

# Diversity and taxonomic status of some New Zealand grasshoppers

Steve Trewick and Simon Morris

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# Diversity and taxonomic status of some New Zealand grasshoppers

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## ABSTRACT

Little is known about the taxonomic and conservation status of low-altitude populations of New Zealand grasshoppers (Acrididae). We examined the extent of differences between populations belonging to three groups: *Sigaus piliferus*, the *Brachaspis nivalis* complex and the *Sigaus australis* complex. There is evidence that the North Island species *S. piliferus* falls into two groups: individuals in the Tararua Ranges and those north of the Manawatu Gorge. In the South Island, the *B. nivalis* complex is made up of two subgroups: from central Canterbury to Marlborough, and from south Canterbury to north Otago. There are four subgroups within the *S. australis* complex: one in central Canterbury and three in Otago. There are also several morphologically distinct populations within the *B. nivalis* and *S. australis* complexes, but further work is needed to fully describe these forms. When managing these grasshoppers, it is important that this geographic and morphological variation is considered and represented within management units.

Keywords: Orthoptera, management units, mitochondrial DNA, hybridisation, grasshoppers, *Sigaus*, *Brachaspis*, Acrididae, New Zealand

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# 1. Introduction

The taxonomy of New Zealand endemic grasshoppers (Insecta, Acrididae) was substantially revised by Bigelow (1967), drawing on museum collections and the publications of Hutton (1897, 1898) and Salmon (1950), in addition to his own observations and collections. More recent contributions on the taxonomy of endemic genera include papers by Jamieson (1999), Morris (2002a, b, c, 2003) and Trewick (2001a).

In New Zealand, there are some 16 species of grasshopper belonging to four endemic genera (*Sigaus*, *Brachaspis*, *Alpinacris*, *Paprides*). These are largely restricted to montane areas above the natural treeline. Where grasshoppers occur below the treeline, this is in association with non-forest habitats, such as exposed river beds and the semiarid grassland environments of Central Otago and Canterbury. Species within and among genera have a range of allopatric<sup>1</sup> and sympatric distributions, often with some degree of altitudinal or microhabitat segregation among taxa. For instance, *Sigaus villosus* occurs at the highest altitudes (c. 2000 m a.s.l.) for New Zealand grasshoppers, while *S. campestris* is found at the lower extreme (800–1200 m a.s.l., and some specimens have been recorded close to sea level; Bigelow 1967). *Brachaspis collinus* favours areas of tussock grass, whereas *B. nivalis* is found almost entirely in habitats with a high proportion of rocky substrate. In many South Island locations, it is not uncommon for three or four species to be found in sympatry, but only one species (*Sigaus piliferus*) is described from the North Island. Three taxon groups are currently of particular conservation concern by virtue of their scarcity and/or taxonomic uncertainty. These are *Sigaus piliferus*, *Brachaspis nivalis* complex and *Sigaus australis* complex.

The following subsections summarise the history and current taxonomic situation of New Zealand grasshoppers, the background and rationale to the methods chosen for this study, and the objectives of this study.

## 1.1 HISTORY AND TAXONOMIC STATUS OF NEW ZEALAND GRASSHOPPERS

### 1.1.1 *Sigaus piliferus*

*Sigaus piliferus* is currently the only representative of the endemic grasshopper genera found in the North Island, New Zealand. It was described by Hutton (1897) from a single specimen (now missing) collected at ‘Auckland’. The species has never been reported from this location since, but Hutton’s description agrees, according to Bigelow (1967), with specimens collected at other locations in the North Island. Bigelow (1967) proposed a ‘neotype’ for the species, distinguishing a specimen from the Pohangina Saddle, eastern Ruahine Range. Although the species has been reported from subalpine areas throughout the North Island, it has never been found on Mt Taranaki. According to Bigelow (1967), the main locations for *S. piliferus* were the Kaimanawa, Tararua, Ruahine

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<sup>1</sup> See glossary for definitions of technical terms.

and Kaweka Ranges, Central Plateau, and Mt Hikurangi (East Cape), but he also reported specimens from Coromandel (Kauaeranga Valley), Cambridge (Maungatautari), Rotorua area, and near Lake Taupo.

Bigelow (1967) considered that *S. piliferus* could be subdivided into three spatial groups (northern, central and southern) on morphological grounds (size and colour), but a great deal of variation exists within these broad groupings.

The conservation status of *S. piliferus* is of concern, with McGuinness (2001) expressing the view that it has already disappeared from much of its former range except the East Cape.

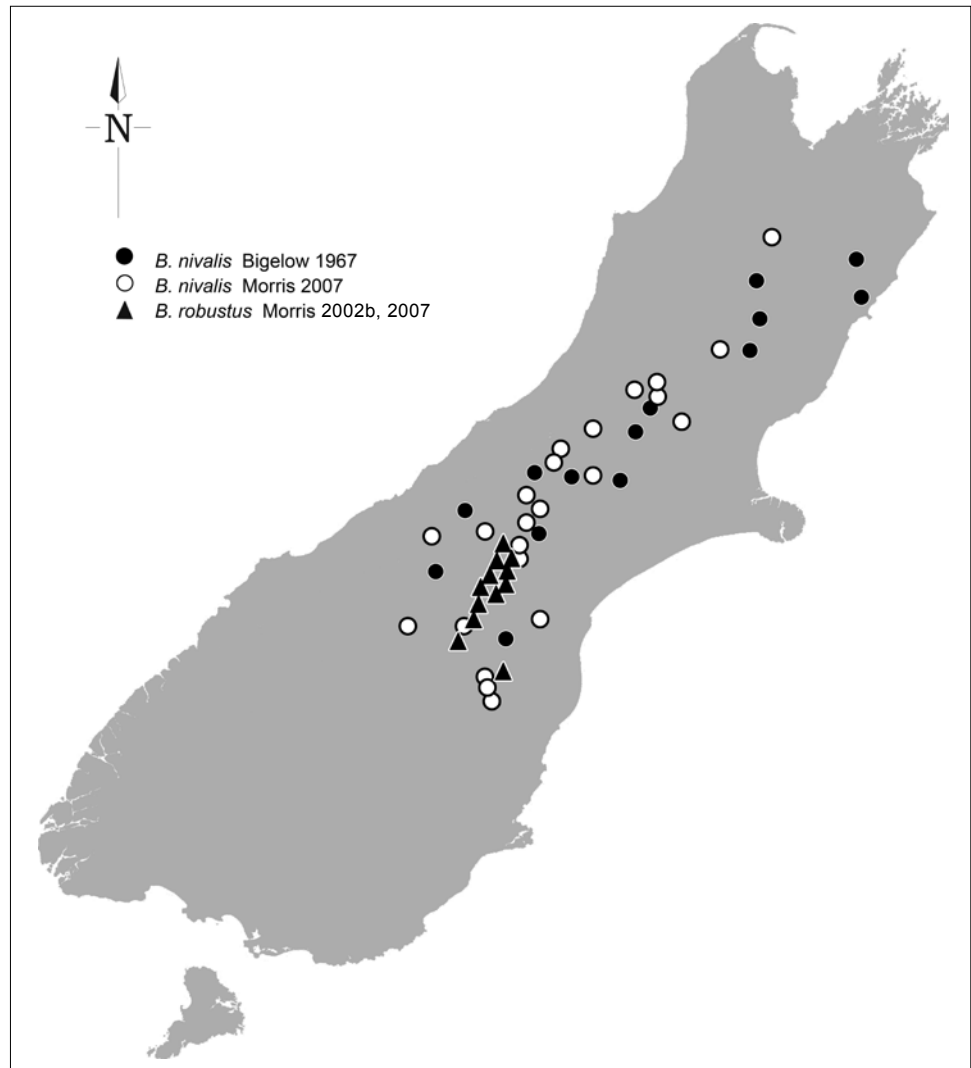
### 1.1.2 *Brachaspis nivalis* complex

Hutton (1897) described four species of *Pezotettix* Burmeister (a northern hemisphere genus) from New Zealand. At the time, he was hesitant to put these new species into a new genus due to the absence of northern hemisphere material for comparison. *Pezotettix nivalis* was named from specimens from the Mount Cook area; *Pezotettix collina* was named from specimens collected from Mount Arthur; *Pezotettix petriocola* was named from a female collected at a low-altitude site (Dee River) in Marlborough; and *Pezotettix terrestris* was named from a female specimen stated as collected in Wellington.

These species were later removed from *Pezotettix* and placed in a new genus *Brachaspis* (Hutton 1898). Hutton named a second low-altitude species of *Brachaspis*, *B. petricolus* from 'Kowai River'. Unfortunately, there are two Kowai Rivers in the South Island, one on the east coast, north of Rangiora, the other south of the Torlesse Range. This second location is far more likely to be the type location. Bigelow (1967) suggested that the single specimen of *P. petriocola* and the males under the name of *B. petricolus* represent the same taxon, and he concluded that the original specimen of *P. petriocola* be named the 'type' of the 'low altitude' species. Further confusion arose with regard to *B. terrestris*, as the type location was Wellington, yet no other *Brachaspis* have ever been collected or recorded from the North Island. Bigelow (1967) assumed a labelling error had occurred, and confusion about the provenance of Hutton's type material remains.

Bigelow (1967) revised *Brachaspis* and distinguished three species: *B. collinus* (Nelson area), *B. robustus* (the large and rare Mackenzie Basin grasshopper, which he described) and *B. nivalis* for all other populations (including the small, low-altitude forms). Bigelow concluded, on the basis of the few individuals available, that the small, low-altitude *Brachaspis* were geographic variants that did not warrant species status. However, Bigelow (1967) did suggest that further study of the low-altitude populations of *B. nivalis* from Dee River, Cora Lynn and the Wilberforce was required. He understood that these specimens appeared to be well-isolated from the nearest high-altitude populations, as well as from one another, and that their very small body size suggested that they may be living under adverse conditions (marginal habitats) relative to those optimal for the species as a whole. It is likely that his interpretation may have put undue emphasis on the 'typical' forms because the *B. nivalis* material examined by Bigelow (1967) was dominated by specimens from the central part of the range (Mt Cook, Mt Hutt, Cameron Valley), with few from the south and north of the range as it is now known (Fig. 1). Bigelow (1967) did, however, examine three individuals of the low-altitude morph from Dee Stream (= Hutton's Dee River), all of which were females.

Figure 1. The known distribution of *Brachaspis nivalis* and *B. robustus*. Taxonomy follows Bigelow (1967) and therefore includes putative taxa, such as the small, low-altitude morphs at Dee Stream.



Preliminary re-examination by one of the authors (SM) indicated that several characters do distinguish individuals of the low-altitude form from other *Brachaspis* species, including shape of the male epipallus lophi; overall small size; grey colouration without any gold, purple or orange tinge; and number of spines on the hind tibiae.

In 2001, A.M. Evans (Canterbury Conservancy, Department of Conservation (DOC)) collected a single male grasshopper belonging to a low-altitude population of *Brachaspis* from the Cam River near Blenheim (Marlborough). This grasshopper was collected within 10 km of the original Hudson specimen (examined by Hutton). More recently, Steve Trewick collected specimens from Dee Stream (Clarence Valley, Marlborough). A southern low-altitude population was also recently found at Porter River by Simon Morris, who also collected specimens from the Hakatere, Manuka Point, Glenfalloch and Mesopotamia Pastoral Leases during DOC High Country Tenure Review surveys.

The phylogenetics of the low-altitude species *B. robustus*, montane *B. collinus* and populations of the montane species *B. nivalis* across its spatial range (which extends further south than recognised by Bigelow (1967)) was examined by Trewick (2001a). However, the relationship between the small, low-altitude forms and the above species has not previously been addressed.



### 1.1.3 *Sigaus australis* complex

Bigelow (1967) examined spatial and altitudinal variation in *S. australis* using pronotum and femur dimensions. More recently, one of the authors (SM) examined morphological variation of *S. australis* and allied taxa in the southern South Island, including an appraisal of male internal genitalia. These structures promise to be the most stable and informative morphological features for determining species within the *S. australis* complex. At present, none of the females in the *S. australis* complex can be distinguished by morphological characters. Bigelow (1967) noted that there was extensive size variation in *S. australis*, but much of the colour polymorphism that exists in living grasshoppers was not evident in the pinned material he examined. The species is distributed in the South Island from Otago north to the Waimakariri River (Fig. 2).

Jamieson (1999) named a new species of *Sigaus* from the Alexandra area as *Sigaus childi*, with a type locality at Graveyard Gully; this was named after Peter Child, who first collected the species in 1967. In an unpublished report in 1999, Colleen Jamieson suggested that another new species of grasshopper, *Sigaus* species A, might exist in the Alexandra area (Morris 2002a). Morris (2002a) agreed that this entity was related to, but a separate species from, *S. childi*, but there is considerable morphological variation among and within *S. childi*, *S. species A* and *S. australis* (Fig. 3).

Figure 2. The known distribution of *Sigaus australis*, *S. obelisci* and *S. childi*. *Sigaus australis* here is the species as given by Bigelow (1967) and therefore includes putative species such as *S. species A*.

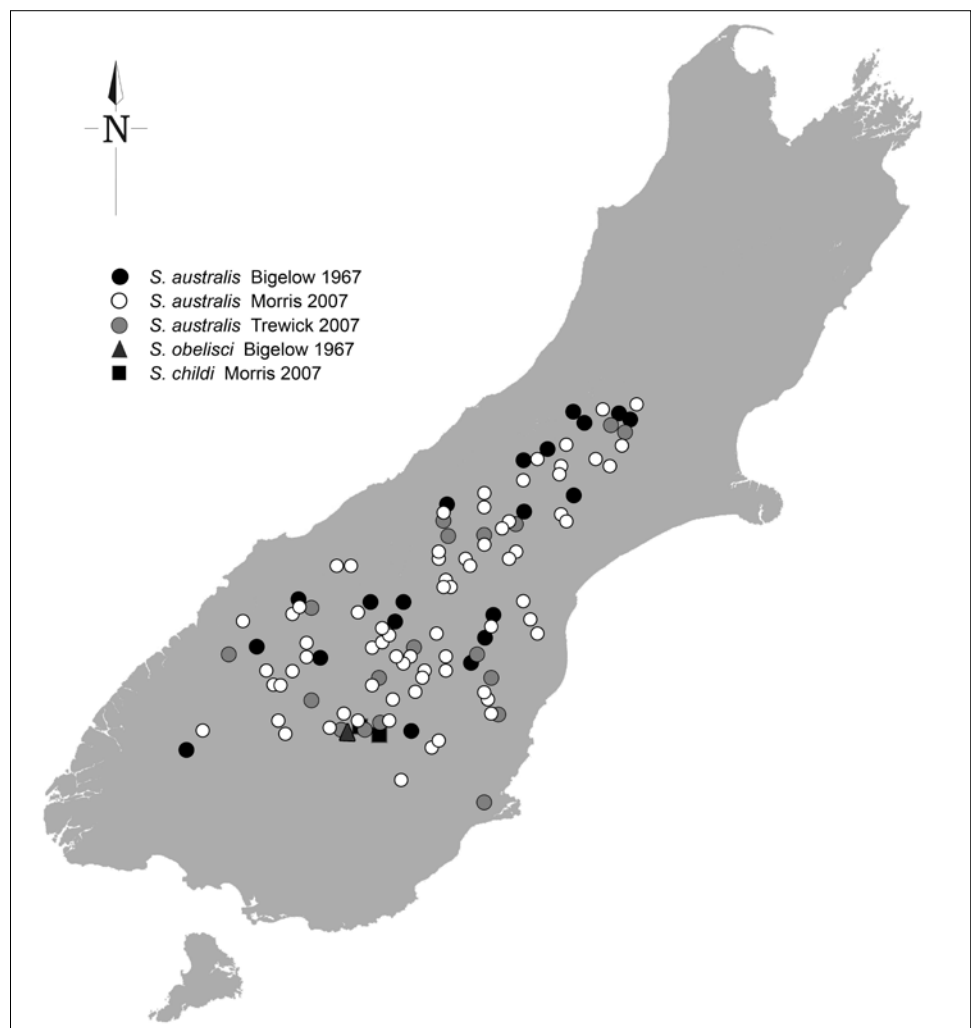




Figure 3. Colour and pattern diversity among *Sigaus australis* complex grasshoppers. A. Unusual *S. australis* from the gold tailing of Northburn (SM); B. unusual *Sigaus australis* from the gold tailings between Alexandra and Northburn (SM); C. *Sigaus childi*, Earnsclough Tailings, Alexandra (ST); D. male *Sigaus childi* (SM); E. female *Sigaus childi* (SM); F. *Sigaus* "undescribed", juvenile cryptic on lichen, Alexandra (ST); G. *Sigaus childi*, Little Valley Rd, Alexandra (ST).

Bigelow (1967) described *Sigaus obelisci* from specimens collected on the Old Man Range in Otago, but it has proved difficult to distinguish *S. obelisci* from the other grasshoppers in the *S. australis* complex. Five colour morphs are known for *S. obelisci*, all of which are subtly different from other *S. australis* forms. In addition, the habitat that *S. obelisci* prefers is slightly different from the other grasshoppers in the *S. australis* complex. *Sigaus obelisci* appears to prefer cushionfields and herbfields on or near the ridge tops, and is restricted, as far as is known, to the Old Man Range, Central Otago.

Two new species have recently been added to the *S. australis* complex: *Sigaus homerensis* Morris and *Sigaus takabe* Morris (Morris 2003). Both are allopatric at the southern periphery of the *S. australis* complex range. The grasshopper *Sigaus* “Remarkables” (Morris 2002c) is currently undescribed and is very similar externally to *S. obelisci*; however, initial data suggest that the epiproct is consistently longer and broader on *S.* “Remarkables” than on *S. obelisci*.

The *S. australis* group presents the greatest taxonomic and conservation challenge. The status of local allopatric morphs is uncertain and particular confusion exists about species boundaries among the diverse forms of the Central Otago area centred on Alexandra.

## 1.2 MITOCHONDRIAL SEQUENCE DATA AND TAXONOMY

For the purposes of conservation, where maintenance of biodiversity is the goal, mitochondrial sequence data can provide an effective means of revealing populations/taxa with distinct genealogical histories; genealogical separation between morphologically similar but spatially separate entities; and introgressed taxa resulting from recent speciation and/or hybridisation. Phylogenetic analyses of mitochondrial DNA sequences were developed in the early 1990s and have proved highly informative for conservation (Avice 1989, 1992).

The random, neutral effects of genetic drift (lineage sorting; Avice 2004), whereby some DNA sequence lineages are lost from populations whilst novel mutations are accumulated in those that remain, result in a pattern of inherited sequences that can be used to infer the genealogy of populations. In general, where splits between clusters of similar DNA sequences are correlated with the spatial distribution of the animals from which the DNA came, some barrier to gene flow (movement of grasshoppers in this instance) is indicated. The degree of difference (genetic distance) between clusters of DNA sequences provides a useful indicator of how long ago an existing barrier may have first emerged; the more genetically divergent, the older the event causing the split is likely to be. One can also expect that different species will be genetically distinct from one another even when they exist in sympatry.

For many species that have overlapping ranges, the barrier to gene flow is often behavioural (e.g. differences in microhabitat preference, or the operation of mate recognition systems). However, sister species often exist in allopatry, and therefore express phylogeographic signatures similar to that among spatially separate populations of a single species. Indeed, many species as defined by taxonomy are the descendents of allopatric populations that have accumulated

morphological or behavioural attributes that now distinguish them (in the taxonomist's eye) from one another. Whether or not all allopatric forms that are named as distinct species are biological species (i.e. reproductively isolated should they meet) is a moot point, as the emergence of mate recognition systems would normally require selection against hybrid offspring, i.e. nature does the experiment in such cases.

The application of neutral haplotypic data (i.e. the frequency of alternative mitochondrial DNA sequence variants) for the recognition of species can be very effective. However, it is difficult to detect hybridisation using just mitochondrial sequence data (which are inherited only on the maternal line). It is also difficult to differentiate species that have evolved over a short and recent time frame, i.e. shorter than the time required for lineage sorting to result in the retention and inheritance of mitochondrial lineages by distinct species (which is dependent on effective population size). Although the existence of these processes (recent speciation and hybridisation) can be relatively easy to infer, distinguishing between them is more difficult.

The mitochondrial genes chosen for use in this study—12S and COI (cytochrome oxidase subunit one gene)—have been widely applied to species-level studies of insects. The COI gene has proved useful in both revealing hitherto cryptic taxa to explore the spatial partitioning of phylogenetic structure of species (phylogeography) and demonstrating close genealogical histories of morphologically or ecologically distinct taxa (e.g. Funk et al. 1995; Szymura et al. 1996; Trewick 2000; Buckley et al. 2001).

### 1.3 OBJECTIVES

The objectives of this study were to:

- Use phylogenetic analyses of mitochondrial DNA sequence data to identify the extent and pattern of genetic diversity within and among *Sigaus piliferus*, the *Brachaspis nivalis* complex and the *Sigaus australis* complex
- Examine the taxonomic, and thus conservation, status of these three grasshopper taxonomic groups