ORIGINAL RESEARCH

DIVERSITY, ABUNDANCE AND POPULATION STRUCTURE OF MONGOOSE SPECIES (FAMILY HERPESTIDAE) IN NECH SAR NATIONAL PARK, ETHIOPIA.

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ABSTRACT

Study of the carnivore guild is the key to understand quantitative relationship between members of the carnivore community. The aim of the study was to investigate diversity, abundance and population structure of the mongoose in Nech Sar National Park. Ecological data collection on mongoose species has been carried out from September 2017 to August 2018 in Nech Sar National Park (NSNP). Based on the habitat type and topography of NSNP, 10 transects, each of 4-5 km long were sampled to traverse the major habitat types in the park. Line transect distance sampling methodology was used to determine abundance and population status. DISTANCE (Version 6.0, Release 2) Software was used for density and abundance estimation of mongoose populations. The key to distance sampling analyses is to fit a detection function to the observed distances, and hence, the key functions hazard rate + hermite polynomial, unform + cosine polynomial and half normal + hermite polynomial models were chosen over the others on the basis of best fit. Three species of mongoose namely- Egyptian mongoose (*Herpestes ichneumon,)* Slender mongoose (*Herpestessanguineus)* and White tailed mongoose (*Ichneumiaalbicauda)* were identified in the study. The overall density of mongoose in the study area was 2.3048$\pm$0.16070 individuals/km^2 with population estimate of 943$\pm$85.593 individuals. Based on season and habitat type, density and abundance estimates showed variation ($P<0.05$). However, species composition between seasons and habitats was the same. The highest species diversity (H=1.197) was recorded in bushland habitat. The population was female-baised with 1:1.171 and 1:1.59, male to female ratio during wet and dry seasons, respectively. Adult to young (subadult and juvenile) ratio was1.05:1 and 0.94: 1 during wet and dry seasons, respectively. Further researches on other ecological parameters viz. behavior, feeding habit and activity pattern are important to acquire a complete picture about mongoose ecology in the park.

Key words: Density, Mongoose, Nech Sar National Park, Population structure, Species composition

Cover Letter

The manuscript entitled ‘’ Diversity, Abundance and Population Structure of Mongoose Species (family herpestidae) in NechSar National Park, Ethiopia’’ is an original work that has been carried out in one of the national parks in Ethiopia – Nech Sar National Park. The study used distance sampling method (i.e robust method to estimate absolute abundance of animal population) so as to estimate the population size of mongoose in the park The authors believe this work meets publication standard though it has be passed through the formal review process of the journal. The authors are quite aware of the journal reputability and that is why we are pleased to send the manuscript to the same.

1. Introduction

The distribution, diversityand population structure of an organism is primarily dependent upon the quality of the habitat forits survival, growth, and reproduction. Therefore, knowledge of ecology, physiology and systematic of the concerned organisms isvery essential. Animals vary widely in their tolerance to environmental conditions. Some casurvive in a variety of habitats, whereas others perish when removed from their natural surroundings. However, when this natural factor is disturbed by theanthropogenic factors that push the animals to exist outside of their range of tolerance, this condition leads them to dwindle to the point of extinction, if immediate conservation measure is not applied(Fetene,2011).

Researchers study animal distribution, diversity and population ecology to understand the spread of animal-borne diseases, to acquire knowledge about the preservation of rare species that may have special needs, and to be informed about the changinggeographical conditions, and our environmental history and its future(Fetene,2011; Mwangi and Western, 1997). Based on this understanding, this study was conducted to identify species evenness and richness; temporal and spatialpattern mongoose (Family Herpastidae) in the Nech Sar National Park (NSNP), which is a biodiversity hot spot in the Great Rift Valley system of Southern Ethiopia.

Due to its geographical isolation and wide variety of ecological environment, NSNP supports an impressive fauna viz. mammalian, avian, amphibian, reptilian and fish species. Some larger mammals are locally extinct; there are more than 90 species of larger and smaller mammals recorded in the diverse habitats of the park (Yisehak*et al*., 2007).

Mongooses are small-bodied, long, furry creatures with a pointed face and a bushy- tailed carnivores that their body length ranging from 34cm to 151cm, and body weight from 200 g to 5 kg. Majority are mainly carnivorous, feeding on invertebrates or small vertebrates, while some species are omnivorous (Gilchrist *et al.,* 2009). They are terrestrial and mostly diurnal, although some species, such as the marsh mongoose (*Atilaxpaludinosus*), white-tailed mongoose (*Ichneumiaalbicauda*) and Meller's mongoose (*Rhynchogalemelleri*), are crepuscular or nocturnal (Kingdon, 1997; Gilchrist *et al.,* 2009). According to Wozencraft (2005), the family herpestidae comprises 34 species from 14 genera, with only one genus (Herpestes) occurring in Asia. Molecular studies on the Herpestidae revealed the existence of two main clades: the true social mongooses, and the solitary mongooses (Veron*et al.,* 2004; Perez *et al.,* 2006).

Most species of mongoose are found in Africa, but some also live in southern Asia and the Iberian Peninsula. Mongooses occupy a wide range of habitats, from deserts to tropical forests, across their natural range in Africa and Asia (Kingdon, 1997).

Mongoose species which are widely distributed in Africa are the following: Ethiopian Dwarf Mongoose (Kingdon and Van Rompaey, 2013), Egyptian Mongoose (Yalden*et al.,* 1996), Marsh Mongoose (Baker and Ray, 2013), Jackson's Mongoose (Van Rompaey and Kingdon, 2013), , Black-legged Mongoose (Van Rompaey and Colyn, 2013), Sokoke Dog Mongoose (Taylor, 2013), Pousargues's Mongoose (Woolgar, 2014), Common Dwarf Mongoose (Creel, 2013), Black Slender Mongoose (Taylor, 2013), Long-nosed Mongoose (Van Rompaey and Colyn, 2013), Somali Sleder Mongoose (Taylor, 2013), Small Grey Mongoose (Cavallini, 2013), Slender Mongoose (Hoffmann and Taylor, 2013), Whitetailed Mongoose (Taylor, 2013), Liberian Mongoose (Goldman and Taylor, 1990), Gambian Mongoose (Van Rompaeyand Sillero-Zubiri, 2013), Banded Mongoose (Skinner and Chimimba, 2005), Selous's Mongoose (Stuart and Stuart, 2013), Meller's Mongoose (Stuart and Stuart, 2013), Yellow mongoose (Taylor, 2013), and Bushy tailed mongoose (Taylor, 2013).

However, despite the fact that many mongoose species occur in Africa, ecological studies on them are very scarce. Particularly in Ethiopian protected areas, except in few, such as Bale Mountains and Simen mountains national parks, studies on mongooses are finger counted. Therefore, the present study aimed to investigate the ecology of mongooses with major emphasis on their diversity, abundance and population status in Nech Sar National Park.

2. Materials and Methods

2.1 Study area

The study was conducted on Nech Sar National Park, found at a distance of 505 km south of Addis Ababa, the capital city of Ethiopia, in the Southern Nations Nationalities and Peoples Regional State. Astronomically it is situated between $5^{0}51^{'}$- $6^{0}10$'N latitude and $37^{o}32$’-37048’E longitude with altitude ranges between 1108 ma.s.l at Lake Chamo and 1650 ma.s.l at the peak of Geda hill (Alemu *et al*., 2016). NSNP covers a total area of 514 km^2 of which 436 km^2(85%)terrestrial ecosystems and 78km^2(15%)aquatic formed by Lake Abaya and Lake Chamo(Clark, 2010).

There are, two main river systems that flow through the park forming riverine forests and woodlands. Sermele River crosses north-south at the eastern part of the park along the grassy plains and Acacia woodlands and meets with Miyo River. The Kulfo River flows through the north of Arba Minch town and then cuts across the neck of the narrow land and ends in a swamp on the shore of Lake Chamo (Tamrat, 2001; Fetene 2019). The landscape of the park is a mosaic of savannah grasslands, hill scrublands, lakes, riparian and groundwater forest, woodlands, bush and thickets (White 1983; Duckworth et al. 1992). The groundwater forest and Kulfo riparian forest dominate the western part of NSNP and the Sermele riparian forest is found in the eastern part of the park along the Sermele River. Wooded bush land, thickets, hill areas and wide savanna plain of white grass are spread out between the evergreen ground water to Sermele riparian forest (Figure1).

The climate of the study area is characterized by a relatively hot climatic condition with low and unevenly precipitation distribution. The annual rainfall is bimodal with a long rainy season during March - June and a short rainy season during September - November. The mean annual rainfall is between 800mm and 1000mm (Getachew, 2007). The peak mean monthly rainfall is in April (159.7 mm). The hottest months of the year in the study area are January - March, while the cooler months are November and December. The mean annual maximum and minimum temperatures in the area are 31.05 °C and 16.22 °C, respectively(Alemu *et al*., 2016).

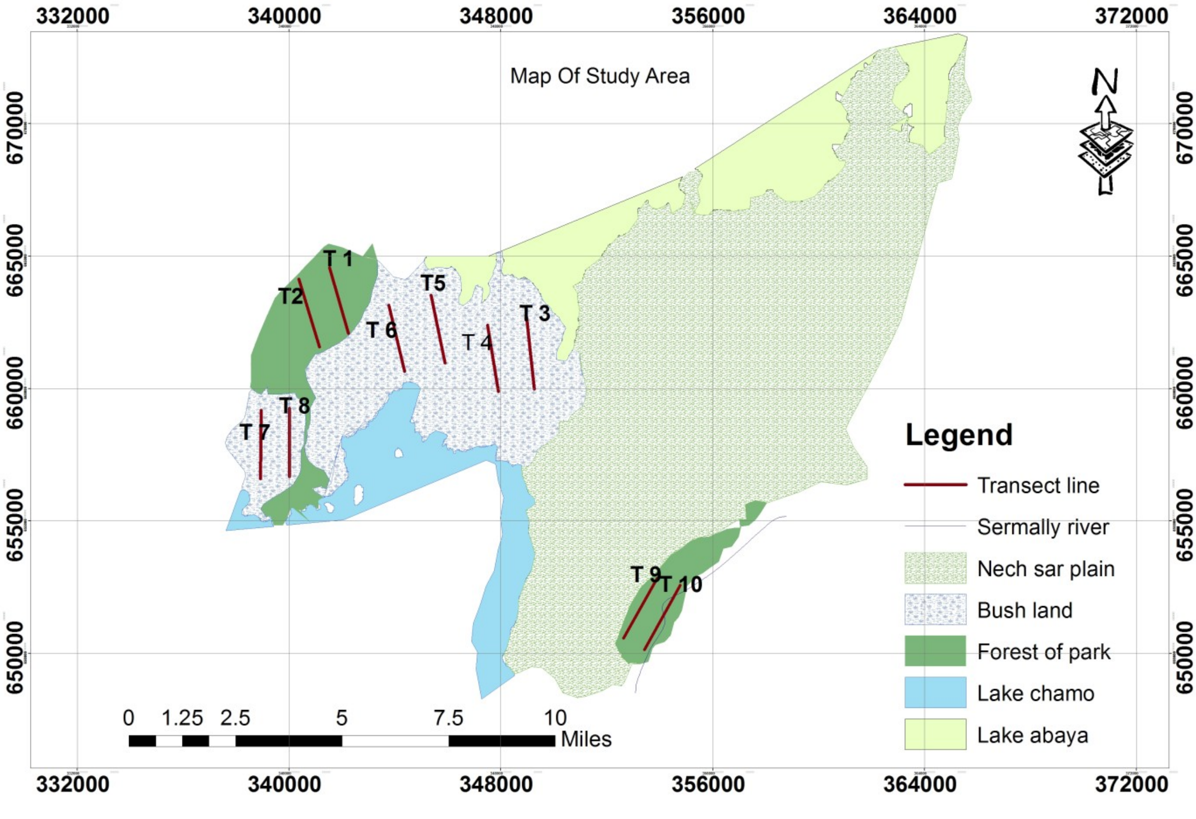

Figure 1 Map of the study area with distribution of transects

2.2Data Collection

Reconnaissance observations were made before data collection to acquire information onaccessibility, climate, vegetation type, topography, and other biophysical features of the study area. Trial transects were laid randomly based on representation of the main vegetation zones in the park; and trial transect runs were conducted to observe changes in the behavior of mongoose and to estimate detection distances in different habitats.

Based on preliminary survey and satellite images, the survey design, line-transect distance sampling methodology was used (Thompson *et al.* 1998, Buckland *et al.* 1993; Len *et al.* 2010). Based on the habitat type and topography of NSNP, ten transects, each of 4-5 km long were sampled to traverse the major habitat types in the park. Since mongoose avoid open habitat and no single individual has been located both by direct and indirect methods during reconnaissance survey, transects were not sampled from the grassland habitat of the study area (Abdel Fetah,2019;Ben-yakov and Yom-tov, 1983; Palomaresand Delibes,1992:1993). Hence, from the total potential transects of 17 and 16, in forest and bushland habitats, 4 and 6 transects were randomly selected, respectively (Table 1). To obtain a uniform coverage of the entire area and ensure that transects were randomly placed with respect to the types of habitat, transects were originated from a random point on the map of the study area.

Table 1: Number of potential and sampled transects in the study area

Habitat type	Number of Potential Transects	Number Of Sampled Transects	Length of each transect	% of Coverage
Forest	17	4	5km	23.5
Bush land	16	6	4km	37.5
Total	33	10		30.3

Intensive field work on ecological aspects of mongoose was carried out from September 2017 to August 2018. The data collection was carried out from September to Mid-December in 2017 and from March–May 2018 for wet season and, from Mid-December–February 2018 and from June–August 2018 for the dry season. Observation of the mongoose was carried out on each transect line laid at different habitats following Buckland *et.al* (1993). Transects were traversed on foot. The average speed for walking transects was 2.5km/h. All transects were visited bi-monthly during the data collection periods of both seasons. To enhance sampling effort, in a single visit, each transect was walked twice: 05:00–07:30AM and 05:00–07:30 PM.

During transect visit, researcher and one trained field assistant traversed the track lines. Both were assigned to the left or right side of the transect line and scanned the route with spotlight. Following Buckland *et al.* (1993), whenever mongooses were observed, group size, sighting distance (ri), sighting angle (θ) and perpendicular distance(x) were recorded on the data sheet. When mongooses were observed, vegetation or other obstacles hindered clear visibility,then the observer silently approached them by leaving the transect route; however the sighting distance was measured from the center line to the animals (Buckland *et al.,* 1993). The same transects were used to carry out census during the investigation period (Focardi *et al.,* 2002; Yisehak*et al.,* 2007). Double recording of the same individual or group in a single visit was avoided to the extent possible using easily recognizable features of individual mongoose, group size and composition (IUCN Canid Specialist Group, 2004). Since mongoose are dimorphic the male mongoose is larger than the female one (Ben-yakov and Yom-tov, 1983; Delibes *et al.,* 1983). Therefore, sex of individual has been identified using this morphological difference. Adult mongoose is larger than young in body size, body mass and general condition (Hollen and Manser, 2006) which has been used to identify between adult and young. The physical and morphological features of different species of mongoose such as color of fur,body length and tail length has been used to identify the species. In all spotlight surveys, no avoidance behavior (Buckland and Turnock, 1992) was observed. Data were collected using assumptions for line transects distance sampling, which was adopted from Buckland *et. al.* (1993).

2.3 Data analysis

DISTANCE (Version 6.0, Release 2) Software was used for density and abundance estimation of mongoose population. The key to distance sampling analyses is to fit a detection function to the observed distances, and use this fitted function to estimate the proportion of objects missed by the survey. All observations recorded from transects laid in a specific habitat were grouped together for analysis. Following Buckland *et al.* (2001), a variety of key functions and adjustment term combinations were considered to model the detection function (uniform + cosine or simple polynomial, half normal + cosine or simple polynomial, hazard rate + cosine or hermite/simple polynomial). And finally, the key functions hazard rate + hermite polynomial, unform + cosine polynomial and half normal + hermite polynomial models were chosen over the others on the basis of best fit (i.e., minimum AIC value). Hence, density of mongoose groups within the area surveyed (Dg) was estimated as (Buckland *et al.*, 2001)

$$Dg = \frac{nf(0)}{2L},$$

where L denotes the aggregate length of the transects, n is the number of mongoosesgroups observed and $f(0)$ is the probability density function of observed perpendiculardistances evaluated at x = 0. Thus, density estimates were obtained from the estimates of $f(0)$ and encounter rate $n/L.f(0)$ equal to 1⁄μ, where μ is the effective stripe half-width, corresponding to the perpendicular distance from the transect line within which the number of undetected groups is equal to the number of groups detected beyond it. Multiplying double the effective stripe half-width by the aggregate length of transects yields the effective area surveyed. Mongoose density (D) was obtained by multiplying the estimated group density by the estimated expected group size E(s). The density of individuals was multiplied by the total area of the study area or survey stratum to obtain the corresponding abundance estimate (N).

Analysis of species diversity was made using Shannon- weaver diversity index(Shannon and waever,1949). Shannon- weaver diversity index was calculated as:

H’= -∑(pi Ln pi) where :

H’= Shannon- waever Index

Pi= proportion of i^{th}species

Ln= Natural logarithm

Species which measures the pattern of the distribution of mongoose population present in the park, was evaluated using Shannon- waever evenness index(E) as follows:

E= H’/ HMax   where

E= shannon- waever evenness index

H= shannon- waever diversity index

Hmax=lnS= Natural logarithm of total number of species (S) in each month (Tramer,1969)

Moreover, datacollected during the study period were analyzed using SPSS Software (Version 22.0) statistical program to obtain the population structure of mongoose in NSNP. Chi- square test was used to investigate the effect of season and habitat on abundance of mongoose. Data were presented descriptively using graphs, charts, tables and figures.

3. RESULTS

The study covered bushland and forest habitats of the study area which was a total of 148.37 km^2; bushland80.87 Km^2 and forest 67.5 Km^2.The transect visit applied to both habitats was the same (n=48), and the number of sighting mongoose species was not statistically significant ($\chi 2$ = 2.907, d.f. = 1, p > .05). Although thetotal number of sightings during the whole study period was more than the present report, only 728 sightings which were not violated the assumptions of Buckland *et al.* (1993) were used for the analysis. Of these, the highest record was in bushland (53.16%, n =387) followed by forest (46.84%, n=341)

3.1 Density and Abundance

The population density of mongoose in the study area was 2.3048±0.16070 individuals/km^2 with estimated detection probability (p) of 0.41946±0.22821E-01 (%CV: 5.44 and 95% CI: 0.37686-0. 46687) (Table2, Figure, 2). Between seasons, mongooses were found at different densities as 1.8686±0. 16228/ km^2 and 2.8509+0.28408/km^2 during dry and wet seasons, respectively. On the other hand, overall abundance/population estimate of mongoose in the study area 943±85.593 individuals. This has varied between seasons as 726±91.305 and 1254±157.01 individuals during dry and wet seasons, respectively (Table 3). In general, there was significant variation in both density and abundance of mongoose population betweenseasons ($\chi 2$=1.440E2ap< 0.05) population size of mongoose (family herpaestidae) was 943±85.593 individuals with 95% confidence interval.

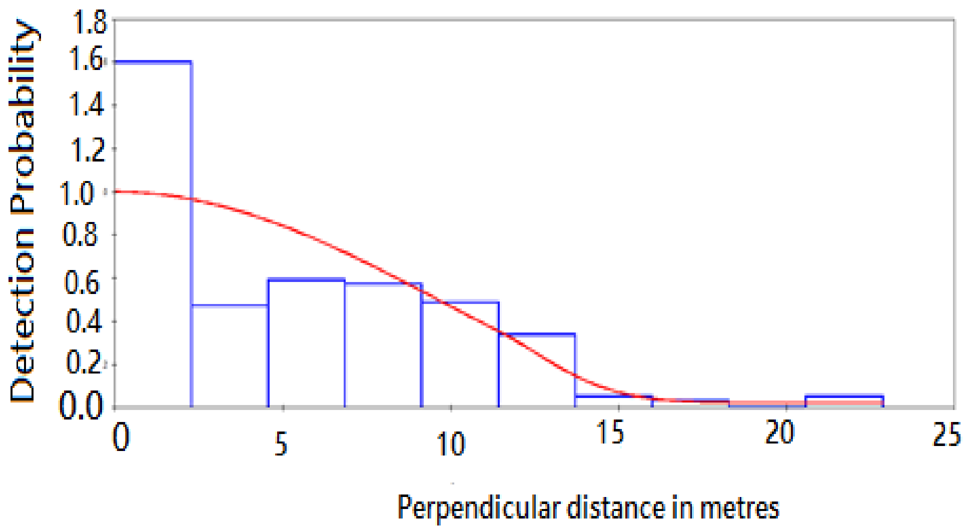

Figure 2 Number of sightings of mongoose species at different distances from the transect centerline in Nechi Sar national park (detection function is hazard rate with hermite polynomial adjustments).

The density estimate in forest habitat was D ± S.E. = 2.3887± 0.24056 mongoose km-^{2} (%CV: 10.07and 95% CI: 1.9175-2.9756) and estimated total abundance, N ± S.E. was 424 ± 56.203 (%CV: 13.26 and 95% CI: 324- 555) for the entire area of 67.5 km^2 (Table 4; Figure,3). On seasonal basis, the density and abundance of mongoose were 1.9424±0.32287/ km-2, 298±63.409 and 2.5863 ±0.28306/km-2, 528±83.333 during dry and wet seasons, respectively. Both abundance and population density of mongoose in the forest habitat were higher during wet season than dry season ($\chi 2$= 77.543a p< 0.05).Unlike in the forest habitat, density estimated in bush land habitat was higher, D + S.E. = 2.5890± 0.22003mongoose km-2 (%CV: 8.5 and 95% CI: 2.1667-3.0936). Consequently, estimated total abundance, N ± S.E. was 607 ± 70.396 (%CV: 11.6 and 95% CI: 481-764) for the entire area of 80.87 km2 (Table 4; Figure, 4). Regarding season, the density and abundance of mongoosein the bushlandwere 3.0274±0.47563 individuals/km-2, 735±137.46 and 1.9666 ±0.22867 individuals/km-2 ,469±80.971 during wet and dry seasons, respectively. There was significant variation between seasons in both density and abundance in this habitat (x^2= 58.767ap< 0.05).

Table 2: Overall density and population estimate of mongoose population in Nech Sar National Park

Parameter	Estimation	Standard Error	95% CI	% CV
Probability Of detection(P)	0.41946	0.22821E-01	0.37686-0. 46687	5.44
Density (D)	2.3048	0.16070	2.0044 - 2.6501	6.97
Population (N)	943	85.593	788- 1128	9.08

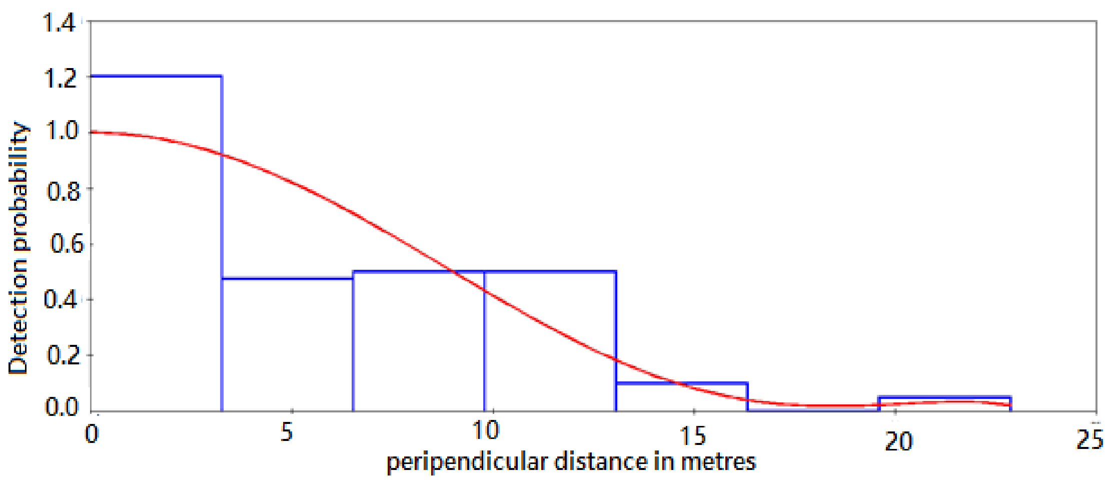

Figure 3 Number of sightings of mongoose species at different distances from the transect centerline in forest habitat (detection function is uniform with cosine polynomial adjustments)

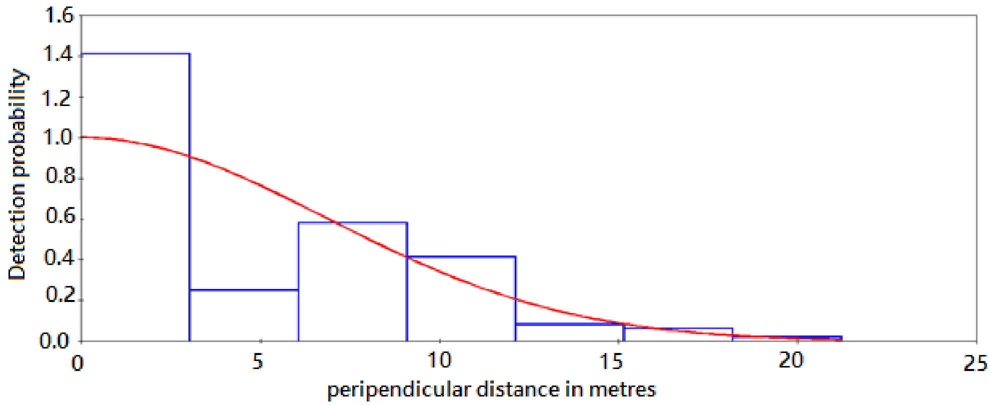

Figure 4 Number of sightings of mongoose species at different distances from the transect centerline in bushland habitat (detection function is half normal with hermite polynomial adjustments).

3.2 Population Structure

Of the total number of 728 individual mongooses identified during the study period, 122 (34%) were adult males, 162(45%) were adult females, 75 (20.9 %) were adult unidentified sex, 84(11.5 %) were sub adults and 285 (39.5%) were juveniles. On seasonal basis, adult male 76(36.7%) and 46 (30.3 %), adult females 89 (43 %) and 73 (48%), unknown sex 42(20.3 %) and 33(21.7 %), sub adult 65 (16.1%) and 19 (5.8%), and juvenile 131(32.5%) and 154 (47.4%) during wet and dry seasons, respectively (Table 5).

The adult male to adult female sex ratio was 1:1.171 and 1:1.59, during wet and dry seasons, respectively. Alternatively, adult to young (subadult and juvenile) ratio was 0.94:1 and 0.87: 1 during wet and dry seasons, respectively.

3.3 Species Composition and Diversity

In the present study, 3 species of mongoose namely- Egyptian mongoose(*Herpestes ichneumon)*, slender mongoose (*Herpestessanguineus*) and white tailed mongoose (*Ichneumiaalbicauda*)

those belong to family herpastidae were identified which is comparable to many global studies (Abdel Fetah,2019). Of the total 728 individuals identified, 70.47% (n=513) were Egyptian mongoose*(Herpestes ichneumon)* followed by slender mongoose (*Herpestessanguineus*) 20.88% (n=152), and white tailed mongoose (*Ichneumiaalbicauda*) 8.65% (n=63). During the study period, all the three species of mongoose were observed in both forest and bushland habitats with different abundance estimate (Table 5).

The species diversity and evenness was higher in wet season (H' = 1.156, E=0.596) than in dry season (H= 1.096, E= 577).The highest species diversity (H'=1.211) was observed in the bushland habitat during wet season followed by forest habitat during dry season (H'=1.191) and forest habitat during wet season (H'=1.084). Furthermore, the highest species evenness was observed in the bushland habitat during wet season (E=0.621), followed by forest habitat during dry season (E= 0.62) and forest habitat during wet season (E=0.567). The lowest species diversity (H'=0.965) and species evenness (E=0.526) were observed in the bushland habitat during dry season. In the perspective of habitat the highest species diversity is recorded in the bushland (H=1.197) than forest (H= 1.07).

Other Observed Animals

During the study period other carnivores were observed in the study area. Among these:- Spotted hyena (*Crocuta crocuta)*, Caracal (*Felis caracal*), African civet (*Civetticitiscivetta*), Leopard (*Panthera pardus*), Serval cat (*Felis serval*), Cheetah (*Acinonyx jubatus),* Lion (*Panthera leo),* Black backed jackal (*Canis mesomelas*), Common/golden jackal (*Canis aures*), and Honey badger (*Mellivora capensis)* were frequently observed.

4. Discussion

4.1 Density and Abundance

Distance-sampling data analyzed using the program DISTANCE provided estimates of density of mongooses with good precision. According to White *et al.,* (1982) precision, as measured by Coefficient of variation (CV), need to be lower than 30% for distance-sampling estimates. Particularly, CV<20% is highly recommended for estimates of density while the program distance is used.

The overall density of mongoose in the study area was 2.3048$\pm$0.16070 individuals/km^2 (%CV: 6.97) with population estimate of 943$\pm$85.593 individuals (%CV: 9.08). As compared to similar studies in different parts of Africa and Europe, the density estimate in the present study was lower. For instance, Joseph and Michael (1998) has estimated 950 individuals/Km^2 in Antigua, West Indies by following the same method used in the present study. The low-density estimate in the present study might be attributed to reduced prey base and human interference. Low mammal densities may be related to several factors that are known to limit mammal densities such as rainfall amounts and patterns (Coe *et al.* 1975) and human pressure (Bonnington*et al.,* 2007). However, some other studies such as Maddock (1988) and Palomares and Delibes (1992) estimated, 2.4individuals/Km^2 and 2 individuals/Km^2 in Vernon Crookes Nature Reserve (South Africa) and Spain, respectively and these estimates are relatively close to the present study finding (Table 6). In general, habitat structure, anthropogenic pressure, prey availability, type of method used, climatic pattern and so on might be reasons for varied density estimates of mongoose at different regions.

Regarding season, there was variation on density of mongoose in the study area. It was higher during wet season (2.8509$\pm$0.28408). During wet season it is expected that the prey availability for mongoose would increase along with good vegetation cover. Higher ground cover provides safety to the small mammals, which explains higher abundance (Serekebirhan*et al.,*2011). Thus, mongoose population would also markedly increase as compared to during dry season. Waser*et al.* (1995) mentioned that in mongoose population, young are usually born during the wet season, which coincides with a peak in the abundance of prey species. According to Sinclair (1977), correlation between population densities and rainfall levels has often been accepted as evidence that the populations are food-limited. Rodents and other small mammals are the main diets of mongoose (Cavallin and Nel, 1990). Different investigators suggested that vegetation cover; climate, food abundance, food quality and predation are the major causes for rodent population fluctuations (Demeke*et al.,* 2007; Serekebirhan*et al.,*2011). On the other hand, it is assumed that mongooses are prey to other large carnivores in the study area such as Spotted hyena (*Crocuta crocuta)*, Leopard (*Panthera pardus*), Cheetah (*Acinonyx jubatus)* and Lion (*Panthera leo).* Accordingly, during wet season prey preference for these large carnivores might increase and this presumably lessen predation pressure on mongooses.

The distribution of mammals and their diversity is highly associated with habitat types (Meseret, 2010). In the present study, there was high density of mongooses in the bushland habitat (2.589±0.22003) than the forest. This might be due to the fact that prey availability and abundance in the former habitat is higher. Demeke*et al.,* (2007) has mentioned that there is high abundance of rodents in bushland habitat than in forest habitat of the study area. Similarly, Emmons (1984) explained that there is high density of rodents in bushland areas, which are near or adjacent to rock hills. Besides, the forest habitat of the study area is highly subjected to human disturbance. To make the impact worse, most fuel wood collection activities in the forest are conducted during night time which is suitable time for mongooses' activity. Hence, there might be migration of mongoose population towards the bushland habitat that provides them good shelter and protection. Furthermore, the forest habitat of the study area is almost devoid of ground vegetation that might expose mongooses for predation at ease. AsAbdul fetah(2019) stated that, disturbed habitat have had a marked impact on the on the mongoose aundance. Meseret (2010) stated that bushland is relatively more stable habitat than open grassland and open ground forest habitats.

4.2 Population Structure

The knowledge of sex ratio and age distribution among the mammalian populations is vital for evaluating the viability of the species as these variables reflect the structure and the dynamics of population (Wilson *et al.,* 1996). Sex and age structure of a population at any given point of time are also indicators of the status of the population. In the present study, the adult male to adult female sex ratio was 1:1. 171 and 1:1.59, during wet and dry seasons, respectively. Similar to other carnivores, morphologically, female mongooses are smaller than males and this difference was used as one criterion to identify sex during the study. Inspite of the fact that the expected ratio of males to females is 1:1 (Hoagland *et al.* 1989), in the present study, mongoose population was female-baised. Similar studies have been reported from different regions such as 1: 1.8 in south western Spain (Palomares and Delibes, 1992), 1:2 in Poerto Rico caborojo (Johnson *et al,* 2016). Unlike the finding of the present study, Palomeres (1990) mentiond that male mongooses had as rule, larger home range and higher area of core areas, and thus, they have higher probability to be observed as compared to females. Similarly, Gorman, (1979) and Buskirk and Lindstedet (1989) study revealed that female-baised population in carnivores is a rare situation. Although a bias in one sex being more observation shy than the other could result in sex being an important covariate on encounter rates, this does not appear to be the case with mongooses because of the inconstant trend in the sex ratios. Therefore, as Hays and Conant (2003) revaled the factor might be sex-specific factors, such as breeding and maternal behaviors, affecting movement and home range size and ultimately affecting the encounter rate of males and females.

With respect to age structure, adult to young ratio in the present study was1.05:1 and 0.87: 1 during wet and dry seasons, respectively. The average age ratio was 0.97:1 (Adult to Young). Relatively, higher adult to young ratio during wet season might reflect the breeding season of the mongoose population in the study area. Pups start traveling with their mothers when they are about 6-weeks of age (Hays and Conant, 2007). Pups emerge for the first time between 4–6 weeks, and start foraging with their mother 6–9 weeks after their birth (Graw and Manser, 2017). Moreover, according to Waser*et al.,* (1995), young are born during the wet season that coincides with a peak in the abundance of prey items.

4.3 Species Composition and Diversity

In the respective of habitat, the highest species diversity was recorded in the bushland (H'= 1.197) than forest (H'= 1.07). The occurrence of higheist species diversity (H=1.197) in the bushland habitat is an indication that the habitat is relatively undisturbed by human activity and hence it provides sufficient ground cover/shelter and prey preferences to mongoose populations. According to (Mugatha, 2002), good vegetation cover, foliage and availability of food in a typical habitat favor high species diversity. The study that has been carried out in the forest habitat of the present study area has also revealed that due to the homogeneous vegetation that is dominated by few species of trees as well as openness of the underground habitat resulting in shortage of cover, food and diversity of microhabitat, rodent's species composition and diversity is very poor (Demeke*et al.,* 2007). The tendency of mammals to favor one habitat over the others following the change in the abundance and quality of resources is also reported in different studies (Smith, 1992; Mekonen*et al.* 2011; Yimer and Yirga, 2013).

In conclusion the effective management of animal species is greatly improved by the accurate knowledge of population structure, distribution and abundance. Hence, density and abundance are the essential ecological information required for population ecology.Mongooses are one of the medium-sized carnivores reside in park. In the present study, a total population of 943 mongooses with overall density of 2.3048/Km^2 was estimated. Therefore, the population status of mongoose in the study area is above minimum viable population. Season and habitat types were factors for varied density and abundance estimates. Thus, the estimates were higher in bushland habitat during wet season. As the bushland has good vegetation cover and relatively undisturbed, it is expectd to host large number of mongooses in the study area. The occurrence of the same species composition in both habitats refelect mongooses are habitat generalist. The female-baised sex ratio in the present study indicates that more females were being observed during the study period. This might be due to sex related factors such as breeding and maternal behavior. Increased number of youngs in the average age ratio indicates that the population is growing.

Based on the findings of the present study, the following recommendations are forwarded:-Regular assessment and monitoring of nocturnal carnivores in the park is crucial to know their population status, other ecological aspects of mongooses such as feeding habit, activity pattern, breeding, and so on should be studied in order to make the ecological information about the species complete and this study will be base line for other scholars those interested to work similar research's in other protected areas of the country, Ethiopia as well.

CONFLICT OF INTEREST

No conflict of interest

AUTH O R S ' CO NTRI B UTI O N

Matewos Masne and SerekebirhanTakele conceived the study. MatewossMasneconducted fieldwork, analysis and write the manuscript.SerekebirhanTakelesecured funding and permits, edited the manuscript and revised the final version.

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DATA AVAILABILITY STATEMENT

All data collected during studying Diversity, Abundance and Population Structure of Mongoose Species are available and included within the article.

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