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The Persian Leopard





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Original contributions and short notes about wild cats are welcome

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Cover Photo: Persian Leopard in Kazakhstan © USNR/CADI/ACBK, camera trap picture taken 1 January 2020, photo was provided by Tatjana Rosen

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Distribution and status of the Persian leopard in the eastern part of its range

The present report uses published and grey literature and expert observations to review the distribution and conservation status of the leopard *Panthera pardus* in Afghanistan, Pakistan, Tajikistan and Uzbekistan. The study confirmed the presence of the species in the central and eastern parts of Afghanistan, in lower Himalayan range and south western borders of Pakistan, and did not identify confirmed contemporary records (>2000) from Tajikistan and Uzbekistan where nowadays the species is believed to be extinct (Tajikistan) or quasi-extinct (Uzbekistan). The present study provides novel information on the species distribution in Pakistan outside the Himalayan range, and confirms its wider distribution in Afghanistan. The leopard population size in the assessed region remains unknown. Poaching has been identified as the one outstanding, most critical threat that significantly affects leopards on a large scale and across all the assessment area. In north Pakistan and east Afghanistan this threat very likely results from the rapid loss of its preferred forest habitat and primary natural prey-base. Infrastructural development such as fences along the international Pakistan-Afghanistan border presumably contribute at further fragmenting the leopard habitat and isolate the species in more or less disjunct sub-populations vulnerable to depleted genetic variation and chronic stress. While across the region science and awareness are increasingly supported by proactive and alerting conservationists, the implementation of active and effective conservation measures remains vastly underdeveloped and is complicated by regional political instabilities, such as in Afghanistan, where the recent change in governing leadership might require new approaches to support wildlife conservation.

In the present report, the eastern part of the Persian leopard distribution range is the Asian region extending from Afghanistan in the west to Pakistan in the east and including also Tajikistan and Uzbekistan. Recent information on the distribution, ecology and conservation status of the leopard in the region is scarce outside Pakistan. This is due in part to the region remoteness and limited national investments in wildlife studies, but also in Afghanistan to a lack of detection efforts because of decades of political unrest or armed conflicts (e.g., Smallwood et al. 2011, Gaynor et al. 2016). It has been presumed that the leopard distribution range in the assessment area, as in most of Asia, is fragmented and that populations are declining (Jacobson et al. 2016). At the 13th Conference of Parties to the Convention of Migratory Species CMS in February 2020 the Range States have agreed to include the Persian leopard under the Central Asian Mammals Initiative CAMI, which coordinates conservation activities, cross-border coopera-

tion and efforts to address major threats to a selection of focal species and landscapes in Central Asia. In the present chapter, a broad representation of leopard specialists have evaluated the recent information on the geographic distribution and habitat, prey and threats of Persian leopard in the eastern part of its distribution range and have created a foundation for the future development of an action plan piloted by the CMS and the International Union for the Conservation of Nature IUCN.

Methods

We used multiple data sources to consolidate information on the leopard in Afghanistan, Pakistan, Tajikistan and Uzbekistan. The assessment used a standardised questionnaire developed by the IUCN SSC Cat Specialist Group CSG and completed by co-authors based on original data published in peer-reviewed, grey literature and unpublished information collected from reliable sources and often

released with photographs on social media networks. To characterise leopard habitats, feeding habits, threats and national conservation statuses we reviewed about 40 contemporary and old publications in English and Russian. The present assessment which is to guide a conservation action plan focuses only at “contemporary” records (>2000). Leopard records were categorised according to their robustness based on Status and Conservation of the Alpine Lynx Population (SCALP) criteria: C1 (“Hard facts”, verified and unchallenged observations), C2 (“confirmed observations”, e.g. verified reports by experts/trained staff”), or C3 (“unconfirmed observations”), adapted from Molinary-Jobin et al. (2012). To produce the regional distribution map, we overlaid the C1, C2 and C3 georeferenced records with polygon shapes according to the IUCN Red List distribution categories: Extant (the species is known to occur), Possibly Extant (the species may possibly occur or likely occurs but the area could not be surveyed, such as in Afghanistan where, for security reasons, vast areas have not been surveyed since 2000), Possibly Extinct (the species is likely to be extinct in the area), and Extinct (the species is thought to be extirpated in the area). In Pakistan Extant and Possibly Extant polygons were drawn based on presence evidence, published peer-reviewed information and habitat suitability. In Afghanistan where most verified records (C1) could not be more precisely georeferenced than the district level (i.e., first territorial sub-categorization within the administrative province), the district polygons were overlaid by a distributional gap analysis geographic model produced by the Wildlife Conservation Society WCS in 2009 that delineated higher and lower priority areas of interest as suitable habitat for the leopard (Kanderian et al. 2009, Fig. 1). Final Extant polygons corresponded to suitable habitat areas within the districts with C1 and C2 records. Possibly Extant polygons were drawn manually based on the possibility of leopard presence in these areas. Areas along Iranian and Turkmen international borders were considered as Possibly Extinct for resident leopard population. In Uzbekistan areas encompassing C3 records were categorised as Possibly Extinct.

Taxonomical remarks

The revised taxonomy of the Felidae carried out by the Cat Classification Task Force of the CSG proposed to include *ciscaucasica* and *saxicolor* subspecies under *Panthera pardus tulliana* (Valenciennes, 1856) as the prior sy-

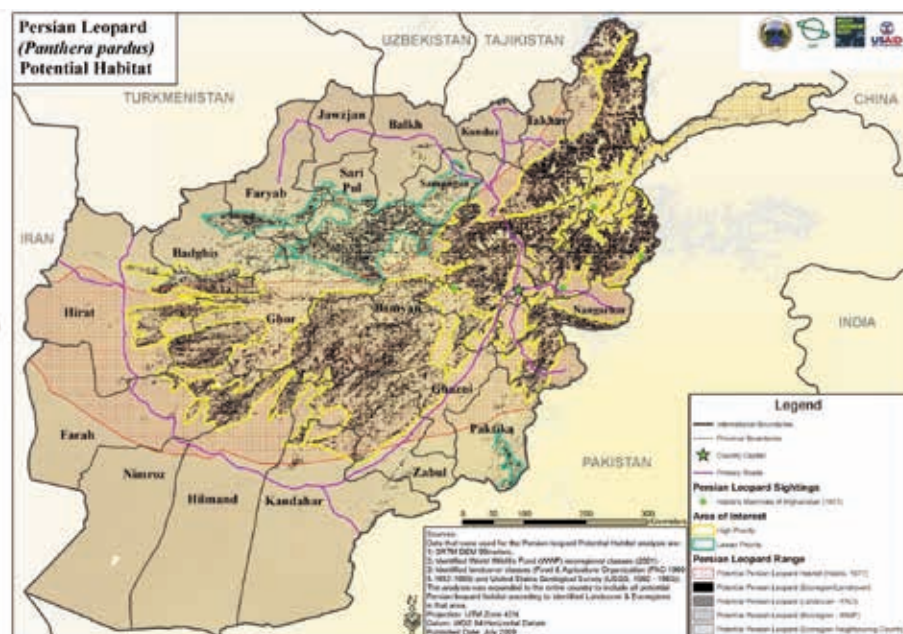


Fig. 1. Persian leopard potential habitat across Afghanistan, with areas of interest (high in yellow and lesser in green) displayed based on a preliminary gap analysis modelling carried out by Kanderian et al. (2009).

nonym, with a distribution extending from Turkey in the west to Pakistan to the east (Kitchener et al. 2017). This subspecies (known as the Persian leopard) is distinct from *Panthera pardus fusca* (Meyer, 1794) distributed across the Indian subcontinent, Burma and western China. While the present study confirms the presence of the leopard *Panthera pardus* in Afghanistan and Pakistan, there remain uncertainties on the taxonomy of leopards in Pakistan, a contact zone for the subspecies *P. p. tulliana* and *P. p. fusca* (Jacobson et al. 2016). Based on a very limited number of samples ($n=2$), the genetic information retrieved from leopards in Balochistan (Baluchistan), south-west Pakistan, suggests that this subpopulation is closely related to *P. p. tulliana* (Uphrykina et al. 2001, Jacobson et al. 2016, Asad et al. 2019a). However, in the north Indus area the hypothesis that the Indus River separates both species (Khorozyan et al. 2006, Jacobson et al. 2016) has recently been weakened by a study that showed the presence of both subspecies east of the Indus where only *P. p. fusca* was assumed to be present (Asad et al. 2019a, Fig. 2). The geographical extent of this overlap will have to wait for further genetic investigations to achieve clarity, but it is possible that *P. p. tulliana* and *P. p. fusca* haplotypes extend more to the east and west, respectively, than anticipated. Northern Pakistan appears therefore as an area of potential high gene flow between these two subspecies (or two subpopulations) assuming no mating restrictions exist (Asad et al. 2019a). However, the still imperfect understanding of subspecies and subpopulation situations in Pakistan should not shadow the fact that leopards, regard-

less of their genetic profiles are all Critically Endangered in Pakistan (Sheikh & Molur 2004) and remain in great need of conservation. In the course of this regional assessment, we have therefore incorporated all recent leopard records from Pakistan regardless of their possible affiliation to two different subspecies.

Distribution and habitat

We gathered a total of 182 locality records in the current assessment out of which 132 and 50 were points and polygon data, respectively. We could confirm 156 as C1, 6 as C2 and 20 as C3. Pakistan is undoubtedly the stronghold of the species in the region with 159 location points. Uzbekistan provided 13 C3 location records, Afghanistan 10 C1, C2, and C3 location points, and Tajikistan nil (Table 1). In Pakistan data retrieval varied according to the geography and time. Eighty seven percent of C1 and C2 locations with known dates in Pakistan referred to the period 2019–2021, suggesting a collection bias towards most recent records, probably as a result of more readily accessible information to assessors and perhaps also increased detection/reporting. It is also interesting to note that the majority (82.4%) of location data were collected from the north Indus/Himalayan region encompassing Azad Jammu and Kashmir (87), Khyber Pakhtunkhwa (35), Islamabad Capital Territory (8) and Gilgit Baltistan (1). In contrast only 17.6% of location data came from the rest of the country in Balochistan (20), Sindh (6), and Punjab (2). Without doubt these geographical differences highlight a far greater detection and reporting effort in the Himalayan landscape of north Pakistan than in the rest of the country

and possibly also a higher leopard abundance in this area. Because of the known scarcity of data from the south of the country, assessors have made great efforts at retrieving information from this area. As a result, the dataset for the south of Pakistan, presumably referring to *P. p. tulliana* only (see taxonomical note), is probably the most exhaustive in recent years, whereas admittedly data collection from the north has been less exhaustive than anticipated. Yet, because of the relatively good geographical coverage of location reports in the north, it is unlikely that missed information would have changed the proposed final distribution map significantly. In contrast, far fewer location data were collected from Afghanistan and all but one (i.e., Moheb and Bradfield 2014) resulted from a passive, hence presumably more random-ised, information collection process essentially vectored by social media (6/7 of reported C1 records). The geographical distribution of leopards in this country is therefore far less detailed and extensive than in Pakistan but presumably less biased towards a specific area, assuming a similar access to social media communication across the country. No confirmed data locations were retrieved from Tajikistan and Uzbekistan.

Afghanistan

The distribution of the leopard in Afghanistan is imprecisely known. Habibi (2003) citing mostly Hassinger (1973) and adding information he collected prior to the Soviet invasion in 1979, reported that the species occurred in all of the major dry mountain ranges in Afghanistan, including the Hindu Kush, Koh-e

Baba, Koh-e Paghman and Safed Koh ranges of the central highlands, the Wakhan District in Badakhshan Province and also in the lowland riparian forests of Darqad area in Takhar Province. Using collated habitat descriptions, important location data from field surveys or community questionnaires, two forms of land classification system, and a number of environmental refining factors, WCS conducted in 2009 a distributional gap analysis modelling for the government of Afghanistan that allowed to delineate higher and lower priority areas of interest as suitable habitat for the leopard (Kanderian et al. 2009, see also methods). Unfortunately, the chronic insecurity that prevailed for the following 13 years in many parts of the country hindered the extend and comprehensiveness of zoological investigations that could be safely undertaken to ground-truth the proposed distribution model. However, the contemporary verified and confirmed records (C1 and C2) have so far not contradicted the gap analysis model, and support that the central part of the Hindu Kush Mountain range and its offshoots to the east, are two main strongholds of the species in Afghanistan (Fig. 2). It includes monsoonal western Himalayan forests in the province of Nuristan (Karlstetter 2008), dry steppe and rocky mountainous outcrops in Bamyan Plateau protected area, Bamyan Province (Moheb & Bradfield 2014), Farah (2016), Daykundi (2018), Ghor and Laghman (2021), and dry open woodlands in broken hilly areas of Nangarhar (2020) provinces. Although photographic evidence and DNA barcoding failed to confirm the presence of the Persian leopard and snow leopard *Panthera uncia* in Nuristan (Stevens et al. 2011), the leopard species was among those reported as most often sighted by local residents (73%; Karlstetter 2008), and the photograph of a specimen recently killed near Sar-e Pul Village, Wama District, was released on social media in late February 2022 (Z. Moheb, pers. comm.). In contrast, because few residents (<15%) reported the presence

of the leopard, and there is possibility of confusion with the snow leopard, its presence in the dry mountains of Darwaz District in north-east Afghanistan remains questionable (Moheb & Mostafawi 2013). Based on the confirmed presence of leopard in immediately adjacent locations of Pakistan, the assessment has delineated 'Possibly Extant' areas along the international border with Pakistan between latitudes N 30°56' and N 33°49' and in the northwestern part of the country in Herat Province, the area along the international borders with Iran and Turkmenistan does not seem to present any longer suitable habitat (Kanderian et al. 2009, Fig.1), and resident leopards have been considered Extinct in this area. The vast Possibly Extant area in the central Hindu Kush encompasses several Extant polygons and overlaps to a great extent suitable habitat area proposed by Kanderian et al. (2009). Finally, in Wakhan District, where high altitude dry and cold habitat prevails, the WCS has deployed camera traps in a variety of habitats and altitudes between 2011 and 2020, but to no avail for Persian leopard despite more than 7,000 wildlife capture events, including numerous snow leopard captures (S. Ostrowski pers. comm.), supporting that the Persian leopard is currently absent from this area. Records gathered during the last decade, confirm that in Afghanistan the leopard is present in a range of forested to open mountain habitats, including in areas of the central Hindu Kush Mountain range where its occurrence had never been confirmed in the past. However, because of the great variance in detection efforts according to geographical areas and security conditions, our understanding of the species distribution in Afghanistan remains very patchy, as reflected in the proposed distribution map (Fig. 2).

Pakistan

Pakistan provided the largest number of verified records of leopard in the assessed area, but the species current distribution still re-

mains partially understood owing to varying detection efforts. Based on the global trend affecting leopard populations in Asia, the leopard population in Pakistan is likely to be fragmented and possibly with depleted genetic variation (Asad et al. 2019a). In this country, leopards were once widely distributed across the country in a variety of habitats and regions in Azad Jammu and Kashmir AJK, Balochistan, Khyber Pakhtunkhwa KP (before known as North-West Frontier), Punjab, Sindh (Roberts 1997). Nowadays the species seems to be more sparsely distributed across the country. Recently AJK and KP provinces, where *P. p. tulliana* and *P. p. fusca* intermingle in distribution (Asad et al. 2019a), have reported the highest number of contemporary records in particular from the Himalayas, Hindu Raj mountains and Hindu Kush mountains. The species occurs in the lower arid hilly areas to the Himalayan monsoonal forest areas at high altitude, and in the fragmented hilly parts all over Swat, Waziristan, Galliat, Kohistan, Abbottabad and Kaghan valley (Kabir et al. 2013). The species is also found in forested hilly areas of Abbottabad, Mansehra, Shangla, Battagram, Haripur, Kohat, Kurram, Orakzai Swat, Kohistan, and Upper Dir. In 2017 WWF-Pakistan photo-captured a leopard in a typical snow leopard habitat in Chitral Gol National Park, KP. In AJK leopards are found in all hilly and forested areas in districts of Kotli, Mirpur, Bhimber, Muzaffarabad, Neelum, Hattian Bala, Haveli, Bagh, Sudhanoti and Poonch. The species has also been reported by a joint study of the Snow Leopard Foundation (SLF) and Islamabad Wildlife Management Board in Margalla Hills National Park in Islamabad Capital Territory, in the foothills of the Himalayan range. In 2021 during a camera trapping study of northern red muntjac *Muntiacus vaginalis* in the area, leopards were photographed at eight out of 19 different camera trap locations (Muhammad Kabir/Wildlife Ecology Lab/ UOH, pers. comm.). Noticeably, in AJK leopards are frequently encountered in areas relatively distant from their natural habitats, particularly in agriculture lands where they rest during day to enter rural semi-urbanised areas at night, and prey on livestock and dogs (M. Kabir pers. comm.).

In Gilgit Baltistan (northernmost part of Pakistan) there are unverified reports of leopard presence near Chilas in Diamer District. In 2018, a camera trapping study conducted by SLF confirmed the presence of a leopard in Passu Valley at an elevation of 3,000–3,300 m. Both common and snow

Table 1. Number of contemporary (>2000), C1 (“verified”), C2 (“confirmed”) and C3 (“unconfirmed”) occurrence records of the leopard (*Panthera pardus*) compiled in this study.

Country	Point locations			Polygon locations		
	C1	C2	C3	C1	C2	C3
Afghanistan	1	0	1	6	1	1
Pakistan	127	3	0	22	2	5
Tajikistan	0	0	0	0	0	0
Uzbekistan	0	0	0	0	0	13
Total	128	3	1	28	3	19

leopard were photo-captured at this station. The presence of the common leopard in the snow leopard habitat in Chitral Gol National Park in 2017 and Passu Valley in 2018 suggests a possible expansion of the former species to higher, cooler elevations. In Punjab, leopards are still found in Murree hills, Kotli Sattian, Kahuta area of district Rawalpindi and possible Kala Chita hills. Its survival in the salt range in Punjab is not clear, though it is claimed to still be present in small numbers. Leopards are less recorded from elsewhere in Pakistan although this could result from lower detection efforts. We have gathered patchily distributed contemporary records of leopards from broken and dry hilly mountainous areas of Balochistan (Fig. 2) and Sind, and forested hills in Punjab. The leopard is found in the Kirthar Mountain Range of Sind and the Toba Kakar, the Makran and the Suleiman ranges of Balochistan. A recently photographed specimen in Hazarganji-Chiltan National Park by Balochistan Wildlife Department, in the Sulaiman mountain range suggests that the species uses a desertic habitat with localised dry and scattered woodlands in this remote area. Leopards in Pakistan seem to adjust fairly efficiently to a wide range of habitats from lowland tropical humid forests to deserts and dry steppes, scrub, to mid and high elevation forests up to the tree limits (Shehzad et al. 2015). The protected areas in Pakistan with authenticated records of leopard include Margalla Hills, Ayubia, Murree-Kotli Sattian-Kahuta, Ayubia, Machiara, Pir Lasorsa, Tolipir, Mahasheer, Ghamot, Musk deer, Deva vatal, Hazarganji-Chiltan and Chitral Gol national parks.

Tajikistan

Verified (C1), Confirmed (C2) and unconfirmed (C3) contemporary data (>2000) on the species were not recorded in Tajikistan, and the species, as a functional ecological entity, is probably extinct in this country. Recent records in Babatag, a mid-mountain range consisting primarily of loess hills and rugged dry ravines in Uzbekistan, bordering Tajikistan to the southwest, are unconfirmed. On the Tajik side the extreme scarcity of water for most of the year combined to the lack of claims of livestock loss to leopard predation despite large flocks pasturing the area over winters, and the declining number of large wild prey species (i.e., urial *Ovis vignei*, wild boar *Sus scrofa* and possibly goitered gazelle *Gazella subgutturosa*) advocate for the species no longer residing in this area.

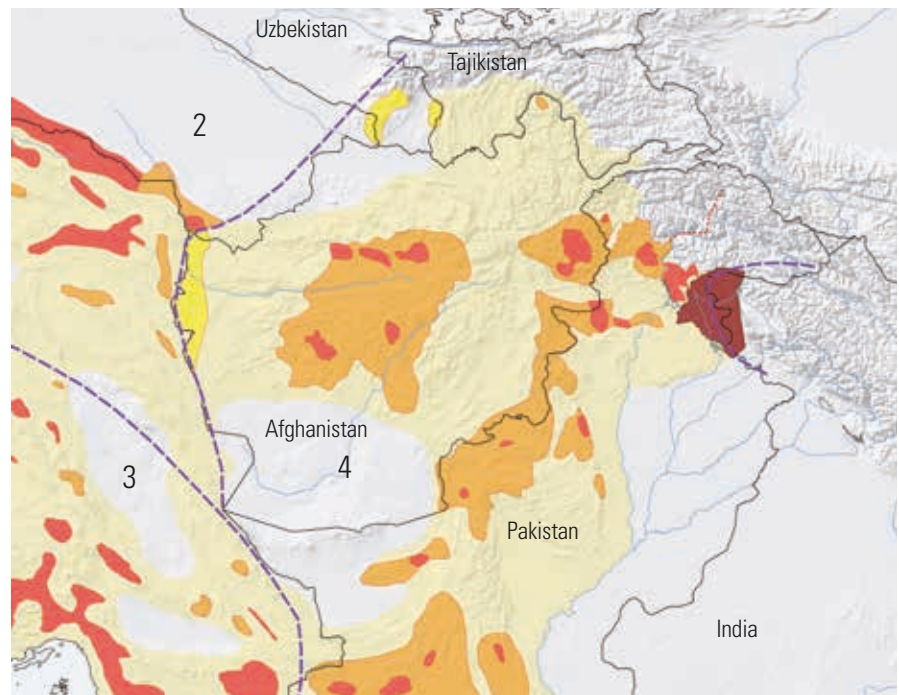


Fig. 2. Geographic distribution of the leopard (*Panthera pardus*) in Afghanistan, Pakistan, Tajikistan and Uzbekistan (4) mapped according to contemporary (>2000) occurrence records collated in this study. Red = extant, orange = possibly extant, dark yellow = possibly extinct, light yellow = extinct, black shaded red area = overlapping Extant area of *P. p. fusca* and *P. p. tulliana*, violet lines = regional division. 2 = Alborz-Kopetdag, 3 = Zagros range, and 4 = eastern range. Map courtesy to Peter Gemgross, based on Ostrowski et al. (2022).

Uzbekistan

Assessors did not recover verified and confirmed (C1, C2) contemporary data (>2000) on the species in Uzbekistan. All contemporary records were unconfirmed (C3) and originated from three mid-mountains ranges; Babatag, and the complex composed of Kugitang and Boysun, in the far southeastern part of Uzbekistan bordering Afghanistan, Tajikistan, and Turkmenistan (Marmazinskaya 2016, Marmazinskaya and Abdunazarov 2019). The reliability of the record from Boysun is questionable due to possible confusion with the snow leopard. The habitat is composed of deep ravines and rocks with bare vegetation and open woodlands. All these records refer to direct sightings by local people including shepherds and foresters but lack supportive documentation. If any Persian leopards still survive in south-east Uzbekistan, there are to be very few, and in absence of immigration of new specimens the functionality and survival of this population would be in immediate jeopardy.

Prey

Leopards are extremely opportunistic, killing virtually everything easy to capture and available in number in their environment

(Hunter 2011). Almost nothing is known about the leopard's diet in Afghanistan but the species occurs in areas where one or more of the following four species of mountain ungulates occur; Himalayan ibex *Capra sibirica*, wild goat *Capra aegagrus*, urial *Ovis vignei*, and markhor *Capra falconeri*, as well as a variety of small prey species including carnivores and rodents, lagomorphs, birds and reptiles. Recent events of capture and killing of leopards in Afghanistan resulted from them allegedly preying on domestic sheep and goats. Because the eastern part of its Afghan distribution range is ecologically similar to its range in northern Pakistan, particularly in KP, the leopard diet can probably be inferred from extensive studies carried out in Pakistan (Dar et al. 2009, Kabir et al. 2013, Shehzad et al. 2015, Ahmad et al. 2016, Hussain et al. 2019, Khan et al. 2018, Khan et al. 2020, Akrim et al. 2021). All these authors point out that in Pakistan domestic animal species, including cattle, buffalo, sheep, goat, horse, donkey and dog are usually significant part of leopard's diet. Among medium- and small-sized wildlife preyed upon by leopards the most frequently reported in northern Pakistan are Himalayan ibex, wild boar, rhesus monkey *Macaca mulatta*, Himalayan gray langur *Semnopithecus*



Fig. 3. An adult Persian leopard with an amputated left front limb at Kabul Zoo, April 2021. The animal was snared with a gin trap by villagers in Laghman Province, Afghanistan, who alleged that the animal had killed their sheep and goats in March 2021 (Photo WCS/Ali Madad Rajabi).

schistaceus, Himalayan goral *Naemorhedus goral*, northern red muntjac, Kashmir musk deer *Moschus cupreus*, as well as a variety of small carnivores, lagomorphs, rodents and birds. In contrast very little recent information is available on the diet of leopards in Balochistan and Sind. Roberts (1977) reported that wild goat, markhor, urial and porcupine *Hystrix indica*, were amongst favorite wild prey species in these parts of Pakistan and also underlined that leopard in the south and southwest is notorious for killing a variety of livestock as large in size as adult dromedaries.

Threats

The assessment did identify poaching as the one outstanding, most critical threat that significantly affects leopards on a large scale and across all the assessment area. Primary reasons for leopard killing vary, are often multiple and operate in anticipated or opportunistic associations. They include retaliation over livestock predation, intentional killing to sell the skin or body parts, self-defense and probably more frequently than usually reported killing out of fear or pride in the course of an opportunistic encounter. In Afghanistan and Pakistan killing as retaliation to livestock loss seems preponderant, and possibly also in the past in Tajikistan and Uzbekistan as a result of opportunistic encounters with hunters, armed shepherds or border military. In Afghanistan the three most recent (2021 and 2022) confirmed records of leopard presence were linked to a poaching case in Ghor, a foot-snare capture in Laghman (Fig. 3), and a poaching case in Nuristan, in all cases these intentional retaliatory actions resulted from the leopard

killing sheep and/or goats (Z. Moheb, pers. comm.). In Pakistan destruction of leopards in retaliation of livestock or human predation seems widespread (Dar et al. 2009, Kabir et al. 2013, Akrim et al. 2021; Fig. 4). Lodhi (2007) compiled data from the Wildlife Department of Pakistan since 2000 on human-leopard conflict in and around Ayubia National Park and reported nine human deaths by leopards, 30 leopard killings, and 82 instances of livestock predation. Kabir et al. (2013) reported 301 livestock killed between June 2007 and August 2008 by leopards in and around Machiara National Park and in another study in the same area Dar et al. (2009) found that leopards were responsible for the majority (90.6%) of the 363 livestock killed, mainly goats (57.3%) and sheep (27.8%). In Galliat region including Ayubia National Park, livestock represented the staple of the leopard diet, with a frequency always greater than 80%, goat was not only the most frequently used food item, but it also constituted the large majority of the consumed volume (Khan et al. 2020). Respondents to a questionnaire survey in this area lost 209 domestic animals to leopard attacks, primarily goats (78.5%), followed by dogs (11%; Akrim et al. 2021). Results of these studies and dietary analyses based on fecal investigations support that leopards forage consistently and significantly on domestic animals in several areas of the Himalayan range (Chattha et al. 2015, Shehzad et al. 2015, Akrim et al. 2018). Inevitably such high level of livestock predation generates a great deal of resentment and hostility within affected rural communities although people often recognise the species as protected under national law

(Dar et al. 2009). Between 2000 and 2010, Kabir & Waseem (2010) reported six retaliatory killings in Pir Lasora National Park, and Kabir et al. (2013) mentioned four such instances in Machiara National Park between June 2007 and August 2008. In Kashmir four leopards were killed in retaliation by the local community at Ghaziabad, Narakot, Surang and Rangla in 2009–2010 (Bibi et al. 2013), 17 leopards killed between 2000 and 2016 in Pir Lasora National Park (Kabir et al. 2017), on average 2.5 leopards/year in the Abbottabad District alone (Khan et al. 2020), and at least 6 leopards/year at the national level (105 individuals from 1998 to 2015; see Khan et al. 2018). Retaliation to attacks on humans and destruction to collect and sell the high value skin or other body parts are also described by Irshad et al. (2018) and Asad et al. (2019b) in Pakistan, and several surveys carried out in Afghanistan have confirmed that leopard skins are still offered for sell in this country (Mishra & Fitzherbert 2004, Johnson & Wingard 2010), although in fewer numbers than in the past (Shoemaker 1993).

Natural prey depletion is also a main threat to leopards in the studied area presumably at the origin of leopards shifting their diet towards more vulnerable and 'easy' domestic prey. In Asia the historic range of the leopard has decreased by 80% (Jacobson et al. 2016). As for mountain-dwelling ungulates, the populations of Himalayan goral, the Kashmir musk deer and the northern red muntjac have declined or disappeared locally, which has narrowed the prey spectrum for large carnivores in general and more specifically leopards targeting mid-sized prey species (Anwar et al. 2011, Shehzad et al. 2015, Khan et al. 2018). In Uzbekistan overhunting of markhor and urial, two key prey species for leopards, might have been the main driver to the species possible extinction. A main seminal threat to leopards in the Himalayan/Indus range in north Pakistan and in the eastern offshoots for the Hindu Kush in Afghanistan is degradation and loss of forest habitat, which in turn have resulted in wild prey loss and increased conflicts with humans (FAO 2007, Karlstetter 2008, Ripple et al. 2014). Isolation resulting from fragmentation of habitats further threatens leopards in the east part of the eastern range by presumably reducing genetic diversity and increasing deleterious edge effects (O'Brien & Johnson 2005, Balme et al. 2010). Locally, linear infrastructure contributes remarkably to this ongoing fragmentation process, such as along the Afghanistan-Pakistan border,

where Pakistan has been erecting a fence since 2017 that renders movements of leopards and prey very difficult. Even so leopards are excellent climbers the new border fence could be a significant barrier to them and prey. It is made of two sets of 4-meter-high chain-link fences topped with razor wire separated by 2-meter space that has been filled with concertina wire coil. Recently Pakistan army has claimed that it completed 90% of fence along Afghan border (Yousaf 2021), though it is not clear which segments of the 2,611 km of the international border with Afghanistan are concerned by this 'closure' operation. Fences along larger areas are widely considered as ecological barriers (Xu et al. 2021) and the fences along the Afghan-Pakistan border could not be an exception.

Finally, the ongoing aridification of the Persian leopard landscape, both due to increasing human footprint and climate change is a significant threat to a species dependent in part of its range on moist ecosystems and in the most arid parts of its distribution on sources of drinking water that become inaccessible because of droughts and human use.

Future research and conservation

Although the Persian leopard is officially protected in the four countries of its eastern range its protection remains scarcely implemented. Significant research attentions have been devoted to the leopard in the north-Indus region of Pakistan (Fig. 5) and, as a result, current status is better understood in this part of the country. Similar efforts in the future should be devoted to other areas of Pakistan and par-

ticularly Balochistan and Sind provinces. Continuing research and monitoring of surveyed areas in the north is high priority and should in the future inform through modeling efforts leopard's suitable habitat, distribution and occupancy, and perhaps also abundance trends. While in Pakistan the impetus in science and monitoring is largely positive, and served by a competitive and pro-active community of scientists, the concrete actions at conserving leopards and reducing human-leopard conflicts remain comparatively less developed. There is great need at developing a national conservation action plan for the species and piloting on the ground practical and socially acceptable measures to reduce conflict levels and favor a safer cohabitation with leopards. Such an approach that aims at changing the behaviour of a majority of people will require protracted investments supported by a consistent political will from the government and genuine implementation of existing policies. The situation of the leopard in Afghanistan remains poorly known and fragmentary. In August 2021, Afghanistan witnessed a historical change in its national governance. The situation, that has unfolded at unexpected speed, resulted on 15 August in the fall of the elected government to the benefit of a new regime led by the Taliban. This situation has acted as a brake, hopefully transitorily, on the fledging efforts of the country at protecting wildlife. The new administration will have to enact effectively existing environmental policies, and address in the challenging context of chronic food insecurity and degraded economy, threats on biodiversity and the en-

vironment from people using unsustainably natural resources for food or incomes. Ideally a blanket hunting ban, as enacted in the early 2000's, and control over weapons should be called for as beneficial to security and wildlife. Concomitantly the greater engagement of academics and the development of participatory and citizen science approaches to monitor leopard presence and collect, store information on human-leopard conflicts could be explored to the best extent possible. In this country the future adoption of human-leopard conflict resolution practices will likely benefit to some extent from international aid and support.

In Uzbekistan where the leopard is on the brink of extinction, it is urgent to organise a specific and comprehensive field survey, using modern methodology, to clarify the situation of any remaining leopard individual in the country, and whether transboundary movements to Tajikistan and Turkmenistan exist.

Conclusions

The number of leopard records was the highest in Pakistan presumably because detection efforts have been more consistent in space and time. This is mostly because there is increased awareness of the species, most of the country is accessible to a highly capacitated active scientific community, and possibly also because leopards remain relatively abundant close to large urban areas (e.g., Islamabad Capital Territory). In Pakistan the assessment confirmed broadly what has recently been published on the leopard distribution in the north of the country (e.g., Jacob-



Fig. 4. An adult common leopard killed by people in Sudhnoti District, Azad Jammu and Kashmir, Pakistan (left), and another leopard which was roaming free in Samani area, Bhimber District, Azad Jammu and Kashmir, Pakistan, and was killed, for no clear reasons, by a mob from surrounding villages (right; Photo A. Mughal, 2021).

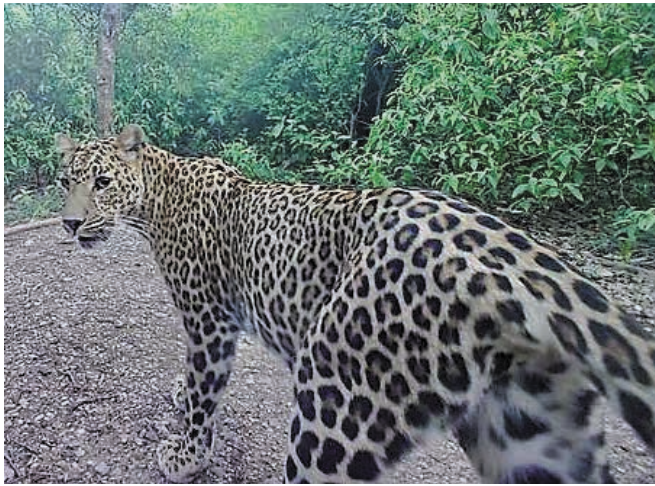


Fig. 5. Camera-trapped leopards in forested areas in Margalla Hills National Park, Islamabad Capital Territory, Pakistan (left) (Photo Islamabad Wildlife Management Board), and in Hindu Raj Mountain range, Khyber Pakhtunkwa, Pakistan (right) (Photo Wildlife Ecology Laboratory, University of Haripur), 2021.

son et al. 2016), and added a rather unique set of contemporary records for the south part of the country, especially in Balochistan. In Afghanistan, although many areas seemingly suitable to leopards have remained unexplored because of poor security condition, recent records mostly vectored through social media have provided unique new locations of leopard presence. The lack of confirmed records from Tajikistan and Uzbekistan despite efforts at documenting any evidence of presence, combined to the occurrence of large numbers of livestock with no reports of possible leopard predation (in Tajikistan) signal a local extinction or quasi-extinction situation of the species. This assessment supports that killing by herders or other armed people is the one outstanding and critical cause of mortality for leopards in the eastern part of its range. Retaliation resulting from livestock destruction seems to be the main driver for leopard killing in the region. Exploitation of the species for its fur and other body parts could also be a significant threat in the region although the nature of this exploitation (organised vs. opportunistic), scale, and trends are poorly understood. The distribution map we proposed for the leopard in the region supports that leopards occur in habitat patches, and the extent to which anthropogenic activities impact the persistence and connectivity of these patches is not known but likely significant, such as in the case of the border fence currently erected by Pakistan along its international border with Afghanistan. Based on this regional evaluation, we suggest that the leopard should be classified as conservation priority species in Pakistan and Afghanistan where the situation should be actively monitored including

through citizen and participatory science initiatives, and human-wildlife conflict innovative actions implemented. A specific comprehensive field survey in Uzbekistan is urgently needed to appreciate the situation of any remaining resident population in the country

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