Distribution Pattern of Anuran Species in Kimboza Forest Reserve, Morogoro, Tanzania

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Ikisiri

Utafiti ulifanyika kati ya Machi na Aprili 2017 ulitambua aina ya vyura wanaopatikana katika msitu wa hifadhi wa Kimboza. Katika kutafuta makazi yao njia ya kutegeshea muda ilitumika kama njia ya utambuzi katika mazingira saba tofauti ndani ya msitu. Jumla ya aina 13 ya spishisi za vyura ambazo ziko katika familia saba walionekana katika msitu wa Kimboza. Idadi kubwa (70%) walionekana zaidi ndani ya msitu na karibu ya mashamba yanayopakana na msitu. Kwa kuangalia uwiano, kulikuwa hakuna tofauti ya wingi wa vyura miongozi mwa mazingira tofauti saba yaliyofanyiwa utafiti (Q=11; DF =6; P=0.096). Hata hivyo kulikuwa na utofauti wa upatikanaji wa vyura kati ya eneo la juu na chini la msitu (Mcnemar Test, P> 0.05). Utafiti huu ni wa muhimu sana katika kuchangia usimamizi na uhifadhi wa msitu wa wanyamapori. Inashauriwa kuwa utafiti zaidi wa utambuzi wa vyura ufanyike katika majira tofauti ya mwaka ili kuweza kupata uhalisia wa vyura waliomo na jinsi walivyotapakaa katika msitu huo.

Abstract

An assessment of the distribution of anuran species of Kimboza forest reserve, Tanzania was conducted between March 2017 and April 2017. Visual encounter survey applying Time-Constraint Search (TCS) approach was used to study the distribution of anurans in seven micro-habitats within the forest. A total of 13 species of amphibian belonging to seven families of order anuran were found to exist in Kimboza forest. The highest occurrence of anurans (70%) was recorded in areas along forest and farms border and along Kimboza forest streams. The study shows that there was no significant variation of occurrence of anurans among different habitats in the forest (Q=11; DF =6; P=0.096). However, the variation of total number of occurrences of anuran species between the upper and lower segment of the forest was significant (McNemar Test, P<0.05). The study provides a preliminary estimation of the general distribution pattern for these species in Kimboza forest. These findings are important for understanding and management of anurans in Kimboza forest reserve. It is recommended that further studies should focus on dry season and nocturnal species so as to come up with a complete description of the distribution of anuran species of Kimboza forest reserve.

Key words: Kimboza, Forest, Reserve, Anura, Eastern Arc

1. INTRODUCTION

Anurans have a wide global distribution being absent only in Polar Regions as well as in highly saline areas (França *et al*., 2004; Menin *et al*., 2005). Among many known habitats, forest streams with their structural heterogeneity are known to harbour high number of anuran (Naniwadekar and Vasudevan, 2007; Cubides and Cardona 2011; Narváez *et al*., 2014) increasing along edge-interior gradient (Cubides and Cardona 2011; McCracken and Forstner, 2014). The inner parts of the forests provide broader habitat gradients favouring high species diversity (Maynard *et al.,* 2016). Although there is no correction between habitat variables and anuran species occurrence in the forest (McCracken and Forstner, 2014; Ernst and Rödel,2005) abiotic and biotic factors are important parameters in influencing anuran distributions (Ernst and Rödel, 2008). Therefore, broad scale environmental parameters rather than specific measure are important in determining patterns of animal distribution (Maynard *et al.,* 2016).

Kimboza forest reserve located at the edge of Eastern Arc Mountains range is one of the heterogeneous habitats (IUCN category IV) known to harbour broad spectrum of fauna species including amphibians (Kacholi, 2013). However, the home ranges and foraging habitats for

these species are threatened by increased anthropogenic disturbances resulting from illegal agriculture activities, timbers and pole harvesting carried out by people in the villages surrounding the forest. The presence of the tarmac road in the forest and farms bordering the forest are among the factors which led to increased anthropogenic disturbances to the forest (Kacholi, 2013). Significant changes to the habitat structure such as forest clearing and edge effects have negative effect on abundance and diversity of animals especially the cryptic and physiologically limited anurans. Ecologically, the animals are critically important in maintaining ecosystems food webs as well as supporting massive remineralisation (Sparks *et al.,* 1998). However, at a global level numbers of amphibian populations are in steady decline (Stuart *et al.,* 2004) prompting instituting appropriate conservation strategies (Dodd and Smith, 2003). The observed disturbance is an alarm and call for stepping up management for the forest. Studies by Bayliss (1994) and Clarke and Dickinson (1995) on forest have given some insights on the biodiversity but with little information on anurans. Consequently, this study aims at describing the distribution of amphibian (anuran) species in Kimboza Forest Reserve, through (i) examined distribution of anurans in different habitats including forest interior, along forest streams and areas along forest boundaries and ii) the distribution of anurans between the little disturbed segment and highly disturbed segment of the forest.

2. MATERIALS AND METHODS

2.1.Study Area

This study was conducted in Kimboza forest reserve located approximately 50km south east of Morogoro district in Morogoro region, Tanzania (Fig. 1). The forest lies between 06°59' - 7°02' S and 37°47'- 37° 49'E covering an area of about 385ha (Werema, 2016). The study site is a lowland rain forest ((Rodgers *et al*., 1983), which some of its flora species are facing intensified threat due to ongoing deforestation activities (Temu and Andrew, 2008). The local climate of this region is characterized by bimodal rainfall pattern averaging 1600 mm per year. Most of the rains fall between April and May which is the rain season, while the dry season with little rain is between October and March (Werema, 2015).

2.2. Sampling Design

Sampling was carried out for eight days for each month of March and April 2017. Majority of amphibians usually tend to aggregate near water sources (Naniwadekar and Vasudevan, 2007)

as such these months mark the period of heavy rain in the area. Visual encounter survey was applied to detect anuran species in order to study their distribution. In order to capture data that is representative, the forest was divided into two parts (less disturbed upper and more disturbed lower segments) separated from each other by a dirt road and from these; seven microhabitats were identified. These are interior of the forest in the upper segment= UFI, along the forest and farm border in the upper segment of the forest = UFF, along the Kimboza streams in the upper segment of the forest= UFS, along the forest and road border in the upper segment of the forest= UFR, interior of the forest in lower segment of the forest = LFI, along the forest and farm border in the lower segment of the forest = LFF and along the forest border with road (LFRS).

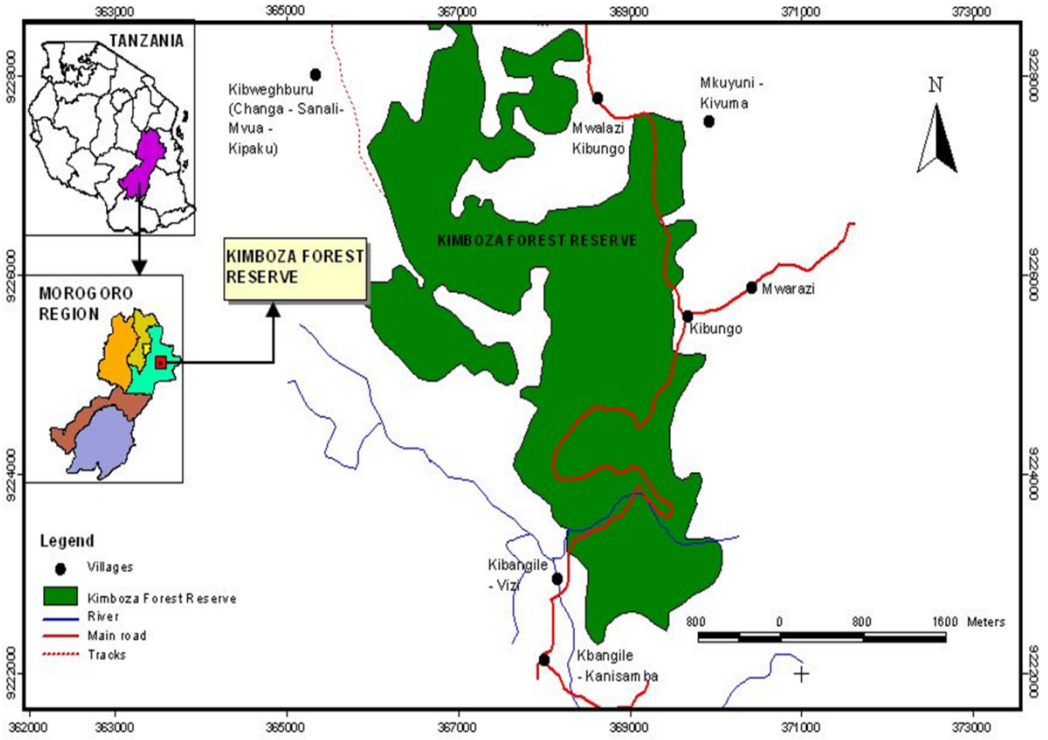

Figure 1. Map of Morogoro region showing Kimboza Forest Reserve

Time Constrains Searches (Bury and Raphael, 1983; Campbell and Christman, 1982) was applied in data collection. This involved actively search for animals in the study area for a pre-defined amount of time to achieve this, one sampling station was purposively chosen and established in each selected study habitat making a total of seven sampling stations in both parts of the forest. The edge effect on amphibians is known to extend 100m from the forest boundaries to the forest interiors (Maynard, 2016). In each habitat per segment (upper and lower) one belt transect (300×4m) was defined. Within each transect, six rectangular plots of

50 × 4 m were established making a total of 48 plots in both segments of the forest for the entire study. The rectangular plots of 50 × 4 m were searched for anurans in 30 minutes by four persons. A total of eight 300×4m transects (0.96ha of the forest) was searched from 0600 to 1700 hours for diurnal anurans. Each transect was surveyed four times in each month (March and April). The searching involved going into leaf litter, under logs, tree holes and stones. Similarly, tree canopies and bushes near water sources were also searched for arboreal amphibians

Identification was performed for sighted anurans and was done on spot, but for some of the species which could not be identified were captured, fixed in 10% formalin and then preserved in 70% ethanol as representative voucher for identification. The identification was guided by keys and field guidebooks (Channing and Howell, 2006; Spawls *et al.,* 2006; Harper *et al*., 2010). The preserved specimens were deposited in a Zoology Laboratory of Sokoine University of Agriculture.

2.3. Data Analysis

Data were coded in excel sheet and the distribution of species in the whole forest was analysed using Cochran's Q test (SPSS version 20). Further, the comparison of anurans' distribution between the upper and lower segment of the forest was analysed using McNemar Test (SPSS version 20).

3. RESULTS AND DISCUSSIONS

3.1. Results

During this study, thirteen species of amphibians belonging to 7 families of order anuran were recorded (Table 1). *Arthroleptis xenodactyloides* species had the highest occurrence (occurred in 6 out of 7 habitats) followed by *Leptopelis flavomaculatus* (five out of seven habitats) (Table2). *Ptychadena anchietae, Phrynobatrachus acridoides, Hyperolius mitchelli*, *Afrixalus stuhlmanni* were among the species with the lowest occurrence, each one of them occurred only in one habitat (Table 2).

Table 1: Anuran species of Kimboza Forest Reserve

Family	Species
Arthroleptidae	*Arthroleptis affinis, Arthroleptis xenodactyloides* *Leptopelis flavomaculatus* *Leptopelis uluguruensis*
Bufonidae	*Nectophrynoides tornieri*
Hyperoliidae	*Afrixalus stuhlmanni* *Afrixalus uluguruensis* *Hyperolius mitchelli*
Phrynobatrachidae	*Phrynobatrachus acridoides* *Phrynobatrachus natalensis*
Pipidae	*Xenopus borealis*
Ptychadenidae	*Ptychadena anchietae*
Rhacophoridae	*Chiromantis xerampelina*

Among all habitats in Kimboza forest reserve areas the upper segment of the forest had the highest number of anurans (Table 2). Each habitat part had 70% of anurans, meaning each had seven out of 10 species number. The next was a forest interior of the upper segment of the forest which had six out of 10 species number (60%). However, areas along the forest and tarmac road border and along Kimboza streams of the lower segment of Kimboza forest had the lowest number of anurans.

Table 2: Distribution of anuran species in different habitats of Kimboza Forest Reserve

Species name	HABITATS							% species in different habitats
	UFI	UFF	UFS	UFR	LFI	LFF	LFRS	
Leptopelis uluguruensis	x			x				25.0
Leptopelis flavomaculatus	x	x	x	x		X		62.5
Arthroleptis xenodactyloides	x	x	x	x	x	X		75.0
Arthroleptis affinis	x		x			X		37.5
Nectophrynoides tornieri	x			x	x			37.5
Afrixalus stuhlmanni		x						12.5
Afrixalus uluguruensis		x	x					25.0
Hyperolius mitchelli							x	12.5
Phrynobatrachus acridoides			x					12.5
Phrynobatrachus natalensis		x				x		25.0
Xenopus borealis	x	x	x					37.5
Ptychadena anchietae			x					12.5
Chiromantis xerampelina		x			x			25.0
% occurrence of all species in each habitat	60	70	70	40	30	40	10	

UFI= interior of the forest in the upper segment, UFF=along the forest and farm border in the upper segment of the forest, UFS= along the Kimboza streams in the upper segment of the forest, UFR= along the forest and road border in the upper segment of the forest, LFI = interior of the forest in lower segment of the forest, LFF = along the forest and farm border in the lower segment of the forest andLFRS=along the forest border with road.

Statistically, there was no significant difference in the number of occurrences of anurans in different habitats of the whole forest (Q=11; DF =6; P=0.096). However, the total number of occurrences of anurans in the forest upper segment was significantly greater than that of the lower segment (McNemar Test, P<0.05). Six out seven habitats in Kimboza Forest Reserve had anura species in both March and April (Fig.2). However, areas along the forest and road border in the lower segment of the forest had species occurrence in April only. Areas in the

forest interior, along the forest and road border in the upper segment and interior of lower segment of the forest had more species in March (Fig.2). Further, areas along Kimboza streams in the upper segment and along forest and farms border in the lower fragment of the forest had more species in April, while the area along forest and farms border in the upper segment of the forest had equal number of anura species in both months (Fig. 2).There were no significant variation of the total number of anurans in different habitats within the same month March (Cochran's Q test, Q=10; DF =6; P>0.05) and April (Cochran's Q test, Q=7; DF =6; P>0.05). Also, the variation of total number of occurrences of anurans in the forest between April and March (McNemar Test, P>0.05) was not significant.

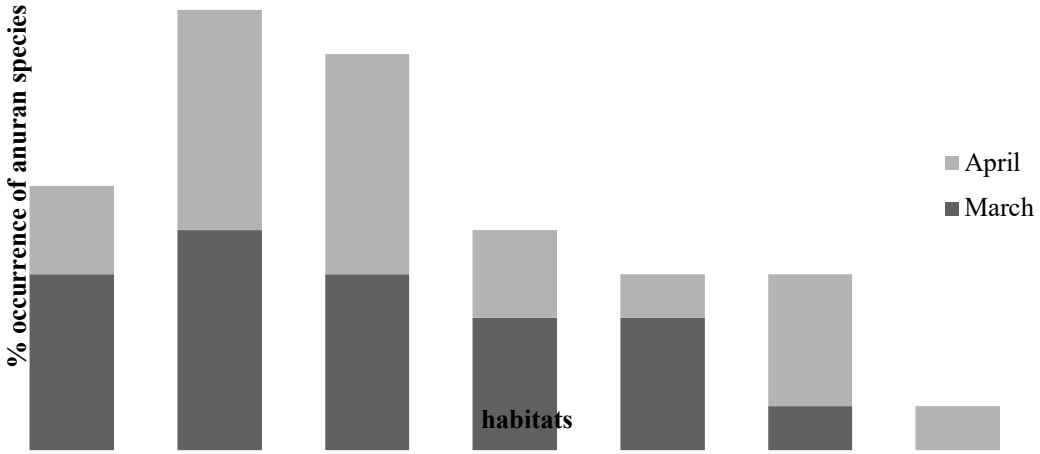

Figure 2: The total occurrences of anuran species in different habitats during March and April

The most frequently encountered species in March was *Leptopelis flavomaculatus*, while in April were *Arthroleptis xenodactyloides Arthroleptis affinis and Xenopus borealis* (Fig. 3). Some of the species occurred only in one month. For instance, *Leptopelis uluguruensis* and *Nectophrynoides tornieri* were recorded in March only, whereas *Hyperolius mitchelli, Phrynobatrachus acridoides, Phrynobatrachus natalensis* and *Xenopus borealis* were recorded in April only. In general, *Leptopelis flavomaculatus* and *Arthroleptis xenodactyloides* were the most frequently encountered species in both months (Fig.3).

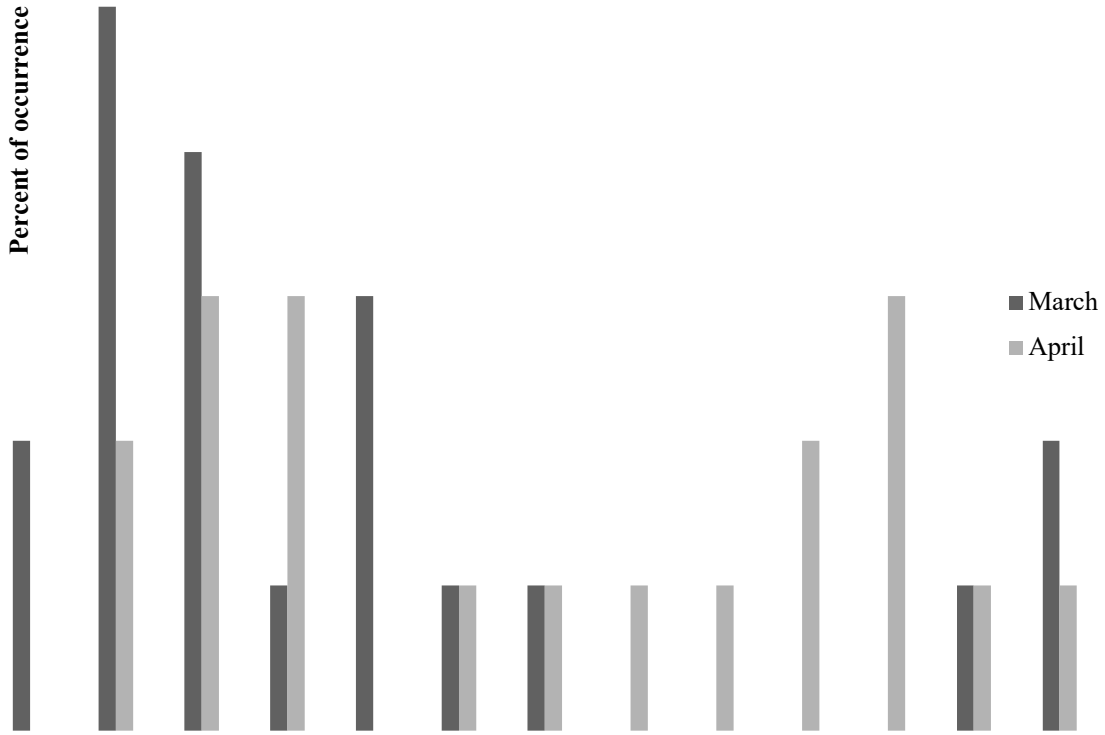

Figure 3: Occurrence of anuran species during March and April in Kimboza Forest Reserve

There was significant variation in the distribution of the species among habitats in the whole forest during March (Q =26; DF =12; P <0.05), but the variation was not significant during April (Q =11; DF =12; P>0.05). The variation of species distribution among habitats in the whole forest between March and April was not significant (McNemar Test, P>0.05). The variation of the distribution of the species between upper and lower segment was significant in both months March (McNemar Test, P<0.05) and April (McNemar Test, P<0.05).

3.2. Discussions

The distribution of anurans across different habitats within the Kimboza forest and along its borders demonstrates the importance of habitat conservation. Most of anurans occurred in areas along Kimboza forest streams, and along forest and farms border followed by the interiors of the forest while the least occurrence was along forest and road borders. The highest occurrence of anuran species in areas along forest streams was attributed to the fact that areas with water sources have high structural heterogeneity offering different microhabitats for various species to exploit, and thus led to high diversity of species in these areas (Narváez *et al*., 2014).

Likewise, areas along forest and farms border had the highest occurrences of anurans species, and this was due to the presence of ponds which were formed during the period of heavy rain used for breeding purposes. Water bodies especially those collected during rainy season provide important media for anurans breeding (da Silva and Rossa-Feres, 2011; da Silva *et al*., 2012). In addition, most of these species occupy forest habitats for shade and foraging purposes (Naughton *et al*., 2000), even though are most likely to utilize non-forested habitats as adults (e.g., *Phrynobatrachus natalensis*and *Afrixalus stuhlmanni*). Furthermore, forest interior had higher occurrence of anurans than areas along forest and road border and this is similar to a study by Maynard *et al.* (2016) which also found an increase in amphibian species occurrence along the forest edge-interior gradient. Forest edges are known to have higher changes in moisture (e.g., Humidity in important microhabitats), microhabitat availability, food availability and more risk of predation than forest interior (McCracken and Forstner, 2014). As a result, some of anurans which are sensitive to such changes tend to avoid forest edges and prefer more forest interiors (Maynard *et al*., 2016). Additionally, several aspects of roads that are known or suspected to influence anurans such as road salt (Collins and Russell, 2009), vehicle-related pollutants (Coffin, 2007; Andrews *et al.,* 2008), road-traffic noise (Hoskin and Goosem, 2010) and vehicle mortality (Vijayakumar *et al.,* 2001; Andrews *et al.,* 2008).

Among the thirteen anuran species found in Kimboza forest the most common species were *Arthroleptis xenodactyloides* and *Leptopelis flavomaculatus*. These species were found in all habitats of the forest although *Arthroleptis xenodactyloides*was found mostly hiding under leaf litters and *Leptopelis flavomaculatus* was found on low vegetation but also on forest floor. Harper *et al.* (2010) reported that *Arthroleptis xenodactyloides* live and breed in the leaf litter of the forest floor, while *Leptopelis flavomaculatus* is a tree frog primarily found in semi deciduous forest in coastal areas, but also occurs in lowland and montane forest. The least occurrences species were *Ptychadena anchietae, Phrynobatrachus acridoides, Hyperolius mitchelli* and *Afrixalus stuhlmanni.* Each of these species occurred on only one habitat that is all of them occurred in areas along Kimboza forest streams only except *Afrixalus stuhlmanni* which was found in ponds along forest and farms borders. The least occurrence of these species was due to the fact that most of these species are associated with water and thus they could only be found in the habitats within the forest that has water sources such as along Kimboza streams and in ponds along forest and farms borders (Harper *et al.,* 2010; Channing and Howell, 2006). Another interesting finding was the occurrence of *Chiromantis xerampelina*in the interior of the lower segment and its absence in the interior of upper segment. *Chiromantis*

xerampelina is usually found in disturbed forest (IUCN, 2017), as a result its occurrences in the forest interior of the lower segment shows clear sign of high level of disturbance in lower segment than the upper segment. Species which are uncommon in the interior forest habitat are usually observed only in the few plots of the interior forest that show clear signs of disturbance, and such species are indicators of forest disturbance levels (Maynard, 2016). Further, the study data established that the number of occurrence of anurans in the upper segment was significantly higher than of the lower segment. Changes caused by deforestation are known to threaten amphibian species (Cushman, 2006; Harper *et al.,* 2015), and these changes alter their distribution, habitat use and range (Duellman and Trueb, 1994). For instance, deforestation cause changes like increase in temperature and decrease in soil moisture in the forest. As a result, anuran species with high rates of water loss by evaporation fail to survive in such areas and leading to mortality due to desiccation (Rothermel and Semlitsch, 2002).

4. CONCLUSION AND RECOMMENDATIONS

The major difference on anuran species occurrence between the upper and lower segment of Kimboza forest reserve reveal a need for future studies to focus on impact of deforestation activities on anurans distribution. The study findings also reveal a need for the forest management to form conservation strategies that will aim to protect the forest areas along forest and farm borders as they have proven to be important breeding habitats for different anuran species during heavy rain season. Future research should also in detail investigate the effect of road effect on anurans of Kimboza forest reserve so as to come up with proper conservation plan but also research which focus on dry season and nocturnal species are needed so as to come up with a complete description of the distribution of anuran species of Kimboza forest reserve.

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