Invertebrate Trapping at Tūhaitara Coastal Park

Garden wolf spider (Anoteropsis sp.)

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CONTENTS

Executive summary	3
Introduction	4
• Background information	5
• Background studies on Invertebrates	6
Methods	6
• Pitfall traps	7
• Design	7
• Site selection and trapping transects	8
• Trap monitoring	9
• Data analysis	10
• Statistical methods	10
Results	11
• Abundance	11
• Diversity	14
• Relationships	15
Discussion	16
• Comparison of invertebrate abundance and diversity	16
• Factors influencing diversity and increasing populations	16
• Enhancing habitat	17
• Invertebrate monitoring	18
Conclusion	19
Acknowledgements	20
References	21

EXECUTIVE SUMMARY

Tūhaitara Coastal Park (TCP) is a wetland of natural and cultural significance and is home to threatened endemic wildlife species. Te Kōhaka o Tūhaitara Trust (TKOT) are working towards restoring native coastal wetland vegetation whilst continuing to host exotic pine plantations. Invertebrates are key to both native and exotic ecosystems and the TKOT are seeking a greater understanding of their populations. To capture a fully representative sample of all invertebrates, multiple trapping methods are required. This project used pitfall trapping to study the variation in ground-dwelling invertebrates between native and exotic vegetation over a three-week period in late winter/early spring. The results were uploaded onto a website for identification by entomologists and citizen scientists.

The results showed that areas of native vegetation had greater vegetation and species diversity than exotic vegetation. Species were found in similar levels of abundance in both vegetation types, however those in the exotic vegetation were mainly spiders. To increase invertebrate biodiversity TKOT should continue to plant native vegetation, including corridors of low, bushy, native vegetation to create links between existing and future biota nodes that encourage distribution of species. Invertebrate studies should include multiple types of trapping to avoid the limitations of this study such as predation, seasonality and repeat capture. Similar studies should be repeated regularly to increase familiarity with invertebrates and observe trends in population diversity.

Flat backed millipede (Order Polydesmida)

INTRODUCTION

An estimated 97% of the animal kingdom are invertebrates (Salvador, 2021) and they play a crucial role in ecosystems as herbivores, detritivores, predators, and prey (McCary & Schmitz, 2021). Many ecosystems have been drastically altered through land use change and settlement, with substantial reductions in native vegetation and wetland areas. In New Zealand, only around 10% of wetlands remain (Johnson and Gerbeaux, 2004), and they are home to many endemic birds and fish that rely on invertebrate populations for food (Watts, Peters & Suren, 2012). New Zealand is home to an estimated 20,000 species of invertebrates, of which about 98% are endemic (Patrick, 1994).

Tūhaitara Coastal Park in North Canterbury is a coastal strip of 700 hectares between the Waimakariri River and Waikuku Beach (Figure 1). It was gifted to the people of New Zealand as part of the settlement between the Crown and Ngāi Tahu (Te Kōhaka o Tūhaitara Trust, 2015).

Figure 1

Trapping sites at Tūhaitara Coastal Park, North Canterbury.

Note. Approximate boundary of Tūhaitara Coastal Park, North Canterbury with trapping Sites A, B and C. Adapted from Canterbury Maps. Copyright (n.d.) Canterbury Maps, Creative Commons Attribution 4.0 International Licence.

The coastal dunes have formed over a relatively recent geological period due to progradation, wave action, and coastal weather systems (McGlone, 2009). They have blocked the natural drainage of rivers and streams leading to the formation of shallow palustrine wetlands and a freshwater lagoon (Johnson and Gerbeaux, 2004).

The vision of Te Kōhaka o Tūhaitara Trust (TKOT) is to create a healthy coastal wetland and forest area at TCP (TKOT, 2015) that provides essential ecosystem services whilst retaining the exotic pine plantation which provides an important source of income. Understanding and increasing the biodiversity of the invertebrate community is part of this vision as invertebrates can be a key indicator of successful restoration (Palmer, 2022).

The aim of this project is to discover what variations in ground-dwelling invertebrates (GDI) exists between the areas of native vegetation and exotic pine plantations within the Tūhaitara Coastal Park and what improvements can be made to increase local biodiversity.

Background Information

Biodiversity is declining globally, and following the ongoing trends in ecosystem health and function are set to worsen as a response to future human population growth. Human population growth creates a need for increased production and consumption, and when done in an unsustainable manner has a significant effect on the terrestrial and aquatic environment (Clarkson, 2022). Biodiversity has a major benefit to the natural systems and the organisms reliant on them and creates high levels of resilience in the ecosystem (Department of Conservation, 2020).

The main drivers of biodiversity loss within New Zealand are climate change, disease, land use changes, invasive species, pest predation and habitat loss. New Zealand has a unique history due to being secluded from other major landmasses, resulting in an environment with high levels of endemism. This has led to New Zealand's flora and fauna becoming highly susceptible to invasive alien species (Clarkson, 2022). New Zealand has the highest number of non-native plant species out of any island nation in the world, with approximately half the total wild vascular plants being invasive (Hulme, 2020). These invasive alien plants pose a threat to over half of New Zealand's critically endangered ecosystems, and the estimate of damage to native biodiversity is estimated to be over USD 1 billion (Hulme, 2020). The establishment of invasive alien invertebrate species has had a detrimental effect on native invertebrate communities in New Zealand, as well as invasive mammalian and reptile species, many of which prey upon the native invertebrate species (Department of Conservation, 2020).

To counter this, Te Kōhaka o Tūhaitara Trust is carrying out restoration work in the TCP through numerous projects, including the creation of a biota node network and rehabilitation of the Tūtaepatu Lagoon and The Pines Beach Wetland. In 2016, the Trust began planting a podocarp forest with the help of many volunteers. They planted 2000 kahikatea, matai and totara and have added many more native tree species each year (Te Kōhaka o Tūhaitara Trust, 2023).

By examining the invertebrate communities through trapping, this study evaluates and compares the effect habitat has on population variations. Through understanding existing ground-dwelling invertebrate population and reviewing similar studies, strategies can be developed to enhance future restoration work.

Background studies on invertebrates

Prior to this research being conducted, an extensive literature review was taken to anticipate what might be expected within the TCP ecosystems. A comparable study was the Styx Living Lab assessment on invertebrates at the Styx Conservation Reserve (Macfarlane, 2007).

The Styx Conservation Reserve runs along the Styx River in Northwood, Christchurch, with grasslands, wetlands and woodland ecosystems hosting significant levels of biodiversity. Using light traps, malaise traps and yellow pan traps, they recorded over 9300 specimens, with between 354 and 386 different species found. This information was comparable, as a large part of the TCP consists of native wetlands and exotic pine woodland ecosystems, and it is located nearby.

The assessment found that the woodlands had the most species diversity as well as the highest number of parasitic specimens. The most frequently found spider species were wolf and nursery spiders, and the study found that wolf spiders preferred grasslands, while Nursery spiders preferred wetlands.

Litter and wood decomposing beetle and gnat species had highest richness in woodlands areas but had greater abundance in wetlands areas. These are indicative of what may be found within the TCP, however as the Styx Conservation Reserve has different tree species, the results may differ (Macfarlane, 2007).

Anderson & Death (1999) found through their pitfall trapping study in New Zealand that invertebrate abundance and species richness was highest in native forest ecosystems compared to pine, but species evenness did not differ between forest types.

METHODS

The scope of this research was limited to ground-dwelling invertebrates after consulting a wide range of literature about trapping. Malaise traps are often used to capture flying invertebrates (Hutcheson & Jones, 1999) however this study was conducted at a time of year when there are fewer flying invertebrates. There were also practical issues with other methods such as trapping freshwater invertebrates and the method chosen, pitfall trapping, was suitable for a park with public access.

Pit Fall Traps

Pitfall trapping was selected due to its high success rate for capturing GDI compared to other GDI capture methods and its suitability for a public park (Montgomery et al., 2021). Site capture methods were adapted from a nearby and similar coastal environment GDI study of the Charlesworth Reserve, Christchurch (Palmer, 2022).

Design

The pitfall traps consisted of three components, two clear 330ml plastic cups, a plastic plate and two metal stakes (Figure 2). After digging a hole approximately, the size of the plastic cups, 2 plastic cups were stacked on top of each other (one in the other) and inserted into the hole, keeping the top of the cup flush with the soil surface. The space around the cup was then filled in with soil to create a snug fit. The bottom cup was left in throughout the study period to maintain the integrity of the hole. A small amount of plant litter was then added into the top cup but well below the cup top to help shelter and protect smaller trapped invertebrates from larger predacious GDI. As GDI crawl across the ground surface they inadvertently fall into the cup and are unable to climb out. The plastic plate was placed horizontally about one cm above the cup top, fixed in place by a metal stake on either side of the plate. The plate protected the cup from excess plant litter and flooding.

Figure 2

Pitfall Trap and GDI Collection

Note. Left: Trap A2 at Site A showing the trap roof (plastic plate) and trap cup used to capture GDI. Right: An ice cream container lined with graph paper was used to count and identify specimens in the traps.

Figure 3

Trapped spider and prey at trap C4

This methodology is a live trapping method, in contrast to other pitfall methods where a liquid (such as antifreeze) is poured into the bottom of the trap to kill the invertebrates (Murray et al., 2017; Bowie et al., 2011). The use of pitfall traps, and a live trapping method, had the disadvantage that winged invertebrates and larger beetles were able to escape and predation of some GDI occurred (Figure 3). Invertebrates once counted were released back to the locality of the traps, increasing the possibility of repeat trapping of invertebrates.

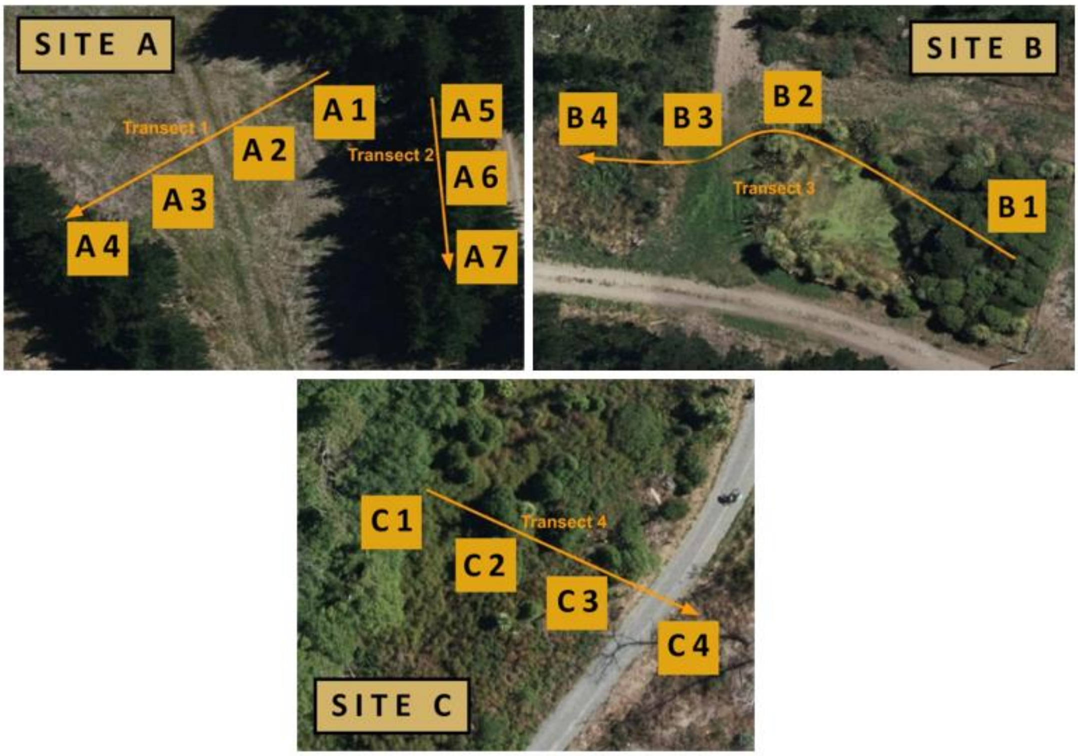
Site Selection and Trapping Transects

To get an effective overall representation of GDI at TCP, three trapping locations were chosen: Site A, Site B and Site C (Figure 1) to include native and exotic vegetation and a wetland area. Site A consisted of a developing wetland, open grassland, and exotic pine forest (EPF), Site B consisted of a well-developed native wetland forest and EPF and Site C consisted of native bush (mainly bracken) and some open grassland.

Four transects, between 30 – 40m long, were set up between the sites, two at Site A and one each at Site B and Site C (Figure 4). All transects originated at a water source, having pitfall traps placed at 10 m increments consistent with other GDI trapping research (Montogomery et al., 2021). Transect 1 (traps A1–A4) at Site A ran from a developing wetland, through grassland and into EPF and transect 2 (traps A5–A7) ran from the same wetland into EPF. Transect 3 (traps B1-B4) at Site B ran from a well-developed wetland into EPF. Trap B2 flooded at its original site, so it was relocated during the second site visit to higher ground. Transect 4 (traps C1-C5) ran through native bush (bracken) and into an open grass area. The Wetland at Site C was the only natural wetland as the developing wetlands at Site A and Site B were man-made.

Figure 4

Site maps showing the layout of the traps and direction of each transect.



Note. Clockwise from top: Site A (-43.360911, 172.705372), Site B (-43.344415, 172.703876) and Site C (-43.330601, 172.705623). Pitfall traps sites are labelled A1 - A7, B1 - B4 and C1 - C4. The orange lines indicate the four transects. Adapted from Canterbury Maps. Copyright (n.d.) Canterbury Maps, Creative Commons Attribution 4.0 International Licence.

Trap Monitoring

Traps were checked weekly for three consecutive weeks after the initial site visit and pitfall trap installation. A one-week grace period between the initial site visit and trap collection was used to reduce any collection bias caused by site and soil disturbance created when traps were placed into the ground (Andersen, 1995; Montgomery et al., 2021). At each trap the contents of the top cup were emptied into an ice cream container lined with graph paper (Figure 2). Excess plant matter was then carefully removed, ensuring any GDI attached to that plant matter were not removed. The graph paper helped with the identification of individual invertebrates and their size. New or unknown invertebrates were photographed.

The number of specimens observed in traps was limited by the trapping methodology. Palmer (2022) was able to check her traps four times per week, reducing the possibility of predation. In this study the traps were checked weekly due to time constraints, however this increased the possibility of predation.

Data Analysis

The 351 specimens collected over the three weeks were grouped into 51 recognisable taxonomic units, each with a photograph and field description. The groups were loaded onto a purpose-built project on iNaturalistNZ (iNaturalistNZ, n.d.), providing a central platform for identification that could be accessed by entomologists. This method has been used successfully in other invertebrate studies (Palmer, 2022).

This study aimed to identify all the specimens to the lowest taxonomic level as their characteristic traits and habitat preferences can vary widely above genus level, however this was difficult with live specimens. Murray (2017) used preserving fluid to trap invertebrates at Tūhaitara and was able to view microscopic features to assist with identification, however due to time limitations only 20 of the 75 pitfall traps in that study were identified to species level.

Invertebrate studies are ideally carried out during the summer months (Murray, 2017; Palmer, 2022; Bowie et al., 2011) when temperatures are warmer. Due to time limits with this study, trapping took place during late winter – early spring when temperatures were cooler and invertebrates are less active, a factor that may have influenced trapping rates (Evans, 2016).

Statistical methods

Traps were grouped into one of five habitats that align with their respective site characteristics. An example of the characteristics considered is that traps situated in wet soil types were categorised under the wetland habitat, and traps placed in areas with a high percentage of canopy cover were included in the Exotic and Native habitat. Traps surrounded by grass were grouped into open areas, considering the surrounding vegetation (Table 1). This was necessary because the groundcover at site A and B featured both exotic and native vegetation as well as open areas. Grouping traps based on habitat characteristics provided a more logical way to relate invertebrates to vegetation types, and in a way that links directly to the biodiversity goals within TCP (Table 1).

Table 1

Vegetation categories, descriptions, and traps in each category.

Category	Exotic Open Area	Exotic Pine	Native Open Area	Native Wetland	Native
Description	Minimal canopy. Litter - grass to 5 cm. Surrounding exotics	80-100% canopy. No ground vegetation. Litter - pine needles 6-7 cm. Surrounding exotics.	Minimal canopy. Litter - grass to 0.5 cm. Surrounding natives.	Varying canopy cover. Maximum vegetation height 4m. Litter - grass. Surrounding natives. Wet soil type	100% canopy cover. Maximum vegetation height 5m. Litter - native to 1 cm. Surrounding natives.
Traps	A1, A2, A3, A5, B3	A4, A6, A7, B4	C4	B2, C1	B1, C2, C3

The Shannon Diversity Index (SDI) was used in our analysis as a biodiversity measurement tool, quantifying the level of diversity within an ecosystem. The SDI considers both the richness (the number of different species) and evenness (the distribution of individuals among those species) in the community. SDI is calculated by looking at how many of each species there are, and their percentage of the species (Ortiz-Burgos, 2016). Higher SDI values indicate greater diversity. This allowed us to compare invertebrate species diversity between sites and habitats at the TCP.

RESULTS

The results examine abundance, diversity and relationships between invertebrates and habitats.

Abundance

The total number of invertebrates caught at the TCP was 351, with millipedes being the most abundant (48.1%) (Table 2 and Figure 5). Spiders made up the next largest group (24.2%) followed by beetles and weevils (8%) land hoppers (5.2%).

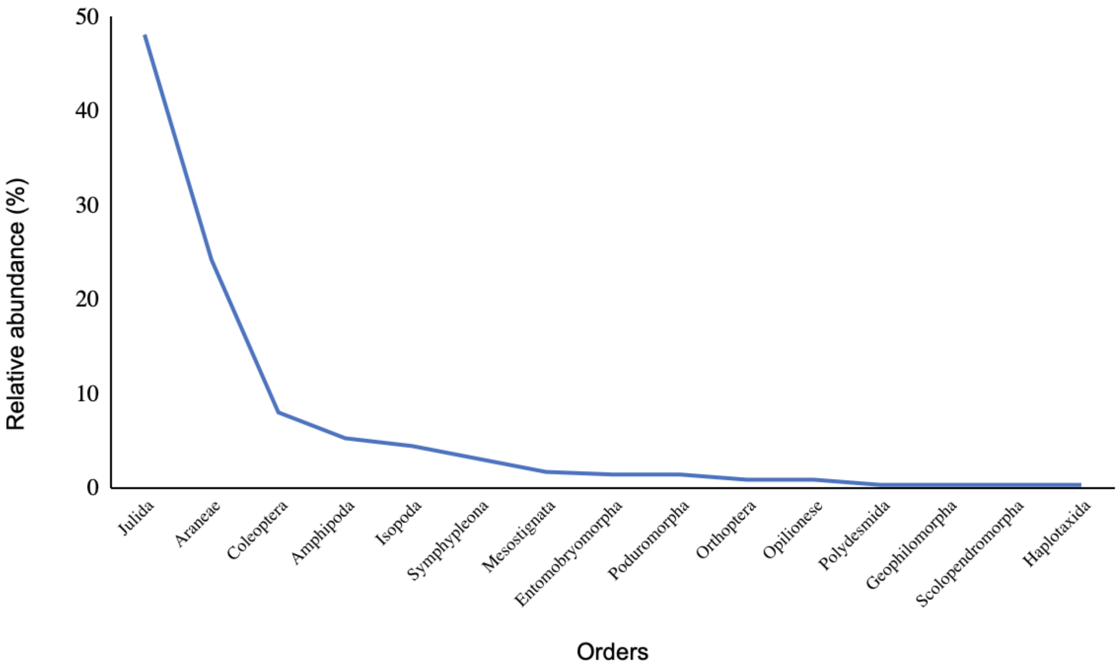
Table 2

Invertebrates caught at Tūhaitara Coastal Park with totals and relative abundance.

Phylum	Class	Order	Common name	Total caught	Relative abundance (%)
Arthropoda	Arachnids	Mesostignata	Mite	2	1.6
		Araneae	Spider	88	24.2
		Opilionese	Harvestman	3	0.8
	Diplopoda	Julida	Millipede	175	48.1
		Polydesmida	Flat millipede	1	0.3
	Chilopoda	Geophilomorpha	Soil centipede	1	0.3
		Scolopendromorpha	Centipede	1	0.3
	Malacostraca	Amphipoda	Land hopper	19	5.2
		Isopoda	Woodlouse	16	4.4
	Insecta	Coleoptera	Beetles & weevils	20	8
		Orthoptera	Wētā /cricket	2	0.8
	Entognatha	Entomobryomorpha	Springtail	6	1.4
		Poduromorpha	Springtail	11	1.4
		Symphypleona	Springtail	11	3
Annelida	Clitellata	Heplotaxida	Worm	1	0.3

Figure 5

Relative abundance curve showing the difference in capture rates by order.

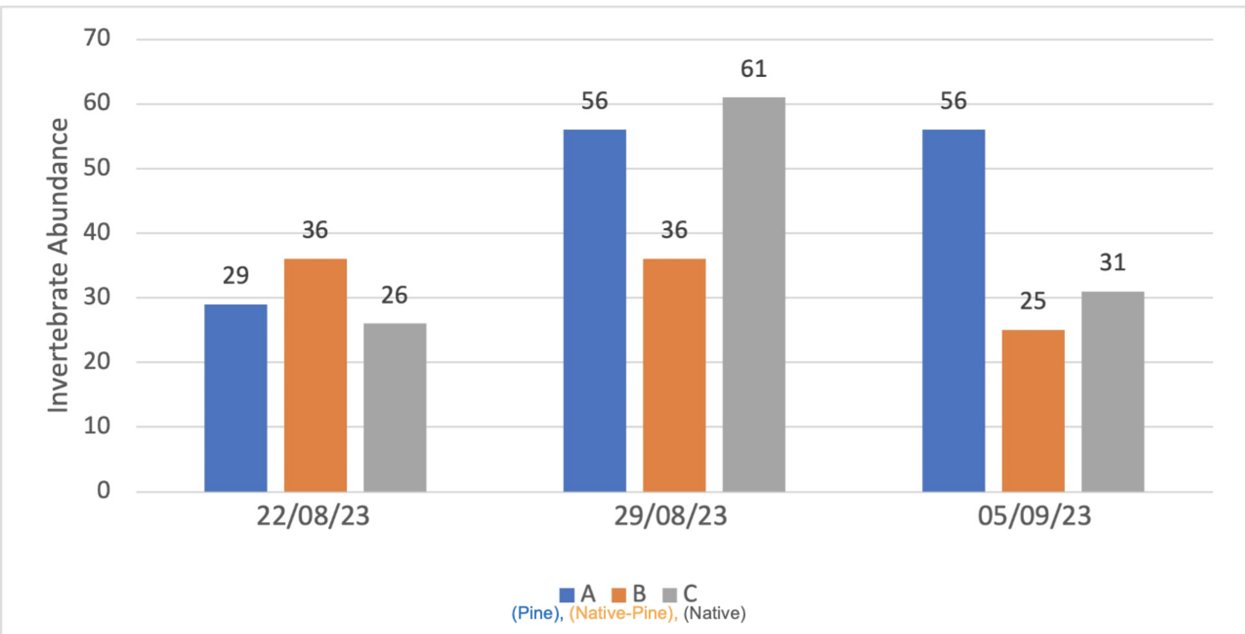


Note. This curve is typical of an invertebrate study and similar results were found by Murray (2017) except from the proportion of millipedes (Order Julida).

There was a significant difference in invertebrate abundance between the first and second collection days. On the first day (August 22) there were 91 invertebrates in the traps and on the second day (August 29) there were 153 (Figure 6).

Figure 6

Invertebrate abundance by collection date at Sites A, B and C.

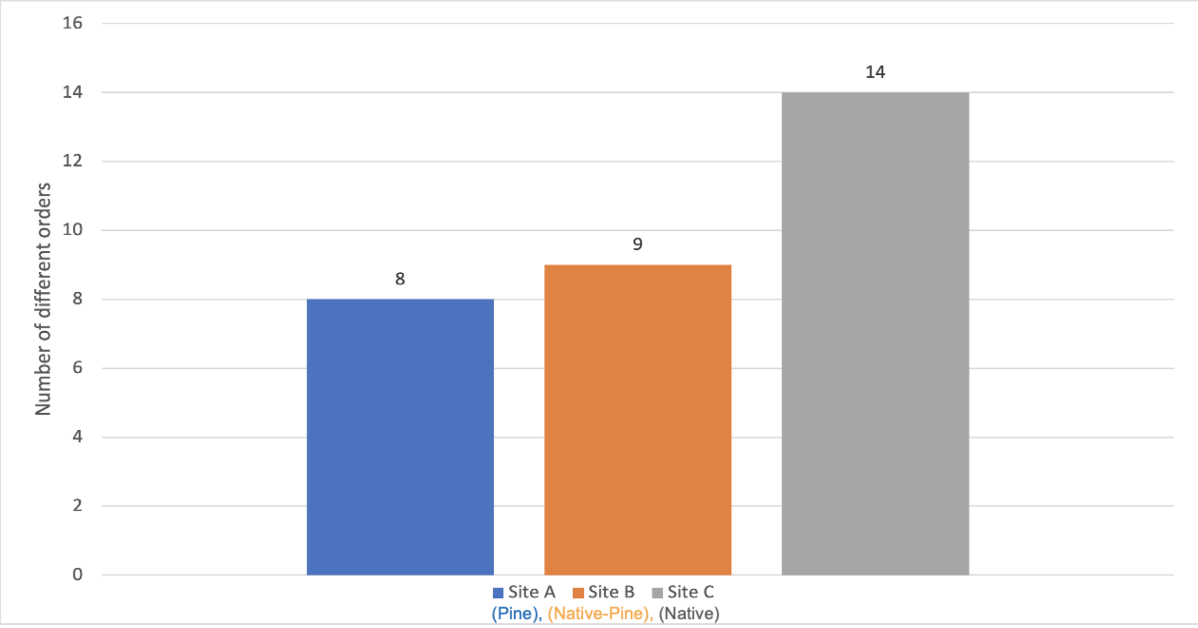


Diversity

Analysis of invertebrate diversity showed Site C supported the highest different species orders (14), followed by Site B (9), and Site A (8) (Figure 7).

Figure 7

Number of invertebrate orders caught at each of the three trapping sites.



The Shannon Diversity Index for the three sites showed Site C had the most significant species diversity (1.40). Site A (1.29) and site B (1.31) had similar results (Table 3). The Shannon Equability index indicated Site C also had the most significant evenness between the three sites (Table 3).

Table 3

Shannon diversity Index comparing invertebrate diversity between the trapping sites.

Calcs	Site A	Site B	Site C
Shannon Diversity	1.29	1.31	1.40
# Diff orders	8	9	14
Evenness	0.48	0.49	0.52

The Shannon Diversity Index for the different habitats showed the Native wetland had the most significant species diversity (1.83), this was followed by the Native area (1.44). The remaining habitat types had similar results. The Shannon Equability Index indicated the Native wetland also had the most significant evenness between the habitats (0.68) (Table 4).

Table 4

Shannon Diversity Index comparing invertebrate diversity across the different vegetation types.

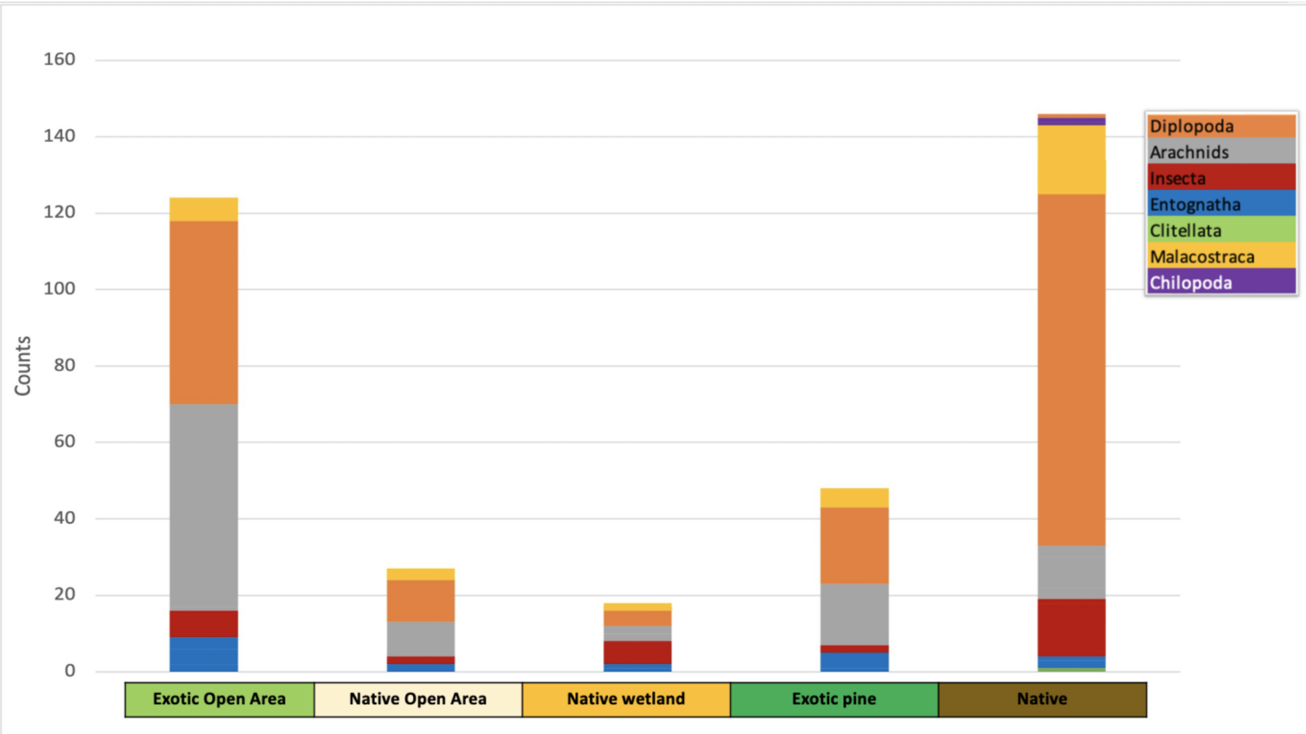
Calcs	Exotic open	Native open	Native wetland	Exotic pine	Native
Shannon Diversity	1.38	1.36	1.83	1.39	1.44
# Diff orders	9	5	8	6	14
Evenness	0.51	0.50	0.68	0.51	0.53

Relationships

Five of the seven Classes were found in every vegetation type (Figure 8). Chilopoda (centipedes) and Clitellata (worms) were only found in the Native vegetation area. The Exotic Open Area and Native vegetation area have the highest average abundance which is justified by the number of traps allocated to these habitat types (Table 1).

Figure 8

Relationship between invertebrate diversity and vegetation type categorised by taxonomic order.



DISCUSSION

In the following section abundance refers to the total number of species present, while diversity is linked to the number of different types of species present, represented by the order level.

Comparison of Invertebrate Abundance and Diversity

At a site level, invertebrate abundance is seen to be variable across the trapping period (Figure 6). This variability was expected due to the weather conditions and soil disturbance from the trapping methods, which is most prominent through the first collection date (August 8) (Sherley & Stringer, 2016). There are no evident patterns in invertebrate abundance between collection periods which is reflected by the variability between sites (Figure 6), despite the different number of traps at site A (7) compared to B (4) and C (4). The abundance at each site is characteristic of the total abundance at each trap within that site. Therefore, due to the transect design of this study, site characteristics such as canopy cover or openings resulting in environmental changes such as altered soil moisture at individual traps between collections could be consequent for the varying abundance experienced between dates (Perry & Herms, 2019). The site characteristic variations between sites and within them resulted in millipede collections from each site while the majority of the spider populations (72%) came from Site A. This is because 2 of the 4 traps within one of the transects at Site A were in grassland, which is a preferred habitat of wolf spiders (Macfarlane, 2007). In comparison, Murray, (2017), only collected one millipede out of nearly 700 specimens at TCP. This may be due to seasonality or trapping methods used.

The diversity of invertebrate species shown in Figure 7 and the SDI (Table 3) highlight the highest diversity was found at Site C. To minimise the variation within site traps it is best to investigate the underlying factors of diversity at a habitat level. This is because the grouping of traps into habitat types allowed for traps with similar vegetation and characteristic states to be compared to other groups to understand vegetation influence. The SDI in Table 4 highlights that invertebrate diversity is highest in the Native Wetland area (1.83) followed by the Native area (1.44) highlighting that native vegetation characteristics have a significant influence on invertebrate diversity. However, it is important to mention that difference in abundance between habitat types is negligible due to the uneven sorting of traps into these categories. For example, Figure 8 shows that the Exotic Open Area and Native Area have the highest average abundance which may be due to these categories containing five traps and three traps respectively. However, Figure 8 highlights the most common Classes across all habitats were Diplopoda and Arachnids.

Factors Influencing Diversity and Increasing Populations

Throughout this study higher invertebrate diversity has coincided with native habitat types at Tūhaitara Coastal Park. This is a trend seen in other studies (Cifuentes-Croquevielle et al., 2020); Brockerhoff et al., 2017), where native vegetation supports ecological conditions that are preferable for invertebrates. This relationship is driven by the diverse vegetation cover compared to the dense monoculture of pine plantations (Cifuentes-Croquevielle et al., 2020). These pine environments are often associated with low fertile, dry, and acidic soils with limited light, all of which limit diverse invertebrate uptake. The southern end of TCP, study sites A and B, has limited established native vegetation, with recently planted sites surrounding man-made scraped wetland areas. There are large distances between established native vegetation and the new restoration sites. Watts (2006) highlighted that the increased distance from established natives to native restoration sites results in decreased total invertebrate uptake. This trend is observable with the Shannon diversity result seen for Sites A and B, compared to the well-established native vegetation on the northern side of TCP where Site C was located, and diversity was the most significant (Table 3).

Enhancing Habitat

It is important to consider the diversity of invertebrates due to the ecosystem services they provide in their inhabited environments (Patrick, 1994). Ground-dwelling invertebrates are integral to soil aeration, decomposition of dead plant matter, pollination as well as providing a significant food source for other native and exotic birds (Patrick, 1994). Therefore, promoting invertebrate diversity helps replenish vegetation through their ability to create higher fertility environments. To achieve increased invertebrate biodiversity at TCP it is recommended to increase the overall percentage of native vegetation. This can be achieved by implementing understory native shrubs beneath pine plantations to create habitat linkages between areas of significant native vegetation (Brockerhoff et al., 2017; Cifuentes-Croquevielle et al., 2020). However, the dense canopy of pine plantations reduces light levels, making it important to consider the light requirements of selected shrubs to ensure uptake. Secondly, as ground-dwelling invertebrates have low dispersal, Watts (2006) recommends the direct translocation of established native vegetation to newly restored sites due to the success within her study. Without adequate linkages between sites, it can take up to 40 years for invertebrates to recolonise a restored habitat. Overall, it is important to consider the amount and distance between areas of native vegetation and ‘green corridors’ to generate habitats suitable to low mobility invertebrates. General plant management such as keeping areas free of pollutants, pests and understanding soil conditions alongside TCP’s restoration planting regime will help support these invertebrate populations.

Invertebrate Monitoring

A future recommendation for the TCP is to enhance trapping efforts. Conducting more research on trapping and implementing long-term monitoring for invertebrate traps will aid in understanding population trends, particularly in response to environmental changes. Another recommendation is to share the photographs made during this study with TKOT if they are interested in adding invertebrates to their online teaching resources (Figure 9). This could be beneficial for educational purposes and allow people to identify invertebrates they encounter at the park. Additionally, citizen science can be valuable for advancing ecological restoration efforts at the TCP. Past studies have found that the combination of citizen science and experts can find reliable data to contribute to the restoration of invertebrates (Barbato et al., 2021; Deacon et al., 2023; Kevin, 2011; Lawson et al., 2022). Citizen science involves engaging volunteers from the community in scientific activities, enabling non-expert individuals to contribute their efforts, time, and observations to assist in invertebrate trapping, increasing biodiversity at the TCP.

Figure 9

Examples of photographs taken during trapping.

Note. Clockwise from top left: Ground Beetle (Tribe Harpalini); Common millipede (Family Julidae) and mite (Order Mesostigmata); Wētā (Pleioplectron simplex); Land hopper (Order Amphipoda) and Sheet web/Dwarf spider (Family Linyphiidae); Harvestman (Genus Aglidia); Rove Beetle (Tribe Xantholinini). The photographs are different scales.

CONCLUSION

To summarise, the study conducted at Tūhaitara Coastal Park (TCP) has provided valuable insights into the invertebrate populations within the unique coastal wetland environment. The study has shown that native vegetation areas, particularly the wetlands, held greater invertebrate biodiversity when compared to the exotic pine forests. These findings emphasize the importance of preserving and restoring native vegetation within the TCP. The results further emphasize the importance that ground-dwelling invertebrates play as crucial contributors to soil health, nutrient cycling, pollination, and as a food source for the higher trophic levels. Enhancing invertebrate diversity is crucial for maintaining the TCP's ecosystem health and resilience. To achieve this, it is recommended to increase levels of native vegetation within the park, creating understory native shrubs beneath pine plantations and creating habitat linkages to promote ground-dwelling invertebrate biodiversity. The research also highlights the importance of continuous monitoring of invertebrate populations to understand long-term trends and the effects of restoration activities. Sharing data and photographs collected during this study can help promote educational initiatives and help engage the local community and citizen scientists in the park's conservation efforts.

The study helps contribute to the broader understanding of invertebrate populations within the ecological restoration context and emphasizes the importance of preserving native habitats. By improving ground-dwelling invertebrate biodiversity, the long-term sustainability and resilience of the TCP can be preserved for future generations.

Setting up trap A2 in the exotic pine plantation clearing

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Springtail (Order Entomobryomorpha)

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