Wakhi livestock in Big Pamir in 2006

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Wildlife Conservation Society, New York

Cover photo: The yak and the man. More than just a pastoral capital, yaks are the spirited companions of Wakhi herders.

All photographs: Dr Stéphane Ostrowski, WCS
Maps: Mr Haqiq Rahmani, WCS

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EXECUTIVE SUMMARY

The Afghanistan Ecosystem Health Project team carried out two surveys in the Wakhan District in 2006, aimed at collecting field data on Wakhi livestock in Big Pamir and their interactions with wildlife. The Wakhi are mostly sedentary farmers who live in small villages located at lower altitudes. Only a minority of them are transhumance herders. They use the surrounding Pamir Mountains as seasonal pastures, bringing their livestock (sheep, goats, yaks, cattle, Bactrian camels, horses and donkeys) into potential contact with wildlife.

During our summer survey (16 July – 22 August 2006), we identified 11 currently used Wakhi herding settlements in Big Pamir and visited 10 of them. They were set in the Jermasirt (4), Manjulak (3), and Shikargah (4) pasture areas, which are either within the Big Pamir Protected Area or are reached by passing through it. Overall, the 11 settlements consisted of 62 households. We interviewed 55 of them in summer. During our winter survey (23 November – 18 December 2006), we visited the 14 villages the 62 identified households originated from, spread throughout the lower, mid, and upper Wakhan. We could interview the remaining 7 households not interviewed in summer and reinterviewed 31 households. Data presented in this progress report are based on the interviews (84 questions each), as well as on direct observations and veterinary investigations (clinical examinations and sampling).

According to the interviews, an estimated 4749 sheep, 1070 goats, 557 yaks, 288 heads of cattle and 57 Bactrian camels were present in the western Big Pamir in summer 2006. Our direct counts give enlarged figures: 5929–6077 sheep, 1546–1659 goats, and 637–657 yaks. Twenty-four households (38.7%) practiced complete transhumances, transferring all of their livestock from the villages to altitude pastures in spring and from altitude pastures to the villages in autumn. Thirty-six households (58.1%) performed partial transhumance. In autumn, they moved down to the village most of their goats, all of their sheep from the *gadek* breed and some of the *turki* breed, part of their yaks and Bactrian camels, and all of their cattle. They left in Pamir for winter the 'strongest' goats, the rest of the *turki* breed sheep and of their yaks and Bactrian camels. Finally 2 households (3.2%) adjusted their livestock seasonal movements according to weather. If winter was harsh, they moved down to the village all of their livestock. Overall, we estimated that 60.7% of sheep, 82.4% of goats, 65.6% of yaks, 100% of cattle, and 86.7% of camels returned to villages in October 2006.

We estimated the size of the summer and winter pasture areas in Big Pamir at 153.1 km^2 and 76.8 km^2, respectively. Population size estimates coupled to pasture size estimates translated to summer densities of 41–44 heads/km^2 in the Jermasirt, 76–79 in the Manjulak, and 31–32 in the Shikargah pastures for sheep and goats. In the same way, we found an overall density of 31–32 heads/km^2 for sheep and goats in winter pastures of Big Pamir.

Three interrelated factors play important roles in the health status of livestock in Wakhan: seasonal availability of forage, presence of infectious diseases, and mixing of animals. Mixing concerns animals from different owners in the same herd during summer or animals from the same herd but of different health status (diseased or healthy). The principal cause of recorded mortality in ruminants was undernutrition, which affected all species during winter. Infectious diseases were the second cause of death, especially gastrointestinal and respiratory tract disorders. At the beginning of spring there was a burst of abortions among sheep, goats and yaks. We noted that many diseases affected domestic ruminants in Big Pamir including: Foot and Mouth Disease, contagious ecthyma, scabies, infectious mastitis, infectious keratoconjunctivitis, monieziasis, as well as infestation with sheep ked in summer pastures and with ticks in villages. We estimate that Wakhi lost around 925–950 sheep, 220–250 goats, 120–130 yaks, 18–25 cattle heads and 6–10 Bactrian camels between December 2005 and December 2006. More than 70% of deaths occurred during winter.

In Big Pamir, Wakhi maintain a population of horses and donkeys for riding and packing purposes. In summer 2006, 29 (46.8%) and 60 (96.8%) households owned collectively 58 horses and 165 donkeys, respectively. Only the most prosperous households owned horses. Horses and donkeys are susceptible to cold weathers and are never left in Pamir during winter. Interviewed households reported the loss of 19 donkeys (11.5%) and 4 horses (6.9%) in 2006. Notably all losses occurred during winter, because of glanders, starvation and anecdotally wolf predation. Overall, livestock mortality tallied with a direct economical loss of c. 125,000 $US in 2006 for the Wakhi community we studied.

Results of interviews suggested that direct transmission of infectious agents from small ruminants to wild ungulates is very unlikely in Big Pamir as there are no direct contacts between them in the current land use context. However, the risk of indirect transmission of pathogens to wildlife through insect vectors, contaminated foods, soil or water cannot be ruled out, especially for Marco Polo Sheep (*Ovis ammon polii*), which are said to use on occasion the same pastures as livestock in summer. Another source of potential disease spillover between livestock and wildlife could also emerge from cattle, yaks and Bactrian camels often left unattended at high altitude pastures and possibly in closer contact with wild ungulates than sheep and goats.

According to our interviews, 18 sheep from a unique herd were predated by a snow leopard (*Uncia uncia*) in winter 2005-2006, while 2 Bactrian camels, 7 yaks, 3 sheep, 1 horse, 1 donkey and 2 dogs were killed by wolves (*Canis lupus*), between winter 2005–2006 and August 2006. We found that predation by wild carnivores accounted for less than 2.5% of reported livestock deaths in a year.

INTRODUCTION

The present document is a progress report by two instances. First, because the results of the serological screening on blood samples collected during the winter survey are not available yet, limiting our understanding of health issues in livestock to a largely qualitative and clinical picture. Second, because our surveys are part of a larger study that intends to document population size, geographical origins, ownership, range use and health status of livestock that use permanently or intermittently Big and Little Pamirs. We still need to investigate livestock populations of Wakhi in Little Pamir as well as those from Kirghizes in Little Pamir and eastern Big Pamir. We need to carry out more work to understand the complex issue of livestock disease epidemiology in the Afghan Pamir ecosystem and more importantly to estimate the risk of disease spillover between domestic and wild mountain ungulates.

OBJECTIVES AND METHODS OF 2006 SURVEYS

Objectives

The surveys carried out in 2006 were dedicated at studying livestock of the Wakhi population using western Big Pamir in summer and at collecting field data concerning their management and the presence of pathogens in their populations. Our goal was to estimate the number of Wakhi settlements and households in Big Pamir in summer, the number and ownership of livestock, to determine the seasonal patterns of range use, the timing of transhumances and the existence of over wintering practices in livestock, to assess the health status of livestock and occurrence of transmissible diseases, and to evaluate risk of disease spillover from domestic to wild ungulates. To a few exceptions we only provide firsthand data collected in the field. The report tries to be a snapshot as accurate as possible of the presence and health status of livestock in Big Pamir at the time of the surveys.

Methods

Dates of surveys

Summer survey took place between 16 July and 22 August 2006, after spring transhumance, while livestock was grazing summer pastures. Winter survey took place between 23 November and 18 December 2006, after autumn transhumance. Summary of activities per day can be found in the Appendix.

Composition of teams

The ecosystem health project team which carried out the summer survey (Plate 1) was composed of:

- Dr Stéphane Ostrowski, team leader / WCS Ecosystem Health Project Manager;
- Dr Khadr Abdul Kadhr, Afghan counterpart, Senior Veterinarian at Kabul Zoo;
- Drs Ali Madad Rajabi and Hafizullah Ziauddin, two Afghan veterinarians recently graduated from Kabul Veterinary College, trainees;

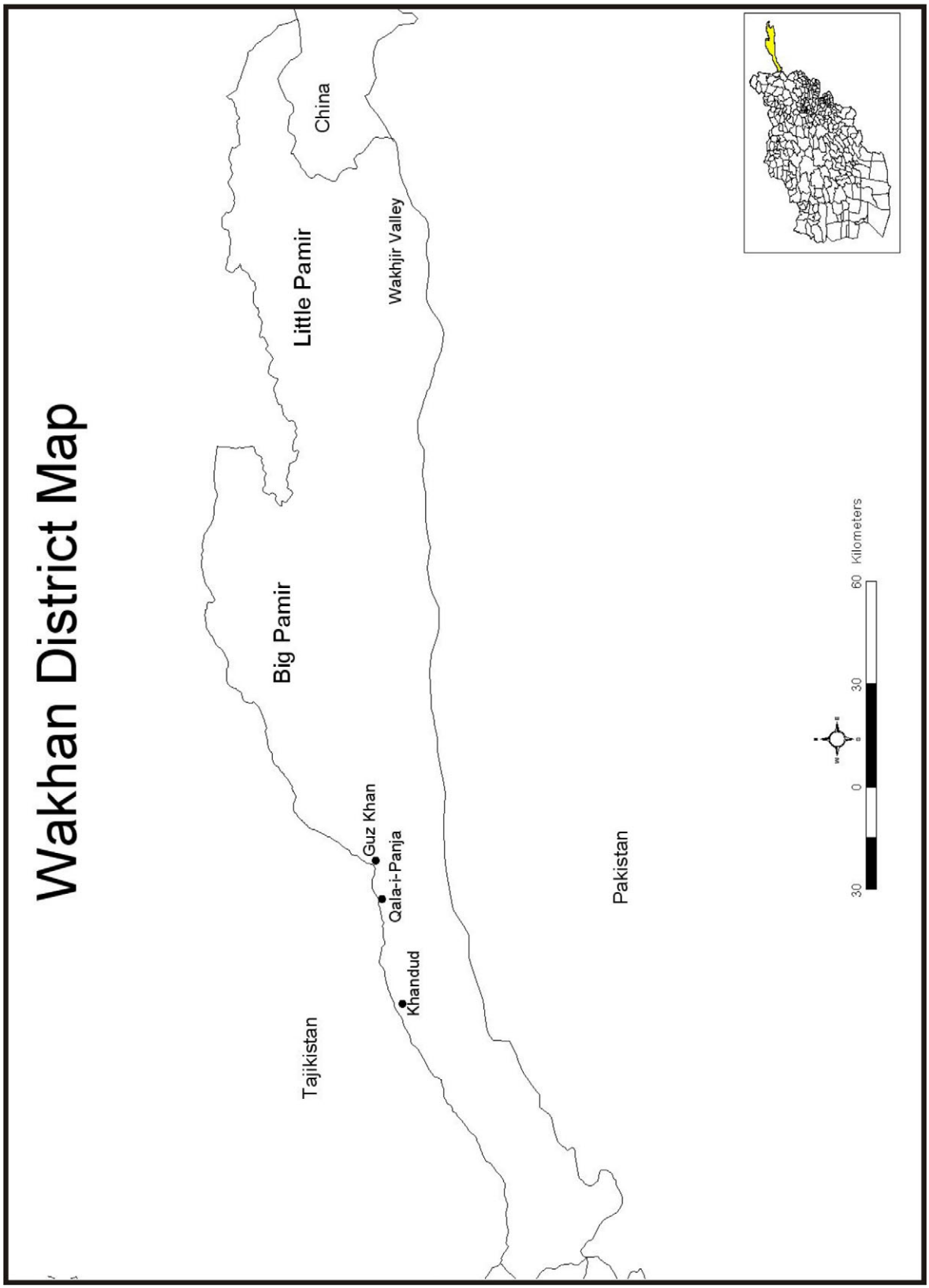

Figure 1 — Map of the Wakhan District, Badakhashan Province, Afghanistan

- Mr Mallang, a Wakhi cook trained by the tourism department of the Aga Khan Foundation (AKF) in Wakhan.

The team which carried out the winter survey was composed of:

- Drs Ostrowski, Madad Rajabi, and Ziauddin;
- Mr Inayat, a Wakhi trainee from Qila-e Panja identified by Mr Inayat Ali, WCS community conservation staff member based at Kret, upper Wakhan;
- Mr Attam Beg, a Wakhi man from Kret, trained as a cook by Mr Inayat Ali.

Survey area

For our first survey, we focused on western Big Pamir, Wakhan district, Badakhshan Province (Figure 1). Locally known as Pamir-e-Kalan or Pamir-i-Buzurg, the Big Pamir comprises the main block of mountains at the western end of the Pamir Knot between the fork of the Pamir and Wakhan rivers. It encompassed high mountains that culminate at 6700–6900 m and high plateaus that average between 3900 and 4700 m in elevation. The Big Pamir extends over about 5,500 km^2 of the Wakhan. A notable part of the western Big Pamir was once included in the so-called Big Pamir Wildlife Reserve encompassing about 700 km^2 (Haqiq Rahmani, pers. comm.). Although designated a reserve, it has never been legally established, and between 1968 and 1977 has functioned as a hunting reserve for foreigners, managed by the Afghan Tourist Organization. Before that, part of the area was a royal hunting reserve of the former king Muhammad Zahir Shah (Petocz, 1978).

In 2007, we will extend our study to livestock populations of eastern Big Pamir and Little Pamir.

Transport

In summer team members flew or drove to Kundunz, capital of Kunduz Province in northern Afghanistan, and drove to Ishkeshim via Faizabad. To reach the starting point of our summer expedition in Big Pamir, we traveled in the Wakhan Valley with four-wheel-drive cars rented in Kabul or Faizabad. On 25 of July, we sent back the cars, hired 8 donkeys and 2 horses for riding and packing purposes, and proceeded walking and riding from Goz Khun. Later, we had to return pack animals and hire new ones (horses, donkeys and yak) between each pasture areas. Between 26 July and 15 August, we walked or rode (on horse or yak) between and within Wakhi summer pastures and settlements of Big Pamir. After mapping the journey with ArcView 3.2, we could estimate the distance covered by our team for this period at 270 km.

During the winter survey, we used four-wheel-drive cars to reach the villages and visited households in villages by foot. Villages are often widespread and households within one village can be kilometers apart.

Location of summer pasture areas and settlements in Big Pamir

We identified the summer pasture areas and settlements of the Wakhi community in western Big Pamir according to the information provided to us by Shah Ismail's youngest brother in Qila-e Panja on 23 July 2006. We regularly cross-checked this information with elders of each settlement

Data collection and analysis

We collected data through interviews of local land users, direct counts and veterinary investigations on livestock (clinical examinations and sampling).

Interviews

We collected most of the data used in this study by interviewing Wakhi who pasture their livestock in western Big Pamir. At the beginning of each settlement visit we asked the older person about the number of households present in the settlement Out of the 62 identified and present households, 55 were interviewed in summer 2006. In winter 2006, we could reinterview 31 of those 55 households and interviewed the 7 households not investigated in summer. Overall we conducted 93 interviews. Between 2 and 4 team members conducted the interviews (Plate 2). We interviewed once or twice (in summer and after the autumn transhumance) all the Wakhi households that we had identified as pasturing their animals in Big Pamir.

Interviews were conducted in Dari (Persian language in Afghanistan) and subsequently translated in English by one of the interviewers. We carried out these interviews as part of a larger study that intends to document population size, geographical origin, ownership, range use and health status of livestock using permanently or intermittently Afghan Pamirs. Each interview lasted roughly 30–45 minutes and consisted in 84 predetermined questions about the background of the respondent, the number of livestock his household owned or attended in Big Pamir, transhumance timing and mapping, range use, current livestock health status, livestock management practices, diseases and current clinical symptoms observed in livestock. The same questions were presented in the same manner and order to each subject. The data used here derived from answers to questions dealing specifically with pastoral practices, livestock husbandry and health status. We tallied answers, calculated the percentages of various responses and carried out statistics with Statistix 8.1 software.

Size and geographical origin of livestock populations

We evaluated the size and geographical origin of the livestock populations attended by Wakhi in western Big Pamir according to the interviews carried out in the area in summer 2006. We also visited systematically each pasture and 10 of 11 functioning settlements. Most of the time, we interviewed elders of the households. We asked them to provide us with the current number of sheep, goats, cows, yaks, Bactrian camels, horses and donkeys they were tending in Pamir as well as their geographical origin. After the interviews, we carried out direct counts of livestock numbers to compare our figures to the one provided by the respondents and assess the interviews' sensitivity. Three of us counted on three consecutive times (total 9 counts) the total number of sheep, goats and yaks herded in each visited settlement. We repeated this cross-checking operation in all settlements except two: Mulung Than and Kund-a-Thur, in Shikargah pasture.

The interviews of herders and owners that we carried out in summer and winter, as well as the reinterviews performed after the autumn transhumance provided us with information on the seasonal movements of Wakhi livestock in Big Pamir.

Top to bottom: Plate 1 — The Ecosystem Health Project Team rests in Bai Tibat, 30 July 2006. From left to right, Dr Hafizullah Noori, Dr Khader Abdul Khadr, Dr Ali Madad Rajabi, and Mr Mallang. In the background, a Wakhi guide gathers pack donkeys before departure. Plate 2 — Drs Ali Madad and Hafizullah interview a Wakhi herder in a yurt in the Qabal Gah settlement, Shikargah, 10 August 2006. Interviews were usually carried out in such yurts, erected in each camp to house visitors.

Seasonal movements and range use of livestock in Big Pamir

Interviews provided us with information about the seasonal movements and the geographical extent of range use of livestock in Big Pamir. In addition, while visiting each settlement, we consistently scanned with binoculars the mountain slopes for livestock herds, and pinpointed upon sighting their estimated position on a 1/50 000 map. Finally we visited some areas reputedly located at the fringes of pasture areas and recorded sightings of livestock and indirect markers of their recent presence (fresh droppings, tracks, and carcasses). Pasture areas were then delimitated on a 1/50 000 map, digitalized and processed using ArcView 3.2 software by Mr Haqiq Rahmani, at WCS office in Kabul.

Livestock husbandry and health status

Interviews and direct observations provided us with data on husbandry and health status of livestock. We also carried out clinical examinations and got the chance to do postmortem examinations of five healthy subadult sheep slaughtered for meat. Finally we collected *c.* 471 blood samples on sheep and goats during the winter survey for serological screening.

RESULTS OF 2006 SURVEYS

Wakhi summer pasture areas, settlements and households

We identified three main summer pasture areas in Big Pamir: Jermasirt, Manjulak, and Shikargah. They are located in the north-western part of Big Pamir, lying along the north facing slopes looking across the valley of the Pamir River to the main massifs of the Tajik Pamirs. Manjulak and Shikargah pasture areas are within the Big Pamir Protected Area, while Jermasirt, located north of the reserve, can be reached by passing through it (Figure 2). In summer pastures, the steep mountain slopes alternate with high terraces and are dominated by woody shrub species such as *Artemisia*, *Ephedra*, and *Astragalus*. Areas of perennial tussock grasses seem uncommon. Above the 4500-m contour appears a zone of typical alpine flora composed of *Aster*, *Potentilla* and *Saxifraga*, with sporadically distributed sedge meadows dominated by *Carex* and *Kobresia*. Although livestock use mainly the *Artemisia* mountain steppes, they also graze sporadically areas at higher elevations with Alpine flora, particularly in Shikargah. Jermasirt and Manjulak are high-terraces and gently undulating altitude pastures (Plate 3) whereas Shikargah, located on both sides of the Istimoch/Shikargah River, encompasses plots of altitude wetland vegetation and steeper pasture locations. Wetland areas also occur in winter pastures such as in Tila Bai Valley (Plate 4). We identified 11 Wakhi summer pasture settlements in use in Big Pamir during our visit in summer 2006: 4 in Jermasirt, 3 in Manjulak, and 4 in Shikargah (Plate 5). The settlement of Khushabad in Shikargah was apparently not in use at the time of our survey (Mr Mohamed Reza, Mulung Than/Kret, pers. comm., confirmed by Mr Ali Akbar, Sargez, pers comm. during winter survey). Eventually there was apparently another settlement named Asan Katich in Shikargah pasture (Mr Ali Akbar, Sargez, pers comm.) that was used by Wakhi from upper Wakhan in summer 2006 (Mr Mohamed Reza, Mulung Than/Kret, pers. comm.) but we could not locate it. The 11 identified settlements consisted of 62 households (Table 1).

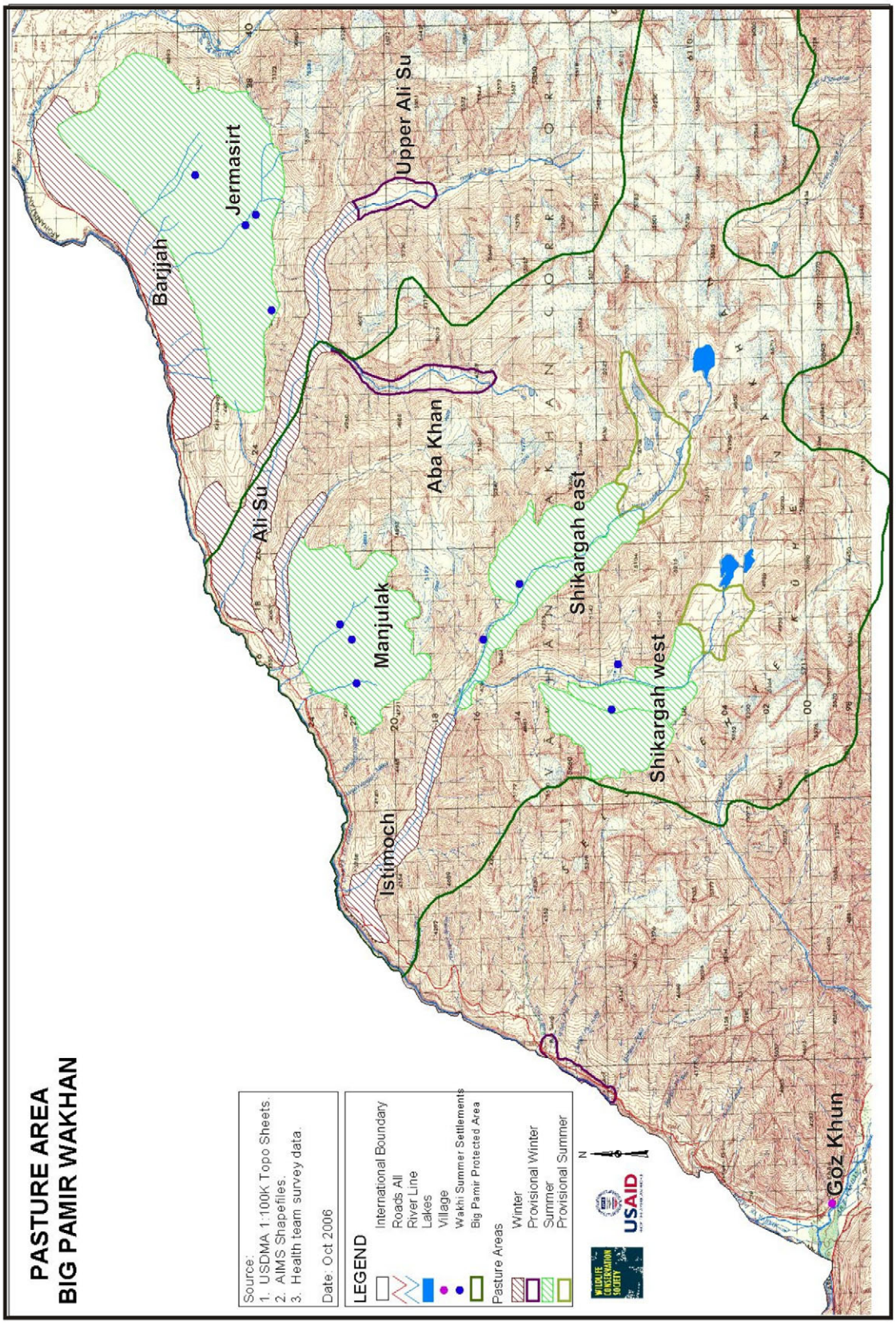

Figure 2 — Location of Wakhi pasture areas in western Big Pamir.

Top to bottom: Plate 3 — Typical high-terraces and gentle slope-type altitude pastures between Bai Tibat and Jermasirt, Big Pamir, 31 July 2006. Plate 4 — Unattended Bactrian camels in Kirghize winter wetland pastures in summer, Tila Bai Valley, Big Pamir, 30 July 2006. Plate 5 — The Wakhi summer settlement of Jabar Khan (altitude 4317 m), Jermasirt pasture area, Big Pamir, 1 August 2006. The Jermasirt pasture is typical of the *Artemisia* altitude steppes found in Big Pamir.

Table 1 — Wakhi pasture areas, settlements, and households in Big Pamir in July–August 2006.

*Name of pasture area	*Name of settlement	Location of settlement (UTM WGS 84)	Number of households
Jermasirt	Jabar Khan	43S 334535 4129195	10
	Buqbun	43S 332576 4126798	5
	Lupghil Kshun	43S 332947 4126306	6
	Bulok Kshun	43S 329378 4126486	2
Manjulak	Nakchirshitk	43S 317204 4122537	5
	Tor Bulok	43S 316134 4121553	6
	Ganj Khatun	43S 314916 4121820	7
Shikargah	Darah Big	43S 316470 4115637	3
	Qabal Gah	43S 314916 4121820	3
	Mulung Than	43S 315382 4109150	8
	Kund-a-Thur	43S 313700 4107800	7

*Spelling follows Mock (2006)

Data on livestock[1]

Numbers

Interviews

Results of the 62 household interviews give an estimate of 4749 sheep, 1070 goats, 557 yaks, 288 cattle heads and 74 Bactrian camels being pastured by Wakhi in Big Pamir during summer 2006 (Table 2). Some Wakhi did not know or were unwilling to communicate about the livestock they tended but which belonged to other Wakhi, often their relatives, not present in the settlements during our visit, or to non-Wakhi livestock owners. At least two herds of small ruminants tended by non-Wakhi herders, actually dealers from Panshir and central Badakhshan, were also present in the region during our summer survey. We counted one herd of 250–270 sheep and 50–80 goats in Jermasirt and another one of 180–200 sheep and 70 goats in Manjulak. These herds were composed of animals recently acquired from Wakhi, bartered for market goods, such as cloths, shoes, tools, vegetable oil, tea and opium. It seems that in recent years the increased desire of Wakhi households for new market goods has impacted the volume of trade with non-Wakhi merchants and favored an endemically high level of debt. Because of lack of cash, livestock constitute the main source of barter for Wakhi to acquire from traders the goods they do not produce themselves. In the past such economy mostly involved Kirghizes, shopkeepers in local bazaars, itinerant merchants, and peddlers (Shahrani, 2002). Nowadays, it relies more and more on livestock dealers who settle the whole summer in Wakhi pastures, bartering goods for livestock and attending the recently bought animals around the Wakhi settlements until the autumn transhumance. As the summer advances, these herds progressively increase in size at the expense of the Wakhi herds, with which they compete for forage.

[1] Data concerning horses and donkeys which are non-ruminant livestock are treated separately.

Table 2 — Number of livestock attended by Wakhi in Big Pamir in summer 2006 according to the interviews.

Name of pasture area	Name of settlement	Sheep	Goat	Yak	Cattle	Bactrian camel
Jermasirt	Jabar Khan	1438	129	131	80	23
	Buqbun	68	40	14	18	0
	Lupghil Kshun	208	39	38	17	1
	Bulok Kshun	250	40	36	22	28
	Subtotal (%)	1964 (41.4)	248 (23.2)	219 (39.4)	137 (48.4)	52 (70.2)
Manjulak	Nakchirshitk	450	141	60	28	2
	Tor Bulok	513	79	66	31	10
	Ganj Khatun	545	218	47	31	0
	Subtotal (%)	1508 (31.7)	438 (40.9)	173 (16.2)	90 (31.8)	12 (16.2)
Shikargah	Darah Big	304	38	29	7	0
	Qabal Gah	520	200	34	12	10
	Mulung Than	203	56	61	22	0
	Kund-a-Thur	250	90	41	15	0
	Subtotal (%)	1277 (26.9)	384 (35.9)	165 (15.4)	56 (19.8)	10 (13.6)
	Grand Total	4749	1070	557	283	74*

*Actually only 27 Bactrian camels were present in Wakhi summer pastures (17 in Jermasirt and 10 in Shikargah). Seventeen were tended by Kirghizes in eastern parts of Big Pamir, 28 were left unattended in Ali Su Valley and 2 in Tila Bai Valley.

Concerning the unlocated settlement of Asan Katich, it seems that no more than 250 sheep, 50 goats and 65 yaks were tended at this location in summer 2006 (Mr Mohamed Reza, Mulung Than/Kret, pers. comm.).

Direct counts: sensitivity test for livestock estimates

One of our main concerns when compiling livestock numbers from questionnaires was to evaluate the accuracy of the provided figures. As with all interviews, it is not always easy to motivate the respondents and to find out if they are telling the truth. In some settlements (Jabar Khan, Bulok Kshun, Ganj Khatun, Tor Bulok, and Qabal Gah) Wakhi had an accurate knowledge of the number of animals they possessed and were willing to communicate those figures. They were less cooperative in other settlements (Nakchirshitk, Buqbun, Lupghil Kshun, and Darah Big), and seemed more reluctant to provide us with information, especially about the number of animals they tended for other Wakhi. We were able to carry out direct counts of the livestock for 9 out of the 11 settlements we identified in Big Pamir in summer 2006. The comparison of the figures driven from interviews with direct on-site counts (Table 3) constituted a sensitivity test. Interview estimates were usually within 10% of direct count results in Jabar Khan, Bulok Kshun, Ganj Khatun, Tor Bulok, and Qabal Gah, whereas they were usually more than 20% lower in Nakchirshitk, Buqbun, Lupghil Kshun, Darah Big. Overall, estimates driven from interviews underestimated real herd size by *c.* 15–20% (Table 3).

Table 3 — Comparison of livestock estimates in Big Pamir based on interviews versus direct counts.

Name of pasture area	Name of settlement	Methods	Sheep	Goat	Yak
Jermasirt	Jabar Khan	Interviews	1438	129	131
		Counts[1]	1495–1511	128–139	132–136
		Error (%)	<10	<10	<5
	Buqbun + Lupghil Kshun	Interviews	276	79	52
		Counts	621–642	185–210	126–141
		Error (%)	>100	>100	>100
	Bulok Kshun	Interviews	250	40	36
		Counts	261–268	42–44	38–39
		Error	<5	<10	<5
Manjulak	Nakchirshitk	Interviews	450	141	60
		Counts	641–657	226–239	54
		Error (%)	>30	>30	<10
	Tor Bulok	Interviews	513	79	66
		Counts	494–509	87–93	–
		Error (%)	<10	<15	–
	Ganj Khatun	Interviews	545	218	47
		Counts	567–576	235–244	49
		Error (%)	<10	<15	<10
Shikargah	Darah Big	Interviews	304	38	29
		Counts	440–445	97–99	31
		Error (%)	>20	>30	<10
	Qabal Gah	Interviews	520	200	34
		Counts	527–546	280–295	39
		Error (%)	<10	<30	<15
	Mulung Than	Interviews	203	56	61
		Counts[2]	–	–	–
		Error (%)	–	–	–
	Kund-a-Thur	Interviews[3]	250	90	41
		Counts	–	–	–
		Error (%)	–	–	–
	Subtotal	Interviews	4749	1070	557
		Counts	5499–5607	1426–1509	637–657
		Error (%)[4]	14.8–16.6	27.8–32.2	17.0–20.4
Jermasirt + Manjulak	Non-Wakhi herds		430–470	120–150	–
	Grand Total count		5929–6077	1546–1659	637–657
	Provisional Grand Total[5]		6179–6327	1596–1709	702–722

[1]Direct count results correspond to three consecutive counts made by three observers ($N=9$). [2]Only interview estimates could be used for livestock of Mulung Than. [3]Kund-a-Thur settlement could not be visited in summer and livestock estimates were collected from *a posteriori* interviews conducted in winter in Sargez, upper Wakhan. [4]Calculated for interview results of 9 settlements for sheep and goats and 8 settlements for yaks. [5]Provisional Grand Total includes animals supposedly tended in Asan Katich settlement

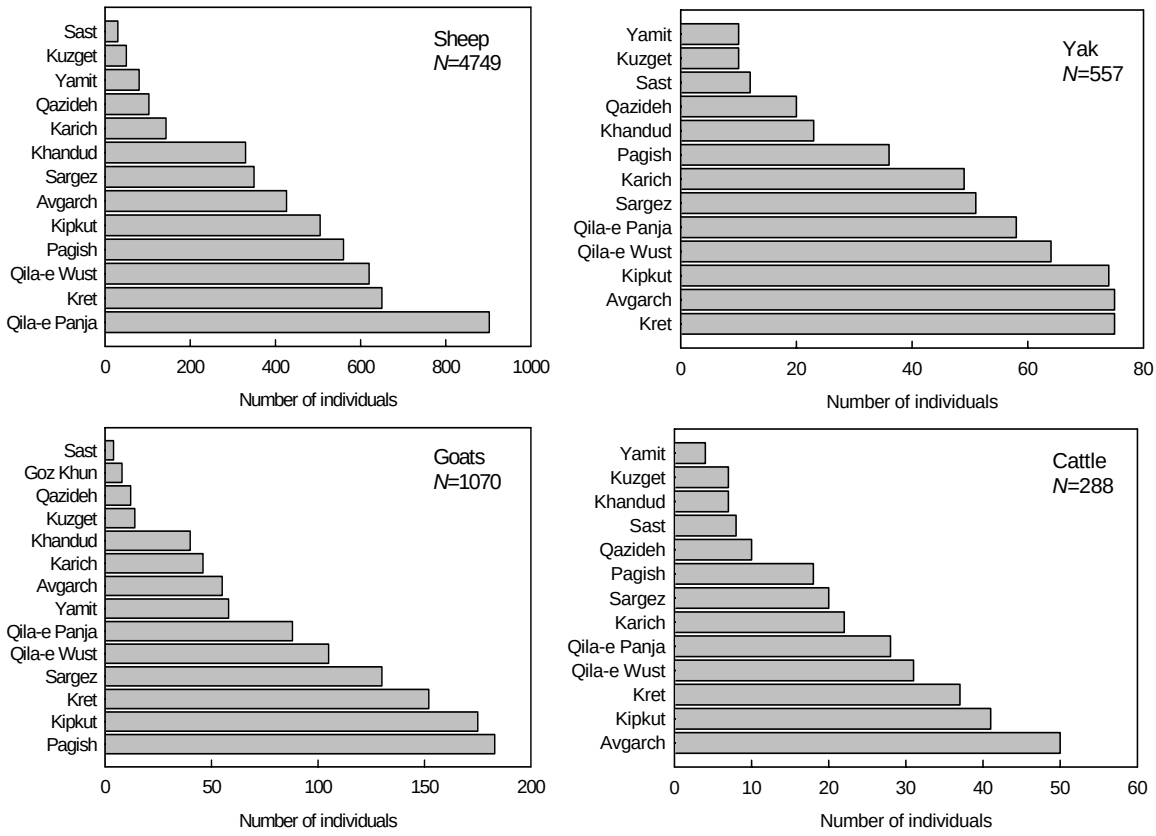

Figure 3 — Geographical origin of sheep, goats, yaks and cattle pasturing in Big Pamir in summer 2006. Origin of animals supposedly present at Asan Katich settlement is not known.

Origin

According to the data collected through the interviews, livestock pastured by Wakhi in western Big Pamir during summer 2006 originated from 14 villages: 4 were located in lower Wakhan (Qazideh, Pagish, Yamit, and Khandud), 5 in mid Wakhan (Qila-e Panja, Goz Khun, Avgarch, Qila-e Wust, and Sast), and 5 in upper Wakhan (Kipkut, Sargez, Kuzget, Kret, and Karich) (Figures 3 and 4). It seemed that transhumant livestock from villages located east of Karich and up to Sarhad-e Broghil pastured in Little Pamir. We do not know of the origin of animals supposedly tended in Asan Katich settlement in summer 2006. It is remarkable that livestock originating from as far west as Qazideh, the first village after Ishkeshim at the entrance of the Wakhan corridor, use Big Pamir during summer. It shows that the geographical isolation of livestock in Big Pamir is only relative and that the risk of disease introduction from the rest of the Badakhshan Province to the Wakhan Valley and as far east as to the Big Pamir exists. Only 22.4% of livestock that summer in Big Pamir originate from lower Wakhan (Table 4), where villages are supposedly more exposed to infectious agents from outside Wakhan. However, these herds are represented in the three pasture areas: Jermasirt (23.3%), Manjulak (3.8%), and Shikargah (72.9%). Also we did not take into account that a significant part of the 1200–1400 animals not mentioned in questionnaires but present in Big Pamir could also originate, at least partly, from owners living in lower Wakhan (Dr Duncan, pers. comm.).

Table 4 — Numbers of sheep, goats, yaks and cattle pasturing in Big Pamir in summer 2006 according to their geographic origin.

Species	Lower Wakhan[a]	Mid Wakhan[b]	Upper Wakhan[c]
Sheep	1073	1978	1698
Goat	293	260	517
Yak	89	209	259
Cattle	39	117	127
Total	1494	2564	2601

[a]Lower Wakhan = From Qazideh village to Qila-e Panja village. [b]Mid Wakhan = From Qila-e Panja village inclusive to Qila-e Wust/Sast village inclusive. [c]Upper Wakhan = From Qila-e Wust/Sast to Sarhad-e Broghil village.

We investigated the number of livestock per household. We noted a large variability in numbers of sheep and goats contributed to each settlement herd by different households, ranging from 6 to 730 animals. We found that herds coming from lower Wakhan were significantly larger than those coming from mid and upper Wakhan ($P<0.002$)[2].

Seasonal movements

Wakhi livestock operate seasonal movements (Figure 4) of which magnitude varies according to species and weather. Out of the 62 interviewed households, 24 (38.7%) acknowledged proceeding a complete transhumance of their livestock twice a year: from their village to the western Big Pamir summer pastures in spring (as early as in April) and from summer pastures to their village in autumn (usually in October). A total of 36 households (58.1%) operated only a partial autumn transhumance of their livestock, moving down to villages most of their goats, all sheep of *gadek* breed, some *turki* breed, all cows, and leaving in Big Pamir for winter the 'strongest' goats, most *turki* breed sheep, and part of their yaks and Bactrian camels. Finally 2 households (3.2%) admitted that they adjusted their livestock seasonal movements according to weather. Should winter conditions be harsh, these households would move down to villages all their livestock. We found that the largest the herd of sheep and goats and the higher the probability that the tending household proceeded a partial transhumance only ($U=221$; $P<0.001$, Mann-Whitney *U*-test). Since herds from lower Wakhan were among the largest (see previous chapter), they were also the most susceptible to perform only a partial transhumance. It is however unknown whether this was motivated by the relatively long trip necessary to bring back the animals to villages or the lack of winter grazing areas around villages for relatively large numbers of animals. During winter animals wintering in Pamir are either tended by Wakhi or by Kirghiz herders of eastern Big Pamir.

[2] The ANOVA model with Log(number of sheep and goats) as normalized dependent variable and type of transhumance practiced by each household, pasture area used by households, their origin in Wakhan, and the presence of horses in household as categorical effects was highly significant ($F_{3,56}=8.77$, $P<0.001$). Within the model the effects of origin and type of transhumance were significant ($F_{2,56}=7.18$, $P<0.002$, and $F_{1,56}=11.8$, $P<0.002$, respectively). Post-hoc Newman-Keuls multiple-range test showed that lower Wakhan herds were the largest and the most susceptible to perform only a partial transhumance in autumn ($P<0.05$)

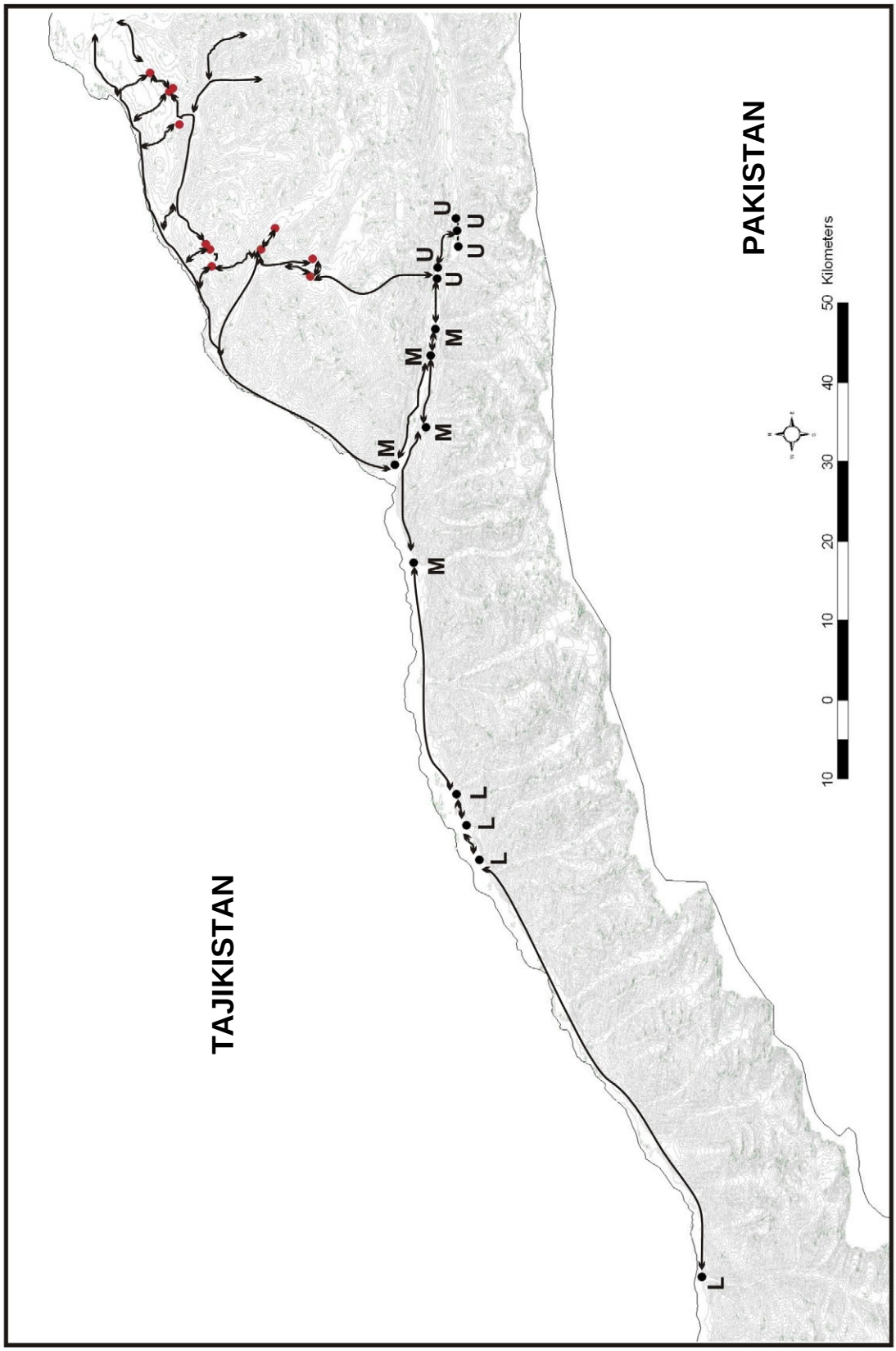

Figure 4 – Study area (2006 surveys) showing villages (black dots) of lower (L), mid (M) and upper (U) Wakhan from where some Wakhi send their livestock to Big Pamir settlements (red dots). Arrows represent transhumance routes.

Table 5 — List and sizes of Wakhi spring, summer, and winter pastures in Big Pamir.

Pasture name	Type	Status	*Perimeter (km)	*Surface (km^2)
Barjjah/Jermasirt	Spring	Provisional	30.20	15.52
Jermasirt	Summer	Confirmed	40.95	57.70
Khushabad	Summer	Provisional	10.97	6.10
Manjulak	Summer	Confirmed	27.84	32.84
Shikargah east	Summer	Confirmed	32.29	22.36
Shikargah west	Summer	Confirmed	26.31	21.96
Upper Shikargah east	Summer	Provisional	18.99	12.14
Abar Khan	Winter	Provisional	17.53	5.09
Gormatek	Winter	Confirmed	36.13	28.57
Jangal-e Guvarsh	Winter	Provisional	9.74	1.91
Lower Istimoch	Winter	Confirmed	23.22	8.46
Upper Ali Su	Winter	Provisional	9.67	3.23
Ali Su	Winter/Spring	Confirmed	60.97	29.56

Typically Kirghizes would charge Wakhi 7 kg of wheat flour per loaned yak at the beginning of winter (Ammuurdin Bakhshah, pers. comm.). Kirghizes are entitled to use the milk after female yaks calve. Another interesting symbiotic cooperation between Wakhi and Kirghizes concerns *turki* sheep. Kirghizes may rear *turki* sheep loaned to them by Wakhi from birth to 3–4 years old. Payment is made in the free use of sheep's milk and wool. Then, loaned animals are returned to Wakhi who usually sell them for meat. Offspring of these animals stay with Kirghizes, fueling a new cycle of cooperative rearing.

Spring transhumance starts usually in late May but can start as early as April depending on snow cover. Herds take between 2 and 9 days to reach spring pastures. In October, high-altitude pastures are deserted progressively according to weather and snowfalls. After the 2006 autumn transhumance, we revisited 31 (56.3%) of the 55 households we had interviewed in summer. They all came from upper and mid Wakhan villages i.e. Karich, Kret, Sargez, Kipkut, and Avgarch. We found no inconsistency in their answers about partial or complete autumn transhumances between their summer and winter interviews.

According to them, 60.7% of sheep (N_{tot}=1177; presumably all *gadek* and the weakest *turki*), 82.4% of goats (N_{tot}=420), 65.6% of yaks (N_{tot}=241), 100% of cattle (N_{tot}=168), and 86.7% of Bactrian camels (N_{tot}=15) had been brought back to villages in October. Should we extrapolate these proportions to the livestock population using Big Pamir during summer, it would mean that approximately 2330–2388 sheep, 271–292 goats, and 219–226 yaks stayed in Big Pamir for winter. One should keep in mind that the winter subset study did not include households from lower Wakhan, which we suspect to own larger proportions of *turki* breed in their herds and to rely more on Big Pamir pastures in winter (see previous chapters). Therefore our extrapolated estimate of number of sheep kept in Big Pamir is probably underestimated.

Pasture areas

We visited in summer 2006 the pasture areas indicated by herders during their interviews. If we noted livestock actively foraging in the area or found recent signs of their presence, the pasture was "confirmed". Pastures that we could not visit are referred to as "provisional".

Summer pastures

There are two provisional summer pastures located in the Shikargah and Khushabad areas and presumably used by semi free-ranging cattle and yaks (Table 5). Among confirmed summer pastures, Jermasirt is the largest with 57.7 km^2, followed by Shikargah (divided in east and west areas) with 44.2 km^2 and Manjulak with 32.8 km^2 (Table 5). We believe that our estimates of summer pasture sizes were conservatively low since we evaluated neither the range used by livestock of Kund-a-Thur and presumably Asan Katich settlements nor that used by semi free-ranging unattended livestock such as yaks and cattle. Population size estimates coupled to pasture size estimates translated to sheep and goat summer densities of 41–44, 76–79, and 31–32 heads/km^2 in Jermasirt, Manjulak, and Shikargah respectively. This density is probably overestimated in Shikargah.

Winter pastures

Winter provisional pastures are in the upper Ali Su Valley, in the Aba Khan Valley, and in the Jangal-e Gurvash area by the Pamir River (Table 5).

Jermasirt — The livestock from Jabar Khan winters in Gormatek, the one from Buqbun, Lupghil Kshun and Bulok Kshun winters in Ali Su to the notable exception of one household from Bulok Kshun which leaves livestock with Kirghizes, presumably in Tila Bai, in eastern Big Pamir.

Manjulak — The livestock from Nakchirshitk winters either in the Aba Khan Valley or in Kasilitek (locality not identified yet), animals from Tor Bulok winter in Ali Su (i.e. Garmchechma, alias hot springs), and those from Ganj Khatun winter in Shakarak (locality not identified with certainty but presumably below Ganj Khatun).

Shikargah — The livestock from Darah Big winters in Kut Hil (lower Istimoch Valley), one household from Qabal Gah leaves its sheep in Sarsin (lower Istimoch Valley) if weather allows, one household from Kund-a-Thur leaves livestock in Abar Khan, and all households from Mulung Than move back their livestock to village during winter.

Based on our sampling interviews carried out in winter, population size estimates coupled to pasture size estimates translate to an overall density of 31–32 heads/km^2 for sheep and goats in winter pastures of Big Pamir.

Spring pastures

Spring pastures are usually located near summer pastures, although always at lower altitudes. It was difficult to delimitate spring pastures and even sometimes locate them accurately. This will be a priority task when we revisit the area in spring 2007. It appears the extent of occupation of spring pastures varies according to snow cover and weather.

Left to right, top to bottom: Plate 6 — Adult female *gadek* sheep with young, Qazideh, lower Wakhan, 9 December 2006. Plate 7 — Adult *turki* sheep and goats mixed in one herd in Manjulak pasture area, Big Pamir, 7 August 2006. Plate 8 — Herders clean their sheep in the stream before shearing them, Nakchirshitk, Manjulak, Big Pamir, 7 August 2006. Plate 9 — In summer pastures, yak calves are usually tied to a rope and enclosed in an open corral during night, Jabar Khan, Jermasirt pasture area, Big Pamir, 2 August 2006. Mothers milk them twice a day. Plate 10 — Young sheep and goats are tied to a rope before the adult herd comes back to the camp, Jabar Khan, Jermasirt pasture area, Big Pamir, 2 August 2006. This measure prevents mixing of adults and youngsters and allow split-herding of livestock according to age. Plate 11 — While male yaks are still extensively used as pack animals by Wakhi from Afghanistan, this is less the case in neighboring Tajikistan. Notice in the background Tajikistan Pamir with the graded track cutting the mountain slope in two. This track allows transporting goods with motorized vehicles on average eight times faster over the same distance.

Table 7 — Average numbers of sheep, goats and yaks per age category in a selection of settlements of Big Pamir, summer 2006.

Name of pasture area	Name of settlement	Sheep		Goat		Yak	
		Ad	Subad[1]	Ad	Subad	Ad	Subad
Jermasirt	Jabar Khan	1090	415	65	68	90	46
	Buqbun / Lupghil Kshun	450	170	110	100	–	–
	Subtotal	1540	585	175	168	90	46
Manjulak	Nakchirshitk	440	209	170	68	36	18
	Subtotal (%)	440	209	170	68	36	18
Shikargah	Darah Big	235	210	50	47	19	12
	Qabal Gah	310	236	170	135	29	10
	Subtotal (%)	545	446	220	182	48	22
	Grand Total	2525	1240	565	418	130	69

Ad = adult. Subad = subadult. [1]Animals born between January and June 2006.

However, these areas are usually used for 45–70 days, before livestock is moved to summer areas. Spring and summer pastures can sometime overlap as it is the case in the areas of Barjjah and Jermasirt (Figure 5), livestock foraging at increasing altitudes as snow melts.

Jermasirt — After being joined by livestock from Wakhan, households from Jabar Khan and those but one from Buqbun pasture their livestock in Barjjah. One household from Buqbun uses Abar Khan Valley, all livestock from Lupghil Kshun use Daallan (to be identified) and those from Bulok Kshun use Qui Hil (presumably just below Bulok Kshun).

Manjulak — Animals from Nakchirshitk use in spring the areas of Kasilitek or Trilitek (locality not identified yet), those from Tor Bulok spend spring in Dachterel (upper Ali Su Valley) and those from Ganj Khatun use Gulas Ghol near Ganj Khatun.

Shikargah — Animals from Darah Big spend spring in Dost Honah and Kut Hil (mid Istimoch Valley), those from Qabal Gah pasture in Frakchakor (lower Istimoch Valley) whereas those from Mulung Than and Kund-a-Thur join directly summer settings.

Husbandry

According to interviews carried out in summer 2006, sheep were the most common livestock species in Big Pamir (4749), followed by goats (1070), yaks (557), cattle (283) and Bactrian camels (27) (Table 2). Yaks are the most precious livestock followed by sheep and goats. Cows are brought to Pamirs to provide milk. Bactrian camels are essentially owned for prestige as, unlike Kirghizes, Wakhi do not ride them. Sheep belong to two breeds: the dwarf, more or less native, *gadek* breed (body mass=16–25 kg) (Plate 6), and the large Western Asian fat-tailed sheep breed known as *turki* or *gissara* (body mass=28–55 kg) (Plate 7). With their shorter legs and thinner wool cover than *turki* sheep, *gadek* sheep are less efficient in snow and more susceptible to cold weather. Because of that, most *turki* sheep are left in Big Pamir during the whole winter while all *gadek* sheep are brought back to the villages in autumn. Small ruminant herds also include goats in variable numbers.

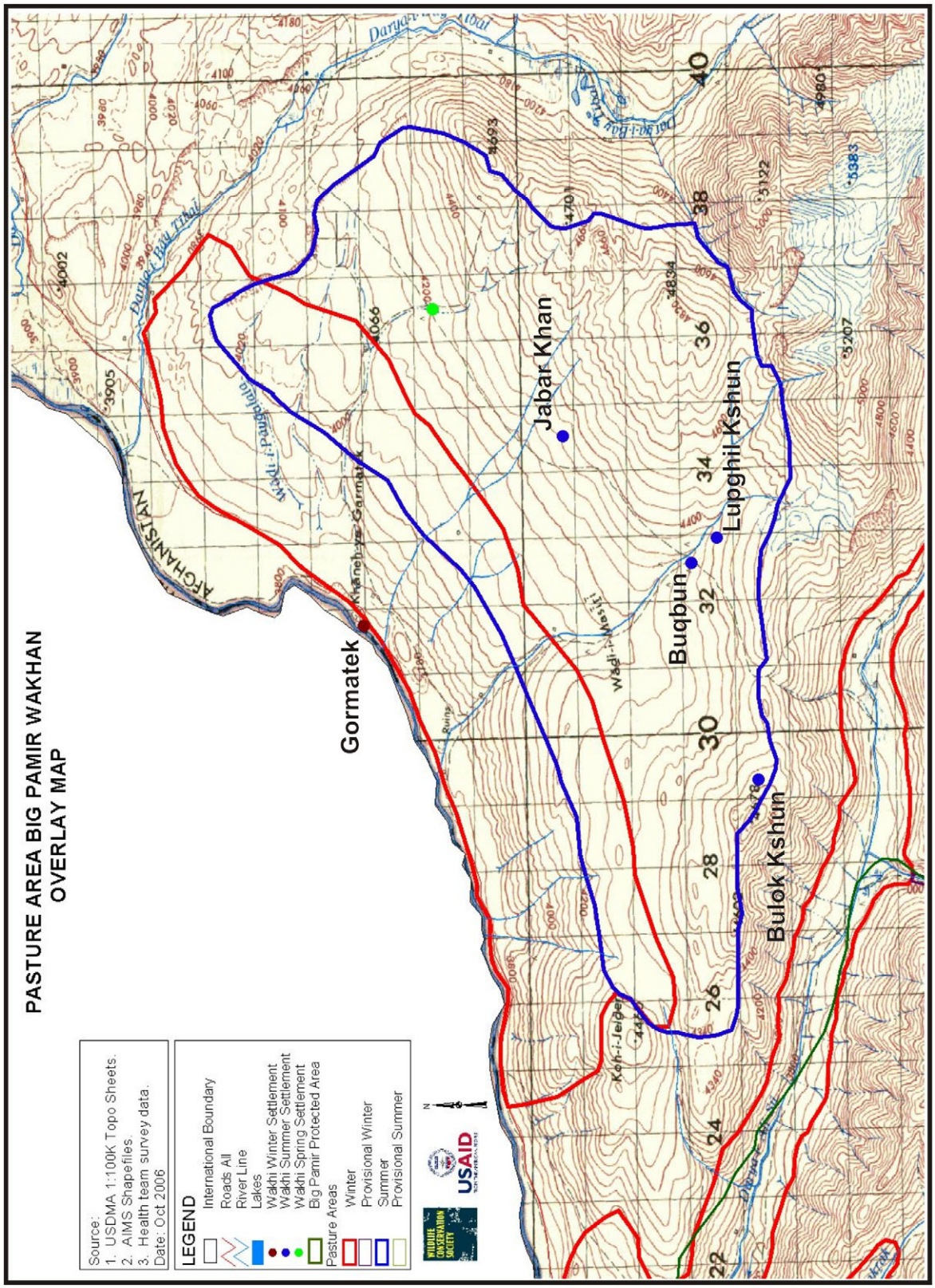

Figure 4 – Map of the Jermasirt and Barjjah pastures areas in Big Pamir.
The overlay between the two areas varies in extent according to spring forage accessibility.

In summer 2006, the sheep to goat ratio in settlements varied from 2.5/1 to 12/1. Only the strongest goats are kept in Big Pamir during winter and more than 80% of them are moved down to the villages in autumn.

Sheep and goats are sheared on average twice between spring and early autumn, an operation that requires cleaning the sheep by literally throwing them in streams (Plate 8). Cleaning and shearing are to our understanding the only mass handling activities practiced by Wakhi during summer. Cleaning may help reducing the level of ectoparasite infestation especially with *Melophagus ovinus* (sheep ked).

Births occur mainly from January to March in small ruminants. Newborn sheep and goats are left with their mothers in the settlement for the first 4–6 weeks and then join the subadult animals. In summer, age-specific split-herding of communal populations prevails in small ruminants, cattle and yaks. In each settlement animals from different households are herded together. Calves are kept in pens or around camps while adults and subadults are brought to the open range for grazing during the day (Plate 9). In summer pastures, adult to subadult ratio varied from 3:1 in sheep and yaks to around 1:1 in goats (Table 7).

During the night adult sheep and goats are maintained in corrals made of 1.5 m-high stone walls, usually located in the center of the settlements. Close to the corrals subadult animals (born in winter/spring and older than one month) are tied to long ropes grounded at both ends (Plate 10). They are guarded by dogs during the night. In summer every day around 4:00 am some ewes and goats are milked, while those with the youngest offspring are left to milk them. The group of adults leaves the settlement around 4:30 am with one shepherd and one or two dogs. They will return around 11:30 am for milking and then leave again the settlement around 13:30 to come back shortly before night at 18:30–19:00. Meanwhile subadult animals leave the settlement around 5:30, return around 11:00, leave again at 14:00 to come back around 17:00. Shepherds and dogs always attend sheep and goats during their daily moves, mainly to avoid predation by wolves. Yaks when not used for transporting pack (Plate 11) are driven out of the settlement around 7:00 am by young shepherds or children to graze freely in the upper range of pasture areas. They return back by themselves in the evening usually driven by females eager to milk their calves (Plate 12). A similar husbandry pattern is practiced for cattle. Adult and subadult cattle as well as Bactrian camels and yaks can remain in remote pastures unattended for months (Plate 13).

All cattle and 65% of yaks, mainly females, subadults and males used as pack animals during the transhumances, are moved to the villages in autumn. During winter, age-specific split-herding of communal groups disappears to the profit of an age-regrouped separate-household herding system. Small ruminants of different ages are assembled and each household attends separately its livestock except for herds with very few animals which may join a larger herd or forage more or less unattended near the village. Sheep, goats and cattle graze in the vicinity of villages (within 15 km as the crow flies) in upper Wakhan, usually on south facing mountain slopes. During our winter survey, we spotted with binoculars herds of yaks, grazing unattended for days in the upper ranges of Hindu Kush mountain chain above Avgarch/Sast, the villages they 'belonged to', at an estimated altitude of 4500 m.

Top to bottom: Plate 12 — Three female yaks wait to be milked, Jabar Khan, Jermasirt pasture, Big Pamir, 2 August 2006. Female yaks return to the camp by themselves in the evening to milk their calves and be milked by Wakhi women as well. Plate 13 — In Wakhan and Pamirs domestic Bactrian camels are often unattended during most of the year, Kret, upper Wakhan. 30 November 2006. In winter however their owners try to keep them in proximity of villages. Despite their impressive stature, isolated individuals are vulnerable to starving wolves.

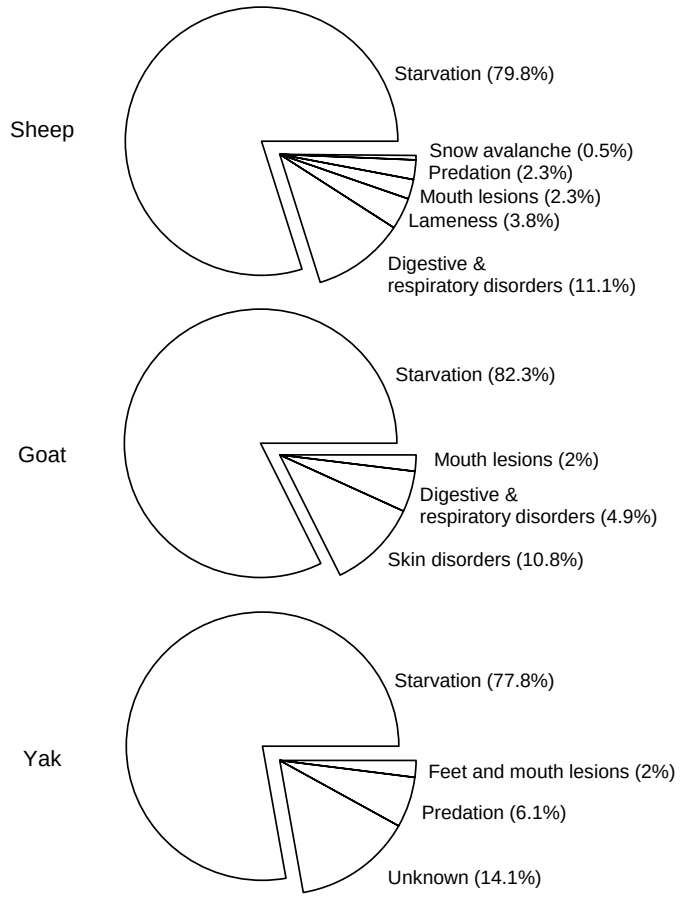

Figure 6 — Causes of death of livestock in winter. Data are compiled from questionnaire answers of 62 Wakhi households using western Big Pamir pastures during summer 2006.

Health status

Three inter-related factors play important roles in the health status of livestock in Wakhan: 1/ seasonal variability in the availability and quantity of forage, 2/ occurrence of infectious diseases, 3/ and free mixing of animals from different villages in the same pasture during summer as well as mixing within these herds of diseased and healthy individuals. We collected *c.* 471 blood samples on sheep and goats during the winter survey for serological screening. Results are pending.

Mortality

Winter mortality — Preliminary discussions with field workers of AKDN and leaders of the Wakhi community suggest that Wakhi livestock suffer significant losses during winter due to the unavailability of forage. Out of the 55 households interviewed in Big Pamir in summer 2006, only 7 (12.7%) reported no losses during preceding winter. The other lost 764 sheep, 204 goats, 99 yaks, 18 cattle and 6 Bactrian camels. Assuming a constant productivity and extrapolating summer 2006 estimates — diminished by 30% for sheep and goats and by 5% for yak, cattle and Bactrian camels to account for animals bartered, sold or

dead after summer — we estimated mortality rates of 21% for sheep, 22% for goats, 17.5% for yaks, and 7% for cattle for winter 2005–2006. Although such rates seem considerable, several community leaders pinpointed that mortality of sheep and goats wintering in Pamir may reach 100% during very harsh winters. Starvation was perceived as the primary cause of winter mortality, accounting for 79.8%, 82.3%, and 77.8% of deaths of sheep, goats and yaks respectively (Figure 6). Several sheep, goats and yaks died with lameness and mouth lesions evocating Foot and Mouth Disease. Also, some deaths imputed to starvation may have been caused by undiagnosed chronic diseases affecting body condition. Mortality due to predation accounted for 2.6% of total losses: 18 sheep killed by a snow leopard in Karich; six yaks, and two Bactrian camels killed by wolves. All animals predated by wolves were unattended (Plate 13).

Spring mortality — Mortality during spring 2006 was dominated by abortions and digestive tract disorders. Forty-five households (80.4%) reported abortions. Overall a minimum of 90 sheep, 80 goats, 32 yaks, and 5 cows aborted in spring 2006. Following the assumptions we used to estimate winter mortality rates, spring abortion would affect 3.1%, 11.1%, 6.8%, and 2.1% of sheep, goat, yak, and cattle populations, respectively. A total of 75 sheep, 5 goats, and 4 yaks died with digestive tract disorders such as severe diarrhea and tympani.

Summer mortality — Mortality level was lower in summer than in winter and spring. However our 55 interviews were done in mid summer (July–August) and therefore underestimate the overall summer mortality. Respondents reported 9 sheep, 3 goat and 7 yak deaths. Three adult sheep, 5 lambs, 2 adult goats, 1 kid, 4 subadult yaks, and 1 adult yak died with severe diarrhea, one sheep was preyed by a wolf, one yak died with anorexia and another one of overloading. Three sheep aborted and one adult yak was injured by wolves but recovered. Winter interviews of 38 households provide more complete estimates of summer mortality. Within this cohort 35 sheep, 7 goats and 5 yaks died, translating to summer mortality rates of 2.9%, 1.7%, and 2.1% for sheep, goats, and yaks, respectively. No abortions were reported during summer in the interviewed cohort. Three sheep and one yak were killed by wolves.

Autumn mortality — Autumn is a period of transhumance and reacclimation to valley settlements. According to the 38 interviews carried out in winter 2006, 5 subadult and 2 adult sheep, as well as 1 subadult and 1 adult goat, died during the autumn transhumance. Subadult sheep died of severe diarrhea (2), coldness (2), or trauma from a falling stone (1). The two adults died of unknown causes. The subadult goat died of unknown cause whereas the adult, an old animal, died of coldness. According to these figures, transhumance mortality rates were of 1% for sheep, 0.6% for goats and 0% for cattle and yaks. Finally, 8 sheep, 1 cow and 1 yak died after returning to villages. No abortions were reported in autumn.

Overall annual mortality rate and economic loss — Annual mortality rate in livestock was difficult to estimate. As we interviewed only a subset of the study population in December 2006, our knowledge of the number of deaths between midsummer 2006 and December 2006 is incomplete. Nevertheless, considering that our sampling was representative, we extrapolated collected data to the whole livestock population using Big Pamir.

Clockwise from top left: Plate 14 — A feverish subadult sheep showing besides its dry cough a mucopurulent discharge encrusting nostrils, and swollen eyelids, Nakchirshitk, Manjulak pasture, Big Pamir, 7 August 2006. Plate 15 — A feverish cow shows clinical symptoms evocative of Foot and Mouth Disease, Karich, upper Wakhan, 2 December 2006. Before displaying excessive salivation (insert) the animal presented an episode of lameness on a front leg involving interdigital lesion. Within the last week all cows in the village presented similar symptoms. Plate 16 — A verrucose mass proliferating underneath a large scab at the corner of mouth in a subadult goat, Nakchirshitk, Manjulak pasture, 7 August 2006. Such lesion is typical of contagious ecthyma, a poxvirus infection encountered worldwide in sheep and goats.

We estimate that the studied Wakhi population lost around 925–950 sheep, 220–250 goats, 120–130 yaks, 18–25 cattle and 6–10 Bactrian camels between December 2005 and December 2006. We did not include in these figures aborted neonates and stillbirths. Given an average cost of 55 US$ per sheep and goat, 300 US$ and 200 US$ per yak and cattle head, respectively and 400 US$ per camel, the annual economic loss due to livestock deaths ranged between 104,975 and 114,000 $US. That figure would probably reach 125,000 $US, should we include equid mortality and revenue shortfalls as the result of abortions.

Infectious diseases

Gastrointestinal disorders — Sheep and goats were significantly affected by gastro-enteric disorders. The causes of diarrheic events are unknown, but they occur most often in spring when animals access newly grown vegetation. This pattern suggests *Clostridium perfringens*

enterotoxemias. However, adult and subadult small ruminants also die of diarrheic disorders later in spring and in summer, which evocates other infectious agents. Heavy stocking densities, overgrazing, crowded night housing and inexistent sanitary management could favor outbreaks of coccidiosis or cryptosporidiosis in lambs. Infections with *Salmonella* can cause diarrhea in small ruminants of all ages. Bluetongue orbivirus can also be responsible for diarrheic events in sheep but we are not sure that *Culicoides* vectors of the disease exist at the altitude of summer pastures. Peste des Petits Ruminants (PPR) morbillivirus may be present in the small ruminant population of Big Pamir as suggested by AKDN veterinarians based in Ishkeshim. They reported of past episodes of nasal discharge and profuse diarrheas associated with severe salivation, a possible result of necrotic stomatitis, and a common symptom of PPR. However we did not note clinical symptoms evocative of a recent exposure to PPR morbillivirus during our surveys.

Respiratory disorders — During our summer investigations, we estimated the prevalence of respiratory disorders in small ruminants at 5–15% in adults and 35–60% in subadults. The recorded clinical symptoms included sporadic coughs, dyspnea, and most often mucopurulent nasal discharge (Plate 14). Respiratory disorders seemed to frequently become chronic. We did not observe severe respiratory disorders such as acute pneumonias and pleurisy, two commons symptoms in acute forms of contagious caprine pleuropneumonia (CCPP) or pasteurellosis. It was difficult to figure out from the interviews whether these respiratory disorders translated into a significant mortality, particularly among young animals.

Abortions — According to the interviews, the peak of abortions in small ruminants is observed at the beginning of spring. However, it was difficult to know whether it is concomitant to the peak of parturitions. The expected poor body condition of females at the end of winter must certainly predispose them to abortions at this period of the year. However many infectious agents such as Foot and Mouth Disease picornavirus, *Brucella* spp., *Coxiella burnetii*, *Toxoplasma gondii*, and *Chlamydiophila* spp., can also be causative. Exposure to these agents will have to be investigated with serological screening.

Foot and Mouth Disease (FMD) — According to the interviewed Wakhi, FMD is a relatively new disease in Wakhan Valley and Pamirs. Seemingly the disease appeared in their livestock between 1992 and 1995 when large herds of small ruminants originating from Panshir and Badakhshan started using the Wakhan corridor to reach livestock markets of northern Pakistan. Kabul, the secular marketing outlet for this livestock, was no longer accessible, destroyed by interethnic wars of succession. Contaminated herds moving through the corridor arguably have spread the disease among Wakhi livestock. From an historical point of view, the story is believable since Wakhan and Pamirs were renowned for centuries as livestock production areas where non-native domestic animals were seldom introduced (Dr Farman Ali, AKDN, pers. comm.). However from an epidemiological point of view this is a more questionable theory since FMD has been endemic for a long time in neighboring areas of Pakistan, Afghanistan and Tajikistan. During our summer visit we observed on several occasions lame sheep and yaks in pastures with interdigital or coronal foot lesions that could have resulted from initial lesions of FMD. Yet, we did not record

typical febrile cases with mouth vesicles in cattle, yaks or small ruminants. Wakhi and Kirghizes report in unison about regular outbreaks of a disease that affects the feet and mouth of their sheep, goats, cattle, yaks, and Bactrian camel simultaneously. Horses and donkeys are not affected. During our winter survey, we noticed in Karich village in the upper Wakhan, cattle presenting dullness, inappetence, fever (39.2°C), lameness of one or two feet and intense salivation (Plate 15). Examination of feet and mouth revealed ulcers between claws and in the oral cavity. However we did not see vesicles or blisters. The disease was highly contagious since it could affect 100% of the cattle of the village within 5 days. We collected mouth swabs and results of laboratory investigations are pending.

Contagious ecthyma (Orf) — A very common infection in juveniles of both sheep and goats was contagious ecthyma. This infectious dermatitis, caused by a Parapoxvirus, affects primarily lips of young animals (Plates 16 and 17). In settlement such as Jabar Khan (Jermasirt) it affected 10 to 15% of lambs and kids. Some of the lambs could not eat normally and were emaciated. Lip lesions were often surinfected. We also recorded one case of scrotal lesion on a subadult goat. Herders confirmed the disease was common on young animals, which sometimes die of starvation but most often recover uneventfully.

Keratoconjunctivitis — During our winter survey, we observed sporadic cases of keratoconjunctivitis in adult goats in upper Wakhan villages (Plate 18). According to the interviews, the disease affects mainly goats and to a lesser extent sheep, after autumn transhumance. Wakhi believe disease outbreaks are linked to livestock consuming a specific plant. Locally called *kurkamal*, it only grows at lower altitudes in the Wakhan Valley. Unfortunately we could not collect any specimen when we visited the concerned villages in early December 2006. Clinical examination of 7 cases revealed the disease always affects both eyes but usually not to the same extent. Presumably one eye is affected before the other. Clinically the disease starts as a mild conjunctivitis seemingly evolving from the internal canthus. Soon cornea is opacified by a faint haze which is due to edema and possibly cellular infiltration. The lesion progresses preferentially from the limbus towards the center presumably as an inflammatory response to an external aggression. Bilateral keratoconjunctivitis precludes trauma as a possible origin. At the initial stage of the disease we did not observe any signs of anterior uveitis. Retina and its visible vascularization showed no lesions. At a later stage, complete corneal opacification made it difficult to see internal parts of the eyes. We did not see a progress of the disease towards corneal ulceration, but saw varying degrees of lacrimation. Apparently animals do not present symptoms of systemic infection during the disease. They start losing condition when they become blind and cannot find forage. Some animals recover spontaneously whereas others die of starvation or after a fatal fall in the mountain. We do not know of plant intoxication causing keratoconjunctivitis in ruminants. Also a group of Kirghizes from Big Pamir whom we met in winter mentioned that a similar disease affects their yaks in altitude pastures where *kurkamal* does not occur. However irritants such as pollens, grasses or thorny plants may predispose to or aggravate such disease. In 2007, we will investigate about the origin of the disease which affects many yaks in Pamirs. Among known pathogens that can be responsible of keratoconjunctivitis in cattle, *Moraxella bovis* is the commonest. Infectious bovine rhinotracheitis (IBR) virus and *Mycoplasma* spp. can also

produce transient corneal opacification and conjunctivitis. In sheep and goats rickettsiae and *Mycoplasma conjunctivae* have also been associated with keratoconjunctivitis. Infection with *M. conjunctivae* causes temporary blindness. It has been recorded in domestic livestock worldwide (Jones, 1991) and in wild ruminants in Europe and North America (Tschopp et al., 2005; Jansen et al., 2006). When associated with *Moraxella ovis* the disease can increase in severity (Dagnall, 1994).

Mastitis — We saw sporadic cases of severe mastitis in sheep and goats in Big Pamir. Incidence could be diminished by improving milking hygiene and sanitation of settlements.

Parasites

Endoparasistes — In Big Pamir, we collected feces samples from sheep, goats and yaks and stored them in 4% formalin. We will carry out coproscopies of these samples in spring 2007. Field examination of sheep droppings revealed the presence of tapeworm bell-shaped proglottids in fresh feces. These proglottids were most commonly found in subadult animals. Examination of the digestive tract of five healthy subadult sheep slaughtered for meat confirmed the presence of tapeworm in the duodenum of all individuals. We found no nematodes in their digestive tract and no trematodes in their livers. Subsequently the parasitology laboratory of the Royal Veterinary College, London, UK, identified the anoplocephalid tapeworms as *Moniezia* spp. (possibly *benedeni*). *Moniezia* is recognized as a relatively nonpathogenic organism in sheep although heavy infestation such as that observed in subadult sheep of Pamir may result in mild unthriftiness and digestive disturbances. The absence of nematode and trematode in the five slaughtered animals is nevertheless remarkable. A larger sample size including adult sheep and goats is still required to confirm the low exposure of small ruminants to these parasites in Big Pamir.

Ectoparasites — The sheep ked (*Melophagus ovinus*) is one of the most widely distributed external parasites of sheep. We found adult specimens in all the 26 sheep examined in Big Pamir, sometimes in heavy infestations (>50 specimens/animal). Surprisingly, 3 sheep examined in the village of Goz Khun during summer did not have the parasite. The high infestation rate found in sheep of Pamirs may be related to the rapid spread of the parasite when animals are densely assembled during the night. The skin irritation created by the parasite causes sheep to rub and bite themselves. The fleece becomes thin, ragged and dirty, while wool can be permanently discolored in patches. Although *Melophagus ovinus* spends its entire life on its host, we did not find any in the sheep from Big Pamir we examined in December. On the other hand, sheep, cows and yaks were often heavily infested with ticks in winter. We still need to confirm their identification but they belonged to the family Argasidae or soft ticks, which typically live in crevices for weeks or months and emerge briefly to feed when their hosts pass near their microhabitat. Argasidae are polyhostal, that is feeding and dropping to the substrate to molt between different developmental stages nad then infesting another host. Because of that, we believe that Argasidae infestation is rare in summer in mobile hosts such as livestock in Big Pamir. This could perhaps explain the absence of ticks in the sheep we examined in Pamir. Many Argasidae-transmitted salivary toxins or arboviruses cause irritation or febrile illnesses in man. Wakhi always feared to touch the ticks and knew they could kill their livestock.

Clockwise from top left: Plate 17 — Widespread skin lesions developing on the muzzle, mucopurulent nasal discharge and lacrimation, evocate a *Capripoxvirus* infection in this young sheep, Nakchirshitk, Manjulak pasture, 7 August 2006. Plate 18 — Keratoconjuctivitis accompanied of mild lacrimation and blepharospasm in an adult goat, Kret, upper Wakhan, 2 December 2006. Plate 19 (general view and close-up) - Areas of alopecia with mild hyperkeratosis and scratching lesions (close-up) affect the back, trunk, and neck of an adult sheep, Qazideh, lower Wakhan, 9 December 2006. Such very pruritic lesions developing on woolly areas of sheep during winter are typical of psoroptic scabies.

During summer we also noticed outbreaks of *Tabanus* horseflies infesting livestock, horses, donkeys, and man. Horseflies cause painful wound and a significant blood loss when many of them feed on an animal for several hours a day during summer. Reputedly they can carry several pathogens on their mouth parts and body, including *Bacillus anthracis*, *Anaplasma* spp., and *Francisella tularensis*. In winter we observed cases of psoroptic scabies (*Psoroptes ovis*) infestation in three sheep in lower Wakhan. The acaria parasite affected the woolly parts of their body. They were biting and scratching themselves as a result of intense itching, presented large areas of alopecia with scaly lesions and were emaciated (Plate 19). We heard of similar symptoms developed by goats in winter pastures of Pamir. Affected goats usually die of emaciation and coldness before spring. Although we have not recorded such cases, Wakhi shepherds reported to us that genital and udder myiasis in sheep and

sometimes cattle and yak is relatively common during spring and early summer. We will further explore the occurrence of screwworms in 2007.

Population mixing

A striking observation we made during our surveys was the total absence of split-herding practice between sick and healthy animals. For example, sick females were sometimes milked before healthy ones, a practice that favors indirect transmission of pathogens.

Given that livestock is assembled in dense herds during the night, a strict isolation (quarantine) of sick animals would decrease the risk of disease transmission within the herd. At least, unhealthy animals should be excluded from transhumance. After transhumance, split-herding should also be maintained for several weeks between animals wintering in Pamir and those joining them in spring, in case some of them develop subclinical disease because of transhumance stress. Improvement of livestock health status in the region would also need an array of methods more sophisticated than simple split-herding, since most infectious diseases in Wakhi livestock populations have become endemic. In summer pastures clinically healthy adults live in direct contact with the younger subpopulation affected by an array of respiratory and gastrointestinal disorders. This supports the theory of adult population playing the role of pathogen reservoir for juveniles, and creating an irreversible situation of endemism. One way of improving the health status of livestock population would be to detect and eliminate adult reservoir individuals. Such work would only be relevant if carried out at a regional level since in summer pastures, herds from different villages in Wakhan are typically mixed.

Data on equids

Introduction

Wakhi keep a population of horses and donkeys in Big Pamir during summer which they ride or use as pack animals. Like yaks, equids and especially horses are a mark of prestige and thriving households may own several of them (Plate 20). Horses are expensive, costing 15,000 to 20,000 Afghanis (around 300–400 $US) each, and are often traded or sold to Kirghizes.

Equids are deeply enrooted in the way of life of human communities living in this remote mountain range. As such, they will be directly concerned by any resource development project in the area such as ecotourism or mountaineering. Indeed, both horses and donkeys are invaluable for transporting equipment, mountain gear and people during summer in steep terrains of Pamirs. While donkeys can bear heavier loads relatively to their body mass, horses have the advantage of being taller when surging streams are to be crossed (Plate 21).

Numbers and origins

Out of 62 Wakhi households who used Big Pamir during summer, 33 (53.2%) owned no horses, 16 (25.8%) had one horse, 5 (8.1%) had two horses, 4 (6.4%) had three horses and 4 (6.4%) possessed four horses (median=0). Overall 29 (46.8%) households owned together 58 horses. Forty-five horses were maintained in Big Pamir, either near settlements (N=26) or in Ali Su pasture area (N=19), and 13 were left in villages.

Table 6 — Geographical origin of equids owned by Wakhi land users in Big Pamir in summer 2006.

Origin	Horse	Donkey	Number of households without horses
Lower Wakhan	21	20	0/6
Mid Wakhan	23	65	11/24
Upper Wakhan	14	80	22/32
Total	58	165	33/62

[a]Lower Wakhan = From Qazideh village to Qila-e Panja village. [b]Mid Wakhan = From Qila-e Panja village inclusive to Qila-e Wust/Sast village inclusive. [c]Upper Wakhan = From Qila-e Wust/Sast to Sarhad-e Broghil village.

All but two households of Big Pamir owned donkeys. Sixty households owned 165 donkeys distributed: 12 households (19.3%) had one donkey, 17 (27.4%) had two, 14 (22.6%) had three, 11 (17.7%) had four, four (6.4%) had five, one (1.6%) had six, and one (1.6%) had seven (median=3). Analysis of equid ownership confirmed that only the most prosperous households own horses. In Big Pamir the six households from lower Wakhan villages, who are notoriously among the wealthiest in Wakhan (Dr Farman Ali, AKDN, pers. comm.), owned 36.2% of the horse population even though they represented only 9.7% of Big Pamir Wakhi users. When comparing number of households without horses according to their geographical origin, lower Wakhan families appeared again as the richest in term of the number of horses owned (G-test applied to contingency table, $G=6.4$, $df=2$, $P<0.05$) (Table 6).

Seasonal uses and husbandry

Horses and donkeys are mostly used during spring and summer as pack animals. Typically horses can carry loads of 35–65 kg for 5–7 hours a day compared to 25–35 kg for donkeys (Plate 22). After work, horses are attached and left to rest for at least 5 hours before being offered food and water. Donkeys are fed and watered as soon as unpacked. When not of use during summer, equids are left to pasture around pasture settlements or for some of them such as horses from Jermasirt, left unattended in Ali Su pasture area.

In winter equids, which are susceptible to cold weather, always return to the villages in the valley, following livestock autumn transhumance. During winter Wakhi use their horses to ride from one village to another or for longer trips outside Wakhan. When they are not of use, they are mainly stall-fed or left to forage around villages, usually in small groups. Equids are enclosed during the night to avoid predation by wolves.

Health status and mortality

Health status

When questioned about diseases affecting their horses and donkeys, Wakhi generally acknowledged that both species are very resilient to diseases and seldom die of disease outbreaks.

Counterclockwise starting top left: Plate 20 — Young Wakhi on their way back to Goz Khun, Big Pamir, 26 July 2006. Plate 21 — Our pack donkeys cross Bai Tibat stream under supervision of Wakhi guides, Big Pamir, 30 July 2006. Crossing surging streams in summer is always a risky operation especially for donkeys which have to be unpacked. Plate 22 — A horse is laid down on the ground to ease removal of equipment drums, Jangal-e Gurvash, Big Pamir, 26 July 2006. Typically horses used in Big Pamir carry loads of 35–65 kg for 5–7 hours a day.

Only one infection seems to kill them sporadically. Outbreaks usually happen in winter, in their own words "*blood vessels in the nose become large, then the animal loses blood and water from the nose and die after several days to weeks*". We believe this is a fairly accurate description of an acute case of glanders. This contagious, sometimes chronic but usually fatal disease of equidae is caused by *Burkholderia mallei* bacteria and characterized by serial development of ulcerating nodules that occur chiefly in the upper respiratory tract, lungs, and skin. Acute form of glanders is more frequently reported in donkeys than horses and present few pathognomonic features, but most infected animals show a tenacious, unilateral, hemorrhagic, mucopurulent nasal discharge, and obvious ulceration of the nasal mucosa. Glanders has been eradicated from large areas of the world, but is still endemic in parts of Asia and the Middle East. The disease has been known for centuries; its severity and zoonotic nature have resulted in an almost universal fear of it (Knottenbelt and Pascoe, 1994). The disease is known to occur in the Badakhshan Province and a veterinarian for AKDN reported to us that it is endemic in the Ishkeshim/Zebak area. It is however unknown to which degree the disease affects equid populations of Wakhi, as horses with chronic form of the disease often appear to be remarkably well with only a discrete nasal discharge of benign appearance.

Mortality

Interviewed households reported the loss of 19 donkeys (11.5%) and 4 horses (6.9%) between winter 2005–2006 and mid summer 2006. All deaths occurred during winter. Five donkeys presented symptoms evocative of glanders (i.e. nasal discharge, pneumonia, skin abscesses), while 13 died in poor body condition and one donkey was killed by wolves. Also three horses died in poor body condition and one was killed by wolves. Poor body condition can result from undernutrition or undercurrent diseases such as chronic forms of glanders.

DISCUSSION

Validity of presented results

The bulk of the data we have presented in this report comes from interviews. One may legitimately question their validity. Respondents may lack accuracy in their answers, involuntarily provide biased information, or even distort the facts on purpose. Whenever possible we tried to cross-match the information they provided to us by repeating interviews several months apart, or by assessing objectively the reality on the ground (see 'Sensitivity test for livestock estimates). For example we believe that livestock number estimates based on our direct counts (coefficients of variation of estimates < 5%) as well as equid number estimates based on duplicate interviews (in summer and winter) and direct counts, constitute solid data. So are transhumance choices (complete vs. partial) by different households based on duplicate interviews, husbandry practices recorded *in situ*, composition of settlements as well as location of pasture areas visited during summer, and origin of households and their livestock double- or triple-checked during interview sessions. Geographical extent of summer pastures and timing of transhumance are probably less accurate. In particular we believe the extent of summer pastures, based on

presence/absence indications, could be increased by as much as 15% beyond what Wakhi land users told us. We were not able to check the geographical extent of winter and spring pastures on the ground and plan to explore the subject in the future. Asan Katich will have to be located and visited in the future to accurately document number and range use of livestock herded in surrounding pastures. We also need to further study causes of deaths in livestock. For example several animals which supposedly died of starvation during winter could have died of chronic diseases resulting in a loss of body condition. In a herd endemically infected with Foot and Mouth Disease it is difficult even for expert eyes to discriminate the primary cause of death of infected animals concomitantly exposed to food shortage. Obviously energetic deficit would probably play an exacerbating role in most diseases through an immunodepressing effect. Still concerning mortalities, it is possible that our figures are underestimated. Some losses could have been forgotten, miscounted (when herds of different origins are assembled in spring/summer pastures), or overlooked, unnoticed abortions for example. It will also be worth studying deaths related to carnivore predations, particularly those related to wolf predation of unattended animals. Indeed in several cases it was not clear whether animals found eaten by wolves had been effectively killed by this predator or only scavenged. We plan to carry out more work in the Wakhi and Kirghize communities pasturing their domestic animals in Little and Big Pamirs in 2007. They will hopefully bring some clarifications to all these questions.

Wakhi pastoralism in Big Pamir

Our 2006 surveys aimed at identifying Wakhi populations pasturing their domestic animals in Big Pamir. Only a minority of Wakhi are transhumance herders using the surrounding Pamir Mountains for seasonal or permanent grazing of their livestock. They can be categorized as strict pastoralists or agropastoralists. Only a few Wakhi are strict pastoralists depending entirely on self-regenerating and self-maintaining range resources throughout the year and very little if at all on fodder for livestock supplementation during winter. We believe they are mostly from upper Wakhan where land is in place of little value to grow crops. A larger number of transhumance herders are in fact agropastoralists. In winter, they feed their *gadek* sheep and to some extent their goats, with fodder from agricultural farms owned by their families or by tenant farmers in the irrigated tract of Wakhan. The croplands provide food security for both the livestock and their owners. The importance of crops and fodder for this category of livestock owners varies according to their dependence level on free grazing in Wakhan and the need to support livestock in winter. In spring when sufficient forage becomes available, *gadek* sheep, goats, cattle, yaks and Bactrian camels are moved to Pamir pastures for grazing. Agropastoralists are relatively wealthier that strict pastoralists. They are sometimes commissioned by other families, to tend their livestock in Pamirs (John Mock, pers. comm.). Our analyses showed that the wealthiest households using Big Pamir originate from lower Wakhan. They are few but possess the largest herds of sheep and goats and several horses. They tend to keep most of their livestock in Pamir during winter, a practice that appears, despite the risk of heavy losses when winters are particularly harsh, to profit their wealth on the long term. Finally, the vast majority of Wakhi, especially those living in lower Wakhan, are now sedentary farmers. They live in permanent settlements of Wakhan, often in the lower part working as

tenant or small farmers. Their livestock, if any, comprises a few *gadek* sheep, goats and one or two cows. They are mainly stall-fed, only use surrounding areas for grazing and are brought back to the settlements in the evening. The feed resources comprise a variable proportion of crop residue, fodders and peri-irrigation grazing areas. Due to the competition from the transhumant livestock, feed supply may be constrained during winter.

We believe we have identified the majority of Wakhi pastoralists and agropastoralists in Big Pamir in 2006. They only used the western part of the Big Pamir and were regrouped in 62 households, probably representing less than 5% of the c. 11,500 Wakhi inhabitants of the Wakhan District (Dr Shams, AKDN, pers. comm.). However, our livestock counts suggest that they owned approximately 60% of sheep and 36% of goats reported in Wakhan (FAO, 2003). As such they are, with Kirghizes of eastern Big Pamir, the primary land users of the Big Pamir range. In the perspective of the establishment of a protected area in Big Pamir they should legitimately be involved in the planning process of the reserve.

Risk of interspecies disease transmission

Horizontal interspecies transmission is a central mechanism in the emergence of diseases in wild living populations (Lafferty and Gerber, 2002). The probability for a pathogen to cross the species barrier from a 'source' to a 'receptor' species depends on its prevalence in the 'source' species, on the susceptibility of the 'receptor' species and on the rate of efficient contacts between the two species (Richomme et al., 2006). Our investigations intend to document the prevalence in livestock of Pamirs of several pathogens to whom wild ungulates might be susceptible. Foot and Mouth Disease, contagious ecthyma, scabies, and possibly infectious keratoconjunctivitis are for example potentially dangerous diseases for wild Caprinae. Their presence in livestock using Big Pamir suggests that the risk of domestic to wild animal transmission exists. Results of serological screening of blood samples collected in livestock in December 2006 will hopefully clarify that issue. Disease susceptibility of Marco Polo sheep (*Ovis ammon polii*) is still unclear but solid data have been collected and published on genetically-close non-domestic Ovinae and Caprinae species. They could probably be used to predict which pathogens are susceptible to be dangerous for the Marco Polo sheep.

We interviewed the shepherds and elders of 62 Wakhi households pasturing their livestock in Big Pamir in summer 2006. We asked them about the possibility of direct contacts between their livestock and Marco Polo sheep; i.e. observations of a Marco Polo sheep and a domestic animal within a 100-m horizontal distance. We chose 100 m as most infectious agents nebulized into a wind tunnel will not remain viable after a distance of 50–100 m (Dixon et al., 2002). None of the respondents had made such observations. Nowadays Marco Polo sheep are shy of men and dogs and do not approach tended herds closer than several hundred meters. Such avoidance behavior is probably linked to a significant level of persecution and may also suggest a decreasing number of Marco Polo sheep in Big Pamir. We can tentatively assume that currently in Big Pamir the risk of spillover of infectious agents from livestock to wild ungulate by direct contact is reduced. However, six (9.6%) of the 62 household elders mentioned that they spotted occasionally Marco Polo sheep in summer pastures although not in closeness of their livestock.

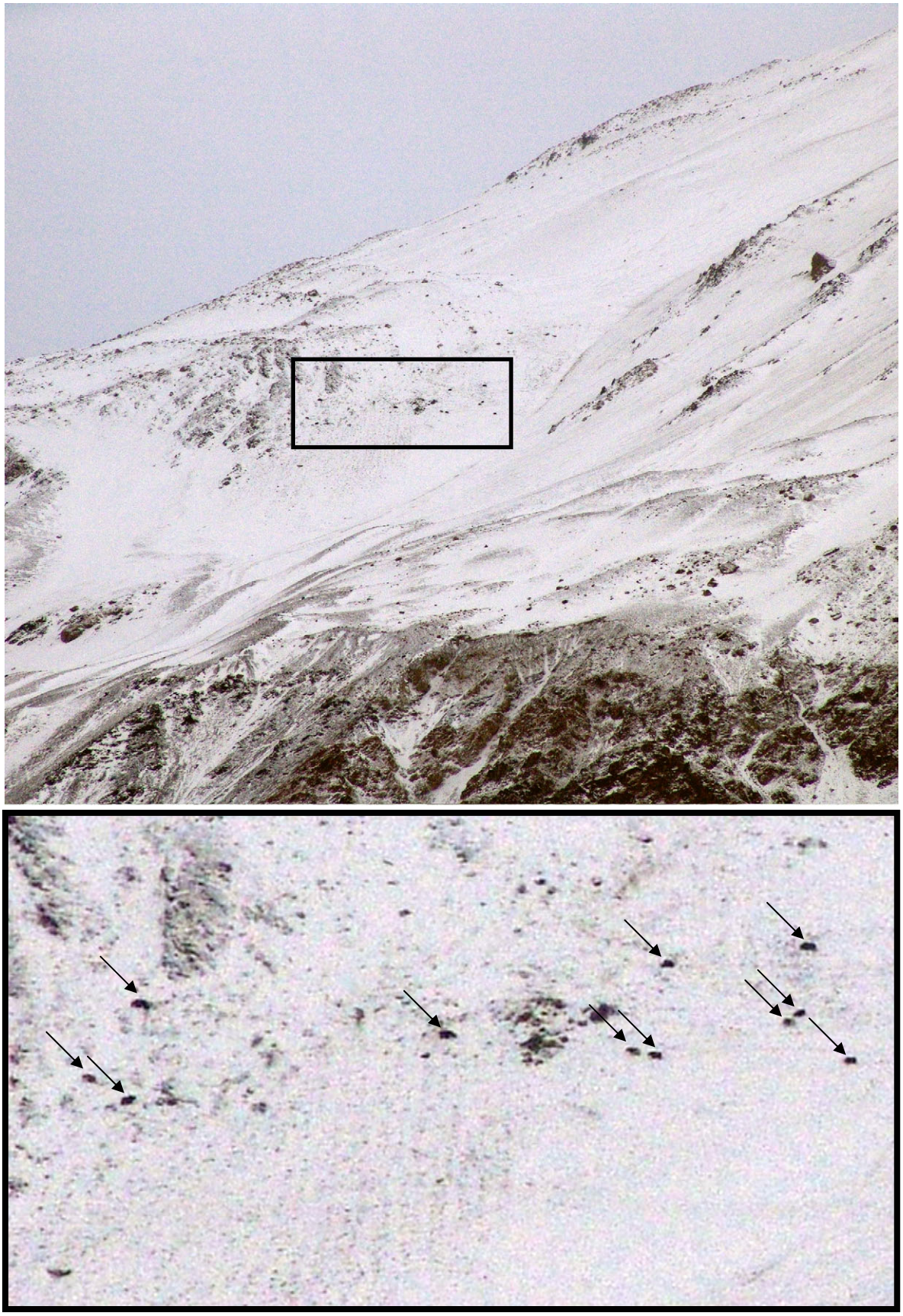

Plate 23 (general view and close-up) — Eleven adult yaks (arrows) left unattended during winter in high altitude mountain range, above Avgarch/Sast villages, Hindu Kush Mountain range, 3 December 2006.

WCS Biodiversity team watched the same situation in Nakchirshitk and Kund-a-Thur valleys during summer. Wild ungulates may therefore be exposed to livestock pathogens by indirect contacts. For example, tapeworms or contagious ecthyma poxvirus, which can survive in the environment, may be a threat, likewise a number of pathogens such as *Mycoplasma* spp. which can survive on mouth parts of vector insects. Finally disease spillover may occur from cattle, yaks and Bactrian camels which are often left untended in high altitude pastures (Plate 23). For example, subadult cattle and yaks are often left unattended in Shikargah pasture where Marco Polo sheep has been recorded. It belongs to the former Marco Polo sheep hunting reserve of king Zaheer Shah and was part of the Marco Polo sheep range (Petocz, 1973; Petocz et al., 1978). We don't know for sure whether Marco Polo sheep inhabit these altitude pastures but WCS Biodiversity team's first investigations suggest they do. We also plan to fit GPS collars on some unattended livestock pasturing in Shikargah in 2007 to document their movements and range use. This would help clarifying the risk of disease transmission by direct contact from unattended livestock to Marco Polo sheep.

Losses of domestic animals due to predation

In mountains of Central Asia, extensive livestock herding is often the major source of revenue for pastoralist populations (Schaller, 1998). These areas are also home to large carnivores such as snow leopard (*Uncia uncia*) and wolf (*Canis lupus*). The level of livestock predation by these carnivores is important to assess as retaliatory persecutions are one of the most widespread and direct threats to these carnivore species (Jackson and Wangchuk, 2001). Fitzherbert and Mishra (2003) have shown that the nature of human-wild carnivore conflict in the Wakhan Corridor is similar to what is observed in other parts of the snow leopard's range. These authors suggest that the levels of predation by these large carnivores are substantial. They quote studies estimating the annual losses at an average of 2 to almost 5 heads of livestock per family (Oli et al., 1994; Mishra; 1997; Jackson and Wangchuk, 2001). Our investigations however suggest much lower levels of predation in Wakhan. According to the interviews we carried out, between December 2005 and August 2006 18 sheep from a unique herd were predated by a snow leopard during winter, while 2 Bactrian camels, 7 yaks, 3 sheep, 1 horse, 1 donkey and 2 dogs were killed by wolves (Plates 24 and 25). Our study focused on transhumance herders who represent only a small proportion of the Wakhi population of Wakhan but they own a very large part of the small ruminants in the Wakhan District (approximately 60% of sheep and 36% of goats). As such, they are the most likely to suffer livestock losses from predation. All killed animals apart from sheep were unattended, which confirms the comments of Fitzherbert and Mishra (2003) that leaving animals to graze unattended is a poor anti-predatory management, especially against wolves. In Big Pamir, herds of sheep and goats were most often guarded by a young adult determined to deter any predator and accompanied by one or two dogs. Unlike Fitzherbert and Mishra (2003) we did not see children tending livestock but like them we noted the poor construction of open corrals and stables where animals are penned in winter. Often, large holes left in the corral roofs for lighting provide snow leopards a way to enter corrals (Plate 26). However given the relative rarity of snow leopard attacks on livestock, predator-proofing of corrals should be recommended with care.

Top to bottom: Plate 24 — In winter wolves kill a number of unattended animals both in Wakhan and Pamirs. They are never caught red-handed, and rarely venture inside villages. Plate 25 — However in the morning their tracks and foot prints (close-up) crisscrossing the snow of village surroundings testify that threat on any stray livestock is real. Qazideh, lower Wakhan, 9 December 2006.

Plate 26 — Wakhi people with their livestock in pen, Kret, upper Wakhan, 1 December 2006. To a few exceptions livestock corrals in villages of Wakhan are not leopard-proof. Large holes are left in the roof to allow for light and ventilation.

Indeed the net benefit of a complete roof ceiling should be balanced with the increased risk of disease occurrence because of loss of ventilation, decreased action of disinfecting UVs on overstepped grounds, and paradoxical improvement of soft ticks' microhabitat. We confirmed the observation made by Fitzherbert and Mishra (2003) that most predator attacks on livestock occur in winter; according to them this seasonal pattern suggests that marmots must be an important buffer prey for the snow leopard in summer. Decline in prey availability for the snow leopard could be one reason for preying on livestock during winter but apart of marmots an array of other potential preys may also be less accessible to snow leopards during winter. Indeed mountain rodents also use dormancy and hares as well as ungulates are known to shift their range use in winter towards valley floors, in search of more accessible forage. The sporadic, both timely and spatially, occurrences of snow leopard predations on livestock in Wakhan could arguably be the fact of isolated individuals, possibly old and debilitated, which are no longer able to feed on their natural preys.

It is noteworthy that, although livestock suffer cumulatively more losses from wolves than snow leopards, more anger seems to have developed towards leopards. One explanation could be that the highly visible, excessive surplus killing of livestock, as practiced by snow

leopards intruding into a livestock-packed corral, has a big psychological impact on people. This factor is important to consider in any action committed to conserve carnivore species in the area.

Finally nothing is known about the occurrence and role of other possible livestock predators, such as Himalayan lynx (*Lynx lynx isabellina*) or pariah dog (*Canis lupus familiaris*).

To conclude, our investigations on the causes of mortality of livestock from 62 households using Big Pamir pastures suggested that predation by wild carnivores accounted for less than 2.5% of reported deaths in their livestock between December 2005 and December 2006. Although this is of significant impact in the subsistence economy of Wakhi, globally this is a relatively low predation level and compensatory policy (not necessarily cash-based) could be an economically viable solution to smooth over human-carnivore conflicts in Wakhan. If proposed, compensation will have to be grounded on systematic collection of evidences.

The paradoxes of sanitary improvement

Livestock in Big Pamir and in villages in the valleys suffer primarily from undernutrition in winter and from infectious disorders the rest of the year. Although Wakhi herd owners reported frequent disease outbreaks, it seems that most pathogens have co-evolved with livestock populations to become endemic, usually affecting the animals on a chronic mode. Typically most infectious disorders we have observed seemed to have a high morbidity but resulted in a relatively low mortality. This is surprising in regard of the total lack of prophylaxis and of the frequent overcrowded situations in corrals. Improving health status of livestock would need implementing sanitary management, adjusting husbandry practices, following split-herd practices towards unhealthy animals which should be isolated in quarantines, introducing mass vaccinations and most importantly detecting and eliminating scruffy specimens, those that carry asymptomatically infectious agents and transmit them to healthy neighbors. Developing concomitantly all these measures would significantly improve health status of livestock and as a consequence the revenues driven from herding. However whether such measures would decrease global poverty in Wakhan and Pamirs, optimize resource use and serve conservation goals is questionable. Indeed the 'happy few' using Pamirs are already among the most prosperous of the Wakhi community and represent less than 5% of the population. Will an increase of their income improve life conditions and decrease poverty of the rest of the population? Should Wakhi have maintained their ancestral resource sharing code and Ismaili charity system, the answer would probably be positive. More research is needed to understand these social issues.

More disturbing is the problem of opium addiction. Crucial corollary information is required to better understand the origins and current extent of the problem. What proportion of resources is directly or indirectly allocated to opium use? What is the reversibility level of the problem? Answers to these questions are essential to adjust any self-sustaining conservation policy. If improving health status of livestock translates at the far end into an increase in opium consumption the development efforts will be

counterproductive. In such eventuality poverty will presumably not be diminished and number of opium dealers will probably increase indebting Wakhi on the long term, and progressively dispossessing them from their pastures.

Eventually improving health status of livestock and decreasing their mortality level could also have negative impact on rangelands and cohabiting wildlife. An increased number of livestock in Big Pamir could be damageable to a land already significantly degraded. As a consequence biodiversity would decrease; wildlife would vanish, turning away tourists from visiting the area. On the other hand living a status quo situation on the front of livestock health issue is not desirable. An array of livestock diseases are known to be zoonotic, and impact fatally human populations as well. The presence of such contagious diseases may deter tourists from visiting the area and sharing traditional ways of life of locals. Also retaining a high level of pathogen endemism in livestock could pose a risk to wildlife. Even if nowadays the risk of disease transmission by direct contact between livestock and wildlife seems reduced in western Big Pamir, it may still happen and the risk of disease transmission by indirect contact is real.

So what are the solutions? We provide below ideas that could be debated with land users, developmental agencies and actors of ecosystem conservation. First, we must acknowledge that we know little about disease ecology, a discipline that has only emerged less than 10 years ago (Hudson et al., 2002). Thus, endemic situations of diseases such as in Big Pamir livestock could on the mean term evolve towards epidemics if inadequately disrupted (Hudson et al., 2002). Any introduction of modern sanitary and prophylactic practice should therefore be done progressively and with proper indicators of efficiency. Second, land users must decipher and accept the consequences of existing indications of ecosystem suffering. For example the severe losses of livestock in winter due to undernutrition sound like a signal in favor of an excessive stocking rate. Bypassing this strong ecological signal by helping Wakhi resolving the forage deficit situation in winter could be ineffective and detrimental on the mean term for the ecosystem. Likewise it is also possible that a number of animals acting as pathogen reservoirs are eliminated during winter starvation, a beneficial situation that could contribute at diminishing the level of disease endemism in infected herds. Third, support development actions that promote simultaneously the long term optimization of resource uses in Wakhan and the decrease of resource use in Pamirs, among others the increase of education level in the community, the improvement of health status of sedentary livestock, the improvement of agricultural/irrigation practices. Four, re-appropriate rangeland of western Big Pamir to Wakhi by developing or supporting actions aimed indirectly at driving livestock/opium dealers out of Pamir.

CONCLUSION

In mountainous areas of western Big Pamir, the abundance of domestic herds and over utilization of forage resources during summer have led to a relative impoverishment of range land and to a poor vegetation recovery rate (D. Bedunah pers. comm.). Use of the Big Pamir range during winter could be a recent practice (Petocz quoted in Fitzherbert and

Mishra, 2003) which could even exacerbate this situation. Because of this intense grazing pressure wild ungulates compete with livestock in summer ranges and are de facto more or less excluded from these areas at this period of year. Cohabitation between domestic and wild ungulates seems excessively diluted in space and time and the risk of disease spillover by direct contact between domestic and wild ungulates is much reduced. However we still need to assess the risk of disease transmission by direct or indirect contacts from unattended cattle and yaks to wild ungulates, especially Marco Polo sheep. Similarly we will need to study livestock/wildlife cohabitation patterns in Wakhi pastures of Little Pamir and Kirghize pastures of eastern Big Pamir and eastern Little Pamir.

We hope the data about herders, livestock and wildlife that we have collected through our surveys will help to draw action plans for the future Big Pamir Protected Area. But the Ecosystem Health Management Project is only one of the five interwoven projects developed by WCS or affiliated organizations in the Wakhan. Our work will benefit from the field work of four other teams: the Community Conservation Program Team led by Dr Mock, the Rangeland Assessment Team led by Dr Bedunah, the Biodiversity Team lead by the International Snow Leopard Trust, and the Marco Polo Sheep Team led by Dr Walzer. In turn, those teams will hopefully benefit from the information collected during our surveys. Knowing ownership, accurate numbers and extent of range use of livestock should help the Community Conservation Team identify the future actors of wildlife–livestock conflicts and start proposing up-front solutions. Knowing accurate numbers, range use and seasonal movement patterns of livestock will help the rangeland assessment team to evaluate the level of grazing in the area, quantify ecological capacities of the future protected area and identify overexploited and possibly substitution areas for grazers. Eventually data collected by the Biodiversity and Marco Polo sheep teams on the current distribution of wild ungulates will be combined to our data to assess the risk of disease transmission between livestock and wild ungulates and to draw an action plan to limit this risk.

APPENDIX: SUMMARY OF DAILY ACTIVITIES

Summer survey (16 July to 22 August 2006)

- Sunday 16 July: Kabul to Kunduz — Part of the team drove in four cars from Kabul to Kunduz, capital of Kunduz Province in northern Afghanistan.
- Monday 17 July: Kabul to Kunduz — Drs Khadr and Ostrowski flew to Kunduz, completing the team. I stayed overnight at the UNICEF[3] guesthouse.
- Tuesday 18 July: Kunduz to Faizabad — We drove for 12 hours from Kunduz to Faizabad, capital of Badakhshan Province. I stayed overnight at the GTZ[4] guesthouse.
- Wednesday 19 and Thursday 20 July: Faizabad — In Faizabad we paid a visit to the governor of Badakhshan who was absent. We had meetings with the deputy chief of police, the representative in Badakhshan of the Aga Khan Development Network [5](AKDN), and the tourism facilitator appointed by AKDN. We rent a fifth car and bought supplies and equipment for our survey to Pamirs.
- Friday 21 July: Faizabad to Ishkeshim — We drove from Faizabad to Ishkeshim on the Tajikistan frontier. On the way we paid a visit to Cdt Wahid Khan in Baharak, the head of police authority for Wakhan and Pamirs. I stayed overnight at the private guesthouse of Mr Ayan Beg.
- Saturday 22 July: Wakhan — We drove up lower Wakhan Valley as far as Khandud (district center of Wakhan). We hired Mr Mallang as a cook, met Shah Langar, the spiritual leader of the Wakhi community in lower Wakhan, in Qazideh village.
- Sunday 23 July: Wakhan — In Khandud we met the local chief of police. We drove to Qila-e Panja village where we met Shah Ismael, the spiritual leader of the Wakhi community in mid and upper Wakhan.
- Monday 24 July: Wakhan — We tried to reach Sarhad-e Broghil village but failed to cross a surging stream near Ptukh village and went to Goz Khun village.
- Tuesday 25 July: Wakhan — We settled for one day in Goz Khun waiting for pack animals. We sent back the cars to Faizabad. I spent the day teaching ornithology and zoology to trainees.
- Wednesday 26 July: Big Pamir — We hired eight donkeys and two horses and proceeded up the Pamir River into the Big Pamir, on foot and by horse. We camped overnight near Jangal-e Gurvash.
- Thursday 27 July: Big Pamir — We walked and rode to Istimoch Valley.
- Friday 28 July: Big Pamir — We walked and rode along Pamir River to Ali Su Valley.
- Saturday 29 July: Big Pamir — We walked and rode along Pamir River to Gormatek.

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[3] UNICEF stands for the United Nations International Children's Fund, the United Nation branch for children's rights, their survival, development and protection.

[4] GTZ is the acronym for Deutsche Gesellschaft für Technische Zusammenarbeit GmbH, the German international cooperation enterprise for sustainable development with worldwide operations.

[5] The Aga Khan Foundation is a non-denominational international development agency and a modern vehicle for traditional philanthropy in the Ismaili Muslim community.

- Sunday 30 July: Big Pamir — We walked and rode to Tila Bai River. We met with several Kirghize leaders heading to Bai Tibat Valley for a wedding party.
- Monday 31 July: Big Pamir — We walked and rode to Jabar Khan, a Wakhi summer settlement in Jermasirt area.
- Tuesday 1 to Thursday 3 August: Big Pamir — We worked in Jermasirt area: assessment of number of livestock, their range use, questionnaire investigations on health issues in the four Wakhi settlements located in the area.
- Friday 4 August: Big Pamir — We hired six yaks and walked and rode to Ali Su, a wintering site for Wakhi livestock.
- Saturday 5 August: Big Pamir — We walked and rode to Manjulak area. We started working in this pasture area.
- Sunday 6 and Monday 7 August: Big Pamir — We worked in Manjulak area, assessed number of livestock, their range use, interviews households about livestock health issues in the three Wakhi settlements located in the area.
- Tuesday 8 August:. Big Pamir — We hired six yaks and walked and rode to Shikargah area. We started working in this pasture area.
- Wednesday 9 and Thursday 10 August: Big Pamir — We worked in Shikargah area assessed number of livestock, their range use, interviews households about livestock health issues in the four Wakhi settlements located in the area.
- Friday 11 August: Big Pamir — We hired six horses and we walked and rode to Istimoch Valley.
- Saturday 12 August: Big Pamir — We walked and rode to Goz Khun village.
- Sunday 13 and Monday 14 August: Wakhan — We settled for two days in Goz Khun. We carried out washing up, equipment repair, data basing, observations of wildlife during daytime, and ornithology and zoology training in the evening.
- Tuesday 15 August: Wakhan — We hired six donkeys and two horses and walked and rode to Qila-e Panja.
- Wednesday 16 August: Wakhan — We visited Shah Ismail. Ornithology course with trainees.
- Thursday 17 August: Wakhan — Drivers came back to pick us up. We drove down Wakhan Valley to reach Iskeshim village. We visited the field veterinary unit of AKDN, and Dr Farman Ali, head of the tourism department of AKF in Ishkeshim.
- Friday 18 August: Ishkeshim to Faizabad — We drove from Ishkeshim to Faizabad. I stayed the night at the GTZ guesthouse.
- Saturday 19 August: Faizabad to Kunduz — We drove from Faizabad to Kunduz. I stayed the night at UNICEF guesthouse.
- Sunday 20 August: Kunduz — We stayed at the UNICEF guesthouse in Kunduz, waiting for PACTEC flight to Kabul scheduled for 21 August.
- Monday 21 August: Kunduz to Kabul — I flew to Kabul with PACTEC flight.
- Tuesday 22 August: Kunduz to Kabul — The rest of the team drove to Kabul.

Winter survey (23 November to 18 December)

- Thursday 23 November: Kabul to Kunduz — Part of the team drove from Kabul to Kunduz, provincial capital of Kunduz Province in northern Afghanistan.
- Friday 24 November: Kunduz to Faizabad — They drove from Kunduz to Faizabad, provincial capital of Badakhshan Province in north-eastern Afghanistan.
- Saturday 25 November: Kabul to Faizabad — I flew to Faizabad (via Kunduz) and spent the night at GTZ guesthouse.
- Sunday 26 November: Faizabad to Ishkeshim — We drove with three cars from Faizabad to Ishkeshim. I stayed overnight at the private guesthouse of Mr Ayan Beg.
- Monday 27 November: Wakhan — We drove up lower Wakhan Valley as far as Qila-e Panja. We were honored to stay overnight at Shah Ismail's house.
- Tuesday 28 November: Wakhan — We drove to the village of Kret in upper Wakhan Valley, where we met Mr Inayat Ali (WCS community conservation project).
- Wednesday 29 November: Wakhan — We sent back one car to Faizabad. We worked in Kret, interviewing owners of herds summering in Big Pamir about health issues, performing clinical examination of their livestock and collecting blood samples on a selection of their sheep and goats. During the afternoon I accompanied Mr Inayat Ali to the village of Shelk and attended a community conservation workshop. I also assisted also to cloth distribution. We hired a Wakhi cook from Kret and a para-veterinarian trainee from Qila-e Panja.
- Thursday 30 November: Wakhan — We drove to Karich village. We worked at Karich interviewing owners of herds summering in Big Pamir about health issues, examined their livestock and collected blood samples on a selection of their sheep and goats. We processed blood samples collected in Kret. During the afternoon Dr Ali Madad, Dr Hafizullah and I went to the Baba Tungi and Kuzget villages to give out donated cloths.
- Friday 1 December: Wakhan — We drove to Kipkut village. We worked at Kipkut interviewing owners of herds summering in Big Pamir about health issues, performing clinical examination of their livestock and collecting blood specimens on a selection of their sheep and goats. We processed blood samples collected in Karich. We also visited the village of Sargez to interview owners of livestock summering in Big Pamir.
- Saturday 2 December: Wakhan — We visited the village of Karich again to investigate suspected clinical cases of Foot and Mouth Disease in cattle. In the afternoon we drove to Goz Khun, met a caravan of Kirghizes heading to their wintering grounds in Big Pamir (Tila Bai Valley) and provided them with a temperature logger. We processed blood samples collected in Kipkut.
- Sunday 3 December : Wakhan — We drove and walked to the village of Avgarch to carry out interviews. We also did some wildlife observations in Goz Khun area in the morning.
- Monday 4 December: Wakhan — We revisited the village of Avgarch and performed blood samples on their sheep and goats. We processed the blood samples on the same day.

- Tuesday 5 December: Wakhan — We drove in snowstorm to Khandud. There we collected blood-samples from sheep and goats of a herd that returned from Big Pamir in October. We drove further down the corridor but had to stay one night in the village of Urgundi Payan because of a partially frozen impassable stream.
- Wednesday 6 December: Wakhan — We drove in snowstorm to Ishkeshim.
- Thursday 7 – Friday 8 December: Ishkeshim — In Ishkeshim we processed the blood samples collected in Khandud. We visited two houses as possible operational centers for WCS in the future and met with one candidate for the position of operational center manager. We proceeded with the ornithology and zoology training courses.
- Saturday 9 December: Ishkeshim to Qazideh — We drove to Qazideh in lower Wakhan, met with Shah Langar, provided him with cloths to distribute to the poorest households of the village and performed blood-samples on a selection of sheep and goats from his herds that returned from Big Pamir in October.
- Sunday 10 December: Qazideh to Ishkeshim — We drove back to Ishkeshim. We processed blood samples collected in Qazideh. We met with Dr Farman Ali, Mr Mehboub Aziz, and Dr Shams at the AKDN/AKF offices.
- Monday 11 December: Ishkeshim to Faizabad — We drove to Faizabad. Dr Ali Madad, Hafizullah and I stayed at the GTZ guesthouse for the following 4 days.
- Tuesday 12 to Friday 15 December: Faizabad — We worked at GTZ guesthouse. We databased questionnaires collected during the survey, performed some knowledge examinations on trainees, and started reporting work.
- Saturday 16 December: Faizabad to Kabul — I flew to Kabul with PACTEC.
- Sunday 17 and Monday 18 December: Faizabad to Kabul — The rest of the team drove back from Faizabad to Kabul via Kunduz and the Sallang tunnel.

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