Bird diversity, abundance and distribution in Kuzikus Wildlife Reserve, Namibia

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Birds can be used as an important indicator of environment health. Being used in this way, study of the birds in Kuzikus can indicate the health of various parts of the reserve. Being home to several endangered species, long term monitoring of the birds of Kuzikus gives clues into population fluctuations and the plausible future for threatened and endangered species. The aim of the study was to accurately assess population size of birds and investigate differences in diversity of birds with vegetation. Line transects were used to document the species present in Kuzikus in the winter season and to investigate habitat preferences of birds. Distance sampling was used to estimate the population numbers of some bird species, finding the most common bird in Kuzikus to be the White Browed sparrow weaver, a sociable year-long breeder. The diversity and abundance of birds is dependant on the vegetation of the region they are in, providing shelter and provisions. This study found a correlation between the number of birds and vegetation types in areas of Kuzikus. Bird diversity increased with certain combinations of shrub and grass species, but no correlations were found between bird diversity and single species of vegetation. This highlights the need for mixed vegetation structure to support a diversity of birds. The results of this study have therefore important implications for the management of the reserve to ensure a diverse range of vegetation is preserved for birds.

Introduction

Accurate assessment of bird populations can often be overlooked in wildlife reserves where the primary function is tourism (*pers. comm.* B. Reinhard), with large mammals and the "Big 5" being the main attraction for tourists to wildlife reserves in southern Africa. Functioning not solely a tourist attraction but as a wildlife reserve with aims to preserve biodiversity, Kuzikus is interested in knowing all species of animal and plant present on the reserve, including bird numbers and species diversity. With BRinK (Biological Research in Kuzikus) populations of birds are studied twice yearly, in summer and winter seasons, to estimate species diversity population fluctuations.

Monitoring bird density is important for tracking long term changes to the populations (Lee & Marsden, 2008) and identifying areas which are important for preservation of rarer species and assessment of extinction risk (BirdLife International, 2004). Kuzikus hosts a number of IUCN red-list endangered bird species, including the Lappet-faced vulture (*Torgos tracheliotos*). As well as monitoring direct bird diversity, studying birds can give guidance for diversity of large scale areas. Birds can be indicative of general environmental health (Bibby, 1999) as they score highly broad criteria defined for taxa which can be used to indicate whole ecosystem biodiversity (Pearson, 1995). Knowledge of bird species and population fluctuation can be used to investigate changes in the environment (Lambert, 1993, Gregory *et al.* 2003). In this way, knowledge of the bird of Kuzikus is vital in realising areas of the reserve that may require more management and areas which are thriving.

Counting birds can be problematic in that they easily flush and detectability can vary between individuals and species. Distance sampling analysis is a survey technique that tackles these issues regarding animal detection. As an efficient and reliable method for estimating density (Buckland et al, 2001), it has been used extensively in bird population studies (e.g. White *et al.*, 2007; Azhar *et al.*, 2008). Survey methodology can be point or line transects where observers must accurately record the distance from the point or line to every bird detected, in its initial location. Detection of animals in their initial location (before movement in response to the observer) prevents the creation of a bias which would often be towards overestimation of distance, as animals tend to move away from observers. Movement independent of the observers' presence creates a much smaller bias, so provided the animals are moving at a speed less than half that of the observer, the animal can be recorded accurately. The technique has a strong theoretical background based on the principle that animal detections reduce with increasing distance from the observer (Buckland *et al.*, 2001). Based on this, it becomes imperative that animals on the line are detected with a 100% probability. Analysis of data with Distance sampling software (Thomas *et al.*, 2006) allows a detection function to be plotted for each species, from which total density can be estimated. This detection function can vary between animal species and habitats. Analysis through distance sampling allows estimation of density to be calculated using detection functions, thus taking into account birds that went undetected as well as those detected providing a reliable density estimate.

Method

Study site

Kuzikus Wildlife Reserve is situated 180km south-east of Windhoek, Namibia, on the Western Kalahari Desert, 1380m above sea level. The reserve is a 10,000ha fenced area, functioning as a tourist lodge, with no more than ten tourists at a time and focus being on biodiversity preservation. The large mammal population of the reserve is managed through game catching and translocations and specific hunting (*pers. comm.* B. Reinhard). There have been recorded 132 species of bird on the reserve, including endemic and migrant species. Kuzikus is surrounded by cattle farms, whose only available water for birds is in dams, pumped from underground into steep sided concrete basins. Kuzikus has natural-effect water holes, where water is pumped up into shallow pools and large pans. This makes the environment ideal for wild animals and birds and the reserve acts as an island in the area where they can drink.

Kuzikus vegetation is Acacia dominated savannah. *Acacia. erioloba, A. melifera, A. hebeclada, A. karoo* and *Gravia flava* are the predominant tress and shrubs with *Stipagrostis*, *Schmidtia* and *Aristida* grasses. Preliminary knowledge implies that Kuzikus holds a range of different habitat types such as grass-covered dunes and large vegetation-sparse salt-pans.

This current study was carried out during the month of July 2010, the Namibian winter, when temperatures ranged from 4.3°C to 38.1°C during field work. There was no rainfall in the period, and humidity ranged from 6% to 42 % during research time period.

Methodology

For this study we opted to use line transects. Line transects can accurately estimate density when using a series of randomly positioned lines (Cassey *et al.*, 2007). This survey method is well suited to open, uniform habitats (Bibby *et al.*, 2000) as the western Kalahari is. Line transects reduce the probability of double-counting birds, making the method more reliable than point counts for this study. Line transects Additionally errors in distance estimation have a smaller influence on the final density estimate with data collected by line rather than point transect (Buckland, 2008). A pilot study in Kuzikus confirmed Buckland, 2008: that we were able to study a larger area of the reserve per time doing line transects as opposed to point transects due to reducing the time wasted travelling between points. The pilot study also showed after collecting data by line transect there were more detections at smaller distances from the observer meaning that the data did not need to be truncated in analysis.

A systematic grid of 10” was superimposed on the map of the Kuzkius. Incomplete squares of size 1’ by 1’ were excluded, then thirteen squares of the grid were randomly selected in which the line-transect 1 km long was placed centrally on a north-south axis. Transects were 500m apart from each other, decreasing the likelihood that the same animal was counted on more than one transect. One transect line was not walked as a Black Rhino was spotted on the line and posed too much danger. All transects were walked twice, expect one where the Black Rhino was seen at the start of the second repeat so the line's repeat was abandoned. Transects were repeated twice to obtain enough detections for the distance analysis and to account for varying detectability of animals. Transects that were walked in the morning and the afternoons to account for differences in animal abundance at the different times, to certify full detection of all species in the area.

For each bird seen, the sighting distance from the observer (r) and angle from the transect (θ) were recorded to its initial location. The perpendicular distance (x) to the line could then be calculated using the formula $x=r\sin\theta$. The angle was taken using a sighting compass and the distance with a laser range finder. Secondary information such as age, sex, behaviour and identifying features were also recorded to aid in identifying each animal and avoid recounting the bird on the transect. Birds identified by sound were also recorded, as were flyovers, though these were solely for presence/absence records as without a distance they could not be in the distance analysis.

The vegetation of each line was recorded every 100m in a 1ha area. Tree and shrub coverage were estimated by percentage and scored on the Braun-Blanquet scale and $1m^2$ quadrates were used to asses grass % coverage, also scored on the Braun-Blanquet scale. The dominant tree, shrub and grass species of each 1ha was recorded. Over the 1km transect, ten 1ha areas were surveyed, providing a broad description of the vegetation habitat of each line. Vegetation species on each line were grouped to form habitat types for comparison to bird abundance and diversity. A Shannon-Weiener diversity test was used to investigate differences in bird diversity between these habitat types

The statistical software Distance 5.0 (Thomas *et al.* 2006) was used to estimate density of the most abundant species, following the analysis approach and recommendations of Buckland *et al* (2001). Data from the two repeats to each line was pooled as recommended by Buckland *et al.* 2001 to provide bird sightings for 2km transects to increase animal detections. Half-normal, hazard rate and uniform key functions with cosine or simple polynomial series expansion terms were used to obtain a fit for the detection functions. The best fitted model was selected using the lowest Akaike Information Criterion (AIC), high Chi-squared goodness of fit values and low variance. The best models were then used to calculate density and estimate common bird species' abundance in Kuzikus.

Results

A total of 3825 bird observations were recorded. 76 species of bird were recorded during the line transects, including visual, audio and flyovers. 56 species were recorded visually with a distance to the line, for use in Distance sampling data analysis.

Bird diversity

To compare bird distribution to habitat we classified the vegetation data into combinations of shrub and grass, into habitat types. The four most common habitat combinations were *Aristida* grass with *Acacia. hebiclada* shrub; *Aristida* grass with *Acacia melifera* shrub; *Stipagrostis* grass with *A. melifera* shrub and *Stipagrostis* grass with *A. hebeclada* shrub. *Acacia erioloba* was the dominant tree on all transects, so the effects of this tree were excluded from analyses of habitat type correlation with bird diversity. Identifying these combinations allowed comparison of the 10 most frequent birds' distribution to habitat type (Fig. 1a-d). Bird count for each habitat type is the average number of birds seen on all transects in the habitat type, hence mean number of birds seen in 1km of the habitat.

Figure 1a. Comparison of birds between habitats with *Aristida* grass and either *A. hebeclada* or *A. melifera* shrub.

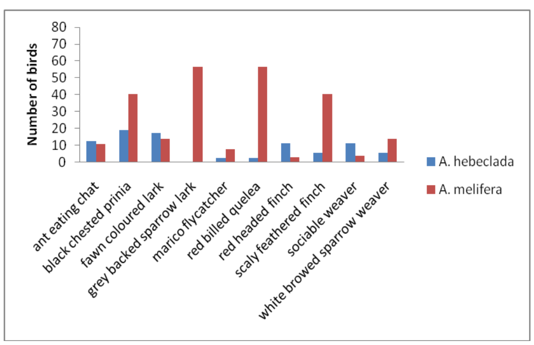


Figure 1b. Comparison of birds between habitats with *Stipagrostis* grass and either *A. hebeclada* or *A. melifera* shrub.

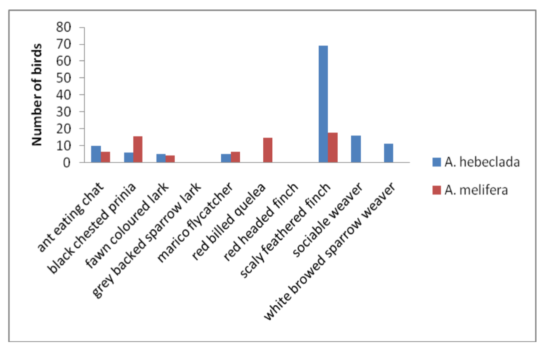


Figure 1c. Comparison of birds between habitats with *A. hebeclada* shrub and either *Aristida* or *Stipagrostis* grass.

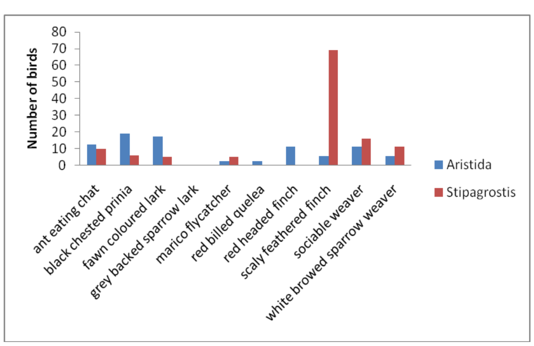
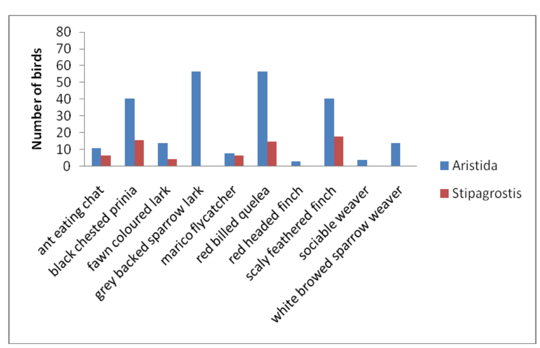


Figure 1d. Comparison of birds between habitats with *A. melifera* shrub and either *Aristida* or *Stipagrostis* grass.



Aristida grass dominated combinations seem to support more birds, than those habitat types with *Stipagrostis* grass dominating (Fig 1a-d). This is supported by a Shannon-Wiener test for diversity where *Aristida* grass with *A. hebeclada* shows the highest diversity of bird species (H=2.42), followed by *Aristida* with *A. melifera* (H=2.02). When the dominant grass in a habitat combination is *Stipagrostis*, H values were found to be lower (H=1.09 *Stipagrostis* with *A. melifera*; H=0.93 *Stipagrostis* with *A. hebeclada*).

The results of a further Shannon-Wiener test showed the need for a combined environment of grass and shrub for increased bird diversity as when the two grass types were compared directly, rather than in combination with shrub species the H values were shown to be more similar (*Aristida* H=2.42; *Stipagrostis* H=2.25).

Bird abundance

We analysied species with over 100 detections for the distance analysis, these were the Ant-eating Chat (*Myrmecocichla formicivora*), Marico Flycather (*Bradornis mariquensis*), and the White-browed Sparrow-Weaver (*Plocepasser mahali*).

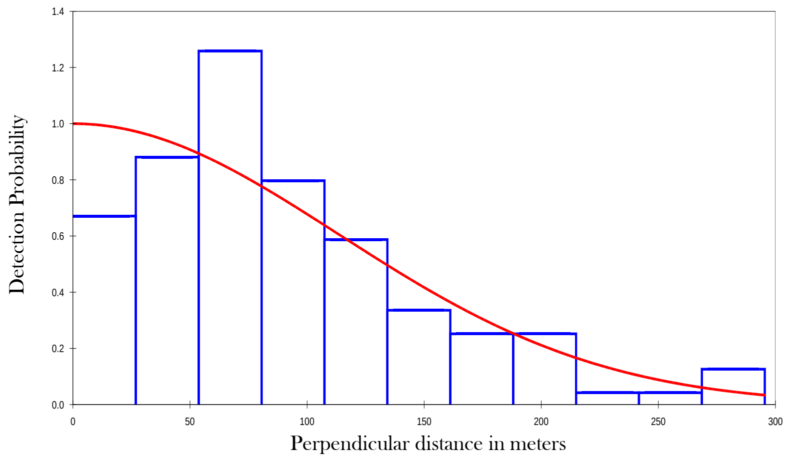
When employing Distance to estimate the density of these birds, several detection function models were tested, and the model that performed best was chosen for each species. The density results are presented in Table 1. The histograms illustrating how probability of detecting the bird species declines with increasing distance to the bird are presented in Figure 2a-c.

Table 1. Estimated density of the three most common bird species in Kuzikus and the distance 5.0 detection function model definition used to calculate the density.

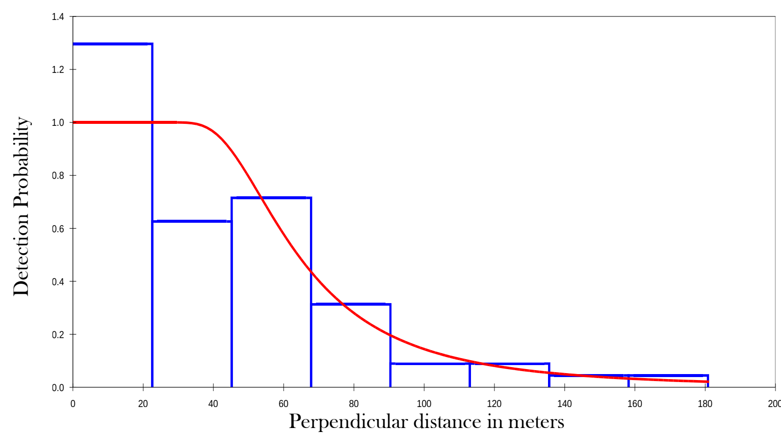
Species	Detection function model	Estimated density per km^2
Ant-eating Chat	Half normal cosine	8.876
Marico Flycatcher	Hazard-rate cosine	21.52
White-browed Sparrow-Weaver	Half normal cosine	53.34

Figure 2a-c. Histograms of perpendicular distances from bird to the line and fitted detection functions for a) Ant-eating Chat; b) Marico Flycather and c) White-browed Sparrow-Weaver.

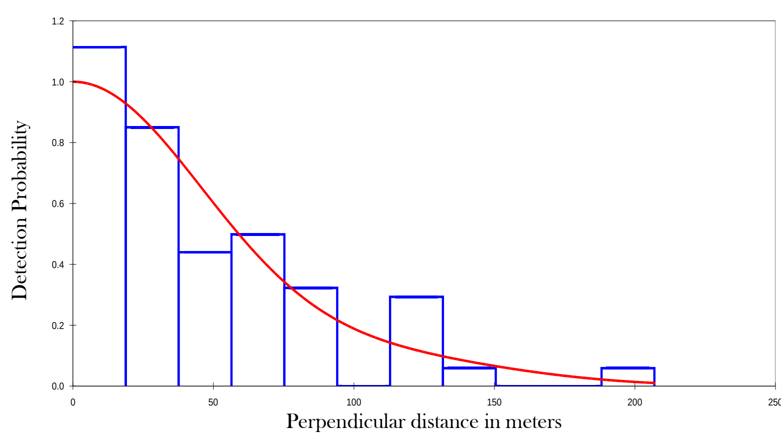
a) Ant-eating Chat



b) Marico Flycatcher



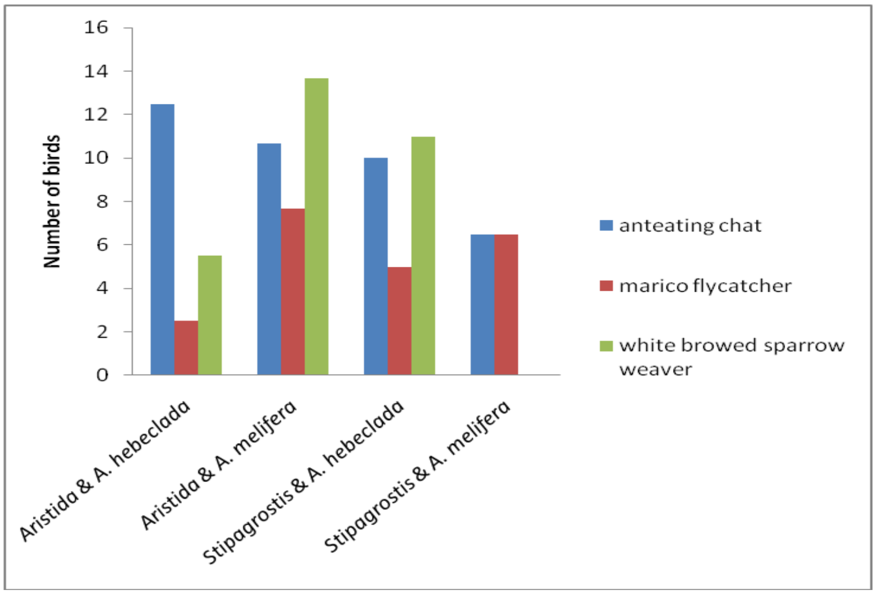
c) White-browed Sparrow-Weaver



The most common bird in Kuzikus is the White-Browed Sparrow-Weaver with an approximate population of 53 birds in each km^2, more than twice the density of the second most common bird, the Marico Flycatcher.

The habitat combination preferences of these three birds are shown in Fig. 2. None seem to show a strong preference. Although the the White-browed Sparrow-Weaver was never detected in the habitat where *Stipagrostis* grass grows with *A. melifera* shrub.

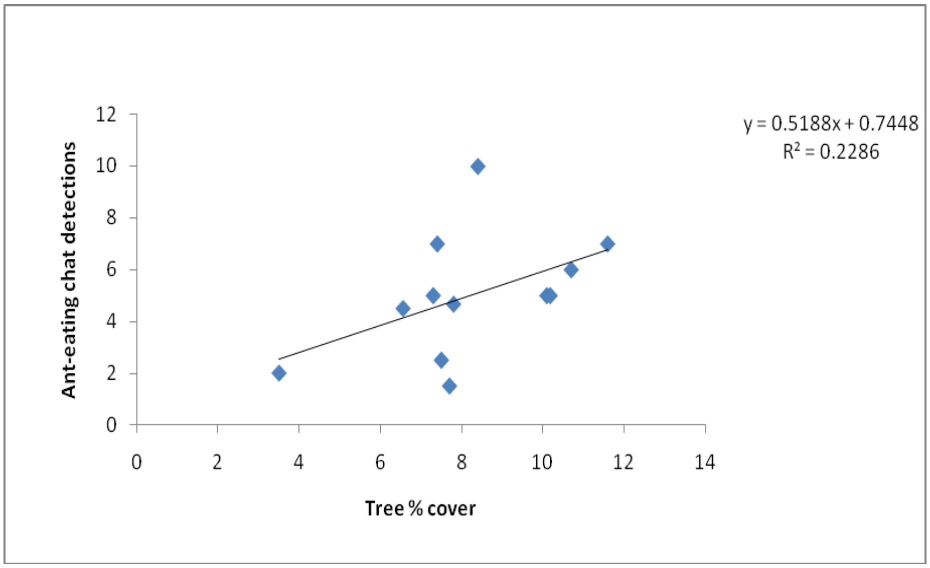
Figure 2. Habitat preferences of the three most abundant birds in Kuzikus.



The Ant-eating Chat was observed most frequently in *Aristida* grass with *A. hebeclada* shrub, though the preference does not appear strong. The Marico Flycatcher detections peak when the shrub species present is *A. melifera*, a denser shrub which tends to attract insects on which this bird may forage.

During data collection observers often noted the ant eating chat's behaviour as perched on tree tops. This observation was tested on the data using a Pearson's product moment correlation and a positive correlation between bird number and tree cover was found (r=0.48; Fig. 3).

Figure 3. Correlation between abundance of Ant-eating Chats and percentage tree cover.



Seven bird species were only noted once on transects, including the Lappett-faced vulture. As an IUCN red-list endangered species, it is valuable to have this bird in the dataset, though the data does not represent the true population of Kuzikus and is not sufficient for analysis.

Discussion and management implications

The results of this study are part of ongoing research into the fluctuations of bird numbers in Kuzikus, therefore data and results must not be considered conclusive to the region, only to this time period within the wildlife reserve. As an indicator of ecosystem health the large number of birds identified indicates high biodiversity in Kuzikus and generally healthy ecosystem functioning.

Density estimations of animals through distance sampling have previously been used in Kuzikis, to investigate the numbers of large ungulates (Springbok, Blesbok and Gemsbok) (Reinhard *et al.*, 2009). Soon after this study, an aerial count of large mammals was performed in Kuzikus and results were concurrent with the mammal numbers found through the distance sampling analysis (Reinhard *et al.*, 2009; *pers. comm.*, B. Reinhard). We therefore can consider that this method was reliable to use in Kuzikus' habitat and density estimate of bird species discussed are reliable. However limitations remain: many birds had to be recorded as flyovers, rather than with associated distances because the birds flushed as the observers approached. These birds were recorded as being present in the area, but could not be included in the distance analysis for density estimates. Vegetation structure and species' behavioural differences also puts a limit on bird detections, some species are shy and would hide deep in the vegetation.

The White-Browed Sparrow-Weaver being the most common bird is similar to results of the pilot study conducted in found in Jan 2009, where the bird was also frequently detected, though not the most abundant. The density of this Sparrow-Weaver at 53.34

birds per km^2 was possibly high as it is a sociable bird with flocks of sizes up to 20, sharing nesting tree sites. Bird nest placement is to the leeward side of trees, to enhance the usable life span of the nest, allowing year round breeding (Seigfried, 1989). This explains why despite the cold winter weather and strong prevailing winds, population of these birds was high even in winter time.

The ant eating chat is a territorial bird, singing year long to define its territory. This bird nests in disused aardvark holes but is often seen sitting on tree tops either singing or hunting for arthropod prey. The positive correlation with the tree cover in an area of Kuzikus and the number of chats recorded reflects this behavior. The distance analysis the histograms show that the Ant-eating Chat was not detected at a probability of 1 on the line (at distance zero), as it should have been. This may be a reflection of the nature of this bird's high perching whereby it was able to see the observers and move away before detection. This demonstrates the problem that birds' behaviour affect their detectability and hence the distance analysis. However the noted correlation between this Chat's density and tree cover has management implications in that it shows the need for high trees to remain in the reserve, without removal of standing dead wood which acts as ideal perches for the Ant-eating Chat.

It would seem that observers tended towards overestimation of the Marico flycatcher at close distances to the line as reflected by the distance histograms. As with the Ant-eating Chat, this observer error could be accounted for by the birds' behavior. These birds tended to be mostly in habitats dominated by *A. melifera*, a dense shrub which attracts insects on which the bird feeds. Marico flycatchers were mostly noted as foraging, flying up and down from shrub perches to food on the ground and back up. This behaviour could explain the overestimation of this birds' density as its constant movement can potentially cause confusion as to if a certain bird has already been recorded or not.

A link between habitat type and bird diversity has been demonstrated in this study. Taking grass or shrub species alone and investigating diversity differences yielded no large differences in bird diversity. However when the vegetation combinations were investigated, then bird diversity differences were found. From this we can infer that the mixed habitat type may also be of benefit to arthropods in the reserve, as a large diversity of birds can be indicative of a large diversity of prey species, and general high biodiversity (Pearson, 1995). In order to test the theory that Kuzikus' natural water bodies promote high bird diversity, the study should be replicated in neighbouring farms, where the only water sources are in contained dams. This could also confirm the need for mixed habitat vegetation for birds as surrounding cattle farms are usually dominated by one grass species, ideal for rearing cattle. This study highlights the importance of keeping a mixed vegetation structure in the reserve, to allow maximum habitat quality for the birds. Management of vegetation through controlling herbivorous game populations is essential for Kuzikus to maintain its unique habitat combinations to support bird life.

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