

Population of the ngaio weevil (*Anagotus stephenensis*) on Stephens Island/Takapourewa

Mark Anderson

Marlborough Boys College, 5, Stephenson Street, Blenheim, 7201

Email: marka@mbc.school.nz

Introduction

Stephens Island is a remote island in western Cook Strait, three kilometres north of D'urville Island. It was heavily deforested by fire and grazing following the building of a lighthouse in 1894, removing around 90% of the forest cover. Presently, the island consists of small patches of original forest, which cover approximately 12% of the island area (East et al., 1995). The remainder of the island's vegetation consists of vines, tall and short grass, scrub and areas of regenerating forest, where trees have been planted since 1990.

The island has a rich diversity of reptiles, with the largest population of tuatara in the world, three species of gecko, and four species of skink. The presence of these reptiles in unusually large numbers is attributed to the presence of over one million burrowing fairy prions, whose nutrient enrichment of the soils provides minerals for enhanced vegetation growth and an increased density of ground dwelling invertebrates (Brown, 2001; Mulder et al., 2001). Stephens Island has never had mainland mammalian predators, other than some cats which were removed in 1925 (Brown, 2001). The ngaio weevil is a large, nocturnal, flightless weevil ranging in length from 20 to 31mm. The species was discovered in 1916 on Stephens Island and is considered a relict population (Kuschel et al., 1996). It has a historic range as far as South Canterbury and was once common, having been found in reasonable numbers (39) in cave deposits produced by the extinct laughing owl (Kuschel et al 1996). Intensive searches in 1971 and 1995 saw only one or two specimens, indicating it had become rarer than when discovered in 1916 when 15 specimens were collected from Stephens Island (Kuschel et al., 1996). It has previously been seen on ngaio (*Myoporum laetum*) and feeding notches on leaves are a sign of presence (McGuinness, 2001).

Methods

A search area was determined following two visits to Stephens Island in July and September 2011. Because of seabird burrows, the search area was limited to the tracks, fence lines and roads on the island and one area of retired grass paddock that was not burrowed. Searching occurred over 31 nights. This began at least one hour after sunset and involved scanning the leaves and stems of ngaio with a head torch from the ground upwards.

The search area used to ascertain the presence or absence of ngaio weevils consisted of a core area which was searched on 28 nights and other areas which were searched as time allowed. The core area was determined from observations of four ngaio weevils in September 2011. The other areas were determined by the presence of ngaio trees larger than 1 metre. These other areas were each searched on 3-8 occasions.

Each ngaio weevil was individually marked on their dorsal side, using up to 6 dots of brown/black/white nail varnish to produce a code. They were photographed to determine sex (see Figure 2). The specimen's mass (accuracy +/- 0.01g) was measured using an electronic balance. Length (accuracy +/- 1mm) was measured at its longest point, from the end of the rostrum to the end of the thorax.

The height above the ground that the weevil was found was recorded with a tape measure. The temperature at the start of the search and towards the end of the search was recorded using a Pasco data logger. When a new site was found for a ngaio weevil, the tree was marked with flagging tape and later measured. The GPS position of each sighting was recorded, along with tree height (estimate) and circumference at the lowest point possible. The host plant species was also recorded.

Weevil Sexing

The sex of Helm's beech weevil (*Anagotus helmsi*) is determined by observing the shape of the terminal sternite (McBurney, 1976) and this method was also used to determine the sex of the ngaio weevil. In *Anagotus helmsi*, McBurney distinguishes the sexes by 'the male having a terminal sternite approximately half as long as wide, with a concave area apically'.

The female is described as ‘the length and width are subequal, the surface is uniformly convex’ (Figure 2).

On the third search night, a male and female were seen on the same branch and photographed together (Figure 3) to determine differences in morphology and confirm the gender differences. Following this discovery, the ventral side of each weevil was photographed using a macro feature on a Panasonic digital camera using a head torch for illumination. This photograph was then analysed the following day to determine the sex of each weevil. Data were only entered for individuals where there was a clear photograph and unambiguous shape of the terminal sternite.

Results

Population, distribution and habitat

There were 528 ngaio weevils sighted over 28 nights of searching: this number included 259 marked individuals. Photographs of 248 individuals were analysed to determine sex and the sample consisted of 173 males and 75 females, giving a male:female sex ratio of 2.3:1.

Figure 1. Sex determination in Helms beech weevil (after McBurney, 1976)

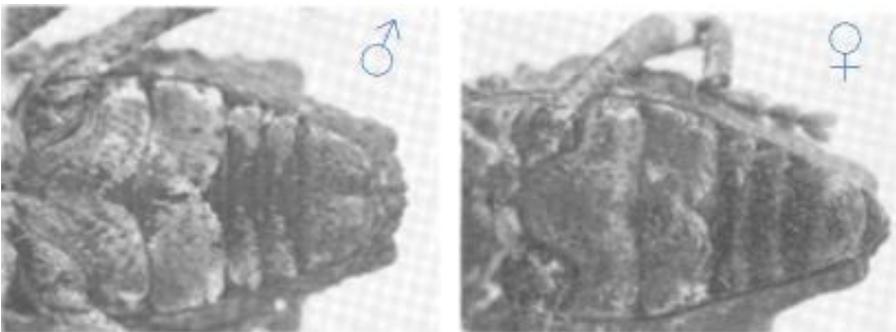


Figure 2. Female (left) and male (right) ngaio weevils



Figure 3. Ngaio weevil in defence posture



The population of the ngaio weevil is not evenly distributed across Stephens Island: 92% of individuals were found in one area of relatively recently planted (c. 25 years) ngaio with low numbers seen in ngaio elsewhere. Weevils were not seen in the mature forest areas in Keepers Bush around the two ex-lighthouse keeper's houses or in mature forest areas on the summit track.

All ngaio weevils were seen either on ngaio trees (85% of sightings) or in the proximity of ngaio. Other invertebrates seen on ngaio included tree weta, Cook Strait giant weta, chafer beetles (seen browsing) and small *Lyprobates* sp. The ngaio weevils were quite frequently found on grass under ngaio branches (10.6% of sightings) and occasionally on vines growing under or next to branches of ngaio. Sightings occurred on trees of average height of 2.67m (range 1.29-4m) and average circumference of 51cm (range 20-88cm). These trees were mostly planted trees (82%), the remainder on more mature trees with low branches that overhung fences or paths. All of the ngaio weevils observed, were on trees that had leaf litter under the canopy and low branches that touched the grass or vines growing underneath. The ground cover in mature bush was devoid of leaf litter due to the presence of petrels and their burrows.

Behaviour

Ngaio weevils are nocturnal and were observed on Stephens Island from 81 minutes after sunset at 9:15pm (Nelson data) until 3.00am. One individual was kept inside a large dark coloured bucket with a lid in a brightly lit room for further study. It retained a pattern of emergence at various times of night and crawling into the leaf litter at the bottom of the container before daylight, where it remained until dusk. It did not emerge from the leaf litter during the daylight when the bucket followed the sunrise/sunset patterns. When the bucket was moved to a darkened room, the pattern was disrupted and the weevil was seen actively feeding at 2pm and 7.11pm. Despite checking every 2-4 hours, in one instance, it was not seen to emerge for 47 hours.

When the weevil was found during daytime searches of the leaf litter in the bucket, it was found 20-30mm deep in the leaf litter, motionless, clinging to leaves or bark. In the field, one individual was found on two occasions during the daytime (10.40am and 4.00pm) following searches of the grass

underneath low-hanging ngaio branches. It was clinging to grass stems on both occasions. During evening searches, it was common (56 sightings) to see ngaio weevils on grass underneath ngaio branches. Some of these (three sightings) were very close to the ground (0.02-0.04m). Ngaio weevils were seen at an average height above the ground of 0.59m (range 0.02-1.70m), despite good visibility on most trees up to 3m. They are most frequently seen at the lower end of this height range with 90% of sightings occurring below 1m.

A variety of behaviours was recorded, including moving up and down plant stems, feeding, playing dead, dropping off a leaf onto the ground and standing still on leaves. Most observations were of ngaio weevils standing motionless, when even a small amount of light (including red light) illuminated them. Occasionally, they would continue their behaviour of moving or feeding when illuminated. When handled, they would usually remain completely motionless with legs tucked underneath their body (Figure 3). This behaviour was also observed in the weevils found hiding in leaf litter or grass during the day. Occasionally they would remain active and walk away from the electronic balance or hand. On a few occasions, they would release their grip of the leaf when an attempt to collect them was made and fall into the leaf litter or grass below and remain motionless. On other occasions, they would grip onto leaves or stems tightly and would not let go.

Three pairs of ngaio weevils were observed mating, with the male weevil on top of the female (Figure 4). Male and female weevils were frequently seen close together on the same area of a tree.

Marked individuals were frequently seen on consecutive nights, although some re-sightings did not occur for up to three weeks. On a follow-up visit to the island in December 2014, one marked weevil was observed that was marked 3 years and 2 months previously. Weevils were observed to move between adjacent ngaio trees, but never to move distances further than 5m. Most of the repeat sightings of individuals occurred on the same tree.

Feeding

Ngaio Weevils have been observed feeding on ngaio leaves and leaf stalks. The feeding sign is a large semi-circular notch in foliage which has a deeper

indentation on the rostrum side (Figure 5). The weevils feed by continuously browsing on the same area, making deeper and deeper incisions. The captive weevil appeared to be chewing leaves off at the stalk and allowing them to drop onto the floor of the bucket. A small number of leaves were chewed along the leaf stalk, but not enough to cause them to drop. A secondary feeding sign is the production of dark brown, fairly liquid, faecal matter which has been observed on leaves with ngaio weevils and being produced by the weevils.

Sex differences

There was a large difference in the numbers of sightings of male and female weevils. Males were sighted on 361 occasions (71% of sightings) and females on 144 occasions. Of the sample of individuals that were sexed, 173 were males and 75 were females, and therefore the sample (70 % males) appeared to be representative of the sex ratio seen in the wild population.

Length and mass showed a linear relationship for both males ($r_P = 0.75$, $P < 0.001$) and females ($r_P = 0.79$, $P < 0.001$) (Figure7). There were significant differences in the length and in the mass of male and female Ngaio Weevils. Male average length was 24.9mm (range 20-29mm); female average length was 27.8mm (range 23-31mm) ($t = 12.5$, $P < 0.001$). The average male mass was 0.68g (range 0.36-1.05g); female average mass was 0.96g (range 0.48-1.30g) ($t = 12.0$, $P < 0.001$).

Discussion

The development of new habitat for ngaio weevils has allowed their numbers to increase dramatically over the last 20 years. Habitat loss due to deforestation, which began in 1894, would likely have caused a population decline that continued after 15 specimens were collected when the species was discovered in 1916. In 1989, there had not been any sightings of the ngaio weevil for 18 years (unpublished note to J Dugdale, 1989). The actual population count of 259 individuals over 28 nights is the highest ever recorded. The population has benefitted from the reforestation of the island and specifically by the planting of ngaio trees. The distribution of the weevils is not uniform, possibly due to the preference for feeding on trees with low branches that allow easy access from their daytime refuges in the leaf litter/dense grass (Figure 8). Many areas of the island were not searched

due to the fragile nature of the ecosystem and further surveying is therefore required.

The area where 92% of individual weevils were found, the Ruston Spur, is an area of planted ngaio (in approx. 1990), which is separate, but close to the mature Ruston Bush. Some movement of ngaio weevils has occurred along the ground in this area, as the trees are planted in groups. Within 300m is a similar sized area of planted ngaio where this species is currently absent, providing potential for further dispersal and population increase.

Tuatara are an obvious predator of the ngaio weevil. Adult tuatara have been observed on top of muhlenbekia and grass next to ngaio branches that host weevils. Tuatara are ambush predators, that rely on movement of prey for detection and have sight perception capabilities comparable to birds and mammals (Woo, 2004), and can prey upon the movement of ngaio weevils as they move onto low branches. In the area of highest weevil population density, the population of tuatara and fairy prion appears to be much lower than the other core search areas on the island. Fairy prion densities are linked to tuatara densities (Markwell, 1998) due to the reliance on the seabird as a food source for the reptiles. The very low density of fairy prion burrows in the core search area could explain the higher density of ngaio weevils in this area. Conversely, in other areas with suitable ngaio but with higher fairy prion/tuatara populations, the weevils occurred in considerably lower numbers.

Tuatara densities are highest in mature forest (18 sightings per person per hour), low in vines (7 sightings per person per hour) and much lower in tall grass (3 sightings per person per hour) (East et al, 1995). The tall grass in the core area provides a protective screen for access for weevils onto the tree, which is absent in the mature forest. The canopy forest is almost devoid of an understory with seedlings negatively affected and leaf litter removed by burrowing fairy prions (Mulder, 2001). This could explain the lack of sightings in the mature forest where visibility is increased for predators and the preference for forest margins, where grass and vines can grow and allow access for the species onto their host plant and screening from predators.

The lack of dead ngaio on Stephens Island was thought to be a possible limiting factor for weevil population growth due to the larval stage requirements (McGuinness, 2001). In the area where most sightings were

made, there are very small amounts of dead ngaio and distances of nearly 50m to mature bush, where there is a greater amount. Large holes have been observed in dead ngaio (Figure 6) close to ngaio weevil sightings, however, the size of emergence holes was smaller (5.5mm) than those of the smaller weevil *Anagotus helmsi*, which have been observed to ‘not exceed 10mm’ (McBurney 1976). Ngaio weevils have only been observed eating ngaio on Stephens Island. Their diet may include small amounts of karaka, a food source of its sister species *Anagotus turbotti*, although it is unlikely that this would be in large enough amounts to host a large population. The ability of ngaio weevil to use karaka should be tested, as this may provide opportunities for their translocation.

Whilst feeding, this species was observed to produce faecal matter, which is deposited on the leaves and may attract the opposite sex or other individuals to aggregate for mating, as other species have been observed to aggregate on production of pheromones in their faecal matter (Barnes, 1989).

The nocturnal ngaio weevil was observed to emerge from the leaf litter/grass, where it stays motionless during the day, and their daytime behaviour provides a safe place for them to hide away from predatory birds. The weevils climb up the surrounding plants, which are grasses, muhlenbekia or spinach and access ngaio in this manner, and then use the stem and adjoining leaves to move around the ngaio, having been frequently observed on the stem and moving between leaves. The weevils usually stop activity when illuminated by torchlight and bury themselves in leaf litter to move away from light during the day, and their emergence patterns are strongly affected by light levels, as shown by the individual that began to emerge during the day in a darkened environment. However, sightings of this species were unaffected by the presence of moonlight.

Ngaio weevils did not appear to be a mobile species during this study. On rare occasions, weevils were observed to have moved to adjacent trees and on one occasion approximately 5m away from the original site. They were not observed in transit on grass between ngaio trees, although this was not deliberately searched. Generally, each individual would be seen on the same aspect of the same bush on each occasion. There was not a single sighting of a ngaio weevil in two different locations greater than 5m apart. It is possible that there is a seasonal movement that occurs outside of this study period, when females disperse to lay eggs on suitable ngaio. A minimal

movement between trees for this large flightless weevil may be a behavioural adaptation, as the chances of surviving predation by tuatara would be minimised (Kuschel, 1996).

There was a bias towards males over females in the ngaio weevil population on Stephens Island (male:female =2.3:1). It is possible that the energy requirements of the larger female larvae are greater than male specimens and thus they mature more slowly or fail to reach maturity. Alternatively the sex ratio could be caused by higher levels of predation on the larger and possibly slower-moving female.

There was a large mass and length difference between male and female ngaio weevils and the data collected on mass and length should allow easy identification of sex by someone collecting weevils for translocation. Of the weevils that were >0.9g mass, 94% were female. Of the weevils that were 28mm in length or greater, 91% were female. Identification using these parameters would allow over 85% of weevils to be correctly sexed in this study without studying the terminal sternite.

There was also a large range of sizes within each gender. Males ranged from 20-29mm and females from 23-31mm. These large size ranges may be caused by differences in larval nutrition (Trumble et al., 1978) or temperature (Guppy, 1974) during development and may reflect a lack of optimum conditions throughout the study area for this species. There may be an imbalance of smaller sizes during the study period due to smaller individuals emerging earlier due to lower fat reserves. Emergence of adults may have continued throughout the study period, as sightings of new individuals occurred on most days, even in areas that had very good visibility of trees. This species was thought to live for two years (Dugdale, 1993) and so would have a cycle of mating and feeding through two seasons of activity, with fertilised eggs deposited throughout this season. A sighting of a marked weevil three years and two months after being marked records a new longevity for this species.

Mating behaviour was been observed in this study in October and November and in December. This has important impacts on any translocation proposal. If a small number of this species were to be moved to a tuatara-free island in the Marlborough Sounds, it should be before mating and egg deposition has occurred, so that this process can occur in the new habitat. This would

allow successful breeding in case this species has less than a two year life span as an adult.

Figure 4. Ngaio weevils mating



Figure 5. Ngaio weevils feeding



Figure 6. Wood boring in ngaio



References

- Anon, 1989. Notes to JS Dugdale about *Anagotus stephenensis* and *Mecodema punctellum* on Victoria University headed notepaper, Stephens Island Records, Department of Conservation, Sounds Area Office, Picton.
- Barnes BN, Capatos D, 1989. Evidence for an aggregation pheromone in adult frass of banded fruit weevil, *Phlyctinus callosus* (Schoenherr) (Col., Curculionidae). *Journal of Applied Entomology* 108: 512–518.
- Brown D, 2001. Stephens Island; ark of the light. Cloudy Bay Publishing, Blenheim, NZ.
- Dugdale, JS, 1993. Letter to I Millar, Stephens Island Records, Department of Conservation, Sounds Area Office, Picton.
- East TK, East M, Daugherty CH, 1995. Ecological restoration and habitat relationships of Reptiles on Stephens Island, New Zealand. *New Zealand Journal of Zoology* 22: 249-261.

- Guppy JC, Mukerji MK, 1974. Effects of temperature on developmental rate of the immature stages of the Alfalfa Weevil, *Hypera postica* (Coleoptera:Curculionidae). *Canadian Entomologist* 106: 93-100.
- Kuschel G, Worthy TH, 1996. Past distribution of large weevils (Coleoptera:Curculionidae) in the South Island, New Zealand, based on Holocene fossil remains. *New Zealand Entomologist* 19:15-19.
- Markwell TJ, 1988. Relationship between Tuatara *Sphenodon punctatus* and Fairy Prion *Pachyptila turtur* densities in different habitats on Takapourewa (Stephens Island), Cook Strait, New Zealand. *Marine Ornithology* 26: 81-83.
- Marris J, 2001. Beetles of Conservation Interest from the Three Kings Islands, A report submitted to the Department of Conservation, Northland Conservancy Ecology and Entomology Group, Lincoln University.
- May BM, 1987. Immature stages of Curculionoidea (Coleoptera): Rearing records 1964-1986. *New Zealand Entomologist* 9:44-56.
- McBurney GR, 1976. Notes on the Life History and Distribution of *Anagotus helmsi* (Coleoptera:Curculionidae). *New Zealand Entomologist* 6: 177-181.
- McGuinness CA, 2001. The conservation requirements of New Zealand's nationally threatened invertebrates. *Threatened Species Occasional Publication* 20: 658.
- Mulder CPH, Keall SN, 2001. Burrowing seabirds and reptiles: impacts on seeds, seedlings and soils in an island forest in New Zealand. *Oecologia* 127: 350-360.
- Pawson S, 2002. Survey of threatened Coleoptera on Stephens Island, Stephens Island Records, Department of Conservation, Sounds Area Office, Picton.
- Sibul I, Voolma K, 2004. The Abundance, seasonal dynamics and Sex Ratio of the large Pine Weevil, *Hylobius abietis* (L.), in reforestation areas:

Assessment by ground pitfalls and baited pitfall traps. *Transactions of the Faculty of Forestry, Estonian Agricultural University* 37: 56–62.

Trumble JT, Kok LT, 1978. Laboratory propagation of *Ceuthorrhynchidius horridus* (Coleoptera: Curculionidae), An introduced Weevil for Biocontrol of Caduus Thistles, *Canadian Entomologist* 110:1091-1094.

Ure G, 1994. Stephens Island Weevil, Summary of A Survey Carried Out From April 1993-March 1994, Report compiled for The Department of Conservation, Stephens Island Records, Sounds Area Office, Picton.

Woo KL, 2004. Acquisition of a Learned Operant and Critical Flicker-Fusion Rate in the Tuatara (*Sphenodon spp.*) Unpublished Msc Thesis, VUW, New Zealand.

Figure 7. Relationship between mass and length of male and female ngaio weevils

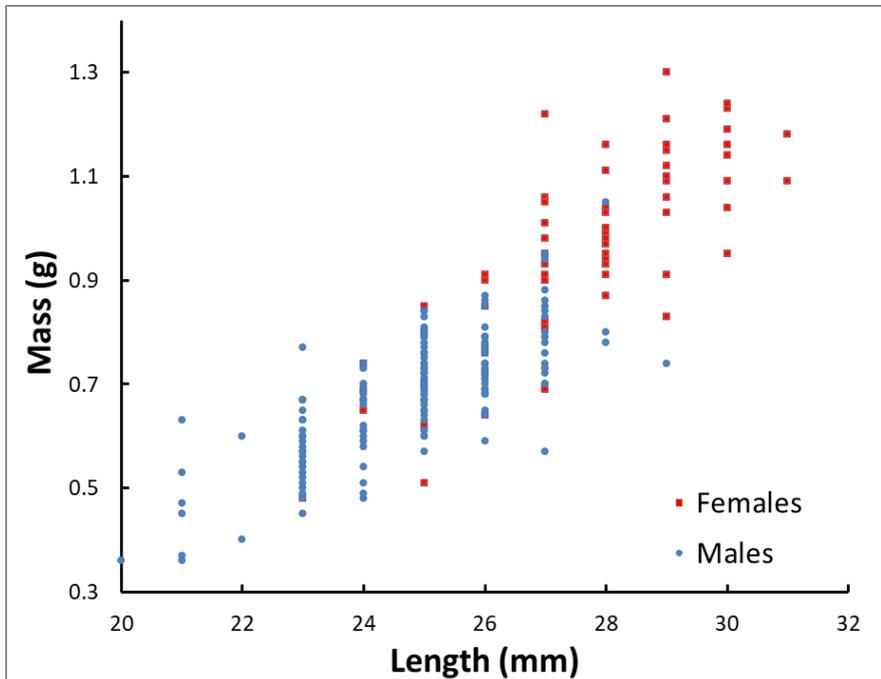


Figure 8. Tall grass providing access onto ngaio.

