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An updated population status of Astor Markhor (*Capra falconeri falconeri*) in Gilgit-Baltistan, Pakistan

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ABSTRACT

Gilgit-Baltistan (Northern Pakistan) has a rich diversity of wild caprinae and is one of key area for caprinae community-based conservation programs. In this program, selective hunting of small proportion of adult males with large horns is done on annual basis to generate money for the conservation, habitat improvement and livelihood of local communities. The current study aimed at collecting reliable data about population status of Astor Markhor (*Capra falconeri falconeri*). For this purpose, fixed-point direct count method was used for estimation of Astor Markhor population in 16 catchments including 15 Community-Controlled Hunting Areas (CCHAs). A total of 1087 animals were counted, comprising of 266 (24%) males (including sixty-two (6%) trophy-sized males), 388 (36%) females, 227 (21%) yearling and 206 (19%) kids. Population density of Astor Markhor was estimated 0.13 individuals/km^2, with male to female ratio 0.69:1, yearling to female 0.54:1 and kids to female 0.51:1. CCHA/catchment wise assessments showed that Kargah area has highest population (211 animals). It is suggested that consequences of trophy hunting should be strictly contingent upon population data obtained through robust methods, duly verified by a panel of conservation experts and may be extended to other areas also for fruitful results.

1. Introduction

Markhor (*Capra falconeri* Wagner 1839) is a magnificent species of the family Bovidae and sub-family Caprinae (Roberts, 1997; Schaller, 1977). There are four sub-species of markhor reported to occur in Pakistan; Astor Markhor (*Capra falconeri falconeri*), Kashmir or Pir Panjal Markhor (*Capra falconeri cashmiriensis*), Kabul Markhor (*Capra falconeri megaceros*), Suleiman Markhor (*Capra falconeri jerdoni*) (Roberts, 1997).

There are two sub-species of flare horned markhor; Astor and Kashmir Markhor described by Schaller and Amunallah Khan (1975). Flare horned Markhor is adapted to mountainous terrain and typically inhabit sparsely wooded scrub forests made up primarily of oaks (*Quercus ilex*), pines (*Pinus gerardiana*), and junipers (*Juniperus macropoda*). They are distributed in northern

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areas (Chitral, Kohistan, Azad Kashmir and Gilgit-Baltistan) of Pakistan at an elevation of 700 to 4000 m (Schaller, 1977). Astor Markhor is confined to small and scattered populations of ca. 22–100 individuals distributed along Indus River and its tributaries in Gilgit-Baltistan (Khan et al., 2014).

Astor Markhor is classified as Near Threatened globally (Michel and Rosen, 2015) and considered as endangered in Pakistan (Sheikh and Molur, 2004). Different authors have provided rough estimates of Flare horned markhor population ca. 4500 individuals in different areas of its distribution; Gilgit-Baltistan (1500), Khyber-Pakhtunkhwa (2959) and Azad Jammu (ca. 50) (WCS, 2012; Arshad, 2011; Sheikh and Molur, 2004).

All of the markhor sub-species are facing many threats throughout their distribution range including competition with livestock for food resources, increased human population, deforestation, poaching, illegal hunting, genetic isolation due to reduced connectivity among sub-populations, hybridization, habitat fragmentation, reduced specialized habitat for forage and low reproductive rate (Shackleton, 1997; Bhatnagar et al., 2009).

In the study area, trophy hunting of four adult male Markhors is being carried out annually and 80% share of the revenues from a trophy hunting license goes to the local communities for their socio-economic wellbeing (Shackleton, 2001). However, there is a growing debate worldwide about trophy hunting and the people are arguing about legitimacy of the hunting programs and their impacts on rare wildlife species (Aryal et al., 2015; Challender and Cooney, 2016). There are generally two views exist about trophy hunting programs; one suggest that hunting programs are beneficial for local communities and in return they protect illegal use of animals (Gunn, 2001; Edwards et al., 2006; Naidoo et al., 2016) while the other group showed serious concern about trophy hunting and argue that it badly affects the viability of the population (Caro et al., 1998; Wilson, 2008; López-Bao et al., 2017).

To continue the program of trophy hunting for the social benefits of local communities and wildlife protection, there is need to have a comprehensive baseline data on population status covering the entire range of Astor Markhor in Gilgit-Baltistan. However, there is very little information available on the population status and demographic structure of Astor Markhor in Gilgit-Baltistan. The available data has some serious constraints and is limited to certain catchments having no consistency in timing and methods of surveys.

Keeping in view the importance of trophy hunting programs and to acquire reliable and comprehensive population estimates, the present study was designed to study population abundance, density and demographic structure of Astor Markhor in the Gilgit-Baltistan, Pakistan.

2. Materials and methods

2.1. Study area

Gilgit-Baltistan (GB) is located in extreme north of Pakistan (Fig. 1) between 35° and 37°N and 72–75°E at the confluence of the great Himalaya, Karakoram, Hindu Kush and Pamir mountain ranges, characterized by rugged and precipitous mountains, high peaks, deep narrow valleys and gorges (Ahmed and Joyia, 2003; Khan et al., 2014).

The elevation of the area ranges from 1500 to 8000 m and spanning over 72,496 km^2 (Khan, 2003). Natural vegetation is classified into four distinctive zones viz., sub-tropical scrub forest, mountain dry temperate coniferous forest, dry temperate broadleaved forest and northern dry scrub forest (Rao and Marwat, 2003). The area is dominated by mountains (34%) and rangelands (52%) followed by natural forest (4%), cultivated agriculture lands (1%), cultivable waste (1%) and uncultivated waste constitute 8% of the geographical area (Khan, 2003). Administratively, GB is divided into 10 districts, namely Gilgit, Skardu, Diamir, Ghizar, Ghanche, Astor, Hunza, Nagar, Shigar and Kharmang. The overall climatic condition of GB varies widely from monsoon-influenced moist temperate to arid and semi-arid cold deserts. Annual average rainfall is less than 200 mm with a temperature range between +40 °C in summer to below −10 °C during winter (Babar et al., 2010).

The study area is rich in wildlife species, including 54 mammal, 230 bird, 23 reptile, 20 cold-water fish and 6 amphibian species. The study area is habitat of many globally threatened wildlife species including snow leopard (*Panthera uncia*), brown bear (*Ursus arctos*), black bear (*Ursus thibetanus*), Ladakh urial (*Ovis vignei vignei*), Astor Markhor (*Capra falconeri falconeri*), Blue sheep (*Pseudois nayaur*), Himalayan musk deer (*Moschus chrysogaster*), Marco Polo's sheep (*Ovis ammon polii*), Himalayan ibex (*Capra ibex sibirica*), woolly flying squirrel (*Eupetaurus cinereus*) and Eurasian otter (*Lutra lutra*) (Roberts, 1997).

2.2. Study design

The present study was designed to estimate the population density, sex-ratios and habitat usage of Astor Markhor (*Capra falconeri falconeri*; Fig. 2) in five districts (Gilgit, Astor, Diamer, Skardu and Nagar) of GB from November, 2015 to January 2017. Reconnaissance surveys were conducted to identify the potential habitat in terms of occurrence of the species in five out of the ten districts, covering 16 valleys/major catchments, 25 sub-catchments that fall within 15 Community-Controlled Hunting Areas (CCHAs) (Fig. 1). For this purpose, fixed-point direct count method using specific vantage point was employed for population estimation (Jackson and Hunter, 1996; Khan et al., 2014). Survey team at each site was comprised of trained staff of the GB Wildlife & Parks Department, Village Wildlife Watchers and one of the authors. After the selection of vantage points, members started scanning the sites simultaneously during dawn (3 h) and dusk (2 h) in winter season, when the animals were more active and grouped together for rutting (Roberts, 1997) with the help of spotting scope (20 × 60 Swarovski), binoculars (10 × 50 Pentax XCF) and hand-held GPS (Garmin eTrex 20x). Topo maps were used to delineate the location of markhor and

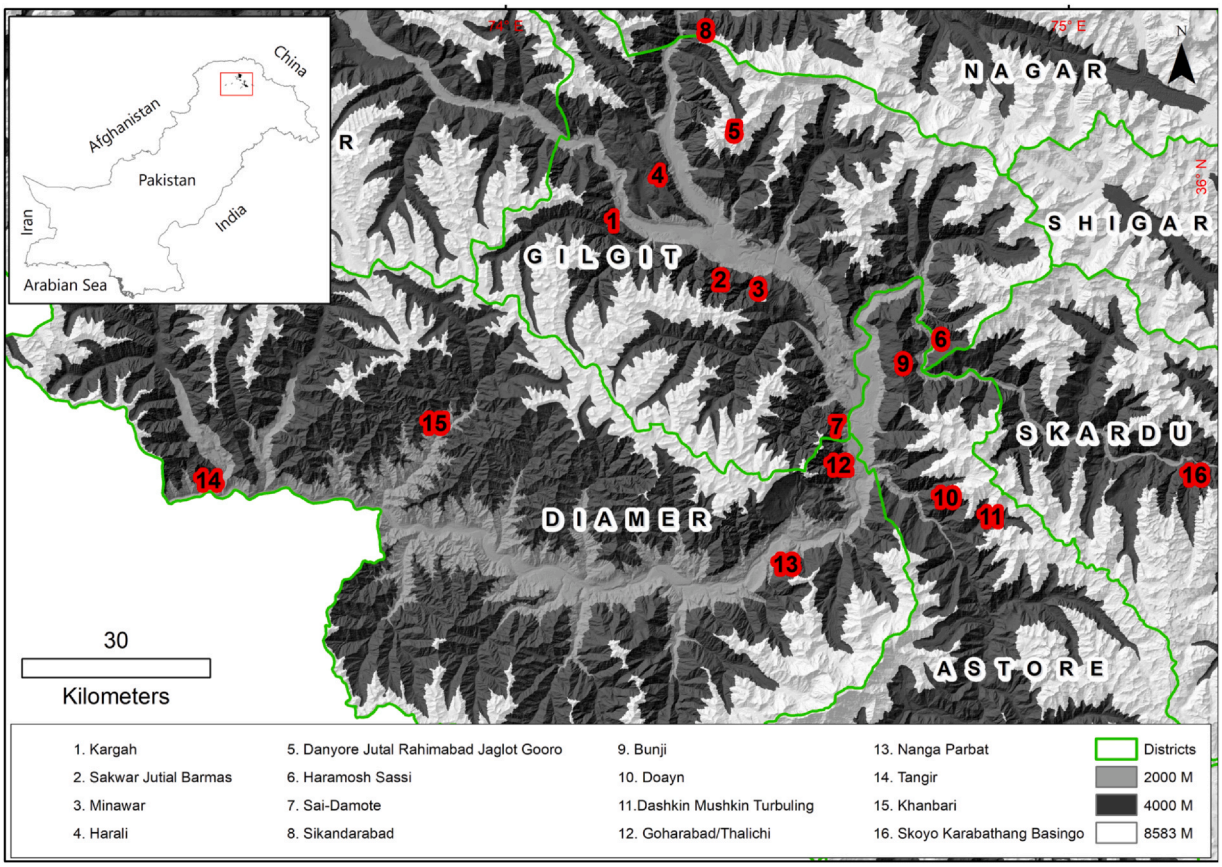

Fig. 1. ArcGIS map of the study area showing sampling sites of Astor Markhor (*Capra falconeri falconeri*) in Gilgit-Baltistan, Pakistan.

Fig. 2. Photograph of Astor Markhor (*Capra falconeri falconeri*) in Gilgit-Baltistan, Pakistan.

used as geo-reference to the vantage points. The data were recorded carefully in especially designed field sheets. After counting was finished, in the evening, all teams matched their data, and identified same herds counted by both teams on the basis of herd demography, topo map location and the time of their presence at the position (Namgail, 2014).

2.3. Age and sex classes

The animals were classified into various age and sex classes i.e. kids, yearlings, females and males. Males were further classified on bases of their horn length and age into Class I ($2^{1/2}$ years old with horn size- 45 cm with no ruff), Class II ($3^{1/2}$ years old with horn size over 50 cm with initiation of ruff), Class III ($4^{1/2}$ to $5^{1/2}$ years old with beard and long ruff and horn length is over 70 cm) and Class IV males >6 years old (trophy sized male) with huge ruff and strikingly long horns (Schaller, 1977).

2.4. Statistical analysis

The data were analyzed in MS Excel office version 2007 and presented as Province wise population size and age-sex ratios. The density in each CCHAs was calculated by dividing the area of CCHA from total number of animals counted in that CCHA. Age and sex ratio were determined by calculating proportion of male to female, yearling to female and kids to female (Ali, 2008; Haider et al., 2018).

3. Results

A total of 1087 animals were counted in 15 CCHAs and an unclassified catchment (Minawar nullah), altogether covering 8099 km^2, comprising of 266 (24%) males (including sixty-two (6%) trophy-sized males), 388 (36%) females, 227 (21%) yearling and 206 (19%) kids (Table 1). Overall Province wise population density was 0.13 animal/km^2, with male to female ratio 0.69:1, yearling to female 0.54:1 and kids to female 0.51:1. CCHA/catchment wise assessments showed that Kargah area has highest population (211 animals) followed by Bunji (187), Doyan (119), DMT (101) and Sakwar-Jutial-Barmas 75 and Tangir 74. Population density was higher in Doyan (0.92 Individuals/km^2) followed by DMT (0.56 Individuals/km^2) and Kargah (0.48 Individuals/km^2). Trophy sized males were 10% in the population of SKB, 8% in population of Haramosh-Sassi, 7% in DMT, 9% Sai Damote, and 6% in Kargah, Danyore-Jaglote Gooro, Bunji and Khanbari.

The data on sex ratio in all catchments were skewed towards females (61–67 males to 100 females) except in Khanbari valley (101 males to 100 females) and Sai-Damote (100 males to 100 females) as shown in (Table 2). Yearling to female ratio was highest in Goharabad (94 yearlings to 100 females), followed by Tangir (86 yearlings to 100 females) and Doyan (76 yearlings to 100 females), whereas in rest of the CCHAs, it was 24–63 yearlings to 100 females. Kids to female ratio were highest in Khanbari (73 kids to 100 females) followed by Kargah (67 kids to 100 females), Bunji and Sai-Damote (64 kids to 100 females). Both kids to female and yearlings to female ratio were lowest in Danyore-Jaglote Gooro (only 15 kids to 100 females and 24 yearlings to 100 females).

4. Discussion

The present study provides the first ever complete estimates of *C. f. falconeri* population (±1087) in Gilgit-Baltistan (GB). Hess et al. (1997) reported 1000–1500 markhor in Gilgit-Baltistan. Astor Markhor current distribution data shows its presence along the banks of River Indus and its tributaries ranging from Tangir area of District Diamer upstream to Sassi at the right bank and Skoyo-Karabathang-Basingo area at left bank in District Skardu to Sharote-Shikyot in District Gilgit to Sikandarabad in District Nagar and up to Doyan and DMT in District Astor. Previously, in addition to above mentioned locations *C. f. falconeri* have also been reported upstream to Gahkuch in District Ghizer, to Parishing in District Astor and to Chalt in District Nagar (Schaller and Amunallah Khan, 1975).

The available abundance estimates for Astor Markhor reported from few catchments only and reported 75–100 animals in Darel and Tangir valleys (Arshad, 2011) and found similar to current estimate of 74 individuals in Tangir and 32 in Khanbari valley. Another study reported the presence of 163 individuals from Central Karakoram National Park valleys (CKNP; Haramosh, Danyore, Jutal, Rahimabad, Jaglote Gooro and Skandarabad) and 162 in Jutial Conservancy (Sakwar, Jutial, Barmas and Minawar) (Khan et al., 2018). In present study, decline in CKNP population and Jutial conservancy was observed with only 127 individuals and 90 individuals respectively. Similar decline in Astor Markhor population (211 Individuals) was observed in Kargah area compared to previous reports. In Kargah area, Roberts (1969) reported 500–600 individuals and sharp decline of Astor Markhor population (109) was reported by Hess et al. (1997). There was sharp declining in populations of *C. f. falconeri* in GB up to the mid-1990s and the eventual increase over the two decades attributable to the community-based conservation efforts.

The existing populations are sparsely distributed and the crude density for the entire GB region is 0.13 animal/km^2. However, the density is higher in some catchments such as Doyan (0.9 animals/km^2), followed by DMT (0.6 animals/km^2), Kargah and Bunji (0.5 animals/km^2). In rest of the majority of catchments it is 0.1 animals/km^2. The higher density in Doyan, DMT, Bunji and Kargah valleys is possibly due to better habitat conditions and contiguity of the habitats with adjacent valleys with relatively abundant markhor populations. Populations of Doyan and DMT are mixed with Bunji and also populations of Kargah with that of Khanbari and supported from literature where abundant populations were reported in Kargah valley (Roberts, 1969). Areas with abundant Astor Markhor populations were those, where trophy hunting programs were started in Gilgit-Baltistan in late 1990s. In these valleys the local people are proactively engaged in conservation, primarily focused on trophy hunting of markhor, which enables the local community to get 80% of the license revenue, utilized for wellbeing of the concerned communities. The socio-economic benefits earned from trophy hunting have persuaded the local people to be the stewards of wildlife populations, especially of the high prized Markhor species.

Table 1
Abundance and density of *C. f. falconeri* in various Community-Controlled Hunting Areas (CCHAs) of Gilgit-Baltistan, Pakistan.

#	CCHA	Area (km^2)	Locations/sub catchments	Male	Female	Yearling	Kids	Trophy size males	Average population	SE	Density (animals/km^2)
1	Kargah	443	Kargah, Hanzel, Sharot Shikyot, Napura	33	74	41	50	13		23	0.48
								211			
2	Sakwar-Jutial-Barmas (SJB)	195	Sakwar-Jutial-Barmas total	13	28	15	15	4	75	10	0.38
3	Un-declared/open area	85	Minawar Nullah	2	7	2	4	0	15	8	0.18
4	Harali	406	Chilmish	6	11	6	4	1	28	2	0.07
5	Danyore -Gooro	483	Danyore, Jutal, Rahimabad, Jaglote Gooro	8	27	7	4	3	49	19	0.10
	Haramosh-Sassi	136	Sassi	6	20	7	8	4	45	23	0.33
7	Sai-Damote	326	Sagachal Damote	5	7	3	5	2	22	1	0.07
8	Skandarabad	114	Skandarabad	9	13	6	4	1	33	3	0.29
9	Bunji	415	Bunji	35	62	39	40	11	187	42	0.45
10	Doyan	130	Doyan	25	39	30	21	4	119	10	0.92
11	Dashkin-Mushkin-Turbuling (DMT)	180	Dashkin, Mushkin, Turbuling	19	35	20	20	7	101	11	0.56
12	Goharabad	310	Thalichi	4	8	8	5	1	26	13	0.08
13	Nanga Parbat	640	Jelipur, Ghanu, Batzulai	6	9	4	3	0	22	3	0.03
14	Tangir	1445	Tangir	16	22	19	13	4	74	16	0.05
15	Khanbari	810	Khanbari	7	8	9	6	2	32	0	0.04
16	Skoyo-Karabathang-Basingo (SKB)	1981	Skoyo, Karabathang, Basingo	10	18	11	4	5	48	13	0.02
	Overall GB	8099		**204**	**388**	**227**	**206**	**62**	**1087**	**30**	**0.13**

Table 2
Age, sex ratios of Astor Markhor in various Community-Controlled Hunting Areas (CCHAs) of Gilgit-Baltistan, Pakistan.

#	CCHA	Locations	Male-female ratio	Yearling female ratio	Kids-female ratio
1	Kargah	Kargah, Hanzel, Sharot Shikyot, Napura	0.62:1	0.55:1	0.67:1
2	Sakwar-Jutial-Barmas (SJB)	Sakwar-Jutial-Barmas total	0.61:1	0.53:1	0.53:1
3	Un-declared/open area	Minawar Nullah	0.29:1	0.29:1	0.57:1
4	Harali	Chilmish	0.64:1	0.55:1	0.32:1
5	Danyore -Gooro	Danyore, Jutal, Rahimabad, Jaglote Gooro	0.41:1	0.24:1	0.15:1
	Haramosh-Sassi	Sassi	0.5:1	0.33:1	0.41:1
7	Sai-Damote	Sagachal Damote	1.0:1.0	0.43:1	0.64:1
8	Skandarabad	Skandarabad	0.77:1	0.42:1	0.31:1
9	Bunji	Bunji	0.74:1	0.63:1	0.64:1
10	Doyan	Doyan	0.74:1	0.76:1	0.54:1
11	Dashkin-Mushkin-Turbuling (DMT)	Dashkin, Mushkin, Turbuling	0.74:1	0.58:1	0.57:1
12	Goharabad	Thalichi	0.63:1	0.94:1	0.63:1
13	Nanga Parbat	Jelipur, Ghanu, Batzulai	0.67:1	0.47:1	0.35:1
14	Tangir	Tangir	0.91:1	0.86:1	0.57:1
15	Khanbari	Khanbari	1.13:1	1.2:1	0.73:1
16	Skoyo-Karabathang-Basingo (SKB)	Skoyo, Karabathang, Basingo	0.83:1	0.63:1	0.23:1
	Overall GB		0.69:1	0.54:1	0.51:1

The population structure in most of the catchments/sub-populations is skewed towards females. In mountain ungulates kids: females' ratio is important to ascertain fecundity rate and yearling: female ratio to determine survival of the kids to yearling stage (Bonenfant et al., 2005). Female biased sex ratios have also been attributed to lower survival rates of males than females (Gaillard et al., 1998) and it has also been noted that mature females have a higher survival and reproductive rate (Festa-Bianchet and King, 2007) than younger and old aged females (Caughley, 1966; Gaillard et al., 1998).

However, in wild ungulates female biased sex ratio has been taken as a point of caution. In a population, a minor number of males than that of females has been attributed to various reasons such as a higher mortality rate of young males, death of old males due to weakness after the rut and trophy hunting; furthermore, an apparent more killing of males than females by predators such as snow leopard and wolf (Fedosenko and Savinov, 1983; Heptner et al., 1961; Savinov, 1962).

The low density, female-biased sex ratios are some of the major concerns for the current *C. f. falconeri* populations in GB. In addition, the small populations are kept isolated by the rugged topographic conditions, impossible ravines and human settlements, possibly leading to inbreeding and loss of vigor in the populations. Although some protection measures are taken by the Provincial government and conservation NGOs especially through engaging local communities in wildlife protection in Community-Controlled Hunting Areas, but stringent measures are needed to regulate the trophy hunting programs.

Astor Markhor prefers grasslands and avoids higher altitudes with snow cover as previously reported that it dwells in lower elevations for grazing on tussocks of grasses in winter and avoids heavy snow (Arshad et al., 2012; Roberts, 1997) it chooses fairly dry terrain and they avoid deep snow and cold temperatures (Schaller and Amunallah Khan, 1975).

Trophy hunting of *C. f. falconeri* is currently taking place in eight of the fifteen CCHAs in GB containing markhor populations namely Kargah, Sakwar-Jutial-Barmas, Harmosh-Sassi, Skandarabad, Bunji, DMT, Doyan and SKB. Trophy hunting of *C. f. falconeri* in northern Pakistan was allowed in 1997 after 10th meeting of the CITES to promote conservation of endangered species by community-based conservation programs (Shackleton, 2001). Each year four markhor trophies are harvested in GB, usually one animal per catchment with an interval of one to several years.

5. Management implications

The viability of *C. f. falconeri* population in terms of its structure is a serious point of concern, especially in valleys where populations are subject to trophy hunting. Impact of trophy hunting may be detrimental in areas where the Markhor inhabits in fragmented sub populations, somehow isolated from each other, like in case of Gilgit-Baltistan and Chitral where the small populations live in isolation (given the specific mountain topographic conditions). For an area like Chitral Gol National Park's surrounding areas in KPK or Bunji-Doyan-DMT (Astor District) in Gilgit-Baltistan with large herds inhabiting contiguous habitats, harvest of one mature male per year would not be a serious matter of concern. But harvest of one individual in a small catchment with a small, isolated population (e.g. only 10–20 individuals) may jeopardize the population structure and the essence of trophy hunting program.

While allocating a markhor trophy first time to a new area, the survey reports containing appropriate information about population structure should be endorsed by a third party for accuracy and authenticity, may be by a consortium of conservation organizations, wildlife researchers and independent conservation experts. Such a consortium should be officially declared by the relevant ministry in consultation with CITIES secretariat/ focal person in the country. For a small catchment with a small, isolated population there should be at least 3–5 years of interval between the two trophy hunts. The small, isolated populations need to be identified and mapped based on certain criteria to link these populations for gene flow and better resource access by designating corridors. The CITIES implementing authority in the country need to have that map while allocating trophy-hunting quotas in a certain Province/region. In case of repeated hunts in certain area the trophy allocation should be conditional with (a) desired population size with viable population structure; and (b) at least 50% of the trophy hunting revenue should be spent on

conservation related activities in that particular area. The population size and structure and spending on conservation related activities should be verified by a third party, may be by the above-mentioned consortium.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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