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Research Article

Status of Woody Vegetation along Riparian Areas in Gonarezhou National Park, Zimbabwe

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ABSTRACT

We assessed the composition and structure of woody vegetation along Save, Runde and Mwenezi rivers in Gonarezhou National Park, Zimbabwe. Data were collected from 62 sample plots between April and May 2011 using a stratified random sampling design. Our results showed significant differences in plant height, shrub density and numbers of stems per plant across the three major perennial rivers. However, there were no significant differences in basal area, tree density, dead plant density, browsed plant density, fire damaged plant density and species diversity. Our findings suggest that disturbances, e.g., herbivory, are affecting the woody vegetation structure in all major rivers in Gonarezhou. We therefore, recommend for the continuous monitoring of riparian vegetation in Gonarezhou and other similar protected areas.

INTRODUCTION

Savannas occupy sixty percent vegetation cover of sub-Saharan Africa and they are typified by the coexistence of woody plants and grasses (Ludwig et al., 2004; Sankaran et al., 2005), with the relative proportions of each being influenced predominantly by water availability, fire, nutrients, herbivory and people (Scholes and Walker, 1993; Sankaran et al., 2005; Russell-Smith et al., 2012). Riparian areas could be defined as areas of direct physical and biotic interactions between terrestrial and aquatic ecosystems, with boundaries extending outward to the limits of flooding and upward into the canopy of streamside vegetation (Vannote et al., 1980; Ringrose, 2003). Furthermore, vegetation in riparian areas may be influenced by elevated water tables or extreme flooding and by the ability of the riparian soils to hold water (Ringrose, 2003; Richardson et al., 2007). These areas provide critical habitat for numerous terrestrial and aquatic species (Kauffman et al., 1997).

Erratic rainfall interacting with the effects of herbivory, are reported as leading to many wild animals, especially large herbivores, to frequent perennial rivers in savanna ecosystems (Tafangenyasha, 1997; Smit et al., 2007; Mworia et al., 2008). This situation often results in vegetation degradation in areas near water sources (O'Connor et al., 2007; Gandiwa et al., 2011). Therefore, the present study aimed at assessing the composition and structure of woody vegetation along three major perennial rivers in Gonarezhou National Park (hereafter, Gonarezhou), Zimbabwe. The patterns in woody species composition and structure are valuable parameters for vegetation monitoring; thus, the woody vegetation component is suggested to provide a more reliable index on habitat status (Walker, 1976). This study could inform and contribute to riparian vegetation management in Gonarezhou and other similar areas in savanna ecosystems.

MATERIALS AND METHODS

Study area

Gonarezhou is located in southeastern Zimbabwe between latitudes 21° 15' S and longitudes 30° 32' E. The park extends over 5053 km^2. The mean annual rainfall for Gonarezhou is 466 mm, but is highly variable. The vegetation of Gonarezhou is typically of the semi-arid *Colophospermum mopane* zone and is predominantly dry deciduous savanna woodland of varying types. Gonarezhou is endowed by a high diversity of large herbivores including African elephant (*Loxodonta africana*) and giraffe (*Giraffa camelopardalis*).

Study design and data collection

We used a stratified random sampling design based on the location of the three major rivers of Gonarezhou. We stratified our study into three areas, namely, Save (32 km), Runde (77 km) and Mwenezi (57 km) (see Sithole et al. (2012) for a detailed description of the study area). Sample plots were randomly placed based on Gonarezhou topographical map using grid intercept method along the three major perennial rivers. A total of 62 sample plots were sampled between April and May 2011 in Gonarezhou (i.e., Save River = 7 sample plots, Runde River = 25 sample plots and Mwenezi River = 30 sample plots). Plots measuring (20 × 30 m) were used throughout the study. Woody species occurring within a sample plot were identified using the field identification guides (Coates-Pelgrave, 1997). In addition, the following variables were assessed in each plot following methods outlined by Gandiwa and Kativu (2009): tree height, basal circumference, plant status (dead or alive) and number of stems per plant.

Data analysis

Descriptive statistics (mean and standard errors) were calculated for all vegetation variables. The Shannon-Weiner diversity index (H1) was used to calculate the woody species diversity of sampling units across the study strata (Ludwig and Reynolds, 1988). Data were tested for normality using Kolmogorov-Smirnov test in STATISTICA for Windows version 6 software (StatSoft, 2001) and for the variables which were not normal, data were normalized using: log10 (y + 1) where y is the vegetation variable, in order to satisfy the assumptions of normality and equality of variance. Differences across the study stratum were determined using a one-way analysis of variance (ANOVA). Post-hoc analyses using the Least Significant Difference (LSD) were carried out where differences across strata were recorded.

Moreover, Discriminant Analysis with river stratum as grouping variable and woody vegetation structure and composition variables as independent variables was used to explore differences and similarities among the 62 sample plots in the three river strata. Furthermore, we performed a Hierarchical Cluster Analysis using Wards method with a matrix of 62 sample plots and only woody vegetation composition (diversity and species richness) data.

RESULTS

Woody vegetation structure and composition

A total of 1874 individual woody plants were assessed from 62 sample plots and 102 woody plant species were recorded. Plant height, shrub density and numbers of stems per plant significantly differed across the three major perennial rivers' riparian vegetation (Table 1). However, there were no significant differences in basal area, tree density, dead

plant density, browsed plant density, fire damaged plant density and species diversity.

Table 1: Summary of statistical analyses results of the study variables in Save, Runde and Mwenezi riparian vegetation in Gonarezhou National Park, Zimbabwe. Notes: Values across columns not sharing the same superscript letters are significantly (LSD; P < 0.05) different

Variable	River stratum			$F_{2,59}$	*P-value*
	Save	Runde	Mwenezi		
Plant height (m)	3.72 ± 0.68[a]	4.05 ± 0.21[a]	6.28 ± 0.45[b]	11.49	0.000
Basal area (m^2/ha)	0.31 ± 0.12	6.14 ± 1.43	3.70 ± 1.49	0.88	0.421
Tree density (ha^{-1})	269.05 ± 43.25	310.0 ± 21.15	309.44 ± 16.04	0.53	0.591
Shrub density (ha^{-1})	319.05 ± 89.64[a]	218.67 ± 21.13[b]	143.33 ± 19.12[c]	7.42	0.001
Dead plant density (ha^{-1})	2.81 ± 0.14	10.67 ± 3.02	2.67 ± 0.13	0.40	0.674
Number of stems/plant	26.19 ± 16.21[a]	3.68 ± 0.28[b]	19.44 ± 10.87[c]	6.91	0.002
Species diversity (*H'*)	1.73 ± 0.23	1.37 ± 0.14	1.46 ± 0.12	0.74	0.479
Browsed plant density (ha^{-1})	388.18 ± 119.34	321.56 ± 37.13	298.65 ± 36.88	0.52	0.597
Fire damaged plant density (ha^{-1})	0.00 ± 0.00	28.31 ± 18.11	37.78 ± 18.15	0.78	0.464

Discriminant analysis results of nine woody vegetation variables showed that Root 1 explained about 73% (eigenvalue = 0.81) whereas Root 2 explained about 27% (eigenvalue = 0.30) in woody vegetation structure and composition in the sample plots across the three strata in Gonarezhou. Root 1 was negatively correlated to taller woody plants, high density of fire damaged plants and low density of browsed plants, and positively correlated to high numbers of stems per plant, low tree density, high shrub density and high woody vegetation species diversity. Root 2 was negatively correlated to high basal area and high tree density, and positively correlated to high woody vegetation species diversity. Mwenezi riparian stratum was generally negatively correlated to both Roots 1 and 2 whereas Runde riparian stratum was positively correlated to Root 1 and negatively correlated to Root 2. Lastly, Save riparian stratum was positively correlated to both Roots 1 and 2 (Fig. 1). Overall, there were significant differences in distances between Mwenezi and Save riparian strata (P = 0.020) and between Mwenezi and Runde riparian strata (P = 0.001). In contrast, there was no significant difference in distances between Save and Runde riparian strata (P = 0.112).

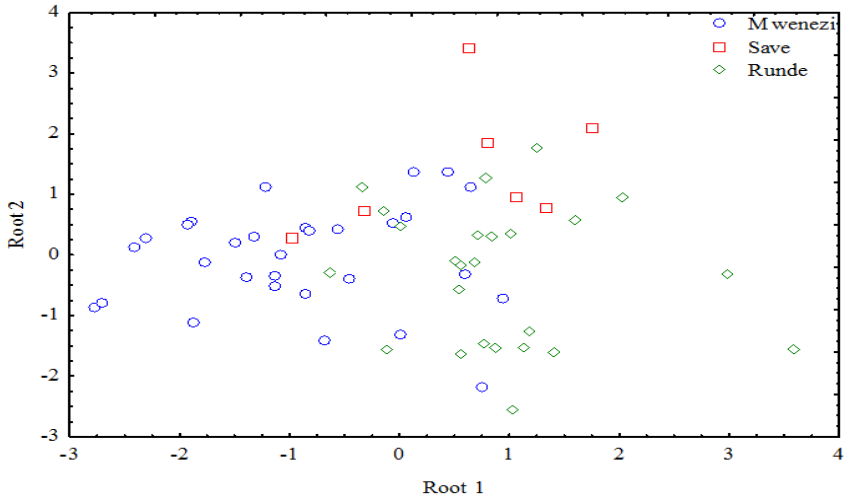

Fig. 1: Discriminant analysis output of the 62 sample plots from Mwenezi, Runde and Save riparian vegetation in Gonarezhou National Park, Zimbabwe

Woody vegetation composition

Sub-cluster A consisted of 20 sample plots with 10 (50%), 7 (35%) and 3 (15%) sample plots for Mwenezi, Runde and Save riparian strata respectively (Fig. 2). Generally, sample plots in sub-cluster A were characterised with low woody vegetation species diversity. In contrast, sub-cluster B consisted of 42 sample plots with 20 (47%), 18 (43%) and 4 (10%) sample plots for Mwenezi, Runde and Save riparian strata respectively. Sample plots in sub-cluster B were characterised with high woody vegetation species diversity. Common woody species found within the Save riparian area were: *Acacia nigrescens, Albizia anthelmintica, Acacia xanthrophloea, Sclerocarya caffra, Hyphaene natalansis* and *Kigelia africana*, whereas, the Runde riparian area had the following common woody species: *Acacia tortilis, Combretum imberbe, Berchemia discolor* and *Dischrostachys ceneria.* Within the Mwenezi riparian area, the common woody species found were: *Acacia senegal, Combretum apiculatum, Pseudocardia zambesiaca, Lannea discolor* and *Afzelia quanzensis. Colophospermum mopane* was the dominant woody species in all the riparian areas across the three major rivers in Gonarezhou.

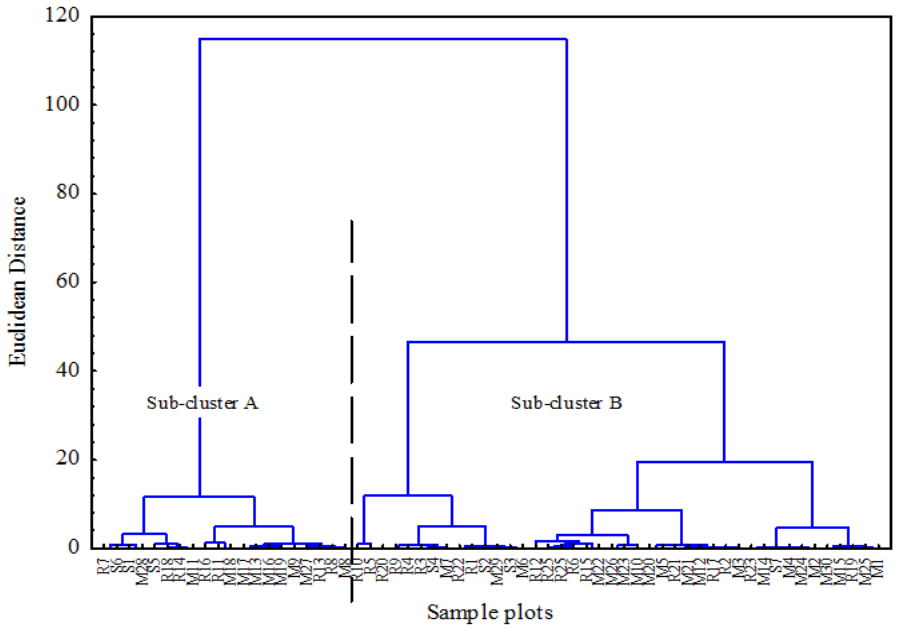

Fig. 2: Hierarchical Cluster Analysis dendrogram showing sample plots from Mwenezi, Runde and Save riparian vegetation in Gonarezhou National Park, Zimbabwe

DISCUSSION

Our results showed significant differences in plant height, shrub density and number of stems per plant across riparian vegetation in the three major perennial rivers in Gonarezhou. We recorded higher plant heights in Mwenezi riparian stratum as compared to the Save and Runde riparian strata. We attribute this difference to elephant herbivory and human activities. High elephant density in Gonarezhou (approximately 1.8 elephants per km2) have been reported to be partially accommodated by the seasonal shifts in distribution, i.e., during the wet season, the elephant population is distributed throughout the park, but water supplies in the Central Guluene-Chefu catchment area, dry up in the dry season and food supplies diminishes drastically and this prompt large herbivores to move towards permanent perennial water courses, largely along the Save, Runde and Mwenezi rivers, resulting in high concentration of elephants within the riparian area (Dunham, 2012). Low elephant densities have been recorded within the Mwenezi riparian area which is bordered with Malipati Safari Area, where elephant inhabitant is likely disturbed by trophy hunting activities (ZPWMA, 2011).

As suggested by Anderson and Walker (1974), Gonarezhou riparian woodlands have a combination of palatable plant species, shade and proximity to water which render them more vulnerable to elephant damage. Elsewhere, Simpson (1975) recorded the persistence of a narrow strip of riparian forest along the Chobe River of Botswana in 1970 and by 1980 many of the large trees near the river appeared to be dying due to elephant herbivory. Save riparian area recorded the highest mean number of stems per plant, thus indicating a higher rate of woody plant resprouting after plant growth disturbance which can be attributed to human activities like selective woody vegetation logging, firewood harvesting and overgrazing by encroaching domestic animals. The

human and livestock encroachments into the Save and Runde riparian areas in Gonarezhou were noted to have resulted in both vegetation changes as woodlands were cleared to open up space for settlements and fields for cultivation (Zisadza-Gandiwa et al., 2013).

The present study found that shrub density was higher in Save and Runde River riparian zones as compared to the Mwenezi River riparian zone. The present study recorded no significant difference in density of fire damaged plants in the study strata. As reported by Gandiwa et al. (2012), there was relatively less negative impact of fire on woody vegetation near water sources in Gonarezhou. The study results showed no significance difference in woody species diversity across the study strata across the riparian zones of the Gonarezhou major rivers. Cumming et al. (1997) reported that Elephants open up tree canopy and in the process open up woodlands, thus transforming habitats and altering animal and plant species composition.

There are several factors not investigated in the present study which could have influenced the riparian vegetation structure and composition of Gonarezhou major rivers. It is apparent that degraded sites of Save and Runde riparian areas have been also influenced by areas formerly disturbed by humans in Gonarezhou (O'Connor and Campbell, 1986; Gandiwa and Kativu, 2009; Mombeshora and Le Bel, 2009). The then resident people vacated these areas in 1968, because of the legislative removal of inhabitants from areas proclaimed as game sanctuaries (ZPWMA, 2011). Changes in plant structure in Gonarezhou riverine woodlands and mixed shrub woodlands during the dry season have been also attributed to termite activity (O'Connor and Campbell, 1986). Moreover, droughts have been noted as important in reducing the protective tree cover along river banks in Gonarezhou as a result of tree mortality (e.g., Tafangenyasha, 1997). However, in this present study, we recorded a relatively low density of dead plants in the riparian areas. Gonarezhou is located in the downstream of the south-easterly flowing rivers that drain Zimbabwe, and as a result, it is at risk of receiving adverse hydrological changes from upstream developments. The effects directly impact on the fauna and flora, for example, if large quantities of silt are transported downstream the river water pools inevitably disappear, and if water is not released from upstream impoundments the recharge in the rivers diminish with consequent loss in aquatic life and related degradation on floodplain vegetation.

CONCLUSION

Our findings show that disturbances, for example, herbivory are affecting the woody vegetation structure in all major rivers in Gonarezhou. We therefore conclude by recommending the continuous monitoring of riparian vegetation in Gonarezhou and other similar protected areas.

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