

Systematics of the genus *Asaccus* (Sauria: Gekkonidae) on the Zagros Mountains, Iran

Nasrullah Rastegar-Pouyani

Abstract. The gekkonid lizards of the genus *Asaccus*, Dixon and Anderson 1973, are currently recognized with at least nine known species (*Asaccus elisae*, *A. griseonotus*, *A. kermanshahensis*, *A. kurdistanensis*, *A. nasrullahi*, *A. gallagheri*, *A. montanus*, *A. platyrhynchus*, and *A. caudivolvulus*). Of these, the first taxon, *A. elisae*, occurs in western Iran, Iraq, Turkey, and Syria; and the next four species occur in the Zagros Mountains and its western foothills. On the other hand, the last four species of *Asaccus* are mostly restricted in distribution to the mountains of northern Oman in southeastern regions of the Arabian Peninsula. Based on long-lasting field work and research in most parts of the Zagros Mountains, systematics and distribution of the genus *Asaccus*, with especial reference to the Iranian species, are discussed. Some new records and new localities as well as specimens belonging to undescribed taxa of this genus are presented. The role of the Zagros Mountains in radiation, isolation, speciation and subsequent evolution of *Asaccus* is explained. It is shown that *Asaccus* is a vicariant taxon and that the evolution and progression of the Persian Gulf, as a huge vicariant event, has played the most important role in separation and isolation of the northern (Zagros) populations from the southern (Arabian Peninsula) populations of this vicariant taxon. Based on new evidence, the Zagros Mountains is regarded as the center of diversification for *Asaccus*.

Introduction

One of the least known genera of Gekkonidae is the genus *Asaccus* Dixon and Anderson, 1973 (formerly *Phyllodactylus* Gray, 1828) which is distributed in some parts of the Middle East region. In 1973, Dixon and Anderson described a new species and genus of gecko from an unidentified locality around Islamabad, Kermanshah Province, western Iran. These workers suggested the generic name *Asaccus*, based on the absence of cloacal sacs, and named their new taxon as *Asaccus griseonotus*. About one month later (in December 1973), Eiselt described a new species belonging to the genus *Asaccus* and named it as *Phyllodactylus ingae*, based on only one specimen from about 110km southwest of Khorram Abad city, Lorestan Province, southwestern Iran (Eiselt, 1973). Later on, and due to time priority role, it was shown that Eiselt's new species is just a junior synonym of *Asaccus griseonotus* (Anderson, 1999: 136). Prior to suggestion of *Asaccus* as a new generic name, all the gekkonid lizards with the same generic characters were regarded as belonging to the genus *Phyllodactylus* Gray, 1828 with just one described species in Iran (e.g., *Phyllodactylus elisae* Werner 1895, from western and southwestern regions of the Iranian Plateau) (Kluge, 1991, 1993, 2001; Bauer et al., 1997). Since then, several new species of *Asaccus* have been described based on distinctive species-specific characters: *Asaccus montanus* Gardner,

1994 (from the mountainous regions of United Arab Emirates); *A. platyrhynchus* Arnold and Gardner, 1994 (from Tanuf, Oman); *A. caudivolvulus* Arnold and Gardner, 1994 (from Jebel Ras, United Arab Emirates); *A. kermanshahensis* Rastegar-Pouyani 1996 (from 45km north of Kermanshah city, Kermanshah Province, western Iran); *A. kurdistanensis* Rastegar-Pouyani, Nilson & Faizi, 2006 (from Kurdistan Province western Iran) and *A. nasrullahi* Werner, 2006 (from Lorestan Province, southwestern Iran). Among all species of *Asaccus*, it seems that *A. elisae* is the most widespread taxon being distributed in Iran, Iraq, Turkey and Syria (Dixon and Anderson, 1973; Martens and Kock, 1991; Leviton et al, 1992; Arnold and Gardner, 1994; Rastegar-Pouyani, 1996; Varol et al., 1997, 2002). The most distinctive morphological characters of four of the Iranian species of *Asaccus* are represented in table 1.

Taxonomy

The distinctive and vicariant lizards of the genus *Asaccus*, Dixon and Anderson 1973, (formerly known as *Phyllodactylus* Gray, 1828) encompass at least nine known species (*Asaccus kurdistanensis*, *A. elisae*, *A. griseonotus*, *A. kermanshahensis*, *A. gallagheri*, *A. montanus*, *A. platyrhynchus*, *A. caudivolvulus* and a newly described species *Asaccus nasrullahi* based on material deposited in the Copenhagen Museum, Denmark previously misidentified as *Ptyodactylus hasselquistii* (Y. Werner, pers. commun.). Of these, *A. griseonotus* occurs in the western foothills of the Zagros Mountains, western Iran, and northeastern Iraq, and the recently described species, *A. kermanshahensis*,

is restricted in distribution to the type locality in the central Zagros Mountains, Kermanshah Province, western Iran. On the other hand, *Asaccus nasrullahi* Werner is restricted in distribution to Lorestan Province, southwestern Iran (Y. Werner, pers. comm.). Arnold and Gardner (1994) revised *Asaccus* based mainly on material from the southern parts of the range in Oman and United Arab Emirates and described two new species (*Asaccus platyrhynchus* and *A. caudivolvulus*). In their morphology-based phylogenetic analysis, and based on a matrix of 16 characters, Arnold and Gardner (1994) divided *Asaccus* species into four monophyletic groups. In their tree, *Asaccus griseonotus* represents a separate taxonomic and phylogenetic entity and the two species, *A. elisae* and *A. montanus*, comprise a monophyletic group (Arnold and Gardner, 1994: 439).

With regards to the Arnold and Gardner phylogenetic tree, the positions of the two new species, *Asaccus nasrullahi* Werner and *A. kurdistanensis* Rastegar-Pouyani et al. remain to be determined, though Werner (pers. comm.) regards his new species of *Asaccus* (= *A. nasrullahi*) as being, phylogenetically, closest to *A. griseonotus*.

Further field work and collecting more material in different parts of the Zagros Mountains and neighboring regions (which is now being carrying out by us through collecting some more specimens of undescribed taxa of *Asaccus* from the central Zagros Mountains in Kermanshah and Lorestan Provinces that are awaiting taxonomic descriptions) will shed more light on taxonomic, biogeographic, and phylogenetic status of this disjunct and vicariant taxon.

Biogeography

The distribution patterns of the Iranian Plateau lizards (including the genus *Asaccus*), to a great extent, have been affected by the occurrence of some important and drastic vicariant events, especially the uplifting and evolution of the Zagros and Elburz Mountains in the

late Tertiary, about 15-9 MYBP (million years before present). These two mountain systems have played the most important role in shaping up the past and present distribution patterns of various taxa (Macey et al., 1998, 2000; Rastegar-Pouyani, 1999a, b, c, Rastegar-Pouyani & Nilson 2002).

As to the study of historical biogeography of the vicariant and disjunct lizards of the genus *Asaccus*, so far, very few scenarios have been proposed regarding the center of origin and diversification of this mainly rock-dwelling genus (Anderson, 1968; Rastegar-Pouyani, 2003). For instance, Rastegar-Pouyani (2003) suggested that either the Zagros Mountains or the mountains of Oman and United Arab Emirates can be regarded as the center of origin and diversification for *Asaccus*. As mentioned earlier, the genus *Asaccus*, as a vicariant taxon, has now been divided into two distinct branches: 1) a northern branch, encompassing at least 5 known species, which are mainly distributed on the Zagros Mountains and its neighboring regions (see above).

2) a southern branch, consisting of 4 described species which are distributed in the eastern and southeastern regions of Arabian peninsula, mostly in the mountains of northern Oman and United Arab Emirates.

Since most described species of *Asaccus* are now occurring in the Zagros Mountains and neighboring areas, I am now inclined to consider the Zagros Mountains as the center of origin and diversification for this taxon.

The ancestor of this taxon was probably distributed in the mountains and small caves. Then firstly via one or more dispersal waves, this ancestral taxon expanded its range towards the high mountains of the south. Due to the occurrence of geomorphic events and climatic fluctuations which led to increasing progression of the Persian Gulf and the Oman Sea, the previously contiguous ancestral populations became disjunct in distribution: one branch was restricted to the southern mountains, south of the Persian Gulf and Oman Sea,

Characters	<i>A. elisae</i>	<i>A. griseonotus</i>	<i>A. kermanshahensis</i>	<i>A. kurdistanensis</i>
Postmentals	Two pairs	Two pairs	Four pairs	Three pairs
Tubercles on head	Present	Absent	Present	Present
Dorsal tubercles	Strongly keeled	Weakly keeled	Smooth	Weakly pointed
Dark rings on tail	Present	Present	Absent	Present
Diameter of individual back tubercle	>2/3 of ear diameter	<half of ear diameter	>3/4 of ear diameter	>half of ear diameter
Ear diameter	>1/3 of eye diameter	>1/2 of eye diameter	<1/3 of eye diameter	<1/2 of eye diameter
Granules bordering postmentals	18-20	15-18	21-24	16-20
Upper labials	9-11	9-10	9-12	9-10
Lower labials	9-10	7-9	8-10	8-9
Dorsal tubercles in a transverse row	9-13	10-12	8-10	8-11
Maximum SVL (mm)	57.9	70.5	55.7	63.5
Scales across midorbital region (in a single row)	23-28	20-25	22-26	18-20

Table 2. Comparison of distinctive morphological characters in four Iranian species of *Asaccus* (Rastegar-Pouyani 1996; Rastegar-Pouyani et al. 2006; present paper).

and the other branch confined to the northern mountains (the Zagros Mountains and its western foothills).

With regards to the above-mentioned account, it is obvious that the present distribution patterns of *Asaccus*, as a disjunct genus, is the result of both dispersal waves from the center of origin in the northern parts of the range (e.g., the Zagros Mountains) towards the south (e.g., Oman and United Arab Emirates mountains) as well as vicariant events (e.g., plate tectonics, and evolution and increasing progression of the Persian Gulf and Oman Sea), in the Late Tertiary (about 15-9 MYBP).

In short, based on all the available evidence, in the history of *Asaccus* separation of the high mountain ranges of the Iranian Plateau and the mountains of eastern and southeastern Arabian peninsula via evolution and progression of the Persian Gulf and Oman Sea, as huge vicariant events, has had a drastic effect in isolation, speciation, and subsequent evolution of this taxon.

Further field work and collecting more material in various parts of the whole range as well as morphological and molecular analysis of relationships among different taxa of *Asaccus* (which is now at hand) may help to shed more light on determination of history and evolution of this south Palearctic primitive genus of gekkonids.

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