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Diversity of Large and Medium Sized Mammals and Their Challenges in Abay (Blue Nile) Gorge in the Amhara Region of Ethiopia

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Abstract

The diversity and threats of medium and large-sized mammals was studied in Abay (Blue Nile) Gorge, Amhara Region, Ethiopia using direct and indirect survey techniques on transect lines crossing natural forest, riverine forest and woodlands. Footprints, camera traps and group discussions were used. Data were analyzed using detrended correspondence analysis, cluster analysis, non-metric multidimensional scaling, and diversity indices. A total of 25 medium and large mammal species belonging to 6 orders and 12 families were recorded. Order Carnivora was the most abundant followed by Artiodactyla, whereas Tubulidentata, Lagomorpha and Procaviida were rare. Leopard is threatened species. The plotting of the detrended correspondence analysis between mammal species and districts showed 61% on axis 1 and 22% on axis 2 and Gozamin district stood at the left side of the plot and Andabet, Enebise Sar Midir and Borena at the extreme right, contributing to the observed association. The mammal species were found lined up along axis 1, where *Lycaon pictus* and *Reducna redunca* were closely associated to Gozamin. The cluster analysis based on the Bray-Curtis single linkage similarity index showed differences and similarities between the mammals species composition recorded in the six districts. *P. anubis*, *C. pygerythrus*, *S. grimmia*, *O. oreotragus*, *G. genetta*, *P. pardus pardus*, *H. hyaena*, *G. sanguinea*, *H. brucei*, *P. capensis*, *H. cristata* stood out clearly separated from the rest of them and showed linkage at almost 50% similarity. The highest similarity (at about 96% similarity) was a cluster of four species, i.e., *T. sylvaticus*, *T.strepsiceros*, *S. scrofa* and *K. ellipsiprymnus*. Non-metric multidimensional scaling also gave clusters of similar districts but not mammal species. Species diversity (H′) ranged from low (1.1) to average (1.9). Anthropogenic impacts were associated with decline in abundance of species and populations. Conservation schemes (nature reserves) need to be launched as soon as possible.

Keywords: Mammals; Diversity; Anthropogenic impacts; Abay Gorge; Ethiopia

Introduction

Ethiopia, located in the Horn of Africa, enjoys a wide variety of topography, diverse sets of ecosystems ranging from humid forests to extensive wetlands, to deserts, thus supporting a wide variety of life forms **(EWNHS,1996; Viveropol,2001]).** Altitudes range from 116 m below sea level in the Afar depression to the highest peak of 4653 m above sea level (m asl) at Mount Ras Dashen. The topographic diversity resulted in variations in rainfall, humidity, temperature, and soils and through them life forms. Ethiopia harbors six of the world's major terrestrial biomes (alpine, coniferous forests, deciduous forest, tropical rain forest, savanna and desert). The wide ranges of altitudes give a variety of ecologically distinct climatic zones, i.e., tropical, subtropical and temperate zones that diversify endemic species.

The elevation of the Amhara region is also diverse, the lowest point found in the northwest of the region, i.e., Metema in West Gondar at about 500 m altitude and the highest point at Mount Ras-Dashen. About 73% of the region constitutes the highlands (> 1500 m asl) and 27% lowlands (< 1500 m asl). The Amhara region is one of the naturally most endowed regions in Ethiopia.

Globally, Class mammalian consists of 5,487 species and in Africa more than 1150 species (Borges, *et al.,* 2014). More than 320 mammals exist in Ethiopia, 36 of them endemic and 60% medium and large-sized (Alemneh, (2015); Rabira *et al*., 2015). Large−sized mammals weigh more than 7 kg and medium-sized ones weigh between 2 and 7 kg. Over 50 mammal species, 5 of them endemic, i.e., Walia Ibex, Gelada Baboon, Ethiopian Wolf, Menelik's bushbuck and Starck's hare are found in the Amhara region. Despite the rich diversity, anthropogenic and natural factors severely threaten their survival.

The Amhara Region in general and Abay Gorge in particular are believed to have been covered by extensive forests in the past. Currently, the remnant forests are threatened by high population pressure, over-grazing, expansion of investment, agriculture, and deforestation (charcoal production, firewood), construction, mining, and climate change. To date, the diversity of mammals is declining at an alarming rate because humans took possession of the resources of mammals and never conserved them.

Materials and methods

Description of the study area

The diversity, relative abundance and habitat association of medium and large-sized mammals were studied in Abaye Gorge, five administrative zones and six districts (six kebeles) through a line transect survey (Table 1). These districts were chosen because parts of their areas lie within Abay Gorge, which in some places is desolate and inaccessible to people and harbors wild animals. Annual total rainfall in the study area is more than 1000 mm, average temperatures range between 10 and 19 °C, altitudes between 900 and 3700 meters above sea level (m asl), and vegetation cover is 12 to 15% (Table 1).

In the central Ethiopian highlands, we find Abay Gorge (or Blue Nile Gorge), which rivals the Grand Canyon in the USA, is a Gorge created by the Blue Nile River itself. The river has incised the highland about 1.5 km deep vertically. The distance from the river bed to the flat area to the top (plateau) where the incision ends is about 10 km on both sides of the river. Much of the Gorge is impenetrable and could be home to some of the mammals. Geologically, the Gorge is made by thick stratified Mesozoic sedimentary rocks overlain by a series of basaltic lava flows (**Japan International Cooperation Agency, 2012**). The vegetation of the Gorge includes dry evergreen Afromontane Forest and grassland and the Combretum-Terminalia woodland **(Kerato, 2014).** The inhabitants of the area rely on natural resources the area provides for their livelihood such as crop production, animal husbandry and charcoal making.

Table 1 physiographic characteristic of study districts in the Amhara region of Ethiopia.

District	Administrative Town	Zone*	Total annual rainfall (mm)	Average annual temperature (°C)	Altitude range (m asl)	Vegetation cover (%)
Andabet	Wolesh	SG	1250	12	900 – 2500	12.4
Ayehu Guagussa	Azena	Awi	1200	16	1301– 2300	15.0
Borena	Mekane Selam	SW	1200	10	1100 – 3700	13.2
Bure Zuria	Bure	WG	1200	18	1300– 2500	14.9
Enebise Sar Midir	Mertule Mariam	EG	1050	16	1500 – 3350	14.7
Gozamin	Debre Markos	EG	1255	19	900 – 2640	15.4

*SG stands for South Gondar, SW for South Wollo, WG for West Gojam, and EG for East Gojam.

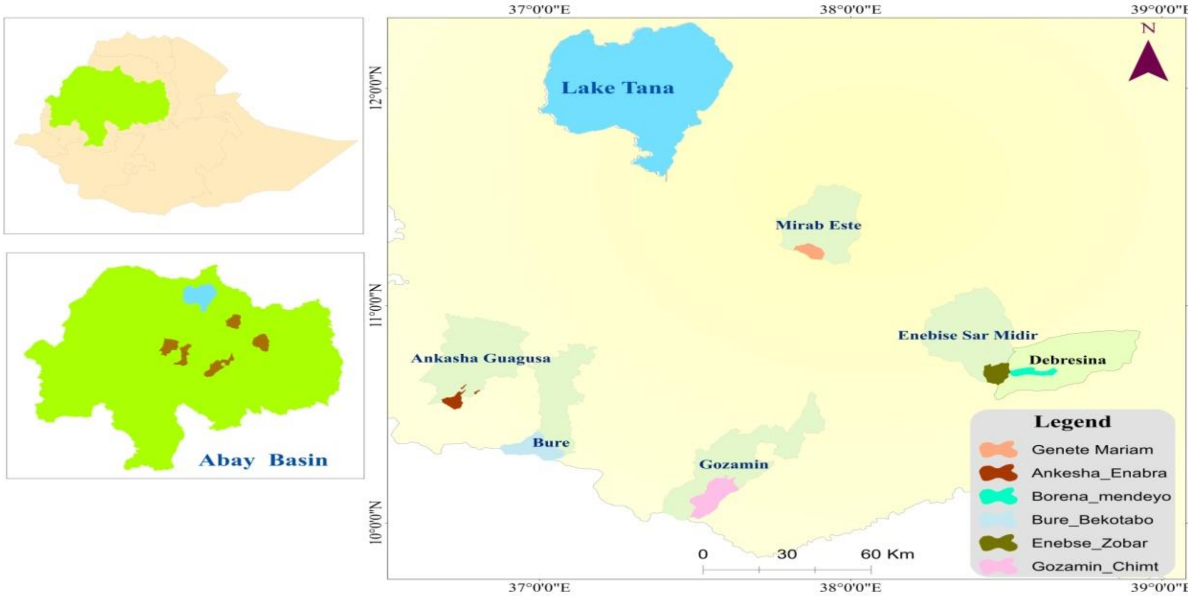

Figure 1 Map of the study area (source from Google Earth)

Materials

Digital camera, 10 × 40 binoculars, Bushnell camera traps, geographic positioning system (GPS), tape measure, field tent, field guidelines, data sheets, topographic map and mammal guide books were used during the survey **(Stuart & Stuart, 2006).**

Data collection methods

Preliminary reconnaissance survey was conducted in the first week of June, 2020 to choose sites for this investigation. During that time, the areas were directly observed and the local people and district experts in wildlife consulted to help choose study sites. Because the study area was heterogeneous in vegetation type and topography, it was stratified into three vegetation zones, i.e., riverine forest, woodland and natural forest.

Transects were established and each marked by global positioning system (GPS) **(Roberts, 2011).** The length of the transect lines varied from 1.5 km to 2 km and a width from 150 m to 300 m based on vegetation cover and topography of the study site. Sixty-three line transects were established.

Several methodologies are currently used for the survey of medium and large-sized mammals. The most commonly used methods are camera traps, direct observation using binoculars and naked eyes, transect walking, indirect surveys (including fresh tracks, feces, hair, horns, and burrows), digging, and interviews with key informants using guidebook with pictures of field guide to African mammals (Kingdon, 2014). Animal tracks were searched in established line transects (Varman & Sukumar, 1995).

Six camera traps were used. This method is widely used in research of medium and large-sized mammals (**Srbek-Araujo & Chiarello, 2007**). Bushnell camera traps (Trophy Cam HD 2012 model) was deployed for a total of 1 trap night (6 cameras). Cameras were placed in a semi-structured way, aimed to observe medium and large terrestrial mammals. Most cameras were placed in riverine forests that are assumed to be frequently visited by mammals such as drinking water. Counting was conducted twice a day, i.e., early in the morning (6:00 to 10:00 AM) and late afternoon (4:00 to 6:00 PM) when most mammals were more active (**Meseret, & Solomon, 2014).** Qualitative and quantitative data were collected.

Sample size and sampling techniques

The study was carried out in five zones of the Amhara region, six districts, and six kebeles (communes) corresponding to the districts (Table 1). The kebeles were randomly selected that bordered Abay Gorge. The kebeles were 019 Wondeye in Borena, 028 Zebere in Enebise Sar Midir, Chemete in Gozamin, Bekotabo in Bure Zuria, Enabara in Ayehu Guagussa and Gatamariam in Andabet. Samples were taken from different census zones based on the vegetation cover (riverine forest, woodland, and natural forest).

Data analysis

Descriptive statistics was first employed to show mammals with respect to habitat, district, and body weight.

Ordination analysis using detrended correspondence analysis:- A statistical visualization method known as detrended correspondence analysis (a modified form of correspondence analysis) was used for picturing the association between the levels of two-way contingency tables. In a two-way contingency table (count data), the observed association of two traits is summarized by the cell frequencies, and a typical inferential aspect is whether a certain level of one characteristic is associated with some level of another. The technique displays the rows and columns of a two-way contingency table as points in a low-dimensional space. In the current case, detrended correspondence analysis was invoked with butterfly species in rows and their habitats, study locations, or sampling dates in columns using PAST 4.03 software **(Hammer, 2001).**

Cluster analysis:- Hierarchical grouping of multivariate data set (26 mammal species) and eight districts, which shared part of Abay Gorge, was conducted for the cluster analysis. The hierarchical clustering produces a dendrogram of data points (rows). Taxa were assigned in rows and districts in columns. The single linkage (nearest neighbor) algorithm was adopted. Then the distance matrix was computed by using Raup-Crick index because this was suited for presence-absence data [15].

Non-metric multi-dimensional scaling (NMDS):- Non-metric multidimensional scaling with Bray-Curtis distance measure was also used to investigate patterns in the mammal community. NMDS is a robust unconstrained ordination method commonly used in community ecology

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studies **(Harper, 1999).** It runs on a distance matrix (or a matrix of dissimilarities) and presents pairwise dissimilarities between objects – in our case districts where the study was carried out or mammal species recorded- (given by their rank order) in a low-dimensional space as defined before by *(Borcard et al., 2011)*. NMDS diagrams keep districts with similar species composition close to each other, and those with less similar species further apart. The fit of the data is assessed by the stress value – the lower the stress value the better the fit, and values larger than 0.3 indicate a poor fit (Zuur, *et al.*, 2007). The NMDS was performed on presence/absence data of each species at each district using PAST 4.03 software **(Hammer, 2001).**

Diversity indices:- Mammals observed were tallied in accordance with family name and the Order they belonged to and with respect to the district where they were found and their body weight range. Shannon-Wiener Index was used to determine the diversity of various mammalian species of the study area **(Shannon, and W. Weaver, 1949)**. Shannon-Wiener diversity Index is denoted by $H' = -\Sigma$ (pi ln pi). Species evenness, J, which represents the distributional patterns of mammals, was also computed using Shannon's equitability formula, i.e., by dividing H' by H_{max} (here $H_{max} = ln(S)$). Equitability assumes a value between 0 and 1 with 1 being complete evenness, where H′ is observed index of diversity, H' max = $ln(S)$, S = the number of species in each habitat, and ln = Natural logarithm **(Dereje, 2015**). Mammals were categorized based on IUCN (International Union for Conservation of Nature and Natural Resources) Red List criteria, which resulted in the status of each species. They were also grouped into medium- and large-sized mammals.

RESULTS

Mamma species occurrence

Overall, through visual observation, camera trapping, interview and indirect signs, 25 medium-and large-sized species of mammals were recorded, distributed among 12 families and 6 Orders during the study period (Table 2). Carnivora was the most abundant Order in terms of number of families (6) and species (10), followed by Artiodactyla of 2 families and 9 species. Primates were represented by 1 family and 2 species. Orders Tubulidentata, Lagomorpha, Procaviida and Rodentia were represented by one family and one species each.

Based on the IUCN Red List criteria, mammals found during the study were grouped into threatened and least concerned. Leopard (*Panthera pardus*) is categorized as near threatened species and the rest 24 species are least concerned (Table 1). Six of the 25 species were medium sized mammals, i.e., vervet monkey (*Chlorocebus pygerythrus*), rock hyrax (*Procavia capensis*), slender mongoose (*Galerella sanguine*), common genet (*Genetta genetta*), African wildcat (*Felis lybica*), and crested porcupine (*Hystrix cristata*). And 19 were large sized mammals, i.e., olive baboon (*Papio anubis*), water buck (*Kobus ellipsiprymnus*), bohor reed buck (*Redunca redunca*), bush buck (*Tragelaphus sylvaticus*), common duiker (*Sylvicapra*

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grimmia), greater kudu (*Tragelaphus strepsiceros*), oribi (*Ourebia ourebi*), wild pig (*Sus scrofa*), common warthog (*Phacochoerus africanus*), wild dog (*Lycaon pictus*), black-backed jackal (*Canis mesomelas*), African civet (*Civettictis civetta*), serval cat (*Leptailurus serval*), leopard (*Panthera pardus*), striped hyaena (*Hyaena hyaena*), honey badger (*Mellivora capensis*), aardvark (*Orycteropus afer*).

Table 2 Distribution and abundance of mammals from Abaye Gorge.

No.	Common Name	Scientific Name	Family	Order
1	Olive baboon	*Papio anubis*	Cercopithecidae	Primates
2	Vervet monkey	*Chlorocebus pygerythrus*	Cercopithecidae	Primates
3	Water buck	*Kobus ellipsiprymnus*	Bovidae	Artiodactyla
4	Bohor reed buck	*Redunca redunca*	Bovidae	Artiodactyla
5	Bush buck	*Tragelaphus sylvaticus*	Bovidae	Artiodactyla
6	Common duiker	*Sylvicapra grimmia*	Bovidae	Artiodactyla
7	Klipspringer	*Oreotragus oreotragus*	Bovidae	Artiodactyla
8	Greater kudu	*Tragelaphus strepsiceros*	Bovidae	Artiodactyla
9	Oribi	*Ourebia ourebi*	Bovidae	Artiodactyla
10	Wild pig	*Sus scrofa*	Suidae	Artiodactyla
1**1**	Common warthog	*Phacochoerus africanus*	Suidae	Artiodactyla
12	Wild dog	*Lycaon pictus*	Canidae	Carnivora
13	Black-backed jackal	*Canis mesomelas*	Canidae	Carnivora
14	African civet	*Civettictis civetta*	Viverridae	Carnivora
15	Common genet	*Genetta genetta*	Viverridae	Carnivora
16	African wildcat	*Felis lybica*	Felidae	Carnivora
17	Serval cat	*Leptailurus serval*	Felidae	Carnivora
18	African leopard	*Panthera pardus pardus*	Felidae	Carnivora
19	Striped hyaena	*Hyaena hyaena*	Hyaenidae	Carnivora
20	Honey badger	*Mellivora capensis*	Mustelidae	Carnivora
21	Slender mongoose	*Galerella sanguinea*	Herpestidae	Carnivora
22	Aardvark	*Orycteropus afer*	Orycteropodidae	Tubulidentata
23	Yellow-spotted rock hyrax	*Heterohyrax brucei*	Procaviidae	Hyracoidea
24	Rock hyrax	*Procavia capensis*	Procaviidae	Hyracoidea
25	Crested porcupine	*Hystrix cristata*	Hystricidae	Rodentia

*Status of species - only leopard is near threatened while the rest are least concerned species.

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Distribution of mammals with respect to district

Gozamin had the highest number of mammal species (23) followed by Ayehu Guagussa (22) and Bure Zuria (21). Olive baboon, vervet monkey, common duiker, klipspringer, oribi, common genet, serval cat, leopard, striped hyaena, aardvark, slender mongoose, and rock hyrax were common to all districts studied (Table 3). Bohor reed buck and wild dog were found only in Gozamin district. Black-backed jackal was found only in Ayehu Guagussa and African wildcat in Burie Zuria district. Bush buck, greater kudu, water buck, and wild pig were found in three districts.

Plate.1

Photo credit (Desalegn Taye, 2012 Plate 1. Warthog from camera Trap

Plate.2

Photo credit (Desalegn Taye, 2012 Plate 1. Slender mongoose from camera Trap

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Plate.3

Photo credit (Desalegn Taye, 2012 Plate 1. Crested porcupine from camera Trap

Plate 4

Photo credit (Desalegn Taye, 2012 Plate 1. Crested porcupine from camera Trap

Body weight

Out of 25 mammal species observed during the study, eight of them, i.e., rock hyrax (*Procavia capensis*), yellow-spotted rock hyrax (*Heterohyrax brucei*), slender mongoose (*Galerella sanguinea*), African wildcat (*Felis lybica*), common genet (*Genetta genetta*), African civet (*Civettictis civetta*), vervet monkey (*Chlorocebus pygerythrus*), olive baboon (*Papio anubis*), were medium sized mammals whereas the rest 17 were large sized mammals (Table 4).

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Table 4 Body size of mammals in the study area.

No	Common name	Scientific name	Body weight
1	Olive baboon	*Papio anubis*	M
2	Vervet monkey	*Chlorocebus pygerythrus*	M
3	Water buck	*Kobus ellipsiprymnus*	L
4	Bohor reed buck	*Redunca redunca*	L
5	Bush buck	*Tragelaphus sylvaticus*	L
6	Common duiker	*Sylvicapra grimmia*	L
7	Klipspringer	*Oreotragus oreotragus*	L
8	Greater kudu	*Tragelaphus strepsiceros*	L
9	Oribi	*Ourebia ourebi*	L
10	Wild pig	*Sus scrofa*	L
11	Common warthog	*Phacochoerus africanus*	L
12	Wild dog	*Lycaon pictus*	L
13	Black-backed jackal	*Canis mesomelas*	L
14	African civet	*Civettictis civetta*	M
15	Common genet	*Genetta genetta*	M
16	African wildcat	*Felis lybica*	M
17	Serval cat	*Leptailurus serval*	L
18	African leopard	*Panthera pardus pardus*	L
19	Striped hyaena	*Hyaena hyaena*	L
20	Honey badger	*Mellivora capensis*	L
21	Slender mongoose	*Galerella sanguinea*	M
22	Aardvark	*Orycteropus afer*	L
23	Yellow-spotted rock hyrax	*Heterohyrax brucei*	M
24	Rock hyrax	*Procavia capensis*	M
25	Crested porcupine	*Hystrix cristata*	L

NB: M = medium, S= small

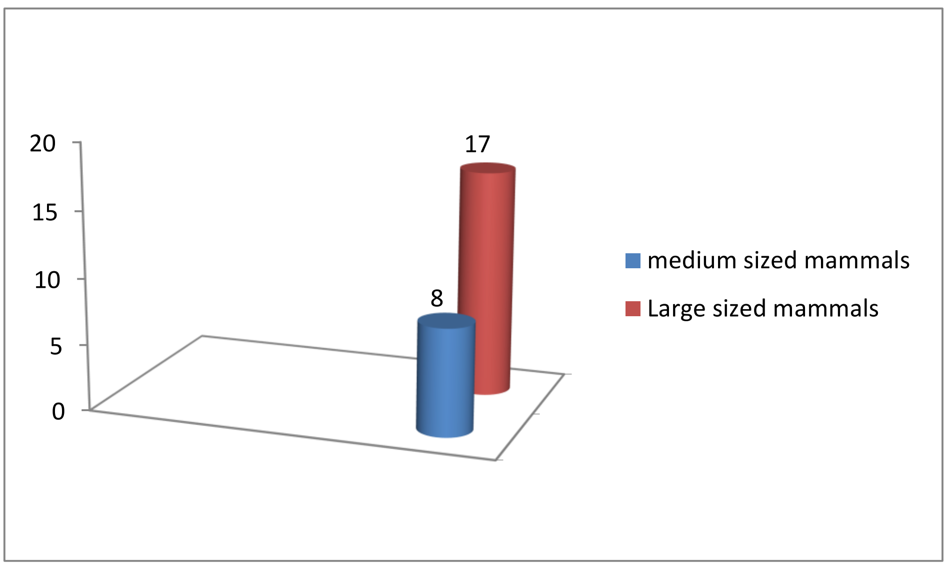

Figure 2. Body size of mammals in the study area

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Detrended correspondence analysis

Association between study locations and their habitats

The **detrended** correspondence analysis was conducted to determine the association between mammal species (assigned to rows) and districts (columns), whereby the first axis explained 61% and the second axis 22% of the relationship (Pearson's χ^2) between the two factors, i.e., species and districts (Figure 3). For column points, i.e., districts, Gozamin stood at the opposite end (left side of the plot) to Andabet, Enebise Sar Midir and Borena, found away from the centroid at the extreme right side of the plot, thus contributing to the opposite association. The two sides behaved differently in connection with mammal species distribution. In axis 2, it was explained by the difference between Ayehu (found away from the centroid) and Burie Zuria (found right at the centroid).

In the case of mammal species (rows), they were found lined up along axis 1, where *Lycaon pictus* and *Reducna redunca* were closely associated to Gozamin, while the rest of the species were found lined up between Gozamin on one side of the plot and Andabet, Enebise Sar Midir and Borena on the other (Figure 3). In axis 2, *Canis mesomelas* was associated to Ayehu district and *Felis lybica* to Burie Zuria.

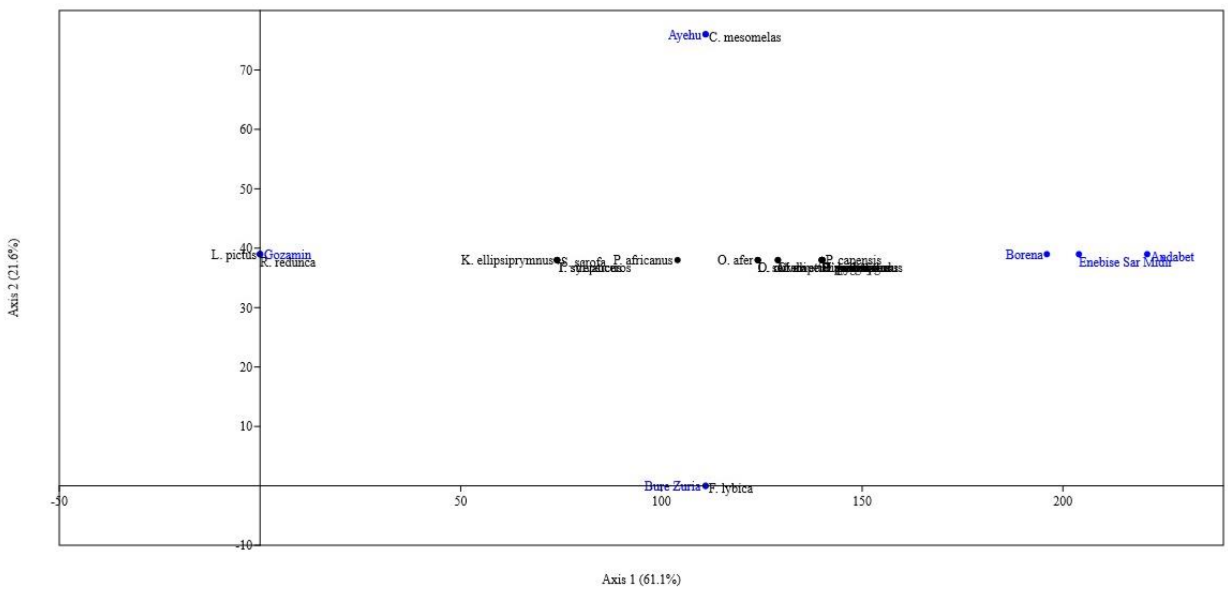

Figure 3 Ordination of mammal species distribution and districts by using detrended correspondence analysis in Abay Gorge, Amhara Region, Ethiopia.

Species Diversity

Variation in the number of species was observed among the three habitats. The highest species richness was recorded in riverine forest (19) followed by natural forest (15) and the lowest

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number of species were recorded in the woodland (9). Correspondingly, the highest species diversity index was observed in riverine habitat (H′=1.9), Followed by Natural Forest habitat (H′= 1.8 and Woodland habitat had the least species diversity (H′= 1.1). The highest species evenness was registered in the riverine habitat (*J*= 0.64) followed by natural forest habitat (*J*=0.43) and the least species evenness was woodland habitat had (*J*=0.35) ((Table 5).

Table 5 The mammalian species diversity and eveness in different habitat types in Abay Gorge

Habitat	Species richness	Abundance	H′	Evenness (*J*)
Riverine	19	230	1.9	0.64
Natural Forest	15	124	1.8	0.43
Woodland	9	65	1.1	0.35

Species composition (cluster analysis)

The cluster analysis based on the Bray-Curtis single linkage similarity index showed differences and similarities between the mammals species composition recorded in the six districts. *Papio Anubis*, *Chlorocebus pygerythrus*, *Sylvicapra grimmia*, *Oreotragus oreotragus*, *Genetta genetta*, *Panthera pardus pardus*, *Hyaena hyaena*, *Galerella sanguinea*, *Heterohyrax brucei*, *Procavia capensis*, *Hystrix cristata* stood out clearly separated from the rest and showed linkage at almost 50% similarity (Figure 4). Then, *Canis mesomelas* got separated from the rest at about 75% similarity. At about the same level of similarity (75%), *Civettictis civetta* and *Mellivora capensis* got their own group in the same fashion and *Felis lybica* alone and *Redunca redunca* and *Lycaon pictus* together made their own cluster. The rest of the species were clustered to two at about 82.5% similarity. The highest similarity (at about 96% similarity) was a cluster of four species, i.e., *Tragelaphus sylvaticus*, *Tragelaphus strepsiceros*, *Sus scrofa* and *Kobus ellipsiprymnus* (Figure 4).

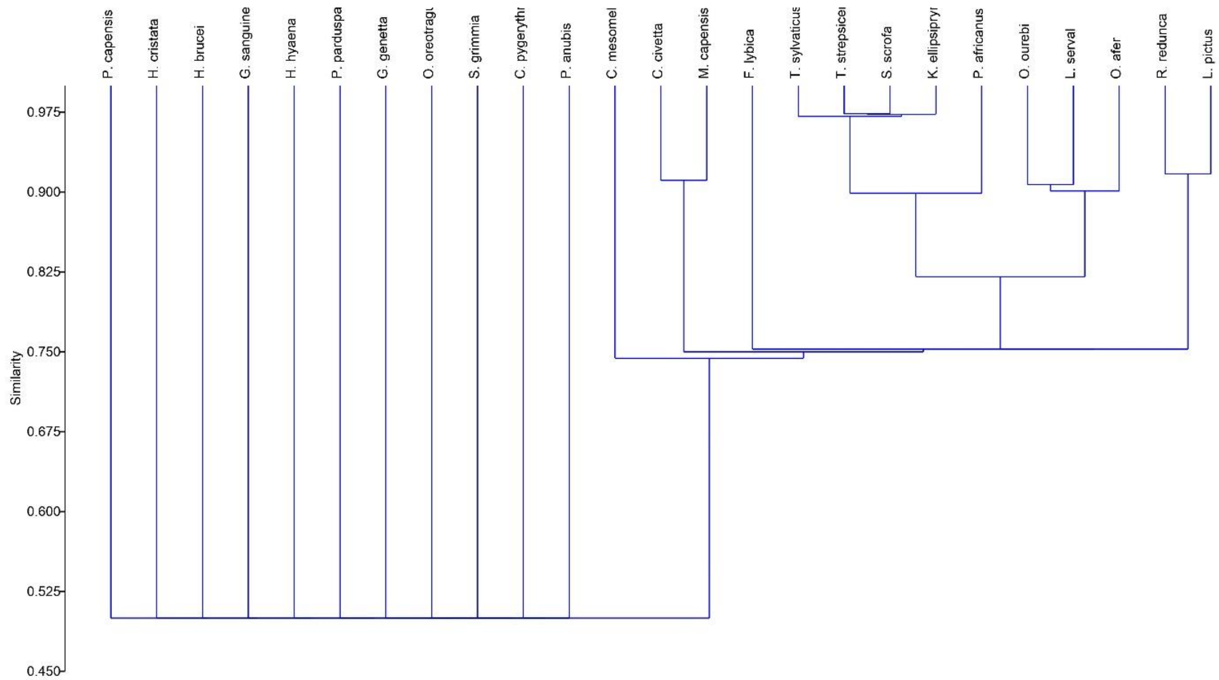

Figure 4 Single linkage cluster analysis between mammal species and districts based on Bray-Curtis similarity in Abay Gorge, Amahra Region, Ethiopia.

Non-metric Multidimensional Scaling (NMDS)

In the ordination plot, the distribution of the study sites (districts) was found clustered into two, one cluster (composed of Andabet, Borena and Enebise Sar Midir at the right) and another (Gozamin, Bure Zuria and Ayehu) at the left of the plot along the X-axis (Figure 5, top). This pattern showed a remarkable geographic delineation whereby adjacent districts that shared similar ecological makeup were clustered together. The wetter districts of Gozamin, Bure Zuria and Ayehu are found in the hinterland of Gojam province while Andabet, Enebise Sar Midir and Borena are either adjacent to or inside Wolo province where they all share recurrent dry episodes. This clustering also goes in line with abundance and diversity of mammals whereby the cluster in Gojam proper had more and Wolo had less (Table 3).

The ordination plot for mammal species had about three clusters, though not clearly demarcated but rather in a somewhat continuous progression. Some four of them had one cluster at the right, about 6 or more of them at the left and the rest at the middle (Figure 5, bottom). As one moves from the left to the right in the plot, one can notice a steady decline in abundance and diversity of the mammals. Therefore, species at the extreme left were more abundant and were found in all study locations (districts) than the ones at the right and at the middle.

Different Carnivores were found at various clusters in the plot (e.g., *R. redunca* at the right end of Axis 1, *F. lybica* and *C. mesomelas* at opposite ends of Axis 2, and others mixed up with other groups at the left of Axis 1). Many herbivores were clustered at the right side of Axis 1 close to the origin (e.g., *O. oreotragus*, *O. ourebi*) (Figure 5, bottom).

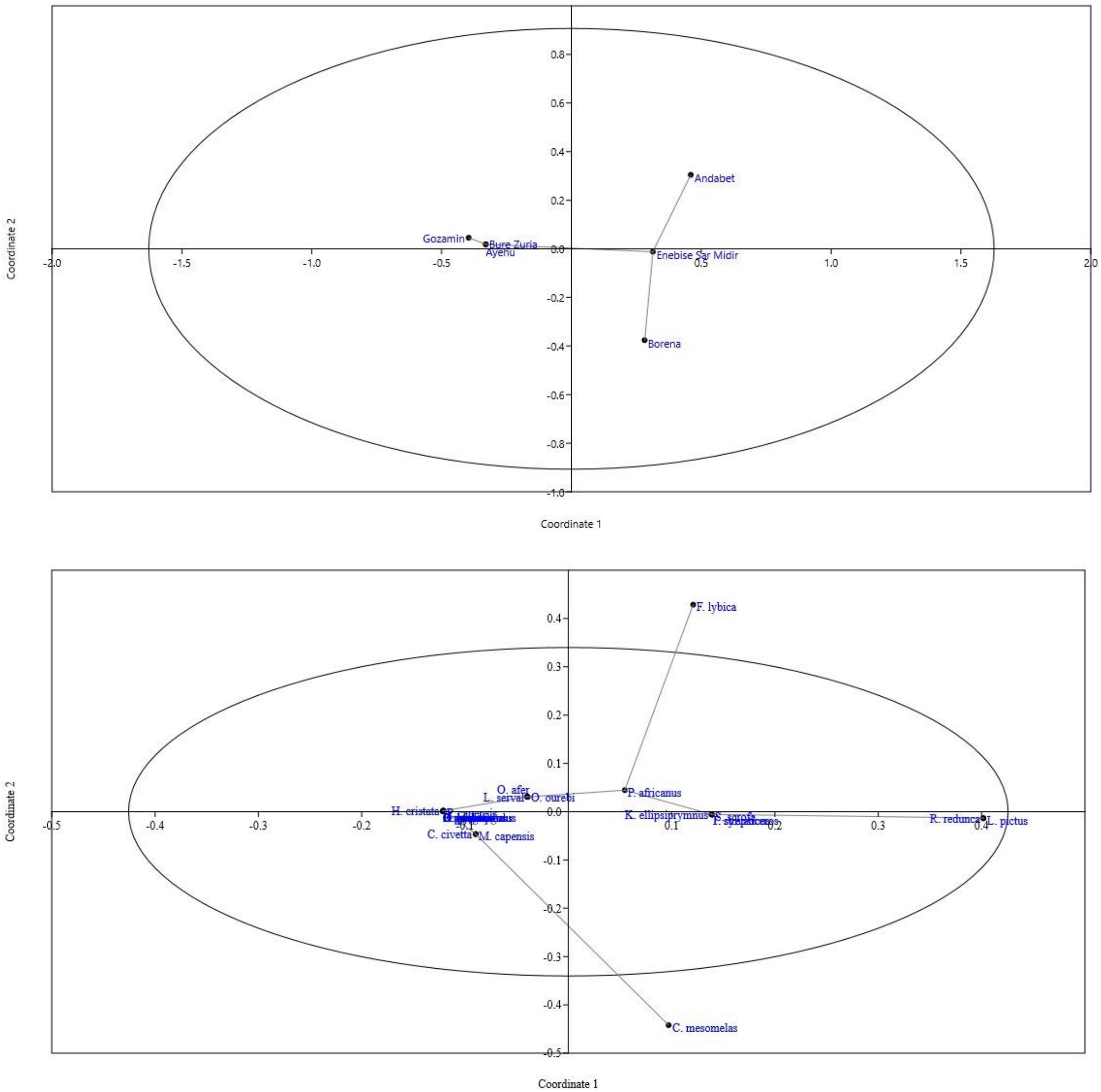

Figure 5 Ordination of study locations (districts) (top) and mammal species (bottom) by Non-metric Multidimensional Scaling in Abay (Blue Nile) Gorge, Amhara Region, Ethiopia.

Anthropogenic disturbance of mammals

Charcoal making was found to be one of the major anthropogenic disturbances of habitats of mammals (Figure 6). Forest clearance was the culprit in loss of animal habitats. Currently, the growing population satisfies the need for wood resources and food crops by encroaching into forest lands. Severe overgrazing by a large number of cattle destroys newly emerging forest seedlings and denies wild mammals the habitat they need for survival. The problems are clear and understandable to every concerned body, but no functioning system exists to mobilize the community and alleviate the problem.

DISCUSSION

In this study, we confirmed that 25 medium- and large-sized mammals that are grouped into six orders and 12 families existed in the study area. Medium-sized (weighing 2–7 kg) and large-sized mammals (weighing more than 7 kg) were found.

Abay Gorge is unique in harboring greater number of carnivores especially wild dogs (*Lycaon pictus*), black-backed jackal (*Canis mesomelas*), African civet (*Civettictis civetta*), common genet (*Genetta genetta*), African wildcat (*Felis lybica*), serval cat (*Leptailurus serval*), leopard (*Panthera pardus*), striped hyaena (*Hyaena hyaena*), honey badger (*Mellivora capensis*) and slender mongoose (*Galerella sanguine*).

Mammals were not found to be evenly distributed in the different habitat types because of differences in food and habitat preferences. And also, the distribution of mammals varied from district to district. Gozamin and Ayehu Guagussa had more animals. These differences may have come from differences in ecological setup, vegetation cover, forest size, water source, food resources, human interference, and conservation efforts.



Plate.5 Plate.6 Plate.7

Photo credit (Desalegn Taye) Borena saynt district vegetation cover



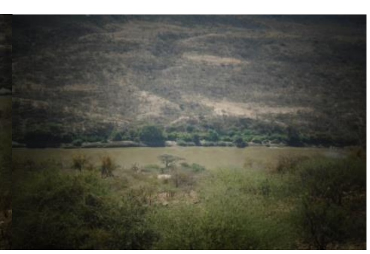

Plate.8 **Plate.9** **Plate.10**

Photo credit (Desalegn Taye) Enbesy sarmidder district vegetation cover



Plate.11 **Plate.12** **Plate.13**

Photo credit (Desalegn Taye) Gozamen district vegetation cover



Plate.14 **Plate.15** **Plate 16**

Photo credit (Desalegn Taye) Burie Zuriea district vegetation cover



Plate.17 **Plate.18** **Plate. 19**

Photo credit (Desalegn Taye) Ayehu gagussa district vegetation cover

Using cameras, one species of Artiodactyla, common warthog (*Phacochoerus africanus*), one species of Carnivora, slender mongoose (*Galerella sanguine*) and one species of Rodentia, *Crested porcupine (Hystrix cristata*) were recorded, i.e., 3 orders, 3 families and 3 species.

Both detrended correspondence analysis and cluster analysis showed that some mammals were associated to certain areas and not to others. NMDS discriminated the different districts in accordance with ecological differences, whereby districts that shared similar environmental conditions were found clustered together. NMDS did not repeat clearly what was observed on districts to the case of mammal species distribution, because members of one mammal group were found at several clusters sometimes mixed up with other mammal groups. In contrast, **Rodrigues *et al.*, (2019**) reported that different mammal groups (e.g., carnivores, angulates, primates and wild pigs) were found clustered separately at different ecological guilds in the less disturbed rainforest area of southwestern Ethiopia. In the current study, the mixed cluster may be the case because each group of mammal depends on another for survival according to the food web (trophic levels). In other words, different groups may have overlapping habitats in order to sustain.

Forest destruction generally resulted in loss of mammal species. Mammal species can get extinct because of habitat destruction **(Pimm & Raven, 2000).** As human populations increase, so do needs for food and space and that leads to the conversion of forests to serve human needs rather than wild animals **(Evangelista, *et al.*, 2007).** Human settlement, needs for firewood and charcoal, livestock encroachment, anthropogenic fire, and agriculture all enhance the extinction of wild mammals. Migrating people increase population density and clear forests they get close to (Kerr**, 2004**).

Plate.17

Plate.18

Plate. 19

Photo credit (Desalegn Taye) deforestation for charcoal making.

Lowland semi－evergreen forests of the region are part of the biodiversity hotspots, which Abay Gorge belongs to. However, Abay Gorge's lowland semi－evergreen forest is the most threatened habitat in the region due to rapid expansion of farmland following unmanaged investment, excessive deforestation (firewood, charcoal, construction, mining, agriculture, fire, hunting, and free-grazing).

Forests provide ecosystem services, the lack of which creates systemic imbalance, including loss of animal biodiversity. The lack of them promotes greenhouse emissions, which in turn change patterns of weather, water and eventually invites extreme weather events, all too harmful to the survival of wild animals.

Conclusion and Recommendatin

In this study, we confirmed that the survival of mammals is severely threatened. The distribution of mammals varied with respect to habitat and geographic area, necessitating individual attention.

Anthropogenic factors such as deforestation, agricultural expansion, overgrazing, illegal settlement, lack of sense of ownership, limited awareness, human and wildlife conflict, lack of coordination among various stakeholders, conflict of interest over resources, human induced fire, expansion of investments, low attention to conservation of wild mammals, illegal hunting, fuel wood exploitation, charcoal production, mining and climate change may all contribute for the danger. Developing a sense of ownership within the community, awareness creation, collaborative approach among stakeholders, avoiding conflict, reduction of free grazing, offering alternative work opportunity for fuel wood collectors and charcoal makers, awareness creation to the local people are all mandatory. Nature reserves should be established in cooperation with the host native people for each threatened species as soon as possible.

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