

Distribution of bumble bees in New Zealand

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ABSTRACT

The introduction and redistribution of bumble bee species throughout New Zealand is summarized and distribution maps are given. *Bombus terrestris* (L.) was found in all areas of the North and South Islands. It is the only species known from Stewart Island and 27 other offshore islands. *B. ruderatus* (Fabr.) was also widespread, except for the southwest of the South Island. *B. hortorum* (L.) had been confined to the east and south of the South Island until successful releases were made in 1965 to Manawatu, in 1981 to Nelson and 1983 to Marlborough. It has since spread at least 105 km in the southern North Island. *B. subterraneus* (L.) is mainly found in the drier colder inland part of the South Island. Differences in the ecological and economic significance of bumble bees between the islands within New Zealand are discussed.

Keywords: New Zealand, distribution, offshore islands, *Bombus terrestris*, *B. ruderatus*, *B. hortorum*, *B. subterraneus*, pollinator value.

INTRODUCTION

In 1875/1876, the first attempt was made to introduce bumble bees from England to New Zealand for red clover pollination (Farr 1889). Success came in 1885 with the fourth season of shipments, at the third release area of Christchurch (Farr 1889; Macfarlane & Griffin 1990). In 1885, 93 queens of at least two species were released, while in 1906, 143 queens were liberated at Lincoln and Taitapu (Hopkins 1914). Since 1906, no more bumble bees have been brought to New Zealand. Canterbury settlers probably knew of English red clover pollination studies highlighting the importance of bumble bees before Darwin (1889) published the results (Crane pers. comm.). This was the first successful introduction for pollination in the world.

No one concerned with these introductions recorded the species that were released, but at least six species were imported (Hopkins 1914). Four surveys between 1914 and 1951 produced conflicting results with uncertainty about the presence of *B. hortorum* (L.) and *B. lucorum* (L.) (Gurr 1957). Thus between 1953 and 1960, Gurr (1964) mapped and tabulated *B. terrestris* (L.), *B. ruderatus* (Fabr.), *B. hortorum* and *B. subterraneus* (L.) at 289 sites in the South I. only. Releases from Canterbury of *B. hortorum* at Nelson in 1981 and near Tuamarina in 1983 established this effective red clover pollinator in the remaining important districts for red clover seed production (Macfarlane & Griffin unpubl.).

Undetermined species from colonies in Canterbury were sent to the North I. for several years from 1887 (Thompson 1922) including one colony in 1887 to Motiti I. in the Bay of Plenty (Matheson 1979). Details of the establishment and spread of *B. terrestris* and *B. ruderatus* were meagre (Thompson 1922; Cumber 1954). Published details of distribution were limited to nine places in the Wellington, Manawatu, Taranaki and Gisborne districts (Hudson 1921; Cumber 1954, 1959; Gurr 1972; Pomeroy 1981) and in the Bay of Plenty (Motuhora I., Quilter 1971). Wilkinson (1957) and Johannesson (1972) recorded bumble bees (species unspecified) from Kapiti and Red Mercury Is respectively. In 1965, *B. hortorum* was successfully introduced to the Manawatu (Gurr 1972).

Dempsey (1967) first recorded bumble bees (species unrecorded) from Stewart I. Pastoral farming has never been important here, hence there was little impetus for any introduction or recording of bumble bees. Farming is much more important on the Chatham Is, and unknown species of bumble bees were sent there from Canterbury in 1890 (Thompson 1922). In 1955 and 1976, a *B. ruderatus* colony and seven queens respectively were released on Chatham I. (Macfarlane 1980).

In the 31 years, since Gurr's (1964) survey was published the situation with bumble bees has changed considerably. Results of dispersion from relocations and establishment for the Manawatu, Nelson, Marlborough and Chatham I. releases have not been reported. Before 1960, the main economic interest with bumble bees was as pollinators of red clover and lucerne seed crops; over 90% of these crops are grown in the South I. The first commercial use of colonies in the world began in 1982 on red clover (Macfarlane & Griffin 1985, unpubl.), followed by use on kiwifruit and lucerne (Read *et al.* 1989). Since 1989, *B. terrestris* queens have been consistently exported to Europe and colonies to Japan (Donovan 1993). This commercial activity and the production of *B. terrestris* colonies for glasshouse pollination in New Zealand have shifted the emphasis in economic value to horticulture and to both main islands. Furthermore, seed formation of major weeds such as gorse is affected by availability of pollinators (Macfarlane *et al.* 1992), but so far no management plans have been made for weeds that are pollinated by bumble bees on islands of importance for conservation (Townsend *et al.* 1990). These developments justify updating the distribution of the four bumble bee species throughout New Zealand.

This paper summarizes the known distribution of bumble bees for the North, South, Stewart and offshore islands, and outlines differences in the significance of bumble bees as pollinators for the different islands.

METHODS

Many records for *B. terrestris* and *B. ruderatus* were made as they foraged on flowers especially where there were just these two species. *B. hortorum* and *B. subterraneus* records are based on close visual inspection of live bees in a tube; voucher specimens that extended the range of these species were added to the New Zealand Arthropod Collection (NZAC). Over 28,000 bumble bees were recorded on over 300 species of flowers, with an emphasis on crops. Macfarlane examined 707 bumble bees from 17 collections (NZAC; Auckland, Canterbury and Otago Museums; Museum of New Zealand; Auckland, Massey, Victoria, Canterbury, Lincoln and Otago Universities; N.Z. Forest Research Institute; L. Gurr, T. Davies and P. Quinn private collections; Australian National Insect Collection and the Bishop Museum).

In the North I., Macfarlane gathered most of the records from 114 new sites between 1975 and 1991. Specimens in insect collections provided 31 new site records from the North I., 47 from the South I. and 11 from Stewart I. From 1969-1993, bumble bees were recorded from 428 sites in the South I., with 283 new sites compared to previous surveys (Gurr 1964). People listed in the acknowledgements provided records from 41 more sites. In 1991, 24 days were spent on Chatham I.

The district codes for the new sites listed are those designated by Crosby *et al.* (1976).

RESULTS AND DISCUSSION

The species

Bombus terrestris

B. terrestris breeds in all areas of New Zealand (Fig. 1) apart from the subalpine zone, but workers foraged up to 2,500 m in the Mount Cook region. It survives in annual rainfall from 339 mm (Alexandra, CO) to over 10,000 mm (near McKinnon and Wilmot Passes, FD) (N.Z. Meteorological Service 1973; Wards 1976). Its occurrence and distribution on offshore islands is discussed separately below.

Bombus ruderatus

B. ruderatus was found up to 960 m (Lindis Pass, OL) in the South I. It is less common in the North I. than *B. terrestris* (Figs 1 & 2). North I. localities were sampled only once

(before October) and this discriminated against *B. ruderatus* which emerges in late spring (Donovan & Macfarlane 1984). Even in summer, *B. ruderatus* is barely half as common as *B. terrestris*, and it uses a narrower range of flowers freely compared to *B. terrestris*. *B. ruderatus* is prominent in lightly settled districts with the warmest and driest climates in both main islands (Fig. 2). In rural coastal Otago and Southland, where the sunshine hours are lower, *B. ruderatus* changed from second to the third ranking bumble bee species. No *B. ruderatus* were recorded from 92 bumble bees collected from southern Westland or Fiordland (Fig. 2) with an annual combination of less than 1,800 sunshine hours and over 5,000 mm of rain. Further collecting from favoured flowers between November and March is needed to determine if *B. ruderatus* is truly absent from the south west of the South I.

Bombus hortorum

This species was newly found at 11 North I. and 36 South I. sites (Fig. 3, Appendix 1). In the North I., *B. hortorum* has spread at least 105 km to Lower Hutt from Palmerston North within 20 years. By 1988, *B. hortorum* was established in Nelson and near Richmond (NN) and Marlborough in a circle up to 8 km diameter around Tuamarina to include Spring Creek (MB). In Canterbury, it was found at 19 new sites from the upper Waiau, Hurunui and Waimakariri catchments and along the foothills. It has not extended its range in coastal North Canterbury since the 1960s survey. It may still be spreading slowly inland in northern Canterbury, because none were found in the Waiau catchment until 1993, despite extensive earlier collections (Gurr 1964; Macfarlane & Griffin 1990) and this survey. New Otago and Southland records extend the known western and southern range into settled areas with cooler and wetter climates (Fig. 3). Sampling in Fiordland occurred too soon in spring to be sure that *B. hortorum* does not occur there. *B. hortorum* workers foraged up to 1,250 m in the Mount Cook area, but it has not spread west through the 923 m Arthurs Pass or the 561 m Haast Pass to the West Coast.

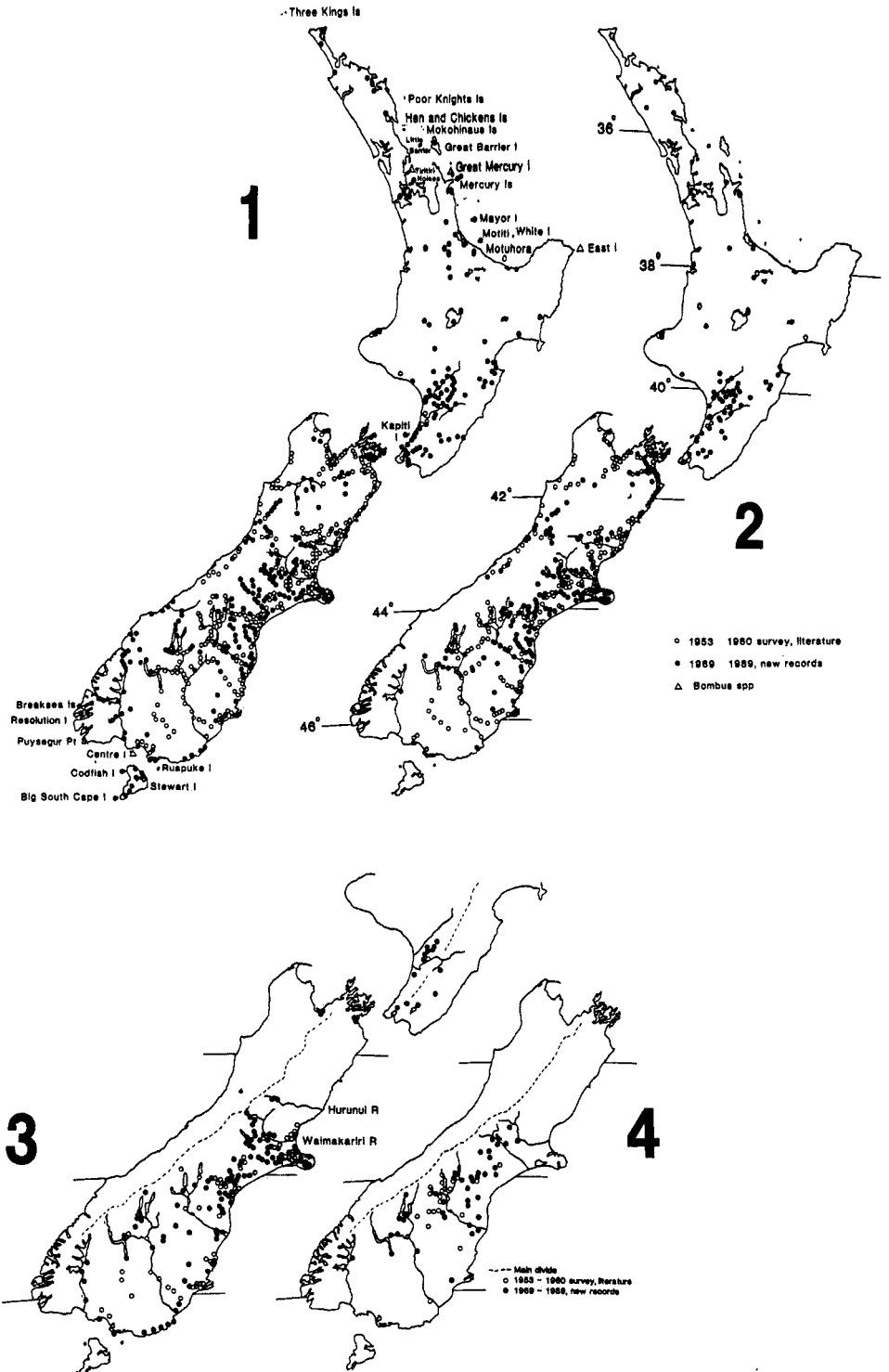
The causes for its failure to spread into the drier, mild and more lightly settled coastal north Canterbury remain enigmatic. The limited distribution has reduced its potential value as a pollinator in the South I. and makes its eventual spread throughout the drier and warmer parts of Hawkes Bay and Gisborne uncertain. *B. hortorum* was found at only 38% of 110 inland Canterbury and Otago sites where both *B. ruderatus* and *B. subterraneus* were usually more common (see Figs 2-4). These rural inland sites where *B. hortorum* is the least common species had less than 600 mm of rain per year, but in suburban Christchurch it is the second most common species. This indicates that *B. hortorum* is poorly adapted to areas with regular early summer droughts and a limited sequence of flowers compared to the other three bumble bee species.

Similarly, throughout central and northern Europe, *B. hortorum* is much more common than *B. ruderatus* (Loken 1973; Delmas 1976; Banaszak 1986; Hagen 1986; Williams 1986). Conversely in the drier and warmer climate of central Italy (D'Albore & D'Ambrosio 1981) and elsewhere (Loken 1973), *B. ruderatus* is dominant compared to *B. hortorum*. Possible reasons for the change over in abundance between these sister species include reliability of spring food supplies during colony formation, and hibernation site shading (Alford 1969) and dryness. Clarification of these factors may be pertinent to management of populations on farms and commercial overwintering of their queens respectively.

B. subterraneus

This species was found at 43 new sites in Canterbury and Otago (Fig. 4, Appendix 1). On cultivated plains, one *B. subterraneus* queen was found as far as 4 km from the Rangitata riverbanks by the Highgate/Arundel road. Workers or males from *B. subterraneus* colonies were found up to 2 km from hills on the fringe of the Canterbury/North Otago plains. On these plains, *B. subterraneus* queens were absent from 102 sites and among over 11,000 bumble bees. These absences included the original two release sites in Christchurch and the possible Taitapu and Lincoln College release sites.

B. subterraneus is confined to the inland parts of the South I. mainly at 180-820 m, but down to 80 m at Peebles by the hills near Oamaru. This region has colder winters and



Figs. 1-4: Distribution of bumblebees in New Zealand.
1 = *B. terrestris*; 2 = *B. ruderatus* 3 = *B. hortorum*; 4 = *B. subterraneus*

in most of the range rainfall averages 340 mm (Central Otago) to 1,000 mm in the upland river basins in Canterbury. At Umbria, which is 43°-44°N in Italy, *B. subterraneus* is only present from 500-2,000 m above sea level (D'Albore 1986), so that it does not penetrate the Italian lowlands quite as much as it does in the South I.

Importance as crop pollinators

From our survey and the literature we conclude that bumble bees, notably the most common *B. terrestris*, are important back-up pollinators of pastoral legumes. They are efficient pollinators of flowers with a widely separated style and stamens, notably kiwifruit, passion fruit, feijoa and cucurbits (Macfarlane 1994). Bumble bees are cool-active, continuing to pollinate spring-flowering fruit, berry and nut (almonds, macadamia) crops during adverse weather, when other bee species are inactive.

The importance of the short-tongued *B. terrestris* in the North I. is in pollination of glasshouse, fruit crops and pasture legumes. Its main value in the South I. is for pollination of white clover, lucerne and fruit crops, but it also pollinates at least 53 species of native plants from coastal to subalpine areas. The long-tongued *B. hortorum*, *B. ruderatus* and *B. subterraneus* are of most value for red clover pollination, while populations of *B. hortorum* are best synchronised for faba bean and blueberry pollination (Macfarlane 1992, 1994; Free 1993). *B. subterraneus* is of the least value to New Zealand, because its distribution does not coincide with production of these crops.

Stewart, Chatham and other offshore islands

In all, 142 *B. terrestris* were recorded from 10 sites on Stewart I. and over 100 from Codfish I. *B. terrestris* was nesting there at least by 1955, when workers were first collected. Site records were: Christmas Village; Lee Bay; Oban; Freshwater River; Table Hill; Scollays Flat; South West Cove; Port Pegasus; Big South Cape I.

All three attempts to establish self-managing, bumble bees for white clover, lotus and garden crops pollination on the Chatham Is were unsuccessful. The October 1890 introduction almost certainly involved *B. terrestris* for two reasons. Firstly, only *B. terrestris* and *B. ruderatus* were definitely established in Canterbury (the source of the transferred bees) in 1890 (Hopkins 1914; Gurr 1957). Secondly, in October when the introduction was attempted, *B. terrestris* is 12 times more abundant than *B. ruderatus* in Canterbury (Macfarlane unpublished).

B. terrestris is established on seven offshore islands which are free of rats and mice; evidently this species can be completely independent of old rodent nests for nesting sites. *B. terrestris* or undetermined bumble bees were recorded from 23 islands that are 2.5-30 km offshore (Table 1). Conversely, seven island groups of 150-3,052 ha were devoid of bumble bees, based on absence of specimens in insect collections and observations during conservation studies (Early, Jansen, Robinson, Shelley pers. comms.). These islands and their distance offshore are: Three Kings Is (55 km), White I. (45 km), Mokohinau Is (24, 20 km), Cuvier I. (23 km), Poor Knights Is (22 km), The Aldermen Is (18-21 km) and Little Barrier I. (16 km).

In Europe, straits over 10 km wide act as a barrier to bumble bees, restricting colonisation and gene flow. Four subspecies each of *B. terrestris* and *B. lucorum* have developed in populations when separated by straits of 10 km (Elbe/Corsica), 12 km (Italy/Sardinia), 16 km (Spain/North Africa) and 32 km (Great Britain/Europe) (Rasmont 1983). Similarly in Japan, incipient speciation within *B. diversus* Smith has occurred where populations are separated by 19 and 43 km straits (Ito 1987). Nevertheless, bumble bees do venture across the ocean and *B. terrestris* queens have been collected from European lightships at sea; three times more queens reached 10 km from shore compared to 30 km (Haesler 1974). Thus, limited numbers of *B. terrestris* may have flown to the largest and most remote islands of Stewart, Mayor and Great Barrier. Alternatively, bumble bees may have been deliberately introduced for farming or accidentally via transport to these bigger and more remote offshore islands despite the lack of published records. It seems most likely that *B. terrestris* naturally colonised most smaller offshore islands. These islands attract much less passenger traffic and often had, at best, short periods of farming.

Table 1: New Zealand offshore islands at least 2.5 km from the North and South Islands colonised by bumble bees. District codes as in Crosby et al. 1976; # = rodents absent.

District	Islands	km offshore	size (ha)	<i>Bombus terrestris</i>	<i>Bombus</i> sp.
AK	Noises Is	2.5	32	+	
WN	Mana I.	2.7	217	+	
SI	Codfish I.	3.0	1490	+	
SD	Chetwode Is #	3.0	271	+	
SD	Stephens I. #	3.2	150	+	
FD	Hawea I.	3.3	9	+	
TO	Motutaiko I. #				
	(L.Taupo)	3.3	15	+	
AK	Tiritiri Matangi	3.5	210		+
FD	Wairaki I.	4.0	5		+
WN	Kapiti I.	5.4	1965	+	
CL	Great Mercury I	6.0	1800	+	
CL	Mercury 3 Is #	7.0	30	+	
SL	Centre I.	7.0	210		+
BP	Motuhora I.	7.2	143	+	
BP	Motiti I.	7.5	688	+	
CL	Red Mercury I.	8.3	203	+	
CL	Great Barrier I.	17.5	28510	+	
BP	Mayor I.	28	1277	+	
SI	Stewart I.	30	174600	+	

Even if bumble bees successfully cross ocean stretches to islands, establishment may not be easy. Macfarlane & Griffin (unpubl.) found that deliberate releases to new sites in New Zealand and Chile may require 100-150 queens in a season to guarantee establishment if sites are not particularly favourable.

Conservationists should record whether or not bumble and honey bees *Apis mellifera* L. forage on the remaining larger, more remote, (i.e. over 10 km offshore), and conservationally important islands. This basic information could be critical in assessing seed formation potential of gorse and other weeds that need cross pollination on offshore islands (Macfarlane *et al.* 1992).

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Appendix 1: New site records for *B. hortorum* and *B. subterraneus*

Bombus hortorum

- WI Mount Biggs; Makino; Aorangi; Cheltenham; Kimbolton.
- WA Konini; Black rock Rd-Masterton; Featherston.
- WN Levin; Birchville; Lower Hutt.
- NN Nelson, Richmond
- MB Tuamarina, Spring creek, 3 km west Tuamarina
- NC Waiau /Hope R. junction; between L. Sumner and Mason; by L. Katerine; View Hill corner; Coopers Ck; Oxford; Woodend; 2.5 km east of Arthurs Pass township.
- MC Kowhai Bush; Porters Pass; by L. Lyndon; Castle Hill; Flock Hill; Grassmere; Cass; Bealey Hotel.
- OL Makarora; Glendhu Bay; Wanaka; Cardrona; Kingston.
- OL/FD Te Anau.
- SL/FD Manapouri.
- SL Blackmount-Redcliff Ck; Tuatapere; Riverton; Bluff Hill; Haldane; Waikawa R.; Tautuku and Pounawea Beaches; Nugget Point.

Bombus subterraneus

- MC Kowhai Bush; Acheron R. (Coleridge Rd); Glenariffe; Highgate—Arundel Rd; Stavely; Ashburton Gorge; L. Clearwater;
- SC Orari and Pareora Gorges; Sherwood Downs; Ashwick Flats; Fairlie/Clayton; N. Opuha R.; Larcombe; Kimbel; Oldfield; Mt Dalgety.
- MK Sawdon; Glenmore; Balmoral; Ben Ohau Stn; Shelton and Huxley Downs Stns; Hakataramea Downs; Cattle Creek.
- DN Duntroon; Ngapara; Peebles; Outram.
- CO Omarama; Manuherika; Gibbston; Kawarau Gorge; Luggate; St Bathans; Alexandra; Clyde.
- OL Hawea motor camp; Wanaka; Makarora; Glendhu Bay; Kingston.
- OL/FD Te Anau.