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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 Caucasus Ecoregion

The Persian leopard *Panthera pardus tulliana* has been Critically Endangered in the Caucasus Ecoregion. Therefore, its regional status assessment is a timely and essential measure to present the current situation and describe its changes due to existing conservation efforts. This report is aimed to address these issues by incorporating all available leopard records in the Caucasus Ecoregion from 2000–2021. The range of this big cat is confined to the mountain ridges of the Lesser Caucasus, Greater Caucasus, Talysh Mountains and their branches, and is heavily fragmented due to human activities. A continuous monitoring through camera-trapping shows that the minimum numbers of adult leopards are 3–9 in Armenia and 6–17 in Azerbaijan. There are very few individuals recorded in the Turkish and Russian parts of the Caucasus and only one confirmed individual is known from Georgia. Iran has been the main country for leopard survival in the Caucasus containing the largest population in the region, but of unknown size. Long-term and large-scale conservation activities coordinated by WWF and its partners led to the recovery and breeding of a small population in the Zangezur triangle, including the extreme south of Armenia, south-east of Azerbaijan’s Nakhchivan Autonomous Republic, and the adjoining part of north-western Iran. Some juveniles originated from this triangle disperse to other areas and potentially are able to re-establish new populations but such events are so far rare and documented only for males. Lack of breeding females and insufficient connectivity between the key areas of the range are the main problems for today’s population of the leopard in the Caucasus.

The Persian leopard *Panthera pardus tulliana* = *P. p. saxicolor* = *P. p. ciscaucasica* is a very rare and globally threatened predator living in Southwest and Central Asia (Fig. 1). It also lives in the Caucasus Ecoregion, which is located between the Black and Caspian Seas and encompasses all territories of Armenia, Azerbaijan and Georgia and parts of Russia, Turkey and Iran (Zazanashvili et al. 2020a, b).

Its status in the IUCN Red List of Threatened Species™ has not yet been updated, but the last assessment designated it as “Endangered” (EN C2a(i); Khorozyan 2008). At present, “Endangered” is the most appropriate category for the Persian leopard globally, but for the Caucasus it should be upgraded to “Critically Endangered”, presumably as CR C2a(i); D (Khorozyan 2010), due to very small

population size and high exposure to imminent threats such as habitat fragmentation and poaching (Bleyhl et al. 2017, 2021).

In the Caucasus, this big cat lives in arid grasslands, sparse and dense forests, subalpine and alpine meadows (Fig. 1). An essential requirement to leopard existence in this region is the presence of precipitous rocky areas which hold the main prey (especially bezoar goat *Capra aegagrus*), provide shelters and cover for hunting, and remain least accessible for people and livestock. As leopards are not well adapted to moving and hunting in deep snow, in winter they stay mostly on the southern slopes and at lower elevations (Khorozyan et al. 2010). They lead a very cryptic, mostly nocturnal, life and try to avoid interactions with humans.

Being a well-known flagship species, leopard attracts attention and resources to the conservation of biodiversity and habitats. Since the early 2000s, substantial efforts were mobilised to improve the status of leopard, its prey and habitats, and local livelihoods, within the framework of conservation projects coordinated by World Wide Fund for Nature (WWF) and its partners. In this report, we summarise the leopard status and its trends in the Caucasus Ecoregion from 2000 to 2021.

Methods

We collected all records of leopard occurrence in six countries of the Caucasus Ecoregion from the years 2000–2021. They were categorised as C1 (“hard facts”, verified and unchallenged records such as photographs, camera-trap pictures and results of genetic or biochemical analyses), C2 (confirmed observations) and C3 (unconfirmed observations) following the Status and Conservation of the Alpine Lynx Population (SCALP) protocol (Molinari-Jobin et al. 2012). One of us (G. Be-



Fig. 1. A Persian leopard (left) and juniper sparse forest as its habitat (right) in Armenia (Photos WWF Armenia/A. Malkhasyan).

Table 1. Distribution of C1, C2 and C3 records in the countries of the Caucasus Eco-region.

Country/area	C1	C2	C3	Total
Armenia	116	177	13	306
Azerbaijan	46	10	0	56
Georgia	2	3	9	14
Iranian Caucasus	57	16	67	140
Russian Caucasus	5	16	13	34
Turkish Caucasus	3	0	1	4
Total	229	222	103	554

ruchashvili) mapped them and current leopard range in ArcGIS 10.2 (ESRI Co., USA). Distribution of C1–C3 records in each country of the Caucasus Eco-region is provided in Table 1.

The range was divided into the categories “Extant”, “Possibly Extant”, “Possibly Extinct”, and “Extinct” according to international standards (Red List Technical Working Group 2018). The “Extant” areas included only repeatedly obtained C1 records. The “Possibly Extant” areas encompassed C2, C3 and single C1 records. “Possibly Extinct” was specified for the areas which had no records, but contain suitable habitats and can potentially provide leopard records once the search effort is increased. This category is particularly important to identify, describe and survey corridors linking the areas of “Extant” and “Possibly Extant” categories. The boundaries of the areas of all three categories were delineated during consultations to indicate potential barriers or unsuitable habitats such as settlements, infrastructure, large rivers and glaciers. We strived to be conservative in range mapping and took all efforts to avoid the exaggeration of range areas, but also understood that leopards move widely and may cross their boundaries.

Current distribution

Distribution of the Persian leopard in the Caucasus is fragmented. Geographically, the core areas retaining the most reliable leopard records of C1 and C2 categories are located in the following areas and conservation landscapes (Zazanashvili et al. 2020b, Fig. 2):

1. Lesser Caucasus Ridge: the Zangezur triangle encompassing southern Armenia, Nakhchivan Autonomous Republic of Azerbaijan (thereafter - Nakhchivan), and West Azerbaijan and East Azerbaijan provinces of north-western Iran. Conservation landscapes: Eastern Lesser Caucasus, Arasbaran.
2. Alborz Ridge: Gilan Province of north-western Iran extending to the Talysh

Mountains in Azerbaijan along the Caspian coastline. Conservation landscapes: Hyrcan.

3. Greater Caucasus Ridge: isolated patches in the republics of North Ossetia-Alania, Kabardino-Balkaria and Dagestan of the Russian Caucasus, and Tusheti in Georgia. Conservation landscapes: Central Greater Caucasus, Eastern Greater Caucasus.

Conservation landscape is “a geographicaly defined large area, typically larger than 5,000 km², identified as priority for conserving biodiversity and maintaining ecological processes and environmental services” (Zazanashvili et al. 2020b). All other parts of the leopard range in the Caucasus represent a network of actual and potential corridors linking these three core areas. This range structure makes the leopard extremely vulnerable to regional extinction if human activities, especially habitat fragmentation and direct poaching, continue (Bleyhl et al. 2021). The corridors are generally long and narrow, meaning that they are penetrable to anthropogenic pressures exerted from the outside. As leopards tend to avoid deserts, semi-deserts, permanent snow and human-dominated landscapes, viable corridors are limited to mountain ridgetops and canyons having dense vegetation and rugged terrain (Bleyhl et al. 2017).

Armenia

In Armenia, the range is extended from the Geghama Ridge (Khosrov Forest Reserve) in the south-western part of the country via the Vayk, Zangezur, Bargushat and Meghri ridges to the Araks River in the extreme south, over which the range merges with north-western Iran, including Kantal National Park, Dizmar Protected Area and Kiamaky Wildlife Refuge (Fig. 2). The first C1 records were collected in 2000–2004 from a leopard killing event and the biochemical analysis of faecal samples, until the first camera-trap pictures were pro-

duced in 2005 and 2007 (Khorozyan & Malkhasyan 2005, Khorozyan & Abramov 2007, Khorozyan et al. 2007, 2010).

Beginning from 2005, WWF-Armenia has been implementing large-scale monitoring of leopards and their prey within the WWF regional leopard conservation programme, mainly through camera-trapping and also, since recent times, faecal DNA analysis (Askerov et al. 2015, 2019). Apart from WWF, in 2002–2007 leopard camera-trapping was carried out in the Meghri Ridge and Khosrov Forest Reserve by an independent team of I. Khorozyan and A. Malkhasyan. Moreover, since 2013 until present camera-trapping has been done in the privately owned Caucasus Wildlife Refuge near Khosrov Forest Reserve by the Foundation for the Preservation of Wildlife and Cultural Assets FPWC.

In 2005–2013, leopards were camera-trapped only on the Meghri Ridge in Arevik National Park, until the first capture was obtained also in the Caucasus Wildlife Refuge in May–June 2013 (R. Khachatryan, pers. comm.). In 2018–2019, apart from Arevik, several new individuals appeared in Khosrov Forest Reserve, Arpa Protected Landscape and surroundings (Vayk Ridge), and the Caucasus Wildlife Refuge (Figs. 3 and 4). The male leopard from Khosrov Forest Reserve immigrated from its natal place in the south-eastern corner of Nakhchivan, which is 170 km aerial distance away (Askerov et al. 2019). In January 2020, a very surprising case of a leopard capture took place in the area of Yenokavan, Tavush Province in north-eastern Armenia where leopard records were extremely rare even in historical times. This individual was identified as the one camera-trapped earlier in the Caucasus Wildlife Refuge (V. Ananyan, pers. comm.). In April 2021, a new male appeared in Arpa Protected Landscape (V. Ananyan, pers. comm.). All individuals from the Caucasus Wildlife Refuge have most likely arrived here from Nakhchivan, and the individual captured there in 2013 was camera-trapped later in Nakhchivan and Iran (R. Khachatryan, pers. comm.). On 16 November 2021, a female with two big cubs was video-recorded by a car driver at night in Zangezur Sanctuary, which is the first record of breeding leopards in the country (<https://newsarmenia.am/news/armenia/leopardikha-s-detenyshami-zasvetilas-na-kameru-v-armenii-video/>). The C2 and C3 records of sightings, tracks, scats, scrapes, and a few leopard killings and livestock kills are documented in all these areas. Apart from this, two interesting C3 records of a sighting

and a killing were reported from the area of Arzakan in Kotayk Province of central Armenia, thus suggesting that local mountains and canyons can serve as a vital corridor connecting Khosrov Forest Reserve and Yenokavan and, generally, the southern and northern parts of Armenia. Yet, Kotayk Province is a risky potential corridor due to the presence of the Yerevan-Tbilisi highway and a number of popular ski and spa resorts such as Arzakan, Hankavan, Aghveran, and Tsaghkadzor.

Azerbaijan

In Azerbaijan, most leopard records are concentrated in Ordubad district on the Zangezur Ridge in the south-eastern part of Nakhchivan very close to the borders with Armenia and Iran, and in Astara and Lankaran districts in the southern part of the Talysh Mountains (Fig. 2). Since 2005, WWF-Azerbaijan conducts large-scale leopard and prey monitoring by camera-trapping and faecal DNA analysis within the WWF regional leopard conservation programme. The most reliable and numerous evidence (C1) comes from intensive camera-trapping (Avgan et al. 2012, Askerov et al. 2015, 2019, Spassov et al. 2019), but several confirmed cases of leopard killings by people in the Talysh Mountains are also documented. The C2 records are originated from the same districts as C1, as well as from the neighbouring Jalilabad and Julfa districts and from Ilisu Reserve, and include a sighting, tracks, a livestock kill and a prey kill.

There is only one leopard record from northern Azerbaijan, namely tracks on the Akhar-Bakhar Ridge in Ilisu Reserve very close to the border with Georgia. This record is old (2005) and most likely belongs to the same male which was regularly camera-trapped in adjacent Vashlovani Protected Areas in south-eastern Georgia in 2004–2008 (see below). Subsequent camera-trapping in 2008–2011 failed to record leopards in Ilisu Reserve (Muradov 2011).

Ordubad district (Zangezur Ridge) and Hirkan National Park (Talysh Mountains) in Azerbaijan and Zangezur Sanctuary in Armenia are the only areas in the Caucasus, except for north-western Iran, where the presence of females and their breeding is confirmed (Breitenmoser et al. 2017, Askerov et al. 2019, see “Armenia” above). In Ordubad, one pair with three cubs was camera-trapped in 2016 and another pair with one cub in 2018, two cubs in 2020 and three cubs in 2021. In November 2021, a female with two cubs, possibly the same as from Ordubad, was recorded in Zangezur Sanctuary (Table 2). This was

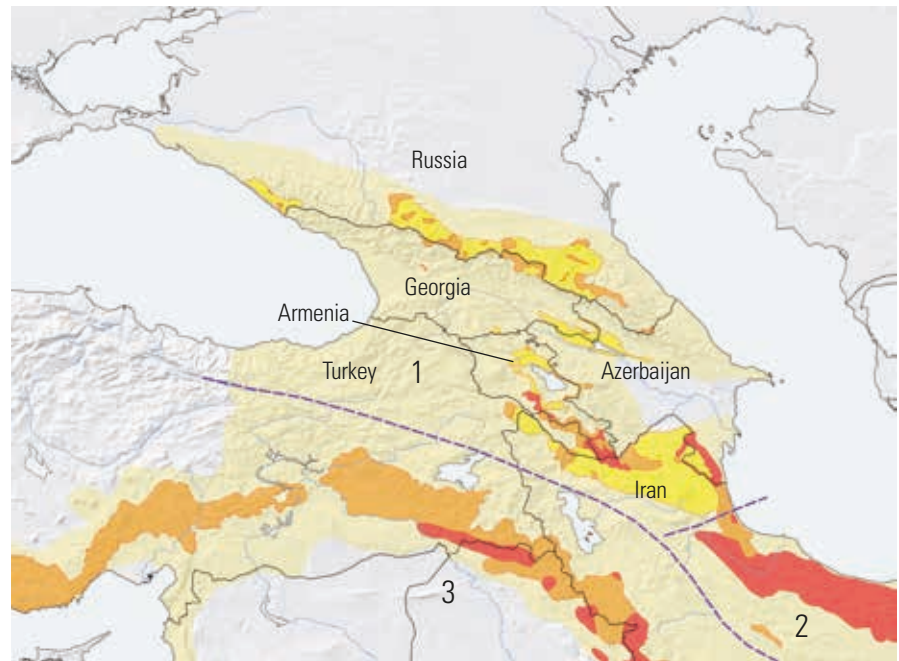


Fig. 2. Distribution of leopard *Panthera pardus* in the Caucasus (1) in 2000–2021. Red = extant, orange = possibly extant, dark yellow = possibly extinct, light yellow = extinct, violet lines = regional division. 1 = Caucasus Ecoregion, 2 = Alborz-Kopetdag, and 3 = Zagros range. Map courtesy to Peter Gerngross, based on Khorozyan et al. (2022).

achieved due to the hunting ban declared in Nakhchivan in 2001, low human density, and the functioning of Zangezur National Park and Ordubad Sanctuary whose landscapes are connected with those of Zangezur Biosphere Complex (including Zangezur Sanctuary) in Armenia on the opposite side of the Zangezur Ridge (Askerov et al. 2015). The dispersal of a sub-adult male born in this area to Khosrov Forest Reserve in south-western Armenia is documented (Askerov et al. 2019) and another male successfully dispersed further to Yenokavan in northern Armenia.

In Hirkan National Park, a female with two cubs was camera-trapped in 2014–2015. Here, leopard breeding resulted from strengthened conservation and the proximity of this area to Gilan Province of Iran. Yet, transboundary movements between the Talysh Mountains and Gilan can be risky and end up with leopard poaching (Maharramova et al. 2018). Also, leopards in the Talysh Mountains are more affected by retaliatory killing in response to attacks on cattle (Askerov 2002, Spassov et al. 2019, Askerov et al. 2020).

Most recently, in autumn 2021 a short video of a leopard was made on a mobile phone in the Kelbajar district. This is a very interesting record showing that the Karabakh Upland can be a vital corridor linking southern Armenia and Nakhchivan with the Russian Caucasus, northern Azerbaijan and eastern Georgia.

Georgia

Since 2000, a leopard was documented in Georgia in 2003 when NACRES, a non-governmental organization, found a leopard track in Vashlovani Protected Areas in the extreme south-east of the country, close to the border with Azerbaijan (Lortkipanidze et al. 2004). As numerous camera-traps showed, a male leopard had been living in Vashlovani in 2004–2008, but after its track recorded in 2009 no further information has become available (Askerov et al. 2020). Vashlovani is the closest stepping stone between the Lesser and the Greater Caucasus (Fig. 2). All the other records from Georgia were indirect, such as tracks and observations in Svaneti, Khevsureti and Tusheti regions on the Greater Caucasus Ridge. However, most recently on 25 August 2021 a leopard was camera-trapped in Tusheti Protected Areas on the northern slopes of the Greater Caucasus, close to the border with Russia (<https://www.caucasus-naturefund.org/the-persian-leopard-is-back-in-georgia/>). It is yet unclear, but important to know, whether this individual is resident or a migrant from the Russian Caucasus, northern Armenia or the Karabakh Upland.

Iranian Caucasus

Iran is the stronghold for the leopard in the Caucasus and generally in Southwest and Central Asia, hence it is not surprising that

species records from this country are most numerous. Within the Caucasus part of Iran, most leopard records come from the humid Hyrcanian forest of Gilan Province, which extends to the small tract of this forest in the Talysh Mountains of Azerbaijan. There are also several records in the arid and rocky areas of Zanjan and Ardabil provinces to the south-west of the Hyrcanian forest. However, this region needs much stronger enforcement of conservation as the anthropogenic transformation of landscapes is ubiquitous there (Moqanaki et al. 2013, Farhadinia et al. 2015). Human-leopard conflicts over livestock depredation are quite frequent in Gilan, which may cause persecution and retaliatory killing of leopards (Babgir et al. 2017, Soofi et al. 2019). Fewer records are available from the provinces of West Azerbaijan and East Azerbaijan adjacent to Armenia and Nakhchivan. The record sites can be grouped into three areas, from the west to the east: Marakan Protected Area, Kiamaky Wildlife Refuge with Kantal National Park and Dizmar Protected Area, and Arasbaran National Park and Protected Area. It is notable that Kantal National Park, which strides close to the Araks River in front of Armenia, is marked mostly by C1 records such as camera-trap pictures and photographs, and also by C2 records including scats and sightings. Dizmar has one C1 and one C2 records. Marakan and Arasbaran hold mostly C3 records and only one C2, but no C1. The presence of hard facts from Kantal, but not Marakan, Kiamaky and Arasbaran, was also described by Moqanaki et al. (2013) and Askerov et al. (2020). Undisturbed prey-rich suitable habitats and the absence of livestock grazing and poaching are the main causes of the existence of leopards in Kantal, whereas in Marakan, Kiamaky and Arasbaran suitable habitats are limited and

the densities of humans and livestock are higher (Moqanaki et al. 2013). Scientifically most reliable methods should be used to get confident information about such rare and elusive animals as leopards. In this sense, intensive camera-trapping efforts should be undertaken to elucidate the status of leopards in Marakan, Kiamaky and Arasbaran.

It is of particular importance to find and describe leopard records in the corridor, which in the Iranian Caucasus connects the Zangezur triangle with the Talysh Mountains and Gilan Province (Fig. 2). This corridor is stretched across the Garadagh Ridge in East Azerbaijan and Ardabil provinces, but recent records from this area are located mostly in its south and concentrated in the east towards Gilan, whereas vast areas located towards the mentioned triangle have no records. The northern parts of Ardabil Province connecting the triangle with the Talysh Mountains are almost deprived of leopard records, with only one C1 record of a male killed in 2007 (Maharramova et al. 2018). A disrupted structure of the Zangezur triangle-Talysh Mountains and the Zangezur triangle-Gilan corridors is also suggested by landscape modeling (Farhadinia et al. 2015, Bleyhl et al. 2017). Absence of leopards and the lack of their prey in Lisar Protected Area (Moqanaki et al. 2013, Soofi et al. 2018, 2019) just to the south of Hirkan National Park in Azerbaijan undermines the connectivity of the Talysh Mountains and Gilan Province, in addition to the poaching of leopards moving between these two areas (Askerov 2002, Maharramova et al. 2018).

Russian Caucasus

Recent C1 records of leopard presence in the Russian Caucasus began to appear much later than elsewhere in the Caucasus (Fig. 2). This

may indicate that at least some individuals could be non-resident and immigrate here from the unknown areas of the South Caucasus. The probability of this is quite high considering that all documented leopards were large, i.e. most likely they were males capable of taking long-distance dispersal forays. These C1 records are mostly photographic: three in the North Ossetian experimental hunting area (2013), Gizeldon (2015) and Zamarag (2017) hydropower plants of the Republic of North Ossetia-Alania and one in 2015 near Tlyaratinsky Federal Sanctuary of the Republic of Dagestan (Yarovenko & Zazanashvili 2016, Weinberg et al. 2018). Most recently, on 17 November 2021 a male leopard was camera-trapped on the boundary of Pri-elbrusye National Park in the Kabardino-Balkarian Republic (<https://www.youtube.com/watch?v=xUj-ZbrRHAc>). There is no evidence that these individuals belong to the reintroduced stock (see below).

The C2 records are more common, including direct sightings, tracks and hearsay in almost all mountainous parts of the North Caucasus, from the Krasnodar Region in the west to Dagestan in the east. There are several C2 and C3 records describing leopard sightings and livestock kills in the mountainous areas of southern and south-western Dagestan (Yarovenko 2017), up to the year 2020. In 2016, a shepherd observed a female with two cubs. In Kabardino-Balkaria, the C2 and C3 records include a sighting in 2016 and a number of sightings, tracks and a goat kill in 2003–2004 on the right bank of the Chegem River (Akkiev & Mokaev 2006), apart from hearsay in later years. There are also a few C2 and C3 records of leopard sightings and tracks in the western (Krasnodar Region, Karachay-Cherkess Republic and Caucasian Biosphere Reserve) and eastern (Republic of Ingushetia) parts of the Russian Caucasus (Kudaktin & Trepets 2008, Khokhlov & Khubiev 2016, Kudaktin 2016), but hard facts of leopard presence from these areas are missing.

In 2008, the Russian government approved a programme on leopard breeding in captivity in Sochi National Park and the reintroduction of trained second-generation individuals in the North Caucasus (Rozhnov & Lukarevsky 2008). The founder stock consisted of two wild males brought from Turkmenistan in 2009, two wild females from Iran in 2010, one male and one female from Lisbon Zoo in 2012, and a male from Parc des Félines in 2015. In total, they produced 15 cubs (Voronin & Kharchenko 2016). Following a series of studies to moni-



Fig. 3. A Persian leopard caught on camera in Armenia on 14 April 2022 (Photo WWF Armenia).

tor and select the best candidates for release (Rozhnov et al. 2007, 2011, Yachmennikova & Rozhnov 2011, Ertuev & Semenov 2016, Voronin & Kharchenko 2016), two females and four males were originally released into the wild. One female and three males were released in Caucasian Biosphere Reserve in the western North Caucasus in 2016 and 2018. The other male and female were released in 2018 in the central part of the North Caucasus, in Alania National Park of North Ossetia-Alania (Rozhnov et al. 2020). All these six individuals were tracked by GPS collars and monitored according to specially developed and published guidelines (Rozhnov et al. 2018, 2020). In 2020, one male and one female were released in Turmon Regional Sanctuary of North Ossetia-Alania (<https://rg.ru/2020/09/02/reg-ufo/na-kavkaze-vypustili-na-voliu-chetyreh-peredneaziatskih-leopardov.html>) and another male and female were released in Caucasian Biosphere Reserve (<https://wwf.ru/resources/news/bioraznoobrazie/na-kavkaze-sostoyalsya-vypusk-dvukh-peredneaziatskih-leopardov-v-dikuyu-prirodu/>). Later in 2021, a female, presumably the one released in Alania National Park, was spotted in Kabardino-Balkaria and her collar with exhausted batteries was found not far from there (<https://wwf.ru/resources/news/kavkaz/nayden-osheynik-samki-leoparda-volny/>). So, in total 10 individuals were released: six in Caucasian Biosphere Reserve and four in North Ossetia-Alania. Three of them died from unknown reasons (<https://www.rgo.ru/ru/article/na-kavkaze-pogibla-samka-peredneaziatskogo-leoparda-laba>), poaching and starvation (<https://www.kuban.kp.ru/daily/26939/3990050/>), of which two were females making these losses particularly poignant.

It is important to note that locations of reintroduced leopards are not shown in Fig. 2, otherwise the western and central North Caucasus would be overloaded with C1 records of their GPS locations and create a misleading impression that most of C1 records in the region are concentrated here. Thus, Fig. 2 contains records of only leopards born in the wild.

Turkish Caucasus

In Turkey, the only reliable mapped information on leopard presence is originated from the south-east of the country, to the south and west of Lake Van. A number of recent leopard killings (2001–2013) and camera-trap pictures (2018–2019) from there are known and published (Avgan et al. 2016, Toyran



Fig. 4. A Persian leopard caught on camera in Armenia on 31 July 2021 (Photo WWF Armenia).

2018, Karataş et al. 2021). As this area geographically belongs to the Zagros sub-region, it is not considered further in this report. Three C1 records of a skin photograph and photo/video material from mobile phones and thermal cameras were reported from Erzincan and Tunceli provinces in 2008–2019 to the south of the Turkish Caucasus. However, these records are not credible as thermal images from this area depicted other animals, even wild *Felis silvestris* and domestic *F. catus* cats, and were published as “leopard” records (Sari et al. 2020). Misidentification of different species as leopards has occurred in the past and such false positives have been readily published to claim that leopards are more common in Turkey than they are thought to be (Baskaya & Bilgili 2004, Sari et al. 2020), but fortunately such cases of misidentified leopards are unmasked (Spasov et al. 2016). Similarly, tracks claimed to belong to leopards have been confused with those of shepherd dogs and other animals (Spasov et al. 2016).

However, most recently it has become known that several C1 records of two males were taken by camera-traps and border surveillance cameras on the Agri dag (Mt. Ararat) in Iğdir Province and in Yusufeli district of Artvin Province. This information is not available to the public for security reasons. Therefore, these records are not presented in Fig. 2. Overall, it can be concluded that the current range of leopard in the Turkish Caucasus covers only the very east of Turkey close to the borders with Armenia and Georgia, but generally this part of the range can be ranked as uncertain presence.

Population size and trends

Leopards can be reliably recognised from their spot patterns, which are unique for each individual and also differ between the same animal’s left and right flanks (Miththapala et al. 1989). Due to this, it is possible to estimate the minimum population size of leopards in southern Armenia and Azerbaijan (Nakhchivan, Talysh Mountains) from the numbers of individuals captured by camera-traps over large areas. These estimates represent the minimum population size because there is always a possibility that some individuals may be present, but have so far gone undetected. According to the results of camera-trapping in the South Caucasus, the numbers of camera-trap sites, leopard photographs and videos, and individual animals have increased over time since the early 2000s (Table 2). Poaching appears to decrease but remains an issue in the Talysh Mountains, mostly as a retaliatory or preventive measure to reduce cattle losses to leopard attacks (Askerov 2002, Spasov et al. 2019, Askerov et al. 2020). However, an increase in the numbers of photographs/videos and individuals should be treated with caution because these numbers are higher in longer periods due to active movements of leopards between Armenia and Nakhchivan. For example, in Armenia there were eight leopards identified during five years between September 2014 and June 2019, but only four in one year from June 2020 to June 2021 (Table 2). As the Armenian population is dominated by males which actively move, it is unstable and fluctuating over time. These movements include not only transboundary forays between

Table 2. Sampling efforts and an output of leopard camera-trapping in Armenia, Azerbaijan and Georgia. Data from independent non-WWF camera-trapping in Nakhchivan, Azerbaijan (B. Avgan) are not available.

Period/year	No. camera-trap sites	No. leopard photos/videos	No. captures of females with cubs	No. identified individuals	No. known killings	Source
Armenia						
Sep 2002-May 2005	4	1/0	0	1	0	I. Khorozyan; WWF-Armenia data
Jan 2005-Dec 2013	32	1/0	0	1	1	WWF-Armenia data
Aug 2006-May 2007	22	1/0	0	1	2	I. Khorozyan; WWF-Armenia data
Mar 2013-Jul 2021	10	> 70/30	0	5	0	R. Khachatryan, FPWC
Dec 2013-Aug 2014	24	17/3 ¹	0	3	0	Askerov et al. 2015; WWF-Armenia data
Sep 2014-Jun 2019	72	53/23	0	8	0	Zazanashvili et al. 2020a
Jun 2019-Jun 2020	88	88/29	0	5	0	WWF-Armenia data
Jun-Dec 2020	69	163/53	0	4	0	WWF-Armenia data
Jan-Jun 2021	85	37/14	0 ²	4	0	WWF-Armenia data
Azerbaijan						
Nakhchivan, Jan 2013-Oct 2014	7	164/18	0	3	0	Askerov et al. 2015
Nakhchivan, Nov 2014-Jun 2021	80	471/178	33 ³	11	0	Zazanashvili et al. 2020a; K. Ahmadova, WWF-Azerbaijan
Talysh, May 2013-Jul 2014	5	39/8	0	3	4 ⁴	Askerov et al. 2015
Talysh, May 2015-Jun 2021	21	34/12	1	6	2 ⁵	Zazanashvili et al. 2020a; K. Ahmadova, WWF-Azerbaijan
Georgia						
Vashlovani PAs, Dec 2003-Dec 2009	6	23/0	0	1	0	NACRES data
Tusheti, Jul 2009-Nov 2009	11	0/0	0	0	0	WWF/NACRES data
Tusheti, Jul 2010-Oct 2010	16	0/0	0	0	0	WWF/NACRES data
Vashlovani-Chachuna, Feb 2011-Jun 2011	25	0/0	0	0	0	NACRES data
Khevsureti, Jun 2012-Sep 2012	25	0/0	0	0	0	WWF/NACRES data
Khevsureti, Jul 2013-Oct 2013	28	0/0	0	0	0	WWF/NACRES data
Chachuna, Feb 2014-Apr 2014	7	0/0	0	0	0	NACRES data
Poladauri, Oct 2018-Apr 2019	9	0/0	0	0	0	NACRES data
Tusheti, Jul 2021-in progress	24	2/0	0	0	1	WWF/NACRES data

¹ Videos were produced in an additional site within the project conducted by the Foundation for the Preservation of Wildlife and Cultural Assets (FPWC).² Later on 16 November 2021 a female with cubs (possibly, the same as ³ going next) was video-recorded in Zangezur Sanctuary of Armenia.³ Later on 24 September 2021 a female with cubs was camera-trapped in Zangezur National Park of Nakhchivan.⁴ This number of leopards was killed in the Talysh Mountains from 2002 to 2014.⁵ One leopard was killed in Iran (Maharramova et al. 2018).

Armenia and Azerbaijan, but also movements within the countries to the areas where camera-traps are not present and animals may have been missed. Consequently, transboundary movements can produce double counts of the same individuals captured in Khosrov Forest Reserve, Caucasus Wildlife Refuge and Nakhchivan. High numbers of photographs and videos do not indicate an increase in population size as camera-traps can be placed to repeatedly capture the same individuals moving over the same trails.

As Table 2 shows, current leopard population size is a minimum of 3–9 individuals in Armenia and a minimum of 6–17 individuals in Azerbaijan. However, the actual population in Azerbaijan should be lower because populations of large mammals, including predators, are estimated in numbers of adults and not of all individuals.

Although some camera-trapping efforts were undertaken in the Iranian Caucasus, e.g., in Kantal National Park, no population estimates are available from this part of the range.

The most reliable methods of population size estimation in leopards are the capture-recapture analysis of camera-trap pictures and the genetic analysis of faecal material or hairs (Sugimoto et al. 2014, Rostro-García et al. 2018). Capture-recapture analysis has been proposed by the regional wildlife monitoring framework for the future use in the Caucasus (Ghoddousi et al. 2019). As these methods have not yet been used, or at least not published, only minimum numbers from Table 2 and the numbers of reintroduced leopards in

the Russian Caucasus should be considered as reliable, until the population size is estimated more precisely by capture-recapture and/or genotyping.

Some information about leopard densities in the Caucasus is also available in the literature. The density of 0.34 individuals/100 km² in the Meghri Ridge of southern Armenia (Khorozyan et al. 2008) and the density of 3 individuals/100 km² in Hirkan National Park of south-eastern Azerbaijan (Askerov et al. 2021) have been recorded.

It is impossible to evaluate trends in leopard numbers before and after 2000, because current C1 records come mostly from camera-trapping and older C1 records originated mainly from leopard killings, which are incomparable in principle. It is even harder to estimate or even guess trends in the areas which have only C2 and, let alone, C3 records. Dynamics of leopard records appear to be strongly biased by survey efforts in particular areas rather than related to leopard numbers. This trend was evident in historical times and continues to be plausible now.

However, one trend can be clearly ascertained since the mid-2000s when camera-trapping began to be widely used in the Caucasus: from the year 2010 onward, the population is recovering in the southern part of the Lesser Caucasus within the Zangezur triangle (Askerov et al. 2015, Breitenmoser et al. 2017, Askerov et al. 2019, Zazanashvili et al. 2020a). Breeding females are present on the Nakhchivan and Armenian sides of the Zangezur Ridge and two long dispersals of sub-adult males to Khosrov Forest Reserve in south-western Armenia and to Yenokavan in northern Armenia are proven (Askerov et al. 2019, see above). The appearance of leopards in North Ossetia-Alania and Dagestan of the Russian Caucasus in 2013–2017 also can imply immigrations, although the existence of a small local population cannot be ruled out. A camera-trap video of a leopard in Kabardino-Balkaria in 2021 (see above) supports the idea of possible existence of an independent “nucleus” in the Russian Caucasus as this individual was not recorded previously in Armenia and Azerbaijan (A. Yachmennikova, pers. comm.).

Population structure

No scientific research of the sex and age structure of the leopard population was ever conducted in the Caucasus. However, the analysis of camera-trap images and video materials shows that most of captured individuals are males whereas females are

known only from the Zangezur triangle, Talysh Mountains, and a few places in Gilan Province and nearby.

Space use by females indicates the areas of best suitability in terms of sufficient prey resources and shelters and a minimum level of disturbance (Snider et al. 2021). Sub-adult females tend to move much shorter distances than males and show a strong fidelity to their natal sites. In turn, male movements are more exploratory in nature and directed towards the search of mates. Hence, male leopards can potentially be found anywhere and their presence is less related to habitat suitability (Breitenmoser et al. 2017). In contrast, the areas of presence of females and/or their breeding cases (proven by females with cubs) represent the core habitats.

This can be best illustrated with the example of the leopard recovery in the Zangezur triangle. Here, females live on the Nakhchivan side of the Zangezur Ridge (two breeding females are known – see above, and a female found dead in May 2021) and only recently in 2021 a breeding female, possibly one of those two, was recorded on the Armenian side. Dispersing males moving, inter alia, to Armenia fail to find mates in spite of intensive territorial marking. This is a case for a resident male from Khosrov Forest Reserve (Fig. 4), which stays alone since he arrived in 2018 (Askerov et al. 2019) and also for the males from the Meghri Ridge and Yenokavan (V. Ananyan, pers. comm.).

All wild-living leopards in the Russian Caucasus, Georgia and eastern Turkey are males and the only two females are the ones released within the reintroduction programme. Lack of females and breeding is also a problem for the Iranian Caucasus where only three C1 records of females are indicated in the dataset: Deylaman-e-Dorfak No-Hunting Area in Gilan Province (Breitenmoser et al. 2017, Farhadinia et al. 2018), Kantal National Park, and south-eastern East Azerbaijan Province near the border with Gilan (Fig. 2). Many more records of females with or without cubs belong to C2 and C3 records (M. Sofi, pers. comm.).

Ecology, prey and threats

Ecology, prey, distribution patterns and threats related to the Persian leopard in the Caucasus are very similar to those in other parts of its range, which are described in other chapters. However, several aspects are known to be specific to this region.

Ecology

One of the main natural factors limiting the leopard distribution in the Caucasus is snow (Khorozyan & Abramov 2007, Gavashelishvili & Lukarevskiy 2008, Khorozyan et al. 2010). As leopard is tropical by origin, it has a high paw pressure and cannot move and hunt in deep snow (Pikunov & Korkishko 1992). For this reason, it prefers southern slopes at low and middle elevations, and stays on northern slopes only during the snow-free seasons (Khorozyan et al. 2010). This makes leopards suffer from the deficiency of suitable habitats and become vulnerable to clashes with people, who in the Caucasus are present mostly in lowlands, mountain valleys and canyons. From a phylogeographic point of view, the Caucasus represents a dead end where the leopard presence was limited by the Greater Caucasus Ridge, with only slight penetration towards the plains of Russia (Vereschagin 1959).

Prey

Three mid-sized ungulates are the unique prey species for the leopard in the Caucasus: western tur *C. caucasica*, eastern tur *C. cylindricornis* and chamois *Rupicapra rupicapra* (Mallon et al. 2007). Both turs are the endemics of the Greater Caucasus Ridge and chamois occurs in Europe where leopards are absent. The wild boar *Sus scrofa* is the second most important prey for leopards after the bezoar goat in the region (Ghoddousi et al. 2017), but in the Christian countries like Armenia and Georgia where swine breeding is common, wild boars have been heavily affected by transmission of African swine fever (Sarkisyan et al. 2019). The key protected areas located in forests of Armenia, namely Shikahogh Reserve and Dilijan and Arevik National Parks, experience a sharp long-term decline of wild boar numbers. This possibly poses a serious threat to leopard survival in Armenia. In contrast, wild boars are very abundant in Azerbaijan’s Talysh Mountains (Askerov et al. 2021) and Iran (Ghoddousi et al. 2017) where swine are not bred for religious reasons.

Threats

In Armenia, Azerbaijan, Georgia and Russia, hunting (often with official bounties) was the main threat to leopard before the 1960s and 1970s when it was granted official protection. During that time, leopards and other large predators had been wiped out as vermin for livestock breeding and for fur trade (Heptner

& Sludsky 1972, Aghajanyan 1986). Since the 1970s, poaching still continued to be a major threat, especially after the collapse of the Soviet Union until the mid-2000s, but trade ceased and leopards used to be killed for own trophies or as a threat to livestock. From the mid-2000s onwards, leopards appear to be threatened predominantly by fragmentation of habitat patches intensified by the socio-economic development and politically challenging conditions.

Leopard conservation efforts in a nutshell

The main reason for the leopard recovery in the South Caucasus, first of all in the Zangezur triangle, is the implementation of the long-term leopard conservation and monitoring programme by the national WWF teams of Armenia, Azerbaijan and Georgia in cooperation with the national governments. These efforts include, among others, the monitoring of leopards and their prey by camera-trapping and field tracking, assistance in establishing new protected areas or effective management of existing ones, establishment of wildlife corridors, awareness-raising events and engaging local people in Persian leopard conservation. The Persian leopard programme in the Caucasus was launched in 2002 and keeps on running until now due to main funding from WWF Germany and WWF Switzerland. Generous co-funding, which allowed to expand and develop project activities, came or continues to come from the Critical Ecosystem Partnership Fund (CEPF, <https://www.cepf.net>), Ministry of Foreign Affairs of Norway (<https://www.regjeringen.no/en>), Eco-Corridors Fund for the Caucasus (<https://www.ecfcaucasus.org>) and the Caucasus Nature Fund (<https://www.caucasus-nature-fund.org>), to name a few. More information about leopard conservation activities in Armenia is available online (<https://leopard.am>). Another reason of leopard recovery is the restoration of its prey base, first of all bezoar goats, in Nakhchivan Autonomous Republic due to the hunting ban lasting from 2001. In Iran, conservation of leopards and other wildlife species has been implemented by the Iranian Department of Environment. Leopard reintroduction in the Russian Caucasus began only recently (Rozhnov et al. 2022) and it takes time to assess its effectiveness.

Conclusion

Continuous conservation efforts, including the long-term projects on population con-

servation, monitoring and reintroduction, and the maintenance of hunting ban in a key area, allow the leopard population to recover in the Caucasus. Population recovery in the Zangezur triangle is encouraging, but also shows a very shaky ground for the long-term sustainability of the leopard population in the Caucasus. The regional leopard population is still small, fragmented and demographically unstable. The main concern is the lack of females and the failure of males to find mates. All possible efforts should be directed towards the creation and maintenance of transboundary and in-country connectivity of leopard habitats, and the continuation of support to protected areas, anti-poaching activities, and awareness-raising.

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