PRE- AND POST-DISPERSAL PREDATION OF NODDING THISTLE SEEDS BY BIRDS AND RODENTS

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SUMMARY

Seed predation in nodding thistle (*Carduus nutans*) was examined at Fereday Island in Canterbury in 1988-89. Pre-dispersal seed predation, mainly by goldfinches (*Carduelis carduelis*), destroyed 31% of all seeds. Post-dispersal seed predation from the ground, due to birds and/or mice, destroyed 85% of the seed which reached the ground. Overall seed losses to all predators (including *Rhinocyllus conicus* (nodding thistle receptacle weevil) which destroyed 3%, but ignoring other invertebrates) were estimated at 90%. However, 84 seeds/m² still survived to germinate.

INTRODUCTION

The European goldfinch *Carduelis carduelis* (Fringillidae) was introduced into New Zealand from Europe during the 1860's and is now common throughout settled areas (Kinsky and Robertson 1987). In Europe and New Zealand thistle seeds are reported to be an important component of the goldfinch diet (Newton 1967, 1972; Campbell 1972). Considering the widespread distribution and abundance of the goldfinch in New Zealand and reports that thistle seeds form a large component of their diet, goldfinches could be responsible for a considerable amount of seed predation in nodding thistle. Goldfinches are known to be involved in pre-dispersal seed predation in nodding thistle as they have often been observed feeding from thistle plants. It is not known what animals are involved in post-dispersal seed predation in nodding thistle, but it is likely that birds and/or mice are important.

METHODS

All field work was carried out in a nodding thistle infested paddock on the farm of Mr Dave Turner, at Fereday Island. Fereday Island is beside the Rakaia River in mid-Canterbury. The paddock was fenced to exclude stock.

Pre-dispersal seed predation by goldfinches

Observations of goldfinches in the field revealed that when feeding on nodding thistle they husk seeds and discard empty husks. By collecting seeds and empty husks from around thistle plants, it was possible to estimate pre-dispersal seed predation.

On 23 January 1989 four relatively isolated flowering plants were chosen for study. Six enamelled metal trays 31 cm x 31 cm were placed end to end on each side of each plant in line with the prevailing wind (north-west and south-east). The trays were covered with a thin layer of grease and at fortnightly intervals, from 31 January 1989 until the four plants had died (5 April 1989), all seeds trapped in the grease were collected and counted. The number of 'good' (unhusked, normal sized) seeds and husked seeds collected from each tray were adjusted for the fraction of the total area sampled by the trays at that distance from the plants in order to estimate the overall fraction of all seeds predated. There was no evidence of bird or rodent footprints in the grease.

Post-dispersal seed predation

Post-dispersal seed loss was examined by measuring the effect on numbers of seeds germinating, of excluding birds and mice from plots where seed was sown.

On 1 March 1989 eight plots, 44 cm x 44 cm were marked out in the field. Four of these plots were covered by wire cages 44 cm x 44 cm x 10 cm high, of galvanized wire

Proc. 43rd N.Z. Weed and Pest Control Conf. 1990: 216-219

with a mesh of 1 cm x 1 cm to exclude mice and birds. On half of each plot, extra seed was sown at a density of 290 seeds per 10 cm x 10 cm area (an estimated 2,830 seeds per plot). This density is comparable with the high density of seed often found in the field. The majority of nodding thistle seeds are not dispersed far and are deposited in a dense pattern close to the parent plant (Delahunty 1962; Stuckey and Forsyth 1971; Kelly *et al* 1988).

Germinated seedlings were counted and removed at fortnightly intervals from 30 March 1989, when the first seedlings appeared, until 12 September 1989.

A caged goldfinch and a laboratory mouse were fed with nodding thistle seeds to see if any differences were apparent in the husks discarded by birds and mice.

RESULTS AND DISCUSSION

Pre-dispersal seed predation by goldfinches

A total of 2940 seeds were collected from the greased trays over the 10 weeks. Over the four plants and six collection dates, $32.2 \pm 9.9\%$ (mean $\pm 95\%$ C.I.) of seeds were estimated to have been husked (Table 1), although there was variation between dates and between plants. The estimate of 32% seed loss is based only on seeds which landed within 1.86 m of the plants. Delahunty (1962) and Kelly *et al* (1988) have shown that very few filled nodding thistle seeds travel far. Therefore most seeds produced by the four plants studied would have been dispersed within the sampling area.

Goldfinches are assumed to have been responsible for the majority of seed loss. This assumption is based on observations in the field where goldfinches were the only birds ever seen feeding on nodding thistle plants and were frequently observed doing so. Information concerning the behaviour and feeding habits of goldfinches supports this assumption. The agility and small size of goldfinches makes them ideally suited to feeding on thistle heads (Kear 1962; Newton 1967; Power 1987).

Two factors seem important in accounting for the large number of seeds destroyed by goldfinches. Firstly, goldfinches were very abundant at Fereday Island. The study site was near extensive areas of old river-bed, covered with scrubby vegetation providing ideal breeding sites for them (I.G. McLean pers. comm.). Secondly, thistle seed is reported to be a highly preferred food of goldfinches (Newton 1967, 1972; Campbell 1972) and they will concentrate their feeding on such food (Campbell 1972).

TABLE 1: Percentage of nodding thistle seeds husked (mainly by goldfinches) from four plants in Canterbury at six dates in 1989. Percentages are weighted to give the estimated loss for all seeds dispersed within 1.86 m of the parent. The overall mean is based on the 20 individual replicates.

Plant	Date trays cleared						Total % by plant
	31 Jan	10 Feb	22 Feb	8 Mar	22 Mar	5 Apr	
1	22	19	31	30	15	dead	26
2	10	3	3	12	35	6	14
3	88	65	55	26	67	69	64
4	58	22	8	dead			27
Total % by date	61	34	20	22	41	29	32.2 ± 9.9

Post-dispersal seed predation

On the first return to the field site after this experiment was set up, many of the sown seeds on uncaged plots had been predated and empty husks were found.

At both levels of seed density, more seedlings germinated in caged than uncaged plots (Table 2). Where seed had been sown, germination in uncaged areas was only 15% of that in the caged areas, suggesting that 85% of the seeds were lost to ground seed predation. Where seed had not been sown, an estimated 61% of seed was lost to ground seed predators, but numbers are low. It is possible that predation was more severe in areas of high seed density because predators concentrated their feeding where the food supply was richest.

TABLE 2: Mean numbers ($\pm 95\%$ C.I.) of nodding thistle seedlings germinating per plot from 30 March to 12 September 1989, with and without cages to exclude ground seed predators. Approximately 2,830 seeds per plot sown on 1 March 1989.

	Caged	Uncaged
Seed sown	383 $\pm$ 193	59.0 $\pm$ 48.9
No seed sown	7.00 $\pm$ 6.23	2.75 $\pm$ 3.53

In the field the majority of shed seed occurs in areas of high density as most seed is shed close to the parent plant (Delahunty 1962; Stuckey and Forsyth 1971; Kelly *et al* 1988). Thus the estimate of 85% seed loss is applicable to the majority of seed produced by nodding thistle plants.

Only 13% of sown seeds emerged on caged plots, indicating that a large number of seeds failed to emerge for reasons other than loss to vertebrate ground seed predators. These reasons may include seed inviability (estimated at 9% by McCallum 1989), invertebrate predators (not considered in this experiment), and seed dormancy. Work on the numbers of seeds dormant in the soil is continuing.

Little can be concluded as to the nature of the seed predators involved as no animal was observed in the field feeding on nodding thistle seed on the ground. Finches, house sparrows (*Passer domesticus*) and mice (*Mus musculus*) may have been responsible for ground seed predation. All these animals husk seeds. No differences were apparent between seeds husked by the mouse and the goldfinch in the laboratory. Goldfinches and sparrows were the only primarily granivorous birds frequently seen at the field site. The field site was near several farm buildings and it is likely that mice were also present.

Overall seed losses

It was estimated that *Rhinocyllus conicus* destroyed 3% of nodding thistle seed at Fereday Island in 1988-89 and that the potential seed production at the site was 6,427 seeds/m² (Kelly *et al* 1990). Including those results, overall losses to all seed predators (ignoring invertebrates other than *R. conicus*) were estimated at 90% (Table 3). Goldfinches seem to be the most important predator by a large margin. An estimated 84 seeds/m² (1.3% of seeds) survived to germinate in the first autumn.

TABLE 3: Fates of seeds in nodding thistle at Fereday Island, Canterbury, in 1988-89.

Cause of loss	% of seed destroyed (this stage)	% of total seed prod'n destroyed	% of total seed prod'n remaining	Seeds/m ² remaining
<i>Rhinocyllus conicus</i> ^c	—	—	100	6427 ^a
Predispersal predation	2.83	2.83	97.2	6245
by goldfinches	32.0	31.1	66.1	4248
Ground seed predators	85.0	56.2	9.9	636
Failure to germinate ^b	87.0	8.6	1.3	84

^aEstimated seed production at site in absence of predators (Kelly *et al* 1990); ^bincludes inviability, predation by invertebrates and microorganisms, and dormant seed (see text); ^cdata from Kelly *et al* (1990).

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