

# Population Size, Activity Patterns, Diet, and Ranging Ecology of Boutourlini's Blue Monkey (*Cercopithecus mitis boutourlinii*) in Apini and Dokuma Forests, Awi Zone, Ethiopia

Zemenu Birhan (✉ [zedbirhan12@gmail.com](mailto:zedbirhan12@gmail.com))

Bonga University

Dessalegn Ejigu

Bahir Dar University

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## Research Article

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# Abstract

**Background:** By studying population size, activity patterns, diet, and ranging ecology of Boutourolini's blue monkey (*Cercopithecus mitis boutourlinii*) we can get sufficient information to conserve the subspecies in the area. Boutourolini's blue monkey is endemic subspecies found in the western and northwestern parts of Ethiopia. The study was conducted in Apini and Dokuma forests, northwestern Ethiopia, from October 2018 to June 2019. The block count method was used to estimate its total population size and scan sampling method was used to collect data for activity patterns, and diet. The ranging ecology of the study subspecies was determined for each group based on the point to point movements of the group between consecutive GPS locations recorded.

**Results:** On average a total of 71 and 111 individuals of Boutourolini's blue monkey were counted in Apini and Dokuma forests, respectively. Boutourolini's blue monkey spent 47.5% and 48.6% of time feeding, 20.2% and 18.6% moving, and 14.1% and 13.5% resting by the Apini and Dokuma groups, respectively. The Apini group frequently fed on young leaves (52.8%), fruits (30.2%), and mature leaves (6.6%), while the Dokuma group fed on young leaves (39.8%), fruit 942.3%), and mature leaves (8.3%). Ranging ecology of Boutourolini's blue monkey was 44.4 ha and 78.3 ha for the Apini group, and 51 ha and 56.9 ha for the Dokuma group during the wet and dry seasons, respectively.

**Conclusions:** The total population size of blue monkeys in the Apini and Dikuma forests counted were different. Activity budgets vary during the wet and dry seasons. During the entire study period blue monkeys consumed different food items from the two forests. The home range size of blue monkeys during the two seasons was different in both groups and they traveled long distance during the dry season. As the habitats of Boutourolini's blue monkey in the present study area is degraded due to various anthropogenic activities, there is a need to design strategies to minimize conservation problems of the subspecies in the area.

## Background

Most primate species including blue monkey (*Cercopithecus mitis*) face ongoing habitat disturbance, yet not all species respond to such disturbance the same way [1, 2]. While many primate species experience declines in population density when their habitats are disturbed, there are several primate species that do not, and these flexible species will generally require less conservation attention [3]. Habitat loss is perhaps the serious threat facing blue monkey inhabiting tropical forests [4]. As a result, they are adversely affected by the fragmentation of their habitat [5, 6].

Boutourolini's blue monkey (*Cercopithecus mitis boutourlinii*) is a subspecies of blue monkeys [7]. According to IUCN (2005), 17 subspecies of blue monkeys are recorded in different parts of Africa, and Boutourolini's blue monkey is one of the endemic subspecies to Ethiopia. It is occurring from Lake Tana southwards along the western side of the Ethiopian Rift Valley [8]. Boutourolini's blue monkey is categorized as vulnerable in the IUCN Red List of threatened species [5].

Blue monkey must optimize their time, and can flexibly adjust their activity budgets to deal with changeable environmental conditions [9]. Fruits are the most frequently used plant components of blue monkey's diet though high amounts of leaves and invertebrates are consumed periodically [10]. Thus, as an omnivore, it

mostly feeds on fruits, leaves, invertebrates, flowers, seeds, bark and shoots [11]. Understanding an altered diet in fragmented habitats is important for conservation efforts because the shifts can impact many aspects of its ecology and behavior, and ultimately affect survival of the species. Generally, the quality of food resources directly impacts health and body condition, which can affect birth and mortality rates as well as susceptibility to predation and disease [12].

To conserve the endemic Boutourlini's blue monkey in its current habitat, information on its population size, activity pattern, diet, and ranging ecology is very important. Currently, this subspecies is widely distributed in protected areas and remnant forest patches of the western and northwestern parts of Ethiopia including in Apini and Dokuma forests. However, it is not yet studied. The present study, therefore, aimed to estimate population size of the Boutourlini's blue monkey, to describe its activity patterns, to examine its diet, and to determine ranging ecology of the study subspecies in Apini and Dokuma forests.

## Results

### *Population size*

The average numbers of Boutourlini's blue monkeys counted in the Apini and Dokuma forests were 71 and 111, respectively. The mean number of individuals counted in block 1, block 2, and block 3 in Apini forest were  $19.5 \pm \text{SD } 2.12$ ,  $22 \pm \text{SD } 4.24$ , and  $29.5 \pm \text{SD } 2.12$ , respectively. The mean number of Boutourlini's blue monkey among the three blocks did not show significant difference ( $\chi^2=2.73$ ,  $df=2$ ,  $P>0.05$ ).

The total number of individuals counted in the Apini forest during the wet and dry seasons were ( $n=74$ ), and ( $n=68$ ), respectively. This showed there is no significant difference in population size estimate between the wet and dry seasons ( $\chi^2=0.25$ ,  $df=1$ ,  $P>0.05$ ). The individual numbers of Boutourlini's blue monkey counted in the three blocks in Apini forest is showed below (Fig. 1).

The total numbers of individuals in Dokuma forest during the wet and dry seasons were ( $n=118$ ), and ( $n=104$ ), respectively. The highest number of individuals was counted in block 2, while the lowest was counted in block 1. The total number of individuals counted during the wet and dry seasons among the four blocks did not show significant difference ( $\chi^2=0.88$ ,  $df=1$ ,  $P>0.05$ ). The mean number of individuals counted in block 1, block 2, block 3, and block 4 in Dokuma forest were  $12 \pm \text{SD } 2.83$ ,  $57.5 \pm \text{SD } 6.36$ ,  $22 \pm \text{SD } 2.82$ , and  $19.5 \pm \text{SD } 3.54$ , respectively. The variations in the mean number of individuals counted between blocks 1 and 2 were statistically significant ( $\chi^2=30.22$ ,  $df=1$ ,  $P<0.05$ ), and the same was true in blocks 2 and 4 ( $\chi^2=18.51$ ,  $df=1$ ,  $P<0.05$ ). However, there was no significant difference in the mean number of individuals counted between blocks 3 and 4 ( $\chi^2=0.09$ ,  $df=1$ ,  $P>0.05$ ), and blocks 1 and 3 ( $\chi^2=2.94$ ,  $df=1$ ,  $P>0.05$ ). The individual numbers of Boutourlini's blue monkey counted in blocks during the wet and dry seasons among the four blocks are shown below (Fig. 2).

In general, the populations size of Boutourlini's blue monkeys in the Apini and Dokuma forests showed a relatively more mean number of individuals in Dokuma forest than in Apini forest, and the difference was significant ( $\chi^2=8.79$ ,  $df=1$ ,  $P<0.05$ ).

### *Activity budget*

A total of n=2436 individual observations were recorded from 773 scans for the Apini group, and n=2512 individual observations were recorded from 822 scans for the Dokuma group. The Apini group spent 47.5% time feeding, 14.1% resting, 20.2% moving, 12.3% different social activities, and 6.0% other activities including vocalization, defecation, urination, and looking to the observer. Whereas, the Dokuma group spent 48.6% of their time feeding, 13.5% resting, 18.6% moving, 14.3% different social activities, and 5.0% other activities (Fig. 3).

There was no significant difference in time spent on diurnal activity budgets between the Apini and Dokuma groups ( $\chi^2=1.17$ ,  $df=1$ ,  $P>0.05$ ).

Boutourlini's blue monkey of the Apini group on average spent 48.1% of the time feeding and 17.9% of the time resting during the wet season, and 46.8% feeding and 9.8% resting during the dry season. However, they spent relatively more time 25.6% moving and 7.0% for other activities during the dry season than the wet season which were 15.4% moving, and 5.0% other activities. There were statistically significant differences in time spent feeding ( $\chi^2=5.12$ ,  $df=1$ ,  $P<0.05$ ), resting ( $\chi^2=39.91$ ,  $df=1$ ,  $P<0.05$ ), moving ( $\chi^2=20.24$ ,  $df=1$ ,  $P<0.05$ ), and grooming ( $\chi^2=7.47$ ,  $df=1$ ,  $P<0.05$ ) in the Apini group between the wet and dry seasons.

The Dokuma group on average spent relatively more time feeding (51.5%) during the wet season than during the dry season (45.4%). They also spent relatively more time moving (21.9%) during the dry season than the wet season (15.6%) (Table 1).

There were significant difference in time spent feeding ( $\chi^2=19.40$ ,  $df=1$ ,  $P<0.05$ ), resting ( $\chi^2=7.39$ ,  $df=1$ ,  $P<0.05$ ), and moving ( $\chi^2=5.14$ ,  $df=1$ ,  $P<0.05$ ) for the Dokuma group between the wet and dry seasons.

### ***Dietary ecology***

A total of n=1157 feeding observations were recorded from 381 scan samplings in the Apini group, and n=1222 feeding observations were recorded from 400 scan samplings in the Dokuma group. For the Apini group, young leaves contributed 52.8% of food items of blue monkey which was the highest proportion of food items foraged. Fruits and mature leaves made the second and third largest contributions of its diet with 30.2% and 6.6%, respectively. Flowers (3.3%) and tree buds (2.5%) made the least contributions of the diet (Fig. 4).

The most frequently consumed food item in Dokuma group was the fruit which contributed 42.3% of the diet. Young leaves were the second most frequently consumed food items which accounted for 39.8% of the diet. Mature leaves and tree buds were the third and the fourth most consumed food items which made 8.3% and 4.6%, respectively, of its diet. Other food items consumed were stems, flowers, seed and animal preys which accounted for 0.5%, 1.2%, 1.8% and 1.6%, respectively, of the diet. There was significant difference in time spent feeding young leaves ( $\chi^2=14.24$ ,  $df=1$ ,  $P<0.05$ ), fruit ( $\chi^2=32.59$ ,  $df=1$ ,  $P<0.05$ ), tree buds ( $\chi^2=8.57$ ,  $df=1$ ,  $P<0.05$ ), stem ( $\chi^2=11.64$ ,  $df=1$ ,  $P<0.05$ ), and flowers ( $\chi^2=9.98$ ,  $df=1$ ,  $P<0.05$ ) between the Apini and Dokuma groups.

Boutourlini's blue monkeys in the Apini forest spent 62.7% of time feeding on young leaves, and 7.5% of mature leaves during the wet season than the dry season which accounts 41.5%, and 5.6%, respectively. However, they spent 39.3% of time feeding on fruits, and 5.1% on flowers during the dry season than the wet season 22.2%, and 1.1%, respectively. There was significant difference in time spent feeding on young leaves ( $\chi^2=43.48$ ,  $df=1$ ,

$P < 0.05$ ), fruits ( $\chi^2 = 16.11$ ,  $df = 1$ ,  $P < 0.05$ ), tree buds ( $\chi^2 = 7.75$ ,  $df = 1$ ,  $P < 0.05$ ), and flowers ( $\chi^2 = 15.15$ ,  $df = 1$ ,  $P < 0.05$ ) between the wet and dry seasons in the Apini group.

In the Dokuma forest, they spent 44.9% of time feeding on young leaves, 9.2% on mature leaves, and 4.9% on tree buds during the wet season than the dry season which were 33.1%, 7.1%, and 4.1%, respectively. However, they spent 49.1% of time feeding on fruits, and 2.4% on flowers during the dry season than the wet season which was 37.1%, and 0.3%, respectively (Table 2).

There was a significant difference in time spent feeding young leaves ( $\chi^2 = 35.85$ ,  $df = 1$ ,  $P < 0.05$ ), mature leaves ( $\chi^2 = 6.18$ ,  $df = 1$ ,  $P < 0.05$ ) and flowers ( $\chi^2 = 8.06$ ,  $df = 1$ ,  $P < 0.05$ ) between the wet and dry seasons in the Dokuma group.

Boutourlini's blue monkey of the Apini and Dokuma groups consumed a total of 14 plant species in their overall diet during the study period (Tables 3 and 4). In the Apini forest, the highest contribution of the diet was from the *Albizia gummifera* (33.7%), and *Hyppocratea spp.* (29.1%), while in the Dokuma forest, the most consumed plant species in the percentage contribution was *Hyppocratea spp.* which accounted (35.1%), and *Albizia gummifera* (24.7%).

### ***Ranging ecology***

Ranging ecology of Boutourlini's blue monkeys in the Apini group during the wet and the dry seasons were 44.4 ha and 78.3 ha, respectively (Fig. 5) whereas the ranging ecology of Boutourlini's blue monkeys in the Dokuma group during the wet and the dry seasons were 51 ha and 56.9 ha, respectively (Fig. 6).

There was a significant difference between the wet and dry seasons in the home range size of blue monkeys in the Apini group ( $\chi^2 = 9.47$ ,  $df = 1$ ,  $P < 0.05$ ). However, there was no significant difference between seasons in the home range size of the Dokuma group ( $\chi^2 = 0.33$ ,  $df = 1$ ,  $P > 0.05$ ).

The mean daily range distance for the Apini group during the wet and the dry seasons were 648 m, and 732 m, respectively whereas for the Dokuma group the mean day range distance during the wet and the dry seasons were 715 m and 774 m, respectively. There was significant difference in the daily range lengths of blue monkeys of the Apini group between the wet and dry seasons ( $\chi^2 = 5.11$ ,  $df = 1$ ,  $P < 0.05$ ). However, in the Dokuma group, the difference did not show significant difference between the two seasons ( $\chi^2 = 2.33$ ,  $df = 1$ ,  $P > 0.05$ ).

## **Discussion**

Boutourlini's blue monkey is one of the endemic primate subspecies of Ethiopia. Blue monkeys are strictly associated with primary tropical deciduous and riverine forest [8]. However, the present study area is classified as moist Afro-montane forests with different vegetation strata within tree dominated habitats [13].

The population size of Boutourlini's blue monkeys in the Dokuma forest is more than the Apini forest. This might be because the total area of Dokuma forest is relatively larger than the Apini forest. The total number of individuals counted in Apini and Dokuma forests during the wet season is more than the dry season. This might be because during the wet season there is sufficient food availability that makes the Boutourlini's blue monkey concentrated at specific habitats as a result we can get sufficient data for population census. During the dry

season most trees drop their leaves and become deciduous and individuals are sparsely distributed throughout the entire forest that makes population count not easier as during the wet season. Similarly, [14] estimated more numbers of Boutourlini's blue monkey during the wet season than the dry season. The densities of primates are directly related to the availability and distribution of food trees [15].

The result of this study showed that the seasonal and the overall activity time budgets of Boutourlini's blue monkey showed that feeding as the predominant activity, accounting for 47.5% of the time spent in the Apini, and 48.6% in the Dokuma than other diurnal activities such as moving, resting, and socialization. Similarly, [16] and [17] found that monkeys spent more time feeding than other diurnal activities followed by moving and resting. Boutourlini's blue monkey activity time budgets showed variation with other *Cercopithecines* or guenons. They spent more time feeding and socializing compared to *Cercopithecus lhoesti* and *Cercopithecus mitis doggeti* and they spent less time moving and resting than other *Cercopithecines* (Table 5). In addition, when compared to *C. mitis stuhlmanni* and *C. campbelli*, blue monkeys spent less time in feeding, resting and moving activities. However, they spent more time socializing and other activities.

Boutourlini's blue monkey classified as folivores and frugivores. They foraged different food items and mostly, they feed 52.8% of the time on young leaves, and 30.2% on fruits in the Apini, and 39.8% of the time on young leaves, and 42.3% on fruits in the Dokuma forest. Fruits accounted 45.8–57.1% of their food source for blue monkey [18]. This showed that they considered as folivores and frugivores. Similarly, [19] showed that Boutourlini's blue monkey spent more time feeding on young leaves and fruits.

In the present study, the Apini and Dokuma groups spent most of the time constantly feeding on young leaves on different trees and fruits of lianas during the study period. This might be due to the high abundance of leaves and fruiting lianas in both sites. Similarly, groups of Boutourlini's blue monkeys spent most of their time feeding on leaves of different herbs, lianas and trees as studied by [17]. In addition, Boutourlini's blue monkey spent most of their time feeding on young leaves and fruits of different plants in Komto protected forest, Ethiopia [20].

Boutourlini's blue monkeys of the group devoted more time foraging on young leaves and fruits in the Apini and Dokuma forests during the wet and dry seasons. [21] indicated that young leaves have more protein, low fiber content and are easily digestible than mature leaves. They showed seasonal variation by consuming young leaves during the wet season as young leaves are more abundant in the area. The feeding time budget for the Apini group was almost the same in both seasons whereas the feeding time budget for the Dokuma group showed some variation between the two seasons. In the same way, the feeding activity of one group showed no variation between the two seasons, while the other groups showed some variation between the two seasons [19].

In Dokuma forest, fruits are the most sources of food items of Boutourlini's blue monkey that they spent more time on fruits than young leaves. This might be due to the relatively high abundance of fruits of *Hyppocratea spp.* available throughout the study period in the Dokuma forest. This might be when there are no enough leaves available in the area; they invest their time feeding on fruits during the dry season than the wet season. The dry season is the time for most fruiting plants to bear fruits. Boutourlini's blue monkey showed high movement patterns to encounter fruits when there is scarcity of food [22]. Similarly, *Colobus guereza* spent more time feeding on fruits due to the high abundance of fruits during the dry season than the wet season [23].

Similarly, they spent more time feeding on fruits than young leaves during the dry season in the Jibat forest, Ethiopia [19]. In addition, [16] suggested that Bale monkeys (*Chlorocebus djamdjamensis*) spent more time feeding on fruits during the dry season. Similarly, *C. guereza* spent more time feeding on fruits during the dry season than the wet season [24]. Boutourlini's blue monkey at Apini and Dokuma forests feed more on young leaves and matured leaves compared to other *Cercopithecus spp.* (Table 6).

The ranging ecology is the area in which an animal normally travels in pursuit of its routine activities. In primates, primarily frugivores species generally have larger home ranges for their bodily sizes than those of folivores or herbivores species [25]. However, Boutourlini's blue monkeys are both folivores and frugivores species. In the present study the home range size of Boutourlini's blue monkeys during the dry season was greater than the wet season as they traveled more distance during the dry season in search of food and water. This is because during the dry season there is scarcity of food, and hence to search for food both groups traveled long distance. Similarly, the study conducted by [16] on Bale monkeys showed that they traveled long distance during the dry season than the wet season which is linked to the need to search fruits. In addition, [19] described that blue monkeys traveled longer distances during the dry season than the wet season.

## Conclusion

Study about population size and diurnal activity patterns of blue monkeys could give important information about this species. The population size of blue monkeys in the Apini and Dikuma forests were counted by using study blocks. Boutourlini's blue monkeys spent most of their activity time budgets on feeding and moving. Activity budgets vary during the wet and dry seasons. During the entire study period blue monkeys consumed different food items from the two forests. Thus, young leaves, fruits, mature leaves, shoots, flowers and seeds were consumed from variety of plant species during the wet and dry seasons. Blue monkeys consumed different plant species in the study sites.

The home range size of blue monkeys during the two seasons was different in both groups and they traveled long distance during the dry season. Since Boutourlini's blue monkeys never engaged in crop raiding there was no conflict with the local people. However, this subspecies is threatened due to habitat destruction since there is high deforestation of the habitats and agricultural expansion by local people. Moreover they are threatened by the predator leopard as witnessed by the local people. In addition, local people in the nearby forest extracted woods from the forest for different purposes such as fuel wood, house construction, furniture and for other purposes. Hence, the forest habitat is constantly changing in size and quality which may not support different wildlife species including blue monkeys.

Management action should be practiced or implemented to conserve the forest and awareness creation among local people about the importance of forests and how they protect and manage it from different anthropogenic activities should be forwarded. In addition, further investigation should be conducted to determine the sustainable and beneficial level of harvesting some plant species mainly *Albizia gummifera* and other important plants to participate the local people in benefit sharing so that they become responsible to ensure sustainable conservation of resources in the area.

## Methods

## Description of the study area

The present study was conducted in two forest patches of Awi Administrative Zone, namely Apini and Dokuma forest patches, which are located 33 km west of Injibara town, the capital of Awi Administrative Zone, and 480 km northwest of Addis Ababa. Apini forest patch lies between 11°1'39.22"N to 11°2'30.18"N latitudes, and 36°41'0.90"E to 36°41'36.00"E longitudes, with the altitudes range of 2031 m to 2186 m a. s. l., and Dokuma forest patch lies between 10°58'33.22"N to 10°59'30.17"N latitudes, and 36°39'55.58"E to 36°40'28.00"E longitudes, with the altitudes range of 2040 m to of 2105 m a. s. l. (Fig. 7).

The total size of Apini and Dokuma forests are 139 ha and 226 ha, respectively. The distance between Apini and Dokuma forests is 3 km, and the two forests are almost similar in vegetation composition and structure. The different vegetation structures include trees, shrubs, and grasses. The dominant tree species in both study sites are *Ficus vasta*, *Croton macrostachyus*, *Rosa abyssinica*, *Acacia abyssinica*, *Buddleja polystachya*, *Cordia africana*, *Olea sepecies*, *Albizia species*, *Apodytes dimidiata*, *Ekebergia capensis*, *Prunus africana*, *Schefflera abyssinica*, *Rhus glutinosa*, *Pittosporum viridiflorum* [13]. Both are community protected forests even if the habitats are degraded as a result of deforestation by the local people. These forests are used as home to different wildlife species including *Cercopithecus mitis boutourlinii*, *Colobus guereza*, *Papio anubis*, *Chlorocebus aethiops*, *Crocuta crocuta*, *Panthera pardus*, and *Sylvicapra grimmia*.

The climate data was obtained from Bahir Dar town, West Amhara Meteorology Agency which is 153 km from the study area showed a uni-modal rainfall distribution with heavy rainfall from June to September. The highest intensity of rainfall occurs in August with 464.1 mm. The mean annual rainfall from a period of 2009 to 2018 was 1690.2 mm, and the mean monthly minimum and maximum temperature records were 10.8°C in December, and 31°C in April, respectively (Fig. 8).

## Study species and groups

Boutourlini's blue monkey is medium-sized, short-tailed arboreal primate which is endemic to Ethiopia. The behavioral study was conducted on two groups from both forests after a period of two months of habituation with the two study groups.

## Abbreviations

GPS: Global Positioning System; IUCN: International Union for the Conservation of Nature; KDE: Kernel Density Estimations; SPSS: Statistical Package for the Social Sciences; SD: Standard Deviation

## Declarations

### Ethics approval and consent to participate

The study was approved by institutional review board (IRB) guideline and regulation of college of Sciences at Bahir Dar University, Ethiopia. Permission for the study to be conducted was also obtained from office of Kidamaja kebele and from Awi Administrative Zone office.

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### **Authors' contribution**

ZB and DE proposed the research idea and collected the behavioral data of Boutourlini's blue monkey. ZB organized the data in computer and did the analysis, interpretation and wrote the manuscript. DE revised the manuscript for scientific content and did check the language. The authors read and approved the final manuscript.

### **Availability of data and materials**

The data used and analyzed during the current study is available in the hand of corresponding author for further request if request is available from reviewers without disclosure of the interviewees.

### **Consent for publication**

This manuscript does not contain any individual person's data, and further consent for publication is not required.

### **Competing interests**

On the behalf of all authors there is no competing interest.

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## Tables

**Table 1:** Seasonal diurnal activity time budgets for blue monkeys in Apini and Dokuma groups.

Group	Season	Diurnal activities (%)							
		Feeding	Resting	Moving	Grooming	Sexual activity	Aggression	Playing	Others
<b>Apini</b>	Wet	48.1	17.9	15.4	10.8	1.0	0.5	1.2	5.0
	Dry	46.8	9.8	25.6	8.4	0.7	0.9	0.8	7.0
<b>Dokuma</b>	Wet	51.5	14.5	15.6	11.5	1.3	0.2	1.1	4.3
	Dry	45.4	12.2	21.9	12.7	0.8	0.4	0.7	5.9

**Table 2:** Percentage of time spent by the two groups of blue monkeys feeding on different food items during the wet and dry seasons

Diet	Apini group (%)		Diet	Dokuma group (%)	
	Wet season	Dry season		Wet season	Dry season
Stems	1.3	3.1	Stems	0.7	0.2
Mature leaves	7.5	5.6	Mature leaves	9.2	7.1
Young leaves	62.7	41.5	Young leaves	44.9	33.1
Tree buds	3.6	1.3	Tree buds	4.9	4.1
Flowers	1.1	5.1	Flowers	0.3	2.4
Fruits	22.2	39.3	Fruits	37.1	49.1
Seeds	1.0	1.7	Seeds	1.9	1.8
Animal preys	0.7	1.9	Animal preys	1.0	2.2
Total	100	100	Total	100	100

**Table 3:** List of plant species, parts consumed, and percentage contribution in the Apini forest

Local name	Species	Family	Life forms	Parts consumed	Percentage contribution
atsini	<i>Albizia gummifera</i>	Fabaceae	Tree	YL, FR, FL, ST, SD	33.6
vi	<i>Hyppocratea spp.</i>	Urticaceae	Liana	YL, ML, FR	29.1
issi	<i>Croton macrostachyus</i>	Euphorbiaceae	Tree	YL, ML, FR	6.2
ntsi	<i>Prunus Africana</i>	Rosaceae	Tree	YL, SH	8.3
ahtahi	<i>Allophylus abyssinicus</i>	Sapindaceae	Tree	YL, ML	7.8
uyi	<i>Ficus sur</i>	Moraceae	Tree	YL, ML, FR	3.0
ringi	<i>Celtis Africana</i>	Cannabaceae	Tree	YL, ML	2.6
kishi	<i>Urera hypselodendron</i>	Urticiaceae	Liana	YL, ML	2.9
iri	<i>Olea europea</i>	Oleaceae	Tree	YL, ML	1.3
di	<i>Apodytes dimidiata</i>	Icacinaceae	Tree	YL, SH	1.9
biltigni	<i>Maerua tryphylla</i>	Capparidaceae	Tree	YL, ML	1.6
ri	<i>Dombeya torrida</i>	Sterculiaceae	Tree	YL, ML	0.6
ginbi	<i>Mimusops kummel</i>	Sapotaceae	Tree	YL	0.8
bi	<i>Maesa lanceolata</i>	Myrsinaceae	Tree	YL, FR	0.3
tal					100

YL: Young leaves, FR: Fruits, ML: Mature leaves, ST: Stem, FL: Flowers, SH: Shoots, SD: Seed

**Table 4:** List of plant species, parts consumed, and percentage contribution in the Dokuma forest

cal me	Species	Family	life forms	parts consumed	percentage contribution
ivi	<i>Hyppocratea spp.</i>	Urticaceae	Liana	YL, ML, FR	35.1
ntsini	<i>Albizia gummifera</i>	Fabaceae	Tree	YL, FR, FL, ST, SD	24.7
sissi	<i>Croton macrostachyus</i>	Euphorbiaceae	Tree	YL, ML, FR	7.6
mtsi	<i>Prunus Africana</i>	Rosaceae	Tree	YL, SH	8.9
tahtahi	<i>Allophylus abyssinicus</i>	Sapindaceae	Tree	YL, ML	6.4
ıdi	<i>Apodytes dimidiata</i>	Icacinaceae	Tree	YL, SH	3.5
aringi	<i>Celtis Africana</i>	Cannabaceae	Tree	YL, ML	2.2
nkishi	<i>Urera hypselodendron</i>	Urticiaceae	Liana	YL, ML	3.4
ali	<i>Combretum molle</i>	Combretaceae	Tree	YL, FR	2.1
uiri	<i>Ekebergia capensis</i>	Meliaceae	Tree	YL	1.5
ari	<i>Dombeya torrida</i>	Sterculiaceae	Tree	YL, ML, FL	1.9
ıuyi	<i>Ficus sur</i>	Moraceae	Tree	YL, ML, FR	1.1
ıbiltigni	<i>Maerua tryphylla</i>	Capparidaceae	Tree	YL, ML	1.3
kitsi	<i>Vernonia amygdalina</i>	Asteraceae	Tree	YL	0.3
otal					100

YL: Young leaves, FR: Fruits, ML: Mature leaves, ST: Stem, FL: Flowers, SH: Shoots, SD: Seed

**Table 5:** Activity time budgets devoted to different activities by members of the genus *Cercopithecus* from studies in different parts of Africa

Species	% of time contribution						country and site	Reference
	F	FR	M	R	S	Os		
<i>Cercopithecus mitis</i>	48.1	-	19.4	13.8	13.3	5.5	Apini and Dokuma forest, Ethiopia	This study
<i>C. mitis boutourlini</i>	48.4	-	17.9	21.7	12.0	0.0	Jibat forest, Ethiopia	Tesfaye et al. 2013
<i>C. lhoesti</i>	45.1	2.5	23.0	14.0	10.0	5.0	Nyungwe forest reserve, Rwanda	Kaplin, 2001
<i>C. mitis doggetti</i>	44.6	2.4	20.0	16.0	11.0	0.0	Nyungwe forest reserve, Rwanda	Kaplin, 2001
<i>C. mitis stuhlmanni</i>	60.3	-	19.7	9.9	8.3	1.8	Kibale forest, Uganda	Butynski, 1990
<i>C. campbeelli</i>	48.5	-	28.0	18.0	5.2	0.3	Tai, Ivory Coast	Buzzard, 2004; 2006
<i>C. Diana</i>	40.6	-	27.7	24.4	7.3	0.0	Tai, Ivory Coast	Buzzard, 2004; 2006

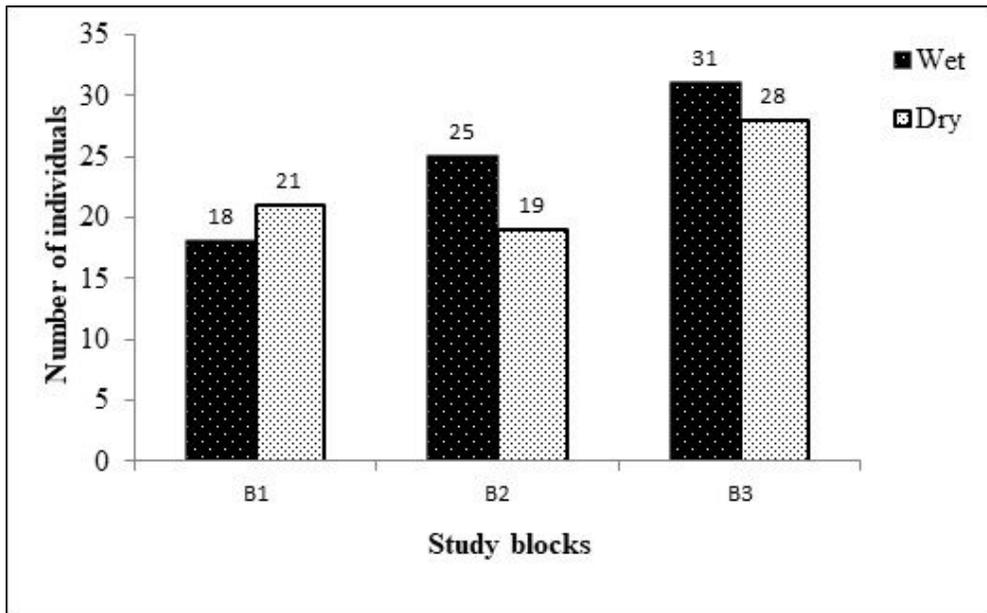
F: Feeding, FR: Foraging, M: Moving, R: Resting, S: Socializing, Os: Others

**Table 6:** Comparison of percentage of feeding records on different food items by members of the genus *Cercopithecus* in Africa

Species	YL	ML	TL	R	FL	FR	SH	ST	AP	SD	BA	country	reference
<i>opethicus</i>	46.3	7.5	53.8	-	2.3	36.3	3.6	1.4	1.4	1.6	-	Apini and Dokuma Forest, Ethiopia	This study
<i>nitis tourlinii</i>	27.4	20.3	47.7	-	11.2	15.4	8.99	-	3.4	4.9	6.9	Komto Forest, Ethiopia	Geleta and Bekele, 2016
<i>nitis tourlini</i>	14.4	3.9	18.3	-	7.0	32.4	20.6	-	13.8	5.7	1.6	Jibat Forest, Ethiopia	Tesfaye et al. 2013
<i>nitis getti</i>	-	-	6.4	-	6.2	47.4	-	-	24.9	9.3	-	Rwanda	Kaplin, 2001
<i>scanius</i>	-	-	34.7	-	2.7	44.6	-	-	17.6	-	-	Kibale at Sebatoli, Uganda	Chapman et al. 2004
<i>scanius</i>	-	-	28.8	-	3.7	35.7	-	-	31.2	-	-	Kibale at Kanyawara, Uganda	Chapman et al. 2004
<i>nictitans</i>	10.0	0.1	10.1	-	4.1	35.5	-	-	-	50.2	-	Makand'e Forest, Gabon	Brugiere, 2002
<i>ogonias</i>	13	0.1	13.1	-	4.7	26.9	-	-	-	49.8	-	Makand'e Forest, Gabon	Brugiere, 2002

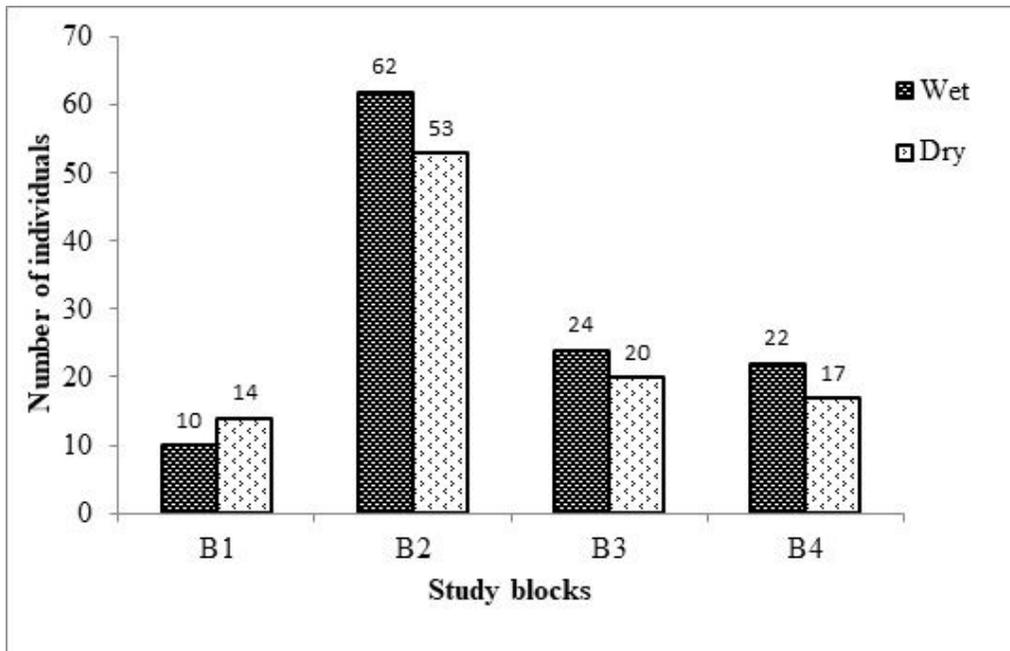
YL: Young leaves; ML: Mature leaves; TL: Total leaves; R: Root; S: Stem; FL: Flower; FR: Fruit; SH: Shoot; AP: Animal preys; SD: Seeds; BA: Bark

## Figures



**Figure 1**

The individual numbers of blue monkeys counted in different blocks during the wet and dry season in Apini forest



**Figure 2**

Individual numbers of blue monkeys counted in different blocks during the wet and dry season in Dokuma forest

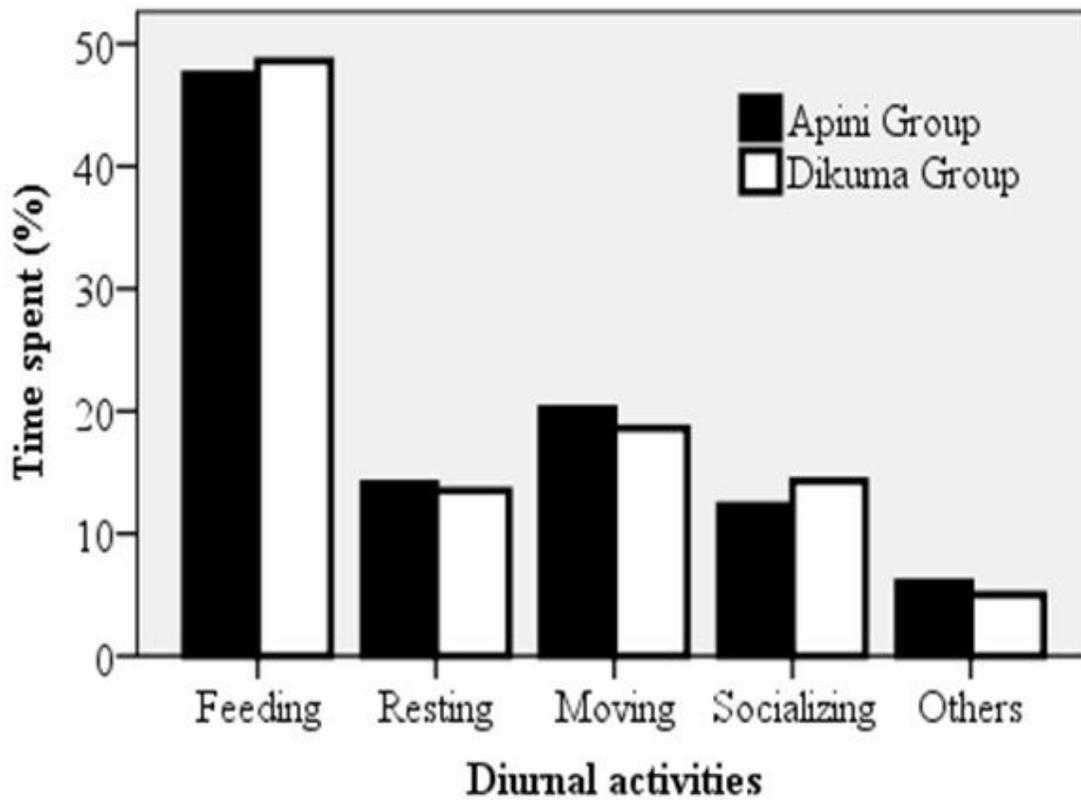


Figure 3

Overall activity patterns of Apini and Dokuma groups of blue monkeys

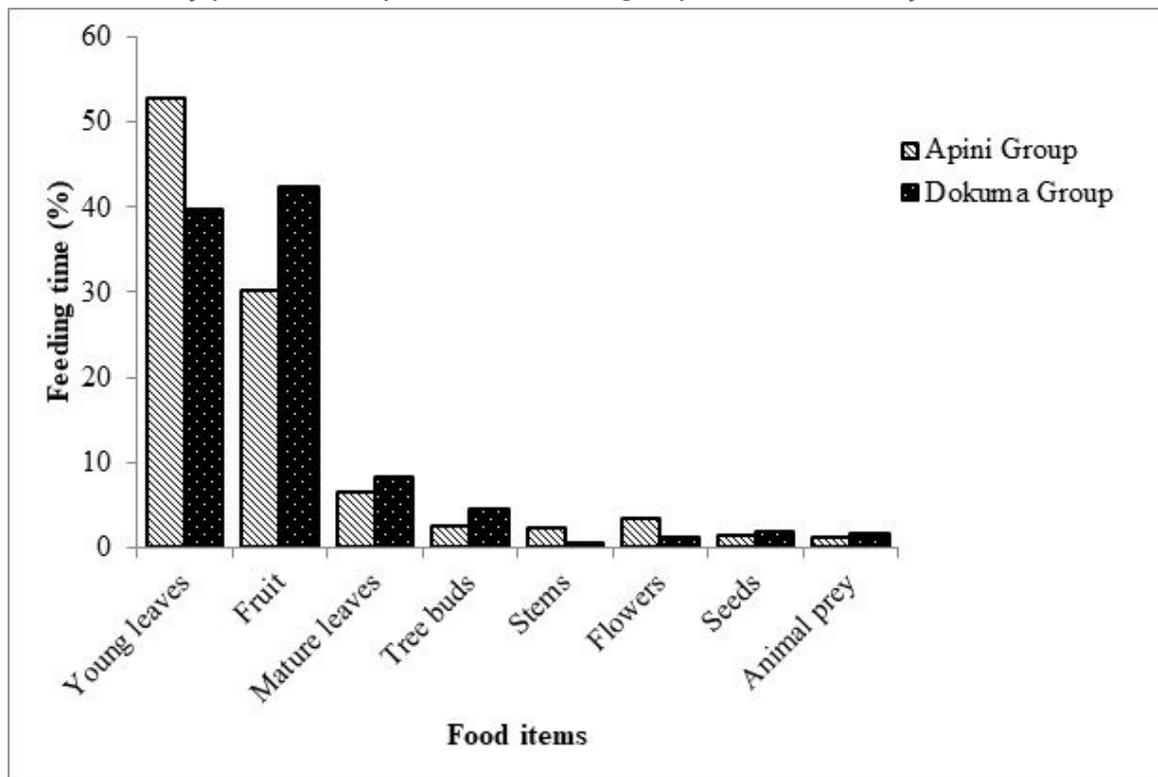


Figure 4

Percentage contribution of food items consumed by blue monkeys in Apini and Dokuma groups

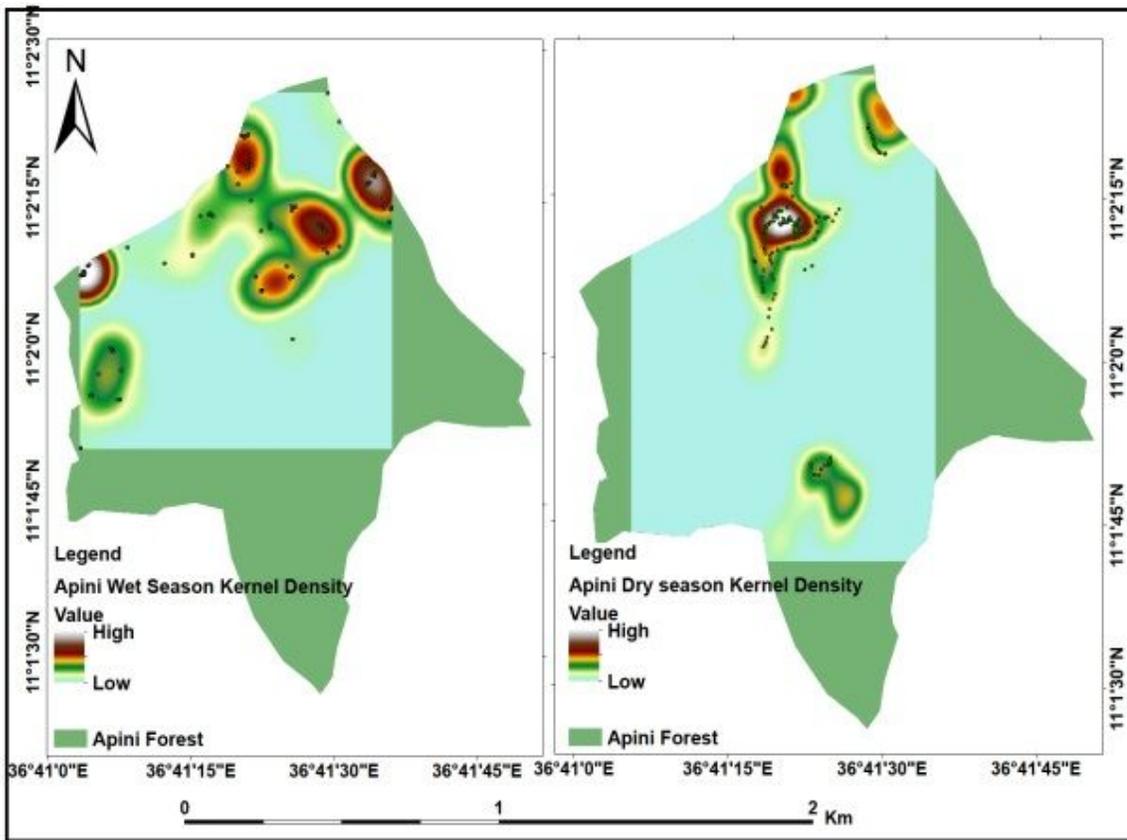


Figure 5

Home range size of blue monkeys in the Apini forest between the wet and dry seasons

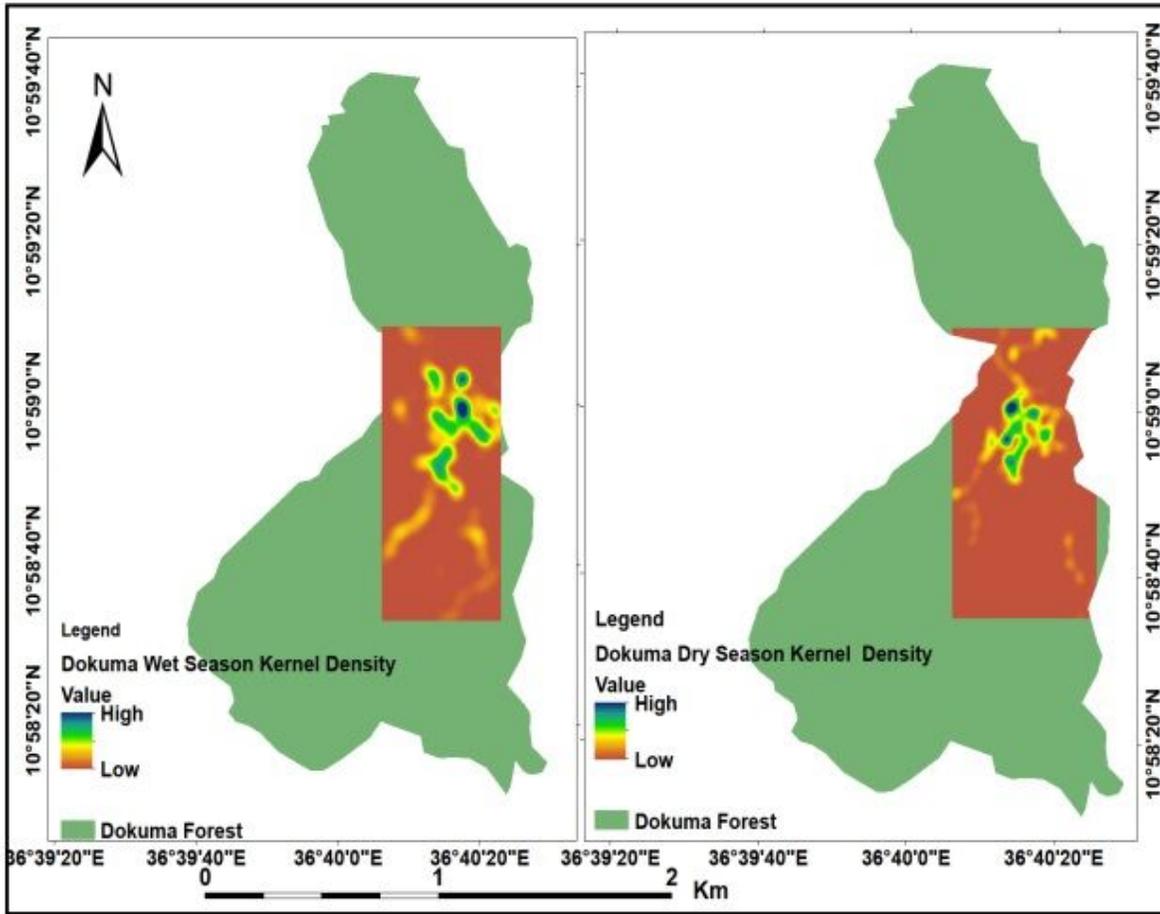


Figure 6

Home range size of blue monkeys in the Dokuma forest between the wet and dry seasons

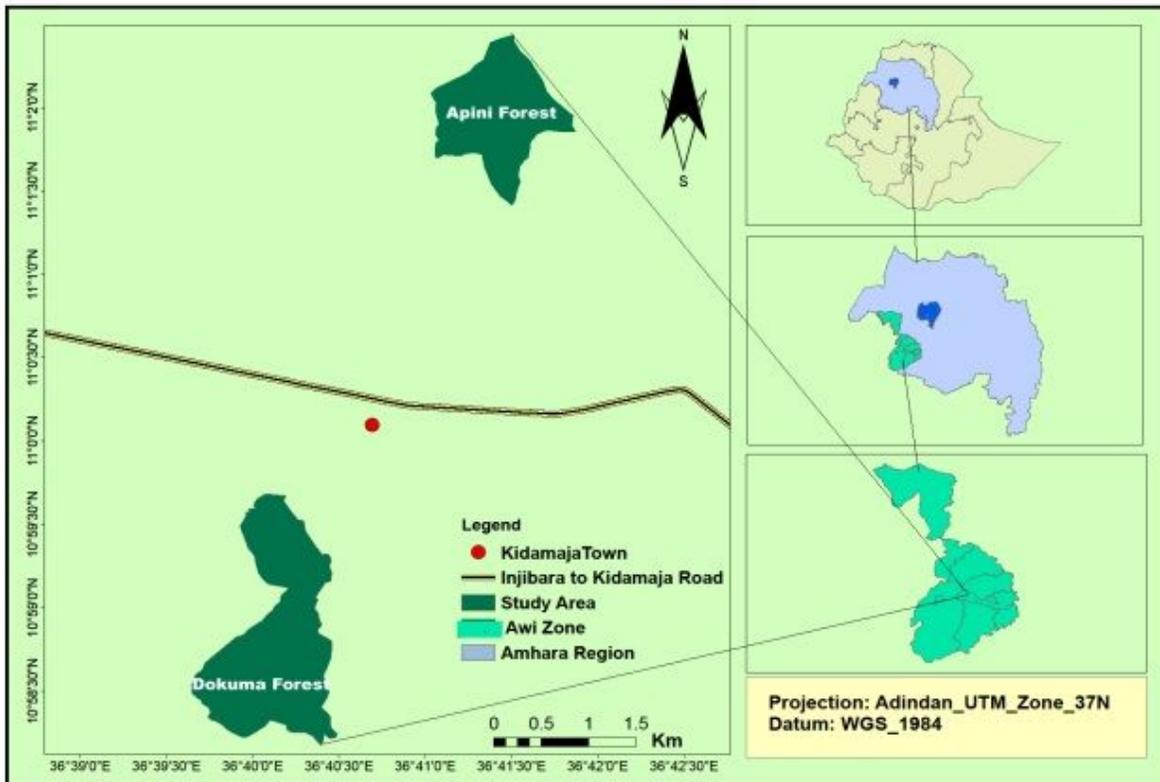


Figure 7

Location map of the study areas

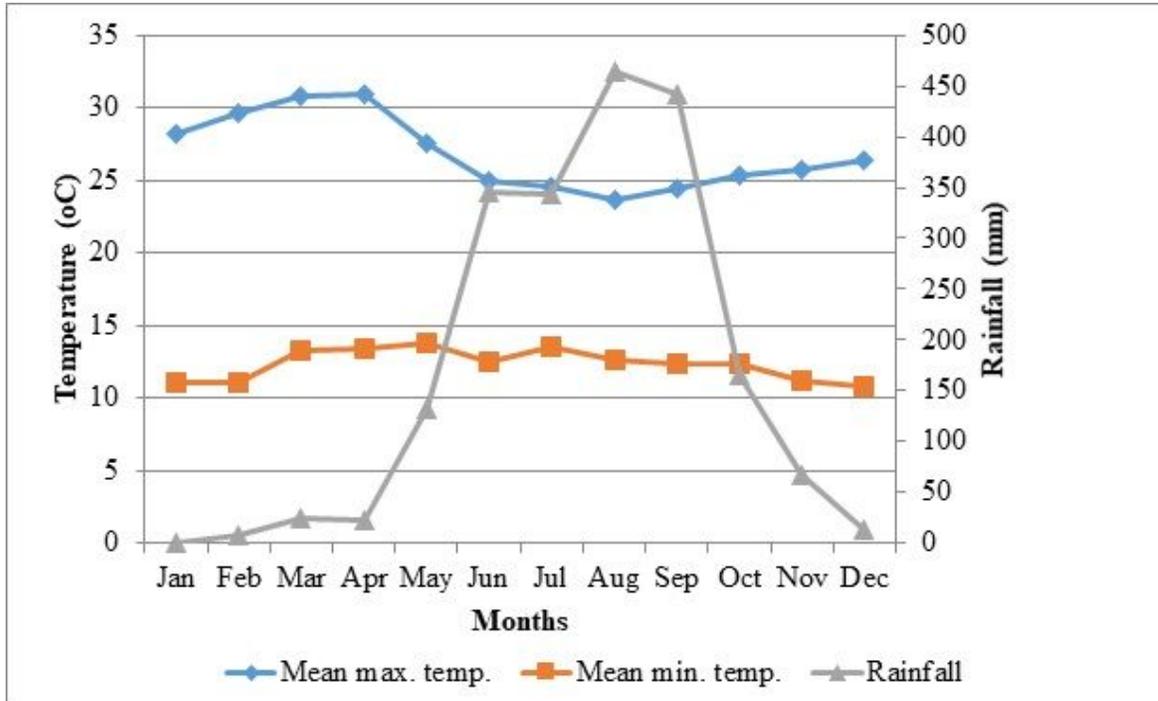


Figure 8

The mean monthly minimum and maximum temperature and rainfall of the study area in the years from 2009-2018. (Source: West Amhara Meteorology Agency).

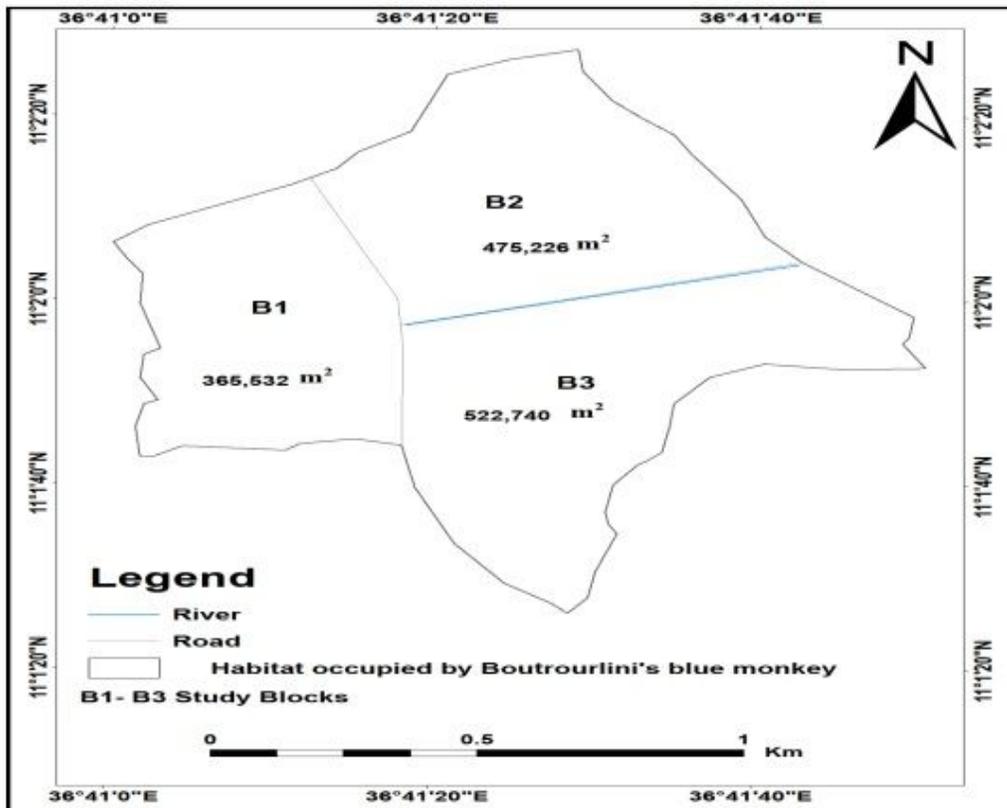


Figure 9

Population counting blocks in the Apini forest

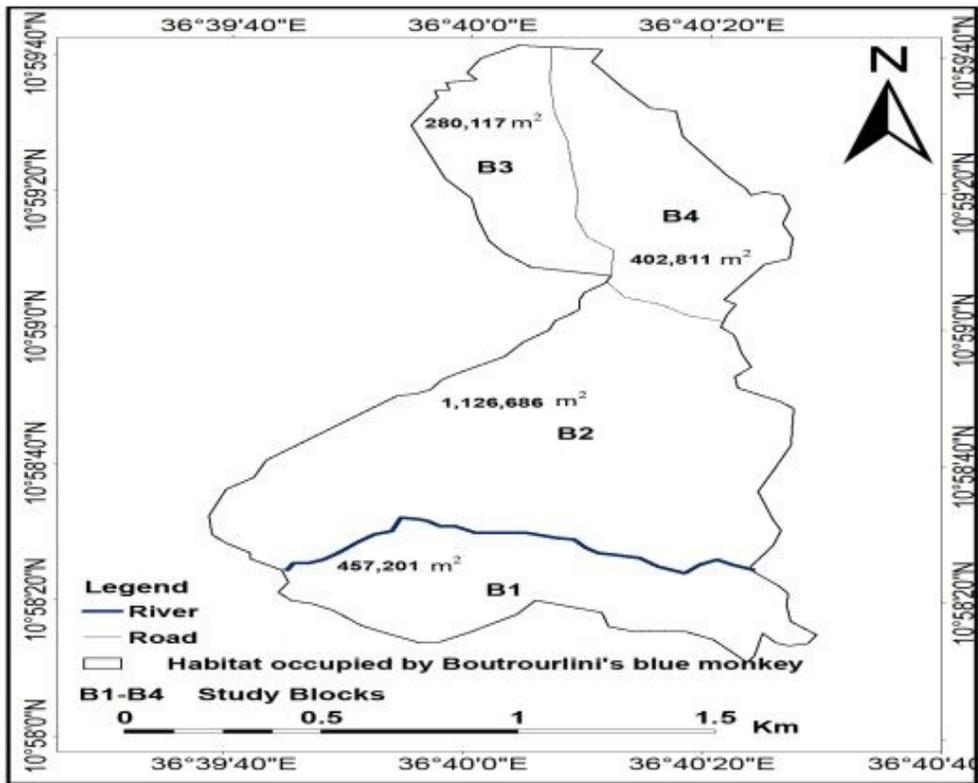


Figure 10

Population counting blocks in the Dokuma forest