



Preliminary analysis of insect chorus patterns at an ecological thinning demonstration site in southwestern Australia

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ABSTRACT

Passive acoustic monitoring (PAM) offers a powerful, non-invasive tool for assessing ecological change across broad temporal and spatial scales. This study presents preliminary PAM results from an ecological thinning demonstration site in the Jarrah (*Eucalyptus marginata*) Forest of southwestern Australia, approximately two years post-thinning. Surveys were conducted across two control cells and four treatment cells to evaluate patterns in soniferous insect communities. Measures of the Bioacoustic Index were calculated across the characteristic frequency bands of two insect choruses to track the presence and intensity of these chorus types. Chorus activity varied spatially across treatment types, suggesting potential species- or guild-specific responses to thinning activities. However, the actual drivers of these patterns remain unclear, as baseline soundscape data were unavailable and species-level identification was not achieved. These findings provide a valuable foundation for future research aimed at disentangling the complex interactions between insect acoustic behaviour, environmental conditions, and forest management practices. Integrating insect bioacoustics into long-term monitoring frameworks may enhance our ability to assess ecological health, detect disturbance, and track recovery in forest ecosystems.

1 INTRODUCTION

Climate change, often characterised by hotter, drier conditions and increased fire frequency, poses a significant threat to forest ecosystems globally (Dale et al. 2001). Forest thinning - an established silvicultural technique - has been applied as a management strategy to mitigate impacts of climate change (D'Amato et al. 2013). However, the structural alteration that results from this silvicultural technique can have implications for the fauna inhabiting them. Fauna responses to thinning have been mixed and are often taxa-specific and/or location-specific (Gonsalves et al. 2018). Several insect groups have demonstrated a sensitivity to thinning activities (Yi and Moldenke 2005; Taki et al. 2010).

Insects underpin forest functions, contributing to soil fertility, nutrient cycling, and pollination (Hartley and Jones 2008), while also providing an important food source for a variety of fauna species. Therefore, it is important to consider the impacts of thinning activities on this faunal group within an ecosystem management context. Insects are vulnerable to environmental disturbances associated with thinning activities such as soil movement and compaction, changes to flora diversity and assemblages, and the application of herbicides (Taki et al. 2010). Many forest insect species actively produce sound for communication purposes (Do Nascimento et al. 2024); therefore, passive acoustic monitoring (PAM) can be a viable method of tracking the responses of these animals to environmental or anthropogenic change.

This study presents the preliminary analysis of PAM data collected across an ecological thinning demonstration site located within the Jarrah (*Eucalyptus marginata*) Forest of southwestern Australia. This analysis was undertaken to identify patterns in insect sonic activity across several thinning techniques, approximately two years post-treatment. Insect choruses are produced when more than two individuals (most commonly of the same species) call simultaneously for a prolonged period, significantly increasing sound levels in a characteristic frequency band in association with life functions (Greenfield and Shaw 1983). An examination of insect chorus activity across thinning treatment types revealed significant, chorus type-specific variation across treatment types. These findings suggest that ecological thinning practices may influence acoustic insect activity, offering a novel perspective on forest health and biodiversity monitoring. By integrating passive acoustic methods into forest management frameworks, this study contributes to the development of non-invasive tools for assessing ecological responses to silvicultural interventions.

2 METHODS

Acoustic data collection was undertaken within the 60 ha Munro ecological thinning demonstration site (henceforth termed Munro), located approximately 196 km south of Perth, Western Australia. Munro is situated within a Mediterranean climate-type, sclerophyllous eucalypt forest, with a canopy dominated by Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) trees. The demonstration site is comprised of one control cell and four treatment cells (one of which was a split treatment cell) ~10 ha in size, each separated by four buffer zones. Three of the treatment cells - Leave tops, Take all, and Leave all - underwent mechanical thinning treatments (Table 1). The Split treatment cell underwent manual thinning (approximately half the cell underwent notching and the other half, ringbarking), and the Control cell and Buffer zones were exempt from thinning activities completely (Table 1). All treatments were completed in early to mid-2022.

Table 1: Descriptions of the thinning treatment applied across the cells of the Munro ecological thinning demonstration site

Cells	Thinning treatment description
Control	No thinning treatment applied.
Buffer zone	No thinning treatment applied but located between the Leave all and Notching treatments.
Leave tops	Mechanical thinning treatment – trees cut to length using single grip harvester, bark and tops left on site, and glyphosate applied to the resprouts.
Take all	Mechanical thinning treatment – whole trees removed with a feller buncher, with glyphosate applied to stumps immediately after.
Leave all	Mechanical thinning treatment – trees cut to length using a feller buncher and retained intact on site with no chemical treatment applied to stumps.
Split	
A) Notching	Manual thinning treatment – 5-6 cuts made into the cambial layer of each treated tree by hand using an axe, glyphosate applied to each cut.
B) Ringbarking	Manual thinning treatment - axe was used to make a circumferential cut through the cambial layer of each treated tree, with no chemical treatment applied.

Six Song Meter Mini Bat 2AA (SMMB) recording units (Wildlife Acoustics, Maynard, MA, USA) each with a standard acoustic microphone attached, were deployed at Munro from the 18th – 31st March 2024. A single recording unit was deployed within each control and treatment cell (except for the Ringbarking half of the Split cell), and one Buffer zone area. Each recording unit was set to record at a sampling rate of 24 kHz, with a gain of 15 dB, for 60 s every 180 s. The sensitivity of each SMMB was obtained prior to deployment following the procedure outlined in the Wildlife Acoustics Song Meter Mini Bat 2 User Guide, available at https://www.wildlifeacoustics.com/uploads/user-guides/Song_Meter_Mini_Bat_2_User_Guide_en.pdf.

The power spectral density (PSD) of each acoustic recording was calculated using customised MATLAB (MathWorks, Inc., Natick, MA, USA) software. Long-term spectral averages (LTSAs) were then manually scrutinised by author L. A. H. to detect insect chorus presence and obtain approximate spectral characteristics of the respective choruses to delineate insect chorus types. Measures of the Bioacoustic Index (Boelman et al. 2007) were then calculated to track and compare the activity of each insect chorus type between treatments. This metric was chosen as it has previously demonstrated a sensitivity to insect chorusing events (Bradfer-Lawrence et al. 2025). Calculations of the Bioacoustic Index were made in RStudio (Posit software, Boston, MA, USA, Version: 2025.05.1+513) using the *soundecology* software package (Villanueva-Rivera and Pijanowski 2018). Calculations were made within a defined characteristic frequency band between the hours of 6:30 pm and midnight for Insect chorus 1, and between 4 pm and midnight for Insect chorus 2 on each night the respective chorus was present. Insect chorus activity was then statistically compared across treatment cells using a Kruskal-Wallis test and pairwise Dunn's tests using the *rstatix* R software package (Kassambara 2019).

3 RESULTS

Two nocturnal insect chorus types were detected across each treatment cell and buffer zone (Figure 1a). Insect chorus 1 occupied a low-frequency band between 3 and 4 kHz (Figure 1b). Insect chorus 2 occurred at a higher frequency range, between 4.5 and 6 kHz (Figure 1). Activity of both insect chorus types peaked around sunset, with Insect chorus 2 demonstrating an earlier start time (~ 4 h prior to sunset) and a longer duration (> 12 h) than Insect chorus 1 which started around sunset and continued for ~ 9 h (Figure 1a). The source species producing these choruses are currently unknown. Both insect chorus types demonstrated variations in activity across thinning treatments (Figure 2). Insect chorus 1 exhibited lower levels of activity over the Leave tops, Take all, and Leave all cells (Figure 2a). Insect chorus 2 activity was lowest across the Leave tops, Take all, and Notching cells (Figure 2b).

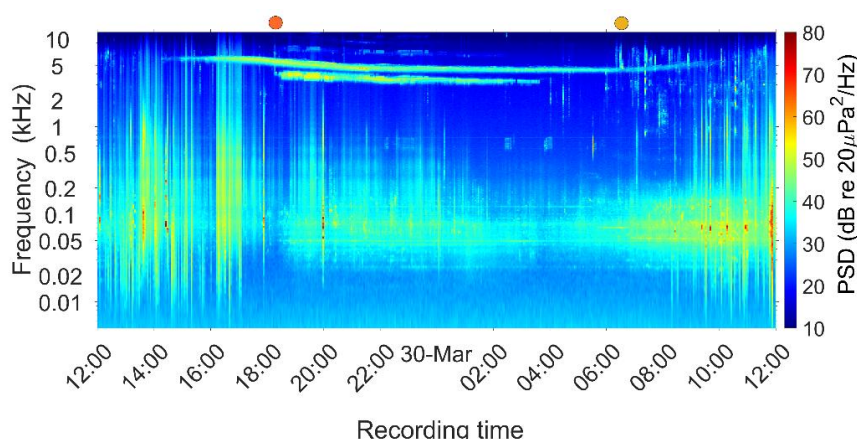


Figure 1: A 24 h soundscape demonstrating Insect chorus 1 (line between 3 – 4 kHz) and Insect chorus 2 (line between 4.5 – 6 kHz) activity in the Control cell over the 29th and 30th of March 2024, at the Munro Ecological thinning demonstration site, southwestern Australia. The orange and yellow circles denote the times of sunset and sunrise respectively in Australian Western Standard Time (UTC + 8 h).

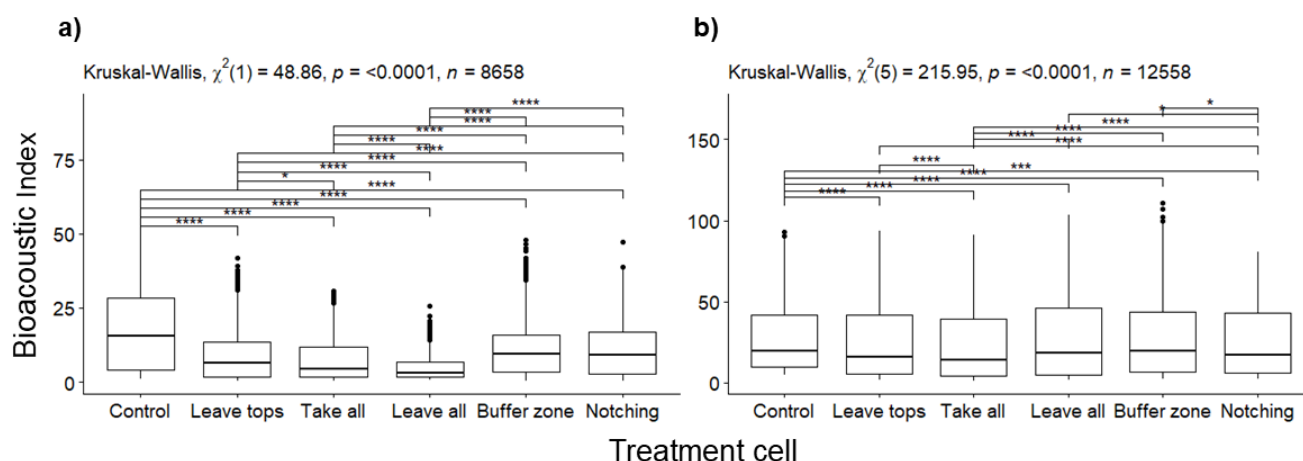


Figure 2: Comparison of activity across the Munro Ecological thinning demonstration site treatment cells for a) Insect chorus 1 and b) Insect chorus 2, in southwestern Australia. The star symbols indicate the significance of the difference between respective variables, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$, **** = $p < 0.0001$

4 DISCUSSION AND FUTURE WORK

Two insect chorus types were identified within the audible range (0.2 – 12 kHz) across all treatment cells at Munro. Each insect chorus type exhibited unique spatial variation across treatment type. Insect chorus 1 demonstrated a lower level of activity across thinned cells where trees were mechanically felled, and soil movement had occurred (the Leave tops, Take all, and Leave all cells). These results suggest that the source species of Insect chorus 1 may have been impacted by vegetation structure change, soil, or litter disturbance as a result of mechanical thinning activities. The Buffer zone, while not directly treated, demonstrated a lower level of chorusing activity than the Control site, indicating possible edge effects or spill-over impacts from the adjacent Leave all and Notching treatment cells. Alternatively, this anomaly may also be an indication of the presence of additional unknown factors contributing to or driving the production of Insect chorus 1. Insect chorus 2 also demonstrated a unique pattern in activity across thinning treatments. Chorus activity was typically lower across cells where glyphosate had been applied (the Leave tops, Take all, and Notching cells). Herbicide impacts on insect fauna are well-documented (Capinera 2018) and may have influenced insect activity at Munro. However, it is likely that multiple site-specific factors - potentially including herbicide application - are likely interacting to shape insect sonic activity patterns across the landscape.

Baseline soundscape data for Munro prior to ecological thinning was not available, limiting the ability of this study to definitively attribute the observed patterns in insect chorusing to specific silviculture techniques or disturbances. Nonetheless, these preliminary findings demonstrate distinct patterns in the two insect chorus types, which may reflect species- or guild-specific responses to environmental change (e.g., Do Nascimento et al. 2024).

Further analysis is planned to consider a broader range of spatial and environmental variables to better understand the drivers of these chorusing patterns and the role thinning activities may have played. The observed differences in chorusing activity imply that insect responses are likely influenced by how individual species interact with and utilise their environment. The apparent sensitivity of Insect chorus 1 may indicate a reliance on specific structural features, such as soil condition, potentially positioning it as a bioindicator of acoustic habitat change. In contrast, the drivers behind Insect chorus 2 activity remain unclear. Insect choruses are typically associated with courtship and reproductive behaviours (Greenfield 2015), reduced activity may signal declines in reproductive success, warranting further investigation into these two insect chorus types. The uncertainty around the drivers of insect sonic activity at Munro highlights the need to consider both a range of disturbances in forest management (including mechanical and chemical) and how these disturbances may be interacting with site- or habitat-specific factors.

PAM shows promise as a non-invasive tool for detecting insect responses to environmental or anthropogenic change. While this study highlights PAM's potential to reveal insect responses to disturbance, its effectiveness is currently limited by the lack of baseline data and species-level identification. Long-term monitoring at the Munro site will help address these gaps and track recovery over time.

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