A Field Mission of the Ecosystem Health Component to Band-e-Amir in May–June 2007

Stéphane Ostrowski, Ali Madad Rajabi & Hafizullah Noori
Afghanistan Ecosystem Health Team, WCS
September 2007

EXECUTIVE SUMMARY

Between 27 May and 6 June 2007, the Afghanistan Ecosystem Health team of the Wildlife Conservation Society (WCS) undertook a field mission in the northeast of Band-e-Amir, a naturally created group of lakes in the Bamiyan Province. The survey had several objectives: 1/ collect data on livestock health and possible interactions of livestock with wildlife; 2/ study a recent case of fish die-off in Band-e-Gholaman, one of the lakes of Band-e-Amir; and 3/ record observations on wildlife.

1/ People living in Band-e-Amir are mostly sedentary farmers who live in small villages located around lakes. Only a minority of them are involved in herding and use the surrounding mountains as seasonal pastures, potentially bringing their livestock into contact with wildlife. We interviewed 27 of them about their livestock. They herded 876 sheep, 235 goats, 167 cattle heads, 18 horses and 90 donkeys. Livestock suffered from disorders including diarrhea, abscesses, skin problems, lameness, coughing, and heavy tick burdens. Shepherds also reported clinical symptoms compatible with those observed in Foot and Mouth Disease (FMD), contagious caprine pleuropneumonia, and glanders, all diseases that affected their livestock in the recent past. We performed 228 blood samples on sheep and goats and forwarded them to the Central Veterinary Laboratory (CVL) in Kabul for FMD, Peste des Petits Ruminants and brucellosis serological testing. Results are pending. We estimated annual mortality rate in the investigated subpopulation at 15–25% for sheep and goats, <15% for cattle, and around 10% for horses and donkeys. Most deaths occurred during winter and were caused by diseases. Abortions concerned around 18% of ewes and 26% of goats. All but one of the 27 interviewed herders used tetracycline antibiotics for their livestock, and several of them other commercial drugs. In addition 15 (55.5%) of them also used local plants to treat livestock disorders, especially those locally known as *buzbash*, *joli gao*, *pasha kushak* and *gandabaghal*. We identified *buzbash* as *Hymenocrater sessilifolius* Benth, Lamiaceae family, a perennial aromatic plant, and *joli gao* as *Hyoscyamus niger* L., Solanaceae family. Interviews suggested that direct transmission of infectious agents from domestic ruminants to wild ungulates is very unlikely in Band-e-Amir, owing to the scarcity of wild ungulates in the area and to the current land use context. We also investigated the impact of predators on livestock in Band-e-Amir. Wolves (*Canis lupus*) killed 38 sheep, 4 donkeys and 1 goat during the year preceding the interviews. Basing our calculation on the estimated global annual mortality rate, we propose that predation by wolves accounted for up to 25% of yearly losses in sheep population.

2/ We studied the fish die-off that occurred in Band-e-Gholaman at the end of winter 2006–2007 through 12 interviews of local land users. It apparently started in February and peaked in March 2007. Our observations and analyses rule out the hypotheses of eutrophication and direct poisoning by pesticides. Harsh winter, as reported by local people, is the most likely cause of ecosystem disturbance and could be responsible for the investigated fish die-off.

3/ We recorded four species of birds new to the area: the common moorhen (*Gallinula chloropus*), the twite (*Acanthis flavirostris*), the common cuckoo (*Cuculus canorus*), and the European linnet (*Acanthis cannabina*).

OBJECTIVES AND METHODS OF THE SURVEY

Objectives

The first goal of the survey was to evaluate livestock health in Band-e-Amir at the end of spring by collecting field data and blood samples to determine the exposure level of livestock to specific pathogens. The second objective was to study a recent episode of fish die-off in Band-e-Gholaman, one of the lakes of Band-e-Amir, through a brief questionnaire survey. Fishes are good indicators of the health status of aquatic ecosystems and die-off episodes can reveal a dysfunction of the ecosystem. Eventually, the survey also included opportunistic observations of animal life in the area, which will be included in the biodiversity database implemented by Dr. C. Shank (Shank, 2007b).

Survey timing and area

The survey took place between 27 May and 6 June 2007, when most livestock had joined spring grazing pastures. Summary of our daily activities can be found in Appendix. We drove to the survey area on roads and tracks with a WCS car (Plate 1). We walked to reach pasture areas. For our first survey in Bamiyan Province, we focused on Band-e-Amir (dam of Amir in Dari). This naturally created group of lakes is well-known for its spectacular landscapes. It is located about 75 km to the northwest of the ancient city of Bamiyan (Figure 1). There are six lakes: Band-e Gholaman, Band-e Qumbar, Band-e Haibat, Band-e Panir, Band-e Pudina and Band-e Zulfiqar. It belongs to the Hindu Kush mountain range and lies at an average altitude of 2,900–3,200 m. A large part of the area was once included in a designated reserve, which was unfortunately never legally established. The mountainous surroundings present significant pastoral activities that may pose disease threats to local wildlife. We conducted our survey in the northeast of the area, where contacts between livestock and wildlife seemed to be the more likely (Shank, pers. comm.). In 2008, we will extend our study to the livestock populations of the Ajar Valley. This area, located in the north of Band-e-Amir, could become a wildlife reserve in the future (Shank, 2007a).

Data collection and analysis

We collected data through interviews of local land users, direct counts, and veterinary investigations on livestock (clinical examinations and sampling). Drs Ali Madad and Hafizullah interviewed the shepherds and elders of Wakhi households pasturing their livestock in the northeastern part of Band-e-Amir in spring 2007. They conducted 27 interviews in Dari on livestock health issues (Plate 2) and 12 on the fish die-off event. They subsequently translated them in English. Each interview on livestock lasted 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 Band-e-Amir, transhumance timing, range use, livestock health status and management practices. Interviews on the fish die-off lasted on average 10 minutes and consisted in 11 predetermined questions.

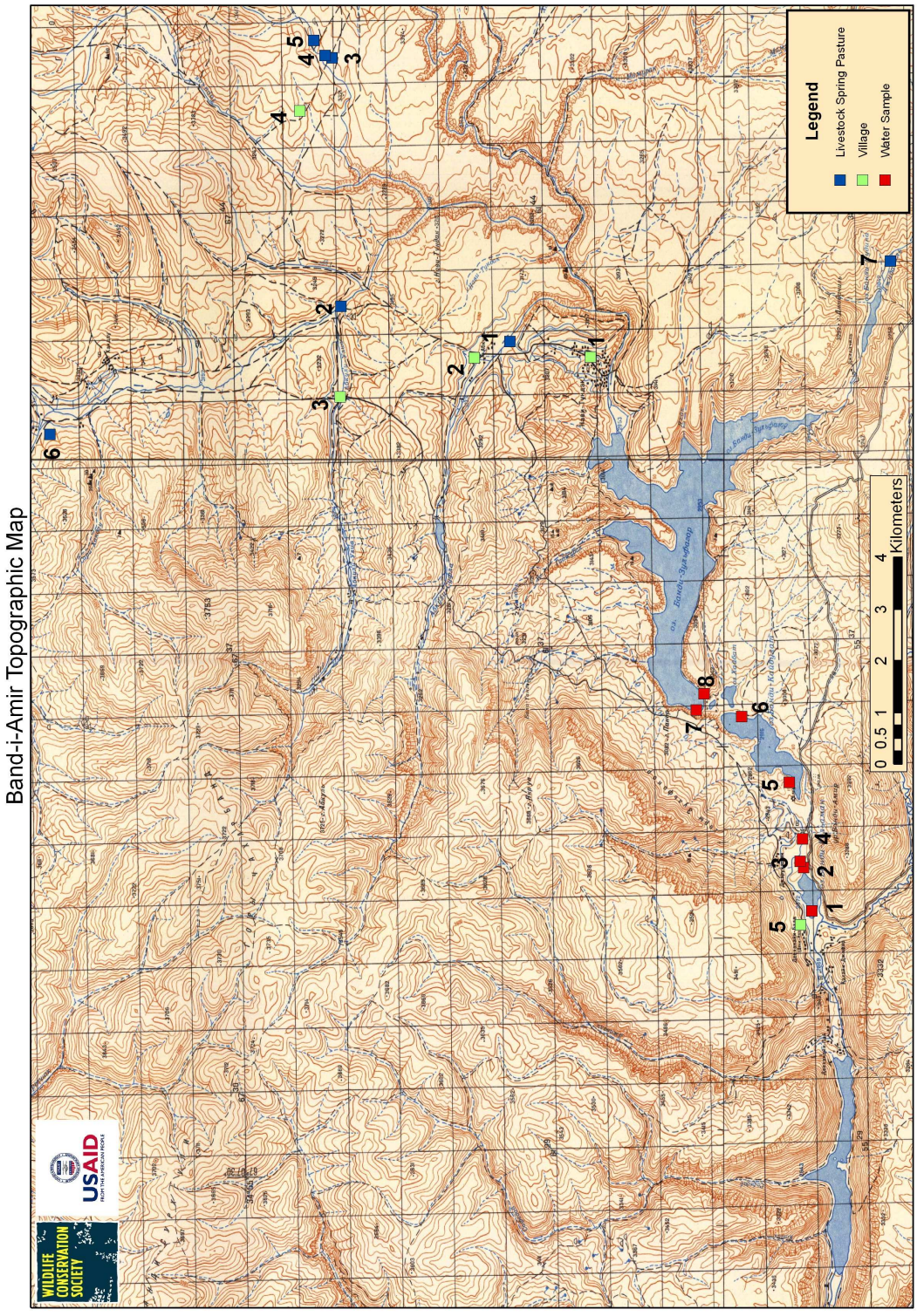

Figure 1. Map of the surveyed area. Water sampling sites are in red: Band-e-Gholaman (1 & 2), Band-e-Qumbar (3 & 4), Band-e-Haibat (5 & 6), and Band-e-Zulfiqar (7 & 8). Visited villages are in green: Kopruk (1), Abqul (2), Abqul-e-Bala (3), Kopruk Dandaw-e-Payan (4), and Deohone Bala (5). Spring pastures are in blue: between Kopruk and Abqul (1), Abqul Bala Daragak (2), Kopruk Dandaw (3 & 4), Abqul Dandaw (5), Kakdaw-e-Bala (6), and Kopruk Yakhak (7).

From top left, clockwise: Plate 1. We used a WCS car to travel in Band-e-Amir. On the side of the car, Mr Khoja Khalil, the mission's dedicated driver, Band-e-Amir, 1 June 2007. Plate 2. Dr Ali Madad interviews shepherds in the field about their livestock health, Kopruk Dandaw-e-Payan pasture, 31 May 2007. In the background, sheep are still in their winter coat and only few goats are present. Plate 3. Drs Ali Madad and Hafizullah (handler) perform a blood sample on a clinically healthy sheep. Herders were very supportive of the team's work throughout the mission, Kopruk Dandaw, 29 May 2007.

For each questionnaire, questions were presented in the same way to the interviewed people. About clinical examinations of livestock, we focused on the most visible symptoms: poor body condition, coughing, sneezing, lameness, presence of abscess, signs of diarrhea in the ano-genital area and on the back legs, and mastitis. We did not have the opportunity to perform postmortem examinations. Finally we collected 228 blood samples on sheep and goats by jugular punctures (Plate 3). We forwarded the samples to the Central Veterinary Laboratory (CVL) in Kabul for serological screening against Foot and Mouth Disease (FMD), Peste des Petits Ruminants (PPR), and brucellosis. Finally, we tallied figures provided during the interviews and carried out descriptive statistics with Statistix 8.1 software.

SHEEP, GOATS AND CATTLE

Numbers, movements and husbandry

People in Band-e-Amir are mostly sedentary farmers who live in small villages located around lakes. Only a minority are involved in herding and transhumance activities; they use the surrounding mountains as seasonal pastures, potentially bringing their livestock into contact with wildlife. According to the interviews and to our direct counts, the 27 interviewed households owned overall 876 sheep, 235 goats, and 167 cattle heads. Herd size averaged 32.5 (0–120), 8.7 (0–55), and 6.2 (0–20) heads per household for sheep, goats and cattle, respectively. Coefficient of variation of herd size exceeded 78% for all species. Most small ruminant herds in Band-e-Amir perform seasonal movements over small distances (<15 km). Out of the 27 interviewed households, 24 (88.9%) kept their animals in villages during winter. At this period of the year they graze around household homes at daytime and are corralled in villages at night. Spring transhumance usually starts in late May but can start as early as mid April depending on snow cover. Herders move sheep and goats to a succession of summer pastures, according to a predefine land use. Our impression was that most of the visited areas were heavily overgrazed. In general animals are moved back to villages as soon as ambient temperatures decrease, sometimes as early as mid September. Cattle are the most precious livestock followed by sheep and goats. They are primarily used for milk and draft. The sheep to goat ratio in visited settlements varied from 100:1 to 1:55. In most cases (70.1%) however, sheep largely outnumbered goats as suggested by a global sheep to goat ratio of 3.7:1. Apparently sheep are of better value when sold, are more resistant to winter cold, and provide wool and more meat than goats, although, as argued by one herder with more goats than sheep (1:55), goats may produce more milk than ewes per year. Shepherds shear their sheep once a year between spring and early autumn, usually after cleaning them in water. Cleaning and shearing are to our understanding the only mass handling activities practiced on herds during summer apart from some sporadic prophylactic interventions. Cleaning may help reduce the level of ectoparasite infestation, especially with *Melophagus ovinus* (sheep ked; a wingless bloodsucking fly resembling a tick). At night, shepherds keep adult sheep and goats in corrals with 1.5 m-high stone walls, usually located in the center of the settlement. Dogs guard them. In summer ewes and goats are milked every day around 4:30 am, except those

which milk the youngest offspring. The herd leaves the settlement around 5:30 am with one shepherd and one or two dogs. They will return shortly before night at 18:30–19:00. We noticed that herders do not separate sick and healthy animals, favoring direct and indirect pathogen transmission in their livestock. For example, they often milk sick females before healthy ones and keep them together in crowded corrals at night. Split herding and a strict isolation (quarantine) of sick animals would decrease the risk of transmission.

Clinical findings

Examination of sheep, goats and cattle revealed clinical symptoms. We categorized them in 6 main syndromes: 1/ respiratory tract disorder (coughing, sneezing or respiratory distress); 2/ digestive tract disorder (visible and recent signs of diarrhea); 3/ poor physical condition (no other symptoms apart from a visible thinness); 4/ locomotor disorder (broken legs or severe lameness); 5/ visible abscesses (in the skin or in tissues just beneath the skin); and 6/ mastitis (reported to us by shepherds) (Table 1). When animals presented more than one syndrome, for example a severe respiratory tract disorder with a poor body condition, we considered the most prominent syndrome only, in this case the respiratory tract disorder. Overall 44.4% of sheep, 61.3% of goats and 76.6% of cattle presented one of the clinical syndromes. The most represented was poor body condition, which affected 21.1% of sheep, 22.9% of goats, and 45.5% of cattle. Because such criterion obviously depends on predetermined standards, decreased body mass was always assessed by discussing with the herder. Interestingly only a minority of animals categorized in poor body condition suffered of anorexia. Nearly 15% of the sheep, 26.4% of the goats and 7.8% of the cattle presented a respiratory tract disorder. We observed milder respiratory symptoms in sheep and cattle than in goats, which presented ventilation distress for 25% of them. Digestive tract disorders affected 5.5% of the sheep, 12.7% of the goats, and 19.7% of the cattle. Locomotor disorders, visible abscesses and mastitis were less common and, combined, affected 2.8% of the sheep, 0.8% of the goats, and 9.6% of the cattle. Origins and possible causes of the different syndromes are discussed below.

Infectious diseases

Foot and Mouth Disease, Peste des Petits Ruminants and brucellosis

We collected 228 blood samples on sheep and goats and forwarded them to CVL in Kabul for serological testing against FMD, PPR, and brucellosis. These three major diseases may result in serious economic losses and pose a threat to wildlife as well. Results of the serological screening are still pending. There are good evidences that FMD is endemic in Afghanistan. This highly contagious viral disease of cloven-hoofed animals is characterized by high fever, blisters inside the mouth that may cause drooling, and blisters on the feet that may cause lameness. According to 11 of the 27 interviewed herders (40.1%), a disease with clinical symptoms and epidemiological traits compatible with FMD occurred in their herds within the last two years. The disease was deemed common to very common, affecting mainly cows and sheep, but they reckoned it was not currently occurring in their herds. Indeed we did not record typical symptoms of the disease such as febrile cases with mouth or foot vesicles in cattle and small ruminants.

Table 1. Clinical syndromes observed in sheep, goat and cattle in the survey area, May-June 2007.

Species	Respiratory tract disorders	Digestive tract disorders	Poor body condition	Locomotor disorders	Visible abscesses	Mastitis	Number presenting clinical syndromes	Overall population
Sheep	131	48	185	15	6	4	389	876
Goat	62	30	54	1	0	1	148	235
Cattle	13	33	76	7	8	1	114	167
Total	206	111	315	23	14	6		

We heard similar reports of an FMD-like disease from herders during our field surveys in Wakhan in summer 2006 and winter 2006–2007 (Ostrowski, 2007). In the same time, we noted lame sheep, cattle and yaks 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 or foot vesicles. PPR and brucellosis could be endemic in Afghanistan but data on their prevalence are sparse. PPR is a viral disease of goats and sheep characterized by fever, erosive stomatitis, conjunctivitis, gastroenteritis, and pneumonia. We did not observe clinical symptoms evocative of PPR during our surveys. Brucellosis is a zoonosis of documented deleterious impact on human health. Infection in livestock results in decreased fertility, lameness, and abortions. The latter are a significant problem in sheep and goats (cf. 'Abortions' section below).

Gastrointestinal disorders

Sheep and goats are significantly affected by gastro-enteric disorders. They occur more often in spring when animals forage newly grown vegetation —a pattern which suggests *Clostridium perfringens* enterotoxaemias— but they also happen later in spring and in summer, and could be caused by several infectious agents. Heavy stocking densities, overgrazing, crowded night housing and poor sanitary management could favor outbreaks of coccidiosis and cryptosporidiosis in lambs and kids. *Salmonella* spp. can cause diarrhea in small ruminants of all ages. Bluetongue orbivirus can also be responsible for diarrheic events in sheep provided the *Culicoides* vector exists at the altitude of Band-e-Amir. Diarrhea seems to be the main cause of death in lambs.

Respiratory disorders

Respiratory tract disorders were common in the herds of 16 out of the 27 interviewed shepherds. They affect adult small ruminants in winter and young in spring. The most common symptom is coughing. Herders also described a severe goat disease suggestive of contagious caprine pleuropneumonia (CCPP). It is an acute highly contagious disease of goats caused by a mycoplasma and characterized by fever, coughing, severe respiratory distress, and a high mortality. It is known to occur in Afghanistan. The main lesions at necropsy are an acute fibrinous pleuropneumonia with an overlying fibrinous pleurisy, and an excess of straw-colored fluids in the thorax. Herders described '*yellow water in lungs, like urine, and red and black lungs sticking to ribs*'. The disease apparently kills half of the affected goats, and an even larger proportion of kids.

Clockwise from top left: Plate 4. Abscesses were common in ruminant livestock of Band-e-Amir, here a jaw abscess in a ewe, Kopruk Dandaw-e-Payan pasture, 31 May 2007. Necrotic parodontal disease of a molar tooth possibly due to too woody forage can be the cause of such fistulization often associated with mandible osteolysis. Plate 5. An adult sheep presenting an extensive area of alopecia with hyper- and para-keratosis on the back, rump and upper sides of the abdomen, Kopruk Dandaw-e-Payan pasture, 31 May 2007. Skin scrapings to determine the presence of ectoparasites were negative and the cause of this dermatological disorder remains none elucidated. Plate 6. Most livestock were infested with ticks. In sheep Ixodidae ticks were mainly located on the head and neck, Kopruk Dandaw-e-Payan area pasture, 31 May 2007.

Skin abscesses

Skin abscesses are usually caused by bacteria and don't affect the animal survival. All herders reported them in their sheep and goats. This high prevalence could be related to heavy tick infestations (cf. 'Ectoparasites' section below). Uncommonly, abscesses were sometimes associated with a quickly degrading physical condition leading to death, especially during winter. We did not observe such cases but noticed many abscesses located on the mandible, tongue, and oropharyngeal tissues (Plate 4). Affected animals were usually in medium to poor body condition, presumably because of their difficulty to swallow forage and water. A large range of bacteria can cause abscesses in the oropharynx tissues and mandible of ruminants (for example *Fusobacterium* spp., *Corynebacterium* spp., *Actinomyces* spp., *Actinobacillus* spp.). They are often associated with nutritional deficiencies (such as mineral deficiency) and consumption of woody/sharp forage. Such conditions largely prevail in overgrazed pastures.

Contagious ecthyma (Orf)

It is a very common infection in juvenile sheep and goats. This infectious dermatitis, caused by a *Parapoxvirus,* affects primarily the lips of young animals. The disease exists in Band-e-Amir, but in much lower prevalence than what we have observed in Pamir in 2006–2007.

Infectious keratoconjunctivitis

During our survey we observed one case of keratoconjunctivitis in a lamb. In sheep and goats, infections with *Chlamydophila* (formerly *Chlamydia*) spp. and *Mycoplasma* spp. are most common. *Mycoplasma conjunctivae* for example can cause keratoconjunctivitis and 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).We performed a *Chlamydophila*-antigen detection test (Speed® Chlam, BVT, France) in the field, which was negative.

Lamb paralysis

Four shepherds reported the occurrence of a neurologic disorder affecting lambs at the end of winter or in spring. The main symptom was partial (paresis) or complete (paralysis) loss of movement. Given the high tick infestation of livestock in Band-e-Amir at this time of the year, tick pyemia could be responsible for this syndrome. It is a debilitating paralysis caused by *Staphylococcus aureus* which develops in conjunction with tick infestation. Histories of lamb paralysis were usually associated with the presence of abscesses, a trait commonly reported in this disease. Other causes could be involved such as navel infection in new lambs or copper deficiency in older lambs, especially in view of the prevailing poor hygiene during lambing and of the overgrazing of pastures.

Mastitis

We observed sporadic cases of severe mastitis in sheep and goats. According to herders, necrotic mastitis are often complicated with myiasis, a disease caused by dipterous fly larvae feeding on the host's necrotic or living tissues.

Abortions

Abortions seem to be a significant problem in sheep and goats. They occur between late autumn and spring with a peak at the end of winter, but it is difficult to know whether they peak concomitantly with parturitions. At this time of year, expected poor body condition of females must certainly predispose them to miscarriage and abortion. Indeed herders often reported cold weather, undernutrition, and the corollary poor body condition, as plausible causes of abortion, but they also occur in autumn when nutritional state of animals is optimal. Many infectious agents such as FMD picornavirus, *Brucella* spp., *Coxiella burnetii* (Q-fever agent), *Toxoplasma gondii*, and *Chlamydophila* spp., can cause abortions. Overall 21 households (77.8%) reported 133 cases of abortion between autumn 2006 and the end of spring 2007, concerning 94 ewes, 36 goats, and 3 cows. If we consider that investigated herds of small ruminants were composed of 60% adult females and 40% of juveniles (<6mo-old) and adult males, such numbers would suggest that 17.9% of ewes and 25.5% of goats aborted during this period.

Parasites

Endoparasistes

Herders mentioned the presence of 'red round worms' in the gut of their sheep and cows. We could not confirm this observation as we did not get the opportunity to carry out any necropsies. Field examination of sheep droppings did not reveal the presence of tapeworm bell-shaped proglottids in fresh feces. On several occasions we noticed the presence of fenbendazole, an anthelmintic medicine, in field pharmacies of herders. One herder reported the presence of fluke worm, and we noticed that Nilzan®, a drug used against liver fluke, was used by 18.5% of the respondents.

Ectoparasites

Two thirds of the 27 interviewed persons mentioned ectoparasites as a significant problem affecting their ruminant livestock in winter and early spring. At the end of spring —time of the survey— all interviewed people admitted that their sheep, goats and cows were currently infested by ectoparasites. The sheep ked (*Melophagus ovinus*) is one of the most widely distributed external parasites of sheep. We found adult specimens on several animals. As the sheep ked sucks blood on the same spot for a prolonged time, an infestation leads not only to irritations with its consequences —loss of or damage to wool due to rubbing and biting—, but also to direct skin damage. We also observed on several sheep macroscopic lesions evocative of infestation with *Psoroptes ovis* (psoroptic mange or sheep scab) or *Psorergates ovis* (psorergatic mange) (Plate 5) but skin scrapings were inconclusive. Mange causes large, scaly lesions developing almost exclusively on the wooly parts of the body, with intense pruritus manifesting by biting and scratching. We will try to perform skin biopsies of dermatological cases during our next visit to Band-e-Amir. Sheep and goats were also often heavily infested with ticks typically located on their neck, face and ears (Plate 6). We still need to confirm their identification but they belonged to the Ixodidae family (hard ticks). They have thick outer shells made of chitin and typically live throughout their adult life cycle attached to their hosts. Superficial examination of sampled ticks suggested they could be *Hyalomma* sp. This genus often infests domestic and wild

ungulates in western Asia and can reputedly carry several pathogens on its mouth parts and saliva. In sheep a high prevalence of skin abscesses can also be related to bacterial surinfections (e.g. with *Staphylococcus*) following heavy tick infestation. Herders also reported the presence of lice-like ectoparasites in their herds but they were unable to show us any, suggesting that lice infestation might be of low prevalence or of seasonal occurrence. Eventually some of them mentioned the occurrence of myiasis in their sheep, in the urogenital region in ewes and in the tail in lambs (1 case). Tail myiasis may occur after tail-amputation. The disease is apparently common in spring. We observed several cases recovered after treatment with antiseptics and insecticides but no on-going case and could not collect larvae for identification.

Mortality

According to the interviews, mortality peaks in winter and early spring. At this time of year, forage is poor, weather is cold, corrals are overcrowded, and new lambs and kids come into contact with adults, favoring direct disease transmissions. Out of the 27 interviewed herders, 4 reported no losses during the preceding winter while the other 23 lost overall 101 sheep, 41 goats and 5 cattle heads. We estimated mortality rates in winter 2006–2007 at 10.3% for sheep, 14.8% for goats, and 2.9% for cattle. Disease —often in conjunction with poor nutrition— was perceived as the primary cause of winter mortality, followed by starvation and wolf predation. Annual mortality rate was more difficult to assess since deaths in summer and autumn are inconsistently reported. Yet we estimated that 135–165 sheep, 55–75 goats and a maximum 15 cattle died during the year preceding the survey. Annual mortality rates ranged between 15 and 25 % for sheep and goats and probably less than 15% for cattle. We did not include aborted neonates and stillbirths in our calculations. Given an average cost of 55 US$ per sheep and goat, and 200 US$ per head of cattle, the annual economic loss due to ruminant livestock deaths would amount to 10,000–15,000 $US in the investigated cohort of 27 herds. This figure would probably reach 20,000 $US, should we include equid deaths and revenue shortfalls due to abortions.

HORSES AND DONKEYS

Numbers and husbandry

There is a small population of horses and donkeys in Band-e-Amir used for riding or as draft animals. Equids in Band-e-Amir do not seem as deeply enrooted in the way of life of human communities as in Wakhan/Pamir, Badakhshan Province. They may nonetheless constitute a useful resource for the development of ecotourism activities in the area. Both horses and donkeys would be invaluable for transporting equipment and tourists in the steep terrains of Band-e-Amir. Out of 27 interviewed herders, 15 (55.5%) owned no horses, while 7 (25.9%) had one horse, 4 (14.8%) had two horses, and 1 (3.7%) possessed three horses (median=0). Overall 12 (44.5%) households owned 18 horses. Horses were usually maintained in the vicinity of settlements. All but one of the interviewed people owned donkeys distributed as: one household (3.7%) had one donkey, six (22.2%) had two, seven

(25.9%) had three, six (22.2%) had four, four (14.8%) had five and two (7.4%) had six donkeys (median=3). Overall 26 households owned 90 donkeys.

Diseases

When questioned about the diseases affecting their horses and donkeys, herders acknowledged that both are very resilient to and seldom die from diseases. Only one infection seems to kill equids sporadically. Timing of occurrence varies according to interlocutors; it happens in winter for some of them or throughout the year for others. In their own words "*donkeys have skin abscesses, pus comes out of their nostrils before they die*". Such description is very evocative of an acute case of glanders. This contagious disease of equids, caused by *Burkholderia mallei* bacteria, can be chronic but is usually fatal. It is characterized by serial development of ulcerating nodules occurring 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 known for centuries; its severity and zoonotic nature have resulted in an almost universal fear of it (Knottenbelt and Pascoe, 1994). It has been eradicated from large areas of the world, but is still endemic in parts of Middle East and Asia, including Afghanistan. It is unknown to which degree the disease affects equid populations of Band-e-Amir, as horses with chronic form of the disease often appear to be remarkably well with only a discrete nasal discharge of benign appearance. Animals in poor body condition without symptoms of glanders could also be asymptomatic carriers. It will be worth investigating the prevalence of the disease, especially if equids are to be used for ecotourism activities. Eradication of the disease would need systematic destruction of clinically affected individuals and asymptomatic carriers. Interviewed herders have also mentioned mild tick infestation in donkeys, sporadic cases of lameness, diarrhea and endoparasite infestation in both horses and donkeys.

Mortality

Interviewed households reported the loss of 13 donkeys (12.6%) and 2 horses (10%) between spring 2006 and spring 2007. Five of the dead donkeys presented symptoms evocative of glanders (nasal discharge, skin abscesses), while 4 died in poor body condition and 4 were killed by wolves. One horse died in poor body condition and one foal with diarrhea. Poor body condition can result from undernutrition or undercurrent diseases such as chronic forms of glanders.

USE OF THERAPEUTIC AND PROPHYLACTIC MEDICINES

Livestock owners in Band-e-Amir use both traditional and modern medicines. Traditional medicine uses natural plant, mineral and sometimes animal-based ingredients, while modern medicine uses standard medical treatments, such as manufactured drugs, which must be purchased. Thus, 15 (55.5%) of the interviewed shepherds used herbalism, a traditional folk medicine practice based on the use of plants, to treat livestock disorders.

Typically they prepare leaf decoctions of selected local plants and administer them per os to sick animals. Four plant species seem to be commonly used: *buzbash*, *joli gao, pasha kushak* (Plate 7) and *gandabaghal* (all names in Dari). They seem to be mainly used for digestive tract impairments, such as bloating, colic, flatulence and diarrhea. There was however great inconsistency among respondents about the diseases and symptoms these plants are supposed to treat. We sampled a specimen of each of them for identification. Thanks to a recent ethno-botanical study carried out in the area (Ali, 2006), we were able to identify *buzbash* and *joli gao*. *Buzbash* would correspond to *Hymenocrater sessilifolius* Benth, Lamiaceae family, a perennial aromatic plant, while *joli gao* would be the black henbane or deadly nightshade, *Hyoscyamus niger* L., Solanaceae family, an annual to biannual herb. This species has a recognized toxicity for humans and animals due to the presence of hyoscyamine, an alkaloid with potent antimuscarinic effects (increased heart rate, mydriasis, decreased secretions, and decreased intestinal motricity). The leaves of *joli gao* are apparently used by people of Band-e-Amir to cure respiratory diseases (Ali, 2006). *Pasha kushak* and *gandabaghal* still need identification. It is important to improve our knowledge about local traditional medicine, as indigenous knowledge could benefit future conservation-based development projects by encouraging self-reliance and lessening the dependence of populations on imported goods that must be bought (Davis et al., 1995). All but one of the 27 interviewed persons used manufactured drugs, at least tetracycline antibiotics, usually to treat tegument abscesses, respiratory tract and digestive tract diseases. Other used drugs were: Nilzan™ (5 persons), an association of levamisole and bithionoloxyde efficient against cestode, nematode and trematode parasites; fenbendazole (5 persons), another anthelmintic drug; ivermectin (1 person), a systemic anti-parasite medicine; multivitamin complex (1 person); and Neguvon™ (1 person) or metrifonate, an anti-ectoparasite powder. A total of 15 (55.6%) of the interviewed shepherds vaccinated their sheep and goats at least once during the past 4 years but they were unclear about the vaccine and vaccination protocol used. On one occasion we were shown a vaccine against enterotoxaemia (Enterotoxaemia vaccine, Hirra Pharmaceutical Laboratories, Lahore, Pakistan) which had obviously not been stored under proper conditions (Plate 8).

RISK OF DISEASE TRANSMISSION TO WILDLIFE

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). Although disease susceptibility of Alpine ibex (*Capra [ibex] sibirica*) and Afghan urial (*Ovis orientalis [vignei] cycloceros*), the main wild ungulate species in Bamiyan Province, has not been extensively studied, it is likely that diseases affecting domestic Ovinae and Caprinae (sheep and goats) could pose a risk. Our investigations intend to document the prevalence in livestock of Band-e-Amir of several pathogens to whom wild ungulates might be susceptible. Foot and Mouth Disease, contagious ecthyma, and mange are for example potentially dangerous diseases for wild Caprinae, such as the Alpine ibex. Shank's wildlife surveys in Band-e-Amir suggest

however that wild ungulate populations have been severely depleted (Shank 2007a, b). Indeed there has been no recent report of sizeable herds of wild ungulates in the area. It suggests that the risk of domestic to wild animal transmission is much reduced. We interviewed the shepherds and elders of 27 Wakhi households pasturing their livestock in the north-eastern part of Band-e-Amir in spring 2007. We asked them about the possibility of direct contacts between their livestock and Alpine ibexes or Afghan urials i.e. have they ever observe an ibex or an urial within a 100-m horizontal distance from their livestock? 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). Only one of the respondents admitted seeing such scene, on one occasion, two years ago, in the Yakhak area (an area not yet identified). Nowadays ibexes and urials 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 suggests a decreasing number of these species in Band-e-Amir. We can tentatively assume that the current risk of spillover of infectious agents from domestic to wild ungulates by direct contact is limited in Band-e-Amir. One may nevertheless argue that wild ungulates could be exposed to livestock pathogens by indirect contacts, for example via feces, or arthropod vectors. This remains a possibility, particularly in view of the high ectoparasite infestation rate of livestock.

LIVESTOCK 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 is important to assess, as retaliatory persecutions are one of the most widespread and direct threats to carnivore species (Jackson and Wangchuk, 2001).

No information is available about people–predator conflicts in Band-e-Amir. According to the interviews we carried out during the mission, the level of carnivore predation on livestock is substantial. Thirteen (c. 50%) of the 27 herders reported wolf attacks on their livestock (sheep, goats, and donkeys) during the year preceding the interview. Without surprise the most preyed species was sheep as it is also the most represented livestock species. In investigated herds wolves killed 38 sheep and injured 24 others. Compared to herd size, it would translate into an average predation (death + injuries) level on sheep herds of 7.3% in the interviewed population and 15.0% among attacked herds. Since herders provided only the total number of animals killed or injured during the year we are not able to estimate the average number of livestock killed/injured per attack. However, the median (min–max) numbers of sheep killed and injured per year were 3 (1–8) and 2 (0–5), respectively. Wolves also killed four donkeys and one goat, and injured three goats. Wolf attacks were evenly distributed between day and night and reported in every season, with no detectable peak during winter. On three occasions that all occurred during daytime, five, two, and two wolves were caught red-handed.

Our study focused on a small proportion of the livestock population in Band-e-Amir, but investigated herds were randomly selected and supposedly representative of the overall population. As such, we estimate that predation is a significant cause of livestock losses in

Band-e-Amir, which could account, based on estimated global annual mortality rate, for up to 25% of yearly losses in sheep. Finally nothing is known about the occurrence and role of other possible livestock predators, such as jackal (*Canis aureus*) or pariah dog (*Canis lupus familiaris*). Our data on livestock predation in Band-e-Amir reveal that human populations are unfortunately embarked into the vicious cycle of environmental impoverishment. Rarefaction of large prey species such as the Alpine ibex and the urial due to overhunting drives large carnivores such as leopards (*Panthera pardus*) to extinction or such as wolves to choosing livestock as their primary food resource.

FISH DIE-OFF

Background

According to Shank (2007b), there have been reports during winter 2006–2007 of a major fish die-off in Band-e-Gholaman, one of the lakes of Band-e-Amir. Shank also mentions that another die-off might have occurred in Yakawlong Woleswali and that a similar event occurred 20 years ago following a hard winter such as the one observed in 2006–2007.

Questionnaire

We questioned 12 adult men, aged between around 35 and 65 years, in the localities/areas of Jarok Hashan (7), Dew-Khana-e-Payan (2), Dew-Khana-e-Bala (1), Qala-e-Jofar (1), and Jeda Chel (1). Results of the questionnaire are detailed below.

Question 1: Do you know of a recent fish die-off in Band-e-Amir? Yes (12/12)

Question 2: Where did this die-off occur? In Band-e-Gholaman for 11 and in Band-e-Gholaman and Jeda Chel (i.e. a shallow lake located south-east of Band-e-Zulfiqar) for 1.

Question 3: When did the die-off occur? The majority (9/12) of interviewed people agreed that it started at the end of February or beginning of March, peaked in March and ended towards the end of April (Figure 2). However we cannot exclude that a die off of lower magnitude continued in May as suggested by two interviewed men and the two freshly dead fishes we found on the shore of Band-e-Gholaman on 28 May.

Question 4: What were the species and size of fishes concerned? It seems that fishes of all sizes (i.e. all ages) were affected. They were all 'shir moi', the local name for the transcaucasian barb *Capoeta capoeta heratensis* (or *C. heratensis*), probably the commonest fish species in the area (Shank, 2007a).

Question 5: Did you notice a change of color of water during the episode of fish die-off? 5 people did not notice any water color change in Band-e-Gholaman, whereas 7 observed that the water became yellow/brown with apparently an increased turbidity, because of snow melting, local land slides and rain.

Question 6: Do you remember of a similar event in the past? 6 people did not remember/know of such event in the past while 5 had personally observed and 1 had been told by elders of a similar fish die-off event in the past.

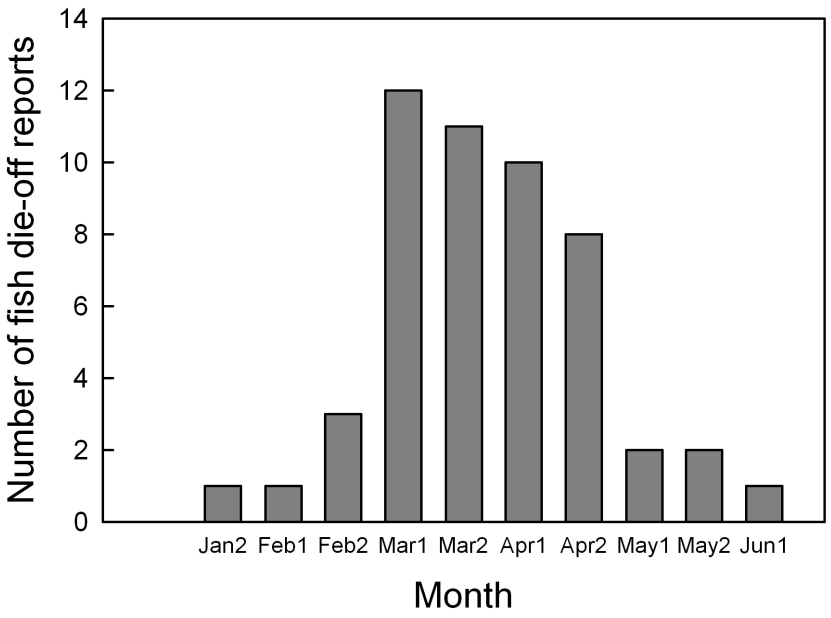

Figure 2. Cumulative numbers of fish die-off reports by 15-days periods between January 1 and June 15, 2007.

Question 7: When did such event occur? The 6 persons who answered yes to the question 6 reckoned that previous fish die-off occurred more than 15 years ago; 3 were even more precise and mentioned respectively that it happened 24, 28, and 36 years ago.

Question 8: Where did such event occur? In Band-e-Haibat for 4 people, in Band-e-Gholaman (36 years-ago) for 1, and in Band-e-Zulfiqar (24 years-ago) for 1.

Question 9: In which season did such event occur? During summer for 4 people or at the beginning of spring for 2.

Question 10: What is your hypothesis about the cause of fish die-off in 2007? Hypotheses were: 1/ Harsh winter that caused an in-depth freezing of the shallow water of Band-e-Gholaman; 2/ Ecosystem disturbed by spring flash floods; 3/ A wash-out of pesticides or ground fertilizers from surrounding fields; 4/ Water poisoning due to cloth washing activities along the shore.

Question 11: Any remarks? Fishes seemed lethargic before they died, swimming very slowly. Five people also mentioned that they found dead amphibians (frogs?) as well.

Water analyses

Drs Ali Madad and Hafizullah collected water samples on 3 June 2007 in Band-e-Zulfiqar, Band-e-Gholaman, Band-e-Haibat and Band-e-Qumbar, at two different locations in each lake. They stepped 2–3 m off the shore, and aspirated with sterile 20-cc syringes 2x40 ml water per site at 1 meter depth that were stored in EPA brown vials. We measured water temperature and pH on site, respectively with a copper-constantan thermocouple and an electronic thermometer (Omega Engineering, US) calibrated in 2005 against a NIST standard, and a pH-tester (Oakton pH 1, US) calibrated for pH=7.0 the same day.

Clockwise from top left: Plate 7. Shepherds in Band-e-Amir use local plants to treat livestock disorders. The widespread plant locally known as *pasha kushak* is used to treat intestinal disorders, Band-e-Amir, 30 May 2007. Identification of this species is pending. Plate 8. People in Band-e-Amir also use commercial medicines for their livestock such as those shown by this shepherd; fenbendazole 2.5% an anthelmintic medicine and a vaccine against enterotoxemia, Kopruk Dandaw-e-Payan pasture, 31 May 2007. Plate 9. A near-to-fledge chick of eastern rock nuthatch (*Sitta tephronata*), near Band-e-Qumbar, 28 May 2007.

Table 2. Results of water analyses carried out in Band-e-Amir on 3 June 2007.

Lake	Location of sampling	Ta (°C)	pH	Ammonia-Nitrogen	Nitrate-N	Orthophosphate	Transparency
Band-e-Zulfiqar	42S 336198 3856406 & 42S 335944 3856562	14.5	7.8	< 1ppm[1]	<0.2 ppm	<0.2 ppm	Clear
Band-e-Gholaman	42S 333396 3854535 & 42S 332708 3854394	13.5	8.1	< 1ppm	<0.2 ppm	<0.2 ppm	Clear
Band-e-Haibat	42S 335825 3855690 & 42S 334762 3854788	13.1	7.9	< 1ppm	<0.2 ppm	<0.2 ppm	Clear
Band-e-Qumbar	42S 333857 3845549 & 42S 333496 3854600	12.5	8.1	< 1ppm	<0.2 ppm	<0.2 ppm	Clear

[1]ppm = parts per million or mg/l

Samples were refrigerated at +6°C until 15 June when they were analyzed at WCS office in Kabul at a temperature of 24–29°C. We used a LaMotte water pollution detection kit (Lamotte, US) for ammonia-nitrogen, nitrates and orthophosphate measurements. For ammonia-nitrogen we used the octet comparator procedure and Nessler method (range 1.0 ppm to 8.0 ppm). For nitrates we used a quartet comparator with modified A.P.H.A. reagent system (range 0.2 ppm to 1.0 ppm). Eventually we also used for orthophosphates a quartet comparator with ascorbic acid method to produce a series of blue colors (range 0.2 ppm to 1.0 ppm). All measurements were made in duplicates. Results are provided in Table 2. They are averages.

Discussion

Although based on a small cohort of interviews, results of the questionnaire provide some interesting information on the 2007 fish die-off event. It presumably peaked in March, a period of increasing ambient temperature resulting in snow melting, thawing and increasing inflow of water into the lakes. It seems to have impacted the ecosystem at another stratum of vertebrate animal kingdom since amphibians appear to have also been affected. Although perhaps of different etiology, a similar episode was already observed in the past, presumably in another lake of the wetland complex and during a different season. Several events were suggested as possible causes of the 2007 die-off. Three of them were unlikely causes: a wash-out of fertilizers from surrounding cultivated fields into the lake, water poisoning due to cloth washing activities, and disturbance of the ecosystem by spring flash floods. Nitrates or phosphate as fertilizers or as by-products of washing powders may build-up in the aquatic food chain and participate in the eutrophication of shallow water lakes such as Band-e-Gholaman. However evidences of eutrophication were not observed during the mission. Nitrates could also be of direct toxicity to fishes when exceeding 50 mg/l, but our water analyzes performed one month after the event showed nitrate concentrations far below this level (Table 2). Phosphates are of questionable direct toxicity to fishes but definitely participate to the eutrophication process and alga bloom, two

phenomena that were neither observed during the mission nor reported to have occurred in March. In addition, Band-e-Gholaman bears a relatively abundant aquatic flora susceptible to trap excess of nitrates or phosphates in case of accidental release in the water system. Concerning pesticide toxicity, one cannot rule out a massive and then presumably voluntary disposal of pesticides into the lake, but such intentional action would have certainly been witnessed and reported to the local authorities. Eventually there is still the possibility of wash-out from surrounding cultivated lands of another chemical, presumably a pesticide, but such use remains unreported. Concerning disturbance of the ecosystem by flash-floods, it is probably a frequent phenomenon that concerns mountain lakes, including Band-e-Gholaman, in spring. However fish die-offs do not occur each spring. In addition spring flash-flood may also contribute positively to the natural life of this poorly studied aquatic ecosystem. Eventually, the hypothesis of an ecosystem disturbance due to an unusually cold winter appears as the most plausible. In cold climates, fishes retreat in winter into deeper waters, where temperature remains above 0°C. Fishes living in cold climates have developed a range of adaptations and adjustments allowing them to survive at temperatures approaching 0°C. Similarly amphibians such as frogs and toads living in cold climates usually hibernate during winter in the direct vicinity of water (under leaves, snow, or even underground) or under the frozen water body. Certain frog species have even developed physiological and biochemical traits that allow them to survive below 0°C, virtually frozen. It is however plausible that during a very cold winter, severe ice and snow limit sunlight penetration, leading to aquatic plant death and to oxygen depletion. A phenomenon reported in northern Canadian shallow lakes and sometimes called 'freeze-out' (C. Shank pers. comm.). Fishes may no longer find enough oxygen in frozen shallow lakes and die. Also during harsh winters temperature may decrease to lethal levels for fishes and amphibians. Unfortunately we dispose of no strong evidence other than oral reports of local people to confirm such climatic event. The mission was carried out after the peak of die-off and no climatic data are available for Band-e-Amir. Nevertheless two pieces of evidence support this hypothesis. First the timing of the event corresponds to thawing period, when dead fishes trapped in ice during winter are released in free water and individuals weakened by a long period of hypometabolism come to the surface. Second, interviewed people reported that dead fishes were often very hard and cold, as frozen in depth and often with missing scales on head and body, a deterioration that might have occurred during thawing process.

We lack evidences to conclude on the cause of fish die-off in Band-e-Amir at the beginning of 2007 although our observations suggest that hypotheses of eutrophication and direct poisoning by pesticides are unlikely. We suggest that harsh winter, as reported by local people, is the most likely cause of disturbance at ecosystem level and could have played an important role in the observed fish die-off. We recommend installing a weather station in the area (an ambient temperature logger has been installed by Dr. C. Shank in May 2007 in Jrukushan) as well as water temperature loggers at different locations and depths of the lake system.

Table 3. Bird species recorded during the mission, sorted and named following Rasmussen and Anderton (2005). Species on grey background are new records to the area.

Common name	Genus	Species	Cumulated number observed
Great cormorant	*Phalacrocorax*	*carbo*	1
Great egret	*Egretta*	*alba*	1
Mallard	*Anas*	*platyrhynchos*	4
Egyptian vulture	*Neophron*	*percnopterus*	2
Eurasian sparrowhawk	*Accipiter*	*nisus*	1
Long-legged buzzard	*Buteo*	*rufinus*	2
Common kestrel	*Falco*	*tinnunculus*	4
Common moorhen	*Gallinula*	*chloropus*	6
Common sandpiper	*Actitis*	*hypoleucos*	5
Eurasian coot	*Fulica*	*atra*	29
Rock pigeon	*Columba*	*livia*	4
Common cuckoo	*Cuculus*	*canorus*	1
Common swift	*Apus*	*apus*	5
Common hoopoe	*Upupa*	*epops*	2
Crested lark	*Galerida*	*cristata*	5
Horned lark	*Eremophila*	*alpestris*	16
Eurasian crag martin	*Ptyonoprogne*	*rupestris*	3
Barn swallow	*Hirundo*	*rustica*	2
White wagtail	*Motacilla*	*alba*	24
Citrine wagtail	*Motacilla*	*citreola*	26
Long-tailed shrike	*Lanius*	*schach*	3
Black redstart	*Phoenicurus*	*ochruros*	7
Isabelline wheatear	*Oenanthe*	*isabellina*	3
Eastern rock nuthatch	*Sitta*	*tephronota*	4
European linnet	*Acanthis*	*cannabina*	3
Twite	*Carduelis*	*flavirostris*	21
Crimson-winged finch	*Rodopechys*	*sanguinea*	7
Common rosefinch	*Carpodacus*	*erythrinus*	4
House sparrow	*Passer*	*domesticus*	56
Tree sparrow	*Passer*	*montanus*	52
White-winged snowfinch	*Montifringilla*	*nivalis*	21
Indian golden oriole	*Oriolus*	*kundoo*	1
Eurasian magpie	*Pica*	*pica*	29
Carrion crow	*Corvus*	*corone*	116
Hooded crow	*Corvus*	*[corone] cornix*	14

WILDLIFE OBSERVATIONS

We observed 35 bird species (Table 3), including four species new to the area (not included in Shank 2007a, b): the common moorhen (*Gallinula chloropus*), the common cuckoo (*Cuculus canorus*), the European linnet (*Acanthis cannabina*), and the twite (*Acanthis flavirostris*). Their status in Band-e-Amir is unknown but according to Rasmussen and Anderton (2005), the former two species would occur throughout the year in the area, the cuckoo would be a spring-summer visitor and the linnet a passage migrant. We found an unfledged chick of eastern rock nuthatch (*Sitta tephronata*), confirming the breeding status of this species in Band-e-Amir (Plate 9).

Two red foxes (*Vulpes vulpes*) were observed during the mission.

CONCLUSION

In Band-e-Amir, the abundance of domestic animals and the over utilization of forage resources have led to a relative impoverishment of range land and to a poor vegetation recovery rate (D. Bedunah pers. comm.). Livestock is impacted by a number of diseases that will not be contained on the long term without resolving overpopulation issues. Because of this intense grazing pressure presumably combined to overhunting practices, recent surveys indicate that wild ungulate populations in Band-e-Amir are severely depleted. Indeed we believe that nowadays wild ungulates are de facto excluded from livestock pasture areas, and cohabitation between these populations is probably a non-issue. In such situation the risk of disease spillover by direct contact between the two populations is very limited. However, we cannot exclude an indirect disease transmission via vectors, such as ticks. Although the improvement of livestock health status is unlikely to benefit the immediate survival of remnant populations of wild ungulates —essentially threatened by overhunting and overgrazing—, we believe that reducing the level of ectoparasite infestation in livestock would help control the risk of transmission of vector-born diseases to wildlife.

We found that a worrying source of people–wildlife conflict is livestock predation. Our investigations suggest that wolf predation accounted for up to 25% of reported deaths in livestock between spring 2006 and spring 2007. Such level of loss is certainly of significant impact in the subsistence economy of livestock owners and probably translates into retaliatory actions against wild carnivores.

Our understanding of the causes of the episode of fish die-off that occurred in Band-e-Gholaman at the beginning of year 2007 has improved. However we carried out our investigations long after the peak of fish mortality. We certainly need to improve our response capacity to emergency situations concerning environmental issues, perhaps through the creation of a task force involving governmental authorities and the development of local partnerships. Understanding the complexity of the ecosystem of Band-e-Amir, a unique area, will require more scientific and monitoring investments.

ACKNOWLEDGMENTS

We would like to thank Mr Taheer Atai, Director of Agriculture Department at Bamiyan for his facilitation work at obtaining authorization to investigate livestock health and fish die-off. We also thank all WCS staff at Kabul for logistical support throughout the mission, especially Mr Khoja Khalil, driver. Special thanks go to Mr Rohullah Sanger, Assistant GIS and remote sensing analyst at WCS Kabul, for producing the map presented in the report.

LITERATURE CITED

Ali, H. (2006). Floristic ethnobotanical studies in Ban-e-Amer national Parl Afghanistan. T4-4541 (AFG): Natural Resources and Poverty Reduction. Unpublished report, ADB, Afghanistan. 41 pp.

Davis, D. K., Quraishi, K., Sherman, D., Sollod, A., and C. Stem. (1995). Ethnoveterinary medicine in Afghanistan: an overwiew of indigenous animal health care among Pashtun Koochi nomads. *Journal of Arid Environments* 31: 483-500.

Dagnall, G. J. R. (1994). The role of *Branhamella ovis*, *Mycoplasma conjunctivae*, and *Chlamydia psittaci* in conjunctivitis of sheep. *British Veterinary Journal* 150: 65–71.

Dixon, D., Rudolph, K., Cowen, L., Hunter, D. L., and A. C. S. Ward. (2002). Viability of air-borne *Pasteurella* spp. Northern Wild Sheep and Goat Council 13. Rapid City, South Dakota, USA.

Jackson, R. M. and R. Wangchuk. (2001). Linking snow leopard conservation and people-wildlife conflict resolution: grassroots measures to protect the endangered snow leopard from herder retribution. *Endangered Species Update* 18: 138–141.

Jansen, B. D., Heffelfinger, J. R., Noon, T. H., Krausman, P. R., and J. C. deVos, Jr. (2006). Infectious keratoconjunctivitis in bighorn sheep, Silver Bell mountains, Arizona, USA. *Journal of Wildlife Diseases* 42(2): 407–411.

Jones, G. E. (1991). Infectious keratoconjunctivitis. In Diseases of Sheep, W. B. Martin and A. I. Aitken (eds.). Blackwell Scientific Publications, London, UK, pp. 280–283.

Knottenbelt, D. C. and R. R. Pascoe. (1994). A color atlas of diseases and disorders of the horse. Wolfe Publishing, 432 pp.

Lafferty, K. D. and L. R. Gerber. (2002). Good medicine for conservation biology: the intersection of epidemiology and conservation theory. *Conservation Biology* 16: 593–604.

Ostrowski, S. (2007). Wakhi livestock in Big Pamir in 2006. Unpublished report, WCS/USAID, Afghanistan. 49 pp.

Rasmussen, P. C., and J. C. Anderton. (2005). Birds of South Asia. The Ripley Guide. Vols. 1 and 2. Smithsonian Institution and Lynx Edicions, Washington, D. C. and Barcelona.

Richomme, C., Gauthier, D., and E. Fromont. (2006). Contact rates and exposure to interspecies disease transmission in mountain ungulates. *Epidemiology and Infection* 134: 21–30.

Schaller, G. B. (1998). Wildlife of the Tibetan Steppe. University of Chicago Press, Chicago, US, 373 pp.

Shank C. (2007a). Hazarajat component. 2006 Annual Report. Unpublished report, WCS/USAID, Afghanistan. 34 pp.

Shank C. (2007b). Bamiyan trip report, May 6–24. Unpublished report, WCS/USAID, Afghanistan. 17 pp.

Tschopp, R., Frey, J., Zimmermann, L., and M. Giacometti (2005). Outbreaks of infectious keratoconjunctivitis in alpine chamois and ibex in Switzerland between 2001 and 2003. *The Veterinary Record* 157: 13–18.

APPENDIX: SUMMARY OF DAILY ACTIVITIES

Sunday 27 May: Kabul to Bamiyan. The Ecosystem Health team drove in one WCS car from Kabul to Bamiyan, capital of Bamiyan Province in central Afghanistan.

Monday 28 May: Bamiyan. We attempted in vain to meet the governor of the province who was absent. We met with her secretary as well as with Mr Taheer Atai, director of Agriculture Department at Bamiyan. He helped us with administrative procedures and provided us with an authorization letter. In the meantime last logistical aspects of the mission were resolved and we drove in the afternoon to Band-e-Amir where we rented a room at the 'Hosseini hotel'.

Tuesday 29 May: Band-e-Amir. We visited livestock herders at Kopruk Dandaw. In the afternoon we briefly visited the shores of Band-e-Gholaman lake to assess the presence of dead fishes.

Wednesday 30 May: Band-e-Amir. We visited livestock herders/owners at different localities: Kopruk Dandaw, Kopruk Yahak-e-Bala, Kopruk Dandaw-e-Payan, and Abqul Dandawak-e-Bala.

Friday 31 May: Band-e-Amir. We carried out field work with livestock herders at Kopruk Dandaw-e-Payan.

Saturday 1 June: Band-e-Amir. We carried out field work with livestock herders at Abqul Dandawak-e-Bala.

Sunday 2 June: Band-e-Amir. We carried out field work with livestock herders at Khakdaw-e-Bala.

Monday 3 June: Band-e- Amir. We carried out field work around lakes to investigate the recent episode of fresh water fish die-off.

Monday 4 June: Band-e-Amir to Bamiyan. We drove back to Bamiyan.

Tuesday 5 June: Bamiyan. We unsuccessfully attempted to visit the governor of the province and investigated the availability of a number of medicines in veterinary and human drugstores in Bamiyan.

Wednesday 6 June: Bamiyan to Kabul. We drove uneventfully from Bamiyan to Kabul (reached at 13:30).

TABLE OF CONTENTS