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

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Abstract.- Intergeneric relationships between angular-toed geckkonid 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 (Szczerbak and Golubev, 1996), and the western Himalayan geckos (Khan, 1993a,b, 2000, 2003b; Khan and Rösler, 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; Szczerbak and Golubev, 1986; Kluge, 1991, 1993, 2001; Rösler, 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-Himalayan angular-toed new geckkoten genera *Cyrtopodion, Indogekko, Siwaligekko* and *Altigekko.*

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MATERIALS AND METHODS

The morphological data used in present analysis were obtained from alcohol preserved specimens. Individual morphological character was assigned polarity using eublepharine geckos as distant outgroup. Sixteen character states were distinguished which were used to construct data matrix (Table I). Primitive and advanced states of the characters were determined by the criteria used and defined by Kluge (1967) and Szczerbak and Golubev (1996). A more detailed analysis awaits collection of fresh material from the western Himalayas, that may hardly differ from the conclusions drawn from present study.

Museum material used

Altigekko baturensis BMNH 1990.3 (MSK 007887), CAS 170529 (MSK 0769.87); *Altigekko stoliczkai* NMW 16756; *Altigekko yarkandensis* BMNH 72.3.22.4; *Cyrtopodion k. kachhense* BMNH 1990.7; *Cyrtopodion kachhense ingoldbyi* BMNH 1931.6.18.1-2, UF 71794, FMNH 235535; *Cyrtopodion caspius* SR 2546:16713-14; *Cyrtopodion fedtschenkoi* SR 1078:8837-8; *Cyrtopodion montiumsalsorum* BMNH 1904.11.19.1, USNM 257535, MSK 014.86; *Cyrtopodion turcmenicus* SR 961:8016-17; *Indogekko longipes voraginosus* CAS 130323; *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 0766.89), USNM 284135 (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 Saddar 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.

	Character		Weight
1.	Scale size (head and body)	a, small (primitive)	1
		A, large (advance)	2
2.	Scale morphology	b, homogenous (primitive)	1
		B, Heterogeneous (advance)	2
3.	Dorsal tubercle morphology	C, Bead-like (primitive)	1
		C, Flat keelless (primitive)	2
		C*, Flat keeled (advance)	3
		C**, Trihedral (advance)	4
4.	Precloacal pores	d, Precloacal pores only in male (primitive)	1
		D, Precloacal pores in male and female (advance)	2
5.	Femoral pores	e, Femoral pores absent (primitive)	1
		E, Femoral pores present (advance)	2
6.	Basal phalanges	f, Wide (primitive)	1
		F, Narrow (advance)	2
7.	Digital angulations	g, Poor (primitive)	1
		G, Acute (advance)	2
8.	Tail segmentation	h, Indistinct (primitive)	1
		H, Distinct at base (advance)	2
		H*, Distinct throughout (advance)	3
9.	Dark band on the back of head	i, Present (primitive)	1
		I, Absent (advance)	2
10.	Subcaudals	j, Indistinct, in several rows (primitive)	1
		J, Distinct, in a single row (advance)	2
11.	Caudal tubercles	k, Small spiny (primitive)	1
		K, Large flat (advance)	2
		K*, Large, flat, keeled (advance)	3
		K**, Large, flat, keeled overlapping (advance)	4
12.	Limb size	l, Short, anterior reaching to eye (primitive)	1
		L, Long, anterior reaching naris and beyond (advance)	2
13.	Size of digits	m, Short (primitive)	1
		M, Long (advance)	2
14.	Snout slope	n, Gradual (primitive)	1
		N, Abrupt (advance)	2
15.	Cloacal sacs	o, Present (primitive)	1
		O, Absent (advance)	2
16	Relative size of body and tail	p, Subequal (primitive)	1
		P, Tail longer (advance)	2

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 *Hemitheconyx* 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

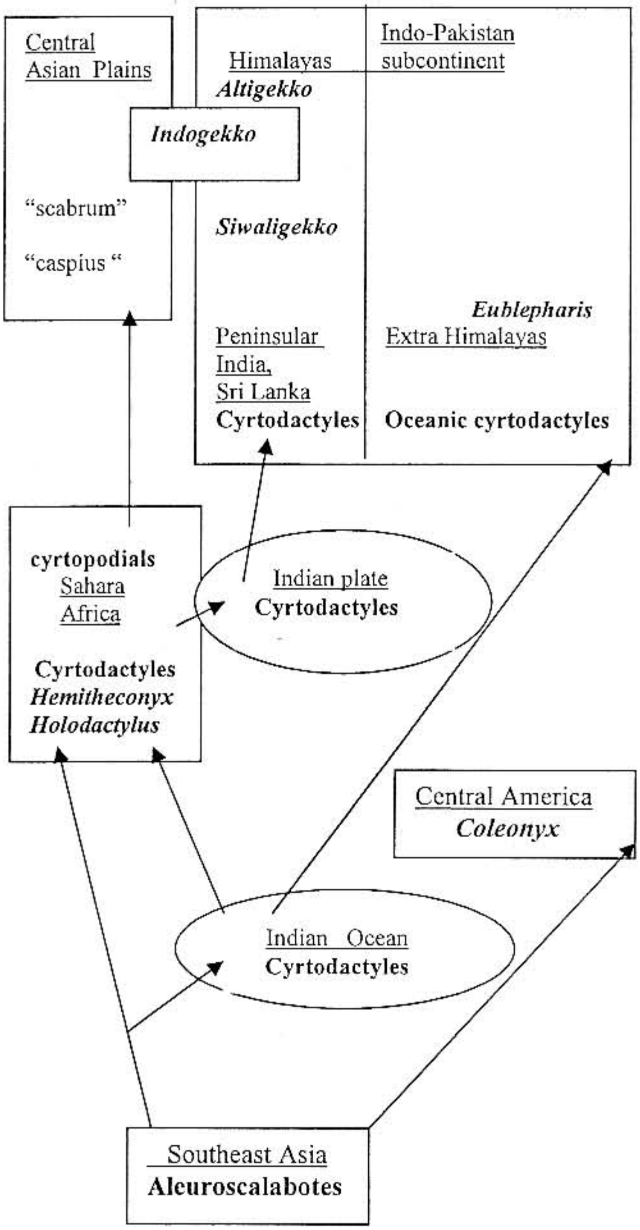

Fig. 1. Radiation and interrelationships between angular-toed gekkota of southeast Asia, and their paleo-zoogeography (modified from Estes, 1983; Fig. 6).

"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 Szczerback, 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 subHimalayan mountainous crumble known as Siwalicks (Khan, 1979; Powel, 1979; Khan, 1980, 1993). The *Swaligekko* are widely distribution 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 macularious* in the analysis. Altigekko are closest to ancestral form while Indogekko and Cyrtopodion occupy farthest position in the spectrum.

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

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

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