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# The distribution of the critically endangered salamander *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940) in Afghanistan

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## Abstract

The Afghanistan Mountain Salamander, *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940), is an evolutionary old species, listed as Critically Endangered by IUCN Red List. The species is endemic to the Hindu Kush mountain range with records from only a few localities from four central-eastern Afghan provinces (Kabul, Ghazni, Parwan, and Wardak). Due to the long-term complicated political situation in the country which makes zoological research almost impossible, the current distribution and the presence of *P. mustersi* at previously known localities has remained unassessed for 40 years. We carried out recent, sporadic surveys between 2017 and 2021 to detect *P. mustersi* in three tributaries of the Paghman stream on the southern slopes of the Hindu Kush Mountains and the two nearby provinces (Panjsheer and Parwan), where the presence of the species was expected. We confirmed the occurrence of *P. mustersi* at all survey sites, and present the first record of the species for Panjsheer Province. We also confirmed that the species is currently endangered by human-mediated factors like habitat disturbance (increased visitors attendance, water pollution, construction activities), especially in the Paghman area.

## Key Words

*Batrachuperus*, conservation, Hindu Kush, Hynobiidae, occurrence, Paghman stream Salamander, Pakistan

## Introduction

The Afghanistan Mountain Salamander *Paradactylodon* (*Afghanodon*) *mustersi* (Smith, 1940), described initially as *Batrachuperus mustersi* Smith, 1940, is currently understood to be endemic to Afghanistan, and is considered to be one of the world's least-known salamanders (Wagner et al. 2016; Ahmadzadeh et al. 2020). However, the possible presence of the species across a wider area of the Hindu Kush range (see Wall 1911), which is zoologically one of the least explored places on earth, would not be unexpected. *Paradactylodon mustersi* is a member of the family Hynobiidae, and was initially discovered at the Paghman streams area in Kabul Province (Smith 1940). The original habitat where the species was initially found mainly comprises a four- kilometer-long, glacier-formed valley (Smith 1940; Nawabi 1965; Böhme 1982; Reilly 1983; Böhme and Jablonski 2022). Overall, the species is known from elevations between ~1800 to 3750 m (Reilly 1983; Wagner et al. 2016). Its population is estimated between 1000–2000 individuals (Papenfuss et al. 2004), but recent data are missing, and it is assumed that the populations of *P. mustersi* declined over the last 40 years of armed conflicts and instability in Afghanistan

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(Jablonski et al. 2021). Although the species is considered as a Critically Endangered B2ab (iii) according to IUCN criteria, and also listed amongst the most Evolutionarily Distinct and Globally Endangered species (EDGE; https://www.edgeofexistence.org/), there is still very limited knowledge about the distribution, morphology, ecology, and current threats of this enigmatic amphibian (see also Böhme and Jablonski 2022).

Despite *P. mustersi* being listed by the Afghan Government as a legally protected species since 2009, it remains unclear to what extent the species is threatened due to continuing political changes and the still complicated security situation in Afghanistan that may affect its conservation (see Gaynor et al. 2016). Thus, data that could inform conservation priorities for the Afghanistan mountain salamanders and other Hindu Kush biota are missing. Most of the information we currently have regarding the presence of the species originate from older published work, comprising studies of *P. mustersi* in the wild or in captivity (Nawabi 1965; Mertens 1970; Seufer 1974; Sparreboom 1977; Bohmë 1982; Reilly 1983; Böhme and Jablonski 2022). In summary, this salamander is commonly found in fast-flowing melted glacier waters with temperatures ranging between 0 to 14 °C (Reilly 1983). The total recorded length of *P. mustersi* ranges from 119 to 215 mm, with individuals showing 14 costal grooves, that extend into the tail. The snout is broadly rounded and limbs are well-developed. The tail is slightly shorter than the body, and the color of the body is dark olive-brown to yellowish-olive and speckled indistinctly with tiny pigmented dots (Reilly 1983). From an evolutionary point of view, *P. mustersi* is a unique species characterized by a long-term independent history and an isolated distribution, when compared to other members of the family Hynobiidae (Zheng et al. 2011; Ahmadzadeh et al. 2020). According to Wagner et al. (2016), there are around 200 specimens of the species in eight museum collections worldwide, mostly housed in the United States.

Besides the area of Paghman (Kabul Province), the species has also been recorded in provinces surrounding Kabul, i.e. Ghazni, Parwan, and Wardak (Bohmë 1982; Wagner et al. 2016; Ahmadzadeh et al. 2020 and Fig. 1 in this study). However, its current presence in localities

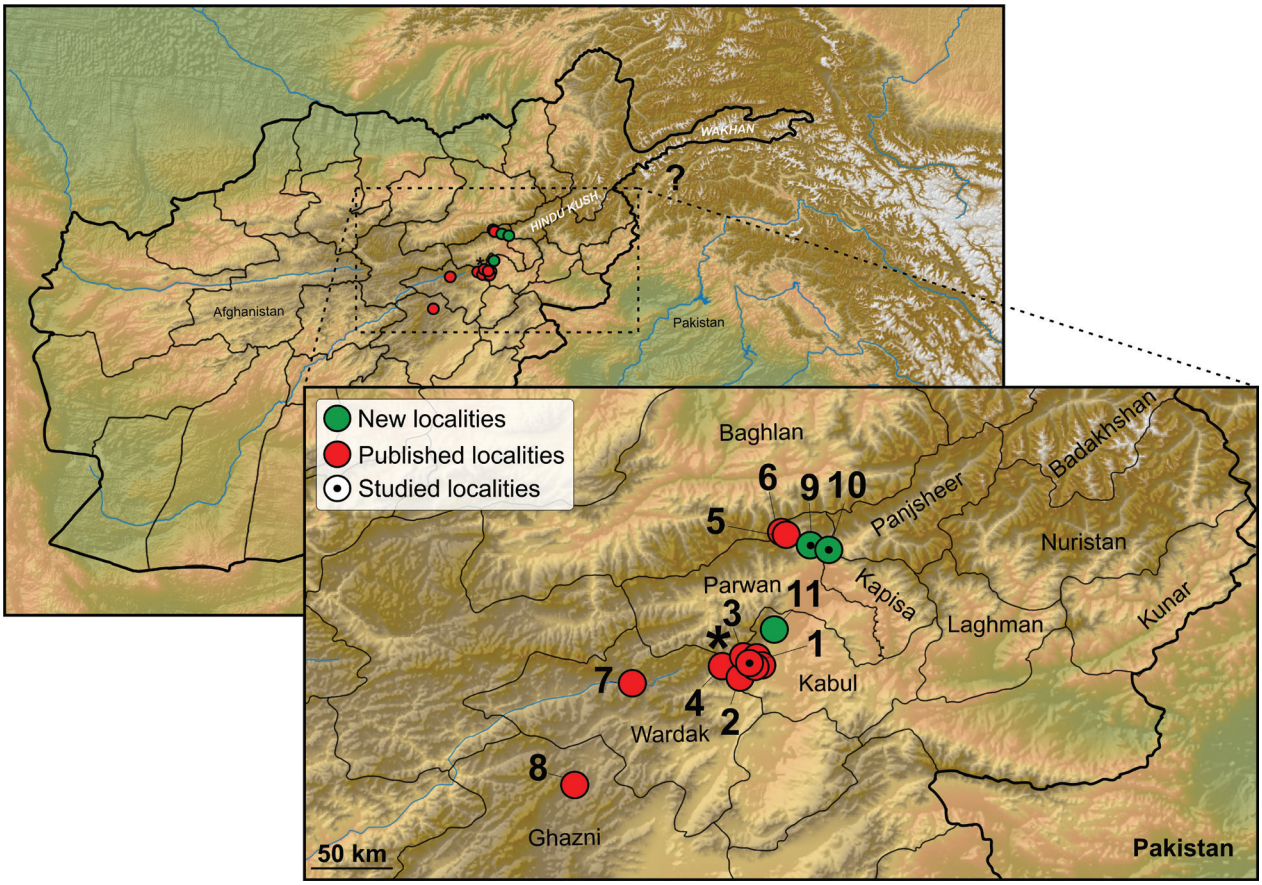


**Figure 1.** The distribution of *Paradactylodon* (*Afghanodon*) *mustersi* represented by published (red circles; for review see Wagner et al. 2016; Ahmadzadeh et al. 2020 and Suppl. material 2) and new records (green circles; this study) from Afghanistan: **1.** Paghman area, Kabul Province; **2.** Rakul', border of Wardak and Kabul provinces; **3.** offsprings of Paghman stream, Parwan Province; **4.** Sanglakh, Wardak Province; **5, 6.** Salang Pass, Parwan Province; **7.** Gardan Diwal in the Koh-i-Baba Massif, Wardak Province; **8.** Dasht-i-Nawar, Ghazni Province; **9.** Gardana Qalatak, Salang Valley, Parwan Province; **10.** Shutul Valley, Panjsheer Province; **11.** Qal'ah-ye Salim Khan, Kabul Province. The asterisk represents the presence of the species mentioned by locals from the Surkh-i-Parsa area, Parwan Province (ca. 34.727°N, 68.740°E). The question mark represents the Wall (1911) record from the Chitral Valley, Pakistan.

beyond Kabul Province (Paghman area; see Jablonski et al. 2020) has not been verified. Therefore, this study aims to bring forth new information from recent field surveys carried out to map the occurrence of *P. mustersi* in Afghanistan and to highlight areas of further investigation and the possible threats the species is facing.

## Materials and methods

Because the species is historically well-known from three tributaries of the Paghman stream, four kilometers above Paghman town (Kabul Province), we carried out time-constrained, visual encounter surveys mostly in this area. Besides, suitable habitats were investigated for the presence of this species in Parwan and Panjsheer provinces. As the presence and abundance of *P. mustersi* may vary throughout the year (Reilly 1983), we made targeted field visits in four distinct seasons between 2017 and 2021. At the beginning of the study in Paghman, semi-structured questionnaires in English (see Suppl. material 1), translated into Dari Persian, and printed photos of the species (available in the literature or internet sources) were distributed among residents and farmers so as to determine the possible localities of the species. The information regarding the presence of the species in Panjsheer and Parwan provinces was gathered during our public awareness lectures in university and school classes, later by distribution of the questionnaires among local people. During field surveys, basic morphological data of encountered individuals, together with geographic coordinates, elevation, and water and air temperature, were recorded (if possible) from the places where salamanders were observed. The total number of field trips was 12, each spanning over five hours' time-constrained searching efforts in a day. Localities were divided across the different areas as follows: eight in the Paghman area (Kabul Province), two in the Gardana Qalatak area of the Salang valley (Parwan Province), and two in the Shutul valley (Panjsheer Province). The Paghman area was surveyed on April 8, 2017; December 17, 2017, May 11, 2018; August 5 and 17, 2019; September 29, 2019 and July 15 and 16, 2021. The Shutul valley (Panjsheer Province) was surveyed on November 9, 2018 and January 17, 2019. The Salang district (Parwan Province) was surveyed on December 26, 2018 and May 3, 2019. We searched for the species using a combination of a visual encounter and randomized walks along the streams. Several observed individuals and their habitats were photographed. Due to security reasons, we were not always able to spend enough time in the studied places, take photographs or particular data, and for the same reasons only the generalized state of the habitat, including anthropogenic effects, were noted. The distribution data (see Suppl. material 2: Table S1) were reviewed with the literature, visualized using QGIS Desktop 3.20.1 software (2021) and used for approximate estimation of the species range.

## Results

We confirm the presence of *Paradactylodon* (*Afghanodon*) *mustersi* in several localities of Kabul (Paghman area is considered as one locality) and Parwan provinces, and for the first time, we report its occurrence in Panjsheer Province (Figs 1–3).

A total of more than 260 individuals were observed during field trips to the Paghman area (Kabul Province; several sites around 34.6155°N, 68.9125°E; Figs 2A–C, 3A, B) at an elevation of about 2,600 meters above sea level in a stream of approximately 4.5 km length. The individuals were found under rocks and near vegetation where the stream flow was low, with a shallow water depth, and with water temperatures ranging between 3 to 16 °C. During the last visit (16 July 2021), the air temperature was 22 °C. The water tilt was low, and salamanders were mostly hidden under rocks and the shade of shrubs and bushes in shallow water. In addition to salamanders, we observed two other amphibian species from families Dicroglossidae and Bufonidae; *Chrysopaa sternosignata* (Murray, 1885) and *Bufotes pseudoraddei* (Mertens, 1971), both species in adult, subadult, juvenile as well as tadpole stages. During the September 2019 survey, we observed the highest number of salamander individuals, i.e., 241, with a minimum of three at a single spot to a maximum of 17. Against this, however, we only observed 16 individuals during our July 2021 survey. One individual has been observed in a human-made pool used as a rainwater reservoir (15 July 2021; 34.6142°N, 68.9117°E; 2,634 m a.s.l. Fig. 2C). During December investigations, we observed three individuals with air temperatures of -4 °C. From a conservation point of view, we noted the increase in the tourist influx and construction activities (including the construction of man-made pools) inside the stream in the Paghman area.

Two field surveys in Shutul Valley, Panjsheer Province (35.1994°N, 69.2611°E, 2,170 m, Fig. 1, loc. 10; Fig. 2D, E) resulted in the sighting of five individuals (Fig. 3C, D), three during the 2018 November survey and two in January 2019. One individual was found under rocks among the shade of shrubs in snow-melted fed streams. Two individuals were found in a human-made pool used as rainwater reservoir. At the same site, two individuals were found in January. They were moving and active. The environmental characteristics of the area were similar to that of the Paghman stream, but the stream flow was very low. The stream dries up during the late summer and autumn seasons, during which the salamanders probably live under rocks near springs that produce water throughout the year (this information emanates from local people). The vegetation cover of the area was very low, limited to the vicinity of water bodies. The common vegetation is *Nasturtium officinale*, which provides shelter to the species. This represents the first record of the species in Panjsheer Province.

**Figure 2.** Localities and habitats in Afghanistan where *Paradactylodon* (*Afghanodon*) *mustersi* were observed. **A, B.** Paghman area, Kabul Province (three individuals at April 8, 2017); **C.** Paghman area, Kabul Province, a human-made pool (one individuals, July 15, 2021); **D, E.** Shutul Valley, Panjsheer Province (five individuals, November 9, 2018); **F.** Gardana Qalatak area, Salang, Parwan Province (three individuals, May 3, 2019).

Two field surveys in Gardana Qalatak (35.2317°N, 69.2086°E, 2,009 m; Fig. 1, loc. 9; Fig. 2F) of the Salang Valley in Parwan Province resulted in observations of three individuals (Fig. 3E). These were found under rocks in shallow water, where the stream flow was relatively low, as well as near springs that produced cooler water (10.8 °C) than that of the stream. One individual was found during the 2018 December investigation in running water and was fully active. Vegetation that covered streams included *N. officinale*, *Schoenoplectus lacustris*, and *Cynodon dactylon*. This locality confirmed the historical records of the species in the Salang area.

Additionally (24 July 2021), we recorded the species from Qal‘ah-ye Salim Khan (34.7749°N, 69.0059°E; elevation between 2,200 to 2,400 m, Fig. 1, loc. 11), situated nearby Qal‘ah-ye Mīrzā, Farza District, Kabul Province. One adult individual (Fig. 3F) was observed in a local mountain stream. This record represents a new locality in Kabul Province, north of the Paghman area, connecting localities from Parwan and Panjsheer provinces. The specimen is currently stored in the Pakistan Museum of Natural History, Islamabad, under the voucher number PMNH 2263.

We took basic morphological measurements from 11 individuals (three from Paghman, five from the Shutul Valley, and three from the Salang Valley) that we sampled during

**Figure 3.** Observed individuals of *Paradactylodon* (*Afghanodon*) *mustersi* from: **A, B.** Paghman stream, Kabul Province, May 11, 2018 and April 8, 2017, respectively; **C, D.** Shutul Valley, Panjsheer Province, November 9, 2018; **E.** Salang Valley, Parwan Province, May 5, 2019; **F.** Qal'ah-ye Salim Khan, Farza District, Kabul Province, July 24, 2021 (PMNH 2263).

our visits. All individuals were adults (sex was not determined) and each of them had 14 coastal grooves extended to their tails. Their total length ranged from 92.0 to 160.0 mm, a tail length between 45.2–75.6 mm, head length 14.8–20.0 mm, and abdomen width 12.7–18.3 mm. The coloration of the body was dark brown to yellowish olive, in some individuals indistinctly speckled with tiny dots (Fig. 3C, D). The tail is oval at the base but flattening at the end.

## Discussion

The present study provides rare insight into the distribution of *P. mustersi* from Afghanistan after an almost 40-year hiatus and provides ecological and conservation notes. Although Jablonski et al. (2020) provided a short contribution concerning predation on this species and confirmed recent occurrence in the Paghman area in Kabul Province (the type locality), detailed data on this critically endangered species has been unavailable for a long time (Böhme 1982; Reilly 1983; Stuart et al. 2008). The last, detailed, field-based study on the species by Reilly (1983) stated that "*Batrachuperus mustersi occurs only in the Paghman Mountains of Afghanistan in a single stream*" – a statement which was probably based on information of Nawabi (1965). However, Reilly (1983) did not survey the distribution extent of this species, as Mertens (1970), and mostly Böhme (1982), had already published

several localities beyond Kabul Province that showed a geographic expansion of about 200 km between the two most distanced localities (Fig. 1). Based on published and new distribution data, we expected that the species range covers about 4,200 km$^2$, limited to mountain streams of the Hindu Kush range. A record of the salamander from the Mastuj area, Chitral valley in Pakistan (Wall 1911), found in the stomach of the dice snake (*N. tessellata*, Natricidae), also suggests that the species could be distributed in the wider area of the Hindu Kush, which could ultimately extend the species range much further. This needs further investigations in Pakistan. We, for the first time, provide the record of this species for Panjsheer Province in Afghanistan. This suggests that provinces with the species presence mentioned in the literature (Böhme 1982; Wagner et al. 2016), as well as suitable habitats of other provinces of Afghanistan (and Pakistan), need to be examined. We highly anticipate the presence of this species in different places of already recorded provinces (e.g. Ghourband Valley in Parwan Province where local people mentioned observation in Surkh-i-Parsa area, ca. 34.727°N, 68.740°E), as well as in Baghlan, Kapisa and Laghman provinces of Afghanistan where the species has never been recorded so far (Fig. 1). Unfortunately, at the time of our investigation, many of these places were not possible to visit due to security reasons. If the record from the Chitral valley in Pakistan is correct (Wall 1911), we can also expect that the species could be present in Afghan provinces bordering Pakistan (e.g. Badakhshan, Kunar, Nuristan) and thus in more new localities in eastern Afghanistan. In this context, we obtained interesting information provided by local shepherds and nomads about the presence of urodelan amphibian from the Wakhan corridor in Badakhshan Province of Afghanistan. The information was provided during a field visit to Wakhan in 2018 and locals confirmed (based on photos we showed) the presence of salamanders in the area between Qala Panja village (36.9500°N, 72.3185°E; ca 2,800 m a. s. l.) and Baba Tungi mountain. Such information is also interesting regarding another salamander, the enigmatic Central Asiatic species *Hynobius turkestanicus* Nikolskii, 1910, and its possible presence in the mountains of Central Asia, e.g. in the neighboring Pamir Mountains (cf. Borkin and Litvinchuk 2011). However, without confirmation based on photographic documentation in the field such information should be taken with caution. Nevertheless, additional research is, therefore, needed for the critically endangered, currently endemic species *P. mustersi*, as well as for other poorly studied species and rather inaccessible areas of Afghanistan (Jablonski et al. 2021).

Although our data are not robust and consistent (mostly due to the sensitive security situation in the country during surveys), we observed that *P. mustersi* is active throughout the year (including December and January), and could be found in streams even with snow cover around. On the other hand, our observations suggest that the presence of the species may be highly influenced by humans (see also Reilly [1983] mentioning the absence of salamanders in places where streams are affected by human activities). In the Paghman stream, the species was mostly observed in areas where human activities were low. Unfortunately, current habitat disturbance is very high, especially close to Kabul city. This decreases the local distribution extent within the Paghman stream area, which constitutes an easily accessible place for local people to seek rest and recreation. Reilly (1983), Stuart et al. (2008), and Wagner et al. (2016) indicate that irrigated cultivation, overgrazing, and physical disturbance by pedestrians and livestock are major threats to the species. This is exacerbated by environmental pollution (passenger transport, garbage), which we observed in the Paghman area. Besides our observation, the movement of vehicles around and even inside streams where the species occurs and breeds is a common practice. The Paghman area is close to Kabul capital city and receives hundreds of residents from Kabul coming for recreation on a daily basis. Moreover, the construction of swimming pools alongside the streams or restaurants increases water pollution, which could highly affect local populations of this endemic and rare Afghan amphibian.

Threats to the species in localities of Parwan and Panjsheer provinces were also documented. Due to an increase in the local resident population, houses and commercial areas are being built inside or nearby streams. Water supply pipelines to Charikar city of Parwan Province are additionally being constructed, taking water from the streams for irrigation purposes. Overgrazing, recreation pressure, and public unawareness constitute additional threats to the diminishing population of *P. mustersi* in the Salang district of Parwan Province. In the Shutul valley of Panjsheer Province, overgrazing and water dam construction for the conservation of water for agriculture purposes pose potential threats to *P. mustersi*.

Unfortunately, due to the long-term unstable situation in Afghanistan and the lack of biodiversity research (Jablonski et al. 2021), our observations remain preliminary. We, therefore, lack information about the current presence of *P. mustersi* from other places mentioned in the literature (see Böhme 1982), and thus we call for intensive field research to improve our knowledge of endangered species of the Hindu Kush.

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## Supplementary material 1

### Baseline survey questionnaire for Paghman stream Salamander in Afghanistan

Authors: Ahmad Samim Ayobi, Rafaqat Masroor, Abdul Basit, Daniel Jablonski

Data type: Adobe PDF file

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Link: https://doi.org/10.3897/herpetozoa.35.e86028.suppl1

## Supplementary material 2

### Table S1. The distribution data of *Paradactylodon* (*Afghanodon*) *mustersi* for the map vizualization (Fig. 1)

Authors: Ahmad Samim Ayobi, Rafaqat Masroor, Abdul Basit, Daniel Jablonski

Data type: excel file

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