The Autecology and Conservation of the North Island Weka

(Gallirallus australis greyi)

A thesis presented in partial fulfilment of the requirements

for the degree

Master of Science

in

Ecology

at Massey University.

Gary Neil Bramley

1994

Acknowledgements

This thesis would not have been possible without the contribution of my supervisor, Dr Clare Veltman, who was always available to help at any stage from planning, to field work, analysis and writing. Her assistance and friendship was invaluable.

Andy Bassett from the DoC field centre in Gisborne was also a big help, particularly in the beginning when he added a lot of technical skill to my early trapping efforts. Andy also raised money from local businesses to support the project and he and his wife Glenys provided occasional accomodation en route to Palmerston.

I could not have collected any data without the co-operation of local people at Rakauroa. In particular, Bernard and Verna Harnett and family graciously allowed me the unrestricted use of their shearer's quarters and access to their land. Graeme and Lavinia Scott and their daughters Sandra and Michelle, made both me and Clare feel more than welcome when we were in Rakauroa. I was allowed free access to land owned by Alister and Gwynneth Redpath and family, Alisdair and Marie McIntosh, Mike and Ali Gibson, Peter and Ian Langer, Mr and Mrs Hall, Mr and Mrs Gault and Dave and Gail Morris. Cecil, Karen and Brendon Richardson and Alex and Jackie Smedley were particularly supportive to (if somewhat bemused by) "the weka man". I enjoyed many conversations about weka with Graeme and Lyn Elliot and Selwyn and Lois Davis, who put themselves out to catch their resident weka and also gave me unrestricted access to their property and a home movie of weka on their lawn.

Dr Tony Beauchamp has been a source of advice from the beginning and has made available to me his unpublished data from other weka populations. Many people in the Department of Ecology at Massey provided help in the field or statistical and computing advice. I thank Ian Henderson, Dale Towers, Alison Franklin, Jonathon Miles, Murray Potter, Isabel Castro, Jackie Townsend, Vanessa Munro, Richard O'Driscoll, Liz Grant, Craig Morley, Vaughan Keesing and Kathryn Whaley. Jens Jorgensen constructed the Edgar traps and Barbara Just and Paul Barrett organised equipment for field trips.

Dave Ward and Kevin Lay at Sirtrack electronics in Havelock North were able to answer my many questions and solve my few problems with radio-tracking equipment. Dr Tony Charleston and Dr Ricardo Palma taught me about bird parasites and Susan Cork carried out several weka autopsies for me. Dr Colin Miskelly, DoC Wellington, answered my questions about weka movements.

I received help in the field from Julie Straka, Tanya Howlett and Mike Conlon who is responsible for some of the best photos of weka I have.

The 1993 and 1994 listening surveys were carried out with help from volunteers from the Gisborne branch of RFBPS: Warner and Eunice Ovenden; Bob and Annette Hughes; Dick MacMurray; Nancy Kirkham; Kath Tagg; Val Gretton; Wym Cleavis; Vera Ingram; Grant and Nicola Vincent and from the East Coast Conservancy Conservation Board: Chris Sharp; Pam Bramwell; Sheila Robinson; Muriel Jones and Terence Murphy.

Graeme Scott helped me in the surveys both years, kept his eyes and ears open for weka at all times and always made sure it was raining when I arrived.

In the DoC office in Gisborne, Chris Ward provided the initial information about where to find weka and helped with the 1992 survey. Dave King helped with the surveys both years. John Ruru and Peter Williamson, Regional Conservators during the study, both gave their support to the project and made permits available allowing me to catch and handle weka.

At Karangahake Gary and Elaine Staples provided me with accommodation and interesting observations of their captive weka. Ann and Basil Graeme have been enthusiastic supporters of my research and the members of the captive breeding group made available information about their young weka. My new colleagues in the Department of Biological Sciences at the University of Waikato have assisted with comments on statistical analysis, plant identification and computing and thesis drafts. I thank Joe Waas, Brendan Hicks, Ann Chapman, John Green, Catherine Beard, Kim King and Gabi Schmidt-Adam who tolerated the invasion of her office by a weka mad colleague. Phil Bannister (Graphic Artist, Waikato University Printery) drew the map.

Sources of Funding

This work was supported mainly by grants from the Lottery Science Board and Worldwide Fund for Nature to Clare Veltman. Other funding was made available by Massey University Graduate Research Fund and the Department of Ecology, the Department of Conservation in Gisborne, Gisborne branch of RFBPS, Juken Nissho Ltd, Hikurangi Forest Farms, Footrot Flats Charitable Trust and the Clark Charitable Trust. I also received a J.S. Watson conservation grant from RFBPS and a Summer field grant from the Waikato Branch of RFBPS.

Abstract

I studied a population of weka in the Waikohu Valley, Rakauroa, near Gisborne from March 1992 to January 1994 using radio telemetry to determine productivity, home range size and resource selection by weka. Fifty-six weka were banded and 28 wore radio transmitters for 1-312 days. The population was estimated to be 39 resident adult birds from call count surveys and banding. Most (68.6%) adult birds found during the study were probably males. The Rakauroa weka population may be declining at a rate of 4 birds per year and without immediate management extinction is likely.

Weka productivity was very low, with 12 eggs needed to produce 1 independent chick. Twenty-five breeding attempts were discovered and breeding occurred throughout the year. The reason for this low productivity was not determined, but predation on eggs and chicks by introduced mammals is likely.

The first evidence of predation on adult weka by ferrets (*Mustela putorious furo*) was recorded with 2 radio-carrying birds and 1 other being killed by a ferret. Weka feathers were also found in the gut of a female ferret killed in October 1993. The main cause of weka mortality was being run over by traffic. Six weka died in this way.

Weka were found in damp, scrubby areas and occupied mostly ungrazed scrub and bush and woodpiles within their home ranges. Weka used an average of 10.00 hectares with males using significantly larger areas than females. Adults used larger areas than juveniles. Weka were secretive and crepuscular, generalist feeders who used food in proportion to its availability.

To test the hypothesis that predation on eggs and chicks was limiting productivity of weka pairs at Rakauroa, I compared the productivity of weka in predator free areas with that of weka in areas with a normal predator density (control areas). The two weka pairs I observed breeding in predator free areas reared 5 chicks to independence. Two pairs in control areas reared no chicks to independence despite 3 breeding attempts.

The release of captive-bred weka at Karangahake Gorge by the Royal Forest and Bird Protection Society in 1992 and 1993 provided an opportunity for me to compare the movement, diet and survival of weka at Karangahake with that of weka at Rakauroa. Any difference between weka in the 2 areas may indicate possible reasons for the success or failure of the release. Predation (mainly by dogs, *Canis familiaris*) was found to be the reason why weka carrying radios released at Karangahake failed to persist. Of 17 birds released between October 1992 and March 1993 only one was known to be alive by 24 June 1993. This has important implications for future releases of weka.

The future monitoring and management of weka is discussed in light of my findings. Weka management should begin immediately on the East Coast. Management should aim to improve the production and survival of young weka by predator removal. Areas of scrub and cover should be

targeted for management and publicity to lessen the destruction of this habitat and the weka road toll is necessary. The release of weka at Karangahake should not continue, these birds being made available for release at a more suitable site. The release of females (either captive-bred or from offshore islands) into areas such as Rakauroa to improve breeding success and link small remnant populations on the East Coast should be considered.

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Chapter One: Introduction

1.0 New Zealand Weka

The North Island weka (*Gallirallus australis greyi*) is one of four sub-species of the genus endemic to New Zealand. The others are the Western weka, (*G. australis australis*), the Stewart Island weka (*G. australis scotti*) and the Buff weka (*G. australis hectori*) (Ripley, 1977). A population of Buff weka persists only on the Chatham Island group after having been introduced in 1905 from mainland Canterbury, where it is now extinct (P. Russell, pers.comm.). Western Weka are found throughout the Nelson/Marlborough area and on Kapiti Island[1] as well as on many other small islands (Ward et al., 1992, unpub.). Stewart Island weka, Buff weka and North Island weka are considered to be under "actual or potential threat of extinction" because of their restricted distribution (Molloy and Davis, 1992). North Island and Stewart Island weka are also present in only low numbers (Ward et al., 1992, unpub., Molloy and Davis 1992, A.J. Beauchamp, pers. comm.).

1.1 Decline of the weka populations

The North Island weka was previously found throughout the North Island. Weka became "regionally extinct" from late last century, continuing

[1]The origin of weka on Kapiti Island is unknown. It was thought the birds were a hybrid of North Island and Western weka (Ward et al., 1992, unpub.). Beauchamp (1987a) showed that their morphology was more like that of Western weka. Current research by Colin Miskelly (pers. comm.) should clarify the situation.

until the 1960's (Ward et al., 1992, unpub.). A large population of weka remained in the Poverty Bay region. From the 1960's the Wildlife Service removed weka from the greater Gisborne area and transferred them to locations all over the North Island (unpub. DoC files). This aimed to ease a local "pest" problem and to establish populations elsewhere. Only two releases were well documented (Robertson, 1976, Macmillan, 1990) although correspondence from Gilbert Severinsen to the Wildlife Service in Gisborne details the initial moderate success and breeding of birds released at Takapau. However weka failed to establish there (unpub. DoC files).

A population was established at Rawhiti (Bay of Islands) in the early 1970's (Robertson, 1976) as a result of translocation and weka survived in these two mainland areas and on three islands until the early 1980's (Graeme, 1991, E. Jones, pers. comm.). In the early 1980's (approximately 1983) the Gisborne/Poverty Bay population declined rapidly (within three years, E. Jones, pers. comm.). Weka in the Rawhiti area had declined to just a few birds in 1988 (A.J. Beauchamp, pers. comm.). Possible reasons for these local extinctions included disease, drought and predation (Ward et al., 1992, unpub.). Drought is implicated because of a coincidence in the timing of these crashes and the El Nino event of 1982/83 (Ward et al., 1992, unpub.).

1.2 Weka in the Poverty Bay

Weka were not found in the Poverty Bay area prior to 1884 (Ward et al., 1992, unpub.). Weka were not common in my Rakauroa study area prior to 1953 (A. and M. McIntosh, D. Beaufoy, G. Scott pers. comms.) and may have entered the area either by natural migration or from a translocation of approximately twelve birds between the Kaiteratahi Tavern and the Rakauroa Country Women's Institute in 1953 (D. Beaufoy, pers. comm.).

Weka have at times reached such high densities they have posed a problem for gardeners and crop growers (Carroll, 1963a).

1.3 Weka Conservation

Carroll (1963a,b) was the first to examine weka autecology when she investigated diet and breeding. Beauchamp (1987a) went on to look at the behaviour and demography of Western weka on Kapiti Island, finding that weka there were territorial omnivores.

Little was known about the mainland ecology of weka. Weka had already shown a plasticity in feeding and reproduction (Carroll, 1963a,b, Beauchamp, 1987a) and it could have been expected that their social behaviour should be flexible in variation with their ecology and demography (Beauchamp, 1987b). More research into mainland weka ecology was seen as high priority by the Recovery Group to "quantify population density, territory and home range size, food availability, breeding success, dispersal and mortality rates with the aim of determining what factors are limiting productivity and survivorship" (Ward et al., 1992, unpub.). The preservation of the mainland population of weka in the Poverty Bay and the establishment of other populations is central to the aim of the Draft Recovery Plan (Graeme, 1991, Ward et al., 1992, unpub.).

A preliminary postal survey by the Department of Conservation (DoC) in 1990, indicated that weka distribution in the Poverty Bay was patchy and local populations were at low density (Ward et al., 1992, unpub.). The Royal Forest and Bird Protection Society (RFBPS) began a captive breeding programme for the North Island Weka in 1990 (Graeme, 1991) and Ward et al. (1992, unpub.) initiated a Recovery Plan for the North Island weka in 1991.

This Recovery Plan was based on assumptions such as the "habitat requirements " of weka. The danger of this assumption is that the more populations of a species studied, the broader the concept of "habitat requirements" will be (Gray and Craig, 1990).

1.4 Research Objectives

1.4.1 Describe the habitat use, diet and reproduction of the weka at Rakauroa. This would verify the assumptions made about "habitat requirements" by the Recovery Group. This data is presented in Chapters 2 and 3.

1.4.2 To determine, if possible, what factor(s) were limiting the Rakauroa population from returning to its former high density. Data relevant to this aim are presented in Chapters 2,3 and 4.

1.4.3 To experimentally remove predators from weka home ranges to determine whether predator removal can be an effective management tool to increase weka productivity. The outcome of this manipulation is discussed in Chapter 4.

1.4.4 To follow juvenile weka wearing radio transmitters and determine their survival and dispersal from natal areas. This data is presented in Chapter 4.

1.4.5 To compare the movements and survival of radio carrying weka at Rakauroa (established birds) and Karangahake (translocated birds). This could potentially shed some light on why the release failed or succeeded and help refine techniques for weka releases. Data on weka movement and survival is discussed in Chapter 5.

1.5 The Study Area

Rakauroa (38°25'S and 177°34'E) is situated 7.5 km east of Matawai on State Highway Two. It is 62 km from Gisborne city. The area has a higher than average density of weka (C. Ward pers. comm.) and was the subject of a population census carried out by the DoC and RFBPS in January 1991. That survey located 54 birds along a 16km stretch of Rakauroa Road and Oliver Road. I commenced my study of these birds in March 1992 and completed field work in January 1994. Trips to the area were made every month except October 1992. I spent 4-22 days in the field each month.

1.5.1 Climate

Rakauroa is known for its reliable summer rainfall. The average rainfall over the five years 1988-1992 was 1429mm (National Institute of Water and Atmospheric Research data, Rotorua). The 21 year (1970-1991) average west of the study area at Burnage was 1953mm. The climate is temperate with hot summers and cold winters. The driest months are typically December and February, the wettest August, September and October. Prevailing winds come from the west.

1.5.2 Topography

The valley is bisected by the Waikohu River along its entire length and access is by Oliver Road and Rakauroa (Tahora) Road (Figure 1.1). The area has historically been geologically unstable (Rasch, 1989) and this has resulted in steep hills with numerous rocky outcrops. The area varies in elevation from 200masl to 900masl. Weka are not found above 700masl in the area.

1.5.3 Vegetation

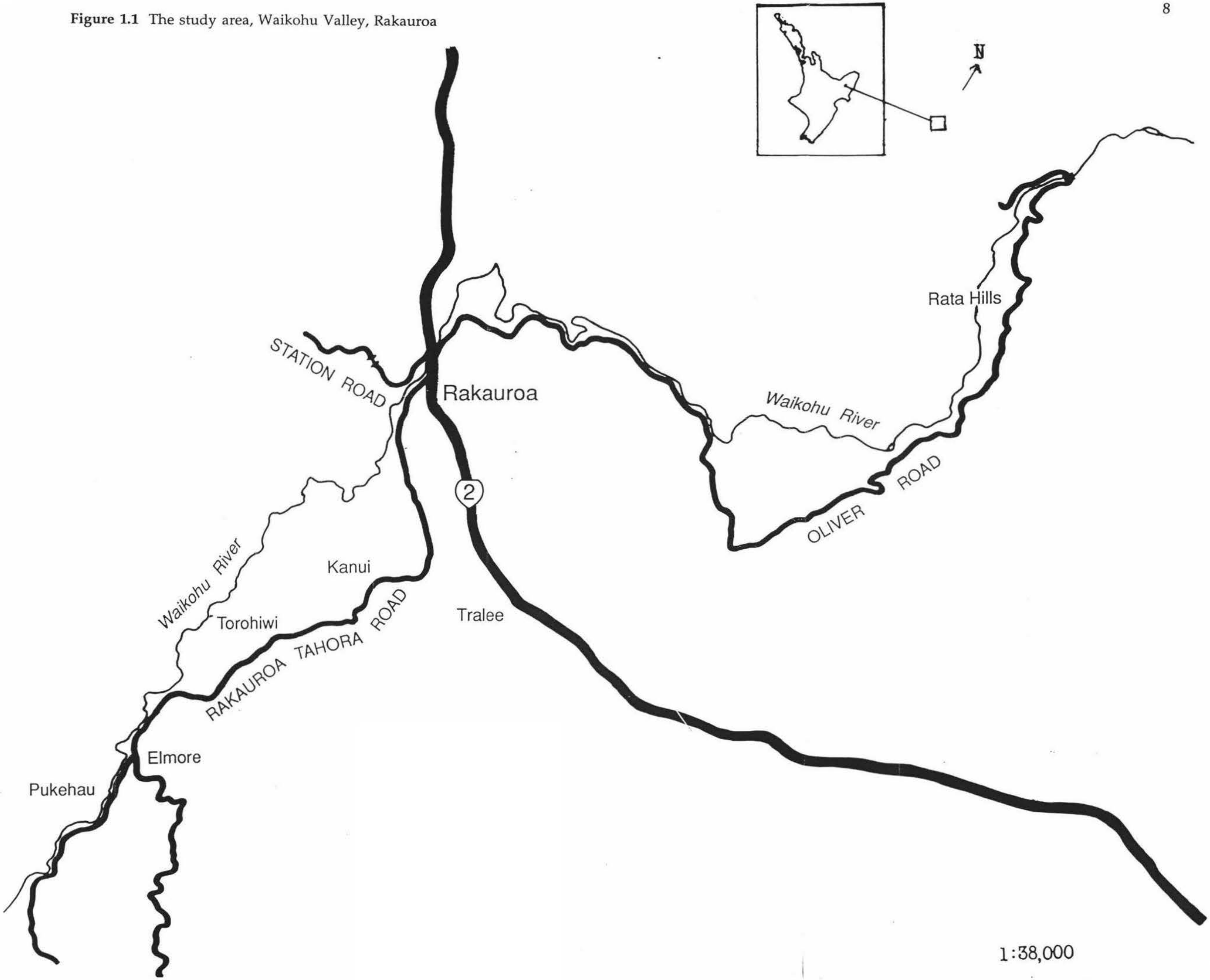
The region is extensively farmed and is mostly grassland with patches of modified riparian vegetation and areas, especially in the gullies, of regenerating scrub (dominated by Manuka (*Leptospermum scoparium*), *Coprosma* species and Five finger (*Pseudopanax arborea*). There are three

DoC Scenic Reserves (Papatu, Whakarau and Mangarere) and two areas of privately owned bush (Rata Hills and Tawa Station). The native bush has been described by Rasch (1989) and is mainly Tawa/Podocarp with Kamahi (*Weinmannia racemosa*) and Rewarewa (*Knightia excelsum*). Mangarere Scenic Reserve and Rata Hills bush have been extensively modified by grazing. There are also several small pine (*Pinus radiata*) plantations in the area.

1.6 Management tool or library archive?

This study was initiated in response to a management dilemma with the problem of how to manage weka for recovery on the mainland implicit in each of the research objectives. Chapter 6 discusses the findings of this study and the implications for Wildlife Managers. Inevitably, two copies of this volume will remain on the shelves of Massey University Library, but a third is being made available to Managers at the Department of Conservation in Gisborne for consideration.

Figure 1.1 The study area, Waikohu Valley, Rakauroa



Chapter Two: Reproduction and mortality in the weka population at Rakauroa.

2.0 Introduction

The number of North Island weka has declined to an estimated 1-3% of its pre-1980 level (Ward et al., 1992, unpub.). Weka have hung on in farmland areas west of Gisborne, but there is no evidence of recovery. Isolated populations of weka are found around Te Karaka, Matawai and Motu and at Tauwhareparae (Ward et al., 1992, unpub.).

Demographic and genetic stochasticity are important in small populations (Shaffer, 1987, Goodman, 1987) and management to increase the growth rate of a population as small as that of North Island weka is essential to lessen the effects of chance events (Goodman, 1987).

Conservation of weka on the North Island (the "mainland") will require invasion of empty patches by weka to restore continuity amongst isolated sub-populations. This requires that reproduction exceed mortality in at least some patches.

The weka population at Rakauroa was the subject of a call count census for weka by RFBPS and DoC in 1991 which counted 54 birds. I aimed to establish the population size with further annual censuses and also a banding study. By following the individual fates of adult weka wearing radios (n=21) and by resightings and recaptures of banded weka (n=56) I aimed to establish the frequency and success of breeding efforts and the causes of mortality.

Rails are characteristically hard to census because of their secretive nature and their habit of living in dense vegetation (Johnson and Dinsmore, 1986). Roadside counts have been used to count Guam rails (*Rallus owstoni*), (Jenkins, 1979), and Miller and Mullette (1985) used territory mapping to count Lord Howe Island woodhens (*Tricholimnas sylvestris*). The elusive habits of weka, being both cryptic and crepuscular, makes survey by either territory mapping or transects prohibitively labour intensive when the weka are at low density. Radio telemetry provides a comparatively easy way to follow the individual fate of flightless birds like the kiwi (Taborsky and Taborsky, 1992, Potter, 1989) and the takahe (J. Maxwell, pers. comm.), but radio-tagging has not been used to study weka before.

Previous studies have found that weka are capable of early first breeding, (before 5 months of age for weka released at Karangahake) and usually incubate clutches of 3-4 eggs (Carroll, 1963b, Beauchamp, 1987a). They are capable of rearing up to four clutches in a year (Carroll, 1963b). Weka are usually monogamous (Beauchamp, 1986, 1987a) and have biparental care of the young (Beauchamp, 1987a). This gives the impression weka are precocious, rapid breeders that one would expect to be capable of colonising suitable empty habitat patches, provided the patches are not too far away (Spurr, 1979, Beauchamp, 1987b, Ward et al., 1992, unpub.).

The concept of an r-K continuum in life history strategies has been recognised for nearly 30 years (Begon and Mortimer, 1986) but has attracted criticism, in part because it is too simplisitic - organisms can show a combination of both r and K features in their life history strategies (Begon and Mortimer, 1986). The r and K dichotomy recognises the split between selective forces that operate in unstable and stable populations respectively (Southwood, 1988). Life histories evolve in response to the impact of different environments on different age classes modified by physiological and ecological constraints on the organism (Partridge and Harvey, 1988). This is expected to result in a range of strategies between opportunistic, short lived species with high productivity, and long-lived competitive species with lower productivity, whose populations fluctuate little around K (the carrying capacity). Weka could be described as r-strategists under this scheme. The fact that there is no obvious recovery in numbers leads me to predict mortality rates will be higher than birth rates.

2.1 Methods

2.1.1 Capture, measurement and banding of weka

Weka were caught using wire cage traps of the type commonly used for trapping possums (300mm x 300mm x 700mm) (Plate 2.1). These traps were sprung when weka pecked at a bait on a hook suspended near the back of the trap. Baits included fish, corn, butter, and Cheddar cheese. I found cheese to be the most effective and easy-to-use bait.

Captured weka were weighed and measurements of the lengths of culmen, middle toe, middle toe plus claw and tarsus were taken, along

Plate 2.1 Weka trapped at Rakauroa. The trap was sprung by the weka pecking at bait on the hook suspended at the back of the cage. Note the radio transmitter aerial visible above the bird's back. Photo by Mike Conlon.

with the culmen depth and the width of the tarsus (lateral width of tarsal bone) using a Vernier micrometer. These measurements were used to sex birds using criteria developed by Beauchamp (1987a) and Carroll (1963c). Initially weka were weighed using a 3kg spring balance (±25g). From April 1993 a Salter 2kg spring balance (±5g) was used. Weka were weighed the first time they were caught and on any subsequent capture, unless the next capture was within 14 days of the previous one.

From August 1992 until January 1994 all captured adult weka were banded with an individual combination of two coloured plastic bands and one numbered metal band (New Zealand Banding Service), except one female who escaped banding, and two females who wore only metal bands. Captured juvenile weka were given one metal band and either one or two coloured bands in a unique combination.

2.1.2 Radio Transmitters

Whenever possible weka were fitted with radio transmitters. Back-mounted two-stage VHF transmitters set at 40 pulses per minute and weighing an average of 19.3g were used. The radios were equipped with a 10-month battery cell and had external whip-type aerials (Sirtrack Electronics, Havelock North). The radio transmission was set at intervals between 160 and 162 MHz, and 21 radios transmitting on channels within this band were used.

To attach the radio transmitters I first immobilised a weka by taping its legs together. A harness made of nylon string was fitted around the weka's wings and threaded through two tubes in the radio casing. The harness was then crimped into position using alloy fishing crimps (size 6A, cut in half) where the nylon string entered the radio casing. The harness was then secured by crimping both ends with an aluminium fishing crimp (size 5AA) where the string re-emerged from the transmitter casing. This held the radio on the back of the weka, between the wings, much as a human might wear a backpack. A weak link in the loops meant that birds could free themselves if snagged (as occurred in at least 3 cases).

2.1.3 Tracking and obtaining point locations of weka

Signals from the radio transmitters were tracked using a MERL receiver (CE12, Custom Electronics of Urbana Inc.) until November 1992. From November 1992 a TR-4 (Telonics) receiver was used. Both receivers were combined with a hand-held 3-element Yagi antenna.

The location of weka chosen at random by drawing band combinations out of a hat with replacement, was checked at randomly chosen times of the day also chosen by drawing hourly times from a hat, without replacement.

Weka were followed for up to seven hours (Section 3.1.1 and 3.2.2). Only the point at which they were first found is used as an independent point location. All weka were checked at least twice during each monthly visit (a period of 4-22 days per month) to ensure they were still alive and carrying a radio. Whenever I found radio-carrying weka I made an attempt to establish the breeding status of each bird. Whenever I checked a radio-carrying bird, I also checked the nest site if possible, to see if it was attended.

It was also possible to observe unradioed adult pairs that had successfully hatched chicks because weka with chicks were highly visible while they were feeding young. Conversely weka without radios that bred unsuccessfully were not observed. When I had established from radio telemetry that weka were breeding I was able to check the nest and record the outcome.

Weka that died whilst still carrying radios were comparatively easy to find. Weka that died whilst crossing the road were also very visible and many of the local people reported any road-killed weka to me or collected the weka from the roadside and gave them to me.

2.1.4 Recovering the radio transmitters

Radio transmitters were recovered either by retrapping weka, finding transmitters that had been removed or by finding dead weka to which radios were still attached. Four of the 21 radios were not recovered.

2.1.5 The listening sites and listening for calls

I chose 13 sites along the valley, based on their topography and ease of access, for listening for weka calls. The sites were spaced at a mean distance of 1007m (range 350m to 1650m) so that the whole area was monitored. All sites were visited periodically on an opportunistic basis to listen for calls. The same sites were used for a census in January 1993 and

11 of them were used for a census in January 1994. I listened for as many nights as possible during each field visit.

I recorded the distance and approximate position of each calling bird, the number of calls, the time and my location (i.e. the listening site). I also noted weather conditions (wind direction (points on a compass) and strength (strong, breeze or calm), percentage cloud cover (0-20%; 20-40%; 40-60%;60-80%; 80-100%), temperature (cold, cool, mild, warm and hot), rain (raining, showers or fine) and phase of the moon (1-6: no moon =1; 1/4 =2; 1/2 =3; 3/4 = 4; more than 3/4 but less than full = 5; full moon =6).

I listened for at least one hour around sunset. I usually took up position and started listening around 30 minutes before sunset and continued until 30 minutes after sunset. The location of the calls was marked on NZMS-260 series topographical maps.

2.1.6 Annual call counts

In January of 1993 and 1994 I enlisted volunteer help at listening stations along the valley. Listeners spent from 2000hrs to 2200hrs NZDT at one of the sites mentioned above. All listeners recorded the time and approximate position of calls onto NZMS-260 series topographical maps and I cross-referenced these records to estimate the total number of weka in the valley. I decided to listen for more than one evening because it was unlikely that all birds would call on any particular evening. Using my knowledge of the area and the weka within it I also cross-referenced the calls between the nights. In 1993 three of the listeners broadcast taped weka calls using hand-held cassette players and one listener whistled, mimicking a weka call at 2100hrs and 2130hrs each night.

2.1.7 Nightly variation in calling

In 1994 I spent 5 evenings listening at one location (19,20 and 22-24 January) recording the number and location of weka calling each night to provide a measure of the variability in calling between nights.

2.2 Results

2.2.1 Number of weka wearing radios

Sixty-two weka were captured. Fifty-six wore bands and thirty-five of them were adults. Twenty-eight weka wore radios, for an average of 109.5 days (s.d.=92.52 days). Only those data collected from the 21 weka from which I obtained 3 or more point locations are presented here. Twelve of these weka were adult males, 4 were adult females, the sex of one was unknown, 1 was a juvenile female when first banded but had paired with a male 6 months later, and 3 were juvenile males. Trapping success ranged from 0 weka per 100 trap nights to 15.2 weka per 100 trap nights (Figure 2.1). The number of trap nights was adjusted to exclude non-target captures and sprung, but empty traps.

Fifty-one weka were able to be sexed using morphometric measurements. No single measurement provided clear distinction of sex, because there was no clear bimodality in any measurement (Figure 2.2). A

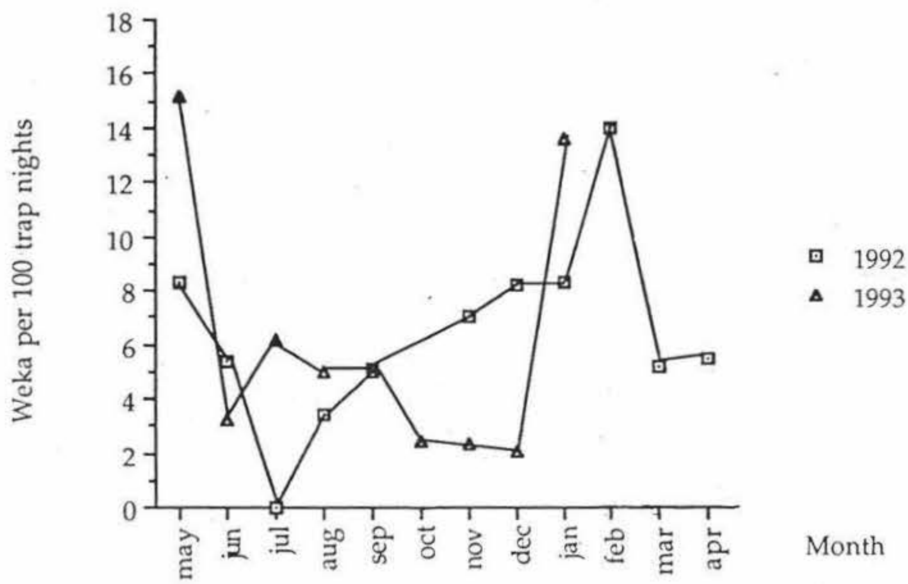


Figure 2.1 Trapping success of weka at Rakauroa.

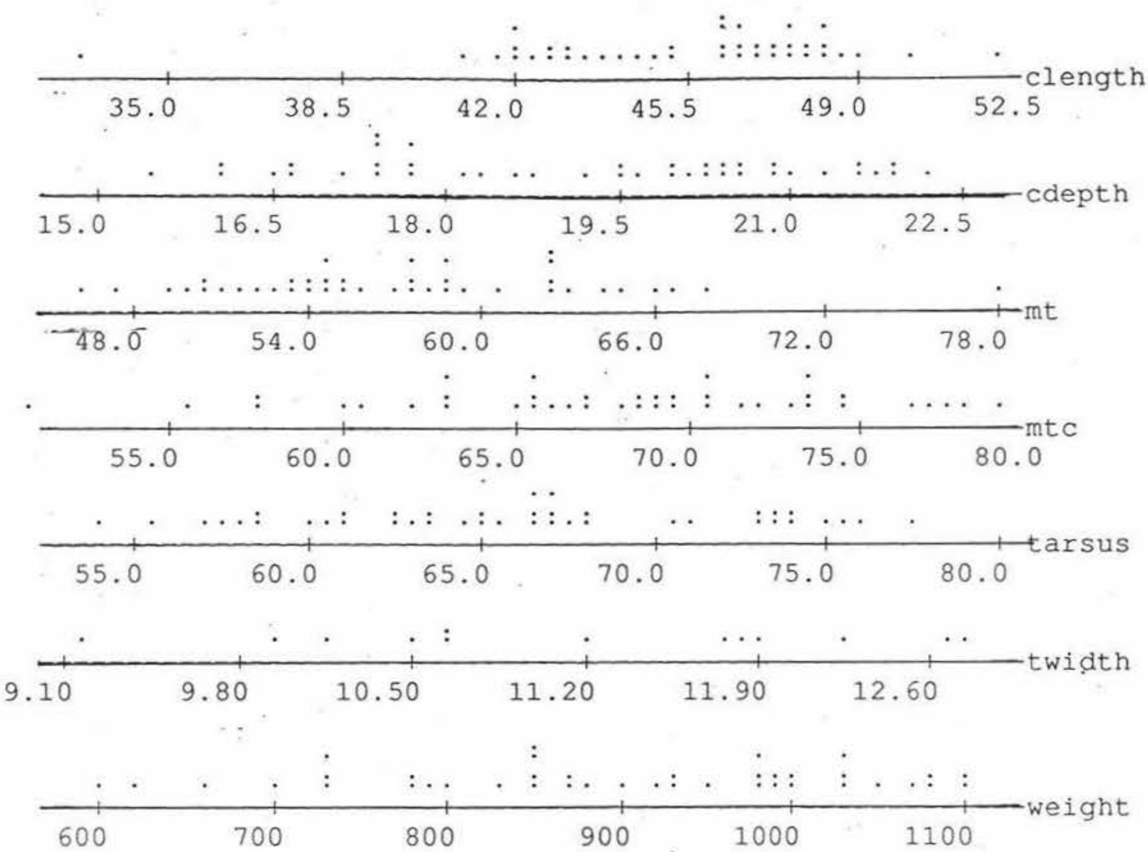


Figure 2.2 Morphological measurements of adult weka at Rakauroa. Clength is the length of the culmen, cdepth is the depth of the culmen, mt is the middle-toe length and mtc is the middle-toe-plus-claw length. Tarsus is the length of the tarsal bone, twidth is the width of the tarsal bone. Weight is in grams, all other measurements are in millimetres. After Beauchamp (1987a) and Carroll(1963c).

combination of culmen and tarsal measurements and weight was used to distinguish male from female birds (Carroll, 1963c). Thirty-five (68.6%) of these birds were male. This may mean male weka were more common or they were more easily trapped. On average 9.5 trap nights (229.3 trap hours) were needed to catch an adult male weka for the first time (n=22) and 14.4 trap nights (346 trap hours) to catch an adult female weka for the first time (n=11). The data were transformed by logging them to make them approximate the normal distribution. The difference between the two transformed data sets was not significant (Two sample t-test, p=0.23). Thus the male-biased sex ratio would appear to be a real one although it is possible the number of females was underestimated because large females could not be reliably sexed and were classed as unknown.

2.2.2 Reproduction

Weka nested in all months of the year except February and May with a peak during the summer months (Figure 2.3). The mean number of chicks seen was 1.94 per brood (median = 2, mode = 1).

Eight nests were discovered at the egg stage. Five of them had 4 eggs, 2 clutches were of unknown size and 1 clutch that was still being incubated when I finished field work at the end of January 1994 was also of unknown size. Of the five clutches of 4 eggs, 3 failed to hatch any young, and the other 2 hatched one chick each. Failures were unlikely to be due to infertility since at least one of the unhatched eggs of a pair breeding at Papatu Scenic Reserve had an embryo when I found it 17 days

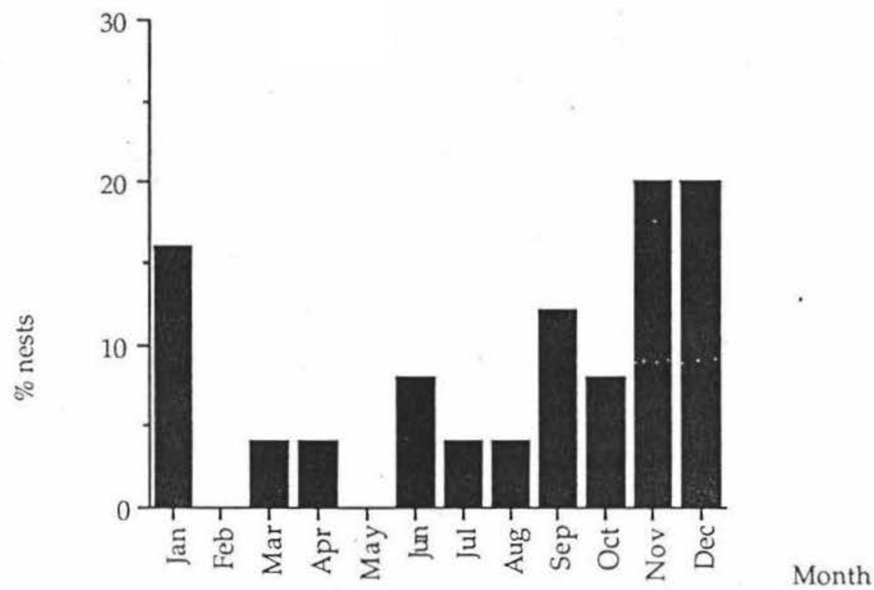


Figure 2.3 Timing of nest events in the study area (n=25)

after a single chick had hatched. Pieces of eggshell or no sign at all were found at other failed nests.

At least 12 attempts at breeding were made by 8 females (1.5 nest attempts per female per 12 months) between March 1992 and March 1993. From April 1993 to January 1994, 10 females were known in the study area and 3 of them were not seen to breed. The seven females that did breed made 13 attempts (1.3 nest attempts per female per 10 months). This is necessarily a minimum estimate as weka may have attempted to breed without my knowledge, but clearly weka bred more than once in a year.

From March 1992 to March 1993 18 chicks were seen in the study area. Only one was known to be still alive at independence, yielding a productivity estimate of 0.125 chicks per pair per year. From April 1993 to the end of the study, 16 more chicks were seen. Three of these survived to independence. Three more chicks were less than 9 weeks old and still alive when the study ended (Chapter 5), yielding a productivity estimate of 0.6 per pair. The survival rate of chicks to 9 weeks of age was 0.118. Ten breeding pairs raised only 4 chicks to independence over 2 years.

2.2.3 Nesting Behaviour

I was able to follow three nesting attempts closely. Two were by the pair yw-a and a-yb (one in 1992 and one in 1993) and one by the pair a-yr and a-wb (in 1993). Both birds shared incubation and were commonly found at the nest site together (Table 2.1)

	Female	Male	Neither	Both	Number of visits	Chicks hatched
Attempt 1 by yw-a and a-yb	39%	39%	22%	0	18(18)	0
Attempt 2 by yw-a and a-yb	69%	0	0	31%	13(24)	4
yr-a and wb-a	43%	0	14%	43%	7(7)	1

Table 2.1 Nest occupancy by weka. The number in brackets is the number of days the nest was followed. The first nest attempt (of 4 eggs) by yw-a and a-yb failed when 2 eggs were taken by predators. The pair then abandoned the nest.

2.2.4 Mortality of adult weka

Dead weka were discovered throughout the year (Figure 2.4) Of 11 deaths, 6 were caused by motor vehicles, 3 were due to predation and one had an unknown cause, perhaps drowning. The remaining weka died in a trap in December 1993.

The corpses of two freshly killed adult weka, one of which was carrying a radio (Bird 1-5), were found in a large underground cavern in Papatu Scenic Reserve in June 1992, along with the bones of 3 others. The partially decomposed body of another adult male weka (rg-a) was found

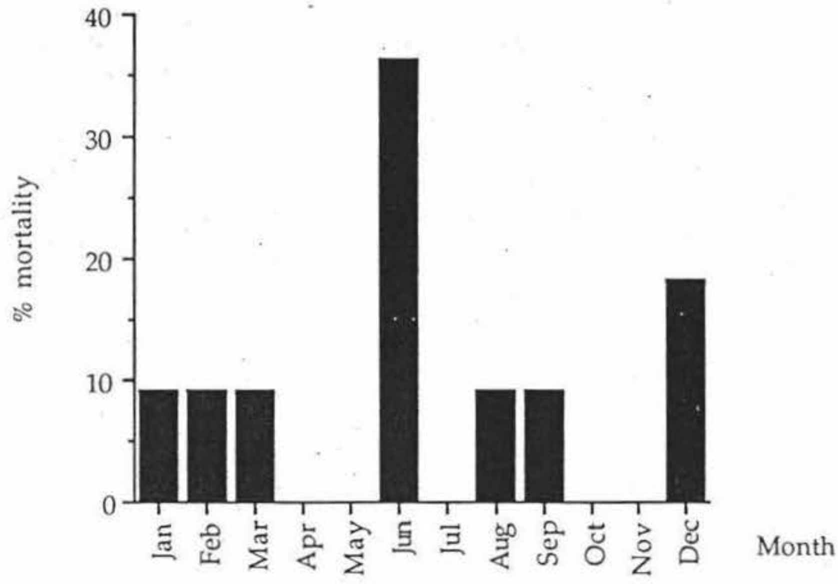


Figure 2.4 Monthly mortality of weka in the study area. Month of death was inferred from the extent of decomposition of corpses.

in a smaller cavern beside the Waikohu River in June 1993.

All of these deaths due to predation were probably due to mustelids. The size of teeth marks and scratches on the bones matched teeth in a ferret skull in the Department of Ecology Museum, so I concluded the deaths were due to a ferret (Plate 2.1).

Of the 12 dead weka discovered, 7 were males and 3 were females. The sex of two birds was unknown.

2.2.5 Variability and seasonality of calling

Weka called most frequently from December to February (Figure 2.5).

When I listened at one site for 5 nights, a total of 5 different weka were heard calling. On the first and fourth nights 3 weka were heard. On the second, third and fifth night four weka called. If five was the total number of weka present in the area, this represents 60-80% detectability on any night. Conditions were similar on all five nights, but it was drizzling on the fifth night. Listening for any one night at Rakauroa probably detected around 70% of all weka.

2.2.6 The effect of weather conditions

Using a log-linear approach with the modelling package GLIM, I found that month and location (listening site) had significant effects when added to the null model (Table 2.2). The interaction between month and location provided the minimum adequate model. Some months were better for

Plate 2.2 The teeth of a ferret (*Mustela putorious furo*) matched the scratch and bite marks on weka bones collected from underground caverns at Rakauroa. Photo by Massey University Central Photographic Unit.

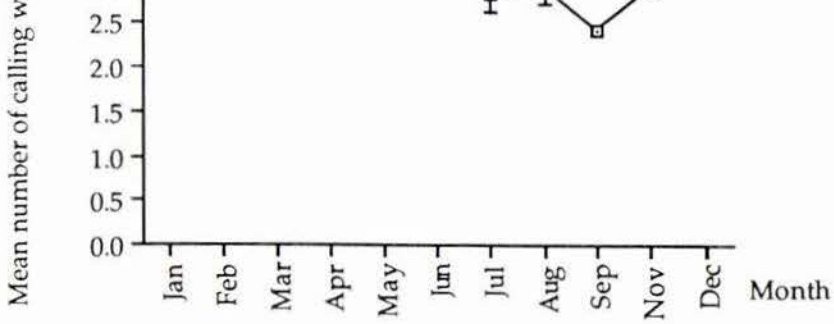


Figure 2.5 The running 3 point mean of calling by weka at Rakauroa.

hearing weka calling (Figure 2.5). Because weka were located patchily in the valley I consistently heard more weka at some sites (Figure 2.6). The other variables recorded (wind strength and direction, rain, phase of the moon, percentage cloud cover and temperature) did not affect calling by weka at Rakauroa.

	Maximal Model				Minimal Adequate Model			
Variable	% var	χ^2	df	P	% var	χ^2	df	P
Month	10.6	19.43	10	0.05	[illegible]	154.7	68	0.001
Location	36.7	66.96	12	0.001				
Moon	4.2	7.68	5	ns				
Cloud	2.9	5.4	5	ns				
Temp.	1.0	2.00	4	ns				
Direction	0.8	1.59	5	ns				
Strength	0	0.00	2	ns				
Rain	2.1	3.96	3	ns				

Table 2.2 The effect of weather conditions on calling by weka at Rakauroa. % var is the percentage variance explained by the variable. Direction refers to the direction of the wind and strength is wind strength.

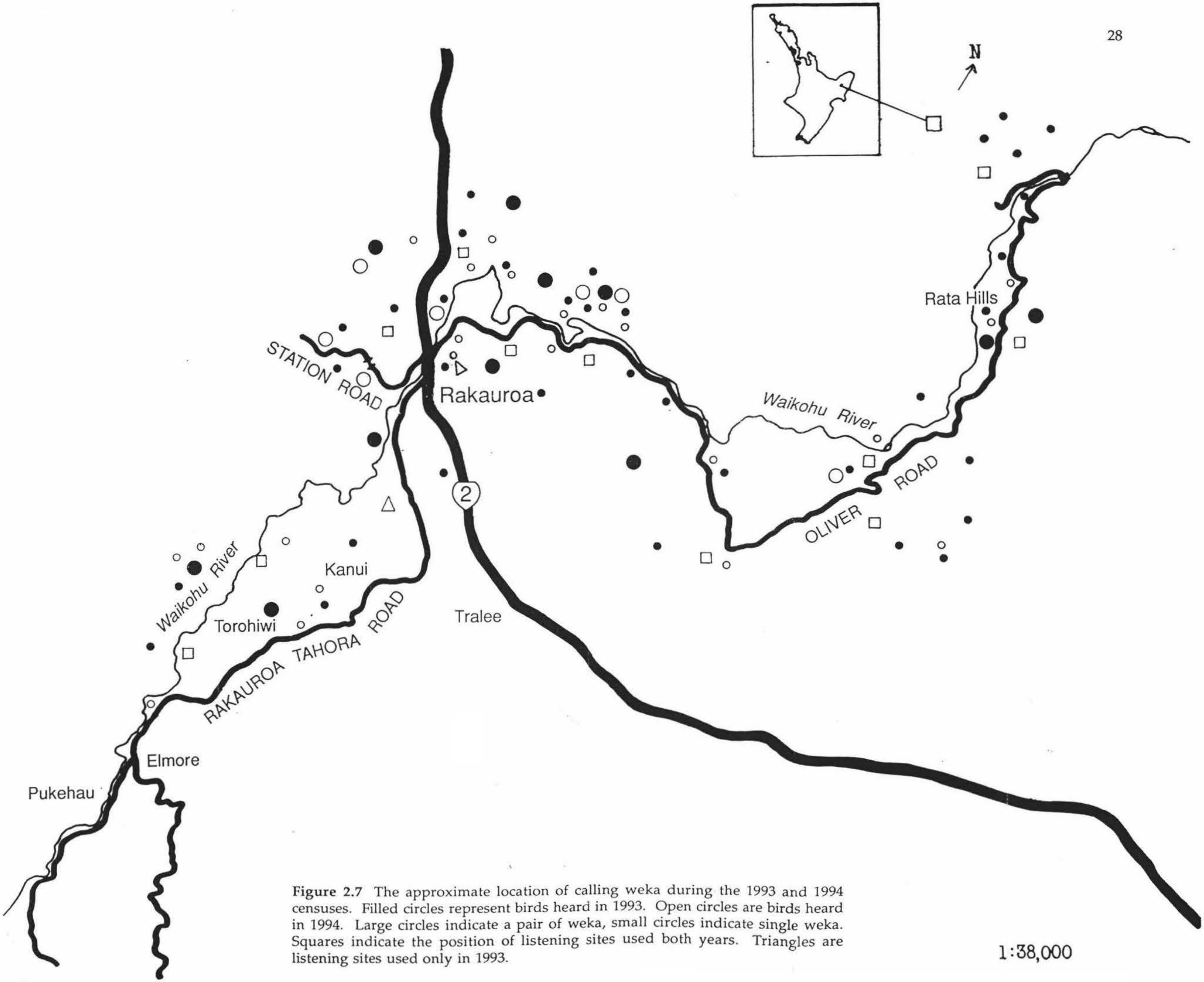


Figure 2.7 The approximate location of calling weka during the 1993 and 1994 censuses. Filled circles represent birds heard in 1993. Open circles are birds heard in 1994. Large circles indicate a pair of weka, small circles indicate single weka. Squares indicate the position of listening sites used both years. Triangles are listening sites used only in 1993.

1:38,000

2.2.7 Estimated population from annual censuses

Weka were distributed unevenly along the valley (Figure 2.6) with clumps of weka associated with water and patches of grazed or ungrazed scrub. Some other patches that appeared similar to occupied areas had few or no weka. The reason for this clumping is unknown. More weka, particularly more solitary weka, were heard in 1993 (Table 2.3, Figure 2.6).

Year	Number of sites (night 1,2,3)	Night 1	Night 2	Night 3	Total
1993	13,13,8	38	36 (10)	33 (9)	57
1994	11,11	31	25 (5)	-	36

Table 2.3 Population census of weka based on call count surveys in 1993 and 1994. The number of new weka heard on each night is listed in brackets. Note that the number of listening sites varies.

Weka in captivity call from 12 weeks of age, so call count surveys probably count all weka older than 12 weeks.

2.2.8 Estimated population size from trapping data

Most of the 62 weka trapped at Rakauroa were not seen or trapped again. Three banded birds are known to have died during the study and a further 2 were assumed to have died. If mortality affected both banded and any unbanded birds equally then the 5 deaths of banded weka lead to an estimated population of just over 100 birds (100.8; 5/56 = 9/x, where 9 is the number of unbanded corpses collected and x is the number of birds in total). There was no evidence that the population was anywhere near 100 weka. At least four of the unbanded birds that were found dead were juveniles and during the study I knew of 9 unbanded adults. A conservative population estimate is therefore 39 resident adult birds (35 banded adults - 5 dead banded adults + 9 known unbanded adults). It is likely that nearly all the adult resident population was banded.

2.2.9 Population trend

Two weka banded as older juveniles in 1992 were alive in 1993. One female (a-rg) was recruited into the breeding pool. The other, a male (br-a) may have been. The loss of an average 6 birds per year (Section 2.2.3) and the recruitment of only 2 results in a loss of 4 birds per year from the population. Clearly a population of 39 birds could be expected to be extinct within 10 years given the current rate of decline.

The longevity of adults will influence persistence times - long lived adults can prolong persistence, even when there is no recovery in population numbers. The only longevity estimate I have is for 1 male bird who was banded in November 1992. This bird (yg-a) was classed as an adult when first banded (i.e. it had red irises, aged more than 4 months) and was killed on Whakarau Road in November 1994 (A. Bassett, pers. comm.). This bird was not seen after banding and had survived for 2 years and moved 3.45km before being killed. If 2-3 years is the expected lifespan of a weka at Rakauroa persistence is unlikely to be enhanced by long lived adults.

2.3 Discussion

A usual assumption of radio telemetry studies is that the carrying of a radio does not appreciably affect the life of the individual carrying it by, for example, altering behaviour, reproduction or survival (Burger et al., 1991). Burger et al. (1991) report female Greater Prairie Chickens (*Tympanuchus cupido*) showed lower survival when wearing 2-stage transmitters than when carrying lighter 1-stage transmitters. Since it was impossible for me to monitor the survival of weka unless they wore radios, I cannot rule out the possibility that my data are biased towards lower survival estimates. However, some weka gained weight while wearing radios and even after carrying a radio for over 200 days were of comparable weights to when first caught. Both male and female weka successfully bred whilst carrying radios and weka were capable of removing the radios themselves (this happened at least 5 times). In no case did it appear that the radio was the direct cause of death.

A male-biased sex ratio is common amongst rails (Ripley, 1977, Miller and Mulette, 1985, Goldizen et al., 1993) and among weka (Coleman et al., 1983, Brothers and Skira, 1984). Brothers and Skira (1984) thought this bias was likely to be due to behavioural differences between the sexes but it is not immediately obvious why this should be so. Typically both male and female rails share incubation and care of the young (Jenkins, 1979, Miller and Mulette, 1985). Rails often show co-operative breeding and in some species there are non-breeders at the nest (Ripley, 1977, Goldizen et al., 1993). Weka too share incubation, but are usually monogamous and have no non-breeders at the nest (Beauchamp, 1986). Since male and female weka are equally trappable this is unlikely to be a sampling bias.

The productivity of the weka at Rakauroa was very low, with an average of 12 eggs being required to produce one offspring at independence. In comparison, 12 weka pairs on Kawau Island had 17 clutches and raised 37 young from mid September 1992 to late February 1993, 3.1 young per pair to independence, (Beauchamp, 1993, unpub.). Clearly juvenile survival on Kawau is better than at Rakauroa and there is room to improve the productivity of pairs at Rakauroa. On Kapiti Island, on the other hand, Western weka usually reared 1 chick to independence and successful breeding occured only on territories above a minimum size. This is consistent with density dependence (Beauchamp, 1987a).

If reproductive success is low that means that egg and juvenile mortality must be high. The cause of this dismal productivity is unknown but it may be due to predation on eggs and chicks.

Predation of weka by introduced mammals has been ignored or lightly dismissed previously (Ward et al., 1992, unpub., Graeme, 1994). This is the first confirmation of predation on adult weka and clearly juvenile weka could be even more susceptible. In light of this information the strategy for recovery of weka will need to be altered.

This study has shown that location (listening site) and month are the most important variables affecting the number of weka heard to call. Colbourne and Kleinpaste (1984), found that NI brown kiwi called more on dark nights and Gibbs and Melvin (1993) found responsiveness of Virginia rails varied positively with cloud cover. Wind and precipitation were not significant environmental variables to the Virginia rails, but time of day was important. Time of day is also important to weka, with most calling being at dusk (Beauchamp, 1987a). The best time to conduct a call count survey for weka at Rakauroa is in January, not April and May as indicated by Ward et al. (1992, unpub.). Not only are more weka calling then, but the weather conditions are generally milder and drier for listeners. The location of listening sites is important in areas where weka are patchily distributed and listening in windy conditions can reduce the ability of listeners to hear weka. Most weka are likely to call from damp areas with abundant cover.

Gibbs and Melvin (1993) broadcast taped calls to a range of water bird species, including the Virginia rail (*Rallus limicola*). This improved the detectability of the rail by 1320%. No responses were recorded immediately after playing taped weka calls during the annual surveys, probably because the tape recorders could not produce the required volume to be heard at any distance (Gibbs and Melvin achieved 80 dB 1m from the source), but playbacks may help improve weka population estimates. Beauchamp (1987a) suggested that calling by weka helped maintain the integrity of pair bonds and of territories. Since the weka at

Rakauroa are not territorial and call mostly in January, young birds may be calling to identify themselves to potential mates. Alternatively they could be using the calls to identify mates or areas with other weka that are likely to be suitable habitat.

The earlier DoC survey and both surveys conducted by me have shown there was somewhere between 30 and 60 birds in the Waikohu Valley at any one time. Three annual surveys are not sufficient to discover or indeed predict population trends. Jenkins (1979) found that Guam rail numbers fluctuated considerably since dawn roadside counts began in 1961. The overall trend was one of decline. So far that seems to be the case at Rakauroa too.

Since several of the female weka bred more than once a year and nearly all the weka I followed attempted to breed, population growth at Rakauroa is clearly limited by how many adult females breed and the survival of their young. This situation, combined with an unsustainable adult mortality, means the weka population at Rakauroa (and by implication on the East Coast) is unlikely to be maintaining its numbers unless adults that do survive do so for a long time which does not seem likely. Alternatively there could be extensive migration from source populations into sink areas, like Rakauroa, which would help maintain the sink population. This is unlikely and I predict the population is still declining.

In the past, weka populations on the mainland may have existed with a "shifting mosaic" dynamic (Harrison, 1991), that is, a balance between colonisation and extinction of local patches forming a metapopulation. Guthrie-Smith (1926) described how weka migrated into new areas and disappeared in others. Weka have not always been found on the East Coast, or even at Rakauroa (Chapter 1). Recent models indicate that a local equilibrium in each subpopulation is required for persistence of a metapopulation to occur (Murdoch, 1994). This could be achieved by immigration and metapopulation models have tended to focus on factors affecting presence or absence in a patch (e.g. Hanski, 1991). Whether regulation is the result of processes in isolated populations or from metapopulation processes remains to be answered (Murdoch, 1994). At least at Rakauroa density-dependent processes are unlikely to be preventing the population from returning to pre-1980 levels.

Density dependent and independent effects on population regulation are arranged in a continuum (Southwood, 1988). The evolutionary selective forces regulating stable and unstable populations would differ, with opportunistic r species being more affected by density independent catastrophes and competitive K species being more affected by density dependent factors like predation, competition and disease. Thus one would expect differing reproductive strategies in different species (Southwood, 1988) and even between different populations of the same species experiencing different environments. If weka on the mainland are regarded as experiencing r-selection with many suitable empty patches available for dispersal, then weka populations on conservation islands such as Kapiti, can be considered to be experiencing more of a K-selection, with few opportunities for successful dispersal. From four different weka populations, three different population trends have been recorded. Weka on Kawau Island were seemingly on the increase (Beauchamp, 1993, unpub.), weka at Double Cove appeared to be increasing in numbers despite a 37.5% mortality of adult birds (Beauchamp, 1987b), weka numbers on Kapiti Island were apparently stable (Beauchamp, 1987a) and weka on the East Coast are probably declining. Data from the East Coast of 30 years ago showing high productivity and low dispersal led Spurr (1979) to predict weka would have only a moderate risk of extinction if the population was severely reduced by possum control using 1080 bait. Given that weka at Rakauroa now show both low productivity and low dispersal, their risk of extinction can be regarded as high without effective management and any possum control operations in weka areas will need to be strictly controlled.

Weka on the East Coast appear to be declining in number because productivity is low. The exact cause of this low productivity is not known, but it may be predation on eggs and chicks. It has been shown for the first time that adult weka are susceptible to predation. A long-term record of weka fluctuations in key populations occupying different habitats on the North Island, the South Island and on offshore islands is necessary to determine what range of variation in numbers is normal (i.e. recoverable) and what constitutes a level below which the weka will not return in numbers without intervention. Given the precarious state of weka on the East Coast of the North Island, management is necessary now to prevent extinction.

Chapter Three: Patterns of habitat use and food intake by weka at Rakauroa.

3.0 Introduction

Johnson (1980) identifed four "orders" of habitat use, first order being the geographical or physical range of the population. North Island weka are now found only on the East Coast (Ward et al. 1992, unpub.) and are found in damp, scrub-covered areas (Chapter 2). Johnson's second order of habitat use was the home range of the individual, the third related to use of the various components of the home range (such as different areas or different habitat types) and the fourth order was the use of food items from those available within the favoured areas of the home range. Nothing is known about the second, third or fourth order habitat use decisions made by weka on the North Island. A knowledge of how weka use their habitat and the food items within it is necessary for conservation of weka on the North Island, in order to establish which habitats should be managed and how they should be managed for population recovery.

Both Beauchamp (1987a) and Carroll (1963a) found that seasonal breeding patterns of weka coincided with seasonal abundances in food availability. Breeding followed increases in body weight after abundant foods such as crickets and fruits had been available. Beauchamp (1987a) claimed that food supply regulated the population of territorial weka on Kapiti Island. If such a density-dependent mechanism was regulating the population at Rakauroa I would expect to see three things: first, a seasonal pattern of breeding closely aligned to food abundances; second, territorial behaviour and competition for resources (Milinski and Parker, 1991); and third, a seasonal variation in body mass with weka being lightest, and probably below "critical" weights (750g for males and 600g for females A.J. Beauchamp, pers. comm.) when least food was available. Weka would be below "critical weight" if competition for food was preventing them from getting enough to eat. Competition would be more intense when less food was available. If any of these predictions were not met by the population then it would be unlikely that food availability was responsible for population regulation.

If you are managing a population, the way that population is regulated is important. Knowing the effect of density dependent processes, such as those above, and density independent processes on weka numbers is useful because different manipulations may be more effective at different densities. If weka are limited by density dependent factors even at low density then management to increase numbers may be hampered. An example would be if weka were territorial, as they are on Kapiti Island (Beauchamp, 1987a), recovery would be limited by the number of suitable territories. If weka showed no active defense of an area then other, possibly density independent factors, would be more important in aiding recovery.

Radio telemetric studies have not been conducted on weka before, but radio telemetry is potentially one of the best ways to gather unbiased information about resource selection (Aebischer et al., 1993. Alldredge and Ratti, 1992). With radio telemetric studies it is possible to achieve a random sample of observations from individuals that are representative of the population of interest (Alldredge and Ratti, 1992).

I aimed to measure the second, third and fourth order resource selection by weka using observations on location and behaviour generated by radio tracking and measurements of insect abundance using pitfall traps, sweep nets and soil samples.

3.1 Methods

3.1.1 Measuring home range sizes of radio-carrying weka

Weka carrying radios were located and followed at random times of the day (Section 2.1.3), initially for 1 hour at a time. In November 1992 it became clear that weka were rarely visible and seldom moved in an hour so I followed randomly chosen weka for up to 7 hours each day from November 1992 to January 1993. This did not produce the expected increase in observability (Table 3.6), so I returned to following birds for 1 hour. From October 1993, because of other field work, weka positions were checked more often (daily) but weka were not followed at all. This resulted in a lower ratio of weka observations per hours spent in the field (Table 3.6).

Only the point at which any weka was first found was used as an independent point location. If a bird was found more than once on a given day, but I had not been following it between locations, then these observations were treated as independent too (they were always separated by at least 2 hours). The point locations were marked on 1:10,000 aerial photographs of the area (Department of Survey and Land Information, Gisborne). Home range sizes were then estimated using the minimum convex polygon method (Hough, 1982). The polygons were drawn on paper, cut out, weighed and converted to area measurements.

The home range sizes of male, female and juvenile weka were compared to each other using a Mann-Whitney test. Because the Mann-Whitney test assumes independence between individuals, I included only data from the female of the pair where both birds carried radios.

The distance moved between consecutive fixes for male and female adult weka (either within the same visit to the area or between 2 visits) was measured from the aerial photographs. These data were log-transformed to approximate normality and then compared using a two-sample t-test to determine if there was any difference in movement between male and female weka and if weka had moved further between trips than within trips.

3.1.2 Habitat use of radio carrying weka

When radio-carrying weka were located, the type of habitat they were in was recorded as described below (Section 3.1.3). When weka were visible I recorded behaviours using a continuous all-occurrence sampling rule into a hand held tape recorder. Weka behaviour was described after Timmis (1972) and Beauchamp (1987a). When weka were observed in family groups I recorded only the behaviour of the bird thought to be the male. Weka were followed until they had not been seen for 10 minutes, or in the case of the radio-carrying birds the observation hour was up.

Weka carrying radios were recorded as being sedentary (as evidenced by radio signals) or active and all active weka seen at any time were recorded, this included radio-carrying birds and any other weka seen to be active. These data measured the diurnal activity pattern of the weka.

3.1.3 Measuring habitat availability

Vegetation in the study area was grouped into eight classes: pine forest; ungrazed native bush; grazed bush and scrub with little or no regeneration; ungrazed scrub, with regeneration; pasture; ungrazed pasture; woodpiles (cut or fallen logs overgrown by weeds and climbers); and "unusable" areas such as roads, houses and the river. Using aerial photographs and estimates obtained by walking over the area, the availability of each of these habitats was measured by cutting out scaled maps and weighing the relevant pieces. The weights were then converted to area measurements.

3.1.4 Sampling available animal prey

Thirty-four pitfall traps were placed in pasture, bush, grazed and ungrazed scrub, pine forest and ungrazed pasture in June 1992. This represented 6 of the 8 vegetation types available to the weka. Traps were placed in accessible areas near the road.

The pitfall traps consisted of plastic containers ([illegible] diameter) placed in the ground and covered with raised wooden lids. One hundred millilitres of ethylene glycol acted as the preservative until the traps were emptied.

All traps were emptied every month from July 1992 until January 1994 except October 1992 and 1993.

To quantify flying insects unlikely to be caught in pitfall traps I took a standardised sweep net sample of twenty sweeps at twelve sites along the valley. Sweep net samples were collected on one fine afternoon each month from August 1992 excluding October 1992 and 1993, November 1992 and April 1993. All sweep sites had similar roadside vegetation (bracken (*Pteridium esculentum*), manuka (*Leptospermum scoparium*), *Coprosma* species, Blackberry (*Rubus fruticosus*), Five finger (*Pseudopanax arboreus*), rank pasture grasses, *Hebe* species, wild fennel (*Foeniculum vulgare*), black nightshade (*Solanum nigrum*) and Kawakawa (*Macropiper excelsum*). Sweep net samples were deep-frozen until they could be sorted and the animals stored in 70% ethanol.

To sample worms and shallow soil-dwelling invertebrates potentially able to be eaten by a weka I took 8 soil and litter samples monthly (excluding October both years) from July 1992. These measured approximately 150mm x 150mm x 100mm. Two sites for soil and litter samples in each of pine forest, native bush, ungrazed scrub and pasture were chosen randomly using 200m grid divisions along the roads which I put in place in June 1992. Each number was put into a hat and drawn out without replacement. Each division was marked by a piece of tape attached to the fence at the roadside. Invertebrates from these samples were extracted by hand within six hours of collection. The samples were hand searched under natural light and all animals preserved immediately in 70% ethanol.

All invertebrates were sorted to Order and in some cases, Family (Appendix 2). One-way analyses of variance were used to test differences in the availability of important (i.e. found in diet) invertebrates caught in pitfall traps using the variables trap, habitat type, month and year. The number of invertebrates caught was transformed by taking the logarithm, the sine or the tangent for each of the different groups. A different model was calculated for each column of transformed data. There were 34 traps (1-34), 6 habitat types (1-6), 12 months (1-12) and three years (92,93 or 94).

3.1.5 Sampling available fruit

In order to estimate the seasonal appearance of fruits in weka diet I identified and marked 110 individual plants, representing 33 different species, in April 1992. These plants were visited each month (excluding October both years) and their phenology recorded. Individuals were recorded as flowering, having immature fruit unavailable to weka, having ripe fruit including some fruit fall available to weka or not fruiting. Both native and introduced fruiting species were marked.

3.1.6 Weka diet measured using faecal and gizzard samples

Faecal samples were collected whenever I found them. In March - August 1992 only those pellets seen to have been from a weka were collected. With more experience I was able to identify weka faeces by appearance and smell. Gizzards of birds I found dead or from birds collected by members of the public in the East Coast Conservancy and handed in to DoC were removed and the contents deep-frozen. Faecal samples were immediately deep-frozen. Later the samples were thawed, shaken vigorously in a small amount of hot water with a drop of detergent and washed through a 250 µm Endecott sieve to collect larger fragments, followed by a 180 µm Endecott sieve to collect worm chaetae. I then sorted the samples into identifiable key fragments, worm chatae, seeds, unidentifiable animal fragments and plant fragments under a dissecting microscope at 25x magnification. I used a Burgerhoff sorting tray and I sorted each tray twice to ensure all fragments were collected. Fragments were identified using specimens from the Ecology Department museum and specimens collected in pitfall traps, sweep nets and soil/litter samples. A minimum number of prey per dropping and percentage use of each taxon found in each season was estimated from the fragments. A Friedman rank test (Conover, 1980) was used to test the hypothesis that the difference in use and availability of food items used by weka did not vary from random, which would be predicted if weka had no preferences. Items were also ranked according to their abundance in a season.

3.1.7 Weka body weight

All captured weka were weighed, unless they had also been caught in the previous 14 days (Chapter 2).

3.2 Results

3.2.1 Home range use by weka

More than 5 point locations were used to estimate most home ranges (Figure 3.1). Weka carrying radios used an average of 10.00 ha (range 0.5 - 37.5ha, s.d.=10.92ha, n=21) as a home range. Males used a significantly larger area (median = 10.56, n=10) than both females (median = 3.50, n=5) and juveniles (median = 1.25, n=3), (Mann Whitney U=80.0 and U=79.5 respectively, $p<0.05$). Juveniles also used a significantly smaller area than females (Mann Whitney, U=26.0, $p<0.05$).

There was no evidence of active defence of home ranges, and adult weka with overlapping ranges were seen foraging within 50m of each other on one occasion. The ranges of many adult weka overlapped (Figures 3.2-3.5). Each home range was made up of a mosaic of different vegetation types, but no weka had all 8 habitat classes in its home range. All weka had some pasture in their home range.

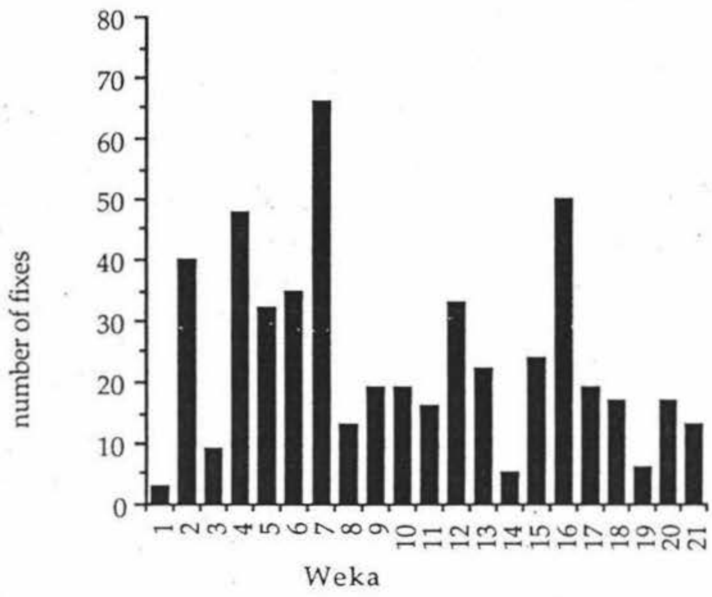


Figure 3.1 The number of radio fixes making up home range estimates of each radio-carrying weka at Rakauroa.

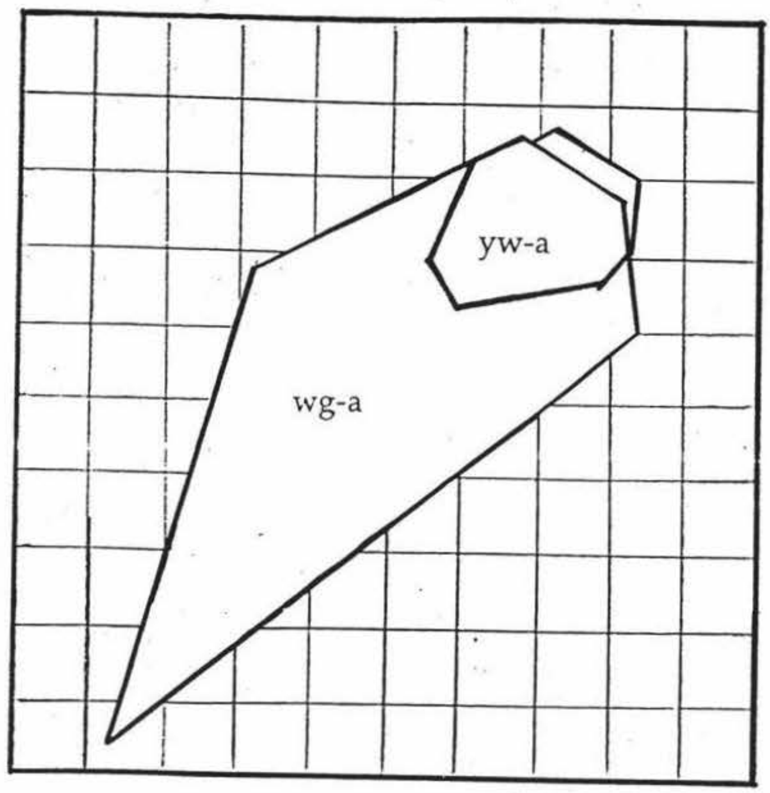


Figure 3.2 The home ranges of 2 paired, adult, male birds. One square=1hectare.

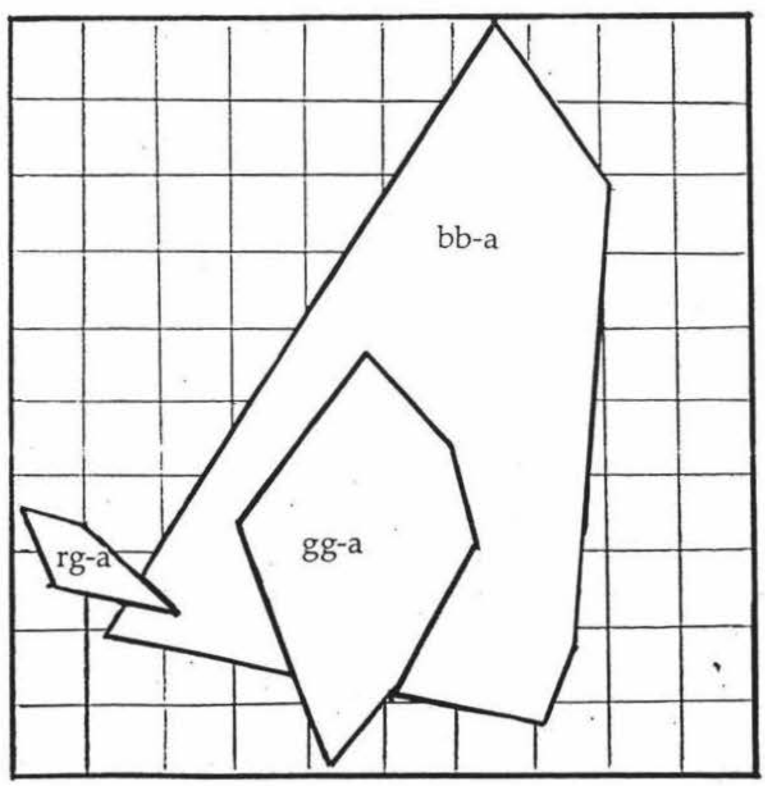


Figure 3.3 The home range of 3 adult birds. Rg-a and bb-a were paired, adult males, gg-a was of unknown sex and status. One square=1 hectare.

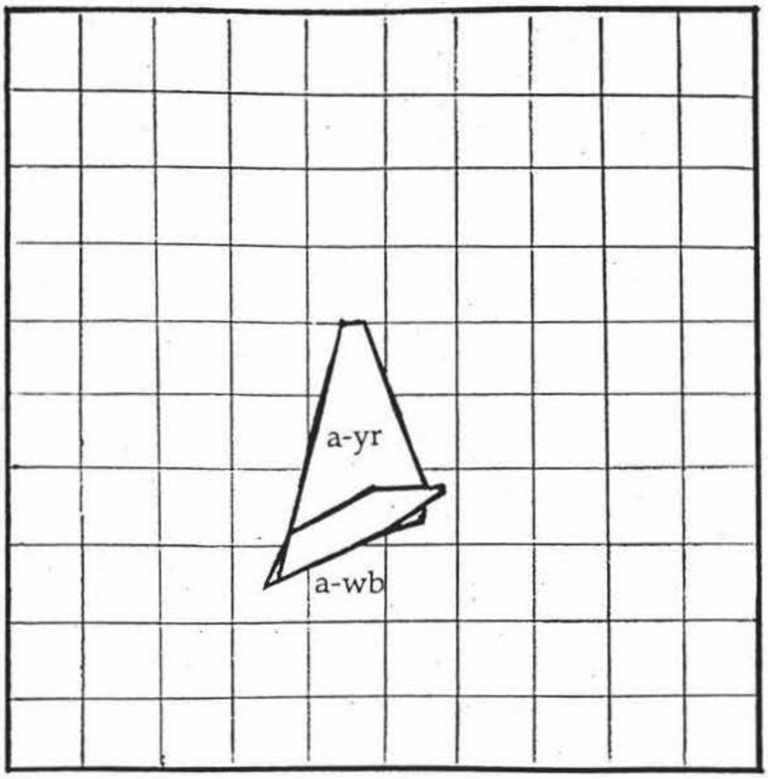


Figure 3.4 The home range of a-yr (male) and a-wb (female). This pair bred together at least twice in 1993. One square=1 hectare.

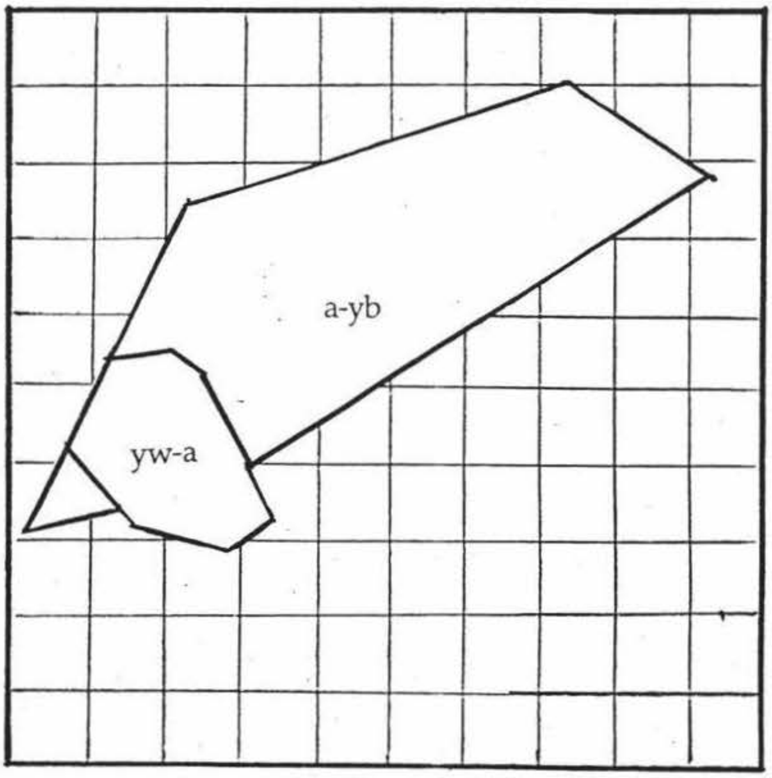


Figure 3.5 The home range of yw-a(male) and a-yb (female). This pair bred together at least 3 times in 1993. A-yb appeared to dissociate from yw-a between breeding attempts. One square=1hectare.

Within those home ranges, ungrazed bush and scrub and woodpiles were preferred weka habitat - 16 of the 21 weka that wore radios used ungrazed scrub more than expected i.e. the percentage use was more than the percentage presence (indicated by a + on Table 3.1). Four of the remaining 5 weka had no ungrazed scrub in their home range (indicated by an n on Table 3.1) and 1 bird used it less than expected (a - on Table 3.1). Habitat classes such as ungrazed scrub and bush seem to be"slightly" preferred - 9 of 21 used grazed scrub more than expected and 7 were found there less often than expected on the basis of availability alone and areas ungrazed pasture and pines were used as expected. Pasture was avoided. This preference was consistent across all seasons (Tables 3.2-3.5). Some weka also used small underground caverns, ("underrunners", Carroll, 1963a) but I could not measure the availability of these to the weka. Weka ry-a and bb-a were both found in underrunners twice.

Habitat type bird	1	2	3	4	5	6	7	8
wg-a	-	n	+	+	n	n	+	-
yw-a	-	n	+	+	n	n	+	n
r-ya	-	n	+	-	n	n	+	n
a-yb	-	n	+	+	n	n	+	-
gr-a	-	n	+	n	n	+	+	-
a-gr	+	n	n	-	n	n	n	n
a-wb	-	n	+	n	-	n	n	-
br-a	-	n	+	n	n	n	n	-
a-yr	-	n	+	n	-	n	+	-
1-5	-	+	n	-	n	n	n	n
rg-a	-	n	+	-	n	n	n	-
a-ry	-	n	n	+	n	-	+	-
a-rg	-	n	n	+	n	+	+	-
2	-	-	+	-	n	n	n	n
bb-a	-	-	+	+	n	n	+	-
rw-a	-	n	+	+	n	n	+	n
gg-a	-	n	+	+	n	n	-	-
yb-a	-	n	-	n	+	n	n	n
a-bg	-	-	+	-	+	n	n	-
rr-a	-	n	+	-	n	n	+	-
a-gb	-	n	+	+	n	n	-	n

Table 3.1 Summary of habitat use for all birds in all seasons. + indicates the bird's percentage use of the habitat was more than its percentage availability, - indicates use was less than availability and n indicates the habitat type in question was so rare in the weka's home range it was classed as not available, and it was not used. Habitat types: 1= pasture, 2= ungrazed bush, 3= ungrazed scrub, 4 = grazed bush and scrub, 5= ungrazed pasture, 6= pine plantation, 7= wood heaps and 8= "unusable" areas such as roads, rivers or houses.

Habitat type bird	1	2	3	4	5	6	7	8
wg-a	-	n	+	-	n	n	+	-
yw-a	-	n	+	+	n	n	+	n
r-ya	-	n	+	-	n	n	-	n
a-yb	-	n	-	+	n	n	+	-
gr-a	-	n	+	n	n	+	-	-
a-gr	+	n	n	-	n	n	n	n
br-a	-	n	+	n	n	n	n	-
a-yr	-	n	+	n	-	n	+	-
a-ry	-	n	n	+	n	-	-	-
a-rg	-	n	n	+	n	+	+	-
bb-a	-	-	+	+	n	n	+	-
rw-a	-	n	+	+	n	n	+	n
gg-a	-	n	+	+	n	n	-	-
a-bg	+	-	-	-	n	n	n	-

Table 3.2 Habitat use by weka in spring. + indicates the bird's percentage use of habitat was more than its percentage available, - indicates use was less than availability and n indicates the habitat type in question was so rare in the weka's home range it was classed as not available, and it was not used. Habitat types: 1 = pasture, 2 = ungrazed bush, 3 = ungrazed scrub, 4 = grazed bush and scrub, 5 = ungrazed pasture, 6 = pine plantation, 7 = wood piles and 8 = unusable areas such as roads, rivers or houses.

Habitat type Bird	1	2	3	4	5	6	7	8
wg-a	-	n	+	+	n	n	+	-
yw-a	-	n	+	+	n	n	-	n
r-ya	-	n	+	-	n	n	+	n
a-yb	-	n	+	+	n	n	+	-
gr-a	-	n	+	n	n	-	+	-
a-gr	+	n	n	-	n	n	n	n
a-wb	-	n	+	n	-	n	n	-
a-yr	-	n	+	n	-	n	n	-
rg-a	+	n	+	-	n	n	n	-
a-ry	-	n	n	+	n	-	+	-
a-rg	-	n	n	+	n	-	-	-
bb-a	-	-	+	+	n	n	+	-
rw-a	-	n	n	+	n	n	n	n
gg-a	-	n	n	+	n	n	-	-
a-bg	-	-	+	-	+	n	n	-
a-gb	-	n	+	+	n	n	-	n
rr-a	-	n	+	-	n	n	+	-

Table 3.3 Habitat use by weka in summer. + indicates the bird's percentage use of habitat was more than its percentage available, - indicates use was less than availability and n indicates the habitat type in question was so rare in the weka's home range it was classed as not available, and it was not used. Habitat types: 1 = pasture, 2 = ungrazed bush, 3 = ungrazed scrub, 4 = grazed bush and scrub, 5 = ungrazed pasture, 6 = pine plantation, 7 = wood piles and 8 = unusable areas such as roads, rivers or houses.

Habitat type Bird	1	2	3	4	5	6	7	8
wg-a	-	n	+	n	n	n	-	-
yw-a	-	n	+	+	n	n	+	-
a-yb	-	n	+	+	n	n	-	-
rg-a	-	n	+	-	n	n	n	-
a-rg	_	n	n	+	n	-	+	-
2	-	-	+	-	n	n	n	n
bb-a	+	-	-	-	n	n	-	-
yb-a	-	n	-	n	+	n	n	n
a-bg	-	-	+	-	n	n	n	-
gg-a	-	n	n	+	n	n	-	-

Table 3.4 Habitat use by weka in autumn. + indicates the birds percentage use of habitat was more than its percentage available, - indicates use was less than availability and n indicates the habitat type in question was so rare in the weka's home range it was classed as not available, and it was not used. Habitat types: 1 = pasture, 2 = ungrazed bush, 3 = ungrazed scrub, 4 = grazed bush and scrub, 5 = ungrazed pasture, 6 = pine plantation, 7 = wood piles and 8 = unusable areas such as roads, rivers or houses.

Habitat type bird	1	2	3	4	5	6	7	8
wg-a	-	n	+	+	n	n	+	-
yw-a	-	n	+	+	n	n	-	n
gr-a	-	n	+	n	n	+	-	-
br-a	-	n	+	n	n	n	n	-
a-yr	-	n	+	n	-	n	n	-
1-5	-	+	n	-	n	n	n	n
rg-a	-	n	+	-	n	n	n	-
a-rg	-	n	n	+	n	+	+	-
bb-a	-	-	-	+	n	n	+	-

Table 3.5 Winter habitat use by weka. + indicates the bird's percentage use of habitat was more than its percentage available, - indicates use was less than availability and n indicates the habitat type in question was so rare in the weka's home range it was classed as not available, and it was not used. Habitat types: 1 = pasture, 2 = ungrazed bush, 3 = ungrazed scrub, 4 = grazed bush and scrub, 5 = ungrazed pasture, 6 = pine plantation, 7 = wood piles and 8 = unusable areas such as roads, rivers or houses.

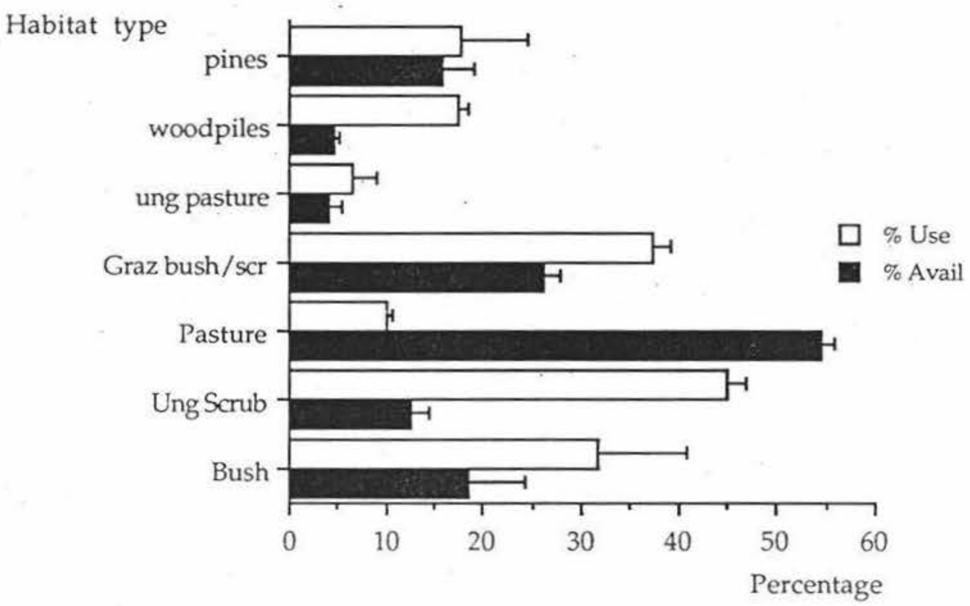


Figure 3.6 The average availability of habitat types and their average use by radio-carrying weka across all seasons. Standard errors of the mean are shown.

3.2.2 Weka activity

The largest movement by a male weka in one day was 835m, by weka bb-a. The largest movement by a female was 885m in one day by weka a-yb, who was incubating at the time. Movements between consecutive fixes were generally less than 200m (Figure 3.7). There was no significant difference between movement of male weka within my visits and between visits (mean=152.55m, s.d.=158.82m within trips, mean=164.5m, s.d.=141.5 between trips, T=0.03, p=0.98). Male weka moved more than female weka within a visit (mean=80.4m, s.d.=140.5m for females, T=32.79, p=0.00001), but not between visits (mean=164.5m, s.d.=141.5m for males and mean=182.5m, s.d.=118.4m for females, T=1.04, p=0.31). Female weka moved more between my visits to the study area than within any visit (T=15.82, p=0.00001).

Weka were sighted on 267 occasions during the 1300.75 hours I spent in the field (this does not include time spent listening for weka either each month or during the censuses, Chapter 2). Most (215) of these were instantaneous sightings (< 4 seconds) of weka running for cover, often across the road. Fifty-two (19.4%) of these encounters were long enough

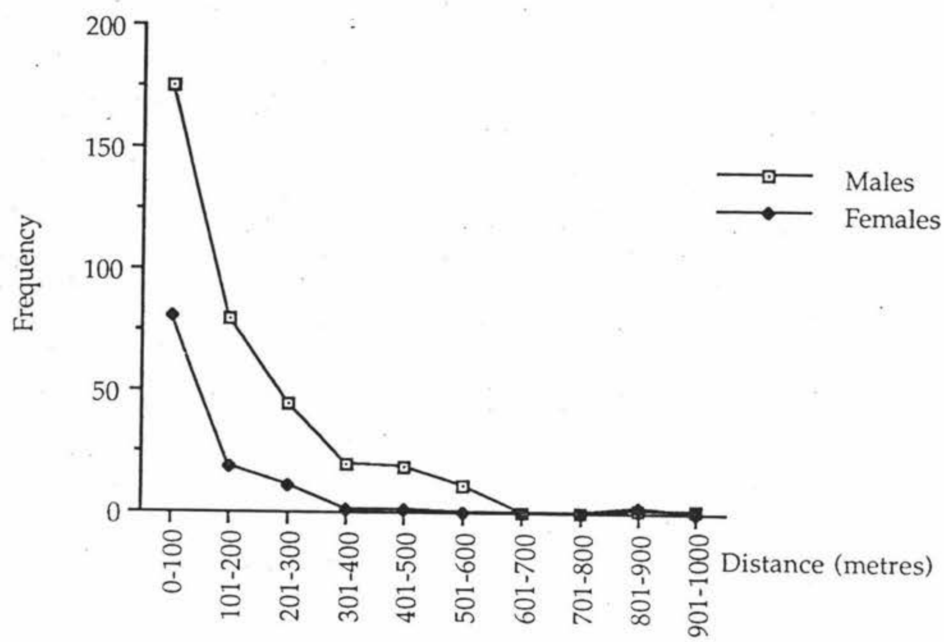


Figure 3.7 Movements made by weka between radio-fixes.

to record weka behaviour.

Despite the increased length of time weka were followed during the spring and summer of 1992, and more hours spent in the field than the preceding autumn and winter, weka were no more visible when they had been followed for 7 hours than for 1 hour (Table 3.6). The weka continued to spend most of their time immobile and under cover. The large increase in the number of hours spent in the field to see a weka in Spring and Summer 1993 was because the birds were checked more often but not followed long enough to see them.

Year	Autumn	Winter	Spring	Summer
1992	1.24 (40)	5 (112.5)	3.55 (231)	3.74 (232)
1993	10.6 (172)	15.29 (132.75)	22.1 (101)	13.45 (279.5)

Table 3.6 The average number of hours spent in the field per weka seen. The number of hours spent searching for weka in each season is in brackets.

Nine banded birds were observed 31 times (Table 3.7) and unbanded birds were followed 21 times.

	gr-a	a-bg	a-yr	a-yb	wg-a	bb-a	gg-a	b-ra	rw-a
number of observations	15	4	3	2	2	2	1	1	1

Table 3.7 Observations of banded weka

Weka gr-a was followed for the longest periods. A-yb was the only female weka followed. I followed weka for a total of 303 hours. Weka were visible for 489 minutes (2.69%). The average observation episode lasted 9 minutes and 24s (s.d.=12 mins 18s). Because there was so few observations of activity in each season both from radio carrying and unradioed birds, the data are presented together in Figure 3.8. Distraction occurred once when the bird had 2 chicks less than a week old and spent 15 minutes trying to lure me away from his mate and chicks, before I gave up and left the area.

3.2.3 Diurnal Activity

Weka were crepuscular with apparently only limited night activity and a peak of activity at dawn during autumn and winter (Figure 3.9 and 3.10). During spring weka showed an increase in activity during the day and a peak at dusk, this was also true in summer (Figures 3.11 and 3.12). When all sightings are taken together (Figure 3.13) most active weka were seen prior to and at dawn, slowly decreasing during the day. Weka were seldom followed during darkness, but on 7 occasions I checked the same weka after sunset and before dawn, only once had the weka moved since the previous night and not more than 50m. The increase in activity towards dusk in spring and summer may be in response to grass grubs (*Costelytra zealandica*) which fly onto grass blades at dusk. Scarabs were an important diet item in summer (Figure 3.16).

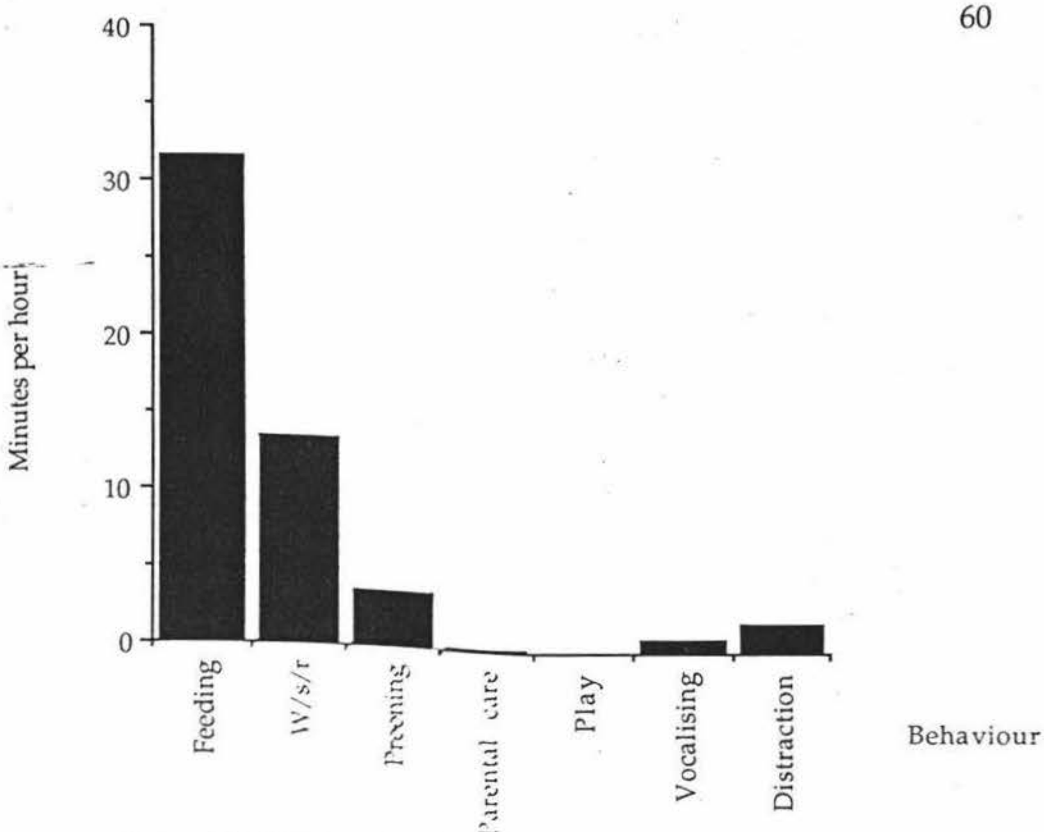


Figure 3.8 Time-activity budget of weka at Rakauroa.
W/s/r is time spent walking, standing or running.
Data are presented as minutes per hour for all weka observed.

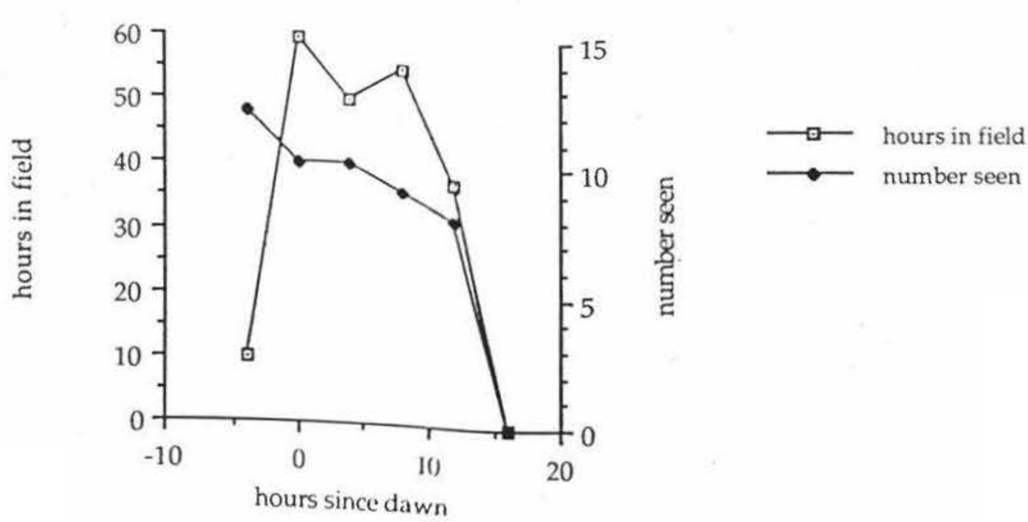


Figure 3.9 Activity of weka in Autumn

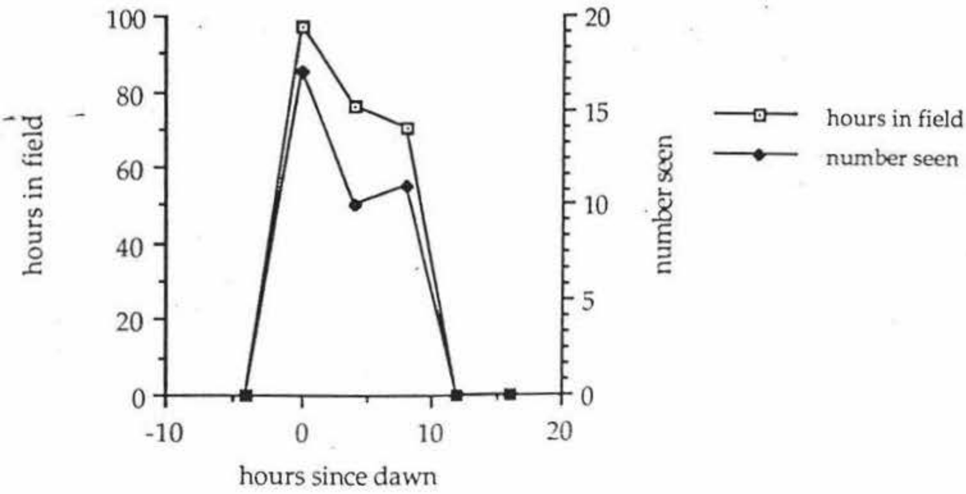


Figure 3.10 Activity of weka in Winter

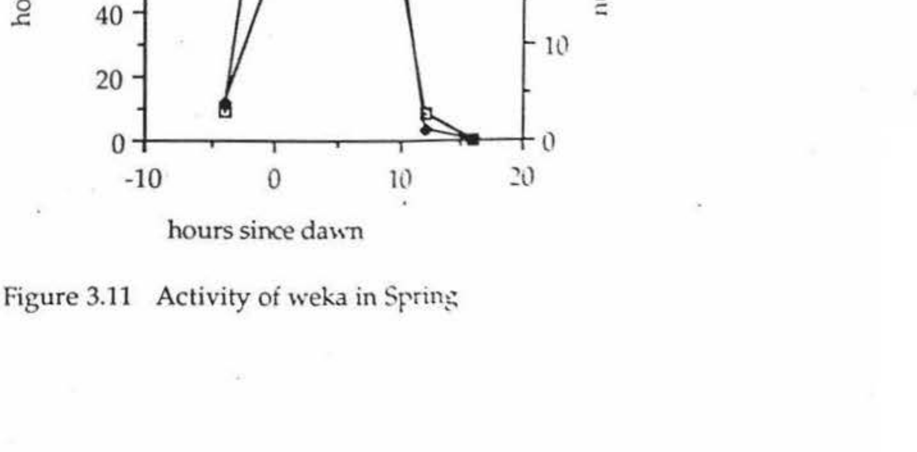


Figure 3.11 Activity of weka in Spring

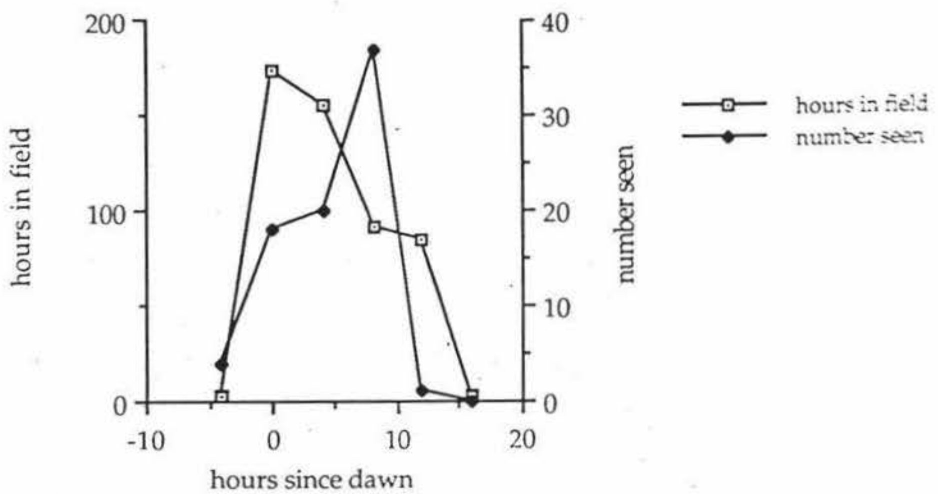


Figure 3.12 Activity of weka in Summer

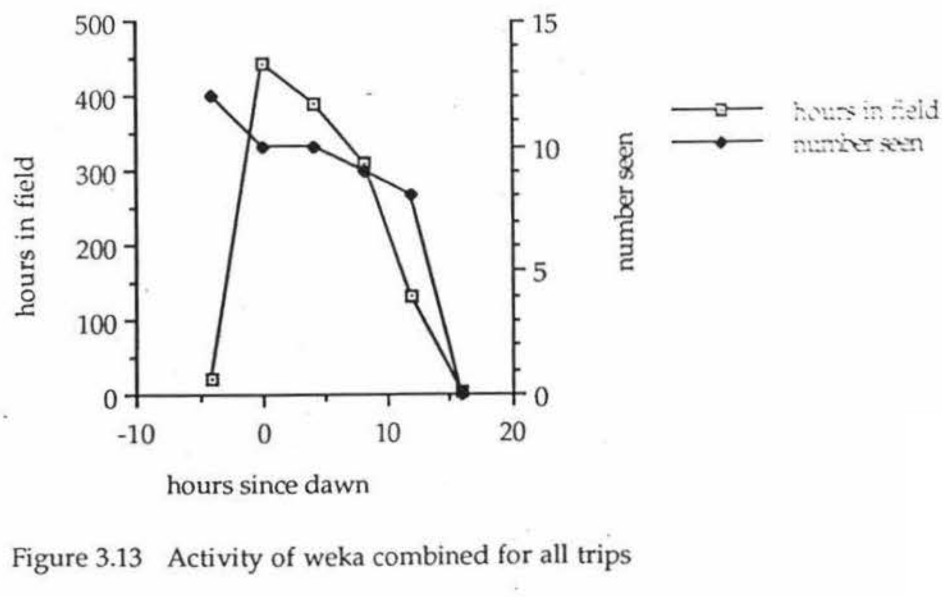


Figure 3.13 Activity of weka combined for all trips

3.2.4 Fruit availability

Fruits available to weka were most common in the study area in late summer, autumn and winter (Figure 3.14).

3.2.5 Invertebrate availability

Invertebrates were most common in summer and autumn (Appendix 2). One-way analyses of variance on the transformed data showed that some traps did consistently catch more of a given taxon. Traps 4, 18 and 8 caught more amphipods (p=0.0001), traps 5, 13, and 15 caught more worms (p=0.0001), traps 9 and 10 caught more snails (p=0.0001), trap 22 caught more scarabs (p=0.001), traps 26 and 34 caught more weevils (p=0.014) and trap 12 caught more tenebrionids (p=0.0042). Trap 28 may have caught more elaterids (p=0.055), but traps were not consistently more successful at catching all taxa. Only small numbers of click beetles (Elateridae), weevils (Curculionidae) and snails were caught, and the more successful traps were simply the "non-zero" ones, i.e. those that caught any at all. The abundance of beetles changed with month of the year (scarabs, p=0.0001, elaterids, p=0.001, tenebrionids, p=0.046 and carabids, p=0.029), and earwigs (p=0.001)) all of them being more common in summer months and rarer in winter months. The year had a significant effect only for earwigs (less were caught in 1993, p=0.042) and tenebrionid beetles (more were caught in 1994, the fewest in 1992, p=0.0001).

Some taxa were more common in some habitat types. Amphipods were most common in ungrazed pasture and pasture (p=0.03), worms were

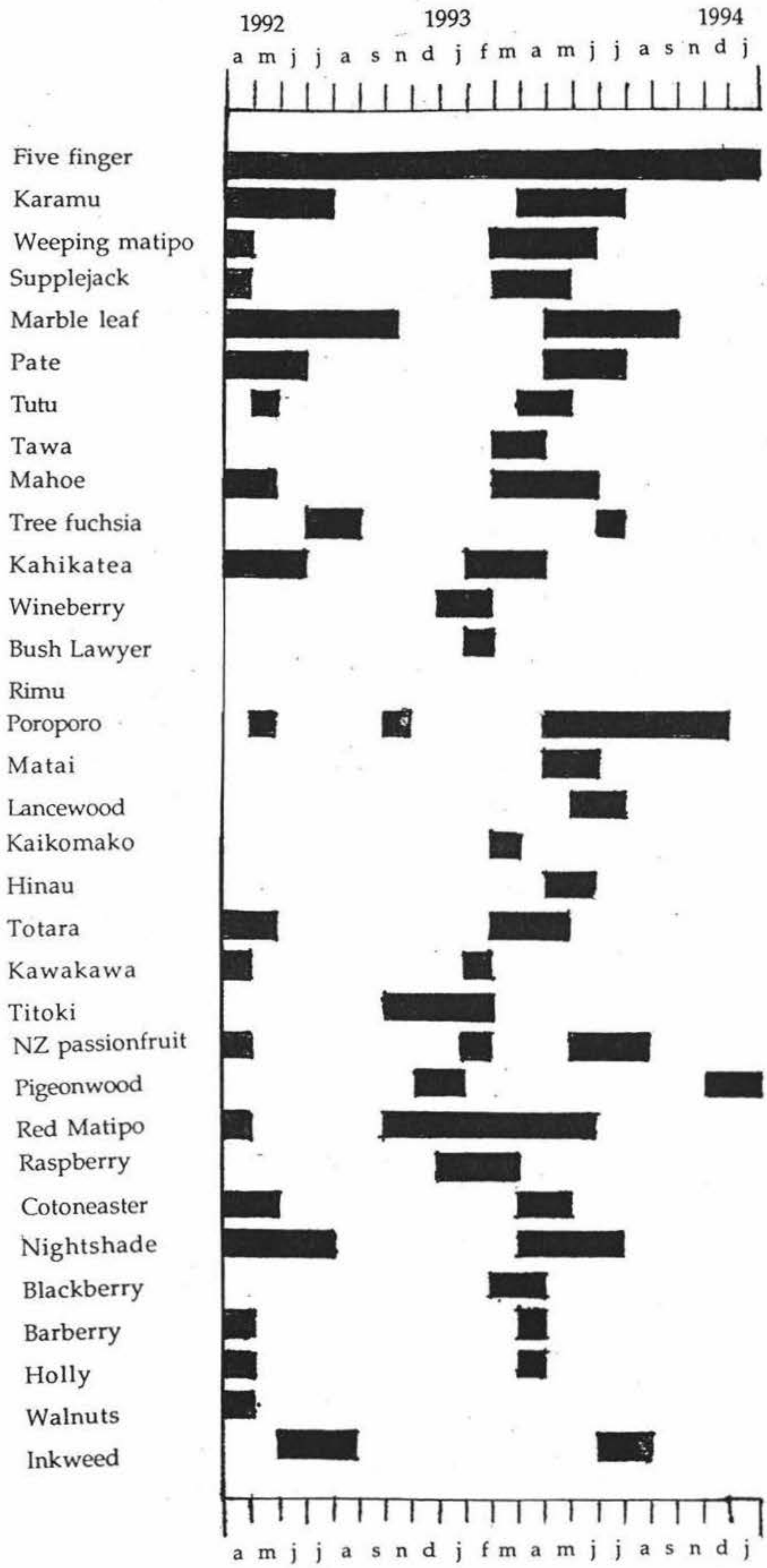


Figure 3.14 The seasonal appearance of ripe fruits available to weka in the Waikohu Valley, Rakauroa from April 1992 to January 1994. For the latin names of species mentioned see Appendix 1.

more abundant in pasture, (p=0.0001). Scarabs were more common in grazed and ungrazed scrub (p=0.046) and snails were most abundant in bush (p=0.0001). Tenebrionids were most common in grazed and ungrazed scrub (p=0.039).

3.2.6 Presence in the diet

Eighty-six droppings and 13 gizzards were collected. Fifteen invertebrate groups were recognisable from their fragments and the use of different items varied seasonally (Figure 3.15). The hypothesis that weka use food in proportion to its availability was supported by the Friedman rank test, which failed to reject the null hypothesis that use and availability of food items did not vary significantly from random (s=5.67, p=0.341). The percentage availability and use of different insect groups varied seasonally (Figures 3.17-3.22).

Some items, for example slugs, that were not seen in the faeces were clearly eaten by weka (Figure 3.16), but were probably too soft to leave fragments. Some very hard fragments such as weta mandibles were also found in gizzards and appeared to be acting as grit. As most of the rest of a weta body is relatively soft, they too may be underestimated in this study.

3.2.7 Annual variation in body mass of adult weka

Adult male weka body weights ranged between 725g and 1160g. The average weight of all male weka (including only the first capture for weka

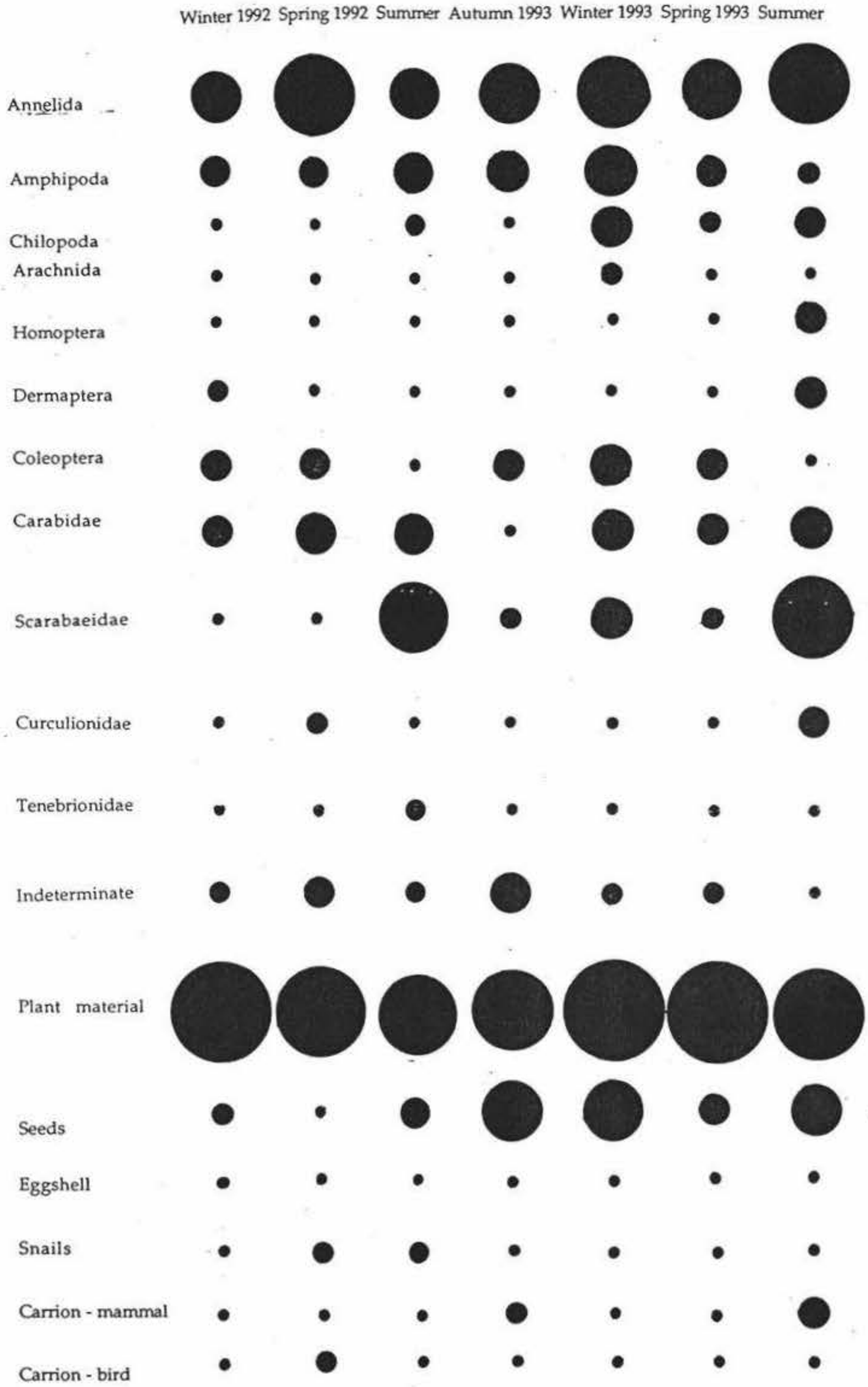


Figure 3.15 The seasonal occurence and relative importance of diet items found in faeces at Rakauroa. The size of the circle is proportional to the rank of abundance i.e. the higher the rank the larger the circle.

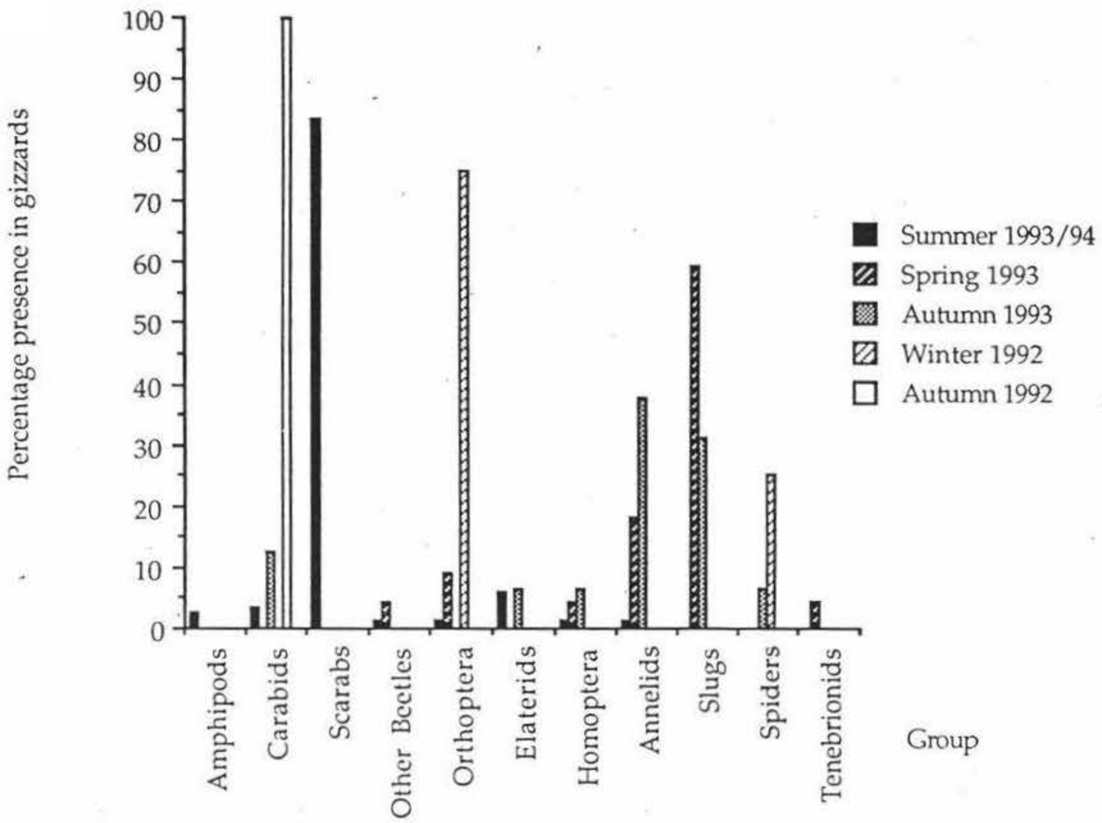


Figure 3.16 The presence of invertebrate groups in gizzards from weka collected dead in the East Coast Conservancy.

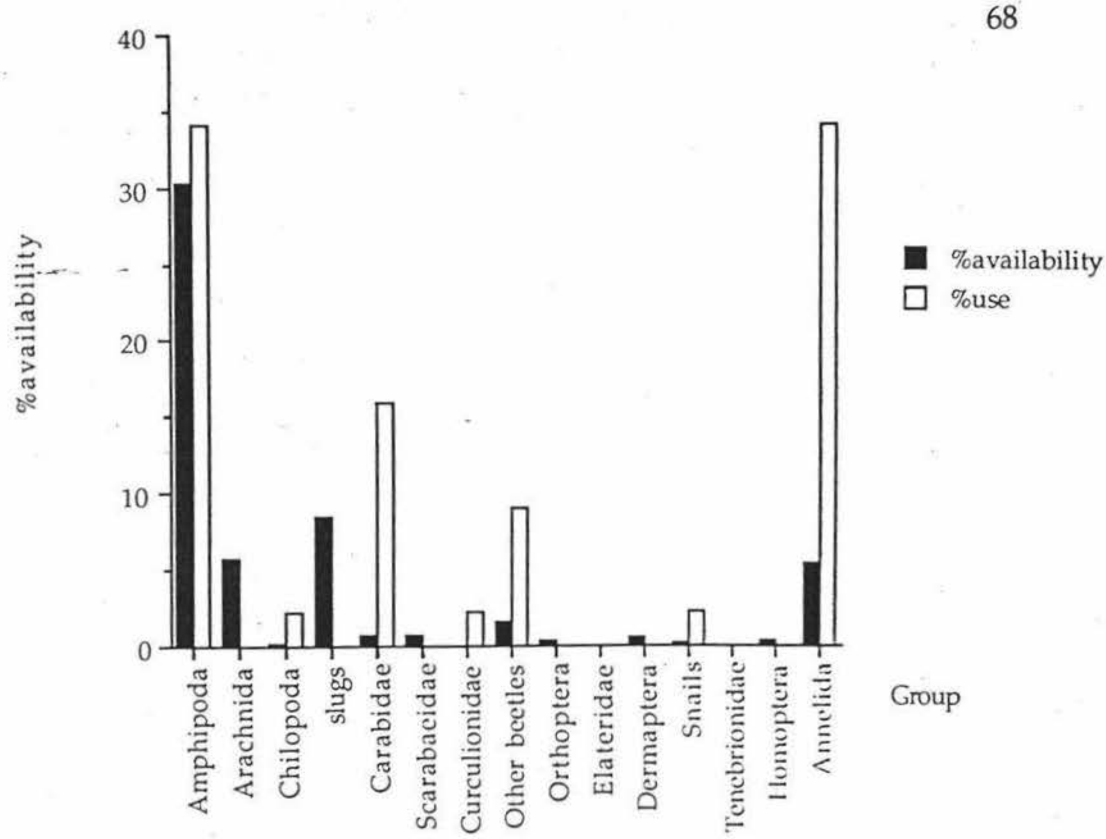


Figure 3.17 The availability of invertebrate groups and their use by weka at Rakauroa in Spring 1992.

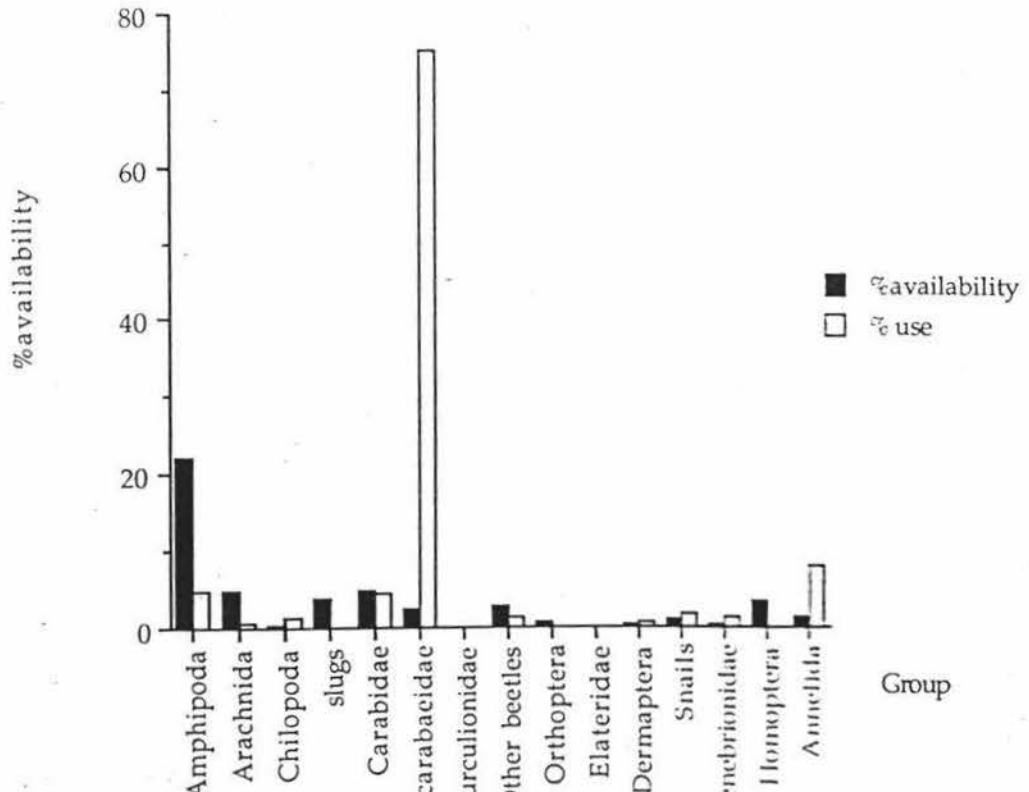


Figure 3.18 The availability of invertebrate groups and their use by weka at Rakauroa in Summer 1992/93.

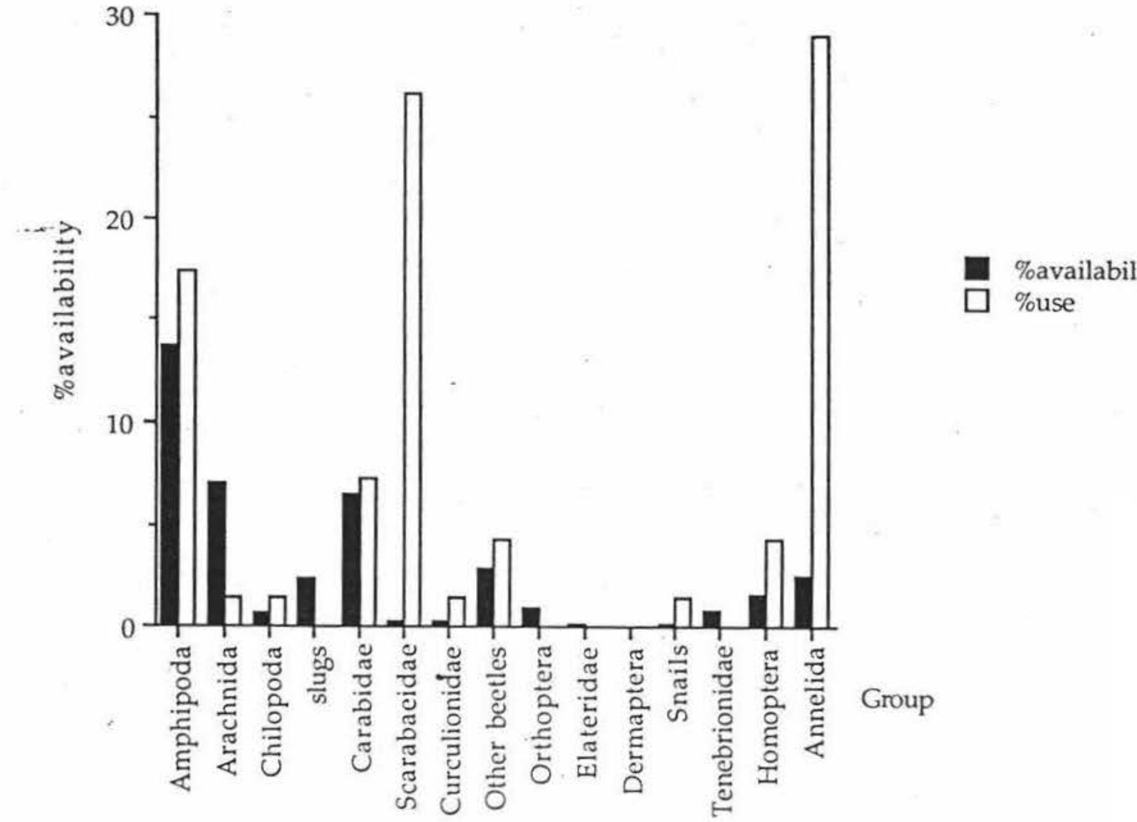


Figure 3.19 The availability of invertebrate groups and their use by weka at Rakauroa in Autumn 1993.

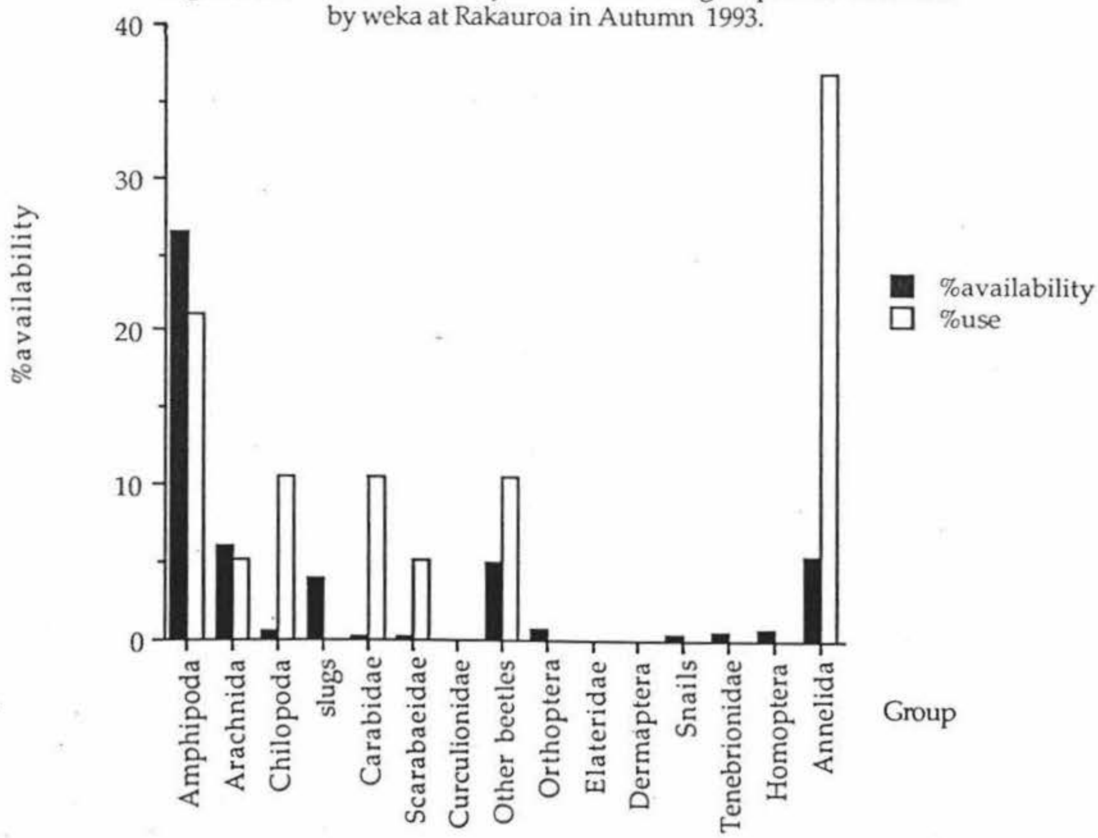


Figure 3.20 The availability of invertebrate groups and their use by weka at Rakauroa in Winter 1993.

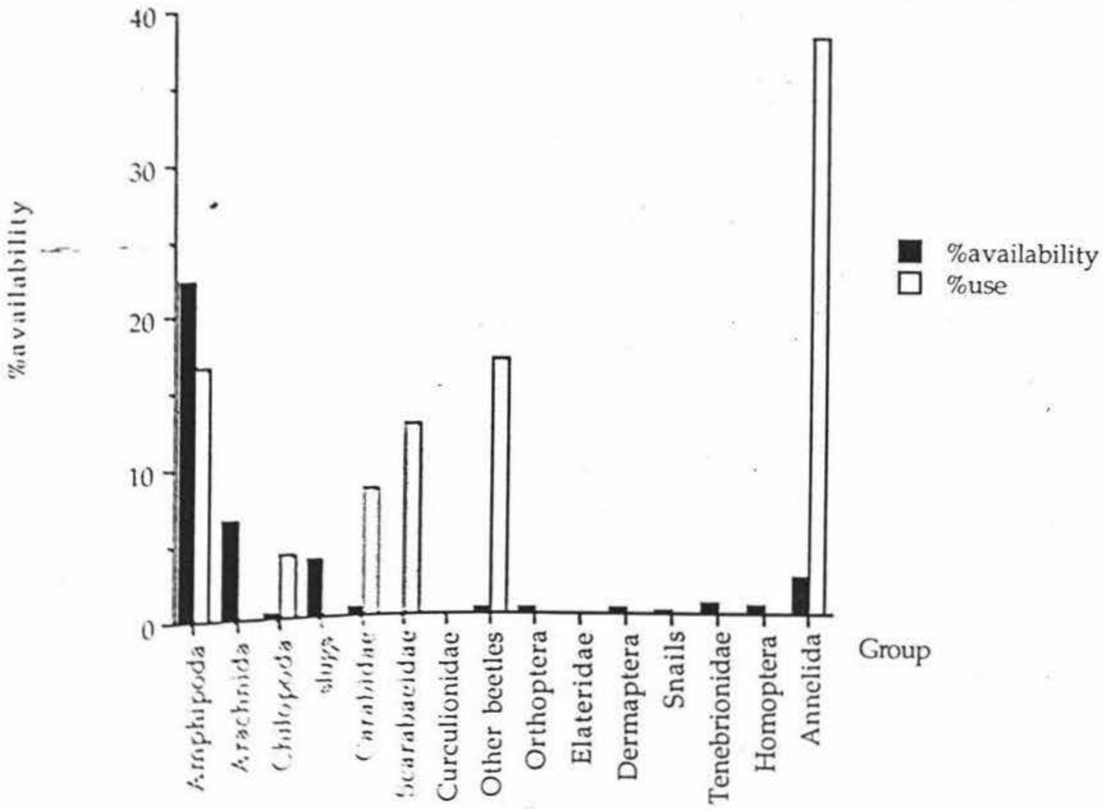


Figure 3.21 The availability of invertebrate groups and their use by weka at Rakauroa in Spring 1993.

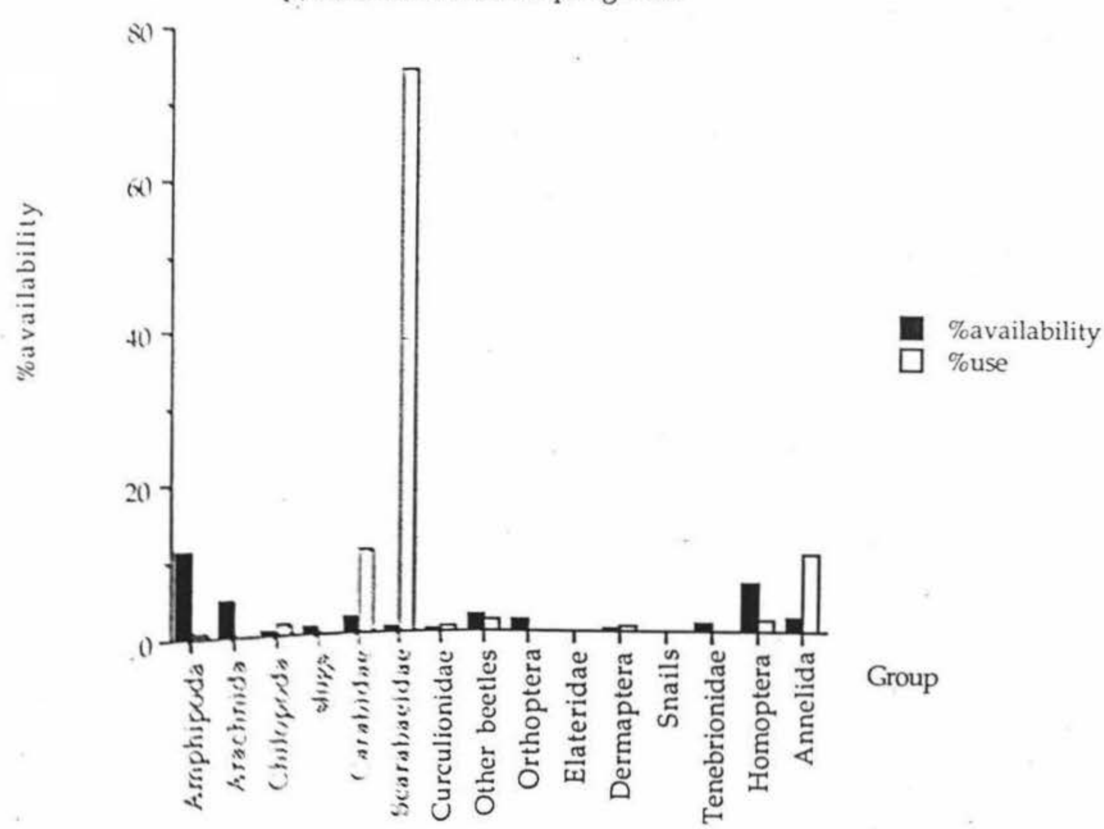


Figure 3.22 The availability of invertebrate groups and their use by weka at Rakauroa in Summer 1993-1994.

caught more than once) was 979.34g (s.d.=83.30, n=22). Female adults caught for the first time weighed less on average (mean=711.75g, s.d.=99.12, n=11). Weka were always above "critical weights" and weights did not show strong seasonal variation (Figure 3.23). Moulting and breeding coincided in 7 of the weka caught. There was some overlap of weights between the two sexes (Chapter 2, Figure 2.2).

Recaptures were made up to a year apart and the average weight difference between captures was 93.42g (s.d.=59.2, n=19) for male weka. Female weka showed an average weight difference between captures of 94.17g (s.d.=69.67g, n=6).

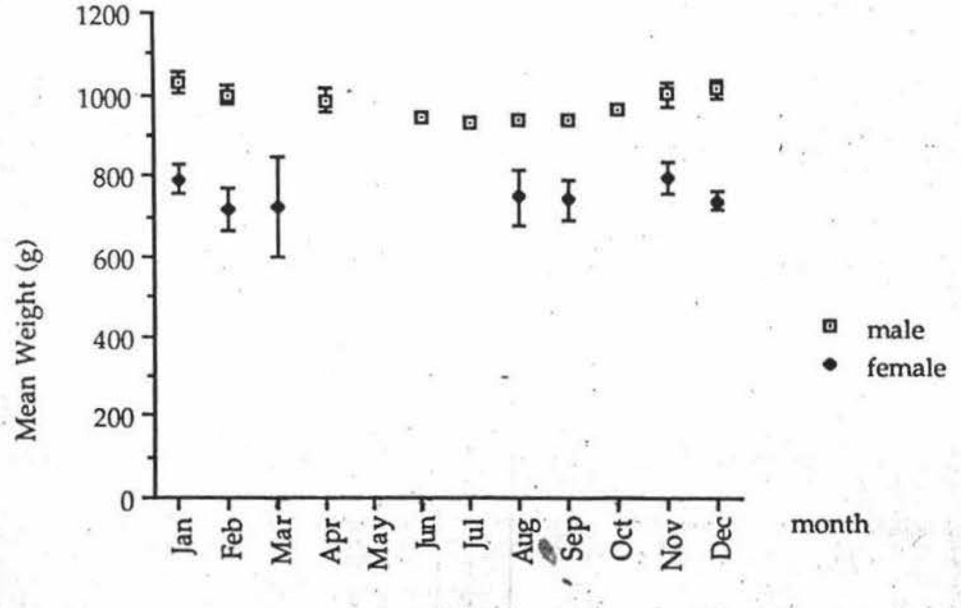


Figure 3.23 Mean weight of weka caught at Rakauroa, presented as a running 3-point mean. Standard error of the means is shown.

3.3 Discussion

Minimum convex polygons tend to include large areas of habitat in the home range estimate that are seldom if ever visited by an animal (Hough, 1982). At Rakauroa these large areas were usually pasture and weka made use of corridors of scrub within it, seldom venturing out from cover. This inconspicuousness is a feature of rails (Johnson and Dinsmore, 1986). I did see weka up to 50m out from cover, but they were very wary and readily ran for cover. Carroll (1963a) reported that weka caused localised damage near sources of cover. These observations support the hypothesis that something about cover is important to weka, and it may be that it provides protection from predators (Krebs and Kacelnik, 1991, McNamara and Houston, 1987). However some predators seek out cover (e.g. wild cats, *Felis catus*, Langham, 1992), so it is not clear whether woodpiles and ungrazed scrub really do provide refugia or not. Weka are most often found in ungrazed scrub and wood piles and only seldom in pasture. This means management of weka should focus initially on these areas of scrub. Weka spent much of their time under cover and not moving. They prefer dense habitat and carry out most of their daily activities there, usually out of the view of an observer. This means they are difficult to study without the use of radio telemetry.

Beauchamp (1987a) found that weka in forest on Kapiti Island defended small territories (0.1-3.7 ha). Weka at Rakauroa did not defend the areas they used. The lack of territoriality is not expected if there is intense competition for resources. At the low density of weka seen at Rakauroa it is unlikely that inter- or intra-specific competition is preventing young weka from establishing and breeding. The overlapping ranges of breeding birds and the absence of seasonal breeding (Chapter 2) or a seasonal weight cycle also imply that food is not limiting the North Island Weka population at Rakauroa. Moulting and breeding coincided in many weka, further indicating food availability is not adversely affecting weka at Rakauroa.

Changes in the social structure of the Tasmanian Native Hen (*Tribonyx mortierii*) accompanied a decline in numbers (Goldizen et al., 1993). Changes in territorial and other behaviour may accompany population declines in weka. Weka territorial boundaries at Double Cove were found to be much more flexible than those on Kapiti Island, and there was some overlap of ranges at Double Cove (Beauchamp, 1987b). This may be because competition is relaxed as resources are no longer limiting in a population at low density, that is an establishing or declining population. This would explain why weka are not territorial at Rakauroa.

Weka did not move long distances between fixes. Males moved more than females both between my visits to the study area and during them. This may be because at least 3 of the females were followed while they were incubating. Weka incubate eggs for 26-28 days (Timmis, 1972, Beauchamp, 1987a) and females tend to do more of the daytime incubation (Beauchamp, 1987a). Since I followed weka during the day, if the female weka happened to be incubating during my visit her recorded movement would be very low. Many of the sequential fixes on these three females were while they were incubating. Since most adult weka were males, it may be that male weka moved further in the hope of finding a (rarer) female. It may also be that male weka were less affected by my presence (Beauchamp, 1987a).

Beauchamp (1987b) reported that weka at Double Cove stayed together between breeding efforts. This did not seem to be true of all weka pairs at Rakauroa, with both members of radio-carrying pairs exhibiting differing home ranges. Pair bonds appeared to be maintained despite the differing home ranges of males and females.

Elliott (1987) reported that Banded rails (*Rallus phillipensis*) were primarily diurnal with a morning peak of activity and a lesser peak at dusk. Many other rails show this pattern (Ripley, 1977, Miller and Mulette, 1985). Weka showed a similar crepuscular pattern, but the peak in activity varied seasonally. The diurnal pattern of activity can affect the reliability of the home range estimate (Hough, 1982). However, by collecting data from random birds at random times of the day fixes were unlikely to be biased towards either roosting or feeding sites. The observed preference for cover and ungrazed scrub was a real one.

Weka are truly omnivorous, eating almost anything they come across including invertebrates, fruits, carrion and eggs. Weka at Rakauroa were generalists that used food in proportion to its availability. The abundance of weka prey items varied seasonally and weka diet changed seasonally following these changes. This trait is likely to reduce the effects of competition on weka because they can switch to other prey if necessary.

This is further support for the conclusion that food availability does not presently limit productivity of weka at Rakauroa.

Chapter Four: Predator removal experiment and juvenile weka dispersal.

4.0 Introduction

Caughley (1994) identified two areas of active research in conservation biology driven by what he called the "small population paradigm", concerned with the effect of small population size per se, and the "declining population paradigm" which focuses on the cause of smallness and its cure. The cause of the smallness of present weka populations is not known (Ward et al., 1992, unpub.) and hence there is a need to identify the cause before effective management can begin to increase the population size. Several factors have been suggested to account for the original decline in weka numbers (Chapter 1) but it is not clear why a bird that is omnivorous, prolific and capable of existence at high densities in a much modified landscape (at least in the past) has not recovered in numbers.

My observations of mustelid predation on weka, the high disappearance rate of chicks (Chapter 2) and many sightings of feral cats (*Felis catus*) showed the potential for predation to have a limiting effect on the weka population at Rakauroa. Predation on weka by any species other than man has not previously been documented. Occasional anecdotal reports of weka defending themselves against rodents, cats and even mustelids have been used as evidence that weka populations are able to withstand predation (Graeme, 1991, 1994).

Caughley (1994) cites cases (e.g. Lord Howe Island woodhen, *Tricholimnas sylvestris*) where the limiting factor (predation by pigs, *Sus scrofa*) has been identifed and removed allowing the recovery of the species with the aid of management such as predator removal and captive breeding. This systematic approach differs from "Research by Management" (the presently favoured recovery option for weka, Ward et al., 1992, unpub.) in that research precedes any management effort. "Research by Management" on the other hand, tests either sequentially or concurrently a range of management options and measures the population response. The management option that achieves the best results is the one adopted.

To determine whether predators were limiting the production of young weka I experimentally removed predators from four home ranges and measured the number of young reared in protected areas and in unprotected areas. Concurrently I measured the dispersal of young weka to determine whether the chicks were disappearing due to dispersal into new areas or whether their disappearance was due to other causes (possibly predation).

If predation were limiting the productivity of weka pairs then one would expect that there would be a difference in the production and survival of young in treatment and control areas, with treatment areas rearing more young.

4.1 Methods

4.1.1 Sightings of cats and ferrets

All cats and mustelids seen in Waikohu Valley from March 1992 to January 1994 were recorded. I also noted the time, place, date and the colour, pattern and length of each cat's pelage to identify individuals.

4.1.2 Assignment of weka pairs to treatment and control groups

Eight weka carrying radios and thought to be paired in August 1993 were randomly assigned to the experimental treatment group (predators trapped and removed) or the experimental control group (no predator trapping) by drawing band combinations from a hat. Two weka with overlapping home ranges were treated as one unit during randomisation. Seven of the weka were males and one (a-rg) was a female. This procedure meant that four weka and their partners were selected for predator exclusion and the remaining four pairs acted as experimental controls (Figure 4.1).

I attempted to capture the partners of experimental weka and attach radio transmitters to them.

4.1.3 Capture and removal of cats and mustelids

Twelve Edgar traps for catching mustelids (King and Edgar, 1977) and six possum cage traps for capturing cats, were placed within the known home ranges of each of the four weka pairs in the experimental treatment group.

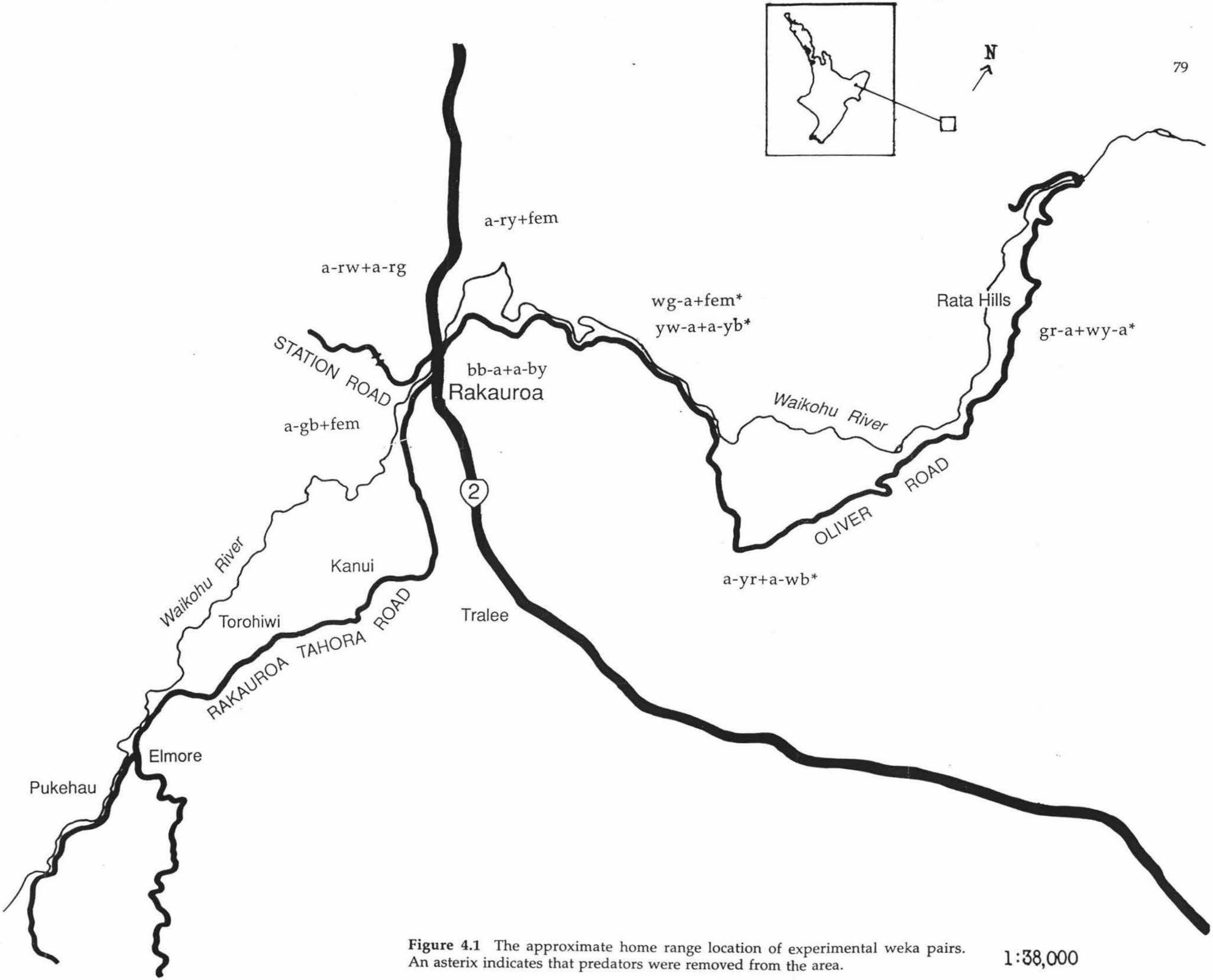


Figure 4.1 The approximate home range location of experimental weka pairs. An asterix indicates that predators were removed from the area.

Initially I placed traps at the boundaries of known home ranges. Edgar traps were baited with one whole (domestic hen) egg and one cracked egg. Cage traps were baited using "sardines in aspic" cat food within a length of nylon stocking which was tied around the trap's hook. All traps were opened on the 11 October 1993 and remained open for 14 trap nights. The traps were checked daily.

I then shifted the traps and reopened them on 13 November 1993. All traps were rebaited and fish heads were used to bait the cage traps. I positioned the traps in areas I thought likely to be visited by mustelids and cats. These were isolated areas of scrub, areas that provided shelter and areas near boundaries such as creeks, roads, hedges and fences (King and Edgar, 1977, Dilks et al., 1992, unpub.).

Trapping was then carried out from 13 to 25 November (13 nights), 30 November to 9 December (10 nights), 13 to 22 December (10 nights), 5 to 16 January 1994 (11 nights) and 19 to 26 January (7 nights). Between each trapping episode the traps were shifted to areas I thought likely to be visited by mustelids and cats.

Edgar traps were rebaited whenever something was caught, or every 7-10 days. Cage traps were re-baited every 4 days.

I checked the traps in each area daily, usually between 0600hrs and 1200hrs NZDT. I also walked through the home ranges of weka pairs making up the control group daily except in the first trapping period. I chose the order of the home ranges to be checked randomly by drawing them out of a hat.

4.1.4 Predators

Ferrets (*Mustela putorious furo*) and feral cats caught in the traps were shot or killed by asphyxiation with carbon dioxide, then sexed. Each gut was then removed for diet analysis. One rat was killed for identification purposes. Any other animals were released.

4.1.5 Identification of prey in cat and ferret guts

The gut samples were deep frozen and then washed over a 500µm Endecott sieve (Day, 1966). I identified fragments using a dissecting microscope at 10x magnification and a key to common diet items (Day, 1966). Hairs were identified as being from lagomorphs or "other" by their medullary pattern and feathers were identifed to family using the criteria in Day (1966).

4.1.6 Breeding by pairs in treatment and control groups

As I walked through the eight weka home ranges, I obtained point locations for each radio carrying bird. Birds were not followed, but I tried to see each bird and establish its breeding status. Triangulation from a distance of <50m allowed me to pinpoint nest sites.

4.1.7 Survival and dispersal of juvenile weka

Three weka chicks were fitted with back mounted radios designed to be shed as they grew. The average weight of these transmitters was 11.4g. A small area of feathers on the back of the weka was cut short. The transmitter was fixed with superglue (Selleys Home Products) to a piece of chiffon which was then attached to the shortened feathers of the weka using Vetbond body cement (Smith and Nephew Ltd). All three chicks had been raised in home ranges in the treatment group. I determined the locality of these juveniles daily, to measure daily survival and dispersal of the juveniles.

In addition, 20 weka had been banded as juveniles and one female weka (a-rg) had been fitted with a radio as a juvenile. Subsequent trappings and resightings of these birds contributed to the data set for dispersal.

4.2 Results

4.2.1 Observations and capture of predators

I saw 55 cats 79 times, 2 stoats (*Mustela erminea*), 2 ferrets and one rat in the 18 months prior to the start of trapping in October 1993.

From October 1993, I saw 10 cats 17 times. Four of the sightings were of one cat in an experimental treatment area in November, that was later captured. All the other sightings were in experimental control areas.

For the three months from November 1992 to January 1993 inclusive the mean number of cats seen was 0.39 per day. In the four months of the predator trapping (October 1993 - January 1994) the mean number seen was 0.22 cats per day. Only one kitten was seen (in an experimental control area) in October. The rat was identified as a ship rat (*Rattus rattus rattus*), (Brockie, 1992, D. Towers, pers. comm.).

I completed 4212 trap nights from 11 October 1993 to 26 January 1994 and caught 16 mustelids and cats (Table 4.1). This equated to 0.38 predators per 100 trap nights (0.26 for cats and 0.12 for mustelids). I made 120 non-target captures including 44 weka, but 29 of these were recaptures.

Trap type	Trap nights	Cats	Ferrets	Hedge-hogs	Rats	Other	Weka
Cage	1289	9	1	2	0	6	42
Edgar	2923	2	4	40	27	1	2

Table 4.1 Results of trapping for mustelids and cats in four weka home ranges.

4.2.2 Sex ratio of the predators

Four of the ferrets were males. One was a pregnant female with 6 early stage embryos. Five of the cats were adult males and five were adult females of which 3 were lactating. One male was a kitten.

4.2.3 Gut contents of predators

All of the ferrets and 9 of the cats had food remains within their stomach. Lagomorph remains were found in 6 of the 14 guts (42.86%). "Other" mammals were found in 5 (35.7%). Insects, mostly wetas (species unknown) and Cicada nymphs (Homoptera), were found in 50% (7) of the stomachs. Feathers were found in 5 stomachs (35.7%), four of these were from Passeriform birds. The stomach of the female ferret contained feathers from a rail. Weka are the most common rail in the area (there are few pukeko, *Porphyrio porphyrio porphyrio*). The colour of the feathers was consistent with it being an adult weka, and the ferret was caught in the range of male weka gr-a about the time he was last seen.

4.2.4 The effect of predator trapping on weka reproduction

Shortly after the experiment commenced, the radio worn by one weka (a-rg) ceased transmitting and one male weka (a-bg) dropped his radio. Both these weka had been assigned to the control group and no data could be obtained from them or their partners. A further male from the treatment group (gr-a) disappeared from his home range in October and was not seen again.

Weka in experimental treatment areas reared 5 chicks to 6 weeks of age from three breeding attempts by two pairs. Unprotected weka reared no young despite 3 breeding attempts by 2 pairs (Table 4.2).

Treatment Pairs	Breeding attempts	Chicks	Control Pairs	Breeding attempts	Chicks
yw-a+a-yb	1	3	a-ry+ fem	1	0
a-yr+a-wb	2	2	bb-a+a-by	2	0
gr-a+wy-a	0 (male died)	0	a-rw+a-rg	no data	
wg-a+fem	0	0	a-gb+fem	no data	

Table 4.2 Number of known breeding attempts and the number of chicks reared to six weeks of age by weka pairs in experimental treatment and experimental control areas. Pair yw-a + a-yb had already raised 2 chicks to approximately 4 weeks of age when I commenced predator trapping in their home range.

4.2.5 Dispersal of juvenile weka

One radio was dropped within 24 hours but two young weka wore transmitters for 42 and 23 days respectively. One weka (a-gb) was first captured at approximately six weeks of age and occupied an area of 0.5ha over 42 days, the other (r-ra) was first caught at approximately 9 weeks old and had a home range of 5.00ha over 23 days. Neither weka was more than 400m from the nest site and both remained in dense scrub or in patches of fallen trees overgrown with vines and weeds. Both weka remained in an area of their parental home range but were separated from their parent birds who had begun to use other areas of their home range. Dispersal by young weka was generally low (Table 4.3).

Weka	Sex	Age at (last)capture	Home range	Dispersal
b-a	male	11 weeks	unknown	none
a-gy	female	13 weeks	unknown	none
r-ga	female	16 weeks	unknown	none
a-rg	female	11 months	31.38ha	0.72km
br-a	male	17 weeks	unknown	1.5km

Table 4.3 Dispersal of juvenile weka from their parental home range. Based on radio tracking (a-rg) or trapping/sightings.

A-rg was trapped as a juvenile female of no more than 12 weeks of age. During the months after her capture in January 1993, she moved no more than 0.68km from her probable parental home range. In July 1993 she appeared to have paired with a male in an area adjacent to her natal area (0.72km from where she was first trapped).

4.3 Discussion

The scale of this experiment was necessarily limited by the number of weka available for study, and the loss of radio transmission from 2 of the 8 pairs has made interpretation of the data difficult. During the first 18 months of the study an average of 0.375 juveniles were seen per nesting attempt (n=25, Chapter 2). In contrast, weka pairs in experimental treatment areas had an average of 2.25 juveniles per nesting attempt (n=2), which is six times the productivity seen in the preceding 18 months. The findings that pairs in areas where there was no predator trapping failed to raise any chicks and that pairs in protected areas raised six times more chicks to six weeks of age are consistent with the hypothesis that predation is limiting breeding success. Note that 0.375 chicks per nesting attempt was an optimistic estimate because it included all chicks seen at any stage, even those that subsequently disappeared. At the commencement of predator removal, an adult male weka (gr-a) disappeared from a treatment area. Such loss of a breeding adult due to predators will also reduce productivity.

Young weka may show limited dispersal because of habitat saturation (i.e. a shortage of suitable openings for breeding) or because the benefits of philopatry outweigh the gains of dispersing or some interaction between the two (Emlen, 1991). There were unoccupied habitat patches at Rakauroa and weka distribution was clumped around scrub-covered damp areas (Chapter 2). There may be 2 phases to juvenile weka dispersal, at least on Kapiti and Kawau Islands (Marchant and Higgins, 1993). The first phase may occur slowly during the first four months of life. This may be followed by a more rapid movement further away from the parental area (averaging 1.3km and with a maximum of 5km)(Marchant and Higgins, 1993). This two stage dispersal appears to be the case at Rakauroa with similar distances involved. The limited dispersal from their parental home range of the young weka I tracked allows me to be more confident that the disappearance of most of the juveniles seen was in fact due to death and not dispersion.

The capture rate of target predators was slightly lower than the reported capture rate for cats and mustelids in the Mackenzie Basin (0.52 cats/100 trap nights and 1.54 ferrets/100 trap nights) (Murray, 1992). Grant and Page (1992) captured a comparable 0.2 cats/100 trap nights on the Chatham Islands. The density of predators at Rakauroa may be sufficient for mortality to exceed recruitment. On Kawau Island weka reared 37 chicks to independence (approximately 9 weeks) over six months (data from 12 pairs and 17 breeding attempts (Beauchamp, 1993, unpub.). Weka at Rakauroa from March 1992 to March 1993 reared 1 chick to independence (data from 8 pairs, 12 breeding attempts) (Chapter 2). Clearly productivity on islands is substantially higher than on the mainland. One major difference between islands and the mainland is the absence of predation on all age classes of weka.

A predator will only have a significant effect on a potential prey population if the two come in contact (both spatially and temporally) often enough for significant predation to occur. Fitzgerald and Karl (1979) found that mammals were the most important diet item for cats in New Zealand forest. Birds were found in only 12% of scats and made up only an estimated 4.5% of diet by weight. Their search of the relevant literature also suggested birds were only a small part of cat diets in agricultural systems. However cats did respond to different food resources, and ground feeding bird species made up the majority of those eaten. Langham (1990) found that birds were both frequent and important by weight in diet of cats in Hawke's Bay farmland in a situation not unlike that at Rakauroa. He found that birds consumed were mainly introduced species (including turkeys, *Meleagris gallopavo*) and were more important in the diet in spring and summer, probably reflecting abundance. Langham (1990) reported fewer than 5% of turkey chicks fledging and seems to attribute that to predation. Hence young weka in particular could be eaten by wild cats during spring and summer.

Langham (1992) found that female cats were mostly nocturnal except when rearing young in spring and summer and adult males were diurnal in spring, autumn and winter. This activity pattern changed seasonally, but activity increased at dusk. Cats actively sought out areas providing cover and protection such as under dense vegetation. Weka activity is also highest at dusk in spring and summer and it is likely that cats would come in contact with weka at this time as weka also seek out cover and dense vegetation (Chapter 3). This is when weka have dependent young that are more vulnerable than the adults.

Ferrets are opportunistic predators that make use of the most easily available prey (G. Medina, pers. comm.). The presence of a weka feather in a ferret gut, and the finding of several ferret-killed weka (Chapter 2) is further compelling evidence that predation is important at Rakauroa.

Several other workers have practised predator removal at critical times, usually during breeding of an endangered species (Grant and Page, 1992, Murray, 1992) or during the irruption of predators due to an abundance of prey (Dilks et al., 1992, unpub., O'Donnell et al., 1992, unpub.). O'Donnell et al. (1992, unpub.) trapped stoats in the Eglinton valley and found pairs of yellowheads (*Mohoua ochrocephala*) reared nearly twice as many young from fewer nests than pairs in control areas. Also fewer breeding females disappeared from trapped areas.

Potts (1980) found that both the amount of nesting cover and the level of predator control were important in the production of grey partridge (*Perdix perdix*) broods in England. Moors (1983) found that native birds at Kowhai Bush lost 70.1% of nests to predators and most depredations were at egg stage. This loss was unaffected by habitat and height of the nest from the ground. I have probably underestimated the effect of egg predation at Rakauroa and any future removal work should include hedgehogs and rats. Moors considered that some mustelids probably became specialised predators on eggs.

In contrast Martin (1993), in a broader study, found that predation on nests in North America did vary with habitat and that predation on ground nesting birds was highest in grassland. The implication from Martin (1993) is that weka in differing habitats are likely to experience different predation pressures and weka at Rakauroa (being in farmland) are expected to be among the most affected.

Goodman (1987) stated that populations go extinct because of "bad luck", and weka seem to have had their share. The population was once flourishing, and widespread on the East Coast. Around 1983 the population underwent a serious decline which has left weka scattered in isolated pockets that do not seem to be linked by dispersal, and thus are probably not protected by the "buffering" effects of a metapopulation dynamic (Harrison, 1991). This means that while the number of weka on the East Coast may be in the order of two to three thousand birds, the effective population size of any subpopulation is very much smaller than that and all subpopulations are vulnerable. The loss of large areas of suitable habitat because of drought or destruction means that no refugia are available for dispersing weka, thus there is little opportunity for immigration. It is at this stage when the population is small and constricted that predation and chance factors would have their largest effect, the result being that populations decline even further (Shaffer, 1987) in a situation described by Caughley (1994) as an "extinction vortex" where "the worse it gets the worse it gets".

Weka productivity is low and the population may be shrinking (Chapter 2). Successful management at the population level that increases productivity and decreases variability in productivity will greatly increase the expected persistence time for the weka population on the East Coast (Goodman, 1987).

Young weka carrying radios, and those seen or retrapped after initial banding, dispersed no more than 1.5km from their parental home range. Because of the bias in sex ratio (Chapter 2) it could be expected that males would show greater dispersion in search of females, who in turn would move only into the nearest suitable habitat. It seems unlikely that dispersal of young weka accounts for the high disappearance rate of chicks observed (Chapter 2). Dispersal from natal areas may be slow (Table 4.3) as young weka gain local knowledge.

It is difficult to prove that predation is limiting weka productivity on the mainland, and impossible based on a sample size of 2. However, weka in predator trapped areas reared more young than weka in experimental control areas and there was no disappearance of adult weka from experimental treatment areas once trapping had begun. The next step is to expand on the results of this work. This could be done by using a larger sample, perhaps using the Western Weka (*Gallirallus australis australis)* in the South Island to provide suitable numbers.

Chapter Five: Movements, diet and survival of weka released at Karangahake.

5.0 Introduction

North Island weka have previously been liberated at Rawhiti, the Waitakere Ranges, the North Eastern Ruahines, Palliser Bay and the Takapau Plains, as well as Kawau, Mokoia and Rakitu Islands (Robertson, 1976, Macmillan, 1990, Pracy, 1969, unpub. DoC files, Ward et al., 1992, unpub.). 107 such translocations occurred between 1960 and 1988, and 104 of them failed to establish new populations that persisted (Ward et al., 1992).

The 3 populations established by translocation that have persisted longer than 15 years are on islands. However an earlier weka population on Kawau Island became extinct by 1945 (A.J. Beauchamp, pers. comm.) and the number of weka on Mokoia Island fluctuates and has been lower than 20 individuals (Graeme, 1994) so the North Island weka is far from secure even on these island refuges.

In some areas, (e.g. Takapau) weka survived and bred for a short time after release, but a population failed to establish (successive letters to the Wildlife Service by Gibert Severinsen, DoC files). The reason for the failure of these releases to persist has usually not been documented (but see Macmillan, 1990) and have been speculatively blamed on weka dispersing and attempting to return to their natal area (Graeme, 1994).

Griffith et al. (1989) predict population persistence is more likely when the number of founders is large, the intrinsic rate of increase is high and the effect of competitors and predators is low. Small random changes in reproduction and mortality (demographic stochasticity) and founder effects (genetic drift and inbreeding) could be expected to be detrimental to a small translocated population (Shaffer, 1987) and to lower its probability of persistence. Unpredictable changes in weather or food supply, and catastrophes such as floods or droughts, would also have a more pronounced effect on a small population (Shaffer, 1987). It was probably just such random effects that led newly established weka populations to fail in the past at least in the Waitakere Ranges where Macmillan (1990) pointed to predation by dogs and stoats as the probable cause of failure.

The Royal Forest and Bird Protection Society aims to release as many captive bred birds into the Karangahake Gorge as possible. In 1992 they successfully reared 17 birds for release. Their omnivorous habit would probably help weka establish, although the effect of predators on adult weka was not considered (Graeme, 1991) but likely to be significant (Macmillan, 1990; Chapters 2 and 4).

Given the past failure of weka translocations it is important to know why any future translocations of weka succeed or fail. Because of the (likely) small number of propagules and the large part chance plays in establishment it is necessary to follow individual fates. Radio telemetry is the only reliable way to follow and record the individual fate of secretive species like the weka (Section 2.0).

The captive breeding and release of weka into the Karangahake Gorge by the Royal Forest and Bird Protection Society (RFBPS) is an integral part of the Draft North Island Weka Recovery Plan (Ward et al., 1992, unpub.). Weka are to be reared from parental stock that came from Kawau Island and Otorohanga Kiwi House by members of RFBPS (A.Graeme pers. comm.). The Kawau population and the breeding birds at Otorohanga originated from birds taken from Gisborne when numbers were high (A.J. Beauchamp, pers. comm.). The release site and the soft release procedure were decided on prior to my involvement, and were based on the only documented successful release of weka on the mainland, to Rawhiti (Robertson, 1976).

The movement, survival and home range size of eleven radio-carrying weka caught and released at Rakauroa between August 1992 and January 1993 was compared to that of radio-carrying weka released at Karangahake between October 1992 and March 1993. If the release failed, any difference between the two groups of weka would indicate possible reasons.

5.1 Methods

5.1.1 RFBPS Preparation of weka for release

Weka released at Karangahake were parent-reared in aviaries around the North Island and taken to Karangahake at approximately 8-10 weeks old. They were released together after approximately 8 weeks in an aviary at the release site. A total of 17 birds were released at Karangahake, 4 females and 13 males. Six of the male birds were over a year old when transferred to the release aviary, being 1991 offspring from weka at Otorohanga Kiwi House. The remainder varied in age between 6 and 18 weeks on arrival. The average age at release was 17 weeks (s.d.=4 weeks, n=11 1992 bred birds). Weka had spent, on average, 8 weeks in the aviary (s.d.=3 weeks, n=17).

Supplementary food (Hilay pellets) was available at the release site after release. Weka were released by opening trap doors in the aviary and allowing them to wander out at will (Plate 5.1).

5.1.2 Weka at Rakauroa

It is not possible to accurately age adult weka in the field without considerable experience and so weka at Rakauroa were of unknown age. All except one were classified as adult because they had red irises and brown legs. The other bird was a young female aged around 16 weeks. Seven birds caught and released at Rakauroa were males, 3 were females and the sex of 1 was unknown. At Rakauroa weka were trapped by me within their home ranges and after radio tagging and banding (Chapter 2) were released back into their own home range.

5.1.3 Release of weka

Immediately prior to release at Karangahake I weighed the weka and sexed them using standard morphometric measurements (Carroll, 1963c, Beauchamp, 1987a). Ten of the weka had a radio fitted (Chapter 2). All weka released at Karangahake wore at least one metal band (NZ Banding

Service) and one coloured plastic band.

Four unradioed weka were released at Karangahake in October 1992. The first release of 3 radio-carrying birds, and 3 others, at Karangahake was on 30 November 1992. There was a second release of 2 radioed birds on 6 January 1993 and the last release, of 5 radio-carrying weka, was 25 March 1993.

5.1.4 Radio tracking

The position of radio-carrying weka (chosen at random by drawing band combinations out of a hat with replacement) was checked at randomly chosen times of the day (again by drawing times out of a hat, without replacement). I visited Karangahake and Rakauroa every month from November 1992 to June 1993. I spent from 4-22 days in each area each month. Because of the way the birds were randomised for data collection some weka were checked more than once on a given day and others were not checked at all. Individual weka were followed for up to 7 hours at Rakauroa (Chapter 2), but no more than 1 hour at Karangahake. Only the point at which they were first found was used as an independent point location. I also checked the location of all weka at least twice each trip to make sure they were still carrying their radios and alive. Point locations were collected in both areas until 24 June 1993. The individual fates of radio-carrying weka were recorded by finding dead weka, having corpses returned to me, recovery of slipped radios (fate unknown), by the weka still being alive at 24 June 1993 or by seeing the bird after recovery of the radio (recorded as alive). Radio survival refers to the length of time the weka wore a radio.

From the point locations I calculated the home range area using the minimum convex polygon method.

The relationship between survival (0-242 days) at Karangahake and age at release (1-52 weeks), length of time spent in the aviary (3-10 weeks), whether or not the birds had formed breeding pairs prior to release (0= no, 1=yes) and the source aviary of the birds (aviaries numbered 1-7) was investigated using a generalised linear modelling approach.

5.1.5 Dispersal from the release site

From the point locations, I measured the maximum distance (in a straight line) that radio-carrying weka dispersed from their release sites at Karangahake and Rakauroa. Two unradioed weka at Karangahake also contributed data to this set. One was recovered dead, the other was paired with a radio-carrying bird released after him and was regularly seen.

5.1.6 Diet Analyses

Faecal samples were collected whenever I found them in both areas. Each sample was frozen as soon as possible after collection, then thawed in hot water with a drop of detergent for microscopic examination. After shaking them vigorously I washed the samples over a pair of Endecott sieves (Chapter 3). I then calculated a "use index", which was the rank abundance (x) of the item in each faecal sample (ranks could be tied). There were no more than 8 different items in any one dropping. If an item did not occur in a given dropping I assigned it the rank of 10 (a rank of 0 would have lowered the total sum and led to the importance of items being exaggerated). I summed the ranks across the whole season (Σx). This number (Σx) was then divided by the number of droppings for the season (n, giving $\Sigma x/n$) to obtain an average rank for each item. These average ranks were then ordered to indicate the relative importance of each item in each season. I also calculated the number of faeces each diet item appeared in.

5.2 Results

5.2.1 Radio Survival

Fewer point locations were gained at Karangahake (Figure 5.1) because radio survival there was significantly lower (Mann-Whitney, $U=68$, $p<0.01$, Table 5.1).

Plate 5.1 A captive-reared weka leaves the release aviary at Karangahake for the first time. Photo by Gary Staples.

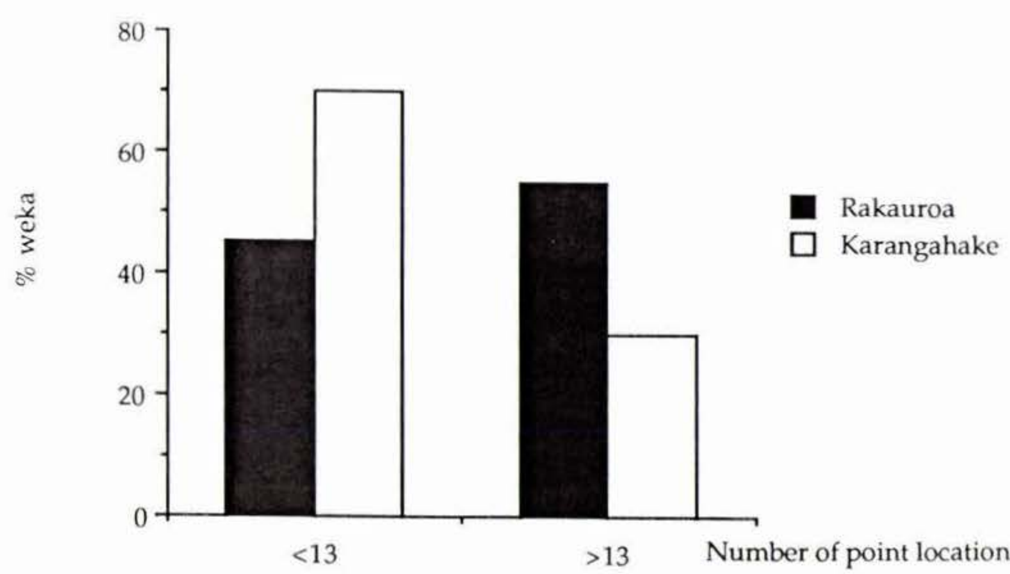


Figure 5.1 The relative frequency of point locations for radio-carrying weka in the two areas.

Location	n	Median (days)	Range (days)
Karangahake	10	13	2-128
Rakauroa	11	110	7-202

Table 5.1 Radio survival of translocated, captive-reared, weka at Karangahake and wild weka at Rakauroa.

This can be accounted for by the ultimate fate of the weka (Table 5.2). Where the fate is recorded as unknown it indicates that a weka removed the radio and was not seen or trapped again.

Location	Fate Unknown	Dead			A	n
		Dog Predation	Mustelid Predation	Unknown Cause		
K	[illegible]	5(2)	(1)	1	0	10
R	3	(0)	1	0	7	11

Table 5.2 Fates of radio-tagged weka at Karangahake (K) and at Rakauroa (R). A is the number of birds still alive on 24 June 1993. The number in brackets indicate probable cause of death as indicated by examination of the corpse (S. Cork pers. comm.).

At least five of the incidences of dog predation were by one dog, but a second dog killed at least one weka. These are necessarily minimum estimates because in some other cases the predator was not able to be identified.

5.2.2 Home range of weka

Translocated weka had substantially smaller home ranges than weka caught and released again at Rakauroa (Mann-Whitney, U=76.0, p<0.001, Table 5.3).

Location	n	Mean (ha)	st.dev.	Median (ha)
Karangahake	10	2.68	2.91	1.56
Rakauroa	11	10.03	7.71	9.09

Table 5.3 Home range size of weka at Karangahake and Rakauroa.

5.2.3 Predictors of survival

All four of the variables measured had a significant effect on the survival of the weka released. Since the data set is small (n=17), the number of paired birds was smaller (4 birds, and they were paired to each other) and two of the variables (age at release and time spent in the aviary prior to release) are correlated, the explanatory power of each variable is hard to interpret. It appears that weka aged between 21 and 30 weeks, having spent 6-10 weeks in the aviary may have survived better (Figures

5.2 and 5.3). Sample sizes are too small to draw any conclusion about the effect of where the weka were bred (Figure 5.4). A similar analysis in the future with a larger data set may be helpful.

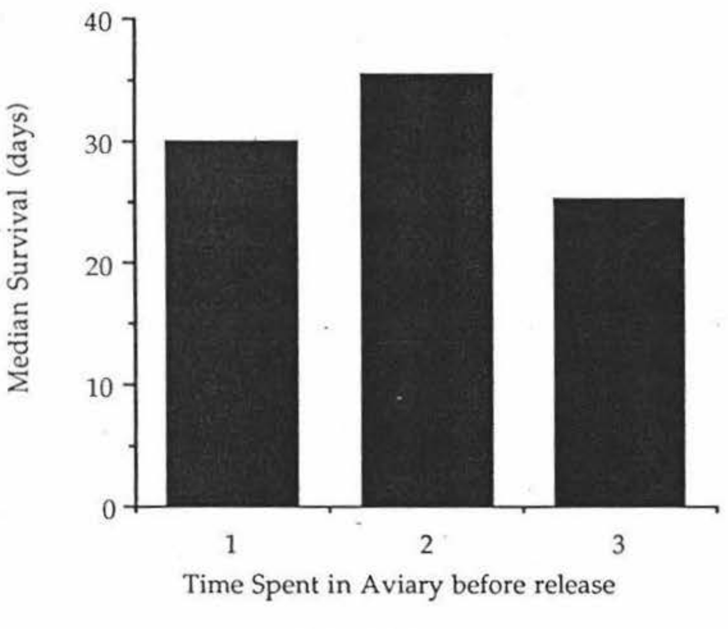


Figure 5.2 Median survival of birds versus length of time spent in the aviary. 1= less than 5 weeks, 2=6-10 weeks, 3=11-15 weeks.

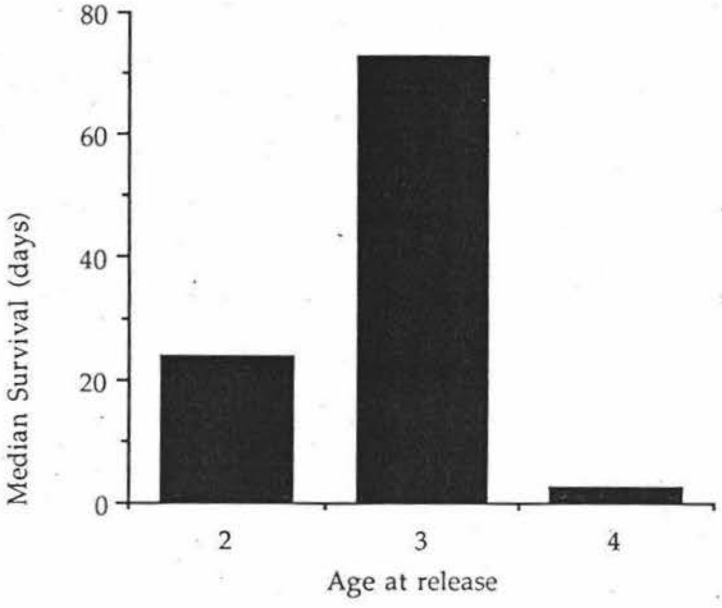


Figure 5.3 Median survival of birds released versus age at release. 2=11-20 weeks, 3=21-30 weeks, 4=>30 weeks.

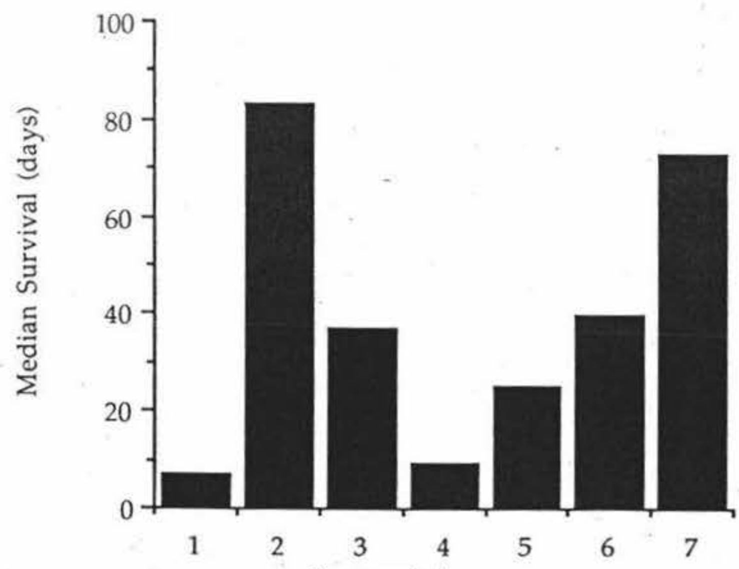


Figure 5.4 Median Survival of birds released for each contributing Aviary. Note that sample size for aviary 1=8, aviary 2=1, 3=1, 4=2, 5=2, 6=2 and 7=1.

5.2.4 Weka dispersal

Weka released at Karangahake had dispersed no more than 100m within the first 48 hours after release. By the end of the study they had dispersed further than those at Rakauroa (Mann-Whitney U=128.0, $p<0.05$, Table 5.4). Dispersal was greater despite smaller home ranges, because the home ranges were long and thin at Karangahake, whereas they were more rounded at Rakauroa. This was not because suitable habitat was long and thin at Karangahake, but probably because weka were still exploring the area, more or less in a straight line, when they were killed. It may be that dispersal is slow as weka gain local knowledge.

Only one or possibly two weka had dispersed so far that they could be considered lost from the potential pool of breeders around the aviary. One of these birds, an older male not fitted with a radio, was collected dead from the roadside 10km away from the aviary. The other, a female carrying a radio, stayed around the aviary until mid-April after her release in March. By mid-April most of her cohort were dead (although there were still weka in the aviaries) and then she moved about 4km, where she appeared to settle and was later killed.

Location	n	mean (m)	st.dev.	median (m)	range (km)
K	12	1,269	2,840	228	0.134-10
R	11	502	349	320	0.16-1.21

Table 5.4 Dispersal of weka from the site of release (R=Rakauroa, K=Karangahake). Note that n=12 at Karangahake because 2 birds not wearing radios contributed data to this set (see methods).

5.2.5 Weka diet

A total of 17 faeces were collected at Karangahake. 9 of them contained Hilary pellet material. 30 droppings were collected during the same period at Rakauroa.

Prey remains in faeces that contained a large proportion of pellet material were usually almost whole i.e. not broken down in the gizzard. Types of prey were similar to those taken at Rakauroa (Table 5.5). A more diverse range of seeds were eaten at Karangahake, probably reflecting the wider availability of fruit in gardens or compost heaps.

Diet item	Occurence in faeces at Karangahake n=17	rank	Occurence in faeces at Rakauroa n=30	rank
Annelida	5 (29%)	6	20 (67%)	2
Amphipoda	9 (53%)	4	13 (43%)	5
Chilopoda	3 (18%)	7	3 (10%)	15
Arachnida	1 (6%)	13	2 (7%)	14
Homoptera	0	n	5 (17%)	9
Diptera	0	n	1 (3%)	16
Dermaptera	0	n	2 (7%)	13
Beetle	2 (12%)	8	4 (13%)	8
Carabidae	2 (12%)	9	8 (27%)	6
Scarabaeidae	11 (65%)	3	15 (50%)	4
Tenebrionid	0	n	3 (10%)	12
Plant	16 (94%)	1	30 (100%)	1
Seeds	5 (29%)	5	15 (17%)	3
Snails	1 (6%)	12	3 (10%)	10
Pellets	9 (53%)	2	4 (13%)	7
Eggshell	0	n	3 (10%)	11
Isopoda	1 (6%)	10	0	n

Table 5.5 Diet items used by weka at Rakauroa and Karangahake. Rank compares the average rank abundance of each item (based on minimum estimates) in each dropping. N means the item did not occur in the faeces from that area.

5.4. Discussion

Weka released at Karangahake Gorge experienced lower survival and used smaller home ranges than weka released back into their home ranges at Rakauroa. Dispersal was further at Karangahake, but only 2 weka could be deemed "lost" from the release site as a result of their movements. The diet of weka in the two areas was similar. At Karangahake only one of the 17 birds released survived to the end of this study. The reason for the failure of the propagules to establish a new population was predation. This is the first time the reason for failure of a release of translocated weka has been known.

Captive breeding of the Lord Howe Island woodhen for re-release into pig-free areas resulted in an improvement of the status of the Lord Howe Island Woodhen (Miller and Mulette, 1985, Caughley, 1994). The weka has the potential to be just such a success story provided the agent of decline is identified and mitigated before any further releases are attempted. Macmillan (1990) was the first to recommend release of weka into predator-proofed areas and on the basis of the Karangahake experience, this seems imperative. The outcome of the private release of 8 buff weka (*Gallirallus australis hectori*) into a 20 hectare predator fenced area by R.D. Beattie Ltd (R. Beattie, pers. comm.) will be an important test of my conclusion.

The release of buff weka planned for Hinewai Reserve, also on Banks Peninsula, (P. Russell, pers. comm.) provides an opportunity to test other variables likely to affect the outcome of weka releases such as the age of individuals released, whether housing on site and post-release supplementary feeding are necessary or whether paired birds have a higher chance of survival (Russell, 1994, unpub.).

Griffith et al. (1989) state that "limiting factors must be identified and controlled... prior to translocation" if the translocation is to succeed. This opinion was reiterated by Komdeur (1994) who said "It is not enough simply to release rare bird species on other islands and gamble on their survival without conducting proper research beforehand." The rear and release programme for North Island weka has failed to consider the likely effect of predators despite evidence showing that predation can affect the outcome of other translocations (e.g. Hawaiian Goose, *Branta sandvicensis*, (Black and Banko, 1994), Cheer pheasant, *Catreus wallichii*, (Garson et al. 1992) and Australian marsupials (Short et al. 1992)). In addition, predators are known to have threatened other rail populations. Predation by rats (*Rattus spp.*) has been blamed for the extinction of the Laysan rail (*Porzana palmeri*, Ripley, 1977). Together with cats (*Felis catus*) the introduction of rats to the Chatham Islands probably spelt the end for the Chatham Island Banded rail (*Rallus modestus*, Ripley, 1977). As well as accounting for previous extinctions at least 2 rail species, predators are apparently responsible for the restricted distribution of other rails, along with the Lord Howe Island woodhen. The Aldabran rail (*Canirallus cuvieri*) now exists only on cat-free islands, and the Guam rail (*Rallus owstoni*) suffers in the presence of cats, rats and the introduced tree snake (*Boiga irregularis*)(Ripley, 1977, Jenkins, 1979, Savidge et al., 1992). The status of the New Caledonia wood rail (*Rallus lafresnayanus*) is unknown, but it was vulnerable to dogs (Ripley, 1977). Furthermore, predators may have affected weka releases in the past (Macmillan, 1990), yet the likely effect of predation on small weka populations has been lightly dismissed by the recovery group (Ward et al., 1992, unpub.) and completely ignored by RFBPS (Graeme, 1991, 1994).

An evaluation of the Karangahake site by A.J. Beauchamp showed that food supply and rainfall were adequate to support a population of weka. The weka population on Kapiti Island is regulated in a density dependent way with food supply determining the number and quality of territories (Beauchamp, 1987a). Since any establishing population is likely to be at low density for some time initially, it is unlikely to be regulated in a density dependent manner (Chapter 3). Environmental fluctuations, catastrophes and independent fluctuations in predator number are considered more important at these low densities (Shaffer, 1987). Indeed it is unlikely the high density of weka seen on Kapiti will be seen on the North Island in the foreseeable future, if it ever is again.

The aim of the RFBPS programme is to establish a weka population that acts as a source from which weka would move into other (sink) areas (Ward et al., 1992, unpub.). That is to develop a metapopulation. Given this aim the programme should attempt to establish weka in an area where productivity will be higher than in present mainland areas, and high enough to produce excess juveniles able to disperse to establish or augment other populations. Since it appears that predation may be affecting mainland productivity (Chapter 4) this should be thoroughly investigated before any attempt is made to introduce weka to mainland areas with the aim of establishing a source population. If the limiting factor(s) are identified then they can be mitigated in the release area allowing weka to live and breed successfully there and for the population to expand from there. It seems unlikely that under the present release regime a self-sustaining population will establish despite the continued release of weka into the area.

The programme aims to produce in excess of 100 juvenile birds for release to estalish other mainland populations (Ward et al., 1992, unpub., Graeme, 1991). Releases are expected to continue for up to 10 years (Ward et al., 1992, unpub.). Macmillan reported the release of 139 birds and attributed the failure to establish to predation. Until predation is mitigated it seems counter-productive to release birds in this way.

A systematic approach to weka releases is required to isolate the factors affecting survival. Such an approach might proceed as follows:

Testing to see if pre-release housing and post-release feeding influence post-release survival. Since both are expensive it would be advantageous to test their efficacy first.

Testing the effect of age of the released weka on post release survival. There is a high juvenile mortality at Rakauroa (Chapter 4) and older birds, whilst still susceptible, may be better able to cope with predation. The programme could thus test the release of mature and juvenile birds and evaluate the success of each.

It may be that wild bred weka are more able to effectively deal with predators than captive bred weka. RFBPS could harvest weka from an island (if this would not adversely affect the island population) and compare survival of island reared and captive reared birds. Alternatively RFBPS could release captive reared birds into an established population to bolster its numbers and then harvest the juveniles produced and release them elsewhere to extend the weka's range.

What makes an area suitable for release (i.e. what makes it have a high probability of establishment and long term persistence of weka) is not known. Weka established at Rawhiti in the absence of possums (*Trichosurus vulpecula*) and mustelids (Robertson, 1976) and persisted for over 10 years. Measuring food supplies, predator and competitor densities and the frequency of environmental catastrophes such as droughts may help clarify this. Release of weka into an area that has a low number of existing weka already that were able to be shifted (either temporarily or permanently) may help clarify whether it is some sites, or types of site, that are consistently more successful or whether other stochastic factors are more important.

Scott and Carpenter (1987) state "Because of the high costs associated with release programs and the endangered status of many of the animals, we cannot afford to introduce individuals to new environments without a high probability of their surviving and contributing genetically to a wild population". The release of weka at Karangahake fails on both counts, not only did birds have a negligible chance of survival (1/17=5.88%), but were they to persist it is most unlikely they would ever expand their range enough for it to be contiguous with the current weka range. For this reason the release of captive-bred weka (particularly females) into an existing population should be seriously considered. Weka at Rakauroa show higher survival and a combination of release and predator management in selected areas could increase weka productivity and create just the core-satellite population envisaged by the Recovery Group and RFBPS.

Chapter Six: Weka conservation and management

6.0 Introduction

Even under the best possible conditions, the long term persistence of a population is not guaranteed (Mangel and Tier, 1994). The population of North Island weka at Rakauroa appears to be declining at a rate of 4 birds per year (Chapter 2). The best population estimate is 39 adult birds. In a worst case scenario, if the current trend continues with no supporting immigration, weka are expected to be extinct at Rakauroa within 10 years. The population of weka at Rakauroa is considered to be one of the densest (although not necessarily the most productive) on the East Coast (Chapter 1). The future of weka in the North Island is clearly in jeopardy. Intervention is required now to prevent extinction.

Just why an omnivorous bird like the weka should be put at risk by an El Nino event remains unclear. A possible extinction scenario follows: Drought would reduce the supply of some foods, like plants, almost immediately and other foods, like fruits and insects, more slowly. The severe El Nino drought would have limited growth of pasture grasses. In response to this, farmers may have grazed stock in areas not normally used, e.g. roadsides and fallow areas. This increased grazing pressure could have destroyed both the cover and food supply of the weka. This would have had two main effects: it would have limited dispersal through habitat corridors that no longer provided protection and it would have reduced food supply to weka in the local patch. The reduced dispersal and food supply for weka combined with mortality due to hunting pressure from humans and a temporarily elevated effect of predators in "unsafe corridors" may have been sufficient to tip weka into a situation where "the worse it gets the worse it gets" (Caughley, 1994). That is, small and disjunct populations that were susceptible to chance factors and predation and not buffered by the effects of immigration. These would shrink in size with each generation thus exacerbating the adverse effects in a dwindling population. In damper areas, such as Rakauroa and Motu, the drought would be expected to have been less severe and more intact habitat would have been available to the weka. This would lessen the impact of habitat destruction and food reduction and promote immigration through continuous tracts of suitable habitat. The interaction of these three things would enhance persistence in damper areas.

Preserving the population of weka on the East Coast is an objective of the Draft Recovery Plan (Ward et al., 1992, unpub.). Management is going to be necessary to ensure that preservation. One of the aims of this study was to identify limiting factors and provide management recommendations.

6.1 Implications of my study

The number of North Island weka on the mainland and their distribution is unknown. A region-wide survey of weka throughout the East Coast Conservancy is necessary to determine how many weka there are, where they are and which populations appear to be the most productive. This will clarify which areas are potential candidates for effective intervention.

History has shown that large weka populations are prone to large fluctuations in numbers (Marchant and Higgins, 1993). The eradication of weka from islands is not compatible with their threatened status, and killing of weka should be discontinued. These weka could be made available for translocation.

Once key populations are identified from a region-wide survey, regular monitoring of these populations and important island populations like Kawau is necessary. In order to establish whether populations are expanding or contracting, surveys on the edge of known populations will be necessary. Ideally the characteristics thought to be important in population limitation e.g. rainfall, (Beauchamp, 1987a), predator density (Chapter 5) and percentage cover (Chapter 3) would be measured periodically at each site. This would provide comparative data from different populations and might indicate signals for management and what factors are limiting (Baillie, 1991, Hellawell, 1991, Green and Hirons, 1991, Usher, 1991, Caughley, 1994). Call counts are the recommended method of survey because they can be easily standardised across different areas and can make extensive use of volunteers, further publicising the plight of weka.

Weka use mainly ungrazed bush and scrub, and woodpiles (Chapter 3) seldom venturing out from cover. Intervention should focus on these kinds of areas initially.

The leading cause of weka mortality at Rakauroa was road deaths (Chapter 2). Publicity in the East Coast Conservancy of this fact and signs to indicate that weka are in the region may alleviate this problem.

Based on my observations and experimental results, predator removal has the potential to be an important management action for weka recovery. Removal of predators from selected areas could increase productivity and aid population recovery.

The release of captive-bred weka at Karangahake has been severely affected by predation on newly released birds. Since the effect of predators at Karangahake is likely to be ongoing and difficult to control without considerable expense a review of the release site is recommmended. The use of islands inhabited by man, and therefore of little conservation value, such as Waiheke, should not be ruled out if conditions can be shown to be suitable (i.e. a low density of predators such as mustelids, cats and dogs and an adequate potential food supply).

The weka population at Rakauroa is limited by the number of females and the survival of their young. It is possible that captive breeding and in situ management could be integrated, with captive-bred females being released to supplement the wild population. Local predator removal and release of females combined with publicity may allow recovery in numbers and restoration of continuity among sub-populations. If weka recover in numbers on the East Coast it will then be an appropriate time to consider other sites for release. If weka on the East Coast recover in numbers to pre-1983 population levels then "harvesting" of birds from there to establish other populations could be considered.

Kleiman et al. (1994) warn against liberating captive animals into an existing population because of potential disease transmission, but this can be countered by pre-release examination and may ultimately increase the resistance of the population as a whole (Craig, 1994). Since weka show low dispersal from their natal area and populations are discontinuous at present it is unlikely all weka on the East Coast would be put at risk.

Craig (1994) recommends a metapopulation approach to conservation. There are three main advantages of such an approach with weka: firstly the piecemeal approach that can be taken to management (Craig, 1994) i.e. managed areas can enlarge and contract on the basis of funding or other constraints. Secondly some kinds of metapopulations can result in increased persistence of a species due to decreased amplitude of population fluctuations brought about by a balance of local extinction and colonisation (Howe et al., 1991, Harrison, 1991, Hanski, 1991). Thirdly a metapopulation confers a broader range of opportunities for research, protection and public involvement (Craig, 1994). At present however each population of North Island weka on the East Coast is small and likely to be geographically and genetically isolated, as they are from the 3 island populations and the captive population, which originated with Gisborne birds.

Metapopulation dynamics rely on some level of density dependence in each population to promote emigration from source populations (Hanski, 1991). This could occur with weka at high density (Beauchamp, 1987), or it could be achieved by intervention (moving individuals).

6.2 Future Research

Future research is necessary into factors that affect the outcome of translocations. Variables that could be tested include time spent in an aviary prior to release, age at release, what makes a good location, whether supplementary food is necessary, suitability of captive birds for release, and whether the age of the birds released has any effect on subsequent dispersal and survival.

Larger scale research into juvenile dispersal on the mainland is required, possibly using genetic analysis to determine parentage.

Removal of predators is the most sensible management option at Rakauroa. An experiment testing the effect of removal of egg predators on weka and other ground nesting species in the area would clarify the role of egg predation in breeding failure. If Rakauroa residents were encouraged to shoot wild cats and mustelids from November to January the ratio of juvenile to adult weka sighted in autumn could be compared with the ratio in a similar (control) area. This could be used as a rough guide to the effectiveness of predator removal and establish the costs of such a procedure.

6.3 Summary

Management should commence soon to prevent extinction of weka on the mainland. Initially a region-wide survey is indicated to identify important populations (in terms of numbers or location). Intervention should focus on removal of predators from breeding areas in these important locations and protection of independent juveniles from predators. Since most breeding occurs between November and January (Chapter 2) this is the best time to trap. The aim of any management should be to increase productivity to allow the population to become self-sustaining in the first instance and then ultimately to allow birds to move out into adjacent (unmanaged) areas. Recovery could be enhanced by release of captive-bred birds (particularly females).

The establishment of habitat corridors away from roads should be a priority. The usefulness of these "rubbishy" areas to weka should be widely publicised in the East Coast Conservancy encouraging farmers and land managers to consider weka in their grazing decisions. Road signs warning motorists new to the East Coast of weka crossing in the area may be beneficial in decreasing the weka road toll.

Longer term monitoring is essential and should be coupled with research and modelling of demographic parameters to help predict persistence and identify irreparable declines.

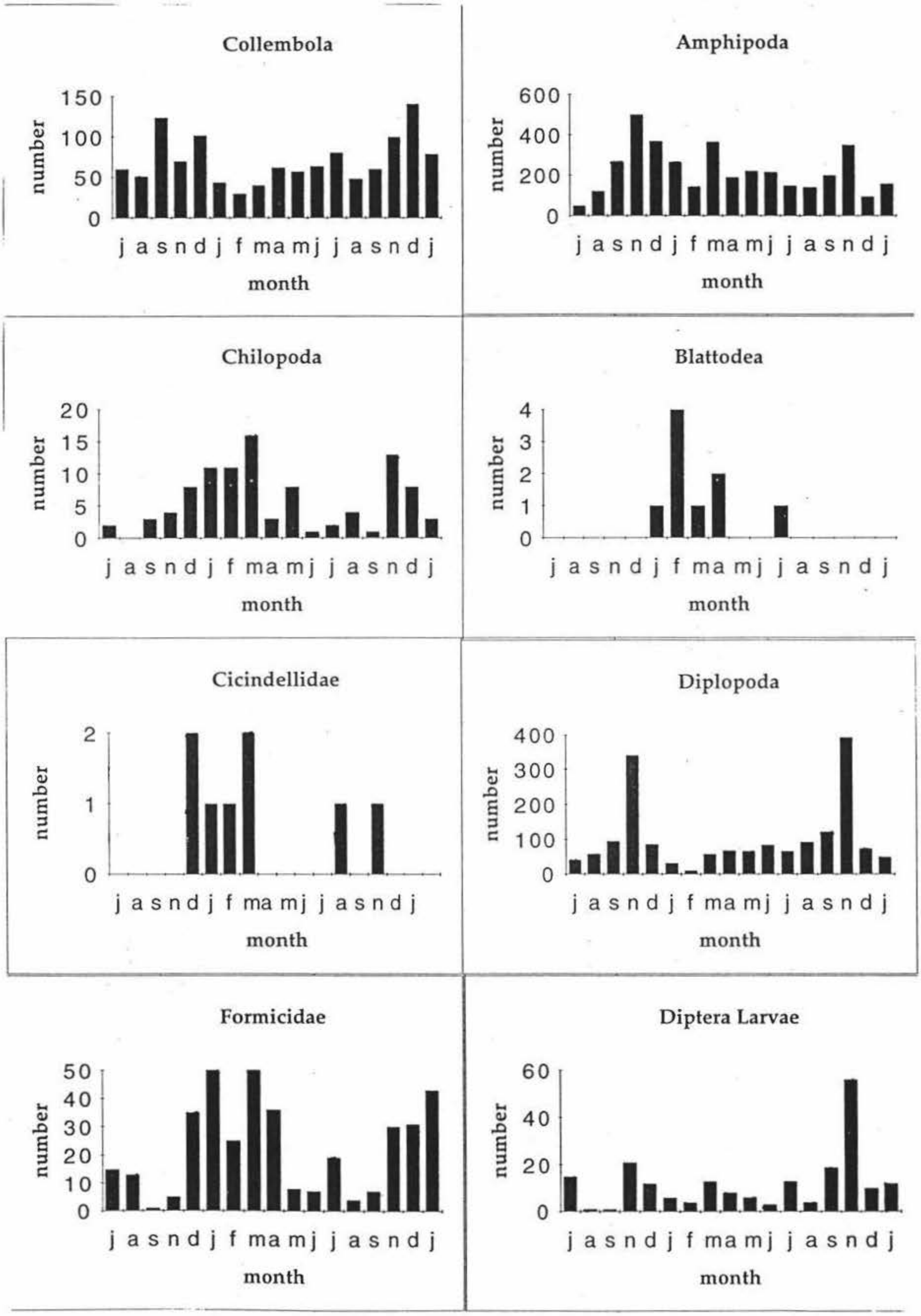
Appendix 1: Plant species referred to in Figure 3.13

Five Finger	*Pseudopanax arborea*
Karamu	*Coprosma robusta*
Weeping Matipo	*Myrsine divaricata*
Supplejack	*Ripogonum scandens*
Marbleleaf	*Carpodetus serratus*
Pate	*Schefflera digitata*
Tutu	*Coriaria arborea*
Tawa	*Beilschmiedia tawa*
Mahoe	*Melicytus ramiflorus*
Tree fuchsia	*Fuchsia excorticata*
Kahikatea	*Dacrycarpus dacryoides*
Wineberry	*Aristotelia serrata*
Bush Lawyer	*Rubus cissoides*
Rimu	*Dacrydium cupressinum*
Poroporo	*Solanum aviculare*
Matai	*Prumnopitys taxifolia*
Lancewood	*Pseudopanax crassifolius*
Kaikomako	*Pennantia corymbosa*
Hinau	*Elaeocarpus dentatus*
Totara	*Podocarpus totara*
Kawakawa	*Macropiper excelsum*
Titoki	*Alectryon excelsus*
NZ passionfruit	*Tetrapathea tetrandra*

Appendix 1 continued:

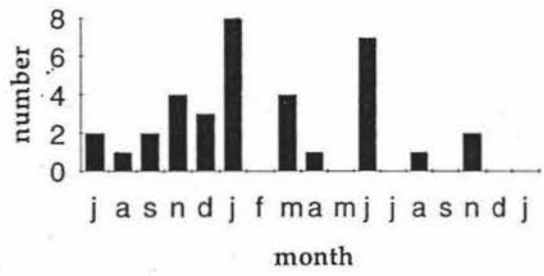
Pigeonwood	*Hedycarya arborea*
Red matipo	*Myrsine australis*
Raspberry	*Rubus idaeus*
Cotoneaster	*Cotoneaster glaucophylla*
Nightshade	*Solanum nigrum*
Blackberry	*Rubus fruticosus*
Barberry	*Berberis glaucocarpa*
Holly	*Ilex aquifolium*
Walnut	*Juglans regia*
Inkweed	*Phytolacca octandra*

Appendix 2: Seasonal abundance of invertebrates at Rakauroa.

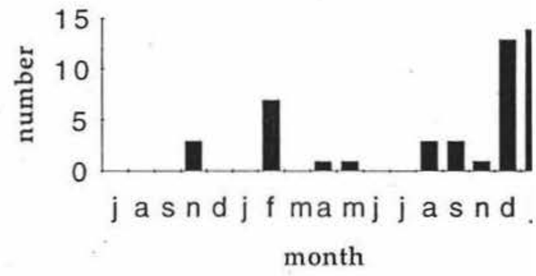


Appendix 2 continued:

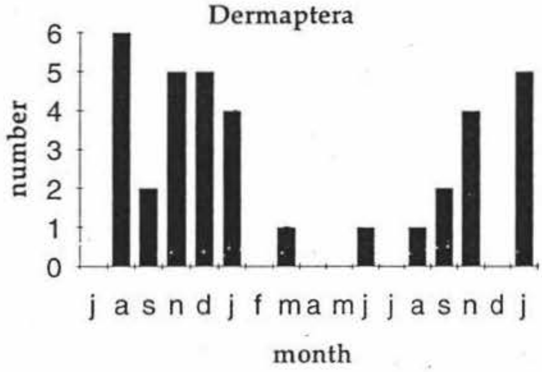
Coleoptera larvae



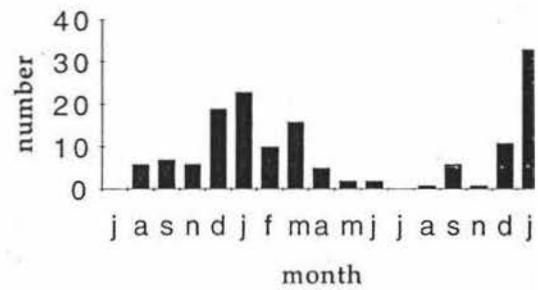
Homoptera larvae



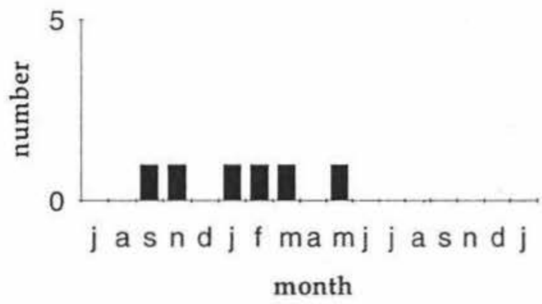
Dermaptera



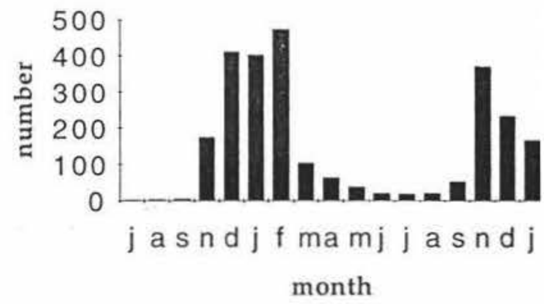
Opilionidae



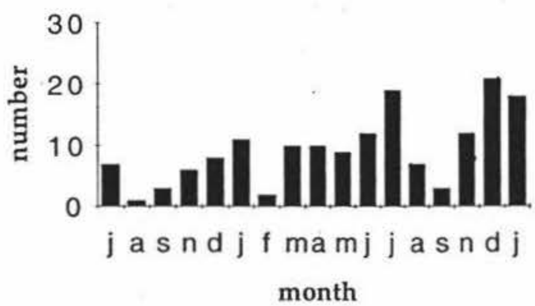
Platyhelminthes



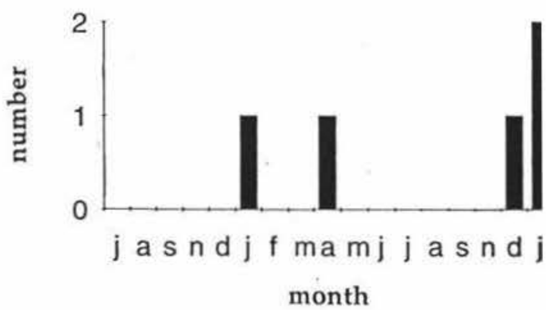
Isopoda



Staphylinidae

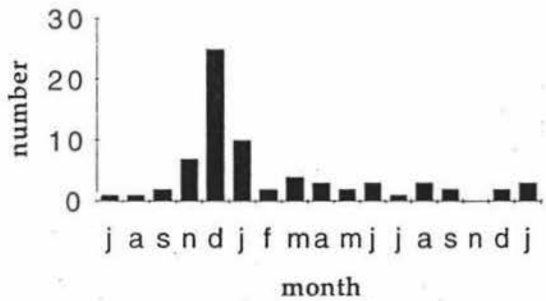


Thysanura

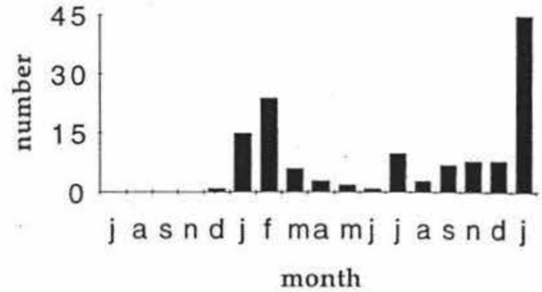


Appendix 2 continued:

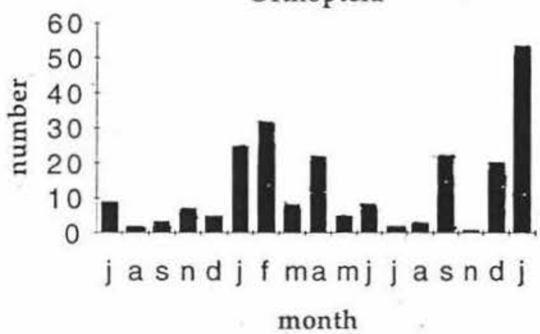
Snails



Tenebrionidae

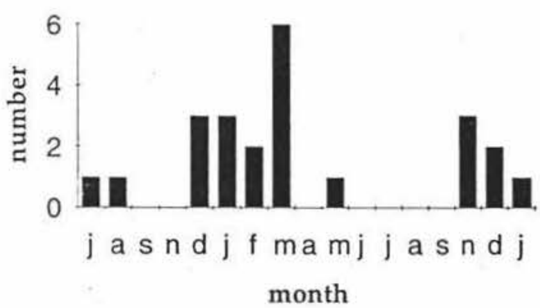


Orthoptera

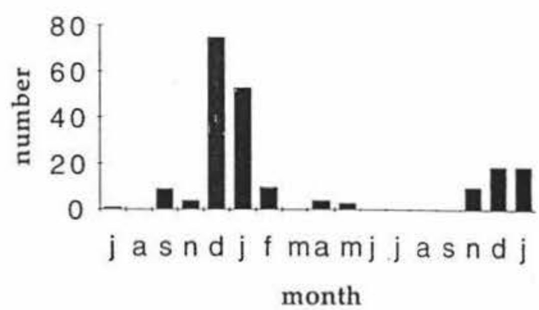


Carabidae

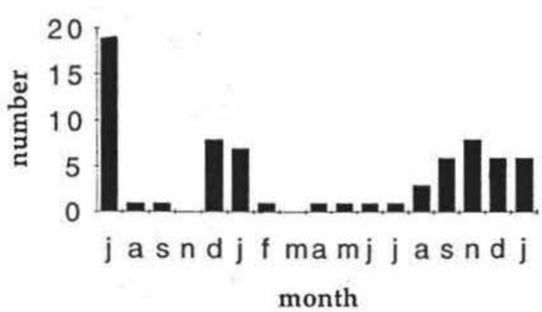
Elateridae



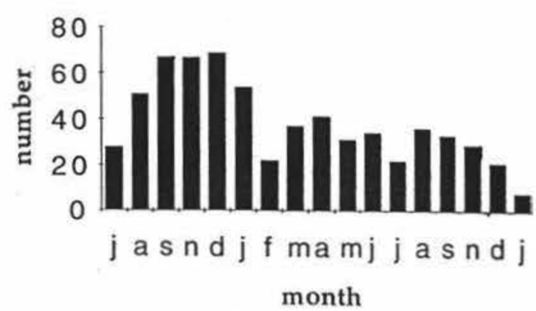
Scarabeidae



Acari

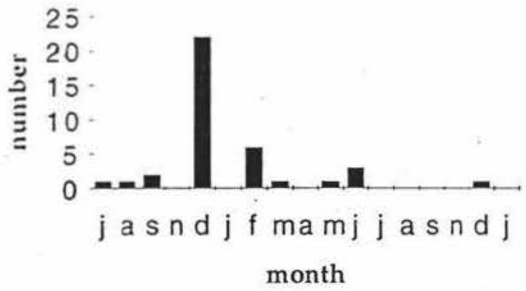


slugs

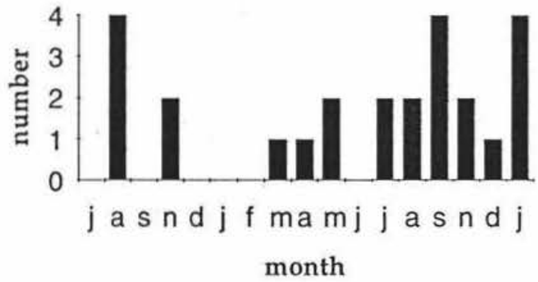


Appendix 2 continued:

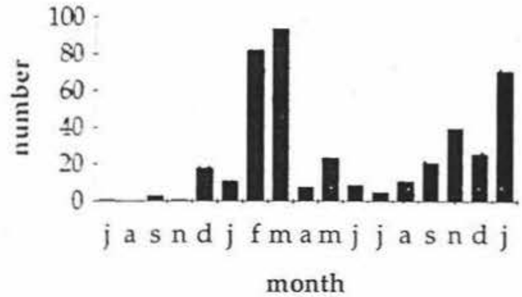
Coccinellidae



Elaterid larvae

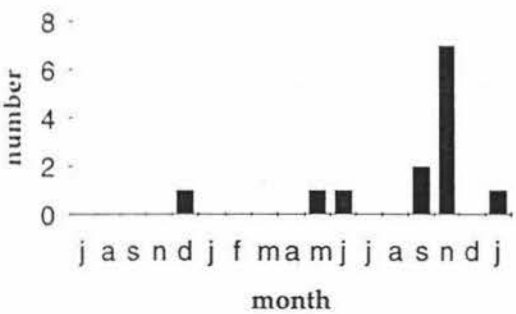


Vespidae

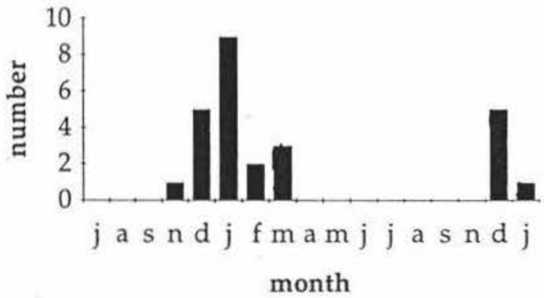


Annelida

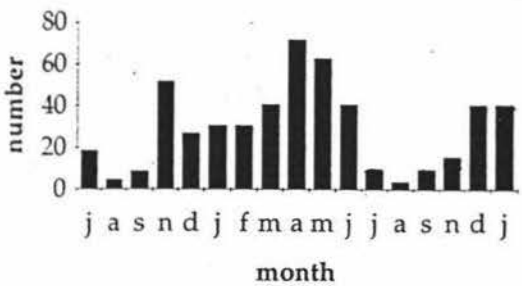
Neuroptera



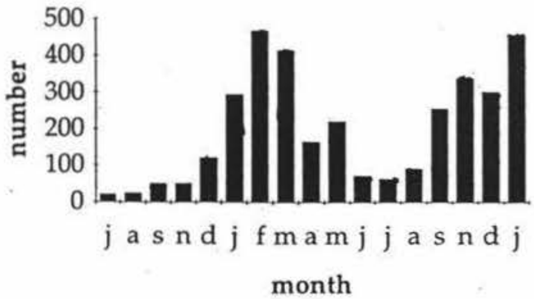
Apidae



Other Coleoptera

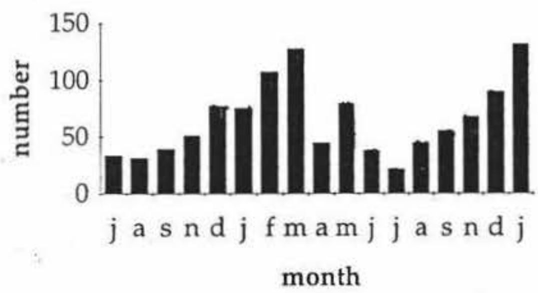


Diptera

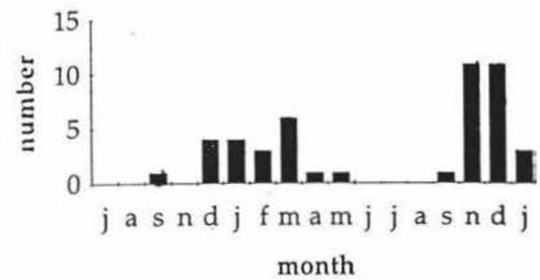


Appendix 2 continued:

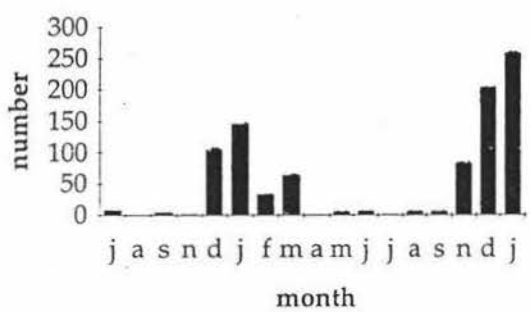
Araneid



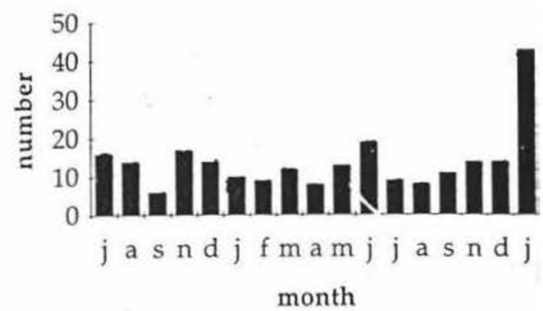
Curculionidae



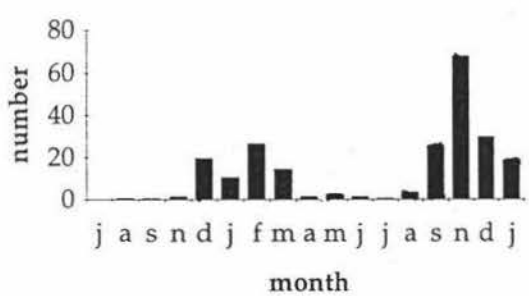
Homoptera



Lepidoptera Larvae



Lepidoptera



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