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Status of the Snow Leopard *Panthera uncia* in Qinghai and Gansu Provinces, China

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ABSTRACT

The status and distribution of snow leopard Panthera uncia *were investigated in two provinces of China. The cats occur over about 65 000 km² or 9% of Qinghai Province, and in a few places along the western edge of Gansu Province. In many areas the animals have in recent decades been decimated or locally eradicated, as has their prey. Counts of wild ungulates in 9 mountain blocks, totalling 1375 km², known for abundant wildlife, had an average of 1·4–5·4 animals km⁻², principally blue sheep* Pseudois nayaur, *which, together with marmot* Marmota himalayana, *represent the snow leopard's main prey. Possibly 650 snow leopard survive in Qinghai but shooting and trapping of this legally protected animal and the hunting of blue sheep for local consumption and export threaten their existence.*

INTRODUCTION

Information on the status of snow leopard *Panthera uncia* is available for at least part of the cat's geographic range in India (Green, 1982; Mallon,

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1984*a*), Pakistan (Schaller, 1977), Mongolia (Mallon, 1984*b*), Nepal (Schaller, 1977; Jackson & Ahlborn, 1984), and the Soviet Union (Andriuskevicius, 1980; Braden, 1982). Little has been published about the species in China where it has a wider range than in any other country; Liao's (1985) map of snow leopard distribution in Qinghai, based mainly on capture records of animals for zoos, is the only important recent reference.

Snow leopards in China are found in the Xinjiang and Tibet autonomous regions and in the Sichuan, Qinghai and Gansu provinces. As part of a project to assess China's high-altitude wildlife resources, we spent about 7 months in the field in Qinghai and Gansu between 1984 and 1987. Our principal aim was to determine the current status of ungulates and large carnivores, including the snow leopard and its prey such as the blue sheep *Pseudois nayaur*.

THE SURVEY REGION

Qinghai covers 720 000 km^2 of the northeastern part of the Tibetan Plateau, the province comprising one-third of the total area encompassed by the plateau. The western edge of Gansu also is part of these highlands (Fig. 1). Although agriculture is possible in a few areas, notably around the city of Xining where most of Qinghai's nearly 4 million people have concentrated, the region consists primarily of rolling grasslands, deserts, and mountains above 3000 m in elevation. Livestock raising is the principal industry, sheep and yak herders using most areas at least seasonally wherever there is pasture.

The most prominent topographic feature in the northern part of Qinghai is the Qaidam Basin, now desert but formerly a huge lake. Several ranges ring this basin. Along its northern rim is the desolate Altun Tagh or Arjin Shan (*shan* means 'mountain'), the drab slopes either bare or sparsely covered with low shrubs (*Artemisia*, *Ceratoides*). Farther east is the Qilian Shan with its parallel subsidiary ranges, among them, from north to south, the Tulai Nanshan, Shule Nanshan, and Danghe Nanshan (Fig. 2). These mountains present a maze of eroded slopes and stony defiles. The low elevations are desert, but higher up, beginning at about 3300 m, shrubs (*Caragana*, *Ephedra*) and some grasses appear, and above 3800 m there are alpine meadows. Patches of conifer forest occur in the eastern Qilian Shan. The eastern boundary of the Qaidam Basin consists of a jumble of hills that extend to Qinghai Lake (Koko Nor), at 4583 km^2 the largest lake in the province. The Kunlun Shan traces part of the western and southern border of the basin. After a small gap it extends eastward as the Anyemaqen Shan. The western Kunlun is as desolate as the Arjin Shan, barren except for low

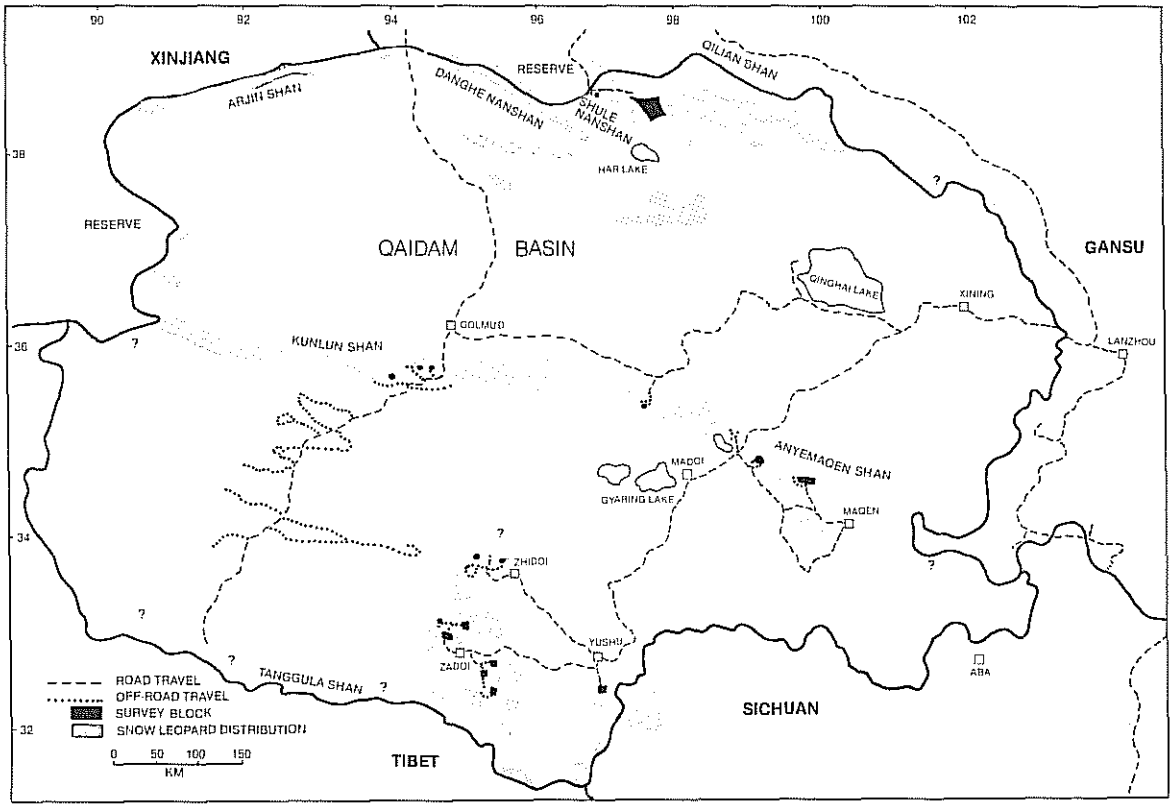

Fig. 1. Distribution of snow leopards in the Qinghai and Gansu provinces, China. ?, denotes areas where snow leopard might occur but presence remains unconfirmed. The black dots indicate localities outside survey blocks where snow leopard spoor was found.

Fig. 2. The Tulai Nanshan in northern Qinghai is rugged and barren. We are camped by a willow-bordered creek in a valley of the Shule Nanshan. 10 October; 3200 m.

shrubs (*Kaladium*, *Salsola*) and a sparse cover of grasses and sedges along seepages (Fig. 3). However, the eastern Kunlun and the Anyemaqen Shan may have good pasture, and north and west-facing slopes may be covered with dense shrub (*Salix*, *Potentilla*) and patches of *Juniperus* forest that extend upward to 4400 m.

Much of the region south and southeast of Qinghai Lake, including southeastern Gansu, as well as the vast uplands south of the Kunlun and Anyemaqen Shan, consist of rolling plains and broad valleys above 4000 m in elevation with hills and ranges breaking the expanses. The eastern two-thirds has lush grasslands which during the summer rains display flowers in colourful profusion, conspicuous among them *Gentiana*, *Meconopsis*, *Pedicularis*, *Aster*, *Polygonum*, and *Saxifraga*. The western third—a region known as the Qian Tang—extends into Tibet. It is arid, cold and high, much of it at 4500–5000 m; it supports only a sparse vegetation of grasses, forbs, and procumbent shrubs. Saline lakes, their drainage internal, dot the landscape. There, as elsewhere in the province, the upper limit of vegetation lies at about 5100–5200 m, only an occasional *Rhodiola*, *Saussurea* or other plant being found higher.

The Tanggula Shan marks the southern border of Qinghai. In the southeastern corner the mountains extend northward to the towns of Yushu

Fig. 3. Broad valleys break the eastern Kunlun Shan. Snow leopards often travel along the base of the hills and leave scrapes (just left of 1) and droppings (just left of 2) at the tip of spurs projecting into the valley. 3 December; 3800 m.

Fig. 4. Typical snow leopard habitat in the northern Zadoi area of southeastern Qinghai consists of limestone massifs. 28 August; 5000 m.

and Zhidoi. This area consists of many isolated limestone massifs and small, rugged ranges, few higher than 5500 m, surrounded by hilly grassland (Fig. 4). Juniper forests grow on many slopes south and east of Zadoi.

METHODS

The province being large, we sampled only parts of it (Fig. 1). Three survey methods were used: (1) We enquired about wildlife from local people, perused topography and habitat conditions, and took note of any animals seen or reported. (2) Cross-country transects were made to tally wildlife. Off-road travel was sometimes possible by car, but we usually rode horses or camels or went on foot, the last-named always when transecting for snow leopard spoor. (3) An attempt was made to obtain total counts of ungulates within survey blocks by searching all drainages. Animals were classified by age class and sex when possible. Carnivore spoor was quantified. Our sample consists of nine survey blocks 45–610 km^2 in size, a total of 1375 km^2, the survey blocks selected on the basis of our having been told that snow leopard and other species were more abundant there than elsewhere in the area. Therefore, our density figures represent the maximum for each region rather than the typical conditions.

Tracks of snow leopards are sometimes difficult to detect without snow cover. However, the cat makes characteristic scrapes by raking its hind paws on the ground at conspicuous locations such as mountain passes, base of cliffs, and confluence of creeks (Schaller, 1977; Jackson & Ahlborn, 1984). A search for spoor was made in the most likely places and all scrapes and droppings were counted, providing a crude measure of abundance. Droppings were usually not associated with scrapes (only 10% of scrapes in south Zadoi, 12% in the Shule Nanshan, and 21% in west Kunlun had droppings within 2 m). Food habits of snow leopard were determined by analysing the content of droppings. Snow leopard droppings can be confused with those of lynx *Felis lynx*, dog, and wolf *Canis lupus*, and, therefore, droppings of questionable origin were not used in analyses. Prey remains in droppings were identified by the distinctive colour and texture of hairs and the presence of bones, claws, and other material. Most droppings contained only one kind of prey; if more than one item was present, the percentage of each was estimated.

RESULTS

Distribution and status of snow leopard

Snow leopard are found in all major mountain ranges of Qinghai as well as in various small massifs (Fig. 1). Although the cats prefer broken terrain with

cliffs (Jackson & Ahlborn, 1984), they may also traverse relatively gentle terrain, especially if ridges provide travel routes, and shrub patches and rock outcrops offer cover. We no doubt overlooked some areas that still harbour snow leopards, especially in the Tanggula Shan, and a few populations that were reported to us may now be extinct. The current range of snow leopards in Qinghai encompasses roughly 65 000 km^2 or 9% of the total area. However, the actual range occupied by viable populations is less than that. In some areas, herdsmen have exterminated the cats or reduced the population to rare stragglers; in other areas, as in parts of the Arjin Shan, the mountains are so arid that wildlife is sparse.

In Gansu, we found evidence of the snow leopard only in the Qilian Shan along the Gansu-Qinghai border and in one small limestone range, the Die Shan, in the southern part of the province. The latter population and an unconfirmed one in Sichuan—the Balang Shan which lies partly in the Wolong reserve—represent the eastern limit of snow leopards in China. As yet we have not surveyed Sichuan province. The cats are known to be rare in the west around Aba and to occur sporadically above the timberline from Gongga Shan westward into Tibet and southern Qinghai.

The number of scrapes and droppings in an area give an indication of the cat's abundance though such data contain biases (Table 1). For example, snow leopards in the Shule Nanshan tended to travel along ridge crests (19% of scrapes found) or in gorges (75% of scrapes) into which prey descended to drink. And in the western Kunlun we noted scrapes primarily along the base

TABLE 1
Relative Abundance of Snow Leopard Spoor in Survey Blocks and along Foot Transects outside Survey Blocks

Area	*No. survey blocks*	*Total km^2*	*No. survey days*[a]	*Spoor*		*Amount spoor/ survey day*
				No. scrapes	*No. droppings*	
Shule Nanshan	1	610	16	170	91	16·3
	Transect	—	2	9	5	7·0
Kunlun, west	Transect	—	4	42	15	14·3
east	Transect	—	4	1	0	0·3
Anyemaqen, east	1	170	7	9	20	4·1
west	1	50	1	0	1	1·0
Zhidoi	Transect	—	4	0	1	0·3
Zadoi, north	2	220	6	7	7	2·3
north	Transect	—	3	8	4	4·0
Zadoi, south	3	185	12	29	25	4·5
Yushu	1	140	8	0	46	5·8

[a] One person or several together searching for one day equals one survey day.

of hills flanking broad valleys, terrain which snow leopard apparently patrolled in search of blue sheep and Tibetan gazelle *Procapra picticaudata* that foraged there (Fig. 3). By contrast, the cat's travel routes were less well defined in the massifs of southeastern Qinghai, making it difficult to locate spoors. Scrapes were more abundant than droppings in some areas and the converse was true in others. An extreme case was the Yushu block where 46 droppings (and 2 fresh tracks) but no scrapes were found. Tallies of just scrapes may thus give a skewed impression of relative snow leopard abundance.

Transects in snow leopard habitat revealed that the cats were rare in some areas. For instance, 4 survey days (one person or several together searching for one day equals one survey day) in east Kunlun yielded one scrape and one track. Some massifs in Zhidoi were apparently visited only at long intervals by snow leopards. The spoor count in several areas was 4–7/survey day (Table 1), suggesting moderate snow leopard numbers. Transects in 3 drainages in west Kunlun gave a spoor count of 14/survey day, but this high figure does not accurately reflect cat abundance in the region because most spoors were in one valley. Only the Shule Nanshan block had a substantial cat population, a spoor count of 16/survey day. Fresh sign was noted in every valley in the western and northern part of the block during our 1985 visit in spite of the fact that 12 cats (3 cubs, 6 subadults 1–3 years old, and 3 adults) were trapped there for the Xining zoo during the winter of 1983–84. Tibetan herdsmen killed at least 11 snow leopards during the winter following our survey (Chen Taiho, pers. comm.).

Judging by sign, the survey blocks in north Zadoi (Zaching commune), south Zadoi (Angsai commune), Yushu (Batang commune) and east Anyemaqen (Xueshan commune) had an estimated 1 cat 25–35 km^{-2}, and density in the Shule Nanshan was probably higher. In many other areas, however, snow leopards have in recent decades been decimated or locally eradicated according to our surveys and informants. Government fur records for the Chambo area of eastern Tibet, just south of Yushu and with similar terrain, showed 88 snow leopard skins purchased in the years 1968, 1970 and 1971 (Feng *et al.*, 1986), an indication of great hunting pressure on this species. In the Arjin Shan (which we visited just west of Qinghai in Xinjiang) the cats were already considered to be 'very rare' (Prejevalsky, 1879) a century ago. Our limited work does not provide the basis for an accurate estimate of the total number of snow leopard. Mallon (1984*a*) 'concluded that a rough figure of one snow leopard to 150 km^2 is a realistic estimate in favorable areas of Ladakh, India'. Large tracts in Qinghai probably have such low densities too, but the cats were more abundant than that in a number of areas. An estimate of 1 cat 100 km^{-2} would give a total of 650 in the 65 000 km^2 terrain, a figure which may be of the correct order of

magnitude. Gansu has few snow leopards: many of those in the Qilian Shan area probably range into Qinghai as well, and those in the small Die Shan apparently comprise only a few individuals.

Status of ungulate prey

Snow leopard occasionally kill such large animals as adult yak, horses and, according to Mallon (1984*b*), wild ass *Equus hemionus*, making all ungulates potential prey. This includes species which avoid precipitous terrain, such as Tibetan gazelle, Tibetan argali *Ovis ammon hodgsoni*, and Tibetan wild ass *E. h. kiang*, but become vulnerable to predation by foraging near the base of cliffs and other sites where snow leopard hunt. For example, white-lipped deer *Cervus albirostris* were sometimes found high on grass-covered ridges, the crests of which snow leopard used as travel routes. However, the most important ungulate, the only one with which the snow leopard shares its habitat throughout the two provinces, is the blue sheep.

The survey blocks encompassed not only rugged terrain but also hills and valleys, suitable habitat for all ungulate species that would normally occupy the area. Our counts, therefore, were representative of the status of the species in that region. The blue sheep was the most abundant ungulate with a density of 1–5 animals km^{-2} (Table 2). Some herds contained over 50 individuals, an indication of local abundance. Reproductive success was

TABLE 2
Number of Wild Ungulates Counted in the Survey Blocks

	Shule Nanshan	*Anyemaqen*		*Zadoi*		*Yushu*
		East	*West*	*North*	*South*	
Total km^2	610	170	50	220	185	140
Species						
Blue sheep	657	906	237	798	949	222
Tibetan argali	0[a]	—	0	0	—	?
White-lipped deer	176	2	0	5	49	4[c]
Red deer	—	0	—	—	—	0
Tibetan gazelle	0	4	2	12	0	2
Tibetan wild ass	14	—	0	0	0	0
Wild yak	0	—	0	—	—	—
Muskdeer	—	+[b]	?	+	+	+
Animals km^{-2}	1·4	5·4	4·8	3·7	5·4	1·6

[a] '0' denotes that species occurs or occurred in the area but was not seen.
[b] '+', muskdeer were observed in the survey block, but not counted.
[c] Identification uncertain; animals were perhaps red deer.

generally high, about two-thirds of the adult females being accompanied by young. However, winter mortality of young appeared to be substantial, only about half of them surviving to become yearlings. Few adult males (2 years and older) were observed in the Anyemaqen blocks, and this suggests that they occupied a summer range different from that of females and subadults (Table 3).

White-lipped deer reached a maximum density of 0·3 deer km^{-2} in two areas, south Zadoi and Shule Nanshan. In the latter, we observed 176 deer in 4 herds, containing 18, 20, 45 and 92 individuals, and a lone male. There were 47 adult males:100 adult females. It being early October and the onset of rut when males and females associate, the data accurately reflect a disparate sex ratio. Reproduction was adequate with ratios of 46 young and 36 yearling:100 adult females.

Other ungulates—argali, Tibetan gazelle, red deer *Cervus elaphus macneilli*, wild ass, wild yak *Bos grunniens*—were either rare in the blocks or had in recent years been extirpated. The number of ungulates in the blocks varied from 1·4–5·4 km^{-2}. These figures are slightly low. A few blue sheep herds were no doubt overlooked, especially in the maze of ravines of the Shule Nanshan. And several blocks contained muskdeer *Moschus sifanicus* which, because of their secretive habits and preference for brush-covered slopes, could not be counted. Based on spoor and sightings, muskdeer were most scarce in Anyemaqen and most abundant in south Zadoi.

Probably no blue sheep densities higher than those in the survey blocks occur elsewhere in Qinghai and Gansu. Exterminated in some areas, and decimated throughout their range, blue sheep nevertheless remain the most numerous and widespread ungulate. The low number of other species in the blocks reflects their current status in the two provinces—in contrast to the abundance of animals before the 1950s (Prschewalski, 1884; Schäfer, 1933). As Migot (1957) wrote after traversing the plains near Gyaring Lake: 'There was a tremendous lot of wildlife in this region, which is in effect a sort of

TABLE 3
Composition of Blue Sheep Population in the Survey Blocks

	Shule Nanshan	*Anyemaqen*		*Zadoi*	
		East	*West*	*North*	*South*
Number of animals classified	347	275	237	244	497
Date	Sept.–Oct. 1985	Sept. 1986	July 1984	Aug. 1986	Sept. 1986
Males: 100 adult females	71	0	15	90	134
Yearlings: 100 adult females	28	37	22	29	37
Young: 100 adult females	65	64	53	65	75
Size of largest herd observed	50	139	83	136	146

sanctuary undisturbed by man. Herds of yaks, wild asses and gazelles were all quite easy to get near...'. White-lipped deer were once widely distributed in the eastern half of Qinghai, inhabiting both grassy hills and forest. Scattered populations persist, especially in the forests south of Yushu. Red deer are often sympatric with white-lipped deer, but they were rare or absent in the areas we visited. Tibetan gazelle survive only as remnants. Inhabitants of plains, hills, and mountain valleys, they were once perhaps the most abundant ungulate, but lack of legal protection and unrestricted hunting have eliminated them from vast tracks. A few goitered gazelle *Gazella subgutturosa* and Przewalski's gazelle *Procapra przewalskii* also occur in and around the Qaidam Basin. Only two argali were seen during the months of field work. Formerly quite common in rolling terrain, argali are now the most seriously threatened of all ungulates. Wild yak still occur in low numbers in the Qilian and Arjin Shan areas but most are found in the southwest bordering Xinjiang and Tibet. Once spread throughout the uplands in plains and hills, wild ass have been almost exterminated in the eastern third of Qinghai and are now uncommon in and around the periphery of the Qaidam Basin; they occur now principally in the southwestern quarter of the province. Tibetan antelopes *Pantholops hodgsoni* persist at low densities mainly on the plains from Gyaring Lake westward into Tibet. The southwestern corner of Qinghai, which remains partly uninhabited, is the only area in the province where wildlife exists in relatively undisturbed conditions. With potential ungulate prey either gone or reduced to insignificant remnants in most areas, snow leopard, as well as wolf, have mainly blue sheep available.

No mention has so far been made of livestock. Densities are high, an average of about 15–45 animals km^{-2} in southeastern Qinghai (Table 4).

TABLE 4
Livestock Numbers in Selected Counties in Southeastern Qinghai, 1984

	County				
	Maqen	*Madoi*	*Zhidoi*	*Zadoi*	*Yushu*
Size (km^2)	13 353	25 253	78 647	34 558	14 766
% county usable pasture	88	57	32	66	79
No. yak	224 600	121 000	209 700	289 000	413 500
No. horse	12 000	7 000	8 400	16 200	18 200
No. sheep and goat	371 100	422 000	488 000	427 200	383 100
Animals km^{-2} pasture	52	38	28	32	70
Livestock units km^{-2} pasture[a]	30	16	13	18	45

[a] 4 sheep equal one horse or yak.

The number of animals often exceeds the carrying capacity of the range, judging by eroding hillsides, especially in Maqen and Zhidoi counties. Penetrating into the mountains to the limit of vegetation, livestock becomes vulnerable to predation. Sheep and goats are usually guarded by herdsmen, whereas horses and yak may be left untended for days. Since pastoralists rotate grazing grounds seasonally, snow leopard may lack livestock as prey during certain periods.

Food habits of snow leopard

Wild ungulates, principally blue sheep, contributed about 30–45% to the snow leopard's diet (Table 5). Livestock was only a minor food item except in the Yushu block where it provided 22%. Marmots *Marmota himalayana* were a staple prey as important as, and in some places more important than, the ungulates. Since marmots hibernate from late September or early October until the end of March or beginning of April, the dropping sample reflects mainly the summer diet of the cats. A winter sample would probably reveal more blue sheep, as well as more livestock, for, according to informants, predation is heaviest in late winter. Woolly hares *Lepus oiostolus* were generally scarce. However, parts of the Shule Nanshan block had a hare eruption—17 animals were counted in one 250 m stretch of

TABLE 5
Food Items in Snow Leopard Droppings, Expressed as Percent of Total Content in Sample

	Shule Nanshan Sept.–Oct. (n = *91*)	*Kunlun, west Dec.* (n = *13*)	*Anyemaqen, east Sept.* (n = *20*)	*Yushu Aug.* (n = *46*)	*Zadoi Aug.–Sept.* (n = *36*)
Blue sheep	39·3	45·0	31·3	30·4	24·0
Muskdeer	—	—	—	—	13·8
Cervus deer	1·1	—	—	2·2	—
Domestic sheep and goat	2·2	—	—	17·4	2·8
Domestic yak	—	—	—	4·3	—
Marmot	36·5	41·9	65·3	41·3	51·1
Hare	5·5	—	—	—	—
Pika or small rodent	2·2	0·4	—	—	—
Unidentified hair	2·1	—	—	2·2	—
Bird	0·1	—	—	—	—
Vegetation: Grass	1·3	—	0·2	2·2	5·3
Sibiraea	—	—	3·2	—	3·1
Salsola	—	12·7	—	—	—
Tamarix	9·7	—	—	—	—

streambank—and snow leopard preyed on them occasionally. Small animals, such as birds and pikas *Ochotona*, were only incidental prey.

Vegetation in the dropping samples varied from 2% to 13%, depending on area. Grass was found in all samples, except in the one from west Kunlun. For reasons unknown the cats sometimes bit off twigs, ingesting pieces 2–4 cm long, in such amounts that entire droppings were composed of them. There was selection for the twigs of *Tamarix* sp., *Salsola arbuscula*, and *Sibiraea angustata* even though other shrub species were available. Elsewhere, *Salix* and *Myricaria* shrubs are eaten in Ladakh (Mallon, 1984*a*) and *Rheum emodi* forb in Pakistan (Schaller, 1977).

Wolves had a diet similar to that of snow leopard. Wolf droppings (n = 29) from the Shule Nanshan contained 24·1% blue sheep, 61·2% marmot, 6·6% hare, 3·4% livestock, and 3·4% white-lipped deer; and droppings (n = 19) from east Anyemaqen contained 47·4% blue sheep, 47·1% marmot, and 5·3% muskdeer, to mention only major items. With plains wildlife decimated, wolves probably prey on blue sheep more now than they did in the past, increasing competition between predators. Emmons (1987) calculated that a predation rate of about 10% of the prey biomass reflects a 'limiting equilibrium state for large predators and large mammalian prey'. With human predation added to that of snow leopard and wolf, this rate is no doubt often exceeded for blue sheep and populations decline. However, the marmot is an important buffer in that it deflects predation from blue sheep.

Large cats require about 40–45 g of food per kg of cat per day (Emmons, 1987). A 35 kg snow leopard (Schaller, 1977) would thus need 1·5 kg per day or 548 kg per year. Inedible parts such as large bones and stomach contents average about one-third of the prey's total weight (Jackson & Ahlborn, 1984), making it necessary for a snow leopard to kill at least 822 kg a year to survive. Floyd *et al.* (1978) presented a method of calculating number of prey animals eaten based on frequency of their occurrence in droppings. They noted that small prey contains relatively more indigestible matter than large prey. Consequently, in a direct proportional analysis, as in Table 5, marmots are underrepresented in terms of numbers and overrepresented in weight. We use the east Anyemaqen dropping sample to illustrate the importance of marmots as a buffer. Marmots occurred in 14 of 20 droppings and blue sheep in 7. The relationship between number of droppings and weight of prey consumed is expressed by the equation $y = 0{\cdot}38 + 0{\cdot}02\,x$ where y is the kg of prey per dropping and x the average weight of prey (Floyd *et al.*, 1978). Adult marmot females average 5·3 kg and males 6·8 kg (Feng *et al.*, 1986); blue sheep females average 35–45 kg and males 60–75 kg (Schäfer, 1937). With subadults weighing less than adults, we assume that the female weight is approximately that of an average individual. To solve the equation, y for

marmot is 0·49 kg and blue sheep 1·18 kg. When multiplied by the number of droppings, the results are 6·9 kg of marmot and 8·3 kg of blue sheep consumed. Marmots thus represent 45·4% of the meat eaten, or 124 kg of the 274 kg required during the 6 months when this rodent is available. Converted to the number of animals, a snow leopard would kill 35 marmots and 5·6 blue sheep. During the rest of the year it would have to prey more heavily on blue sheep, or, if these are at low density, also on livestock.

CONSERVATION

The snow leopard in China has had full legal protection since 1983. However, the wildlife departments in Qinghai and Gansu have neither staff nor funds to enforce regulations with the results that local people kill cats almost with impunity. Men often carry rifles—in the Anyemaqen area, 50% of the Golog tribesmen were armed when travelling—and may shoot any wildlife they encounter. Meat hunting, especially for blue sheep, is common. In the Qilian Shan, as in various other places, large steel traps are set to capture anything from snow leopard and brown bear *Ursus arctos* to gazelle and blue sheep. Snow leopard are killed primarily because they may prey on livestock, although in the areas we visited losses were relatively small. For example, in the east Anyemaqen block, 5 households with a total of 2350 domestic animals had lost 12 (0·5%) to wolf and snow leopard during the previous 12 months.

Another factor affecting snow leopard numbers is the eradication of prey. Marmots are killed for their pelts and poisoned with zinc phosphide because they are said to compete with livestock for grass. Blue sheep are hunted not just for local consumption but also for export. From 1958 onward Qinghai has exported 100 000–200 000 kg of blue sheep meat each year, much of it to West Germany. Since the average dressed weight of a blue sheep is about 20 kg, 5000–10 000 blue sheep are shot annually for the foreign market. Communes are assigned quotas—the Zaching commune in north Zadoi had an annual quota of 5000 kg—and local men shoot animals of both sexes and all ages, using in some instances small-bore rifles provided by the government. Such market hunting has eliminated blue sheep from various ranges and greatly reduced them in others.

County records show that snow leopard occurred near the city of Xining 600 years ago (Guo Gieting, pers. comm.). Although the cat's range has contracted significantly since that time the animals still have a fairly wide distribution in the province. But with an expanding human population and government emphasis on increasing livestock production and income from

wildlife, the snow leopard's future in Qinhai and Gansu is far from secure. And with habitat often being fragmented, there may be so few animals in a population that the loss of even two or three cats can eliminate the species in that locality. As yet Qinghai has no reserves for large mammals, even though suitable areas exist, as in the southwest. Xinjiang has the 45 000 km^2 Arjin Shan Reserve touching Qinghai in the west, and Gansu the 5000 km^2 Yanchiwan Reserve bordering Qinghai in the north (Fig. 1), each with a small snow leopard population. Qinghai could establish contiguous reserves on its side of the border and control the activities of the few pastoralists living there. For instance, only 30 households are responsible for most of the damage to wildlife in and around the Shule Nanshan block.

Blue sheep lack legal protection in Qinghai, market hunting is conducted with little effort to manage the resource on a sustained basis, steel traps, though illegal, take a large, unselective toll of animals, and in Xining and other towns, snow leopard skins are sold in fur shops and bones in medicine shops. The Qinghai government needs to address these problems, considering them first steps in promoting the survival of the snow leopard. Most pastoralists are Tibetans whose Buddhist religion predisposes them against killing wildlife. Using religious sentiment as a basis, an education programme might encourage some herdsmen to lay down arms, and communes to establish their own reserves, especially around temples. Unless the snow leopard, brown bear, argali, and other wildlife in Qinghai and Gansu receive better protection the two provinces will ultimately lose a valuable resource and a part of their natural heritage.

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REFERENCES

Andriuskevicius, A. (1980). Occurrence of snow leopards in the Soviet Union. *Int. ped. book of snow leopards*, **2**, 49–54.

Braden, K. (1982). The geographic distribution of snow leopards in the USSR: maps of areas of snow leopard habitation in the USSR. *Int. ped. book of snow leopards*, **3**, 25–39.

Emmons, L. (1987). Comparative feeding ecology of felids in a neotropical rainforest. *Behav. Ecol. Sociobiol.*, **20**, 271–83.

Feng Zuojian, Cai Guiquan & Zheng Changlin (1986). *The Mammals of Tibet*. Science Press, Beijing. (in Chinese).

Floyd, T., Mech, L. & Jordan, P. (1978). Relating wolf scat content to prey consumed. *J. Wildl. Manage.*, **42**, 528–32.

Green, M. (1982). Status, distribution and conservation of snow leopard in North India. *Int. ped. book of snow leopards*, **3**, 6–10.

Jackson, R. & Ahlborn, G. (1984). A preliminary habitat suitability model for the snow leopard, *Panthera uncia*, in West Nepal. *Int. ped. book of snow leopards*, **4**, 43–52.

Liao Yanfa (1985). The geographical distribution of ounces in Qinghai Province. *Acta Theriologica Sinica*, **5**, 183–88 (in Chinese).

Mallon, D. (1984*a*). The snow leopard in Ladakh. *Int. ped. book of snow leopards*, **4**, 23–37.

Mallon, D. (1984*b*). The snow leopard, *Panthera uncia*, in Mongolia. *Int. ped. book of snow leopards*, **4**, 3–9.

Migot, A. (1957). *Tibetan marches*. Penguin, Harmondsworth.

Prejevalsky [Przewalski], N. (1879). *From Kulja across the Tian Shan to Lob Nor*. Sampson Low, Marston, Searle, and Rivington, London.

Prschewalski [Przewalski], N. (1884). *Reisen in Tibet am oberen Lauf des Gelben Flusses in den Jahren 1879 bis 1880*. Hermann Costenoble, Jena.

Schäfer, E. (1937). Über das Zwergblauschaf (*Pseudois* spec. nov.) und das Grossblauschaf (Pseudois nahoor Hdgs.) in Tibet. *Zool. Gart.*, **9**, 263–78.

Schäfer, E. (1933). *Berge, Buddhas, und Bären*. Paul Parey, Berlin.

Schaller, G. (1977). *Mountain monarchs: Wild Sheep and Goats of the Himalaya*. University of Chicago Press, Chicago.