INSECTS AND SEED PRODUCTION IN CELMISIA

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The articles by John Dugdale and Howard Lintott in the last issue of this Journal are timely reminders of the influence insects can have on our native plants. Most members will be familiar with at least some of the plant galls described by Howard Lintott, and his records for Canterbury should stimulate further inquiry. Fewer members will be familiar with the full range of insects attacking *Celmisia*, as discussed by John Dugdale. For my part, I was particularly interested in his comments on insects damaging the flowers of *Celmisia*, and his statement that our knowledge of these relationships is far from complete. The present article is a botanist's attempt to help bridge this gap.

During the 1957-58 flowering season I collected seed of several native plants from Porters Pass for viability and germination tests. The ubiquitous *Celmisia spectabilis* var. *spectabilis* and *C. gracilenta* were two of those collected. On examination I found that many seed heads of *C. spectabilis* contained insect larvae and/or pupae. Several seed heads were brought back to the laboratory and placed under a ventilated bell-jar at room temperature, and in due course little grey flies (about half the size of the common house fly) with brown legs and blotched wings hatched out. These were sent to the Entomology Division, DSIR, and identified by Dr. R.A. Harrison (now Professor of Entomology, Lincoln College) as a fruit fly or trypetid, *Trypanea centralis*.

By chance I had also collected flowering portions of the vegetable sheep, *Raoulia eximia* and *R. mammillaris*, and laid them aside in plastic containers. In time similar but smaller flies hatched out from *R. mammillaris* and these were identified by Dr. Harrison as the trypetid, *Trypanea alboapicata* (this method of raising adult insects is quite simple and members may care to follow it, using plastic bags, to study insects in other seed heads).

Trypanea centralis and *T. alboapicata*, along with seven other species, all endemic to New Zealand, are described by Dr. Harrison in his bulletin on two-winged flies or Diptera (Harrison, 1959). Both species are widely distributed and had been collected in 1954 from Porters Pass by Dr. R.R. Foster (now Director of the Otago Museum). It is interesting to note that the holotypes for both species were selected from material gathered at Cass in the 1920s. (the holotype is the one specimen designated by the original author as *the* type to which the name of the species is permanently attached. The term is derived from the Greek "holos" meaning whole).

Although *Trypanea centralis* had been recorded before from *Celmisia spectabilis*, no previous host plant was known for *Trypanea alboapicata*. At Porters Pass, on the main ridge to Foggy Peak, I have found trypetid larvae and pupae in the seed heads of *Celmisia spectabilis*, *C. gracilenta*, *C. angustifolia*, *C. lyallii*, and the well-known hybrid, *C. lyallii* x *spectabilis*, but not on *C. viscosa*, *C. haastii*, *C. laricifolia*, and *C. sessiliflora*. Coincidentally the latter species are seldom found below the natural treeline in this district - about 1300 m - and in my experience flower rather more infrequently.

Further afield, on the true left of the Rakaia Valley, where two varieties of Celmisia spectabilis - var. spectabilis and var. magnifica (Given, 1972) - meet at their respective geographic limits, trypetid larvae and pupae can be found in the seed heads of both. These two varieties seem more prone to infestation than other celmisias I have examined, and of the two, var. spectabilis can be heavily infested.

In addition to the above hosts, I have found trypetid larvae and pupae in the seed heads of Senecio bellidioides at Porters Pass. This record, along with that of Trypanea alboapicata from Raoulia mammillaris, suggests that this group of insects is not restricted to Celmisia as John Dugdale claims (Dugdale, 1974).

Trypanea centralis appears to be the main insect attacking Celmisia flower heads at Porters Pass, and in three successive seed years, 1957-59 inclusive, a high degree of infestation seemed apparent. In addition an unidentified geometrid caterpillar was sometimes found, either on its own or together with trypetid larvae.

The 1962-63 flowering season was a good one for Celmisia spectabilis around Porters Pass, and I decided to gather a few figures on these two insects. During the first half of January 1963, I collected a large number of seed heads in a random fashion from the following places: at two different altitudes on the ridge to Foggy Peak, Porters Pass; on the fan surface between Lake Lyndon and the Porter River, near the high point of the Main West Coast Road; at Flock Hill, between the two bridges at the foot of the Craigieburn cutting; and on Goldneys Saddle, near the Main West Coast Road. The annual rainfall probably exceeds 1000 mm at the first three stations, and is probably less at the other two. The plant communities are roughly alike, namely, Chionochloa-Dracophyllum tussock grassland and shrubland.

The following table gives the percentage of seed heads infested at each site with trypetid larvae or pupae, geometrid caterpillars, or both.

	Porters Pass		L. Lyndon	Flock Hill	Goldneys Saddle
	910 m	1372 m	762 m	640 m	580 m
No. heads collected	200	100	144	196	196
% infested:					
trypetid only	96.0	52.0	66.8	63.5	87.3
geometrid only	1.0	19.0	0	5.0	0
both	0	4.0	(1) *	(1) *	0
% uninfested	3.0	25.0	33.2	36.0	12.7

* One head only

At all sites considerably more than half the seed heads collected were infested by Trypanea centralis, with very high percentages recorded at 910 m on Porters Pass, and on Goldneys Saddle. The lowest percentage was recorded from the highest altitude sampled, 1372 m at Porters Pass. This may reflect a true decline in the insect with increasing altitude. Certainly the host, Celmisia spectabilis ascends much higher - greater than 1700 m - although it is found less frequently and flowers less abundantly above 1300 m.

The geometrid caterpillar showed the opposite trend, that is, a low incidence overall, except at the high altitude site. For some reason this site was a favourable one, with almost a quarter of the seed heads harbouring caterpillars. The low figures for caterpillars and trypetids together may also be a reliable estimate, and suggests that these two may be incompatible.

In seed heads infested solely with geometrid caterpillars, or with caterpillars and trypetids together, there was never more than one caterpillar per head. Trypetids, however, usually occur in greater numbers. The following table records the number of insects (trypetids plus geometrids) found in the samples listed above.

	Porters Pass		L. Lyndon	Flock Hill	Goldneys Saddle
	910 m	1372 m	762 m	640 m	580 m
No. insects/head					
Mean	6.38	2.57	6.00	3.13	3.20
Range	1-17	1-10	1-18	1-10	1-10
Standard error *	.31	.17	.10	.21	.14

* a measure of the variability of the sample and the reliability of the mean.

Numbers varied widely among the sites examined, and were not necessarily related to the degree of stand infestation (compare with the previous table).

Various amounts of developing seed (achenes) are destroyed in each seed head depending on the number of insects involved and the size of the seed head. Generally the smaller the seed head, or the larger the number of insects, the greater the chance for total seed destruction. In some cases where insect numbers were high, parts of the receptacle were eaten as well, and in one head trypetid pupae were found 2 cm below the receptacle inside the scape. The following table shows the relationship between insect numbers only and the amount of seed destroyed. Three categories of seed destruction were assessed visually; all, greater than half, and less than half. The percentage of infested seed heads is listed for each category, and the figures in brackets alongside represent the mean number of insects involved.

	Porters Pass		L. Lyndon	Flock Hill	Goldneys Saddle
	910 m	1372 m	762 m	640 m	580 m
Seed destroyed					
All	72.5 (7.5)	21.3 (4.5)	75.5 (7.0)	61.6 (4.1)	59.6 (3.6)
> half	15.5 (4.4)	28.0 (2.8)	12.7 (3.7)	13.0 (4.2)	21.6 (2.7)
< half	11.9 (2.4)	50.7 (1.6)	11.8 (2.0)	25.3 (1.8)	18.7 (1.5)

All the seed was destroyed in more than half the infested heads examined, except at the high altitude site where the influence of insects clearly diminishes. However, if we consider the amount of seed left over, together with the amount of seed in uninfested heads, there is still probably enough seed available for replenishment of Celmisia spectabilis. Just how much seed is available is difficult to estimate accurately. But we can make a reasonable prediction.

For example, take the site with the heaviest insect infestation and the highest level of seed destruction - 910 m at Porters Pass. Five "clean" seed heads from this site gave 155, 165, 178, 187 and 202 seeds respectively - an average of 177 per head. On this basis every 100 heads had a potential output of about 17,700 seeds. From the first table we found that at 910 m 3 in every 100 heads was uninfested, yielding about 531 seeds. And of the 97 infested heads we can calculate from the last table than 14 had less than half their seed left, say one third, yielding 826 seeds; and 12 had more than half their seed left, say two thirds, yielding 1416 seeds. This gives us a grand total of 2773 seeds left over from our potential output of 17,700 - about 16%.

The usefulness of this seed depended initially on its viability or potential germination capacity. Unfortunately seed produced in 1962-63 was not tested. However, seed harvested in 1957-58 had a viability of 34% when tested by the tetrazolium method at the Seed Testing Station, Palmerston North, and actual germinations of 24-44%, according to the treatments applied. If we "borrow" the viability figure of 34%, we can estimate that for every 100 seed heads produced in 1962-63, about 943 surviving seeds may have germinated, providing no further damage occurred and all the conditions for dispersal and germination were met. As this is most unlikely, we can confidently predict a further reduction in the numbers of seed which survived to germinate. Nonetheless, there may still have been adequate numbers for the replenishment of Celmisia spectabilis, if in fact replenishment was necessary.

The picture was not so rosy in the 1965-66 flowering season, another good one for C. spectabilis around Porters Pass. Again I followed the same procedure, but this time the collections were made at the pupal stage, in March, only 100 seed heads were collected from each station, and the high altitude site was omitted. The data are presented below in one combined table, along with germination tests on sound seed.

	Porters Pass 910 m	L. Lyndon 762 m	Flock Hill 640 m	Goldneys Saddle 580 m
No. of heads collected	100	100	100	100
% infested:				
trypetid only	98.0	90.0	92.0	95.0
% uninfested	2.0	10.0	8.0	5.0
No. insects/head				
Mean	3.4	2.9	3.4	2.6
Range	1-9	1-8	1-13	1-7
Standard error	.59	.15	.22	.16
Seed destroyed				
All	80.6 (3.7)	86.7 (3.1)	84.8 (3.5)	93.7 (2.7)
> half	14.3 (2.3)	10.0 (1.8)	10.8 (1.8)	5.3 (2.0)
< half	5.1 (1.4)	3.3 (2.0)	4.3 (1.0)	1.0 (1.0)
Germination of sound seed %	7	6	8	1

Insect infestation was more severe overall during this season, involving fewer insects per head but a greater degree of seed destruction. There was no evidence of attack this time by geometrid caterpillars.

Using the same base figure of 177 seeds per head, and calculating for Porters Pass as before, we arrive at a survival figure of 1770 seeds for every 100 heads produced. However, only 7% - 124 seeds - were capable of germinating, providing other pre-requisites were met, e.g. dispersal, etc. We may safely conclude that few if any seedlings of *Celmisia spectabilis* arose from this seed crop at Porters Pass or any of the other sites examined.

From these two sets of data it is clear that insects can cause a significant reduction in the seed of established *C. spectabilis*, varying in intensity from year to year and from site to site. This must surely affect re-establishment at times, and may be nature's way of controlling "Zero Population Growth" in *C. spectabilis*. Nevertheless, both var. *spectabilis* and var. *magnifica* cover large areas in the eastern South Island and are noted for their aggressive behaviour, mainly through vegetative extension, and their ability to survive burning and grazing. In fact most stands of *C. spectabilis* below the natural treeline are fire-induced, suggesting that periodic fires may reduce seed-eating insects to a level permitting the uncontrolled spread and establishment of the species. Between fires insect numbers should build up again, thereby restricting further spread and establishment, except by vegetative means.

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Note: Since this paper was prepared, two articles by Dr. E.G.White, Tussock Grasslands and Mountain Lands Institute. have appeared in Volume 18 (1975) of the New Zealand Journal of Agricultural Research. One deals with the effect of grasshoppers on alpine plants, including Celmisia, while the other surveys insect damage affecting seed production in Chionochloa.

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OUT IN THE OPEN

The Pulse of Spring

Some writer has said that, "Spring is a shabby excuse for prolonging the winter by three months", but this smart saying, however appropriate to the seasons in Europe, does not apply fairly to this favoured country. Here. there is no broad well marked boundary to cross which separates one season from another; as soon as the middle of the month of August is reached, one can feel the mild incoming of the genial period of growth. Spring comes upon us quietly "doing good by stealth" like pitiful-eyed charity, clothing the naked. She spreads abroad verdure as a garment, causing the face of Mother Nature (like that of many another female) to break into radiant smiles when adorned with the freshness of new apparel.

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