Role of exotic pine forests in the conservation of the critically endangered New Zealand ground beetle *Holcaspis brevicula* (Coleoptera: Carabidae)

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Abstract: The Canterbury Plains in the eastern South Island is one of the most modified regions of New Zealand with less than 2% of indigenous vegetation cover remaining. The critically endangered ground beetle *Holcaspis brevicula* Butcher, a local endemic known only from a small area in that region, is thought to be threatened by the loss and fragmentation of the formerly widespread forest and shrubland habitat. Previously, only the two type specimens, both male, were known to science. From 2000–2005, we conducted a survey for *H. brevicula*, using pitfall traps and active searching, in four of the largest remnants of the once extensive low forest and shrubland of kānuka, *Kunzea ericoides*, each covering less than 20 ha. In addition we conducted extensive trapping in an adjacent 7000 ha plantation forest of exotic *Pinus radiata*, in grassland and pasture areas, exotic shrubland, and in the nearest mountain beech (*Nothofagus solandri* var. *cliffortioides*) forest in the foothills of the Southern Alps. A total of 8658 carabids representing 47 species were collected over 57 494 trap-days, including five specimens of *H. brevicula*, all found in the pine plantation. A search of all major New Zealand collections for this species revealed three additional specimens, bringing the overall total of known specimens to ten, all of which were collected in this plantation forest. We propose that the exotic plantation forest inadvertently provides an important substitute habitat for this forest carabid, whereas the few small and fragmented native kānuka remnants appear to be insufficient to maintain populations of this species.

Key words: Coleoptera; Carabidae; conservation; *Pinus radiata*; plantation forest

Introduction

Loss and fragmentation of habitat have been identified as two major threats to biological diversity, affecting forest-dwelling species in particular (Wilson, 1988; Saunders *et al.*, 1991; Murcia, 1995). Most of New Zealand was previously forested but human colonisation led to large scale deforestation (McGlone, 1989). One of the most modified regions is the Canterbury Plains in the South Island (McEwen, 1987), where indigenous vegetation has been reduced to less than 2% of the total area.

The ground beetle *Holcaspis brevicula* Butcher, 1984 (Coleoptera: Carabidae) is a local endemic known only from an area of the Canterbury Plains near fragmented forest remnants. It is an endangered species listed as 'nationally critical' and 'under acute threat of extinction' (Hitchmough, 2002; see also Pawson and Emberson, 2000). Prior to this study, only two specimens of this beetle were known to science. The part of the Canterbury Plains where these specimens were found is now dominated by exotic vegetation, mainly pasture, agricultural land, and some planted forest. The only forest of significant area is the 7000 ha Eyrewell Forest. This forest has been planted almost entirely with one tree species, the Californian *Pinus radiata*, which is widely used in plantation forests in the southern hemisphere (Lavery and Mead, 1998). This intensively managed, even-aged plantation forest has few physiognomic similarities with the natural forests in this region.

The original vegetation of the Canterbury Plains is thought to have been dominated by low forest and shrubland of kānuka, *Kunzea ericoides*, on sites with poorer soils, and podocarp forest in more fertile areas (Burrows, 1969; Molloy and Ives, 1972; McGlone, 1989). The few natural forest and shrubland remnants on the Plains are fragmented and very small, each covering less than 20 ha. Only two kānuka remnants are part of the conservation estate, Bankside Scientific Reserve and Eyrewell Scientific Reserve, measuring only about 2 ha each (Meurk *et al.*, 1995).

Against the trend of a globally declining forest cover, the area of plantation forests is increasing

(FAO, 2001). Although their potential role in the conservation of biological diversity is controversial (Shiva, 1991; Norton, 1998; Brockerhoff *et al.*, 2001; Hartley, 2002), plantation forests in many countries have been shown to provide habitat for indigenous species from various taxa (Geldenhuys, 1997; Humphrey *et al.*, 2000, 2002; Brockerhoff *et al.*, 2003). This is thought to have conservation benefits where plantations are established on human-modified land that represents poor habitat for biodiversity. However, there are only few published records of rare and threatened species occurring in such forests (Norton, 1998). Is this because intensively managed forest plantations are not suitable for rare or threatened species, which often have specific habitat requirements? Or is the scarcity of such records merely a reflection of the limited number of surveys in plantations, compared with natural forests?

This paper presents the results of a five-year survey for the critically endangered ground beetle *H. brevicula* in the Eyrewell Reserve and three other areas of kānuka shrubland or low forest on the Canterbury Plains, in the Eyrewell Forest exotic pine plantation, in grassland and pasture, in exotic shrubland of gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*), and in mountain beech (*Nothofagus solandri* var. *cliffortioides*) forest in the foothills of the Southern Alps nearest to the Eyrewell Reserve. In addition, we review all available information on this species in order to assist with the development of a conservation strategy that can be implemented in a managed plantation forest habitat.

Methods

Study areas, sampling protocol and effort

Although pitfall trapping has some shortcomings, such as the bias from differences in the activity of species,

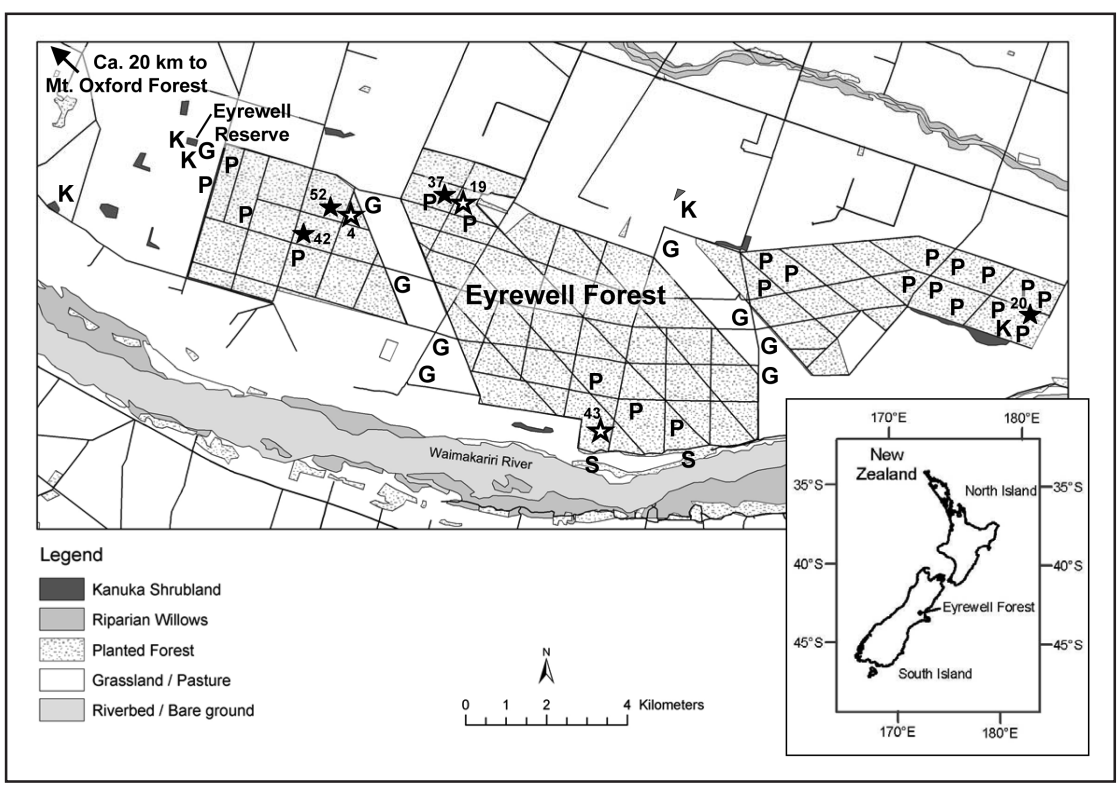

Figure 1. Map of study area with pitfall trapping locations in kānuka remnants (K), grassland and pasture areas (G), the Eyrewell Forest pine plantation (P), and exotic shrubland areas (S). Filled stars show locations where *Holcaspis brevicula* was found during this survey (numbers '20', '37', '42' and '52' refer to stand numbers assigned by us). Open stars indicate probable locations of previously collected specimens based on label information. The numbers '43', '19' and '4' probably represent the previously used compartment numbers of Eyrewell Forest as shown in the label text for some specimens (Table 1).

it is accepted as the standard method for collecting carabids (Larochelle and Larivière, 2001). Pitfall traps were set from 2000–2005 during the peak activity period of carabids from late spring (November) until early autumn (March), except during 2000/2001 when traps were in place until mid-May. Locations where pitfall trapping was carried out are shown in (Figure 1). The survey totalled 57 494 trap-days and collected 8658 carabid specimens. Just over half of the specimens were obtained from the pine plantation where the previously known *H. brevicula* had been collected. The pine plantation samples from Eyrewell Forest represented a total of 30 703 trap-days from 60 traps in young pine stands (about 1–6 years after harvesting and replanting; 2699 carabid specimens), and 12 traps in mid-rotation pine stands (planted in 1989; 240 specimens), and 212 traps in old pine stands (planted between 1976 and 1979; 1667 specimens). A total of 532 specimens was caught in kānuka remnants (11 411 trap-days from 56 traps in Eyrewell Scientific Reserve, 7 traps in an unfenced kānuka remnant next to Eyrewell Reserve, 18 traps in a remnant just south of Burnt Hill, 10 traps in a remnant north-east of the central block of Eyrewell Forest, and 4 traps next to the eastern block of Eyrewell Forest), 1511 specimens in pasture in the Eyrewell region and a grassland area in Eyrewell Reserve (4756 trap-days; 50 traps), and 131 specimens in gorse and broom shrubland (900 trap-days; 8 traps) along the southern boundary of the central block of Eyrewell Forest. In addition, 1182 specimens were caught in 76 traps (6392 trap-days) set up in two mountain beech areas in Mt. Oxford Forest, with 58 traps near the Wharfedale Track (within about 2 km of 43.250° S and 172.049° E) and another 18 traps near the East Branch Coopers Creek (within about 1 km of 43.254° S and 172.095° E). Additional samples were collected in a pine plantation and a pasture area adjacent to the Mt. Oxford beech forest in the Wharfedale track area (Wardle property). In the Mt. Oxford plantation forest a total of 458 specimens were collected (1665 trap-days; 20 traps). In the Mt. Oxford pasture area 238 specimens were collected (1685 trap-days, 20 traps). The total trapping effort was not equal across all habitats because of the larger extent of the plantation forest habitat (ca. 7000 ha) than the kānuka remnants (ca. 65 ha in total) and because the two previously known specimens were caught in the Eyrewell Forest plantation.

Pitfall traps made from 750 ml polypropylene cups with a diameter of 110 mm were installed such that the opening was level with the surrounding soil and litter surface. To increase trap efficiency, two white intersecting guide panels measuring 1.2 m long and 0.1 m high were installed over the pitfall traps, and a white plastic cover (about 150×150 mm) secured with large pebbles was placed over the trap opening. Traps were filled with about 200 ml of preservative (70% water, 30% monoethylene glycol, with some table salt and soap added) and were changed approximately every two weeks in 2000/01, and monthly from 2001/02 to 2004/05.

Two intensive hand-collecting surveys for *H. brevicula* were carried out in Eyrewell Scientific Reserve and in parts of the eastern and central Eyrewell Forest blocks by groups of entomologists in October 2002 and August 2003. The search effort involved in these totalled approximately 40 person hours. Hand-collecting surveys involved searching under logs, stones and litter. Several additional informal searches were carried out in these areas between 2000–2003. While specimens of several carabid species were found during these searches, none were *H. brevicula*.

All carabid specimens were transferred to 70% ethanol for storage and sorted to morphospecies. These were then identified using various keys, named museum specimens, and specialist advice. *Holcaspis brevicula* specimens were identified based on the description of males provided by Butcher (1984) and Johns (2003), and identifications were confirmed by Rowan Emberson, Lincoln University, and Peter Johns, Canterbury Museum. Salient characteristics for the identification of males are the genitalia (Butcher, 1984; Johns, 2003). Females were identified based on the agreement of all their general *habitus* features with those of male *H. brevicula*, except that there is no single characteristic in females as distinctive as the male aedeagus. However, the other species in the *algida* complex of *Holcaspis* do not occur in the northern Canterbury Plains (Butcher, 1984), and females of *H. brevicula* can be distinguished from all other northern Canterbury Plains *Holcaspis* based on their size and general habitus, for example, the patterns of setiferous punctures on the pronotum and elytra (Butcher, 1984).

Collection specimens

In addition to the sampling regime described above, the following insect collections were contacted or searched for specimens of *H. brevicula*: N.Z. Arthropod Collection (NZAC), Landcare Research, Auckland; Forest Research Insect Collection (FRNZ), Rotorua (including the collection of the former Forest Research Institute office in Rangiora); Lincoln University Entomology Research Museum, Lincoln, Canterbury; and the Canterbury Museum, Christchurch.

Results

Trapping results

A total of 8658 carabids from 47 species were collected

over four summers from 2000 to 2005. A detailed analysis of the carabid assemblages trapped in the different habitats will be provided elsewhere (Berndt *et al.*, manuscript in preparation) but the main findings are briefly reported here as background to the information on *H. brevicula*. Overall, carabid assemblages from kānuka remnants were most similar to those of old pine stands with a dominance of indigenous species, whereas both pasture and young pine stands had a number of abundant adventive species. The assemblages from Mt. Oxford mountain beech forest were clearly distinct with less than half the species shared between the two regions. Moreover, only one species, *Megadromus antarcticus* (Chaudoir), was moderately abundant in catches from both regions whereas all other shared species were rare in either one or the other region. Apart from *H. brevicula*, four other species of *Holcaspis* were caught, namely *Holcaspis angustula* (Chaudoir), *Holcaspis elongella* (White), *Holcaspis hudsoni* Britton, and *Holcaspis intermittens* (Chaudoir). The latter four species of *Holcaspis* were only caught at Mt. Oxford apart from one specimen of *H. elongella* and one specimen of *H. intermittens* which were trapped in kānuka remnants on the Plains.

Five specimens of *H. brevicula* were trapped, both in pine stands. No *H. brevicula* were found in the shrubland and pasture areas surveyed. One specimen was collected in November 2001 in stand 20, an old pine stand in the eastern block of Eyrewell Forest (Fig. 1; specimen number 6; Table 1). The second specimen was collected in November/December 2002 in the young pine stand 37 in the north-western part of the central block (Fig. 1; specimen number 7; Table 1). The other three specimens were trapped in December 2004 and February 2005 in stands 42 and 52 in the western part of Eyrewell Forest. Stand 20 was about 23 years old at the time of sampling, had a stocking rate of ca. 250 trees per hectare and was in its second rotation. Understorey vegetation was sparse, consisting of patchy kānuka shrubs and various herbaceous species including *Anthoxanthum odoratum*, *Hypochoeris radicata*, *Microtis unifolia*, *Rytidosperma* spp., and *Thelymitra longifolia*. Stand 37 was about 4 years old with a stocking rate of about 1000 trees per hectare, and was in its third rotation. Trees in this stand did not yet form a closed canopy and provided little shade, and

Table 1. Information on the ten known specimens of *H. brevicula.*

Number	Collection, gender	Label text	Notes
1	Holotype, NZAC ex FRNZ, male	Eyrewell, 9/6/61, R. J. Mack	R. J. Mack = R. J. Mackenzie (see Butcher 1984) a former forest health officer working in Eyrewell Forest
2	Paratype, NZAC ex FRNZ, male	Eyrewell S.F., Trap Collection, 12.2.62, R. J. Mack	'S.F.' stands for State Forest, see also # 1.
3	FRNZ, male	17.5.56, 43 B	
4	FRNZ, female	Eyrewell C 19, 11·11·58	
5	FRNZ, female	Eyrewell S.F. A4, 25·10·67, M[?]SC, under stone	The original label has been lost while the specimen was on loan at a museum, but the exact text had been transcribed previously
6	FRNZ, male	New Zealand, North Canterbury, Eyrewell Forest, 20-1-150, 28 Nov. 2001, E. G. Brockerhoff, Pitfall trap, ca. 23-year-old *Pinus radiata*	Exact location: -43.4226° S, 172.4405° E
7	FRNZ, female	Eyrewell Forest, NC, *Holcaspis* survey 02/03, pitfall trap: Y-37-3, Date: 6 Dec. 2002	Exact location: -43.3973° S, 172.2596° E. Collected in a 4 year old *Pinus radiata* stand.
8	FRNZ, male	New Zealand, North Canterbury, Eyrewell Forest. Ca. 1-year-old *Pinus radiata*. Pitfall trap NP42-9-100. L.A. Berndt, 6 Dec 2004	Exact location: -43.40572° S, 172.2226° E. Collected in a one year old *P. radiata* stand.
9	FRNZ, male	New Zealand, North Canterbury, Eyrewell Forest. Ca. 1-year-old *Pinus radiata*. Pitfall trap NP42-1-100. L.A. Berndt, 9 Feb 2005	Exact location: -43.40553° S, 172.2222° E. Collected in the same one year old *P. radiata* stand as number 8.
10	FRNZ, male	New Zealand, North Canterbury, Eyrewell Forest. Ca. 15-year-old *Pinus radiata*. Pitfall trap MP52-1-100. L.A. Berndt, 9 Feb 2005	Exact location: -43.40101° S, 172.2307° E. Collected in a 15 year old *P. radiata* stand.

woody debris from the previous harvest was scattered across the ground. Numerous forb and grass species covered much of the ground, with some areas of bare, stony soil. Unlike in older pine stands, needle litter was very sparse. Stand 42 had recently been replanted after harvesting and had a similar ground cover as stand 37. Stand 52 had a relatively closed canopy and a limited understorey vegetation.

Information on all known specimens

The only two previously known specimens of *H. brevicula* are those mentioned by Butcher (1984), now housed in the New Zealand Arthropod Collection (Table 1; specimen numbers 1–2). A search of the Forest Research Insect Collection revealed three more, previously unidentified specimens collected between 1956 and 1967 (Table 1; specimen numbers 3–5). Searches of other collections revealed no other specimens. Information on the two specimens collected during the present survey (below) and their exact sampling locations are also given (Table 1; numbers 6–10).

Discussion

Present population status

The identity of the five specimens of *H. brevicula* caught during our survey and of the three newly discovered collection specimens was confirmed based on the agreement with the description in Butcher (1984) and because no other similar species of *Holcaspis* lives in this part of the Canterbury Plains (Butcher 1984; see summary in Methods). The distribution of the other four species of *Holcaspis* we report here is in agreement with Butcher (1984). The trapping of five specimens of *H. brevicula* during our survey, at different locations, confirms that this species is still present in Eyrewell Forest. All previously collected specimens were also found in pine stands in Eyrewell Forest. However, as planting of this forest only began in 1926 (White, 1974) this cannot be the original habitat occupied by this species. Of the 8658 carabids we collected during this survey, about half were obtained from non-pine habitats. Even though the trapping effort in the surveyed kānuka remnants was substantial, carabids were generally less abundant in that habitat than in some others, such as pasture. Due to the smaller number of carabids collected in the kānuka shrubland and because of the rarity of *H. brevicula*, it is not possible to say whether it is absent from this habitat. However, *H. brevicula* is certainly not an abundant species in any of the habitats in the region. Based on the small number of *H. brevicula* collected and its localised occurrence in Eyrewell Forest, its inclusion in the threatened species list of New Zealand as 'nationally critical' (Hitchmough, 2002) appears justified. Temporal changes in the size of insect populations can have implications for the assessment of the rarity of species (Samways, 1994), but the information available on *H. brevicula* does not allow any conclusion regarding long-term population trends. The outcome of our survey is unlikely to have been influenced by seasonal differences in the abundance of this species because *H. brevicula* adults were collected throughout the year (see collection dates in Table 1). Furthermore, the presence of adults during the winter months suggests that *H. brevicula* adults are probably long-lived, as are other carabids, such as *Harpalus affinis*, which can live for up to two years and possibly longer (Lövei and McCambridge, 2002).

Habitat requirements

Holcaspis brevicula is thought to be silvicolous (i.e. a forest or shrubland species) (Larochelle and Larivière, 2001), mainly because it has only been found in forest-type habitat, but also because closely related species that occur nearby are forest species (Johns, 2003), and the area where it occurs was historically forest and shrubland. Therefore it is likely to be reliant on the plantation forest and shrubland habitat in this area. Few remnants of the once widespread kānuka shrubland of the Canterbury Plains remain today (Meurk *et al.*, 1995), and their small size and high degree of fragmentation suggest that such habitats alone are insufficient for the maintenance of viable populations of species requiring forest habitats. The much more substantial plantation forest area at Eyrewell appears to be a suitable refuge for *H. brevicula* even though the canopy trees in these plantations are not indigenous. Larochelle and Larivière (2001) consider *H. brevicula* to be a predator, based on mouthpart morphology, and personal observations of the bycatch of our pitfall traps suggest that there is an abundance of invertebrate prey in the pine forest at Eyrewell.

The fact that all the pine stands in Eyrewell Forest have been clear-felled at least once or twice suggests either that the beetles are able to survive the harvesting disturbance, or that recolonisation of stands during the 27-year inter-harvesting period is sufficient to maintain populations. Given that *H. brevicula* is subapterous (and hence flightless) and only a moderate runner (Larochelle and Larivière, 2001), it is probably a poor disperser. Nevertheless, the three specimens (number 7–9; Table 1) that were caught in a young pine stand could have dispersed about 100 m from an adjacent mature stand. However, a study of carabids in recent clearfells (Steve Pawson, University of Canterbury, *pers. comm.*) indicates that local populations can survive harvesting and site preparation.

Exotic plantation forests as habitat for indigenous species

The observation that indigenous species use exotic plantation forests as a habitat is not a new finding. Actually, many indigenous animals and plants are known to inhabit such forests in New Zealand (e.g., Clout and Gaze, 1984; Norton, 1998; Brockerhoff *et al.*, 2001; Brockerhoff *et al.*, 2003), including a few threatened birds, such as kiwi (Kleinpaste, 1990) and kokako (Innes *et al.*, 1991), and the threatened long-tailed bat (Daniel, 1981). However, to our knowledge this is the only published account of a threatened insect species in New Zealand that appears to occur only in a plantation forest. A few cases of rare and threatened insects occurring in exotic plantation forests have been reported in other countries. For example, three nationally sparse carabid species in the genera *Pterostichus* and *Trechus* were recorded from exotic plantation forests in Britain (Jukes *et al.*, 2001). However, a search of the world-wide literature suggests that threatened species have not often been recorded from plantation forests. This could well be due to a lack of study in plantations, particularly with regard to insects, as considerable effort is required to detect rare species (Martikainen and Kouki, 2003).

Conclusions and recommendations

It is unclear at this stage whether *H. brevicula* requires any specific measures of protection in relation to its plantation forest habitat. The continued presence of a population despite repeated harvesting suggests that production forestry does not need to be abandoned to protect this species. Even if this was the case, it is not likely that the presence of a threatened beetle would have sufficient weight for this to occur. However, if any population hotspots of this species were found, it may be possible that these areas could be given some form of protection, where attempts could be made to conduct forest management more sympathetic to the maintenance of biodiversity. Methods for improving the management of plantation forests for biodiversity conservation have been suggested (e.g., Hartley, 2002). If *H. brevicula* hotspots were found, it could be proposed to set a small area aside for restoration of kānuka shrubland, which probably was the original habitat of this species.

Given the range of uncertainties and the small number of specimens collected, it is not possible at present to reliably estimate the size and any trends of the population of *H. brevicula* and the true extent of its distribution. To gain additional information on the distribution and size of the population of *H. brevicula* it is recommended (1) to carry out further surveys in areas not yet sampled, including other parts of Eyrewell Forest, other kānuka remnants in the area, as well as other *Nothofagus* forests in the foothills nearby, and (2) to continue the survey using pitfall traps, because this appears to be the most effective survey method, but to explore other survey methods in more detail. It would be of interest to gain a better understanding of the abundance of *H. brevicula*, but none of the available methods to estimate populations (Southwood and Henderson, 2000) are likely to be applicable given the rarity of this species.

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