# GENERAL CONSIDERATIONS

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The word reptile has come from the Greek word 'Reptilia' (Latin 'Repere' meaning 'to creep') which means 'creatures that creep and crawl with the support of their belly'. Previously misunderstood and grouped with amphibians by Linnaeus (1758), Laurenti (1768) delinked them into a separated class named 'Reptilia' that included the tetrapods that were neither birds nor mammals.

The evolutionary history of reptiles dates back to the Upper Carboniferous or Pennsylvanian period about 260 million years ago when they are believed to have evolved from some lineage of Urodele amphibians (Owen, 1862; Carroll, 1964; 1969; 1970; Laurin and Reisz, 1995). Reptiles were the most dominant forms of vertebrate life on earth from 140 to 120 million years ago, when they ruled the Mesozoic Era of the earth history. The Mesozoic Era is hence marked as the 'Age of Reptiles' (Colbert and Morales, 2001). Most of the reptilian orders were established by the end of the Triassic period and some became extinct too by that time (Smith, 1933), however presently out of the 19 orders into which the prehistoric reptiles were classified only 4 orders survive (Gunther, 1864; Boulenger, 1890; Smith, 1933). Modern reptiles appeared during the Tertiary period on the geological time scale around 70 million years ago (Carroll, 1994; 2001). The species richness of the extant reptiles accounts for 7,427 species (Cogger *et al.*, 2003) and yet many more awaiting their recognition to science, the number is almost double the mammals known today and not to the surprise half the number of living reptiles are lizards (Bauer, 2003).

Lizards along with snakes belong to order Squamata, a group of fascinating reptiles but still a poorly studied group. Review of literature revealed that a plethora of taxonomic and anatomical studies have been done on the global scale (Owen, 1859; 1860; Baur, 1887; Osborn, 1903; Williston; 1917; Romer; 1966; Gaffney, 1980; Gauthier *et al.*, 1988a; 1988b; Benton, 1990a; 1990b; 1991; 1997; Lee, 2001), so also are the studies done on the ecological aspects (Elton, 1946; Rand, 1964; Pianka, 1967; Sage, 1973; Maragou *et al.,* 1997; Smith and Engeman, 2003). Looking into the Indian scenario since the early nineteenth century till date, many herpetologists have contributed to the knowledge of understanding of reptiles of India (Blyth, 1853; Gunther, 1864; Blandford, 1870; Jerdon, 1870; Boulenger, 1890; Annadale, 1915; Brander, 1923; Underwood, 1948; Biswas and Sanyal, 1977; Daniel, 1983; Das, 1992). Das in 1997a prepared the first comprehensive checklist of reptiles of India and reported about 484 species of reptiles with further 24 subspecies under some of the species to occur within the Indian sub-continent. Further narrowing down to the scope of study in the state of Gujarat, it was evident that many workers have actively contributed to the knowledge of herpetofauna of Gujarat, but the information available is still patchy and incomplete (Stolickza, 1872; Gleadow, 1905; Smith, 1935; McCann, 1938; Kapadia, 1951; Daniel and Shull, 1963; Bhaskar, 1978; Sharma, 1981 and 1982; Daniel, 1983; Vyas, 1988; Vyas and Patel 1990; Naik and Vinod, 1993; Vyas, 1998; 2000). Majority of the studies are on the taxonomy and range extension of species (Sharma, 1981; Vyas 1987a and 1987b, Vyas 1988, Vyas and Jala, 1988, Bhatt; 1989; Verma, 1989; Vyas, 1990; Vyas and Patel, 1992; Naik and Vinod, 1994; Vyas, 1998; 2000), however much less emphasis has been laid on the behaviour, ecology and conservation of reptiles in Gujarat. Fewer studies encompassing behavioural ecology and conservation of species are available and that too are limited mainly to the orders Chelonia and Crocodilia (Joseph *et. al,* 1975; Oza, 1975; Fraizer, 1978; Whitaker, 1978; Chavan, 1979, Bhaskar, 1981a and 1981b; Fraizer, 1989a and 1989b; Bhupathy *et. al*, 1992). Lizards however, have been an ignored group right from the beginning. Though many lizards exist as human commensals and their presence is not much of a botheration to man, studies on the ecobiology of lizards in India are scanty and far from complete especially in Gujarat. Hence, the present study was conducted with an objective of highlighting the significance of reptiles in our surroundings, their microhabitat utilization and the ecological services rendered by these cryptic creatures. The study principally focuses on the secretive life of the lesser known reptiles 'Lizards'.

Role of lizards in the environment as biological pest control agents has never been recognized or highlighted. Lizards are chiefly insectivorous feeding upon many pest species of insects that are either forest pests or agriculture pest. Due to this negligence towards lizards, their diversity in a given ecosystem remains poorly explored. Thus, the first objective of the study was to conduct a qualitative bio-inventory covering the major biogeographic zones of Gujarat, so as to determine the species richness and distribution of lizards (chapter 4). As mentioned earlier, emphasis has hardly been laid on Squamates and the studies involving their behaviour, ecology and conservation are also limited (Sharma, 1982; Knapp, 2004; Dutta and Jhala, 2007) providing a very scanty information. Therefore, the second objective of the current study was to analyze the community structure of lizards vis-à-vis their microhabitat requirements (chapter 5). Species that exist as human commensal have gained a wide interest amongst biologists and studies ranging from their morphology up to molecular level have been conducted on these species (Asana, 1931; Sharma, 1990; Sharma, 1991; Pilo and Suresh, 1994; Pilo and Kumar, 1995; Shanbhag, 2003; Yadav *et al.* 2008). However, some of the common and widely occurring species surprisingly remained unnoticed by herpetologists. One such vivid species was the Fan-throated lizard – *Sitana ponticeriana,* an agamid lizard that was common and widespread throughout the state of Gujarat. Hence, the third and the final objective was to study in detail the ecobiology of one the most common and widespread, yet least attended, agamid lizard the Fan-throated Lizard – Sitana ponticeriana (chapter 6).

As mentioned earlier the published literature revealed a huge lacuna in the ecological studies on the reptiles of Gujarat. Gujarat, the western most state of India is located between 22.40° N to 70.75° E. Gujarat has a very strategic location from the biogeographic point of view as the state covers four biogeographic zones of India i.e. 40% of the total biogeography is represented in the state (Rodgers *et al,* 2002). Reconnaissance surveys were conducted in the major part of the state for documenting the diversity of lizards and their distribution within the state. Further based upon these surveys the sites for the intensive study were selected. Four Intensive Study Areas (ISAs) were selected based upon their topography and landuse patterns. First Intensive Study Area (ISA-1) was Pavagadh Hill forest, located in Panchmahal district of central Gujarat, East of Vadodara city, the second study site (ISA-2) selected was a patch of open scrubland, in Sindhrot village of Vadodara district, central Gujarat, West of Vadodara city. The third study area (ISA-3) was the Vadodara city and the fourth site (ISA-4) was small patch of scrubland near Naliya in Kutch, the arid zone of the state. Each of the selected sites was thoroughly surveyed for their saurian diversity and the habitats were also critically examined for their floral characteristics. Abiotic components such as ambient temperature and humidity were recorded on a periodic basis. Moreover, soil parameters were also evaluated while studying the biology of *Sitana ponticeriana.*

Periodic field visits (weekly/monthly) in all the seasons were made to all the selected sites. Various methods and techniques were employed for recording the reptilian diversity and sampling their population through time and space. Visual Encounter Survey (VES) was primarily used to prepare a checklist for the intensive study areas (ISAs). Transects (Line or Belt Transect) and quadrat sampling were used for a systematic sampling of the lizard communities at various study sites. The time of the day selected was during period of maximum reptilian activity. Identification of the species was done using standard monographs (Gunther, 1864; Boulenger, 1890; Smith, 1935; Daniel, 2002 and Das, 2008). Ecological parameters such as diversity, dominance, evenness, ecological distribution, niche breadth and niche overlap of lizard assemblages at all the selected sites were studied using the formulae from Krebs (1999). The results obtained were computed and analyzed using standard statistical software BD Pro Version 2.0 and EcoSim.

While conducting the study on the community structure of lizards it was observed that *Sitana ponticeriana,* widely occurred in all the study sites and in particular ISA-2 had a good density of this species and thus this study site was further selected for the detailed studies on the ecobiology of *S. ponticeriana.* Studies involving morphometry, behaviour, ecology, breeding biology and population density were conducted on *S. ponticeriana* in its natural habitat i.e. ISA-2.

Lizards undoubtedly are the most numerous amongst all the extant reptiles. As proposed by Pianka and Vitt (2003) lizards truly are the windows to the evolution of diversity. Ranging from a small gecko, *Sphaerodactylus parthenopion* – Monito Gecko with the total length of 34 mm (1½ in, wt: 0.12 g; the smallest of all the lizards and also the smallest reptile) to the monsters of Komodo Islands, *Varanus komodensis* – Komodo Dragon with the total body length reaching maximally up to 310 cm (10¼ ft) and weighing up to 165 kg (Bauer, 2003), lizards exhibit a variety of forms and functions. They have occupied almost all landmasses except Antarctica and some Arctic regions of North America, Europe and Asia. Of the 4,300 species of extant lizards (Bauer, 2003), 484 species are known to occur in India (Das, 1997a), of which 39 species of lizards belonging to 8 families and 19 genera are so far been reported from Gujarat. The saurian diversity in Gujarat accounts for only 0.9 % of the global lizard diversity and 8% of the Indian lizard diversity. According to Vyas (2000) the list of lizards for the state is 36 species grouped under 19 genera and 8 families. Although new records were subsequently added for the state thereafter (Vyas, 2003; Vyas *et al.,* 2006; Giri, *et al.,* 2009) the checklist was never upgraded for the past decade. However, in the current study 30 species grouped under 15 genera and 8 families were recorded from the state.

The species composition within the families showed that family Gekkonidae was the most dominant and accounted for 37% of the total species richness, followed by families Agamidae and Scincidae that accounted for 17% of the total richness while family Chamaeleonidae, Eublepharidae and Uromastycidae were represented only by one species for each family (Fig. 4.1). Families Agamidae, Gekkonidae and Scincidae were found to be cosmopolitan in distribution within the state whereas families Eublepharidae and Uromastycidae were restricted to Kutch and Saurashtra regions only. Family Chamaeleonidae represented by a single species *Chamaeleo zeylanicus* was found to be cosmopolitan in distribution and reported occupying all the arid and semi-arid regions across the country including Gujarat (Daniel, 2002; Das, 2008). Members of the family Lacertidae in the current study were recorded only from Kutch (Table 4.2), but the available literature also reveals their occurrence in part of Saurashtra (Sharma, 1982) and central Gujarat (Vyas, 2003). Family Varanidae was represented by two species *Varanus bengalensis* and *Varanus griseus*; the former exhibited its distribution throughout the state while the later had its range restricted to the desert of Kutch and arid parts of north Gujarat (Table 4.2).

Modern lizards are represented in three major lineages, the Iguania, Gekkota and Autarchoglossa (Bauer, 2003). These three lineages are further subdivided into a total of 19 families of extant lizards across the globe. Of these 19 families of lizards, 10 families are known to occur in India and 8 families are reported from Gujarat. The remaining two families that do not occur in Gujarat or in the western India are family Anguidae restricted to Northeast India and family Dibamidae comprising of Worm Lizards so far reported only from one island of Nicobar. Therefore, taking into account the evolution and biogeography of each of the three major lineages, one can authoritatively say that lizards are the most diverse vertebrates and are widely distributed on this planet.

**Iguania**

The iguanians include the agamids, chamaeleons, pleurodont iguanas and spiny-tailed lizards that are fully limbed and visually well oriented. Crests, fans and dewlaps are common morphological features in this group. Iguanid lizards are chiefly New World relatives of agamids and chamaeleons and are absent from major part of Old World except for the five species occurring on the oceanic islands of Fiji and Tonga in the Pacific and seven species inhabiting Madagascar, where agamids are absent (Bauer, 2003). In the current study family Agamidae was represented by five species while family Chamaeleonidae as mentioned earlier has got only one member in the Asian part i.e. *Chamaeleo zeylanicus*. Family Uromastycidae that includes the spiny-tailed lizards has recently been separated from Agamidae based upon the molecular analysis of their mitochondrial genes (Bohme, 1982) and was recorded with a single species occurring in Gujarat.

**Gekkota**

The gekkotan lineage is represented by only three extant families, the Eublepharidae, Gekkonidae and Pygopodidae. Gekkotans are mostly nocturnal, and the replacement of movable eyelids with fixed transparent spectacle characterizes most species of this group. Pygopodids or commonly called as flap-footed lizards are strikingly dissimilar in overall appearance to their other two allies in having extremely long bodies and reduced limbs and thus remarkably resembling snakes. Pygopodidae members are by and large endemic to the Australian region and one species is restricted to New Guinea (Bauer, 2003). The other two families of the gekkotan lineage namely the Eublepharidae and Gekkonidae are widespread in their distribution, occurring in all the continents except for Antarctica. As mentioned earlier in the present study family Eublepharidae was represented by only one species while Gekkonidae was the most dominant group and was represented by 11 species.

**Autarchoglossa**

The Autarchoglossans are a complex group compared to the other two lineages. Few generalities can be applied to the group as a whole, but many species have osteoderms (bony plates) in the skin, and most rely heavily on chemical cues in their environment (Bauer, 2003). These lizards are mostly terrestrial, burrowing or living among rocks and due to the complexities of this lineage, Autarchoglossa is further divided into two subgroups namely the **Anguimorpha** and the **Scincomorpha.** The Anguimorphs are represented by five distinct types (i.e. five families) that include the anguids, beaded lizards, the earless monitor, true monitors and knob-scaled lizards. The second subgroup Scincomorpha is even more diverse than the Anguimorpha and therefore the relationships among this lineage have not been fully studied. The Scincomorphs account for nearly half the species of all lizards and the families included are Cordylidae, Dibamidae, Lacertidae, Scincidae, Teiidae, Gymnopthalmidae, and Xantusiidae. In the present study the Anguimorpha subgroup of the lineage Autarchoglossa was represented only by the family Varanidae with two species, whereas the Scincomorpha subgroup was represented by the families Lacertidae and Scincidae with four and five species respectively.

Therefore, in the current study an upgraded checklist of lizards of Gujarat based upon the field surveys and reviewed literature was prepared and is presented herein Table 4.3. Apart from the direct sightings the species that have been included in the list, from reviewed literature, are marked with '*' and need a confirmation of their record within the state limits. The records of these species are very old, dating almost a century ago and since then none of the herpetologists in the state have given any authentic records for the occurrence of these species in Gujarat. According to the upgraded checklist (Table 4.3) families Gekkonidae and Scincidae are equally dominant with same number of species in both the families and the proportion of diversity accounting for 31%. The next dominant family was Agamidae with the proportional diversity of 15% whereas families Chamaeleonidae, Eublepharidae and Uromastycidae were recorded to have only one species in each of the family. Figure 4.2 shows the percentile diversity of lizards within the Gujarat state. Moreover, lizards though being the most diverse and commonest of the reptiles have always received least attention from humans. A testimony to this is the identification key to snakes, a less common reptile than lizard, generated by Vyas (1996). Though, he has contributed many additions to the knowledge of lizards, an identification key to the lizards of Gujarat is left unattempted. Hence, efforts were made to develop an identification key to the lizard families and species occurring in the state of Gujarat.

As far as the ancient records are concerned, particularly the records of certain skinks namely *Ablepharus grayanus, Eumeces schneiderii, Eumeces taeniolatus* and *Ophiomorus tridactylus* by Stoliczka (1872) from Kutch need a thorough confirmation. Additionally *Ablepharus grayanus*, *Eumece staeniolatus* and *Ophiomorus tridactylus* were also recorded by McCann (1938) however, the later surveys conducted by Sharma (1982) and Vyas (2002) did not record any of these skinks from Kutch. These species were not recorded even in the present study. One more interesting observation was of *Ophiomorus tridactylus,* essentially a sand dune species commonly known as Indian Sand-swimmer, when surveyed in the entire Kutch desert was never encountered in any sand dune habitats and hence, possibility of occurrence of this species within Gujarat is nil. Although Das (2008) has reported occurrence of another sand dwelling skink namely *Ophiomorus raithmai* – Indian Sandfish to be present in Gujarat but confirmation of both these species of genus *Ophiomorus* occurring in Gujarat is strongly recommended. If looked into the records by Stoliczka (1872) and McCann (1938), it is revealed that both these records are prior to independence. Perhaps at that time the political boundaries were not correctly/clearly defined and the Rann of Kutch had its extension further into Pakistan. The area was known as the 'Cutch Province' or 'Cutch State' which could be the reason for these skinks to be recorded from Kutch area. Similarly, Murray (1886) had recorded *Trapelus agilis*– Brilliant Agama from Kutch but after Murray there is no record of occurrence of this species from Kutch and therefore it is strongly believed that *Trapelus agilis* does not have its distribution in Gujarat. Theobald in 1868 had suggested to group genera *Uromastyx* and *Liolepis* into a separate family 'Uromastycidae' however, his scheme of classification was not widely accepted then until Bohme (1982) reviewed back the family status as Uromastycidae. Even then the separation of the family Uromastycidae was not widely accepted and based upon molecular data (Honda *et al.,* 2000) the family was still considered as a subgroup under Agamidae. Further evaluating the molecular data from the genus *Liolepis* Aranyavalai *et al.,* (2004) again suggested the occurrence of the separate family Uromastycidae. Inspite of the fact that the results presented by Aranyavalai *et al.,* (2004) were accepted by many workers (Grismer *et al.,* 2007; Das, 2008) the separate existence of the family Uromastycidae is still a topic of debate amongst the reptile taxonomists.

Like the spiny-tailed lizards and their new family Uromastycidae, leopard geckos of the family Eublepharidae were also under taxonomic disarray for a long period of time. Leopard geckos or Fat-tailed geckos, as commonly called, were earlier classified alongwith other geckos under family Gekkonidae, though leopard geckos markedly differ from other geckos by a key phenotypic character of possessing fleshy movable eyelids as against the immovable transparent spectacle in other geckos. Boulenger (1885) had grouped leopard geckos into a separate family Eublepharidae but again that was not agreeable to many and the family was considered as subfamily Eublepharinae under family Gekkonidae (Gadow, 1901; Smith, 1935; Underwood, 1948; Anderson and Leviton, 1966; Nader and Jawdat, 1976; Singh, 1984; Baloutch and Thireau, 1986) till Grismer (1988) revealed the phylogeny of eublepharine geckos and restituted the existence of the separate family Eublepharidae. Smith (1935) had described two species of eublepharids from India namely *Eublepharis hardwickii* and *Eublepharis macularis*. Borner (1976) reported occurrence of two subspecies of the species *Eublepharis macularis* namely *Eublepharis macularis macularis* and *Eublepharis macularis fuscus.* The systematic status of *Eublepharis macularis fuscus* was then resolved by Das (1997b) and this subspecies was elevated to the level of species now known as *Eublepharis fuscus* through critical examination of certain morphological characters that differ from *Eublepharis macularis*. Grismer (1988) has suggested allopatry between these two western

Indian species of eublepharids and the distribution pattern revealed that the Rann of Kutch acts as a barrier for both the southern populations of *E. macularis* (on the eastern bank of the Indus, southeastern Pakistan) and northern populations of *E. fuscus* (in Kathiawar peninsula, Gujarat state, western India) (Das, 1997b). Although now established that the eublepharine member occurring in Gujarat is *Eublepharis fuscus,* the status of *E. macularis* remains unevaluated for the Gujarat region and hence the possibility of occurrence of *Eublepharis macularis* in some parts of Kutch adjacent to the border areas close to Pakistan cannot be ruled out.

As far as the largest lizard family is concerned, family Scincidae, the commonly encountered members belonged to genera *Lygosoma* and *Mabuya.* Both these genera are cosmopolitan in their distribution, the molecular evidences suggested monophyly of the Asian members of the group *Mabuya* and thereby all the Indian members of the lygosomind scincid genus *Mabuya* were transferred to genus *Eutropis* by Mausfeld and Schmitz (2003). We also adopted the change in the nomenclature and included the same in the upgraded checklist as presented herein Table 4.3. Genus *Eutropis* (=*Mabuya*) is relatively diverse in terms of number of species with nearly 28 members in India and other parts of south Asia (Utez, 2009).

Auffenberg *et al.,* (1989) reported occurrence of *Varanus flavescens* – Yellow Monitor Lizard from Gujarat. But Tikader and Sharma (1992), Daniel (2002) and Das (2008) have reported the range of the species in the Gangetic Plains, from Punjab to Bengal and therefore the record by Auffenberg *et al.,* (1989) could be a chance observation that needs a confirmation. In the present study also *Varanus flavescens* was never encountered in any parts of Gujarat and it was considered that the species does not have its distribution in Gujarat.

Taking into account the conservation scenario of lizards in Gujarat, Figure 4.4 shows the status of lizards in Gujarat as evaluated through the Conservation Assessment and Management Plan (C.A.M.P.). A workshop was conducted under the Biodiversity Conservation Prioritization Project (BCPP) jointly organized by the Zoo Outreach Organization and Conservation Breeding Specialist Group (CBSG) in 1998. It was evident from the BCPP-CAMP report (1998) that the only species of lizard which was under a taxonomic debate *Eutropis allapallensis* was reported to be endangered from Gujarat. 28% of the species are Data Deficient, which clearly indicated lack of knowledge about the ecology and biology of these species. In addition to this 10% of the species have never ever been evaluated for their status which again indicated huge lacunae in the knowledge regarding these species. Therefore, considering the diversity of lizards in Gujarat and the quantum of available literature, one can infer that lizards have always received negligence from humans, biology of majority of the species is not known and their status remains unevaluated for more than a decade.

On the completion of the inventory studies on the lizards of Gujarat state, further studies on the community structure of lizards in the selected intensive study sites (ISAs) were carried out. Lizards have proven to be ideal organisms for ecological studies, largely because of their basic traits and remarkable diversity (Pianka and Vitt, 2003). Moreover, being ectotherms and often abundant, lizards are relatively easy to locate, observe and capture, thus simplifying the ecological studies. They are conspicuous components of most natural communities, especially those in warmer parts of the world and thus have always gained a wide interest from ecologists (Elton, 1946; Rand, 1964; Pianka, 1967; Sage, 1973; Maragou *et al.,* 1997; Smith and Engeman, 2003).

An ecological "community" consisting of all the organisms that live together at any given habitat can be visualized as a complex network of interacting species (Pianka, 1973). Several properties at the community level emerge from these interactions, which include trophic structure, energy flow, species diversity, relative abundance and community stability (Pianka, 1973). In practice, ecologists are usually unable to study entire communities, instead often focus on some convenient and tractable subset (usually taxonomic) of a particular community or series of communities. Lizard communities for instance, could be compartmentalized into guilds for convenience. Guild concept is applicable to a group of functionally similar species that exploit the environment (use specific niche axes) in similar ways (Pianka, 1966; 1969b; 1971a; 1972). The numbers of species coexisting within communities exhibit a separation in their guilds for example, diurnal terrestrial insectivorous lizards constitute a guild distinct from diurnal arboreal insectivorous lizards. Both these are different from guilds represented by nocturnal or fossorial or herbivorous lizards (Pianka and Vitt, 2003). However, the structure of lizard communities defined as simplest (and perhaps least interesting) would have assemblages with more accurate description (Pianka, 1973). Thus examination of simple lizard communities often allows an investigator to determine underlying causes of structure with minimum number of extraneous variables, whereas examination of more complex system provides a means to assess the importance of often more obscure variables. Finding ways of simplifying communities for more thorough understanding remains a considerable challenge in the emerging field of community ecology. And therefore defining and examining niche axes of component species (in this case lizards) is a good start because it allows to make direct comparison among species on various dimensions.

Studies on the community structure of lizards were performed in four selected ISAs as mentioned earlier. The areas were selected based upon their topography and landuse pattern (refer chapter 2). Various properties of the community such as diversity, dominance, evenness, ecological distribution, niche breadth and niche overlap of lizard assemblages at all the study sites was worked out using the formulae from Krebs (1999). The results so obtained were computed and analyzed using standard statistical software BD Pro Version 2.0 and EcoSim.

The extensive field studies conducted for the period of two years (2007-2008) in all the selected ISAs generated a quantum of data which was further analyzed for the various ecological parameters. Before proceeding with the ecological parameters it was essential to examine whether the sampling done for all the ISAs was sufficient enough to give desirable results. Therefore, a Rarefaction analysis was performed to check the quantum of sampling and Figure 5.5 shows that the rarefaction curves have reached their asymptote for all the selected ISAs thereby indicating sufficient sampling. Knowledge of taxonomic assemblages in the community is required to move ahead with the ecological studies. Thus, it was felt mandatory to have a comprehensive survey through all the selected ISAs for the presence of diverse taxonomic groups of lizard that they harbour. A total of 21 saurian species belonging to 8 families were recorded from all the four ISAs, Table 5.1 presents the percentage species richness as observed for all the ISAs. Figure 5.6 reveals the species richness within the families moreover, two of the lizard families namely Lacertidae and Uromastycidae were found to be exclusive to ISA-4. It was also clearly evident that ISA-4 was the most diverse of all the communities (i.e. selected ISAs) with a maximum of 17 species occurring therein and therefore the species richness being highest for ISA-4 (Table 5.1, Figure 5.6). Based upon the percentage species richness and the periodic sampling in all the study sites, percentage occurrence of each of the lizard species during the study period was worked out (Table 5.2). Depending upon these values the frequency of occurrence of each of the lizard species in the selected ISAs was determined (Table 5.3). Thereafter, habitat preference and the microhabitat choice of each of the lizard species in its given habitat were documented and the results of the same are presented in Table 5.4 and Table 5.5 respectively. Ecological parameters *viz.* species uniqueness, diversity, evenness, dominance, similarity coefficient and coefficient of community were calculated using standard formulae and the computational analysis was done using the statistical software BD Pro Version 2.0. The results of these parameters as presented in Table 5.6 revealed that ISA-4, the scrubland patch in the arid zone was the most diverse of all the selected ISAs. Of the 8 lizard families recorded during the current study, members of three families namely Eublepharidae, Lacertidae and Uromastycidae were recorded only from ISA-4, thus making this area unique in terms of its species richness and diversity. Looking into the evenness amongst the habitats it was observed that the equitability values showed a complete evenness between ISA-2 (rural scrubland) and ISA-4 (scrubland in Kutch), while ISA-1 has the highest index value and lowest value is for ISA-3 (Table 5.6). The possible explanation for this could be that both ISA-2 and ISA-4 are scrubland habitats; although these areas differ in their climatic condition and the floral diversity, more or less the physiography is similar with few plant species being common and no big trees in the area. Therefore, the distribution of the species is horizontal in contrast to ISA-1, which is a forest area with a good density of large trees and provided a scope for both horizontal as well as vertical distribution of the species and hence has a higher index value (Table 5.6). Values of dominance index were surprisingly higher for ISA-3 (Table 5.6; Figure 5.9), this could be explained in a way that since ISA-3 offered narrow range of microhabitats and therefore the species that could maximally exploit these microhabitats occurred in large numbers. Moreover, ISA-3 being an urban environment under complete human influence, harboured few human commensals which were well adapted to the urban habitat. Two of the human commensals namely *Hemidactylus flaviviridis* and *Calotes versicolor* were present in large numbers in ISA-3 and thus dominated the entire community.

The relative similarity between the communities (study sites) is measured through the Jaccard's similarity coefficient '$SC_j$' and the Coefficient of community 'C'. Table 5.7 and 5.8 present the results of similarity coefficient and coefficient of community respectively. It is evident from the results that ISA-1 and ISA-4 were the least similar habitats ($SC_j$ – 0.3333 and C – 33.20) with only 7 species common between them. The maximum similarity was observed between the other three sites i.e. between ISA-1 and ISA-2 $SC_j$– 0.909; between ISA-2 and ISA-3 $SC_j$– 0.9 and between ISA-1 and ISA-3 $SC_j$– 0.8181. It was observed that most number of species (10) were common to both ISA-1 and ISA-2 and similarly between

ISA-2 and ISA-3 maximum number of species (9) were common. Taking a closer look at the results one can also say that ISA-2 and ISA-3 appeared to be the subsets of ISA-1. The coefficient of community was also observed to be least between ISA-1 and ISA-4 (33.20%) and maximum between ISA-2 and ISA-3 (76.86%).

Further, multivariate analysis done through the Principal Component Analysis (Figure 5.10) and the Bray-Curtis Cluster Analysis (Figure 5.11) revealed that ISA-1 and ISA-4 were entirely different in their physiography and climate thus was separated widely. ISA-2 and ISA-3 had much similarity in their climate, though not in the physiography and moreover these areas (ISA-2 and ISA-3) also had a varying degree of anthropogenic pressure influencing the habitat, hence these are closely placed (Figure 5.10 and 5.11).

**Niche Breadth**

Table 5.9 presents comprehensive results of niche breadth of all the lizard species recorded at all the study sites. The results revealed that *Uromastyx hardwickii* had significantly narrow niche breadth possibly because *U. hardwickii* was the only herbivorous lizard recorded in the study area. Varanids too had a significantly narrow niche breadth. This could be attributed to the fact that these lizards largely consumed small vertebrates and their eggs in contrast to the insectivorous diet of other smaller lizards. Niche breadth was broader in case of *Cyrtopodion kachhensis* indicating that the species exploited maximum resources in its habitat.

**Niche Overlap**

To ascertain the community structure in holistic way, analysis of niche overlap was necessary. Niche overlap was calculated for each of the study sites (ISAs) using standard index. Table 5.10 depicts the niche overlap at ISA-1, wherein a significant overlap was observed between *Calotes versicolor* and *Sitana ponticeriana* and between *Calotes versicolor* and two of the skinks namely *Mabuya carinata* and *Mabuya macularia*. However, any concrete conclusion can be drawn only after a thorough analysis of spatial and temporal niches. Least overlap was observed for *Chamaeleo zeylanicus* with majority other lizards (Table 5.10). *Varanus bengalensis* had a significantly low niche overlap and as explained earlier, *V. bengalensis* being a large lizard has an entirely different prey composition and thus hardly any competition over the resources is observed. The niche overlap scenario is fairly comparable for other study sites too, especially ISA-2 (Table 5.11) and ISA-3 (Table 5.12) wherein a near identical picture could be seen. For ISA-2 and ISA-3 *Hemidactylus* *flaviviridis* occurs in sympatry with *Hemidactylus leschenaultii,* while *Mabuya carinata* is found to be sympatric with *Mabuya macularia* in ISA-2. Looking into the niche overlap results for ISA-4 (Table 5.13), it was evident that a significant overlap occurred between agamids, geckos, lacertids and the two species of varanids (Table 5.13). *U. hardwickii* and *Varanus sp.* also showed a significantly low niche overlap.

The number of species coexisting within communities can differ in four distinct ways: **a.** more diverse communities can contain a greater diverse variety of available resources, and /or **b**. their component species may, on the average, use a smaller range of these available resources (the former corresponds to "more niches" or "more niche dimensions" and the latter to "smaller niches". **c.** Two communities with identical range of resources and average utilization patterns per species can also differ in species density with changes in the average degree of overlap in the use of available resources; **d.** finally, some communities may not contain the full range of species they could conceivably support and species density might then vary with the extent to which available resources are actually exploited by as many different species as possible (Pianka, 1973). In the current study also we observed that of the four selected ISAs, ISA-4 was the most diverse community and offered a vast diversity of resources, followed by ISA-1. Both these areas (ISA-1 and ISA-4) were found to have a broad range of resources both in terms of space and food that a species could exploit and therefore partitioning of the resources is quite obvious. ISA-2 and ISA-3 were having a fairly identical range of resources and the utilization patterns of the species therein were also similar thus indicating an average degree of overlap. ISA-3 being an urban environment offered limited scope of resource exploration to a given species and therefore only adaptive species or the species that are established as human commensals thrived well in this habitat.

The use of space varies widely among lizard species. A few are entirely subterranean (fossorial), many others are completely terrestrial, while still others are almost exclusively arboreal (Pianka, 1973). Varying degrees of semi-fossorial and semi-arboreal activities are also known (Pianka, 1973). Similar results indicating subtle differences in the use of shrub canopy occur among some of the arboreal lizards like *Anolis* (Rand, 1964; Rand and Humphrey, 1968; Schoener, 1968; Schoener and Gorman, 1968; Schoener, 1970). Some lizard species in the present study were strongly restricted to a rock-dwelling (*Cyrtopodion kachhensis*), bark-dwelling (*Hemidactylus leschenaultii*) or mid-shrub canopy (*Chamaeleo zeylanicus*) existence. In addition to such microhabitat specificity, various species have specialized in their habitat requirements. Moreover, foraging space is also a part of the habitat and needs to be taken into consideration. For instance, some terrestrial lizards forage primarily in the open areas between plants, whereas others forage mainly under or within plants (Pianka, 1969a). Therefore, where exactly in the environmental mosaic does lizard forage, as well as its mode of foraging in the space, is perhaps an important ecological attribute (Pianka, 1973).

Ecologists have built a strong case for the importance of food as the primary resource for many species (Hairston *et al.*, 1960; Lack, 1954). Substrate preferences (microhabitat segregation) are often important determinants of the food eaten by a species (Pianka, 1966). Even differences in the foraging modes are also closely related with both the substrates and food exploited (MacArthur, 1958). Lizards exhibit plasticity in their foraging behaviour (Huey and Pianka, 1981) and are specialized in exploiting the food species as well as substrates in their respective habitats (Pianka, 1966). Most lizards are insectivorous and fairly opportunistic feeders, consuming without any obvious preference whatever arthropod they encounter with a broad range of types and sizes. Smaller species or individuals, however, do tend to eat smaller prey than larger species or individuals (Hotton, 1955; Schoener, 1967; Schoener and Gorman, 1968). In the current study significant niche overlap was observed amongst skinks (*Mabuya carinata* and *Mabuya macularia*), geckos (*Hemidactylus flaviviridis* and *Hemidactylus leschenaultii*), between the lacertids (*Ophisops jerdonii* and *Ophisops microlepis*) as well as between the varanids (*Varanus bengalensis* and *Varanus griseus*), indicating these species to be sympatric and hence resource partitioning between these species and the groups needs a further evaluation. *Uromastyx hardwickii,* the only herbivorous lizard recorded in the study had a marginal niche overlap with other lizards occurring in the area that too mainly during the dry season when *U. hardwickii* shifted to insectivory from herbivory. Therefore, thorough studies on the niche dimensions of *U. hardwickii* are highly warranted.

Spatial niches and food niches of lizards change in time, both during the day and with the seasons (Pianka, 1973). Temperature also is major determinant of a lizard's place and food niches. Similar behavioural modulations in the time of activity of lizards were observed in the present study, however, a quantification of the time niche for each of the species or a group could not be achieved due to some constraints. Quantification of temporal niche is hence kept on the hold as a future scope of study. As the time of activity strongly affects a lizard's place niche, similarly the composition of the diet affects the food niche (Pianka, 1973). Fluctuations in the types of prey and their relative abundance with the seasons influence the diet composition of lizards. Widely foraging species typically have broader spatial niches than the sit-and-wait species. However, the latter type of foragers often tends to have broader food niches than the former. This is quite understandable amongst the lizards with high overlap along one niche dimension, for instance microhabitat, may have low overlap along another niche dimension such as the food eaten. This may effectively reduce the interspecific competition between them.

Having accomplished the objective of community studies next was to achieve the third and the final objective by studying the ecobiology of *Sitana ponticeriana* in its natural habitat. As mentioned earlier *Sitana ponticeriana* was one of the common agamid species that widely occurred across the state of Gujarat except for the mudflats in the Rann of Kutch. Hence when the study was narrowed down to four ISAs (Chapter 2) it was observed that one of the ISA (ISA-2) i.e. a scrubland in Vadodara district had a sizeable population of *S. ponticeriana,* and therefore this ISA, Sindhrot village scrubland/Vadodara rural was selected for the further detailed study on the ecobiology of *S. ponticeriana.*

Morphological studies are precursor to the ecological studies. The detailed morphometric measurements of *S. ponticeriana* revealed that females are slightly larger than the males in terms of both SVL and TBL (Female: SVL – 47.44±0.86 mm and TBL – 159.91±2.0 mm; Male: SVL – 42.18±1.81 mm and TBL – 157.56±4.9 mm) but with respect to the tail length (TL), males were found to have longer tails as compared to females (Male: TL – 115.37±3.13 mm; Female: TL – 112.46±1.53 mm). Based upon the morphometric measurements Smith (1935) had described two forms of the genus *Sitana,* namely a larger form with SVL ranging between 70-80 mm and a smaller form with SVL ranging between 40-50 mm. The distribution range according to Smith (1935) is that the former is confined to the district around Bombay while the latter ranges over the rest of the India and Ceylon. Workers have described three distinct species under genus *Sitana,* these include *Sitana ponticeriana* (Cuvier, 1829; Gunther, 1864), *Sitana minor* (Gunther, 1864) and *Sitana deccanensis* (Jerdon, 1870). However, after a critical examination of all the morphological characters from quite a large number of specimens collected across the country Smith (1935) has described a single species under genus *Sitana* i.e. *Sitana ponticeriana* and further defined two forms based upon the size difference as mentioned earlier. Gunther's *S. minor* is a synonym of the smaller form and the larger form, if two geographical races could be proved, is Jerdon's *S. deccanensis*. Schleich and Kastle (1998) have described two new species of genus *Sitana* from Nepal namely *Sitana sivalensis* and *Sitana fusca* based upon certain morphological studies but molecular authentication of these species is lacking. Molecular studies on the phylogeny of agamid lizards (Joger, 1991; Honda *et al.,* 2000; Stuart-Fox and Owens, 2003) have so far suggested genus *Sitana* as a monotypic genus with a single species. While analyzing the morphometry of the species it was evident that dorsal diamond pattern was not uniform in all the individuals. Therefore, variation in the dorsal pattern was examined through photo documentation. Close examination revealed that the pattern on the dorsum is not individualistic but a marked difference was evident in the population and based upon the observation one described at least eight different patterns in *S. ponticeriana.* Males were found to possess atleast three distinct patterns whereas females showed five distinct patterns. However, no sex specific variation was observed, and therefore pattern variation as a function for sexual dimorphism could not be ascertained, though males by and large showed uniformity in their patterns, females showed variation to a greater extent.

Lizards being so diverse in their shape, size, scalation and colour, it is not surprising to expect that some of the groups show a variety of morphs widely occurring across a vast landscape and these morphs are not necessarily geographical races. Occurrence of geographical races amongst the Oriental agamids is well documented in many of the genera that include *Calotes, Draco* and *Laudakia* (Das, 1996a, b; 1997a) but for the genus *Sitana* so far any such race has not been proved. Ecotypes were described by Lazell (1972) for the Dominican Anole lizard *Anolis oculatus*, a species which was also under a taxonomic debate for long. Cope (1879) had described *Anolis oculatus* to have multiple species. The confusion nevertheless, was resolved by Lazell in 1962 by defining all the species of *Anolis oculatus* as the subspecies or geographical races. In the present study one therefore speculate the occurrence of such ecotypes for *Sitana ponticeriana* over its entire geographical range, but needless to mention molecular tag for the authentication of the results is a must.

Further, the study was extended to undertand the feeding ecology of *S. ponticeriana* and it was observed that like any other agamid lizard *S. ponticeriana* too was predominantly insectivorous. The diet composition showed significant variation in different seasons and this could directly be correlated with the availability of prey in the environment. Pal and co workers (2007) while working on *S. ponticeriana* from the eastern part of the country

(Balukhnad-Konark WLS, Orissa) revealed similar results, that *S. ponticeriana* is chiefly insectivorous with ants comprising 95-99% of the diet. Results are also in accordance with the studies conducted by Loumbordis and Hailey (1991) and Serdar and Mehmet (2001) on the feeding biology of *Agama stellio.* Moreover, studies by Diong *et al.,* (1994) on the feeding biology of *Calotes versicolor* also supplement the current results. However, Pal *et al.* (2007) has also reported a small proportion of gastropod molluscs and *Casuarina* leaves in the diet of *S. ponticeriana* and studies conducted by Sharma (1982) in Gujarat also indicate trace amount of plant fibers in the diet of *S. ponticeriana* but in the current study neither of these food material was observed in the diet of the species. Other commonly occurring agamids like *Laudakia stellio* and *Calotes versicolor* have also been reported to be partially vegetarian in their diet (Devasahayam and Devasahayam, 1989; Diong *et al.* 1994; Serder and Mehmet, 2001) but *S. ponticeriana* in the current study was chiefly carnivorous and this could be due to sufficient availability of food in all the seasons. The results of the seasonal food composition revealed that ants were the most preferred dietary item therefore a preference index was calculated for ants versus all the rest of the prey species and the index was observed to be significant for ants in all the three seasons (Table 6.5).

Studies on the activity pattern of *S. ponticeriana* revealed that activity is diurnal as of other agamids. Activity budget of *S. ponticeriana* was recorded for two different age groups of the species i.e. adults and juveniles. Amongst adults observations were separately recorded for both males and females. Seasonal as well as diurnal variations were observed in the activity budget of *S. ponticeriana.* Activity was divided into five categories namely basking, foraging, social interaction, courtship/breeding and escape. Looking into the holistic picture of the activity budget it was clearly evident that Fan-throated lizards were strictly diurnal. Maximum activity was noted during the summer while the minimum activity was observed during the winter. Even after so much of extensive activities in all the seasons, the proportion of time per day in all the season was just a fraction *viz.* Animals remained active for 104 min or 15% of the day (12 h day) during summer, 82 min or 12% of the day during monsoon and 76 min or 11% of the day during winter. The activity pattern observed was bimodal in summer and unimodal in monsoon and winter. Activity showed a major peak between 0900-1200 hrs and a minor peak around 1600 hrs. As the day progressed in the summer, the major peak increased in the height and thereafter decreased down to form a minor peak which then declined as the activity terminated. A change from bimodality to unimodality occurred during the monsoon and winter with the peak of the activity between 1200-1600 hrs during monsoon and between 1200-1500 hrs during winter respectively

(Figure 6.10). Activity pattern was highly unpredictable during monsoon due to overcast skies.

The study was finally comprehended after documenting the courtship behaviour and breeding biology of the species. Males of *S. ponticeriana* are described to develop a brilliant blue colour on their dewlap or the throat fan, the colour being blue anteriorly, turning blue-black in the centre and reddish posteriorly (Smith, 1935; Tikader and Sharma, 1992; Daniel, 2002; Das, 2008) whereas females remained dull and drab. However, in the present study males of *S. ponticeriana* even in the peak of their breeding season were never observed to develop such a bright colour as described by the previous workers. The breeding colouration that was observed during the present study was only a purplish-blue coloured patch on neck and a blue coloured streak on the mid-ventral edge of the dewlap (Figure 6.11). The possible functions of lizard displays in communicating information between conspecifics have received considerable attention (Carpenter and Ferguson, 1977) and the colours which are frequently emphasized during the display are increasingly being investigated (Fleishman *et al.,* 1993). However, the role of lizard displays and colouration in sexual selection has received a little attention in comparison to that devoted to bird plumage and display (Endler, 1992; Endler and Thery, 1996; Cuthill *et al.,* 1999). Therefore it was mandatory in the present study to record a comprehensive behavioural repertoire alongwith an ethogram that describes the courtship and mating behaviour of *S. ponticeriana* in total.

Studies on the courtship behaviour or social behaviour of lizards are anecdotal or being serendipitous as an adjunct to larger ecological studies. Several studies on the courtship behaviour and few ethograms have been published for lizards, but these are mainly focused either on iguanids (Jenssen, 1975; Greenberg, 1977a; 1977b; Cooper, 1979; Jenssen and Feely, 1991) or on scincids (Done and Heatwole, 1977; Cooper and Vitt, 1987a; Torr and Shine, 1994; Langkilde *et al.,* 2003). However, studies describing the sequential events in courtship and mating behaviour in agamids are rare (Carpenter *et al.,* 1970; Brattstrom, 1971; Pandav *et al.,* 2007). Jenssen (1975) stated that displays and behaviours of lizards tend to be stereotyped at least at the population level and in most cases at the species level, and thereby this stereotypy makes it possible to compile a list (ethogram) of displays and behaviours that covers the whole range of behavioural acts for a species. Courtship displays in lizards are aided either by auditory, chemical or visual cues (Carpenter and Ferguson, 1977). The study on the courtship behaviour revealed total of 20 types of behaviours associated with the courtship. These behavioural units account for majority of the events during the courtship and further can be distinguished into 11 distinct functional units. The sequential events of courtship behaviour of *S. ponticeriana* are represented through a flow diagram in Figure 6.19. The courtship behaviour may be divided into three distinct phases, namely orientation, persuasion and copulation.The prime role of an ethogram is to facilitate comparisons among species. With the current dearth of information on agamid lizards, little can be achieved in this regard until data are available for a wider range of lizards. Pandav *et al.,* (2007) have mentioned change in the body colour of *C. versicolor* as an initiating step towards courtship while females of *C. versicolor* also showed a colour change as a sign of acceptance. However, in case of *S. ponticeriana* no such body colour change in either of the sexes was observed during the entire courtship period. Head-bobbing behaviour is well documented in many agamids (Brattstorm, 1971; Radder *et al.,* 2006; Pandav *et al.,* 2007), iguanids (McCann, 1993; Martins and Lamont, 1998; Macedonia and Clark, 2001 and Martins *et al.,* 2004) and some of the larger scincids (Done and Heatwole, 1977). Head-bob behaviour was found to be completely lacking in *Sitana ponticeriana,* except for occasional head-nods by the individuals, especially by the males while displaying from the ground. This was perhaps a sign of vigilance for a predator.

Rest of the behavior patterns during the courtship were almost similar to other agamid lizards (Radder *et al.,* 2006; Pandav *et al.,* 2007). Display act through dewlap extensions/fanning by the males of *S. ponticeriana* was a spectacular event of the entire courtship, though not unique to the species, the act is not well pronounced in other agamids found in this part of the country. Push-up displays by both the sexes have been reported in *Calotes versicolor* (Pandav *et al.,* 2007) and *Psammophilus dorsalis* (Radder *et al.,* 2006), however in the case of *Sitana ponticeriana* this display was not observed for females. Push-up displays on hind legs have been described for *Amphibolurus decresii* (Gibbons, 1979) nevertheless, this display was not recorded in the present study as well as not reported earlier by Pandav *et al.* (2007).

As the current ethogram is limited only to the courtship behaviour of *S. ponticeriana,* behavioural acts exhibited by the species in other events of its life are not covered. By and large this ethogram of courtship appears to be simple without any complex communication or visual displays involved therein. However, for a better understanding of the courtship behaviour and movement based visual signals and correlating the same with the evolutionary aspect, a wide range of data on phylogenetically closer species is required. The work shall provide a baseline for future neuroendocrine aspects of behaviour studies.

Following courtship and copulation occurs nesting. The prime requirement of a successful nesting is the selection of a suitable nest site. Gravid females of *S. ponticeriana* after mating made a choice in selecting a suitable site to lay their respective clutches. By and large the shrubs chosen were the ones selected initially by the females for perching during the courtship. With painstaking search and observations 27 nests of *S. ponticeriana* could be located in the area and majority was found to be associated with *Capparis sp.* followed by *Tamarix sp., Calotropis procera* and *Zizyphus nummularia* (Figure 6.20). On a comparative scale *Capparis sp.* had much dense a canopy as compared to other shrubs occurring in the same area thus provided a better cover to the species. Forest lizards have a wider choice for the selection of nest site whereas the habitats such as scrubland and desert provide definitely narrow choice since the resources are limited and hence selecting a suitable nest site is essential for a species to ensure the better survival of its clutch.

Nesting in *S. ponticeriana* occurred only after few showers of monsoon. Lizards are generally seasonal breeders and the breeding by and large coincides with the monsoon. In the present study also nesting commenced in June and continued till September with the maximum during August which is also the peak of monsoon (Figure 6.21). Egg laying in *S. ponticeriana* is reported to begin in July and continue till October (Chopra, 1964; Daniel, 2002) but in the present study not a single nest was observed in the month of October. As a general rule agamids deposit their eggs in a shallow nest dug in the loose soil. *S. ponticeriana* dug a nest that was 5.13 ± 0.38 cm in diameter and 6.21 ± 0.33 cm in depth. Varied nest dimensions have been recorded for different agamids for example, nest is 8-10 cm deep in case of *Calotes versicolor* (Asana, 1941), 5 cm deep for both *Calotes calotes* (Daniel, 2002) and *Draco dussumeri* (John, 1967), 4.2 cm deep in case of *Calotes liolepis* (Asela *et al.*, 2007) and 6 cm deep for *S .ponticeriana* (Chopra, 1964). The nest dimension could be influenced by two factors, body size and the clutch size. A strong correlation between nest dimension and either of the parameter could not be established in the current study nevertheless there is definite scope for further analysis. Mean clutch size of *S. ponticeriana* was observed to be 11.6 ± 2.09 and rest of the morphometric measurements for the egg are as given in the Table 6.10. Multiple clutches per season have been recorded for captive *S. ponticeriana* wherein three clutches were laid at an interval of 41 days (Daniel, 2002). Also prior to laying her clutch, every time this female mated (Daniel, 2002). In the present study, no female was observed laying multiple clutches in the natural conditions. Guarding behaviour towards their nests was exhibited rather. The eggs are chalky white in colour and roughly oval in shape. However, the exact incubation period could not be ascertained, the appearance of hatchlings in the month of August (for the clutches laid in July) and in September (for the clutches laid in August) lead to speculation that the incubation period ranged between 35-41 days.

The present study was thus aimed at understanding the seasonal variation in the density and population dynamics of *S. ponticeriana* in the selected study area. It was evident from the results that the maximum density per sq. km. was observed in summer followed by monsoon and winter (Table 6.11). The possible explanation for this change in the density over the seasons could be given through the resource dispersion hypothesis (Johnson *et al.,* 2002). The resource dispersion hypothesis has been well tested and explained for mammals (Johnson *et al.,* 2002), however for reptiles it has not been well evaluated. Still resource availability (prey types) shall undoubtedly influence the density of the species. Preliminary studies conducted on the demography of *S. ponticeriana* from Dharwad, Karnataka revealed a density of 45 ± 2.19 individuals per 1.9 ha (Shanbhag *et al.,* 2003) and the studies on *Psammophilus dorsalis* from Karnataka showed a density 90 lizards per ha (Radder *et al.,* 2005) indicating healthy population of these agamids in southern India. Results of the current work also indicated that *S. ponticeriana* had good density and abundance in the selected study area. Moreover, review of the literature revealed a rather surprising fact that the demographic studies on lizards from the western part of the country are still at its infancy. Therefore, work was further extended towards analyzing the population trend in *S. ponticeriana* using the capture-mark-recapture technique.

Population studies on *S. ponticeriana* through the capture-mark-recapture technique were conducted from the year 2006-2008, only adults were taken into consideration and it was evident from the results that *S. ponticeriana* had a noticeable population in the study area during the years 2006-2007 (Table 6.11) however a sharp decline in the population was observed in the year 2008 (Table 6.11). The study area as evident in the years 2006 and 2007 (Figure 6.23) was a fairly undisturbed habitat with minor anthropogenic activities *viz.* grazing or collection of minor plant products but in the month of March 2008 a commercial activity of soil excavation began in the study area (Figure 6.24). As mentioned earlier the soil in the area was a clayey loam soil and hence was of commercial importance for using either in nursery or for construction purposes. The soil excavation activity was so fast that in the span of just two months almost an area of a kilometer square was cleared (Figure 6.25 and 6.26).

Since the current work is a pilot study for this area of central Gujarat, no major conclusions could be drawn with regard to the population trend of *S. ponticeriana* but the importance of such unprotected areas supposed to be wastelands, in fact being potential biodiversity rich sites, is justified. Moreover, this pilot study shall provide a base index and future scope for population trend analysis of *S. ponticeriana* over a period of time and space.

Thus, *Sitana ponticeriana,* the only member of genus *Sitana* known from India, seems to be characterized by a unique constellation of morpho-anatomical, behavioural and ecological adaptations that facilitate efficient exploitation of resources in its habitat and sets it apart from other species of lizard. These traits are listed again to summarize this chapter, as compared to other lizard species *S. ponticeriana* 1) has a partially dorso-ventrally flattened body, 2) is entirely day active lizards, 3) has a conspicuously specialized diet consisting largely of ants, 4) exhibits plasticity in predator avoiding strategies, and 5) produces large numbers of relatively small eggs and hence young ones.

From the analysis of the current data one can conclude that the state of Gujarat is rich in its saurian diversity, with some of the unique and spectacular species harmoniously occupying a myriad of microhabitats distributed across the four biogeographical provinces. Further, the comprehensive study on the community ecology of lizards in the selected habitats enabled one to better understand their guild structure and resource utilization. This together with the knowledge gained on the ecophysiology and breeding biology of the representative species of lizard - *Sitana ponticeriana*, will help herpetologists and the wildlife managers to design meaningful conservation strategies for the lesser known fauna in the protected areas as well as in the biodiversity rich unprotected areas in the state. However, the data at hand is still insufficient to develop a meaningful predictive computational modeling which if developed, would come handy in precise and faster decision making at a time of rapid change in the land use pattern in a state like Gujarat with rampant mushrooming of industries. Therefore, ample of avenues are still open for further studies in community ecology and ecophysiology of herpetofauna in the state, and the present work shall offer a robust baseline data for infallible designing of the future studies.