LITERATURE REVIEW
Amphibians are known as indicator species of environmental conditions and hence these may surrogates for the status of other species or environmental conditions (Noss, 1990). They adapt themselves to sudden but mild changes in the weather conditions. In some temperate locations the amphibians breed earlier to avoid the warmer spring temperatures (Beebee, 1995; Forchhammer et al., 1998 and Gibbs and Breisch, 2001). These consequent changes may affect the fitness of the individual and on persistence of population (Ovaska, 1997 and Donnelly and Crump, 1998). The studies have provided the information on the effect of climatic change and air temperature on the breeding phenology of amphibians (Blaustein et al., 2001). The change in the global climate has influence on many interacting variables of the habitats. These changes have been considered as major conservation threats of the past, present and future. These changes affect all levels of ecological organisation like population and life history changes, shifts in geographic range, change in species composition and structure and function of ecosystem (McCarty, 2001). Many times such changes are not universal among amphibians (Corn, 2003).

The changes in abiotic conditions that are associated with fragmentation can influence ecosystem services such as nutrient cycling (Saunders et al., 1991). The fragmentation will often lead to crowding of species in patchy habitats (Dabinski and Holt, 2000), thus leading to the complex relationship between the species and habitat. The process of amphibian decline may occur suddenly or it may be prolonged depending on the environmental conditions. These factors make uneven distribution among the amphibians. Hence, the studies should focus on each and every species and factor at the regional level (Houlahan et al., 2000). The conservation at the regional/local scale, ultimately conserves the species in the global level. Prevention of habitat loss and degradation can reduce the risks of extinction and loss of biodiversity (Caughley and Gunn, 1996).
Regarding the serious problem of amphibian population decline, there are several approaches to conserve the species. The research should occur often at landscape level and conservation efforts should focus on suitable habitat. This includes monitoring, metapopulation dynamics, molecular population genetics and multifactorial studies (Storfer, 2003). The monitoring of amphibians includes the appropriate monitoring methods and these may be species specific (Heyer et al., 1994). The monitoring techniques are crucial, as they should be statistically sensitive having fine-grained temporal scales using time series and are used to determine predictive power (Storfer, 2003).

Amphibians exhibit metapopulation structure (Storfer, 2003) and this needs extensive research (Hanski, 1999). The studies have revealed that different types of metapopulations can be managed in different ways. The amphibian metapopulations that are patchily distributed in a habitat can result potentially in ineffective or inefficient management. The distribution can be estimated by considering the movement among the habitats using mark-recapture and gene flow measurements (Storfer, 2003). If the species is restricted to the specific habitats, the conservation should often occur at landscape level. The extinction and recolonisation dynamics may become an important characteristic of the species (Sjogren, 1994). If local habitat undergoes extinction, there may be recolonisation by the dispersal from nearby habitats (Storfer, 2003) and thus the population relies on maintenance of connected sites, even if they are not currently occupied (Sjogren, 1991; Hanski, 1999; Marsh and Trenham, 2001 and Semlitsch, 2002).

The advancement of technology in the molecular genetics has approached conservation. The amphibians can be effectively conserved, by studying the genetic population structure and estimates of genetic variation, inbreeding and effective population size. These methods help to employ the appropriate conservation and management strategies (Storfer, 2003).
Many parts of the world which contain high amphibian diversity with high endemism have a little or no information (Wake, 1998 and Young et al., 2001). The lack of information has set back the formulation to derive the conservation strategies or contingency action for preventing further decline (Alford and Richards, 1999). The Western Ghats of India also possesses such amphibian diversity with high endemism. The status of the species is the fundamental factor for ecologists and conservation biologists. The status of a species critically includes the species occupancy and its abundance, irrespective of its population stability. Determining the status of a species is quite difficult, unless one as a thorough knowledge of population dynamics and distribution (Hecnar and McClosky, 1996). Moreover the smaller populations are more vulnerable to extinction rather than the larger populations (Richter-Dyn and Goel, 1972 and Leigh, 1981) and hence, they should be studied more seriously. The status of the species provides the baseline information to derive the conservation practices. The species which are vulnerable are easily prone to environmental changes and ultimately they decline (Barbault, 1991 and Waldman and Tocher, 1998). The study of a species in an ecosystem reveals specific microhabitat requirements to derive conservation strategies (Reddy et al., 2002). In the global scale, these studies demonstrate the landscape structure to determine the local abundance, independent of the effects of the local habitat quality (Brown and Brown, 1977; Fehrig and Merrian, 1985; Hanski, 1985; 1994 and Kareiva and Wennergren, 1995). The species that has got restricted ranges would be severely affected (Donnelly and Crump, 1998). The conflict between the ecosystem studies and single species studies has existed among the conservationists, but each is vital and intellectually dependent each other. In global level the autecological studies on Phyllomedusa boliviana, Gastrotheca christiani, Eleutherodactylus discoidalis, Telmatobius oxycephalus, Bufo rumbolli, B. gallardo and Melanophryniscus rubriventris were done with special emphasis on conservation and monitoring programmes (Viara, 2002), yet lacking population dynamics. The distribution
and habitat specificity of the species have been studied, but lack relative abundance and population size of the species (Viara, 2002). Community level approaches to biological conservation have been recognized as major advance in the conservation and management practices. But the single species studies will help in the quantitative analysis of community and environmental relationship along with some limitations. The study of a single species and its functional relationship with other species and environment will lead to derive the conservation models and ultimately to approach the community level (Olden, 2003). In this regard, the biological modelling has been made using the population dynamics of toad population (Joly et al., 2001). Richter et al., (2003) detailed the reproduction success of a rare endangered frog *Rana sevosa* and implications for conservation and population monitoring in Mississippi, USA. The decline of *Bufo bufo* was estimated in England, Scotland and Wales, by comparing the toad population with the common frog (*Rana temporaria*) population as control, the later has no evidence of recent declines (Anne and Beebee, 2003).

Parallel to the alarming rate of amphibian decline worldwide, a few amphibian species of the Western Ghats exhibit population decline. The study of endemic species is considered as a key factor for the amphibian distribution (Inger and Dutta, 1986). The literature review on ecology of Western Ghats amphibians revealed few studies on reproductive behavior (Saidapur, 1997, Krishnamurthy, 1997a; Krishnamurthy et al., 2002), taxonomic status (Daniels, 1997a, b and c), range extensions (Reddy et al., 2001), diversity (Krishnamurthy and Katre, 1993; Krishnamurthy, 1999; Krishnamurthy and Hussain, 2000), feeding habitats (Krishnamurthy et al., 2001b), influence of habitat characters on distribution and habitat feature of some anurans species of Western Ghats (Krishnamurthy et al., 1992; Krishnamurthy, 1996a; b; 1997b; Krishnamurthy and Katre, 1996 and Reddy et al., 2002).
Studies on species-habitat interrelation have made a note of relatively simple facets of dependence of the species on habitat (Begon and Mortimer, 1992). Various properties and causes underlying in their habitat encapsulate the species population. However, studies pertinent to interrelationship between various habitat variables of amphibian species are related. Globally, there are many autecological studies on amphibians in relation to various aspects of biology. In temperate regions, there are some studies on behavior of single species on the topics of predation, mate choice, etc. There is a controversy about the behavioral strategies of individuals as a part of autecology that affects the composition and dynamics of populations or communities. But when hybridogenetic water frogs such as *Rana lessonae* and *R. esculenta* were studied for mate choice on choosy females and indiscriminate males, the obtained result was based on the individual species studies (Engeler and Reyer, 2001). In British Columbia, the distribution and habitat use of about 20 amphibian species were reported based on the individual species studies. The requirement of wetlands with good vegetation structure and sufficient flood duration were noticed among each species of amphibians. This individual species-based study provides the information on habitat occupancy and selection of breeding ponds by the species and their larval survivability. Carey et al., (1996) describes the effect of cold on immune function and susceptibility to bacterial infection in *Bufo marinus*. The drastic climatic changes and variation in temperature affects the immune characteristics and the species becomes susceptible to diseases. The information procured will also help in a comparative study of different species in different thermal conditions. The studies on the effect of soil moisture content, soil temperature, and relative humidity on the movement and microhabitat of *B. marinus* and soil moisture, pH, and light intensity on the distribution of salamander (*Plethodon cinereus*) have been carried out. The autecological studies on amphibians is not restricted to adults only, the studies have also been concentrated on the tadpole issues. Plenet et al., (2000) describes the ecology of *R. esculenta* complex with
special emphasis on differential oxygen requirements of tadpoles. This study was made to understand the response of tadpoles of intermediate hybrid populations. The ecology of *Ambystoma maculatum* and *R. sylvatica* were exclusively studied to understand the effect of disturbance gradients on wetlands. The studies related to the bio-acoustics and mating behavior of *Limnonectus syhadrensis* was made to understand the call, courtship and mating behavior (Kadadevaru et al., 2002). It supports the autecological studies and help in further studies on conservation measures. Hecnar and McClosky (1997) detailed the spatial scale and status of green frog (*Rana clamitans melanota*) with special emphasis on abundance and distribution of the species. The status of single species is a fundamental factor to understand the incidence or occupancy and population stability. The variation in population size and reproductive patterns in *Hyla boans* was studied to understand the status of breeding populations, effects of climatic conditions on breeding populations and their behavior (Magnusson et al., 1999). Such studies are helpful in determining the conservation measures for closely associated species. Zeisset and Beebee (2003) detailed the autecology of *Rana ridibunda* with emphasis on population genetics in Britain. The effects of translocation were studied, which supported the *R. ridibunda* populations in range extensions and for growth of population size. Kiss and Laar (1992) have attempted general field studies on populations of *Bufo bufo* in Hungary. This study focuses on the characteristics of breeding activity and to measure some body size parameters of *B. bufo* individuals. These studies include primarily the population estimation.

The ecological, behavioral and genetic reasons for the spatial differences and temporal stability were studied by the combination of comparative, experimental and theoretical studies. The European water frog *Rana esculenta* is a hybrid of *R. lessonae* and *R. ridibunda*. The distribution and populations of *Rana esculenta* and *R. ridibunda* and their hybrids were studied (Gubanyi,
Such hybrids generally have disadvantages of clonal and hemiclonal reproduction. But *R. esculenta* has shown normal and better distribution patterns *viz.*, it occupies larger areas and maintains larger populations with sexual parentals. This successive reproduction of hemiclonal hybrids and sexual parentals is strongly affected by genotype and environmental interactions. The growth and survival of the tadpoles of *R. esculenta* was experimentally tested in a variety of environmental conditions based on the interactions between density (competition), predators and abiotic factors like temperature and fungicides. The analysis of metapopulation structure through the microsatellite analysis of *Bufo calamita* was made to understand the genetic diversity among the habitat continuity regions in Britain. The barriers to check the migration between the sub-populations was studied (Rowe *et al.*, 2000). Similar studies were also made to *R. ridibunda* species in Britain to know the success of translocations.

In Western Ghats the range extensions and notes on ecological features of *Rana keralensis, R. aurantiaca, Ansonia ornata* and *Indirana brachytarsus* are based on the detailed study of individual species (Daniels, 1991; Krishnamurthy and Katre, 1996 and Reddy *et al.*, 2001). Without the knowledge of geographic range and habitat requirement of a species it is not possible to understand the problem of amphibian population decline (Daniels, 1991). The occurrence, habitat, distribution and ecological conditions of a species lead to further research. The habitat requirement and interaction of abiotic components on *Nyctibatrachus major* have been given in detail (Gururaja *et al.*, 2003). The range of specific microhabitat requirements of *N. major* was determined (Krishnamurthy, 1997b). Habitat features and selection of specific habitat variables by *Micrixalus saxicola* in central Western Ghats was studied emphasizing the microhabitat requirements of the frog (Reddy *et al.*, 2002). There is information on habitat, microhabitat, ethology and a few biological aspects of caecilians of Central Western Ghats (Gundappa, 1985).
The effect of pollutants such as mercuric chloride on embryonic development of *Microhyla ornata* has already been studied (Ghate and Mulherkar, 1980). These autecological studies reveal the supportive information on single species conservation and strengthen the existing conservation methods that check the declining amphibian populations.

The literature on Nyctibatrachinae members of Central Western Ghats has revealed that *Nyctibatrachus* genus is facing the problem of habitat fragmentation and its population is threatened and has showed decline (Gupta, 1998). The genus *Nyctibatrachus* consists of 11 species (Krishnamurthy et al., 2001a). Amongst them, the ecological conditions of *Nyctibatrachus aliciae*, *N. deccanensis*, *N. minor* and *N. vasantii* are vulnerable, *N. beddomii* and *N. major* are at lower risk and near threatened, *N. humayuni* and *N. sanctipululstris* are endangered whereas ecological data are deficient for *N. kempholensis* and *N. sylvaticus*. There were no studies regarding the habitat characterisation of the species of this genus, except on *Nyctibatrachus major* (Krishnamurthy, 1997b). The endemic species are generally said to be the target species for the extinction (Olden, 2003). The *Nyctibatrachus aliciae* is also an endemic frog living in the streams of evergreen forests of Western Ghats. Very limited information is known about its distribution, threats and the habitat requirement of this species (Inger et al., 1984). The species is thinly distributed in Central Western Ghats (Anonymous, 2001). The distribution of the species was known in the latitudinal range of 8 – 9°N and 12 – 13°N and with the altitudinal range of 0 – 1000m msl (Daniels, 1992). The ecological and biological information about the species is limited. Ecological studies of this species could unravel the important habitat characters that could be useful for their conservation.