Intergeneric Relations of the Angular- Toed Geckos of Circum Western Himalayas (Sauria: Gekkonidae)

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Abstract.- Intergeneric relationships between angular-toed gekkonid genera of the western Himalayas are investigated. Cladistic analysis based on a set of external morphological characters indicates that Altigekko is most primitive genus and there exists a monophyletic generic lineage between genera Altigekko, Siwaligekko, Cyrtopodion, and Indogekko of circum western Himalayas.

Key words: Angular-toed geckos, western Himalayas, phylogeny.

INTRODUCTION

Geckos have always been a favorite group of animals with herpetologists because of their circum global distribution and frequent occurrence in the collection bags. Due to extensive work on geckos subfamilial (Underwood, 1954; Kluge, 1967) and intergeneric (Loveridge, 1947) relationships among most of the gekkotin groups are now quite established. However, there still remain some problematic groups: Afro-Malagasy (Bauer, 1990), Palearctic (Szczerek and Golubev, 1996), and the western Himalayan geckos (Khan, 1993a,b, 2000, 2003b; Khan and Rössler, 1999). Recently Cyrtopodion geckos inhabiting Indus Valley, Pakistan, have been found to be monophyletic (Khan, 2003a). Similarly Macey et al. (2000) have established monophyly of Palearctic genera Cyrtopodion and Mediodactylus. Taxonomic problem of the angular-toed geckos of the western Himalayas (Anderson, 1872; Boulenger, 1890; Annandale, 1913; Smith, 1935; Minton, 1966; Mertens, 1969; Szczerek and Golubev, 1986; Kluge, 1991, 1993, 2001; Rössler, 2000; Das, 1996; Schleich and Kästle 1998, 2002), has recently been solved (Khan, 2003b), by erecting three new genera Indogekko, Siwaligekko and Altigekko, solving a long standing taxonomic problem with gekkologists.

Present is the preliminary study to assay the inter-generic relationships among circum-
Indogekko l. longipes CAS 115944, SR 307:3267-68; Indogekko fortmunroi BMNH 1990.4 (MSK 0626.90); Mediodactylus walli BMNH 1910.7.12.1; Mediodactylus chitralensis BMNH 1946.8.23.19; Siwaligekko dattanensis MNHN 1979-7745; Siwaligekko battalensis BMNH 1990.2 (MSK 0764), SR 3046:20252 (MSK 0737.89), NMW 31720 (MSK 0762.89), CAS 170533 (MSK 0767.89), FMNH 235534 (MSK 0765.89), MSK 0763.89.

Abbreviations used
BMNH, Natural History Museum, London; CAS, California Academy of Sciences, California, USA; FMNH, Field Museum of Natural History, Chicago, USA; MSK, Herp laboratory, 15/6 Darul Sadder North, Rabwah 35460, Pakistan (author's personal collection, now deposited in Natural History Museum, Government College University, Lahore, Pakistan); NMW, Naturhistorisches Museum Wien, Austria; SR, Institute of Zoology, Academy of Sciences, Kiev, Ukraine; UF, Florida State Museum, Gainesville, USA; USNM, National Museum of Natural History, Washington, D.C.

Definition and weight assignment to the character states
The following characters were considered. Primitive (primary) states are indicated by lower case letters, while advanced (derived) states by upper case letters, with number of asterisks indicating advance level of the derived state.

<table>
<thead>
<tr>
<th>Character</th>
<th>Weight</th>
</tr>
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<tbody>
<tr>
<td>1. Scale size (head and body)</td>
<td>a, small (primitive) 1</td>
</tr>
<tr>
<td>2. Scale morphology</td>
<td>b, homogenous (primitive) 1</td>
</tr>
<tr>
<td>3. Dorsal tubercle morphology</td>
<td>C, Bead-like (primitive) 1</td>
</tr>
<tr>
<td>4. Precloacal pores</td>
<td>d, Precloacal pores only in male (primitive) 1</td>
</tr>
<tr>
<td>5. Femoral pores</td>
<td>c, Femoral pores absent (primitive) 1</td>
</tr>
<tr>
<td>6. Basal phalanges</td>
<td>f, Wide (primitive) 1</td>
</tr>
<tr>
<td>7. Digital</td>
<td>g, Poor (primitive) 1</td>
</tr>
<tr>
<td>8. Tail segmentation</td>
<td>h, Indistinct (primitive) 1</td>
</tr>
<tr>
<td>9. Dark band on the back of head</td>
<td>i, Present (primitive) 1</td>
</tr>
<tr>
<td>10. Subcaudals</td>
<td>j, Indistinct, in several rows (primitive) 1</td>
</tr>
<tr>
<td>11. Caudal tubercles</td>
<td>k, Small spiny (primitive) 1</td>
</tr>
<tr>
<td>12. Limb size</td>
<td>l, Short, anterior reaching to eye (primitive) 1</td>
</tr>
<tr>
<td>13. Size of digits</td>
<td>m, Short (primitive) 1</td>
</tr>
<tr>
<td>14. Snout slope</td>
<td>n, Gradual (primitive) 1</td>
</tr>
<tr>
<td>15. Cloacal sacs</td>
<td>o, Present (primitive) 1</td>
</tr>
<tr>
<td>16. Relative size of body and tail</td>
<td>p, Subequal (primitive) 1</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

The matrix generated on the basis of above characters is shown in Table I.

Despite counter interpretations of fossil records from Asia and Europe (Smith and Bryden, 1977; Estes, 1983), it is now strongly believed that southeast Asia played an important role in the evolution of major groups of reptiles: gekkonids (Kluge, 1967, 1987; Owen, 1983; Estes 1983; Grismer, 1988), agamids (Moody, 1980), varanids and scincids (Estes, 1983), and amphibians (Darlington, 1957; Blair, 1972; Savage, 1973; Khan, 1980). Geckos had extensive inter-island water-rafting activity in the Indian Ocean during the Cenozoic (Hahn et al., 2004), as depicted in Figure 1. The ancestral aeluroscalabotens radiated in the north, diversified in Asian genus Eublepharis, and crossed into Central America via Beringia, as genus Coleonyx (Kluge, 1967; Grismer, 1988), while in west they reached Africa by early Tertiary as genus Hemithecomys and Holodactylus (Grismer, 1988). However, genus Cyrtodactylus invaded extensively the oceanic islands by water-rafting, from island to island, across the Indian Ocean (Khan and Rösler, 1999). The oceanic cyrtodactylids reached
northeastern Gondwanaland by Miocene. Their xerophilic stock invaded drier north African sub Sahara, was probably ancestral to Indo-Palearctic

“cyrtopodion” geckos (Axelrod and Raven, 1974; Leviton and Anderson, 1984; Bobrov 2000; Khan 2002, 2003a). The African cyrtodactylids on the north-eastern Gondwanaland were rafted when it broke off during Tertiary as “Indian Plate”. Carrying several tropical African Tertiary animals and plants as it moved across Indian Ocean (Blanford, 1876; Simpson, 1965; Estes, 1983; Karanth, 2003), which included geckos, agamids, skinks, varanids (Estes, 1983), and microhylid frogs (Savage, 1973). Briggs (2003), Prasad and Range (1995) and Range (1996) suggested that during late Cretaceous India remained connected to Eurasia, as well as to Madagascar and Seychelles plateau by a land bridge, as also suggested Upper Cretaceous invertebrates (Whatly and Bajpai, 2000).

The cyrtodactylids radiated across the subcontinent, speciating extensively on mainland and oceanic islands (Drevsky and Szczepankowski, 1997; Drevsky et al., 1997; Schleich and Kastle, 1998; Bauer, 2002; Buer et al., 2003; Pauwels et al., 2004). Most probably *Siwaligekko* represent cyrtodactylids that inhibited oceanic islands falling in the way of drifting Indian plate, and were swept along and crushed between the plates (Buffetaut and Ingavat 1985; Jaeger et al., 1989), are now represented by the sub-Himalayan mountainous crumble known as Siwaliks (Khan, 1979; Powel, 1979; Khan, 1980, 1993). The *Swaligekko* are widely distributed in Siwaliks from western to eastern Himalayas (Khan, 1993, 2003b, 2005, 2006). The geckos on the northern part of the plate were carried along the Himalayan massif to high altitudes and now are represented by genus *Altigekko* (Khan, 2004, 2006). Widely distributed peculiar sandstone geckos of genus *Indogekko* (Khan, 2006), have strong affinities with cyrtopodion geckos that invaded circum Indus region (Khan, 2003).

Table I rates the proximity of these genera to the ancestral southeast Asian geckos represented by *Eublepharis macularius* in the analysis. *Altigekko* are closest to ancestral form while *Indogekko* and *Cyrtodactyles* occupy farthest position in the spectrum.

**REFERENCES**


Table 1.- Morphometric analysis of angular-toed gekkonid genera of circum western Himalayas.

<table>
<thead>
<tr>
<th>Genera</th>
<th>Characters</th>
<th>Total weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eublepharis (Ncestral)</td>
<td>States: a b c d e f g h i j k l m n o p Weight: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 16</td>
<td></td>
</tr>
<tr>
<td>Altigekko</td>
<td>States: a b c d e f g H i j k l m n o p Weight: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 18</td>
<td></td>
</tr>
<tr>
<td>Siwaligekko</td>
<td>States: a b c d e f g h i j K l m N O p Weight: 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 19</td>
<td></td>
</tr>
<tr>
<td>Indogekko</td>
<td>States: A B C- D E F G H* i J K* L M N O P Weight: 2 2 2+3 2 2 2 2 2 1 2 2 2 2 2 2 38</td>
<td></td>
</tr>
<tr>
<td>Cyrtopodion</td>
<td>States: A B C** D E F G H I J K L M N O P Weight: 2 2 4 1 1 2 2 2 3 2 2 2 2 2 2 1 35</td>
<td></td>
</tr>
</tbody>
</table>


(Received 14 July 2008, revised 15 October 2008)