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Eggs, hatching and larval development in *Ichthyophis* cf. *malabarensis* (Gymnophiona: Ichthyophiidae)

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Biology of Western Ghats caecilians is a less explored subject with very rare studies on reproductive behaviour. We describe egg laying, hatching and early development of *Ichthyophis* cf. *malabarensis* from Koyana region in northern Western Ghats where a single female with 144 eggs were observed in captivity. As per our knowledge this is the first complete description of initial developmental in caecilians of Western Ghats.

Studies on reproductive biology and reproductive behaviour of caecilians are rare with very few studies from the Western Ghats (Sheshachar, 1933, 1942, 1982; Balakrishna *et al*., 1983). *Ichthyophis* of family Ichthyophiidae and order Gymnophiona is oviparous with internal fertilization (Sheshachar, 1942, 1982; Balakrishna *et al*., 1983; Pillai & Ravichandran, 1999). Females lay eggs in burrows in moist soil close to water. Female *Ichthyophis* show parental care by guarding eggs until hatching. Earlier studies on *Gegenophis carnosus* are restricted to egg and embryo morphology (Sheshachar, 1942). Similar studies have been carried out on *I. malabarensis* (Sheshachar, 1982; Balakrishna *et al*., 1983). As per our knowledge this is the first attempt to describe egg, hatching and larval development of *I.* cf. *malabarensis* from Patan situated in Koyana region of northern Western Ghats.

Koyana region (17023'N & 73053'E) is situated at an altitude 580m on the eastern border of the Western Ghats in Maharashtra. The soil of this region is red loamy, porous and is rich in humus, the pH is 6.2. Average temperature and rainfall of this region are 230C and 1240mm. Vegetation is mainly of paddy, sugarcane and groundnut fields.

A female Ichthyophis cf. malabarensis with 144-egg cluster was collected from a burrow near a rivulet in wet soil. The egg cluster along with the adult was brought to the laboratory and was kept in an artificial tank of 88.2 x 58.5 x 58.5cm. The bottom bed of decomposed leaves, agricultural wastes and sand was prepared and was placed in the tank. The height of soil bed was 35cm. In this bed a round pit was made, resembling the pit present in natural conditions, with the diameter of 17.5cm and depth of 12.5cm to keep the egg cluster. In this pit the female and her egg clutch was released. Water was sprinkled on the bed every 3-4days. The female was fed with earthworms released in the bottom bed. Daily observations on the behaviour of female were noted.

The newly hatched larvae were kept in a 3-4cm-deep plastic tub containing water. Food in the form of finely chopped liver, heart and meat of goat were provided once a day and the water of the tub was changed after

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every two days for up to a month. Photographic and live video recordings of the entire event were made.

We observed 144 eggs in the cluster, which is around 1.5 times more than the suspected maximum number of eggs in *Gymnophiona* by Seshachar (1982). Eggs in a single clutch were connected together by median cord and the cluster looked like black grapes (Fig.1A). Each egg was covered with transparent, elastic and gelatinous membrane, which was continuous with cords at both ends (Fig 1B). The length of each cord was 13mm. Both cords were straight, thin, hollow, untwisted and elastic and their tips coiled together to from hooks for firm attachment to median cord during the early stage (Fig.1C). After embryonic development, one end of cord was detached from median cord due to increase in size of the eggs, while the other side remained attached to the median cord until the eggs hatched (Fig. 1C). This observation was inconsistent from the earlier observation by Seshachar (1982) who mentioned a straight chain of eggs connected end to end by cords (Fig. 1D) in *I. malabarensis*.

The eggs were oval in shape with average weight of 750mg and average size of 14.2 – 13.2mm. Details of the eggs are given in Table 1. The developing larva with external gills, yolk and amniotic fluid could be seen through the thin transparent membrane of the eggs. A prematurely hatched larva is shown in Fig. 2. The early-hatched larva died while handling within 30min. It was elongated, black in colour with white strip on the ventral side and about 65mm in length and weighed 584mg. The eyes were situated on the dorso-lateral side of head and were round and prominent. The embryonic larva had three pairs of external gills; each external gill having median axis surrounded by lamellae. The lengths of the three gills were 8mm, 17.2mm and 10.3mm. The ventral side of the larva showed faint white coloured yolk. Tail was laterally compressed with caudal fin in developing stage.

Balakrishna *et al.* (1983) mentioned that the embryo of *I. malabarensis* did not show any movement. On the contrary, we observed rapid movement of embryos in the eggs with irregular jerks. The female was found to be coiled around the eggs (Fig. 3) in the pit until the hatching of the last egg. This parental care is a well-known phenomenon in caecilians (Pillai & Ravichandran, 1999; Daniel, 2002).

Hatching took place in the night from 0930 to 1130hr and in three successive stages. In the first stage, rapid jerky movements were observed in the egg, which was followed by emergence of head from the egg (Fig. 4A). Stretching of the body could have facilitated the break in the membrane. After the emergence of the head, we observed a gap of a few seconds when the larva showed no movements. In the second stage more than two-third of the body emerged from the egg (Fig. 4B), followed by another pause. In the third stage the tail portion came out and the newly emerged larva coiled around itself (Fig. 4C). The average hatching time for each larva was approximately 2-3min. Just hatched larva was black in colour and 75.2mm in length. The eyes were prominent and round, mouth was sub-terminal and tail, with caudal fin, was laterally compressed. The caudal fin had broad dorsal and short ventral lobes. The vent was situated at

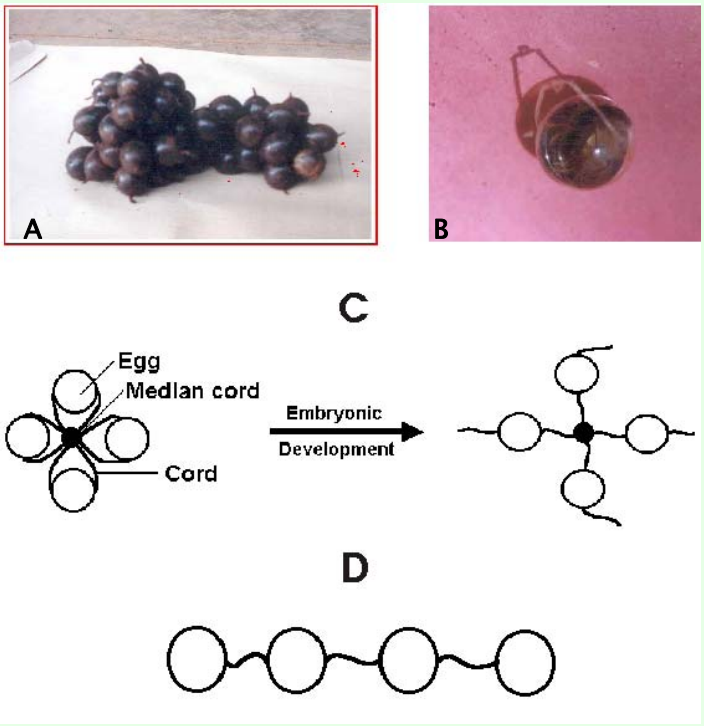

Figure 1. Egg clutch (A), a single egg (B) and structure of attachment by cord (C) of *I.* cf. *malabarensis*. (D) shows the attachment in *I. malabarensis* as per Seshachar (1982)

Figure 2. Early hatched larva with yolk and external gills

Figure 3. Parental care in *I.* cf. *malabarensis.*

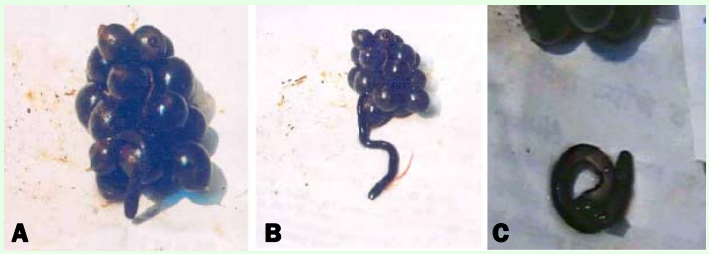

Figure 4. Three stages in the hatching of the larva from the egg. Refer to the text for details of each stage.

Figure 5. Physical mouth-to-mouth contact between larvae before entry into the water.

Table 1. Details of egg clutch and eggs of *Ichthyophis* cf. *malabarensis*

	Values	12 days before hatching	On the day
1	Weight of single egg	843mg	620mg
2	Weight of total egg mass	121392mg	89280mg
3	Length of one cord	13mm	13mm
4	Length of total cord of egg clutch.	1853mm	1853mm
5	Weight of single egg coat	-	34mg
6	Weight of total egg coat	-	4896mg
7	Diameter of egg at cord	44.1mm	38.2mm
8	Diameter of egg opposite to cord	40.1mm	35.6mm
9	Width of egg at cord	14.2mm	13.2mm
10	Width of egg opposite to cord	12.5mm	10.6mm

the junction of body and tail and was longitudinal with white rings surrounding it. The larva had three pairs of external gills at the junction of collar and trunk. The lengths of the three gills were 10.5mm, 24.3mm and 13.4 mm. The gills were dark red in colour up to the first four hours and turned to pale yellow after four hours.

After emergence, the larva started moving towards water at a very slow rate. In captivity, the larva took 15-20min to travel 10cm towards water. Before entry of the larvae in water an interesting behaviour was observed. When the larva touched water it stopped moving and waited for signals from the larvae already present in the water. Then there was a mouth-to-mouth physical contact (two to three times) between the larvae present on the edge and the larvae present in the water (Fig. 5). The larvae entered the water, went to the bottom and remained stationery for up to 2min, followed by undulating movements. The free floating larva bears gills for the first 15 hours. The largest gills got detached after 15 hours and the other gills got detached within the next 20 hours. When the gills were still attached to the larva, the larva remained in water. After detachment the larva came to the surface for respiration. Previous studies have mentioned that the gills of the larvae are absorbed into the body (Pillai & Ravichandran, 1999), however, we think it could be erroneous as we could clearly observe the shedding off of the gills during larval development.

In the free floating stage, the larvae lived in hiding places such as stones, bricks and fallen leaves in the tub and became very sluggish in locomotion. More than five to seven larvae came together and stayed coiled around each other, like a bundle, in shadow places or under crevices. Larvae were frequently observed to show vertical coiling up to 10-15min.

We also recorded cannibalism in *Ichthyophis* cf. *malabarensis.* The adult female consumed young larvae as well as eggs. The female consumed only the last few eggs after most other eggs were successfully hatched. This cannibalism is contradictory to the parental care behaviour; however, we hypothesize that the cannibalism of last eggs could be a means by which the female reduces density dependent competition among successfully hatched larvae. This is the first time record of such behaviour among caecilians of the Western Ghats.

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Diversity and distribution of amphibian fauna in Nagarjunasagar-Srisailam Tiger Reserve, Andhra Pradesh

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Nagarjunasagar-Srisailam Tiger Reserve (NSTR) (15053'-16043'N & 78030'E-79028'E) spread over an area of 3,568km2 in five districts (namely, Kurnool, Prakasam, Guntur, Nalgonda and Mahboobnagar) of Andhra Pradesh is the largest tiger reserve in India. It lies in the Nallamala range an unbroken chain of steep hill ranges with an elevation ranging from 100m (Krishna valley) up to 917m (Durgamkonda in Markapur reserve forest) in the Eastern Ghats. The river Krishna flows through nearly 130km of the Tiger Reserve dividing it into two halves -- the right (or south) bank and the left (or north) bank. Declared a wildlife sanctuary in the year 1978 it was upgraded to the status of the Tiger Reserve in 1983. The Tiger Reserve is also referred to as 'Rajiv Gandhi Wildlife Sanctuary' (named so in 1992, a name less frequently used). The NSTR is a biodiversity-rich region being home to countless number of hitherto unreported species of fauna (Srinivasulu & Nagulu, 2002) and flora (Rao, 1998).

Through this report we put on record observations of amphibian diversity, made through late 1995 to late 2003 and vouchers collected during a faunistic survey conducted from 3 to

Table 1. Amphibian diversity and their distribution in Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh

Species	Distribution	Status
Bufonidae		
1 *"Bufo" stomaticus* Lütken, 1862	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nandikonda Valley Guntur district: Nandikonda Valley, Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
2. *Duttaphrynus melanostictus* (Schneider, 1799)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda Guntur district: Nandikonda Valley, Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
3. "*Bufo" scaber* Schneider, 1799	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nandikonda Valley Guntur district: Nandikonda Valley, Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
Microhylidae		
4. *Kaloula taprobanica* (Parker, 1934)	Kurnool district: Mukhadwaram, Sunnipenta	Rare
5. *Uperodon globulosus* (Günther, 1864)	Mahboobnagar district: Between Mannanur and Farahabad Kurnool district: Between Mukhadwaram and Srisailam	Rare
6. *Uperodon systoma* (Schneider, 1799)	Mahboobnagar district: Between Mannanur and Farahabad Kurnool district: Sunnipenta, Shikaram, between Mukhadwaram and Srisailam	Uncommon
7. *Microhyla ornata* (Duméril and Bibron, 1841)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Vijayapuri North Guntur district: Nagarjunakonda Valley, Vijayapuri South Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Naguluty, Bairluty	Common
8. *Microhyla rubra* (Jerdon, 1854 "1853")	Mahboobnagar district: Mannanur, Farahabad Kurnool district: Thummalabailu, Rollapenta, Pedda Manthanala, Pecheru, Naramammidi Cheruvu	Uncommon
9. *Ramanella variegata* (Stoliczka, 1872)	Kurnool district: Between Potharajupenta and Naguluty	Rare
Dicroglossidae		
10. *Sphaerotheca breviceps* (Schneider, 1799)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
11. *Sphaerotheca dobsoni* (Boulenger, 1882)	From places listed above, owing to its character overlap, specimens could not be discerned with confidence. It could also be possible that the third species in this complex, namely, *Sphaerotheca rolandae* (Dubois, 1983) may also be present.	Uncommon
12. *Euphlyctis cyanophlyctis* (Schneider, 1799)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal	Common

		Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	
13.	*Euphlyctis hexadactylus* (Lesson, 1834)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
14.	*Hoplobatrachus tigerinus* (Daudin, 1802)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
15.	*Hoplobatrachus crassus* (Jerdon, 1854 "1853")	Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda Guntur district: Vijayapuri South, Anupu	Common
16.	*Fejervarya limnocharis* (Gravenhorst, 1829)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Tiger Valley Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram, Hathakeswaram, Thummalabailu, Rollapenta, Chinna Manthanala, Pedda Manthanala, Pecheru, Bairluty	Common
Ranixalidae			
17.	*Indirana leithii* (Boulenger, 1888)	Kurnool district: Rollapenta	Rare
Rhacophoridae			
18.	*Polypedates maculatus* (Gray, 1834)	Mahboobnagar district: Mannanur, Farahabad, Vatvarlapally, Egalpenta, Domalpenta, Amrabad, Ippalapally, Maddimadugu, Umamaheshwaram, Bilakal Nalgonda district: Nagarjunasagar Dam area, Nagarjunakonda, Guntur district: Vijayapuri South, Anupu Kurnool district: Sunnipenta, Srisailam, Shikaram,	Common

16 June 2003, their status and distribution in the tiger reserve. Amphibians were studied following random surveys in all the habitat types and vouchers were hand picked while on ground and more aquatic species were netted. Vouchers were preserved following standard techniques and deposited in the national zoological collection at the Freshwater Biological Station, Zoological Survey of India, Hyderabad. All specimens were examined and carefully identified using diagnostic keys by Boulenger (1890), Daniel (1963a,b; 1975) and Daniel and Sekar (1989). A more detailed systematic account of the amphibians of NSTR is presented elsewhere (Srinivasulu *et al.*, in review).

Murthy (1968) and Sarkar *et al.* (1993) reported the occurrence of eight species of amphibians from Nagarjunasagar area. Excepting these reports not much is documented about the amphibians of the area until recently. Since late 1995 one of us (CS) has been documenting the amphibian diversity of the Tiger Reserve and recently two projects were taken up (one by Andhra Pradesh Forest Department and another by the Freshwater Biological Station, Zoological Survey of India, Kolkata) for documenting faunistic diversity of the Tiger Reserve. These studies have resulted in findings of hitherto unreported and undocumented species of amphibians from the Tiger Reserve (Srinivasulu *et al.*, 2006; Rao *et al.*, 2005; Rao *et al.*, in review).

Amphibian diversity of NSTR is represented by 18 species (consisting 3 bufonids, 6 microhylids, 7 dicroglossids, 1 ranixalid and 1 rhacophorid) belonging to 11 genera and four families (Table 1) (following Frost, 2007). Of this diversity 11 species were common in occurrence while others were rare and restricted in distribution.

The known diversity of amphibians in NSTR could be far from complete as indicated by recent discoveries of hitherto unreported species and absence of montane species belonging to tree and bush frog categories. Further detailed surveys would undoubtedly lead to addition of more species.

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The comments on record and farther distribution of the Ornate Microhylid *Microhyla ornata* from Gujarat

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Recently a note was published on "Record of the Ornate Microhylid *Microhyla ornate* (Dumeril & Bibron) at Timbi (Vadodara district) and Hathipura (Anand district) in central Gujarat" by Suresh *et al.* (2005). It is quite interesting to note the distribution of the species from Gujarat state. The authors have not mentioned distribution of the species from other parts of the state, therefore I have taken the liberty to comment on the note and inform on further distribution areas of the species in the state.

This fossorial species *Microhyla ornate* (Dumeril & Bibron) is very widely and commonly distributed in India and so is it in Gujarat. The distribution of the species can be made out by earlier records from Palanpur (Soman, 1960); Katchchh (Daniel, 1963); South Gujarat (Daniel & Shull (1963); Shoolpaneswar Wildlife Sanctuary (Naik & Vinod, 1992); Rampara Wildlife Sanctuary (Singh & Tatu, 1999); Jambughoda Wildlife Sanctuary (Vyas, 1999); Hingolgadh Nature Education Sanctuary (Vyas, 2000); Vansda National Park (Vyas, 2004); Barda Wildlife Sanctuary (Vyas, 2004) and Ratanmahal Wildlife Sanctuary (Vyas, 2004).

Also I have been able to examine and record a few specimens of this species from the following protected areas and the localities: Jessor Bear Wildlife Sanctuary, Balaram–Anmbaji Wildlife Sanctuary, Kutch Desert Wildlife Sanctuary, Narayan Sarovar Wildlife Sanctuary, Khijadia Bird Sanctuary, Blackbuck National Park and Purna Wildlife Sanctuary (author's unpublished observations).

The note of Suresh *et al.* (2005) is a synchronized result of a few published references referred by him, only on information and distribution of the species particulars of the state. To the best of my knowledge and according to the published literatures, it shows that the species is commonly and widely distributed in the entire state and in most or all the protected areas of Gujarat.

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Status and morphometric data of some anurans with reference to Agra district, Uttar Pradesh

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Abbreviations

Snout Vent Length (SVL); Tibial Length (TL); Head Width (HW); Head Length (HL); Eye Naris distance (EN); Interorbital distance (IO); Inernarial distance (IN); Foot Length (FL); Tarsus Length (TL); Tympanum diameter (TY); Eye Tympanum distance (ET); Body Weight (BW).

Introduction

The amphibian fauna, functionally being an important component of most terrestrial and freshwater ecosystems, contributes significantly to the biodiversity of a given area and serves as the best indicator of environmental health (Blaustein *et al.*, 1994). Northern India comprises of 2.3% and 7.9% of the total endemic and non-endemic species of the amphibians (Amphibian CAMP handbook 2001). Studies in the areas of their morphology and speciation are limited in Agra region, which is situated in the Gangetic plains of northern India. Even though several studies have been conducted on the reptilian fauna of Agra, documentation regarding the amphibian diversity is still insufficient (Gupta *et al.*, 2004). The present survey was made to emphasize the diversity of anurans in and around Agra region.

Study area and it's ecology

Agra district in the state of Uttar Pradesh is situated on the bank of river Yamuna and is spread over an area of 4027sq.km between the 27.110N - 78.00E longitude. Owing to its proximity to the sandy desert on the west, it witnesses extremes of temperature, which ranges from 450C in summers to as low as 20C in winters. Of all the wetlands situated in the vicinity of Agra, Keetham lake of Sursarover Bird Sanctuary is the major one, which occupies an area of nearly 7.2km2 (Gupta *et al.*, 2004) and is connected to the Yamuna river through a feeder canal. The annual precipitation in the district averages about 760.4mm, mainly contributed by monsoon rains. The upper layer of the soil deposit (20-25m) is of fresh alluvium brought down by the river system and which is intermixed with quartz grain of Vindhyan sandstone. The vegetation of this region is chiefly dry-deciduous and thorny and may be classified as scrub jungle. The vegetation of aquatic habitats, mainly contributed by free floating and submerged vegetation, consists of *Ludwigia adscendens, Nymphoides cristata, Hydrilla verticillata* etc. Among rooted water plants *Sagittaria guayanensis* and *Limnophyton obturifolium* are most common. *Eichhornia crassipes* (Jal kumbhi) is a troublesome weed in the area. Plants growing in marshy lands include *Typha angustata*, *Polygonum glabrum* etc.

Methodology

The whole study area was divided into six zones (Table 1) comprising of two reserve forests, one bird sanctuary, riverbank and city areas. Samples were collected from various zones of the study area in the month of April, mainly during early morning and late evening. Methods like capturing by hands, nets and by fixing traps on the sides of the ponds and river were deployed (Bishop *et al.*, 1994). All the water bodies were sampled for aquatic amphibians and soil was dug to determine the presence of burrowing frogs. Specimens were then placed in a jute bag (to prevent suffocation), and area of inspection of each individual frog was recorded. Specimens were then transferred to the respective terrarium for captive care until they were examined for morphological parameters (Gupta, 1998). Identification was done according to keys provided by Dutta (1992). Twelve morphological characters were taken under consideration for morphometric analysis (Rath *et al.*, 1996) and only adult frogs were measured. All measurements were made using vernier calliper and toe clipping was used as a technique for marking. The IUCN status for the collected amphibians has also been shown according to Molur & Walker (1998) (Table 3). The scientific names are after Frost (2007).

Observations and Results

Fifty-three anurans belonging to seven distinct species, under three families were identified (Table 2). Morphometric data for each species was established by taking an average of the measurements of different individuals of that species (Table 4). Inspite of trying our best to search for specimens throughout the district, most of the samples could be collected along the river Yamuna. The observations done during sampling of individual species are given below.

Duttaphrynus melanostictus: Also known as the Common Indian Toad was gray in colour with various patches of brown and red. The skin was heavily tuberculated with many black spine-tipped warts. Gravid females could be seen hopping during dusk in search of prey. It largely feeds on insects and consumes various plant pests, thus is of great economic importance. Because of its drier skin and less dependence on water, it has certainly adapted to drier conditions of township areas in the city and was caught from roadsides and playgrounds during hours of late evening.

Table 1. List of the sampling sites in Agra

1. Poia Ghat
2. Babarpur Reserve forest
3. Bainpur Reserve forest
4. Sursarovar Bird Sanctuary
5. Bichpuri farm
6. Taj nature walk

"Bufo" stomaticus: It is a medium-sized toad, also known as Marbled Toad. Colour of skin varies from gray to olive with distinguished bright yellowish tint in male toads, which they acquire during the breeding season. Individuals of this species were found in all sites mainly during period of late evening moving around in groups in search of food. They burrowed easily in sandy or wet soil using their hind limbs to dig the soil.

Euphlyctis cyanophlyctis: It is a medium-sized frog, also known as skipper frog. It has gray or black dorsal covering of skin with dark spots on white ventral side. It is seen in all possible aquatic habitats of reserve forests and Sursarovar Bird Sanctuary (SSBS) ranging from small ditches, stagnant rainwater pools to the side water pockets of running streams. Many habitats of this frog were seen flourishing amidst the water hyacinth spreading over the Keetham lake of SSBS, which is largely

Table 2. Number of samples collected for study

Species	No. of individuals collected
Duttaphrynus melanostictus	6
"Bufo" stomaticus	10
Euphlyctis cyanophlyctis	4
Hoplobatrachus tigerinus	16
Fejervarya limnocharis	15
Microhyla ornata	1
Uperodon globulosum	1
Total	53

Table 3. List of anurans found in Agra with their IUCN status

Species	Family	Status	IUCN	Criteria
Duttaphrynus melanostictus (Schneider)	Bufonidae	Non-Endemic	VU	A1,acd
"Bufo" stomaticus (Lutken)	Bufonidae	Non-Endemic	LR-nt	A1,acd
Euphlyctis cyanophlyctis (Schneider)	Dicroglossidae	Non-Endemic	LR-nt	B1,2c
Hoplobatrachus tigerinus (Daudin)	Dicroglossidae	Non-Endemic	VU	A1,d
Fejervarya limnocharis (Gravenhorst)	Dicroglossidae	Non-Endemic	VU	A1,ac
Microhyla ornata (Deumeril & Bibron)	Microhylidae	Non-Endemic	LR-1c	B1,2abc
Uperodon globulosum (Gunther)	Microhylidae	Non-Endemic	LR-nt	B1,2abc

Table 4. Morphometric measurements (in mm) of collected anurans

Species	SVL	TL	HW	HL	EN	IO	IN	FL	TL	TY	ET	BW*
Duttaphrynus melanostictus	90	30	30	15	11	22	06	95	17	05	09	62
"Bufo" stomaticus	65	24	21	15	08	17	05	73	13	04	06	30
Euphlyctis cyanophlyctis	47	22	16	15	06	09	02	73	10	03	05	15
Hoplobatrachus tigerinus	105	52	36	32	15	20	05	155	30	07	13	125
Fejervarya limnocharis	62	30	22	20	08	12	04	89	12	05	07	30
Microhyla ornata	22	10	07	08	02	05	02	33	03	01	02	--
Uperodon globulosum	60	28	20	18	07	12	03	85	10	04	05	30

* Body weight in g

known for its avian fauna. It is almost entirely aquatic and is found active during day and night. Because of reducing water bodies, this species is severely affected and now is restricted only to reserve forests.

Hoplobatrachus tigerinus: It is well known as the Indian Bullfrog due to its big size and weight. Its skin colour varies from olive green to brown with variation in habitat and climatic conditions. Males are smaller and bright yellow coloured during the breeding season. When they were housed in terrarium for few days the bright yellow changed to muddy brown. In summers, populations are found in congregation in the moist or damp bed of nullahs, under drainage covers and streams of old city as well as forest areas. However, due to the increasing human population, such habitats are declining for this species. Another aspect of declining of this species is unrestricted trade for the purpose of school practical and for medicine manufacturing units. In slum areas of the city many people are found engaged in bulk trading of live specimens of *H. tigerinus*.

Fejervarya limnocharis: All individuals collected were lacking a median dorsal line. Being semi aquatic in nature, it prefers to live beneath stones, pebbles and under bark of trees and litter near the marshy edges. Individuals were found both in city and reserve forest areas.

Microhyla ornata: The only individual of the smallest microhylid, *Microhyla ornata* was seen dwelling in the university campus under a stone.

Uperodon globulosum: Also known as Gray Balloon Frog due to expanded balloon like abdomen, only one individual was seen in the mud at the edge of a pond.

Discussion

During field survey it was observed that both species of *"Bufo"* were largely adapted to semi arid urban conditions and seem to have coped with spreading colonization and human interference. While other members of Ranidae, dependent on perennial water are largely facing extinction due to spreading of urbanization and shrinking wetlands. The species account reported in the present study contains more number of species than ever reported so far in the given area.

In addition to regularly found species, we also succeeded in collecting *Uperodon globulosum* and members of *limnocharis* complex.

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Record of *Sylvirana leptoglossa* (Cope, 1868) (Anura: Ranidae) from Kolasib district, Mizoram, northeastern India

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This note reports the occurrence of *Sylvirana leptoglossa* (Cope, 1868) from a forest in Kawnpui under Kolasib District of Mizoram, northeastern India, located 60km north of Aizawl. Four adults (1 male and 3 females) of *Sylvirana leptoglossa* were collected from a forest area near a pond located at Kawnpui (28058'15.5"N – 92041'30.9"E ca.310 above msl). One of the specimens (Sl No. V/A/480) was deposited with ZSI, Eastern Regional Station, Shillong. Since, the altitude is not so high summer is hot and wet while winter is cool and dry. During the field survey from 2003 to 2005, collection was done at night time in the month of June where the average air and water temperature were 320C and 31.50C, respectively. Average rainfall of this region during this month is 58.7cm.

The area is dominated by shrubby vegetation like *Ageratum conyzoides, Crassocephalum crepi-dioides, Drymaria cordata, Eupatorium riparium, Hedychium* sp., *Mussauenda glabra, Nymphoides indicum*, *Osbeckia crinata, Pterris* sp., *Thysanolaena maxima, etc.*, bamboos like *Dendro-calamus* spp. and *Melocanna baccifera* and trees like *Careya arborea, Shorea robusta, Tectona grandis,* etc.

Distribution

This species was first described as *Hylorana leptoglossa* Cope, 1868; 139 [syntypes: MCZ 1588 (3 specimens)] from Assam (Dutta, 1997), several surveys in Assam region did not yield positive result (Chanda, 1994), till the year 2004 where Sen (2004) reported the presence of this species in Meghalaya and Assam. The species is also found in Myanmar (Karin Hills), Thailand (Siam) and Vietnam (Annam) as reported by Dutta (1997). This endangered species was recently found to occur in the hills and valleys of certain forest areas in Mizoram.

Diagnostic features

All the four specimens show a brown dorsum with small to large black spots or markings; lateral sides black under which black spots are present; loreal and temporal region dark brown or black. Tympanum distinct, 4/5th diameter of eyes. Ventral parts white and smooth, spotted or marbled with brown on the throat and axial regions. Skin strongly granulated on the head and back, a strong and broad glandular dorsolateral fold running above the tympanum up to the hip. Another glandular fold extends from posterior region of eyes up to the shoulder. Head is slightly longer than broad, depressed, snout is obtusely pointed, pupil of eyes are circular.

Forelimbs moderately long, fingers free and long with small discs, subarticular tubercles are distinct and oval. Hindlimbs long with blackish crossbands, tibiotarsal articulation reaching between eyes and nostrils, heels strongly overlapping when hindlimbs folded at right angles to body; tibia four and a half times as long as broad. Outer metatarsal tubercle is smaller than inner

Table 1. Morphometric measure-ments (in mm) of adult *Sylvirana leptoglossa* collected from Kawnpui area of Kolasib district, Mizoram state.

	Adult male	Adult females		
Snout-vent length	43.5	50	56	59
Head length	14.5	15.6	19	20
Head width	13.5	14.5	17	18
Eye diameter	6	6.2	6.1	6
Interorbital space	3.5	3.5	5	5
Snout length	7	7.6	9	10
Tympanum diameter	3.4	3.8	4.5	4.8
Length of arm	25	26	34	37
Length of hand	11	13.2	16	19
Length of 1st finger	8	9	15	16
Length of 2nd finger	7	8.5	12	13
Length of 3rd finger	11	13.2	16	19
Length of 4th finger	8.5	10	14	14.5
Length of hindlimb	81	88	92	93
Length of tibia	26	32	31.5	28
Length of foot	21	27	30	31
Length of 1st toe	5	10	10	10
Length of 2nd toe	10	14	14	14
Length of 3rd toe	16	21	19	21
Length of 4th toe	21	27	30	31
Length of 5th toe	16.5	22	20	22

Figure 1. Rana leptoglossa

Figure 2. Preserved

Figure 3. Male Ventral

Figure 4. Toes of Male

metatarsal tubercle, subarticuar tubercles distinct and oval. Toes with small discs on the tips and 2/3 to ¼ webbed. Fingers and toes in order of length are 3 > 4 > 1 > 2 and 4>5>3>2>1, respectively. All measurements were made with vernier caliper and ruler as shown in Table 1.

Remarks

During the survey *Sylvirana leptoglossa* could be easily distinguished from other species on the basis of unique calls produced by the males. The present survey shows that the species is moderately common during rainy season. Also, it may be mentioned that in the present case the number of females collected is more but in the field the males outnumber the females.

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Basking in Indian Pond Frogs *Euphlyctis hexadactylus* (Lesson) at Pulicat Lake, Andhra Pradesh, India

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The Indian Pond Frog *Euphlyctis hexadactylus* is predominantly an aquatic species. It is commonly seen resting on the surface or among camouflaged brown drying weeds (Daniel, 2002).

On 14 February 2005, I was involved with fieldwork to select sites for the study on waterbirds of Pulicat lake, the second largest brackish water lake in India (13035'90.9N & 80007'26.0E). The major portion of the lake dries up even during peak winter (January & February) due to its shallow nature. However, the culverts across the road to Pernadu island had pools of water present at a depth of about 1m during my visit. I noticed about 100 frogs were basking on the bank of the small pool of stagnant water at 1130hr. It was quite unusual for me to notice this behaviour of frogs. The frogs were completely out on land exposing their entire body. A few were floating still on the surface of the water. This floating surface bask and half or two-thirds of the body in water is commonly seen in amphibians. The frogs basking on land during the midday sun was an unusual sight. So as I continued my observation until 1200hr. It is a regular phenomenon that pond frogs come out of the water bodies during night and rest on land.

Most of the true frogs are thought to be sensitive to acidic precipitation because they respire through their skin. Temperature regulation is a dynamic process that involves behavioural and physiological adjustments in order to maintain body temperature within a range. The rise in body temperature of reptiles is achieved through external heat sources (Pough, 1983) and is accomplished in part by a combination of heliothermy (basking in the sun) and thigmothermy (absorbing heat from a warm surface) (Huey, 1982). Basking and sweating has been observed in the Indian Tree Frog *Polypedates maculatus* (Lillywhite *et al.*, 1998). Since the behavioural studies on the herpetofauna are scant, it is significant to add the behaviour of the Indian Pond Frogs in the saline environment.

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One eye frog, Sphaerotheca rufescens (Jerdon, 1854) from Konaje, Mangalore, Karnataka

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Anurans are one of the most sensitive indicators of environmental health. Several reports have documented the presence of abnormalities/deformities among Indian anurans (Kurulkar & Deshpande, 1932; Nair & Kumar, 2005; Mathew & Sen, 2006). Field studies indicate that the abnormalities/deformities have become more prevalent in recent times (Mathew & Sen, 2006).

Several factors which have been implicated as to be the causative agents for various abnormalities/deformities in amphibians include UV radiation, cosmic rays, chemical contamination of water, parasitic infestation and ground level ozone (Reaser & Johnson, 1997; Nair & Kumar, 2005).

The present report records a one-eyed female Sphaerotheca rufescens (having only the right eye) collected from within the area encompassing the water treatment plant (Fig. 1) near one of the outlet pipes used to discard the waste collected after treatment of water, situated within Mangalore University Campus (between 12°48'39"-12°49'28"N & 74°54'44"-74°56'21"E; Altitude 100m) Konaje, Mangalore in June 2005.

The major characteristic features (Fig. 1) of the Dicroglossidae frog, Sphaerotheca rufescens (Jerdon, 1854), commonly called Rufescent

Figure 1. Normal (A) and Deformed (B) female frog, *Sphaerotheca rufescens*.

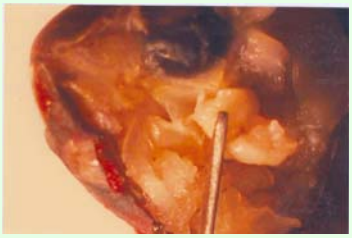

Figure 2. The optic chiasma and the optic nerve are seen intact in the frog with one eye. However, the eyeball is absent in the optic socket on the left side

Table 1. Morphometric measurements (in mm) of normal (with two eyes) and abnormal (with one eye) female frog, *Sphaerotheca rufescens* (Jerdon, 1854)

Characters	Normal frog	Deformed frog	Ratio to SVL in normal frog	Ratio to SVL in deformed frog
Snout to Vent length (SVL)	37	35	1:0.000	1:0.000
Head Length	9.5	8.5	1:0.257	1:0.243
Head Width	13	12.5	1:0.351	1:0.357
Snout Length	3	3	1:0.081	1:0.086
Nostril to Eye	1.5	1.5	1:0.041	1:0.042
Nostrils to the tip of Snout	1	1	1:0.027	1:0.029
Width of Upper Eyelid	3	3	1:0.081	1:0.086
Inter-Orbital Width	2	2	1:0.054	1:0.057
Inter- Narial Width	3	2.5	1:0.081	1:0.071
Eye Diameter	4.5	4	1:0.122	1:0.114
Tympanum Diameter	2	1.5	1:0.054	1:0.042
Forelimb Length	21.5	20	1:0.581	1:0.571
1st Finger Length	5	3.5	1:0.135	1:0.100
2nd Finger Length	3.5	2.5	1:0.095	1:0.071
3rd Finger Length	4.5	4	1:0.122	1:0.114
4th Finger Length	3	2.5	1:0.081	1:0.071
Hind limb Length	60	54	1:1.621	1:1.543
1st toe length	5	5	1:0.135	1:0.143
2nd toe length	8.5	8	1:0.230	1:0.229
3rd toe length	13	12.5	1:0.351	1:0.357
4th toe length	18.5	17	1:0.500	1:0.486
5th toe length	11.5	11	1:0.311	1:0.314

Burrowing Frog, collected in the present study includes smooth skin with folds and fine tubercles, eyes dorsolateral bulging, roundish sub triangular pupil, presence of vomerine teeth, both inner and outer metatarsal tubercles – the inner metatarsal tubercle being bigger and shovel shaped, outer metatarsals feebly separated at distal end, fingers and toe tips without enlarged discs and digits without intercalary cartilage, upper jaw (only) with teeth, bifid tongue without papilla, tibio- tarsal articulation reaching to the anterior border of the tympanum, colour brown with brick red patches, head broader than long and with rounded snout, distinct tympanum, which is about half the diameter of the eye, first finger longer than second and the third finger slightly longer than first. An inverted V shaped ridge present between the shoulders. A clear glandular fold extends from eye to shoulder. Ventrally smooth. Lips and limbs cross-barred.

Important morphometric measurements of the deformed and a normal frog are as detailed in the Table 1. The size of the tympanum expressed as ratio to the diameter of the eye (0.375) is slightly smaller in the case of the deformed frog compared to that of its value (0.444) in the case of the normal frog.

The one eye frog reported in the present study was captured from within the vicinity of the area from where the Indirana species with one eye was documented in the earlier report by Nair & Kumar (2005). The optic socket on the left side did not have the eyeball in the case of the deformed frog captured in the present study. However, unlike the earlier report, the optic chiasma and the optic nerve in the case of the deformed frog was found to be intact (Fig. 2).

The absence of one eye could be due to an injury or due to an abnormality induced during embryonic development/metamorphosis, probably stemming from the ill effects caused by chemicals/ insecticides brought in through run off water from various industries around and/or from agrarian practices.

Since two different species of frogs with similar defects were found in the same area, it strengthens the possibility of this defect being induced by pollutants in anurans and their sensitivity and susceptibility to the change in their environment makes anurans an important indicator species.

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Need of anuran studies in habitats of southern Rajasthan, India

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India is one of the 12 megadiversity countries of the world due to high endemism. Current status of India's biodiversity suggests that, amongst vertebrates, endemism is highest in amphibians and reptiles (Daniels, 1996). So far, high herpetofaunal endemism is found in certain regions such as Western Ghats, Eastern Himalaya and Andaman & Nicobar Islands (Daniels, 1997). Of the 225 species of amphibians known from India (Biju, 2001), more than 120 occur in the Western Ghats and about 60 species occur in Eastern Himalaya; many being endemic. Out of these more than 100 are anurans (frogs and toads) (Daniels, 1997). Dutta (1998) listed systematically all known species from India, primarily using the generic classification of Dubois (1992) and used English name of every species or subspecies so far recognized.

Rajasthan is the largest state of India. Major part of the state is covered by desert. Aravalli Hills diagonally divide the state and delimit desert. The state has the long history of wildlife studies but majority of these were confined to higher vertebrates, and with reference to amphibian these are meager (Sharma, 1995a,b; Dube & Sharma, 2001; Dube, 2002; Dube *et al.,* 2002; Sharma & Khan 2002; Khan, 2004; Sharma *et al.,* 2004; Sharma & Dube, 2005). Since most of the studies were confined to the northern parts of the state, in this paper the emphasis has been given to the southern part (Fig. 1). The southern part involves five districts of Udaipur Division (Banswara, Chittorgarh, Dungarpur, Rajsamand, Udaipur) along with two districts of Jodhpur Division (Sirohi & partly Pali). This area constitutes about 16% of the total geographic area of state and holds approximately 38% of the total forest cover of the state (Anon., 2003). Southern part of the Rajasthan state has 11 sites which are either protected areas namely Jaisamand WLS, Mount Abu WLS, Kumbhalgarh WLS, Sitamata WLS, Bhensrodgarh WLS, Phulwari ki Nal WLS and Sajjangarh WLS or sites identified for conservation namely Baghdara CA, Jawai CA, Sei dam and Udaipur lake complex (Anon., 2003; Islam & Rahmani, 2004). The terrain is mostly hilly constituted with intrusions of the Vindhyan ranges and Malwa Plateau from the east and south/south-east, respectively. Partly, the west side of the area under consideration (Sirohi & Pali) is semi arid.

Taxonomic and experimen-tal studies on anurans in Rajasthan: Many areas have been neglected from biodiversity or ecological point of view especially with reference to amphibians. McCann (1942a,b) pioneered in listing the anuran species from Abu hills of southern belt of state.

The experimental studies on anurans were pioneered by Niazi group of Rajasthan University, Jaipur which were carried on by Sharma, one of the associates of Niazi who developed M.D.S. University, Ajmer as a center of anuran studies. All these works were confined to the central Rajasthan (Jaipur and nearby areas).

In order to understand basic pattern of development of anurans, table of development of two anuran species (*Hoplobatrachus tigerinus* & "*Bufo*" *stomaticus*) were prepared (Agarwal & Niazi, 1977; Shivpal & Niazi, 1979). It was found that due to characteristic genomic organization of cells of regenerating blastomea, studies focused on anurans to investigate positional memories and developmental potencies. This led to exploration of other anuran species found in Rajasthan, their taxonomic identification and ontogenic developmental studies followed by their use in experimental studies (Niazi *et al.,* 1989). During this period attention was also paid for the conservation of anurans by raising the tadpoles in laboratories from the spawn collected from wild and releasing young ones in the wild (Niazi *et al.,* 1989). Anuran species maximally used as experimental models were *Euphlyctis cyanophlyctis* (Niazi *et al.,* 1979), *Sphaerotheca breviceps* (Sharma & Niazi, 1979; Niazi & Sharma, 1981; Sharma, 1982; Sharma, 1984; Sharma & Niazi, 1988) and *"Bufo" stomaticus* (Niazi & Saxena, 1979; Gaur & Sharma, 1987). However, *Euphlyctis hexadactylus*, *Hoplobatrachus tigerinus*, *Fejervarya limnocharis*, *Microhyla ornata* and *Uperodon systoma* were also explored by these investigators (Niazi *et al.,* 1989).

In the 1990s many naturalists developed interest in surveying biodiversity in various parts of Rajasthan. Sharma (1995a); Dube (2002); Khan (2004); Sharma & Dube (2005) enlisted all the anuran species of Rajasthan.

For identification of anurans morphological, cytological and chemical characteristics have been used by many investigators. First attempt to give taxonomic categorization and identification based on their sound in Rajasthan was made by Sharma (2005a,b). The sound spectrum identification and taxonomic categorization is not only precise but environment friendly also because this does not involve unnecessary killing and fixation of animal and data transformation is also very fast. Sharma (2005a) and his associates are using this technique to monitor the anuran species in their habitats in Rajasthan.

Anuran research and conservation needs in southern Rajasthan: It was in the year 1989 at the First World Congress of Herpetology (Barinaga, 1990) the world recognized the threat of global decline in amphibian populations (Alford & Richards, 1999) and showed interest towards these small animals. Dubois (1999) in his book-review pointed out the necessity of taxonomic studies on amphibians in South Asia, as the threats to the natural habitats in this region. At present, it is required that this unique fauna, before it is impoverished at a rapid rate, be inventoried or described. Aravind *et al.* (2004) stated that the recent reports on the discovery of an unusually high number of new species of frogs from Western Ghats hotspot are not surprising and perhaps it was always waiting to happen which could be the case of higher altitudes. Many sites of Aravalli hills in southern Rajasthan are similar with Western Ghats such as Abu hills (area of 326km2, 1,219m), Matarmata hills (600m), Jarghaji (1,000m), terrains of Sitamata forests (423km2, 524m) and Phulwari ki Nal (511km2, 300m).

Daniels (1995, 1999a); Molur & Walker (1998) highlighted the need of am-

Table 1. Anuran species in Rajasthan and their distribution

SNo.	Scientific Name	Common Name	Distribution
	Family Ranidae		
1.	*Euphlyctis cyanophlyctis*	Indian Skipping Frog	Whole State
2.	*Euphlyctis hexadactylus*	Indian Green Frog	Jaipur
3.	*Hoplobatrachus tigerinus*	Indian Bull Frog	Dungarpur, Banswara, Udaipur, Sirohi, Bharatpur, Alwar, Dausa, S. Madhopur, Nagore, Ganganagar
4.	*Fejervarya limnocharis*	Cricket Frog	Udaipur, Chittorgarh, Sirohi
5.	*Sphaerotheca breviceps*	Short-headed Burrowing Frog	Udaipur, Sirohi, Pali, Jaipur, Nagore
6.	*Sphaerotheca rolandae*		Ajmer
	Family Bufonidae		
7.	*Duttaphrynus melanostictus*	Common Asian Toad	Udaipur, Sirohi, Jaipur
8.	*"Bufo" stomaticus*	Marbled Toad	Udaipur, Sirohi, Jaipur, Ajmer, Ajmer, Bikaner, Ganaganagar, Nagore, Jhumjhunu
9.	*"Bufo" viridis*	Green Toad	Jaipur District
	Family Microhylidae		
10.	*Microhyla ornata*	Ornate Narrow-mouthed Frog	Udaipur, Chittorgarh, Sirohi, Pali
11.	*Uperodon systoma*	Marbled Balloon Frog	Udaipur, Jaipur
	Family Rhacophoridae		
12.	*Polypedates maculatus*	Indian Tree Frog	Udaipur

phibian research and conservation in India, in terms of amphibians taxonomy, range distribution, ecology and their conservation requirements. Babu (2005) stressed on long-term monitoring to understand the population fluctuations during seasons in different habitats. Dash & Mahanta (1993) highlighted the need of extensive quantitative ecological studies on the amphibian communities in the Indian ecosystems. Southern Rajasthan needs extensive explorations along with updated ecological studies of amphibians.

Many possible causes for global declines of amphibians have been proposed by several workers. Habitat destruction and alteration was considered one of the most important factors (Blaustein & Wake, 1990; Khan, 1990; Ghate & Pandhye, 1996; Ravichandran, 1998; Alford & Richards, 1999). Clear cutting forests, draining wetlands and altering habitat may directly affect amphibian population (Petranka *et al.,* 1993; Semlitsch, 1998; Ernst & Rodel, 2005). Besides above, there are several other factors such as environmental change, diseases, contaminants, introduced species, which led in loss of amphibian populations. Daniel (1999b) mentioned many issues causing decline of amphibian population in India but such studies are not available for southern Rajasthan belt and the possible causes could not be stated authentically. The preliminary studies point to habitat alterations and destruction of wetlands due to scanty rainfall and anthropogenic activities seem to be the major factors in decline in amphibian population in this region. Besides, frogleg trade from the Banswara and Udaipur districts is another cause, as districts of southern Rajasthan were among the main regions of frogleg supply in the past years (Tehsin 2001, pers. comm.).

Amphibians exhibit a wide range of adaptive radiations suited to their habitats and modes of life such as burrowing, aquatic, semi-aquatic, terrestrial, arboreal and subterranean. But they are, however, restricted to moist habitats only, owing to their sensitive skin, which has to remain moist for normal gas exchange. Temperature and humidity being the important limiting factors in the distribution of amphibians (Ravichandran, 1998), and considered indicators of pollution and disturbance to their habitat as they are the first animals to migrate from a changing habitat (Daniels, 1991). It is due to the fact that these animals are in close contact with both aquatic and land habitats; therefore, one of the main reason for their great concern is their value as indicators of environmental stress (Sharma, 1994; Blaustein & Wake, 1995; Dube *et al.* 2002). Southern Rajasthan is rich in sites of moist habitats. Except the moist habitat sites of protected areas, all other wetlands near human habitation are under threat of pollution. The amphibian habitats of protected areas are also under threat due to the excessive pressure of anthropogenic activities especially the religious fairs and ceremonies which cause the deterioration of aquatic bodies and their catchment areas. Besides these the mining area and fluoride richness of water is another major problem. Although, the work of Khan (2004) states that the fluoride richness could not be considered a threat to anurans in Rajasthan as these organisms thrive on the surface water whereas fluoride content is high in the deeper levels, but it could possibly become a threat in the long run when deep mining operations may help leaching of fluoride molecules from the complex minerals.

The Abu hills of south-western extremity of Aravalli chain is a region of 326km2 of dry deciduous tropical forests with interspersed patches of semi-evergreen forest. It is due to its unique natural set up; hence proposed to be an eco-sensitive zone of Rajasthan (Singh, 2004, pers. comm.). Information on the status and distribution of amphibians of this region is very limited (McCann, 1942a,b) and require immediate attention for conservation planning especially for amphibians. Despite many humid places on the other hilly terrains of Matarmata, Jarghaji, Sitamata Forests, Kumbhalgarh etc., they have never been studied quantitatively and explored regularly with reference to amphibians.

Amphibians are considered to be more sensitive to changes in patterns of temperature or rainfall than other terrestrial vertebrate groups (Blaustein & Wake, 1990; Vitt *et al.,* 1990). Southern Rajasthan has faced rainfall fluctuations and there have been paucity of rains during the last decade (1990-2005). This fluctuation had changed the surface water regime of the concerned area. Due to lack of quantitative studies of the anuran species the alterations in their population structure has not been

ascertained. The recent trends induct the urgent need of studies in such areas where there is possibility of habitats of large anuran populations.

Distribution of anuran species in Rajasthan and its southern region: The distribution of the amphibian fauna of India in present context is poorly known (Dutta, 2004). Inger & Dutta (1986) prepared the list of Indian amphibians and their state-wise distribution. In this list six species, *viz.*, *Duttaphrynus melanostictus*, *Microhyla ornata*, *Fejervarya limnocharis*, *Hoplobatrachus tigerinus*, *Euphlyctis cyanophlyctis* and *Sphaerotheca breviceps* were described to be present in Rajasthan but the presence of *E. hexadactylus* was categorized as doubtful. Further, distribution of the left out species was mentioned in the work of Chanda & Ghosh (1988) and Das (1990) with no any new report from Rajasthan. Then after Sekar (1991) in his note described the distribution of *"Bufo" stomaticus* in Rajasthan making the list of seven species with confirmed distribution.

Dutta (1992) provided the revised and updated distribution record of the species and provided the distribution of eight species.

Sharma (1992) reported *Uperodon systoma* from the Jhalan hills, Jaipur for the first time in Rajasthan. Although, the wide distribution of this species in India was already described in some of the earlier papers (Thurston, 1888; Boulenger, 1890; Ferguson, 1904; Parker, 1934; Mahendra, 1939; Daniel, 1963).

Sharma (1995a) presented the distribution of nine frog species *viz.*, *Euphlyctis cyanophlyctis, E. hexadactylus*, *H. tigerinus*, *S. breviceps*, *M. ornata*, *U. systoma*, *D. melanostictus* and *"B." stomaticus*, from Rajasthan based on earlier work (Daniel & Sekar, 1989; Inger & Dutta, 1986; Mansukhani & Murthy, 1964; McCann, 1942a,b; Sharma, 1992, 1995a,b).

According to Sharma (1995a), *E. cyanophlyctis* and *H. tigerinus* were two species distributed throughout the state. *E. hexadactylus* was distributed in the central part whereas *F. limnocharis* and *M. ornata* were only confined in the southern parts of state. *D. melanostictus* and *U. systoma* were distributed in the eastern and southern parts of state. *S. breviceps* had marked its presence in the northeastern and southern parts whereas *"B." stomaticus* in northern, central, and southern parts of the state. *Polypedates maculatus* was reported from Bansi forest located in the outskirts of Sitamata WLS, Udaipur district (Sharma, 1997). Later the same species was recorded from Banswara (Sharma & Agnihotri, 2002) and Jhalawar (Sharma 2005a). Saxena (1999) reported a burrowing species *"B." viridis* from Jaipur district. In 2005 a new record for *Sphaerotheca rolandae* in Ajmer was reported (Sharma, 2006 pers. comm.) thus making the list of 12 anuran species from Rajasthan. (Table 1)

Preliminary stages of studies contucted by us presently highlight that major population of *U. systoma* shows its distribution in the habitats of northeastern parts whereas that of *F. limnocharis* is restricted to the habitats of southern part of the state. Similarly, Sharma (2005a) showed that *P. maculatus* is confined to south and south-eastern part of state. In a regular survey of areas around Aravalli foothills near M.D.S. University Campus, it has been observed that the family Bufonidae is exclusively represented by *"B." stomaticus* and *D. melanostictus* is almost absent in this region. This situation is reverse in many parts in Udaipur. Such eco-geographical distribution pattern is required to be investigated for other species whether confining to a particular geographical area is a mere chance or linked with some specific characteristics of that particular area.

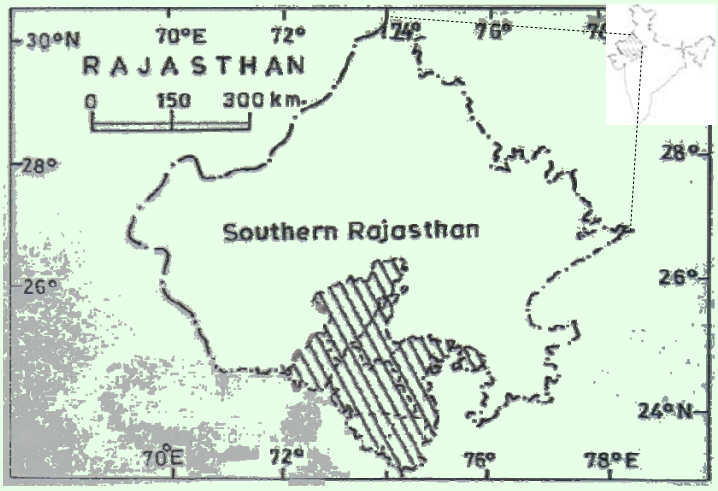

Figure 1. Map of southern region of Rajasthan

While discussing southern Rajasthan the contribution from the adjoining Gujarat state cannot be overlooked. Work of Naik & Vinod (1993); Vyas (1996) and Sharma (2005a) stated the distribution sites of different anuran species. Though not close to southern belt but extensive field surveys are required for studying the gap of such discontinuous distribution of every species as emphasized by Dutta (2004).

Anuran in habitats of higher altitudes: Biologists have approached unaltered habitats, such as the tops of mountains to document anuran species before extinction. Species such as *D. melanostictus* and *Euphlyctis cyanophlyctis* being the most widespread at altitudes 600-900m (Daniels, 1999b; Ravichandran, 1998). Very few studies have been carried on the related aspects of anuran diversity of higher altitudes (McCann, 1942a,b; Waltner, 1974; Ravichandran, 1998; Krishnamurthy *et al.*, 2001). McCann (1942a,b) was the pioneer. Waltner (1974) compiled the information on the altitudinal distribution of amphibians in the Himalaya. Ravichandran (1998) concluded that Tamil Nadu owes its rich amphibian dicersity to its forests in higher elevations along the eastern slopes of the Western Ghats.

All major peaks of Aravallis such as Gurushikhar, Achalgarh, Jarghaji lies in the southern part of Rajasthan. The higher elevations of Chittorgarh and Udaipur holding the seasonal ponds and perennial water sources are still to be explored for anurans.

The Abu hills are very important of all the elevated lands of Rajasthan for amphibian studies. The western slopes of Abu hills have the least disturbed habitat structure with dominant xeromorphic vegetation finally ending in important wetland in the foothills. The eastern slopes have the disturbance due to main connectivity road and vehicular traffic but still have the dense forest patches and some shallow waterbodies in

the foothills. The southern slopes of Abu hills still hold the rich patches of forest and waterbodies even on the higher altitudes. Northern slopes are somewhat barren hills with open rocky cliffs. Achalgarh Tank, Mini Nakki Lake, Oriya waterbody, Trevor's Tank, Upper and Lower Kodra are among the waterbodies or wetlands on the higher altitudes which will be investigated primarily. No site has been studied so far focusing the anuran diversity and their present status as well as distribution in this region.

Future of amphibian studies in Rajasthan: Many areas of Rajasthan have the potential of harbouring large number of varied flora and fauna especially aquatic species, southern Rajasthan is one of these regions. The presence of wet and humid conditions throughout the year in different parts of the southern Rajasthan makes it suitable for such type of studies. The less explored sites of southern Rajasthan, Fulwari ki Nal and Sitamata Wildlife Sanctuary where there is flow of water along with the semievergreen patches of forests harbours anurans in large numbers and attracts the interest of herpetologists. Similarly, the status and the distribution of the anurans of the higher altitudes of this belt will form a foundation for the protection of the amphibians in these unaltered habitats. Moreover, the high altitudinal sites are less prone to the anthropogenic activities except few such as Mount Abu; therefore, the conservation strategy could be successfully implemented. The trends of population fluctuation in this belt which once used to be supplier of froglegs, could be analyzed to update the information on this important component of biodiversity. Recent developments in information technology tools have given an excellent opportunity to the naturalists and conservationists to identify and monitor populations of anurans using their calls. This would also enable them to study anuran biodiversity even in those areas which are inaccessible due to dense vegetation, muddy and swamp places.

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