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Systematics and distribution of the genus *Ablepharus* Fitzinger, 1823 (Sauria, Scincidae): A review

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Abstract

A review of the Snake-eyed Skink *Ablepharus* Fitzinger, 1823 is presented. The specific character of *Ablepharus* involves a lack of movable eyelids, with the lower eyelid fused to the upper one, forming a transparent spectacle covering the eye. The genus *Ablepharus* occurs in southeastern Europe, southwest Asia, and Central Asian Republics (from the Mediterranean Sea coasts to northwest India), including 11 valid species: *A. anatolicus* Schmidtler, 1997, *A. bivittatus* (Ménétries, 1832), *A. budaki* Göçmen, Kumlutas & Tosunoglu, 1996, *A. chernovi* Darevsky, 1953, *A. darvazi* Eremchenko & Panfilov, 1990, *A. deserti* Strauch, 1868, *A. grayanus* (Stoliczka, 1872), *A. kitaibellii* Bibron & Bory St-Vincent, 1833, *A. lindbergi* Wettstein, 1960, *A. pannonicus* (Lichtenstein, 1823), and *A. rueppellii* (Gray, 1839). For identification of species of *Ablepharus*, we used additional scalation and molecular features, used anatomical survey (e.g. osteological and hemipenial characters), and species distribution models. Of the genus *Ablepharus*, *A. bivittatus*, *A. chernovi*, *A. grayanus*, and *A. pannonicus* occur in Iran.

Key words: *Ablepharus*, Scincidae, Systematics, Distribution, Iran.

INTRODUCTION

The family Scincidae Oppel (1811) encompasses more than 25% (1,579 species) of all living genera and species of lizards (Uetz et al., 2021) with a nearly worldwide distribution (Vitt and Caldwell, 2013). Based on morphological characteristics the family Scincidae consists of four subfamilies Acontinae, Feylininae, Lygosominae, and Scincinae (Greer, 1970), but based on molecular analysis it only includes three subfamilies Acontiinae, Scincinae, and Lygosominae (Pyron et al., 2013). According to main evidence from molecular phylogenies and morphological characters the Scincomorpha consist of nine families as follows: Acontidae (26 spp.), Ateuchosauridae (2 spp.) Egerniidae (58 spp.), Eugongylidae (418 spp.), Lygosomidae (52 spp.), Mabuyidae (190 spp.), Ristellidae (14 spp.), Sphenomorphidae (546 spp.), and Scincidae (273 spp.), but usually grouped in a single family, Scincidae (Hedges, 2014).

According to a molecular phylogenetic study the genus *Ablepharus* is nested within Lygosominae and is the sister taxon of the central and East Asian *Asymblepharus* (Pyron et al., 2013). The genus *Ablepharus* Fitzinger, 1823 contains 11 valid species: *A. anatolicus* Schmidtler,



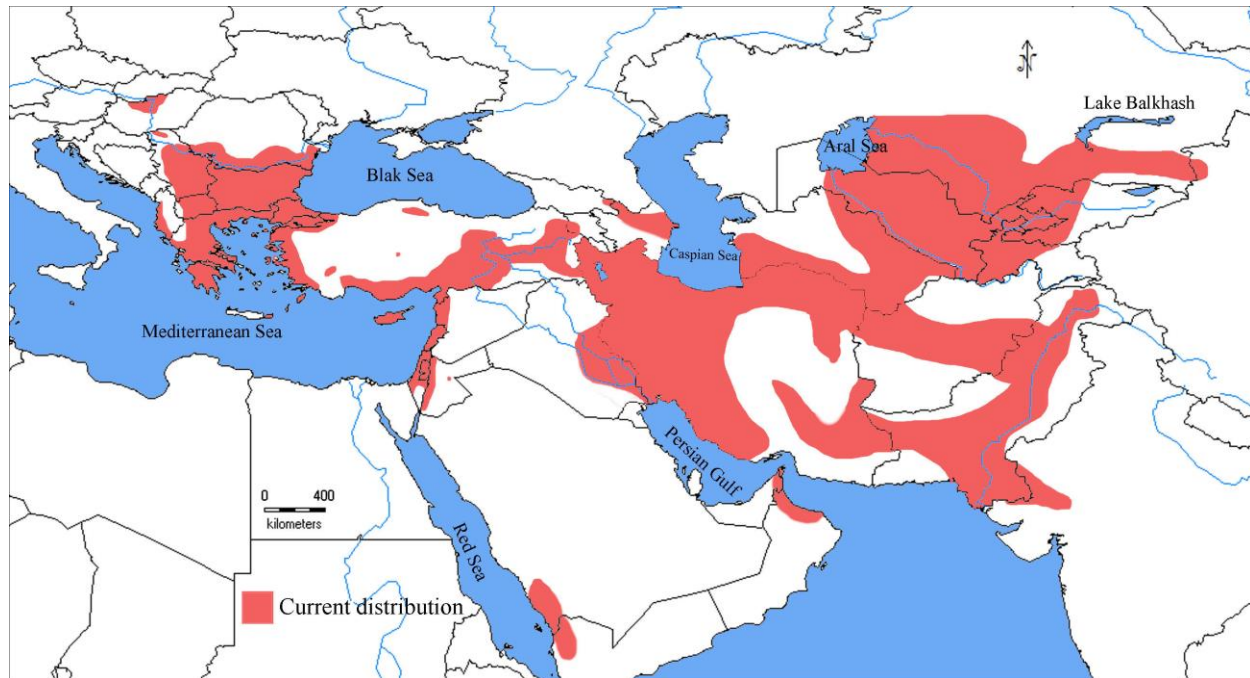


FIGURE 1. Distribution of the genus *Ablepharus*.

1997, *A. bivittatus* (Ménétries, 1832), *A. budaki* Göçmen, Kumlutas & Tosunoglu, 1996, *A. chernovi* Darevsky, 1953, *A. darvazi* Eremchenko & Panfilov, 1990, *A. deserti* Strauch, 1868, *A. grayanus* (Stoliczka, 1872), *A. kitaibelii* Bibron & Bory St-Vincent, 1833, *A. lindbergi* Wettstein, 1960, *A. pannonicus* (Lichtenstein, 1823), and *A. rueppellii* (Gray, 1839) which are distributed in southern Europe, Transcaucasia (Armenia, south-east Azerbaijan), Turkey, Syria to Egypt, Tajikistan, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, Afghanistan, Iran, Iraq, United Arab Emirates, Pakistan and NW India (Fühn, 1969a, b; Anderson, 1999; Khan, 2002; Ananjeva et al., 2006; Vyas, 2011; Rastegar-Pouyani et al., 2008; Šmíd et al., 2014) (Fig. 1).

The morphological characteristics in the genus *Ablepharus* are as follows: small lizards; pentadactyl limbs relatively weakly developed. immovable eyelids, lower eyelid is fused with upper, forming transparent membrane covering eye; outer ear opening small or hidden under the skin; supranasal scales absent; 18-26 rows of smooth scales around middle of body; oviparous (Fühn 1969b; Eremchenko and Szczebak, 1986; Anderson 1999; Ananjeva et al., 2006). Also, the genus *Ablepharus* has particular elements in the cranial osteology as following: no posterior projecting process of palatines separating pterygoids bone; pterygoids not in contact; no recurved process of pterygoids; nine pleurodont teeth on premaxillary bone (Fig. 2) (Fühn, 1969a).

In his monograph on the genus *Ablepharus*, Strauch (1868) mentioned nine pentadactyle species (*A. pannonicus*, *A. bivittatus*, *A. brantii*, *A. deserti*, *A. nigropunctatus*, *A. wahlbergi*, *A. boutonii*, *A. lineo-ocellatus*, *A. anornalus*) distributed in Africa, Eurasia, East Indies, Australia and Polynesia as belonging to a single genus, *Ablepharus* Fitzinger, 1823, and allotted the forms with reduced fingers to other genera. Boulenger (1887), based on the reduction of digits and toes grouped eight genera (*Lerista* Bell, 1833; *Cryptoblepharus* Wiegmann, 1834; *Menetia* Gray, 1844; *Miculia* Gray, 1844; *Morethia* Gray, 1844; *Panaspis* Cope, 1868; *Blepharosteres* Stoliczka, 1872; *Phaneropsis* Fischer, 1881) and 16 species in the genus *Ablepharus*, characterized by having immovable eyelids, and a transparent shield covering eyes. Smith (1937) showed that transparent disc on the eyes of *Ablepharus* is not intact, having a small palpebral slit hidden under the supercilium or the vestige of the upper lid, while several genera of Scincidae have a transparent window in the lower eyelid.

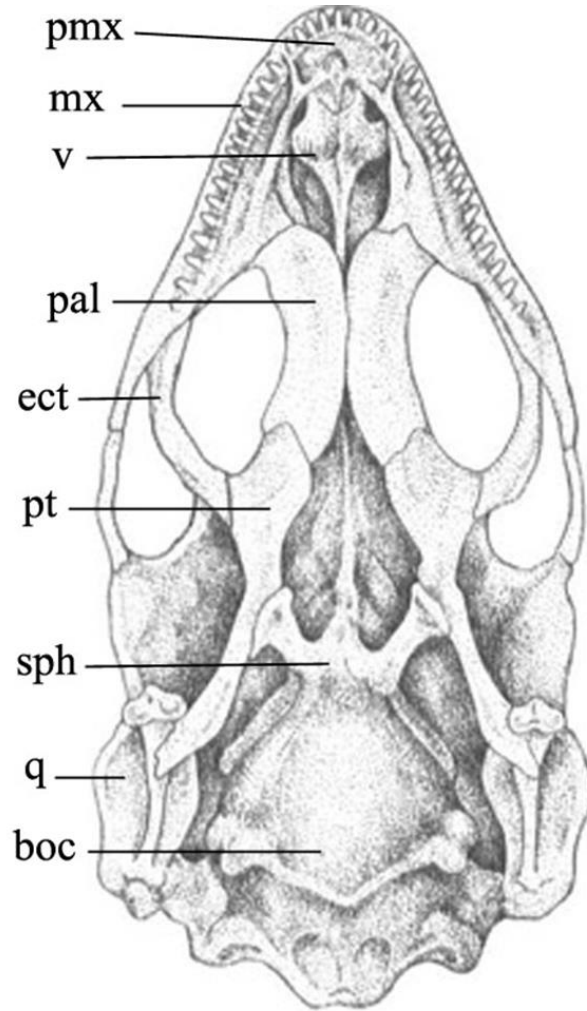


FIGURE 2. Ventral view of skull of *Ablepharus kitaibelii*. Abbreviations: boc, basioccipital; ect, ectopterygoid; mx, maxilla; pal, palatine; pmx, premaxilla; pt, pterygoid; q, quadrate; sph, sphenoid; v, vomer (modified from Fühn, 1969a).

Smith's opinion was accepted by De Witte (1936), and Mittleman (1952). Fühn (1969b) in the revision of the genus *Ablepharus*, based mainly on osteology of the skull (absence of recurved process of the pterygoids, and of posterior projecting process of the palatines) restricted the genus *Ablepharus* only to Eurasian species (i.e., *bivittatus* (*A. b. bivittatus*, *A. b. linddbergi*, *A. b. alaicus*), *deserti*, *kitaibelii* (*A. kitaibelii fitzingeri*, *A. k. kitaibelii*, *A. k. stepaneki*, *A. k. fabichi*, *A. k. chernovi*), and *pannonicus* (*A. p. pannonicus*, *A. p. grayanus*)). Subsequently, based on detailed morphological and molecular analyses, some modifications have occurred in the taxonomic rank of each species and subspecies (Poulakakis et al., 2005). A comprehensive morphological revision of all Snake-eyed Skinks is needed because these fundamental studies were carried out some decades ago. In this study systematics and distribution of the genus *Ablepharus* are discussed.

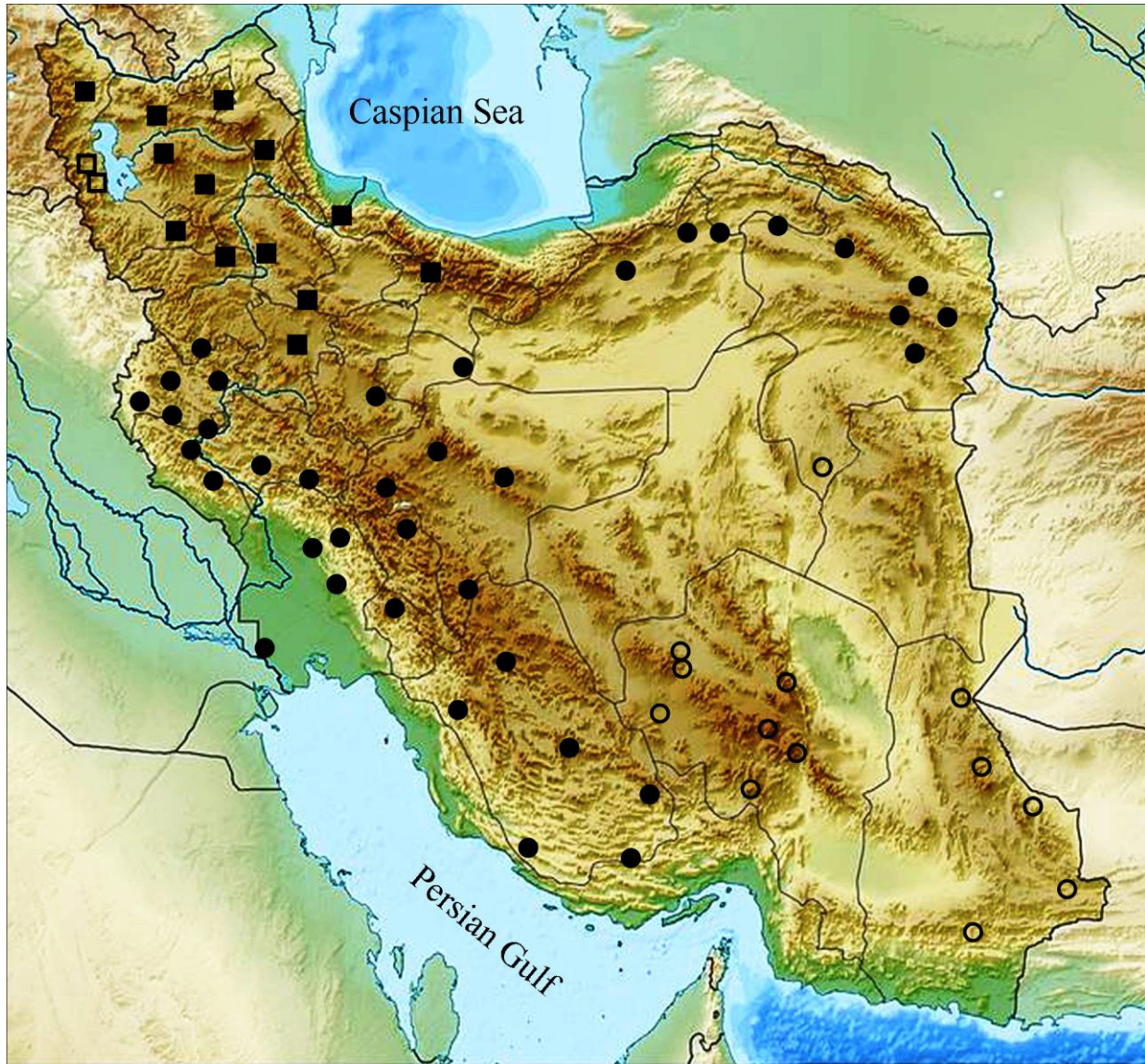


FIGURE 3. Distribution of the genus *Ablepharus* in Iran: solid square = *Ablepharus bivittatus* (Ménétries, 1832), hollow square = *A. chernovi* Darevsky, 1953, solid circle = *A. pannonicus* (Lichtenstein, 1823) and hollow circle = *A. grayanus* (Stoliczka, 1872).

***Ablepharus* Fitzinger, 1823**

The Snake-eyed Skinks of the genus *Ablepharus* Fitzinger, 1823 occur in southeastern Europe, southwest Asia, and Central Asian Republics (Anderson, 1999). These skinks lack movable eyelids, with the lower eyelid fused to the upper, thereby forming a transparent spectacle covering the eye. The genus *Ablepharus* based on scalation characters consists of 11 recognized species as follows: *A. anatolicus*, *A. bivittatus*, *A. budaki*, *A. chernovi*, *A. darvazi*, *A. deserti*, *A. grayanus*, *A. kitaibelii*, *A. lindbergi*, *A. pannonicus*, *A. rueppellii*, of which *A. bivittatus*, *A. chernovi*, *A. grayanus*, and *A. pannonicus* occur in Iran (Anderson, 1999; Sindaco and Jeremčenko 2008; Karamiani et al., 2015; Karamiani et al., 2018a) (Fig. 3). Recently Vergilov et al. (2017) used anatomical hemipenial characters for recognition of some species of *Ablepharus* (i.e. *A. kitaibelii* and *A. budaki*).

Systematic Account

***Ablepharus anatolicus* Schmidtler, 1997**

Ablepharus anatolicus was regarded as a subspecies of *A. budaki* from southern Anatolia by Schmidtler (1997). *Ablepharus budaki anatolicus* was elevated to species level as *A. anatolicus* based on morphological and genetic data (Skourtanioti et al., 2016; Bozkurt and Olgun 2020).

***Ablepharus bivittatus* (Ménétriés, 1832)**

The Two-streaked Snake-eyed Skink, *Ablepharus bivittatus* was described as *Scincus bivittatus* from Perimbal, Talysch Mountains, Azerbaijan by Ménétriés 1832. Wettenstein (1960) described a subspecies of ablepharine skink from upland Afghanistan and Punjab as *A. bivittatus lindenbergi*. Eremchencko and Szczerbak (1986) reviewed the genus *Ablepharus* and regarded *A. lindbergi* as a distinct full species. Elpatjevsky (1901) described a new ablepharine skink from Kirghiz, northeastern Tadjikistan, southeastern Kazakhstan, and western Xinjiang, China as *A. alaicus*. Later on, this species was regarded as a subspecies of *Ablepharus bivittatus* by researchers (e.g., Wettenstein, 1960; Fühn, 1969b). Eremchencko and Szczerbak (1986) assigned *alaicus* to a new genus *Asymblepharus*. The two-streaked snake-eyed skink *A. bivittatus* (Fig. 4A) is distributed in Azerbaijan, Armenia, eastern Turkey, and northwestern Iran (Baran and Atatür, 1998; Anderson, 1999; Ilgaz et al., 2007). Based on morphological characters, females are larger than males. In the other words, sexual differences are female-biased (Karamiani et al., 2017). Conservation status in the IUCN Red List categories and criteria for the species is Least Concern (IUCN, 2021).

***Ablepharus budaki* Göçmen, Kumlutas & Tosunoglu, 1996**

The Budak's snake-eyed Skink, *Ablepharus budaki* was introduced from Northern Cyprus as a subspecies of *A. kitaibelii* based on morphological characters as follows: the ventral side coloration of the trunk and tail, the number of the vertical rows of scales between the masseteric and ear opening, and the size of the ear openings (Göçmen et al., 1996). Poulakakis et al., (2005), based on molecular data, changed its taxonomic status into a distinct species from *A. kitaibelii*. *Ablepharus budaki* is distributed in Turkey, Cyprus, Syria, Lebanon (Hraoui-Bloquet et al., 2002; Baier et al., 2009; Özkan et al., 2019). According to anatomical investigation hemipenis is leaf-shaped in *A. budaki*, folds are also deeply bilobed and the two branches of each hemipenis are equally long and symmetrical, with thick labia surrounding the sulci (Fig. 5; Vergilov et al., 2017). Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.

***Ablepharus chernovi* Darevsky, 1953**

The Chernov's Skink, *Ablepharus chernovi* Darevsky, 1953, was regarded as a subspecies of *Ablepharus kitaibelii* Bibron & Bory St-Vincent, 1833 from the vicinity of the settlement Tkhit, Ashtarak region, middle current of the river Razdan, Armenia. *Ablepharus chernovi* (Fig. 4B), which had previously been accepted as a subspecies (Fühn, 1969b; Baran, 1977), is considered a species. A molecular phylogenetic study confirmed *A. chernovi* to represent a genetically distinct species (Poulakakis et al., 2005). *Ablepharus chernovi* is distinguished based on having a hidden tympanum (versus ear-opening visible in *Ablepharus kitaibellii*) and having two supraocular scales, without supraciliary granular scales between eye and supraocular scales (versus three supraocular scales, a row of supraciliary granular scales between eye and supraocular scales in *Ablepharus bivittatus*) (Arakelyan et al., 2011; Karamiani et al., 2018a) (Fig. 6). *Ablepharus chernovi* is distributed in Razan River valley Armenia, northern Syria and southern and central parts of Anatolian Turkey, and Urmia of West Azerbaijan Province, Iran (Baran & Atatür 1998; Ananjeva et al. 2006; Sindaco & Jeremčenko 2008; Arakelyan et al., 2011; Karamiani et al., 2015). Of the four described subspecies, *A. c. chernovi* occurs in Armenia, *A. c. eiselti* (Adana province), *A. c. isauriensis*, and *A. c. resslie* (Mersin Province) described by Schmidtler 1997 are from southern Turkey (Gemel et al., 2019). Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.



FIGURE 4. Adult specimen of (A) *Ablepharus bivittatus* (Ménétriés, 1832), (B) *A. chernovi* Darevsky, 1953, (C) *A. grayanus* (Stoliczka, 1872), and (D) *A. pannonicus* (Lichtenstein, 1823).

***Ablepharus darvazi* Eremchenko & Panfilov, 1990**

The Darvaz Snake-eyed Skink, *Ablepharus darvazi* was described from Darvaz mountain range, Tadzhikistan by Eremchenko & Panfilov (1990). So far, the species is known only in Darvaz and Khozratishoh mountains and inhabits bushes and montane forest habitats. In other words, it is endemic to the Badakshan Mountains but it is likely to occur in nearby regions of Afghanistan, Pakistan, and northwestern India (Ananjeva et al., 2006; Sindaco and Jeremčenko 2008). Conservation status in the IUCN Red List categories and criteria for the species is Data Deficient.

***Ablepharus deserti* Strauch, 1868**

The Desert Lidless Skink, *Ablepharus deserti* was described from Settlement Ak-Mechet, Kazakhstan by Strauch (1868). The desert snake-eyed skink is distributed in southern Kazakhstan, Kyrgyzstan, northern Tajikistan, Uzbekistan, and eastern Turkmenistan. As well, isolated populations occur in southern Turkmenistan, central Tien Shan, and southeastern Kazakhstan (Kolbintzev et al., 1999; Ananjeva et al., 2006). Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.

***Ablepharus grayanus* (Stoliczka, 1872)**

The Minor Snake-eyed Skink, *Ablepharus grayanus* was first described as *Blepharosteres grayanus* from Waggur District, northeast Kutch, India (Stoliczka, 1872). Later, it was regarded as a subspecies of *A. pannonicus* (Fühn, 1969b). *Ablepharus grayanus* (Stoliczka, 1872) (Fig. 4C) is distinguished based on having a hidden tympanum and 18-20 scales around midbody (versus a small ear opening and 20-22 scales around midbody in *A. pannonicus*), which is distributed in north and west India, through Pakistan, Afghanistan, and Iran (Leviton and Anderson, 1970; Khan, 2002; Venugopal, 2010; Vyas, 2011; Rais et al., 1997; Karamiani et al., 2015). Conservation status in the IUCN Red List categories and criteria for the species is "Not Listed".

***Ablepharus kitaibelii* Bibron & Bory St-Vincent, 1833**

The Snake-eyed Skink, *A. kitaibelii*, distributed in southeastern Europe and west and central Turkey (Schmidtler, 1997), is represented by four subspecies as follows: *A. k. fitzingeri* Mertens, 1952 in southern Slovakia, northern Serbia, and Hungary, *A. k. stepaneki* Fühn, 1970 in Romania, Bulgaria, Serbia, Bosnia, and Albania, *A. k. kitaibelii* (Bibron & Bory, 1833) in Greece, including the Ionian and Aegean islands and *A. k. fabichi* Stepànek, 1937 in the Greek islands of Mikronisi, Amathia, Kasos, and Karpathos (Fühn 1969b; Pasuljević, 1977; Göçmen et al., 1996; Gruber, 1981; Tomović et al., 2001; Ljubisvljevic et al., 2002; Herczeg et al., 2004; Kumlutas et al., 2005). Poulakakis et al. (2005) inferred phylogenetic relationships between populations of the *A. kitaibelii* indicated that *A. kitaibelii* is paraphyletic, as the populations on the Kastelorizo Archipelago (Greece, off the Lycian coast of southwestern Turkey) is distinct, nesting at the base of the ingroup. Moreover, the remaining populations of *A. kitaibelii* consist of two clades, one involving the populations inhabiting continental Greece and the west Aegean (the Cyclades and Kithira) and Ionian (Leukada) islands, and the other including populations that inhabit the East Aegean Islands and Turkey. Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.



FIGURE 5. Inflated hemipenes of (A) *Ablepharus budaki* Göçmen, Kumlutaş & Tosunoğlu, 1996 and (B) *A. kitaibelii* (Bibron & Bory Saint-Vincent, 1833); Scale bar = 1 mm (Vergilov et al., 2017).

***Ablepharus lindbergi* Wettstein, 1960**

The Lindberg's Twin-striped Skink, *Ablepharus lindbergi* Wettstein, 1960, was regarded as a subspecies of *A. bivittatus* (Ménétries, 1832) from the steppes east of Herat, western Afghanistan. Having a widespread distribution within the Hindu Kush Mountains (Wagner et al., 2016), it is endemic to Afghanistan (Sindaco and Jeremčenko 2008), Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.

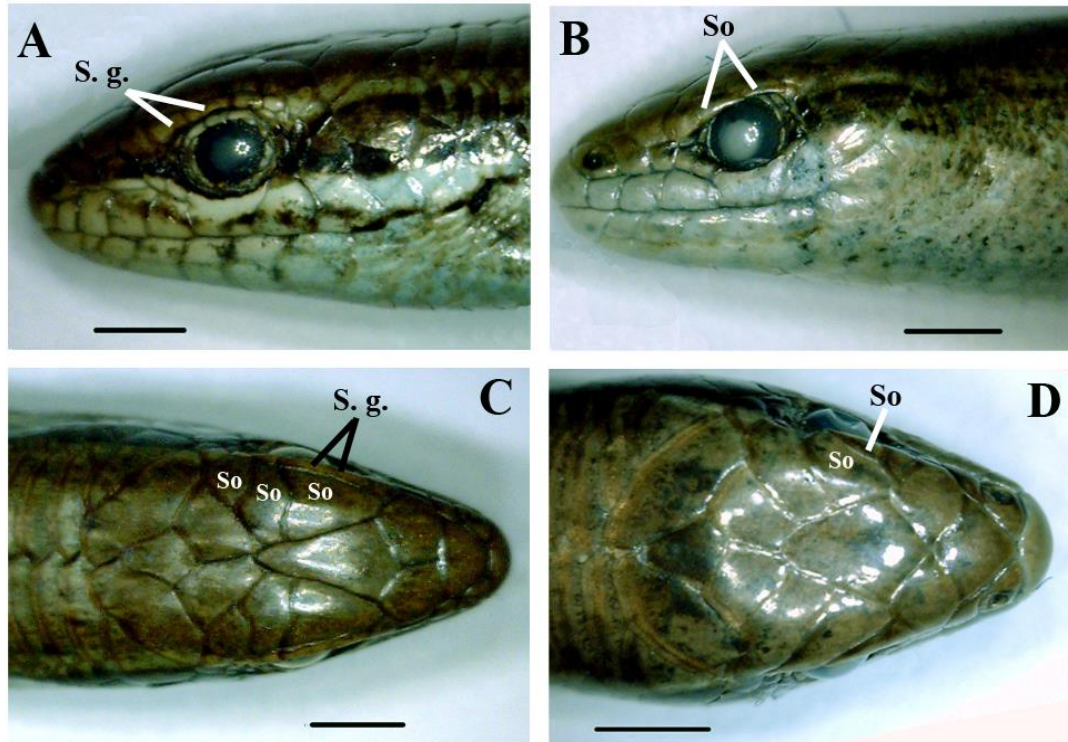


Fig. 6. Lateral (A) and dorsal (C) views of the head sculation of *Ablepharus bivittatus* (Ménétriés, 1832), (RUZM SA10.5, from near Tabriz, East Azerbaijan Province, NW Iran), and lateral (B) and dorsal (D) views of the head sculation of *A. chernovi* Darevsky, 1953, (RUZM SA30.2, from near Urmia, West Azerbaijan Province, NW Iran); So: Supraocular scales, S.g: Supraciliary granules (Karamiani et al., 2018a).

***Ablepharus pannonicus* (Lichtenstein, 1823)**

The Asian Snake-eyed Skink, *Ablepharus pannonicus* was initially described as *Scincus pannonicus* by Lichtenstein (1823) from Bukhara Province, Uzbekistan. During 1868 to 1907 some species including *A. brandtii* Strauch 1868 (Samarkand, Turkestan), *A. pusillus* Blanford 1874 (Bussora = Basra, Iraq), *A. brandti* var. *brevipes* Nikolsky 1907 (Dech-i-Diz and Karun River, Iran), and *A. persicus* Nikolsky 1907 (Schachrud =Shahrud, Semnan Iran) were introduced based on morphological characters which all were synonymized later with *A. pannonicus* (Fig. 4D) by Anderson (1999). The Asian Snake-eyed Skink is the most widely distributed species of the genus *Ablepharus*, occurring in Yemen, Saudi Arabia, Iraq, Syria, Iran, Afghanistan, Pakistan, south of Tajikistan, Uzbekistan, southern Turkmenistan, southeast Georgia, Azerbaijan, and northwestern India (Anderson, 1999; Ananjeva et al., 2006; Karamiani et al., 2018b). Conservation status in the IUCN Red List categories and criteria for the species is "Not Listed".

***Ablepharus rueppellii* (Gray, 1839)**

The Rüppell's Snake-eyed Skink, *Ablepharus rueppellii* was initially described as *Riopa ruppellii* by Gray (1839) from Arabia Petrea (Jordan). For a long time, it was considered to be a subspecies of *Ablepharus kitaibelii* but was raised to species rank by Schmidtler (1997). *Ablepharus rueppellii* is distributed from southern Syria and Lebanon, western Jordan to Sinai Peninsula of Egypt (Sindaco et al., 1995; Saleh, 1997; Disi et al., 2001; Modrý et al., 2004; Al-Quran, 2009; Disi, 2011; Handal et

al., 2016). Conservation status in the IUCN Red List categories and criteria for the species is Least Concern.

Key to the species of *Ablepharus* in Iran (Modified from Leviton et al., 1992; Anderson, 1999; Khan, 2002).

- 1a. Prefrontals usually forming a median suture; frontoparietals divided2
 1b. Prefrontals separated; a single frontoparietal 3
 2a. Three supraocular scales, a row of supraciliary granular scales between eye and supraocular scales (Fig. 6A & C) *A. bivittatus*
 2b. Two supraocular scales, without supraciliary granular scales between eye and supraocular scales (Fig. 6B & D) *A. chernovi*
 3a. Hidden tympanum; having 18-20 scales around midbody *A. grayanus*
 3b. Small ear opening; 20-22 scales around midbody *A. pannonicus*

Table 1. The main morphological characters in various species of the Snake-eyed Skink *Ablepharus* Fitzinger, 1823: Number of scales around mid-body (AMS), frontoparietal scales (FS), Prefrontal scales (PS), Supraciliary granular scales (SG), Tympanum status (TS) (Strauch, 1868; Fühn 1969a; Göçmen et al., 1996; Kumlutas et al., 2005; Karamiani et al., 2015; Karamiani et al., 2018b; Özkan et al., 2019).

	AMS	FS	PS	SG	TS
<i>A. bivittatus</i>	22-24	paired	in contact	present	obvious
<i>A. budaki</i>	18-20	single	usually in contact	present	obvious
<i>A. chernovi</i>	18	paired	in contact	absent	obvious
<i>A. darvazi</i>	-	paired	in contact	-	-
<i>A. deserti</i>	20-22	paired	in contact	present	obvious
<i>A. grayanus</i>	18-20	single	separated	absent	hidden
<i>A. kitaibelii</i>	18-20	paired	rarely in contact	present	obvious
<i>A. lindbergi</i>	26-27	paired	in contact	present	obvious
<i>A. pannonicus</i>	20-22	single	separated	absent	obvious
<i>A. rueppellii</i>	18	paired	in contact	present	obvious

DISCUSSION

The genus *Ablepharus* is restricted in distribution to the western Eurasian region, encompassing the following species: *A. anatolicus*, *A. bivittatus*, *A. budaki*, *A. chernovi*, *A. darvazi*, *A. deserti*, *A. grayanus*, *A. kitaibelii*, *A. lindbergi*, *A. rueppellii*, and *A. pannonicus*. Such characters as prefrontals status, the number of frontoparietal scales, tympanum status (hidden or obvious), supraciliary granular scales (present or absent), and the number of scales around midbody are important key characters for the identification of various species within the genus (Table 1). Additional pholidosis features and anatomical survey (Vergilov et al., 2017), molecular study (Poulakakis et al., 2005), and species distribution models (Karamiani et al., 2018b) can result in delimitation of the species of *Ablepharus*. Sanchooli (2016) modeled range distribution of *A. bivittatus* and showed that it is restricted to the northwest and some isolated areas in the central Elburz and Kopet Dagh Mountains. Karamiani et al. (2017) extended the range distribution of *A. bivittatus* from northwestern regions of Iran to Hamedan Province, western Iran. In an investigation Karamiani et al., (2016) showed variations in erythrocyte and nucleus sizes among *A. bivittatus* and *A. pannonicus* with larger sizes for former species. During recent years, the range of *A. chernovi* extended from Turkey to southwestern Iran by Karamiani et al. (2018a). In another

study, Karamiani et al. (2015) rediscovered *A. grayanus* from two different localities in Sistan and Baluchestan and Kerman Provinces, southeastern Iran, formerly mentioned by Fühn (1969b), Leviton and Anderson, (1970), and Nikolsky (1900) without providing exact localities. A modeling study showed that *A. grayanus* and *A. pannonicus* are confined to specific habitats in distinct geographical areas, which can be good indicators for assessing the effects of climatic changes on the distribution range of vertebrate organisms (Karamiani et al., 2018b). Phylogenetic relationships among the Snake-eyed Skinks found in Iran (i.e., *A. bivittatus*, *A. chernovi*, *A. grayanus*, and *A. pannonicus*) need a more comprehensive survey, now being conducted by the senior author and his colleagues.

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