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Captive Breeding Programme Enables a Successful Wētāpunga (*Deinacrida heteracantha*: Orthoptera: Anostostomatidae) Recovery Programme

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ABSTRACT

Wētāpunga or Little Barrier Island giant wētā (*Deinacrida heteracantha*: Orthoptera: Anostostomatidae) underwent significant decline across Northland and Auckland, New Zealand, and by mid-20th Century was restricted to Te Hauturu-o-Toi/Little Barrier Island. However, surveys of wētāpunga during the early 1990s reported low numbers and concerns that the population was declining. Subsequently, a recovery plan specified the need for at least four wild populations. After Pacific rat (*Rattus exulans*) eradication from Te Hauturu-o-Toi in 2004, the abundance of wētāpunga was resurveyed annually for 5 years from 2005 with low detection rates. Here we report the establishment of two ex situ colonies using cohorts of 12 individuals collected from Te Hauturu-o-Toi every 3–5 years. Over 11,000 wētāpunga were produced for translocations from 2010. Ten new populations have been founded on eight predator-free islands and inside two predator-proof fenced areas on the mainland. Post-release monitoring on Motuora and Tiritiri Matangi Islands has verified fourth- or fifth-generation individuals at two release areas on each island. Ranked as Nationally Endangered in the New Zealand Threat Classification System at the start of the recovery programme the threat ranking for wētāpunga has improved to Nationally Recovering.

1 | Introduction

There is growing interest in the importance of ex situ breeding programmes to facilitate recovery efforts for the conservation of invertebrate species (Keyghobadi and Daniels 2025). Reported animal translocation programmes have been heavily biased towards vertebrates (Sherley et al. 2010; Beckmann and Soorae 2022), and there is a need for detailed reports of successful invertebrate reintroduction programmes. A species translocation programme that results in a self-sustaining population is regarded as successful (Griffith et al. 1989), but measurement of that success lacks consistency (Brichieri-Colombi and Moehrenschlager 2016). In a review of terrestrial insect translocations, Bellis et al. (2019) used persistence as a workable criterion and found that the numbers released were a factor in success. While an increase in post-release numbers is a positive indication, a viable population with growth long enough to be measured in generations (Morris et al. 2021) is a more robust measure likely to reflect ongoing persistence. In this work, we present the results of a translocation programme for wētāpunga or Little Barrier giant wētā (*Deinacrida heteracantha*: Orthoptera: Anostostomatidae) in New Zealand.

Wētāpunga (Figure 1) was first described by Colenso (1882) with a type locality of Bay of Islands, Northland. Initial records reported the species as widespread throughout Northland, Auckland and Great Barrier Island (Colenso 1882; Dieffenbach 1843; Buller 1895;

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FIGURE 1 | An adult female wētāpunga or Little Barrier giant wētā (*Deinacrida heteracantha*), Te Hauturu-o-Toi/Little Barrier Island, Hauraki Gulf, New Zealand, 2011. (Photo C. Green).

Hutton 1897). As with many other large-bodied, flightless, nocturnal invertebrates, the introduction of mammalian predators such as rodents, mustelids and cats, together with habitat destruction, led to a decline in populations throughout its range (Sherley 1998). By mid-20th century, it was confined to just one island in the Hauraki Gulf, Te Hauturu-o-Toi/Little Barrier Island (3083 ha; hereafter referred to as Hauturu). Two species of exotic mammalian predators have been introduced onto the forest-covered Hauturu: kiore/Pacific rat (*Rattus exulans*) in pre-European times by indigenous Māori, and cats (*Felis catus*) c. 1870 (Veitch 2001). Subsequently, cats were eradicated in 1980 (Veitch 2001).

Surveys of wētāpunga during the early 1990s reported low numbers on Hauturu (Meads and Balance 1990; Meads and Notman 1993) and concerns of a decreasing population. They recommended further research on habitat use and improving population survey techniques to assist in the formulation of recovery actions. A Department of Conservation (DOC)-commissioned survey by Gibbs and McIntyre (1997) to address these needs and determine wētāpunga abundance on Hauturu echoed concerns of a population in decline. Around the same time, the DOC Biodiversity Recovery Unit published a Threatened Wētā Recovery Plan (Sherley 1998). Wētāpunga was included in the group of three species with greatest urgency for management action. The plan outlined potential recovery actions, including: (1) the eradication of kiore from Hauturu; (2) establishment of new populations on other islands in the Hauraki Gulf; and (3) the potential for ex situ breeding to facilitate those populations. The recovery plan also stipulated the need for at least four wild populations to safeguard any wētā species against further decline (Sherley 1998); thus, at least three new wild populations would be required for wētāpunga. Following the wētā recovery plan, kiore were eradicated from Hauturu in 2004 (Griffiths 2004, 2006), and a wider assessment of New Zealand Orthoptera in 2004 provided threat rankings. Wētāpunga was listed as a threatened species with a ranking of Nationally Endangered in the New Zealand Threat Classification System (Hitchmough et al. 2007).

Annual wētāpunga surveys from 2005 to 2009 on Hauturu after kiore removal showed an increase in numbers (Green et al. 2011). The total number of wētāpunga found increased from 78 in 2005 to 171 in 2009 during a consistent effort of 121 person-search-hours each year. This equates to detection rates of 0.64–1.4 wētāpunga per person-search-hour (Green et al. 2011). However, enacting the wētāpunga translocations as recommended in the recovery plan had challenges. The first approved translocation authority for wētāpunga releases onto Motuora and Tiritiri Matangi Islands stipulated an aim of 50 or more per release (Department of Conservation 2008). It was feared that the removal of this number for multiple translocations directly onto the two islands to found new populations could have a negative impact on the only source population.

Here, we report on the successful recovery programme for wētāpunga, involving the repeated collection of small numbers of founder wētāpunga from Hauturu to enable ex situ breeding programmes at Butterfly Creek and Auckland Zoo (both Auckland). The progeny from these captive colonies were released in cohorts to initiate new populations as part of a reintroduction programme encompassing 10 sites, all within the past distribution of wētāpunga. Motuora and Tiritiri Matangi Islands were the first to receive translocations, and therefore, more detailed assessments were conducted on these test case islands to record successful population establishment. The aim of our translocation programme was to verify at least four post-release generations at these sites. We discuss the success of the ex situ breeding programme, and its potential replication to assist the recovery of other endangered invertebrate species.

2 | Methods

The first ex situ colony started with the collection of six adult wētāpunga (3M:3F) from Hauturu in December 2008. These were housed at Butterfly Creek, with second and third cohorts of 12 (6M:6F) collected in May 2009 and May 2012. The Auckland Zoo colony was initiated with a further 12 (6M:6F) adults collected in May 2012 and augmented with cohorts of 12 adult, 9th or 10th instar nymphs, collected in April or May of 2016, 2021, and 2024. F1 generation progeny from the last three collections were supplied to Butterfly Creek to supplement that colony.

2.1 | Husbandry

Rearing conditions in both facilities were broadly similar, with only minor variations. Wētāpunga were maintained in climate-controlled rooms with the temperature set within the range of 10–22 °C to reflect the conditions in their natural habitat, though buffered from extremes. The night temperatures were cooler than day temperatures. Low-intensity lighting was adjusted seasonally to reflect outdoor conditions. Humidity was typically maintained at 60–80%, although it was reduced to some extent over the summer period by less frequent water spraying to prevent fungal growth. Ventilation was provided via the room air-conditioning unit and, when necessary, an auxiliary fan.

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Adults were held individually in insect screen enclosures at least 300 × 300 × 400 mm (L × W × H) in size. Enclosures were arranged in an alternating male–female pattern and were furnished with dry, twiggy branches and refugia composed of dense bundles of dry cabbage tree (*Cordyline australis*) leaves, tree fern (*Alsophila* spp.) and/or nīkau (*Rhopalostylis sapida*) fronds. The leaf litter was provided either on the enclosure floor or in trays. Each female was provided with a 1.5–2L container with perforated base and filled to the brim with lightly compacted free-draining moist soil for oviposition.

Males were introduced to female enclosures for a 24–48-h period once every 14 days, and within a breeding group, all individuals were cross-mated. The containers used for oviposition were replaced at 3 monthly intervals and incubated in larger plastic boxes held at the same ambient temperature as the adults. These incubation boxes had no ventilation; however, they were opened once per week to exchange the air within, regulate soil moisture, and inspect for signs of eclosion. Moisture was maintained with light misting of water. The oviposition containers were specific to each female to track the maternal genetic representation of all offspring. After the first eclosion, egg fields were checked daily, and all non-teneral 1st-instar nymphs were removed for rearing.

Initially, wētāpunga at both Butterfly Creek and Auckland Zoo were reared individually. Young, 1st–5th instars, were in containers approximately 100 × 100 mm (D × H) and older instars in containers measuring at least 150 × 200 × 400 mm (L × W × H). Containers were ventilated via holes or embedded fine insect mesh on the lid or sides. Height was critical to facilitate successful moulting, while the large container size allowed for easy movement throughout but still provided plentiful space for foliage and environmental complexity. Daytime refugia started as individual dead leaves and progressed to a clump of dry ponga (*Alsophila dealbata*) fronds suspended from an upper corner. The dry ponga was replaced if damaged through movement or consumption. At Butterfly Creek, a bottle cap with water, covered with pre-soaked *Sphagnum* moss, was included in containers with young instar wētāpunga.

To boost production, individual rearing was later replaced by communal rearing at Auckland Zoo, followed by Butterfly Creek. Following eclosion, many wētāpunga were placed together in large mesh cages, as used for adults. Those not released to the wild were left until they reached sub-adult or adult before being moved to individual adult cages. Refugia were provided by an upright 400 mm long cylinder of plastic 40 mm aperture mesh, filled with dead ponga fronds. Lengths of plastic hose pipe up to 100 mm with one end plugged with paper towel or bamboo (150–300 × 50–60 mm L × D) open at each end were added to the refugia at Auckland Zoo and Butterfly Creek, respectively.

All wētāpunga were maintained on a three-part diet of fresh green foliage, protein source and 'leaf litter'. A range of native plants (Table 1) with fresh growing tips were used as the foliage component of the diet. In most cases, the foliage species used were those that wētāpunga had been observed eating in the wild. Two to three species of plants were offered on each occasion, and the variety of species was rotated frequently. Stems of foliage were misted with water and inserted through a hole in the lid of a capped container filled with water. Alternatively, for young instars, stems were tucked upright into the tree fern refugia. Foliage was replaced two or three times per week.

TABLE 1 | Species used as food plants in rearing of wētāpunga at Butterfly Creek and Auckland Zoo.

Species	Common name	Butterfly Creek	Auckland Zoo
Brachyglottis repanda J.R.Forst. et G.Forst.	Rangiora	Y	
Coprosma arborea Kirk.	Māmāngi		Y
Coprosma macrocarpa subsp. *minor* R.O.Gardner et Heads ex A.Druce.		Y	Y
Coprosma repens A.Rich.	Taupata	Y	Y
Coprosma robusta Raoul.	Karamū	Y	Y
Corynocarpus laevigatus J.R.Forst. et G.Forst.	Karaka	Y	Y
Didymocheton spectabilis (G.Forst.) Mabb. et Holzmeyer.	Kohekohe	Y	Y
Geniostoma ligustrifolium var. ligustrifolium A.Cunn.	Hangehange	Y	Y
*Hebe macrocarpa (*syn. *Veronica stricta)* Vahl.			Y
Hebe stricta (syn. Veronica stricta) Benth.	Koromiko		Y
Melicytus ramiflorus subsp. *ramiflorus* J.R.Forst. et G.Forst.	Māhoe	Y	Y
Myoporum laetum G.Forst.	Ngaio	Y	
Piper excelsum subsp. *excelsum* G.Forst.	Kawakawa	Y	Y
Podocarpus totara var. *totara* G.Benn. ex D.Don.	Tōtara	Y	
Pseudopanax discolour (Kirk) Harms.			Y
Pseudopanax lessonii (DC.) K.Koch.	Houpara		Y
Vitex lucens Kirk.	Pūriri	Y	Y

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Dry fish flake food was provided as the protein component of the diet and was replaced regularly. Quantities were reduced as the wētāpunga progressed through their instars. A 'leaf-litter' component of the diet—consisting of moist, fallen leaves, flowers, berries, mosses, lichens, seed pods and other forest debris—was offered on plastic trays for colonies or scattered on the floor of the enclosure for individually reared wētāpunga. This 'leaf-litter diet' was replaced three times per week for young instars and once per week for older instars.

2.2 | Translocation and Release

The 10 release sites included five islands in the Hauraki Gulf—Motuora (80 ha), Tiritiri Matangi (220 ha), Motuihe (179 ha), two islands in the Noises group—Motuhoropapa (9.5 ha) and Otata (15 ha); three islands in the Bay of Islands—Urupukapuka (208 ha), Moturua (136 ha) and Motuarohia (19.4 ha); as well as Shakespear (500 ha) and Tawharanui (594 ha) Regional Parks on mainland Auckland. All release areas within the 10 sites were assessed for habitat suitability prior to translocation, with the absence of any rat species a vital requirement. Attention was given to the diversity and abundance of food plants (Table 1) in close association with suitable daytime refugia such as dead tree fern or nikau fronds. Several techniques were used to transfer wētāpunga to areas at each release site, but all included careful packaging in large containers with insulation from temperature fluctuation during transport. In the first method, wētāpunga were transferred individually in perforated 2L containers then manually placed into bamboo refuges previously tied onto release tree branches, with the open end facing down and internal diameter wide enough to accommodate the size of wētā. A second method was developed to streamline the field release component. Each wētāpunga was loaded into a bamboo refuge at the breeding facility and transported to the field release area inside the refuge with the open end covered with insect mesh and held in place with a rubber band. The refuge was then tied onto a branch, closed end uppermost, and netting removed, so there was no direct handling of wētāpunga in the field. All refuges were placed 1–2 m above ground, which reflected the common observations of Green et al. (2011). Most releases took place during the day when wētāpunga is inactive. A third method was used for large numbers (hundreds) of 3rd–6th instar nymphs, which were transported in plastic ventilated boxes with kitchen towelling for grip and released within 12 h at night in groups of 7–10 directly onto trees with abundant natural refugia.

To streamline releases, especially those involving large numbers of bamboo refuges, release trees were GPS-located and tagged with flagging tape prior to the day of release. Tagging also aided tree location during post-release monitoring. Where possible, release areas on each island were well-separated to facilitate independent post-release monitoring to track population development at each.

2.3 | Post-Release Monitoring

All release areas were monitored post-release using day and night visual observations on foliage, tree trunks and in bamboo refuges. Where present on release islands, bird nest boxes and other structures were also monitored for all age class wētāpunga.

Wētāpunga were released at three areas on Motuora Island and four on Tiritiri Matangi Island, but only two areas, 1.3 km apart, were chosen on each island for intensive post-release monitoring; Macrocarpa Bay and Pohutukawa Bay on Motuora Island and Bush 22 and Wattle Valley on Tiritiri Matangi Island. The Macrocarpa Bay habitat was a forest restoration area planted in 2000 by the Motuora Restoration Society (H. Lindsay pers. comm. 2025), where there were good numbers of food plant species but limited day-time refugia. Meanwhile, Pohutukawa Bay had good remnant forest with good food plant and refugia. On Tiritiri Matangi, Bush 22 and Wattle Valley both had excellent forest remnant habitat with considerable food plant and refugia. The aim was to record the number of post-release island-bred generations independently at each location. In addition to visual observations, tracking tunnels with a peanut butter lure were set out in 20×20 m grids in the four areas to record the distinctive footprints of adult wētāpunga (Watts et al. 2008, 2013). Released wētā were defined as the Parent (P) generation and the first release wild-born generation as F1.

For all other sites, post-release monitoring was less intense and aimed to confirm the ongoing presence of wētāpunga. Methods were not comparable with those on Motuora and Tiritiri Matangi Islands. For the islands, including the two Noises, Motuihe and the three in the Bay of Islands, monitoring involved recording night spotlight counts of total wētāpunga seen while walking preset transect lines through suitable habitat. The same search effort was repeated on two or three consecutive nights. Lines were walked at the same pace for a repeatable duration and were spaced to avoid double counts by two observers. Counts were converted to detection rates per person-search-hour. Counts were completed from September to November just before the last releases on each island in late 2025. Periodic spotlighting and day searches occurred at Shakespear and Tawharanui Regional Parks to record the ongoing presence of wētāpunga.

2.4 | Data Interpretation

A conceptual model was developed to estimate the timing of post-release generations based on the age of females, including the oviposition period, and involved the following calculations.

First, the mean instar x of each cohort at the time of release was determined according to the equation:

$$x = \frac{(\sum i)}{t}$$

where i is the instar number of each released wētāpunga as an integer from one (1st instar) to 11 (adult), and t is the total number of wētāpunga in that release.

Rearing data was used to calculate the generation period G in months, for wētāpunga according to the equation:

$$G = e + ny + a$$

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where *e* is the mean egg development period between oviposition and eclosion; *ny* is the mean development period of nymphs through all 10 instars; and *a* is the period taken for adults to become sexually mature after their final moult to adult. Generation time represents the minimum potential time between generations represented by adult to adult.

The life span (LS) of wētāpunga was calculated by:

$$LS = G + rs$$

where *rs* is the remaining survival period of adult females following sexual maturity and equates to the period during which females continue to oviposit. The life span period represents the maximum time between generations represented by adult to adult.

Successive estimated generation and life span periods were summed and plotted as two lines in the conceptual model to interpret field observations and infer the post-release generation of each wētāpunga observed.

3 | Results

3.1 | Husbandry

Oviposition appeared to occur primarily during the first one or two nights after copulation, but it also occurred sporadically throughout the mature females' life span, beginning between 1 and 2 months after the final moult to adult. The mean incubation period for the first egg to hatch from 12 oviposition containers was 284 days (SE = 12.39) and varied between 235 and 351 days. This equates to a mean of 9.5 months and variation of 7.8–11.7 months. Incubation duration was temperature-dependent and was greatly extended in cooler temperatures. Some eggs remained viable for 2 years, allowing eclosion across two periods separated by winter conditions.

The number of nymphs hatched per female varied within and between cohorts collected from Hauturu with a typical range of 231–465 per female per cohort and an overall range of 2–1350 nymphs.

Rearing wētāpunga individually provided an understanding of the growth rate as they matured through the life history stages. After eclosion, wētāpunga undergo 10 moults before reaching adult. The mean growth period for all 10 nymph instars was 414.25 days (SE = 4.85), with no significant difference between males and females ($p = 0.97$, Welch's t-test (2 tailed)). In general, the first six instars took approximately 1 month each, but this extended to about 2 months per instar for the last four instars (Figure 2), equalling 14 months for the total growth period for nymphs.

The mean age of colony-bred adult females was 12.90 months (SE = 0.36), which was significantly different from that of wild-caught females (mean = 10.33 months; SE = 0.67; $p = 0.002$). No significant difference in mean age was detected between colony-bred adult males (11.46 months; SE = 0.42) and wild-caught males (9.67 months; SE = 0.83; $p = 0.07$). The mean ages of colony-bred adult males and females were significantly different

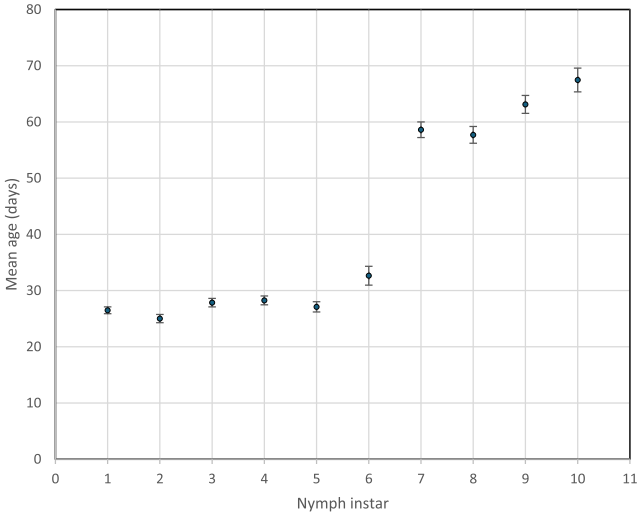


FIGURE 2 | Mean age in days of the 10 nymph instars from colony reared wētāpunga. Bars show the standard error.

($p = 0.014$), whereas the ages of wild-caught adult males and females were not significantly different ($p = 0.32$). Twenty wētāpunga per enclosure was the optimal density for communal rearing, with highest survival rates seen in enclosures containing nymphs that hatched within days of each other, rather than weeks. More than 11,000 wētāpunga were produced from the two ex situ breeding programmes using communal rearing (Table 2).

3.2 | Translocation and Release

Since 2010, when the first release on Motuora Island started the translocation programme, eight islands in Auckland's Hauraki Gulf and Northland's Bay of Islands and two regional parks on mainland Auckland received wētāpunga over a 15-year period (Figure 3, Table 2). Five islands received approximately 600–700 individuals, while the other three islands and the two regional parks received 1200–1900 wētāpunga (Table 2). Motuora and Tiritiri Matangi Islands received F1 or F2 progeny from six collection cohorts from Hauturu (Table 2), with one composed of 3M:3F and five of 6M:6F. Motuhoropapa and Otata Islands received four cohorts, while Motuihe, Urupukapuka, Moturua, and Motuarohia Islands received progeny from three cohorts, all 6M:6F. To date, mainland sites have progeny from a single 6M:6F cohort (Table 2).

Overall, the sex ratio of release cohorts was approximately 1:1, with no significant bias detected in the breeding at either facility.

Occasional escapes from bamboo refuges occurred when an individual chewed through the mesh cover. These wētāpunga always remained within the outer transport container and so were easily reloaded into the bamboo for release. Overall, no deaths were recorded during any transfer and release.

3.3 | Post-Release Monitoring and Data Interpretation

Monitoring on Motuora and Tiritiri Matangi Islands commenced immediately after release and verified that most wētāpunga left

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TABLE 2 | Numbers of wētāpunga translocated to each of eight islands and two regional parks (RP) from Butterfly Creek (BC) and Auckland Zoo (AZ). Parentage/generation includes year that the parents were collected from Te Hauturu-o-Toi/Little Barrier Island.

Year of translocation	Parentage/ generation	Motuora	Tiritiri Matangi	Motuhorapapa	Otata	Motuihe	Urupukapuka	Moturua	Motuarohia	Shakespear RP	Tawharanui RP	Totals
2010 BC	2008-09 collection F1	25										25
2011 BC	2008-09 collection F1		25									25
2012 BC	2008-09 collection F2	35										35
2014 AZ	2012 collection F1	366	370									738
2014 BC	2012 collection F1	15	15									30
2015 AZ	2012 collection F2	100	100	1270								1470
2016 AZ	2012 collection F2				106							106
2017 AZ	2016 collection F1			370	810							1180
2018 AZ	2016 collection F1	174	156		679							1009
2019 AZ	2016 collection F2					339						339
2020 AZ	2016 collection F2					891	43	43	43			1020
2021 AZ	2016 collection F2						27	27	27			81
2022 AZ	2021 collection F1	20	20									40
2022 BC	Mostly F2									241	239	480

(Continues)

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TABLE 2 | (Continued)

Year of translocation	Parentage/ generation	Motuora	Tiritiri Matangi	Motuhorapapa	Otata	Motuihe	Urupukapuka	Moturua	Motuarohia	Shakespear RP	Tawharanui RP	Totals
2023 AZ	2021 collection F1			25	25	56	216	162	206			690
2023 BC	Mostly F2 and F3									350	350	700
2024 AZ	2021 collection F1					70						70
2024 BC	Mostly F3									658	658	1316
2025 AZ	2024 collection F1			223	297	320	328	358	336			1862
Total		735	686	1888	1917	1676	614	590	612	1249	1247	11214

the bamboo refuges within the first week. Occupancy continued to decline slowly over the following weeks. None were marked, but the sex and instar of each were recorded and showed that some vacant bamboo refuges were later reoccupied by different wētāpunga.

The mean instar of each release cohort at Macrocarpa Bay and Pohutukawa Bay on Motuora and Bush 22 and Wattle Valley on Tiritiri Matangi Island varied between 6th–9th instar (Table 3). Of the 891 wētāpunga released at the four areas, the majority (641; 72%) belonged to cohorts with a mean of 7th instar (Table 3). Therefore, 7th was chosen as the starting point of the conceptual model in Figure 4. Husbandry data were used to calculate the expected time for a 7th instar to reach adult, assuming it was halfway through that instar. Thus, $1 + 6 = 7$ months for nominal minimum period before the appearance of the first adults in the P generation (Figure 4).

Husbandry data were also used to infer the expected timing of subsequent generations after P. Generation period G was calculated with $e = 10$ months, $ny = 14$ months and $a = 2$ months; thus, G = 26 months or 2 years 2 months. Using the 13-month life of colony-bred adult females, *rs* was estimated to be 11 months. Thus, the LS is $26 + 11 = 37$ months or 3 years 1 month. The appearance of post-release generations can be inferred from the period between the two lines representing the generation period and life span (Figure 4). Field observation dates that match the likely first record of each generation at each of the four release areas on Motuora and Tiritiri Matangi are provided in Table 4 and, as of November 2025, infer the presence of the F4 generation at three areas and F5 at Bush 22 on Tiritiri Matangi Island. There were many subsequent observations for each generation after the first record.

Post-release monitoring in the four areas tested the feasibility of establishing wētāpunga in different habitats. On Motuora, small numbers were released at Macrocarpa Bay (Table 3) in the forest restoration area, while the second area, Pohutukawa Bay, 1.3 km away had larger numbers released. Similarly, on Tiritiri Matangi, the first release in Bush 22 had small numbers liberated (Table 3), while the second release area in Wattle Valley received larger numbers. Despite the variability in habitat and release cohort numbers, the results infer that wētāpunga have established in each area.

Transect counts during September and October 2025 recorded wētāpunga encounter rates per person-search-hour of up to 11.2 on Otata Island, 28.5 on Motuhoropapa Island and 1.9 on Motuihe Island. Counts were recorded at sites where wētāpunga had been released from 2015 to 2023 (Table 2). There have been ongoing observations of wētāpunga on these islands since the first releases on each island, including verification of the spread away from each release area.

The three islands in the Bay of Islands, together with Shakespear and Tawharanui Regional Parks, were the most recent sites to receive wētāpunga (Table 2). Transect counts over 1.5 h during November 2025 on Motuarohia and Moturua Islands in the Bay of Islands recorded encounter rates of 1.0 and 0.33 wētāpunga per person-search-hour, respectively.

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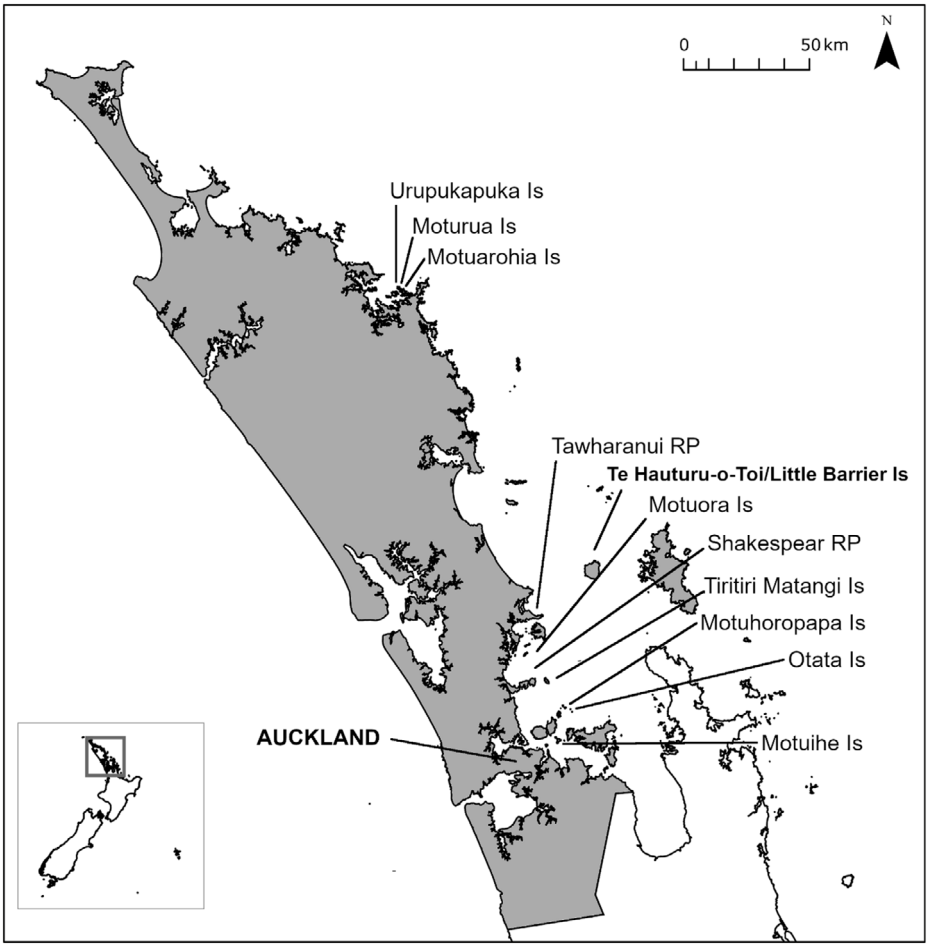


FIGURE 3 | Map of the 10 sites where wētāpunga have been reintroduced as well as the source island Te Hauturu-o-Toi/Little Barrier Island. Northland and Auckland regions, including the Hauraki Gulf Islands, are shaded to indicate likely past distribution.

TABLE 3 | Age class of wētāpunga released at four areas on Motuora and Tiritiri Matangi Islands. Mean instar based on the range and numbers of each instar (see Section 2).

Release area	Release cohort	Number of Weta	Mean instar	Instar range
		Motuora Island		
Macrocarpa Bay	1st	25	7th	6th–7th
	2nd	35	6th	5th–7th
Pohutukawa Bay	1st	150	7th	4th–11th
	2nd	231	7th	2nd–11th
	3rd	20	6th	5th–6th
		Tiritiri Matangi Island		
Bush 22	1st	25	9th	8th–11th
Wattle Valley	1st	150	9th	5th–11th
	2nd	235	7th	2nd–11th
	3rd	20	6th	5th–6th

These most likely represent the F1 generation after the most recent release at these sites in 2023 (Table 2). Tracking tunnels have previously recorded P generation adults on Urupukapuka Island. F1 generation juveniles were first observed at Shakespear Regional Park during night spotlight searches in April 2025.

4 | Discussion

The wētāpunga recovery programme has successfully demonstrated the establishment of new populations on both Motuora and Tiritiri Matangi Islands, with at least four post-release generations confirmed at each site. Under the criteria of Morris et al. (2021),

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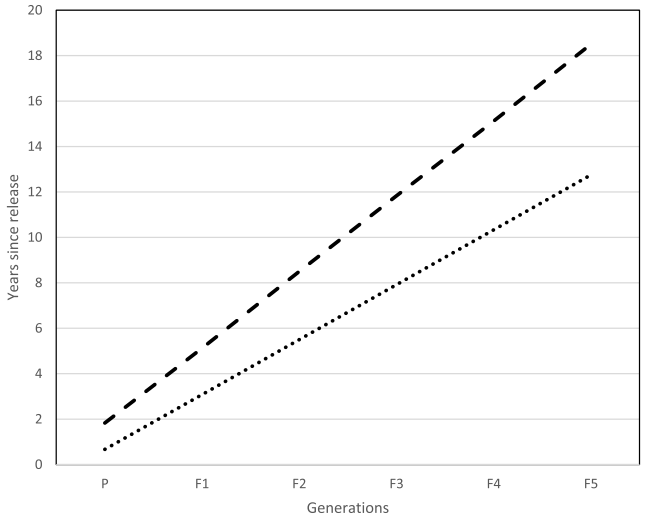


FIGURE 4 | Conceptual model of the predicted period between generations following Parent (P) wētāpunga release at 7th instar. Generation time of 2 years 2 months, adult to adult from F1 onward. The dotted line indicates the minimum period (G), and the dashed line indicates the maximum period (LS) including extended oviposition period of each generation. The different trajectory of the dashed line represents the additional nominal 10-month oviposition period for each generation which compounds over time.

this meets the highest demographic category of translocation success, a 'viable population', where persistence is demonstrated through multiple post-release generations. This aligns with the ultimate objective of any translocation programme: the establishment of a self-sustaining population (Griffith et al. 1989). High rates of detection on the Noises Islands also provide encouraging evidence of establishment, although further monitoring is required to confirm persistence. Verification of multiple wild-born generations at the remaining sites will only be possible following the completion of releases as historical releases at the same locations can obscure identification of subsequent generations.

In 1998, the Threatened Weta Recovery Plan (Sherley 1998) ranked wētāpunga as 'Nationally Endangered' (Hitchmough et al. 2007). Since the ex situ breed and release programme was implemented, subsequent assessments have progressively improved its ranking to 'Nationally Recovering' (Trewick et al. 2012; Trewick et al. 2022). Data is being compiled for a re-assessment in 2027 (P. Michel, DOC pers. comm. 2025).

4.1 | Factors Contributing to Translocation Success

The wētāpunga translocation programme has been running for 15 years (as of 2025) and started on Motuora and Tiritiri Matangi in 2010, and 2011, respectively. These were the 'test cases' to confirm if the species could be re-established in pest-free environments using colony-bred wētāpunga. Despite the variability in habitat and release cohort sizes, post-release monitoring across all four areas on the two islands showed population persistence in all areas. The 20 wētāpunga released at Pohutukawa Bay and Wattle Valley in 2022 were F1 genetic top-ups from a new collection off Hauturu. They were released in small areas separated from those used to confirm the presence of F4 and F5 generations in 2025. Monitoring ceased in 2019 until 2025; thus, the F3 generation was not verified.

The transfer of up to 200 wētāpunga within individual bamboo refuges was successful and allowed for post-release monitoring of each. To minimise disturbance, packing, transport, and release took place in the same day and were completed before nightfall. The release of larger numbers of younger 3rd–6th instar wētāpunga after dark in groups maximised the cost-benefit of ex situ rearing. Across all sites, large numbers were released, which agrees with Bellis et al. (2019) and Morris et al. (2021) who found that the number released was the strongest indicator of success in translocation programmes leading to population persistence.

Objective 5 in the Wētā Recovery Plan (Sherley 1998) stipulated that there should be 'at least four wild populations of a wētā species to safeguard them from further decline', so that became the initial aim of the programme. However, wētāpunga breeding at both facilities was so successful that it enabled additional islands as well as the predator-proof fenced areas in two regional parks to be included in the recovery programme leading to potentially 10 new wild populations with two currently confirmed as established.

Important criteria for each release area included not only suitable food plants and refugia but also the absence of any mammalian predators (see Sherley 1998 and Green et al. 2011). Pest eradication programmes cleared such predators on the eight island sites prior to wētāpunga releases, and there are ongoing pest surveillance programmes. At the regional park sites, seven of the 10 mammalian pests were eradicated, but house mouse (*Mus musculus*), European rabbit (*Oryctolagus cuniculus cuniculus*) and European hedgehog (*Erinaceus europaeus*) persisted at Tawharanui (Maitland 2011). All but mice were eradicated from Shakespear, and hedgehogs have subsequently been eradicated from Tawharanui (M. Maitland pers. comm. 2025). Critically, rats were eradicated at both, and the parks remain rat-free despite short-term reinvasions, which have been eliminated (Maitland 2011). Some giant wētā species can coexist with mice, such as the Cook Strait giant wētā (*Deinacrida rugosa*), which was translocated to Zealandia beginning in 2007 and has established there despite the presence of mice (Watts et al. 2012). This species also survived on Mana Island in the presence of mice, including through periodic irruptions to high densities (McIntyre 2001). The regional parks were included in the release programme as test cases to determine if wētāpunga populations could establish in the presence of mice on the mainland.

Motuora and Tiritiri Matangi Islands had one and two other release areas, respectively, that received wētāpunga in 2015 and 2018, situated between those used for more intensive monitoring. There were many observations across these three areas that verified the ongoing presence of wētāpunga. Over time, we expect that there will be overlap between these and the other areas that will result in full coverage of suitable habitat on each island. Many observations throughout the programme, including those from Supporters of Tiritiri Matangi and members of the Motuora Restoration Society, have confirmed the ongoing range

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TABLE 4 | Field observation dates and equivalent time interval in years (yr) and months (m) that infer the likely first record of each generation at each of the four release areas on Motuora and Tiritiri Matangi Islands. Records were either direct observations of adult (Ad) wētāpunga or from tracking tunnels (TT) which recorded the distinctive footprints of adults on cards. The time intervals were fitted to the conceptual model in Figure 4 to infer the likely generation from P to F5.

			P Adult		F1		F2		F3		F4		F4	
Release area	**Cohort**	**Release date**	**Date and interval observed**	**Record**	**Date and interval observed**	**Record**	**Date and interval observed**	**Record**	**Date and interval observed**	**Record**	**Date and interval observed**	**Record**	**Date and interval observed**	**Record**
Motuora Island														
Macrocarpa Bay	2nd	02/12/2012	25/02/2014 1 yr 3 m	Ad	—	—	01/12/2019 7 yr 0 m	Ad	—	—	16/11/2025 12 yr 11 m	Ad	—	—
			20/05/2014 1 yr 6 m	TT	—	—	—	—	—	—	—	—	—	—
Pohutukawa Bay	2nd	26/06/2014	15/07/2015 1 yr 1 m	Ad	26/10/2017 4 yr 5 m	Ad	07/04/2019 4 yr 9 m	Ad	—	—	16/11/2025 11 yr 5 m	Ad	—	—
			—	—	19/11/2017 4 yr 6 m	TT	—	—	—	—	—	—	—	—
Tiritiri Matangi Island														
Bush 22	1st	10/12/2011	—	—	02/10/2014 2 yr 10 m	Ad	02/03/2018 6 yr 3 m	Ad	—	—	—	—	01/10/2025 13 yr 10 m	Ad
			—	—	15/06/2015 3 yr 6 m	TT	—	—	—	—	—	—	—	—
Wattle Valley	2nd	27/06/2014	03/02/2016 1 yr 7 m	Ad	20/08/2017 3 yr 2 m	Ad	—	—	—	—	01/11/2025 11 yr 4 m	Ad	—	—
			—	—	07/10/2017 3 yr 3 m	TT	—	—	—	—	—	—	—	—

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expansion between areas. Encounter rates from the Noises and Motuihe Islands are higher than the 1.4 wētāpunga per person-search-hour recorded on Hauturu following Pacific rat eradication (Green et al. 2011). The forest habitat on Hauturu had a taller canopy with a greater diversity of food plants than on the release islands, and radio tracking showed that 82% of the daytime refuge sites for adults were greater than 2 m off the ground (Watts and Thornburrow 2011). The lower canopy height on the release islands may have enabled a greater proportion of wētā to be seen. The high numbers could also reflect breeding success on the release islands and may indicate a higher carrying capacity than that of other sites with higher native predator numbers.

Early in the breeding programme there was concern about the higher potential for avian predation of released wētāpunga due to the higher number of insectivorous bird species on Tiritiri Matangi compared to Motuora (McFarlane et al. 2016), so older instars were released on the former. However, P and F1 generations were confirmed on both islands, so later releases included a wider range of instars.

4.2 | Communal Rearing and Husbandry Insights

The majority of wētāpunga were reared communally. Initially, this was trialled to develop less time-consuming methods of rearing and to maximise numbers available for release in the limited space available. Various enclosure sizes and animal densities were assessed, as well as the type and number of refugia. Survival rates varied but tended to be higher when all the 1st instars hatched within a short time (less than a week). Wētāpunga were observed to be cannibalistic, and lower survival was likely due to larger, older wētāpunga opportunistically predating younger, smaller siblings in cages with a wider age range. In addition, cages with refugia too densely packed with fern fronds and/or those having less than one plastic hose pipe/bamboo per wētāpunga often had lower survival rates. Juveniles often occupied the hose pipe refuges until too large to fit, usually around 5th instar. At this point, they began utilising the fern frond columns instead.

Once it was demonstrated that communal rearing could be as productive as individual rearing, the most successful density and enclosure size were chosen and became standard practice. This was further confirmed during the F2 generation rearing period, where cage inoculation with first instars resulted in a survival rate of up to 80% at the time of cohort translocation for release.

The protein component of the diet was critical to the survival of 1st–3rd instars. Offered ad lib, it was replaced three times per week until feeding damage on foliage was observed, typically at 3rd instar. The frequency of protein feeds was subsequently reduced to twice per week and, at maturity, to once per week. This pattern of reduction reflected field observations at night on Hauturu where younger, 1st–3rd instars, were often found close to protein sources (such as fungus, mould or bird droppings). This pattern was less common for older instars (CG and PB pers. obs.). In general, wētāpunga were motionless whenever observed at night using a light, so behavioural observations were rarely possible.

The extended period of egg development, potentially lasting into a second season, was used to efficiently manage the breeding colony by refrigerating some oviposition containers to facilitate diapause. This allowed more controlled eclosion rates to manage genetic representation in release cohorts and match available housing.

4.3 | Genetic and Demographic Considerations

We recognise that establishing populations from small founder numbers can lead to a range of genetic outcomes, including inbreeding depression and unequal breeding success (Jamieson 2015). In an assessment of the genetic diversity of translocated populations of the Cook Strait giant wētā, White et al. (2017) recommended at least 70 unrelated individuals as founders of new populations to avoid genetic bottlenecks. To mitigate risks of poor genetic outcomes, wētāpunga within each of the six cohorts of 12 and one of 6 founders collected from Hauturu were cross-mated to maximise offspring genetic diversity. Motuora and Tiritiri Matangi Islands have had F1 or F2 progeny from the first six collection cohorts, thus a potential pool of 78 founders. However, there was unequal breeding success from the first collection cohort of 3M:3F, which resulted in low offspring numbers for initial releases. Future evaluation of genetic outcomes will be supported by DNA samples collected during 2018–19 from 40 wētāpunga per island across their ranges on Motuora and Tiritiri Matangi Islands (C. Green, unpublished data; samples have been deposited with Bioeconomy Science Institute).

Rearing data showed variability in the age of each life history stage. Thus, the calculation of 2 years 2 months for the time between generations and 3 years 1 month for the life span of wētāpunga used for the conceptual model represent nominal periods that may vary in the wild. The mean age of colony-bred adults was greater than those collected from the wild, but the latter had outliers, with several living for 17 months after capture. Because the age of these wētāpunga prior to capture was unknown, these outliers may indicate that individuals in the wild have the potential for a longer mean age than that of ex situ colony-bred individuals used to estimate the life span. Also, the range in age class of each release cohort added further variability to the timing of subsequent post-release generations. Therefore, the timing of each post-release generation from the conceptual model is an inferred representation of the appearance of adults in each generation.

4.4 | Implications for Invertebrate Conservation

The life history attributes of invertebrates, such as short life span, small size and high fecundity, make them particularly cost-effective for intensive ex situ breeding programmes to facilitate species recovery (Bellis et al. 2019). There are many more critically endangered New Zealand invertebrates, such as the Stephens Island weevil (*Anagotus stephenensis*, Coleoptera: Curculionidae), the Canterbury knobbled weevil (*Hadramphus*

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tuberculatus, Coleoptera: Curculionidae) and several *Geodorcus* stag beetle species (Coleoptera: Lucanidae), which would benefit from similar programmes to safeguard their future. Conservation authorities and practitioners are encouraged to facilitate such endeavours.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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