# CHAPTER 1

## INTRODUCTION

Amphibians have always fascinated man through the ages, dating back to Mandukya Upanishad of the Vedic ages to the recent discoveries in many parts of the world. Frogs and toads, wakes up our memory lane with noisy calls as it dusks during monsoon.

The amphibians were the first terrestrial vertebrate, successfully colonizing the land during the late Devonian period i.e some 350 million years ago. They are believed to be evolved from a common ancestory of Sarcopterygian bony fish. The body structure of amphibians both past and present, shows the advances made over their fish ancestors. Their sound was probably the first vertebrate sound produced on the planet earth. As the first land animals with vocal cords, frogs "probably fathered all of the vertebrate music on earth", nature writer Edward Hoagland once reflected. Besides, they are also the first animals to possess ear drums.

Modern amphibians, called the Lissamphibia, means smooth skinned or scaleless amphibians (liss – smooth) appeared during the Triassic period and they have survived even today. Among the modern amphibians, Anura and Gymnophiona appeared during the early Jurassic period and Caudata during the middle Jurassic. *Triadobatrachus massinoti* is the earliest Lissamphibian fossil available from Madagascar (Piveteau, 1937).

Amphibians are the first vertebrates to leave the ancestral aquatic lifestyle to venture terrestrial mode. Anyway, their umbilical connection with water remained as they needed water to keep their eggs moist. Due to this dual lifestyle they are called as amphibian. The word 'amphibian' comes from the Greek "amphibious" (amphi meaning "of both kinds" and bios meaning "life"). Wake, a well known scientist in the field of herpetology believes that the dual ecological role of amphibians makes them excellent "bioindicators"- species whose fortunes reflect the general health of the environment. The lifestyle and physiology of amphibians combine to expose them to a vast array of environmental pollutants. For example, their eggs, which receive little physical protection, are highly sensitive to chemicals in water. This sensitivity persists into later life also, because a frog's skin is permeable, designed to absorb and release respiratory gases (Young, 1990). Their bimodal life and permeable skin make them vulnerable to environmental pollutants both in water and on land (Blaustein and Wake, 1990). They cannot let their skin dry and that they thrive best

in temperature regimes of 20-30°C certainly limit their geographic ranges (Duellman and Trueb, 1986). Some scientists believe that amphibians can be viewed collectively as a kind of 'global warning system', so that there decline is a serious matter for the planet. It therefore appears that a careful analysis of the patterns of distribution of these sensitive organisms might give us better insights into understanding how closely these organisms are tied to their habitats and other environmental factors.

Among the vertebrates, amphibians are the only class to have a free living tadpole stage and adult stage. They have developed a remarkable diversity in life histories by adapting to many different aquatic and terrestrial habitats. By the carboniferous period the amphibians had diversified greatly. Nevertheless, many of these forms have become extinct now. Hence, the present living species of Amphibia are but a fraction of what existed in the past. Today they are present on every continent except Antarctica, and can be found in almost all habitat types from dry, inhospitable deserts to lush tropical rainforest. The habitat preference of these cold blooded vertebrate varies from arid and swamp to permanent water. Though amphibians are found from equator to Arctic Circle, no species has a world wide distribution. According to Frost, (2007) the number of amphibian species till date is 6091 throughout the world, a number that changes often to reflect new and redefined species.

Amphibian species of world (Frost, 2007)

| | Families | Sub-family | Genus | Species |
|---|---|---|---|---|
| CAUDATA | 9 | 8 | 64 | 556 |
| GYMNOPHIONA | 3 | 2 | 33 | 173 |
| ANURA | 45 | 38 | 387 | 5362 |
| TOTAL | 57 | 48 | 484 | 6091 |

All the living amphibians throughout the world have been grouped in 3 orders, namely Caudata (Salamanders and Newts), Gymnophiona (Caecilians) and Anura (Frogs and Toads).

The order Caudata, in the Class Amphibia, is comprised of salamanders, newts, sirens, amphiuma, waterdogs, and mudpuppies. The term caudata originated from the Latin word for "tail" (cauda) and roughly translates to tailed-amphibian. There are about 556 recognized caudate species grouped into 9 families (Frost, 2007). All caudates, or urodeles, possess tails, a general characteristic that separates this order from Anura (frogs). Some living

caecilians, order Gymnophiona, also possess tails, but differ from salamanders in that caecilian tails are generally indistinguishable from the body, and are highly reduced compared to caudates. Caudates also possess four limbs of relatively equal size, with the exceptions of the Sirens, which lack hind limbs. Unlike the anurans, caudates do not leap to move from one place to the next, they rather walk or sometimes run (Deullman and Trueb, 1986).

The order Gymnophiona is comprised of caecilians, one of the three surviving orders of amphibians. Caecilians are unusual amphibians possessing reduced tails, segmented skin with tiny scales, powerful heads for burrowing, and acute olfactory systems. Caecilians actually resemble giant earthworms, rather than typical amphibians. Caecilians are found throughout most of northeast South America, a few patches in southeast Africa, and much of southern Asia (Hofrichter, 2000). Due to their burrowing, secretive and nocturnal habit they are encountered in the field only occasionally (Nussbaum and Wilkinson, 1989; Wilkinson and Nussbaum, 1989). Nevertheless, they are fairly common in certain habitats (Maurice and Burton, 1988; Nussbaum, 1992). In spite of Taylor's Monograph (1968) *The Caecilians of the World* giving summary of the existing literature and description of many taxa, the diversity of Caecilians remains poorly explored (Nussbaum and Wilkinson, 1989; Nussbaum, 1992; Ravichandran and Pillai, 1996).

The term "anura" roughly translates to "without a tail", and refers to the lack of tails in adult frogs. Anurans represent, by far, the most speciose, diverse, and widespread of the three extant amphibian orders. They are found throughout the world, except in polar regions, and some oceanic islands as well as extremely xeric deserts. The order anura includes frogs and toads. Technically, toads are anurans that possess extraordinary granulous skin that allows them to inhabit drier areas, and shorter hind limbs for "walking" instead of leaping. Frogs are perhaps the most recognizable amphibian species, with their long hind legs and ability to leap, and their great vocalization abilities (Cloudsley-Thompson, 1999). Forty-five families are currently recognized, representing more than 5,362 species, with more being discovered regularly (Frost *et al.*, 2006) and thus making the order Anura the largest of the three. The largest of the forty-five anuran families is Hylidae comprised of over 830 species, followed by Brachycephalidae at more than 803 species, and Bufonidae at more than 500 species. Sooglossidae, Scaphiopodidae and Rhinophrynidae are the smallest families. Not only the number of species is impressive but the variety in size, color, habitat and behavior of the frog is more interesting than we think. There are exceptions to the "typical" frog, as some have developed adaptations for fossorial, aquatic, and arboreal lifestyles. Some may be magnificently colored in bright reds, oranges, blues, pinks, and just about every other

color, while others may be subtle browns or greens. Many species can change their colors to better blend into their environment, or by chemical cues (Duellman and Trueb, 1986). Almost all frogs are expert swimmers and spend considerable time in water during their lifetime. But some species like American short headed toad refuses to enter water even to avoid predators as it cannot swim. Contradictory to this behavior, the members of the family Pipidae never leave water to enter land. Although majority of frogs are harmless to humans and other animals, members of the family Dendrobatidae possess poison-producing glands in their skin. This poison can paralyze and kill animals as large as monkeys. Frogs are usually found jumping and toads hopping. The common bull frog can jump nine times its own length, while the Goliath frog can jump up to three meters. The African red-banded frog neither jumps nor hops, it runs like a mouse (Zug *et al.*, 2001).

Most anurans have external fertilization, and adopt a mating posture called amplexus to insure contact between eggs and sperm. There are exceptions even to this rule of anuran reproduction, which points to the extreme diversity of reproductive modes found in these animals. The primitive mode involves large numbers of aquatic eggs and feeding larvae, however the alternate modes includes terrestrial eggs with aquatic larvae, direct development (in which there is no tadpole stage), viviparity, and non-feeding aquatic larvae (Mara, 1994). Approximately 10% of anurans exhibit some form of parental care. Additionally, many species are highly territorial, defending nests, oviposition sites, or other resources. Many temperate species breed "explosively," congregating in large numbers around water for only a night or two each year, during which time all mating takes place (Mattison, 1987). Whereas, some tropical species breed year-round. Anurans are found from tropical rainforests to dry mountaintops and from deserts to swamps. Adults may be arboreal, terrestrial, aquatic, or fossorial. Unlike caecilians and salamanders, no anurans are fully paedomorphic. Most anurans are nocturnal. In the winter, many temperate anurans enter a state of torpor to avoid freezing; in arid regions, frogs may bury themselves underground, or minimize the cutaneous respiration (and thus the water loss) that usually identifies frogs.

Amphibians are an important component in sustaining a stable ecosystem. Frogs and Salamanders often dominate the animal and plant communities on which they live. Tadpoles are major consumers of plant life, removing large quantities of algae from streams and ponds. Once they have metamorphosed into adult they become voracious carnivores that prey on wide range of insects and also other invertebrates (McDiarmid and Altig, 1999).

Seba (1735) is considered to be the founder of studies on amphibians and he named the first species as *Rana gibbosa*. Since the publication of the tenth edition of the 'Systema Nature' by Linnaeus in 1758, a remarkable number of species were discovered. Carolus Linnaeus (1758) first used the term amphibians for all the animals other than fish, birds and mammals. He considered both reptiles and amphibians as "foul and loathsome" animals and grouped them together. The name AMPHIBIA was restricted to frogs, toads, salamanders and caecilians by Latreille (1825).

**STATUS OF AMPHIBIAN FAUNA IN INDIA**: Amphibians survive best within an ambient or surrounding temperature range of $20^0$-$30^0$ C (Duellman and Trueb, 1986). The combination of the amphibian physiological requirements and environmental factors such as moisture, land as well as water and tolerable surrounding temperature have restricted the distribution of most species of amphibians to the warm and humid tropical parts of the world. Thus, of the total amphibian species of the world, more than 50% are tropical (Daniel, 2000). India is one of the 13 Biodiversity richest countries of the world (Mittermeier and Werner, 1990). However the biological wealth of India is still underexplored or unexplored except for large animals and flowering plants. There are more than 49,000 species of plants and more than 81,00 species of animals (Ministry of Environment and Forest, 2005-06) in India.

India has a rich and varied heritage of biodiversity encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. India accounts for 7-8% of the recorded global species with rich and interesting amphibian fauna (Ministry of Environment and Forest, 2005-06). About 50 million hectares of land has been estimated to be available as the habitats of amphibians (Pandian and Marian, 1985). The earliest study of amphibians in India was made by Günther (1858). Boulenger (1882, 1920) continued the work on amphibian and is considered a pioneer in the study of Indian amphibians. He published a series of papers especially on the taxonomy of Indian amphibians included in the Fauna of British India, including Ceylon and Burma. Later Fergusson (1904), Annandale (1907-1919), Rao (1915-1937), McCann (1932-1946), Myers (1942-1962) and many others contributed to the major works on Indian amphibian. In the later years Daniel (1953-1975) worked on taxonomy, ecology and distribution of Indian amphibians. Many others workers appended a number of papers on diverse aspects of Indian amphibians.

India reportedly harbours about 263 species of amphibians. This includes one species of salamander, 26 species of Caecilians belonging to 2 families and 4 genera and 236 species of frogs and toads belonging to twelve families and 49 genera (Inger and Dutta, 1986;

Dubois, 1992; Dutta, 1997; Dubois *et al.*, 2001; Alfred, 2002; Frost et al., 2007). In India, like most of the tropics, the precise number of species is not stable because new frogs are being discovered and many of the 'hidden names' are elevated to species status form synonymy at remarkable rate (Frost *et al.*, 2007). There is a high level of amphibian endemism occurring both at specific and generic levels in India (Inger, 1999). The Two major centers of distribution of amphibians with high species richness and endemism in India are the northeast India and the western ghats (Inger and Dutta, 1986; Myers *et al.*, 2000).

The Himalayan salamander (*Tylototrition verrucosus*) is the only species of salamander known from India. This tailed amphibian is endangered and listed in Schedule I of the Indian Wildlife (protection) Act of 1972. The species occurs from 1330-2220m in Darjeeling district of West Bengal; Sikkim, Khasi hills of Meghalaya, Kamalang valley in Lohit district of Arunachal Pradesh and Manipur (Deuti, 1996).

Of the 173 species of caecilians present throughout the world, 26 species belonging to 2 families and 4 genera are reported from India (Taylor, 1968; Bhatta, 1998; Bhatta and Prashant, 2004; Frost, 2007). A systematic study on caecilian ecology in India is limited to the studies of Gundappa *et al.* (1981), Balakrishna *et al.* (1982) and Bhatta (1997).

The largest of the three orders is the anurans which represents more than 225 species. This order is represented by 15 families. Rhacophoridae comprises the highest number of species followed by Dicroglossidae. Many of these species are endemic to India (BCCP CAMP, 1997).

Amphibian species of India (Frost, 2007)

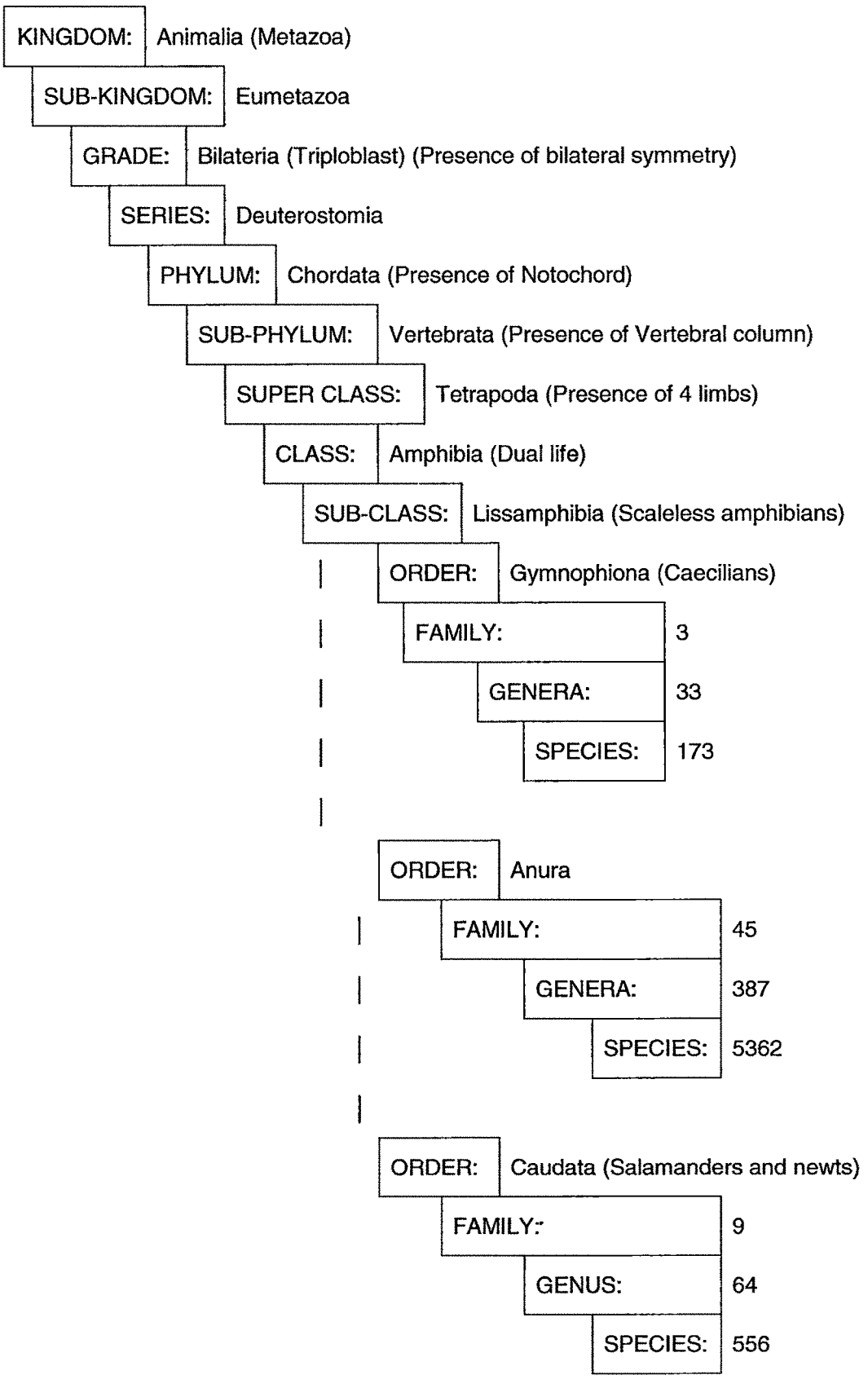
| | Families | Genus | Species |
|---|---|---|---|
| ANURA | 12 | 49 | 236 |
| CAUDATA | 1 | 1 | 1 |
| GYMNOPHIONA | 2 | 4 | 26 |
| TOTAL | 15 | 54 | 263 |

**STATUS OF AMPHIBIAN FAUNA IN GUJARAT:** Gujarat state has a great intrinsic variation in the pattern of vegetation in the different regions. It is one of the most diversified states with respect to its biodiversity. Various types of habitat from dry desert to moist decidous forests and seashore along coastal islands with mangrove forests and mud flats

are available. This provides a conducive environment for many organisms. The state is also the only home for the Asiatic Lion (*Panthera leo persica*) and Asian Wild Ass (*Equs hemionus khur*) in the subcontinent. The reptilian fauna of the state is represented by 107 species belonging to 21 families (Vyas, 2000), but the amphibian fauna is represented comparatively by less number of species.

The Amphibians are one of the poorly studied groups of fauna in Gujarat. They have been greatly neglected even in the fundamental works on Indian amphibians by Boulenger (1920). Very few reports are available on these groups of animals from the state. McCann (1938), Soman (1960) provided a short account of information regarding the amphibian fauna of Kutch. Later in 1963, Daniel and Shull provided a list of Reptiles and amphibians of South Gujarat. First detail and systemic study on amphibian in this region was initiated by Sarkar (1984), who reported the presence of 9 species. Further six more species were reported from the state in addition to the above list (Naik, 1984; Naik and Patel, 1986; Naik and Vinod, 1992). Later Naik and Vinod (1993) reported 15 species of amphibians from Gujarat. This checklist was updated again by Naik and Vinod in 1996, and reported the presence of 19 species. Of the 19 species recorded from Gujarat. (Naik and Vinod, 1996), none of them are endemic to Gujarat. Maximum number of species is recorded from the order Anura while only one species of caecilian *Ichthyophis bombayensis* is reported from Gujarat (Naik and Vinod, 1996; Vyas, 1996 and Pilo *et al.*, 2004; Vyas, 2004a).

## PHYLOGENY TREE OF AMPHIBIANS



## OBJECTIVES

The review of literature exemplified that previous studies on the amphibian fauna of Vadodara and its environs is very less except for few isolated reports (Naik, 1984; Suresh *et al.*, 2005). Moreover, no composite study either short term or long term had ever been carried out.

Amphibians are functionally important part of various habitats and are significant component of earth's biota, as they influence various trophic levels in the ecosystem either as a predator or as a prey. Knowledge about various species and their habitat is fundamental for understanding the intricacies of biological diversities. Thus the **first objective was to construct a qualitative and quantitative bio-inventory in and around Vadodara city, so as to determine the species richness, abundance and community structure of amphibians through space and time.**

Most amphibians have aquatic premetamorphic lifestages lasting from several days to few years depending upon species. Extended duration of the larval period thus puts amphibians at risk of a chronic exposure to aquatic pollutants (Rowe *et al.*, 2001). Further, the stresses incurred during the embryonic and the larval life stages reflect upon the growth and survival of animal (Dunson and Travis, 1991). Therefore **the second objective of the current work was to study the breeding biology of the two most commonly found species so as to understand the influence of the biotic and abiotic factors on the breeding success of these selected animals.**

There are ample evidences indicating decline in amphibian population throughout the world (Blaustein and Wake, 1990; Wake, 1991). Though there are several hypothesized causes for recent amphibian declines, there has been widespread controversy about their relative significance in effecting amphibian population decline (Pechmann *et al.*, 1991; Pechmann and Wilbur, 1994; Alford and Richards, 1999; Blaustein and Keisecker, 2002). However, habitat destruction, pollution and infectious disease are the only few largely accepted causes for decline of amphibians globally. Hence, **the final objective of the present study was to analyze the role of aquatic pollution, in the decline of amphibian fauna, if any, and the prevalence of infectious disease Chytridiomycosis at the selected sites.**