

EFFECTS OF OIL PALM PLANTATION MANAGEMENT ON BIRD COMMUNITIES IN PT. PERKEBUNAN NUSANTARA VI JAMBI WITH PASSIVE ACOUSTIC MONITORING

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**ANIMAL BIOSCIENCE STUDY PROGRAM
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
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SUMMARY

LINTANG YODHY, Effects of Oil Palm Plantation Management on Bird Communities in PT. Perkebunan Nusantara VI Jambi with Passive Acoustic Monitoring. Supervised by RADEN RORO DYAH PERWITASARI, YENI ARYATI MULYANI and INGO GRASS

Oil palm monoculture plantations are known as one of major drivers of biodiversity loss in tropical ecosystems, particularly through the habitat simplification and management practices such as fertilizer and herbicide usage, that may alter ecological complexity and environmental conditions. This may influence many taxa, including birds. Previous study suggested that low-intensity management increase understory vegetation and arthropod diversity, but responses from bird communities in oil palm systems remained weak, making long-term monitoring essential to carried out to give more understanding on how management practices influence bird communities in oil palm plantations, and is important for evaluating the ecological sustainability of plantations systems.

This study was conducted in oil palm plantation management experiment of PT. Perkebunan Nusantara VI (PTPN VI), Jambi, Sumatra, Indonesia, within the Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems (EFForTS – CRC 990). The experiment applied four management treatments combining conventional and reduced-intensity fertilizer and weeding practices: conventional fertilization with herbicide application (CH), conventional fertilization with mechanical weeding (CW), reduced fertilization with herbicide application (RH), and reduced fertilization with mechanical weeding (RW). The study aimed to evaluate the long-term responses of bird communities to these management practices using passive acoustic monitoring (PAM) method. Specifically, the objectives were to: (1) investigate and analyze the bird communities in PT. Perkebunan Nusantara VI; (2) examine the effects of fertilizer and weeding management on bird species richness and species composition; (3) examine species-specific responses of common bird species to management practices; (4) examine feeding guilds responses to management practices; and (5) examine the relationship between acoustic indices and bird species richness in oil palm plantations.

Data were collected using autonomous recording units (ARUs) that deployed repeatedly across treatment plots from 2017 to 2021. Bird vocalizations were automatedly identified from acoustic recordings with BirdNET, and were manually verified to species level, and bird activity was quantified using vocal activity measures. Bird species richness and species-level responses were analyzed using generalized linear mixed models (GLMMs) with negative binomial distributions to account for overdispersion. Year and recording date were evaluated as random effects to account for temporal variability and recording-condition differences. Community composition and common species responses were analyzed using non-metric multidimensional scaling (NMDS) and permutational multivariate analysis of variance (PERMANOVA). In addition, several acoustic indices were extracted from recordings, including Acoustic Complexity Index (ACI), Acoustic Diversity Index (ADI), Acoustic Evenness Index (AEve), Bioacoustic Index (Bio), Normalized Difference Soundscape Index (NDSI), and



Total Entropy (H), and their relationships with bird species richness were tested using GLMMs.

GLMM results indicate that management intensity did not significantly affect overall bird species richness. There was temporal variation in bird species richness, but no specific trend was observed. Community composition analysis using NMDS and PERMANOVA indicated that temporal factors had a stronger influence than management treatment. Differences among years likely reflected environmental fluctuations, seasonal variation, and changes in vegetation conditions over time. These findings indicate that bird communities within oil palm plantations remain relatively homogenized despite moderate differences in management intensity.

Species-level analysis generally showed no effect of fertilizer and weed management treatments on the responses of common bird species. Although two species, the Yellow-vented Bulbul (*Pycnonotus goiavier*) and the Sooty-headed Bulbul (*Pycnonotus aurigaster*) showed sensitivity to the treatments, these responses should be interpreted with caution, given that both species are generalists commonly found in plantations. These findings suggest that species responses depended on ecological traits, habitat preferences, and vocal activity patterns rather than reflecting a uniform community-level response to management intensity.

The acoustic index analyses showed weak performance to reflect bird species richness. ADI and H showed weak negative relationships with bird richness, while AEve showed a weak positive relationship. In contrast, ACI, BI, and NDSI were not significantly associated with bird richness. Several factors, including non-target sound sources, differences in bird vocalization traits (frequency, duration, and amplitude), vegetation structure in the study location, and temporal variation associated with weather and recording conditions, may contribute to detected patterns. These findings showed that acoustic indices alone were insufficient proxies for bird richness in this plantation system, emphasizing the importance of combining acoustic indices with manual species identification and ecological interpretation.

Future studies should further investigate the influence of understory vegetation, landscape connectivity, and surrounding habitats on bird communities in plantations. Expanding the temporal and spatial scale of acoustic monitoring and integrating additional environmental variables may improve understanding of soundscape dynamics in agricultural ecosystems. Further evaluation of acoustic indices across tropical systems is also necessary before they can be reliably used as indicators of biodiversity or ecosystem health in complex tropical soundscapes.

Keywords: Acoustic indices, bird communities, oil palm, plantation management, passive acoustic monitoring

RINGKASAN

LINTANG YODHY, Efek Pengelolaan Perkebunan Kelapa Sawit Terhadap Komunitas Burung di PT. Perkebunan Nusantara VI Jambi dengan Pendekatan Monitoring Akustik Pasif. Dibimbing oleh RADEN RORO DYAH PERWITASARI, YENI ARYATI MULYANI, dan INGO GRASS

Perkebunan monokultur kelapa sawit diketahui sebagai salah satu penyebab hilangnya keanekaragaman hayati di ekosistem tropis akibat simplifikasi habitat dan praktik pengelolaan seperti penggunaan pupuk dan herbisida yang turut mengubah kompleksitas ekologi dan kondisi lingkungan. Hal tersebut dapat berdampak pada beberapa taksa, termasuk burung. Penelitian terdahulu menunjukkan bahwa pengelolaan perkebunan dengan intensitas rendah dapat meningkatkan keanekaragaman tumbuhan bawah dan artropoda, tetapi komunitas burung menunjukkan respon yang lemah terhadap pengelolaan. Pengamatan jangka panjang perlu dilakukan untuk memahami bagaimana praktik pengelolaan memengaruhi komunitas burung di perkebunan kelapa sawit dan sangat penting untuk mengevaluasi keberlanjutan ekologis di sistem perkebunan.

Penelitian ini dilakukan di area eksperimen pengelolaan perkebunan kelapa sawit PT. Perkebunan Nusantara VI (PTPN VI), Jambi, Sumatera, Indonesia, dalam rangkaian kegiatan penelitian *Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems* (EFFoRTS-CRC 990) di Jambi, Sumatra, Indonesia. Eksperimen tersebut menerapkan empat kombinasi perlakuan pengelolaan yang terdiri atas dosis pupuk konvensional dan penggunaan herbisida, dosis pupuk konvensional dan penyiangan manual, pengurangan dosis pupuk dan penggunaan herbisida, serta pengurangan dosis pupuk dan penyiangan manual. Penelitian ini bertujuan untuk menguji respons jangka panjang komunitas burung terhadap praktik pengelolaan menggunakan metode monitoring akustik pasif, khususnya untuk: (1) mengetahui dan menganalisis komunitas burung di PTPN VI; (2) menguji pengaruh pengelolaan pupuk dan penyiangan terhadap kekayaan spesies dan komposisi komunitas burung; (3) menguji respons spesifik spesies burung umum terhadap perlakuan pengelolaan; (4) menguji respons *guild* pakan terhadap perlakuan pengelolaan; dan (5) menguji hubungan antara indeks akustik dengan kekayaan spesies burung di perkebunan kelapa sawit.

Data dikumpulkan menggunakan unit perekam otomatis yang dipasang secara berulang pada plot perlakuan selama periode 2017–2021. Suara burung diidentifikasi dari rekaman suara secara otomatis menggunakan BirdNET dan diverifikasi secara manual hingga tingkat spesies, dan aktivitas burung dihitung berdasarkan aktivitas vokalisasi. Analisis kekayaan spesies dan respons spesifik spesies dilakukan menggunakan *Generalized Linear Mixed Models* (GLMMs) dengan distribusi *negative binomial* untuk mengatasi overdispersi data. Tahun pengamatan dan tanggal perekaman dievaluasi sebagai efek acak untuk mengakomodasi variasi temporal dan perbedaan kondisi perekaman. Komposisi komunitas burung dan respons spesies umum dianalisis menggunakan *Non-metric Multidimensional Scaling* (NMDS) dan *Permutational Multivariate Analysis of Variance* (PERMANOVA). Selain itu, beberapa indeks akustik dihitung dari rekaman suara, yaitu *Acoustic Complexity Index* (ACI), *Acoustic Diversity Index* (ADI), *Acoustic Evenness Index* (AEve), *Bioacoustic Index* (Bio), *Normalized*

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Difference Soundscape Index (NDSI), dan *Total Entropy* (H), kemudian hubungan antara indeks-indeks tersebut dengan kekayaan spesies burung diuji menggunakan GLMM.

Hasil GLMM menunjukkan bahwa intensitas pengelolaan tidak menunjukkan adanya pengaruh terhadap kekayaan spesies burung secara keseluruhan. Terdapat variasi temporal pada kekayaan spesies burung, namun tidak menunjukkan adanya tren tertentu. Analisis komposisi komunitas menggunakan NMDS dan PERMANOVA menunjukkan bahwa faktor temporal memiliki pengaruh yang lebih kuat dibandingkan dengan perlakuan pengelolaan. Perbedaan antar tahun diduga mencerminkan fluktuasi kondisi lingkungan dan variasi musim dari waktu ke waktu. Temuan ini menunjukkan bahwa komunitas burung di dalam perkebunan kelapa sawit cenderung homogen meskipun terdapat perbedaan moderat dalam intensitas pengelolaan.

Analisis tingkat spesies tidak menunjukkan adanya efek dari perlakuan pemupukan dan pengelolaan gulma terhadap respons spesies burung umum. Meskipun terdapat dua spesies yaitu Merbah Cerukcuk (*Pycnonotus goiavier*) dan Cucak Kutilang (*Pycnonotus aurigaster*) yang menunjukkan sensitivitas terhadap perlakuan, respons ini perlu disimpulkan secara hati-hati mengingat kedua spesies tersebut merupakan spesies generalis yang umum terdapat di perkebunan. Temuan ini menunjukkan bahwa respons spesies dipengaruhi oleh karakteristik ekologis, preferensi habitat, dan pola aktivitas vokal masing-masing spesies, sehingga tidak seluruh komunitas menunjukkan respons yang seragam terhadap perubahan intensitas pengelolaan.

Analisis indeks akustik menunjukkan lemahnya performa indeks akustik dalam menggambarkan kekayaan spesies burung di perkebunan kelapa sawit. ADI dan H menunjukkan hubungan negatif yang signifikan dengan kekayaan spesies burung, sedangkan AEve menunjukkan hubungan positif marginal. Sebaliknya, ACI, BI, dan NDSI tidak menunjukkan hubungan yang signifikan dengan kekayaan spesies. Beberapa faktor, seperti sumber suara non-target, perbedaan karakteristik vokalisasi antar spesies burung (frekuensi, durasi, amplitudo), struktur vegetasi di lokasi perekaman, serta variasi temporal akibat cuaca dan kondisi perekaman, diduga berkontribusi pada temuan ini. Hal ini menunjukkan bahwa penggunaan indeks akustik saja belum cukup memadai untuk digunakan sebagai proksi kekayaan spesies burung di sistem perkebunan tropis, sehingga penggunaan indeks akustik perlu dikombinasikan dengan identifikasi spesies secara manual dan interpretasi ekologis yang mendalam.

Penelitian selanjutnya perlu mengeksplorasi lebih lanjut pengaruh vegetasi bawah, konektivitas lanskap, dan habitat sekitar terhadap komunitas burung di perkebunan. Perluasan skala temporal dan spasial dalam pemantauan akustik, serta integrasi variabel lingkungan tambahan, juga dapat meningkatkan pemahaman mengenai dinamika *soundscape* di ekosistem pertanian. Selain itu, evaluasi lebih lanjut terhadap indeks akustik di berbagai sistem tropis masih diperlukan sebelum indeks tersebut dapat digunakan secara andal sebagai indikator biodiversitas maupun kesehatan ekosistem di *soundscape* tropis yang kompleks.

Kata kunci: Indeks akustik, kelapa sawit, komunitas burung, monitoring akustik pasif, pengelolaan perkebunan



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LINTANG YODHY

Thesis
as a requirement to obtaining a
Magister of Science Degree (M.Sc) in
Animal Bioscience Program

**ANIMAL BIOSCIENCE STUDY PROGRAM
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FOREWORD

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Finally, I realize that this thesis is still far from perfect. Therefore, constructive criticism and suggestions are sincerely welcomed for the improvement of this work. I hope this thesis can contribute to the development of ecological research and sustainable management practices in tropical agricultural landscapes, particularly oil palm plantation ecosystems in Indonesia.

Bogor, June 2026

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TABLE OF CONTENT

LIST OF TABLES	xiv
LIST OF FIGURES	xiv
LIST OF APPENDICES	xiv
I INTRODUCTION	1
1.1 Background	1
1.2 Problem Statements	4
1.3 Research Objectives	4
1.4 Research Outcomes	5
1.5 Research Limitations	5
II METHODS	6
2.1 Study Sites and Research Period	6
2.2 Description of Research Plots and Experimental Treatments	6
2.3 Passive Acoustic Monitoring	7
2.4 Data Analysis	8
2.4.1 Bird Species Identification	8
2.4.2 Acoustic Indices Analysis	9
2.4.3 Statistical Analysis	11
III RESULTS	13
3.1 Bird Species in PTPN VI Oil Palm Plantation	13
3.2 Effect of Oil Palm Management on Bird Species Richness and Composition	15
3.3 Species-level Responses to Management	17
3.4 Feeding Guild Responses to Management	20
3.5 Acoustic Indices Relationship with Bird Species Richness	20
IV DISCUSSION	22
4.1 Bird Species in PTPN VI Oil Palm Plantation	22
4.2 Impact of Oil Palm Management on Bird Communities	22
4.3 Temporal and Structural Constraints of Bird Communities in Oil Palm Plantations	24
4.4 Species-level and feeding guilds responses to the management treatments	25
4.5 Acoustic Indices for Bird Diversity Assessment	26
V CONCLUSION AND RECOMMENDATION	29
5.1 Conclusion	29
5.2 Recommendation	29
REFERENCES	30
APPENDICES	40



LIST OF TABLES

1	Table 1 Bird species in PT. Perkebunan Nusantara VI (PTPN VI) Batanghari Jambi on 2017-2021.	13
2	Table 2 Generalized linear mixed-effect models of bird species richness and oil palm management.	16
3	Table 3 PERMANOVA outputs of the bird community composition.	17
4	Table 4 Generalized linear mixed-effect models of common species vocal activity and oil palm management.	17
5	Table 5 PERMANOVA outputs of the common species responses.	19
6	Table 6 Generalized linear mixed-effect models of feeding guild and oil palm management.	20
7	Table 7 Generalized linear mixed-effect models of bird richness and acoustic indices.	21

LIST OF FIGURES

8	Figure 1 Maps of EFFoRTS - CRC 990 Project (Drescher <i>et al.</i> 2016)	6
9	Figure 2 Experimental Plots of PTPN VI (Darras <i>et al.</i> 2019)	7
10	Figure 3 Automated Recording Units (ARUs) that were installed in the survey plots.	8
11	Figure 4 Bird species richness (a) and bird vocal activity (b) year-by-year plots, generated with ggplot.	15
12	Figure 5 Non-metric multidimensional scaling (NMDS) ordination of bird species composition from acoustic monitoring in the oil palm management experimental plots from 2017 to 2021.	16
13	Figure 6 Non-metric multidimensional scaling (NMDS) ordination of common species responses from acoustic monitoring in the oil palm management experimental plots from 2017 to 2021.	19

LIST OF APPENDICES

14	Appendix 1 Bird species checklist among experimental management plots in PT. Perkebunan Nusantara VI from 2017 to 2021. Error! Bookmark not defined.	
15	Appendix 2 Mean of the indicators tested in different fertilizers and weeding treatments in Oil Palm Management Experimental (OPMX).	45
16	Appendix 3 Envfit (Bray-Curtis, Permutation) of sample ordination on NMDS community composition and common species.	46