Lepidopteran diversity of Mangarara station, Central Hawke's Bay, New Zealand.

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Abstract

Lepidoptera are an order which are widely understudied and undersampled across New Zealand, regions and small localities alike, with limited information available on species diversity or abundance. The Lepidoptera of Mangarara Station, Central Hawke's Bay, New Zealand are described, following capture via light trapping, net trapping and visual surveying conducted across two sites on October 8th to 10th 2023. One survey site was located at the Eco Lodge, bordered by pastureland and Horseshoe Lake; the second survey site was located in the native bush block on the loop track and surrounding Bushman's hut. Mangarara Station has a Lepidoptera fauna consisting of at least 46 taxa from 17 families; 38 species were endemic, three were native and four were exotic. Of the species identified, there were 20 species identified at the Eco Lodge site, compared with 36 species identified at the native forest site. Fourty-one Lepidoptera species were captured using the net trapping method, and 14 were captured using the Robinson trap method; five species were only captured using the Robinson trap. Two species which are considered uncommon throughout Hawke's Bay (HB) were identified, including: *Antiscopa elaphra,* and *Trachypepla protochlora*. Three species which are considered rare throughout HB and New Zealand were identified, including: *Pyrgotis zygiana* (first observation in HB), a *Kiwaia* sp. and, *Prothinodes grammocosma*. This study provides the first Lepidoptera

species list for the Mangarara locality, and a baseline for future studies of Lepidoptera richness in the area, and the wider HB region.

Introduction

Mangarara Station is located at 234 Mangarara Road, Elsthorpe, ~45 km South of Hastings, in Central Hawke's Bay New Zealand (general coordinates -39.92710798, 176.755008), at an altitude ranging from ~140 to 170 m above sea level. The property is a 610-hectare station, which is used today for regenerative farming. Within the boundaries of this property is the Eco Lodge, bordered by pastureland and Horseshoe Lake, and a small remnant of old growth forest protected by a QEII covenant, adjacent to an area of ~85,000 newer native plantings, planted since 2008 (Personal communications, Greg Hart Oct 9th 2023). Before land clearing and drainage systems were implemented in the 1800s to late 1900s on this land, once called Elms Hill Station, this area would have consisted of Podocarp forest, dominated by Totara, with interspersed wetlands (personal communications, Greg Hart Oct 9th 2023). The native old and new bush blocks are excluded from farm stock, however deer and possums still frequent the area (Personal communications, Greg Hart 2023) and likely thin the understory in these areas. The old growth bush block consists of namely *Podocarpus totara, Prumnopitys taxifolia*, and *Dacrycarpus dacrydioides* in the overstory, *Leptospermum scoparium, Sophora spp*., and various *Coprosma spp*. along the ridgelines, *Cordyline australis* and *Phormium tenax* in wetter areas of the loop track, and various ferns, *Myrsine australis*, *Corokia* sp., and *Muehlenbeckia* spp. amongst the understory.

Lepidoptera (butterflies and moths) are an order which are widely understudied and undersampled across New Zealand, regions and small localities alike, with limited information available on species diversity or abundance (Emmerson & Hoare, 2019), including in Hawke's Bay (Watts 2018). Lepidotera, due to their small size and largely nocturnal behaviors are often overlooked as study subjects; furthermore, there are few lepidopteran experts in New Zealand (Anderson *et al.* 2017). There are over 1700 species of Lepidoptera in New Zealand, with an endemism of ~90% (Patrick & Dugdale 2000). They are found in all biotypes except caves (Dugdale 1988), are an important source of food for avifauna, and are key pollinators of native flora, and nutrient recyclers within their

respective ecosystems (Anderson *et al.* 2017). Lepidotera, due to their short lifespans and high degree of movement, are considered great indicators of environmental health and environmental change, such as monitoring the consequences of environmental degradation or restoration (Anderson *et al.* 2017, Tikoca *et al.* 2016). Light trapping is considered to be the most effective method for detection of localized night-flying moth fauna, requiring minimal effort for the number of species that can be detected, particularly in conjunction with manual capture methods such as netting (Brehm & Axmacher 2006, Tikoca *et al.* 2016).

This study aims to identify and describe the Lepidoptera of Mangarara Station, Central Hawke's Bay, New Zealand. A subsidiary objective of this study is to compare the species richness between the two survey sites, 1) the Mangarara Eco Lodge (surrounded by pastureland and Horseshoe Lake), and 2) the Mangarara native bush block. The species list resulting from this study is intended to add to the limited local knowledge of Lepidoptera, and provide a foundation for further studies of Lepidoptera species richness in the Hawke's Bay region.

Methods

General methodology

Lepidoptera surveying was conducted on the 8th to the 10th of October 2023 at two sites on Mangarara Station: 1) Mangarara Eco Lodge: pastureland and Horseshoe Lake (Fig. 1), and 2) Mangarara native bush block (Fig. 2). Survey methods included a combination of overnight light trapping, net trapping, and visual surveying during a designated survey period. Net trapping and visual surveying were also conducted opportunistically outside of the designated survey times. On both days the evenings were clear with temperatures hovering around eight degrees during the survey period, and daytime temperatures reaching ~17 degrees celsius. The moon was in its third quarter.

Figure 1: Mangarara Eco Lodge: pastureland and Horseshoe Lake sampling area. Map created in ArcPro 3.1

Each moth trapped, captured or observed was identified to species level (where possible), photographed, and its species, biostatus, abundance and method of collection was recorded. Specimens, for species that could not be immediately identified, were submitted to Ryan Bauckham's collection, photographed, and images uploaded to iNaturalist. Species identifications were confirmed by Dr Neville Hudson and Dr Robert Hoare. The aim of this study was to establish species richness data, each species (abundance). Abundance information for Lepidoptera is based on lists, texts (Hoare &

Ball 2023) and personal communications (Ryan Bauckham), which are subjective and are only reflections of overall abundance and frequency (Emmerson & Hoare 2019), and can be found in **the online supplementary**. Only one voucher specimen of each species for the moth family Geometridae was collected using a specialised killing jar (plaster soaked with 100% acetone); Voucher specimens were stored in the freezer for later pinning.

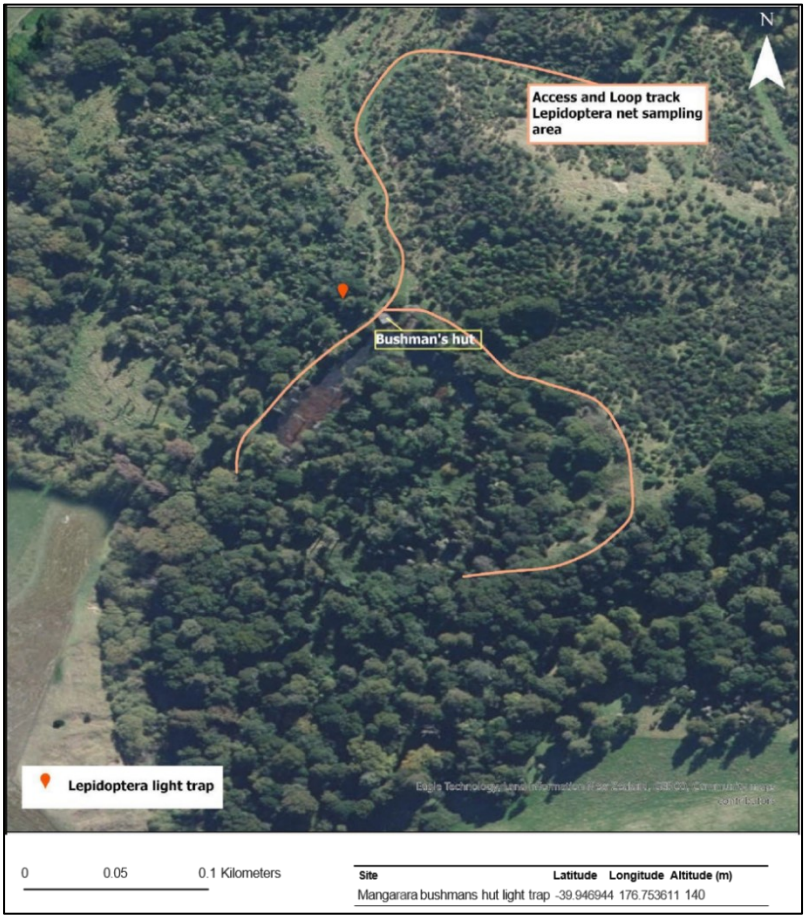

Figure 2: Mangarara native bush block sampling area. Map created in ArcPro 3.1

Robinson light trapping

A Robinson trap (Upton 1991) (supplied by Te Papa), set on top of a white sheet (Fig. 3), was used on October 8th (8.30 pm until 7 am, October 9th) at the Ecolodge site, and on October 9th (9.00 pm until 9 am, October 10th) at the bush block site. Sites were selected that were in clearings to increase the likelihood of moths detecting and being attracted to the light. Scrunched paper towels were placed inside the trap container to provide shelter for any trapped moths, making it more difficult for them to find the exit and encouraging them to stay overnight. Each morning the trap contents' was inspected and recorded.

Figure 3: Robinson Trap in use, showing illuminated black light bulb and perspex panels

Net trapping

In addition, each evening, two hours were spent manually net trapping Lepidoptera around the designated survey sites from 8.30 pm till 10.30 pm, as shown in *Figures 2 and 3*. A flashlight (OSRAM white beam LED, 1000 lumen) was used to attract moths, and an aerial insect net was used to

catch each moth that came to the light. At the Ecolodge site, specimens were captured on October 8th, around the survey perimeter and inside the survey boundaries, including visual surveying on the exterior of the lodge buildings and on the white sheet around the light trap, where moths were attracted to the building and trap lights respectively. At the bush block site, specimens were collected on October 9th, around the loop trap and area surrounding the Bushman's hut, including visual surveying on the white sheet around the light trap. Opportunistic net trapping occurred during the day on October 9th from 10 am until 2 pm, and these specimens have also been included in the species list (see online supplementary), and results of this study. Data and specimens were collected as mentioned in the general methodology above.

Table 1. Number of species identified for each Lepidoptera family.

Families	No of species	Families	No of species
Crambidae	6	**Oecophoridae**	2
Elachistidae	1	**Pieridae**	1
Erebidae	1	**Psychidae**	1
Gelechiidae	1	**Pterophoridae**	1
Geometridae	11	**Stathmopodidae**	1
Hepialidae	1	**Tineidae**	4
Lycaenidae	1	**Tortricidae**	5
Noctuidae	7	**Xyloryctidae**	1
Nymphalidae	1		

Results

There were 46 species of Lepidoptera identified (44 to species level) from 17 families. The number of species identified from each family are listed in Table 1. Geometridae was the most represented family with 11 species identified, followed by Noctuidae with seven species, Crambidae with six species, Tortricidae with five species, Tineidae with four species, and

Oecophoridae with two species; all other families were represented by one species. The names of the species from each family, the site where they were captured, their methods of capture, and biostatus are listed in the online supplementary.

Two species which are considered uncommon throughout Hawke's Bay (HB) were identified; *Antiscopa elaphra and Trachypepla protochlora*. Abundance or frequencies of species were obtained from Hoare and Ball (2023), iNaturalist, and Personal communications Ryan Bauckham (October 8th to 10th 2023).

Notable finds

Three species which are considered rare throughout HB and New Zealand were identified. *Pyrgotis zygiana* was found opportunistically during the day, in leaf litter below a Matai; this was the first observation of this species in HB and ninth in New Zealand. *Prothinodes grammocosma* was identified, providing the second observation of this species made in HB. *Kiwaia sp*. where the entire genus considered uncommon, has only four observations for Hawke's bay. Record of observations obtained via iNaturalist and personal communications with Ryan Bauckham during survey period.

There were 20 species identified at the Eco Lodge site, compared with 36 species at the native forest site. Ten species were only found at the Eco Lodge site, 26 species were only found at the native forest site, and ten species were found at both survey sites (Fig. 4).

38 species were endemic, three were native and four were exotic (Fig. 5). One species, referred to in the supplementary online material as "*Elachista* sp." could not be identified to species level and the genus is found worldwide thus its biostatus could not be determined.

41 species were captured using the net trapping method, and 14 were captured using the Robinson trap method (Fig. 6). The net trapping method was three times as efficient for detection of species compared to the Robinson trap. Of the 14 species captured in the Robinson trap, five were only caught using this method, including: *Capua intractana, Cnephasia jactatana, Ctenopseustis* sp., *Elachista* sp., and *Meterana decorata.* Of the 41 species captured using the net, 32 were only captured using this method.

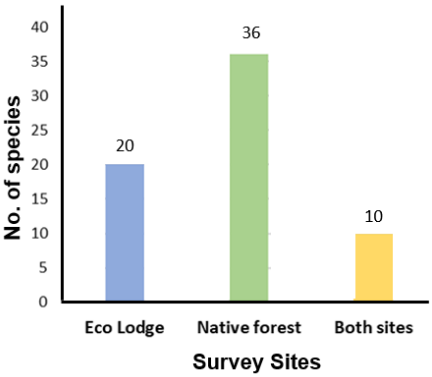

Figure 4: Lepidoptera species richness at the Mangarara Eco Lodge and Native bush survey sites

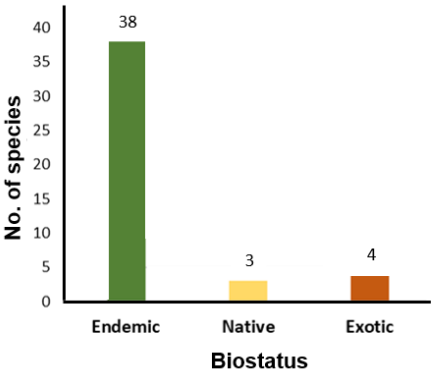

Figure 5: Biostatus of Lepidoptera species identified.

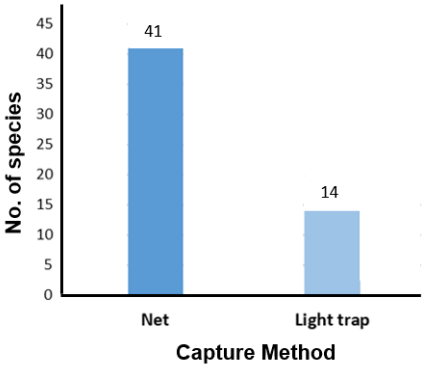

Figure 6: Number of Lepidoptera caught using the net trapping and Robinson light trap methods

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Discussion

Overall Species diversity

This study has identified 46 species of Lepidoptera at Mangarara station, and subsequently provided the first species list of Lepidoptera for this locality. The high degree of endemism found in this study (38 of 46 species) was expected, given the high endemism (~90%) of New Zealand's Lepidoptera overall (Patrick & Dugdale 2000)

It is difficult to determine the significance of the 46 species identified, given the very limited sampling time of the survey across both sites. While there have been historic surveys of the wider Hawke's Bay region such as Davies (1973) which identified 376 species over 17 years, and ongoing sampling by Ryan Bauckham who has identified 488 species since 2020 (personal communications, Ryan Bauckham, Nov 28th 2023), there are very few published lists of Lepidoptera taxa from small localities such as Mangarara, anywhere in New Zealand; furthermore the methodology (daytime, nighttime, larvae rearing), timeframes (often years) and frequency of sampling is highly varied across Lepidoptera surveys making direct comparisons challenging (Brehm & Axmacher 2006, Emmerson & Hoare 2019).

Furthermore, Davies (1973) had listed a number of microlepidoptera species which are notoriously difficult to identify and lack robust taxonomy (Emmerson & Hoare 2019). Similarly, species identified during this study are currently under taxonomic revision (i.e. *Elachista* spp.). Some species have only been identified as new or distinct species in recent years, rather than 'forms of an existing species' i.e. 19 Lepidoptera species, new to science were identified by Hoare (2019), or many species are still unnamed or not formally described (Hoare *et al.* 2015, Hoare 2019). Part of the difficulty in identifying and describing Lepidoptera is the difficulty in discerning defining characteristics of species with the naked eye, high intraspecific variation of wing colour and patterning, and differential perception of these colourings between individuals doing identification (Hoare 2019).

Species diversity between survey sites

Of the species identified, there were 20 species identified at the Eco Lodge site, compared with 36 species identified at the native forest site. Different

Lepidoptera species have different environmental requirements (i.e. temperature, humidity and windspeed), and food source requirements for both adults and larvae i.e. nectar or detritus (Anderson *et al.* 2017; Watts 2018). Simplifications of environments, such as land clearing for pasture, or habitat degradation, such as fragmentation of forest can result in declines of species diversity and homogenization of Lepidopteran communities (Ekroos *et al.* 2010) The higher species diversity of the native bush block site is likely due to it providing for a range of environmental requirements preferred by different species, and providing a higher number of plant taxa, as well as groundcover and detritus that are apparently absent at the Eco Lodge site.

Sampling methods

The net trapping method (manual capture) was three times as efficient for detection of species compared to the Robinson trap. However, five of the species captured during this survey were only caught using the Robinson trap method. Different capture methods have different strengths in terms of their ability to effectively sample Lepidoptera diversity; this includes both the style of traps and variations in lighting colour and intensities (Tikoca *et al.* 2016). The high intensity of the light used for net trapping is somewhat comparable to light towers used by Brehm & Axmacher (2006), which found that light towers attracted both higher numbers of individuals and more species of Lepidoptera, particularly from the family Geometridae, than traps (comparable in this instance to the Robinson trap), which the findings of this study support; however trap sampling may be ideal for capturing understory species (Brehm & Axmacher 2006).

The Robinson and similar traps have been described as being biassed towards larger Lepidoptera, based on underrepresentation of microlepidoptera in trap samples (Brehm & Axmacher 2006, Van Langevelde *et al.* 2011), and this was found throughout the Mangarara survey, with eight species of Noctuidae consistently captured in the Robinson trap. The trap bias towards Noctuidae species found throughout the study may also be a result of a higher attraction of Noctuidae to the wavelength emitted by the Robinson trap's light, resulting in inadvertent, selective sampling of these Noctuidae (Tikoca *et al.* 2016, Van Langevelde *et al.* 2011); similarly, the underrepresentation of other Lepidoptera families may be indicative of their preference for different wavelengths,

like that emitted by the torch utilised for net trapping, or one not used within the confines of the study. Overall the efficiency of the manual net trapping for capturing species compared to the Robinson trap, aligned with the findings of Axmacher & Fiedler (2004), where trap samples significantly differed from manual (net) captures, with manual captures being more efficient for surveying species diversity, particularly in clearings and secondary forest like the areas our study was conducted. Given that there were species detected only using the Robinson trap method, and the high Lepidoptera diversity and range of preferences between species, it is evident that a range of approaches is required to do a full species inventory for Lepidoptera, including light trapping using various lights, passive traps and manual trapping or observation (Brehm & Axmacher 2006).

Limitations and recommendations

The survey period was limited to two night sampling (one night at each site), where net trapping was conducted for two hours. To detect a larger range of Lepidoptera species, this net trapping sampling window could have been extended to include periods throughout the night, to capture species which emerge later in the evening. Ideally sampling would have occurred multiple times at each of the survey sites, across different times of day, and across each season, particularly over the summer season when moths become more active. Moths are more abundant during the new moon phase (Anderson *et al.* 2017), whereas the study was conducted during the third phase (approx 50% brightness). Four nights sampling using a mercury vapour lamp (essentially a very bright lamp) and manual net trapping has been found to be efficient for sampling the full range of Lepidoptera in forests in Fiji (Tikoca *et al* 2016). This would have extended the limits of this study beyond the time that was available, but should be considered for future studies of Lepidoptera diversity.

A stronger light, such as a “Lepilight” which emits more than one wavelength of light or a stronger light source than what was available for use in this study i.e a mercury vapour lamp set on a white sheet, would likely yield a higher species diversity result, by being more attractive to more species at a greater distance, and providing a place for moths to rest while visual observations were made. The Robinson trap’s light emitted a very weak light. Moreover, the trap was very limited in its ability to trap,

being a passive trap; often we noticed moths hitting the perspex, falling toward the funnel, and then flying off again. While setting a sheet underneath the Robinson trap allowed us to detect species which fell out of the trap, this only occurred if we were nearby and noticed it happen. On the second night of trapping, the light and perspex wings had slipped sideways on the funnel / container arrangement (likely around 6 am when the winds picked up), which both blocked moths inside from exiting and prevented any more from entering.

Acknowledgements

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References

Anderson BJ, Cassidy K, Campbell V, Hoare R, Kawe-Small T, MacKenzie T, Ohlemüller, Rewi T, Wehi P & Burns E. 2017. Beginners' Guide to the Macro Moths Te Ihu. Manaaki Whenua - Landcare Research. https://mothnet.org/home/identification-guides.

Axmacher JC, & Fiedler K. 2004. Manual versus automatic moth sampling at equal light sources – a comparison of catches from Mt. Kilimanjaro. *Journal of the Lepidopterists Society* 58 (4): 196–202.

Brehm G, Axmacher JC. 2006. A comparison of manual and automatic moth sampling methods (Lepidoptera: Arctiidae, geometridae) in a rain forest in Costa Rica. *Environmental Entomology* 35(3): 757–764.

Davies TH. 1973. List of Lepidoptera collected in areas surrounding Hastings and Napier. *New Zealand Entomologist* 5(2): 204–216.

Dugdale JS. 1988. Lepidoptera - annotated catalogue, and keys to family-group taxa. *Fauna of New Zealand* 14: 264pp.

Ekroos J, Heliölä J, Kuussaari M. 2010. Homogenization of lepidopteran communities in intensively cultivated agricultural landscapes. *Journal of Applied Ecology* 47(2): 459–467.

Emmerson A, Hoare R. 2019. Lepidoptera from Redvale, Albany, north of Auckland, New Zealand, 2004-2016: an annotated list. *The Wētā* 53: 43–70.

Hoare RJB. 2019. Noctuinae (Insecta: Lepidoptera: Noctuidae). Part 2, Nivetica, Ichneutica. *Fauna of New Zealand* 80: 1–455.

Hoare R, Ball O. 2023. A photographic guide to Moths & Butterflies of New Zealand. White Cloud Books, Upstart Press Ltd, New Zealand. 144pp.

Hoare R, Dugdale J, Edwards E, Gibbs G, Patrick B, Hitchmough R, Rolfe J. 2015. New Zealand Classification series 20 - Conservation status of New Zealand butterflies and moths (Lepidoptera) 2015. Department of Conservation, Wellington, New Zealand. 13pp.

Patrick B, Dugdale J. 2000. Conservation status of New Zealand Lepidoptera, Science for Conservation: 136. Department of Conservation, Wellington, New Zealand. 33pp.

Tikoca S, Hodge S, Tuiwawa M, Brodie GD, Pene S, Clayton JS. 2016. An appraisal of sampling methods and effort for investigating moth assemblages in a Fijian forest. *Austral Entomology* 55(4): 455–462.

Upton MS. 1991. Methods for collecting, preserving and studying insects and allied forms. The Australian Entomological Society, Miscellaneous publication 3. Forth Edition. Brisbane.

Watts C. 2018. Review of threatened and iconic plant, bat, lizard, frog, terrestrial invertebrate, and fungi species in Cape to City and Poutiri Ao ō Tāne. In Landcare Research (Contract Report: LC3283).