

Spatial distribution pattern of Agamid Lizards (Family: Agamidae) in the Western Ghats of Tamil Nadu, India

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Abstract

A study was conducted using visual encounter survey method from January to December 1995 to examine the distribution pattern of agamid lizards in the Nilgiri Biosphere Reserve (NBR), Indira Gandhi Wildlife Sanctuary (IGWLS), Srivilliputhur Grizzled Giant Squirrel Sanctuary (SGGSS) and Kalakkad-Mundanthurai Tiger Reserve (KMTR) of the Western Ghats of Tamil Nadu. Eleven out of 14 species reported from this hill range were observed during this study, and the notable missing species was *Otocryptis beddomii*. The tropical thorn (TTF) and dry deciduous (TDD), forests and shola and montane grassland (SMG) were represented with a few, and tropical moist deciduous (TMD) and wet evergreen (TWE) forests with higher number of species. The TTF was dominated by *Calotes versicolor* and *Pseudomorphus dorsalis*, whereas SMG by *Salea* spp. Lower altitude (<300 m) was dominated by only two species viz., *C. versicolor* and *P. dorsalis* (together contributing 89%). *Sitana ponticeriana* and *Salea* spp. had narrow distributional range with the former species restricted to <600 m, and the latter to >1700 m above sea level (asl). Encounter rate of lizards was the highest in KMTR (3.5/hour) and lowest in NBR (1.4/hour), which decreased considerably from dry (TTF) to wet (SMG) forest types (3.3 to 0.7/hour). Highest species diversity was observed in NBR ($H' = 1.68$), TMD ($H' = 1.73$) and in altitude 601 – 900 m MSL ($H' = 1.79$), and the lowest in SGGSS ($H' = 1.14$), SMG ($H' = 0.86$) and < 300 m ($H' = 1.0$). Agamid communities appear to be different at various spatial levels as they obtained lower overlap indices. It appears that in the Western Ghats, the distribution of agamid lizards is influenced by factors such as vegetation, altitude and climatic conditions.

Keywords : agamid lizards, altitude, microhabitat, vertical distribution, western ghats

INTRODUCTION

Among reptiles, lizards (suborder: Lacertilia) are nearly cosmopolitan in distribution as they occur in a great variety of landscapes ranging from desert to montane tropical forests. Lizards are primarily a tropical group and they have wide altitudinal and latitudinal distribution pattern (Porter, 1972). The relative abundance and diversity of lizards varies from one habit to another. More over the greater occurrence of lizards than any other reptiles in all ecosystems is probably due to their high adaptability, especially opportunistic feeding habits consuming variety of insects (Pianka, 1976). Among lizards, the agamids are confined to the Old World, and a majority of them are distributed in the Oriental region (Smith, 1935) inhabiting most biotopes from sea level to over 5000 m. There are 34 genera and about 315 species of agamids, and these are distributed over southern and southeastern Asia, southeastern Europe, Africa, and Australia. Within Indian political limits, 49 species of agamids have been reported; of which 14 in the Western Ghats (Das, 1994; Ishwar and Das, 1998). Ten species of agamid lizards are endemic to India and seven to the Western Ghats. Despite this high species richness and endemism, agamid lizards in the Western Ghats are poorly documented (Murthy, 1980, 1985; Kannan

and Bhupathy, 1997; Ishwar *et al.*, 2003; Kannan and Kalaiarasan, 2005). In the present paper we describe the spatial use pattern of agamid lizards with respect to distribution and microhabitat and vertical strata use in the Western Ghats of Tamil Nadu, South India.

MATERIALS AND METHODS

Study area

The Western Ghats (8°-20°N) is one of the major biodiversity hotspots of the world (Myers *et al.*, 2000). This hill range (~1600 km) runs parallel to the Arabian Sea along the western side of the Indian peninsula, encompasses a gradient of altitude from 200 to 2500 m above sea level. This gradient resulted high variations in temperature (3–45°C) and rainfall (500–5000 mm). The quantum of rainfall is accompanied by a change in forest types from tropical thorn to dry deciduous to moist deciduous to semi evergreen and wet evergreen and shola and montane grasslands (Puri *et al.*, 1983; Meher-Homji, 1985). The Western Ghats is known for its high biological diversity and endemism (Nair and Daniel, 1986; Groombridge, 1990; Daniels, 1993, 1997; Myers *et al.*, 2000).

Field methods

Agamid lizards were surveyed using visual encounter survey (Campbell and Christman, 1982; Corn and Bury, 1990) from January to December 1995 in the Nilgiri Biosphere Reserve (NBR), Indira Gandhi

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Wildlife Sanctuary (IGWLS), Srivilliputhur Grizzled Giant Squirrel Sanctuary (SGGSS) and Kalakkad-Mundanthurai Tiger Reserve (KMTR). Three surveys (February – May, June – September and October – December) were carried out in each locality during 0600 – 1000 hrs and 1600-1900 hrs searching for lizards. The following data were recorded on sighting a lizard: species, time of the day, area, forest type, altitude and location of the lizard above the ground. Description on the forest types of the Western Ghats are available in Champion and Seth (1968) and Nair and Daniel (1986). The forests of the Western Ghats are broadly divided into six types; tropical thorn (TTF), dry deciduous (TDD), moist deciduous (TMD), semi evergreen (TSE), wet evergreen (TWE) and shola and montane grassland (SMG) for sampling and these were considered as macro habitats. Actual site of the reptiles when first observed was descriptively noted and later classified to various microhabitats such as tree trunk, ground, leaf litter and rock. The position of a lizard above ground when first observed was noted to analyze the vertical strata used. The altitude range of the Western Ghats (200-2500 m) was divided into <300, 301-600, 601-900, 901-1200 and >1200 m and used in the analyses. Forest type that had less than 50 hours of observation (e.g. TSE) was not considered for analysis. Species richness (number of species), diversity (H') and similarity in lizard species community (Hulbert, 1978) were worked out at various spatial levels, locality, vegetation type and altitudinal range.

RESULTS

In all, 2405 lizards of 11 species were observed during 1059 hours of survey covering all seasons and major forest types during this study. Species that was not observed during this study was *Otocryptis beddomii*. Smith (1935) reported two species of *Psammophilus* from the Western Ghats, and their identity was largely based on number of scales around the mid body; 115 – 150 in *P. dorsalis* and 80 – 100 in *P. blanfordianus*. Based on this, identification up to species level was not possible in the field. Hence, both these species were tentatively considered as single species, *Psammophilus dorsalis*.

Distribution in various localities

Nilgiri Biosphere Reserve (NBR)

In NBR, field surveys were conducted in Mudumalai and Mukkuruthi Wildlife Sanctuaries, and Moyar, Thengumarahada and Siruvani Reserve Forests. The survey covered scrub, dry deciduous, moist deciduous, semi evergreen and montane shola grass land forest types. A total of 473 lizards belonging to nine species were recorded, which accounted to 1.4 lizards/hour of search (Table 1). All six species of *Calotes* reported from the Western Ghats were observed during this study, which contributed to 61% of all agamids recorded in

NBR. At species level, *C. versicolor* dominated forming over 43% of the agamids. *Sitana ponticeriana* were not observed in the above survey areas, which may be present in the fringes of NBR in open degraded forests or scrub forests in the plains.

Indira Gandhi Wildlife Sanctuary (IGWLS)

A total of 534 lizards belonging to nine species were recorded in 291 hours of survey (1.8 lizards/hour) in Top Slip (dry and moist deciduous forests), Karian shola, Varagaliyar, Valparai (wet evergreen) and Grass hills (Montane shola grass land). Additionally, *Sitana ponticeriana* may be present in the scrub forest in the eastern fringes of the sanctuary. *O. beddomii* had been reported from Grass hills (Smith 1935), but was not observed during the present study. About 68% of the agamid sightings comprised of two species *C. rouxii* (36%) and *Psammophilus dorsalis* (32%). Barring *C. elliotti*, other species contributed 7% each. *Calotes versicolor* was comparatively fewer in Indira Gandhi Wildlife Sanctuary compared to other survey localities (Table 2).

Srivilliputthur Grizzled Giant Squirrel Sanctuary (SGGSS)

Dry deciduous, scrub and moist deciduous and wet evergreen forests were surveyed in Srivilliputthur and adjoining areas. In 151 hours of survey, 456 agamid lizards belonging to six species were recorded (3 lizards/hour). *C. versicolor* and *P. dorsalis* together accounted for 87% of all lizards. Other species contributed less than 6% each (Table 2).

Kalakad-Mundanthurai Tiger Reserve (KMTR)

Surveys were conducted in the scrub, dry deciduous forest and wet evergreen forests. A total of 942 lizards belonging to seven species were observed in 268 hours of search. (3.5 lizards/hour) About 82% of the total agamid records were contributed by only two species; *C. versicolor* (56%) and *Psammophilus dorsalis* (26%; Table 2). *C. elliotti* accounted for another 6%. *C. calotes* 4% and *C. grandisquamis* contributed less than 0.1% of the total records. In general agamid species composition of this area was similar to that of Srivilliputthur Grizzled Giant Squirrel Sanctuary with only one additional species *C. elliotti*. However later, the Andaman *Calotes C. andamanensis*, which is a new record for mainland India has been reported here by Ishwar and Das (1998).

With respect to spatial distribution of agamid lizards the following conclusions could be deciphered. Mukkuruthi Wildlife sanctuary is probably the only known strong hold of *Salea horsfieldi* in the whole parts of the Western Ghats. *O. beddomii* is very rare or locally extinct in grass hills area. *C. versicolor* and *P. dorsalis* are common all over and *S. ponticeriana* may be present in scrub forests in the rain shadow region of all

protected areas of the Western Ghats. Among the areas surveyed the highest species diversity ($H' = 1.68$) was observed in NBR and the lowest ($H' = 1.14$, Table 1) in SGGSS. Encounter rate of the lizards was the highest in KMTR (3.5/hour) and lowest in NBR (1.4/hour). In all locations but, IGWLS, *C. versicolor* contributed over 40 % in each locality followed by *Psammophilu dorsalis*. Both these species formed over 80% in SGGSS and KMTR. In NBR and IGWLS higher number of species was observed and many of them well represented. *Draco dussumieri*, *C. versicolor*, *C. grandisquamis*, *C. calotes* and *P. dorsalis* were recorded in all localities, while the *Salea* spp. was recorded in one locality each.

Distribution in various forest types

Six vegetation types were considered for analyses, which included (1) tropical thorn (TTF), (2) dry deciduous (TDD), (3) moist deciduous (TMD), (4) semi evergreen (TSE), (5) wet evergreen (TWE) forests and (6) shola and montane grassland (SMG).

Agamid composition in various forests types showed that TTF and TDD in lower elevations and SMG in higher elevations were represented by fewer species. TMD and TWE were represented by higher number of species and all species of *Calotes* of the Western Ghats were observed in these forests. *C. versicolor* and *P. dorsalis* were common in TTF and TDD, whereas in SMG it is *Salea* spp. that was common. In SMG only three

Table 1. Agamid species diversity in the protected areas of the Western Ghats of Tamil Nadu, South India

Details	Protected Area			
	NER	IGWLS	SGGSS	KMTR
Number of hours surveyed	349	291	151	268
Number of species recorded	9	9	6	7
Number of lizards recorded	473	534	456	942
Number of lizards/hour	1.4	1.8	3	3.5
Species diversity(H')	1.68	1.62	1.14	1.22

NBR-Nilgiri Biosphere Reserve; IGWLS-Indira Gandhi Wildlife Sanctuary; SGGSS-Srivilliputhur Grizzled Giant Squirrel Sanctuary; KMTR- Kalakad Mundanthurai Tiger Reserve

Table 2. Percentage composition of agamid lizards in the protected areas of the Western Ghats of Tamil Nadu, South India

Species	Protected Area			
	NBR	IGWLS	SGGSS	KMTR
<i>Draco dussumieri</i>	13	5	1	2.5
<i>Stenaspis poikilosticta</i>	-	-	4	5
<i>Otocryptis beddomi</i>	-	-	-	-
<i>Sialis horsfieldi</i>	11	-	-	-
<i>Sialis asmatensis</i>	-	2	-	-
<i>Crotalus versicolor</i>	43	8	43	56
<i>Crotalus nemoricola</i>	3	1	-	-
<i>Crotalus gularis</i>	1	2	2	0.1
<i>Crotalus carolinensis</i>	1	2	6	4
<i>Crotalus rousi</i>	10	36	-	-
<i>Crotalus ellioti</i>	3	12	-	6
<i>Psammophilus dorsalis</i>	15	32	44	26
Total Number of lizards recorded	473	534	942	456

'-' indicates absence of the respective species

species of agamids, *S. horsfieldi*, *S. anamallayana* and *P. dorsalis* were observed. The former two species are endemic to the Western Ghats and their distribution is largely confined to this forest type. The highest species diversity ($H' = 1.73$) was recorded in TMD and lowest in SMG ($H' = 0.86$). Encounter rate of lizards decreased considerably from dry to wet forest types (3.3 to 0.7 / hour (Table 3).

Altitudinal distribution

Altitude range of the Western Ghats in Tamil Nadu varies from 200 to 2500 m. Samplings above 1200 m were clumped into one category (>1200 m) as area occupied by this elevation gradient is low and resulted in small sample size. Agamid species observed in various altitudinal ranges are given in Table 4. Lower altitude (<300 m) was dominated by only two species; *C. versicolor* and *P. dorsalis*, which together contributing over 89 %. Among all agamid species observed, only *P. dorsalis* accounted for over 15% of records in all altitudinal categories. Number of *C. versicolor* showed inverse relation with altitude. *Sitana ponticeriana* is restricted to <600 m, and *S. horsfieldi* and *S. anamallayana* to >1700m. *P. dorsalis* and *C. ellioti* occurred in a wide range of elevations (200 to 2000 m), and others were restricted to 200 – 1200 m. Mean altitude of eight species of agamid lizards was lower than 1000 m (Table 4). The highest lizard species richness was in 301-600 m and 601- 900 m and the lowest above 1200 m. The highest diversity ($H' = 1.79$) was recorded in 601–900 m and the lowest in <300 m category ($H' = 1.0$) (Table 5).

Micro habitat use of agamid lizards

Among various microhabitats, *Draco dussumieri* and *C. grandisquamis* occurred only on the tree trunk, while all the other species except *Sitana ponticeriana*, *C. calotes*, *Salea anamallayana* and *P. dorsalis* showed a preference for tree trunk. *S. ponticeriana* occurred only on the ground. *C. calotes* was a generalist as it was found in all the microhabitats barring rock. *Salea horsfieldi* mostly used trunk of trees and shrubs, but were also sighted in other microhabitats at times. The present study showed that seven agamid species largely used tree trunk.

Vertical distribution of agamid lizards

All but two species, (*D. dussumieri* and *C. versicolor*), were sighted at < 10 m from ground. Mean height of occurrence of seven species of agamid lizards was < 5 m. *Sitana ponticeriana* and *P. dorsalis* were found only on the ground. When rocks get heated up, *P. dorsalis* would use low trunk of trees or shrubs. *D. dussumieri* occurred in a wide range of vertical positions from 2 to 20 m with a mean of 9 m. This species may also use higher canopy as well. As *D. dussumieri* is small and the visibility was poor beyond 15 m in hill forests, observed vertical distribution of this and some other agamid lizards might be an under estimate.

Agamid community at various spatial levels

Barring a few exceptions, on the whole, the agamid communities appear to be not very similar at various spatial levels as they obtained lower overlap indices. The highest overlap was observed between SGGSS and KMTR among localities ($O = 0.85$), and between < 300 and 600 m among altitudinal range ($O = 0.85$). Overlap of agamid composition was lowest in SMG and at > 1200 m at altitudinal level, when compared to other forest types and altitudinal ranges.

DISCUSSION

The agamids are a large and diverse family of old world lizards exhibiting parallel in adaptive types to many of the new world iguanids. Agamids are widely distributed in India and occupy all biotopes and altitudinal ranges from sea level to over 5000 m (Daniel, 1983). They are ecologically diversified into burrowing, surface dwelling and arboreal species and they are distributed mainly in the drier and open areas. Agamid lizards in the Western Ghats are represented by fourteen species among which seven species are endemic to this hill range. The higher agamid richness and diversity in Nilgiri Biosphere Reserve (NBR) could be due to the availability of a higher number (over 6 major) forest types and topographic variation ranging from low lying valleys in the west to mountains over 2000 m and a flat elevated table of land of nearly 800-1000 m above sea level resulting in diverse climate and vegetations (Daniels, 1993). Lower species richness and diversity in Srivilliputtur Grizzled Giant Squirrel Sanctuary (SGGSS) could be due to lower number of forest types (3), and overall dry nature compared to NBR (Bhupathy and Kannan, 1997). Altitudinal variation is also very high in NBR (200–2500 m) while it is 200-1400 m in SGGSS. Lower species diversity in SGGSS is also due to the higher abundance of species such as *C. versicolor* and *P. dorsalis*, which contributed over 43% and 44% of the agamids, observed respectively, whereas nine species contributed over 64% in NBR, which resulted in higher species diversity. *Otocryptis beddomii* was not recorded from any of the localities surveyed during this study. However, this species was reported from Grass, Cardamom and Sivagiri Hills (Smith, 1935; Murthy, 1980). However, it appears to be common in the Ponmudi Hills of Kerala (Inger *et al.*, 1984). *Salea horsfieldi* and *S. anamallayana* were recorded only from NBR and IGWLS, respectively, indicating their narrow range in distribution.

Higher agamid lizard species richness and diversity in the tropical moist deciduous and evergreen forests could be due to stable climatic conditions and availability of a number of microhabitats. It is reported that the relative abundance and diversity of lizards varied from one terrestrial region to another, and the same was attributed to the variations in food and climate (Porter,

Table 3. Agamid species diversity in various forest types of the Western Ghats of Tamil Nadu

Details	Forest types				
	Scrub jungle	Dry deciduous	Moist deciduous	Wet evergreen	Montane shoal grass land
Number of hours surveyed	125	292	264	191	111
Number of species	5	7	8	8	3
Number of lizards recorded	447	1022	595	262	79
Number of lizards/hour	3.3	3.4	2.1	1.2	0.7
Species diversity(H')	0.95	1.06	1.73	1.54	0.86

Table 4. Percentage composition of agamid lizards in various altitudes of the Western Ghats of Tamil Nadu

Species	Altitude range (m)				
	< 300	301 - 600	601-900	901-1200	>1200
<i>Draco dussumieri</i>	0.3	6	13.1	7	-
<i>Sitana ponticeri</i>	5	2	-	-	-
<i>Otocryptis badhami</i>	-	-	-	-	-
<i>Salea horsfieldi</i>	-	-	-	-	60
<i>Salea am malleayana</i>	-	-	-	-	13
<i>Calotes versicolor</i>	60	53.6	14.3	-	-
<i>Calotes narmadensis</i>	-	0.3	3	1	-
<i>Calotes grandisquamis</i>	-	0.5	2	5	-
<i>Calotes calotes</i>	5	4	3	-	-
<i>Calotes roulei</i>	0.3	9	26.3	25	-
<i>Calotes ellioti</i>	0.2	-	11	13	11
<i>Psammophilus dorsalis</i>	29	24.6	27.3	49	16
No. of lizards recorded	1180	335	525	276	89

Table 5. Agamid species diversity in various altitudes of the Western Ghats of Tamil Nadu

Species	Altitude range (m)				
	< 300	301 - 600	601-900	901-1200	>1200
Number of hours surveyed	255	262	312	142	88
Number of species	7	8	8	6	4
Number of lizards recorded	1180	335	525	276	89
Number of lizards/hour	4.1	1.2	1.5	1.6	0.7
Species diversity(H')	1.0	1.30	1.79	1.35	1.12

1972; Pianka, 1976). Lower number of lizard species in the shola and montane grassland could be due to the extreme climatic conditions in higher altitudes. It is reported that altitudes and latitudes play important role in determining species richness and abundance of an area (Brown and Lomolino, 1998; Gaston, 2000). Decrease in encounter rate of agamids from dry to wet forests types may be due to the abundance of a few generalist species such as *C. versicolor* in the dry forests. The wet undisturbed shola and grass land had only

a few species that too in low number as the ambient temperatures in this area is low (annual average-20 °C). Higher agamid species diversity in mid altitude 601 – 900 m is due to the commonness of as many as five species (which contributed over 10 % each). Agamid distribution in Western Ghats is similar to the general distribution pattern of amphibians and reptiles reported earlier (Daniels, 1993; Ishwar *et al.*, 2003).

Tree trunk (microhabitat) was largely used by as many

as seven agamid lizards of the Western Ghats. This indicates the importance of larger trees for conserving agamid species, especially *D. dussumieri*. The present study showed that most of the agamid lizards restrict to the lower strata (<5 m from ground), which indicates that they could be affected in case of forest fire. Lower overlap index of agamid lizards with respect to locality, vegetation and altitude indicates their unique composition at spatial level. Higher overlap of species in vegetation type TTF – TDD, and elevation < 300 – 600 m are mainly due to similarity in climatic conditions. Lower overlap of agamid community of SMG and > 1200 m could be due to the presence of specialized vegetation type and cold climatic conditions, where a few species have adaptations to inhabit. Cold climate is more effective in restricting the dispersal of lizards, especially agamids are driven by factors such as temperature. This study reveals the importance of mid elevation landscapes, especially the moist forests in the conservation of agamid lizards in the Western Ghats.

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