Ecology of *Calochilus robertsonii* (Orchidaceae) from Rotorua, New Zealand

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Abstract
Calochilus robertsonii is widespread and found in a range of habitats in Australia. In New Zealand, this species is uncommon, occurring mainly in geothermally influenced habitats, although not specific to them. The largest population in New Zealand occurs on heated and hydrothermally altered soils in Rotorua. Active conservation management of its habitat here has helped its survival. The results of monitoring for a number of years shows significant differences in population size between years. Flowering stem height, and the number of flowers per stem also varied during 3 years of monitoring.

Introduction

The genus *Calochilus* (bearded orchids) comprises about 12 species, mostly Australian, but is also recorded from New Caledonia, New Guinea, and New Zealand. The three species that occur in New Zealand are shared with Australia: *C. herbaceus*, *C. paludosus*, and *C. robertsonii* Benth. (red bearded orchid). Although these three species are widespread in Australia, they are uncommon in New Zealand.

Calochilus robertsonii occupies a range of habitats throughout Australia, from the coast to the mountains, but is usually seen on ridges and slopes in open forest, and in heathlands. It has been recorded from swampy habitats in Western Australia (Jones 1988).

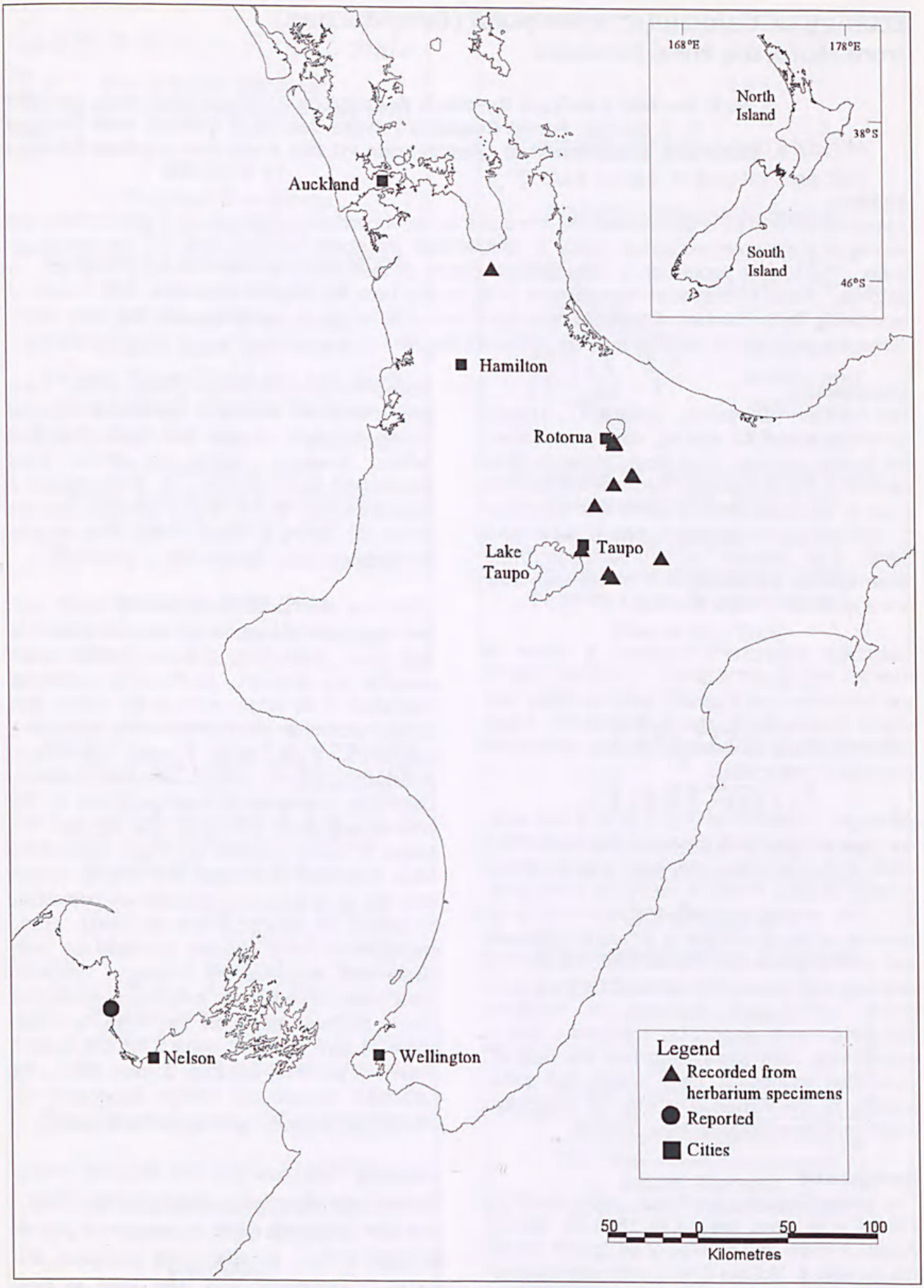
Although *C. robertsonii* (Fig. 1 & 2) is the most common of the three species occurring in New Zealand, it is very rare and found at only a small number of sites, mostly in the North Island (Fig. 3). The largest known population occurs at Rotorua, where its habitat is amongst cultivated and mown grassland. Since 1988, the orchid area has been seasonally managed (left unmown during spring and summer), to facilitate flowering and seed set without undue disturbance. This paper describes the habitat, population abundance, plant height, and some aspects of the flowering biology of *Calochilus robertsonii* from Rotorua, New Zealand.

Background

The genus *Calochilus* (in Greek, *calos* beautiful, *cheilos* a lip) was named in 1810 by Robert Brown, a friend and protégé of Sir Joseph Banks (St George & McCrae 1990) with reference to their attractive, hairy labellum (Jones 1988). All *Calochilus* species are terrestrial and deciduous with a solitary, fleshy, erect leaf, dying back to a fleshy, elongated tuberoid (Jones 1988). New leaf growth is extremely rapid and initiated during autumn. Leaves are fully developed before flowering begins in spring (late September) (Jones 1988). In New Zealand it flowers through to the end of January, and the plants die down in late summer after capsule dehiscence.

Calochilus robertsonii flowers are greenish with red or purplish stripes on the perianth segments and have distinctive, coarse, reddish hairs covering the labellum. In Australia, *Calochilus* pollination is by large, male scollid wasps that remove pollen on their heads while attempting copulation, or by selfing if wasp visitation is infrequent (Jones 1988). In New Zealand, *Calochilus robertsonii* is considered to be predominantly self-pollinating, and although the genus is highly adapted for insect pollination, when this does not occur, the flowers remain open for several days, eventually self-pollinating by default (St George & McCrae 1990). Many angiosperms have obligate relationships with mycorrhizal fungi, usually forming a symbiotic association. Fungal root infection plays a vital role in nutrient uptake for the flowering plant, which in turn provides sugars for the fungus (Raven *et al.* 1992; Salisbury & Ross 1991). All *Calochilus* species are heavily dependent on mycorrhizal fungi (St George & McCrae 1990).

Calochilus robertsonii was first recorded in New Zealand, and described in detail, by Kirk (1892), although under the name *C. campestris* (Moore & Edgar 1970). To add to the confusion, the name *C. campestris* was later used in New Zealand for what is now known as *C. herbaceus*. *Calochilus robertsonii* occurs in scattered



Distribution of *Calochilus robertsonii* in New Zealand

locations in New Zealand (Fig. 3), mainly in the central North Island and more commonly in geothermally heated and/or hydrothermally altered soils. It has also been recorded from disturbed margins of wetlands in the Waikato region, from open sites near Taupo, and reported from Kaitereteri in the South Island (Johns & Molloy 1983; Wilson & Given 1989). Wilson & Given (1989) classified *C. robertsonii* as vulnerable, whereas it is currently classified as 'naturally uncommon' falling into the 'sparse' sub-group category in the latest list of New Zealand's threatened and uncommon plants (de Lange *et al.* 1999). Taxa in this classification are not considered under any immediate or obvious threat but, for various reasons, have the potential to become threatened (de Lange *et al.* 1999).

The population of *Calochilus robertsonii* investigated is located within the boundaries of the city of Rotorua, in the central North Island of New Zealand (Fig. 3). Rotorua City is located at the edge of a volcanic lake inside an ancient caldera. The city and its surrounding district are renowned for their geothermal activity, including hot springs and streams, boiling mud pools, steaming ground, fumaroles, and geysers. Plant communities that occur in geothermally influenced habitats (e.g., heated soils, hydrothermally altered soils, and steamy atmosphere) of the central North Island support a range of species that normally occur in tropical regions and/or at higher latitudes, e.g., the fern ally *Psilotum nudum* (Given 1989; Merrett & Burns 1998).

Materials and Methods

In November 1998, October 1999, and November 2000, plant height and the number of buds, flowers, and capsules were recorded from randomly selected *Calochilus robertsonii* individuals within the known orchid area. In October 1999, 19 flowering plants were tagged; bud and flower numbers, and the position of open flowers in relation to unopened buds were recorded. Follow-up visits were made regularly at 2-week intervals during the flowering season to monitor flowering progress, and 5-minute pollinator observations were conducted. Habitat details were noted, soil temperatures at 10 cm depth were recorded using a Digitron temperature probe, and plant species growing in association with *C. robertsonii* were listed. A final visit on 18 February 2000 revealed recent mowing of the study area had taken place, and no *C. robertsonii* were located.

An annual census of the *Calochilus robertsonii* population has been undertaken by the Department of Conservation each year since 1992 (George Pardy pers. comm.), following an earlier census in 1985. During late November or early December, the reasonably well-defined orchid area is demarcated using hip chain cotton, then the entire area divided into transects. Department of Conservation staff and teams of volunteers walk each transect twice, placing a brightly coloured self-adhesive 'dot' beside each red bearded orchid plant (flowering and non-flowering). The number of individual plants is determined by calculating the number of self adhesive 'dots' per metre of backing tape, and measuring the length of backing tape used for each survey.

RESULTS

Habitat

The dominant feature of the vegetation where *Calochilus robertsonii* occurs is low growing (mown) manuka (*Leptospermum scoparium*) with patches of bracken (*Pteridium esculentum*) and exotic grasses. By getting down on one's knees, *C. robertsonii* flowering stems can be seen scattered throughout the area, primarily amongst the manuka. Patches of bare ground are also a feature, compared with the surrounding cultivated grassland, and are indicative of hydrothermally altered soils that inhibit establishment of sown and adventive grasses.

Soil temperatures and pH

Soil temperatures recorded from *C. robertsonii* habitat ranged from 21 to 27°C, with a mean of 23.5°C. Soil temperatures recorded from the grass patches within the study area also ranged from 21 to 27°C. The mean soil temperature

from the surrounding cultivated grassland was 24.5ºC, and ranged from 23 to 26ºC. Soil bulk density was variable in the study area. For example, there was a noticeable difference in the ease of inserting the temperature probe into the soil within the various habitats. In *C. robertsonii* habitat, the soil was very hard, and inserting the probe to 10 cm depth was often quite difficult. In comparison, grass patches within the *C. robertsonii* study area were much softer and the probe was easily inserted into the soil.

Three soil samples from locations close to orchid plants were tested and all were pH 4.2.

Year	No.
1985	1392
1993	138[1]
1994	1473
1995	2037
1996	1132
1997	1996
1998	1820
1999	1005
2000	3268[2]

1 A different method was used for this count.
2 The area was double-checked and an additional 227 plants were counted, giving a total of 3495.

Phenology

Flowering began in October and continued through December, with a few flowers still present in early January. The lowermost buds opened first, with new buds developing at the apex of the stem. Although occasional plants had two flowers open, it was more common for only one flower to be present.

In the monitored group, 89% had only one flower open at any one time. As one flower senesced, it closed and turned brown, remaining attached to the top of the capsule. The green capsule enlarges once the flower had closed, and as it matured it changed colour to become brown, eventually drying and dehiscing to release its seed.

As one flower dies, the bud above begins opening and maturing. It was noted that in some cases, the capsule had withered, suggesting lack of fertilization.

The maximum number of buds and flowers recorded from a single flowering stem over three flowering seasons was 15 in 1998, 9 in 1999, and 7 in 2000 (Table 2). The height of randomly selected flowering stems from three flowering seasons revealed a significant difference (p= 0.00) between 1998 and 1999, but not significantly different between 1999 and 2000 (p= 0.69) (Table 2).

In 1998, the maximum height was 38 cm, in 1999, 32 cm, and in 2000, 31 cm, (Table 2). Flower length ranged from 18–21 mm and width ranged from 10–19 mm (Table 3). Five-minute flower observations by three people over a 2-hour period did not reveal visitation by any potential pollinators.

Table 2. Minimum, mean, and maximum plant height, number of flowers per stem, and length and width of flowers in *Calochilus robertsonii* from Rotorua, New Zealand.

Plant height (cm)	1998	1999	2000
n	50	71	58
Minimum	18	13	13
Mean	25	21	21
Maximum	38	32	31
Standard deviation	5.0	3.4	3.7
Number of flowers per stem	**1998**	**1999**	**2000**
n	50	71	58
Minimum	3	2	2
Mean	6.5	4.6	4.5
Maximum	15	9	7
Standard deviation	2.40	1.59	1.40

Table 3. Minimum, mean, and maximum flower length and width of *Calochilus robertsonii* recorded in 1999 from Rotorua, New Zealand.

Flower length and width (mm)	
n	34
Minimum length	18
Mean length	21.7
Maximum length	25
Standard deviation	1.72
Minimum width	10
Mean width	14.8
Maximum width	19
Standard deviation	1.96

Calochilus robertsonii has an interesting distribution in New Zealand. It has been suggested that each distinct site probably represents a separate successful establishment event of wind blown seed from Australia. Although mainly confined to geothermal areas, it is not specific to that habitat. It apparently colonises open disturbed ground where suitable habitat presents itself. There was no discernible difference in soil temperatures between *Calochilus* habitat and non-*Calochilus* habitat at Rotorua. The areas that support *Calochilus* have bare ground available for colonisation and establishment, whereas the areas dominated by pasture grasses effectively exclude *Calochilus* colonisation. *Calochilus robertsonii* cannot compete with pasture grasses.

The number of orchid plants located each year shows that numbers of visible plants fluctuates greatly from year to year (Table 1). The extremely low figure for 1993 is possibly due to the area being mown just before the counting, thus reducing visibility of the leaves, or to a less effective counting method being used, or to the count being made relatively late in the season by inexperienced observers. The fluctuations from 1005 to 3495 however are too great to be counting errors and must be largely due to natural population fluctuations or at least to the absence of leaves on many plants when counted. Observations of other orchids over many years have shown that plants with no leaves for most of a season can still have live tubers and produce new leaves in the next season.

Over the last 15 years *C. robertsonii* at Rotorua has gradually migrated into formerly bare areas. Unfortunately, areas of relatively open vegetation suitable for this orchid are gradually diminishing and the population will be expected to decline as the dense sward of exotic grasses gradually invades.

Flower size is apparently larger in Australia where flower stems can reach 45cm in height, and bear one to nine flowers (Jones 1988). Variation in plant height from year to year is possibly a reflection of variation in climatic conditions. For example, plentiful rain and/or sunshine during the growth and development phase may influence food storage for use in the following or subsequent flowering year. Individual plants may not flower annually or biennially, which could explain the wide variation in abundance from year to year. Variation in the size of the population from year to year could also be explained by new recruitment and mortality dynamics. In a study of three terrestrial orchids in England, Wells (1981) recorded fluctuations in population, explained by high levels of recruitment in some years. Over the last 15 years *C. robertsonii* at Rotorua has gradually migrated into formerly bare areas. Unfortunately, areas of relatively open vegetation suitable for this orchid are gradually diminishing and the population will be expected to decline as the dense sward of exotic grasses gradually invades.

The management regime in place at Rotorua allows flowering and seed set of *C. robertsonii* to be completed before mowing, and appears to have been successful in maintaining this population so far. Mowing inhibits taller growing plant species and maintains a sparser vegetation cover more suitable to *C. robertsonii*. A small, previously known population of this species disappeared after its nearby habitat was left unmown.

Additional investigations over several years and would help understand population dynamics and individual plant longevity. For example, by recording the position of individual plants in relation to a permanent marker peg, and recording the state of the plant (flowering or vegetative), would enable the fate of individuals to be followed. Insect visitation observation at various times of the day would also provide more comprehensive information about pollination activity.

Acknowledgments

We would like to thank CHR, AK, NZFRI, and WAIK herbaria for access to their records; George Pardy and Keith Owen (Department of Conservation, Rotorua) who have been involved with management and monitoring the orchid population; volunteers who assisted with the annual consensus; Barbara Swale and Joan Fitzgerald for help with insect observations; Gareth Wilson for the distribution map; Neil Fitzgerald for the photograph; and Mark Smale and Elizabeth Miller for useful comments on the draft.

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Calochilus robertsonii

Flowering plants *in situ* from Rotorua, (North Island) New Zealand

Merrett, M F, Ecroyd, C E, and Cashmore, P. 2001. "Ecology of Calochilus robertsonii (Orchidaceae) from Rotorua, New Zealand." *The Orchadian* 13(8), 375–381.

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