Response of Understory Bird Feeding Groups to Deforestation Gradient in a Tropical Rainforest of Cameroon

Authors: Tchoumbou, Mélanie A., Malange, Elikwo F. N., Tiku, Claire T., Tibab, Brice, Fru-Cho, Jerome, et al.

Source: Tropical Conservation Science, 13(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/1940082920906970

Tropical Conservation Science
Volume 13: 1–12

DOI: 10.1177/1940082920906970
journals.sagepub.com/home/trc
SAGE

Response of Understory Bird Feeding Groups to Deforestation Gradient in a Tropical Rainforest of Cameroon

Mélanie A. Tchoumbou[1], Elikwo F. N. Malange[2], Claire T. Tiku[3], Brice Tibab[2], Jerome Fru-Cho[2], Timoléon Tchuinkam[1], Julius Awah-Ndukum[4], Damian Anong Nota[2], and Ravinder N. M. Sehgal[5]

Abstract

Birds are crucial in maintaining the balance of many ecosystems and provide various ecological services. Understanding their sensitivity to human disturbances should be prioritized in understudy areas for effective conservation practices. Using mist nets, this study characterized mostly understory bird communities (insectivorous, frugivorous, granivorous, and nectarivorous birds) in three habitat types (pristine forest, selectively logged forest, and young oil palm plantation) in the Talangaye rainforest, Southwest Cameroon. A total of 845 birds belonging to 27 families and 85 species were recorded in the three habitats after 294 h of mist netting. Overall, the mist-netted community was largely dominated by insectivores, followed by frugivores, nectarivores, granivores, and carnivores. Although mean species richness, abundance, and Simpson diversity index did not vary significantly among habitat types, mean species abundance and diversity index decreased in selectively logged forest and young oil palm plantation and species richness increased in both habitats. The species richness, abundance, and diversity index for insectivorous and frugivorous birds were lowest in the young oil palm plantations. For granivores, species richness and abundance increased following selective logging and the establishment of oil palm plantation. The highest mean species richness and diversity index in nectarivores were recorded in the young oil palm plantations. The study showed that selective logging and establishment of oil palm plantation had variable effects on the bird communities in the Talangaye rainforest. Also, the frugivorous birds appeared to be more sensitive to both types of disturbances, while the insectivores were more sensitive to habitat loss/conversion.

Keywords

tropical forest, selective logging, oil palm plantation, species diversity, bird feeding guild

Introduction

Tropical forests have high biodiversity and are usually undergoing rapid deforestation due to agricultural expansion, industrial logging, gold mining, and urbanization (Food and Agriculture Organization, 2009; Lewis et al., 2015). The conversion of natural habitats to agricultural areas involves the use of heavy machinery, felling, and dragging of trees over long distances. As a result, the forest is open and fragmented, its structure and composition are heavily damaged, and this may lead to local extinction and reduction of biological diversity of many taxa (Cintra, Magnusson, & Albernaz, 2013). Habitat loss and fragmentation are among the greatest

[1]Vector Borne Diseases Laboratory of the Applied Biology and Ecology Research Unit, Department of Animal Biology, University of Dschang, Cameroon
[2]Department of Microbiology and Parasitology, University of Buea, Cameroon
[3]Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow, Scotland, UK
[4]Department of Animal Science, University of Dschang, Cameroon
[5]Department of Biology, San Francisco State University, CA, USA

Received 7 September 2019; Accepted 15 January 2020

Corresponding Author:
Mélanie A. Tchoumbou, Vector Borne Diseases Laboratory of the Applied Biology and Ecology Research Unit, Department of Animal Biology, University of Dschang, P. O. Box 67, Dschang, Cameroon.
Email: tchoumbou4@gmail.com

threats to biodiversity (Gibson et al., 2011). To stave off mass extinction of species, Wilson (2016) advocated an increasing local and global understanding to the response of biological communities to disturbances is vital for efficient management and conservation actions to stave off mass extinction of species.

Birds are good models to study ecological processes as they are diverse and easy to monitor without disrupting natural populations (De Lima et al., 2013; Seymour et al., 2015). However, species habitat changes due to forest loss, fragmentation, and degradation greatly affect bird dispersal ability and the role of birds in ecosystem functions such as pollination, seed dispersal, and insect pest control among others (Cordeiro & Howe, 2003; Kennedy & Marra, 2010). Widespread degradation and conversion of forests cause reduction in the richness and abundance of bird species and may lead to local extinctions (Asefa, Davies, McKechnie, Kinahan, & Rensburg, 2017; Bett, Muchai, & Waweru, 2016; Casas, Darski, Ferreira, Kindel, & Müller, 2016; Hashim & Ramli, 2013). Bird species specialized to primary forest, their natural habitat, will be negatively affected during disturbances and may be replaced by other species associated with modified habitats. Species responses to disturbances are variable and dependent on factors such as species functional traits including body mass, forest habitat specialization, dietary guild, migratory status, global distribution size, and foraging strata (Mandal & Shankar, 2016; Newbold et al., 2013). As trait composition differs between communities (Kissling, Sekercioglu, & Jetz, 2012), sensitivity of communities to land-use change also differs.

Avian dietary guild is an important trait affecting avian contributions to ecosystem function. Frugivores and granivores contribute to seed dispersal, nectarivores to pollination, and insectivores to pest control (Greenberg et al., 2000; Şekercioğlu, 2006; Van Bael, Brawn, & Robinson, 2007). Studying avian feeding guilds is valuable in monitoring the state of disturbance of tropical forests. Identifying ecological bird groups that are sensitive to forest loss and fragmentation and how these patterns vary geographically (Powell, Cordeiro, & Stratford, 2015) is essential for preserving avian biodiversity. Previous studies have revealed that frugivorous and insectivorous bird populations remained stable after primary forests have been subjected to logging and fire events and reduced with intensification of human land use in eastern Amazonian Brazil (Bregman et al., 2016). Wielstra, Boorsma, Pieterse, and De Iongh (2011) in Borneo have reported lower species diversity in understory and arboreal among insectivorous birds and higher arboreal nectarivore and terrestrial granivores in disturbed forests. The disappearance of avian frugivores from rainforest systems can alter the structure of tree communities and impede regeneration in fragmented landscapes patches (Terborgh et al., 2008). Also, the disappearance of insectivores can lead to increased leaf damage, increased mortality of seedling, and reduced plant growth in degraded and secondary forests (Dunham, 2008). The effects of deforestation (inducing habitat loss and habitat fragmentation) on bird dietary and functional groups have not been well documented in Africa. This study provides the first insights from Cameroon. Identifying bird feeding groups sensitive to deforestation in Cameroon will help develop more effective and protective measures for preventing more loss of key ecological groups.

Cameroon is situated in Central Africa and is rich in biodiversity due to its large variety of biogeographical units and habitats. A total of 954 bird species distributed in four different biomes (Afrotropical Highlands (A07), Guinea Congo Forest (A05), Adamawa Plateau (A04), and Sahel (A03)) have been established in the Cameroon list (Languy, 2019). Also, Cameroon accounts for the second highest deforestation rate (about 1% annual) among the Congo Basin Countries (Food and Agriculture Organization, 2015). The lowland forest region of Cameroon is currently under severe pressure from logging and commercial agriculture (mainly cash crops such as palm oil, cocoa, and bananas). However, there is dearth of information on the effects of such disturbances on understory bird communities. In this context, this study aims to assess the pattern of species richness, abundance, and diversity of understory bird feeding groups in three forest patches with increasing degrees of disturbance (pristine forest, selectively logged forest, and young oil palm plantation) in the Talangaye rainforest of Southwest Cameroon. The Talangaye rainforest is a forest corridor between four protected areas and an important bird area in the country. The study determined the bird community composition and assessed biotic dissimilarity among habitat types, bird species richness, abundance, and diversity of the various feeding groups and their sensitivity to forest disturbances.

Methods

Study Area

The study took place in the Sithe Global-Sustainable Oils Cameroon concession (5°08′–5°20′N and 9°22′–9°24′E), located in the Talangaye rainforest, district of Nguti, Koupé-Manengouba Division, South West Region of Cameroon (Figure 1). It is a forest corridor which lies between four protected areas (Korup National Park, Banyang-Mbo Wildlife Sanctuary, Rumpi Hills Wildlife Reserve, and the Bakossi Mountains National Park) and has been undergoing large-scale deforestation for the establishment of African palm oil trees (*Elaeis*

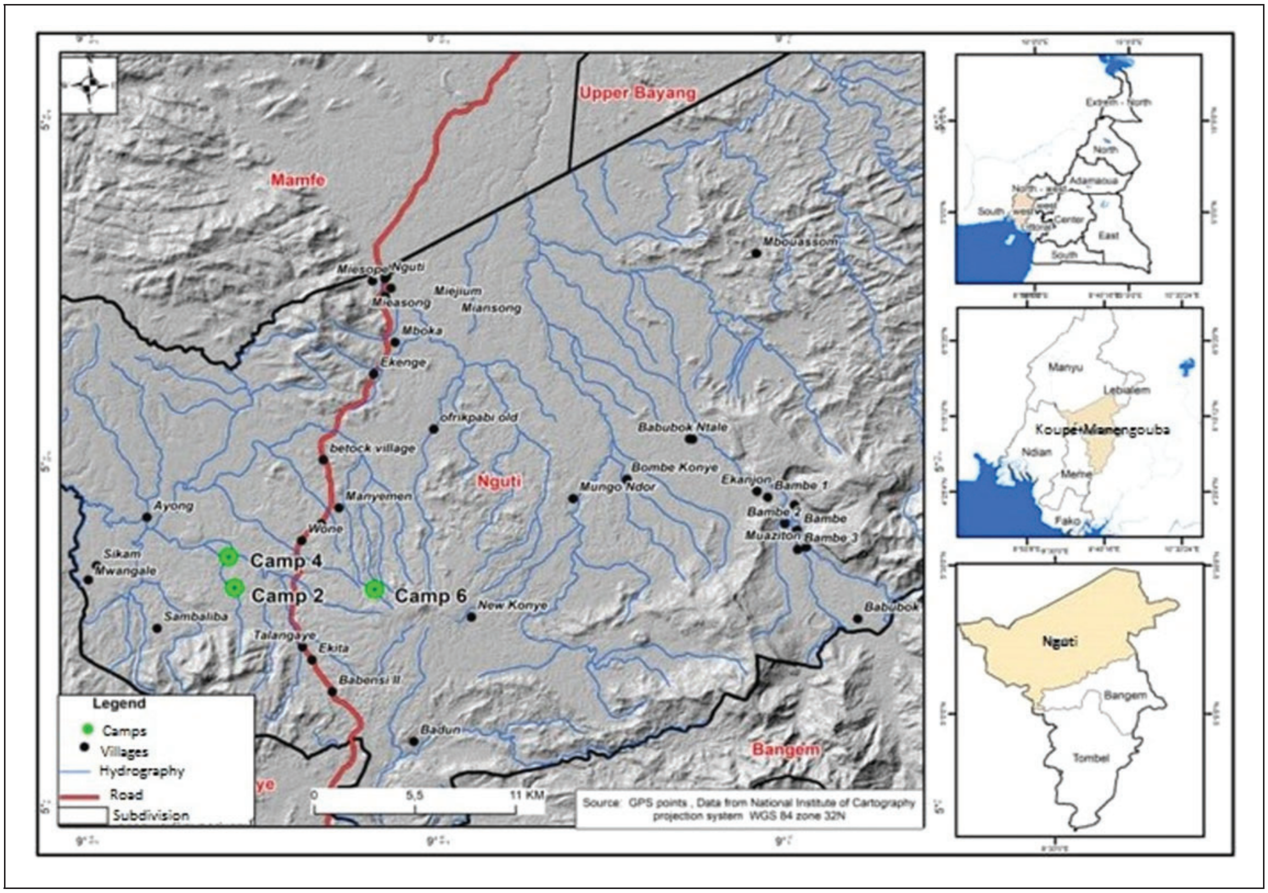

Figure 1. Map showing the study area and sampling camps. Camp 4 = pristine forest; Camp 2 = selectively logged forest; Camp 6 = young oil palm plantation.

guineensis) for palm oil production. It is made up of tropical moist semideciduous and evergreen lowland forest. The Talangaye rainforest has a typical equatorial climate made up of a short dry season (November–February) and one long rainy season (March–October), average annual rainfall of 3,000 mm, annual mean temperature of about 30°C, and relative humidity of about 80% (United Councils and Cities of Cameroon, 2014).

Data Collection

Following the permission of the competent local administration and authorities of the Timber company and oil palm plantation to carry out the sturdy, data were collected in July 2016, January 2017, and October 2017 in three different camps (Camp 4 surveyed in July 2016, Camp 2 surveyed in January 2017, and Camp 6 surveyed in October 2016; Figure 1) representing habitat types using mist netting (Dunn & Ralph, 2004). The habitats (camps) were described based on main land-cover type and evidence of human activities (logging and palm oil trees settlement), namely (Figure 2):

- Camp 4 (5.19093N, 9.34603E): *Pristine forest* defined as a near-primary forest showing no evidence of disturbance. It was characterized by the presence of large and tall trees of about 10 m height, forming a continuous close canopy;
- Camp 2 (5.17530N, 9.34882E): *Selectively logged forest* defined as forest slightly fragmented due to selective logging of commercial trees. It was characterized by the presence of tree stumps, felled trees, road openings, and had a slightly open canopy. Data were collected in this camp about 2 months after the logging;
- Camp 6 (5.17455N, 9.41768E): *Young oil palm plantation* defined as clear-cut forest with establishment of very young palm trees (less than 1 year old). It was characterized by the presence of dead wood, grasses of about 0.5 m height, open ground, soil debris, and had a completely open canopy. The area was bordered by pristine forest that serves as a buffer zone (about 100 m distance from our sampling sites). Data were collected in this camp about 3 months after the establishment of palm oil trees.

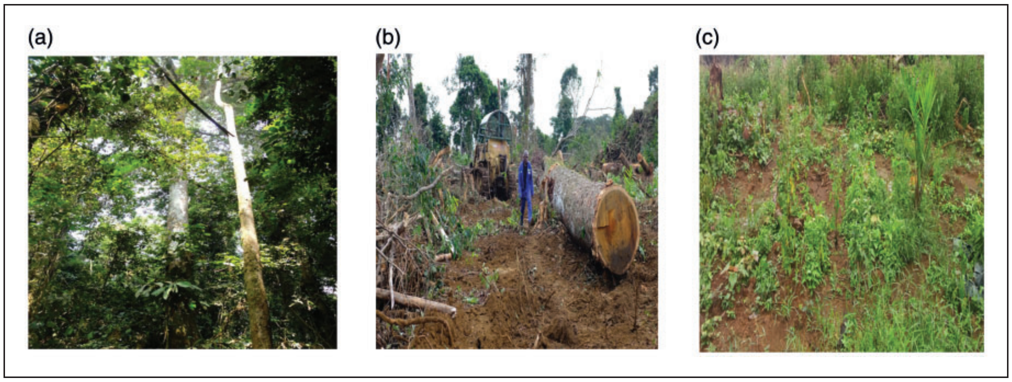

Figure 2. Photos of the different habitat types: (a) pristine forest, (b) selectively logged forest, and (c) young oil palm plantation.

The three habitats were in the same microgeographic area at an elevation between 300 and 400 m. Pristine forest and selectively logged forests were about 10 km from each other, and each had a surface area of about 450 km^2. The distance between pristine forest and oil palm plantation (about 225 km^2) was about 30 km.

Birds were captured in the three habitat types using 15 mist nets (12 m long, 4 shelves, 2.6 m high, 30×30 mm mesh) set in parallel and perpendicularly at three sites (about 200 m apart) in each habitat. Each habitat was monitored during 14 days with sampling effort of 7 h per day (from 6 a.m. to 1 p.m.). Opened nets were checked every 15 min, and all captured birds were identified using standard reference (Borrow & Demey, 2014). Each species was assigned to a dietary functional group as previously described (Del Hoyo, Elliott, Vicens, David, & Christie, 2016). Following primary food choices, five dietary groups of understory birds were defined: carnivores, insectivores (insect eaters), frugivores (fruit eaters), granivores (seed eaters), and nectarivores (nectar eaters).

Statistical Analyses

Obtained data were analyzed in R software version 3.4.1 (R Core Team, 2019), and the difference in between results was considered significant at $p < .05$.

Biotic Dissimilarity Among Habitat Types

The Bray–Curtis index values (Bray & Curtis, 1957) were calculated for use as dissimilarity matrix in cluster analysis. It was used to measure the turnover in species composition among individuals based on abundance data as follows:

$$BC = 1 - \frac{2c}{(a+b)}$$

where BC = Bray–Curtis dissimilarity index, a = number of species in sample 1, b = number of species in Sample 2, and c = number of shared species between both samples (Bray & Curtis, 1957).

Cluster analysis was done and a dendrogram plotted for the overall community following Unweighted Pair-Group Method using arithmetic Average clustering method (Maechler, Rousseeuw, Struyf, Hubert, & Hornik, 2017).

Species Richness and Abundance Among Habitat Types

The estimated number of species for each habitat type was determined using Chao-1 lower bound, an appropriate nonparametric asymptotic species richness estimator for individual-based data (Colwell et al., 2012). Based on the concept that rare species carry the most information about the number of undetected species, the Chao-1 estimator used numbers of singletons (S_1), doubletons (S_2), and observed richness (S_{obs}) to obtain the lower bound for expected asymptotic species richness (Chao, 2005) as follows:

$$S_{Chao-1} = \begin{cases} S_{obs} + S_1^2/2S_2; & \textit{if } S_2 > 0 \\ S_{obs} + S_1(S_1 - 1)/2; & \textit{if } S_2 = 0 \end{cases}$$

where S_{Chao-1} = the total number of species expected in an area, including those species not observed during the survey period; S_{obs} = number of species observed (traditional species richness), S_1 = number of singletons (the number of species with abundance = 1); and S_2 = number of doubletons (the number of species with an abundance = 2).

Species abundance (N) was defined as the total number of individuals recorded in each habitat/day, while mean abundance was estimated using the function *mean* in R.

Species Diversity Among Habitat Types

Bird diversity in various habitats was determined using Simpson's (1949) diversity index (*D*), which is sensitive to the abundance of species and give the probability of two individuals drawn randomly from a community to be the same.

$$D = \sum \frac{ni(ni-1)}{N(N-1)}$$

where D = Simpson's diversity index, ni = the total number of birds of each individual species, and N = total number of birds of all species.

After calculating species richness, abundance, and diversity values using the *vegan* package, the response variables were analyzed for normality using Shapiro–Wilk test. As normality was rejected even after data transformation, a nonparametric test following the Kruskal–Wallis procedure was used to test how response variables differed among habitats in each bird feeding group. These tests were followed by a Tukey's Honestly Significant Difference in case of significant difference, to establish the source of significance.

Results

Bird Community Composition and Biotic Dissimilarity Among Habitat Types

A total of 845 birds representing 85 species and 27 families were recorded in the surveyed habitats (Online Appendix 1). Overall, 42 (49.41%) species were recorded in pristine forest, 39 (45.88%) in selectively logged forest, and 53 (62.35%) in the young oil palm plantation. Also, 9/85 (10.59%) species were present only in pristine forest, 5/85 (5.88%) only in selectively logged forest, and 33/85 (38.82%) only in the young oil palm plantation while 14/85 (16.47%) species were common to all three habitat types. Among species recorded in pristine forest, 12 were absent in selectively logged forest (28.57% lost) and 25 absent in young oil palm plantation (59.52% lost). The most abundant species in the pristine forest was the yellow-whiskered Greenbul (*Eurillas latirostris*, 60 individuals), Fire-crested Alethe (*Alethe castanea*, 43 individuals) in selectively logged forest, and Barn Swallow (*Hirundo rustica*, 56 individuals) in the young oil palm plantation.

A species accumulation curve based on the number of species recorded per day in each habitat type is shown in Figure 3. After 14 days of sampling, the curve in pristine forest and selectively logged forest tended to become stable, while the curve continued to increase in the young oil palm plantation. Because all species present in each habitat were not recorded during the survey, more species would have been found if sampling days were more especially in young oil palm plantation.

Biotic dissimilarity dendrogram from cluster analysis of the overall understory bird community according to habitat types showed that, pristine forest and selectively logged forest were always clustering together (Figure 4) and had low-species composition dissimilarity (Bray-Curtis = 0.30). However, young oil palm plantation

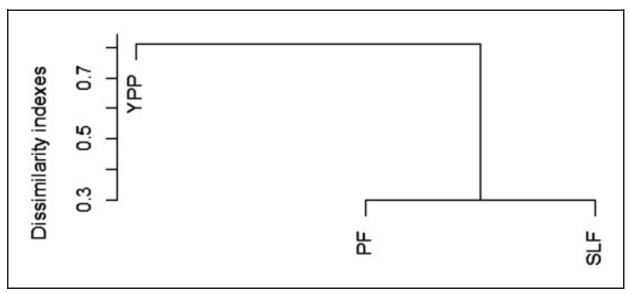

Figure 4. Dissimilarity dendrogram of the overall bird community in three habitats (Bray–Curtis index). PF = pristine forest; SLF = selectively logged forest; YPP = young oil palm plantation.

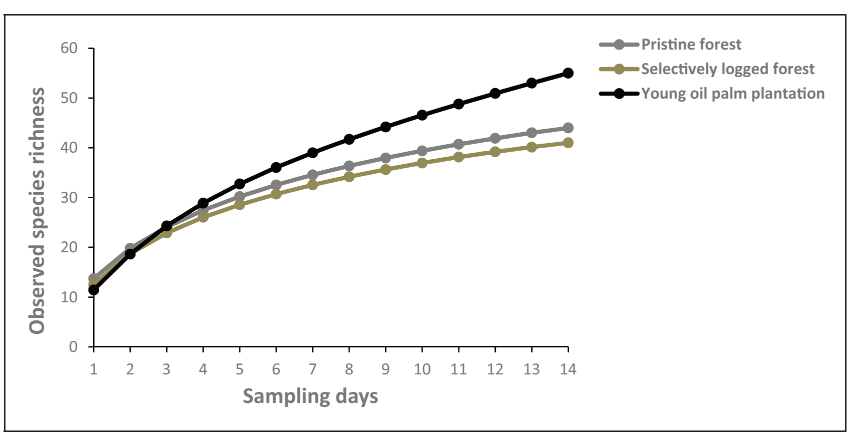

Figure 3. Cumulative number of bird species in three habitats.

showed high-species dissimilarity compared with the other habitats (BC = 0.81 for pristine forest and BC = 0.81 for selectively logged forest).

Bird Species Richness Among Habitat Types

Overall, 1 carnivore, 6 frugivores, 3 granivores, 30 insectivores, and 2 nectarivores were recorded in pristine forest; 6 frugivores, 4 granivores, 27 insectivores, and 2 nectarivores in selectively logged forest; and 8 frugivores, 6 granivores, 34 insectivores, and 5 nectarivores in the young oil palm plantation. However, the number of carnivorous birds was too small to permit robust analysis.

The estimated species richness (Chao-1) for the overall bird community based on dietary functional groups and distribution among habitat types is presented in Figure 5. When all the birds surveyed in each habitat were pooled together, young oil palm plantation had the highest mean daily species richness (mean ± standard deviation, 20.83 ± 12.59) while selectively logged forest registered the lowest mean species richness (18.02 ± 12.84). However, no significant difference was observed among habitat types ($p = .68$). For insectivorous birds, the highest mean species richness was recorded in selectively logged forest (12.77 ± 7.11), while young oil palm plantation had the lowest mean species richness (9.57 ± 6.49). For frugivores, the highest

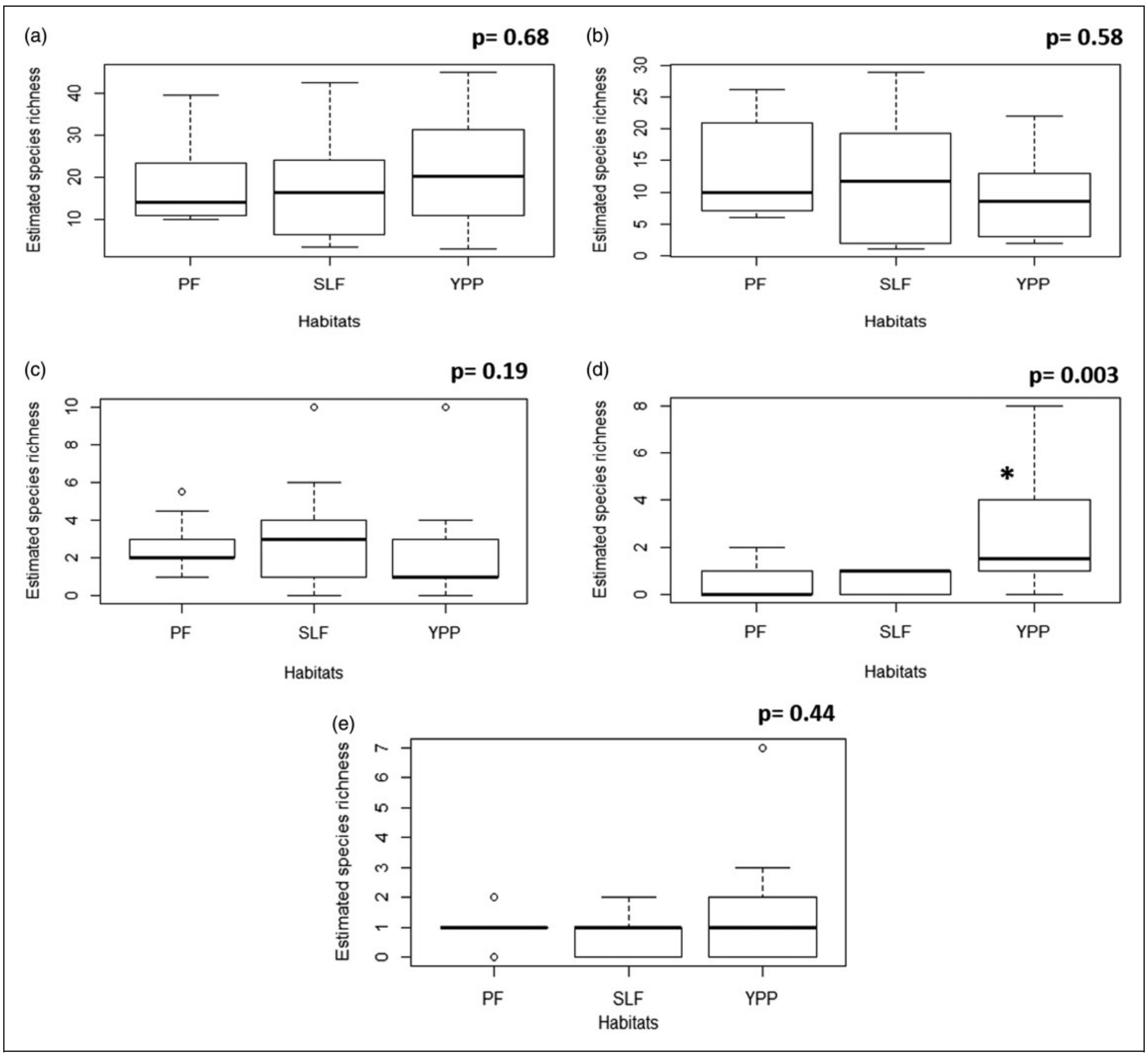

Figure 5. Estimated species richness of the bird feeding groups in three habitats (Chao1): (a) overall species, (b) insectivores, (c) frugivores, (d) granivores, and (e) nectarivores. PF = pristine forest; SLF = selectively logged forest; YPP = young oil palm plantation. *$p < .05$.

species richness estimate was registered in selectively logged forest (2.96 ± 2.65), while young oil palm plantation showed the lowest mean species richness (2.07 ± 2.56). Significant difference in the mean species richness among habitat types was observed in granivores ($p = .003$). This difference was associated to young oil palm plantation which showed the highest mean species richness (2.57 ± 2.50). For nectarivores, no significant difference was observed in the mean species richness among habitats ($p = .44$).

Bird Abundance Among Habitat Types

Considerable variation existed in term of mean abundance between habitat types in the various bird communities (Figure 6). When individuals in each habitat were pooled together, the pristine forest showed the highest mean daily abundance (22.57 ± 8.78) while the young oil palm plantation showed lowest mean abundance (16.29 ± 12.29). No significant difference was observed in the mean abundance of the overall community among habitat types ($p = .14$). For insectivorous birds, the highest mean abundance was observed in selectively logged forest (14.07 ± 11.29) compared with the young oil palm plantation which had the lowest mean abundance (9.57 ± 8.71). No significant difference was observed in the mean abundance of insectivores among habitat types ($p = .26$). For frugivorous birds, the mean abundance of species was significantly different among habitat types ($p < .001$). Tukey's Honestly Significant Difference revealed that the difference was associated to pristine forest, which had the highest species mean abundance (6.86 ± 2.80). The species abundance in granivorous community also varied significantly between habitat types ($p = .005$), and this variation was associated to the young oil palm plantation which had the highest mean abundance (2.57 ± 2.28), compared with other habitats. For nectarivores, no significant difference in the abundance between habitat types was observed ($p = .30$), and pristine forest had the highest mean species abundance (3.14 ± 2.25).

Species Diversity Among Habitat Types

Table 1 shows the mean species diversity values (Simpson index) of the bird communities according to habitat types. Overall, the species diversity index of the understory bird community did not vary significantly among habitat types ($p = .21$). However, pristine forest had the highest mean species diversity index (0.87 ± 0.04), while the young oil palm plantation (0.80 ± 0.12) had the lowest. For insectivorous birds, species diversity index significantly varied between habitat types ($p = .03$) and was associated to young oil palm plantation which had the lowest mean species diversity index (0.66 ± 0.15) compared with pristine forest. For frugivores, no significant difference was observed in mean species diversity indexes among habitat types ($p = .08$). However, pristine forest had the highest mean diversity index (0.41 ± 0.22), while young oil palm plantation had the lowest mean diversity index (0.18 ± 0.27). For granivores, young oil palm plantation showed significantly highest mean diversity index compared with other habitats ($p < .001$). No significant difference was observed in mean diversity index among habitats for nectarivorous birds ($p = .12$).

Discussion

This study presents insights of the effects of two major phenomena, habitat fragmentation through selective logging and habitat loss through the establishment of

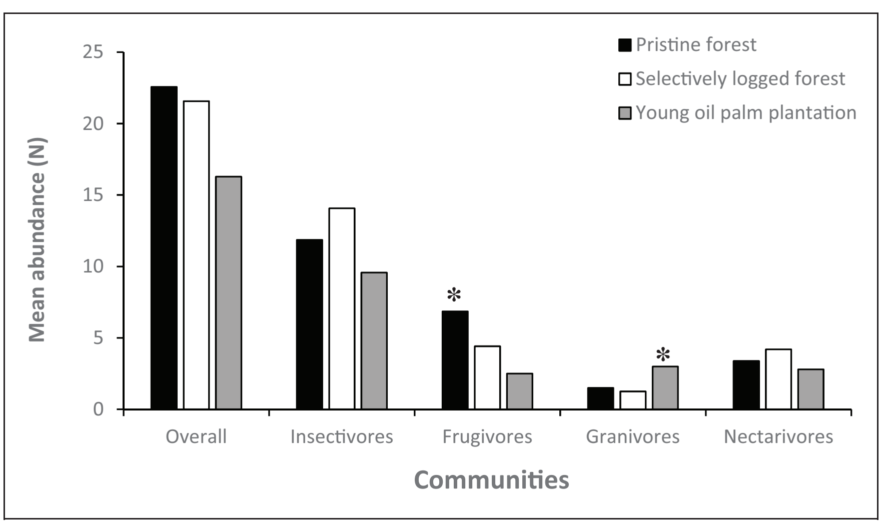

Figure 6. Mean species abundance of the bird feeding groups in three habitats.

Table 1. Diversity Index of the Understory Bird Communities Among Habitats.

Bird groups	Parameters	Pristine forest	Selectively logged forest	Young oil palm plantation	*N* sampled
All species	Observed	316	302	227	845
	Simpson diversity	0.87 ± 0.04	0.83 ± 0.10	0.80 ± 0.12	
Insectivores	Observed	166	197	134	496
	Simpson diversity	0.81 ± 0.05	0.69 ± 0.26	0.66 ± 0.15*	
Frugivores	Observed	96	53	30	180
	Simpson diversity	0.41 ± 0.22	0.37 ± 0.29	0.18 ± 0.27	
Granivores	Observed	9	10	36	54
	Simpson diversity	0.03 ± 0.12	0.00 ± 0.00	0.28 ± 0.31*	
Nectarivores	Observed	44	42	28	114
	Simpson diversity	0.12 ± 0.18	0.32 ± 0.46	0.44 ± 0.44	

Note. *$p < .05$.

oil palm plantation, on key ecological bird groups in Cameroon. The study revealed that a greater number of species (31/85 (36.47%)) were shared between the Pristine forest and selectively logged forest habitats types. In fact, pristine forest and selectively logged forest had a similar vegetation structure compared with oil palm plantation in which the natural vegetation was completely removed. The complexity and nature of habitats constituted a valuable factor that determined the species composition and diversity in a particular area (Bellanthudawa et al., 2019; Casas et al., 2016). Some forest-dependent birds (e.g., forest robin [*Stiphronis erythrothorax*]) were not found in the established young oil palm plantation and seemed to have been replaced by species associated with highly modified habitats such as Barn swallow (*H. rustica*), Black-and-White Mannikin (*Spermestes bicolor*). These results are consistent with previous findings, which revealed that habitat specialized bird species were among the most susceptible species to habitat disturbances (Arcilla, Holbech, & Donnell, 2015; Pavlacky, Possingham, & Goldizen, 2015; Şekercioğlu, 2012). In this study area, only one *endemic* species (Cameroon Olive Greenbul (*Phyllastrephus poensis*)) in pristine forest was recorded, and one *Near threatened* species (Blue-moustached Bee-eater (*Merops mentalis*)) in young oil palm plantation was recorded. The sampling method used (mist netting) was able to record only part of the community. The mist-net method has limited coverage and can only capture a certain size range of mostly understory birds usually those between 5 and 100 g (Angehr, Siegel, Aucca, Christian, & Pequeno, 2002). Also, birds that fly more often would have a greater chance to be captured using mist net, compared with birds that fly less even though they have relatively similar abundance.

In the study, the overall species abundance and diversity index decreased following selective logging and the establishment of oil palm plantation. This result agrees with Azman et al. (2011) in Malaysia and Manu et al., (2007) in West Africa who reported that fragmentation reduces the probability of occurrence of a wide range of bird species. The finding is contrary to Bobo and Waltert (2011) in Cameroon observed low numbers of individuals in near-primary forest compared with modified habitats. Morante-Filho, Faria1, Mariano-Neto, and Rhodes (2015) revealed that bird species richness and abundance were not affected by forest cover reduction in the Brazilian Atantic forest. Changes in the vegetation structure caused by logging and palm trees establishment played major roles in the decrease in abundance of species. The disturbance in selectively logged (2 months after disturbance) and young oil palm plantation (3 months after disturbance) was very recent and the vegetation cover had not yet been regenerated. Also, mature forests are usually structurally complex, offer more niches, more shelters, and have greater diversity of crops that provide more food (Davies & Asner, 2014) and therefore support more birds than deforested areas. Previous study have showed that habitat modification can results from reduced nest availability; fewer nest materials increases competition for nest sites and significantly increase nest predation and parasitism in modified habitats (Dranzoa, 2001).

In this study, the overall species richness increased following logging and establishment of the oil palm. Most birds found in the oil palm plantation were common species, adapted to highly modified habitats. This finding agrees Gove, Hylander, Nemomissa, Shimelis, and Enkossa (2013), Buechley et al. (2015) and Asefa et al. (2017) who reported highest species richness in disturbed tropical forests in east Africa. Similar result was reported by Nana et al. (2014) who found higher species richness on Mt Oku in Cameroon, due to nonforest species that invade the forest interior following recent human disturbance. Contrary to this study, Modest and Hassan (2016) and Dami, Mwansat, and Manu (2012) reported that species richness was influenced by forest edge and patch size rather than level of habitat disturbance in the coastal forests of north-eastern Tanzania and Obudu Plateau of south-eastern Nigeria, respectively. However, the influence of forest edge and patch size were not tested in this study. The oil palm plantation was categorized as an unfavorable environment owing to the low availability of food sources and the frequent disturbances caused by humans, especially during the palm nuts harvest (Aratrakorn, Thunhikorn, & Donald, 2006). The highest bird species richness observed in young oil palm plantation could have resulted from the introduction of species adapted to modified habitats and persistence of some forest-dependent species in the area. Also, the proximity of the buffer zone (pristine forest at about 100 m from oil palm plantation) may have facilitated the quick recolonization and adaptation of many species. Overall, the observed trend was not universal and varied with respect to bird taxonomic groups such as dietary functional groups.

Some bird groups were not affected by habitat disturbances, while others are either negatively or positively affected. Granivorous birds, for example, showed higher species richness and abundance in the young oil palm plantation and logged area. This result is consistent with the previous findings of high proportion of granivores due to habitat effects on forest bird diversity in Korup region, Cameroon (Waltert, Bobo, Sainge, Fermon, & Muehlenberg, 2005) and avian species diversity in cultivated areas in different habitat types in North Nandi Forest, Kenya (Bett et al., 2016). Granivores eat seeds and grains predominantly and play a crucial role in ecosystem restoration. Young oil palm plantation was an opened agricultural landscape, covered by palm trees in the early stage, dead wood and weeds probably offer suitable ground for granivores. The species richness, abundance, and diversity index for insectivores and frugivores decreased following the establishment of the young oil palm plantation. This finding agrees with the previous reports that rainforest's insectivores and frugivores were highly sensitive to land-cover changes, with many species dropping out from disturbed habitats, due to poor dispersal abilities and adaptation to the forest interior (Bregman et al., 2016; Bregman, Sekercioglu, & Tobias, 2014; Şekercioğlu et al., 2002). Contrarily, Tamaris-Turizo, López-Arévalo, and Rodríguez (2017) reported a greater association of insectivores with oil palm crop in a tropical landscape of Colombia. They stated that oil palm served as suitable habitats for a number of widespread bird species, and the height did not seem to be an important factor. The oil palm size included in their study varied from 6 m to 15 m, compared with palms less than 2 m high in this study.

The establishment of young oil palm plantation involved the complete removal of trees including fruit trees and flowering plants that served as food sources for many frugivorous and nectarivorous birds. The presence of more trees provided various food sources or nesting and perching grounds for the birds (Kottawa-Arachchi & Gamage, 2015). The abundance of nectarivorous birds also decreased after selective logging and oil palm plantation. This result agrees with that of Bernardo (2017) who reported the number of species and individuals in nectarivores, frugivores, and insectivores to be fewer in oil palm plantation than in forest in Malaysia. Nectarivores are generally more specialized species, which have only one food resource and do not easily adapt to new environmental conditions (Bennett, Clarke, Thomson, & Nally, 2014). In heavily logged forest, species with more opportunistic feeding behaviors have been reported to be more abundant than specialized feeders (Waltert, 2000).

Habitat nature, abundance of food, breeding season of species, climate, and geographic area are among the most important factors affecting bird species composition and survival worldwide (Bellanthudawa et al., 2019; Bibi & Ali, 2013; Casas et al., 2016; Phalan, Onial, Balmford, & Green, 2011; Rajpar & Zakaria, 2015). Predictors like climate and geographic area were excluded in this study, because the different habitats were in the same small geographic area, and had similar temperature as well as similar elevation. However, annual seasonality has no considerable impact on the abundance and richness of bird communities in Southwest Cameroon (Makuate, 2019). As abundance of food usually depends on the habitat vegetation structure, species habitat type was the main reason for the changes in the bird communities in the study area. Proper identification of habitat features that make species sensitive to disturbances is important for conservation practices.

Implications for Conservation

This study provides key elements of ecological bird groups responses to disturbance in a tropical lowland rainforest of Cameroon. In a given habitat, species richness and abundance were denoted by the presence of resources and mechanisms to avoid predators. These resources were partitioned in between species to weaken the competition that can be raised among them (Ricklefs, 2008). When logging and agricultural expansions were conducted, vegetation and plants were cleared and removed from the sites, creating canopy gaps and loss of some resources. This narrowed down and separated habitat connectivity, making more sensitive species vulnerability and decrease in their population size. In this study, insectivorous and frugivorous birds appeared to be more sensitive to selective logging and the establishment of oil palm plantation. In oil palm plantation, species richness, abundance, and diversity decreased in insectivorous and frugivorous birds, while they increased in granivores and nectarivores. Agricultural activities tend to favor high bird diversity in granivores which can constitute a risk of propagating exotic tree species with eventual competitive exclusion of the indigenous ones (Gomes et al., 2011).

To minimize adverse effects of habitat disturbances on the sensitive bird communities (insectivores and frugivores), conservation and management efforts should be more oriented toward protecting habitat and resources of these key ecological bird groups during the modification of available land uses. The exploitation of the forest should be carried out using few roads and little mechanized equipment as possible to limit the degree of habitat disturbance (Tanalgo, Pineda, Agravante, & Amerol, 2015). Awareness raising campaign of local communities living in neighborhoods of the forest on the importance of understory birds and forest conservation should be planned to minimize uncontrolled human pressure on the forests' biodiversity. Also, strict control measures to stop tree cutting and agricultural activities in forests corridor were recommended to maintain connectivity between habitats. Rescuing sensitive group of birds such as insectivores and frugivores from local extinction in uncontrolled habitat destruction can be achieved through legal authorities (Massimino et al., 2008).

Acknowledgments

The authors are grateful for the international collaboration of Dr. Kevin Njabo as well as for his cooperation and support which facilitated the completion of this work. The authors extend their gratitude to the general manager of Sithe Global-Sustainable Oils Cameroon, Dr. Blessed Okole, for granting access to the Talangaye concession of Sithe Global-Sustainable Oils Cameroon and Mr. Akumsi Alfred for the field support in the forest and plantation. The authors are also immensely grateful to Mr. Forzi Francis (ornithologist) for his professional help during fieldwork as well as all the assistance of students and field guides in the PEER project 4–360.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study received financial support from U.S. Agency for International Development through Partnerships for Enhanced Engagement in Research (project 4–360) awarded to Dr. Anong Damian Nota of the University of Buea, Cameroon and also from a Conservation Action Research Network, USA grant and Idea Wild Equipment, USA grant awarded to Tchoumbou Mélanie Adèle. The National Geographic Foundation (CRE 983616) supported Dr. Sehgal's travels to Cameroon.

ORCID iDs

Mélanie A. Tchoumbou https://orcid.org/0000-0002-6559-778X
Elikwo F. N. Malange https://orcid.org/0000-0001-7138-4847

References

Angehr, G. R., Siegel, J., Aucca, C., Christian, D. G., & Pequeno, T. (2002). *Environmental monitoring and assessment* (Vol. *76*, pp. 69–87). Dordrecht, the Netherlands: Kluwer Academic.

Aratrakorn, A., Thunhikorn, S., & Donald, P. F. (2006). Changes in bird communities following conversion of lowland forest to oil palm and rubber plantations in Southern Thailand. *Bird Conservation International*, *16*, 71–82.

Arcilla, N., Holbech, H., & Donnell, S. (2015). Severe declines of understory birds follow illegal logging in Upper Guinea forests of Ghana, West Africa. *Biological Conservation*, *188*, 41–49.

Asefa, A., Davies, B., McKechnie, A., Kinahan, A., & Rensburg, J. (2017). Effects of anthropogenic disturbance on bird diversity in Ethiopian montane forests. *The Condor*, *119*(3), 416–430.

Azman, M. M., Latip, A. S., Sah, A. M., Akil, M. A., Shafie, N. J., & Khairuddin, L. N. (2011). Avian diversity and feeding guilds in a secondary forest, an oil palm plantation and a paddy field in Riparian areas of the Kerian River Basin, Perak, Malaysia. *Tropical Life Sciences Research*, *22*(2), 45–64.

Bellanthudawa, B. K., Nawalage, M. S., Subanky, S., Panagoda, P. A., Weerasinghe, H. W., Tharaka, D. L., ... Abeywickrama, S. J. (2019). Composition and diversity variation of avifauna, along different vegetative habitat types in a human-modified area, University of Kelaniya, Sri Lanka. *International Journal of Zoology*, 2019, 1–16.

Bennett, J. M., Clarke, R. H., Thomson, J. R., & Nally, R. M. (2014). Variation in abundance of nectarivorous birds: Does a competitive despot interfere with flower tracking? *Journal of Animal Ecology*, *83*, 1531–1541.

Bernardo, A. J. (2017). Disparity in bird communities of oil palm (*Elaeis guineensis*) plantation and adjacent forest in Aborlan, Palawan: Implications to avifaunal conservation. *Journal of Nature Studies*, *16* (1), 45–62.

Bett, M., Muchai, M., & Waweru, C. (2016). Avian species diversity in different habitat types in and around North Nandi Forest, Kenya. *African Journal of Ecology*, *7*, 1–7.

Bibi, F., & Ali, Z. (2013). Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. *Journal of Animal and Plant Sciences*, *23*(2), 469–474.

Bobo, K., & Waltert, M. (2011). The importance of agricultural areas for bird conservation in the Korup region, south-western Cameroon. *International Journal of Biological and Chemical Sciences*, *5*(2), 419–432.
Borrow, N., & Demey, R. (2014). *Birds of Western Africa* (2nd ed.). Princeton University Press, UK.
Bray, J. R., & Curtis, J. T. (1957). An ordination of upland forest communities of southern Wisconsin. *Ecological Monographs*, *27*, 325–349.
Bregman, T. P., Lees, A. C., MacGregor, H. E., Darski, B. D., Moura, N. G., Aleixo, A., . . . Tobias, J. A. (2016). Using avian functional traits to assess the impact of landcover change on ecosystem processes linked to resilience in tropical forests. *Proceedings of the Royal Society B: Biological Sciences*, *283*, 2016–1289.
Bregman, T. P., Sekercioglu, C., & Tobias, J. A. (2014). Global patterns and predictors of bird species responses to forest fragmentation: Implications for ecosystem function and conservation. *Biological Conservation*, *169*, 372–383.
Buechley, E., Sxekercioglu, H., Atickem, A., Gebremichael, G., Ndungu, J., Mahamued, A., . . . Lens, T. (2015). Importance of Ethiopian shade coffee farms for forest bird conservation. *Biological Conservation*, *188*, 50–60.
Casas, G., Darski, B., Ferreira, M., Kindel, A., & Müller, S. (2016). Habitat structure influences the diversity, richness and composition of bird assemblages in successional Atlantic rain forests. *Tropical Conservation Science*, *9*(1), 503–524.
Chao, A. (2005). Species estimation and applications. *Encyclopedia of Statistical Sciences*, 2nd Eds, Wiley, NY, USA.
Cintra, R., Magnusson, W., & Albernaz, A. (2013). Spatial and temporal changes in bird assemblages in forest fragments in an eastern Amazonian savannah. *Ecology and Evolution*, *3*(10), 3249–3262.
Colwell, R., Chao, A., Gotelli, N., Lin, S., Mao, C., Chazdon, R., & Longino, J. (2012). Models and estimators linking individual-based and sample-based rarefaction, extrapolation and comparison of assemblages. *Journal of Plant Ecology*, *5*, 3–21.
Cordeiro, N. J., & Howe, H. F. (2003). Forest fragmentation severs mutualism between seed dispersers and an endemic African tree. *Proceedings of the National Academy of Sciences*, *100*(24), 14052–14056.
Dami, F. D., Mwansat, S. G., & Manu, A. S. (2012). The effects of forest fragmentation on species richness on the Obudu Plateau, south-eastern Nigeria. *African Journal of Ecology*, *51*, 32–36.
Davies, A., & Asner, G. (2014). Advances in animal ecology from 3D-LiDAR ecosystem mapping. *Trends in Ecology and Evolution*, *29*, 681–691.
Del Hoyo, J., Elliott, A., Vicens, J. S., David, A., & Christie, D. A. (2016). *Handbook of the birds of the world alive*. Barcelona, Spain: Lynx Edicions. Retrieved from https://www.hbw.com
De Lima, R. F., Dallimer, M., Atkinson, P., & Barlow, J. (2013). Biodiversity and land-use change: Understanding the complex responses of an endemic-rich bird assemblage. *Diversity and Distribution*, *19*, 411–422.
Dranzoa, C. (2001). Breeding birds in the tropical rain forests of Kibale National Park, Uganda. *African Journal of Ecology*, *39*, 74–82.
Dunham, A. E. (2008). Above and below ground impacts of terrestrial mammals and birds in a tropical forest. *Oikos*, *117*, 571–579.
Dunn, E. H., & Ralph, C. (2004). Use of mist nets as tools for bird population monitoring. *Studies in Avian Biology*, *29*, 1–6.
Food and Agriculture Organization. (2009). State of the World's Forests 2009. Electronic Publishing Policy and Support Branch, communication division, FAO, Viale delle terme di caracalla, Rome, Italy.
Food and Agriculture Organization. (2015). *Global forest resources assessment*. Rome, Italy: Author.
Geist, H. J., & Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience*, *52*, 143–150.
Gibson, L., Lee, T. M., Koh, L. P., Brook, B. W., Gardner, T. A., Barlow, J., . . . Sodhi, N. S. (2011). Primary forests are irreplaceable for sustaining tropical biodiversity. *Nature*, *478*, 378–381.
Gomes, V.S., Tamashiro, J.Y., and Silva, W.R. (2011). "Seed inflow to a forest patch promoted by understory frugivorous birds," *Biota Neotropica*, *11*(4), 95–102.
Gove, A., Hylander, K., Nemomissa, S., Shimelis, A., & Enkossa, W. (2013). Structurally complex farms support high avian functional diversity in tropical montane Ethiopia. *Journal of Tropical Ecology*, *29*, 87–97.
Greenberg, R., Bichier, P., Cruz Agnon, A., MacVean, C., Perez, R., & Cano, E. (2000). The impact of avian insectivory on arthropods and leaf damage in some Guatemalan coffee plantations. *Ecology*, *81*, 1750–1755.
Hashim, E., & Ramli, R. (2013). Comparative study of understorey birds diversity inhabiting lowland rainforest virgin jungle reserve and regenerated forest. *The Scientific World Journal*, *7*, 1–7.
Kennedy, C. M., & Marra, P. P. (2010). Matrix mediates avian movements in tropical forested landscapes: Inference from experimental translocations. *Biological Conservation*, *143*(9), 2136–2145.
Kissling, W. D., Sekercioglu, C. H., & Jetz, W. (2012). Bird dietary guild richness across latitudes, environments and biogeographic regions. *Global Ecology and Biogeography*, *21*, 328–340.
Kottawa-Arachchi, J., & Gamage, R. (2015). Avifaunal diversity and bird community responses to man-made habitats in St.Coombs Tea Estate, Sri Lanka. *Journal of Threatened Taxa*, *7*(2), 6878–6890.
Languy, M. (2019). The birds of Cameroon: Their status and distribution. *Royal Musuem for Central Africa*, *299*, 567.
Lewis, S., Edwards, D., Galbraith, D. (2015). Increasing human dominance of tropical forests. *Sc.*, *349*(6250), 827–832.
Maechler, M., Rousseeuw, P., Struyf, A., Hubert, M., & Hornik, K. (2017). *Cluster: Cluster analysis basics and extensions. R package version 2.0.6*.

Makuate, S. (2019). *Vertical stratification of bird community in mount Cameroon lowland Afro-tropical rainforest* (Master's thesis). University of Dschang, Cameroon.

Mandal, J., & Shankar, T. (2016). Shifting agriculture supports more tropical forest birds than oil palm or teak plantations in Mizoram, northeast India. *The Condor: Ornithological Applications*, *118*, 345–359.

Manu et al., (2007). The effects of edge, fragment size and degree of isolation on avian species richness in highly fragmented forest in West Africa. *Ibis*, *149*, 287–297.

Massimino, D., Masin, S., Bani, L., Dranzoa, C., and Massa, R. (2008). "Partial recovery of an african rainforest bird community 35 years after logging." *Ethology Ecology and Evolution*, *20*(4), 391–399.

Modest, R. B., & Hassan, S. N. (2016). Species composition of tropical understory birds in threatened east African coastal forests based on capture data. *International Journal of Zoology*, *2016*, 1–9.

Morante-Filho, C. J., Faria1, D., Mariano-Neto, E., & Rhodes, J. (2015). Birds in anthropogenic landscapes: The responses of ecological groups to forest loss in the Brazilian Atlantic Forest. *PLoS One*, *10*(6), e0128923.

Nana, D. E., Sedlacek, O., Bayly, N., Ferenc, M., Albrecht, T., Reif, J., . . . Horak, D. (2014). Comparison of avian assemblage structures in two upper montane forests of the Cameroon volcanic line: Lessons for bird conservation. *Biodiversity and Conservation*, *23*, 1469–1484.

Newbold, T., Scharlemann, J., Butchart, S., Sekercioglu, C., Alkemade, R., Booth, H., & Purves, D. (2013). Ecological traits affect the response of tropical forest bird species to land-use intensity. *Proceedings of the Royal Society B: Biological Sciences*, *280*, 2012–2131.

Pavlacky, D., Possingham, H., & Goldizen, A., (2015). Integrating life history traits and forest structure to evaluate the vulnerability of rainforest birds along gradients of deforestation and fragmentation in eastern Australia. *Biological Conservation*, 1, 89–99.

Phalan, B., Onial, M., Balmford, A., & Green, R. E. (2011). Reconciling food production and biodiversity conservation: Land sharing and land sparing compared. *Science*, *333*, 1289–1291.

Powell, L. P., Cordeiro, N. J., & Stratford, J. A. (2015). Ecology and conservation of avian insectivores of the rainforest understory: A pantropical perspective. *Biological Conservation*, *188*, 1–10.

Rajpar, M. N., & Zakaria, M. (2015). Bird abundance and its relationship with microclimate and habitat variables in open-area and shrub habitats in Selangor, peninsular Malaysia. *Journal of Animal Plant Science*, *25*(1), 114–124.

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org

Şekercioğlu, C. (2006). Increasing awareness of avian ecological function. *Trends in Ecology and Evolution*, *21*, 464–471.

Ricklefs, R.E. (2008). Disintegration of the ecological community. *American Naturalist*, *172*, 741–750.

Şekercioğlu, C. (2012). Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. *Journal of Ornithology*, *153*(1), 153–161.

Şekercioğlu, C., Ehrlich, P., Daily, G., Aygen, D., Goehring, D., & Sandi, R. F. (2002). Disappearance of insectivorous birds from tropical forest fragments. *Proceedings of the National Academy of Sciences*, *99*, 263–267.

Seymour, C. L., Simmons, R. E., Grant, S., & Slingsby, J. A. (2015). On bird functional diversity: Species richness and functional differentiation show contrasting responses to rainfall and vegetation structure in an arid landscape. *Ecosystem*, *18*(6), 1–15.

Simpson, E. (1949). Measurement of diversity. *Nature*, *163*(1949), 688.

Tamaris-Turizo, D. P., López-Arévalo, H. F., & Rodríguez, N. R. (2017). Effect of oil palm plantation crop structure *Elaeis guineensis* (Arecacae) on bird diversity in a tropical landscape of Columbia. *International Journal of Tropical Biology*, *65*(4), 1569–1581.

Tanalgo, C. K., Pineda, J. F., Agravante, M. E., & Amerol, Z. M. (2015). Bird diversity and structure in different land-use types in lowland south-central Mindanao, Philippines. *Tropical Life Sciences Research*, *26*(2), 85–103.

Terborgh, J., Nunez-Iturri, G., Pitman, N. C., Valverde, F. H., Alvarez, P., Swamy, V., . . . Paine, C. E. (2008). Tree recruitment in an empty forest. *Ecology*, *89*, 1757–1768.

United Councils and Cities of Cameroon. (2014). *National office/Nguti division*. Retrieved from www.CVUC UCCC.com

Van Bael, S. A., Brawn, J. D., & Robinson, S. K. (2007). Birds defend trees from herbivores in a Neotropical forest canopy. *Proceedings of the National Academy of Sciences*, *100*, 8304–8307.

Waltert, M. (2000). *Diversity and structure of a bird community in a logged forest in Southeast Côte d'Ivoire* (PhD thesis). Georg-August-Universität Göttingen, Germany.

Waltert, M., Bobo, K. S., Sainge, M. N., Fermon, H., & Muehlenberg, M. (2005). From forest to farmland: Habitat effects on Afrotropical forest bird diversity. *Ecological Applications*, *15*(4), 1351–1366.

Wielstra, B., Boorsma, T., Pieterse, S. M., & De Iongh, H. H. (2011). The use of avian feeding guilds to detect small-scale forest disturbance: A case study in East Kalimantan, Borneo. *Forktail*, *27*, 55–62.

Wilson, E. O. (2016, March 12). The global solution to extinction. *The New York Times*.