The Journal of Animal & Plant Sciences, 25(5): 2015, Page: 1322-1328
ISSN: 1018-7081

BIRD SPECIES DIVERSITY ACROSS A GRADIENT OF LAND USE IN SOUTHERN GONAREZHOU NATIONAL PARK AND ADJACENT AREAS, ZIMBABWE

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ABSTRACT

Bird species composition and abundance across a land disturbance gradient in southern Gonarezhou National Park and adjacent areas, Zimbabwe was assessed in April 2013. Three study strata based on land use category were delineated, namely protected Manyanda Pan inside Gonarezhou National Park, unprotected Manjinji Pan and cultivated lands around Manjinji Pan. Bird census points were randomly pegged across the three study strata where bird species and numbers were recorded. Habitat condition of the study strata was estimated using the Global Monitoring Framework method. The study recorded a total of 2706 birds belonging to 131 species and 60 families from the three sites. With its dense woodlands, Manjinji Pan recorded significantly higher bird species diversity (H' = 4) than either the degraded Manyanda Pan (H' = 2.3) or the cultivated lands (H' = 2.6). Bird species evenness was highest in Manjinji Pan (J' = 0.59), whereas, lowest species evenness (J' = 0.18) was recorded on cultivated lands. The results suggest that land use type and woodland status likely influence bird species diversity in the study area. The study recommended for conservation of the remaining forest and wetland fragments in southern Zimbabwe even in unprotected areas in order to maintain avifaunal diversity.

Key words: bird species diversity, land use, vegetation cover, habitat disturbance.

INTRODUCTION

Spatio-temporal variations in historical and ecological factors influence the distribution of bird species. Studies suggest that habitat structure significantly influences bird species diversity (Emlen *et al*., 1986; Telleria *et al*., 1992; Gandiwa *et al*., 2013). The spatial and temporal variation in vegetation cover reflects the inherent physical heterogeneity of a habitat and character of the biotic community utilizing the particular habitat (Michael *et al*., 2004; Gandiwa, 2014). Forest fragmentation due to land conversion for agricultural purposes and habitat degradation are some of the major factors leading to local extirpation of bird species in the tropics (Rappole, 1996; Altaf *et al*., 2015). Past studies have indicated that variation in woody vegetation among land categories influence bird species diversity and assemblages in African savanna ecosystems (Tassicker *et al.*, 2006; Sirami and Monadjem, 2012; Gandiwa *et al*., 2013). In southern Zimbabwe, anthropogenic activities have resulted in decreased woody vegetation cover, thus creating land use gradients that influence bird species diversity and abundance (Gandiwa *et al*., 2013; Zisadza-Gandiwa *et al*., 2013).

The critical role of habitat fragmentation on bird diversity is still to be ascertained across various ecosystems (Rais *et al*., 2010; Joshi *et al*., 2012; Raza *et al*., 2015). Hence, the objectives of the study were twofold: (i) to establish bird species diversity and species assemblages across a disturbance gradient of varying land use categories, and (ii) to determine the effects of spatial variability in woody vegetation cover on bird species diversity.

MATERIALS AND METHODS

Study area: The study focused on a site considered as an Important Bird Area (IBA) in Zimbabwe, the Manjinji Pan (Childes and Mundy, 2001), its surrounding cultivated lands are within the Malipati Communal Lands and the Manyanda Pan in the protected Gonarezhou National Park. The three study sites lie within the Limpopo-Mwenezi flood-plain at an elevation range of 100 to 250m above sea level (Fig. 1). Manjinji Pan is a designated sanctuary under the Parks and Wildlife Act (1975) of Zimbabwe. It includes an old oxbow lake along the Mwenezi River, with a spatial extent of about 300 ha, inclusive of the surrounding cultivated area. It lies at 22° 07′S and 31° 24′E, within the Malipati Communal Area Lands (Gandiwa *et al*., 2013). Common livestock in the Manjinji Pan include cattle (*Bos taurus*) and goat (*Capra hircus*). The Nile crocodile (*Crocodylus niloticus*) is a common wildlife species. The African elephant (*Loxodonta africana*) is occasionally cited in the area (Gandiwa *et al*., 2013). Manyanda Pan which is about 89 ha in size, is located in Gonarezhou National Park, at Latitudes 22° 07′ S and Longitude 31° 31′ E. This is a natural Pan that holds water for the greater part of the

year (ZPWMA, 2011). Long-term mean annual rainfall for the study area is approximately 466 mm, but is highly variable, with most of it falling between November and April (Gandiwa and Kativu, 2009). The vegetation of the Limpopo-Mwenezi flood plain which covers the whole study area is typically semi-arid deciduous *Colophospermum mopane* type (Cunliffe *et al*., 2012).

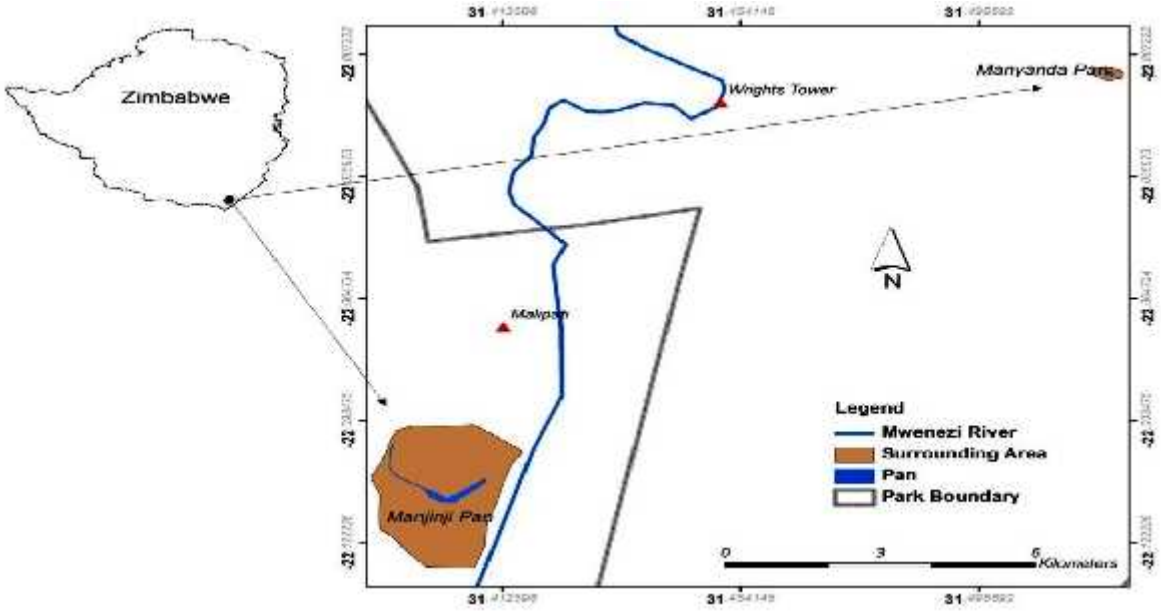

Figure 1. Location of study sites Manyanda Pan inside Gonarezhou National Park, Manjinji Pan and the surrounding area in southern Zimbabwe. Note: the cultivated area is only adjacent to the Manjinji Pan.

Sampling procedure and data collection: Bird census points were randomly assigned to land units across the study area map. The computer generated bird census points were verified for accessibility before commencing bird counting using a hand held Global Positioning System (GPS). Distance from one station of bird census count to another point was about 500 m. The study area was sampled between 1 and 15 April 2013. Five bird census points were randomly selected from the Manjinji Pan study stratum, five from the cultivated area and four from the Manyanda Pan study stratum in relation to the land size of the study stratum.

Species richness data were collected following Javed and Kaul (2002). At each bird census point, two hours observations were made (0600-0700 hrs and 1600-1700 hrs) and bird species and their numbers recorded separately for each species. The avifauna on each census point was surveyed and all individual seen or heard once were recorded. Any new encounters were added to previously recorded numbers to make a cumulative list of the birds in each defined study stratum. Vegetation cover assessments for the census points followed the Global Monitoring Framework method (BirdLife International, 2006). The scoring system uses the weakest link approach, meaning that IBA scores are based on the worst-case indicator score (highest impact score). This implies that the habitat condition for the study area was determined by the status of the woody vegetation cover. Recorded habitat classes were miombo woodland, mopane woodland, gorge, thornveld, savanna, and wetland (mainly river fringes).

Data analysis: Bird species richness and bird numbers from each study stratum were quantified as the total number of bird species present and bird numbers recorded, respectively. Bird species diversity indices (calculated using Shannon-Wiener index, *H'*), species richness, bird abundance and Pielou's evenness index, *J'*, were calculated and compared across the study sites. Using an analysis of variance (ANOVA) for bird species richness and abundance across land use categories was carried out in Statistical Package for Social Science (SPSS) Version 16.0 for Windows (SPSS Inc., 2007). Turkey's Honestly Significance Difference (HSD) multiple comparisons *post hoc* analyses were used to compare bird species composition and abundance among the three study strata. Statistical significance was set at $p < 0.05$. A non-Metric Multidimensional Scaling (nMDS) ordination using PC-ORD 5.1 (McCune and Mefford, 2006) was constructed to graphically represent the relationship between land use categories of the three study strata in terms of bird species diversity. Principal Component Analysis (PCA) was used to illustrate relationships among bird census points based on bird species richness across different land use categories. The Hierarchical Cluster Analysis (HCA) was used to further

explore relationship between bird species richness and abundance across the three land use categories using the Euclidian distance similarity.

Data analysis for habitat condition assessment across land use category followed the State-Pressure-Response indices method developed by BirdLife International (2006). This Global Monitoring Framework provides a guide to arriving at an IBA habitat condition status score in the absence of numerical data. Habitat area and quality codes were assigned by Good (overall >90% of optimum), Moderate (70-90%), Poor (40-70%) or Very Poor (<40%). The percentages relate to the population density of the 'trigger' plant species in its key habitat. Thus, 100% means that the species is at carrying capacity in its habitat.

RESULTS

Bird assemblages and species richness across the three land use categories: The study recorded a total of 2706 birds belonging to 131 bird species and 60 families. The highest number of restricted bird species (n = 9) was recorded at Manjinji Pan (e.g., *Plectopterus gambensis*, *Phalacrocorax africanus* and *Bostrychia hagedash*), with Manyanda Pan in the protected Gonarezhou National Park having the least number of restricted species (n = 3) (e.g., *Corythaixoides concolor*, *Emberiza tahapisi* and *Francolinus sephaena*). Birds restricted to the cultivated area included *Numida meleagris*, *Vidua paradisaea* and *Cisticola chiniana*. There were significant differences in bird species richness across the land categories ($F_{1,2}$ = 8.92; p < 0.001). Further analyses showed that bird species richness for Manjinji Pan was significantly higher than that of Manyanda Pan (HSD, p < 0.05), whereas no significant differences in bird species richness were found between Manjinji Pan and the cultivated area (HSD, p > 0.05). The cultivated area had significantly higher bird species richness than Manyanda Pan (p < 0.05). However, bird species abundance was not significantly different across land use categories ($F_{1,2}$ = 1.71; p > 0.05).

Bird species diversity across the three study strata of land use category in southern Zimbabwe: Manjinji Pan had the highest bird diversity index (H' = 4), followed by the cultivated area (H' = 2.6), with Manyanda Pan having the least avifaunal diversity (H' = 2.3). Manjinji Pan had the highest evenness (J' = 0.59) of bird species and the highest number of water fowls and other birds that depend on riparian forests for such resources as food (e.g., *Eremopterix leucotis*, *Butorides striatus* and *Ardea cinerea*). The highest number carnivorous birds (n = 31) (e.g. *Otus senegalensis*, *Halcyon senegalensis* and *Ceryle rudis*) and 89 omnivorous birds (n = 89) (e.g., *Zosterops senegalensis*, *Actophilornis africanus* and *Eremopterix leucotis*) was also recorded at Manjinji Pan. The lowest evenness (J' = 0.18) of bird species was recorded on cultivated areas followed by the bird species evenness (J' = 0.20) on Manyanda Pan.

Associations of varying land uses in relation to bird species composition and assemblages: The non-Metric Multidimensional Scaling analysis grouped the bird point count stations into four main clusters (Fig. 2). Four bird point count stations from Manjinji Pan formed one cluster, while a second cluster included two bird point count stations from the cultivated area, one from Manyanda Pan and two from Manjinji Pan. The third cluster included two count stations, one from Manyanda Pan and the other from the cultivated area. The fourth cluster included two count stations, one from the cultivated area and the other from Manyanda Pan. There were two outliers each from Manyanda Pan and the cultivated area.

The first two principal components explained 93.9% of the variation. Principal Component 1 accounted for 67.8% (eigenvalue = 2.03) of variance, while Principal Component 2 accounted for 26.1% (eigenvalue = 0.81) of the variance. Bird sample count stations in Manjinji Pan were strongly positively correlated with Principal Component 1, while those from Manyanda Pan and the cultivated area were highly positively correlated to Principal Component 2. Principal Component Analysis generated two distinct clusters where one cluster included count stations all from Manjinji Pan, and the other included count stations from Manyanda Pan and the cultivated area (Fig. 3). There were four outliers. The HCA generated two main clusters (Fig.4). However, count stations from the cultivated area were not closely linked with the rest of the stations.

Estimated habitat status and quality across the three land use categories of the study strata: The overall condition of habitats in relation to woody vegetation was as follows: Manjinji Pan was Good, Manyanda Pan was Moderate but near favorable and the cultivated areas were Moderate but near unfavorable (Table 1). The quality of woody vegetation in Manjinji Pan was recorded as 70-90% of the optimum due to natural dying off of mature trees and slow degradation of the habitat by frequent droughts and anthropogenic activities. The quality of woody vegetation for Manyanda Pan was recorded as 40-70% of the optimum due to degradation of the habitat by elephants and fire disturbances. Whereas, the quality of the existing woody vegetation within the cultivated area was recorded as 70 % of the optimum due to natural dying off of mature trees and slow degradation of the habitat by frequent droughts and agricultural activities. Overall, Manjinji Pan had more dense thick woody vegetation cover, followed by Manyanda Pan, with the cultivated area having less dense woody vegetation cover.

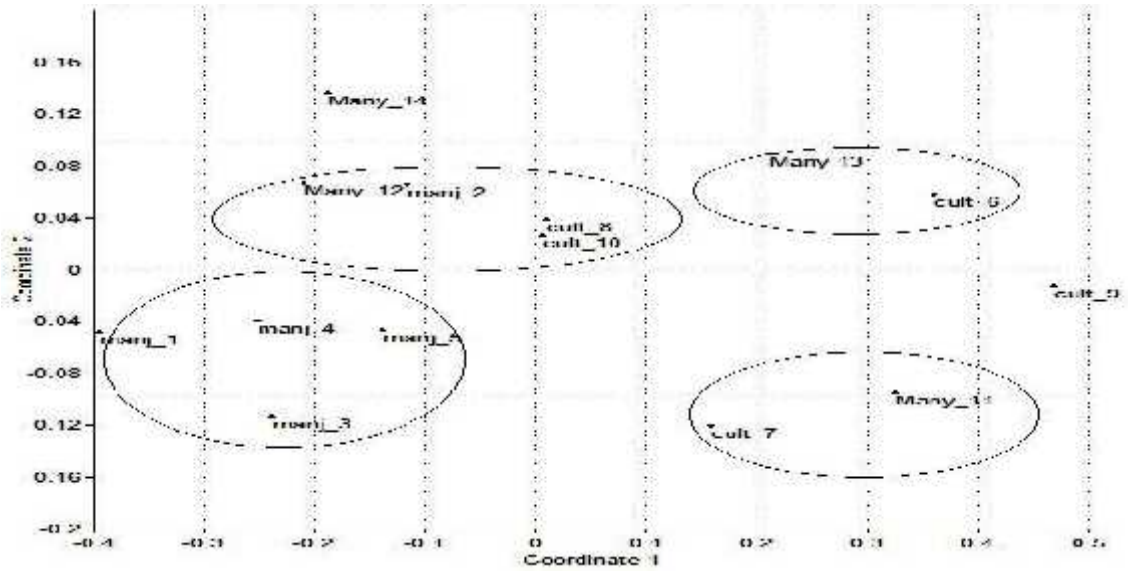

Figure 2. A Non Metric Multidimensional Scaling graph showing the relationship between point count stations across the three land use categories using bird species diversity indices. Notes: manj - Manjinji Pan; Many - Manyanda; cult - cultivated areas.

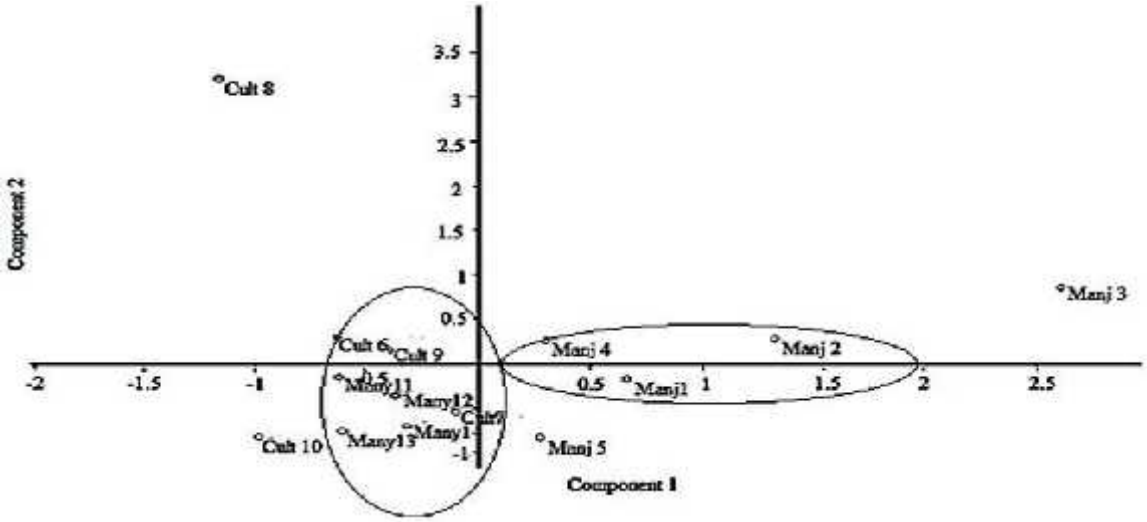

Figure 3. PCA ordination scatter plot showing the relationship between point count stations using bird species richness across different land use categories in southern Zimbabwe. Notes: Many - Manyanda Pan; Cult - cultivated areas; Manj - Manjinji Pan.

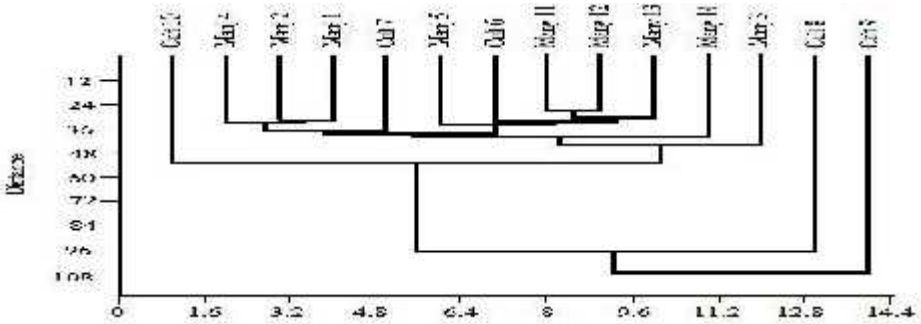

Figure 4. Cluster analysis of bird species richness and abundance across the land use categories. Notes: Cult - cultivated area; Manj - Manjinji Pan; Many - Manyanda Pan.

Table 1. Description of habitat status across the three study strata in southern Zimbabwe, following the habitat condition scoring method, a qualitative assessment.

Land use category	Habitat	Habitat status (area)	Quality Rating	Comments\
Manjinji Pan	Miombo and Mopane woodlands, Savanna woodland and Thornveld	Good	Good	The quality of woody vegetation is 70-90% of the optimum due to natural dying off of mature trees and slow degradation of the habitat by frequent droughts and anthropogenic activities. It seems the woody vegetation is maturing towards climax condition. Generally the condition of the habitat is good. The few trees that were pulled down were due to wood harvesting by humans.
	Wetlands (grassy vleis, rivers, springs)	Good	Good	Rivers include the perennial Mwenezi and its tributary streams. Wet grasslands include the flood plains of the old ox-bow lake of Mwenezi River.
Manyanda Pan	Miombo and Mopane woodlands, Savanna woodland and Thornveld	Moderate	Poor	Qualitatively, the area of the woodlands is not changing. However, the quality of woody vegetation is 40-70% of the optimum due to degradation of the habitat by elephants and fire disturbances. It seems the woody vegetation is not maturing to climax condition and the woodlands are degrading into scrublands.
	Wetlands (grassy vleis, rivers, springs)	Moderate	Moderate	Rivers and streams include headwaters of the seasonal Guluene/Chefu river which becomes a significant feeder of the Limpopo river in Mozambique. However, wet grasslands quality is moderate due to the seasonality of the feeder river to the pan.
Cultivated area	Miombo and Mopane woodlands, Savanna woodland and Thornveld	Poor	Moderate	Qualitatively, the area of woody vegetation is diminishing as people clear arable land for agriculture. However, the quality of the existing woody vegetation is 70 % of the optimum due to natural dying off of mature trees and slow degradation of the habitat by frequent droughts and anthropogenic activities.
	Wetlands (grassy vleis, rivers, springs	Moderate	Moderate	Rivers include the perennial Mwenezi and its tributary streams and related springs. Wet grasslands and pastures include the flood plains of Mwenezi River. Grasslands are being degraded by overgrazing.

DISCUSSION

The results indicated the presence of a large community of birds (about 2706 individuals) belonging to a wide group of species (131 species) and belonging to 60 families. Manjinji Pan is relatively richer in bird species diversity as compared to adjacent cultivated communal lands and protected Manyanda Pan in Gonarezhou National Park. This can be attributed to relatively dense woody vegetation cover associated with the near climax riparian community of Manjinji Pan which sharply contrasts the degraded cultivated areas and the near degraded wooded Manyanda Pan (Zisadza-Gandiwa *et al*., 2013). Past studies have suggested that high bird diversity and assemblages are associated with dense woody vegetation (Skowno and Bond, 2003; Kutt and Martin, 2010; Gandiwa *et al*., 2013). Large tree canopies provide suitable habitats for bird perching, nesting and roosting (Dean *et al.*, 1999; Zisadza-Gandiwa *et al*., 2013).

The present study also revealed that Manjinji Pan, accommodates a high species diversity hosting large number (n = 9) of restricted birds. Cihlar *et al.* (1991) have also noted that habitats with dense vegetation cover have higher species richness and abundances than areas with low vegetation cover. This is supported by our findings where the highest number of water fowls and riparian species (e.g., *Eremopterix leucotis*, *Butorides striatus* and *Ardea cinerea*) mostly occur at Manjinji Pan. The highest numbers of carnivorous birds and omnivorous birds also reside at Manjinji Pan. The dense thickets and wetland conditions at Manjinji Pan (ZPWMA, 2011) creates conditions for habitat heterogeneity that supports large assemblage of birds. Manyanda Pan, with its scrub vegetation (a consequence

of heavy elephant herbivory and frequent fires) and the cultivated areas support fewer bird species primarily due to disturbance factors.

Despite the disturbance gradient across the study area, we recorded no significant difference in bird abundance across the three land use categories. Thus, the present study highlighted the existence of pull factors that attract bird assemblages even to the more disturbed habitats. For instance, the cultivated area included bird species dominated by omnivores which naturally prefer small grains such as *Numida meleagris*, *Vidua paradisaea* and *Cisticola chiniana*. This illustrates the importance of food resource as a pull factor (Fabricante *et al*., 2009). The study was conducted at the tail end of the rainy season when crops are ready for harvesting, and the recorded species for this particular area are primarily omnivores.

The results indicated low migration of birds from Manjinji Pan to the other sites, thus illustrating habitat stability within the pan area. Any future disturbance within the pan riparian and wetland zones is likely to upset the current equilibrium of bird populations at Manjinji Pan (Cunningham and Johnson, 2006). The current study has implications on avifauna conservation at Manjinji Pan Important Bird Area. We note with concern the apparent absence of the Blue throated Sunbird and Lemon breasted Canary at Manjinji pan, species previously recorded at the site (Childes and Mundy, 2001). Their absence is attributed to either migration or altered habitat condition. Bird species composition and habitat selection have been reported to be influenced by habitat status and vegetation cover (Rais *et al*., 2010; Joshi *et al*., 2012). An increase in avian diversity has been associated with increased vegetation structural diversity (e.g., MacArthur and MacArthur, 1961; Hudson and Bouwman, 2007). Accordingly, woody plants are important for a diversity of bird species as they provide cover, and observation posts for raptorial birds (Ffolliott *et al*., 2011).

Conclusion: This study suggested that woodland degradation is likely to alter habitat condition, hence avifaunal diversity and abundance in southern Gonarezhou National Park and surrounding areas, Zimbabwe. The study results suggest the need for conservation of the remaining forest and wetland fragments in southern Zimbabwe even in unprotected areas in order to maintain avifaunal diversity. This view is consistent with the meta-population theory which emphasizes the importance of connectivity of isolated populations for long term survival of species (Huffaker, 1958).

Acknowledgements: We acknowledge the permission to access the protected areas granted by the Director-General of Zimbabwe Parks and Wildlife Management Authority. Staff of Gonarezhou National Park provided logistical support. We appreciate the valuable contributions of anonymous reviewers.

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