

New records of the Endangered Szechwan Rat Snake, *Euprepiophis perlaceus* (Stejneger, 1929) (Squamata: Colubridae: Coronellini), from Shaanxi, China

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Abstract.—The Szechwan Rat Snake (*Euprepiophis perlaceus* Stejneger, 1929) is an Endangered species that is endemic to China. Previous documentation indicates that it is only distributed in narrow mountainous regions in Sichuan. However, some recent sighting records indicate the existence of another population located in the Mts. Qinling, Shaanxi, more than 470 km NW from the original known locality. Here, we report the morphological details of a live-captured individual of *Euprepiophis perlaceus*, and provide information on its taxonomy, distribution, ecology, and conservation implications, along with references to the published literature from Chinese sources.

Keywords. Asia, conservation, morphology, Qinling Mountains, range extension, Reptilia

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Introduction

The Szechwan Rat Snake (also called Pearl-banded Rat Snake) was first described by the American herpetologist Leonhard Stejneger as *Elaphe perlacea*, based on a male specimen obtained in Yachow (Ya'an Prefecture), Szechwan, China, in 1928 (Stejneger 1929), and there had been no further studies on its distribution from then until the early part of this century (Zhao 2006; Hu et al. 2002). This snake was once considered extinct, or regarded as a sub-species or even just a morphological variation of the Mandarin Rat Snake, *Elaphe mandarina* (Schulz 1989; Zhao 2006), since the location of its type species is in the areas where *Elaphe mandarina* is found, and there are many morphological similarities between the two species (Schulz 1989, 1996).

The debate over its status as a distinct species has diminished since three new specimens of *Elaphe perlacea* were recorded between 1980 and 1988, from Wolong National Nature Reserve, Wenchuan County in Aba Tibetan-Qiang Autonomous Prefecture, and Hailuoguo National Glacier Forest Park, Luding County, Ganzi Tibetan Autonomous Prefecture (Deng and Jiang 1989). Zhao (1990) reexamined the morphological

characters of the newly found specimens and argued that *Elaphe perlacea* should be considered as a valid species due to some distinctive features compared to *Elaphe mandarina*. Schulz (1996) supported this assumption, and *Elaphe perlacea* appears on the list of his *A Monograph of the Colubrid Snakes of the Genus Elaphe*. Chen et al. (2014) used multi-locus data obtained from tissue samples of three *Euprepiophis perlaceus* (synonym of *Elaphe perlacea*) individuals and used coalescent model-based approaches to clarify the species validity and explore phylogenetic relationship between this species and others. The results showed that: “*Euprepiophis perlaceus* is a distinct species sister to *Euprepiophis mandarinus* (synonym of *Elaphe mandarina*).” The genus *Euprepiophis* contains three species (*Euprepiophis mandarinus*, *Euprepiophis perlaceus*, and *Euprepiophis conspicillata*), and has also been recently separated from the other rat snake lineages (Utiger et al. 2002; Chen et al. 2014).

Based on the collection of more specimens, the distribution of *Euprepiophis perlaceus* was found to be broader, including two counties in Ya'an Prefecture (Shimian County and Baoxing County) and another two counties in Leshan Prefecture (Mabian County and E'bian

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County) (Hu et al. 2002; Zhou et al. 2012; Ding et al. 2017). All these sites are within a narrow area in western Sichuan (Fig. 1, Zhou et al. 2002; Chen et al. 2014). However, a photograph taken during a field survey by Northwest Agriculture and Forestry University in 2013 raised the question as to whether *Euprepiophis perlaceus* is also located in Ningshan, Ankang Prefecture, Shaanxi, China (Ding et al. 2017). This would extend its known distribution by about 470 km NW from the localities previously reported, and if this is the case, more sighting records of *Euprepiophis perlaceus* should be obtained through extensive surveys in this area. Five years after the 2013 record, one of the authors confirmed another record based on a video recording taken during a field trip on 18 May 2018, at Zhouzhi, Xi'an Prefecture, Shaanxi, China (Table 1). Nevertheless, no voucher specimen was available until an extensive search was conducted during summer 2019, in which the authors obtained a live individual in Foping County, Hanzhong Prefecture, Shaanxi Province, China.

Thus, in this study, the morphological characters of a live *Euprepiophis perlaceus* individual captured in Shaanxi are described, followed by an assessment of all the encounter records recently reported in Shaanxi, including some unpublished records. In addition, a preliminary assessment of its distribution, ecology, and conservation are also discussed based on sources published in the Chinese literature.

Materials and Methods

The specimen was encountered at 1117 h (GMT + 8) from a pile of dead leaves at the base of a cliff, near a cement road, in a valley of Foping County, Hanzhong Prefecture, Shaanxi, China, on 23 June 2019 (elevation: 1,650 m asl). The surrounding habitat was secondary deciduous broadleaf forest consisting of high arbors and shrubs (Fig. 3). The photo of the specimen was taken with a digital Nikon D810 camera with an AF-S Micro NIKKOR 60 mm F2.8G lens, and the specimen was then kept in the Shaanxi Key Laboratory for Animal Conservation, Northwest University, Xi'an, Shaanxi,

China. The equipment used in taking the measurements included a caliper (to the nearest 0.1 mm), a measuring tape (to the nearest 1 mm for snout-vent length (SVL) and tail length (TL)), and a piece of soft rope. The total body length, SVL (from the snout to the posterior margin of the anal plate), and tail length (TL) were firstly marked on the soft rope and then measured with the measuring tape. Sex was determined via a Rapti-zoo SE001 Snake sex probe speculum following the method of Blanchard and Finster (1933) and Fitch (1960).

Additional visual records of *Euprepiophis perlaceus* were collected through browsing local social media (e.g., "WeChat") for the snake's images and the published records in Chinese sources. We also interviewed the witnesses or photographers taking the photos to obtain more information on the locations and times the photos were taken. The elevations where the *Euprepiophis perlaceus* were encountered in Shaanxi are provided in Table 1, and were obtained according to location landmarks with Google Earth Pro 7.3.0.3832 (64-bit), when information on the exact locations could be obtained.

Results and Discussion

This species is characterized by a moss-green color with paired black bands (1–2 widths of the dorsal scale row) mixed with yellow-green edges on the dorsum and tail. The snout and forehead have two black strips extending through the nostrils and eyes, respectively, both ending on the supralabials, with a second strip separated into two branches beneath the eyes. Posterior to the strips, there are three black V-shaped patterns aligned on the upper surface of head, occiput, and back. The belly is greyish white with dark gray blotches. The snout is obtuse. There is no distinct separation between head and neck. The eyes are entirely black. Anal is divided into two parts. Along with the external morphological characters given in Fig. 2 and Table 2, the description and measurements of the captured individual are consistent with those taken by Zhao (1998, 2006) and

Table 1. New distributional records of *Euprepiophis perlaceus* in Shaanxi, China.

Location	Month and year	Elevation (m asl)	Reference
Ningshan, Ankang Prefecture	July 2020	-	pers. comm.
Huxian, Xi'an Prefecture	May 2020	-	pers. comm.
Ningshan, Ankang Prefecture	July 2019	1,520	pers. comm.
Foping, Hanzhong Prefecture	June 2019	1,650	this study
Ningshan, Ankang Prefecture	June 2019	1,422	Wu et al. 2019
Zhouzhi, Xi'an Prefecture	August 2018	1,790	pers. comm.
Zhouzhi, Xi'an Prefecture	May 2018	1,440	this study
Ningshan, Ankang Prefecture	June 2017	-	pers. comm.
Ningshan, Ankang Prefecture	June 2016	-	pers. comm.
Ningshan, Ankang Prefecture	June 2013	1,610	Ding et al. 2017

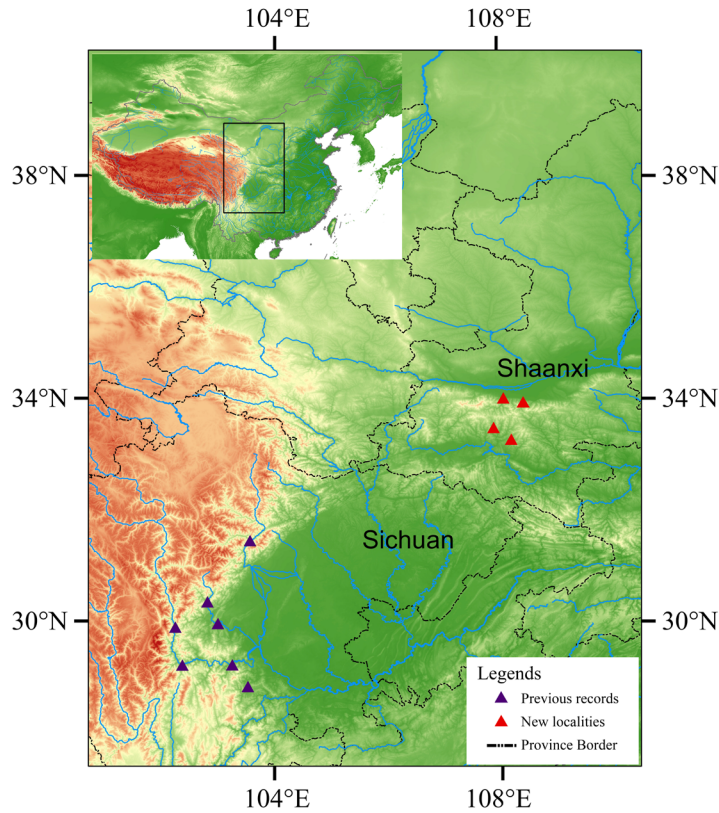


Fig. 1. New locations where *Euprepiophis perlaceus* was found in Shaanxi, including Ningshan, Foping, Zhouzhi, and Huxian. The previous distribution localities of the species in Sichuan include Ya'an, Wenchuan, Luding, Shimian, Baoxing, Mabian, and E'bian.



Fig. 2. Dorsal view of *Euprepiophis perlaceus* captured in Foping County, Hanzhong Prefecture, Shaanxi Province, China. Photo by Shi-Yi Tang.



Fig. 3. View of the *Euprepiophis perlaceus* habitat in Foping, Shaanxi Province, China. Photo by Bin Yang.

Ding et al. (2017) (Table 3).

Records of *Euprepiophis mandarinus* were also reported in various plots around our research area (Wang and Song 2000; S.Y. Tang et al., pers. comm.). However, *Euprepiophis mandarinus* has a greater body length (largest measured specimen: 1,425 mm) compared with *Euprepiophis perlaceus* (largest measured specimen: 1,244 mm) (Zhao 1998). The upper body and tail are purplish gray or yellowish brown with conspicuous yellow spots edged by black diamond circles, which were distinct from *Euprepiophis perlaceus* (see the description above). The temporals of *Euprepiophis mandarinus* were 2+3, which is different from *Euprepiophis perlaceus* and *Euprepiophis conspicillata* (temporals: 1+2) (Table 3; Zhao 1998). The number of dorsal scale rows for *Euprepiophis mandarinus* is 23-23-19 (for the number of dorsal scale rows counted: behind the head-middle ventral-before the tail), which is different from *Euprepiophis perlaceus* (19-19-17) (Table 3). *Euprepiophis conspicillata* is endemic to the Japanese archipelago, which has no distributional overlap with the other two species in the genus *Euprepiophis* (Stejneger 1907).

Preliminary research on the range and ecology of *Euprepiophis perlaceus* in Sichuan indicated that the preferred habitats are deciduous broadleaf forest and mixed evergreen deciduous broad-leaved forest in temperate mountains with elevations of 1,600–2,800

m asl (Gan et al. 2017; Ding et al. 2017). The habitat where *Euprepiophis perlaceus* was found in Shaanxi is very similar to those reported in Sichuan. Considering the topography, climate, mountain range alignment, and the spatial pattern of vegetation types in Southern Shaanxi, Northern Sichuan, and Southeastern Gansu, suitable habitats for *Euprepiophis perlaceus* might be widely distributed in this area (Zhang 2010; Cheng and Wang 2019; Fig. 1). As this snake is constantly being encountered by humans in different counties within the Mts. Qinling (a major mountain range in Southern Shaanxi, where all the sighting records of *Euprepiophis perlaceus* were reported; Fig. 1, Table 1), we believe the actual distribution areas in Shaanxi are broader than previously known. In fact, populations of *Euprepiophis perlaceus* in the two neighboring provinces may form a continuous range. This proposition could be physically confirmed by conducting extensive surveys to the areas with deciduous broadleaf forests in the Mts. Qinling. Additional surveys should focus on the western part of this mountain range, where there are gaps between the known locations of the neighboring provinces. Further studies on the morphological and molecular components, and comparisons with other species in the same genus, are needed in order to fully understand the phylogenetic relationships between the two populations, or sub-populations in varying geographic scopes (e.g., between sub-populations in the southern and northern slopes of the Mts. Qinling).

As the main body of the Mts. Qinling, the southern Shaanxi is famous for its global biodiversity hotspots and refugia and for many endangered mammals and birds, particularly during the last glaciation (Wang et al. 2013). The Chinese Government has invested a great deal of manpower in the conservation of “four precious species in the Mts. Qinling” (Giant Panda, *Ailuropoda melanoleuca*; Golden Snub-nosed Monkey, *Rhinopithecus roxellana*; Crested Ibis, *Nipponia nippon*; and Takin, *Budorcas taxicolor*). *Euprepiophis perlaceus* has been listed as Endangered on the IUCN Red List of Threatened Species (Zhou et al. 2012), and the new distribution records in southern Shaanxi caught our attention for the conservation of this species, as well as other Threatened or Endangered amphibians and reptiles in this area. It is necessary to raise the issues of a conservation strategy for this snake species, in addition to carrying out further surveys and studies on its ecology, behavior, and dietary selection. At the moment, what we know about its conservation status is that like most other ophidian species, the most likely threats to *Euprepiophis perlaceus* could include road accidents (traffic is heavy in the areas), habitat loss, poaching (for bushmeat), intentional killing due to the fear of snakes in the local culture, natural disasters (such as floods), and predation by other animals (Zhou et al. 2019). Although a series of natural reserves has been established in the Mts. Qinling, rapid tourism

Table 2. Morphological information and pholidosis data of the *Euprepiophis perlaceus* specimen used in this study.

Parameter	Value or information
Collection locality	Foping, Hanzhong Prefecture, Shaanxi, China
Elevation	1,650
Sex	male
Date of collection	23 June 2019
Collector	Shi-Yi Tang
Total body length	907 mm
Snout to vent length	725 mm
Tail length	182 mm
Head length	18.1 mm
Head width	13.6 mm
Diameter of eye	3.6 mm
Eye-nose*	6.6 mm
Number of ventrals	225
Pairs of subcaudals	66
DOR1**	19
DOR2**	19
DOR3**	17
Number of temporals	1+2
Number of supralabials	7
Number of supralabials touching the eyes	3 rd and 4 th
Number of infralabials	8
Number of loreals	1
Number of pre-oculars	1
Number of post-oculars	2

* Eye-nose: distance from center of the eye to posterior border of the nostril.

**DOR1: number of dorsal scale rows at one head-length behind the head; DOR2: number of dorsal scale rows at the position of the middle ventral; DOR3: number of dorsal scale rows at one head-length before the tail.

development would inevitably lead to the expansion of roads and other artificial constructions, while increasing human disturbance in this area.

Overharvesting for the pet trade may be another major challenge to the conservation of *Euprepiophis perlaceus* (Zhou et al. 2019). A preliminary investigation into the underground pet market showed this snake had become one of the most sought-after species for reptile collectors. It sells for about US\$400–1,000, probably due to its rarity, mild-temper, and attractive appearance (Zhou et al. 2019; S.Y. Tang et al., pers. comm.). To avoid the risk of increased poaching activity, as suggested by Ngo et al. (2019), we did not provide the exact localities where the *Euprepiophis perlaceus* population was found in this paper.

In summary, the distribution of *Euprepiophis perlaceus* is broader than previously reported. Unfortunately, this Endangered species has received

very little attention, since no conservation plan or effort has been proposed so far. Thus, we argue that appropriate conservation strategies and management are necessary, and scientific studies on its life-history, behavior, reproduction, and population genetics are needed, as proposed by Gan et al. (2017), Ding et al. (2017), and Zhou et al. (2019). A monitoring system on the dynamic population profiles of this species should be established, so that emergency strategies for its conservation could be applied if a significant population decline was detected. On the other hand, more technical programs for captive breeding are also required (Chen et al. 2017).

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Table 3. Morphological information and pholidosis data of the three recognized species in the genus *Euprepiophis*: *Euprepiophis perlaceus*, *Euprepiophis mandarinus*, and *Euprepiophis conspicillata*.

Species	<i>Euprepiophis perlaceus</i>	<i>Euprepiophis mandarinus</i>	<i>Euprepiophis conspicillata</i>
Distribution	China (Sichuan Province and Shaanxi Province)	China (nearly all central and southern provinces), northeastern Indo-Chinese Peninsula	Japanese archipelago
Threat level (IUCN)	Endangered	Least Concern	Least Concern
Number of ventrals	224–231	181–237	200–227
Pair of subcaudals*	57–69	53–75	60–76
DOR1**	19	23	
DOR2**	19	23	21***
DOR3**	17	19	
Number of temporals	1+2 (1+3 in rare cases)	2+3	1+2 (2+2 in rare cases)
Number of supralabials	7	7 (6 or 8 in rare cases)	7 (6 or 8 in rare cases)
Number of supralabials touching the eye	3 rd and 4 th	3 rd and 4 th	3 rd and 4 th
Number of infralabials	7–9	9	9
Number of loreals	1	1 (lacking in one side in rare cases)	1 (lacking in one side in rare cases)
Number of post-oculars	2	2 (1, 3 or lacking in one/both sides in rare cases)	2
Number of pre-oculars	1	1	1
Anal	divided	divided	divided (undivided in rare cases)
References	Stejneger 1929; Zhao 1998; This study; Zhou et al. 2012	Zhao 1998; Ji et al. 2012	Stejneger 1907; Borkin et al. 2017

* The terminal scute had been excluded.

** DOR1: number of dorsal scale rows behind the head; DOR2: number of dorsal scale rows at the position of the middle ventral; DOR3: number of dorsal scale rows before the tail. For DOR1 and DOR3, the positions of scale rows counting are different, and for *Euprepiophis perlaceus*, we counted the scale rows at one head-length behind the head for DOR1 and at one head-length before the tail for DOR3. Zhao (1998) used similar criteria in describing *Euprepiophis mandarinus*, but the scale rows were counted at two head-lengths behind the head (for DOR1), or before the tail (for DOR3).

*** Stejneger (1907) only generally described number of scale rows of *Euprepiophis conspicillata* as 21, without documenting the positions where the scale rows had been counted.

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Shi-Yi Tang has been involved in specimen collection, photography, and behavioral studies of insects, amphibians, reptiles, and birds since childhood. His research interests lie largely with taxonomy, distribution, behavioral ecology, and conservation of wild animals across diverse taxa. Shi-Yi Tang finished his Ph.D. in 2017 at Wuhan University, China, majoring in avian behavioral ecology. He spent nearly 20 months in total at various field research sites in the Qinghai-Tibetan plateau between 2008 and 2016, and had been appointed as a visiting Ph.D. student in Cornell University (Ithaca, New York, USA) from September 2012 to June 2013. Shi-Yi Tang is currently working as a post-doctoral fellow at Shaanxi Key Laboratory for Animal Conservation, College of Life Sciences, Northwest University, Xi'an, China, where he is involved in several research programs on the ecology and biodiversity conservation of endangered animal species in Mts. Qinling.



Chen-Liang Li is a herpetologist currently working as the director of Hubei Board Nature Technology Service Co., Ltd. He obtained his doctoral degree in 2016 at the College of Life Sciences, Central China Normal University, where he majored in animal behavioral ecology and conservation. His research interests include the taxonomy, distribution, behavioral ecology, and conservation of amphibians and reptiles, as well as threatened animal species in other taxa. Chen-Liang Li is currently conducting several projects related to environmental education for wildlife in China, while promoting a habitat conservation plan for the Critically Endangered Baer's Pochard, *Aythya baeri*.



Yu-Li Li is currently working on her Ph.D. degree under the supervision of Professor Bao-Guo Li at Shaanxi Key Laboratory for Animal Conservation, College of Life Sciences, Northwest University (Xi'an, China). Yu-Li finished her M.A.Sc. degree in 2011 at the Northwest Agriculture and Forestry University. Her work focuses on the ecology, population genetics, and conservation of endangered animal species in the Mts. Qinling.



Bao-Guo Li is a professor at Shaanxi Key Laboratory for Animal Conservation, College of Life Sciences, Northwest University (Xi'an, China). He guides the research of Ph.D. students as well as M.Sc. students. He graduated in 1982 from the Shaanxi Normal University with a B.S. in Zoology, and then obtained his M.S. from Northwest University (China) in 1985. He had been appointed as a visiting professor in Kyoto University (Japan) from May 2001 to April 2002, and a visiting professor in Massey University (New Zealand) in 2007. His research interests are mainly on the social behavior and conservation biology of endangered animals in Mts. Qinling. He has been supervising projects supported by NSFC, Pro-Natura Fund of Japan, COSMO Oil Eco Card Foundation of Japan, Primate Conservation Inc., and the Zoological Society of San Diego (California, USA). Prof. Bao-Guo Li has received many accolades for his contributions to wildlife research and biodiversity conservation in China.