INTRODUCTION 1

Amphibians form a connecting link between fishes and reptiles as they are the first group of vertebrate animals to emerge from an aquatic environment to live on land (Ray, 1999). Among the three orders of Amphibia, the order Anura is the largest comprising the most diverse set of species. Anurans include frogs and toads which are tailless (except larvae) and are having long hind legs, webbed and unclawed toes, large eyes and a smooth or warty moist glandular skin (Stebbins and Cohen, 1997). Their size ranges from 1 to 30 cm.

Frogs are adapted to local environmental conditions especially in colouration, body structure and behaviour (Bishop and Haas, 2003). Their colour blends so well with the background that the frogs go unnoticed except when they start moving (Daniel, 2000). They move around mostly during the cooler period of the day or during nights. They spend a lot of time in hiding. During long periods of cold or dry weather, frogs hibernate, and breathe through their skin (Bishop and Haas, 2003). The moist skin acts as a regulator of body temperature, keeping the body cooler than the surrounding dry air and warmer in humid air (Daniels, 2002). They survive best in an ambient air temperature of 20 to 30 ^{o}C (Daniels, 2000). The toads are comparatively better equipped to survive in areas unsuitable for frogs. Toads wander for food during the humid night and seek cool retreats to spend the hours of day light. Anurans are mostly dependent on environmental moisture as, whose habitat, behaviour and life histories are strongly influenced by the distribution and abundance of water (Heyer *et al.,* 1994).

Anurans complete their life cycle in multiple habitats. During breeding and larval stages they require aquatic habitats whereas for adult growth,

foraging, hibernation, aestivation and dispersal, terrestrial habitats are required. Because of this they require favourable conditions in both habitats, as they are exposed to a greater variety of physical, chemical and biotic variations than the other vertebrates (Mc Diarmid, 1992).

Anurans with their sensitive skin, cold bloodedness and dependence on land as well as water, function as potentially excellent bio indicators or *living barometers* for judging the health of the environmental conditions because of their site fidelity and the marked physiological sensitivity (Barinaga, 1990; Blaustein and Wake, 1990; Vitt *et al.,* 1990; Wake, 1991; Dunson *et al.,* 1992; Blaustein, 1994 and Pechman and Wilbur, 1994). Amphibians normally signal environmental stresses earlier than other organisms (Dickerson, 2001). Because of their sensitivity to environmental factors, amphibians are sometimes referred to as the *canary in the coal mine.* Amphibians act as an early warning system for ecological decline which will also impact other species including man.

Anurans are very important group of animals because of the central role they play in many communities (Burton and Likens, 1975 a, b ; Duellman and Trueb, 1986; Stewart and Woolbright, 1996). Frogs are the least harmful animals. They never destroy agricultural crops, fruits and vegetables. They are considered as the friends of farmers as they are known as hunters of various pests and vectors. In many habitats, anurans act as a major *conveyor belt* that helps in the transfer of plant energy to tadpole. Tadpoles are generally herbivorous young ones consuming large quantities of algae from aquatic habitats and as such tadpoles play an important role in nutrient transfer between the aquatic and terrestrial environment (Seale, 1980). Adult amphibians are major predators on insects and other invertebrates (Toft, 1985). They eat insects just like beetles, termites, flies, grass hoppers, butterflies, moths, bugs, earwigs, dragonflies as well as their larvae (Gupta, 1998).

Anurans are functionally important for nutrient cycling and energy-flow in most fresh water and terrestrial ecosystems (Gehlbach and Kennedy, 1978; Werner and Mc Cune, 1979; Scott and Campbell, 1992 and Beebee, 1996).

Anurans are an important resource (Lynn and Lindle, 2002) and are ecologically important as they are primary consumers during their larval stage (Seale, 1980) and primary predators when they are at their adult stage (Murphy and Hall, 1981; Blaustein and Wake, 1990 and Blaustein *et al.,* 1994). Tadpoles and adults are eaten by other higher vertebrates (Blaustein and Wake, 1990; Duellman and Trueb, 1994).

Scientists have reported the existence of more than 6157 species of amphibians (Amphibia web .org. 2007) all over the world. Frogs and toads are known to inhabit every continent other than Antarctica (Bishop and Haas, 2003). They are found in a variety of ecosystems ranging from tropical rain forest to barren deserts (Stebbins and Cohen, 1997). Most of the species live in aquatic to semi aquatic, terrestrial to arboreal habitat at any point of their life cycle (Donnelly and Crump, 1998). The physiological as well as environmental factors have restricted the distribution of many species of amphibians to the warm and humid tropical parts of the world (Daniels, 2000) and the highest anuran diversity occurs in tropical regions (Donnelly and Crump, 1998). Eighty percent of the total amphibians of the world are found within the tropics especially in the Neotropical region having the highest number of species.

Anurans are found in all regions of India. India has a very rich fauna of frogs (Inger and Dutta, 1987).Around 51 million hectares of land in India are available as the habitat of frogs (Pandian and Marian, 1986). Frogs and toads form 91 percent of the Indian amphibians (Inger and Dutta, 1986). According to Amphibia web .org (2007) a total of 249 species representing 6 families occur in India (Daniels, 2005) making India one of the leading habitats of frogs. They survive not only in the cooler parts of the Himalayas, Jammu and

Kashmir but also in the islands of Andaman and Nicobar. The common toad *B. melanostictus* and the skipper frog *R.cyanophlyctis are* the most widespread frog species that occur even at an altitude between 2000 and 3000 m above MSL. Amphibians have high species richness and endemism in India with two major centers of distribution: North - East India and Western Ghats, (Jayaram, 1974 and Inger and Dutta 1986). Out of the above two, the highest diversity is recorded in the Western Ghats which is the home for many amphibians. The Western Ghats of India, one of the 34 biodiversity hot spots of the world, has been the focus of attention for the discovery of new species (Aravind *et al.,* 2007). The recent discovery of a new family of frogs namely, Nasikabatrachidae, the first in the last 77 years, bears testimony to the uniqueness of this region (Bawa *et al.,* 2007). It is the heart of Indian amphibian diversity with 126 species from 24 genera (Bawa *et al.,* 2007) of which 92 species are found to be endemic (Gupta, 1998; Kumar *et al.,* 1998). In Eastern Himalayas and Eastern Ghats 60 and 25 species of anurans were identified respectively (Pillai and Murthy, 1982; Inger and Dutta, 1986; Murthy; 1987; 1988 and Daniels, 1994). A recent assessment based on the revised criteria of the International Union for Conservation of Nature (IUCN) showed that nearly 57 percent of amphibians in India are facing extinction. Western Ghats has the highest number (49) of the threatened species (Kumar et al., 1998 and Ramasamy, 2003). The significance of India's amphibian fauna lies on the fact that nearly 65 percent of our species are endemic. More species of amphibians are being discovered in India even today (Vasudevan and Dutta, 2000).

The herpetofauna of Southern India is one of the most diverse and poorly known spheres in the tropical Asia (Inger *et al.,* 1987). Tamil Nadu with its varied ecological zones harbour about 30 percent of amphibian species of India (Ravichandran, 1998). In Tamil Nadu Ravichandran (1998) reported 61 species of amphibians and Ramasamy (2003) has reported about 72 species in Tamil Nadu. The report of Wild Biodiversity of Tamil Nadu Forest

Department (2005) recorded 76 amphibian species in Tamil Nadu of which 56 are red listed species and 36 are endemic species according to the Conservation Assessment and Management Plan (CAMP) reports.

Anurans are exploited by men for food and medicinal purposes all over the world (Noble, 1931; Cochran, 1961; Heusser, 1974 and Ray, 1999) .Edible frogs constitute an important dietary element in many tropical and subtropical regions of the world (Fugler, 1983). In many countries, notably France, Belgium, The Netherlands, Japan and United States of America the frog legs are considered as rare delicacies among food items (Khare, 1986). Preference for frog legs has spread to Canada, Saudi Arabia and the United Arab Emirates (Khare, 1986). The non edible remnants of anurans were processed as protein supplement for fowl and fish (Fugler, 1983).

India was the leading exporter of frog legs in the past (Rao, 1993). India started exporting frog legs in 1957 and in 1980's it became the biggest exporter by earning substantial foreign exchange (Rao, 1993). More than 60 million frogs were annually butchered for the frog leg industry (Pillai, 1982). As in other frog leg exporting countries, the export of frog legs from India was based on wild hunting.

R. tigerina, R. hexadactyla and *R. crassa* (now known as *H. tigerinus*, *E. hexadactylus* and *H. crassus* respectively) were used for frog leg export (Khare, 1986). Abdulali (1985) reported that 34,000 tonnes of frog legs were exported from India every year. The average annual export of *R. hexadactyla* from India during 1983-86 was 339 tonnes (Andrews and George, 1998). As the natural stock depleted rapidly the Government of India banned its export in 1986.

From the perspective of human health, it is to be known that anurans are the store house of pharmaceutically valuable substances. Today frogs are viewed as a source for the development of new drugs. The valuable

substances present in them can be extracted for many pharmaceutical uses (Gupta, 1998) such as pain killers and in the treatment of victims of traumas ranging from burns and allergy to heart attacks (Gupta, 1998). Recently, researchers have turned their attention on the skin secretions of anurans. It is found that the active elements in the skin of many species have the properties of antibiotics, painkillers, medical adhesives and drugs in the treatment of schizophrenia and gut disorders (Anonymous, 1993). Daly *et al. (*2004) reported that amphibian skin was a source for a wide variety of biologically active substances. Skins of 21 genera of anurans from Thailand were examined for specific secretions (toxins and alkaloids). The study identified the presence of certain toxic substances in three species (bufadrenolides in toads; toxic peptides and pumiliotoxin alkaloids in Ranid frogs) (Daly *et al*., 2004). The secretion *magainin* of the African clawed frog is used in the treatment of diabetic ulcers, eye infections, cystic fibrosis and cancer. Secretions of chosen anurans are used as insect repellants, tooth paste additives and non toxic glues. Tadpoles too have some medicinal values just like the adults (Handerson, 1864).

The use of anurans in academic institutions as test animals is also well known. They have been used as indispensable items in the laboratories of schools, colleges and universities for more than a century in order to impart knowledge on vertebrate anatomy, physiology and embryology (Khare, 1986). It was reported that about 20 million frogs were killed every year for dissection in educational institutions (Gupta, 1998). In India, anurans (H. *tigerinus, H. crassus, E. hexadactylus and E. cyanophlyctis, B. melanostictus and L. limnocharis) were* being collected in large numbers to meet the demands of biology students. Eggs and larvae of frogs have been richly used in toxicological studies (Harfenist *et al*., 1989). Amphibians are particularly useful in hybridization studies because of the ease with which inter specific crosses occur in nature.

Anurans are considered important in those countries where economy depends predominantly on agricultural sector (Jeevan, 1999). Anurans are voracious predators of insect pests and vectors. Certain species of anurans have been introduced to various parts of the world to aid humans in their struggle to eliminate undesirable pests in the forests, farms, and gardens. Their role in the ecosystem to control insect pest is greatly emphasised in the recent past (Daniels, 2000). They devour the pests and prevent the spread of vector borne diseases like malaria as they consume parasites responsible for the disease (Jeevan, 1999). Adult anurans are the major predators on insect and other invertebrates (Toft, 1985). The Zoological Survey of India reported many cases of malaria in rural areas of West Bengal, where around 50 percent of the frogs were captured already for export purposes (Jeevan, 1999). According to the experts of the Bombay Natural History Society, crops in many parts of western Maharashtra were badly hit due to the insect pests as a consequence of large scale slaughter of frogs (Jeevan, 1999). Kharat *et al*. (1983) studied the role of *R. tigerina* in controlling rice pest. They observed the presence of crabs, white grubs, rice skipper, rice ear head bug, swarming caterpillar, stem borer moths, leaf hoppers, rice grass hoppers, and blister beetles in the gut content of many frogs. Abdulali (1985) gave a detailed account of the occurrence of Indian amphibians in rice fields and highlighted their role as bio-control agents against the rice pests and crabs. The role of frogs as an agent to control agricultural pest in Tamil Nadu was studied by Sekar (1987) .It is considered that the existence of frogs in rice fields is necessary for minimising pest infestations. The predation of anurans by higher vertebrates will increase the pest population which will demand high use of pesticides in the fields. Thus, the loss of amphibians in many ecosystems could profoundly affect other populations (Dickerson, 2001).

The potential of omnivorous tadpoles to predate mosquito larvae (Komak and Crossland, 2000) exert significant impacts on fresh water ecosystem (Blaustein and Kotler, 1993). Similarly tadpoles of *R. tigerina* can

also be considered as an efficient mosquito pupal predator (Marian *et al*., 1983). Studies of Komak and Cross land (2000) showed that larvae of the giant Cuban tree frog (*H. sepentrionalis*) had the ability to minimise the incidence of aquatic insects and algae growing in water containers.

The role of amphibians as living indicators of the health of the ecosystem was greatly emphasized (Daniels, 2000). The moist and permeable skin of the frog is sensitive to many pollutants, which is the main reason to consider frog as a good indicator of the health of the ecosystem (Bishop and Haas, 2003). Anurans have intimate contact with many components of the environment in which they live. Hence they are considered to be valuable gauges of environmental health or stress (Barinaga, 1990; Philips, 1990; Blaustein and Wake, 1990, 1995 and Blaustein, 1994). They act as effective monitors of local environmental conditions as they are relatively sedentary throughout their life span as compared with that of other vertebrates (Blaustein and Wake, 1995).

Amphibian species are facing extinction and their populations are declining faster than that of mammals or birds (Stuart *et al*., 2004 and Beebee and Griffiths, 2005). Worldwide focus was made on amphibians because of the specific concern that their populations are fast declining on a global basis (Barinaga, 1990; Wake and Morowitz, 1991). The International Union for Conservation of Nature (IUCN) red list (2004) indicates that one among the three amphibian species is being threatened with extinction (Baillie *et al*., 2004). Globally, about 200 amphibian species have experienced population decline and are slowly disappearing from their native habitats (Griffith and Beebee, 1992 and Blaustein *et al*., 1994) and from many geographical locations throughout the world during the last few decades (Blaustein and Wake, 1990, Donnelly and Crump, 1998; Alford and Richards, 1999; Houlahan *et al*., 2000; Semlitsch, 2003; Lips *et al*., 2005 a and Awasthi, 2007). The extent of decline varies from region to region (Donnelly and Crump, 1998). No

one exactly knows the tangible reason for the decline of amphibian populations. The general factors suspected to the overall crisis are the following:

1. For many amphibian species, loss and degradation of wetlands is a major threat (Houlahan and Findlay, 2003) as wetlands are the suitable habitats for their breeding, larval development and foraging (Semlitsch, 1998).

2. Frogs and toads are vulnerable to human exploitation and are sensitive to a number of environmental factors, both natural and anthropogenic (Lynn and Lindle, 2002). Anthropogenic modification of the habitat (drainage, agriculture, road network and traffic) or habitat destruction, habitat loss or quality deterioration and landscape fragmentation (Delis *et al.*,1996; Semlitsch,1998; Semlitsch and Bodie, 1998 and Alford and Richards,1999), landscape modification (Green, 1997; Lehtinen *et al*., 1999; Pope *et al.,* 2000; Johnson *et al*., 2002 and Pellet *et a*l., 2004) and changed hydrology due to drainage of wetlands, development and management of dams, catchments, streams, urbanization and other structural modifications affect the species by reducing the suitable habitat thereby fragment the population (Knutson *et al*.,1999 ; Bugg *et al.,* 2003; Pellet *et al.,* 2004 and Riley *et al*., 2005). Many amphibian species migrate between the aquatic breeding and terrestrial foraging habitats that make them especially susceptible to changes caused by land conversion (Pope *et al.,* 2000).

3. Excessive exploitation of the economically important species, uncontrolled International trade and indiscriminate collection of specimen for academic purposes are known to threaten several species (Khare, 1986 and Jeevan, 1999). Over exploitation for food and medicinal uses also caused the depletion of the stock (Jennings and Hayes, 1985; Lannoo *et al.,* 1994; Ray, 1999 and Daniel, 2000).

4. Several mega factors were identified as reasons for the decline of the populations which included global warming, altered rainfall patterns, longer periods of drought and drying up of ponds. Changes in global weather patterns can also alter breeding behaviour, fecundity, immune functions and their sensitivity to chemical contaminants (Pounds *et al*., 1999; Kiesecker *et al*., 2001 and Carey and Alexander, 2003).

5. Increased UV-B radiation is likely to kill amphibians directly. It causes sublethel effects such as slowed growth rates and immune dysfunction. It also causes to work synergistically with contaminants, pathogens and climatic change (Blaustein *et al.,* 2003).

6. Chemical contaminants such as pesticides, heavy metals, acid rain, nitrogen based fertilizers and chemical run off can have lethal, sub lethal and endocrine effects on amphibians. Some of these include death, decreased growth rate, behavioural abnormalities, decreased reproductive success, weakened immune systems, feminisation of male frogs and hermophroditism (Hayes *et al.,* 2002). Exposure to pesticide could reduce the size of the animal at metamorphosis and hence reduce the survival until maturity (Berven, 1990; Morey and Reznick, 2001; Hayes *et al*., 2002 and Altwegg and Reyer, 2003). Their unshelled eggs and permeable skin make them extremely sensitive to perturbations in the environment (Blaustein and Johnson, 2003) and make them vulnerable to pollution in water and soil, where they live. The aquatic breeding habits of many terrestrial species result in direct exposure of their eggs, larvae, and adult stages to pesticides, herbicides, acidification, and other human-induced stresses in both aquatic and terrestrial habitats. Uses of pesticides are not only detrimental to frogs directly, but also wipe out their food supply.

7. Introduction of non-native competitors such as voracious game fish, craw fish and bull frogs which prey on or compete with native amphibians (Fisher and Shaffer, 1996; Vredenburg, 2001 and Kats and Ferrer, 2003).

8. Infectious diseases cause the death of adults and larvae (Kiesecker and Blastein, 1997 and Daszak *et al.,* 2003). A fungus disease called Chytridiomycosis causes mass mortality of frogs by damaging their sensitive skins. Certain parasites (trematodes) which penetrate the skin and muscles affect the normal development of frog limbs and cause skeletal deformities. Exposure to toxic substances may weaken frog immune systems, and make them more vulnerable to teratogenic parasites. It is known that combination of a common parasite, trematode worms and pesticide run- off from farms will have combined effects on the normal developmental stages of many frogs. There is no evidence to suggest that a single factor is solely responsible for the decline of amphibians (Laurance *et al.,* 1996 and Halliday, 1998). It is likely that the stress factors are not working independently, but interactions amongst them may be the most likely threat to many species (e.g. Kiesecker *et al.,* 2001, Blaustein & Kiesecker 2002, Pounds *et al.,* 2006).

The decline in the number of frog species is a warning signal of an ecological disaster, as they are the living barometers of the health of the environment. The potential for getting natural medicines for many maladies will be affected due to the disappearance of anurans (Gupta, 1998). If anuran population happens to go down, the pest population will go up, resulting in increased use of pesticides and spread of diseases. The complex life cycle of anurans results in ecological complexity as different stages in the life history would influence different food webs .Similarly changes in population densities will doubtlessly affect the other elements of these webs (Donnelly and Crump, 1998). A worldwide decline of amphibians could affect other organisms, including human beings (Blaustein and Wake, 1990). In India, it is reported that about 48 percent of all amphibian species and 59 percent of endemic

ones are seriously threatened (Awasthi, 2007). It is known that the stress factors are not working independently, but interactions among them may be the most likely threat to many species (Drost and Fellers, 1996).

According to Pechmann *et al*. (1991), reports on declining amphibian populations all over the world are numerous, but a long-term census data are unavailable and thus very little is known on the amphibian ecology especially the spatial and temporal variations in its richness and abundance. Critical examination on the causes of the global decline also is difficult because of the lack of long term data (Pechmann and Wilbur, 1994 and Blaustein *et al.* 1994). Worldwide decline of anuran species have created a need for more extensive and standardized monitoring of anuran population and for elucidating the underlying causes (Heyer *et al.,* 1994; Olson *et al.,* 1997 and Jung *et al.,* 2001). Decline in anuran population also has increased the need for generating scientific data on distribution, population size and other influencing factors (Paton, 2002). More investigations are needed to find out the reasons for the fast disappearance of anurans.

Although in India we have not made any comprehensive investigation so far for quantifying the declines, a few cursory studies have shown that there are significant changes in amphibian communities (Humraskar and Velho, 2007). Surveys and monitoring efforts are the major initial steps towards the creation of conservation and management plans to stop further decline of population (Heyer *et al*., 1994 and Semlitsch, 2000).

Knowledge on the occurrence of various species in an area is very fundamental in understanding the intricacies of biological diversity (Heyer *et a*l., 1994). Furthermore knowledge of local species diversity is very essential in understanding the community structure and ecosystem dynamics (Mc Diarmid, 1994). The acquisition of baseline data on the distribution and status of even a common species is important. Inventory of species in a

particular region forms an essential base line data for the purpose of conservation and resource management. Thus it is important to be aware of the richness of the species, their distribution and composition in each ecosystem. Studies hitherto made (Dash and Hota,1980; Mishra and Dash 1984 a, b; Pandian and Marian, 1986; Mohapatro and Dash 1987 and 1991) were focused only on some specific ecological aspects of few anuran species but no major quantitative ecological assessments were made in India on the entire anuran community of the agro ecosystems.

Das (1991) opined that no long term field studies of amphibians aimed at understanding the lasting ecological relationships were attempted. He said that the amphibian fauna of India richly deserves investigation as they are unusually diverse, economically valuable and are of considerable ecological interest. Anuran surveys provide information on the distribution, abundance and habitat requirements of species and the environmental variables that control diversity (Parris, 1999).Though investigations on anurans are in progress in many parts of India, no published data is adequate to understand the behaviour and existence of anuran in various agro eco systems. Given the urgency of the global amphibian crisis and the lack of data we need to protect unique biotopes which would help us to carry conservation measures (Humraskar and Velho, 2007). To properly assess anuran populations and the factors affecting them, detailed monitoring surveys are necessary. This has created interest in the collection of data on the distribution of amphibians. So the present study of the anuran resources of Periyakulam Taluk was undertaken with the major objective to study anuran community with reference to various habitats and periods in Periyakulam Taluk. The specific objectives are as follows:

1. To enumerate species diversity, richness, abundance and distribution pattern in Periyakulam Taluk.

2. To study species diversity, density, abundance, niche breadth, niche overlap, and richness with reference to habitats and periods and

3. To study the factors (meteorological and physiochemical) influencing anuran community structure in Periyakulam Taluk.