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Walia ibex have increased in number and shifted their habitat range within Simien Mountains National Park, Ethiopia

Dessalegn Ejigu[1]*, Afework Bekele[2], and Larkin Powell[3]

[1]*Department of Biology, College of Science, Bahir Dar University, Ethiopia;* [2]*Department of Zoological Science, Addis Ababa University, Ethiopia;* [3]*School of Natural Resources, University of Nebraska-Lincoln, USA*

ABSTRACT

Walia ibex (*Capra walie*) is an endemic and endangered species restricted to Simien Mountains National Park (SMNP). The population of Walia ibex appeared to have gradually increased during the decade prior to our study. Our goal was to determine the current population status of Walia ibex in SMNP. We conducted censuses throughout 2009 to 2011 to study population size, structure, and distribution of individuals. We stratified the Park using habitat features into eight different census sites, and a simultaneous total count was used to estimate the population size of Walia ibex. The mean population size during the study period was 752 (S.D.12.7) individuals. Walia ibex were found in groups of 12 individuals on average, and group size remained similar throughout the year. Density in our surveys was 8.0 individuals per km^2, which is higher than the density of Siberian ibex. The male to female ratio was 1:1.6, and 19% of the population was in the yearling or kid age classes. Our surveys confirm that Walia ibex have shifted their range in SMNP. We believe the change in distribution is likely to be a response of Walia ibex to human and livestock disturbances, and the presence of predators in the previous habitat range. Community-based conservation with fair and equal benefit sharing of resources of the Park is an important strategy for sustainable conservation of Walia ibex in SMNP.

Keywords: *Capra walie*, endangered, endemic, Simien Mountains National Park, SMNP, Walia ibex

INTRODUCTION

Walia ibex (*Capra walie*, Rüppell, 1835) is an endemic and endangered species restricted to Simien Mountains National Park (SMNP). It is one of the Palaearctic ibex in Ethiopia (Nievergelt, 1981; Last, 1982; Haltenorth and Diller, 1993), and is believed to have immigrated from the Middle East 26,000 to 14,000 years ago (Nievergelt, 1981). Through time, it has successfully colonized the Simien

* *Corresponding author:* D. Ejigu; e-mail: dessalegn_ejigu@yahoo.com; address: P.O. Box 1817, Bahir Dar, Ethiopia

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Mountains and represents the evolution of *Caprinae* in Ethiopia. It has moved to a higher altitude of Simien, which is characterized by a wet climate and year-round supply of water (Nievergelt, 1981; Kingdon, 1997; Ejigu *et al.*, 2015). Yalden and Largen (1992) suggested that gorges and cliffs in the region provide a level of protection to the species. Walia ibex live in areas with a higher altitude, colder temperature, and with more precipitation than do the Nubian ibex. As a result, the geographical isolation of Walia ibex and Nubian ibex leads them to develop adaptations in response to ecological requirements within their respective geographical distribution ranges (Nievergelt, 1981; Gebremedhin *et al.*, 2009).

In the early 20th century, Walia ibex existed in significant numbers in the Simien highland massifs (Brown, 1965, 1969b, as cited in Yalden and Largen, 1992). However, in the late 1930s, the species drastically declined to the brink of extinction (Last, 1982). Gradual increases followed, but the lack of proper strategies of wildlife conservation in the country led the population to decline again. Moreover, during the time of civil war in Ethiopia in the late 1980s, there is evidence that Walia ibex were heavily poached (Debonnet *et al.*, 2006). Their limited number and restricted habitat range coupled with various anthropogenic disturbances have caused Walia ibex to be one of the most endangered mammal species in the world. As a result, in 1996, IUCN registered Walia ibex in the Red List of Critically Endangered species. In 1989, the total number of Walia ibex in SMNP was 400 individuals (Falch and Keiner, 2000). One decade later, Nievergelt (1998) estimated the population of Walia ibex to be between 200–250 individuals, out of which about half was in the Park and distributed mostly in the Gich plateaux and along the escarpment of Shayno Sefer to Chenek. According to Ludi (2005), 450–530 individuals of Walia ibex were estimated in the park.

In Walia ibex, adult males are usually larger and heavier than adult females (Nievergelt, 1981; Macdonald, 1984). Horns are present in both sexes and semi-circular in shape. In some males, horns exceed a metre in length (Schwartz, 2009), but females have shorter and thinner horns (Dunbar, 1978; Last, 1982). Adult males had beards, while females had no beards. Both adult males and sub-adult males had a bony process in their foreheads, which was not found in the females. Sub-adult females were smaller in size than adult females, and they differ from sub-adult males by the presence of small and thin horns, relatively small body size and with no bony process on their foreheads. Yearlings were relatively smaller and with very small horns, and kids were new-born individuals that closely followed and suckled their mothers.

Walia ibex is currently the most endangered *Capra* species (Festa-Bianchet, 2009; Schwartz, 2009) and have been the most endangered ungulate in the world for over 50 years. Given the apparent increase in population size following a long period of decline, and given the restriction of the species to a single protected area (IUCN, 2008), our research goal was to determine the current population status of Walia ibex in SMNP and then to design appropriate and sustainable conservation measures. Thus, we conducted intensive censuses throughout 2009 to 2011 to assess population size, sex and age structures, and the distribution of individuals in the Park.

MATERIALS AND METHODS

Study area

The study was carried out in SMNP, which is located in the Amhara National Regional State of Ethiopia in the North Gondar Administrative Zone (37°51′26.36″–38°29′27.59″ E, and 13°06′44.09″–13°23′07.85″ N), at about 865 km north of Addis Ababa and 132 km northeast of Gondar town.

SMNP includes broad undulating plateaux and the highest mountain of Ethiopia, Ras Dejen (4,620 m a.s.l.), which is also the fourth highest mountain in Africa (Puff and Nemomissa, 2001; 2005). The altitudinal variations of the Park produce different landscape units including the lowland vallies that extends below 2,000 m a.s.l. The extreme steep escarpments between 2,000–4,000 m a.s.l. include most of the wildlife habitats and the major parts of the highland plains that are intensively utilized for cultivation and livestock grazing by the local people. Prior to the 1960s, the area had been used as a controlled hunting area, and was regarded as a royal hunting ground (Falch and Keiner, 2000). At the time of its establishment in 1978, SMNP was the smallest Park in the country with an area of only 136 km^2 (Hurni and Ludi, 2000), but at present the Park covers 412 km^2 (Figure 1).

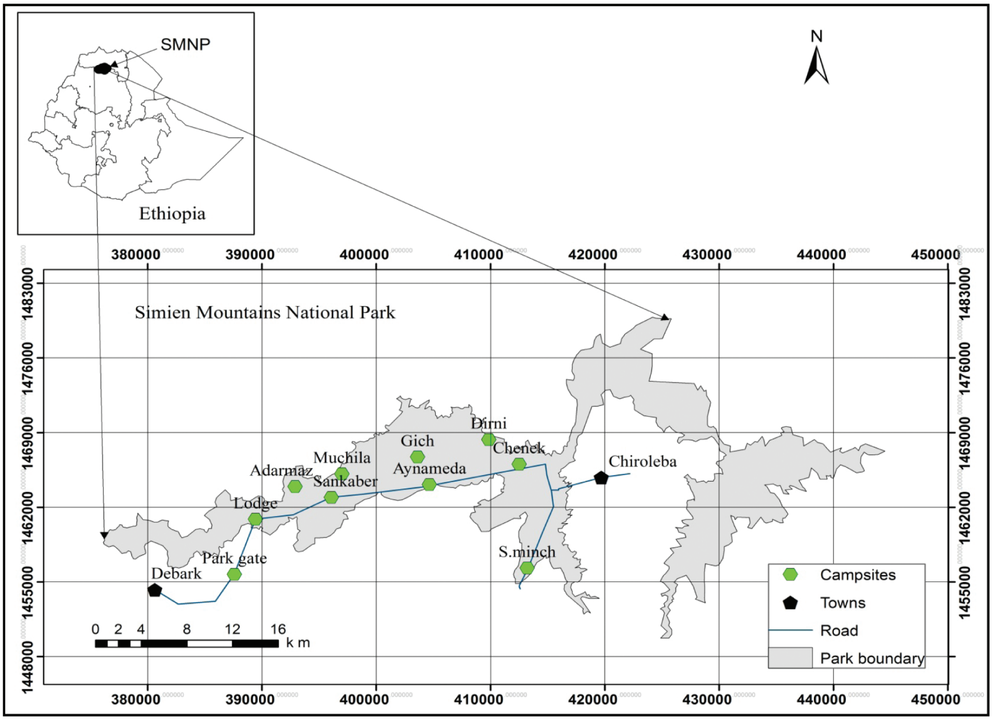

Figure 1 Location of SMNP within Ethiopia (inset), and the distribution of towns and campsites for comparison to descriptions of changes in range for Walia ibex during surveys in the Park in 2009–2011.

The main rainy season in SMNP lasts from the end of June to September with the dry season from December to April. Mean annual rainfall is 1,054 mm (2000–2009 average), but rainfall shows significant variation with altitude in the Park (Puff and Nemomissa, 2005) with an annual range of 1,000 mm in the lowlands to 1,500 mm in the highlands (Hurni and Ludi, 2000).

Ground frost commonly occurs at night during the dry season especially in February and April (Crook, 1966). Hurni (1982) reported the mean annual temperature at Gich of 7.7 °C, which is often accompanied by dry winds during the day time. At night, however, the area experiences temperature variations ranging from +2 °C to –10 °C. The 10-year (2000–2009) mean annual minimum and maximum temperature data were 8.7 °C and 20.0 °C, respectively. Despite fluctuations in daily temperatures, seasonal variations in temperature are minimal due to Ethiopia's proximity to the equator (Nievergelt, 1990). As a result, variations in diurnal temperature far exceed seasonal variation.

Simien Mountains vegetation mainly consists of a mixture of Afro-alpine woods, heath forest, high mountain vegetation, montane savannah, and montane moorland (Hurni and Ludi, 2000). The vegetation of the Park consists mainly of *Erica arborea*, *Lobelia rhynchopetalum*, *Hypericum revolutum*, *Rosa abyssinica*, *Helichrysum* sp., and *Solanum* sp. The major herbaceous vegetation in Simien include *Festuca* sp.(Poaceae), *Thymus schymperi* (Lamiaceae), *Alchemilla pedata* (Rosaceae), *Mosses and liver worts* (Grimmiaceae), and *Usnea* sp.(Usneaceae). Walia ibex feed on a diverse diet of more than 28 species of grasses, forbs and above-ground plants. The most commonly used plants by Wali ibex were *Festuca sp.*, *Lobelia rhynchopetalum*, *Helichrysum citrispinum*, and *Helichrysum horridum*.

The Park's unique landscapes support some of Ethiopia's most important endemic mammals, such as the Ethiopian wolf (*Canis simensis*) and the gelada baboon (*Theropithecus gelada*), in addition to the Walia ibex. Twenty large and 14 small mammal species reside in the Park (UNESCO, 2001). Large mammals including Menelik's bushbuck (*Tragelaphus scriptus meneliki*), Grimm's duiker (*Sylvicapra grimmia*), klipspringer (*Oreotragus oreotragus*), bush pig (*Potamochoerus porcus*), rock hyrax (*Procavia capensis*), porcupine (*Hystrix cristata*), Abyssinian hare (*Lepus starcki*), leopard (*Panthera pardus*), serval (*Felis serval*), spotted hyaena (*Crocuta crocuta*), golden jackal (*Canis aureus*), anubis baboon (*Papio anubis*), hamadryas baboon (*Papio hamadryas*), grivet monkeys (*Chlorocebus aethiops*), and black and white colobus monkeys (*Colobus guereza*) commonly occurred in the park.

Study species

Although the population is well below 1,000 individuals, Walia ibex are the flagship species for the Park and the image of the species is commonly used for symbols of athletic teams and organizations in Ethiopia. When Walia ibex were first recorded in 1835, and subsequently observed by Powell Cotton in 1901, their number and status were not known (Last, 1982). Walia ibex often breed throughout the year, which makes it distinct from other ibex species in which breeding behaviour is largely associated with seasons (Nievergelt, 1981; Massicot, 2001). The lack of significant changes in temperature in the tropical Simien Mountains may produce no environmental costs to individuals that breed year-round. However, the peak sexual activity in Walia ibex occurs from March to May (Dunbar and Dunbar, 1981; Nievergelt, 1981). The gestation period is approximately 150–165 days, and females usually give birth to one offspring. Rarely, twins have been recorded as described in other ibex species (Chris and Stuart, 1997; Guttman, 1999). The main parturition period for Walia ibex is from September to October (Nievergelt, 1981). Age, physical condition of the animal and external stimuli could affect sexual maturity for young Walia ibex (Nievergelt, 1981; Eckhart, 2002), and they reach sexual maturity at the age of one (Massicot, 2001).

Field methods

To estimate the population size of Walia ibex, we used the total count method as adopted by Norton-Griffths (1978), Sutherland (1996), and Wilson *et al.* (1996). Evenings and mornings provided the best opportunities to see Walia ibex because they move to and from overnight roosting sites in caves and/or gorges into open habitats (Aryal, 2005). However, the terrain of SMNP is very difficult to cross during the evening, so all censuses were carried out simultaneously early in the morning from 0630 H to 0930 H. Simultaneous counts from different vantage points were used to assess the local position, number, age, and sex structures of Walia ibex. We used the methods of Ganskopp and Vavra (1986) to determine the identity and number of animals in the herd.

As the terrain of SMNP made transect methods inappropriate for population surveys, censuses were carried out by classifying the area into eight different census sites and GPS readings were taken to mark each of these census sites. The eight census sites were represented by local names within the Park: Buyetras, Sankaber, Adarmaz, Muchila, Gich, Dirni, Chenek and Sebatminch. As the size and physical features of the census sites required, we sub-divided each site into counting blocks (Buyetras: 3 blocks; Sankaber: 2; Adarmaz: 4; Muchil: 5; Gich: 5; Dirni: 8; Chenek: 7; and Sebatminch: 9). Thus, 43 total counting blocks were used for the population census of Walia ibex in SMNP.

Simultaneous surveys of each block were carried out by two well-trained field assistants who were selected from the staffs of SMNP and the local community. Thus, a total of 86 operators participated during each census time. Participants received a brief training on methods for surveying in each block so that all surveyors had a common understanding in order to gather reliable data.

We conducted the total count in each survey block twice each year (one survey each for wet and dry seasons) for three consecutive years. To avoid double counting, each block was distinguished from other blocks using natural land marks and local names. Land marks such as escarpments, vantage points, gorges, and rivers were used to delineate each counting block in each census site. When ibexes were encountered during each census time, we recorded the group size, age, sex, time and directions of departure of the herd (if they moved) as adopted by Lewis and Wilson (1979).

Based on the morphological features of Walia ibex by Nievergelt (1981), detailed observations on herd size were carried out during the census. Herd size was determined prior to classifying individuals into their respective age and sex categories. We identified age and sex based on external morphology.

To minimize double counts, we held discussions with operators who were involved in the population census at adjacent counting blocks at the end of each census. This was performed by comparing similarities in observations based on herd size, age and sex structure, time of observation and direction of movement (Anderson *et al*., 2007). During censuses, individuals were considered as members of the same group if the distance between them was less than 100 m as adopted by Nievergelt (1981). These criteria could also be relaxed when Walia ibex moved across areas with varied topographic landscapes or when members were dispersed while feeding, as described by Gross *et al.* (1995) in other animals. Data on the proportion of age and sex structures were gathered during each census period in order to predict population dynamics.

Data analysis

The mean herd size of Walia ibex was calculated using the total number of individuals and the herd number (Feng *et al.* 2007). We used a chi-square test to compare variations in population and herd size during the wet and dry seasons as well as the variation in population size among age classes. Statistical tests were two-tailed at 0.05 significance level, and data were analyzed using SPSS software version 16.0 (SPSS Inc., Chicago).

RESULTS

Population increase

The mean number of Walia ibex counted during our six census periods was 752 (S.D.12.7). Counts ranged from a low of 680 during the 2009 dry season to 801 during the 2011 wet season. We found no changes in the proportion of individuals counted in wet and dry seasons across the three years of surveys (χ^2 = 0.42, df = 1; p >0.05; Table 1).

Table 1 Summary of census counts for Walia ibex at SMNP during wet and dry seasons of 2009–2011.

Year	Dry season	Wet season	Mean
2009	680	740	710
2010	747	763	755
2011	779	801	790

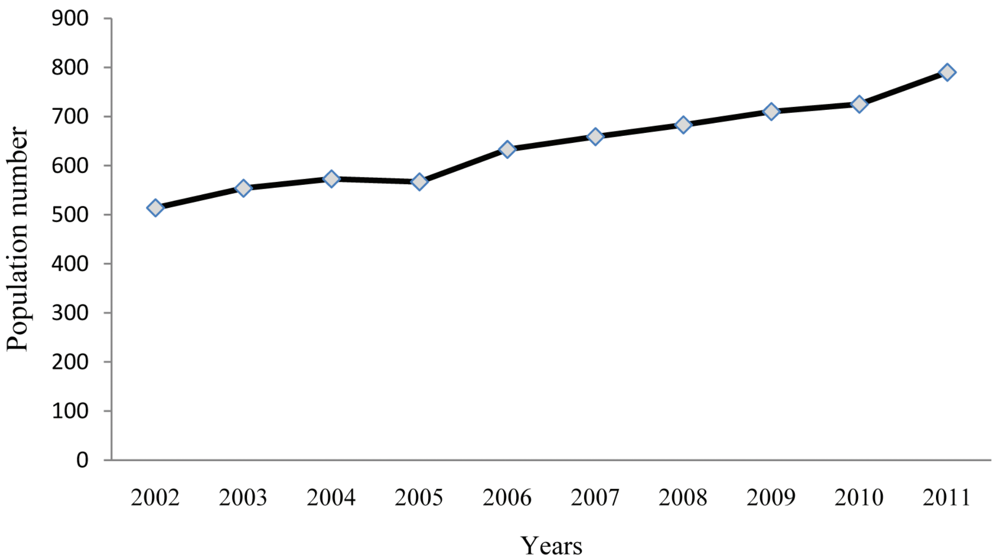

Figure 2 Population trends of Walia ibex (2002–2011) in SMNP. Data from 2002–2008 are provided by the Park office; 2009–2011 represent data from this study.

Our counts contributed to continued data during the past decade that suggests a gradual increase in the number of Walia ibex at SMNP (Figure 2). The mean population count of Walia ibex was 514 individuals in 2002 (data from the Park Office), and our 2011 mean count was 790. This showed that, on average, 28 individuals per year are being added into the population.

Distribution changes of Walia ibex within SMNP

The distribution of Walia ibex in SMNP extends from Buyetras in the western parts of the Park to the southeastern end of Sebatminch (Figure 3). The density of Walia ibex in its current range was 8.0 individuals per km^2, and our surveys showed that more than 50% of the population was distributed in the eastern and southeastern regions of the Park.

The density of Walia ibex was not spread evenly through the regions of SMNP ($\chi^2 = 19.40$, df = 7, $p < 0.01$), and we found higher densities in Dirni, Chenek and Sebatminch compared to other sites in the Park, and the density at the various sites of the Park showed statistically significant differences (Table 2).

The census areas with the highest mean proportion of the population were in the eastern and southern regions of the Park. Although Walia ibex had previously been restricted in distribution to the region from Sankaber to Meflekiaw-Ambaras-Gich, the majority of the current population occurred in the regions from Chenek to Sebatminch (Table 3). Figure 4 showed different counting blocks in the Park.

Figure 3 Distribution of Walia ibex in SMNP.

Table 2 Density of Walia ibex (individuals/km^2) among census sites in SMNP 2009–2011. Mean values are from eight counting blocks during 2009–2011.

No.	Census sites	Mean count	Area (km^2)	Density (individuals / km^2)
1	Buyetras	2.5	4.3	0.6
2	Sankaber	9.5	5.3	1.8
3	Adarmaz	11.3	4.9	2.3
4	Muchila	61.8	9.1	6.8
5	Gich	96.5	17.0	5.7
6	Dirni	166.8	17.9	9.3
7	Chenek	184.5	18.1	10.2
8	Sebatminch	219.5	17.8	12.4
	Total	**752**	**94.4**	**6.2**

Table 3 Mean numbers of Walia ibex during wet and dry seasons during 2009–2011 in each census region and the distribution (%) of the total population in SMNP.

Season	Census sites								Total
	Buyetras	Sankaber	Adarmaz	Muchila	Gich	Dirni	Chenek	S.minch	
Wet	2	9	15.5	60	107	188.5	192.5	208.5	783
Dry	3	10	7	63.5	86	145	176.5	230.5	721.5
Mean count	2.5	9.5	11.3	61.8	96.5	166.8	184.5	219.5	752
Population (%)	0.33	1.26	1.49	8.21	12.83	22.17	24.53	29.18	100

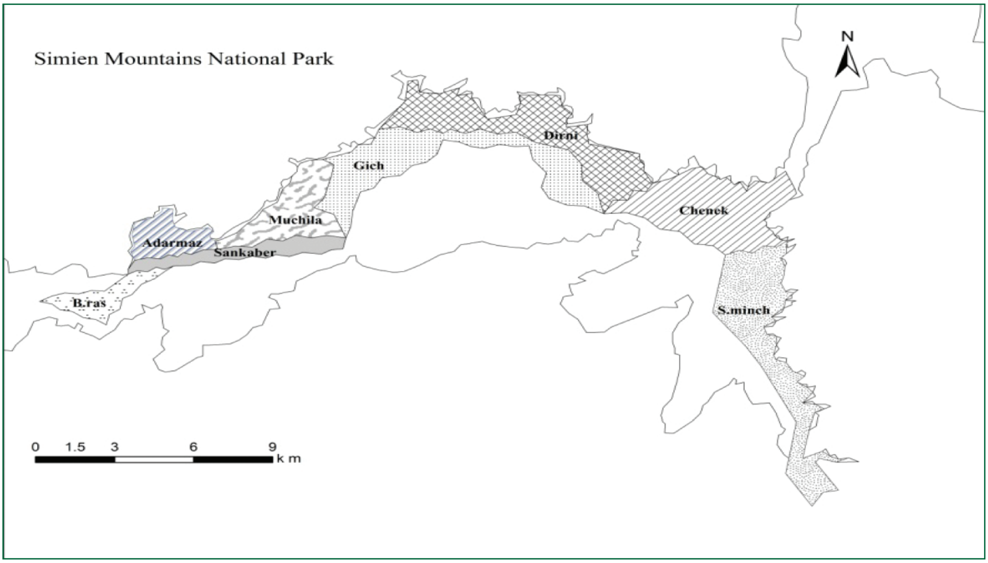

Figure 4 Different counting blocks used during population census of Walia ibex in SMNP.

Table 4 Counted individuals of Walia ibex in 1968–1969 in and near SMNP for comparison with current population distribution and abundance (from Nievergelt, 1981).

Habitat range	Census sites	Individuals counted
Sankaber	Sankaber	20
	Gidirgot	15
	Zemedyelesh – Muchila-Afaf	25
	Muchila-Afaf – Setderek	30
	Setderek – Imetgogo	50
Gich	Imetgogo – Meflekiaw	15
Gich – Chenek	Meflekiaw – Ambaras – Chenek	25
Outside the Park	Near Silki	30
Total		**210**

The 1968–1969 population census conducted by Nievergelt (1981) indicated that 64.3% of the Walia ibex population occurred around Gich, 9.5% in Sankaber, 11.9% occurred in habitats located between Gich and Chenek, and 14.3% outside the Park boundary near Silki (Table 4). Currently, however, only 1.3% of the population occurred in Sankaber and 12.8% in Gich, indicating a shift in distribution from Gich towards the eastern and southeastern parts of the Park.

Population structure of Walia ibex

We observed more adult females than other age and sex classes in the herds. Our average count for females was 365 (48.5% of the population), of which 288 were adults (38.3% of population). We counted an average of 236 adult and sub-adult males, of which 146 were adults (19.4% of population), and the age structure varied between males and females (χ^2 = 26.04, df = 4, p <0.01). Yearlings and kids together constituted 19.2% (n = 144) of the population and, on average, we failed to identify age and sex for only 7 individuals during each survey.

The sex ratio (male to female ratio) in the average count was 1:1.6 (χ^2 = 27.69; df = 1; p <0.01). The ratio of adult males to adult females was 1:2, which showed more female bias (χ^2 = 46.46; df = 1; p <0.01). The ratio of yearlings/kids to adult females was 1:2 (Figure 5).

The number of individuals within age and sex classes did not change during wet and dry seasons, except for kids (wet: 57.0 ± 15.5; dry: 84.0 ± 4.0; p <0.05). We counted an average of 56 herds during wet seasons and 53 herds during dry seasons. Maximum herd sizes were larger during dry seasons (wet: maximum = 23 individuals; dry: maximum = 34). But, the mean herd size did not vary between seasons (wet: 11.3 ± 2.2; dry: 13.0 ± 1.3; p >0.05)

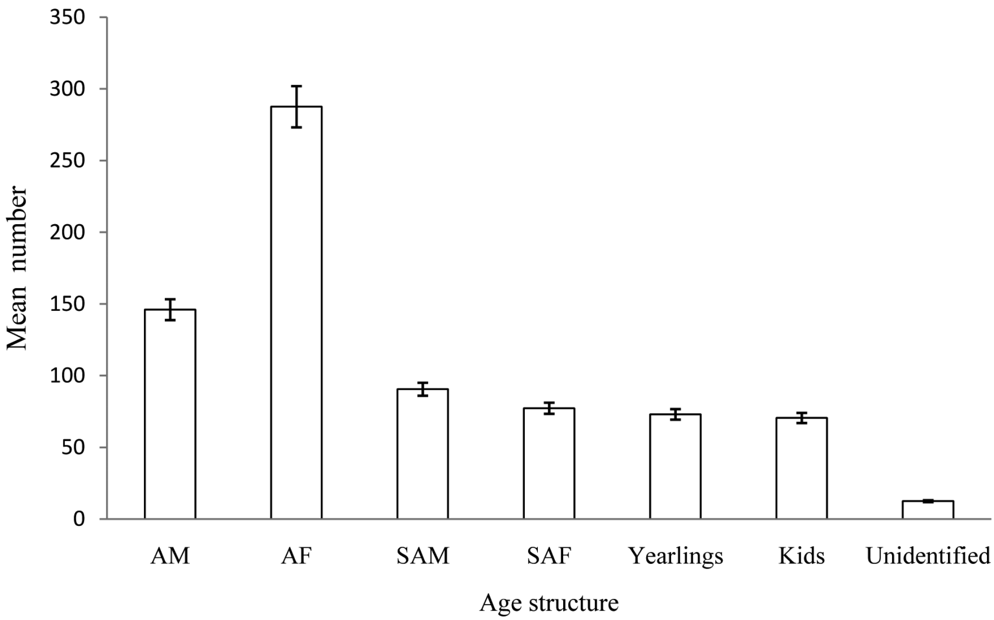

Figure 5 Distribution (mean ± S.D.) of Walia ibex among age and sex classes (AM = Adult Males, AF = Adult Females, SAM = Sub-adult Males, SAF = Sub-adult Females) in SMNP. Means represent six counts during 2009–2011.

DISCUSSION

Population increase

The population of Walia ibex at SMNP appears to have grown at a fairly constant rate during the past decade. The mean count from our six surveys of 752 is higher than counts in previous decades, which is a good sign for conservation of the species. The establishment of surveys to estimate population size is central to the conservation and management of species of concern (Elphick, 2008). The main causes for the population increase of Walia ibex in SMNP are protection of the Park by the rangers that has prevented poaching of Walia ibex by the local people, and expansion of the Park's boundary to increase the habitats of Walia ibex towards the southern and southwestern parts of the Park. Moreover, protective measures including minimizing habitat destruction, awareness creation to the local community, and participation of the local people in tourism activities are considered to be the possible causes for the population increase of Walia ibex in SMNP.

Distribution changes within SMNP

There was an uneven distribution of Walia ibex at its habitat ranges in SMNP, with more individuals counted towards the eastern and southeastern parts of the Park (Ejigu *et al.*, 2015). As all areas within their habitat ranges are not equally suitable, species are not evenly distributed in all their habitat ranges (Rondinini *et al.*, 2004).

Our study demonstrates that the density of Walia ibex has increased towards the eastern and southeastern parts of the Park. Population density among the different census sites showed statistically significant differences, with the highest density observed at the Sebatminch site and the lowest at the Buyetras site. Such a difference was caused by various factors including human and livestock disturbances in the previous habitat ranges that led to the shifting of Walia ibex habitats towards inaccessible areas at the higher altitudes (Ejigu *et al.*, 2015). Regardless of the severe habitat disturbances that occur in SMNP, protection of the Park by the park rangers has prevented the problem of poaching by the local people, and as a result of this the population gradually increased.

Currently, the distribution of Walia ibex in SMNP is restricted to an area of 94 km^2, which accounts for less than 25% of the total Park area. As the main habitats of Walia ibex were highly disturbed by various human-related activities, its distribution was further confined towards the escarpments and inaccessible areas. Small populations when concentrated in small habitat patches become easily reduced by poaching or predation (Smith and Smith, 2001). A species with a small population size is, therefore, more likely to become extinct, especially if it occurs in areas that are being radically changed (Johnson, 2000). The density of Walia ibex in its current habitat range was about 8 individuals per km^2. This is higher than 2.7 individuals per km^2 of Siberian ibex (*Capra* *sibirica*) in other parts of the world (Feng *et al.*, 2007). A high density of Walia ibex in its restricted habitat might lead to various problems, including competition for scarce resources, loss of fitness, and being prone to predators and disease.

Previously, 70% of the Walia ibex population existed in the western parts of SMNP, especially from Michotish to Tiruwata (Nievergelt, 1981). At present, however, more than 50% of the population occurs in the eastern and southeastern habitat ranges that extended from Chenek to Sebatminch (Ejigu *et al.*, 2015). There were also differences in the mean percentage individual count of Walia ibex within the different census sites of the Park. Such differences might be due to differences in human and livestock disturbances, and habitat quality, as well as the presence of predators in the area. Severe alteration to the species because of various human-related activities on the natural habitat influences its ecology, population dynamics and physiology (Geist, 1970).

Population structure

The population number of Walia ibex showed significant differences among the various age classes. In ibex, the population is strongly age structured and the different age classes respond differently to various external factors (Yoccoz and Gaillard, 2006). The sex ratio in the Walia ibex population indicated that the population was female biased and there were more adult females than any other age classes. Generally, age structure in ibex population is characterized by a high proportion of old-age classes, especially when the population is stable or declining (Yoccoz and Gaillard, 2006).

In Walia ibex in SMNP, more adult females were observed compared to the number of kids and such a decline in the number of kids during the population census might be for various reasons. Animals from different age and sex categories may use habitats differently (Aebischer *et al.*, 1993). Thus, females take care of the young and they should find areas with few predators even at the expense of forage quality (Ruckstuhl, 1998; Mysterud, 2000; Grignolio *et al.*, 2007a; Accevedo and Cassinello, 2009). Females with kids in Alpine ibex, for example, used more rocky terrain and stayed on steeper slopes than females without kids (Grignolio *et al.*, 2007a, b). In the Iberian ibex, more males occurred in risky habitats than females in general, and lactating females preferred safer habitats (Accevedo and Cassinello, 2009).

As ibex kids are more vulnerable to predation than adults, females with kids either increase their use of escape terrains or show high movement rates (Neuhaus and Ruckstuhl, 2002). In Alpine ibex, young of a few months old were easily susceptible to golden eagles (Grignolio *et al.*, 2007b). Thus, kids in SMNP are easily susceptible to predators as their carcasses were observed during the study period. Generally, high levels of mortality among newborn and young individuals are recorded in ungulates (Mysterud, 2000). Thus, infant mortality might be one possible reason for the occurrence of a smaller number of kids compared to adult females in the population of Walia ibex.

Also the proportion of mature females that give birth affects birth rate and influences population growth (Robinson and Bolen, 1989; Wronski, 2002). Nevertheless, in our study only few adult females were observed with their young, indicating that further research on recruitment is needed.

Sex-ratio within a population might be changed because of an unbalanced sex ratio at birth or because of sex-specific mortality associated with age (Robinson and Bolen, 1989). Moreover, as hunting pressure normally selects males with desired characteristics, such as the presence of long horns, populations of large ungulates are usually female biased (Robinson and Bolen, 1989; Estes, 1991). The emigration of mature males from the herd could also contribute to an unequal sex ratio in a given population (Lewis and Wilson, 1979). At present, however, poaching in SMNP is not a problem, and its contribution to an unbalanced sex ratio in the population of Walia ibex could be less likely.

As the number of adult females increases in the population, they can produce more new-born individuals and can maintain a more viable population in the future. However, long-term survival of the Walia ibex population can be determined not only by the number of adult females but also by the number and survival of new-born individuals. Many species of large mammals have life history strategies with high adult survival and low and variable recruitment (Yoccoz and Gaillard, 2006). Thus, juvenile survival is critical to understanding the survival of Walia ibex population in general.

Group size in mixed herds of Walia ibex remained more or less the same throughout the year. Nevertheless, slight changes were observed during the rutting peaks in the dry season. It declines from May onwards and then increases again towards the peak in April (Dunbar and Dunbar, 1981; Nievergelt, 1981). The group size varied from 1 to 27 individuals during the wet season and 1 to 34 during the dry season. The slight difference in group size between the wet and dry seasons was thanks to the fact that adult males are mixed with adult females during the dry season because of the occurrence of a rutting peak. However, ibexes in general live most of the year in sexually segregated groups (Neuhaus and Ruckstuhl, 2002).

Mean group size in Walia ibex was relatively higher than the mean group size of Siberian ibex (Feng *et al.*, 2007). The higher group size might be due to its adaptive behaviour in habitats where anthropogenic disturbances were very common, since animals living in groups can save more energy and time (Wilson *et al.*, 2003).

In mixed groups of Walia ibex, it is the adult female that leads the herd. This is also true in other ungulates such as the Mountain nyala (*Tragelaphus buxtoni*) in which the alpha female leads the herd (Refera and Bekele, 2004). In Mountain gazelles, the adult female is the basic unit of social organization and the herd size is determined primarily by her reproductive status (Dunham, 1999). In Walia ibex the number of males mixed with females decreases with increasing age as males attain the body weight of adult females (Nievergelt, 1981). A study on Nubian ibex also showed similar results in which mature males and females lived in separate groups, except during the rut when the former move into areas occupied by the latter to form mixed groups (Gross *et al.*, 1995).

Conclusion

Currently, the population status of Walia ibex in SMNP shows a gradual increase. Nevertheless, a radical decline in population size occurred in 1996 in which only about 200 individuals of Walia ibexes were counted in the Park. Moreover, poaching from the local people and habitat destruction had driven the remaining Walia ibex population further east (Shackleton, 1997; Nievergelt, 1998). As a result, in 1996, SMNP was inscribed on the list of World Heritage Sites in danger (Falch and Keiner, 2000). However, in 2005 after the incorporation of 'Limalimo' and 'Mesareria' wildlife reserves into SMNP, the population size of Walia ibex increased to 623 individuals (Debonnet *et al.*, 2006).

It is important to monitor population trends of a species in order to establish whether the population is stable, declining or increasing over time (Blom *et al.*, 2004), and detecting population changes is of high priority in order to take appropriate conservation measures (Nievergelt, 1981). Thus, the present population status of Walia ibex is achieved thanks to strong protection measures carried out by the government. Nevertheless, additional work is required to ensure the sustainable conservation of Walia ibex by involving the local community in particular and other concerned stakeholders at large.

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