However, as in the other studies, earlier or later produced pods escaped attack (Hill et al. 1991). Hoddle (1991) found that the weevil oviposits only in young green pods. The female weevil shows a preference for pods that are 21 days old and have not been previously attacked by other females. Cowley (1983) found that pods up to one month old may be used before they become too tough to penetrate.

The purpose of the current investigation was to determine how effective *E. ulicis* was in affecting the viability of seed, as measured by its germination rate, at three sites with different climatic conditions and soil types in Golden Bay, Nelson, New Zealand.

MATERIALS AND METHODS

Sampling

Pod samples were collected from three sites in Golden Bay, Nelson, New Zealand on 21–22 December 2002. The sites were East Takaka (40° 54.4655' S 172° 50.1835' E, 60 m above sea level), Onekaka (40° 46.3365' S 172° 43.5039' E, 59 m above sea level) and Bainham (40° 43.5238' S 172° 35.6269' E, 31 m above sea level).

East Takaka has an average annual rainfall of 1800 mm. The gorse was in pasture on a north-south hillside. The soil in this region is a Pikikiruna soil (Anon. 1965). Onekaka's average annual rainfall is 2300 mm. The gorse was growing on the side of a gully, along with native flora and broom (*Cytisus scoparius* L.). Gorse was sampled from Ikamatua and Onahau soils (Anon. 1965). Bainham has an average annual rainfall of 3830 mm. The gorse was growing on a river flat where other scrub present was broom and bracken (*Pteridium aquilinum*). The soil types for this region are Otere and Denniston soils (Anon. 1965).

The daily minimum and maximum temperatures and daily rainfall were recorded from November to January. However, temperature records for East Takaka and rainfall data for Onekaka were not available so the NIWA readings for Kotinga were used. Kotinga is approximately 10 km northwest of East Takaka and 30 km southeast of Onekaka. No temperature readings were taken in January at Bainham.

After collection, seed was stored in a refrigerator at 4°C until needed for testing. Damaged seed was separated into lightly and heavily damaged categories. Lightly damaged seed had less than 1/3 of the seed cover removed and heavily damaged seed had more than 1/3 of seed cover removed. This separation was done visually. Undamaged seed was sorted into undamaged seed from pods that had been attacked by the gorse seed weevil and undamaged seed from non-attacked pods.

Treatment of seed

There were four replicates of 25 seeds from each seed category from each site. A replicate consisted of a Petri dish containing the 25 seeds. The Petri dishes were placed in an incubator at a constant temperature (15°C) and a 16:8 h light:dark cycle (Sixtus et al. 2003). Dishes were inspected daily and watered with sterilised water as required. Germinated seeds were removed at 10 and 20 days. After 10 days, seed that had not been damaged by the weevil larvae and had not imbibed, had a portion of the testa removed with a scalpel. It was then replaced in the incubator for a further 10 days.

The seeds were not surface sterilised, because it was possible that this treatment would damage the seed embryo. As a result, fungi that were present on a seed could survive and multiply. Such infestation helped reduce the viability of the gorse seed.

Data collection and analysis

The total number of germinated seeds at 5, 10, 15 and 20 days after commencement of incubation was counted. A seed was considered to be germinated and viable when it showed a radicle that was at least the length of the seed. Normal and abnormal seedlings were not identified. The presence of fungi in the Petri dishes was noted. The species' identities were ascertained under an Olympus stereomicroscope. A pathologist confirmed identifications. Data were analysed using analysis of variance with the SYSTAT 9 package.

RESULTS

The monthly average maximum and minimum temperature and the rainfall for the three months that the seed weevil is active (October, November and December) are shown in Table 1. There was a marked difference between the sites in both the rainfall records and the minimum and maximum daily temperature records. Bainham had a wet and cool climate, while East Takaka had a dry warm climate. Onekaka had a climate that was between the climates of East Takaka and Bainham in both rainfall and average daily

temperature. Although there were climatic differences between the sites, there was no significant difference in the amount of gorse seed that germinated ($P=0.84$).

TABLE 1: Monthly mean daily minimum and maximum temperatures (°C) and monthly rainfall (mm) at three sites in Golden Bay for the period when the gorse seed weevil was active (November 2002–January 2003).

Site	November			December			January		
	Min.	Max.	Rain	Min.	Max.	Rain	Min.	Max.	Rain
East Takaka ¹	8	19	48	10	21	150	11	23	73
Onekaka ²	13	23	77	14	24	166	15	23	80
Bainham	10	18	286	14	19	395	nd ³	nd	163

¹Temperature data obtained from Kotinga.
²Rainfall data obtained from Kotinga.
³Temperature not measured at Bainham in January.

Weevil-damaged seed germinated without scarification (Fig. 1a). After scarification, there was a high viability of undamaged seed from both damaged and undamaged pods (Fig. 1b). Significantly less damaged seed germinated than undamaged seed ($P<0.001$). Damaged seed was not scarified as the testa was already ruptured. There was no further germination of damaged seed after 10 days.

FIGURE 1: Germination of gorse seed (%) exhibiting different levels of weevil damage. Seed was taken from three sites in Golden Bay and germinated at 15°C. (a) Unscarified seed after 10 days incubation. (b) Germination from 10-20 days. Undamaged seed that had not germinated was scarified after 10 days and germinated for a further 10 days. Damaged seed that had not germinated was not scarified at 10 days. Note that the scale of the Y-axis differs for the two plots.

Fusarium spp. and *Cladosporium cladosporioides* reduced the number of seeds that germinated (data not shown). Fungi were present only in pods that had been attacked by the weevil (Table 2). The difference between the presence of fungi on the damaged seed and the undamaged seed in damaged pods was significant ($P < 0.001$).

TABLE 2: Percentage of gorse seed infected by *Fusarium* spp. and *Cladosporium cladosporioides*.

Site	Seed from damaged pods			Seed from undamaged pods
	Undamaged seed	Lightly damaged	Heavily damaged	Undamaged seed
East Takaka	5	96	100	0
Onekaka	20	87	97	0
Bainham	13	75	95	0

DISCUSSION

The purpose of this experiment was to determine the effectiveness of the gorse seed weevil in reducing gorse seed viability. It had previously been assumed that seed damaged by the weevil would not be viable. Cowley (1983) found weevil attack reduced viable seeds from 3/pod to 1/4 pods. Seed remaining in pods that had been attacked by the weevil failed to sprout in germination tests. However, the current work shows that 11% of gorse seeds damaged by the gorse seed weevil were still viable (Fig. 1a). Cowley (1983) did not test seed until after the weevil larvae had stopped feeding and pupae or adults were found in undehisced pods. In this research the larvae were still active and feeding on the gorse seed, which may explain the different results. There were minor differences between the three Golden Bay sites. The average rainfall in East Takaka is considerably less than the rainfall at Onekaka or Bainham.

Cowley (1983) found that, in the Auckland region, gorse seed weevil larvae were active from October to mid December. However, larval activity in Golden Bay did not start until November and continued to January (C.R. Sixtus, unpubl. data). Hill et al. (1991) found that at Burnham and Hoon Hay Valley, near Christchurch, weevil eggs were in pods as early as September. There was a lack of synchrony between weevil activity and pod production, thus allowing a proportion of the annual pod crop to escape attack by the gorse seed weevil.

At only one site, East Takaka, was heavily damaged gorse seed not viable. This indicates that it is essential that the larvae destroy most of the seed before it is effective at reducing the amount of viable seed. Undamaged seed in damaged pods had a high germination potential (mean over all sites of 71%). This was similar to the seed germination of undamaged seed from undamaged pods (mean over all sites of 77%). Only at Onekaka did fewer seeds germinate from undamaged seed from damaged pods than undamaged seed from undamaged pods (59% versus 81%). The differences between sites may have been due to the climate differences. As shown in Table 1 there was a considerable difference between the sites in both their average annual rainfall and the average monthly minimum and maximum temperatures.

Fungi (*Fusarium* spp. and *Cladosporium cladosporioides*) may have further damaged a proportion of the gorse seed that had been damaged by the gorse seed weevil (Table 2). The fungi did not attack any seed in the undamaged pods or, by inference, most (71%) of the undamaged seeds in the damaged pods. Hoddle (1991) found that *C. cladosporioides* infection was more common in pods that contained weevil eggs and first instar larvae than in pods that only had oviposition holes. The fungi are carried from the outside into the pod by the weevil at the time of oviposition. The presence of fungi seemed to assist in lowering the germination of the damaged gorse seed (data not shown).

The results of this experiment show that the gorse seed weevil kills a large proportion of the spring seed production (77% germination of undamaged seed from undamaged pods and 71% for undamaged seed from damaged pods versus 19% for lightly damaged seed and 4% for heavily damaged seed). For the gorse seed weevil to kill the gorse seed, it is essential for larvae to attack the seed so that the embryo has been damaged. Cowley (1983) found that the larvae cause enough damage for the seeds to lose their viability. In this experiment, some seed was still viable but, it is possible, given more time, 100% of the seed would be killed.

These results show that *E. ulicis* damages the gorse seed that is available when the seed weevil is present. However, due to the inability of weevil larvae to move from pod to pod and the short season that the weevil is active in New Zealand, a large portion of seed produced by a gorse bush will escape weevil predation. Thus the insect may play an important part in the biological control of gorse but the assistance of other agents is required to obtain a complete kill.

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REFERENCES

- Anon. 1965: General survey of the soils of South Island, New Zealand (maps). Department of Scientific and Industrial Research, Wellington.
- Cowley, J.M. 1983: Life cycle of *Apion ulicis* (Coleoptera: Apionidae), and gorse seed attack around Auckland, New Zealand. *N.Z. J. Zool.* 10: 83-86.
- Hill, R.L.; Gourlay, A.H.; Martin, L. 1991: Seasonal and geographic variation in the predation of gorse seed, *Ulex europaeus* L., by the seed weevil *Apion ulicis* Forst. *N.Z. J. Zool.* 18: 37-43.
- Hoddle, M.S. 1991: The reproductive biology of *Apion ulicis* (Forster) (Coleoptera: Apionidae). Masters thesis, University of Auckland, Auckland. 136 p.
- Kuschel, G. 1972: The foreign Curculionidae established in New Zealand (Insects: Coleoptera). *N.Z. J. Sci.* 15: 263-289.
- MacCarter, L.E.; Gaynor, D.L. 1980: Gorse: a subject for biological control in New Zealand. *N.Z. J. Exp. Agric.* 8: 321-330.
- Miller, D. 1970: Gorse (*Ulex europaeus* L.). Biological control of weeds in New Zealand, 1927-48. D.S.I.R. Report No. 74. Pp. 27-58.
- Sixtus, C.R.; Hill, G.D.; Scott, R.R. 2003: The effect of temperature and scarification method on gorse (*Ulex europaeus* L.) seed germination. *N.Z. Plant Prot.* 56: 201-205.