STATUS OF SULEIMAN MARKHOR AND AFGHAN URIAL POPULATIONS IN THE TORGHAR HILLS, BALUCHISTAN PROVINCE, PAKISTAN

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BELLEVUE, WASHINGTON, USA
(1994)

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INTRODUCTION

The Torghar Hills of Baluchistan Province, Pakistan (Figure 1), part of the Pushtun (or Pathan as they are called in the West) tribal areas located on the border with Afghanistan, have long been known for their abundant wildlife, most notably their populations of Suleiman markhor (Capra falconeri jerdoni; also called straight-horned markhor, C. f. megaceros) and Afghan urial (Ovis vignei cycloceros or O. orientalis cycloceros) (District Gazetteers of Baluchistan 1906). The Torghar Hills are inhabited by the Jalalzai branch of the Sanzar Khel tribe of Kakar Pathans (Naseer A. Tareen, pers. comm.). The Pathans are the world's largest tribal society, with their own language (Pushto), culture, and complex tribal hierarchy (Caroe 1958, Spain 1962, Quddus 1987). The local ruling family of Pathans, the Jogezais, exercises authority over the tribesmen of Torghar.

In the early 1980s the local Pathan leader, the late Nawab Taimur Shah Jogezai, and one of his relatives, Sardar Naseer A. Tareen, became alarmed at what they perceived to be a dramatic decline in Suleiman markhor and Afghan urial populations in Torghar (Tareen no date, 1990a, 1990b). They attributed this decline to an increase in poaching brought about by a dramatic influx of weapons and, especially, cheap ammunition into the area during the Afghan war (the 14-year war that started in 1978 between Muslim guerrillas and a series of Soviet-backed governments). The Nawab asked the Baluchistan Forest Department (BFD) to station wildlife officers in Torghar to solve the poaching problem. The BFD did not respond to the request, so the Nawab and Tareen decided they would have to

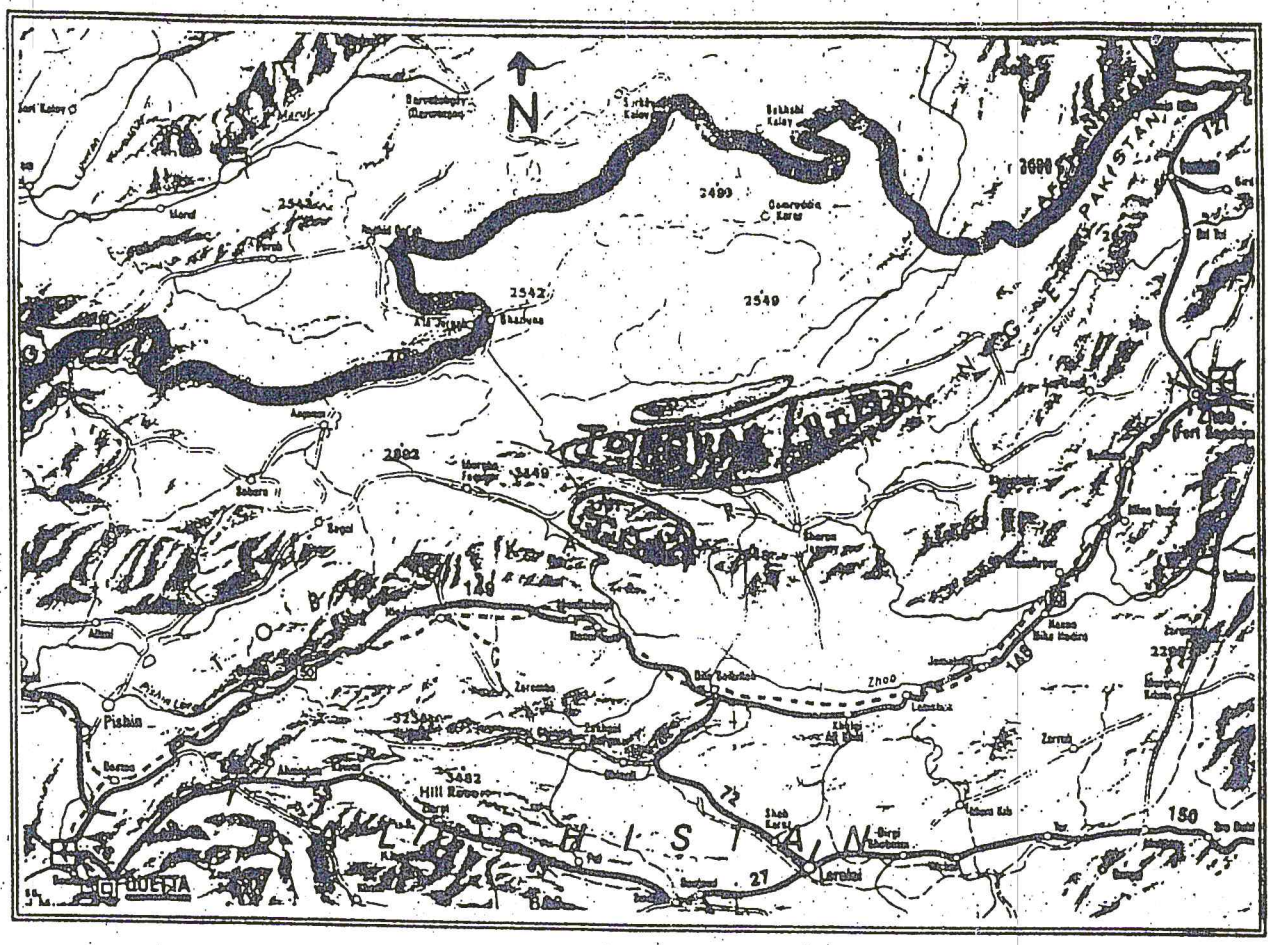

Figure 1. Location of the Torghar Hills and the Torghar Conservation Project, Baluchistan Province, Pakistan. (Pink = the core protected area; Yellow = peripheral areas under TCP management.) Scale: 1 inch = approximately 38 km.

solve the problem themselves. In 1984, they sought assistance from professional wildlife biologists in the U.S.A., with whom they developed the idea for the **Torghar Conservation Project** (TCP).

As a private, "grassroots" initiative, the TCP's goals were to conserve local populations of the Suleiman markhor and Afghan urial, and to improve the economic condition of local Pathan tribesman in the Torghar Hills. The Project's design was simple. Local Pathan tribesmen under the authority of Nawab Jogezai would be requested to refrain from hunting in exchange for being hired as

salaried game guards to prevent poachers from entering the Torghar Hills to hunt. Game guard salaries and other costs of the TCP would be defrayed entirely by trophy fees paid by foreign hunters for the privilege of hunting a small, strictly controlled number of Suleiman markhor and Afghan urial. The TCP was instituted in 1986 and run informally by Tareen and members of the Jogezai family until April 1994. At that time, they formed an officially-registered nongovernmental organization, the Society for Torghar Environmental Protection (STEP), to administer the TCP.

As of November 1994, the TCP employed 33 local Pathan game guards who were protecting an area of approximately 1,000 sq. km. in the Torghar Hills and the adjacent Tora Range (see Figure 1). Game guards are concentrated in the "core protected area", an area of approximately 300 sq. km. in the heart of Torghar. The Project has achieved a virtually-complete cessation of poaching of markhor and urial by both locals and outsiders, especially within the core protected area. As a result, the Suleiman markhor and Afghan urial populations of Torghar, which were virtually extirpated by 1983-84, have grown steadily since 1985-86. The TCP has been largely self-sufficient since its inception, having relied primarily on the income generated through the trophy harvest of only 14 markhor and 20 urial over its 10-year history.

Although the TCP has succeeded in curtailing poaching, and this has lead to recovery of the markhor and urial populations in Torghar, STEP has received little recognition for this success, in large measure because the Project has lacked quantitative data on the size and growth of markhor and urial populations. To address this need, STEP decided to conduct a systematic field survey of the Suleiman markhor and Afghan urial populations of Torghar in November 1994. This paper presents the results of the survey, addresses some problems encountered during the survey, and discusses management implications of the results.

STUDY AREA

The TCP is located in the Torghar Hills (Tor Ghar means "Black Mountain" in Pushto), a chain of ruggedly-upturned, predominantly sedimentary ridges approximately 90 km. long and 15-30 km. wide in the NE-SW trending Toba Kakar Mountains of Qila Saifullah District, Zhob Division, Baluchistan Province (Figure 1). The approximately 300 sq. km. "core protected area" of Torghar consists of three parallel ridges separating two NE-running stream drainages. The southernmost ridge has a north-facing slope which rises gradually to an elevation of almost 2,800 meters, and is dissected by a number of deeply-incised drainages. From the ridge, the south-facing slopes drops precipitously in a step-like series of cliffs to the Khaisore Valley. The northern ridges consist of rock layers that are so steeply upturned that they resemble a series of parallel, jagged-toothed combs. The climate of Torghar is seasonal and arid. The vegetation is semi-desert or shrub-steppe dominated by perennial bunchgrasses, shrubs and scattered trees--primarily junipers (Juniperus macropoda) and wild pistachios (Pistacia khanjak). Domestic livestock--primarily sheep and goats but also some donkeys and camels--are grazed on the valley bottoms and lower slopes.

SPECIES

The TCP is primarily concerned with conservation of the Suleiman markhor and Afghan urial. Both species are listed on the Third Schedule of The Baluchistan Wildlife Protection Act 1974; these are "protected animals, i.e., animals which shall not be hunted, killed or captured" except as permitted under specific circumstances (Government of Baluchistan Agriculture Department 1977). The Suleiman subspecies of markhor has a limited distribution that includes the rugged mountains of western Pakistan

(e.g., Suleiman, Takatu and Toba Kakar Ranges) and some of Afghanistan (Roberts 1977). It has been extirpated from much of its former range, and now occurs in very low numbers (Roberts 1977). It is listed as "Endangered" under the U.S. Endangered Species Act (ESA) (Fish and Wildlife Service 1994) and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Fish and Wildlife Service 1992). The Afghan urial is more widespread and common than the markhor, although it is not abundant (Roberts 1977). It is not listed on either ESA or CITES.

The local Pathan tribesmen of Torghar have a wealth of firsthand knowledge about the natural history of both the markhor and urial. They report that markhor prefer extremely rugged terrain, with bare rock surfaces and precipitous cliffs intermingled with small patches of vegetation (trees, shrubs, and/or bunchgrasses). Urial prefer more gradual, open slopes with a more continuous vegetative cover of bunchgrasses and shrubs. Habitat usage, however, is not mutually exclusive. Both species will utilize many of the same areas.

METHODS

Field Surveys

Population surveys of desert ungulates such as markhor and urial are notoriously difficult because of the species' high mobility, cryptic-coloration, and shy nature (i.e., they can detect and will flee from humans at a great distance). The situation at Torghar is even more difficult because the extremely rugged terrain makes aerial surveys from fixed-wing aircraft all but impossible, helicopters are not readily available, and the politically-sensitive location of Torghar near the Afghan border precludes all

flights except by the military. Ground surveys are the only viable option. Although systematic transects would be the best approach from the standpoint of quantifying results, the rugged terrain at Torghar precludes this choice. The only viable option at Torghar is fixed-point counts of areas which can be readily identified on maps. And, while fixed points rarely afford a full view of the survey area (e.g., because canyon bottoms may be hidden), utilizing several observers and observing throughout the morning and afternoon hours (active periods for the markhor and urial) can increase the probability that animals will be detected.

The nine-day survey was conducted from 3-13 November 1994. November is the rut season for both Suleiman markhor and Afghan urial. This time period was selected because markhor and urial form large groups during the rut, and larger groups have a higher probability of detection by human observers. Five major survey areas within the TCP's core protected area were pre-selected: Tanishpa, Khand, Shin Narai, Tor Aghbarg, and Kundar/Uria (Figure 2). These spatially-separated areas were selected in an attempt to minimize the possibility of double counting.

Each day during the survey, from one to three survey teams (consisting of two to five game guards and STEP's Manager for Natural Resources or the author) went into the field at sunrise and selected a point from which to conduct the day's survey. A prominent, readily-identifiable point was selected to maximize the amount of terrain that could be surveyed, and to ensure that the point could be relocated for use in future surveys.

The survey team(s) spent morning and afternoon hours continuously surveying the area through binoculars (10 x 35) and spotting scope (15-60 variable power). The game guards are particularly adept at locating distant ungulates as the animals rest against a background of shadows, boulders, cliffs, and

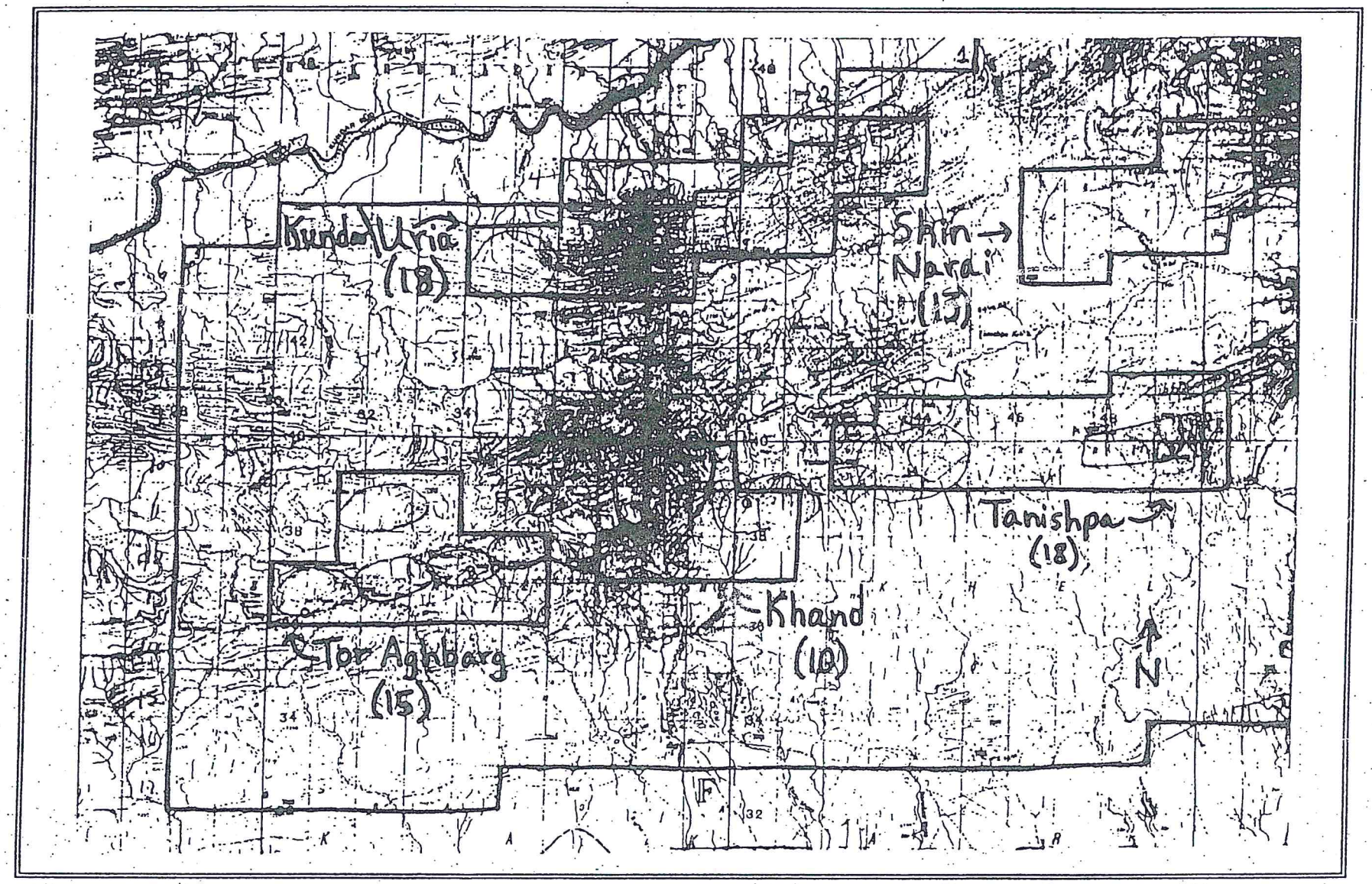

Figure 2. Major survey areas within the core protected area of the Torghar Conservation Project. Numbers in parentheses represent the number of 1,000-yard x 1,000-yard blocks contained within each major survey area.

vegetation. The tribesmen see with binoculars what most non-native people can see only through a spotting scope set at 30x. Survey points were occasionally changed in the middle of the day if few animals were observed in the morning.

For each group of markhor or urial located, data were recorded on total number in group and number in each sex/age category: lambs(.5 years old), yearling females (1.5 years old), yearling males (1.5 years old), adult females (2.5 years or older), adult males I (2.5 to 5.5 years of age), and adult males II (trophy animals of 6.5 years or more). It was not always possible to accurately classify animals observed at a distance, and the author suspects that some yearling males of both species may have been incorrectly classified as adult females. Conversely, the tribesmen are very good at classifying adult males at a distance.

Population Size Calculation

Estimated population sizes for markhor and urial in the core protected area and for the entire TCP area were calculated as follows. First, the size of each of the five major survey areas was estimated. Using an old (surveyed in 1910-11) topographic map of Torghar (1:50,000-scale), the approximate boundaries of each major survey area were drawn (exact boundaries were impossible to determine because of the terrain's ruggedness, the lack of Global Positioning System (GPS) receivers in the field which precluded determination of precise locations, and the inadequate quality and scale of the map). The boundaries of each survey area were then enlarged in order to produce a conservative estimate of markhor/urial density, and altered into geometric shapes (i.e., straight lines and right angle corners) in order to utilize the map's 1,000-yard by 1,000-yard grids to calculate area. The size of each major survey area was then calculated by counting complete and partial grid squares contained within the drawn boundaries.

Second, a population density for each species was calculated for each major survey area by dividing the number of individuals counted in the survey area by the size of the survey area. This calculation was based on the assumption that the number of markhor or urial counted in each major survey area was the total number of markhor or urial actually in that area (i.e., there was no "visibility bias" and no double counting took place)--a questionable assumption that will be discussed later in the paper.

Third, a population density for markhor in high-quality habitat was calculated by averaging population densities in the three major survey areas that had the most markhor (Tanishpa, Khand, and Kundar/Uria). Population density for markhor in low-quality habitat was calculated from the remaining two major survey areas (Shin Narai and Tor Aghbarg). A population density for urial in high- and low-quality habitat was calculated in the same manner. Population densities for three major survey areas (Shin Narai, Tanishpa, Tor Aghbarg) were averaged to obtain a population density for urial in high-quality habitat. Population densities for the remaining two survey areas (Khand, Kundar/Uria) were averaged to obtain low-quality habitat population density.

Fourth, the amount of high-quality markhor habitat and high-quality urial habitat in Torghar were crudely estimated. Habitat quality types (i.e., high and low) were based on tribesmens' descriptions of preferred habitat for both species and actual numbers counted in the field. High-quality markhor habitat is extremely rugged terrain, with bare rock surfaces and precipitous cliffs intermingled with small patches of vegetation (trees, shrubs, and/or bunchgrasses). High-quality urial habitat is more gradual, open slopes with a more continuous vegetative cover of bunchgrasses and shrubs. The areal extent of each habitat type was roughly estimated from the map.

An estimated population size for markhor in the core protected area was then calculated by: (1) multiplying high-quality population density by the total size of the core protected area (300 sq. km.) by the percent of high-quality habitat in the core protected area; (2) multiplying low-quality population density by 300 sq. km. by the percent of low-quality habitat in the core protected area; and (3) adding the results of (1) and (2). Results were then extrapolated to the remainder of the TCP project area.

RESULTS AND DISCUSSION

Markhor

During the nine-day survey, 135 Suleiman markhor were counted (Table 1), including 24 lambs, 6 yearling females, 2 yearling males, 75 adult females, 12 adult males under six, and 16 adult males older than six. It is suspected that a few yearling males may have been incorrectly classified as adult females.

The population density for markhor in high-quality habitat was calculated to be 3.22 markhor per sq. km.; the population density in low-quality habitat was 0.47 markhor per sq. km. High-quality markhor habitat was estimated to cover 30 percent of the core protected area, leaving the remaining 70 percent as low-quality habitat. An estimated population size for markhor in the core protected area was then calculated by: (1) multiplying high-quality population density (3.22 markhor per sq. km.) by the size of the core protected area (300 sq. km.) by the percent of high-quality habitat in the core protected area (30 percent), yielding an estimate of 290 markhor in high-quality habitat; and (2) multiplying low-quality population density (0.47 per sq. km.) by 300 sq. km. by 70 percent low-quality habitat, yielding an estimate of 99 markhor in low-quality habitat. Adding the two, the

Table 1. Numbers of Suleiman markhor and Afghan urial counted in survey areas in the Torghar Hills, Baluchistan Province, Pakistan, November 1994. (Tot = total number counted, LB = lamb, YF = yearling female, YM = yearling male, AF = adult female, AMI = adult male less than 6 years old, AMII = adult male greater than 6 years old)

Location(Date)	Markhor							Urial						
	Tot	LB	YF	YM	AF	AMI	AMII	Tot	LB	YF	YM	AF	AMI	AMII
Tanishpa														
Malao(11/3)	17	2	0	0	13	0	2	16	0	0	0	12	4	0
Garai(11/3)	24	3	2	1	12	3	3	12	2	1	0	5	1	3
Art(11/3)	19	5	0	0	9	3	2	0	0	0	0	0	0	0
Shin Narai														
Thakarai(11/4)	0	0	0	0	0	0	0	25	7	0	13	0	2	3
Thakarai(11/4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Khand														
Khand(11/5)	21	2	3	0	12	1	3	6	0	2	0	4	0	0
Khand(11/5)	0	0	0	0	0	0	0	8	0	0	0	6	1	1
Tor Aghbarg														
Walla(11/7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saliwata(11/8)	0	0	0	0	0	0	0	35	0	0	0	22	2(7)	4
Whuchhokai(11/9)	4	0	1	0	1	1	1	59	2	7	0	40	5	5
Bazalai(11/10)	0	0	0	0	0	0	0	17	0	0	0	12	2	3
Saiduchina(11/11)	7	0	1	1	4	1	0	7	0	0	0	6	0	1
Kundar/Uria														
Uria(11/12)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Murdara(11/12)	15	3	0	0	9	3	0	0	0	0	0	0	0	0
Zerzha(11/13)	15	5	0	0	8	0	2	4	1	0	0	2	1	0
Salawata(11/13)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surkham(11/13)	13	3	0	0	7	0	3	0	0	0	0	0	0	0
TOTALS	135	24	6	2	75	12	16	189	12	10	0	122	25	20

estimated markhor population size in the core protected area is 389 animals.

Although this simple calculation may not be subject to statistical treatment (i.e., no confidence limits can be derived), it is a conservative approach because the assumptions and approximations used to calculate population size and density were

conservative. For instance, the size of each major survey area was overestimated, resulting in an underestimate of markhor population density in each survey area. It is also likely that there was considerable "visibility bias" (sensu Pollock and Kendall 1987), i.e., the probability of detection of an individual markhor or urial within each major survey area was considerably less than the assumed 100 percent. It has been repeatedly demonstrated that visibility bias affects aerial survey estimates of big game species, including bighorn sheep (Ovis canadensis) (Bodie et al. 1995, Neal et al. 1993) and Dall sheep (Ovis dalli) (McDonald et al. 1990). Bodie et al. (1995) estimated that they observed, on average, 67.1% of the bighorn sheep population during helicopter surveys of sagebrush-steppe canyon habitats in southwestern Idaho. Visibility bias for ground surveys would be expected to be even greater than for aerial surveys. Any visibility bias at all would result in an underestimate of markhor (and urial) populations.

To calculate an estimate of the markhor population in the remainder of the TCP area, it was assumed that the remainder of the TCP area covers 650 sq. km. (a conservative approximation), and that all markhor habitat in that area is of low quality (another conservative approximation). Thus, multiplying 650 sq. km. by 0.47 markhor per sq. km. yields a population estimate of 306 markhor in the remainder of the TCP area. The two population estimates can then be combined for an estimated total population of 695 Suleiman markhor in the TCP area.

Assuming that a few yearling males were incorrectly classified as adult females and that lambs had a lower probability of detection than other age categories, then survey results suggest that the Suleiman markhor population in Torghar is reproducing well and that survival of adult males into older age categories is good. This further suggests that markhor habitat in Torghar is in good condition (because it is not limiting reproduction) and that the

population is not being overhunted (an overhunted population would be expected to have fewer males in the older age categories).

Most markhor were observed in Tanishpa (Malao, Art, Garai), Khand, and Kundar/Uria (Uria, Murdara, Zerzha, Salawat, Surkham). These are among the most rugged parts of Torghar, with exposed rocks and precipitous cliffs making up most of the habitat. These results thus corroborate the tribesmens' first-hand knowledge of markhor habitat preferences.

Urial

During the nine-day survey, 189 Afghan urial were counted (Table 1), including 12 lambs, 10 yearling females, 0 yearling males, 122 adult females, 25 adult males under six, and 20 adult males older than six. The author suspects that, as with markhor, a few yearling male urial may have been incorrectly classified as adult females.

Estimated urial population sizes for the core protected area and for the entire TCP area were calculated in the same manner as the markhor estimates. An average population density for high-quality urial habitat was calculated to be 4.45 urial per sq. km.[1]; average population density for low-quality urial habitat was calculated to be 0.77 urial per sq. km. High-quality urial habitat was estimated to cover 40 percent of the core protected area, while low-quality habitat covered the remaining 60 percent. An estimated population size for urial in the core protected area was calculated by: (1) multiplying 4.45 urial per sq. km. by 300 sq. km. by 40

[1] In comparison, Edge and Olson-Edge (1987) documented urial population densities in the range of 1.7-2.5 urial per sq. km. in their study area in Kirthar National Park, Sindh Province, Pakistan, although they concluded that the study area could sustain a higher density of urial.

percent, yielding an estimate of 534 urial in high quality habitat; and (2) multiplying 0.77 urial per sq. km. by 300 sq. km. by 60 percent, yielding an estimate of 138 urial in low-quality habitat. Thus, the estimated population size of urial in the core protected area is 672.

An estimate of the urial population in the remainder of the TCP area was calculated in the same manner as the markhor estimate. It was assumed that the remainder of the TCP area covers 650 sq. km., and that all urial habitat in the area is low-quality. This yields an estimate of 501 urial (650 sq. km. x 0.77 urial per sq. km.). These two figures can then be combined for an estimated total population size of 1,173 urial in the entire TCP area.

Most urial were counted in Shin Narai, Tor Aghbarg (Saliwata, Whuchhwokai, and Bazalai)--some of Torghar's less rugged and more gently sloping habitats. But a substantial number of urial were also seen in areas where markhor were also abundant, most notably Khand and Tanishpa. These results, therefore, also corroborate the tribesmens' first-hand knowledge of urial habitat preferences.

Markhor and Urial Population Changes

Numerous first-person accounts from game guards (pers. comm. with Sagzai, Khoshalay, Noordad and others), managers of the TCP (pers. comm. with Naseer A. Tareen and Mirwais Jogezai), and visitors to Torghar (pers comm. with Reza Abbas) as well as observations made by a wildlife biologist from Fall 1985 to Spring 1988 (Mitchell 1989) and the literature (Roberts 1977) strongly suggest that the Suleiman markhor and Afghan urial populations of the Torghar Hills were at very low levels in the early 1980s before the TCP was instituted (Johnson 1994). After the TCP began in 1986, both populations appear to have begun growing steadily, a conclusion supported by results of the November 1994 survey.

The most likely cause of this population growth is the substantial reduction in human-caused mortality that occurred when the TCP went into effect and uncontrolled hunting was stopped. A large source of mortality (uncontrolled hunting) was replaced by a much smaller source (controlled, limited trophy hunt). Other than stopping uncontrolled hunting, the TCP has not instituted any management practices (e.g., elimination of competition from domestic livestock, creation of water holes) that could have contributed to this degree of population growth.

Populations of markhor and urial in Torghar are likely to continue growing as long as hunting is controlled. Reducing the size of domestic herds of sheep and goats should also help both species, but especially the urial, by reducing competition for forage and reducing the possibility of disease transfer from domestic to wild animals. Carrying capacity should be reached, and the Torghar Hills may become a source of emigrants for other mountain ranges in the area (intermountain movement of markhor and urial is probably already taking place (see Bleich et al. 1990)).

Population Viability for Sustainable Harvesting

Today, the Suleiman markhor and Afghan urial populations of Torghar are of adequate size and condition (in terms of sex and age ratios and reproduction) to be considered "viable" for both population and genetic processes (e.g., Soule 1987, Hebert 1991). Concern about population isolation and fragmentation appear to be unfounded, especially if intermountain movement of urial and markhor is taking place (Bleich et al. 1990).

Such populations should be able to sustain an annual "trophy harvest of males, in numbers equivalent to 1-2 percent of the total population size," without negative consequences to the population according to Harris' (1993) review of the literature on similar

species. This is true, in part, because markhor and urial have a polygynous mating system, and the populations' overall reproductive rates would be little affected by the loss of a small number of males (Caughley 1977, Schaller 1977).

Assuming a total markhor population of 300 animals in the core protected area, a sustainable annual trophy harvest in the core area should be 3-6 markhor. And, assuming a total urial population of 675 animals in the core protected area, a sustainable annual trophy harvest in the core area should be 7-13 urial. Since no more than 3 adult male markhor and 4 adult male urial have been harvested in any given year at Torghar, it is apparent that harvest levels have been conservative in accordance with the "precautionary principle" (Freese 1994). The simple fact that both populations have continued to grow steadily while subject to a strictly-controlled trophy hunt is ample evidence that harvest levels have been conservative.

CONCLUSION AND RECOMMENDATIONS

Results of the November 1994 survey of Suleiman markhor and Afghan urial, perhaps the first formal survey ever conducted on these two species, indicate that the TCP area may have a population of around 700 markhor and 1,200 urial. Although most mountain ranges in Baluchistan have not been formally surveyed, these results suggest that Torghar may be one of the last remaining strongholds for both species. Surveys results also support the conclusions that: (1) these populations have increased, most likely substantially, from their levels in the mid-1980s; and (2) these populations are of adequate size and condition to support a limited trophy hunt. Taken together, these conclusions support the further conclusion that the Torghar Conservation Project has been a successful tool for conserving the markhor and urial of the Torghar

Hills (Johnson 1994). If applied elsewhere in Baluchistan (e.g., Takatu, Tora, Balol Nikah), the TCP model could help recover other markhor and urial populations which now verge on extirpation.

The TCP should begin conducting markhor and urial population surveys each year (during the rutting season). Only data collected over a number of years will adequately document population changes that have resulted from the TCP's management program. Spring surveys would be useful for obtaining an index to each population's annual reproductive performance. Annual survey data would allow greater "fine-tuning" of harvest limits in accord with the principles of adaptive management (Walters 1986).

The population size estimates presented in this paper are only as accurate as the assumptions and approximations used in the calculations. Additional effort must be expended to further refine and improve the accuracy of these assumptions/approximations. First, major survey areas must be delineated more precisely on an accurate, large-scale topographic map. Such delineation will improve the precision of estimates of the total area surveyed, thereby improving the precision of population estimates. Use of GPS technology would allow survey points and major survey area boundaries to be accurately located on topographic maps.

Second, more major survey areas must be identified and surveyed, especially outside the core protected area, in order to improve the precision of density estimates in each habitat type. Third, the actual areal extent of each habitat type needs to calculated more accurately, thus allowing further refinement of density estimates. Analysis of satellite imagery in a Geographic Information System (GIS) framework, followed by ground truthing, will provide more accurate estimates of the quantity and distribution of habitat types.

The field methodology used in the November 1994 survey could benefit from a number of improvements. First, all major survey areas should be surveyed on the same day. This would reduce the opportunity for double counting animals that move long distances from day to day. Second, all game guards participating in the survey should have modern, high-powered binoculars. In November 1994, many guards used old, poor-resolution binoculars made in the former Soviet Union. This undoubtedly contributed to visibility bias (i.e., increased the number of animals missed). Third, combining GPS with accurate rangefinding equipment would allow observed groups of ungulates to be pinpointed accurately on maps.

Novel approaches to population sampling may prove useful in Torghar. Ultralight aircraft or a hot air balloon may be sufficiently quiet and safe to allow for more-accurate aerial surveys to be conducted. In addition, it may be possible to use capture-resight methodology (e.g., Minta and Mangel 1989) to improve ground survey estimates of markhor and urial populations. Although it would be very difficult to capture and mark markhor and urial by traditional means (e.g., dart gun or remotely fired net-gun (Edge et al. 1989)), it may be possible simply to mark them with splotches of dye fired from a powerful paint ball gun. Resightings made during ground surveys could then be analyzed to obtain a statistically-valid population estimate. These approaches should be given further consideration.

Additional ecological studies of markhor and urial need to be undertaken in Torghar. Studies of habitat use/preference and breeding biology could be undertaken for relatively little cost or need for sophisticated equipment.

ACKNOWLEDGMENTS

Financial and logistical support for this survey was provided by the Office of International Affairs of the United States Fish and Wildlife Service (OIA, FWS) and the Society for Torghar Environmental Protection (STEP). Special thanks in this regard are due to David Ferguson (OIA, FWS) and Naseer A. Tareen (STEP). Additional thanks go to TCP managers (Maboob Jogezai, Mirwais Jogezai, Paind Khan), workers (Sharafhuddin), and game guards (especially Khoshalay, Abdullah, Sagzai, Noordad, Safferkhan, Khodaidad, Baqidad, Mohammad Afzal, Abdul Raziq, Janan, Piao, Mohammad Khan) without whose tireless assistance the fieldwork would not have succeeded. Drafts of the manuscript benefitted from a critical review by Dave Ferguson (OIA, USFWS).

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