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Research Article

Population Status of Hamadryas Baboon (*Papio hamadryas*) and their Conflict with Local Communities in Highland Forests of Tigray Regional State, Ethiopia

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Abstract | Ecological studies on wildlife distribution, population status, and human-wildlife conflicts are crucial for developing effective conservation strategies. This study assessed the population status of Hamadryas baboons and their conflicts with local communities in two adjacent highland forests, Shekeli and Mizrene, in the Tigray regional state of Ethiopia from March to October, 2019. A total count method was used to estimate the baboon population, while structured interviews were conducted to evaluate the nature, extent and cause of conflicts between the baboons and local people. Data analysis was performed using descriptive statistics and chi-square test. A total of 400 individual Hamadryas baboons, with a significant difference in population size between the two forests (χ^2 = 41.46, df = 1, P < 0.05) were recorded. However, there was no significant variation in population size between wet and dry seasons (P > 0.05). A significant difference between male and female populations and age structure were also observed (P < 0.05). Across both seasons, the total population included 212 adults, 93 sub-adults, 79 juveniles, and 16 infants, with females being predominant in all age groups. The study revealed ongoing conflicts between the baboons and local communities, primarily due to human encroachment, crop damage, livestock predation and vegetable damage by the baboons and there was significant difference (χ^2 = 97.5, df = 1, P < 0.05). Majority of the respondents identified that guarding is the most effective method against conflict with baboons and their response was significantly different (χ^2 = 78.21, df = 1, P < 0.05). The study forests are important habitats for Hamadryas baboons in the region and there is high conflict between Hamadryas baboons and local people. To mitigate these conflicts, it is recommended that targeted strategies be implemented, including conservation awareness campaigns to educate the local community and administrators about the importance of Hamadryas baboon conservation.

Novelty Statement | The current study provides the first assessment of the distribution, population status, and human-Hamadryas baboon interactions in the highlands of the Tigray Region, Ethiopia. By integrating ecological and socio-ecological data, it establishes a scientific baseline for conservation planning, human-wildlife conflict mitigation, and the long-term management of the species.

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Introduction

Africa is home to the largest and most diverse primate fauna, with 175 species and subspecies inhabiting a

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wide range of ecological niches (Robbins and Hohmann, 2006; Addisu *et al.*, 2010). Ethiopia, in particular, is a hotspot for biodiversity and endemism, due to its varied geography, altitudinal gradients, diverse habitats, and climatic conditions (Leykun, 2000; Lavrenchenko and Afework, 2017). The country is home to 13 species and subspecies of primates (Fairgrieve and Muhumuza, 2003; Addisu, 2004; Dagnachew and Melese, 2016). Among these, baboons stand out as the most successful and widespread primates, renowned for their behavioral flexibility, which allows them to thrive in various natural habitats (Zinner *et al.*, 2001a; Lauren *et al.*, 2009).

Historically, Hamadryas baboons had a wide distribution in south-west Arabian Peninsula and north-east Africa, including Egypt (Winney *et al.*, 2004). However, due to various anthropogenic activities, such as agricultural expansion, irrigation projects, human settlement, deforestation, hunting, and human-wildlife conflicts, the geographical range of this species has gradually declined, as a result, Hamadryas baboons are now restricted to specific areas in a few countries, including Sudan, Eritrea, Ethiopia, Djibouti, Somalia, Saudi Arabia, and Yemen (Zinner *et al.*, 2001a; Mesele *et al.*, 2014; Kopp *et al.*, 2014; Gippoliti, 2019). Despite their reduced geographical range, Hamadryas baboons remain abundant and are classified as a species of least concern (Gippoliti, 2019). Their distribution across different localities is influenced by the availability and distribution of essential resources, such as food, water, and suitable sleeping cliffs, which are crucial for their survival (Schreier and Grove, 2010; Mesele *et al.*, 2014; Hussein *et al.*, 2023a). The limited and widely dispersed distribution of resources in the natural habitats of Hamadryas baboons has been identified as a significant factor contributing to human-wildlife conflict (Ahmed, 2019; Binega and Mezgebu, 2023). Habitat deforestation, driven by activities such as charcoal production, firewood collection, and human settlement expansion, exacerbates these conflicts (Mesele *et al.*, 2014). As human populations encroach upon the natural habitats of Hamadryas baboons, these animals increasingly come into direct conflict with local communities. This conflict often manifests in the form of crop raiding, theft of property, and attacks on domestic animals, particularly young goats and lambs (Mesele *et al.*, 2014; Haylegebriel, 2016; Ahmed, 2019). The encroachment of human activities into baboon habitats forces these primates into closer contact with agricultural lands and livestock, leading farmers to view them as pests. In response, farmers may resort to killing or hunting baboons to protect their livelihoods and property (Ahmed, 2019; Zewdu and Afework, 2020). This escalating conflict highlights the need for effective management strategies to mitigate the impact of habitat interference and reduce the negative interactions between humans and Hamadryas baboons.

Hamadryas baboons are ecologically important as seed dispersers, insect predators, and contributors to the trophic structure of their environments (Schreier and Grove, 2010; Mesele *et al.*, 2014). However, their conservation poses several challenges, including human-wildlife conflict, habitat loss, overhunting, and competition with livestock (Haylegebriel, 2016; Ahmed, 2019). Addressing these issues requires a holistic approach that includes local community involvement, effective wildlife management practices, legal protections, and strategies to reduce conflict with human populations (Hussein *et al.*, 2023a). Balancing the ecological significance of these primates with the needs of local communities is key to ensuring both baboon conservation and the well-being of the people who share their habitats.

In Ethiopia, the geographic distribution of Hamadryas baboons has traditionally been associated with lowland and semi-desert habitats, particularly in and around Awash National Park (Swedell *et al.*, 2008; Schreier, 2010; Mesele *et al.*, 2014). However, recent studies have confirmed their presence in the highland areas of the country, such as Bale zone, Borena-Sayint National Park, and Semien Mountain National Park (Ahmed, 2020; Binega and Mezgebu, 2023; Hussein *et al.*, 2023a). Despite this broader distribution, most biogeographic research in Ethiopia has focused on the central regions, leaving significant gaps in our understanding of wildlife species, particularly primates, in the northern Ethiopia. The distribution ranges and population status of primates like the Hamadryas baboon in the highlands of Ethiopia's Tigray region remain largely unexplored due to limited surveys. Additionally, the extent of conflict between Hamadryas baboons and local communities in this region are not well documented. To address these data deficiencies, the study aims to assess the population status of Hamadryas baboons and investigate the nature, extent and causes of their conflicts with local people in the highland forests of Shekeli and Mizrene located in the Tigray National Regional State (TRNS) of northern Ethiopia.

Materials and Methods

Study area

The study was conducted in the southeastern part of the TRNS within the Saharti and Samre districts, focusing on the Shekeli and Mizrene forests (Figure 1). These forests are located approximately 60 km southwest of Mekelle city, with a distance of about 3 km between the towns of Samre and Gijet. Geographically, Shekeli and Mizrene forests are situated between 13° 15' 32" to 13° 17' 33" N latitude and 39° 11'13" to 39° 14' 12" E longitude. Currently, Shekeli forest covers an area of 544 hectares (5.44 km^2), while Mizrene forest spans 183 hectares (1.83 km^2), with elevations ranging from 1,746 to 2,330 meters above sea level (m.a.s.l). The climate in the study area is characterized by unpredictability and uneven seasonal

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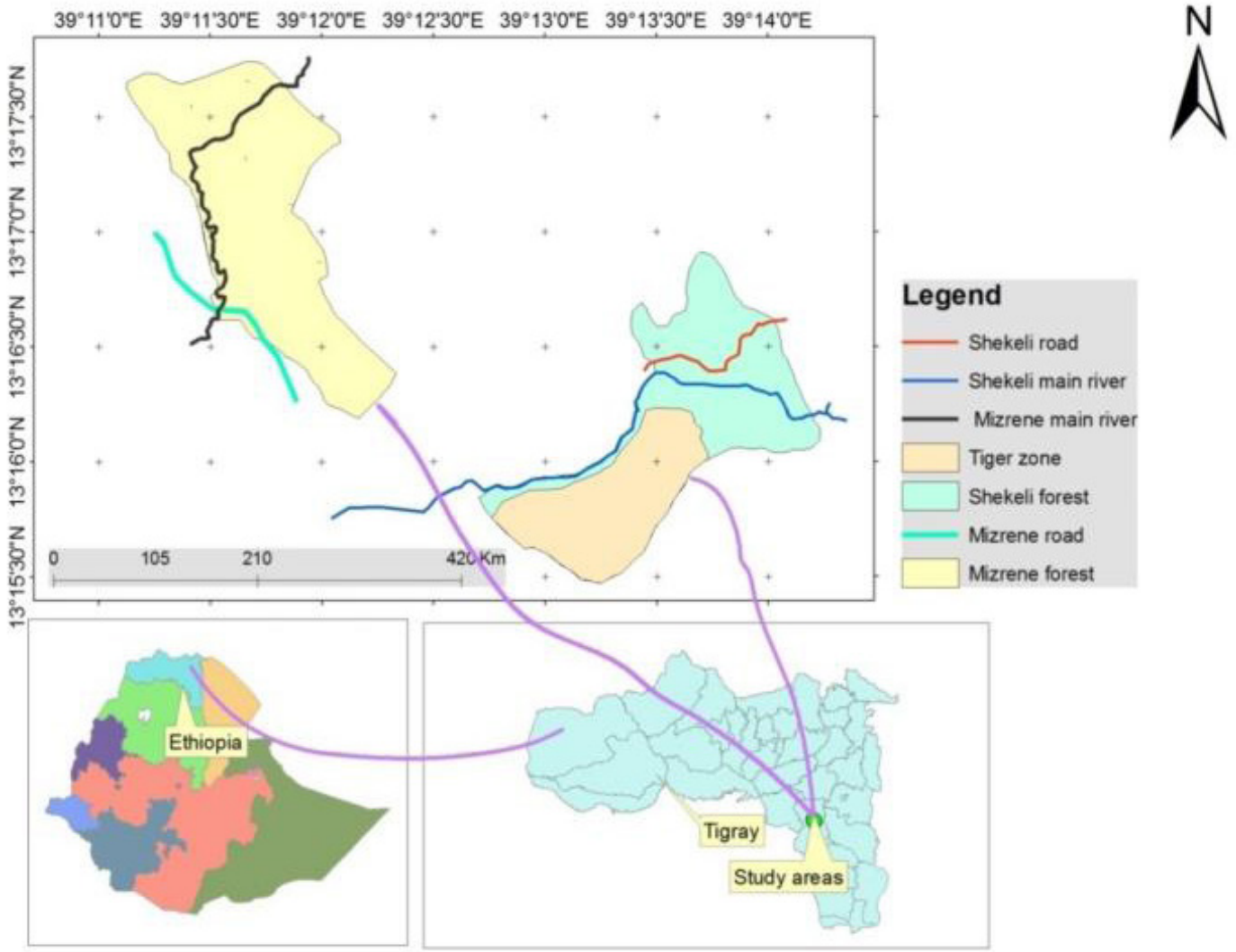

Figure 1: Map of the study area.

rainfall distribution. The region experiences a short rainy season from June to September, with the majority of the 525 mm average annual rainfall occurring in July and August. The temperature in the area varies throughout the year and is classified under the "Kola" and "Weina-Dega" climatic zones, with maximum and minimum temperatures recorded at 27.8°C and 13.3°C, respectively.

The study area is rich in plant diversity, with dominant species including *Acacia etbaica*, *Euclea racemosa*, *Senna singueana*, *Dodonaea angustifolia*, *Hyparrhenia* spp., *Dichrostachys cinerea*, *Combretum molle*, *Mimusops kummel*, *Ficus sycomorus*, *Ficus vasta*, *Ficus sur*, *Carissa spinarum*, and *Pittosporum viridiflorum*. In addition to Hamadryas baboons, the Shekeli and Mizrene forests also support a variety of wildlife, such as the common genet (*Genetta genetta*), spotted hyena (*Crocuta crocuta*), leopard (*Panthera pardus*), grivet monkey (*Chlorocebus aethiops*), rock hyrax (*Procavia capensis*), and numerous bird and amphibian species. More than 5,000 farmers live adjacent to these forests, relying primarily on mixed farming (crops and livestock) as their main source of income. They also engage in small-scale irrigation and honey production. The study forests are surrounded by farmland on all sides, where common food crops include wheat (*Triticum* spp.), barley (*Hordeum vulgare*), beans (*Vicia faba*), peas (*Pisum sativum*), maize (*Zea mays*), sorghum (*Sorghum bicolor*), teff (*Eragrostis tef*), finger millet (*Eleusine coracana*), and various fruits and vegetables.

Data collection

Before the data collection began, a preliminary survey was conducted to gather essential information about the study area. This initial survey aimed to map the boundaries and geographical features, assess the distribution and accessibility of Hamadryas baboons, identify their sleeping sites, and investigate human-baboon conflicts. Additionally, it provided an overview of the flora and other fauna in the area. The data collection spanned both the dry season (from January to March, 2019) and wet season (from August to October, 2019). During these periods, the highly mobile Hamadryas baboons were observed, known to cover long distances in their daily activity patterns, ranging from 4.6 to 14.2 km (Binega and Mezgebu, 2023). Baboons typically prefer cliffs and large trees for resting and hiding spots to avoid predators, human disturbance, and harsh weather

conditions. Sampling sites were strategically selected based on the areas where the baboons were known to sleep or rest. Communication with local residents provided valuable insights into these locations, allowing researchers to verify the presence of baboons and select sites with high baboon activity for further study. These sites were chosen based on the abundance of baboons, ensuring that the data collected would be representative of the population and their behaviors in these environments.

A total count method was employed to estimate the population size of Hamadryas baboons by tracking the bands within each forest, following the methodology of Beehner *et al.* (2007) and Mesele *et al.* (2014). This involved conducting total counts along pre-established transects, with six transects in total four in Shekeli Forest and two in Mizrene Forest. The census was conducted over four days each month, with counts taking place twice daily: once in the early morning (6:00–10:00 a.m.) and once in the late afternoon (4:00–6:00 p.m.), times when baboons were most likely to be present. The pace of travel along transects was maintained at 1 km per hour on foot to ensure accurate observation. The direct counting process involved a team of six individuals. These selected individuals are trained to monitor and manage baboon populations, with a strong foundation in ecological theory and wildlife behavior. They possess practical skills in conflict mitigation, excel in community engagement, and have a deep understanding of the challenges faced in areas with high human-wildlife conflict. Three counters were assigned to each counting site, particularly at the baboons' sleeping sites. According to Schreier (2010), Hamadryas baboons typically remain at their resting sites or cliffs from late afternoon until 5:00 to 6:00 a.m. and then leave these sites to forage between 6:00 p.m. and 1:00 a.m. Efforts were made to minimize double counting by understanding the movement-related behavior of the baboons. Data were recorded using standardized checklists designed for counting the number of individuals. The age and sex of the baboons were categorized into groups: Adult male, adult female, subadult male, subadult female, juvenile, and infants. These groups were identified using various features, including natural markings (such as the nature of the mantle), body size or height, coat color, and facial features, as described by Binega and Mezgebu (2023). Finally, the collected data were used to calculate the age and sex ratios of the Hamadryas baboon population, providing a detailed demographic profile of the species in the study area.

In addition to the field survey, structured interviews were conducted with the local community to assess the extent and causes of the conflict between Hamadryas baboons and local people, the methods used to manage this conflict, and baboons foraged on crops and preyed upon livestock. The study focused on five villages surrounding the study forests namely Waza, Eyesus Hintsa, Mai-Tekli, Metkel-lmat, and Addisalem. All these villages were included in the study. Households were selected based on the proximity of their agricultural lands to the study forests. A household sample frame was established using a complete list of householders obtained from the land administration office. From this sample frame, 120 respondents were randomly selected for interviews. The respondents included farmers, students, and governmental agricultural officers. The interview was administered in the respondents' native language, Tigrigna, to ensure clear communication and accurate data collection. Moreover, direct observations were carried out to document the occurrences of conflict between Hamadryas baboons and the local community. These observations focused on key aspects, such as the proximity of the study forests to agricultural areas and human settlements, types of crops that were damaged by the baboons, human activities within the forests, causes of the conflict between the baboons and the local people and control methods employed to mitigate the conflict.

Data analysis

The collected data were coded and stored in Microsoft Excel, then analyzed using SPSS version 22.0. Descriptive statistics were computed to summarize the data. The Chi-square (χ^2) test was employed to determine significant variations in population size, age structure, and sex ratio of Hamadryas baboons across the study forests and between seasons. A p-value of less than 0.05 was considered to be statistically significant.

Results

Population status of Hamadryas baboon

The Mizrene Forest hosted a significantly higher number of Hamadryas baboons compared to the Shekeli Forest. Specifically, Mizrene Forest contributed 72.5% of the total population, while Shekeli Forest contributed 27.5% (Figure 2). In Shekeli forest, 57 (range: 55-60) and 52 (range: 49-55) individual Hamadryas baboons were counted during the wet and dry seasons, respectively. Similarly, in Mizrene forest, 144 (range: 134-150) and 147 (range: 133-153) individuals were counted during the wet and dry seasons, respectively (Figure 3). Across both seasons, a higher number of Hamadryas baboons were consistently recorded in Mizrene Forest. The statistical analysis revealed a significant difference in population size between the two forests (χ^2= 41.46, df= 1, $P < 0.05$). However, there was no significant difference in the population size between the wet and dry seasons ($P > 0.05$).

In both forests 78 adult females and 28 adult males, 35 subadult females and 13 subadult males, 26 female juveniles and 12 male juveniles, and 9 infants were recorded during the wet season. Likewise, 78 adult females and 28 adult

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males, 33 subadult females and 12 subadult males, 32 female and 9 male juveniles, and 7 infants were recorded during the dry season. The data revealed a significant difference in population size between adult females and adult males (χ^2 = 68.25, df = 1, P < 0.05). Significant differences were also observed between subadult females and subadult males (χ^2 = 47.67, df = 1, P < 0.05), and between juvenile females and males (χ^2 = 49.83, df = 1, P < 0.05). Overall, adult females comprised the largest portion of the Hamadryas baboon population, while infants made up the smallest portion. In both seasons, the total population of Hamadryas baboons was 212 adults, 93 subadults, 79 juveniles and 16 infants. Adults contribute the highest proportion of the population (53%), followed by subadults (23.25%), juveniles (19.75%) and infants (4%) (Table 1). A significant difference was found in the population structure among age groups (χ^2= 46.93, df=3, P < 0.05). The total population count of Hamadryas baboons in both forests during the study period was 400 individuals.

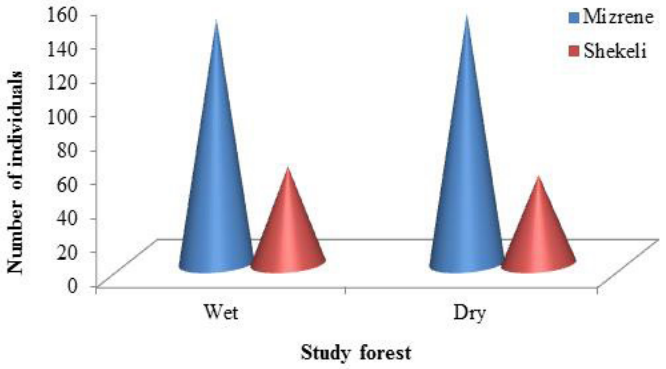

Figure 2: Population size of *Hamadryas baboon* between Shekeli and Mizrene forests during the wet and dry seasons.

Figure 3: Baboon control method (trapping) (left) and trapped baboon (right).

The estimated age and sex ratios of Hamadryas baboons showed variation between the two study forests and across seasons. The male-to-female ratio during the wet season was 1:2.6, and during the dry season it was 1:2.9. Regarding the age group, the male-to-female adult, subadult and juvenile ratios during the wet season were 1:2.8, 1:2.7 and 1:2.2, respectively and during the dry season they were 1:2.8, 1:2.75 and 1:3.67, respectively (Table 2). The overall ratio of males and females in the study area was high (1:2.76), indicates that Hamadryas communities contain relatively more females than males. The seasonal male-to-female ratio of Hamadryas baboons in each forest was compared. Accordingly, during the wet season the adult male-to-female ratio was 1:4.5 in Shekeli Forest and 1:2.3 in Mizrene Forest, subadult male-to-female ratio was 1:9 in Shekeli Forest and 1:2.2 in Mizrene Forest and the juvenile male-to-female ratio was 1:2.33 and 1:2.1 in the Shekeli and Mizrene forests, respectively. Similarly, the adult male-to-female ratio during the dry season was 1:4.2 in Shekeli Forest, and 1:2.4 in Mizrene Forest. The subadult male-to-female ratio was 0:7 in Shekeli Forest and 1:2.2 in Mizrene Forest. The ratio of juvenile male-to-female in Shekeli Forest was 1:10, and in Mizrene Forest was 1:2.8 (Table 2). These ratios reflect a higher proportion of females compared to males across different age groups and seasons, with notable differences between the two forests.

Table 1: Population size, age structure and sex of Hamadryas baboons in Shekeli and Mizrene forests between the wet and dry seasons.

Forest type	Adult				Subadult				Juvenile				Infants	
	Wet		Dry		Wet		Dry		Wet		Dry		Wet	Dry
	M	F	M	F	M	F	M	F	M	F	M	F	SNI	SNI
Shekeli	6	27	6	25	1	9	0	7	3	7	1	10	4	3
Mizrene	22	51	22	53	12	26	12	26	9	19	8	22	5	4
Total	28	78	28	78	13	35	12	33	12	26	9	32	9	7

M= Male, F= female, SNI= sex not identified.

Table 2: Age and sex ratio of Hamadryas baboons in Shekeli and Mizrene forests.

Forest type	Adult		Subadult		Juvenile	
	Wet	Dry	Wet	Dry	Wet	Dry
	M:F	M:F	M:F	M:F	M:F	M:F
Shekeli	1:4.5	1:4.2	1:9	0:7	1:2.3	1:10
Mizrene	1:2.33	1:2.4	1:2.2	1:2.2	1:2.1	1:2.8
Total	1:2.8	1:2.8	1:2.7	1:2.75	1:2.2	1:3.67

Hamadryas baboon and local people conflict

The study involved a survey administered to 120 respondents from the local community, providing insights into the demographic profile of the participants and their involvement in the study area. The age of the respondents varied widely, ranging from 18 to 84 years. The majority of the respondents (89.1%) were local farmers, while 9.1% were students, and 1.8% were agricultural officers. A significant portion of the respondents (70.9%) were illiterate; indicating limited access to formal education in the study area, while 21.8% had attained primary school education, and 5.5% had attained secondary school education.

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All respondents reported conflicts between Hamadryas baboons and local communities in the study area. The primary causes of these conflicts were identified as crop damage, predation on domestic animals, and destruction of vegetables by baboons. A significant portion (61.7%) of the respondents indicated that unlike other wildlife Hamadryas baboons cause crop damage and their response was significantly different (χ^2= 39, df=1, P < 0.05). The baboons were reported to raid all available crop species in the surrounding areas, including barley, beans, wheat, peas, teff, sorghum, fruits, and vegetables. Respondents ranked Hamadryas baboons as the third most common predator of domestic animals, after leopards and hyenas. The majority of respondents stated that the baboons were primarily known for attacking young goats, followed by chickens and lambs and their response was not significantly different (P > 0.05). Consequently, most respondents regarded Hamadryas baboons as pests.

The majority of respondents reported a significant increase in the number of Hamadryas baboons in the forests over the past five years and their response was significantly different (χ^2= 41.9, df= 1, P < 0.05). To mitigate conflicts with these baboons, local farmers employed various methods, with 90.83% of respondents identifying guarding as the most effective strategy to protect crops and their response was significantly different (χ^2= 78.21, df= 1, P < 0.05). Additionally, a few respondents (9.17%) mentioned trapping as another control method. Many respondents attributed the increase in crop raiding by baboons to high levels of human disturbance in the forests, including activities such as firewood collection, charcoal production, overgrazing, grass cutting, farmland expansion, and new settlements around the forests and their response was significantly different (χ^2= 97.5, df= 1, P < 0.05). All respondents confirmed that local communities had no received training on managing conflicts with Hamadryas baboons or their ecological importance and their response was significantly different. The lack of training in wildlife conflict management can exacerbate tensions between communities and wildlife, lead to retaliatory actions, economic losses, and social instability, and hinder effective wildlife conservation efforts. Investing in training programs for local people can significantly improve their ability to handle wildlife conflicts in a way that benefits both human communities and biodiversity. Despite the conflicts, most respondents believed that every citizen has a responsibility to conserve both the forests and the Hamadryas baboons and their response was significantly different (χ^2 = 56.3, df = 1, P < 0.05). Moreover, all respondents confirmed that no killing of baboons occurred in the study area (Table 3). Field observations supported these findings, revealed the proximity of farmlands to forests, significant human activity within the forests, and ongoing agricultural expansion likely to exacerbate baboon-human conflicts. Observations also included cereal crops damaged by baboons and the use of trapping as a control measure by local farmers (Figure 3).

Table 3: Respondents' responses on Hamadryas baboon and local people conflict.

Questions	No. of respondents
What are the common issues or concerns related to Hamadryas baboons in your area?	
• Crop damage	74
• Livestock predation	23
• Vegetable damage	13
• Others	-
How severe is crop damage by hamadryas baboons compared with other animals around the forests?	
• Highly sever	105
• I do not know	15
What is the frequency of sightings of the most common crop-raiding wild animal around your crop fields?	
• Always	93
• Often	1
• Usually	12
• Sometimes	11
• Never seen	3
How has the level of crop damage and domestic animal predation changed over the past 5 years?	
• Increased	68
• Decreased	-
• No change	27
• I do not know	25
Which animals are the most dominant predators for domestic animals?	
• Hamadryas baboon	33
• Hyena	34
• Leopard	51
• Others	2
Have you ever witnessed or experienced baboons attacking or predating on domestic animals, such as livestock or pets?	
• Yes	112
• No	8
If yes, which type of domestic animals have been attacked or preyed upon by baboons?	
• Chicken	38
• Young goat	51
• Lambs of sheep	31
What methods do you use to prevent or mitigate crop damage caused by baboons?	
• Fencing	-
• Trapping	15
• Chemicals	-
• Guarding	105
• Killing/shooting	-
Which method is the most effective control method of crop raiding?	
• Fencing	-
• Trapping	11
• Chemicals	-
• Guarding	109
• Killing	-

Table continues on next page.....

Questions	No. of respondents
Have local people received any training on how to manage conflicts with Hamadryas baboons?	
• Yes	-
• No	120
Have you observed human activities like firewood collection, charcoal production, grazing, or grass cutting within the forest areas?	
• Yes	120
• No	-
Do the local people kill the hamadryas baboon?	
• Yes	-
• No	120
How would you describe the trend in Hamadryas baboon numbers over the last 5 years?	
• Increased	77
• Decreased	25
• I do not know	18
Who is responsible for the conservation of forests and Hamadryas baboons?	
• The government	23
• NGOs	-
• Every citizen	97

Discussion

Hamadryas baboons are primarily found on cliffs within protected areas, including national parks and forests. They also inhabit areas outside these protected zones, such as adjacent areas. This distribution may be influenced by their habitat preferences, reduced predation risks, and the availability of essential resources, such as food, water holes, and sleeping sites (Binega and Mezgebu, 2023). Some studies suggest that, in addition to cliffs, trees, such as acacia and palm trees, serve as sleeping or resting sites for Hamadryas baboons. This behavior could be attributed to human disturbance and predation risks near cliffs (Schreier and Swedell, 2008; Mesele *et al*., 2014).

During the study period, the total population count of Hamadryas baboons recorded (400) was relatively similar to the count in Semien Mountain National Park (495) (Binega and Mezgebu, 2023). However, the population count was lower than that of recorded in Awash National Park (1845), the community forests of the Gasera district in the Bale zone (1173), and central Eritrea (835) (Zinner *et al*., 2001b; Mesele *et al*., 2014; Ahmed, 2020). The spatial variation in Hamadryas baboon populations may be related to the availability and distribution of preferred food resources, water holes, sleeping cliffs, forest cover, topographic features, and levels of human disturbance around protected areas (Moritz *et al*., 2012; Kummer, 2017). Research indicates that Hamadryas baboons typically inhabit semi-desert and savanna habitats (Schreier and Grove, 2010; Mesele *et al*., 2014), with their distribution affected by the availability of resources. When resources become scarce, baboons may move to higher altitudes, reaching up to 4533 meters, in search of food and water (Hussein *et al*., 2023a; Binega and Mezgebu, 2023). According to Zinner *et al*. (2001a) and Lauren *et al*. (2009), Hamadryas baboons occupy a wide range of ecosystems, including semi-desert, steppe, alpine grassy meadows, plains, and savanna woodlands up to 2600 meters. This suggests that their distribution is constrained by the presence of food, water, and suitable sleeping cliffs. The availability of these resources is a key limiting factor for the distribution of Hamadryas baboons (Lauren *et al*., 2009; Massussi *et al*., 2009; Ahmed, 2020).

The Hamadryas baboon population in the Shekeli and Mizrene forests differs from those in other parts of Ethiopia, such as Semien Mountain National Park and Borena-Sayint National Park, where these baboons primarily rely on *Olinia rochetiana*, *Rosa abyssinica*, and various crop types for sustenance (Binega and Mezgebu, 2023; Hussein *et al*., 2023a). In the Shekeli and Mizrene forests, however, Hamadryas baboons predominantly depend on *Acacia etbaica*, *Cynodon dactylon*, and *Cyperus bulbosus*. This feeding ecology is similar to that of the Hamadryas baboon populations in Awash National Park, the community forests of the Gasera district in the Bale zone, and the Wonchit Valley, where they also rely on acacia trees, albeit in different altitudinal regions (Mesele *et al*., 2014; Ahmed, 2019; Zewdu and Afework, 2020).

Although a larger population of Hamadryas baboons was recorded during the wet season, there was no significant difference in population size between the wet and dry seasons. This suggests that Hamadryas baboons use specific sites for sleeping or resting throughout the year, regardless of the food and water availability. Similar findings have been reported in other studies, which found no significant difference in Hamadryas baboon populations across wet and dry seasons (Mesele *et al*., 2014; Ahmed, 2020; Binega and Mezgebu, 2023). However, seasonal variations in population counts might be influenced by factors such as differences in food availability, rainfall, water sources, weather conditions, the quality of sleeping sites, and the level of human interference. During the wet season, abundant food and water sources are available within short distances, helping the baboons conserve energy. In contrast, during the dry season, they may need to travel further to find food and water.

In this study, the number of female Hamadryas baboons was found to be larger than that of males. However, in terms of social organization, males exhibit clear dominance. Consistent with finding by Mesele *et al*. (2014), dominant males in this species prevent females from interacting with other males and tend to monopolize access to them. High-ranking dominant males in

Hamadryas baboons control access to females, with larger groups of females providing potential advantages for the male, unless resource scarcity or human interference disrupts the population dynamics. The adult male-to-female, sub-adult male-to-female, and juvenile male-to-female ratios all indicated that females outnumber males. This higher number of females is advantageous for the social structure of Hamadryas baboons, as dominant males can form a one-male unit, consisting of multiple females, their offspring, and sub-adult males.

A significant difference in Hamadryas baboon populations was observed between the Shekeli and Mizrene forests. The highest population count was recorded in Mizrene Forest, despite having a smaller area and less vegetation cover; it supported a larger baboon population. In contrast, the lowest population was observed in Shekeli Forest, which has a larger area and more heterogeneous vegetation. The higher population count in Mizrene Forest may be attributed to the availability of sufficient food and water sources, suitable sleeping sites, low levels of human interference, and fewer natural predators. During our field observations in Shekeli Forest, we frequently heard the sound of leopards, the most formidable predator of Hamadryas baboons, which were not present in Mizrene Forest. This predator presence could contribute to the lower baboon population in Shekeli. A similar pattern was observed in a study by Mesele *et al.* (2014), which found that Hamadryas baboons were highly concentrated in the northern part of Awash National Park due to the availability of abundant forage, water holes, and suitable sleeping cliffs and trees. The variation in Hamadryas baboon populations across different habitats can be linked to the uneven distribution of ecological resources (Ahmed, 2020; Binega and Mezgebu, 2023).

This study confirms that there is significant conflict between Hamadryas baboons and local communities in the study area. Such conflicts are anticipated when baboons inhabit protected areas close to human settlements, as these areas are often encroached upon and disturbed by local people (Chapman and Peres, 2001; Zewdu and Afework, 2020). The primary issue reported by most respondents was crop damage, which is particularly prevalent when farmlands are adjacent to wildlife habitats. Large mammals like baboons often cause substantial crop damage due to direct contact and competition for resources with local people. This problem is exacerbated by the conversion of forestland into agricultural and settlement areas, as well as the appealing nature of crops to baboons (Haylegebriel, 2016; Zewdu and Afework, 2020; Hussein *et al.*, 2023b). In addition to crop damage, some respondents noted that Hamadryas baboons were responsible for damaging vegetables and fruits. Baboons also prey on domestic animals such as young goats, lambs, and chickens. Local practices, such as using protected areas for livestock grazing, grass cutting, and deforestation for firewood, charcoal production, settlement, and agricultural expansion, further exacerbates the conflict between baboons and humans. The deforestation of key food sources for baboons, like *Acacia etbaica*, *Cyperus bulbosus*, and *Cynodon dactylon*, due to these activities, aggravates the situation. Similar patterns have been observed elsewhere, such as in Awash National Park, where deforestation for short-term human interests, like charcoal production, threatens wildlife including Hamadryas baboons (Mesele *et al.*, 2014). In Uganda, deforestation of wildlife habitats has led primates to rely on nearby agricultural fields for food (Hill and Wallace, 2012). Crop damage and livestock predation by wildlife are significant issues in Ethiopia, particularly for communities living near national parks, sanctuaries, reserves, and forest areas (Zelalem et al., 2022). The economic losses from crop raiding and livestock predation by Hamadryas baboons and other primates can substantially impact the livelihoods of local people, similar to the effects observed elsewhere (Kaplan *et al.*, 2011).

Intense conflict between Hamadryas baboons and local people often leads to population declines. Strum (2010) noted that baboons have become increasingly threatened by human-induced impacts on their natural habitats. Similarly, several studies from Ethiopia have reported that local farmers and nomadic pastoralists kill Hamadryas baboons in retaliation for damage to domestic animals and crops (Mesele *et al.*, 2014; Hussein *et al.*, 2023b). Given the severity of this conflict, it is crucial to implement urgent conservation and management measures. Without immediate intervention, the situation could escalate beyond the control of local authorities, potentially leading to the extinction or significant migration of Hamadryas baboons from the area. According to the respondents, over the last five years, the growing Hamadryas baboon population has resulted increased conflicts with local farmers. To mitigate this conflict, farmers employ various methods, with guarding reported as the most effective strategy for protecting crops from baboon damage. In Ethiopia, the guarding method is commonly used by farmers to safeguard their fields from pest primates, including Hamadryas baboons (Dagnachew and Melese, 2016; Zewdu and Afework, 2020). However, this method requires individuals to be present in agricultural areas throughout the day, which can disrupt daily activities. For example, it may affect school attendance for children and increase the workload for parents (Ahmed, 2019; Zewdu and Afework, 2020). Additionally, local people in the study area use trapping as a control technique and other control methods such as fencing, shooting, and chemical deterrents are also commonly used in Ethiopia (Ahmed, 2019; Zewdu and Afework, 2020).

The majority of respondents in the study area is

illiterate and lack formal education on the economic and ecological importance of wildlife and the rationale behind conservation efforts. Additionally, no training has been provided to local people to enhance their understanding of the benefits of wildlife species. Formal education plays a crucial role in wildlife conservation and management and in promoting awareness of wildlife importance. Despite this, many respondents in the study area believe that every citizen has a responsibility to conserve forests and their biological resources, including Hamadryas baboons. A significant problem in biodiversity conservation in Ethiopia is the lack of sufficient training for local communities (Mesele *et al*., 2014; Ahmed, 2019). Therefore, forest authorities and non-governmental organizations should focus on delivering training programs to raise awareness among local people about wildlife and habitat conservation. Although Hamadryas baboons cause considerable damage to farmers' properties, there were no instances of baboon killings in the study area. However, killing baboons as a control measure is commonly practiced in some protected areas of Ethiopia, such as Awash National Park, the community forests of the Gasera district in the Bale zone, Semien Mountain National Park, and Borena-Sayint National Park (Mesele *et al*., 2014; Ahmed, 2020; Binega and Mezgebu, 2023; Hussein *et al*., 2023b).

Conclusions and Recommendations

The present study highlights the significance of Shekeli and Mizrene forests as crucial habitats for Hamadryas baboons in the highlands of the Tigray national and regional state. On average, a total of 200 Hamadryas baboons were counted, with notable variation between the two forests but minimal seasonal changes in population size. The age distribution of Hamadryas baboons in the area was as follows: 53% adults, 23.5% subadults, 19.5% juveniles, and 4% infants. The male-to-female ratio indicates a higher proportion of females compared to males in the population. The Hamadryas baboons in the study forests face significant human-related challenges and the primary sources of conflict between Hamadryas baboons and local people are crop raiding and predation of domestic animals. Additionally, human activities such as settlement expansion, agricultural practices, firewood collection, charcoal production, cattle grazing, and grass cutting have extensively disturbed the natural habitats of the animal. Notwithstanding the high level of conflict, the Hamadryas baboon population has experienced a significant increase over the past five years. To address this issue, it is crucial to implement effective mitigation strategies and conduct conservation awareness campaigns to educate local communities and administrators about the importance of Hamadryas baboon conservation. Further research is needed to gain a deeper understanding of the feeding ecology and activity patterns of Hamadryas baboons in the region. This study is the first of its kind in Ethiopia's Tigray region and provides a valuable baseline for future research on Hamadryas baboons and other wildlife of the region whicht is important to design conserveation actions.

Declarations

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The research was carried out in-line with the IRB Guidelines of Mekelle University, Ethiopia.

Ethical statement

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Consent for publication

All authors give their consent for publication.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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