SPIXIANA	9	1	111–115	München, 31. Oktober 1986	ISSN 0341-8391

The genus Calotes (Sauria: Agamidae) in Sri Lanka: Clutch Sizes and Reproductive Seasonality of Calotes versicolor – Preliminary Results

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Abstract

Clutch sizes of four species of *Calotes* from Sri Lanka are compared. There is evidence that the endemic species tend to produce smaller clutches than the non-endemic species. For *C. versicolor,* the most widespread species, the data are in accordance with a north-south trend of decreasing clutch size and less pronounced seasonality of reproduction from Northern India to Sri Lanka: In Sri Lanka egg laying occurs throughout the year and clutches are much smaller than in Northern India.

Introduction

Probably the best known aspect of lizard reproduction is clutch size (Turner 1977). Most of the available information on clutch size is derived from temperate regions and, for tropical and subtropical regions, from a single genus, the iguanid *Anolis* (see Fitch 1970, 1982). Although information from the tropics has accumulated considerably during the last decade (see references in Fitch 1982) we still have very limited knowledge about reproductive strategies of lizards in these environments.

Very few papers so far have dealt with the adaptive significance of clutch size (e. g. Andrews & Rand 1974; Tinkle et al. 1970). Recently Vitt (1981) investigated possible relations between reproductive strategies of two iguanid species and their affinities to particular habitats and microhabitats.

In my study clutch sizes of some *Calotes* species inhabiting Sri Lanka are compared and possible relations with their occurence in certain microhabitats are discussed. Data on *Calotes versicolor,* the most widespread and best known of the Sri Lankan species, are used to discuss intraspecific variation in the reproductive cycle in different geographical regions.

In Sri Lanka six species of *Calotes* occur, viz. *Calotes calotes, C. versicolor* and the four endemic species *C. ceylonensis, C. liocephalus, C. liolepis* and *C. nigrilabris.* In contrast to the endemic species, which prefer primary forests, *C. versicolor* and *C. calotes* are found where human activities have influenced the vegetation considerably (Erdelen 1978).

C. calotes occurs in Sri Lanka, South India, and on the Nicobar Islands (Wermuth 1967). *C. versicolor* is found in Iran, India, the former Indochina, on the Malayan Peninsula and on some of the islands of Indonesia. Its northern range extends to the Himalayas, up to 2000 m above sea level (Smith 1935), its north-eastern range to South China (Pope 1935). Very little is known about the reproductive biology of *C. versicolor* (Misra nee Haldar & Thapliyal 1980; Pandha & Thapliyal 1967; Singh & Thapliyal 1962). Almost no data are available about the other species of Calotes found in Sri Lanka (Deraniyagala 1931, 1953; Taylor 1953).

Materials and Methods

Data on clutch sizes and on the egg laying periods where collected during a two year field study in Sri Lanka (ERDELEN 1983). Informations on clutch sizes were obtained either from field observations or from pregnant females kept in terraria until oviposition. For the analysis of reproduction of *C. versicolor* published data had to be used for comparison.

Results and Discussion

Clutch Sizes in Sri Lanka

The clutch size data suggest that the endemic species produce smaller clutches than the non-endemic species (Table 1). This is in agreement with data of DERANIYAGALA (1953) who reports clutch sizes of 6–14 eggs for *C. versicolor*, 6–12 eggs for *C. calotes*, 3 for *C. liocephalus* and 5 for *C. ceylonensis*. Because no clutch production data are available for *C. liolepis*, it is not known whether this endemic species is also less productive than the non-endemic species.

Table 1. Mean clutch size of four species of the genus *Calotes* in Sri Lanka. CL = mean clutch size. Minima and maxima are given in parentheses. N = sample sizes. E = endemic species.

Species	E	CL	N
C. liocephalus	+	2.2 (2–3)	5
C. nigrilabris	+	4.0 (3–5)	4
C. calotes	–	7.0 (6–8)	2
C. versicolor	–	7.3 (6–9)	3

As TINKLE et al. (1970) concluded from a general survey of literature data, lizards laying only one clutch per year tend to produce larger clutches than species laying several clutches. From the limited information on clutch sizes of the Sri Lankan species of *Calotes* it is not possible to estimate their total species-specific variation.

The differences in clutch sizes between the endemic and non-endemic species of *Calotes* in Sri Lanka seem to be correlated with the habitats in which these are found. The endemic species are mainly arboreal, living in more or less undisturbed habitats whereas *C. calotes* and *C. versicolor* are to a much lesser extent arboreal, preferring man-made open habitats (ERDELEN 1978, 1983). In general, tree-dwelling forms seem to produce smaller clutches than non-arboreal species (FITCH 1973; TINKLE et al. 1970).

The higher number of eggs per clutch in the two non-endemic species *C. calotes* and *C. versicolor* might also be a result of adaptations to strong fluctuations in their environment due to man's influence. When compared to *C. nigrilabris*, the only endemic species for which data are available, the non-endemic species showed a much higher population turnover (ERDELEN 1983). This could reflect a general difference between the endemic and non-endemic species of *Calotes* found in Sri Lanka.

Both species groups, i. e. endemics and non-endemics, might be placed at different points in the r-K-strategy continuum of adaptations of lizards to different environments. This heterogeneity within the *Calotes* species of Sri Lanka clearly shows that lizard reproduction, even within closely related species, can be quite diverse and consequently, as pointed out by VITT (1981), data on components of life histories should not be interpreted in the absence of ecological data.

Intraspecific variation of clutch size and egg laying period in *C. versicolor*

The clutch size data indicate that there might be a close correspondence between the wettest months and the egg laying period (Table 2). This is shown by the high and positive correlations between lati-

Country	Locality	Altitude	Lat	CL	Period of reproduction	3 wettest months	CA	Ref.
Nepal	Katmandu	1337	28	12.6 (39)	March to May	June to Aug.	0.00	1
N-India	Varanasi[1)]	98	25	1 - 23	July to Aug.	July to Sept.	0.83	2
W-Pakistan	Karachi	4	25	6 - 19 (6)	June to Sept.	June to Aug.	0.83	3
NW-India	Ahmedabad	50	23	11 - 23	May to Sept.	June to Aug.	0.67	4
W-India	Salsette Is.[2)]	11	19	16.6 (13)	April to Aug.	June to Aug.	0.67	5
S-India	Bangalore	920	13	?	May to Nov.	Aug. to Oct.	0.33	6
Sri Lanka	———	——	8	7.3 (3)	Continuous	April to June + Oct. to Dec.	0.00	7

1) = climatic data from Allahabad. 2) = climatic data from Bombay

*) $CA = \frac{(a+d) - (b+c)}{a+b+c+d}$; a(c) = moist months with (without) oviposition; b(d) = dry months with (without) oviposition

References: 1) ERDELEN 1977; 2) PANDHA and THAPLIYAL 1967; 3) MINTON 1966; 4) ASANA 1931; 5) McCANN 1937; 6) IYER 1942; 7) ERDELEN 1983.

Table 2. Intraspecific comparison of clutch sizes and period of oviposition in *C. versicolor*. Climatic data from Müller (1980). CL = mean clutch size or range. Sample sizes given in parantheses where available. Altitude in meters above sea level. Lat = Latitude in degrees. CA = coefficient of association.*)

tude and the coefficients of association in Table 2 ($r = 0.98$, $p<0.001$ ($N = 6$, Katmandu excluded); r = Pearson product-moment correlation coefficient). Similar trends were already reported for other lizards (FITCH 1982; TURNER 1977). Only the values for Katmandu do not fit into this pattern, but these data were inferred from dissected museum specimens (ERDELEN 1977).

Although *C. versicolor* seems to show considerable variation in clutch size, it is very probable that the high numbers of eggs per clutch as found for example in Northern India do not occur in Sri Lanka, or they are at least much less frequent there.

In contrast to the other regions, reproduction in Sri Lanka appears to occur throughout the year: During the two year field study in Sri Lanka egg laying of *C. versicolor* was observed in March and December. Gravid females were found in April and May.

Additional although indirect evidence on the egg laying period was obtained in the field from the time of appearance of newly hatched juvenile specimens. Assuming an incubation period between 69 and 76 days (DERANIYAGALA 1953), egg laying must have taken place during the months of January, February, April, May, June, and September.

All these data strongly indicate continuous reproduction in *C. versicolor*. According to ERDELEN (1983) there is no evidence for peaks in reproductive activity in this species.

The comparatively small clutch size for *C. versicolor* from Katmandu could be due to the fact that the sample was taken between March and May (ERDELEN 1977). Many of the oviducal eggs might not yet have developed to a size large enough to allow conclusions about the actual clutch size and the time of egg laying. For *Agama tuberculata* from Kashmir KOUL & DUDA (1976) found oviducal eggs only during May, June and July. Climatic conditions at their study site were very similar to those in Katmandu, so more data from *C. versicolor* might indicate a similar reproductive cycle for this species at higher altitudes in Nepal.

The absence of a correlation between the peak of reproduction and the wettest three months in Katmandu could indicate that at high altitudes not only rainfall but also temperature conditions during certain months or even both factors could determine the period of egg laying in *C. versicolor*. Temperature, according to LICHT (1972) the most important and widespread of the timing cues for Saurian reproduction, could even be more important than precipitation. However, detailed field data from this region are needed before the relative importance of these factors for the reproduction of *C. versicolor* can be estimated.

If *C. versicolor* immigrated from India to Sri Lanka as assumed by DERANIYAGALA (1959) it could have been preadapted for year round reproduction as indicated by the permanent activity of male gonads and the long lasting period of sexual activity in males in Northern India (MISRA NEE HALDAR & THAPLIYAL 1980). This seems to be a quite common pattern of sexual activity among lizards from subtropical and tropical regions (e. g. BELLAIRS 1971).

The data presented here suggest that the seasonality in reproduction of *C. versicolor* becomes less pronounced from Northern India south to Sri Lanka, where this species lays eggs throughout the year. Additionally, perhaps as a consequence, clutch size is reduced.

A similar trend, i. e. a decrease of clutch size in less seasonal climates, was reported by FITCH (1982) for *Agama agama* (Rainbow Lizard), a common and widespread African agamid.

As indicated above *C. versicolor* varies considerably in its reproductive behavior correlated with differences in precipitation in different parts of its geographic range. It remains unknown whether this is the causal factor itself or not.

Acknowledgements

I gratefully acknowledge Prof. Dr. J. Jacobs for criticizing drafts of the manuscript. In addition, the constructive comments of A. Burnhauser, T. Saks, and Dr. H. Utschick were greatly appreciated.

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