REVIEW OF LITERATURE 2

Amphibians are the uniquely engineered masterpieces of nature and have become integral components of many ecosystems as well as our intangible natural heritage. They are ecologically, economically and biomedically important animals which have played a significant role in various scientific spheres and contributed directly to the economy of our country. Frogs and toads are in serious trouble and have declined dramatically in many areas of the world by direct or indirect human activities. These reductions have worsened over the past few years. Other animal groups face similar threats but evidences indicate that amphibians are more vulnerable to ecological stress than many other organisms.

Although there is a growing concern that amphibians are declining globally (Wake, 1991; Blaustein and Wake, 1990 and Blaustein *et al*., 1994), much of the supporting evidence is either anecdotal (Wake and Morowitz, 1991 and Pechmann and Wilbur, 1994) or facts derived from short term studies at small geographical scales.

This has created a need for more extensive and standardised monitoring of amphibian populations worldwide and for elucidating the underlying causes of amphibian decline. Many surveys and investigations on amphibians were hitherto carried out worldwide.

The amphibian fauna of India is one of Asia's most diverse living resources (Inger and Dutta, 1986). Around 249 species of amphibians were reported from India, in varied ecological conditions from the plains to mountains, low to heavy rainfall areas, river beds to ponds, and forest to

deserts (Chanda, 2002) making it one of the world's leading frog habitats. Most of these are said to be thriving in the Western Ghats, Andaman and Nicobar Islands, the foot hills of the Himalayas and the North-East of India (Jeevan, 1999).

Research on the taxonomy and distribution of Indian amphibians was carried out even before 1900 by many herpetologists. The first study on amphibians in India was made by Gunther (1858). He mainly worked on the preserved herpetological specimens. Boulenger (1882) made a comprehensive account of the Indian amphibians including a large number of new species. He published a series of papers especially on the taxonomy of Indian amphibians which included the fauna of the British India, Ceylon and Burma. Besides, he published the *Catalogue of Batrachia in the British Museum* and a monograph on the genus *R. linnaeus*. Significant work was carried out mainly during the period 1901 to 1947 (Ferguson, 1904).

Rao (1920) studied the South Indian amphibians and described 19 new taxa. Smith (1924) published a series of papers on the taxonomy of amphibians especially from Assam, Burma, Tibet, Nepal and the Malay Peninsula. Bhaduri (1945) documented the distribution, ecology, taxonomy, anatomy and physiology of Indian amphibians. Noble (1931), Bhaduri and Kripalani (1954) were the others, who contributed to the knowledge of Indian amphibians during the last one hundred years (1858 -1958).

Studies on the taxonomy of South Indian amphibians were made by Sathyamurthy (1967). Daniel (1963 a and b) investigated the taxonomy, ecology and distribution of Indian amphibians. A detailed note on the biology, conservation and culture of Indian frog species was prepared by Khare (1986).

Ravichandran and Pillai (1990) reported the existence of 329 varieties of frogs and toads from Periyar wildlife sanctuary. The study yielded 14 new

species of amphibians falling under three families and six genera. Sharma (2001) made a survey of herpetofauna of Kela Devi wild life sanctuary, Machiyas safari park and Bardod.

A three year faunistic survey of the Kalakad wild life sanctuary, Tamil Nadu was conducted by Ravichandran (1996) who recorded 29 species under ten genera and four families. Malhotra and Davis (1991) of Oxford University collected and recorded a total of nine species of frogs and toads from Srivilliputhur reserve forest. Subsequently, Vasudevan *et al.* (2001) studied the structure and composition of rain forest floor amphibian communities in Mundanthurai tiger reserve, Kalakad and identified a total of 32 species during their study. Studies were carried out on the amphibian fauna in Indira Gandhi wildlife sanctuary by Ramaswamy and Srinivas (2003 a) and recorded a total of 72 species of amphibians which included one Bufonidae, nine Ranidae, six Rhacophoridae and one unidentified species. Malu (1999), Gokulakrishnan (2000), Madivanan (2001) and Babu (2003) were the other investigators.

Sharma and Dube (2005) studied the distribution pattern of amphibian biodiversity in South Eastern plateau of Rajasthan and recorded seven species of anurans belonging to the families of Bufonidae, Microhylidae and Ranidae.

The Western Ghats of India, one of the 34 biodiversity hot spots of the world, was the focus of attention for the discovery of new species (Aravind *et al*., 2007). It is said that Western Ghats can be a home to an amazing variety of amphibians due to its diversity and extraordinary endemism. The Western Ghats has the highest level of amphibian endemicity in India (Ravichandran, 1998). The largest family recorded was Ranidae with 49 species followed by Rhacophoridae with 30 species (Bawa *et al.,* 2007). In Western Ghats there are more than 100 new species of frogs still awaiting taxonomical identity, mostly from the genus *Philautus* (Biju, 2001).

Aravind *et al.* (2004) also recorded a total of 115 species of frogs from Western Ghats mostly from the genus *Philautus*, all new to science. Daniels (1991) highlighted the problems of conserving amphibians and the geographical distribution pattern of it in Western Ghats. According to him the Western Ghats has 21 genera, 6 families and 2 orders with 48 species of Ranidae (true frogs) and 30 species of Rhacophoridae (tree frogs). He documented the altitudinal distribution of 35 species of anurans in Western Ghats in 1995.

Biju (2001) gave a synopsis of the frog fauna existing in Western Ghats. Krishnamurthy *et al*. (2001) identified a new species of frog belonging to the genus *Nyctibatrachus* (Anura: *Ranidae)* from Kudremukh National Park, Karnataka. Dutta *et al*. (2004) studied the jurassic frogs and the evolution of amphibian endemism in the Western Ghats. Dahanukar and Padhye (2005) studied the amphibian diversity and distribution in Tamhini of Western Ghats and prepared a checklist of species from different habitats. These findings indicated that Western Ghats region represented a hot spot of amphibians and there could be many more species waiting to be discovered (Biju, 2001).

The herpetofauna of the Great Nicobar Islands, one of the eight Biosphere Reserves were studied by Daniels and David (1996) who recorded eight species of amphibians.

Inger and Dutta (1986 and 1987) catalogued the amphibian species of India and summarized the problems and lacunae of amphibian investigations and provided a list of amphibians of India indicating state wise distribution of each species. The amphibians of Southern, North Eastern and Western India were investigated by Pillai and Chanda (1973, 1976, 1979, and 1981) and Pillai and Yazdani (1973). Many new taxa from North Eastern and Southern parts of India were described by Pillai and Chanda (1973). Pillai and Chanda (1979) gave details of 20 species of amphibians from Kasi hills, Meghalaya.

Ravichandran and Pillai (1990) worked on the amphibians of Maharashtra and examined 223 frogs and toads listed under 4 families, 6 genera and 13 species, out of which one was found to be new (*Ansonia*), a torrent toad. Amphibians of Orissa were studied by Hejmadi (1977) and Dutta (1990) and they worked on the taxonomy, life history, ecology and conservation.

Duda and Sahi (1977) published a checklist of herpetofauna of Jammu and Kashmir. Tilak and Mehta (1983) recorded nine species of frogs from the District of Sirmour, Himachal Pradesh. Chanda (1986) recorded 14 species of amphibians from Sikkim and Darjeeling. A detailed survey of amphibians in Dehradun was carried out by Ray (1999). This study was on 16 species of amphibians belonging to 7 genera and 4 families such as Ranidae (9 species) Bufonidae (single species) Rhacophoridae (single species) and Microhylidae (2 species) and another three new species. Sarkar (1984) studied the amphibian fauna of Calcutta and its environment.

Meren (1986) studied the edible tadpoles of ten anuran species of Nagaland. Ahmed (2001) studied the ecology and status of the anuran fauna of Assam and recorded 20 anuran species. Sarkar and Ray (2004) prepared a synopsis of the amphibian fauna of Goa, Western India and reported 27 species belonging to 12 genera, 5 families and 2 orders. Amphibians of Pune city were surveyed by Padhye and Mahabaleshwarkar (2006) and the survey revealed the existence of 14 species belonging to 7 genera and 4 families. They observed that nine of them existed outside the city while the rest of them were recorded 20 km away from the centre of the city. Crump (1971) made a quantitative analysis of the ecological distribution of a tropical herpetofauna.

Pillai and Ravichandran (1991) observed a rare toad *Bufo hololius* (Gunther) in Nagarjunasagar, Andhra Pradesh. Natesh and Ray (1998) studied the amphibians in Hassan District of Karnataka and recorded the presence of 2 species of Microhylidae, 2 species of Ranidae and 1 species of

Rhacophoridae. Fifteen anurans were reported by Abdulali (1962) from Talawadi.

Inger *et al.* (1984) investigated the amphibian fauna of Ponmudi, Kerala. They provided larval descriptions and ecological notes of about 25 species of amphibians and two new species of *Nyctibatrachus*. Andrews and George (1998) investigated the amphibian resources of Kerala and recorded 74 anurans belonging to 4 families consisting of nine species of Bufonidae, ten species of Microhylidae, thirty six species of Ranidae and nineteen species of Rhacophoridae. Radhakrishnan and Ravichandran (1999) reported the presence of 12 species of anurans in Kasargod District of Kerala. The identification keys as well as taxonomic and ecological data regarding these species were also provided by them.

Biodiversity of the amphibian fauna of Tamil Nadu was highlighted by Ravichandran (1998). It was indicated that its varied ecological zones harboured about 30 percent of the amphibian species known to live in India. Sathyamurthy (1967) evaluated the taxonomy of South Indian amphibians. Daniels (1994) gave the methodology for inventorying amphibians and the reptiles. The Tamil Nadu Forest Department listed a total of 76 amphibian species. Among them, sixteen species were observed from the plains (Ravichandran, 1998).

Daniels (2005) recorded that the family Bufonidae was one of the largely distributed anurans which included 25 genera and 350 species. Chanda (1991) reported that about 50 percent species of this family was observed in South India. In this 21 species representing four genera were found in India. Studies on the distribution and ecology of Indian Bufonids were carried out by Boulenger (1882 and 1919), Chanda (1986) and Inger and Dutta (1986). Pillai (1981) observed the occurrence of two new species *M. thampi* (Ranidae) and *B. silentvalleyensis* (Bufonidae) from Silent Valley,

South India. Ten species were found in the Western Ghats and among them six were endemic to that region (Biju, 2001).

Seven genera and 20 species of the family Microhylidae occur in India (Daniels, 2005). The earlier studies on the family Microhylidae were made by Boulenger (1890), Pillai and Chanda (1973 and 1981), Chanda (1986), Dutta (1985 and 1997), Dutta and Ray, (2000) and Andrews and George, (1998). Ten species of the family Microhylidae from Kerala were recorded by Andrews and George (1998). Dutta and Ray (2000) recorded a new species of Microhylid frog, *Microhyla sholigari* from Karnataka.

Biju (2001) highlighted the cosmopolitan distribution of the family Ranidae. Gunther (1858), Dubois, (1999), and Das and Dutta (1998) did some works related to the family Ranidae. Daniels (2005) reported that this was the third largest amphibian family in the world in which 97 species of this family existed in India.

Boulenger (1882 and 1890) and Inger and Dutta (1986) together made important studies on the taxonomy and distribution of the family Rhacophoridae. Andrews and George (1998) recorded 19 species of the family of Rhacophoridae from Kerala. Girish and Saidapur (1999) investigated the mating and nesting behaviour and early development of tree frog *P. maculatus*. According to Daniels (2005) the family Rhacophoridae had six genera and 65 species in India and 36 species were recorded from Western Ghats. Patil and Kanamadi (1997) studied the direct development of Rhacophorid frog *Philautus variabilis* (Gunther). Eight species of Rhacophoridae were recorded from Kerala by Easa *et al.* (1997).

Price *et a*l. (2004) indicated that amphibians required multiple habitats to complete their life cycle. Their distribution patterns were mainly influenced by environmental factors.

Rice and Jung (2004) correlated the chemical composition of water and amphibian populations from ephemeral pools and stream sites in Maryland, Washington D.C. Boyer and Grue (1995) developed the water quality standards for frogs and suggested that the eutrophic conditions (elevated pH, water temperature and un-ionized ammonia) might be associated with frog embryo mortality and malformations. They reviewed the need for the study of water quality parameters on the existence of frogs in agro ecosystems and other habitats. Leslie (1999) reported that variation in the pH and salinity of water affected the anuran population in addition to chemical contaminants. The growth rates of frogs and toads could be significantly affected by even short term exposure to acidic conditions, resulting from acid rain or snow fall (Dickerson, 2001). Strijbosh (1979) correlated the habitat selection of the amphibians with physico chemical variables of water and also with the plant communities of the habitat.Freda,(1986) and Hecnar and M'Closkey (1996) reported the influence of water chemistry of wetlands on anuran distribution and abundance.

The activities of frogs are largely governed by temperature, precipitation, soil moisture, humidity, light intensity and wind. Donnelly and Crump (1998) observed that high temperature, dry weather conditions, low moisture of the soil and high annual rainfall would affect the survival of neotropical frogs strongly. Rome *et al.* (1992) indicated that daily and seasonal activities of anurans were largely influenced by temperature. This view was also supported by Donnelly and Crump (1998).

Influence of rain fall on anurans was reported by Rabb (1973). He observed that rainfall seems to be the main controlling factor on anuran reproduction. Heyer (1974) was of the view that the role of rainfall on anuran reproduction was more important in seasonal climates. Duellman (1995) studied the temporal fluctuations on the abundance of anurans in Peru and

recorded that anuran activity was closely correlated with the occurrence of peaks of heavy rainfall and not with the total rainfall during a sampling period.

pH and moisture of the soil was known to influence the density of amphibians (Huang and Hou, 2004). They suggested that low soil pH enhances release of aluminium and heavy metals into soil solutions that would harm young and adult amphibians

Paton (2002) carried out an amphibian survey especially on the breeding habitat in the Montane and sub alphine regions and the threats identified were fish stocking, loss of wetlands, degradation and loss of terrestrial habitats and all terrain vehicle activities (ATV) in breeding ponds. Studies of Babbitt *et al*. (2006) at south central Florida, USA, indicated that pH, conductivity and water depth significantly influenced the species richness of the larval anurans.

Jones (1986) observed that terrestrial amphibians and reptiles were excellent indicators of the nature of the microhabitats in ecosystems. He recorded that change in microhabitats within a riparian ecosystem influenced the distribution, abundance, and diversity of herpetofauna. Microhabitat preferences of the anurans were also reported by Easa *et al.* (1997) and Ramaswamy and Srinivas (2003 b).

Studies on *niche overlap* and interspecific competition in three species of Rana in Sarawak were undertaken by Inger and Greenberg (1966). Habitat usage, *niche breadths*, *overlaps*, altitudinal distribution, and biogeography of the various species of amphibian fauna were studied by Inger *et a*l. (1984) at Ponmudi.

Gardner *et al*. (2007) reported the importance of understanding the baseline patterns of amphibian diversity and habitat preferences to monitor the

declining population and to evaluate the impacts of different conservation efforts in the light of the sensitivity of amphibians to environmental changes. The urgency of understanding amphibian relationship with habitat was justified as the concerns for global amphibian (Blaustein and Wake, 1990 and Phillips, 1990) increased. Gibbons (2003) reported that not much was known about amphibian habitat requirements away from their breeding places. Thus there is a pressing need to quantify terrestrial habitat requirements of amphibians.

Parris (1999) highlighted the importance of conducting anuran surveys by reporting that surveys provided information about distribution, abundance, habitat requirements of species and the environmental variables that control diversity. Das (1991) reported that no estimates of population size were available even for the commonest species. Pechmann *et al*. (1991) pointed out that the reports on declining global amphibian populations were numerous, but the long-term census data were not available and very little was known on the amphibian ecology especially the spatial and temporal variations in richness and abundance.

Khare (1986) pointed out the need for the preparation of a list of frogs and toads available in the country with information on their biology, ecology, breeding pattern, fecundity, and development. Scott and Campbell (1992) highlighted the need for the study of the ecology of amphibian populations not only at the species level but also at community level, where they co-existed and interacted. Mc Diarmid (1994) explained the necessity for understanding the local species diversity to know the community and ecosystem dynamics.

Gardner *et al*. (2007) described the patterns of diversity across major habitat types and between different seasons from western Tanzania. Influence of habitat on anuran distribution at several spatial scales was studied by Price *et al*. (2004). Daniels (2003) analysed the impact of tea cultivation on anurans in Western Ghats and indicated that anurans were affected by

pesticides. Many authors like Wunderle and Latta (1996), Daily *et al*. (2003) and Tejeda-Cruz and Sutherland (2004) indicated that coffee and cacao plantations harboured a large number of native species.

Wetlands are the most precious natural resources on earth and are cradles of biological diversity. They are aptly described as the kidneys of the ecosystem as they ensure the health of the land. For many amphibian species, loss and degradation of wetlands are major threats (Houlahan and Findlay, 2003), as the wetlands are the suitable habitats for breeding, larval development and foraging (Semlitsch, 1998). Seasonal or temporary wetlands can support a variety of amphibian species which produce numerous metamorphosing juveniles, and provide refugia for recolonisation and dispersal from one breeding area to another (Semilitsch and Bodie, 1998). These sites can provide breeding habitats for a variety of amphibians depending on the length of water holding time (Paton, 2002).

Effects of agriculture on amphibians were studied by various scientists. While some of them reported positive influence of agriculture on anurans, others gave negative reports. Pimentel *et al*. (1992) and Vitousek *et al*. (1997) observed that the agriculture caused problems such as habitat conversion, chemical pollution, disturbance of water quality and nutrient cycles. Abdulali (1985) gave a detailed account of the ecology of some amphibians living in rice fields and their effective role as bio-control agents against rice insect pests and crabs in India. Das (1991) assessed the role of frogs in agricultural ecosystems. Kannan *et al.* (1994) focused on the herpetofaunal assemblage at Mayiladuthurai area and identified eight anuran species from different eco systems (1 Bufonidae, 3 Ranidae, 3 Rhacophoridae and 1 Microhylidae species).

Hecnar and M'Closkey (1997) indicated that amphibians living in wetlands of disturbed landscapes were observed to be richly associated with

agricultural cultivation on a large scale. Bambaradeniya and Amerasinghe (2003) were of the opinion that rice fields were the preferred habitats of amphibians and they listed 18 species of anurans from rice fields of Sri Lanka.

Johansson (2004) evaluated the effects of agriculture on amphibians and observed that abundance and occurrence were adversely affected by agriculture in southern Sweden, whereas in the central and northern regions, it was unaffected or even promoted by agriculture. A report prepared by Pearlstine *et al.* (2004), on the wildlife habitat in the Everglades Agricultural Area (EAA), Southern Florida indicated that agricultural, aquatic and edge areas provided ideal habitats for the diversity and abundance of species.

Studies confirmed that a variety of environmental factors together with vegetation zones (Allmon, 1991), land elevation (Giaretta *et al.,* 1999) and agroclimatic conditions (Giaretta *et al.,* 1999; Vonesh, 2001 and Woolbright, 1996) influenced the species composition and abundance. Mazerolle and Desrochers (2005) observed that anthropogenically disturbed areas, which were devoid of vegetative cover such as mined peat lands and agricultural fields disrupted the ability of frogs to reach habitat patches, hence caused limitation to their abundance in mega environment. Knutson *et al.* (2004) studied the importance of small constructed ponds and its effects on the breeding behaviour of amphibians.

There were limited studies on the status, distribution, habitat requirements and behaviour of Indian amphibians (Daniels, 1999). Although no published data on the community structure of amphibians in Indian ecosystems is available, it is generally believed that amphibian population has numerically decreased in recent years due to large scale application of pesticides in Indian agro ecosystems and denudation of habitats (Dash and Mahanta, 1993). They further reported that, quantitative ecological studies were not made on the entire amphibian community in Indian ecosystems.

There is much to be understood concerning the amphibians. Long-term survey data are essential to explore the effects of ecological factors on species richness. Surveys along with monitoring of population are necessary to create conservation and management plans (Heyer *et al*., 1994 and Semlitsch, 2000). In the light of amphibians' sensitivity to environmental change, it is particularly important to understand baseline patterns of amphibian diversity and habitat preferences.

For conservation purposes, the study of the distribution patterns of species richness in diverse habitats and their ecological determinants are vital steps to understand the processes, that affect the spatial distribution of biological diversity, and to predict the response of ecosystems to global changes (Stoms and Estes, 1993 and Peterson *et a*l., 2002). The acquisition of baseline data on the distribution and status of even common species is important. Such accurate appraisals of amphibian populations in most areas have not been achieved.

Information on anuran abundance and diversity helps to determine the relative health of the ecosystems. By learning more about these animals and their habitats, we can assess the ecological importance of anurans and to conserve the environment in order to prevent their massive destruction. In the present work, the anuran resources of Periyakulam Taluk is explored so as to provide new vistas for further investigation and to elucidate the role of different ecosystems in supporting the anuran communities.