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A range extension of *Walterinnesia morgani* (Mocquard, 1905) (Reptilia: Squamata: Elapidae) to Southeastern Iran

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Abstract

One juvenile specimen of the desert Cobra (*Walterinnesia morgani*) was obtained from Kerman Province, southeastern Iran. Three further localities of the species were recorded during 2010–2020. The farthest locality is situated about 270 km northeast of easternmost limit of the range. These records indicate a wider distribution of *Walterinnesia morgani* on the Iranian Plateau than previously thought. Results indicated that *Walterinnesia morgani* has a compatible distribution pattern with the zoogeographical region of Khuzestan Plain and the Persian Gulf Costs. In addition, information of pholidosis and habitat is presented.

Key words: Desert Cobra, distribution, Kerman, morphology

With two species, the genus *Walterinnesia* is distributed in Arabia and the Middle East (Sindaco et al., 2013). Szyndlar and Rage (1990) considered it a close relative of *Naja*, but Kelly et al. (2009) and Pyron et al. (2011; 2013) indicated that *Walterinnesia* occupies a basal position within a clade that includes *Naja* and clusters with the southern African genus *Aspidelaps*. Pyron et al. (2013) and Lee et al. (2016) found that *Calliophis melanurus* Shaw, is sister to all other elapid taxa with strong support. These authors have also recognized three main groups within Elapidae: group 1 including *Maticora*, *Micruroides*, *Sinomicrurus*, and *Micrurus*; group 2 including *Hemibungarus*, *Ophiophagus*, *Dendroaspis*, *Walterinnesia*, *Aspidelaps*, *Hemachatus*, and *Naja*; group 3 including *Elapsoidea*, *Bungarus*, and all of the Hydrophiinae.

The description of *Naja morgani* Mocquard is based on five syntypes (three male and two female specimens from Khuzestan Province in the southwest of Iran) collected by M. Morgan, as follows: Neck does not appear dilatable: snout protruding; length of the upper part of the rostral equals two-thirds of its distance to the frontal; internasals do not touch the preocular, from which they are separated by the prefrontals, which form a suture with the nasal; frontal noticeably longer than its distance from the rostral; parietals bordered externally by 3 temporals, of which the posterior is the largest; 5th supralabial almost always in contact with the 2 postoculars; anal plate divided, and the 40 to 46 urosteges (subcaudals) are partly single. Coloration is a uniform, very dark brown above, pale below (Mocquard, 1905).

The Iranian specimens were long considered as *Walterinnesia aegyptia* Lataste (Marx, 1953; Hass and Werner, 1969; Leviton et al., 1992; Latifi, 2000), but Nilson and Rastegar-Pouyani (2007), based on dorsal scale counts in the anterior part of body, lower number of ventrals and subcaudals, and color pattern of juveniles, identified the eastern populations of *Walterinnesia* in Iran, Iraq and eastern Saudi Arabia as the distinct species, *W. morgani* Mocquard.

More recently, Rajabizadeh (2018) noted that there was less than 1 percent difference between Iranian and Palestinian specimens (*W. aegyptia*) in the Cyt b gene; therefore, he considered Iranian specimens as a subspecies of *W. aegyptia*. Furthermore, it was considered that the specimens referred to as *W. morgani* from Saudi Arabia were conspecific with *W. aegyptia* based on 16S rRNA and 12S rRNA gene analyses (Alshammari et al., 2022). However, a comprehensive phylogenetic study that examines at

least all three of these genes among populations of this species has not yet been conducted, and the taxonomic status of Iranian specimens remains unclear. Therefore, in this paper, the name currently accepted in the Reptile Database (Uetz et al., 2023), *Walterinnesia morgani*, is used.

Previous studies have delineated the distributional pattern of *W. morgani* in Iran across the western Zagros Mountains, Khuzestan Plain, southern Zagros slopes, and Persian Gulf coastal regions (Leviton et al., 1992; Latifi, 2000; Nilson and Rastegar-Pouyani, 2007; Fathinia et al., 2010; Gholamifard and Rastegar-Pouyani, 2012; Gholamifard and Şahin, 2023). A record from the Alborz Mountains from Nilson and Rastegar-Pouyani (2007) created confusion, but further investigation by Rajabizadeh and correspondence with the collector revealed the specimen was actually collected in Lorestan Province, and subsequently mislabeled at the Zoological Museum (Rajabizadeh, 2018).

In recent years, additional observations have expanded the documented range of *W. morgani* in southeastern Iran. The current study presents new distribution records that were evaluated through examination of specimens or photographic evidence. The aim is to synthesize these recent easternmost records with the previously known distribution in order to update the overall distribution map for *W. morgani* in Iran, and to discuss the biogeography of the species.

In 2020, a preserved juvenile specimen from Jabal Barez Mountain, Jiroft with no precise locality was sent to the zoological museum of Shahid Bahonar University of Kerman (Fig. 1A). The specimen was photographed using a digital camera prior to examination. Morphometric measurements, including width or length of plates on or behind the head, and head length for detecting the exact place for counting dorsal rows, were then taken with calipers to the nearest 0.1 mm. Furthermore, snout-vent length (SVL) and tail length (TL) were measured using a tape measure. We investigated meristic characteristics including counts and arrangement of postocular; subocular; temporal; supralabial; infralabial; dorsal scales in three places (one head length behind neck, mid-length of SVL, one head length before vent); ventral, anal plate, and subcaudal scales using by stereomicroscope in the Zoological Lab of the University of Kerman. Finally, the specimen was deposited in the Zoological Museum, Shahid Bahonar University of Kerman (ZMSBUK) and labeled W-2020.

For defining the putrefied specimens, we dissected heads and investigated dentition, considering just *Walterinnesia* has fixed large proteroglyphous fangs; definition of species is easier. We were unable to validate photographic records except in the case of one video clip taken by a trusted colleague that showed a juvenile specimen with clear dorsal pattern.

The voucher specimen (W-2020) was identified as *Walterinnesia morgani* based on the following combination of morphological characteristics previously described for the species (Leviton et al., 1992; Latifi, 2000; Uğurtaş et al., 2001; Nilson and Rastegar-Pouyani, 2007; Rajabizadeh, 2018): Slender snakes of medium size with body lengths up to one meter. Venom-conducting fangs large, fixed in position; maxilla behind fangs without teeth. The head large, oval shape, flat and slightly distinct from body; pupil round; rostral wide; head covered above with nine large symmetrically arranged plates, two internasals, two prefrontals which are slightly larger than internasals, frontal as wide as or wider than supraoculars, two long parietals; loreal shield absent; nasal shield divided; one preocular directly contacting to nasal shield, two postoculars; and one posterior subocular. 21–29 dorsal longitudinal rows in the middle of body, smooth anteriorly, keeled posteriorly and on tail; anal plate divided; subcaudal plates divided or some of the anterior plates united and the rest divided.

The preserved specimen (W-2020) is a juvenile measuring 263 mm SVL and 34 mm TL. The dorsum is black with 29 white crossbars. The venter is black with a matte silver tint (Fig. 1A). The body is cylindrical with a short tail (total length/TL ratio = 8.7) and a vertebral furrow from the neck to mid-trunk. Pholidosis in both sides of the head is symmetrical. There are two postoculars and one posterior subocular; temporals 2 + 3; upper anterior temporal contacts both postoculars; lower anterior temporal is in contact with the fifth and the sixth supralabials; Lower posterior temporals are in contact with the sixth and the seventh supralabials (Fig. 2C). The third and the fourth supralabials in contact with eye, the fifth one with lower postocular and subocular. There are 7 supralabials and 9 infralabials. Rostral very large an approximately 5 times larger and 2 times wider than triangle-shaped mental shield (Fig. 2B). Anterior chin shields are slightly longer than posterior. All of the body scales smooth. Dorsal scales in 23:23:17 rows, scales of the first row behind neck are larger than others. Ventral scales 186 (preventrals included); anal divided; subcaudals 40, first and second united, and the rest of them divided (Fig. 2D).

During the last decade, there have been several reports of the presence of desert cobra in Kerman Province, southeastern Iran. The first observation was made in 2010 by A. Sarkhosh in the Khabr National Park (28°36′ N, 56°8′ E; 1360 m a.s.l.). But only one photo (Fig. 1D) and no voucher specimen was obtained. In the same year, a dead specimen was found and identified by N. Moradi near the previous location (28°38′ N, 56°6′ E; 1389 m a.s.l.), but due to severe putrefaction of the specimen, it was not possible to preserve it in the zoological museum. The habitat was a rocky desert with arid grasslands, surrounded by rocky hills. The vegetation is dominated by *Artemisia* sp., *Amygdalus scoparia*, *Cousinia stocksii*, and *Ebenus stellata* (Fig. 3C).

Figure 1: (A) Juvenile specimen of *Walterinnesia morgani* (W-2020) from Jiroft, Kerman Province, southeastern Iran; (B) specimen from 82 km southeast of Bam, Kerman Province (photo by M. Sa'adat-Nejad); (C) juvenile specimen from about 17 km northeast of Kahnooj, Kerman Province (video clip by M. Darabi); (D) specimen from the Khabr National Park, Kerman Province (photo by A. Sarkhosh).

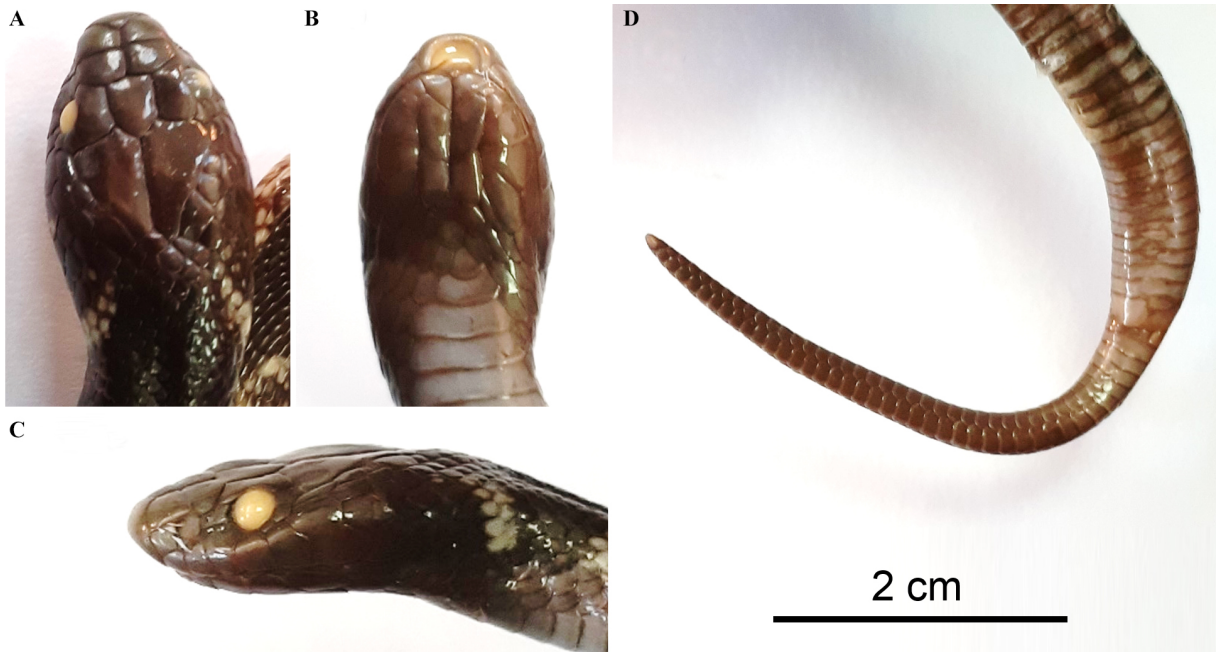

Figure 2: Pholidosis of voucher specimen (W-2020). (A) Head from above; (B) head from below; (c) head from left side; (d) tail from below.

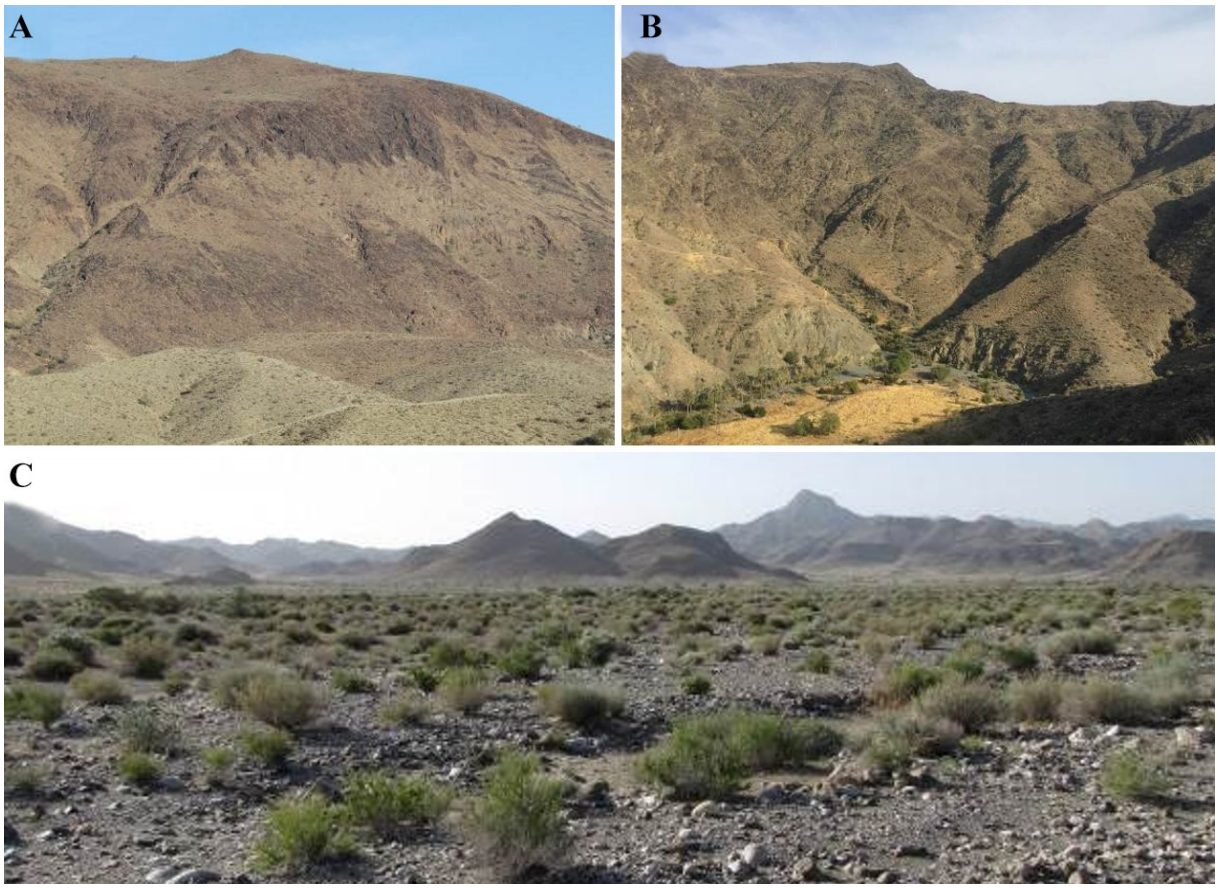

Figure 3: The habitats of *W. morgani* in southeastern Iran: (A) about 82 km southeast of Bam, photo by M. Sa'adat-Nejad; (B) about 17 km northeast of Kahnooj, photo by Adel Salari; (C) Khabr National Park.

In 2014 another dead specimen was recorded by M. Sa'adat-Nejad in the non-hunting area of Rigan (28°24′ N, 58°40′ E; 1203 m a.s.l.) and sent to ZMSBUK, but due to severe putrefaction, we were not able to preserve that one either (Fig. 1B). This specimen was observed at the base of an arid rocky mountain (Fig. 3A). In 2020, a short video clip was recorded by M. Darabi showing a juvenile specimen near Kahnooj (28°0′ N, 57°31′ E; 1338 m a.s.l.), but no specimen was caught (Fig. 1C). The specimen was observed near a spring in a rocky valley (Fig. 3B).

Since the exact coordinates of the voucher specimen were unavailable, the updated distribution map was drawn using the coordinates of two putrefied specimens and one juvenile snake identified in the video clip, in addition to incorporating previous published data (Fig. 4). The farthest locality is situated about 270 km northeast of easternmost limit of the currently recognized range. These new records indicate a wider distribution of *W. morgani* on the Iranian Plateau than previously thought. The distributional pattern of this taxon shows that *W. morgani* has been able to reach southeastern Iran across the southern slops of the Zagros Mountains and shore line. It seems that the Zagros Mountains have acted as a barrier, preventing the spread of the species range to the Central Plateau (Gholamifard and Rastegar-Pouyani, 2012; Gholamifard and Şahin, 2023).

According to the zoogeographical subdivision presented by Anderson (1999), which divided Iran into 13 regions, *W. morgani* is distributed in three of them. 1- "Western Foothills of the Zagros Mountains" [WZ] containing the westernmost part of Iran (Ilam, Kermanshah provinces and small part of western Lorestan). The climate type of this region is "Mediterranean, winter rains" (Walter and Lieth, 1960–1967), and there are two main biomes "Deserts and Xeric Shrublands" [DX] and "Temperate Broadleaf and Mixed Forests" (Olsen et al., 2001). 2- "The Khuzestan Plain and Persian Gulf Coast" [KH] containing Moesopotamian Plain (Khuzestan and small part of southern Ilam), the southern slopes of Zagros Mountain and the coast of the Persian Gulf, to the south of Kerman Province. The climate type of this region is "Subtropical, hot and arid" [HOT] (Walter and Lieth, 1960–1967) and comprises two main biomes: DX and "Flooded Grassland and Savannas" (Olson et al., 2001). 3- "Islands of the Persian Gulf" [I] however, *W. morgani* has only been documented on Qeshm Island (Sindaco et al., 2013). Climate type of this region is HOT (Walter and Lieth, 1960–1967) and the main biome is DX (Olsen et al., 2001).

Safaei-Mahroo et al. (2015) drew a map of Iran's ecoregions based on a shape file provided by Olson et al. (2001). According to this map, a) [WZ] includes three ecoregions: "Mesopotamian shrub desert", "South Iran Nubo-Sindian desert and semi-desert" (NSD), and "Zagros Mountains forest steppe" (ZFS); b) [KH] includes three ecoregions: "Arabian Desert and East Sahero-Arabian xeric shraublands", NSD, and "Tigris-Euphrates alluvial salt marsh"; c) [I] has just one ecoregion, NSD. Safaei-Mahroo et al. (2015), also mentioned that *W. morgani* is a common species in ZFS, but based on the previous studies, our field observations and matching the distribution map to the ecoregion's map, it was found that this species is found in all three ecoregions of the WZ, and is only distributed in ecoregion NSD of KH and I. The present study indicates that *W. morgani* is probably a common species in the "South Iran Nubo-Sindian desert and semi-desert" ecoregion and has an isolated range in ZFS, which is related to western Iran. The chorotype is mentioned "Arabian-Saharan-Mediterranean transition zone" + "Arabian" by Sindaco et al. (2013) therefore, the wide distribution of *Walterinnesia* in the lowland and tropical regions of the Middle East, including Iraq, Syria, the Arabian Peninsula, to the southeastern coasts of the Mediterranean confirms that species in this genus prefer tropical and desert regions.

Studying the range dynamics of *W. morgani* in Iran (Gholamifard and Şahin, 2023) also confirms that suitable habitats for this species exist in southwestern and southern tropical regions of Iran. It has been found that daily and annual temperature cycles and seasonal factors, especially the driest seasonal precipitation dynamics affect the distribution of this species, but the most limiting factors for the distribution of this snake are the distance to water sources and topographical parameters (Gholamifard and Şahin, 2023). The Desert Cobra is abundant in south and southwest palm farms. At the northwesternmost limit of distribution, it occupies flat plains and agricultural lands (Fathinia et al., 2010). Furthermore, our observations show that all of the snakes observed in Kerman Province were either immediately adjacent to water sources or a short distance from water sources that the distribution of *Walterinnesia morgani* is best characterized as compatible with the zoogeographical region "the Khuzestan Plain and Persian Gulf Coast" which has a unique topographic features, climate type, ecoregions and suitable habitats.

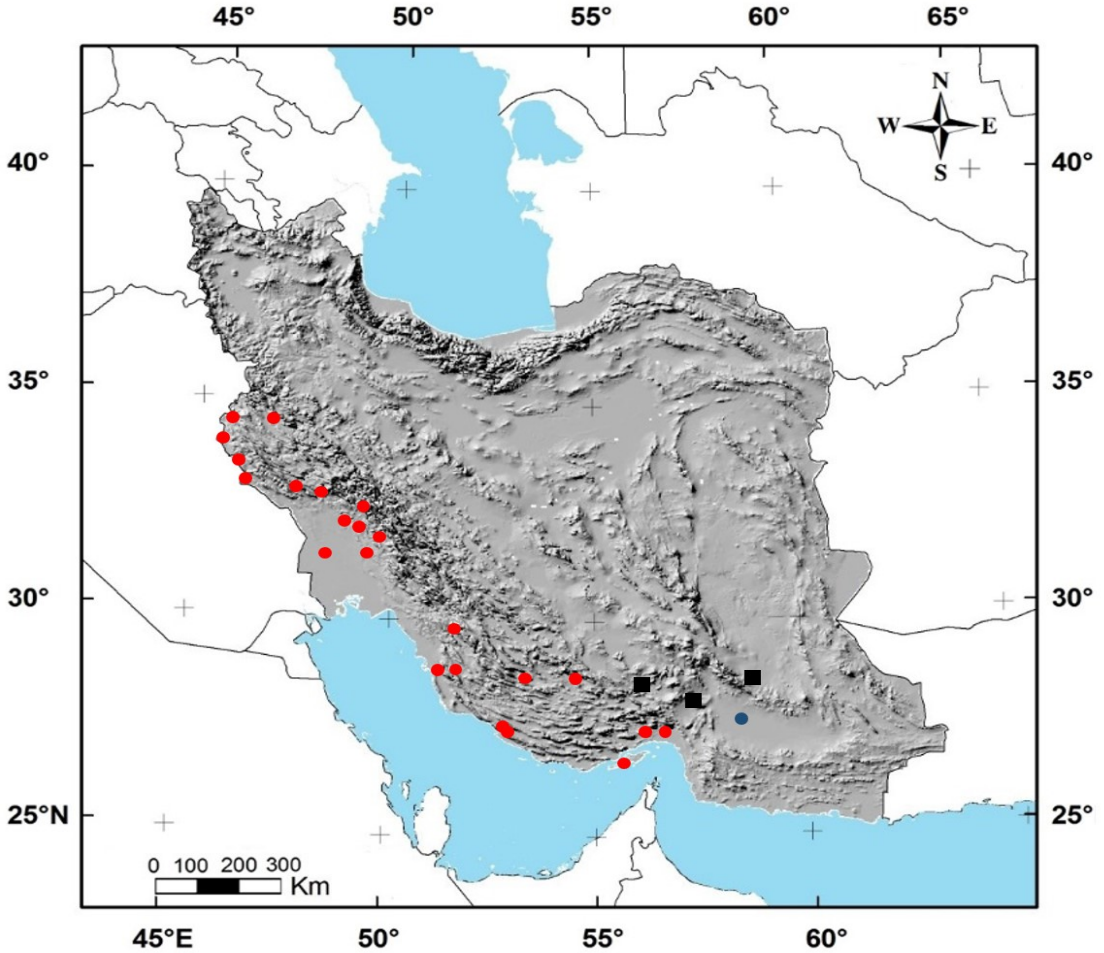

Figure 4: Updated distribution map of *Walterinnesia morgani*. Black squares represent the new localities; red circles represent previous localities (Sindaco et al., 2013; Rajabizadeh, 2018; Gholamifard and Şahin, 2023), blue circle presented by Sindaco et al. (2013), however, rejected by Rajabizadeh (2018).

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Author contributions

M.S. and S.S. contributed to data collection, including obtaining samples and photographic documentation. Taxonomic identification of specimens was conducted by N.M. and S.S. The manuscript was drafted by N.M. S.S. provided supervision throughout the study and writing process.

Conflict of interest

The authors declare that there are no conflicting issues related to this short communication.

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