British Journal of Applied Science & Technology
3(1): 48-64, 2013

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Human-induced Disturbances Influence on Bird Communities of Coastal Forests in Eastern Tanzania

Shombe N. Hassan[1*], Amina R. Salumu[2], Alfan A. Rija[1], Robert Modest[1], Jafari R. Kideghesho[1] and Pius F. Malata[3]

[1]Department of Wildlife Management, Sokoine University of Agriculture, P.O.Box 3073, Morogoro, Tanzania.
[2]Tanzania National Parks (TANAPA), P.O. Box 3134 Arusha, Tanzania.
[3]College of African Wildlife Management (CAWM), Mweka, P.O. Box 3031 Moshi, Tanzania.

Authors' contributions

This work was carried out in collaboration between all authors. Author SNH designed the study, wrote the protocol, guided the statistical analyses and wrote the first manuscript; author ARS did field work, managed the data, and performed the core statistical analysis; author AAR managed literature searches, performed additional analysis, read and commented on the draft manuscripts along with other authors. All authors read and approved the final manuscript.

Research Article

Received 6th September 2012
Accepted 23rd November 2012
Published 17th December 2012

ABSTRACT

Aims: To assess the influence of human-induced disturbances on bird communities.
Study Design: Longitudinal study.
Place and Duration of Study: Four forests; - Kion/Zaraninge, Kwamsisi/Kwahatibu, Msumbugwe and Gendagenda in Pangani–Saadani ecosystem, from October 2010 to January 2011.
Methodology: Eight permanent transects, each 500 m long stratified into forest core and forest edge habitats were used in each forest to identify types and quantify levels of human-induced disturbances, determine bird species composition, diversity and richness, and abundance. Therefore three circular plots, each 20 m radius were allocated at beginning, middle and end of each transect. The level of disturbance was assessed using four disturbance indicators; tree lopping, human trails, Pit-sawing and animal snaring while

**Corresponding author: E-mail: hassanshombe@yahoo.co.uk;*

bird species were identified by sight and call. One-way Analysis of Variance was used to test for differences in bird abundance between forests. Moreover, Shannon-Wiener Diversity Index (H') was calculated for each forest to assess species diversity and evenness, and Bray-Curtis Cluster analysis was used to determine similarity in bird species composition between the forests.

Results: A total of 564 individuals composed of 88 bird species distributed in ten Orders were recorded. The level of Pit-sawing and lopping differed significantly between forests (P<.05) with Msumbugwe being more disturbed than the rest. Bird abundance differed significantly between the forests (P<.05) with the highest abundance occurring in Msumbugwe. As expected, species richness and diversity were greater in least disturbed forests-Kiono/Zaraninge and Kwamsisi/Kwahatibu than in the highly disturbed forest, but forest dependent species were not significantly different between the study forests. Apparently, only Pit-sawing was found to correlate with bird abundance (P<.01) whereas similarities in species composition were evident with Kion/Zaraninge and Gendagenda exhibiting much overlap.

Conclusion: Increasing forest disturbances seems to negatively impact on distribution of birds thus challenging conservationists to devising sustainable forest management strategies in order to sustain bird diversity and abundances in these unique forests.

Keywords: Costal forests; disturbance indicators; human-induced disturbance; Saadani National Park; Species richness and diversity; Tanzania.

1. INTRODUCTION

East African coastal forests comprise of a diverse group of isolated evergreen or semi-evergreen closed canopy forest occurring within 60 km of the Indian Ocean and usually from sea level to 600 m above sea level [1]. They are distinct from the lowland forests that surround mountainous areas, and which form a natural continuum with the sub-montane forests that occur at higher altitudes [2]. Their isolation from other forest blocks for at least 27 million years [1] along with continued exposure to a relatively stable moist climatic regime offered by Indian Ocean [2] has enabled high level of biological endemism and near endemism in the region [1,3,4]. Consequently, the forests are one of the highest priority ecosystems for conservation in Africa and globally [5].

The Saadani-Pangani ecosystem in eastern Tanzania, which encompasses several coastal forest reserves, is also an avifauna diversity zone [5]. For example, the 11 bird species reported by Azeria et al. [5] as endemic to East African coastal forests are represented in the famous Kiono/Zaraninge Forest Reserve and other comparable forest reserves in the ecosystem [5]. Unfortunately these forests are increasingly subjected to unsustainable biomass extractions by humans. Ongoing human activities include logging for timber, uncontrolled wildfires, collection of fuel wood and illegal hunting, and conversion to agriculture accompanied by extensive burns [6]. As a result, the size and quality of the forests have continued to decline [6]. Uncontrolled human activities may cause significant changes in forest structure and plant composition [7] as well as habitat loss which have important implication on bird species composition, abundance and diversity [8,9]. Understanding the subsequent effect of different disturbances on birds, and how the birds respond to each type and magnitude of human induced perturbations is fundamental to avifauna ecology, given that birds are good indicators of environmental quality [10]. Existing studies in the East African coastal forests have concentrated primarily on biogeography [4] and biodiversity inventories of flora and fauna [1,11,12]. Therefore there is currently no ecological study that has attempted to fathom out the links between human-induced disturbances and biodiversity measures using birds as indicators of environmental quality despite continued forest disturbances, which are increasingly fragmenting these forest remnants, thus threatening long-term viability of the bird populations. Yet we are still uncertain to what extent and in what direction the fine-scale human-induced disturbances might influence various components of faunal diversity of East African coastal forest birds. This paper, therefore presents information on species composition, abundance and diversity of birds of four Tanzania coastal forest reserves in respect of anthropogenic disturbances, specifically Pit-sawing, tree lopping, animal snaring and haphazard walking by humans. We predicted low bird abundance in highly disturbed than least disturbed forests.

2. METHODOLOGY

2.1 Study System

The study area (Fig. 1) comprised of four forests: Kiono/Zaraninge (174 km^2), Kwamsisi/Kwahatibu (45 km^2), Gendagenda (28 km^2) and Msumbugwe (44 km^2) in Pangani - Saadani ecosystem, eastern Tanzania. In terms of protection status, all four forests are recognized as Forest Reserves. Located at 5º38' to 6º16' South and 38º36' to 38º53' East [13], Saadani National Park (SANAPA) harbours portions of the former two forest patches while the remaining parts fall on village lands. The latter two are located north of SANAPA. Gendagenda is between 5º32'and 5º34'South and 38º38'and 38º39' East, and partly occupies Handeni and Pangani Districts in Tanga Region whereas Msumbugwe is located at 5º32'South and 38º45'East in Pangani District (LK Stubblefield, Frontier Tanzania, Unpublished technical report no. 12).

Although rainfall is bi-model, amount and distribution are generally very seasonal and variable within and between years with short rains expected from October through December with the small peak in December, and long rains from March through May with the main peak in April. Average rainfall is 1300 mm/yr with maximum and minimum around 1500 mm/yr and 1000 mm/yr, respectively (LK Stubblefield, Frontier Tanzania, Unpublished technical report no. 12). In addition to the period of long dry season that spans from June to September, January and February are frequently dry. Temperature variation throughout the year is marginal thus high mean annual temperatures, averaging 25ºC [11].

2.2 Research Design

Data were collected from October 2010 to January 2011, and each forest was visited for 5 consecutive days a month (n = 20 days a month for all 4 forests). Each forest was stratified into forest core (300 m from the edge) and forest edge. Then, permanent transects (n = 8) each 500 m long were randomly established in the core and the edge of each forest (Table 1). Selection of sites for placement of transects followed judgment sampling procedure while ensuring that each site was a reasonable representative of the forest in question [14]. However, a minimum inter-transect distance of 100 m was maintained. Three plots, each with 20 m radius were established along each transect: one at the start, centre and end of transect, leading to an inter-point distance of approximately 170 m [7]. Position of all transects (starting and ending points) and the plots were recorded using a hand held GPS unit. Identification of birds in the plots was done with the aid of a pair of binoculars (Kite Petrel; 10x42) and field guides [15,16].

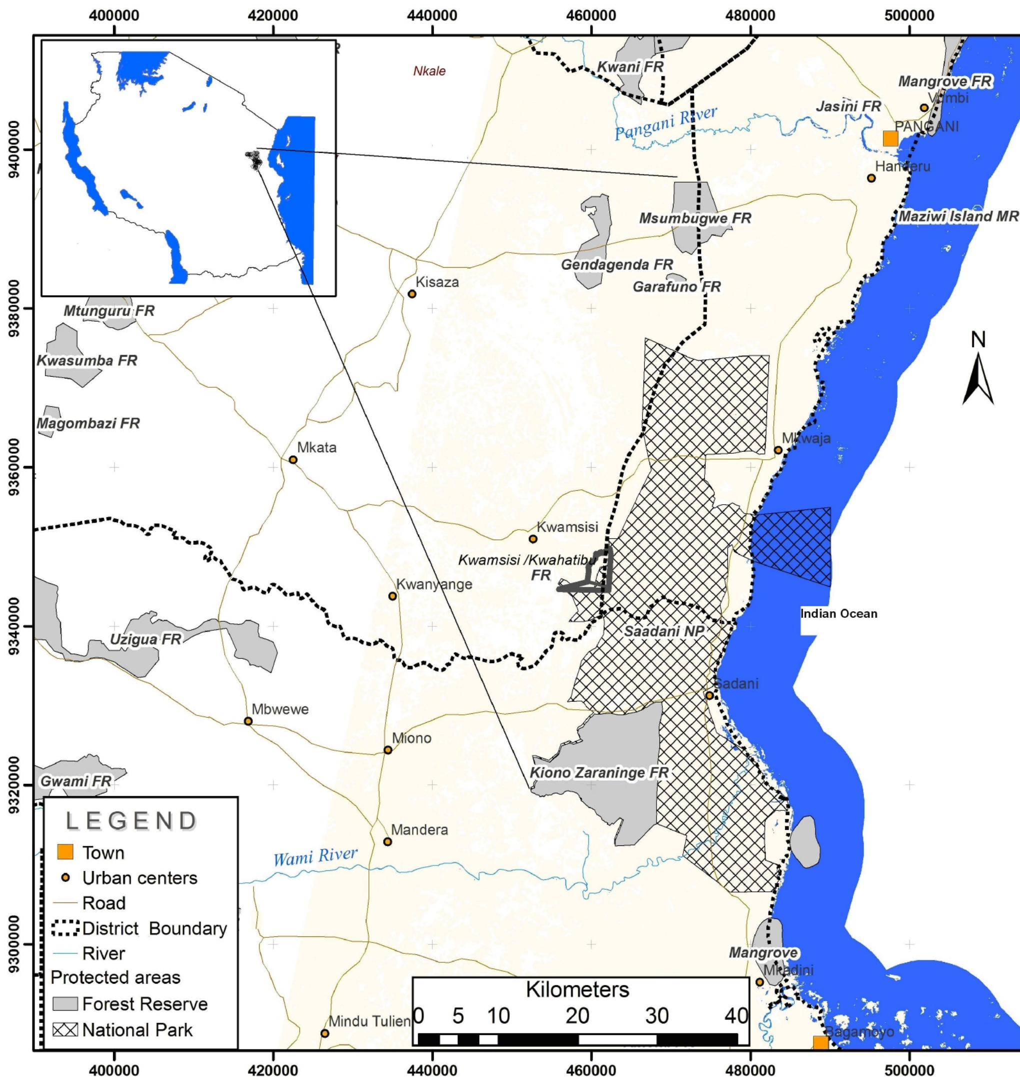

Fig. 1. Locations of Gendagenda, Msumbugwe, Kwamsisi/Kwahatibu and Kiono/Zaraninge Forest Reserves in Pangani-Saadani ecosystem (coordinates in UTM)

Kiono/Zaraninge Forest had 6 transects in the national park and 2 on the village land whereby 4 were in the forest core and 4 at the forest edge. Similarly, Msumbugwe and Gendagenda forests, each had 4 transects in the core and the other 4 at forest edge. However, Kwamsisi/Kwahatibu had 4 transects in the national park and 4 on the village land, resulting to 5 transects in the core and 3 at forest edge. Therefore, the design amounted to a total of 96 circular plots. The following variables were recorded in each circular plot; name of forest reserve, transect and plot number, bird species and their number, and type and level of human disturbance.

Table 1. Distribution of transects in the four Tanzania coastal forest reserves in Pangani-Saadani ecosystem from data collected during October 2010 to January 2011

Forest reserve	Transect number	Part of forest	Position of transect			
			Start		End	
			UTM 1	UTM 2	UTM 1	UTM 2
Kiono/Zaraninge	1	Forest edge	458029	9325754	457781	9325484
	2	Forest edge	457554	9325548	457066	9325213
	3	Forest edge	457531	9325105	457066	9325213
	4	Forest edge	456963	9325223	457042	9324782
	5	Forest core	456022	9322407	456292	9322537
	6	Forest core	456255	9322031	455985	9322320
	7	Forest core	456793	9322152	456799	9322673
	8	Forest core	457073	9321791	456601	9322011
Kwamsisi/Kwahatibu	1	Forest edge	456582	9345907	456217	9346002
	2	Forest edge	456204	9346153	456060	9346517
	3	Forest edge	456060	9349754	455000	9347146
	4	Forest core	455716	9346931	456022	9346695
	5	Forest core	456116	9346248	456182	9345076
	6	Forest core	456740	9345925	457057	9346034
	7	Forest core	457197	9345856	457130	9345585
	8	Forest core	456824	9345920	459641	9345614
Msumbugwe	1	Forest edge	471496	9390096	471839	9389932
	2	Forest edge	471966	9387949	472054	9389603
	3	Forest edge	472040	9389475	472315	9389210
	4	Forest edge	472379	9389328	472669	9389493
	5	Forest core	472507	9389659	472506	9390109
	6	Forest core	472710	9390249	472793	9390732
	7	Forest core	472460	939096	472211	9391023
	8	Forest core	472122	9390973	472089	9390536
Gendagenda	1	Forest core	460622	9383807	460208	9383713
	2	Forest core	460733	9383733	460682	9384233
	3	Forest core	460631	9384332	460379	9384394
	4	Forest core	460511	9384380	460300	938460
	5	Forest edge	460674	9383011	460998	9383197
	6	Forest edge	461280	9383356	461269	9383751
	7	Forest edge	461218	9383907	461316	9384296
	8	Forest edge	461347	9384487	461373	9384871

2.3 Field Methods

2.3.1 Species composition, abundance and diversity

To employ point count method [17,18], the 20-m radius plots served the purpose. On reaching a point, about 10 minute were passed before sampling commenced to allow disturbed birds to settle down. Recording of birds (seen and heard) within each plot was also carried out for a period of 10 minutes. Unidentified calls were recorded using a micro-cassette tape recorder for later identification of the species. Data collection was carried out from 0630 - 1000 hrs and from 01600 - 1800 hrs when birds are most active [19].

2.3.2 Human disturbances

Indicators of human-induced disturbances encountered as a result of forest utilization by humans were recorded on the same plots used for bird sampling. Four indicators: (i) trees showing signs of lopping, (ii) human trails traversing the site, (iii) Pit-sawing, and (iv) presence of animal snares [7] were used. The lopping score for each tree was measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump.

2.4 Data Summaries and Analyses

2.4.1 Species composition, abundance and diversity

A check list of birds for all forest patches was compiled in Microsoft Office Excel 2007. Order and Family names were organized following [20] whereas common and species names were adopted largely from [16] and supplemented from [21]. To examine whether there was similarity in species composition between the forest patches, Bray-Curtis Cluster Analysis [22] was used in the Paleontological statistics package (PAST-version 2.12). Furthermore, Shannon-Wiener Diversity Index was used to compute diversity and evenness of birds for each forest [23] whereas chi-square goodness-of-fit test was used to compare distribution, status and abundance based on birds' habitat ecology between the four forests [24].

2.4.2 Effect of human disturbance

Percent score of a disturbance indicator for a particular forest was computed by dividing the observed frequency of the indicator in that forest by the total number of the frequency of the indicator in all forests. Therefore, $\geq$50% implied high disturbance while <50% implied less disturbance. The difference in the level of human-induced disturbance between the forests was tested with one-way ANOVAs in SPSS ver.14. In addition, Pearson Correlation Coefficient test was used to investigate association between levels of disturbance with bird abundance. It was neither possible to compare the effect of human disturbance between core and edge parts of the forests nor between protection status due to limited dataset.

3. RESULTS AND DISCUSSION

3.1 Type and Level of Human Disturbance

The current study shows that the forests differ in types and level of human disturbances. However, lopping was the largest form of disturbance in nearly all forests (Table 2). In this regard, Kiono/Zaraninge experienced the minimum types and level of human disturbances whereas Msumbugwe was the most disturbed with lopping and Pit-sawing being high on the list. Contrary, animal snaring, which was absent in Msumbugwe and Kwamsisi/Kwahatibu was instead a severe problem in Kiono/Zaraninge while tree lopping and Pit-sawing were not observed at all in that forest (Table 2). The snares were of rope and wire materials aimed at capturing ground dwelling mammals such as warthogs, buffalo, red-duiker and forest hogs.

Interaction of effectiveness of protection, economic activities of local communities in the neighbourhood of a forest and forest location could have influenced variation in the intensity of disturbances among the forests. Msumbugwe Forest Reserve is a government resource managed by Pangani District Council. Due to insufficient resources to accord effective protection of this forest, it has resulted into unsustainable use of forest resources by the surrounding communities. Local communities in Matongo village, approximately 5 km away from Msumbugwe forest are involved in charcoal, hardwood poles and timber harvesting, suggesting that occurrence in the forest of several trees species of commercial value subjects Msubugwe forest to various types of human induced disturbances through resources extraction. Charcoal making has become a lucrative business, thus replaces farming activity after rains have ended in May in the area. Easy accessibility of the forest on foot, bicycle and motor cycle confers additional loophole.

Table 2. Types and extent of human disturbances as observed in Gendagenda, Kwamsisi/Kwahatibu, Msumbugwe and Kion/Zaraninge forests in the Pangani-Saadani ecosystem from data collected during October 2010 to January 2011

Forest	Human disturbance indicator	Frequency	Percentage
Gendagenda			
	Lopping	8	18
	Human trail	2	29
	Pit-sawing	2	20
	Snare	1	20
Kwamsisi/Kwahatibu			
	Lopping	7	15
	Human trail	1	14
	Pit-sawing	1	10
	Snare	0	0
Msumbugwe			
	Lopping	31	67
	Human trail	3	43
	Pit-sawing	7	70
	Snare	0	0
Kino/Zaraninge			
	Lopping	0	0
	Human trail	1	14
	Pit-sawing	0	0
	Snare	4	80

Previous commercial logging of valuable timber trees undertaken in Kiono/Zaraninge forest negatively impacted on the birds' habitats [2], however, cessation of the logging activity from the forest in the recent years is explained by the rigorous patrols by SANAPA rangers along and within the Saadani National Park boundaries. This explains why parts of Kiono/Zaraninge and Kwamsisi that fall within Saadani National Park were also comparatively secured from human caused disturbances than other portions of the same forests that fall on village land. Village governments responsible for managing forests on village land are notoriously resource-limited to enable effective protection of forest resources. Therefore, the factors favoring illegal extraction of plant resources in the ecosystem account either in combination or singly for the significant difference in Pit-sawing and lopping between Msumbugwe and the rest of the forests. Existing evidence confirms that even for some years back, Msumbugwe forest used to experience extensive logging (GP Clarke, LK Stubblefield, Frontier Tanzania, Unpublished technical report no 16). Therefore, our findings on effect of human-induced disturbances fit well with the previous study in the area. High vulnerability of coastal forests to illegal activities has been a common experience along the East African cost. For example, [25] reported pole cutting and felling of large trees to be a big concern in Lower River Tana Forest reserves in Kenya. The authors alleged increasing human population to be the cause for high human pressures on the forest reserves despite being legally protected.

3.2 Bird Species Composition and Abundance

A total of 564 individuals comprising of 88 bird species in 10 Orders (Appendix 1) were recorded across the four forests. Passerines constituted 59.1% of all species and this was higher than for the none-passerines by 18.2%. Furthermore, over half (55.7%) were recorded in the forest edge (denoted as ‘fdg’), compared to only 44.3% recorded in the forest core ((denoted as ‘fc’) - Appendix 1). Overall, the list included forest specialists, forest generalists, forest visitors [24] including the winter visitors/passage migrants and savanna/woodland species as well as threatened species (Table 3 and Appendix 1). Moreover, species endemic to East African coastal forests were recorded (Appendix 1). Twenty seven (27) bird species were recorded from all forests.

Table 3. Total number of bird species, and their habitat ecology (FF= forest specialist species, F = forest generalist, f = forest visitor and s = savanna/woodland species) and conservation status of threatened bird species (a = Near threatened species, b = Endangered species) as observed in Pangani = Saadani ecosystem from data collected during October 2010 to January 2011

Variables	Study forests			
	Gendagenda	Kwamsisi/ Kwahatibu	Msumbugwe	Kiono/ Zaraninge
Total number of species	48	62	46	60
Total number of threatened species	2^{a}	2^{a}	2^{a}	3^{ab}
FF species	12	9	8	10
% FF species	25	14.52	17.39	16.67
F species	15	19	18	21
% F species	31.25	30.64	39.13	35
f species	16	24	13	22
% f species	33.33	38.71	28.26	36.67
s species	5	10	7	8
% s species	10.42	16.13	15.22	13.33

Neither did we find significant difference in distribution of the forest dependent species (FF+F +f) between the four forests (χ^2 = 1.33, df = 3, P = 0.99) nor was there any significant difference in the status of the FF-, F- or f- species between the forests (χ^2 = 0.00, df = 3, P = 1.0). Similarly, for the F-species and f-species, no significant differences in the number of species respectively across the four forests (χ^2 = 0.00, df = 3, P = 1.0). However, the study revealed significant difference in bird abundance among the forests (P = 0.02) with Msumbugwe registering the highest number of bird counts while Gendagenda and Kwamsisi/Kwahatibu recorded lowest (Table 4). On the other hand, species richness ranged from 48 to 62 while Shannon–Weiner diversity and evenness ranged from 3.232 to 3.89 and 0.5504 to 0.8418, respectively. Both diversity and evenness were lowest in Msumbugwe forest while Kwamsisi/Kwahatibu had the highest diversity in addition to species richness. Evenness was highest in Gendagenda forest (Table 4).

Table 4. Bird species richness (S), Shannon-Wiener Diversity Index (H') and Evenness Index (E), and Abundance (A) in Gendagenda, Kwamsisi/Kwahatibu, Msumbugwe and Kiono/Zaraninge in the Pangani-Saadani ecosystem from data collected during October 2010 to January 2011

Forest patch	S	H'	E	A
Gendagenda	48	3.699	0.8418	136
Kwamsisi/Kwahatibu	62	3.89	0.7892	136
Msumbugwe	46	3.232	0.5504	173
Kiono/Zaraninge	60	3.829	0.7673	149

According to Bray-Curtis Cluster analysis, only three pairs of forests overlapped in variety of species with the values $\geq$ 50% whereas Msumbugwe was relatively dissimilar from the rest of the forests with the values <50% (Table 5, Fig. 2).

Table 5. Results of Bray-Curtis cluster analysis showing similarity measures between forests on bird species composition

	Gendagenda	Kwamsisi/ Kwahatibu	Msumbugwe	Kiono/Zaraninge
Gendagenda	1.00	0.50	0.45	0.61
Kwamsisi/Kwahatibu	0.50	1.00	0.49	0.58
Msumbugwe	0.45	0.49	1.00	0.48
Kiono/Zaraninge	0.61	0.58	0.48	1.00

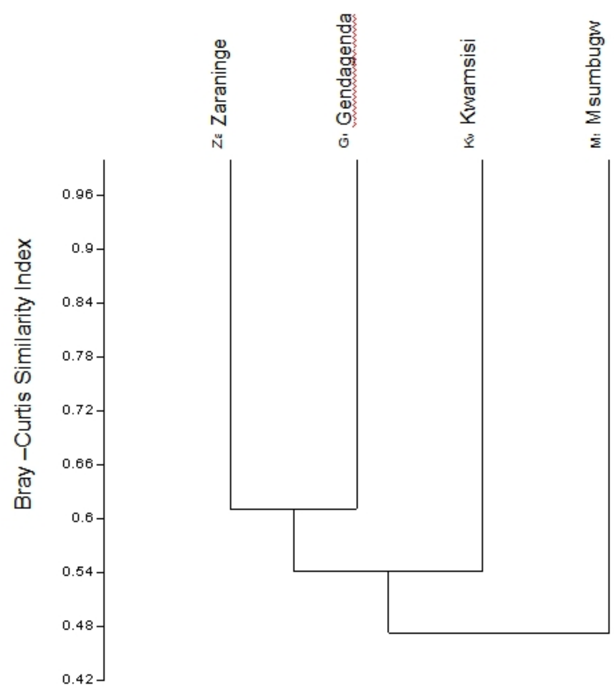

Fig. 2. A Dendrogram showing similarity in bird species composition in the four forests in Pangani - Saadani ecosystem from data collected during October 2010 to January 2011

Evidently, Pangani-Saadani ecosystem supports a variety of birds. Among them were 9 bird species (see Appendix1) of the varying number reported by various sources as endemic to East African coastal forests [5, 16]. Six of the 9 species were also observed in Kwamsisi/Kwahatibu forest reserve, which had not been studied before. However, other 3 IUCN Red-Data Book species (endemic), and a 'candidate' Red-Data Book species whose global population is poorly known, but also previously reported to occur in the study forests were not observed anywhere in the ecosystem. The endemic species not observed are Fischer's Greenbul *Phyllastrephus fischeri*, Eastern Green Tinkerbird *Pogoniulus simplex* and Southern Banded Snake-eagle *Circaetus fasciolatus* [CV Ansell, A Dickson, Frontier Tanzania, Unpublished report no 11; ND Burgess and C Muir, Society of Environmental Exploration and University of Dar-es-Salaam, Tanzania, Unpublished report] whereas the candidate Red-Data Book species also not observed is Chestnut-fronted Helmet-shrike *Prionopus scopifrons* [ND Burgess, Society of Environmental Exploration and University of Dar-es-Salaam, Tanzania, Unpublished report]. Their absence could be associated with the short period of this study (4 months) and variation in the starting of short rains (started in December instead of late October), which could have influenced the species dispersal patterns. Thus our sampling might have missed out these species. An extended period of study across seasons is therefore necessary before we can make any sound conclusions on the status of these birds. The similarity in bird species among the three pairs of forests reflects the widespread habitat use (guild richness) exhibited by the twenty-seven species that were found across. On the other hand, Msumbugwe forest was only little similar to the other forests, and recorded low species richness because of high effect of human disturbances. This finding corroborates with other studies that have shown negative impact of habitat disturbances on forest birds [7,26].

3.3 Relationships between Human-Induced Disturbances and Bird Parameters

Only the effect of Pit-sawing (P = 0<.001) and tree lopping (P = <0.001) differed significantly among the four forests, but only the effect of Pit-sawing did correlate positively with bird abundance (P = 0.01). In both cases, the difference appeared between Msumbugwe and the other three forests with the former recording highest habitat disturbances (Table 6).

Table 6. Results of Post hoc (Bonferroni test) showing variation in the effect of Pit-sawing and tree lopping between forests in Pangani-Saadani ecosystem from data collected during October 2010 to January 2011

Forest patch (I)	Forest patch (J)	*P*-value
pit-sawing		
Gendagenda	Kwamsisi/Kwahatibu	1.00
	Msumbugwe	0.03*
	Kiono/Zaraninge	1.00
Kwamsisi/Kwahatibu	Gendagenda	1.00
	Msumbugwe	0.002*
	Kiono/Zaraninge	1.00
Msumbugwe	Kion/Zaraninge	<0.001**
Lopping		
Gendagenda	Kwamsisi/Kwahatibu	1.00
	Msumbugwe	<0.001**
	Kiono/Zaraninge	0.349
Kwamsisi/Kwahatibu	Msumbugwe	<0.001**
	Kiono/Zaraninge	1.00
Msumbugwe	Kino/Zaraninge	<0.001**

**Mean difference statistically significant at P< 0.05 level; **Mean difference statistically significant at P< 0.001 level*

Three lopping scales i.e. no lopping, rudimentary sign of lopping and tree reduced to a stump were observed. Msumbugwe forest had all three while Gendagenda and Kwamsisi/kwahatibu had two, and only one at Kiono/Zaraninge forest (Fig. 3). Msumbugwe forest had more trees reduced to stump than the rest of the forests. The number of trees reduced to stump in Msumbugwe forest constituted 61% of all trees reduced to stumps in the four forests pooled together.

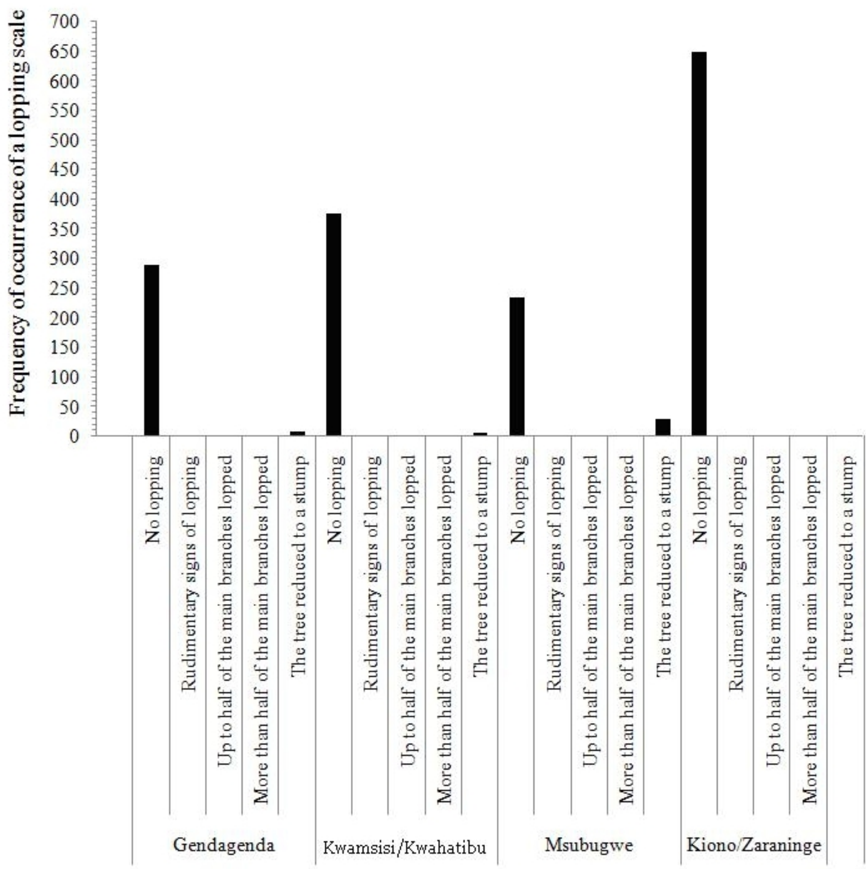

Fig. 3. Lopping scale and frequency of occurrence of each lopping scale in Gendagenda, Kwamsisi/Kwahatibu, Msumbugwe and Kiono/Zaraninge forests in the Pangani-Saadani ecosystem from data collected during October 2010 to January 2011

Forest disturbance not only causes loss of large trees but also leads to clearance of understory vegetation thus changing forest structure, reducing the habitat quality for persistence of the understory birds [27]. Therefore, high abundance in a highly disturbed habitat contradicts with our prediction that there would be more birds in less disturbed than highly disturbed forest. According to Shahabuddin and Kumar [7] and Lees and Peres [28], human disturbance has been reported to negatively affect several bird species, but there is evidence that some species may show higher densities in disturbed areas than in undisturbed habitats [29,30,31]. Higher density in disturbed areas exhibited by resident birds was associated with the new ecological resources created following the disturbance [32]. But, continued logging and pole harvesting along with other uncontrolled extraction of plant resources will lead to further reduced size of the existing forests hence affect the long-term survival of forest dependent birds in the ecosystem. Currently, our data do not show significant effects on forest dependent birds as a result of the recorded habitat disturbances in the forests, however these birds may be agents for re-directing necessary conservation efforts into these forests to protecting already threatened species [33]. Such birds include Fischer's Turaco, *Tauraco fischeri* (near threatened) and Sokoke pipit *Anthus sokokensis* (endangered) [34, 35]. Unlike Msumbugwe, Kwamsisi/Kwahatibu showed highest diversity and species richness in the presence of moderate disturbance. These results agree with intermediate-disturbance hypothesis, which predicts that biotic diversity will be greatest in communities subjected to moderate levels of disturbance [36, 37].

4. CONCLUSION

This study reports on the status of abundances and diversity of forest birds in four remnants of coastal forests in the face of existing human-induced disturbances. Habitat disturbances in the form of human trails, lopping, wildlife snaring and Pit-sawing were common practices across the four forests and varied in type and frequency according to the level of pressure exerted by the surrounding local human populations. These disturbances had varying effects on the bird species richness and diversity among the study forests. However, it was clear that highest habitat disturbance impacted negatively on the bird richness and diversity. Further, increasing human pressures reduce the quality of the forests to harbouring different bird species, although it is not clear, until further studies, how such pressures might affect the food base and reproductive potential of the birds, thus long-term survival of their populations. However, with innovations and awareness among humans population on adaptation to and copping with climate change, we expect reduced extraction pressure in future. Our findings stress the urgency of stopping the human pressures onto these forests to save the habitat for winter visitors or passage migrants, the IUCN Red-Data Book species and other birds from further declining. However, this would come about through comprehensive conservation awareness programs and economic alternative strategies by the relevant conservation authority (e.g. SENAPA) and conservation NGOs geared towards serving the surrounding local people. Such efforts will help reduce pressures on forests and bird habitats, thus offering lasting positive impact in this threatened coastal forest ecosystem.

ACKNOWLEDGEMENTS

We are grateful to VLIR Program through the Saadani Project in the Department of Wildlife Management, Sokoine University of Agriculture (SUA) for the financial support to cover fieldwork, and to the Authority of Tanzania National Parks (TANAPA) for granting free entry and permission to stay and work in Saadani National Park. Japhet Kashaigiri helped with the production of study area map. We also thank the local communities adjacent to the four study forests for supplying us constantly with food stuff, without which our stay in the field would have been more costly than it was. We also thank the anonymous reviewers for their constructive comments that led to notable improvement of this paper.

COMPETING INTERESTS

We declare that no competing interests exist either among authors or between authors and the managing authorities responsible for the study forests.

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APPENDIX

Appendix 1: Bird's species recorded and their habitat ecology in Gendagenda (Gen), Kwamsisi/kwahatibu (Kwm), Msumbugwe (Msu) and Kiono/Zaraninge (Zar) Forest Reserves in the Pangani-Saadani ecosystem between October 2010 and January 2011 (forest habitats: **fdg = forest edge; fc=forest core; habitat ecology: FF = forest specialist species, F = forest generalist, f = forest visitor and s = savanna/woodland species; endemism: * = endemic to East African coastal forests; conservation status: Nt = near threatened; En = endangered).**

Order	Family	Common name	Species	Forest Reserve			
				Gen	Kwm	Msu	Zar
FALCONIFORMES	Accipitridae	Bat Hawk **(fdg)**	*Macheiramphus alcinus*				F
	Accipitridae	Long-crested Eagle **(fdg)**	*Lophaetus occipitalis*		f		
	Accipitridae	African Goshawk **(fc)**	*Accipiter tachiro*		F		
	Accipitridae	African Harrier-Hawk **(fc)**	*Polyboroides typus*		f		f
GALLIFORMES	Numididae	Crested Guineafowl **(fc)**	*Guttera pucherani*		F		F
GRUIFORMES	Otididae	Black-bellied Bustard **(fdg)**	*Eupodotis melanogaster*			s	
COLUMBIFORMES	Columbidae	Red-eyed Dove **(fc)**	*Streptopelia semitorquata*		f	f	f
	Columbidae	Eastern Bronze-naped Pigeon (**fc**)	*Columba delegorguei*				f
	Columbidae	Emerald-spotted Wood-Dove **(fc)**	*Turtur chalcospilos*	f	f	f	f
	Columbidae	Tambourine Dove **(fc)**	*Turtur tympanistria*	F	F	F	F
	Columbidae	Ring-necked Dove **(fdg)**	*Streptopelia capicola*		f	f	
CUCULIFORMES	Musophagidae	Purple- crested Turaco **(fc)**	*Tauraco porphyreolophus*	f	f	f	f
	Musophagidae	Fischer's Turaco **(fc)***	*Tauraco fischeri*		F, Nt	F, Nt	F, Nt
	Cuculidae	Klaas's Cuckoo **(fdg)**	*Chrysococcyx klaas*	f	f		f
	Cuculidae	White-browed Coucal **(fdg)**	*Centropus superciliosus*	s	s	s	s
	Cuculidae	Yellowbill **(fdg)**	*Ceuthmochares aereus*	F		F	
CAPRIMULGIFORMES	Caprimulgidae	Eurasian Nightjar **(fdg)**	*Caprimulgus europaeus*		s		s
TROGONIFORMES	Trogonidae	Narina Trogon **(fc)**	*Apaloderma narina*	F	F	F	F
CORACIIFORMES	Coraciidae	Broad billed Roller **(fdg)**	*Eurystomus glaucurus*				f
	Alcedinidae	African Pygmy Kingfisher **(fc)**	*Ispidina picta*				f
	Alcedinidae	Brown-hooded Kingfisher **(fc)**	*Halcyon albiventris*	s	s	s	s
	Alcedinidae	Half-collared Kingfisher **(fdg)**	*Alcedo semitorquata*				F
	Alcedinidae	Grey-headed Kingfisher **(fdg)**	*Halcyon leucocephala*	f			
	Bucerotidae	Trumpeter Hornbill **(fc)**	*Bycanistes bucinator*	F	F	F	F
	Bucerotidae	Crowned Hornbill **(fdg)**	*Tockus alboterminatus*	f	f	f	f

	Meropidae	Little Bee-eater **(fdg)**	*Merops pusillus*	s			
	Meropidae	White-throated Bee-eater **(fdg)**	*Merops albicollis*	f	f		f
	Phoeniculidae	Green Wood-hoopoe **(fdg)**	*Phoeniculus purpureus*	s	s	s	s
	Phoeniculidae	Common Scimitarbill **(fdg)**	*Phoeniculus cyanomelas*		s	s	s
PICIFORMES	Picidae	Mombasa Woodpecker **(fc)***	*Campethera mombassica*		F	F	
	Picidae	Cardinal Woodpecker **(fc)**	*Dendropicos fuscescens*	f	f		f
	Capitonidae	Brown-breasted Barbet (fdg)	*Lybius melanopterus*		f	f	
	Capitonidae	Black-collared Barbet **(fdg)**	*Lybius torquatus*			f	f
	Indicatoridae	Greater Honey-guide **(fc)**	*Indicator indicator*		f		
	Capitonidae	Yellow-rumped Tinkerbird **(fdg)**	*Pogoniulus bilineatus*	F	F	F	F
	Capitonidae	Red-fronted Tinkerbird **(fdg)**	*Pogoniulus pusillus*		s		
PASSERIFORMES	Monarchidae	African Paradise-flycatcher **(fdg)**	*Terpsiphone viridis*	f	f		f
	Monarchidae	Blue-mantled Crested-flycatcher **(fc)**	*Trochocercus cyanomelas*	FF	FF	FF	FF
	Monarchidae	Little Yellow Flycatcher **(fc)***	*Erythrocercus holochlorus*	FF	FF	FF	FF
	Muscicapidae	Spotted Flycatcher **(fdg)**	*Muscicapa striata*		FF	FF	
	Muscicapidae	Ashy Flycatcher **(fc)**	*Muscicapa caerulescens*		F		F
	Eurylaimidae	African Broadbill **(fc)**	*Smithornis capensis*	FF	FF		FF
	Nectariniidae	Purple-banded Sunbird **(fdg)**	*Cinnyris bifasciata*		f		
	Nectariniidae	Scarlet-chested Sunbird **(fdg)**	*Chalcomitra senegalensis*		f		
	Nectariniidae	Collared Sunbird **(fc)**	*Hedydipna collaris*	F	F	F	F
	Nectariniidae	Plain-backed Sunbird **(fc)***	*Anthreptes reichenowi*	FF, Nt	FF, Nt	FF, Nt	FF, Nt
	Nectariniidae	Amethyst Sunbird **(fdg)**	*Chalcomitra amethystina*		s		s
	Nectariniidae	Uluguru Violet-backed Sunbird **(fc)***	*Anthreptes longuemarei*	FF			
	Nectariniidae	Variable Sunbird **(fdg)**	*Cinnyris venusta*		f		f
	Nectariniidae	Olive Sunbird **(fc)**	*Cyanomitra olivacea*	FF	FF		FF
	Oriolidae	Eurasian Golden Oriole **(fdg)**	*Oriolus oriolus*				f
	Oriolidae	African Golden Oriole **(fdg)**	*Oriolus auratus*	f	f		
	Oriolidae	African Black-headed Oriole **(fdg)**	*Oriolus larvatus*		f		
	Malaconotidae	Grey-headed Bush-shrike **(fdg)**	*Malaconotus blanchoti*				s
	Malaconotidae	Tropical Boubou **(fdg)**	*Laniarius aethiopicus*	f		f	f
	Malaconotidae	Four-coloured Bush-shrike **(fc)**	*Malaconotus quadricolor*	F		F	
	Malaconotidae	Brown-crowned Tchagra **(fdg)**	*Tchagra australis*		s		
	Malaconotidae	Black-backed Puffback **(fc)**	*Dryoscopus cubla*	F	F	F	F
	Sturnidae	Black-bellied Starling **(fc)**	*Lamprotornis corruscus*	F	F	F	F
	Campephagidae	Black Cuckoo-shrike **(fdg)**	*Campephaga flava*		f	f	f
	Prionopidae	Retz's Helmet-shrike **(fdg)**	*Prionops retzii*			f	f

Prionopidae	Chestnut-fronted Helmete-shrike **(fdg)***	*Prionops scopifrons*		F	F	F
Ploceidae	Black-headed Weaver **(fdg)**	*Ploceus cucullatus*		f		
Ploceidae	Spectacled Weaver **(fdg)**	*Ploceus ocularis*	f			
Ploceidae	Dark-backed Weaver **(fc)**	*Ploceus bicolor*	F	F	F	F
Sylviidae	Grey-backed Camaroptera **(fc)**	*Camaroptera brachyura*	f	f	f	f
Sylviidae	Rattling Cisticola **(fdg)**	*Cisticola chiniana*		s		
Sylviidae	Black-headed Apalis **(fc)**	*Apalis melanocephala*	FF	FF		
Sylviidae	Kretschmer's Longbill **(fdg)***	*Macrosphenus kretschmeri*	FF			
Sylviidae	Tawny-flanked Prinia **(fdg)**	*Prinia subflava*		f		
Pycnonotidae	Eastern Nicator **(fdg)**	*Nicator gularis*	F	F	F	F
Pycnonotidae	Common Bulbul **(fdg)**	*Pycnonotus barbatus*	f	f	f	f
Pycnonotidae	Terestrial Brownbull **(fdg)**	Phyllastrephus terrestris			F	F
Pycnonotidae	Tiny Greenbul **(fc)***	*Phyllastrephus debilis*	FF	FF	FF	FF
Pycnonotidae	Yellow-streaked Greenbul **(fc)**	*Phyllastrephus flavostriatus*	FF		FF	FF
Pycnonotidae	Zanzibar Sombre Greenbul **(fdg)**	*Andropadus importunus*			s	
Pycnonotidae	Northern Brownbul **(fdg)**	*Phyllastrephus strepitans*	f			
Pycnonotidae	Yellow-bellied Greenbul **(fc)**	*Chlorocichla flaviventris*	F	F	F	F
Turdidae	Eastern Bearded Scrub-Robin **(fc)**	*Cercotrichas quadrivirgata*			f	
Turdidae	Red-capped Robin-Chat **(fdg)**	*Cossypha natalensis*	F	F	F	F
Turdidae	Red-tailed Ant-Thrush **(fc)**	*Neocossyphus rufus*	FF	FF	FF	FF
Turdidae	White-browed Scrub-Robin **(fdg)**	*Cercotrichas leucophrys*	f			f
Motacillidae	Sokoke Pipit **(fc)***	*Anthus sokokensis*				FF, En
Dicruridae	Fork-tailed Drongo **(fc)**	*Dicrurus adsimilis*	s	s	s	s
Dicruridae	Square-tailed Drongo **(fc)**	*Dicrurus ludwigii*	F	F	F	F
Platysteiridae	Forest Batis **(fc)**	*Batis mixta*	FF		FF	FF
Estrildidae	Peters's Twinsport **(fdg)**	*Hypargos niveoguttatus*	F	F		F
Estrildidae	Black-and-white Mannikin **(fdg)**	*Lonchura bicolor*	f	f		f

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