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Effect of density and management of oil palm plantations on the avifauna of Southeastern Sierra Leone

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Oil palm (*Elaeis guineensis*) is a tropical perennial plant that provides most of the vegetable oil traded internationally. Although native to Africa, oil palm is grown throughout the humid tropics, and the largest producers are now in Southeast Asia. In many regions of cultivation, oil palm has been identified as a leading cause of deforestation and biodiversity loss. In Sierra Leone, oil palm grows wild in secondary forest and fallow land, as well as in plantations; research into its impact on biodiversity is limited. The effects of natural (wild) and plantation oil palm on the avifauna of southeastern Sierra Leone was examined. Over a two-year period, point-count surveys of birds were conducted on six occasions during the wet and dry seasons. Four plots were established in each of the six land-use types: Primary Forest, secondary forest, farm-bush with few oil palms, farm-bush with many oil palms, small plantations and larger plantations. Results from the study suggest that small-scale oil palm plantations, even under traditional low-intensity management, have a reduced avifauna compared to farm-bush. The difference between secondary forest and farm-bush is small, suggesting that traditional management of oil palm as a "non-timber forest product" is less detrimental to biodiversity.

Key words: Natural oil palm plantations, birds, biodiversity/conservation, farm bush.

INTRODUCTION

Oil palm (*Elaeis guineensis Jacquin*) is a tropical perennial monocotyledonous plant that belongs to the family Arecaceae and is cultivated for vegetable oil (Corley and Tinker, 2016; Vijay et al., 2016; Meijaard et al., 2018). Oil palm is the most productive oil crop in terms of yield per unit area, prompting its rapid expansion from its origin in West Africa to 43 tropical countries (Corley and Tinker, 2016; Fitzherbert et al., 2008; Koh, 2008; Koh and Wilcove, 2008; Najera and Simonetti, 2010; Barcelos et al., 2015; Srinivas and Koh, 2016; Yaap et al., 2010; Vijay et al., 2016; Meijaard et al., 2018; Qaim et al., 2020). Due to plant breeding efforts, mostly undertaken in Asia (Barcelos et al., 2015), it is now the most consumed vegetable oil (Yudea and Santosa, 2019; European Oil Palm Alliance, 2019) and accounts for about 40% of international trade in vegetable oils (Murphy et al., 2021). Between 2008 and 2017, the global plantation area expanded at a rate of 700,000 ha per year (Meijaard et

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al., 2020) and is a principal cause of deforestation in tropical Asia (Koh and Wilcove, 2008; Fitzherbert et al., 2008; Corley, 2009; Wilcove and Koh, 2010; Srinivas and Koh, 2016), with estimates of forest loss reaching 270,000 ha per year in the major palm oil exporting countries (Vijay et al., 2016). Where land-use planning is inadequate, oil palm is sometimes used as an excuse by companies wanting to clear forests for other purposes (Srinivas and Koh, 2016; Fitzherbert et al., 2008). Africa was the leading producer of palm oil until the 1960s, after which its oil palm industry faced neglect (Bakoumé et al., 2020); recently, Sierra Leone has made efforts to revitalize the oil palm industry, partly for food security and partly through the promotion of oil palm for agrofuels by multinational companies (Carrere, 2010).

The conversion of forest to oil palm plantations leads to habitat loss and fragmentation, a reduction in the diversity and abundance of forest-dependent species, and the loss of ecosystem services (Mandal and Raman, 2016; Yaap et al., 2010). The International Union for the Conservation of Nature (IUCN), in their Red List of Threatened Species, asserts that oil palm plantations are a threat to 321 species (Meijaard et al., 2020), and its expansion is estimated to affect 64% of all threatened birds. Declines in forest bird species are reported as 75 to 95% in Amazonia (Srinivas and Koh, 2016), Malaysia (Koh and Wilcove, 2008), South-East Asia (Senior et al., 2012), Sumatra (Danielsen et al., 2008) and Thailand (Aratrakorn et al., 2006; Srinivas and Koh, 2016). Oil palms are native to Sierra Leone and are very common in 'secondary forest' and 'farm bush.' Farm bush is part of the traditional farming process where the land is left fallow for 5 to 10 years before the woody vegetation is cut and burnt, and crops are grown for one or two years. The Famine Early Warning System Network (FEWS NET) estimated in 2017 that about 60% of crude palm oil (CPO) is extracted from fallow lands (the farm bush), where traditional low-yielding varieties of oil palm are encouraged to grow but are not planted. CPO is an important source of income for farmers as well as being crucial to their food security. Farmers rarely process kernel palm oil (KPO), but a company in Freetown buys and processes a certain amount of palm kernel to make KPO (FEWS NET, 2017). Commercial-scale plantations were established in Sierra Leone in the 1950s but experienced neglect and abandonment (Bakoumé et al., 2020). Small-scale plantations under traditional management in Sierra Leone are usually only 1 to 2 ha in extent but cover a total area of over 300,000 ha (Gboku et al., 2017), which is about 5% of the total productive land area of the country. About 30% of the production area is on foreign-owned plantations of up to 50,000 ha. The government of Sierra Leone has recently signed at least four agreements with European companies for large-scale palm oil production. In 2020, total oil palm production was estimated at 75,000 metric tons (ITC, 2022). The forests of Sierra Leone belong to the Upper Guinean Rainforest biome and are recognized as a global biodiversity hotspot. Sierra Leone is moderately forested with 17% forest cover (FAO, 2015); the history of deforestation is subject to debate, but population growth, unregulated logging, wildfires and agricultural expansion all play a role (Wadsworth and Lebbie, 2019). The remaining forests have a rich indigenous flora and fauna, including many endemic species and internationally rare and threatened species. Birds can be found in almost every habitat on earth; some species are generalists and some highly restricted and indicative of particular habitats. Birds may be important for a range of ecological functions such as seed dispersal, scavenging, pollinating and pest control (Mariyappan et al., 2023). They are easy to observe and detect without disturbing them or the habitat and can be used as bio-indicators to monitor quality and change in ecosystems (Egwumah et al., 2017; Mekonen, 2017; Gupta, 2022; Mariyappan et al., 2023).

Birds are found in oil palm plantations and perform diverse functions like insect pest control (*Centopus sinensis*), seed dispersal (*Teron vernans*), pest/rodent control (*Tyto alba*) and weed control (Putri and Kwatrina, 2023). However, despite the ecological roles of birds in oil palm plantations, their populations in oil palm plantations are currently facing threats. The majority of palm oil in Sierra Leone is still produced from natural oil palm plantations or from very small plantations using traditional management practices. However, the trend is towards more large-scale intensively managed industrial plantations, often as a result of foreign investment. Large-scale industrial plantations may cause the same sort of biodiversity loss as has been observed in Southeast Asian countries like Malaysia and Indonesia. The extent to which small-scale oil palm plantations and harvesting from wild oil palms are detrimental to biodiversity has not previously been studied in countries like Sierra Leone, where oil palm is native. The objective of the study is to determine whether oil palms growing wild in farm bushes and plantations have a detrimental impact on bird species diversity.

MATERIALS AND METHODS

Study area

Six land-use types were selected, covering a gradient based on palm plant density from very low through to near mono-culture in the more intensively managed plantations and with a corresponding gradient of exploitation from the least to the most exploited. The six land-use types are 'primary' forests (no disturbance for >50 years), secondary forests (no disturbance for >20 years), farm-bush with few oil palms (20 palms/ha), farm-bush with a high density of palms (>200 palms/ha), low-intensity plantations (2 tons oil per ha/year) and high-intensity plantations (>8 tons oil per ha/year).

Photographs of some of the survey plots in these land covers are illustrated in Figure 1. The six study sites are located in Kenema and Kailahun Districts in the Eastern Province of Sierra Leone (Figure 2). The two districts contain the Gola Rainforest National Park and the Kamboi Hills Forest Reserve, but most of the land is under traditional

Figure 1. Photographs of some of the research plots at each of the six sites.

swidden agriculture (bush-fallow) with fallow periods of between 5 and 10 years. There are scattered small plantations of cocoa, coffee and oil palm.

Sampling methods

This study adopted the point count method used by the Gola Rainforest National Park to ensure that the results for non-primary forest habitats would be consistent in terms of methodology and sampling effort with their records. Birds were most commonly detected by their calls, and this usually limits the distance they can be detected to less than about 100 m (Volpato et al., 2009); in the data, the median detection distance is 40 m. Four plots, separated by at least 250 m were established at each of the six sites. Each plot was visited four times in the first year and twice in the second year.

As it can be difficult to observe birds during heavy rain, there is a slight bias with more visits in the dry season compared to the wet season. All sites had at least two visits in each season. Each plot was observed for a 15-min period in the morning; the earliest first plot was recorded at 7:20 and the last at 10:50, with a median start time (for a plot) of 09:16. Most birds were detected by their calls (83%), and audio recordings were made for verification of field data. Birds observed were identified based on morphology, behavior and vocalization according to Borrow and Demey (2014). The conservation status was determined by the International Union for the Conservation of Nature (IUCN 2014), and feeding guilds classification was based on Senior et al. (2012).

Methods to assess the impact of oil palm on avifauna

The impact of oil palm production (as a non-timber forest product and as a plantation crop) was determined on bird diversity by comparing the biodiversity found in the oil palm plantations (oil palm plantation high and medium) with that found in other land cover types (farm bush high density, farm bush low density, primary forest and secondary forest).

Data analysis

The Chi-squared test was carried out in Microsoft Excel and used to determine which species show strong seasonal preferences. Ordination using the metaMDS program in the vegan package in R (Oksanen et al., 2022) was employed to compare bird communities with habitats. Hierarchical clustering to produce dendrograms of associations between species, etc., was done using the ape package in R (Paradis and Schliep, 2019).

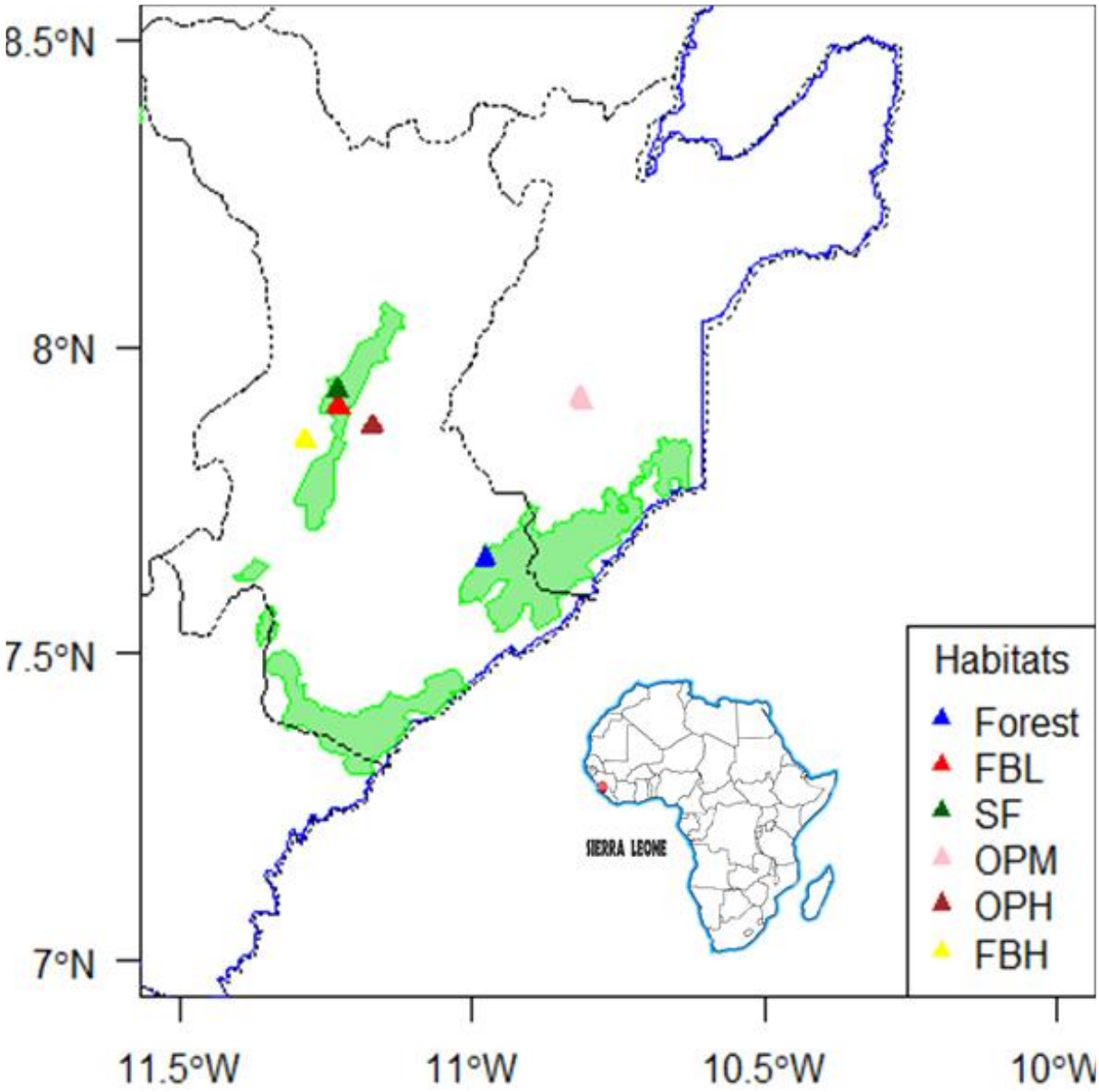

Figure 2. Location of the six study sites. Protected Areas are shown in green. Forest, primary forest; FBL, farm-bush with low density of oil palm; SF, secondary forest; OPM, oil palm plantation low intensity; OPH, oil palm plantation high intensity; FBH, farm bush with many oil palms.

RESULTS

Rare species

One hundred and twenty-five species from thirty-five families were identified. Primary forests and secondary forests were the most diverse habitats with 74 and 65 species, respectively. The farm-bushes (low density and high density) had almost as many species (61 and 63 species), while plantations (low intensity and high intensity) had the least (53 and 42 species). One species, the Timneh parrot (*Psittacus timneh*) has been classified as 'endangered,' two species, the brown-cheeked hornbill (*Bycanistes cylindricus*) and yellow-casqued hornbill (*Ceratogymna elata*), are classified as 'vulnerable,' and two, the rufous-winged illadopsis (*Illadopsis rufescens*) and the green-tailed bristlebill (*Bleda eximius*), are 'near threatened'; the remaining species are of 'least concern' (Birdlife International, 2023). The endangered Timneh parrot was only observed in the primary forest, while the vulnerable and near-threatened species were also observed in the secondary forest and farm-bush and, in one case, in an oil palm plantation (Table 1). Table 1 shows the lists of endangered (E), vulnerable (V) and near

Table 1. Number of individuals of species of conservation concern by habitat.

Species	Forest	SF	FBL	FBH	OPM	OPH	IUCN
Timneh parrot (*Psittacus timneh)*	7						E
Brown cheeked hornbill *(Bycanistes cylindricus)*	6		1				V
Yellow casqued hornbill (*Ceratogymna elata)*	36	18	3	2			V
Rufous winged illadopsis *(Illadopsis rufescens)*				1			NT
Green tailed bristlebill (*Bleda eximius*)		1	10			2	NT

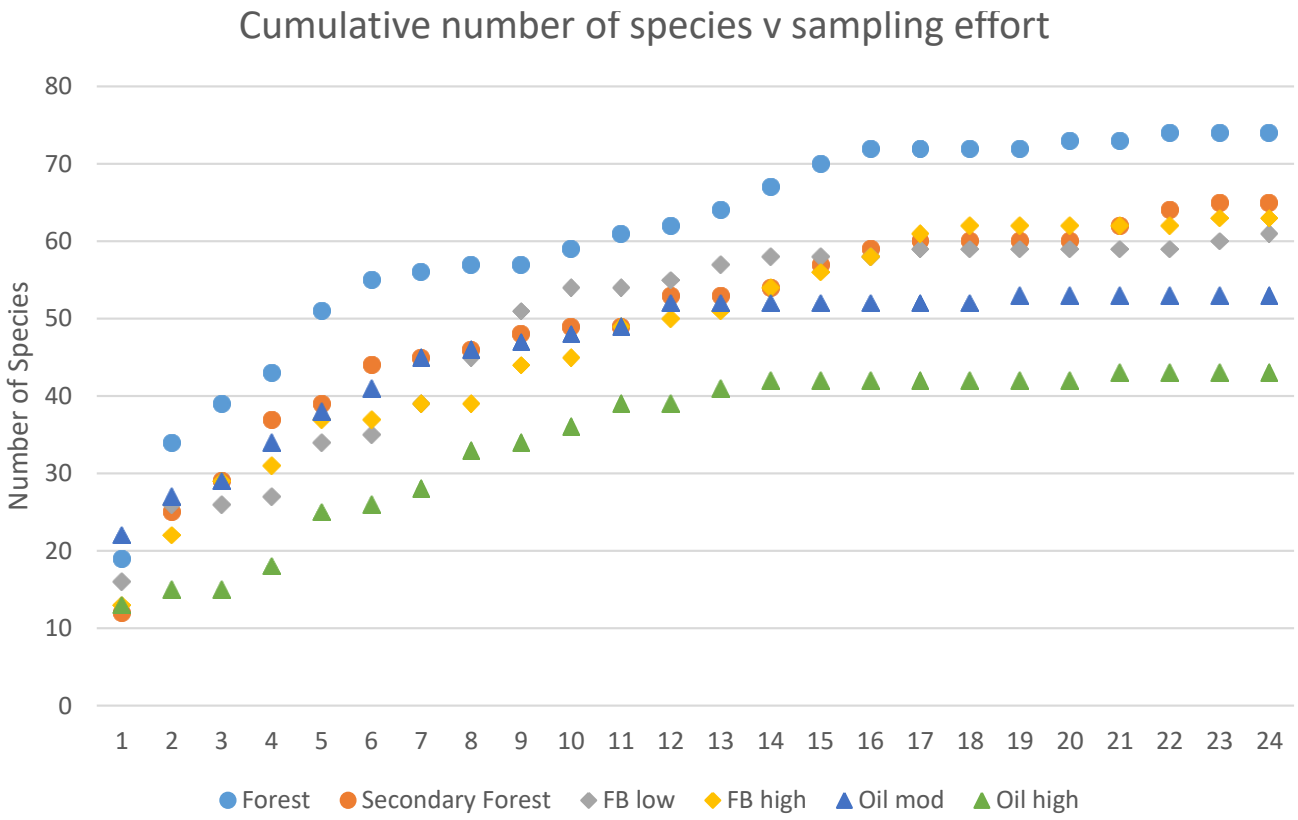

Figure 3. Number of species encountered versus sampling effort. FB low, farm bush with low density oil palm; FB high, farm bush high density oil palm; Oil mod, oil palm plantation medium; Oil high, oil palm plantation high density.

threatened (NT) species by habitat.

Number of species and sampling effort

Figure 3 shows the number of species recorded in relation to sampling effort, suggesting that visiting twice per year (wet and dry season) for two years is sufficient to identify most species using the point-count method. Some species will be challenging to detect with this method, such as nocturnal and crepuscular species (e.g., owls, nightjars, nightingales, etc.), those with very large ranges and low densities (e.g., eagles), and those that are silent during parts of the year.

Seasonal patterns

Sierra Leone experiences a very pronounced wet and dry season, with less than 20 mm of rainfall often occurring from December to March, while July and August regularly receive well over 500 mm each. Despite this pronounced seasonal pattern, relatively few of the common species (those with 10 or more records) are significantly more common in one season compared to the other (estimated using the $\chi 2$ test). The abundance and distribution of birds in any habitat are largely influenced by the presence of key environmental resources, such as season (Girma et al., 2017). Seasonality affects the availability of food and cover for bird populations, which, in turn, influences breeding

Table 2. Species significantly more common in one season compared to the other.

Dry season	P	Wet season	P
Western black headed *oriole (Oriolus brachyrynchus)*	<0.01	Village weaver (*Ploceus cucullatus*)	<0.001
Red vented malimbe (*Malimbus scutatus*)	<0.01	Senegal coucal (*Centropus senegalensis*)	<0.01
Cattle egret (*Bubulcus ibis*)	<0.05	Western nicator (*Nicator chloris*)	<0.05
Lizzard buzzard (*Kaupifalco monogrammicus)*	<0.05	African black swift (*Apus barbatus*)	<0.05
Red bellied paradise flycatcher (*Terpsiphone rufiventer*)	<0.1	Swamp palm bulbul (*Thescelocichla leucopleura*)	<0.05
White throated bee eater (*Merops albicollis)*	<0.1	Common bulbul *(Pycnonotus barbatus)*	*<0.1*
		Great blue turaco *(Corythaeola cristata)*	*<0.1*

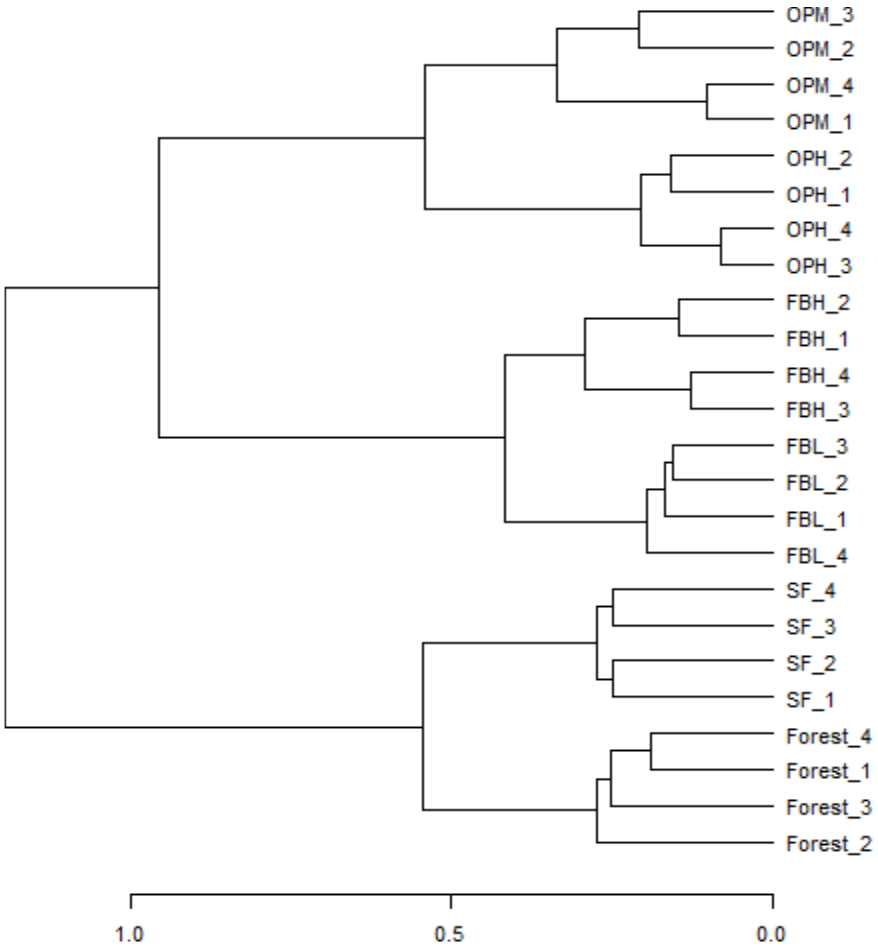

Figure 4. Classifying the plots on the basis of their bird fauna. OPM, oil palm plantation medium intensity; OPH, oil palm high intensity; FBH, farm bush with high density of wild oil palm; FBL, farm bush with low density of wild oil palm; SF, secondary forest; Forest, primary forest.

success and the survival of birds. Table 2 shows the species that are significantly more common in one season compared to another, along with four species that are close to conventional levels of statistical significance. The significant variation in the abundance of birds between the dry season and the wet season can be attributed to seasonal movement patterns and climatic conditions.

Habitat use

The 24 plots were characterized using hclust (hierarchal clustering) in the software package R, Figure 4. The groups identified from the bird fauna are remarkably similar to those identified by the authors. The correlation between the different habitats (based on the abundance of

Table 3. Pearson's correlation coefficient for relationship between habitat types.

	Forest	SF	FBL	FBH	OPM	OPH
Forest	1					
SF	0.738	1				
FBL	0.181	0.650	1			
FBH	0.160	0.434	0.790	1		
OPM	0.127	0.391	0.387	0.631	1	
OPH	0.143	-0.092	0.053	0.240	0.647	1

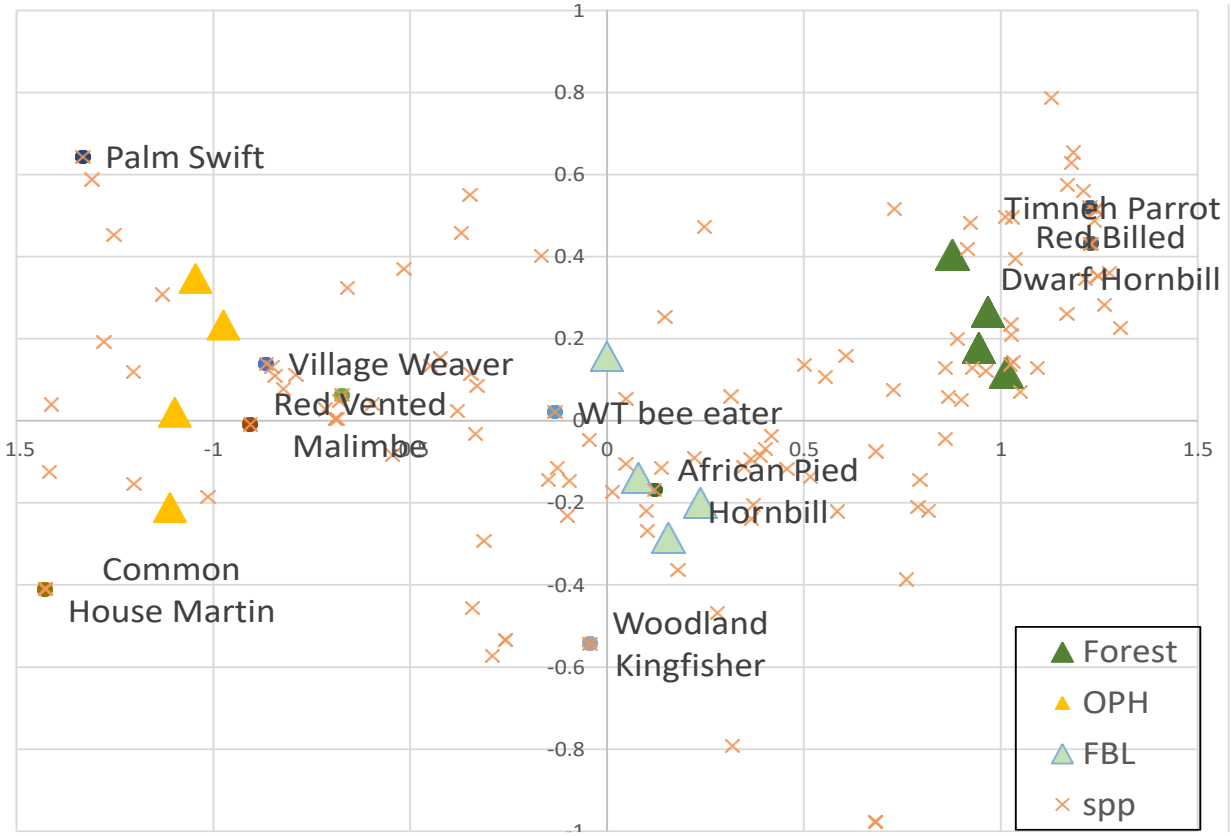

Figure 5. Ordination showing the relationship between bird species based on their co-occurrence in different habitats for clarity emphasis on forest (forest), farm bush with low density oil palm (FBL) and oil palm plantation with high intensity (OPH).

each species) is shown (Table 3).

The trend in the sites is reflected in the ordination of the species (using metaMDS in R) where the primary axis strongly reflects the gradient from the managed (high intensity oil palm plantations) to the wild (forest) (Figure 5).

Species feeding guilds

The dominant feeding guilds of each species were taken from Senior et al. (2012). Table 4 shows the number of individual birds observed at each site in relation to their dominant feeding guilds.

From Table 3, it can be seen that the main change in the sequence from forest to plantation is the decline in frugivores as the canopy becomes more open and disturbance increases, while granivores show the opposite pattern. Carnivores also tend to be more common in more open habitats.

DISCUSSION

Oil palm is a versatile crop and can be used in many

Table 4. Individual birds by dominant feeding guilds in each habitat.

	Carnivore	Frugivore	Granivore	Insectivore	Omnivore	Nectavore
Forest	11	187	39	233	113	21
SF	4	128	13	150	52	28
FBL	6	104	24	216	53	23
FBH	20	62	54	254	82	37
OPM	29	72	163	212	121	32
OPH	16	16	201	160	120	16

products. This versatility has led to its widespread cultivation across the tropics, putting more pressure on biodiverse-rich areas in the world. The results from the study show that bird diversity was greatest in the forests (primary and secondary), was high in the farm bush (low and high), and low in the oil palm plantations. Birds found in oil palm plantations were non-forest species of least conservation value that are adaptable to human-modified environments (Harkrider, 1993, Yudea and Santosa, 2019). This indicates that oil palm plantations in Southeastern Sierra Leone support species-poor avian communities of common and widespread species compared to the other land-use types (secondary forest, farm bush and primary forest). This finding is consistent with results from similar studies on oil palm plantations where bird species decline following the conversion of forest to oil palm plantation (Edwards et al., 2010; Azman et al., 2011; Lees et al., 2015; Srinivas and Koh, 2016). Recording species of conservation value in the farm-bush indicates that it is more favorable to forest birds than oil palm plantations and has the potential to accommodate some forest birds. This finding aligns with similar research conducted in India by Mandal and Raman (2016). Farm-bush has the potential to retain some of the biodiversity of primary forests if left undisturbed for a considerable period and this will attract forest-dependent species. Bird communities in any environment depend on vegetation diversity and habitat structure. The forests (primary and secondary), farm-bush (low and high density), and oil palm plantations (high and medium) provide food sources needed for different bird feeding guilds. Oil palm plantations, being near monocultures exhibit reduced vegetation structural complexity. Frugivore and nectavore populations decline as forests are converted to oil palm plantations, while carnivores, omnivores and granivores increase. The low abundance of frugivores and nectavores in the oil palm plantations indicates a lack of fruit trees. This finding aligns with similar studies that have shown a correlation between the abundance of frugivores and undisturbed habitat.

Birds found in oil palm plantations are noted to perform diverse ecological functions like insect pest control, seed dispersal, pest/rodent control and weed control (Puri and Kwatrina, 2023). Therefore, maintaining their diversity is crucial for the sustainability of oil palm plantations.

Conclusion

Palm oil is a traditional crop in Sierra Leone used in most dishes and is produced from three main sources: Farm bush, commercial large-scale plantations owned by multinational companies, and small-scale farms owned by families. In the farm bush, palm oil is produced from the palms mixed with other vegetation that remains after a piece of land is cleared for farming. In small-scale family farms, a piece of land can be cleared, leaving behind a few trees like *Terminalia ivorensis* for timber production. The plantation can be brushed either once a year, allowing the presence of birds in the shrubs. In large-scale plantations, a huge tract of land can be cleared using bulldozers and oil palm is grown as a monoculture. Underbrush is regularly cleared either by weedicides or by cutting. Results from the study indicate that the farm-bush has a reasonable biodiversity value, lower than the forests but still home to a range of species that cannot persist in plantations. At the moment, the country is self-sufficient in palm oil, and the move towards large-scale industrial plantations is driven by foreign investment companies, not concerns over food security. Palm oil grown and processed under traditional methods is much more compatible with biodiversity, avifauna and sustainability than modern improved methods.

Palm oil production in the fallow bushes is less detrimental to birds than even in small-scale plantations, as they support species of conservation significance. Farm bush is crucial for maintaining biodiversity lost to intensive agriculture, provided the fallow period is long enough. Oil palm is an essential commodity needed for the food security, livelihoods and economic development of Sierra Leone; therefore, ruling out its cultivation is unrealistic. However, it should be cultivated in an environmentally friendly manner where impacts on biodiversity can be mitigated. This could be achieved by growing oil palm in a mosaic of patches with other tree crops and natural vegetation that can serve as habitats for birds; similar measures are proposed by the Round Table on Sustainable Palm Oil (RSPO). The government, through its line Ministries (Agriculture and Forestry, Environment, and Lands and Housing), should develop a land-use policy aimed at regulating oil palm growers on the expansion of plantations in areas considered to be biodiversity hotspots.

This can be achieved by growing oil palm in unused farmlands with lower biodiversity as compared to primary and secondary forests. Most of the palm oil produced is for local consumption; however, a small portion of it is exported to other neighboring countries, thereby causing the local price to increase and ultimately leading to more land clearing for oil palm development. The government should implement policies aimed at limiting the exportation of palm oil to reduce the rate of deforestation from oil palm development.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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