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Relocation and establishment of nesting populations of the native bee *Leioproctus huakiwi* Donovan (Hymenoptera: Colletidae).

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ABSTRACT

Environmental changes in New Zealand over the last 200 years such as the intensification of agriculture have nearly eliminated some species of native bees from parts of their historic ranges. Consequently, the reproductive success of native plants reliant on native bees for pollination may be adversely impacted, thereby altering native ecosystems. The potential pollination rate of some introduced crops might also be reduced. Overwintering prepupae of the ground-nesting colletid bee *Leioproctus huakiwi* Donovan, 2007, were re-located in nests in soil and in artificial cells to new nest sites, where they established new populations which expanded by about 8-25 times over three years (and for the two sites together by 12.75 times), showing that large populations can develop rapidly. The two transference methods should be applicable to other species of colletids, indicating that relocation of these bees to new areas for both conservation and economic values is readily achievable.

KEYWORDS

Leioproctus huakiwi, New Zealand native bee, population relocation.

INTRODUCTION

Since the arrival of primarily European settlers in New Zealand beginning about 200 years ago, the environment has been changed enormously by the destruction of native vegetation, the introduction of new species of plants and animals, and the intensification of modern agriculture (Kirkpatrick 2005). For example the Canterbury Plains are almost completely devoted to maximising the production of food, where cultivation of the ground destroys nests of species of *Leioproctus,* and dense populations of introduced grasses and irrigation precludes bees from excavating nests. Collection localities for some native ground-nesting species of the bee genus *Leioproctus* (Hymenoptera: Colletidae) summarized in Donovan (2007) are hundreds of kilometres apart, possibly because environmental changes have eliminated nesting areas and/or foraging opportunities, causing localised extinctions, or significant population reductions so that populations are not easily detected. Native bees are generally regarded as significant pollinators of many flowering plants (Donovan 2007), so insufficient bees could impact very negatively on the pollination of some native plants, with consequent adverse impacts on community ecosystems which are dependent on the presence of native plants to maintain their integrity. Impacts could be especially severe where species of flowering plants and native bees have developed co-dependencies, where the plants are visited and apparently pollinated by just a few species of native bees, such as some species of *Carmichaelia* and *Hebe* (Donovan 2007). Also, some species of native bees are frequently recorded visiting and apparently pollinating several introduced plants of high economic value such as kiwifruit (*Actinidia deliciosa*) (Macfarlane and Ferguson 1983, Donovan 1987, 2007), chestnuts (*Castanea sativa*), avocados (*Persea americana*) (Donovan 2007), and seed crops of white clover (*Trifolium repens*), onions (*Allium cepa*) and brassicas (*Brassica* spp.) (Howlett *et al*. 2005, Donovan 2007; Rader *et al*. 2009). The native bee *Leioproctus huakiwi* Donovan (2007), is one species that readily collects nectar and pollen from a wide range of native plant species (Donovan 2007) and economically important introduced crop plants including onion and pak choi (Howlett *et al*. 2009). This species is widely distributed in North, South and Stewart Islands (Donovan 2007). Despite its wide distribution and many former records of nest sites, in 2005 we knew of just one nest site in Canterbury, at Lincoln, mid-Canterbury, with only half a dozen nests apparent each year, and also a few scattered nests at Okains Bay, Banks Peninsula, mid-Canterbury. When the presence of several hundred nests in a domestic vegetable garden at Akaroa, mid-Canterbury, was identified, the opportunity was taken to attempt to relocate part of the population to a new area. The establishment of a new nesting population which increased in numbers each year would demonstrate that ground-nesting bees can be restored to areas from which they may have been eliminated, and that they can be introduced into crop environments as a supplemental pollinator. Outcomes would be not only of high conservation value, but also of economic importance through increased pollination of some crops such as onions and brassicas for seed, and kiwifruit and avocados for fruit.

The annual life-cycle of native *Leioproctus* spp. is very similar to that of the ground nesting solitary alkali bee *Nomia melanderi* Cockerell which is successfully managed in the United States of America primarily for the pollination of lucerne crops (Donovan 1980, 2007, Cane 2008). Beginning about 50 years ago, methods for transferring and establishing populations of the alkali bee were developed (Bohart 1958, Stephen 1960, 1965, Parker and Potter 1974). Alkali bees overwinter as diapausing prepupae in cells from about 100-350 mm below the surface of nest sites. With the onset of spring, prepupae develop to adult male and female bees which begin to emerge in early summer. After mating, females construct new cells within which bee larvae rapidly grow and become diapausing prepupae. By autumn adults have died.

New populations of alkali bees are normally established in suitable crop production areas by transferring diapausing prepupae. This can be achieved in two ways:

(1) the removal from nest sites of intact blocks of soil measuring about 300 mm on all sides, which contain an unknown number of cells with prepupae; and,

(2) individual prepupae removed from cells and inserted into artificial cells such as holes drilled in blocks of wood and potters clay, or short lengths of paper straws arranged vertically side-by-side in trays and closed at each end with a sheet of paper or some similar material.

Soil blocks and paper straw trays are buried in new nest sites at about the same depth as cells in the original nest sites. With the onset of spring the normal cycle of emergence and renesting is initiated.

From 1964 to 1972 the methods used to transfer alkali bee prepupae within the United States of America were used to import and establish the species in New Zealand, and later to transfer prepupae within New Zealand (Donovan 1979). However, because of the unavailability of suitable drinking straws, specially manufactured porcelain beads (walls 4 mm thick and a central cylindrical cavity 15 mm long and 9.5 mm in diameter) were used. Up to 200 beads were sited vertically, side-by-side, in a wooden frame on a sheet of beeswax comb foundation, and the beads were topped with another sheet of foundation. These release trays were buried in new nest sites with the tops 80 mm below the surface. Adult bees successfully chewed their way through the upper sheet of beeswax and tunnelled their way to the surface, after which they mated, and females subsequently constructed nests in the nest sites.

Both methods were applied to *L. huakiwi* and are described here.

MATERIALS AND METHODS

Collection site

On 10 February 2005, in clear, calm, hot weather, 194 nests of *Leioproctus* sp. were counted in and around a domestic vegetable garden on a north-facing hillside in Akaroa (43º49´S, 172.58´E), Banks Peninsula, mid-Canterbury. Females carrying large loads of pollen in their scopae were seen entering nests, and some females disappeared into the ground among plant debris before nest entrances could be located, so there were perhaps several score more nests than were counted. Two females which were captured were both *L. huakiwi*. An area about 1 m x 1 m containing at least 49 nests was marked out in the vegetable garden.

On 21 October 2005, two soil cores presumably containing intact cells with prepupae, and 65 prepupae removed from their cells, were excavated from the marked-out area of vegetable garden. The substrate had originally consisted of a layer of soil about 200 mm thick overlying an unknown depth of wind-blown loess, but many years of cultivation had intermixed the two, although soil predominated towards the surface. Preliminary excavation showed that bee cells were between about 160 - 450 mm below the surface, so the upper 150 mm of soil was spaded away, and a large hole was excavated to form a flat vertical face extending to 500 mm below the original surface. Straight cuts were then made with a flat-bladed spade to the sides, back and base to produce cubes of undisturbed soil about 300 mm on all sides. The cubes were slid onto a flat metal sheet and the sides were sheathed in similar flat metal sheets for stability during transport to the new site. Prepupae which were uncovered during soil core extraction were each placed into a porcelain bead in one of two release trays as described for alkali bee prepupae, but with just 50 beads each. In addition, as a control, three irregular chunks of substrate which were thought not to contain bee cells were excavated from nearby ground.

New nesting sites

At the research station of Plant and Food Research Ltd. at the Canterbury Agriculture and Science Centre, Lincoln (43º35´S, 172.28´E), prior to this study, three areas 6 m apart on a north-facing, gently sloping grassy side of a dry gully were each cleared of vegetation and topsoil between 2000 and 2004 to expose 3m x 3m of the underlying fine-grained Temuka silt loam. The sites were treated twice annually with a herbicide (glyphosphate) to maintain plant-free ground so bees could nest freely. All bared ground was rapidly colonised by up to hundreds of nesting female native halictine bees, *Lasioglossum sordidum,* per square metre, which showed that the substrate was suitable for ground-nesting bees. Adult female *L. sordidum* at 4.9-6.1 mm long are distinctly smaller and much less robust compared to female *Leioproctus huakiwi* which are 9.1-11.8 mm long (Donovan 2007) (see *NZ Entomologist* Vol. 33 frontispiece).

The two soil cores were buried in the western area to a depth of c. 150 mm (the Core site), the two trays of porcelain beads were similarly buried in the central area (the Tray site), and the three chunks of substrate thought to not contain bee cells were buried in the eastern area (the Chunk site).

Sources of pollen and nectar

For successful propagation, female *L. huakiwi* require ready access to their preferred sources of pollen and nectar, which for native flowers are species of Myrtaceae, Malvaceae and Plantaginaceae (Donovan 2007). The known plants in these families closest to the new nest sites were in extensive gardens planted around buildings c. 700 m S away across an open field where in years past female *L. huakiwi* had been seen foraging particularly on *Hebe* spp. (Plantaginaceae). However, for introduced plants, a plantation of 17 *Castanea sativa* (Fagaceae) trees began 70 m E. away, where female *L. huakwi* had occurred on flowers for many years previously. Another 34 trees were about 60 m further away to the NE. Annually about 60 m² of flowering onions *Allium cepa* (Alliaceae) 130 m to the W. had attracted some female *L. huakiwi*.

Starting sites for nests

On 9 December 2005, 50 holes about 6 mm in diameter and 15 mm deep were punched in the surface around the buried release trays, and 20 around the soil cores to provide starting sites for female bees to begin excavating nest tunnels.

Bee emergence and identity

On 9 January 2006, the trays of porcelain beads were exhumed and examined for evidence of bee emergence and for identification of any non-emerged dead bees.

For further confirmation of the identity of bees from the Akaroa site, six females were caught by Dr. W. Harris from 2 - 4 February 2007 over nests in the vegetable garden, and four males were caught over flowering *Hebe* sp. in an adjacent flower garden on the same domestic property. At the Tray site one male was caught on 13 December 2008.

Assessing population size

Each summer the nest sites were observed on an irregular basis more than 25 times and as weather permitted for evidence of bee activity and to count nesting holes. The numbers of nesting females were assessed by counting the nesting holes, which are often recognizable by the presence of fresh spoil ejected onto the surface, forming a volcano-shaped tumulus up to 2 cm high as a female excavates a tunnel into the substrate. Population size can only be estimated rather than exactly determined because females will frequently utilize emergence holes from which little or even no spoil may be ejected, and sometimes nest entrances may be beneath leaves or other objects which makes detection difficult. Also, rain, wind and animal activity, such as scratching by foraging birds, can destroy tumuli and fill in nest entrances, so that sometimes if the surface is covered with fine loose dry powdery soil, females might enter where nests cannot be discerned. In addition, males will sometimes return towards the end of the day and dig holes within which to shelter for the night, and these holes can be confused with those dug by female bees. During the summers of 2006/2007 (Year Two), 2007/08 (Year Three), and 2008/09 (Year Four), nests that were entered by female bees were marked with small numbered plastic labels to better track the number of nests.

RESULTS

Nest numbers established in each of four summers were conservatively estimated to range from six to 52 at the Tray site, and possibly two to 50 at the Core site. For the two sites together the overall increase was 12.75 times. Nests and bees were not seen at the Chunk site (Table 1).

Table 1. Conservative assessment of the number of nests of *Leioproctus huakiwi* per summer at Lincoln.

Summer	Year	Nest sites		
		Tray	Core	Chunk
2005/06	One	6?	2?	0
2006/07	Two	6	7	0
2007/08	Three	17	12	0
2008/09	Four	52	50	0

On 7 December 2005 (Year One), one bee emergence hole was present over a tray, and the following day there were three, and one over the soil cores. By 14 December the number of emergence holes over the trays had increased to nine, of which one was partly plugged with loose spoil and three others had some loose spoil around the hole. Two of the nearby punched holes also had some loose spoil around them. Unfortunately, the surface over the soil cores became powdery dry, after which, with much scratching by birds, just two apparent emergence holes remained visible. By 16 December one of the holes over the trays had become surrounded by fine soil particles out to about 12 mm, forming a typical nest tumulus. The maximum number of nine holes over the trays was reached on 21 December, but there was no change over the soil cores. No holes were seen at the Chunk site, nor were adult bees seen at any site.

On 9 January 2006, of the 65 beads which had each held one prepupa, 12 had a large hole chewed through the beeswax topping the bead, and the beads were filled with soil, which indicated that a bee had emerged from each. Two beads held live bee prepupae, ten other beads held four dead females and six dead males, and 41 held dead stages from white prepupae to black pupae. All recognizable bees were *L. huakiwi*.

On 3 January 2007 (Year Two), there were six new nest tumuli at the Tray site, and five, and possibly six, at the Core site: one possible tumulus had been disrupted by birds. On 8 January under high thin cloud and mild weather, during 30 minutes after 1.30 pm, six female *Leioproctus* sp. entered nests at the Core site, and during the following 30 minutes, one entered a nest at the Tray site. At least two of the females at the Core site carried large loads of pale pollen in their scopae. During the next three weeks until 29 January when the last bee was seen, seven nests at the Core site were entered by females, and two were entered at the Tray site. All females carried pollen. There were no nests and no bees at the Chunk site. On 18 January about two dozen house sparrows (*Passer domesticus)* were foraging on the two sites near mid afternoon. The last female bee for the season of activity was seen on 29 January.

On 18 December 2007 (Year Three), 14 nest entrances were present at the Tray site, of which five had been eroded by 19 mm of rain which fell during the previous several days, so evidently the first bees emerged before about 14 December. Five rain-affected tumuli were present at the Core site. Bees were seen to be active in ten nests at the Tray site, and four at the Core site. Bee activity appeared to peak on about 29 December, and the last bee was seen on 7 January 2008.

On 11 December 2008 (Year Four), about half a dozen nests were evident at each of the Tray and Core sites, and female bees were entering with pollen, and were expelling spoil from nest tunnels. At about mid afternoon on 13 December two males crawled under dead leaf litter on the edge of the Tray site, and a male and female mated on the site. From 2.50 pm to 4.40 pm, eight females dug into the nest sites, taking from 30 seconds to six minutes to disappear beneath the surface. Peak bee activity was from about 15-24 December, and bees were not seen after 6 January 2009, by which time female bees had been seen in 14 nests at the Tray site, and 20 at the Core site. At the Tray site nests were found out to a metre from the release trays, and at the Core site the furthest nests from the planted cores were 1.4 m away.

All bees collected at Akaroa, and the male from the tray site, were *L. huakiwi*.

DISCUSSION

Although bees were not seen at both the Tray and Core sites during Year One, the occurrence of emergence holes at both sites indicated that bees had emerged. The presence of 12 holes in beeswax above 12 beads in the trays, and the replacement of bees in the beads by soil all indicated that bees had emerged successfully, kicking soil backwards as they tunnelled to the surface. The presence of only nine emergence holes over the release trays might have been due to several bees from adjacent beads exiting through the same emergence holes, and/or the obscuring of emergence holes by birds or other creatures disrupting the surface. Disadvantages of soil cores are that the number of prepupae in the soil cores is unknown, as is whether cells might contain bee enemies such as the prepupae of the parasitoid *Pseudofoenus* sp. (Hymenoptera: Gasteruptiidae) rather than bee prepupae.

The emergence of only 12 bees from 65 prepupae (18.5%) in the trays is much lower than might be expected from undisturbed prepupae, and could be due to a number of reasons, including unobserved damage to prepupae during transference to beads, possible lower than normal humidity in release trays causing dehydration, and much higher temperatures because of the shallow depth of the release trays compared to the greater depths at which most prepupae were found in their Akaroa nest site. Because most unemerged stages died during development to bees, factors such as dehydration and higher than normal temperatures may have contributed to their mortality. Further research focussing on how these factors may affect emergence from trays could assist in developing more effective techniques for improving the success of bee emergence following transfer to new sites.

The establishment of rapidly expanding populations at both the Tray and Core sites from very small numbers of nesting females is quite remarkable, and especially so because the sites were not protected from birds such as house sparrows which will eat ground-nesting native bees and alkali bees (Donovan 1967, 2007), and which were seen on the nest sites.

Because *L. huakiwi* was already known to exist at Lincoln MC, there is a possibility that some nests at the release sites were made by immigrant bees. However, because there was no colonisation of the nest sites during four years prior to the emergence of the transferred bees, later immigration seems unlikely. On the other hand, perhaps bees in the area may possibly be attracted by the established nests. Conversely and almost certainly, some females may have emigrated from the nesting sites.

The successful establishment of populations of *L. huakiwi* which increased by 8-25 times over three years from small numbers of prepupae transferred by two different methods, opens the way for the development of new populations of bees wherever required for both conservation pollination, and pollination of some economically valuable crops.

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