

# Phenotypical variation and range extension distribution of the Snake-eyed Skink, *Ablepharus bivittatus* (Sauria: Scincidae) in Iran

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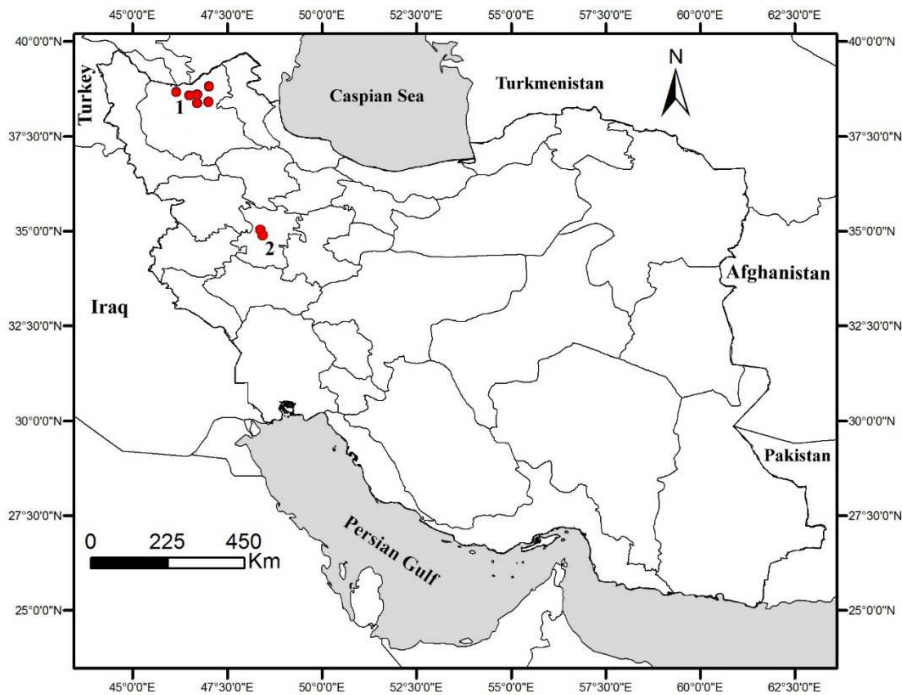
The Snake-eyed Skink genus *Ablepharus* Fitzinger, 1823 occurs in southeastern Europe, southwest Asia, and central Asian Republics (Anderson 1999). Lizards in this genus lack movable eyelids, with the lower eyelid fused to the upper eyelid, thereby forming a transparent spectacle covering the eye. The genus *Ablepharus* consists of 10 recognized species, of which *A. bivittatus* (Ménétriés, 1832), *A. pannonicus* Fitzinger, 1823, and *A. grayanus* (Stoliczka, 1872) occur in Iran (Anderson, 1999; Karamiani et al. 2015). *A. bivittatus* is distributed in eastern Turkey, Armenia, Azerbaijan, and Iran (the northern Zagros Mountains, and only one record from the Kopet Dagh Mountains), (Anderson 1999; Ilgaz et al. 2007; Sindaco and Jeremčenko 2008; Smid et al., 2014). Although *A. bivittatus* is widely distributed, no quantitative data on sexual size dimorphism (SSD) have yet been published.

Sexual dimorphism refers to differences in size, body shape, or coloration between males and females (Becker and Paulissen 2012). Comparative studies of sexual dimorphism should generally encompass body size as a potential determinant (Fairbairn et al. 2007). Proximate causation (affecting the ontogeny of growth) and ultimate causes (i.e., evolutionary) are responsible for sexual dimorphism (Frayer and Wolpoff 1985).

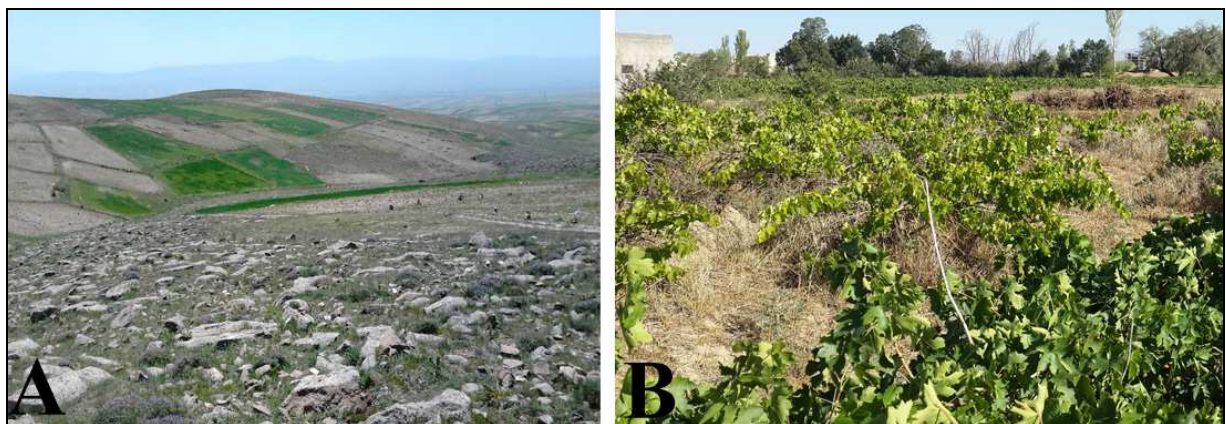
In this study *A. bivittatus* specimens were collected from the known localities (from northwestern Iran) and a new locality (Hamedan province, western Iran) were examined in terms of pholidotic characters, morphometric measurements and color-pattern features. The known range of the species was also extended inside Iran. We discuss the importance of SSD in the adult Snake-eyed Skink, *A. bivittatus* (Ménétriés, 1832) that collected from East Azerbaijan Province, northwestern Iran.

We searched for lizards by walking randomly through the habitat from 09:00 to 11:00 AM and from 15:00 PM to evening (much of the activity time of *A. bivittatus*). During the summer 2012 and 2015, we examined 63 adult specimens of *A. bivittatus* (28 males and 35 females) from East Azerbaijan Province, northwestern Iran, and 10 specimens (six males and four females) from Hamedan Province western Iran (Fig. 1, 2). All the specimens were anaesthetized with ether, fixed with 96% ethanol and later kept in 70% ethanol, and are deposited in the Razi University Zoological Museum (RUZM). For comparison of specimens from East Azerbaijan and Hamedan (new locality) Provinces, all the specimens initially were examined based on 11 morphological characters (seven

pholidotic and four morphometric characters). The pholidotic characters used in this study are as follows: supralabials (SL), infralabials (IL), number scales between eye to ear (NEE), longitudinal rows of ventral scales (LRVS), number of scales between eyes to nostril (SBEN), number of scales around mid-body (AMS), number of supraciliaries (SUCI). The morphometric characters examined in this study: axilla-groin length (AGL) and snout to vent length (SVL), head width (HW) and head length (HL).



**FIGURE 1.** Distribution map of the newly found specimens of *A. bivittatus*. **1:** East Azerbaijan Province (previous records); **2:** Hamedan Province (new record).



**FIGURE 2.** Habitat of *A. bivittatus*. A) Varzaqan county steppes, East Azerbaijan Province; B) a vineyard in Behar county, Hamedan Province.

Finally, all the specimens of East Azerbaijan Province were examined based on pholidotic characters mentioned above and 14 morphometric characters for SSD. The morphometric characters examined in the study of SSD: SVL, tail length (TL), HL, HW, head height (HH), eye diameter (ED), distance of orbit-ear (DOE), length of forelimb (LFL), length of hind limb (LHL), AGL, distance between eye and nose (EYEAR), length of 4<sup>th</sup> toe (L<sup>4th</sup> TOE), width of cloaca (LC), width of widest part of basal tail (LBT). Morphometric measurements were taken with digital calipers model Shoka Gulf to the nearest 0.01 mm accuracy, and for meristic characters a stereo microscope was used. Statistical analyses were carried out using the program SPSS 19.0; Data were examined for assumption of normality (the Kolmogorov–Smirnov test). The values for the significant characters:  $P \leq 0.05$ .

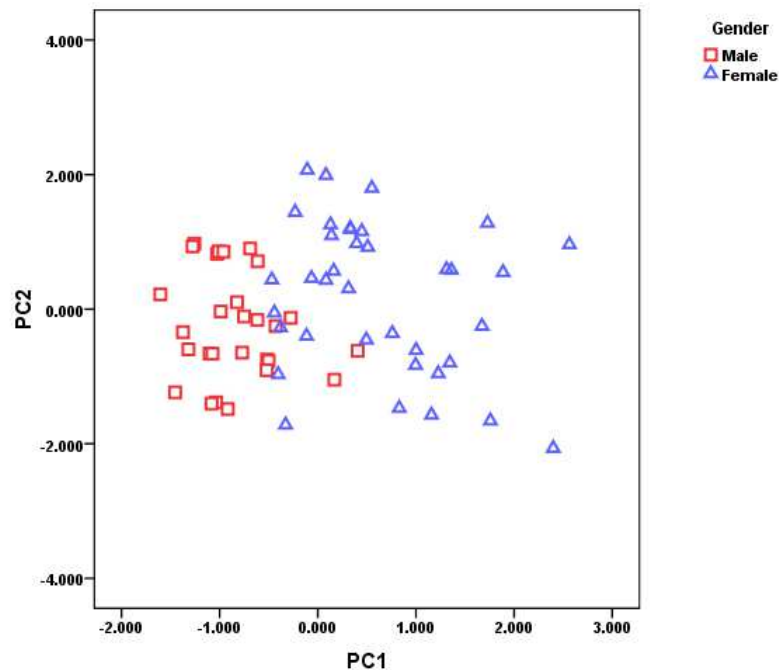
We performed a principal component analysis (PCA) as an exploratory method to investigate between-sex variation of morphometric variables at the multivariate level, as several morphological parameters were significantly correlated with SVL and AGL. Differences in the value of metric and meristic variables were disclosed between the sexes using the One-way ANOVA. Females had higher values for four characters (two morphometric, two meristic) than those of males.

Prefrontal scales in all the examined specimens in both localities (East Azerbaijan and Hamedan Provinces) are always are in contact. All the examined specimens from Hamedan Province have seven supralabials but in East Azerbaijan Province populations there are six (64.5%) and seven (35.5%) supralabials. Comparison of pholidosis and some morphometric characters among specimens from East Azerbaijan, and Hamedan (new locality) Provinces in Iran as follows respectively: LRVs: 61-75 vs 65-70; NEE: 4-5 vs 5; SBEN: 3-5 vs 3; AMS: 21-24 vs 24. Each both two populations were equal in some of the characters (e.g. IF: 7 scales; SUCI: 5 scales). The ANOVA showed statistical difference in SVL between the sexes ( $48.11 \pm 0.65$  and  $42.77 \pm 0.52$  mm for females and males, respectively,  $F = 37.06$ ,  $P = 0.00$ ), in AGL ( $28.66 \pm 0.60$  and  $23.09 \pm 0.38$  mm for males and females, respectively,  $F = 53.24$ ,  $P = 0.00$ ). Results of the ANOVA test of scalation (meristic) characters for SSD implied SBEN, and AMS in females paucity to differentiate (22-24, and 21-23 scales around mid-body for females and males, respectively).

The ANOVA showed statistical difference in SVL and AGL between the sexes. The ANOVA revealed no significant differences ( $P > 0.05$ ) in TL, HL, HW, HH, ED, DOE, LFA, LA, LFL, EYEAR, L<sup>4th</sup> toe, LC, LBT, LRVs, SL, IL, and NEE between the sexes.

The results of the PCA for morphometric characters showed that the first three axes collectively represented 97.63% of the total variation. Of these, 49.23% is explained by the PC1, with SVL, and AGL mainly responsible for the observed variation, and 30.49% was explained by the PC2, in which the AMS, SBEN and had the highest value, and also 17.90% was explained by the PC3, in which the SBEN, and AMS had the most important role. This analysis showed that the PC1 is chiefly responsible for separation of males and females of *A. bivittatus* (Ménétriés 1832) (Fig. 3). Generally, males had orange color on ventral surface and females were olive-green in ventral regions. Based on Sanchooli (2016) range distribution was restricted to the northwest and some isolated records in the central Elburz and Kopet Dagh Mountains except Khorasan Razavi and Fars Provinces. This study represents the first record of occurrence of *A. bivittatus* (Ménétriés, 1832) from western regions of the Iranian Plateau in Hamden Province. According to our observations in more than three years in different regions of the Iranian Plateau, the distribution of *A. bivittatus* is restricted to northwestern and western regions of Iran (Karamiani, 2016; Karamiani et al., 2016). Results of this study (e.g. AMS, SBEN, SUCI, SVL, AGL, AMS) were relatively similar to specimens studied from Armenia, Azerbaijan, and Iran by Ilgaz (2007), and probably indicate that those resemblances refer to closed localities.

In *A. bivittatus*, SSD occurs in general body size and several body parts, with females being significantly larger than males in four out of 21 characters. This suggests that, as lizards grow, the length of the head of males has a tendency to grow faster than that of females (Vitt and Cooper 1985; Griffith 1991; Becker and Paulissen 2012). The most common hypothesis advanced to explain



**FIGURE 3.** Ordination of the individual males and females of *Ablepharus bivittatus* on the first two principal components. Note the separation of males and females in the PC1.

why (ultimate causes) female reptiles are larger than males is that fecundity selection favors larger body size in females to increase clutch size and/or clutch mass (Heideman et al. 2008; Becker and Paulissen 2012). Also, fecundity selection favors large female size when number of offspring increases with maternal size (Fairbairn et al. 2007). Brooks (1963) found a significant positive relationship between female SVL and clutch size or egg length. In this study we found similar results, and showed that females of *A. bivittatus* are larger (have larger SVL and AGL) than males.

Large females usually have high potential fecundity. Herein fecundity selection should favor an increase in body size given that these females get opportunities to realize their potential advantage by maturing and laying more eggs (Berger et al. 2008). Body size (morphometric characters) and number of scales around mid-body in females of *A. bivittatus* is more than those of males. According to the Rensch's rule (Rensch 1950), females of various animal clades tend to be larger than males in small species, whereas males are larger than females in large species. Also Rensch's rule states that SSD characteristically increases with size when males are the larger sex and decreases with size when females are the larger sex (Colwell 2000; Fairbairn et al. 2007; Chang and Oh 2012; Karamiani et al. 2013), In case of *A. bivittatus* Rensch's rule holds true where adult females have larger bodies than adult males. The ventral color pattern in males is uniformly orange and ventral surface of females is olive-green such as dorsal region. However, in *A. bivittatus* males and females show clear differences in coloration and color pattern. In summary, our data show that males and females of *A. bivittatus* are relatively dimorphic in body size, and it seems likely that this is

due to different growth patterns (as a proximate cause) and/or differences in intrasexual or natural selection forces acting on the sexes of this taxon.

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