Past distribution of large weevils (Coleoptera: Curculionidae) in the South Island, New Zealand, based on Holocene fossil remains

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ABSTRACT

A survey of 12 fossil sites in North and South Canterbury, where faunal remains were accumulated by the apparently extinct laughing owl (*Sceloglaux albifacies* Gray) and the New Zealand falcon (*Falco novaeseelandiae* Gmelin), revealed sediments containing abundant remains of not only bones but also invertebrates. Amongst the latter were several species of large weevils (Curculionidae), including *Anagotus stephenensis* Kuschel, *A.rugosus* (Broun), *Hadramphus tuberculatus* (Pascoe), and *Ectopsis ferrugalis* Broun. Their current and past distributions are discussed. *H. tuberculatus* has not been found for 84 years, hence is presumed extinct. The others had their territories greatly reduced, in particular *A. stephenensis* which now is known only from Stephens I. which it shares with the tuatara (*Sphenodon punctatus* Gray), a likely natural predator. The clearing of vast areas of native vegetation for pastures and crops might have played a part in the likely extinction of *H.tuberculatus* because its host plant *Aciphylla* (Apiaceae) is a prickly pastoral weed. However, the main cause of the drastic reduction in territory and numbers of the large weevils came from rats and mice. Some samples of devastation caused by rodents are presented. In New Zealand, large weevils are now more numerous and diverse on the mountains than in the lowlands in New Zealand, which could well be attributed to some extent to the introduced predators.

Keywords: Coleoptera; Curculionidae; Holocene fossils; caves; distribution; predators; New Zealand.

INTRODUCTION

Almost any animal or plant can be preserved *in toto* or in part for millions of years if the right anaerobic conditions occur during deposition and these conditions are maintained. The deposited specimens will usually undergo changes by gradually becoming mineralised to end up as casts, imprints or inclusions called fossils. On occasions the deposited specimens are not mineralised, and while most such specimens are relatively recent, some can be thousands of years old. We prefer not to use the term 'subfossils' for these remains, but instead use the more informative term 'Holocene fossils' (Holocene being the recent epoch, less than 10,000 years BP). The peat of old, long-lasting bogs and water-logged holes in caves often contains almost perfectly preserved bones and remains of invertebrates and plants that allow accurate identification. An example of a bog that yielded excellent fossil materials, including large weevils (Kuschel 1987), was the Buried Forest of Pureora, North Island (38°32'S 175°37'E), which was deposited at the time of the violent volcanic eruption 1800 years BP that produced a huge crater now occupied by Lake Taupo (Clarkson *et al.* 1988). An example of water-logged deposit in a cave was in F1c in the Fred Cave catchment at Waitomo (38°16'S 175°07'E), North Island. In this deep limestone shaft sediments were permanently water-logged and rich in fossils, some 1680±50 years BP old according to radiocarbon dating (Worthy 1984, Kuschel 1987).

Specimens can also be preserved under aerobic conditions for a while, at least for a few hundred years provided they are deposited and maintained in a very dry environment.

Sites offering such conditions are occasionally found in caves, rock crevices and under ledges. One of us (THW) recently recovered fossil insect remains from 12 sites in crevices and caves in limestone cliffs in Canterbury during a survey of fossil deposits in the region (Worthy & Holdaway, in press; Worthy, in press). These insects were the remains of prey, taken by either laughing owls or falcons, which had accumulated following breakdown of the ejected pellets these birds of prey produce. The robust and durable exoskeletons, mostly of carabids and weevils, remain. Full listings of the 41 taxa represented in the North Canterbury deposits are given in Worthy & Holdaway (in press, Appendix 4), and of the 43 taxa for South Canterbury deposits in Worthy (in press, Appendix 5). The purpose of this note is to comment on the status and distributions of four large weevil species represented in these faunas.

METHODS AND STUDY SITES

Dry sediment from various small caves, crevices and ledges on rocky limestone bluffs and cliffs in the Canterbury region of New Zealand's South Island was processed by THW; the sites are listed in Table 1 and details can be found in Worthy (in press). Limestone rocks were removed before sieving the sediment through a 6 mm wide mesh. The faunal material that did not pass through the 6 mm mesh sieve was sorted on site and the screened material was further sieved through a 1.5 mm mesh. Residue retained on the finer sieve was taken for further fine processing in the laboratory.

Several dozen species of weevils, in many hundreds of fragments, were extracted. While the majority of species were small, rarely more than 5 mm long, four species were of moderate to large size: *Anagotus stephenensis* Kuschel, *A. rugosus* (Broun), *Ectopsis ferrugalis* Broun and *Hadramphus tuberculatus* (Pascoe). These merit attention because discovery of their remains in these sites indicates that their past distributions were considerably larger than present. They have since become locally extinct in these areas and one species has disappeared completely.

Fossil fragments from the first three sites (Table 1) are deposited with the New Zealand Arthropod Collection, Auckland, in boxes reserved for fossil remains. The material here reported from sites 4-12 is in the Entomology Research Museum, Lincoln University, New Zealand.

THE LARGE WEEVIL SPECIES REPRESENTED BY HOLOCENE FOSSIL REMAINS

Anagotus stephenensis Kuschel, the ngaio weevil: Fig. 1.

Anagotus Sharp is an endemic genus that holds about two dozen species, some of which are amongst the largest weevils of New Zealand; *A. stephenensis* is the largest in the genus. *Anagotus* species occur throughout New Zealand from Three Kings Is to Stewart I. but not on subantarctic or other outlying islands. Some are lowland species, others subalpine; some are ground species associated with monocots and herbaceous dicots, others are canopy dwellers on conifers and dicotyledoneous trees and shrubs; some have larvae that are herbaceous plant feeders, others that are woodborers on conifers and dicots; some have more or less exposed larvae (ectophytic), others have larvae completely enclosed by plant tissue (endophytic).

A. stephenensis belongs to the *Anagotus helmsi* species group, which consists mainly of tree canopy dwellers. Larvae of some species of the group are known to be woodborers, but larvae of *A. stephenensis* and the closely related *A. turbotti* (Spiller) (Three Kings, Poor Knights Is and Muriwhenua I. of the Hen and Chickens group) are unknown but adults are consistently found on ngaio (*Myoporum laetum*) and karaka (*Corynocarpus laevigatus*) suggesting that their larvae might feed in wood of these trees. A closely related undescribed species is found from Resolution I. (45°40'S) on the west coast of Fiordland to Puwai I. (47°15'30S) in Puwai Bay on the south coast of Big South Cape I. Adults of

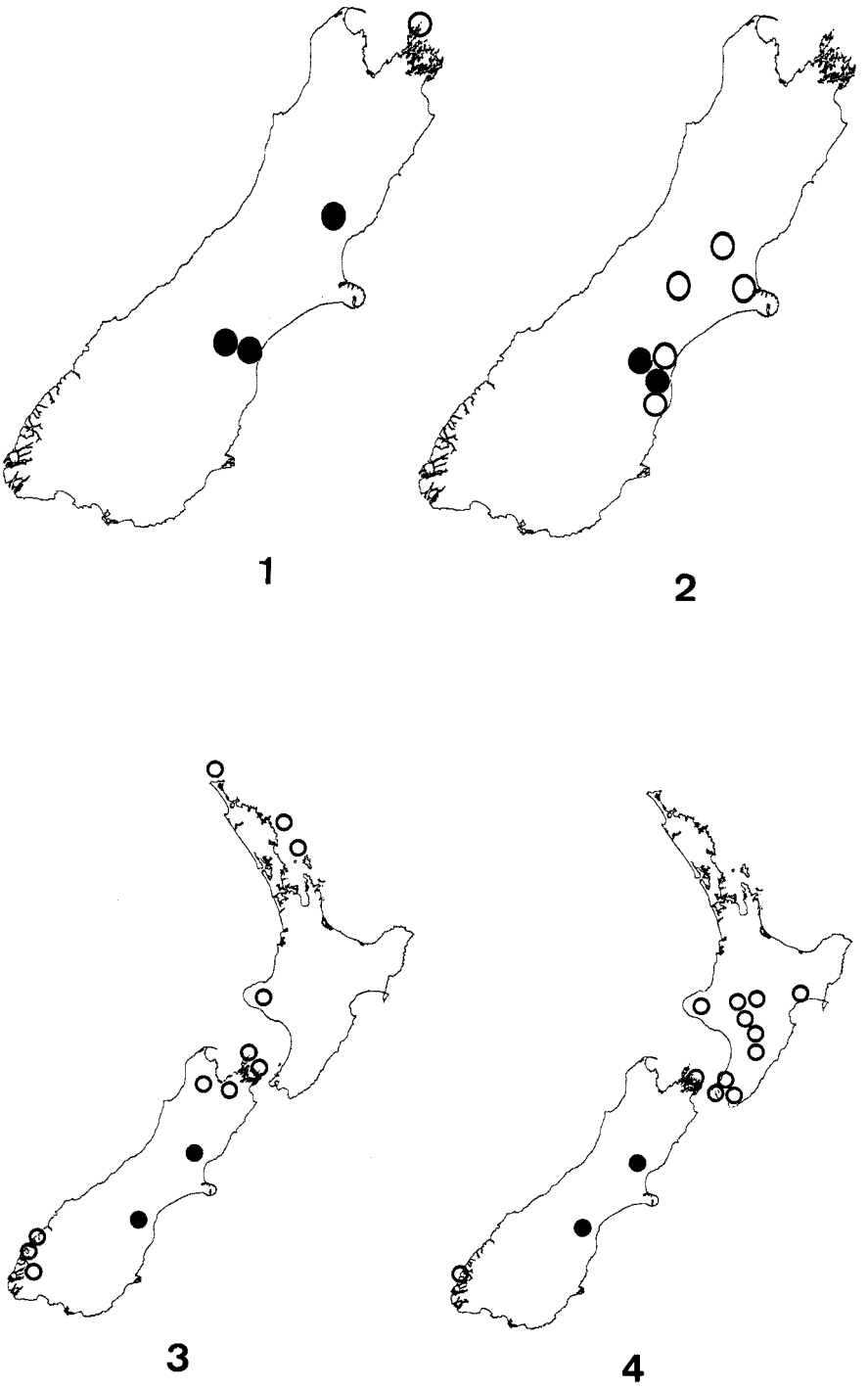
Table 1: Study sites and weevils found. Numbers in brackets are minimum numbers of individuals represented.

Site	Grid Reference (NZMS 260 series)	Origin	Weevil species present (number)
1. Ardenest, Waikari, North Canterbury	N33 916073	laughing owl	*A. stephenensis* (10) *A. rugosus* (6) *E. ferrugalis* (15)
2. Albury Park, Tengawai River, South Canterbury	J38 335670	laughing owl	*A. stephenensis* (13) *A. rugosus* (33) *E. ferrugalis* (13) *H. tuberculatus* (3)
3. Braeburn Station, South Canterbury	J38 475631	falcon	*H. tuberculatus* (6)
4. Gordons V. Niche, South Canterbury	J39 527371	laughing owl	*A. stephenensis* (1)
5. Gordons V. site 2b, South Canterbury	J39 526371	laughing owl	*A. stephenensis* (2)
6. Gordons V. site 4, lower layer, South Canterbury	J39 524369	laughing owl	*A. stephenensis* (2)
7. Gordons V. site 4, upper layer, South Canterbury	J39 524369	laughing owl	*A. stephenensis* (10) *E. ferrugalis* (1) *H. tuberculatus* (1)
8. Gordons V. site 5, South Canterbury	J39 523368	falcon	*H. tuberculatus* (1)
9. Gordons V. site 7, South Canterbury	J39 527379	laughing owl	*A. stephenensis* (1) *H. tuberculatus* (1)
10. Gordons V. site 8, South Canterbury	J39 528380	laughing owl	*H. tuberculatus* (4)
11. Craigmore Station site 1, South Canterbury	J39 497404	laughing owl	*H. tuberculatus* (4)
12. Glenlea Station, South Canterbury	J39 496701	laughing owl	*H. tuberculatus* (3)

this species were found feeding on *Olearia oporina* and *O. angustifolia*. It is virtually certain that the larval workings of a large *Anagotus* species found in a stem of *Dracophyllum longifolium* on Big South Cape I. (south of Stewart I.) were those of the sole *Anagotus* species occcurring south of Foveaux Strait.

The ngaio weevil was discovered on Stephens I. (40°40'S 174°00'E), situated in Cook Strait 5 km NNE of D'Urville Island, by A.C.O'Connor on 15 September 1916. It is reported that the specimens were found 'feeding on tall fescue and the leaves of trees'. Broun immediately described it as *Phaeophanus oconnori*, naming it after the collector, but publication was delayed till 1921 due to World War I. Because *Phaeophanus* Broun and a few other genera proposed by Broun were considered synonymous with *Anagotus* Sharp (Kuschel 1982), the ngaio weevil was renamed *A.stephenensis* due to a homonymy within the genus resulting from the synonymies.

The New Zealand Arthropod Collection, Landcare Research, Auckland holds 17 specimens of *A. stephenensis*, ranging in length from 15 to 23 mm, all from Stephens I. Of these, 15 represent the original series of O'Connor's 1916 expedition, one from



Figs 1-4: Distribution maps of *Anagotus stephenensis* (1), *Hadramphus tuberculatus* (2), *Anagotus rugosus* (3), *Ectopsis ferrugalis* (4). (O for recent distribution, ● for Holocene fossil sites)

1931, and one from 1971 collected by GK. No more recent specimens are known to the writers. The 1971 specimen was found on a ngaio tree (*Myoporum laetum*) at the top of the island above the caretaker's house. The tree was part of a grove on a barren ground heavily undermined by tuatara (*Sphenodon punctatus* Gray) and petrels. The chances of the flightless, nocturnal weevils surviving predation by tuatara while moving across the ground from one tree to another would be minimal. Despite adult specimens being conspicuously pale and easily spotted by bright torch light while feeding at the end of branchlets, only one specimen was found in 1971 after intensive searching. I. Millar (pers. comm.) carried out a special search in 1995 and saw only one or two specimens in three out of five nights devoted to the task. This evidence indicates that the weevil has become rarer than it was in 1916. The ngaio weevil is now known only from Stephens I. where it continues to exist although very sparingly. However, fossil evidence from seven caves that had been inhabited by the presumed extinct laughing owl had numerous heads, elytra and other body parts of *A. stephenensis*, a sure proof that the weevil used to be more widespread and common in the South I.

***Anagotus rugosus* (Broun), the coprosma weevil: Fig.3.**

This 9-15 mm long species is found almost exclusively on rodent-free offshore islands from Three Kings Is to Fiordland. Because differences were noted in populations scattered over such a wide geographical range, Broun described the species four times naming the first one in 1883 *Phaeophanus rugosus* from two specimens provided by P. Stewart-Sandager from The Brothers (41°32'S 174°26'), which are poorly vegetated rocky islets in Cook Strait. This species has a woodboring larva that develops in live branches of *Coprosma* species and can seriously affect stands of taupata (*Coprosma repens*), a shrub that mainly inhabits dunes and coastal cliffs.

The species is surviving well on offshore islands free of rats and mice, but poorly elsewhere. Odd specimens were found only on Dun Mountain, French Pass, Mt Arthur and the west side of Lake Manapouri in the South I. In the North I., the species occurs only on the slopes of Mt Taranaki (Mt Egmont) where some 20 years ago it could readily be found at night on blades of *Astelia nervosa* and *A. cockaynei* along the track that leads from the Dawson Falls to the top of the mountain.

A.rugosus used to be even more common over North and South Canterbury than *A. stephenensis*, judging by the extremely abundant fossil remains retrieved from sediments of caves frequented by the laughing owl.

***Hadramphus tuberculatus* (Pascoe), the spaniard weevil: Fig. 2.**

This 9-17 mm long weevil used to be common over the Canterbury plains where spaniard (*Aciphylla* species) abounded. Many specimens were collected in the Christchurch area in the 1870s by C.M. Wakefield who sent them to F.P. Pascoe (1877) for description. *H. tuberculatus* must have been reasonably abundant at the time of discovery because museums and collections hold about 50 specimens altogether, all but one dated before the turn of the century. The last specimen of the spaniard weevil now in collections was obtained at Blackford on 2 December 1912 by T. Hall. Since no specimens have been found for over 80 years, it is likely that the species is extinct.

Hadramphus Broun, notwithstanding its rather strikingly different habitus, is closely related to *Lyperobius* Pascoe, the former consisting of three lowland species, the latter of about 20 lowland and montane species. There is no evidence that the montane species have been greatly reduced in numbers, but there is ample evidence that all lowland species have lost much, if not all, of their original territory.

The numerous Holocene fossil remains of *H. tuberculatus* extracted from dry sediments of caves and rock crevices visited by laughing owls and New Zealand falcons are a firm indication that the spaniard weevil was common in Canterbury a good time before its discovery.

***Ectopsis ferrugalis* Broun, the five-finger weevil: Fig.4.**

This 8-16 mm long, rather handsome forest floor weevil was described by Broun (1881) from Wellington. It is associated with *Pseudopanax* (Araliaceae) and continues to be rather plentiful in the southern half of the North Island and the Chatham Is. Farther south it is now known only from Maud I. in the Marlborough Sounds and Secretary I. in Fiordland.

The samples from the laughing owl sites of Ardenest and Albury Park show that *E. ferrugalis* was once bountiful also on the mainland of the South I., at least in Canterbury. Why this species has disappeared from the South I. mainland, whilst remaining common on the North Island mainland, defies easy explanation.

WHY HAS THE GEOGRAPHICAL RANGE OF LARGE WEEVILS SHRUNK?

In order to explain the huge loss of territory of large weevils in the South I., consideration must be given to possible climatic changes, volcanic eruptions, environmental impact through human activities, and introductions (voluntary or unintentional) of animals and plants. Climatic deviations would have to have been drastic in relatively recent time were these to have affected either host plant or weevil. There is no evidence for such climate change since the first people came to New Zealand. Volcanic eruptions have certainly influenced some areas of the North I. but not the South I. in recent times.

As far as the impact of human activities on the environment is concerned, *Homo sapiens* did little to deserve the epithet 'sapiens' (Latin: 'wise', 'discreet'). The four weevil species under discussion were once widespread and common on the Canterbury plains. They have disappeared from this large area due in part to thorough clearing of bush pockets and native grassland with persistent burnings and large-scale cultivation. The tough and prickly native genus *Aciphylla*, hostplant of *Hadramphus tuberculatus*, was regarded by many farmers an undesirable weed to be removed at all costs, achieved by repeated burning of dry grassland. No doubt, the removal of *Aciphylla* has contributed to the likely extinction of *H. tuberculatus*, but probably very little to the loss of the other three species from the area.

The arrival of both herbivorous and predatory animals, by design or accident, had a disastrous effect not only on the avifauna of New Zealand, but also probably equally on the entomofauna, something suspected but not yet sufficiently supported by concrete evidence. The introduced animals are mainly of two kinds: those that browse on vegetation thereby altering the landscape, and those that prey on native creatures in the wild. Goats on Great I. of the Three Kings group, for instance, caused such a devastation of vegetation and soil that a whole series of bush floor litter endemics was presumably eliminated from the island. These species only escaped total extinction because of their presence on other little islands of the group, principally Southwest I., 5 km off Great I. This island has an unusually high number of endemics which,with a few exceptions (Franz 1975), are undescribed. A second example comes from the Chatham Is where the coastal, non-pungent *Aciphylla dieffenbachii* survives on the main islands only on cliff ledges with no or difficult access to sheep. Grazing by sheep is thought to have precipitated the disappearance of *Hadramphus spinipennis*, a large weevil totally dependent on this umbelliferous plant, from the two main islands. It still is common on the small offshore islets of Mangere and South East and a rocky outcrop right by the southern tip of Pitt I. where sheep are absent and the *Aciphylla* flourishes.

The deliberate release of introduced predators, such as ferrets, stoats, weasels and hedgehogs and the invasion of fields and forests by rodents, opossums and game birds has contributed to the downturn in numbers of large insects. Weevils are vegetarians, lack defensive glands, and the large ones are avidly preyed on especially by rodents. Although native birds, such as wekas (*Gallirallus* spp), takahe (*Porphyrio mantelli* (Owen)), laughing owl, kakapo (*Strigops habroptilus* Gray) and also kiwis (*Apteryx* spp) take large weevils, they could hardly be responsible for the depletion of large weevils since this has happened only in relatively recent times. Evidence points to rodents, *Rattus exulans*

(Peale), *R. rattus* (L.), and *Mus musculus* (L.) as the prime agents for the large reduction in numbers and geographical range of many large lowland weevil species in New Zealand. In some cases weevil species have disappeared from all areas frequented by rodents, while in others, species have vanished from some areas but not others although the rodents seem to occur in equal numbers at the sites.

An example of severe depletion, close to extermination, comes from the Auckland Is where *Oclandius* species were extremely common before mice arrived from boats. Nests of mice on the main Auckland I. have been found with heaps of weevil bodies, many elytra showing the characteristic tooth marks of the rodent (body remnants of weevils are in the N.Z.Arthropod Collection).

Another case is Big South Cape I., which had a very dense population of *Hadramphus stilbocarpae* Kuschel when B.A.Holloway[1] spent the night of 24 January 1955 at Murderers Bay and saw the hostplant *Stilbocarpa lyallii* teeming with feeding weevils. The black rat got on to the island shortly after from a fishing boat, quickly multiplied, eliminated the species and ate the host plant down to the roots. The members of two later three-week long expeditions (November 1968 and February 1969) searched extensively to find adults, larvae and also their characteristic frass marks but without success although the host plant had already fully recovered. Remains of the weevil, however, were found which were presumed several years old (Kuschel 1971). The apparent total absences of *H. tuberculatus* from the South I. and *H. spinipennis* from Pitt I. are assumed to have been induced by large scale clearings of the fields, sheep feeding on the hostplant, and by rodents preying on the weevils.

Ectopsis ferrugalis was once common on the mainland of the South Island but seems to persist in large numbers on the North Island, although both islands have had rodents for about the same span of time. Possibly rodents multiplied to plague numbers on one island and not on the other, although if so, there ought to be a historical record of this, which is apparently not the case.

Clearly, large weevils are rare in species and numbers in all lowland areas inhabited by rats and mice while rich in species and numbers on rodent-free lowland areas as well as on the mountain ranges where the rodents do not seem to thrive. The implication is that predators have played a role in determining the weevil distributions that occur today, compared with that indicated by Holocene fossil remains.

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[1] Beverley Holloway draws attention to an error on the printed labels of the 28 specimens collected that night that say 4 January 1955 instead of 24 January 1955.

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