Returning Wētāpunga to the Islands of Ipipiri.

Post translocation report 2021-2022

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Abstract

When the name Wētāpunga (*Deinacrida heteracantha*) is translated literally from Te Reo Māori, it means the God of ugly things. However, the unique appearance that inspired such a title has also earned them a position of flagship species for New Zealand insect conservation. Of the 11 endemic giant wētā species, the wētāpunga are the largest, but despite their fearsome appearance and large size they were almost defenceless against the habitat modification and invasion of predators which accompanied human colonisation. As a consequence, this once prolific insect was reduced to a single population on O' Hauturu-O-Toi, Little Barrier Island. Recognising the vulnerability of such a small population, a wētāpunga recovery plan was initiated and a breeding program established at Auckland Zoo and as a result, over 5000 individuals have been translocated to safe, predator-free islands. Three of the island's recipient to the translocation of wētāpunga are part of a wider restoration program known as Project Island Song. Here, just over 200 individuals have been introduced over two releases during December 2020 and June 2021. Vital to the translocation process is the monitoring of founder populations to look for evidence of persistence as this can help shape the success of future operations. 60 tracking tunnels were set with inked cards baited with peanut butter, and ad hoc visual searches conducted between October 2021 and May 2022. 11 cards across the 3 islands returned positive tracking results with the majority over the summer months on the island of Motuarohia. Whilst these results are promising, continued monitoring over the coming years will be necessary to confirm the presence of a self-sustaining population considered the hallmark of a successful translocation.

Introduction

New Zealand's unusual biota

The unique ensemble of flora and fauna in New Zealand has led to its recognition as one of the world's biodiversity hotspots (Conservation International, 2010). Separating from the ancient land of Gondwana over 80 million years ago, the consequence of New Zealand's isolation has been the evolution of a high degree of endemism (Trewick et al, 2007). Ninety per cent of an estimated 20,000 insect species (Watts et al, 2012) and 85% of vascular plants are found nowhere else on earth (McGlone et al, 2001) and yet some classes and orders such as Mammalia and Squamata have very little or no representation whatsoever (Daugherty et al, 1993). Of the species present, some, such as the Leiopelmatidae frogs and the tuatara (*Sphenodon punctatus*) have changed little since ancient times. For others, such isolated evolution has led them to develop several unusual traits such as gigantism, longevity, flightlessness and low reproductive rates (Daugherty et al, 1993). Among those exhibiting both ancient lineage and a suite of unusual traits are the 11 species of giant wētā, including one of the world's heaviest insects, the wētāpunga (Pratt et al, 2008). Named after Punga, the Māori God of deformed and ugly creatures, these giant insects can measure up to 82mm in length with the larger females weighing up to 35g and gravid females up to 70g (Richards, 1973).

Taxonomy

Considered Gondwanan in origin, the orthopterans from the family Anostostomatidae consist of 41 genera containing in the region of 200 species found predominantly in the southern hemisphere (Johns, 1997). In New Zealand they are represented by four groups, the most encountered being the *Hemideina* or tree wētā which frequent human habitats. Together with the *Deinacrida* or giant wētā they are unique among anostostomatids in that they are largely herbivorous by nature whereas New Zealand's other two groups, the most speciose *Hemiandrus* (ground) wētā and *Anisoura/ Motuweta* (tusked) wētā are predatory (Johns, 1997).

Life history

Nocturnal and arboreal, the preferred habitat of wētāpunga is lowland mixed forest which provides them with plenty of daytime refuge in crevices and amongst leaf cover. Almost totally herbivorous, they climb into the canopy by night and browse on a wide variety of flora including kohekohe (*Didymocheton spectabilis*), mahoe (*Melicytus ramiflorus*), and *Coprosma grandifolia* (Richards 1973, Watts and Thornburrow, 2011). In doing so, they are fulfilling a vital nutrient cycling role within the forest as their excreta falls to the ground. Although juveniles show some shelter fidelity, adults are largely nomadic, rarely returning to the same shelter on consecutive nights. Males tend to travel further than females, most likely in search of mates and can travel up to 80m in a single night (Watts and Thornburrow, 2011). It has been suggested that stridulatory signals may be used to attract mates (Field,1993) which are picked up by complex tympanal ears located on their tibia (Strauß et al, 2017). The release of pheromones also seems a likely method of communication between potential mates. During behavioural observations, males have been recorded following the female at close proximity whilst continually waving their antennae and retracing their steps to become reunited should they become separated (Richards 1973, Watts and Thornburrow, 2011). Coupling occurs overnight with the pair moving to the forest floor to mate the following morning (McIntrye, 2001). Copulation may occur several times in a single day, lasting about an hour each time using one of four different positions (Richards 1973, Watts and Thornburrow, 2011). Females return to the ground for oviposition where they select soft substrates in which to place their eggs. The incubation period for eggs averages 125 days but depends on the time of year as they will enter embryonic diapause during winter if conditions dictate. Eggs laid in spring or early summer undergo the most rapid development and have the highest hatch rates (Richards, 1973). Hatchlings will undergo 2 instars before the onset of winter when they may enter nymphal diapause until the following spring when growth recommences. They will undertake ecdysis a further 8 times, enlarging between 25 and 40% each time, before reaching a 10th instar prior to the onset of a second winter. Only in the spring of their third year, do they reach the full maturity necessary for reproduction, surviving as adults for 6 to 9 months (Richards, 1973, Watts et al, 2021).

The decline of the wētāpunga

Frequent ecdysis leaves wētāpunga especially vulnerable to predation without the protection of their rigid exoskeleton and their lengthy life history inhibits the chance of a rapid population recovery should their numbers decline. The arrival of mammalian predators and in particular, *Rattus* sp., which accompanied human colonisation, brought unprecedented change for much of New Zealand's fauna, and for some giant wētā species, introduced a predator they were ill equipped to overcome. Their large size, nocturnal habits, strong olfactory and acoustic presence rendered them easy targets, whilst flightlessness and slow movement offered them little defence (Gibbs, 1998). Habitat loss, although not directly responsible for the decline in numbers would have accelerated the process (Sherley, 1998).

The outcome for the wētāpunga was the decimation of once abundant numbers throughout northern New Zealand (Colenso, 1882) to a single remnant population on Te Hauturu-O-Toi, Little Barrier Island (Meads & Notman, 1993). A survey of the Te Hauturu-O-Toi population in 1992 backed up Meads and Balance's (1990) conclusion that numbers were alarmingly low, most likely due to the presence of Kiore (*Rattus exulans*) (Meads & Balance, 1990; Meads and Notman, 1993). A subsequent recommendation was made to further protect this delicate population by extending the current limits of predator control and an immediate establishment of a captive breeding program (Meads and Notman, 1993).

A further survey by the Department of Conservation during 1994 and 1995 revealed a further decline in numbers in areas where predator control had ceased and tīeke *(Philesturnus rufusater)* numbers had increased. It was noted that remaining populations were becoming increasingly isolated, heightening the risk of extinction through stochastic events or genetic vulnerability (Gibbs & McIntyre, 1997). A high priority was placed on the need to establish a population on a predator-free island and with numbers too low to risk wild-to-wild translocations, it was becoming evident the eradication of rats from the island and a captive breeding program were essential to the survival of this species. Several captive breeding programs for giant wētā were already in place including those for the Cook Strait giant weta (*Deinacrida rugosa*), Mahoenui giant weta (*Deinacrida n. sp*), Poor Knights giant weta (*Deinacrida fallai*) and Middle Island tusked weta (*Motuweta isolata*). Relative to vertebrates, invertebrate captive breeding programs are relatively easy to establish as they require limited space and resources and the animals have high reproductive rates (Sherley, 1998).

A challenging kiore eradication program concluded successfully in 2004 (Bellingham et al, 2010) and as a result, wētāpunga numbers were estimated to increase by 50% over the following 5 years (Green et al, 2011). By 2009, recovering numbers enabled the harvesting of founding individuals to establish a captive breeding program at Butterfly Creek in Auckland in association with Auckland Zoo. As a result, over 5000 wētāpunga have been released onto offshore predator-free islands (Healey, 2020).

Project Island Song

Located in Northland's Bay of Islands, Project Island song is a partnership between a local community group known as the Guardians of the Bay of Islands, Ngati Kuta, Putukeha and the Department of Conservation. Together they are dedicated to the restoration of the Islands of Ipipiri, a group of 7 islands situated off the coast of Cape Brett. Predator-free since 2009, 5 species of bird have now been re-introduced to the islands along with Duvaucel's gecko (*Hoplodactylus duvaucelii*) and now, wētāpunga. The translocations are the culmination of over 4500 hours of work from volunteers who have planted 39,000 trees since 2003 and dedicate their time to restoring the native habitats on the islands to provide refuge to rare and endangered species (projectislandsong.co.nz).

Translocation

Translocation is the managed transfer of living indigenous flora and fauna to a new location for the maintenance of biodiversity. This can be either to re-establish a locally extinct species, augment an existing small population or establish a new population when extinction is considered imminent without intervention. Translocations are multi-faceted processes which include years of planning prior to the actual transfer, followed by several years of post-release monitoring and management. The translocation is only deemed successful when a population is established and producing viable young among multiple generations. Success is limited, with the overall rate in New Zealand estimated between 7 and 40% depending on species (doc.co.nz).

The first recorded successful translocation of a giant wētā species was the transfer of Cook Strait giant wētā (*Deinacrida rugosa*) from Mana Island to Maud Island in September 1977. Their consequent abundance has enabled them to become a donor population for further transfers (Watts et al, 1998a). Another species, the Mahoenui giant wētā (*Deinacrida mahoenui*) were retrieved from the edge of extinction when released at 7 sites between 1989 and 2002, with 4 of those sites proving successful. Upon investigation, the difference between the successful and unsuccessful transfers proved to be the presence of rats (Watts & Thornburrow 2011) and it was only through stringent post-translocation monitoring that these differences were revealed. If populations fail to establish it is vital to be able to identify causative factors and equally, should they be flourishing, information can be forwarded to assist the success of further translocations. With limited translocations of giant wētā species to date, a formal protocol for the monitoring of these populations is yet to be established. Their presence can be confirmed by locating their distinctively large faecal pellets (Island et al, 1995) or through the use of baited tracking tunnels (Watts et al, 2008b). Alternatively, visual searches can be undertaken either by searching refuges within their habitats by day or in the hours following dusk when they are most active using spotlights. Both visual methods require multiple people with experience in locating and identifying the target species. Previous studies have revealed that the majority of giant wētā activity is recorded on damp, still and warm nights and particularly during darker phases of the moon (McIntyre, 2001, Watts & Thornburrow, 2011).

Returning wētāpunga on the Islands of Ipipiri

Two translocations have been undertaken, releasing a total of 210 late-instar wētāpunga onto Urupukapuka, Moturua and Motuarohia Islands. Forty-three individuals of close to even sex ratio were released onto each island in December 2020, augmented by an additional 27 to each island in June 2021 (Richard Robbins, pers comm). Post translocation monitoring of these populations will be challenging. As wētāpunga are cryptic and arboreal, they are discovered typically amongst dense foliage, affording them excellent camouflage, and making them difficult to detect. When using tracking tunnels to detect wētāpunga, only the large tarsal dimensions belonging to fully grown adults may be recorded as smaller footprints belonging to juveniles or subadults are indistinguishable from the Auckland tree weta or Auckland cave weta (*Gymnoplectron acanthocera*) (Watts et al, 2013), both known inhabitants of the islands (R Robbins pers com).

The limited number of post-translocation surveys of wētāpunga conducted previously means there is still much to learn about detecting this elusive species. The objective of this study was to detect the presence of wētāpunga on the Islands to be able to confirm their survival through the introductory phase of the translocation and provide baseline data for future surveys. Secondly, to gain further understanding of the environmental conditions best suited for their detection.

Methods

Study Area

The Islands of Ipipiri are located in the Northland region of New Zealand and comprise of seven main islands and a multitude of associated rock stacks and Islets (Figure 1). The release sites on Urupukapuka and Moturua Islands are both in shallow gullies under canopies of mānuka/ kānuka forest with regenerating understories of coastal broadleaf forest. The site at Motuarohia is in a steep sided gully, lined with an understory of *Coprosma* sp., kawakawa (*Piper excelsum*) and hangehange (*Geniostoma ligustrifolium*)

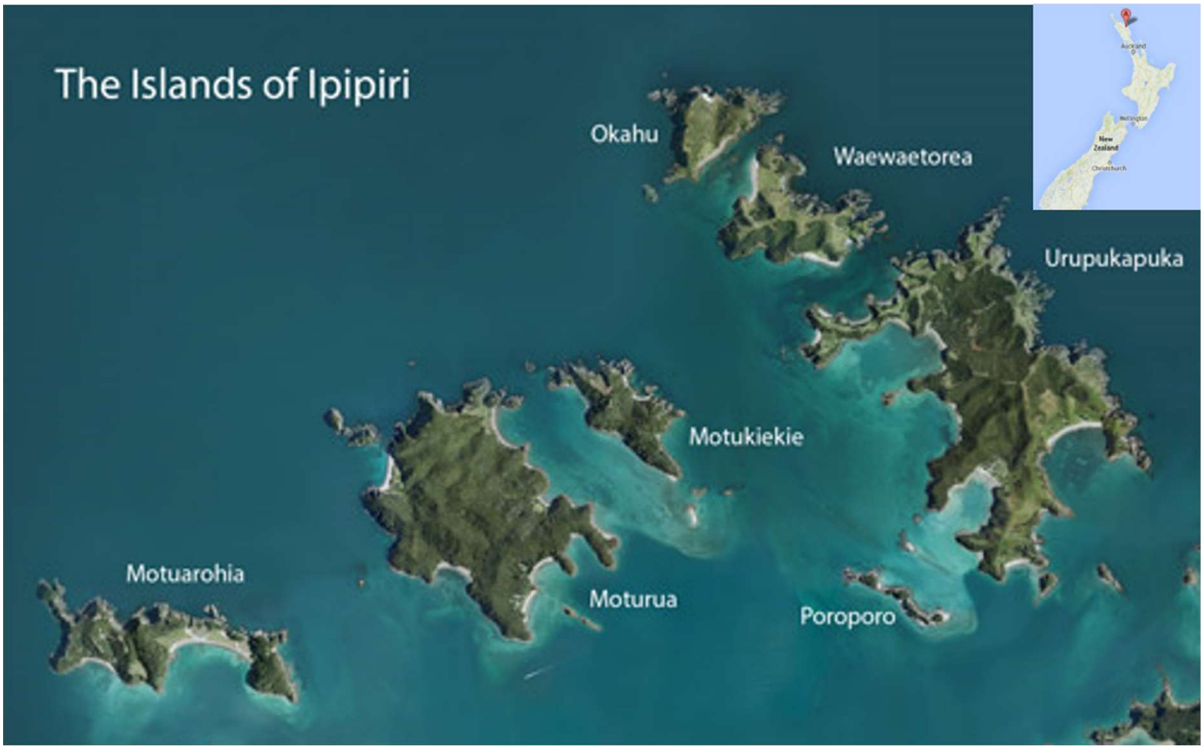

Figure 1. The location and position of the Islands of Ipipiri

beneath a tall canopy of maritime pines *(Pinus pinaster)* of approximately 30m, some of which have fallen.

Tracking tunnels

Tracking tunnels have been used extensively in New Zealand to detect the presence and estimate densities of introduced mammals (King and Edgar, 1977, Blackwell et al, 2002). More recently they have been used to detect giant wētā which produce distinctive footprints consisting of a row of four closely adjacent dots originating from contact with their distended tarsal pulvilli pads (Watts et al, 2008b). Cards containing a central strip of non-toxic, non-drying and waterproof ink are secured inside a waterproof polypropylene tunnel allowing animals to pass through and leave impressions of their footprints. Bait may be used to attract the target species and adding peanut butter has been found to result in twice as many wētā footprints to be recorded (Watts et al 2008). It is important to note that only the prints of the largest wētā species present can be used to identify the presence of giant wētā in areas where other species are present. The dimensions allowing for positive identification of wētāpunga are 4.3mm for the protarsus, 4.9mm for the mesotarsus, and 8.9mm for the metatarsus (Watts et al, 2008b).

Two transects, each comprising of 10 'Black Trakka' tracking tunnels (Gotcha Traps, 2 Young St. RD2 Warkworth) approximately 20 m apart were positioned on each island. Most of the tunnels used for this survey were already in situ but any missing tunnels were replaced, and their location recorded using a Garmin handheld GPS device and marked with flagging tape for ease of rediscovery. Each transect passed close to or through release sites and was loosely associated with the downward direction of a gully. Pre-inked tracking cards were placed in each of the tunnels with a teaspoonful of peanut butter placed in the centre as bait. At each subsequent visit, cards were removed, and any prints were recorded and photographed before new baited cards were installed. Tunnels were set on Urupukapuka island between 29 September 2021 and 4 May 2022 and on Moturua and Motuarohia from 4 November 2021 until 4 May 2022. The timeframe during which the tunnels were set was dependent on available boat transportation to the islands and ranged from 6 to 60 days. This inconsistency was largely due to the effects of ongoing covid associated restrictions.

Meteorological data were acquired from the NIWA weather station at Russell which is between 6 and 12km away from Motuarohia and Urupukapuka islands respectively (cliflo.niwa.co.nz).

Figure 2

Figure 3

Figure 4

The position of the tracking tunnel transects on Moturua (*Figure 2*), Urupukapuka (*Figure 3*) and Motuarohia (*Figure 4*) islands. (Maps sourced from Google Earth)

Visual searches

As time permitted, *ad hoc* searches of areas immediately surrounding the tracking tunnels were conducted for live individuals, paying particular attention to the dead fronds of *Cyathea dealbata* and crevices among larger tree branches as well as the bamboo refuges which were used for their transportation and subsequent release. Nearby foliage was also inspected for signs of browse and the ground below was searched for faecal pellets. On one occasion searching by spotlighting was conducted for several hours after dusk on Moturua Island in the areas adjacent to the tracking tunnels.

Data Analysis

The percentage of tunnels to record wētāpunga footprints was calculated for each sampling duration both overall and separately for each island. Rain, wind, and temperature averages were calculated for each sampling duration and two-tailed t-tests conducted to look for significant differences when tracked and untracked results occurred. Results were also compared against the moon cycles for each sampling duration to look for any consistencies.

Results

Tracking tunnels

Tracking tunnels on all three islands displayed footprints with tarsal dimensions consistent with wētāpunga. An overall tracking rate of 1.3% was recorded from the total 700 cards that were analysed from all three Islands. Urupukapuka recorded the lowest tracking rate at

0.8% with Moturua and Motuarohia islands recording 1.4% and 1.9% respectively. 81.9% of the tunnels tracked were during, or within a week of the summer months (Figure 5).

The first positive tracking card was collected from Urupukapuka island during the initial sampling duration. This was the only island to have cards installed in the tracking tunnels during this time as installations did not occur on either Moturua or Motuarohia islands until early November. A second tracking occurrence, some distance from the first, was recorded on Urupukapuka between 4 and 5 months later during the latter half of February.

Tracking was most consistent on Motuarohia where one or more tunnels were tracked during 4 of the 11 sampling durations, all of which occurred during, or within a week of summer. This was also the only island to have the same tunnel tracked on more than one occasion although there were additional tunnels tracked some distance away. There was also a degree of separation between the tunnels to record tracks on Moturua, which was the only island to detect tracking later into autumn for the extent of time covered by this report.

There was a definite increase in tracking at the onset of summer (*Figure 5*) which saw a slight rise in mean minimum temperatures and reduced average rainfall. However, any differences between the weather indices during tracked and untracked sampling durations were minimal (*Figures 6,7 and 8*) and t-tests revealed no evidence to support an association between either wind ($t= 0.019268$ df 9 $p=>0.05$), rain ($t= 1.3204$ df 9 $p=>0.05$), or minimum temperature ($t= 1.5752$ df 9 $p=>0.05$) and the presence of tracks in tracking tunnels.

There appeared to be some level of correspondence between moon phases and tracking occurrences. This was more apparent through a lack of tracking results during brighter or full moon phases than by a comprehensive tracking record when the moon was new (Table 1). This could not be statistically confirmed using a chi-squared test of association as the expected frequencies would be too low.

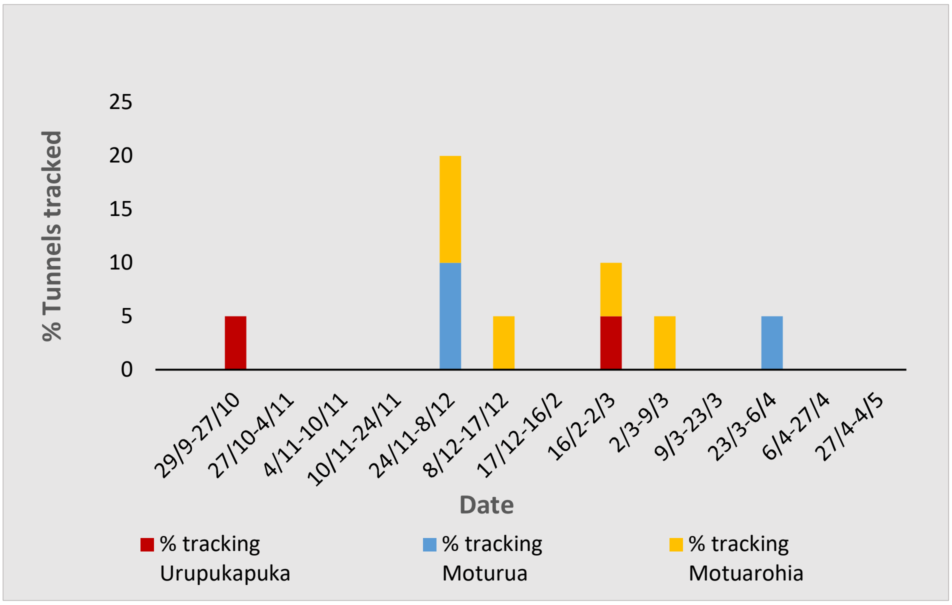

Figure 5. Percentage of tunnels tracked on each of the islands and for each sampling duration

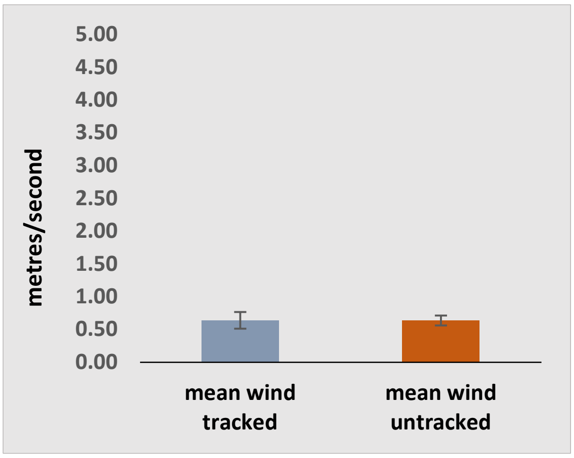

Figure 6. Average daily wind conditions during sampling durations when tracks were detected versus not detected showing standard errors of the mean.

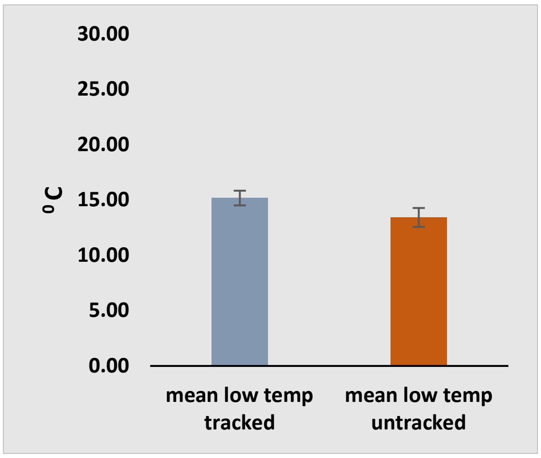

Figure 7. Average daily minimum temperature during sampling durations when tracks were detected versus not detected showing standard errors of the mean.

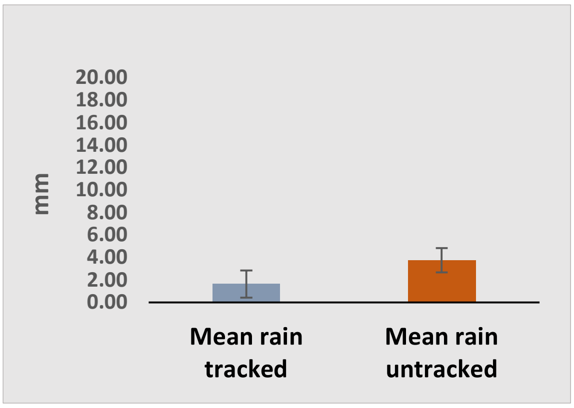

Figure 8. Average daily rainfall during sampling durations when tracks were versus not detected showing standard errors of the mean.

Table 1. Summary of moon phases for tracked and untracked sampling durations

	New	Rising-Full	Waning-New	Full-Waning-New	All	Rising-Full-Waning
Tracked	1	1	2	1		
Untracked	2				1	3

Visual Searches

Visual observations of browse and faecal matter or by spotlighting did not reveal any conclusive evidence of the presence of wētāpunga. (Total time searching would have been under 10 hours).

Discussion

Wētāpunga indices

Results from the tracking tunnels confirm the persistence of wētāpunga on all three islands. Although tracking rates were low, this was expected with just 70 individuals introduced onto each island. There was, however, sufficient to show contrasting results between Motuarohia, which showed the greatest consistency in tracking, and the other two islands where results were more sporadic. The position of the release sites on Motuarohia in a steep gully and under a tall canopy of *Pinus pinaster* makes it the most protected of the sites. It is well shaded and sheltered from prevailing winds making it noticeably damp throughout. The ground is littered with fallen trees and branches which are in varying stages of decay adding plenty of organic matter to the soil which is quite thick in places. Smaller tracks were also recorded here on multiple occasions, which although cannot be confirmed as belonging to wētāpunga do show a preference toward this site by wētā species (McIntyre, 2001).

The absence of tiēke (*Philesturnus rufusater*) on Motuarohia may be of benefit to the establishing wētāpunga as these are known predators of wētā species (Armstrong and McClean,1995) and common on both Moturua and Urupukapuka Islands where they may be exerting a degree of predator pressure. The vulnerability of wētāpunga to predation is highlighted by their disappearance from the mainland and tiēke beaks are well suited to explore crevices large enough to harbour wētāpunga by day. One study found that wētā species made up 36% of prey items for male tiēke (Pierre, 1995) and following their investigation into the Hauturu population, Gibbs and MnIntyre (1997) recommended that subsequent populations be established in the absence of both rats and tiēke.

This does not necessarily mean that the Urupukapuka and Moturua populations will succumb to these or other predators on the islands as the presence of predators frequently dictates corresponding behaviour in prey (Moller, 2008). As the captive-born wētāpunga become more accustomed to their novel surroundings living alongside these birds, their impacts will lessen and future generations of island-born wētāpunga will almost certainly adopt behaviours which have enabled these species to exist side by side for millennia. This has certainly been the case on both Tiritiri Matangi and Motuora where translocated wētāpunga have successfully established despite the presence of tiēke (Soorae, 2018).

Any future investigations into the predator pressure exerted on wētāpunga on the islands may do well to include a population density estimate of Ruru (*Ninox novaeseelandiae*). These have been shown to display a preference towards wētā species and are one of the few avian predators known to feed on adult giant wētā. Remains of wētā were detected in over 85% of morepork pellets on both Otata and Motuhoropapa islands during one survey (Aikman, 1997).

Whilst it was encouraging from a conservation point of view to see evidence of Moho pererū/ banded rail in the tunnels, it may have proved compromising for the subject species to find themselves in such close quarters with another known predator (Whitaker, 1968). They almost certainly impacted the results from Urupukapuka Island where they frequently removed the cards from the tunnels and by doing so prevented the recording of any additional species which may have visited the tunnels. This became more widespread as the monitoring continued, severely hampering the results from this island. The development and construction of wooden tunnels by Bunnings, Kerikeri which are now installed on Urupukapuka Island appears to have provided a solution to this issue although any effects of neophobia may need to be overcome before further positive tracking results will be gained.

The results from visual searches failed to provide any evidence of the presence of wētāpunga but this is reflective of the limited amount of time and expertise available to give these methods enough meaningful focus. To put this into context, even with experienced personnel on Te Hauturu O Toi, wētāpunga were discovered at a rate of 1 per 8.8 hours of searching (Watts & Thornburrow,2009) and during a study where densities were extremely low just 4 *Motuwēta isolata* were discovered during 284 hours of searching over 65 nights (Stringer, 2005). No wētāpunga were discovered in the bamboo refuges. This is contrary to results from Tiritiri Matangi and Motuora where post-translocation monitoring revealed up to 20% wētāpunga remained faithful to the bamboo from which they were released (Soorae, 2018).

The effect of weather and moon phases

The majority of tracking occurred during sampling durations when a new moon was present. In addition, during one of the time frames found to contradict this, average rainfall was higher, indicating a possible increase in cloud cover. Also of note was a marked increase in tracking results with the onset of summer. However, the temperate climate experienced in the Bay of Islands region meant that temperatures remained relatively constant throughout the weeks leading up to and following the peak in tracking during December. The peak in tracking also coincided with a new moon cycle which was preceded by some significant rainfall in the lead up to the darkest nights. McIntyre (2001) observed that the nocturnal activity of Cook Straight giant wētā (*Deinacrida rugosa*) was influenced by both weather conditions and the cycle of the moon. She concluded that warm, damp and dark nights made for optimum conditions and noticed a marked increase in activity when temperatures rose above 12^{0}C. This is further reiterated by Watts et al (2013) who suggested that both temperature and vapour pressure deficit are considered influential when assessing wētā detectability and should be regarded as driving variables when assessing monitoring techniques.

Advantages and limitations to the use of tracking tunnels

The use of tracking tunnels has been able to provide a simple method to detect the translocated wētāpunga with minimal disturbance to their habitat and without the need to handle individuals. Enthusiastic community volunteers have been able to become involved with minimal training, providing first-hand experience in the translocation process and giving exposure to an otherwise cryptic species. Although tracking tunnels are useful in indicating the presence or absence of wētāpunga and hence information on their range and some behaviours, they cannot reveal ancillary information made possible by visual searches. Tracks left by juvenile wētāpunga cannot be differentiated from adult tree or ground wētā reducing the capacity to calculate overall population densities or dynamics. The spacing between tunnels reduces but doesn't eliminate the likelihood of a single adult wētāpunga passing through more than one tunnel, males have frequently been observed travelling in excess of 20m in a single night (Watts and Thornburrow, 2011).

An acknowledged limitation to the use of tracking tunnels is the inability to reliably make estimations of abundance of wētā species (Watts et al, 2008b). However, a 2013 study found a correlation between tracking tunnel detections and relative abundance concluding that for every tunnel tracked, 1.3 wētā could be located through hand searching (Watts et al,2013). It is important to note that the people conducting the hand searching were highly experienced and searching was undertaken during similar environmental conditions which enabled the creation of a quantitative population index. The same study acknowledged that daytime searches required 3 hours per transect compared to the use of tracking tunnels which required just 1.4 hours (Watts et al,2013).

Ageing foundering population

Given the mid to later in-star stages among the cohorts released onto the islands, they will most likely be reaching the end of their life cycle going into the winter of 2022. Island-born nymphs should be starting to emerge and evidence of this was confirmed by the observation of a juvenile wētāpunga by a recent visitor to Urupukapuka Island (Dr. Dai Morgan pers comm)(*Figure 9*). These will be the first wētāpunga to be born on or close to these islands in more than 150 years and are testament to the work and dedication of all those who have been involved. These island-born nymphs will reach adulthood towards the end of 2023, when hopefully they will leave their footprints to announce another generation is forthcoming. For both Otata and Motuhoropapa islands, it took 34 months to confirm that wētāpunga populations were growing following translocation (Soorae, 2018).

Figure 9: One of the first generation of Northland born wētāpunga in over 150 years. Photo by kind courtesy of Dr Dai Morgan

Future recommendations

The methods employed to continue monitoring this founder population will need to be adjusted to accommodate both the age or instar of the first island-born generation and how cohorts are structured among future translocations. Further releases of captive-bred stock are anticipated in the coming years with possible supplementation from wild-to-wild transfers from sources on Tiritiri Matangi, Otata, Motuhoropapa and Motuora Islands (R Robbins pers com). These will ensure genetic diversity is captured from original founder lines (Weeks et al, 2011). Augmentation of founder stock with individuals of similar age is standard international practice to synchronise life stages and promote breeding potential (Pearce-Kelly et al, 1998). Should each of the populations consist only of juveniles, tracking tunnels can no longer provide certainty of wētāpunga detection over other wētā species. Alternative methods would at this stage need to be adopted or supplemented to achieve robust results. This may include the use of hand-searching by experienced or trained individuals although the use of more sophisticated night vision equipment may help to mitigate any lack of experience.

It could be advantageous to use radiotelemetry to track some of the adult individuals which are anticipated to be introduced during subsequent translocations, as this may give some indication as to where future searching efforts should be focused. Radiotelemetry has previously been used successfully to monitor behaviour and movement of translocated *Deinacrida* species including wētāpunga (Stringer, 2005, McIntyre, 2001, Kelly et al, 2010, Watts & Thornburrow, 2009, Gibbs & McIntyre, 1997). Recent technological advances have seen both the range and battery life extended in increasingly smaller units which can weigh as little as 1.08g.

The development of the trail camera, CrittaPic © by Red Fern solutions and Boffa Miskell provides another potential method to monitor small cryptic species such as wētāpunga. This produces high-quality images, identifies the species, and may allow for the monitoring of individuals to learn more about their behaviour.

Ongoing covid restrictions limited both the accessibility to the islands and the availability of species experts to aid in visual searches. The ability to regulate the time-duration for each set of cards with more frequent changes will enable a better understanding of the associations between moon cycles, environmental conditions, and the detection of wētāpunga and allow more extensive visual searches to be undertaken to learn about expanding populations. Future monitoring efforts could do well to focus visual methodology on the Motuarohia release sites given the level of wētā activity recorded there. Several of the detections were concentrated towards the upper altitudinal limits of the tunnels suggesting that further tunnels should be deployed to extend the monitored area beyond the current transects. It can be expected that as the wētāpunga populations on the islands grow, so will the area they inhabit. *Motuweta isolata,* when translocated onto Red Mercury Island were found to expand their range by 50-100 metres annually (Stringer et al, 2014).

Conclusion

The monitoring of flightless, nocturnal, and arboreal orthopterans has been described as one of the more challenging aspects of entomological conservation. With only 70 individuals translocated to each island and being restricted to using the largest footprints as an indication of their presence, a limited tracking percentage was expected. However, although detection rates are low, they are unlikely to represent the number of wētāpunga survivors.

The results from the tracking tunnels provides unequivocal evidence that adult wētāpunga are present and are attempting to establish. Their detection on the ground indicates the presence of either mating pairs or ovipositing females as it is only during these processes, they are terrestrial. Whilst encouraging, it is important to note that the life history of the species dictates much more time is needed before any conclusions of their establishment can be drawn. For a translocation to be deemed successful, a fully fecund population must first be established. For these pioneering wētāpunga, it will take the arrival of two generations of fertile offspring to be able to claim the presence of a self-sustaining resident population.

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Te Rawhiti hapu (Ngati Kuta and Patukeha) and the Guardians of the Bay of Islands in Project Island Song in a partnership with Auckland Zoo are returning Aotearoa's unique wētāpunga to Te Tai Tokerau (Northland) after a 180-year absence.

Critical to this species recovery programme is the kaitiakitanga of all mana whenua of Te Hauturu-o-Toi, in particular Ngāti Manuhiri, Ngātiwai, and Ngāti Rehua. The dedication of Hauturu Supporters Trust We is also recognised.

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Appendix 1

Table 2 Summary of each of the tunnels tracked for the 2021-2022 monitoring

	1	2	3	4	5	6	7	8	9	10
Urupukapuka A										
B				1					1	
Moturua A									1	
B					1	1				
Motuarohia A			1							
B	1			2						

Figure 9

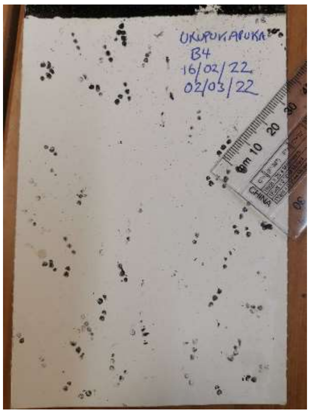


Figure 10

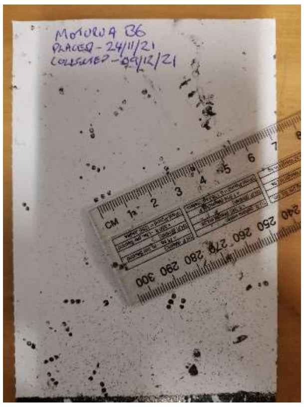


Figure 11

Figure 13

Figure 14

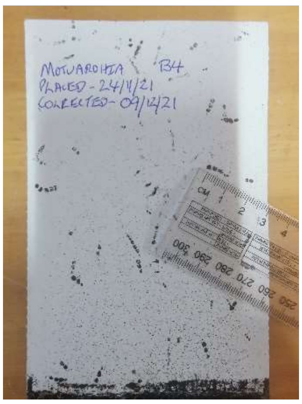


Figure 15

Figures 9-15 A collection of tracking cards from 2021-2022 monitoring showing tarsal dimensions of wētāpunga

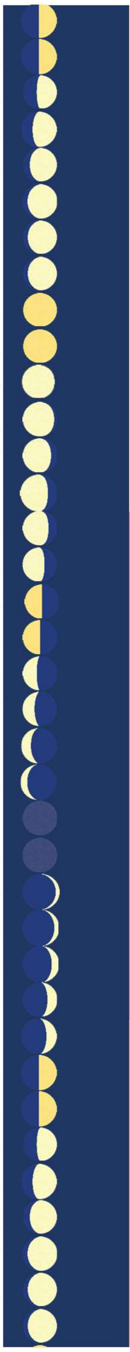
Table 3. Summary of tracking percentages for Urupukapuka, Moturua and Motuarohia Islands for each sampling duration between 29/9/21 and 4/5/22, the total number of nights the cards were deployed for each sampling duration, mean wind, rain and minimum temperatures and associated moon phases.

Date	% tracking Urupukapuka	% tracking Moturua	% tracking Motuarohia	Number of nights	Mean wind (m/s)	Mean rain (mm)	Min temp (°C)	Moon phase
29/9-27/10	5	n/a	n/a	28	1.88	14.29	10.53	All
27/10-4/11	0	n/a	n/a	8	1.45	3.45	12.4	Waning
4/11-10/11	0	0	0	6	0.88	5.3	12.7	New
10/11-24/11	0	0	0	140	0.87	4.24	13.94	Rising-full
24/11-8/12	0	10	10	14	0.7	0.13	15.06	Waning
8/12-17/12	0	0	5	9	0.77	6.4	17	Rising-full
17/12-16/2	0	0	0	60	0.99	1.66	15.87	All
16/2-2/3	5	0	5	14	0.66	0.56	13.61	Full-waning
2/3-9/3	0	0	5	7	0.71	1.14	16.34	New
9/3-23/3	0	0	0	14	0.41	8	15.07	Rising-full
23/3-6/4	0	5	0	14	0.35	0.04	13.92	Waning-new
6/4-27/4	0	0	0	21	0.39	2.58	13.07	Rising-full-waning
27/4-4/5	0	0	0	7	0.27	0.89	9.96	New

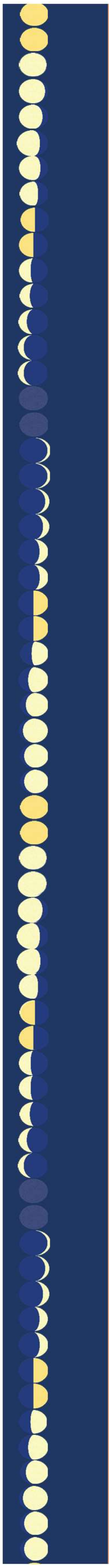
Appendix 2 Daily meteorological data , moon phases and tracking summary (including small tracks

Date	Wind (m/s)	Gust (m/s)	Rain (mm)	Max temp (C)	Min temp (C	Moon phase	Tracking
29 09 2021	1.7	11.3	0	18.3	5.8		**Set 1**
30 09 2021	1.2	11.8	0	20.2	7		**29/9-27/10**
1 10 2021	1	6.2	0	19.1	9.8		**Urupukapuka**
2 10 2021	0.4	7.7	0	20	5.4		**A9**
3 10 2021	2.5	11.3	35.4	18.4	8.3		
4 10 2021	0.6	9.8	5.4	21.4	14.9		
5 10 2021	1.7	8.2	0	24.7	12.1		
6 10 2021	1.2	7.7	3.8	20.7	12.6		
7 10 2021	2.9	8.8	74.2	16.3	15.5		
8 10 2021	1.9	10.8	0	20.5	10.8		
9 10 2021	1.8	11.8	0	20.2	8.6		
10 10 2021	1.3	10.3	0	19.5	8.7		
11 10 2021	1.3	8.2	7.4	19.7	7.4		
12 10 2021	4.7	13.9	0.4	18.4	13.6		
13 10 2021	1.8	11.8	0	17.7	8		
14 10 2021	2.4	10.8	0	17.8	5.7		
15 10 2021	1.1	6.2	0	19.4	4.9		
16 10 2021	0.5	8.2	1.2	18.1	4.3		
17 10 2021	3	11.8	35.4	18.1	12.4		
18 10 2021	1.1	11.3	0	23.4	15.2		
19 10 2021	1.2	6.2	0	20.8	7.5		
20 10 2021	1.6	8.2	6.4	20.4	10.6		
21 10 2021	2.8	9.8	49	17	14.2		
22 10 2021	3.1	13.4	32	16.5	15		
23 10 2021	4.8	13.4	136.6	16.4	14.4		
24 10 2021	3.4	12.9	11.6	18.7	14.6		
25 10 2021	0.7	5.7	1.2	23.5	13.2		
26 10 2021	0.8	6.7	0	23.4	14.2		
27 10 2021	1.3	7.2	0	21.8	16		**Set 2**
28 10 2021	0.4	7.2	10	19.2	13.4		**27/10-4/11**
29 10 2021	1.7	9.8	0	22.1	11.3		**Urupukapuka only**
30 10 2021	1.9	12.4	14.2	21.7	10		**Nothing tracked**
31 10 2021	2.7	12.4	0	19.3	15.4		
1 11 2021	0.7	6.2	0	19.5	11.5		
2 11 2021	1.8	7.7	2.6	19.6	8.3		
3 11 2021	1.1	7.2	0.8	16.6	13.3		
4 11 2021	0.9	5.1	14.4	19.3	11.9		
5 11 2021	1.5	4.6	17.4	20.2	13.8		**Set 3**
6 11 2021	1	4.1	0	21.5	13.7		**4/11-10/11**
7 11 2021	0.6	4.6	0	22.1	11.9		**All three islands**
8 11 2021	0.9	4.1	0	22.8	12.6		**Nothing tracked**
9 11 2021	0.4	4.6	0	22	12.3		

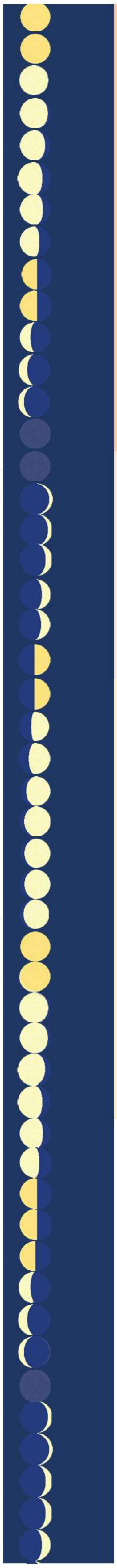
10 11 2021	0.8	4.6	0	22.7	13.1	**Set 4 10/11-24/11 All three islands Nothing tracked**
11 11 2021	0.4	4.6	0	22.4	11.8	
12 11 2021	0.8	5.1	0	22.2	15.1	
13 11 2021	0.9	7.2	21.8	22.2	17.8	
14 11 2021	1.4	6.2	24.2	25.1	19.6	
15 11 2021	1.1	6.7	0	24.7	14.7	
16 11 2021	1.2	5.1	0	23.8	12.5	
17 11 2021	0.6	5.1	0	23.4	14.1	
18 11 2021	0.5	4.6	0	20.8	10.3	
19 11 2021	0.9	5.1	0	20.5	7.4	
20 11 2021	0.4	4.6	0	21.5	10.6	
21 11 2021	0.8	4.1	0.6	22.8	14.1	
22 11 2021	0.6	3.1	0	22.4	17.7	
23 11 2021	1.8	6.2	12.8	23.7	16.3	
24 11 2021	0.6	5.1	0	21	14.9	**Set 5 24/11-8/12 Positive tracking Motorua A9, B6 Motuarohia, B1,B4, (A8 B5 Small)**
25 11 2021	0.4	3.6	0	21.3	13.1	
26 11 2021	0.6	4.6	0	22	12.8	
27 11 2021	0.3	4.1	0	21.8	10.8	
28 11 2021	0.5	4.1	0	22.7	10.6	
29 11 2021	0.5	4.1	0	23.6	14.7	
30 11 2021	0.4	4.6	0	24.3	14.6	
1 12 2021	0.4	4.1	0	23.2	12.6	
2 12 2021	0.4	4.6	0.8	22.2	14.3	
3 12 2021	1.5	5.7	0.4	23	15.6	
4 12 2021	1.2	6.2	0.4	21.4	18.5	
5 12 2021	1.3	5.7	0.2	23.8	19	
6 12 2021	1	4.1	0	24.5	19.8	
7 12 2021	0.7	3.1	0	22.3	19.5	
8 12 2021	0.4	3.6	0.2	24.2	17.3	**Set 6 8/12-17/12 Positive tracking Motuarohia B4 (A8 Small)**
9 12 2021	0.4	4.1	0	23.7	13	
10 12 2021	0.3	4.1	0.6	23.9	15	
11 12 2021	0.5	5.1	3.4	24.5	14.9	
12 12 2021	0.8	4.6	3.4	21.8	19.6	
13 12 2021	2.3	5.7	11.6	21.3	20	
14 12 2021	1	10.3	38.2	20.7	18.7	
15 12 2021	0.4	6.2	0.2	25.1	18.2	
16 12 2021	0.8	5.7	0	24.1	16.3	



17 12 2021	0.7	5.1	0	24	16.7
18 12 2021	0.5	6.7	0	24.1	10.4
19 12 2021	0.4	4.6	0	23.6	9.1
20 12 2021	0.4	5.1	0.2	23.6	10.2
21 12 2021	0.4	3.6	0	22.9	13
22 12 2021	0.4	4.1	0	25.1	13
23 12 2021	1.6	7.2	0	25.7	16.4
24 12 2021	1.7	5.7	0	27.5	18.1
25 12 2021	1.4	4.6	0	25.4	12.7
26 12 2021	0.5	4.6	0	25.2	14.4
27 12 2021	0.5	4.6	0.8	24.8	15.2
28 12 2021	0.7	4.1	4.2	25.9	18.4
29 12 2021	1.6	8.2	0	22.9	17.2
30 12 2021	0.7	6.7	0	23.5	11.3
31 12 2021	0.5	6.2	0	24.8	10.6
1 1 2022	0.7	7.2	0	27.4	11.1
2 1 2022	1	6.7	0	25	12.2
3 1 2022	1.3	5.7	0	24.8	17.3
4 1 2022	0.5	4.1	0	26.3	11.1
5 1 2022	1.2	4.6	0	26.9	14.6
6 1 2022	1	5.7	0	27.7	14.6
7 1 2022	1.7	5.1	4.8	24.7	16
8 1 2022	0.8	4.1	1	23.6	17.5
9 1 2022	0.4	4.6	0	24.4	15.1
10 1 2022	0.6	4.1	0	24.6	15.9
11 1 2022	0.4	4.6	0	25.4	15.7
12 1 2022	0.6	4.6	0.8	25.1	15.4
13 1 2022	0.8	8.8	0.4	24.7	12.8
14 1 2022	2.2	10.8	0	22.5	17.6
15 1 2022	2.4	10.8	0.6	22.9	17.8
16 1 2022	1.3	9.3	0	24.2	16.1
17 1 2022	1	6.7	0	29	12.4
18 1 2022	0.4	5.1	0.2	26.6	11.2
19 1 2022	0.4	4.6	0	25.1	11.7
20 1 2022	0.2	4.1	0	25.4	15
21 1 2022	1.2	6.2	0	26.2	16.3
22 1 2022	0.3	6.7	0	25.3	9.9
23 1 2022	0.5	4.1	5.4	22.7	12.3
24 1 2022	0.6	5.1	3.4	21.5	17.7
25 1 2022	1.3	6.7	11.8	22.7	18.8
26 1 2022	0.3	4.6	16.8	25.1	15.6
27 1 2022	1.4	6.7	0	24.9	18.6
28 1 2022	1.8	7.7	0	23.3	12.9
29 1 2022	1.5	7.7	0	22.6	15.7
30 1 2022	0.6	6.2	0	23.8	14.2
31 1 2022	1.5	8.2	6	23.2	13.7
1 2 2022	1.4	6.7	0	22.7	19.4
2 2 2022	2.2	6.7	0	25	20.7
3 2 2022	1.5	6.7	0	24.5	20.4
4 2 2022	1.2	5.7	0	25.1	20.8
5 2 2022	1.2	5.1	11.6	25.4	21.2
6 2 2022	0.5	6.2	24	24	21.2
7 2 2022	0.7	5.1	2.6	24.4	22
8 2 2022	0.8	6.2	0.8	26.2	21.9
9 2 2022	0.8	5.1	0.6	25.3	22.3
10 2 2022	1.1	5.1	1	25.3	22.1
11 2 2022	1.8	7.2	0.8	24.7	22.2
12 2 2022	1.4	9.3	1.6	24.9	22.9
13 2 2022	2.4	9.8	0	24.5	19.7
14 2 2022	0.3	5.1	0	24.4	11.8
15 2 2022	0.4	4.6	0	23.9	11.3



Set 7
17/12-16/2
Positive tracking
Motuarohia,
A8, A10.B4 (all small)



16 2 2022	1.4	4.6	0	24.4	10.2	**Set 8**
17 2 2022	0.2	3.1	0	23.1	11.2	**16/2-2/3**
18 2 2022	1.6	6.2	0	24.8	11.6	**Positive**
19 2 2022	0.3	4.1	0	24.7	16.4	**tracking**
20 2 2022	1.2	3.6	0	25.1	14.3	**Urupukapuka B4**
21 2 2022	0.4	5.7	0	25.9	14.2	**Motuarohia B4**
22 2 2022	0.2	4.6	0	25.7	14.8	**Motorua B1(small)**
23 2 2022	0.4	7.2	0.6	26.3	13.3	
24 2 2022	0.8	7.2	1.4	24.7	18.1	
25 2 2022	0.2	6.2	0.2	24.3	15.2	
26 2 2022	1.8	5.1	0	24.5	12.1	
27 2 2022	0.3	6.2	5.4	24.6	12.3	
28 2 2022	0.3	4.6	0.2	22.3	14.3	
1 3 2022	0.1	3.6	0	23.4	12.5	
2 3 2022	0.1	7.7	0.6	23.4	14	**Set 9**
3 3 2022	1.3	8.8	0.8	22.5	16.9	**2/3-9/3**
4 3 2022	1.2	7.7	1.8	23.3	18.4	**Positive tracking**
5 3 2022	0.7	6.2	1.4	21.9	15.7	**Motuarohia A3**
6 3 2022	1.4	6.2	2	22.3	17.6	
7 3 2022	0	5.7	0	24.7	15.3	
8 3 2022	0.3	5.1	1.4	23.4	16.5	
9 3 2022	0.2	5.1	1	23	14.6	**Set 10**
10 3 2022	0.2	6.7	0.2	23.8	14.3	**9/3-28/3**
11 3 2022	0.1	4.6	0	24.7	17.2	**Nothing Tracked**
12 3 2022	0.1	3.1	0	24.6	15.8	
13 3 2022	0.4	6.2	0.4	24.3	15.1	
14 3 2022	0.3	4.1	0.2	24.3	13.5	
15 3 2022	0.2	4.1	0	25.2	13.4	
16 3 2022	0.2	4.6	0	24	14	
17 3 2022	0.1	5.1	0	23.3	15.3	
18 3 2022	0.2	4.6	2.4	24	12.5	
19 3 2022	0.2	5.1	5.2	21.8	13.4	
20 3 2022	2.6	9.3	73.4	21.2	15.8	
21 3 2022	0.2	9.3	0.2	24.7	18.3	
22 3 2022	0.8	7.2	29	24.5	17.8	
23 3 2022	0.4	5.1	0	25.8	17.6	**Set 11**
24 3 2022	0.4	6.7	0	24.2	14.7	**28/3-6/4**
25 3 2022	0.7	6.2	0	23.6	17	**Motorua B5**
26 3 2022	0.7	5.7	0	24.7	14.8	**Urupukapuka B2 (small)**
27 3 2022	0.3	4.6	0	23.2	11.5	
28 3 2022	0.3	3.6	0	22.5	10.9	
29 3 2022	0.4	5.1	0	26.3	10.9	
30 3 2022	0.2	3.6	0	24.1	12.6	
31 3 2022	0.2	4.1	0.2	24	11.9	
1 4 2022	0.1	3.6	0	23.3	12.7	
2 4 2022	0.2	3.6	0	24	13.7	
3 4 2022	0.3	3.1	0	24.2	14.1	
4 4 2022	0.2	2.6	0	23.6	17.6	
5 4 2022	0.5	3.1	0.4	21.5	14.9	

6 4 2022	0.4	3.6	0.2	26	17.4	**Set 12**
7 4 2022	0.5	6.2	0	21.9	14.4	**6/4-27/4**
8 4 2022	0.3	4.6	0	21.4	10.7	
9 4 2022	0.1	3.6	0	21.1	9.5	
10 4 2022	0.4	5.1	0	22.5	9.9	
11 4 2022	0.2	4.6	0	21.1	10.1	
12 4 2022	0.8	5.7	0	20.5	15	
13 4 2022	0.2	6.7	0	20.8	15.4	
14 4 2022	0.3	5.1	0	21	13.1	
15 4 2022	0.4	3.1	0	20.9	6.2	
16 4 2022	0.1	3.1	0	21.7	7.5	
17 4 2022	0.1	8.8	28	20.2	13.2	
18 4 2022	1.2	11.8	2.8	20.6	16.2	
19 4 2022	0.3	6.2	3.2	23.5	19.3	
20 4 2022	0.4	4.6	0.8	22.7	19.5	
21 4 2022	0.4	4.6	18.8	22.9	19.1	
22 4 2022	0.6	7.7	0	22.2	18.4	
23 4 2022	0.3	7.2	0	19.9	10.5	
24 4 2022	0.5	5.1	0.4	20.6	8.6	
25 4 2022	0.4	5.1	0	21.1	11.2	
26 4 2022	0.2	4.6	0	21.2	9.2	
27 4 2022	0.2	3.6	0	19.6	9.7	**Set 13**
28 4 2022	0.2	4.6	2.2	19.2	8.9	**27/4-4/5**
29 4 2022	0.3	7.2	3.6	19.2	10.1	
30 4 2022	0.2	5.1	0	19.1	10.8	
1 5 2022	0.3	3.6	0	20.8	9.3	
2 5 2022	0.2	3.6	0.4	20.9	9.9	
3 5 2022	0.5	4.1	0	20.6	11	
4 5 2022	1.6	5.7	4.6	19.8	9.1	
5 5 2022	0.3	6.2	0	19.6	12.5