CHAPTER 6

ECOBIOLOGY OF *SITANA PONTICERIANA* (AGAMIDAE: SAURIA) IN ITS NATURAL HABITAT

INTRODUCTION

Agamids or Agamas of the family Agamidae are confined to Old World and majority of their genera occur in the Oriental Region (Smith, 1935; Daniel, 2002), thus making Oriental Region a prime hub of agamid diversity. In general appearance and habits, agamids bear a close resemblance to the iguanas of New World, since both the groups belong to the same lineage. However, the two groups are geographically separated of the two families and nowhere in the world are these two families reported to be in co-occurrence (Smith, 1935).

The Agamidae can be distinguished from all the other Oriental lizards, by their dentition which is acrodont and heterodont, the exception being the chamaeleons (Smith, 1935). These teeth are borne on the rim of the jaw unlike the pleurodont teeth that are borne on the inner side of the jaw. Moreover, the heterodont pattern divides the teeth into three kinds *viz.*, incisors, canines, and molars. The latter are compressed laterally and are more or less solidly united to one another at their bases, so as to form an uninterrupted row along the jaw. Agamids are diurnal, visually well oriented and all but a few species are oviparous (Pough *et al.,* 1998; Zug *et al.,* 2001). All the agamid members are fully limbed and lack fracture plane in the tail and therefore, do not exhibit autotomy as seen in geckos and skinks (Pough *et al.,* 1998; Zug *et al.,* 2001). The Agamidae is a group of about 360 species in 45 genera, with a continuous distribution throughout the warmer regions of the Old World, except for Madagascar and most oceanic islands (Bauer; 2003). With such diversity the largest radiations of agamids are seen in Australia, India and the Indo-Australian Archipelago having some of the most spectacular species exhibiting peculiar morphological structures, thereby making a species unique in itself. Few such bizarre agamids include *Moloch hurridus* – the Thorny Devil and *Chlamydosaurus kingii* – the Frill-necked Lizard of Australia, the desert dwelling group of toad headed agamids belonging to the genus *Phrynocephalus* from central Asia and Middle East, while the Southeast Asia is represented by *Cophotis ceylanica* – the Earless Agama (the only known viviparous tropical agamid) and *Hydrosaurus amboinensis* – the Water dragon (the largest agamid reaching the total length of over one meter) (Bauer, 2003). Africa has relatively few agamid species and those present include some of the arboreal species and numerous rock dwelling forms (Bauer; 2003). Forests of Southeast Asia and peninsular India in particular have the most specialized agamids the 'Flying Dragons' of the genus *Draco* that not only climb but glide through air as well (Daniel, 2002; Bauer, 2003; Das, 2008).

The Indian region is not only rich in its agamid diversity, but also diverse morphological forms occur across the region. Agamids have a widespread distribution in India occupying all the biotopes from the sea level to over 5,000 m altitude. A species of toad-agama (*Phrynocephalus*) has been recorded from 5,182 m (Daniel, 2002). The Indian agamids account for 48 species grouped under 18 genera that include certain endemics as well as few human commensals (Das, 1997a). Agamid genera endemic to India include *Bufoniceps* and *Salea,* the former is restricted to the Thar Desert in the state of Rajasthan while latter occurs in the southern Western Ghats (Das, 1994). Of the 48 species occurring within India, 17 species are endemic, indicating 35 % endemism for the family Agamidae. Table 6.1 presents the number of agamid genera along with their respective number of species and the list of endemic agamids of India.

Majority of the Indian agamids are forest dwellers and few are arid or semi-arid species, relatively few occur as human commensals when compared to geckos or skinks. Perhaps *Calotes versicolor* is the only agamid that is largely a human commensal and also one of the most widespread agamids of India. *Bronchocela cristatella* – Green Crested Lizard is an occasional invader of parks and gardens whereas *Ptyctolaemus gularis* – Green Fan-throated Lizard is reported to occur in urban localities, otherwise rest all agamids occur in wilderness areas (Das, 1994). *Calotes versicolor* thus being a commensal with humans, has been a species of interest for zoologists as it has been widely used in zoology laboratories for morphological and anatomical studies and because of its co-occurrence with humans, extensive studies on the ecobiology of the species have also been conducted (Asana, 1931; 1941; Rao, 1975; Devasahayam and Devasahayam, 1989; Sharma, 1990; 1991; 1999; Shanbhag and Prasad, 1993; Shanbhag *et al.,* 2000; Shanbhag, 2003). Few ecological studies have also been conducted on other Indian agamids (Kastle *et al.,* 1993; Radder *et al.,* 2005). However, few other commonest species widely occurring across the country like *Sitana* *ponticeriana* remains feebly studied (Chopra, 1964; Subba Rao and Rajabai, 1972a; Radder and Shanbhag, 2003; Shanbhag *et al.,* 2003). Therefore, the current study was aimed at understanding the ecobiology of this Indian agamid which also is a widely occurring species in the country.

Sitana ponticeriana – the Fan-throated Lizard is a medium sized ground dwelling agamid lizard distributed throughout the open scrublands and dry deciduous forests of India. It can easily be distinguished from other Indian agamids by the presence of only four toes as against five toes in all others (Gunther, 1864; Smith, 1935). Males of this species possess a flap like gular appendage which is operated like a fan during the courtship display to allure the female, thus presence of this gular appendage makes *S. ponticeriana* a sexually dimorphic species. As a general rule goes for the agamids, *S. ponticeriana* is also diurnal in its habits and principally insectivorous in diet. It is a fast and graceful runner, occasionally adopting bipedal gait when hard pressed. The throat fan in males is not an exclusive character to this species, as similar such structures are present in few other agamids too. The species can also be identified from its dark brown, black margined, diamond shaped spots along the mid dorsal line of the body. As far as the distribution of the species is concerned, *S. ponticeriana* inhabits all the biotopes except for the dense evergreen forests and the interiors of the desert (Tikader and Sharma, 1992; Daniel, 2002). The most preferred habitats are the scrublands, grasslands and periphery of the deserts. It is widely distributed from the foot hills of Himalayas to Kanyakumari, but not reported from east of the Ganga in eastern India (Tikader and Sharma, 1992; Daniel, 2002). Outside the political boundary of India, the species occurs in Nepal, Pakistan and Sri Lanka (Smith, 1935; Manamendra-Archchi, 1990; Das, 1994).

During the course of the present study it was observed that *S. ponticeriana* was one of the common species and 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 (Intensive Study Areas) (Chapter 2), it was observed that one of the ISA i.e. a scrubland in Vadodara district had a sizeable population of *S. ponticeriana,* and therefore this ISA, Sindhrot village /Vadodara rural was selected for the further detailed study on the ecobiology of *S. ponticeriana* in its natural habitat.

Table 6.1 Agamid Diversity of India and the list of Endemic Indian Agamids

Sr. No.	Genus	No. of Species
1.	*Brachysaura*	1
2.	*Bronchocela*	3
3.	*Bufoniceps*	1
4.	*Calotes*	11
5.	*Coryphophylax*	1
6.	*Draco*	2
7.	*Japalura*	6
8.	*Laudakia*	6
9.	*Mictopholis*	1
10.	*Oriocalotes*	1
11.	*Otocryptis*	1
12.	*Phrynocephalus*	5
13.	*Psammophilus*	2
14.	*Pseudocalotes*	1
15.	*Ptyctolaemus*	1
16.	*Salea*	2
17.	*Sitana*	1
18.	*Trapelus*	1
List of Endemic Indian Agamids		**IUCN Status**
1.	*Bronchocela danieli*	EN
2.	*Bufoniceps laungwalansis*	VU
3.	*Calotes andamanensis*	VU
4.	*Calotes ellioti*	LR-nt
5.	*Calotes grandisquamis*	LR-nt
6.	*Calotes nemoricola*	VU
7.	*Calotes rouxii*	LR-nt
8.	*Coryphophylax subcristatus*	LR-lc
9.	*Draco dussumieri*	LR-nt
10.	*Japalura major*	CR
11.	*Mictopholis austeniana*	CR
12.	*Oriocalotes paulus*	EN
13.	*Otocryptis beddomeii*	VU
14.	*Phrynocephalus alticola*	VU
15.	*Psammophilus dorsalis*	LR-nt
16.	*Salea anamallayana*	EN
17.	*Salea horsfieldii*	EN

CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LR-nt – Lower Risk-near threatened, LR-lc – Lower Risk-least concern.

INTENSIVE STUDY AREA (ISA)

As per the detailed description provided in chapter 2, Intensive Study Area 2 (ISA-2), was selected for the current study, as the area had a healthy population of *Sitana ponticeriana*. Intensive Study Area 2 is located to the west of Vadodara city at an approximate distance of

16 km from the main city. It is an open scrubland near the village Sindhrot (22° 18' N - 22° 08' N and 73° 06' - 73° 21' E: Garmin, GPS 12XL) (Fig. 2.5). The scrubland is spread over a vast area of around 7 sq km and is actually a part of ravines of two rivers namely river Mahi, a major river of central Gujarat and river Mini, a small but perennial river of central Gujarat. River Mini basically meets river Mahi at one point and this scrubland is sandwiched between these two rivers (Gazetteer of India, 1979). The terrain is highly undulating with steep slopes at many locations. For further details of the study area refer chapter 2.

METHODOLOGY

SAMPLING FOR POPULATION ANALYSIS

Since the selected area was studied with two objectives i.e. community structure of lizards and the biology of *S. ponticeriana,* to achieve the former objective quadrate sampling technique was used essentially. Quadrates of 5m X 5m at random were laid in the entire study area and were marked by placing different coloured flags. After the quadrates were laid, they were surveyed starting from centre walking towards the periphery along a circular path forming concentric circles. Care was taken while recording the individuals falling in a particular quadrate, the individuals found on the bordering line were not taken into consideration.

MORPHOMETRIC STUDIES

Morphometric studies of *S. ponticeriana* were performed by grouping the individuals sex wise and also into different age classes, *viz.* hatchlings, juveniles and adults and adults. However, adults being sexually dimorphic, measurements were separately recorded for males and females. Hand-capturing technique (Blomberg and Shine, 1996) was used to capture the lizards from their habitat and the measurements were recorded in the field itself using calibrated dialer Vernier Caliper (Mitutoyo, Japan). Since majority of the morphometry work was done in the field, the captured animals were released back into their habitat but in few cases collection of a holotype was essential. Live animals were collected from the field and brought to the laboratory and preserved using 5% - 10 % formalin depending on the body size of the animal, the preserved specimens were then deposited in the museum of the Department of Zoology, The M. S. University of Baroda. Photo documentation of the animals depicting the dorsal pattern was done using both analog SLR camera – Canon T70 and a Digital Camera – Olympus C770.

GUT CONTENT ANALYSIS

Gut content analysis of *Sitana ponticeriana* was done in all the three seasons to understand the seasonal variation in the feeding habits of the species. Captured individuals of *S. ponticeriana* were brought to the laboratory, euthanized with chloroform fumes and their alimentary canal was dissected out. Thereafter, the region from stomach to rectum was excised out and the content therein was flushed out into a Petri dish containing reptilian saline solution (composition in millimolar concentration NaCl, 145; KCl, 2.5; CaCl2, 3.6; MgSO4, 1.8; KH2PO4, 1.0 HEPES, 5.0; NaOH as needed for pH 7.4). The content was then examined thoroughly under a Binocular Research Microscope (Leica MZ 16A) and recorded. Refer chapter 3 for further details.

MEASUREMENTS OF DIETARY PREFERENCES

Preliminary gut content examination revealed a marked variation in the feeding habits of *S. ponticeriana* depending upon the seasonal availability of food and therefore it was thought mandatory to further understand the food preference of the species. The dietary preference was thus measured by calculating the Forage Ratio (Manly *et al.*, 1993) in all the different seasons for each of the prey species present in the diet of *S. ponticeriana*. Moreover, based upon the forage ratio, the utilized food types (prey species) were broadly grouped into two-prey case and choice made by the animal between these two prey species was analyzed through Murdoch's Index (1969). Refer chapter 3 for further details.

STUDIES ON THE ACTIVITY BUDGET AND BREEDING BIOLOGY

Close *in-situ* observations were made to record the activity pattern of *S. ponticeriana* and the diurnal as well as seasonal variations occurring therein. The observations commenced at 0700 hrs and continued till 1830 hrs in all the seasons. The activity pattern was recorded at an interval of every 10 min and then broadly grouped into categories *viz.* basking, foraging, social interaction, escape and courtship. Depending upon the age and the sex of the individual a seasonal variation in the activity pattern was obvious and hence, was taken into consideration.

Observations on the breeding biology of *S. ponticeriana* were also recorded in the field through hand written notes and photo documentation. The courtship behaviour of *S. ponticeriana* was studied in total of 12 field visits during the breeding season and these visits were made with focused objective of recording the courtship behaviour only. Observations were recorded from mid April to mid June, which coincided with the breeding season of *S. ponticeriana i.e.* when males attained their breeding colouration and started with the fanning behaviour till the final act of copulation. Lizards became highly motile during the breeding season and males with their fanning displays immediately captured the sight and hence spotting individuals was not difficult. Mating pairs were observed from a distance of approximately two meters remaining in still position as much as possible (except for noting the observations) thereby making no disturbance in their activity. The courtship behaviour was mainly encountered between 0830 h and 1230 h as well as 1600 h and 1830 h. Observations were recorded manually as field notes and the sequence of events were tried to be captured using the digital camera without disturbing the individuals. The terminologies used for behaviour are mostly after Carpenter and Ferguson (1977).

DENSITY AND POPULATION STUDIES

The healthy population of *S. ponticeriana* in the selected study area prompted one to study the density of individuals per sq. km. and further look up on the seasonal variation if any. Population studies were performed using 'Capture-Mark-Recapture Technique' (Seber, 1982). The technique was first designed by Peterson, a Danish fisheries biologist in the year 1896 (Ricker, 1975) and he developed a systematic method and a formula for the population estimation studies known as the 'Peterson Method'. Peterson Method was employed in the current study to estimate the population of *S. ponticeriana,* and results with 95% confidence limits were obtained. Individuals of *S. ponticeriana* were hand captured (Blomberg and Shine, 1996) and were marked by the toe clipping method. Toe clipping was found to be one such method that was less injurious to the animal when compared with other marking methods suggested in the literature and moreover, numbering of toes and clipping each at a specific point could lead to a multitude of combinations. Refer chapter 3 for further details.

SOIL PARAMETERS

Sitana ponticeriana being a ground dwelling lizard, soil of its habitat becomes an important abiotic factor influencing the lifestyle of the specie. Soil was collected from the ISA and was analyzed for parameters such as Soil Surface Hardness or Penetrability, Soil Texture, pH of the soil, Soil Temperature and Soil Moisture (Jones and Reynolds, 1996).

1. Soil Surface Hardness or Penetrability:

Soil penetrability was an important property in the current study. Although *S. ponticeriana* is not fussorial lizard, it needs to dig the soil at the time of laying eggs. Moreover, it does take shelter into the burrows when threatened but these burrows are not the self burrows and perhaps dug by some rodent. The penetrability of the surface soil was examined with the simplest method the 'BJPS' or "Bob James' Pointy Stick' method. Refer chapter 3 for details.

2. Soil Texture:

Soil texture was determined based upon the percentage content of its various constituent particles. The method followed was the most widely used and developed by United States Department of Agriculture (USDA), refer chapter 3 for the details.

3. Soil pH:

pH of the soil is an essential criteria for evaluating the fertility of the soil and thus has a direct impact on the cultivation or is important for the microflora and microfauna inhabiting it. Since the property was not of much relevance to any terrestrial fauna it was still examined so as to establish any kind of correlation if existed. pH of the soil was determined using a hand held pH meter (Eutech Cybernetics-Model pHScan 2).

4. Soil Temperature:

Temperature of the soil is an important parameter to be considered for partial ground-dwelling forms. The sub-surface temperature is usually lower than the ambient temperature and also the humidity is relatively higher thus making soil an ideal place of shelter for the burrowing animals. Though, *S. ponticeriana* is not a burrowing lizard but as a typical agamid, it lays its clutch by digging a nest in the soil. As soil acts as an incubation medium, recording the soil temperature becomes essential. Soil temperature was thus measured using standard calibrated soil thermometer.

5. Soil Moisture:

As mentioned that humidity in the soil is relatively higher than the ambient humidity and therefore soil moisture was an essential parameter to be considered since soil in this case acts as the incubation medium for the eggs of *S. ponticeriana.* To estimate the soil moisture wet soil immediately after the rain was collected (monsoon being the incubation time) from the ISA and 100 g was weighed and spread onto a newspaper for a week. After the moisture had evaporated the soil was weighed again and the loss in weight was taken as the percentage of moisture present in the soil.

RESULTS AND DISCUSSION

MORPHOMETRIC STUDIES

Morphological study was the stepping stone to begin with study on the biology of *S. ponticeriana*. Table 6.2 presents the detailed morphometric measurements of the species. It is evident from the data that females are slightly larger than the males in terms of both SVL (Snout to Vent Length (mm)) and TBL (Total Body Length (mm)) (Female: SVL – 47.44 ± 0.86 and TBL – 159.91 ± 2.0; Male: SVL – 42.18 ± 1.81 and TBL – 157.56 ± 4.9) 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; Female: TL - 112.46 ± 1.53). The TBL was largely in accordance with majority of the specimens deposited in the collection of the museum of BNHS (personally examined); however the largest of the specimen present in the collection of BNHS was found to have TBL 205 mm, which is much larger a specimen as compared to those collected during the present study. 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. According to Smith (1935), the distribution range of the former is confined to the district around Bombay while the latter ranges over the rest of the India and Ceylon. Though a century ago workers have described three distinct species under genus *Sitana, viz. Sitana ponticeriana* (Cuvier, 1829; Gunther, 1864), *Sitana minor* (Gunther, 1864) and *Sitana deccanensis* (Jerdon, 1870) 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. Smith (1935) strongly believed that 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*. The present morphometric studies revealed that the species occurring in western region of the country belonged to the smaller form of *S. ponticeriana* as described by Smith (1935). Figure 6.1 and 6.2 depict adults of *S. ponticeriana* male and female respectively while figure 6.3 shows a gravid female. 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. Agamids in general are conspicuous members of the herpetofauna and therefore, are a well studied group. Molecular studies on the phylogeny of agamid lizards (Joger, 1991; Honda *et al.,* 2000; Stuart-Fox and Owens, 2003) has so far suggested genus *Sitana* as a monotypic genus with a single species. However, these studies encompassed the entire of the agamid group, hence focused studies on the molecular phylogeny of exclusively Oriental agamids is highly warranted, since Oriental agamids are much more diverse as compared to rest of their allies from other parts of the Old World.

PATTERN VARIATION

While critically examining the individuals of *S. ponticeriana* we observed that the diamond shaped pattern on the dorsum of the animal is not uniform amongst all the members. Hence, large numbers of specimens from the ISA as well as from other parts of Gujarat state were examined to analyze the variation in the dorsal pattern which is also a characteristic of *S. ponticeriana.* A close examination of the pattern revealed that the pattern on the dorsum is not individualistic, yet a marked difference in the pattern was evident in the population. Based on the observations, I described at least eight different patterns within the studied population of Fan-Throated Lizard. *S. ponticeriana,* though being a common agamid lizard and a dominant species in the scrublands, surprisingly escaped the attention of researchers as well as naturalists in this particular aspect of pattern variation. Males of this species were found to possess at least three distinct patterns whereas females showed five distinct patterns. Altogether eight distinct patterns were identified from the species occurring in the western part of the country. 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, the females showed variation to a greater extent. As per the description given by Smith (1935), there are dark brown, black edged six diamond shape patches along the mid dorsal line of the body from the lower nuchal portion till the base of the tail and sometimes a light vertebral line dividing them. The various patterns, however, observed in individuals of *S. ponticeriana* are as follows:

PATTERN VARIATIONS AS OBSERVED IN MALES

1. Uniform paired pattern

This was the most common pattern amongst all the different forms wherein the diamond marks were properly arranged in pairs along the mid dorsal line of the body without any misalignment.

2. Uniform paired pattern with blunt tips

This pattern closely resembled uniform paired pattern but the only variation observed here was that the laterally projecting tips of the diamonds were blunt in contrast to the pointed tips as seen in case of pattern number 1 (Figure 6.4a).

3. Uniform paired pattern with slight misalignment

This pattern at first glance appeared to be very similar to the uniform paired pattern but a careful observation revealed that 1st, 5th and 6th diamond patch were properly paired whereas 2nd, 3rd and 4th diamond patch were found slightly misaligned (Figure 6.4b).

PATTERN VARIATIONS AS OBSERVED IN FEMALES

1. Uniform paired pattern

This pattern in females was similar to the uniform paired pattern as seen in males wherein the diamond marks were properly arranged in pairs along the mid dorsal line of the body with no misalignment (Figure 6.4c).

2. Uniform paired pattern with blunt tips

This pattern was similar to the pattern number 2 of males wherein the laterally projecting tips of the diamond patches were blunt in contrast to the pointed tips as seen in pattern number 1 in females (Figure 6.4d).

3. Uniform paired pattern with a complete misalignment leading to increase in number of diamond patches

In this pattern there was observed a complete misalignment in the diamond patches that resulted in an increase in the number of diamond patch by one. The total number of diamond patches present in this case were seven, of which the 1st, 2nd, 6th and 7th pair were in complete alignment whereas 3rd, 4th and 5th pair were misaligned (Figure 6.4e).

4. Uniform unpaired pattern

This pattern lead to an unequal number of diamond patches on the either side of the mid vertebral streak. It was observed that 1st, 2nd patch and also the last diamond patch were completely paired and aligned. However, the 3rd patch and 6th patch though paired were marginally misaligned. Moreover, the 4th and 5th pair of diamond patches were observed to be completely unequal wherein two halves of the diamond patches on the right side complemented with a single half patch on the left side thereby forming six triangle patches on the left side in contrast to seven patches on the right side (Figure 6.4f).

5. Uniform paired pattern with blunt tips and additional small diamonds in between the main patches

This peculiar pattern was altogether different from rest of the observed patterns and was exclusive to females. In this case six pairs of diamond patches with blunt tips were observed arranged in a uniformly paired manner. In addition to these six pairs of patches there was ,observed additional small diamond patches in pairs along the mid dorsal axis, in between the main patches numbered 2nd and 3rd, 3rd and 4th as well as between 4th and 5th (Figure 6.4g).

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 no such race has been proved. Moreover, in the current study wherein we discuss about the variation in the dorsal pattern, the sample size was much less and the study being restricted only to the state of Gujarat which is much smaller an area when compared to entire distribution range of this species, it was not possible to arrive at any consensus of occurrence of any geographical race. Therefore, the study needs a further extension across the varied geographical locations wherein *S. ponticeriana* is known to occur. However, the possibility of occurrence of ecotypes for *S. ponticeriana* cannot be negated. 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. Based upon further morphological and molecular studies on *Anolis oculatus*, Lazell in 1972 again determined that there is no interruption in the gene flow between the different populations of the Dominican Anole, instead only a clinal variation adaptive to local ecological factors was observed. Hence the former subspecies were then named as ecotypes by Lazell (1972) based upon their geographical ranges. In the present study we therefore speculate the occurrence of such ecotypes for *Sitana ponticeriana* over its entire geographical range, but not to mention, molecular tag for the authentication of the results is a must.

GUT CONTENT ANALYSIS

Agamids are predominantly insectivorous (Pianka, 1971; Subba Rao, 1975; Kastle *et al.,* 1993; Anibaldi *et al.,* 1998) and few species are partially herbivorous (Pianka, 1971; Devasahyam and Devasahayam, 1989). Studies indicate that the changing climate is a key regulator of food diversity and abundance in any habitat and hence influence the dietary composition of a lizard (Ballinger and Ballinger, 1979; Dunham, 1980; Robinson, 1987; Durtsche, 1995).Therefore, gut content of fifteen adult *S. ponticeriana* was analyzed in all the seasons to understand the food composition of the species and to further find seasonal variation, if any, in the dietary pattern. The analysis revealed the presence of eleven food items (and a fraction of unidentified or amorphous material) in the diet of *S. ponticeriana* and all the prey species belonged to the class Insecta, thus proving the principally insectivorous diet of the species (Table 6.3). Since all the prey species belonged to insect group, they were broadly classified under major heads to look into their percentage composition in the diet. Figures 6.5a-c depict that in all the three seasons ants were on the top of the menu of *S. ponticeriana,* followed by beetles and termites. During summers *S. ponticeriana* consumed almost equal proportion of termites and beetles but the consumption of termites increased markedly during monsoon whereas an increase in the beetle consumption was evident during winter. The possible reason that could be attributed to this change in the dietary pattern might be the availability of a given prey species in the environment. Studies conducted by Pal *et al.* (2007) on *S. ponticeriana* from the eastern part of the country (Balukhnad-Konark WLS, Orissa) also reveal similar results, that *S. ponticeriana* is chiefly insectivorous with ants comprising 95-99 % of the diet. The present 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 reported a small proportion of gastropod molluscs and *Casuarina* leaves in the diet of *S. ponticeriana.* Studies conducted by Sharma (1982) in Gujarat also indicate trace amount of plant fibers in the diet of *S. ponticeriana.* However, in the current study no such materials were observed in the diet of the species in question. Although, land snails in small numbers occurred in the ISA during the monsoon neither they were encountered in the diet of *S. ponticeriana* during the gut content examination and nor any time the lizards were observed feeding upon these gastropod molluscs. As far as the occurrence of vegetable material in the diet is concerned the ISA had no plantation of *Casuarina* at all and from the available vegetation in the area, none of the floral species was found in the diet of *S. ponticeriana.* The close examination of the unidentified or amorphous material from the gut appeared to have cellular material with cellulose or lignin deposition but the material being so obliterated that its plant origin could not be ascertained. 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. Moreover, Pal *et al.* (2007) had also hypothesized that the species utilizes gastropods or plants as food source due to scarcity of preferred insect prey but this was never a case in the present study.

MEASUREMENTS OF DIETARY PREFERENCES

An animal when posed with variety of possible food types prefers some and avoids others. Manly *et al.*, (1993) has reviewed this problem of resource selection by animals and provided a statistical solution in terms of 'Forage Ratio'. Lizards depending upon their habit and habitat exhibit both active foraging (Avery, 1971; Bennett and Gleeson, 1979) and sit-and-wait strategies (Andrews, 1979) for procuring their food. Lizards of the open landscape such as desert are largely active foragers (Pianka, 1966; Robinson and Cunningham, 1978) while the forest dwelling species are the masters of ambush (Andrews, 1979). In the present study the ISA was a scrubland and therefore it was of more or less open landscape and thus our species of interest *S. ponticeriana* was mainly found to be an active forager. However, it was also observed to be an opportunistic feeder i.e. while basking or resting if any insect passed by, it was immediately picked up by the individual. To understand the choice of *S. ponticeriana* towards a particular food type and avoidance of other the proportion of prey species in the environment in all the seasons was determined and thereafter their relative proportion in the diet of *S. ponticeriana* was established. Table 6.4 and Figure 6.6 depict the forage ratio in all three different seasons for the various prey species. Although, ants as a group dominated the food composition of the organisms in all the seasons, when analysed at the species level the significant forage ratios differed during various seasons. The forage ratio for *Camponotus sp.* (ants) was significantly higher during summer while *Carabid sp.* (beetles) showed a higher value during winter. This might be because of the relative availability of particular prey species in the environment. Ants especially of the genus *Camponotus* were found in large numbers during summers whereas *Carabid* beetles increased in their numbers in winter. In the monsoon season the ratio was significantly higher for lepidopteran larvae and this was clearly correlated with frequent occurrence of the caterpillars in the ISA and was easy to devour as compared to other active insects. *Sitana ponticeriana* is reported to be sympatric with other ground dwelling lizards like skinks (Pal *et al.,* 2007). In the present study also *S. ponticeriana* was observed to be sympatric with two species of skinks namely *Mabuya carinata* and *Mabuya macularia* and partially sympatric to *Calotes versicolor.* Intra as well as inter-specific competition over the resources is well documented amongst lizards (Tinkle, and Ballinger, 1972; Dunham, 1980; Dhindsa and Toor, 1983; Kalita, 2000) and sympatry could be one of the contributing factors (Broadley, 1972; Robinson and Cunningham, 1978; Tollestrup, 1979; Schoener and Schoener, 1980; Heideman, 2002). Though *S. ponticeriana* was observed to be sympatric with two of the skinks and one agamid, the species was observed to have narrow niche breadth compared to its sympatric species that exhibited a broad range of food types. *C. versicolor* is much larger an agamid compared to *S. ponticeriana* and is reported to feed not only on invertebrates but also on smaller vertebrates (Sharma, 1991b; 1999) to the extent that even cannibalism is reported in *C. versicolor* (Sharma, 1991a; Diong, 1994). Observations of the current study showed that in addition to ants, beetles and termites, *C. versicolor* also feed upon grasshoppers, lepidopterons, centipedes, millipedes, spiders, gastropods and in one case was also found preying on the young one of *S. ponticeriana.* Thus, *C. versicolor* did not pose much competition to *S. ponticeriana.* As the results of the seasonal food composition revealed ants were the most preferred dietary item, therefore, a preference index was calculated for ants versus rest all prey species and the index was observed to be significant for ants in all the three seasons (Table 6.5).

ACTIVITY BUDGET OF *SITANA PONTICERIANA*

Agamids are primarily diurnal (Smith, 1935; Daniel, 2002; Das; 2008). However, abiotic factors *viz.* temperature and humidity strongly influence the activity of lizards (Hertz, 1992; Rivera-Velez and Lewis, 1994; Nicholson *et al.,* 2005). The activity pattern of Indian lizards has hardly been studied (Radder *et al.,* 2005; Dutta and Jhala, 2007) and hence, it was thought pertinent to derive the activity budget of this common agamid, *Sitana ponticeriana.* 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. Hatchlings were not taken into consideration since they were seen only during the monsoon and were highly cryptic and posed a great difficulty in sighting. Moreover, the increased herb density during monsoon provided more hiding places to the hatchlings and added on to the visibility problem. Seasonal as well as diurnal variation was observed in the activity budget of *S. ponticeriana,* which is discussed further season wise. Activities were grouped and divided into five categories namely basking, foraging, social interaction, courtship/breeding and escape.

Activity budget of *Sitana ponticeriana* during summer

During the summer months the activity of *S. ponticeriana* commenced in the morning hours between 0730-0800 hrs with basking in the first place (Table 6.6 and 6.7). The temporal/ diurnal observations recorded at an interval of every 30 minutes revealed that males and juveniles were the first to become active, followed by the females (Table 6.7). Table 6.6 depicts the time budget allocation towards various activities by *S. ponticeriana,* wherein males were observed to be maximally active (109.32 min/day), followed by the females (107.23 min/day) and then the juveniles (98.48 min/day). Figure 6.7 indicates that apart from basking and foraging, males were keenly focused on the courtship and devoted a considerable time towards their peculiar courtship display of fanning. However, females by this time were turning gravid and spent a major time in foraging to supplement their heightened nutritional needs (Figure 6.7). Juveniles on the other hand spent the least time in basking and rest of the day, they were observed actively moving around in the area, these active movements were considered as part of foraging activity (Figure 6.7). During the foraging activity juveniles exhibited some kind of social interaction that could not be clearly defined whereas for males the social interaction was defined as a sporadic combat over the female (Figure 6.7) but unlike the reports of other lizards (Asana, 1931; Carpenter *et al.,* 1970; Auffenberg, 1981) the male-male combat in *S. ponticeriana* was short and spontaneous one. Escape rates were also observed to be higher in case of males since their courtship activity made them more visible to the predators, juveniles were second in line to exhibit the escape behavior. The juvenile escape behaviour could be explained in a way that their inexperienced state made them over cautious and hence they showed an escape behaviour towards slightest disturbance in the habitat. The current results are in accordance with Pianka *et al.* (1998) and Dutta and Jhala (2007) who reported similar behavioural patterns in *Moloch hurridos* and *Uromastyx hardwickii* respectively. During summer the activity of *S. ponticeriana* however, culminated between 1800-1830 hrs.

Activity budget of *Sitana ponticeriana* during monsoon

Activity of *S. ponticeriana* began during the morning hours between 0730-0800 hrs during the monsoon months again with basking (Table 6.6 and 6.8). Like the summer activity the diurnal observations in the monsoon also showed that males and juveniles became active ahead of females and the maximum activity exhibited by males (101.02 min/day) followed by females (76.83 min/day) and juveniles (67.66 min/day). Figure 6.8 depict that males concentrated on the breeding activity, along with basking and foraging, while females and juveniles spent a near equal time in basking and foraging. Gravid female by this time were ready for the mating and spent a considerable time for the breeding activity. Maximum numbers of mating pairs were observed during this season. Social interaction was altogether absent in case of males and females since the adults were involved in breeding, however juveniles exhibited social interaction, even though that was of a lesser extent. Escape rates for all the three classes were found minimum during monsoon since the increased herb density as well as shrub canopy provided a greater cover to the individuals as compared to the dry summer months. Similar activity patterns have been reported in other agamids as well as lizards of other families (Pianka *et al.,* 1998; Nicholson *et al.*, 2005; Radder *et al.,* 2005; Dutta and Jhala, 2007).

Activity budget of S*itana ponticeriana* during winter

Winter activity of *S. ponticeriana* began little late in the morning hours between 0800-0900 hrs with basking to start the day (Table 6.6 and 6.9). The change could directly be correlated with the change in the day and night cycle. Again during winter males and juveniles became active in the first place followed by the females but the remarkable point was that females were observed to become active much later in the morning *i.e.* between 1000-1100 hrs. Maximum activity again was observed in case of males (86.9 min/day) followed by females (73.9 min/day) and juveniles (68.52 min/day). Winter budget was dominated by the basking activity since all the three classes devoted a major proportion of time towards thermoregulation (Figure 6.9). Reptiles being ectothermic, temperature is a prime factor regulating their activity (Avery, 1979; Lillywhite, 1987; Bauwens *et al.,* 1999; Nicholson *et al.,* 2005). Breeding activity was entirely absent and social interactions were observed to be almost nil during the winter months (Figure 6.9). Figure 6.9 also reveals that next to basking *S. ponticeriana* spent rest of the time in foraging and since foraging individuals had to escape their predators, the escape activity was also documented.

OVERALL TIME BUDGET AND ACTIVITY PATTERN OF *SITANA PONTICERIANA*

Looking into the holistic picture of the activity budget it was clearly evident that Fan-throated lizards are strictly diurnal. Maximum activity was noted during the summer while the minimum activity was observed during the winter. The daily activities followed the following sequence: the animals emerging from their shelter initially basked near their shelters or covers so as to escape from any potential predator and thereafter, they basked in the open areas concealing themselves with the surroundings. Gradually as they became fully active, they moved, foraged and had little interactions with the conspecifics. A spontaneous escape occurred on the notice of a predator and the re-emergence from the shelter was observed only after the predator had left. During summers, males after basking spent a little time in foraging and rather got involved in the courtship activity in the morning hours. Foraging by males was largely done during the late afternoon hours. Females on the other hand spent much time in foraging after basking so as to supplement their nutritional demands, since they were turning gravid. Juveniles spent the least time in basking and this was directly proportional to the body size. During monsoon immediately after basking, both males and females were actively engaged in the breeding activity while foraging was secondary and occurred in the later part of the day.

Even after so much of extensive activities in all the seasons, the proportion of time per day in all the seasons was just 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 was observed 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.

Since the winter temperatures were never so extreme during the entire study period (Table 6.9) hibernation was altogether absent in the species. The lizards could utilize barely two hours a day for daily activities as the movement was interrupted by frequent livestock grazing, predators and other anthropogenic activities. Coping with the time constraints, involved time budgeting with trade-offs. The relative proportions of activities in the behavioural repertoire represented the evolutionarily optimized time allocation to maximize the net benefit and thereby, fitness. The metabolic weight per se would determine, among other things, the activity duration and foraging behaviour of a species (Bartholomew and Tucker, 1964). Earlier studies associated the lower metabolic rate of large agamids with a nutrition poor, herbivorous diet (Pough 1973) and reduced activity had always been a rule among herbivorous lizards (Andrews 1971; Iverson, 1982). However, this is not the case with medium or small sized agamids that are principally insectivorous (Pough, 1973) and the activity is proportionately higher for these lizards (Grant and Dunham, 1988; Ellinger *et al.,* 2001; Melville and Schulte, 2001; Radder *et al.,* 2005) as well as for the diurnal lizards of other families that also exhibit a shift between bimodality and unimodality (Rivera-Velez and Lewis, 1994; Zari, 1996; Mohamed *et al.,* 1999; Foa and Bertolucci, 2001; Nicholson *et al.,* 2005; Dutta and Jhala, 2007). Consequently, the thermal niche use was generalized, naturally asking for thermoregulatory adaptation in this thermophilous ectotherm. Intermediate rests, during the hottest hours of the day reduced the body contact of the individuals with the external environment. Thus, smaller lizards had to utilize a larger temperature range for their activity.

BREEDING BIOLOGY OF *SITANA PONTICERIANA*

Reproduction is the major event in the life history of all organisms. Organisms perceive this event through variety of reproductive strategies or tactics that are either evolutionarily conserved within a group or species specific in some of the cases. Our knowledge regarding reproduction and breeding biology of reptiles is greatly enhanced in all the major reptilian groups (Dunson, 1975; Pritchard, 1979). Lizards are by and large oviparous and exhibit variety of courtship displays and mating strategies (Stamps 1975; Vitt, 1992; Dunham, 1994; Ord *et al.,* 2001). Breeding biology and life history of many lizard species has extensively been studied (Schmidt, 1935; Blanc and Carpenter, 1969; Andrews, 1979; Ruby 1984; Greer, 1989; Cooper and Guillette, 1991) but however, that of the Indian scenario is poor and limited only to a handful of species (Asana, 1941; Deraniyagala, 1958; John, 1967; Snayal and Prasad; 1967; Subba Rao and Rajabai, 1972b; Singh *et al.,* 1984). Although agamids being prominent amongst the lizards, studies are largely restricted to the genus *Calotes* (Subba Rao and Rajabai, 1972; Shanbhag and Prasad, 1993; Shanbhag *et al.,* 2000; Shanbhag 2002; Shanbhag, 2003; Asela *et al.,* 2007) whilst for other agamid species our knowledge on their breeding behaviour is far from complete. Hence, the current study is focused towards improving one's understanding on the courtship behaviour and reproductive traits in *S. ponticeriana.*

BREEDING COLOURATION AND VISUAL SIGNALING

It has been suggested that lizard displays and brightly coloured dewlaps are the functional equivalent of bird song and plumage (West-Eberhard, 1983). Many of the lizards in the Agamidae, Iguanidae and Lacertidae families show complex display behaviours and brightly coloured ornaments (Carpenter and Freguson, 1977; Cooper and Greenberg, 1992). Australian agamids are no exception with frequent sexual dichromatism (Cooper and Greenberg, 1992), territoriality and highly visually orientated behaviour (Greer, 1989). In a similar fashion, males of *S. ponticeriana* are also 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). This difference in the breeding colour could be a result of geographical variation in the habitat, as the previous workers have described the species from the peninsula and the forms from the western part of the country were never touched upon. 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.,* 1992). However, the role of lizard displays and colouration in sexual selection has received 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 along with an ethogram that describes the courtship and mating behaviour of *S. ponticeriana* in total.

ETHOGRAM OF COURTSHIP AND MATING BEHAVIOUR OF *SITANA PONTICERIANA*

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). Nocturnal lizards like geckos mainly rely on auditory/vocal cues (Frankenberg, 1982) or chemical cues (Cooper and Vitt 1987b) while agamids being primarily diurnal communicate through visual signals often delivered in a predictable sequence, together with characteristic postures and changes in body colouration as mentioned earlier. Interestingly, agamid lizards exhibit strikingly colourful visual displays. The current study presents a complete catalogue of the events during the courtship of *S. ponticeriana* as recorded in nature.

The courtship behaviour of *S. ponticeriana* was studied in wild. In total 12 encounters were carefully observed, recorded and analysed. Observations were recorded from mid April to mid June with the commencement of the breeding season of *S. ponticeriana,* when males attained their breeding colouration and started with the fanning behavior, till the final act of copulation was observed. Lizards became highly motile during the breeding season and males with their fanning displays immediately captured the sight and hence, spotting individuals was not difficult. Mating pairs were observed from a distance of approximately 2 m remaining in a still position as much as possible (except for noting the observations) thereby making no disturbance in their activity. The courtship behaviour was mainly encountered between 0830 h and 1230 h as well as 1600 h and 1830 h. Observations were recorded manually as field notes and the sequence of events were tried to be captured using a digital camera 'Olympus C770' without disturbing the individuals. The terminologies used for behaviour are mostly after Carpenter and Ferguson (1977).

The sexually matured males measured 42.2 ± 0.02 mm (SVL) and weighed 2.48 ± 0.24 g, while the SVL of gravid females was 46.4 ± 0.1 mm and weighed 2.65 ± 0.08 g. The courtship behaviour was observed with an uninterrupted gap between the said time intervals and based upon the observations an ethogram presenting a complete sequence of the events was prepared. A total of 20 types of behaviours associated with the courtship was recorded and is presented as below:

Behaviour types:

Aggression – Aggressive and dominating actions performed by male.

Amplexus – Male mounting over the female with fore-leg holding female's trunk and hind-leg holding female's tail base.

Chase – Rapid pursuit of one individual by another and the recessive male retreats.

Circling – Male approaches female with lateral orientation facing off the female in a circular or semi-circular path.

Combat – A sporadic fight followed by a chase between the two approaching males for the female.

Copulation – Intromission of hemipenis into the vent of the female; stationary for 4-8 seconds and withdrawal of the hemipenis.

Copulatory Plug – Both male and female held up in a plug for 3-5 seconds during copulation while facing in opposite direction.

Dewlap Extensions/Fanning – Rapid extension of the gular flap by the male due to the muscular movements of the hyoid apparatus.

Flee – Rapid retreat of the recessive male when chased by the dominant male also post-mating retreat by the copulating male.

Follow – Following of the female by the male.

Fore-leg Push-up – Rapid raising and lowering of the body by the male only on the fore legs.

Grip Release – Male releases the grip over the female.

Neck Bite – Male bites the skin on the neck of the female with its jaws, causing no injury and releases immediately.

Push-up – Rapid raising and lowering of the entire body, chiefly the anterior region on all the four legs.

Stand High – A stiff pose by the male on the ground by raising the body high on the forelegs.

Stationary – No body movements for 3-4 s during the mounting.

Straddle – Male holds the female by embracing with the limbs and climbs onto the back of the female.

Submission – Final acceptance of the female for the mating.

Tail Twitching – Tail lifted at the base, mid portion up and tip directed in the air not touching the substrate.

Tail Twist – Male's tail twisted under the female's tail bringing the cloaca close to that of the female.

These behavioural units account for majority of the events during the courtship and further can be distinguished into 11 distinct functional units as described below:

Circling – As the female signals her acceptance by the courtship stand, the male approaches her by circling.

Courtship Approach – Male's approach towards female with courtship displays i.e. dewlap extensions or fanning.

Courtship Display – Male performs the courtship display by his dewlap extension/fanning, initially from the shrub canopy and later from the ground.

Courtship Response – Female shows an acceptance response by moving to the ground from the shrub.

Courtship Stand – The female stands rigid and immobile as the courting male approaches her and does not try to flee.

Display Site Selection – Male chooses a strategic position on the shrub always higher to the female for the initial display.

Female Acceptance – Female shows her acceptance by moving to the ground from her perch followed by the courtship approach by the male in semi-circular path.

Grip Release – Male releases the leg hold on the female and the female is released free. Both the lizards face opposite to each other while in copulation and thereafter the male withdraws the hemipenis.

Mounting – The male assumes superior position on the female's dorsum and front leg hold on the female's trunk.

Post-mating Behaviour – The male moves to a near by shrub after mating and perches on the middle branches of the shrubs. The female retreats to the base of the shrub where she was perching prior to mating and this is perhaps the site she has selected to lay her clutch.

Submissive Behaviour – The receptive female shows this behaviour with head down, back arched and cloaca touching the ground with tail up at base. The receptive female shows submissive behaviour in acceptance for mating as the male approaches with circling.

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.

Orientation: Initially the males searched for a suitable shrub near to a gravid female to begin with their fanning activity (Figure 6.12) while the gravid female perched on a shrub selected by her (Figure 6.13) at an approximate height of 30-40 cm. She was then approached by the courting male. By and large a single male was seen approaching a female but in 3 field encounters of the total 12, two approaching males were observed. In this case as both the males tried to gain an access to the canopy height the dominant male chased the other competitor from the shrub. This resulted into a very short rather sporadic combat between the two on the ground and an immediate flee by the recessive male. The winner male then continued to gain its highest position on the shrub canopy, higher to the female (Figure 6.14) and began the initial displays through dewlap extensions (32-35 extensions per min; Figure 6.15). This initial phase of the courtship lasted for about 4.82 min. Thereafter, the receptive female moves to the ground from the shrub as an indication to the courtship response followed by the male. The male then begins his later part of display through dewlap extensions from the ground along with fore leg pushups (Figure 6.16) and approaches the female by circling movements. This event lasted for about 9.63 min.

Persuasion: The receptive female that has already expressed the courtship response by moving to the ground, now takes the courtship stand by remaining immobile towards the approach of the courting male (Figure 6.17). The male moves further towards the receptive female by circling movements and got closer to the receptive female (Figure 6.17). When the male is at distance of 20-30 cm from the female, he makes his first approach through a sudden sprint towards the female, bites her on the neck and moves behind. The neck bite and release of the male subdues the female and she expresses the submissive posture by lowering her head, arching the back and touching the cloaca to the ground by lifting the tail up at the base (Figure 6.17). These events of the second phase of the courtship last for about 2.14 min.

Thereafter, the male makes his second approach while the female is still in her submissive posture and mounts the female (approx 0.6 min).

Copulation: Copulation though clearly defined was observed to be a very short act (0.8 min) wherein male takes a firm grip hold on the female's back and twists its tail under that of female's tail. The male then brings his cloaca in contact with that of female and this is followed the intromission of hemipenis and copulation is achieved. The pair remains in this position for 6-9 s and then faced opposite to each other locked in copulatory plug (Figure 6.18). After the copulation, male moves in the opposite direction, looses the contact with the female and moves away. The male and female exhibit post-mating behaviour as described earlier.

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. Our discussion is therefore necessarily speculative, and based mainly on comparisons with *Calotes versicolor* (Pandav *et al.,* 2007) and distantly-related lizards in other families. Pandav *et al.,* (2007) mentions 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. The colouration that was attained by the males of *S. ponticeriana* at the commencement of the breeding season remained unaltered throughout, whereas females of this species show no change in their body colour, neither before nor after the courtship.

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). If this behaviour does increase visual acuity, then this behaviour in agamids and iguanids is perhaps has arisen for gaining of better visual information about an intruder in their territory and over a temporal scale has developed into the species-specific displays seen today. Head-bob behaviour was found to be completely lacking in *S. 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. Torr and Shine (1994) have not documented this behaviour in a species of small skink

Lampropholis guichenoti and suggest this as a secondary loss in lieu that small lizards do not tend to defend territories. As territoriality is not well documented in *S. ponticeriana*, this justifies the absence of head-bob behaviour in this species.

Rest of the behaviour patterns during courtship was 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 case of *S. ponticeriana* this display was not observed for females. Push-up displays on hind legs have been described for *Amphibolurus decresii* (Gibbons, 1979) but this display was too not encountered in the present study and also not reported 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.

NESTING BIOLOGY

Selection of Nest Site

Following the courtship and copulation occurs the 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. Locating the nests was a herculean task since majority of the nests occurred underneath a thorny shrub (*Capparis*) that was present in the study area. By and large these shrubs were those ones that were initially selected by the females for perching during the courtship. Selection of such a site (i.e. underneath a thorny shrub canopy) is justified as during the act of oviposition, females would be most vulnerable to the predators had they selected open sites for nesting. 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 *Cappris sp.* has much dense a canopy as that of other shrubs occurring in the area, thus providing a better cover to the species. A large quantum of studies has been conducted on the breeding biology of various lizards (Pianka and Pianka, 1970; Pianka, 1971b; Pianka and Parker, 1972; Parker and Pianka, 1973), however the parameter of nest site selection is poorly understood. Some of the earlier literature does mention about the selection of the nest site (Reese, 1922; Schonberger; 1945; Ramsey, 1956; Van Devender and Howard, 1973) but its relevance in the breeding of the species is not signified. Observations by *Asela et al.* (2007) on the egg laying of *Calotes liolepis* showed that the species selected soil covered with leaf litter for egg laying, also the workers have measured the canopy cover at the various study sites however the correlation of the canopy cover with the nest site selection is lacking. Forest lizards have a wider choice over the selection of nest site but in habitats such as scrubland and desert, the choice definitely narrows, since the resources are limited and hence, selecting a suitable nest site is essential for a species to ensure better survival of its clutch.

Nesting Period, Nest Dimensions and Ovipostion

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 also is the peak of monsoon (Figure 6.21). June was perhaps too early for the nesting as only two nests were observed. 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 in depth. Varied nest dimensions have been recorded for different agamids; 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 but definitely has scope for further analysis.

As again, a habit generalized to all agamids, *S. ponticeriana* dug the nest with its forelimbs, later straddling over the nest, laid its clutch, arranged the eggs with its snout, replaced the soil with its forelegs and tamped down the soil with the snout. Time taken by the individuals to lay their respective clutches varied between 12 and17 min. Since agamids lay their clutches in soil, soil acts as an incubation medium, therefore it was important to analyze some of the soil parameters to understand the significance, if any, of soil in the breeding biology. The soil in the study area was a clayey loam soil with particle size of 0.002-0.05 mm (30-40 % Clay: 60-70 % Silt). Table 6.13 depicts some of the important soil parameters. Penetrability was found maximum in the months of July, August and September thereby indicating that the soil was loose enough for the animals to dig their nests. Similarly soil moisture was also observed to be higher in these months and moreover, the soil temperature was observed to be approx 2°C lower than the ambient temperature thus setting in ideal conditions for the incubation (Table 6.13).

Clutch Size and Egg Morphometry

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). Currently no female was observed to lay multiple clutches in the natural conditions rather exhibited guarding behaviour towards their nests. With a marginal variation results of egg morphometry are in accordance with earlier reports (Chopra, 1964; Daniel, 2002; Radder and Shanbhag, 2003). The eggs are chalky white in colour and roughly oval in shape. Even though the exact incubation period could not be ascertained, from the appearance of hatchlings in the month of August (for the clutches laid in July) and in September (for the clutches laid in August) one can speculate with relative certainty that the incubation period ranged between 35-41 days.

DENSITY AND POPULATION STUDIES

Spatial distribution of Indian lizards is well known (Tikader and Sharma, 1992). It is believed that they are sparsely distributed and some species are endangered, though in reality they are still abundant in a given area of their distribution (Shanbhag *et al.*, 2003). Hence, it is necessary to monitor populations of Indian reptiles in the wild by surveying a large number of sites throughout the year and this will help in assessing changes in the species abundance and density. Such data represented as indices, could be used as first/pilot year data for assessing the future status and also for long-term monitoring of the population dynamics (Zuiderwijk and Smit, 1993; Zuiderwijk *et al.,* 1998). The findings of such studies will help in evolving conservation and policy making strategies (Shanbhag, 2003).

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 possible explanations could be given in a way that the resources (in this case prey/food) were found more clumped over a small area in the summer and dispersed or rather widely available across the area during monsoon and thus the density of lizards also varied accordingly. The least density during the winter was perhaps not because of resources but the activity period of lizards was minimum and thus fewer individuals were encountered per sq. km. 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 of 90 lizards per ha (Radder *et al.,* 2005), indicating healthy population of these agamids in southern India. Results of the current work also indicate that *S. ponticeriana* has good density and abundance in the selected study area. Moreover, review of the literature strangely 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.

Before proceeding with the Capture-mark-recapture technique pilot observations were conducted in all the seasons to gaze the variation in the population within different age groups of *S. ponticeriana.* These observations further showed that adults (both male and female) were maximally sighted during summer (Figure 6.22) since they were actively involved in foraging as well as courtship, while the hatchlings in large numbers were observed during monsoon (Figure 6.22). Number of juveniles was highest in winter followed by summer and monsoon (Figure 6.22), while for adults their numbers in monsoon and winter were fairly similar (Figure 6.22). Capture-Mark-recapture technique has been widely used for varied group of animals (see chapter 3) and also for reptiles (Turner, 1977) including lizards (Ruibal and Philibosian, 1974; Pianka, 1975). Population studies on *S. ponticeriana* through the capture-mark-recapture technique were conducted for the years 2006-2008, only adults were taken into consideration and it was evident from the results that *S. ponticeriana* had a healthy population in the study area for the year 2006-2007 (Table 6.11) but 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 6.23a) 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 6.23b). As mentioned earlier the soil in the area is clayey loam and hence is of great commercial importance to be used 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 6.23c and 6.23d).

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, infact 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.

PREDATORS AND PREDATION PRESSURE

Historically, insectivorous lizards are divided into active (or wide) and ambush (or sit-and-wait) foragers (Perry and Pianka, 1997). Typically active foragers move through their habitat in search of stationary and often hidden prey, and this is the time when the active foragers are in the sight of the predators that prey upon them (Huey and Pianka, 1981). In the current study *S. ponticeriana* was also found to be an active forager and while foraging was in turn predated by many of the predators that were recorded from the study area. Table 6.12 and Figure 6.24 depicts the potential predators of *S. ponticeriana* and the rate of predation. It was observed that *Accipiter badius* – Shikra was the foremost predator of *S. ponticeriana* (Figure 6.24) followed by *Varanus bengalensis* – Monitor Lizard and *Bubulcus ibis* – Cattle Egret (Figure 6.24). Other birds such as *Centropus sinensis* – Coucal and passerines were observed to prey upon mainly the juveniles and hatchlings of *S. ponticeriana,* whereas *Accipiter badius* – Shikra, *Bubulcus ibis* – Cattle Egret and *Halcyon symrnensis* – White-throated

Kingfisher largely took a toll of adult *S. ponticeriana.* Although many snakes were recorded from the study area of which only four species were occasionally observed feeding on *S. ponticeriana* (Table 6.12; Figure 6.24). The defense mechanism adopted by *S. ponticeriana* towards a predator attack was either to remain immobile and try to conceal itself with the surroundings or seek a refuge in the nearest thorny shrub. The strategy of remaining immobile helped in case of snakes that were foraging and might not see the lizards as they became stationary or even for small birds that foraged on ground and somehow missed these motionless lizards. A reluctance to move, even when threatened by a potential predator, could be advantageous since movement might attract a predator's attention and negate the advantage of cryptic colouration. Such a strategy is well observed amongst the desert lizards (Pianka and Parker, 1975) but for *S. ponticeriana* the strategy does not hold true always as the species does not exhibit a truly cryptic colouration. Hence, for the attacks of *Accipiter badius* and *Bubulcus ibis* it was observed that the lizards rushed towards the nearest bush since that was the only survival possibility against these predators.

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

Table 6.2 Morphometric Measurements (in mm / gm) of *Sitana ponticeriana* ($\bar{X}$ ± SD; n=15)

Parameters	Male	Female	Juvenile	Hatchling
Snout-Vent Length (SVL)	42.18 ± 1.81	47.44 ± 0.86	29.25 ± 0.81	12.64 ± 0.49
Tail Length (TL)	115.37 ± 3.13	112.46 ± 1.53	73.52 ± 0.93	28.6 ± 0.51
Total Body Length (TBL)	157.56 ± 4.9	159.91 ± 2.0	102.78 ± 1.67	41.25 ± 0.8
Weight (Wt)	2.64 ± 0.08	2.46 ± 0.01	0.87 ± 0.20	0.30 ± 0.03
Gravid Weight (GWt)	-----	2.59 ± 0.01	-----	-----
Fan Length (FL)	27.11 ± 1.14	-----	11.69 ± 0.75	-----
Fan Width (FW)	17.02 ± 0.17	-----	7.55 ± 0.65	-----

Table 6.3 Seasonal variation in the Food Composition of *Sitana ponticeriana* ($\bar{X}$ ± SD; n=15)

Food Type	Seasonal Variation in the Food Composition					
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Termites	5.4±1.50	9.4±1.77	3.2±0.91	8%	11%	7%
Bugs	0.7±0.82	1.2±1.03	1.6±1.34	1%	1%	3%
Crickets	1.2±1.03	1.4±1.17	1.9±1.19	2%	2%	4%
Lepidoteran Larvae	5.4±1.07	12.2±1.31	4.1±1.44	8%	14%	9%
Cocciniella sp.	2.7±0.82	2.4±1.07	3.2±1.39	4%	3%	8%
Carabid sp. (Adults)	2.2±0.78	2.4±0.69	4.8±0.91	3%	3%	11%
Carabid sp. (Grubs)	1.1±0.73	2.7±1.41	0.9±0.73	1%	3%	3%
Camponotus sp.	**24.8±1.47**	**26.1±1.59**	**13.0±1.05**	**35%**	**31%**	**28%**
Myrmica sp.	18.4±1.71	19.8±1.13	7.2±1.61	26%	23%	17%
Pheidole sp.	4.1±1.52	3.2±1.03	2.2±1.22	6%	4%	6%
Wasps	1.3±0.67	2.3±1.15	0.8±0.78	1%	3%	2%
Unidentified/Amorphous	3.6±1.26	1.8±0.78	1.1±0.73	5%	2%	2%

Table 6.4 Seasonal variation in the Forage Ratio (w_i) for the different prey species in the diet of *Sitana ponticeriana*

Food Type	Summer	Monsoon	Winter
Termites	0.83	0.76	0.61
Bugs	0.28	0.36	0.68
Crickets	0.66	0.8	0.72
Lepidoteran Larvae	1.11	1.49*	1.01
Cocciniella sp.	0.69	0.96	1.26
Carabid sp. (Adults)	0.37	0.56	1.33*
Carabid sp. (Grubs)	1.09	0.67	0.45
Beetles	**2.15**	**2.19**	**3.04**
Camponotus sp.	1.2*	1.17	1.18
Myrmica sp.	1.16	1.17	0.91
Pheidole sp.	0.67	0.43	0.64
Ants	**3.03**	**2.77**	**2.73**
Wasps	0.57	0.77	0.58

'*' are the significantly higher forage ratios for a particular prey species during the season

Table 6.5 Food preference index of *Sitana ponticeriana* during the different seasons

Murdoch's Preference Index 'C'	Summer	Monsoon	Winter
Ants Vs Others	1.58	1.2	1.15

Table 6.6 Seasonal variation in the Activity Budget (in min/day) of *Sitana ponticeriana*

Activity	Summer			Monsoon			Winter		
	Male	Female	Juvenile	Male	Female	Juvenile	Male	Female	Juvenile
Basking	18.51	26.47	15.27	39.21	31.54	28.60	46.19	40.29	37.12
Foraging	54.35	67.3	71.07	40.17	37	36.3	35.15	30.24	30.11
Soc. Int.	2.47	0.53	6.03	0.56	0.14	1.48	0.34	0.12	0.23
Courtship	26.58	4.04	0	17.6	5.6	0	0	0	0
Escape	7.41	4.39	6.11	3.48	2.55	1.28	5.22	3.25	1.06
Summation	**109.32**	**102.73**	**98.48**	**101.02**	**76.83**	**67.66**	**86.9**	**73.9**	**68.52**

Table 6.7 Temporal variation in the Activity Pattern of *Sitana ponticeriana* during Summer

Time	Male	Female	Juvenile	Hatchling	Total	$\bar{X}$± SD
7:30-8:00	4	0	10	0	14	3.5 ± 4.72
8:00-9:00	6	8	24	0	38	9.5 ± 10.24
9:00-10:00	21	13	19	0	53	13.25 ± 9.46
10:00-11:00	24	14	18	0	56	14 ± 10.19
11:00-12:00	13	8	23	0	44	11 ± 9.62
12:00-13:00	11	4	13	0	28	7 ± 6.05
13:00-14:00	9	2	10	0	21	5.25 ± 4.99
14:00-15:00	6	2	8	0	16	4 ± 3.65
15:00-16:00	9	3	11	0	23	5.75 ± 5.12
16:00-17:00	12	5	9	0	26	6.5 ± 5.19
17:00-18:00	5	0	4	0	9	3.6 ± 2.62
18:00-18:30	1	0	1	0	2	0.8 ± 0.57

Table 6.8 Temporal variation in the Activity Pattern of *Sitana ponticeriana* during Monsoon

Time	Male	Female	Juvenile	Hatchling	Total	$\bar{X}$ ± SD
7:30-8:00	1	0	1	0	2	0.5 ± 0.57
8:00-9:00	2	0	1	1	4	1 ± 0.81
9:00-10:00	3	2	4	3	12	3 ± 0.81
10:00-11:00	5	3	7	6	21	5.25 ± 1.7
11:00-12:00	8	6	7	8	29	7.25 ± 0.95
12:00-13:00	9	7	12	16	44	11 ± 3.91
13:00-14:00	14	11	15	23	63	15.75 ± 5.12
14:00-15:00	11	8	10	17	46	11.5 ± 3.87
15:00-16:00	10	8	9	14	41	10.25 ± 2.62
16:00-17:00	9	7	8	11	35	8.75 ± 1.7
17:00-18:00	8	5	6	9	28	7 ± 1.82
18:00-18:30	4	1	3	1	9	2.25 ± 1.5

Table 6.9 Temporal variation in the Activity Pattern of *Sitana ponticeriana* during Winter

Time	Male	Female	Juvenile	Hatchling	Total	X̄± SD
7:30-8:00	0	0	0	0	0	0
8:00-9:00	1	0	1	0	2	0.5 ± 0.57
9:00-10:00	1	0	2	0	3	0.75 ± 0.95
10:00-11:00	3	2	3	0	8	2 ± 1.41
11:00-12:00	6	3	5	0	14	3.5 ± 2.64
12:00-13:00	11	4	13	0	28	7 ± 6.05
13:00-14:00	10	5	11	0	26	6.5 ± 5.06
14:00-15:00	9	4	11	0	24	6 ± 4.96
15:00-16:00	5	3	10	0	18	4.5 ± 4.2
16:00-17:00	3	1	5	0	9	2.25 ± 2.21
17:00-18:00	2	1	2	0	5	1.25 ± 0.95
18:00-18:30	1	0	1	0	2	0.5 ± 0.58

Table 6.10 Egg Morphometry (in mm & gm) of *Sitana ponticeriana*

Parameter	X ± SD	Range
Clutch Size	11.6 ± 2.09	9 – 16
Egg Lt	10.02 ± 0.14	9.8 – 10.2
Egg Wd	6.05 ± 0.19	5.8 – 6.4
Egg wt	0.103 ± 0.005	0.093 – 0.107

Table 6.11 Population size of *Sitana ponticeriana* during the study period from 2006-2008 and Seasonal variation in the Density

Parameters	2006	2007	2008
'Peterson Estimate' for the Population Size	208*	273*	79*
	Summer	**Monsoon**	**Winter**
Density of lizards per Sq. km.	21.12 ± 3.28	16.18 ± 2.5	8.25 ± 2.64

'*' Corrected to the nearest whole number.

Table 6.12 Potential predators of *Sitana ponticeriana* and the rate of predation

Predators	Predation Rate
Herpestes edwardsii	7%
Accipiter badius	31%
Bubulcus ibis	11%
Halcyon smyrnensis	2%
Centropus sinensis	4%
Dicrurus macrocercus	2%
Acridotheres ginginianus	9%
Turdoides malcolmi	4%
Turdoides stiatus	2%
Varanus bengalensis	13%
Coelognathus helena	7%
Oligodon arnensis	2%
Ptyas mucosus	2%
Echis carinatus	4%

Table 6.13 Soil Parameters (Year 2008)

Month	Soil Penetrability	Soil pH	Soil Temperature	Soil Moisture
Jan	4.82 ± 0.17	7.17 ± 0.05	32.52 ± 0.48	3.13
Feb	3.95 ± 0.12	7.25 ± 0.1	33.47 ± 0.55	2.15
Mar	3.4 ± 0.18	7.17 ± 0.15	36.92 ± 1.26	1.5
Apr	2.82 ± 0.17	6.75 ± 0.1	39.62 ± 0.17	1.38
May	1.4 ± 0.14	6.8 ± 0.08	38.52 ± 0.44	0.23
Jun	3.1 ± 1.58	6.92 ± 0.05	36.6 ± 0.39	7.68
July	7.25 ± 0.94	7.9 ± 0.14	32.3 ± 0.54	19.75
Aug	8.2 ± 0.21	8.42 ± 0.12	31.82 ± 0.17	21.13
Sep	6.62 ± 0.17	8.1 ± 0.16	34.2 ± 0.25	12.4
Oct	4.22 ± 0.25	7.47 ± 0.12	36.4 ± 0.29	10.6
Nov	3.15 ± 0.12	7.3 ± 0.05	33.42 ± 0.38	6.88
Dec	3.92 ± 0.15	7.02 ± 0.09	33.52 ± 0.25	4.5

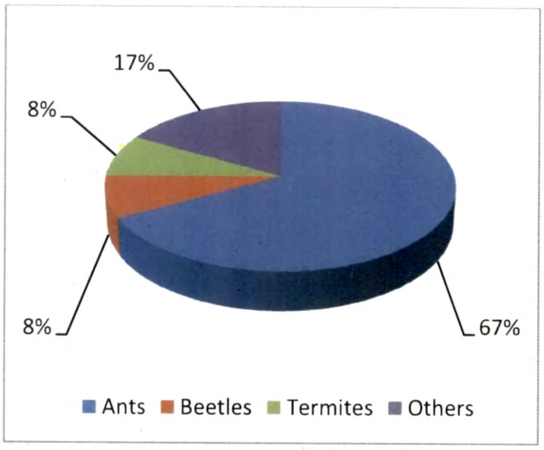

Figure 6.5a Diet Composition of *S. ponticeriana* during summer

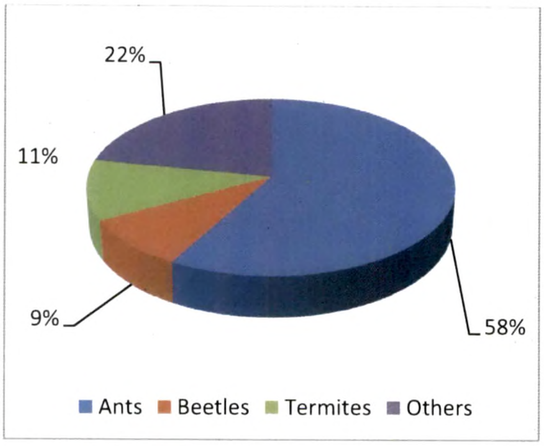

Figure 6.5b Diet Composition of *S. ponticeriana* during monsoon

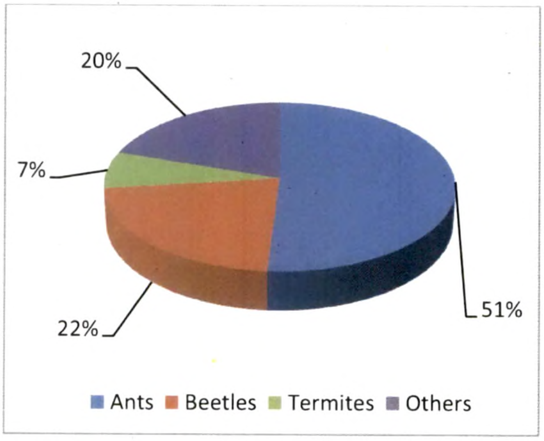

Figure 6.5c Diet Composition of *S. ponticeriana* during winter

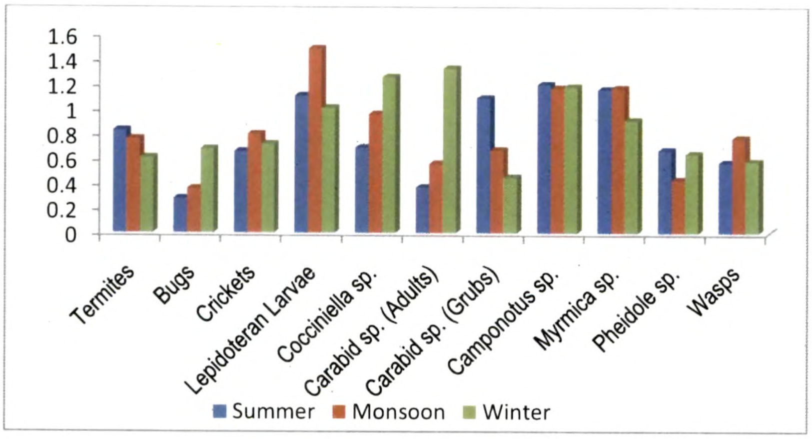

Figure 6.6 Forage Ratio (w_i) for the various prey species in all the three seasons

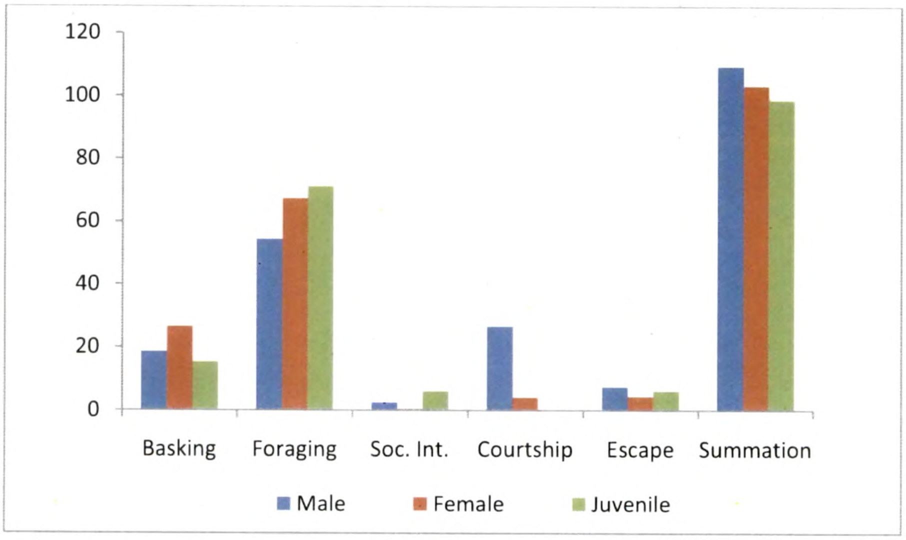

Figure 6.7 Activity Budget of *S. ponticeriana* during summer

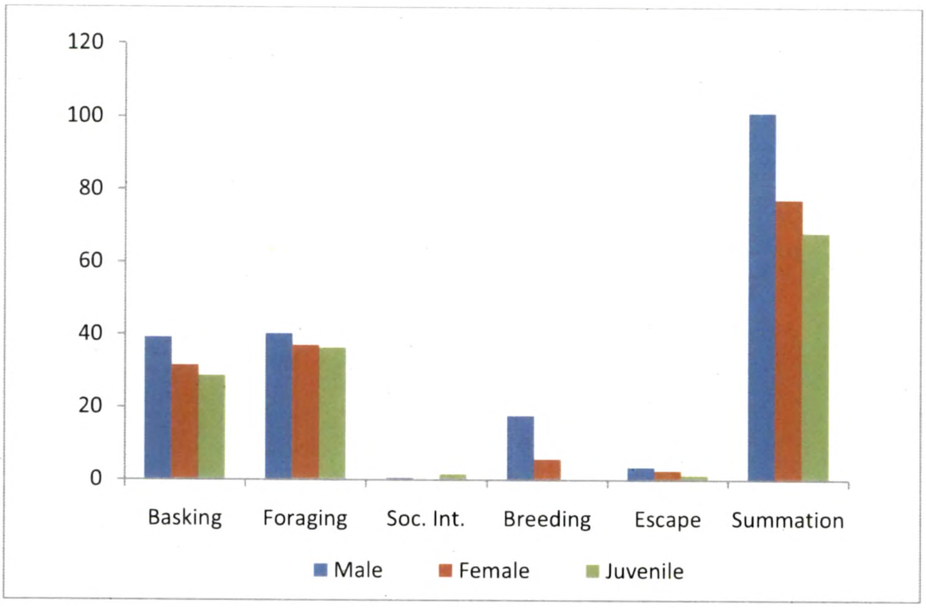

Figure 6.8 Activity Budget of *S. ponticeriana* during monsoon

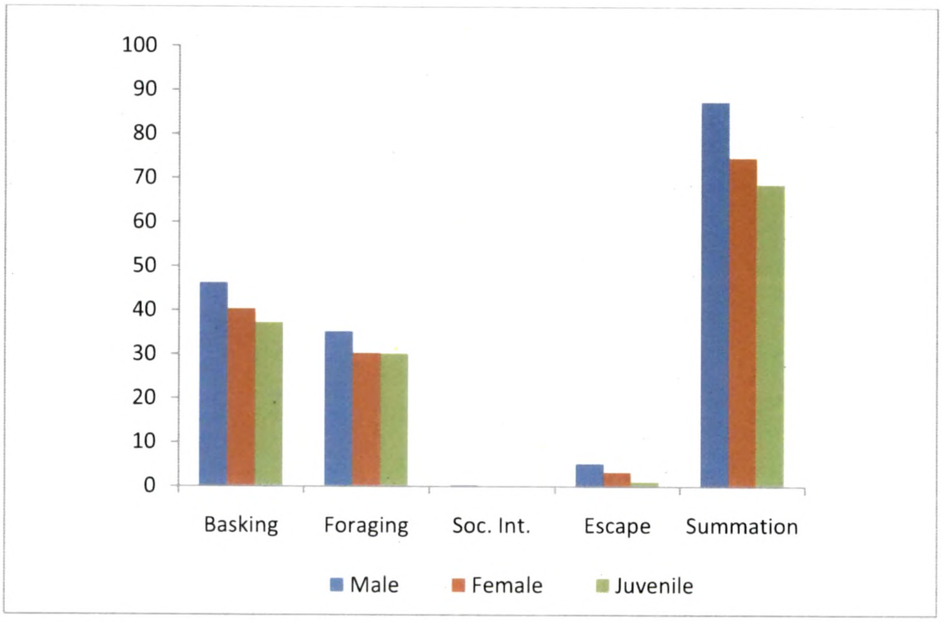

Figure 6.9 Activity Budget of *S. ponticeriana* during winter

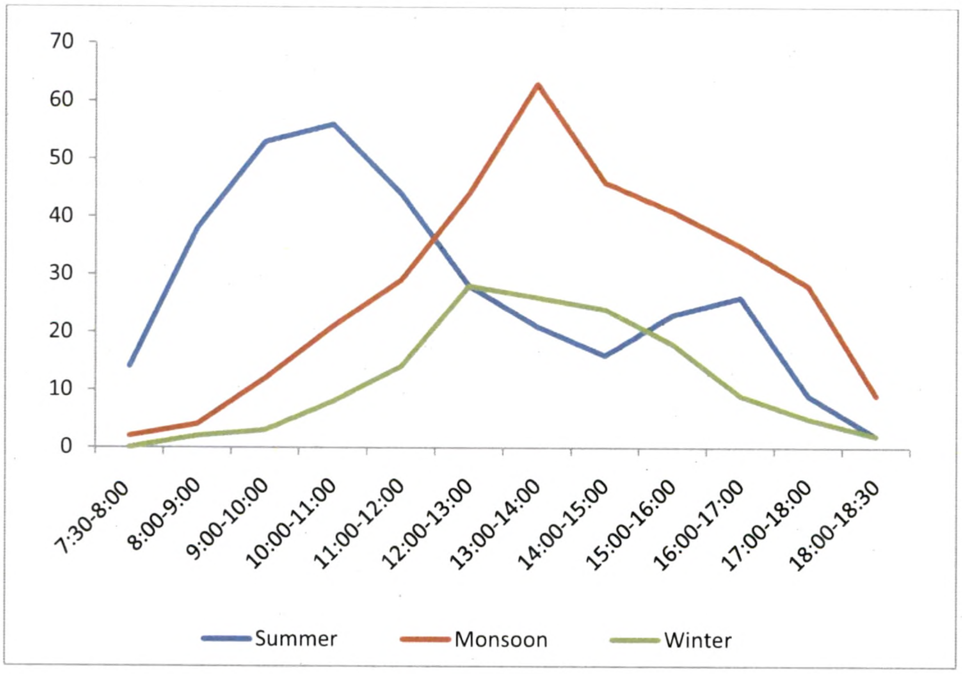

Figure 6.10 Seasonal comparisons of diurnal patterns in the activity of *S. ponticeriana*

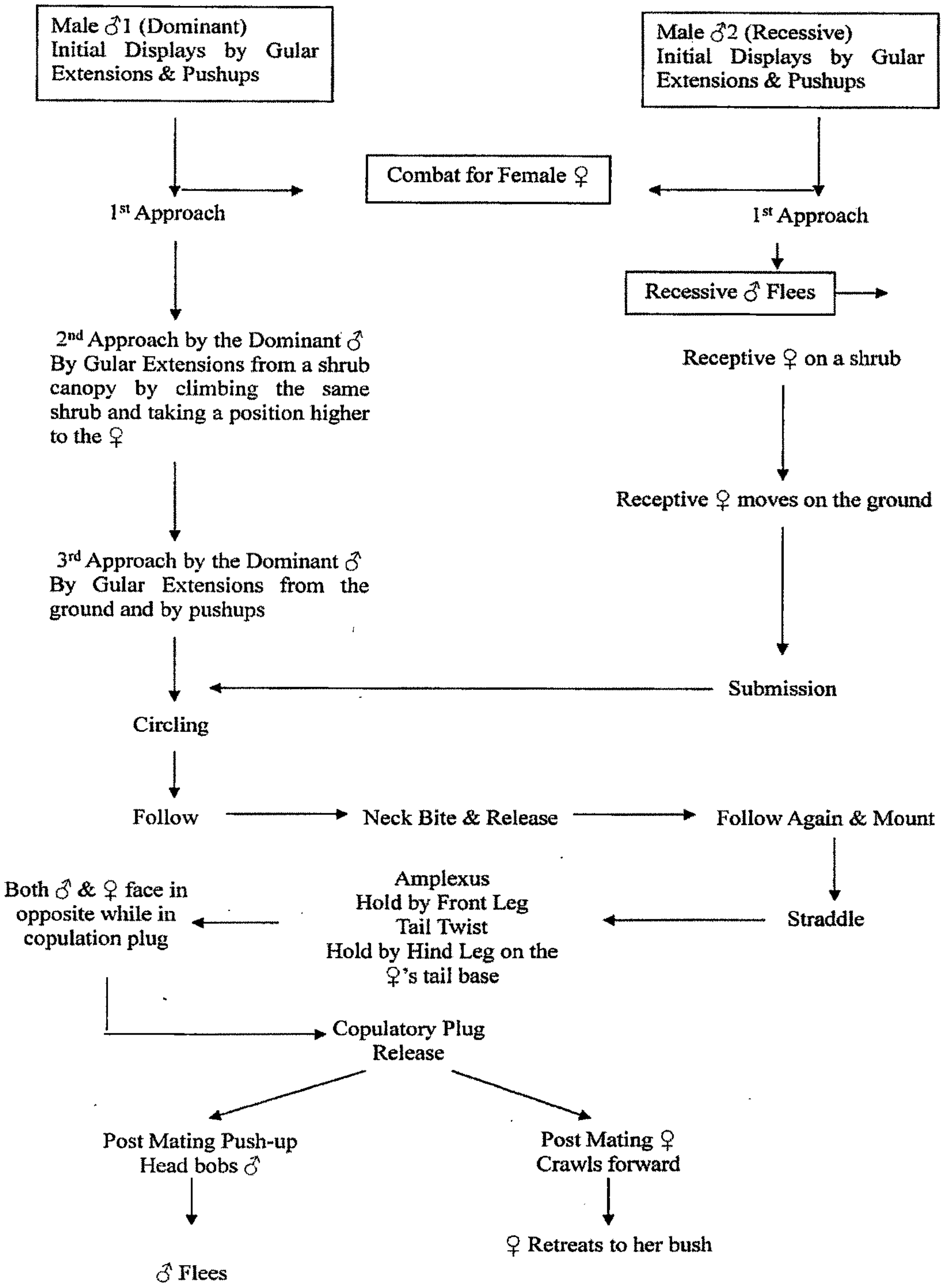

Figure 6.19 Summary of sequential events during the courtship and mating behaviour of *Sitana ponticeriana*

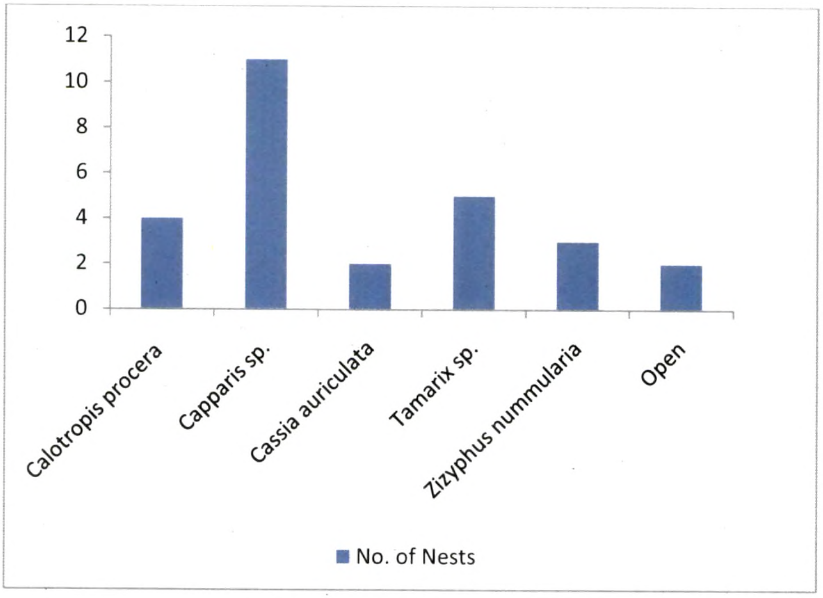

Figure 6.20 Selection of nest site by *S. ponticeriana*

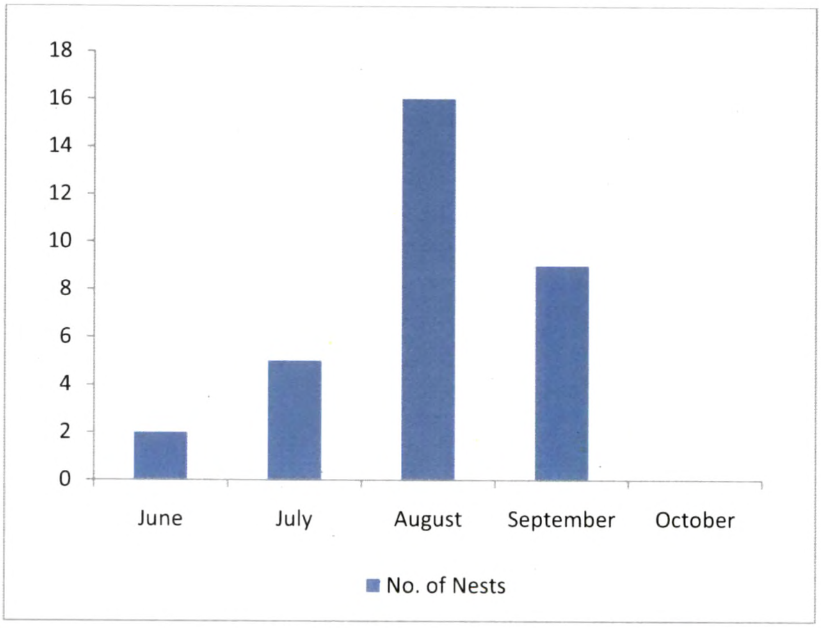

Figure 6.21 Nesting period of *S. ponticeriana*

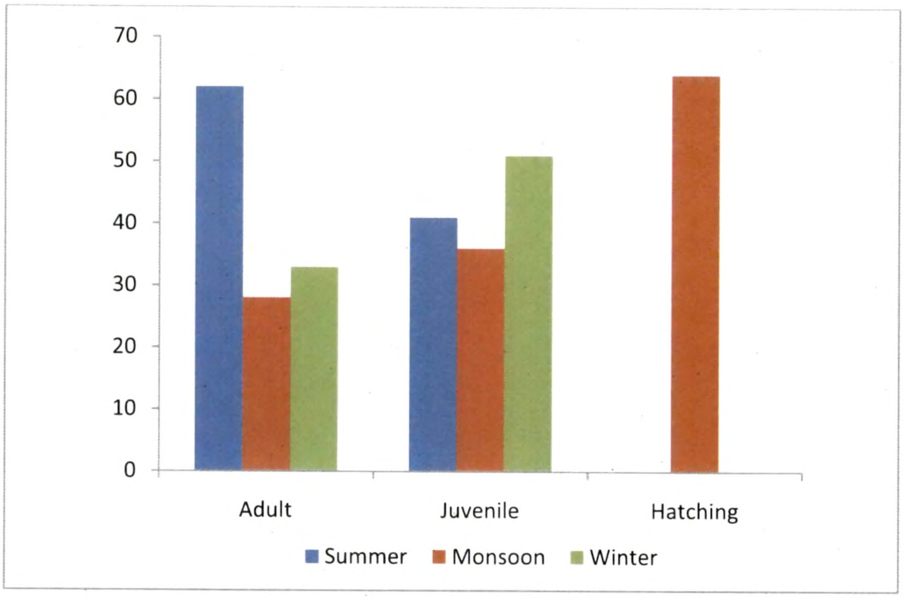

Figure 6.22 Population structure of *S. ponticeriana* of different age class in all the three seasons

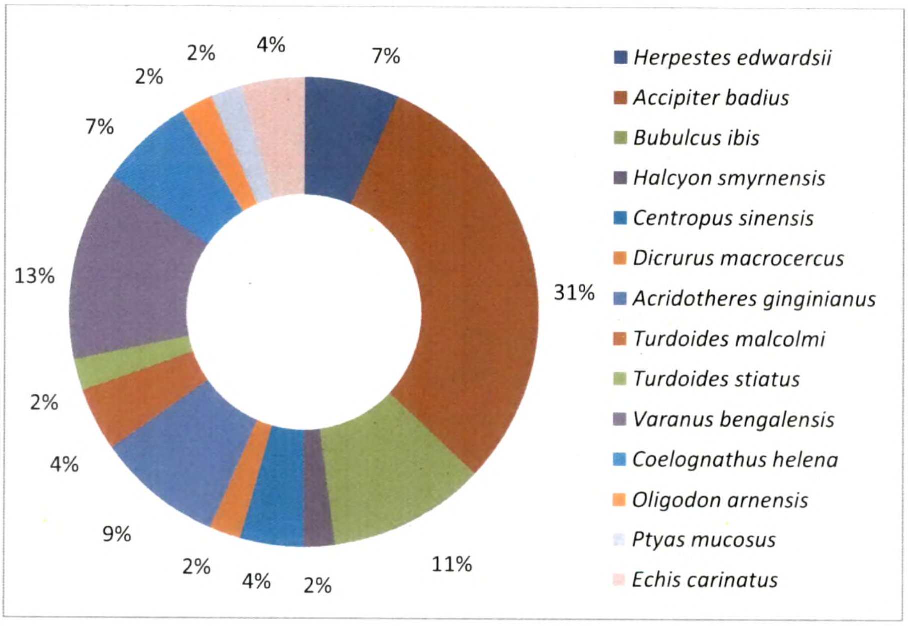

Figure 6.24 Potential Predators of *S. ponticeriana* and their rate of predation

Figure 6.1 *Sitana ponticeriana* (Adult Male)

Figure 6.2 *Sitana ponticeriana* (Adult Female)

Figure 6.3 *Sitana ponticeriana* (Gravid Female)

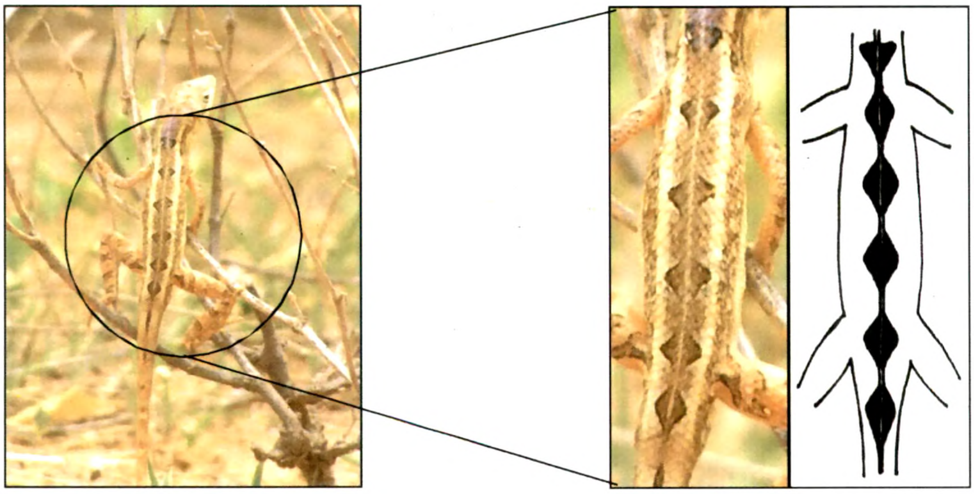

Figure 6.4a Uniformed paired pattern with blunt tips (Male)

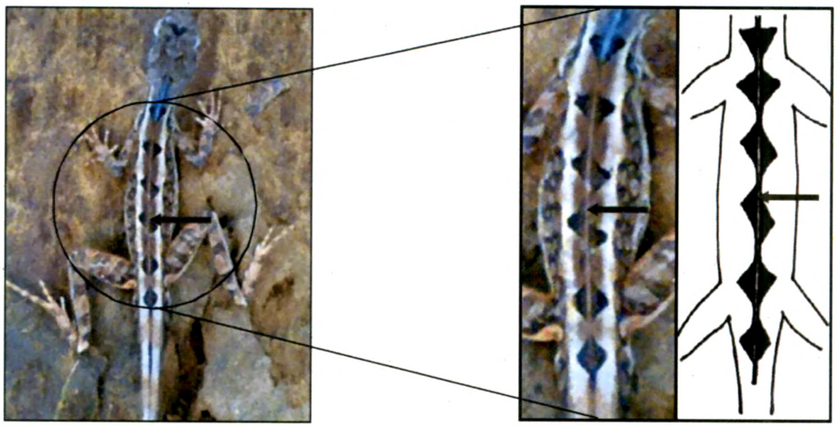

Figure 6.4b Uniformed paired pattern with slight misalignment (Male)

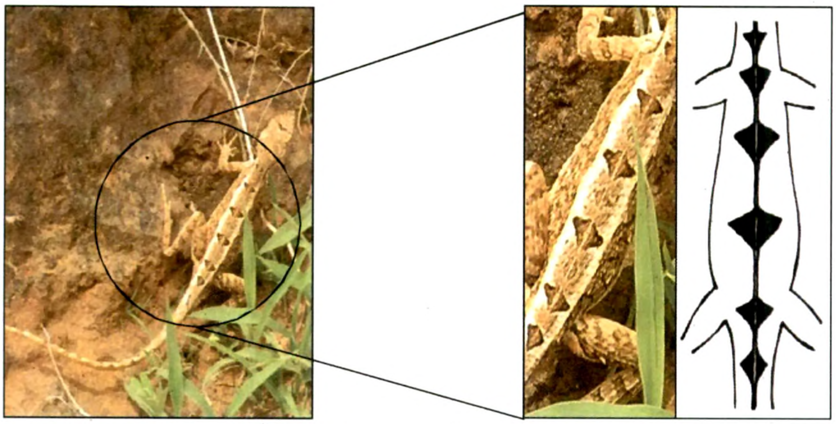

Figure 6.4c Uniformed paired pattern (Female)

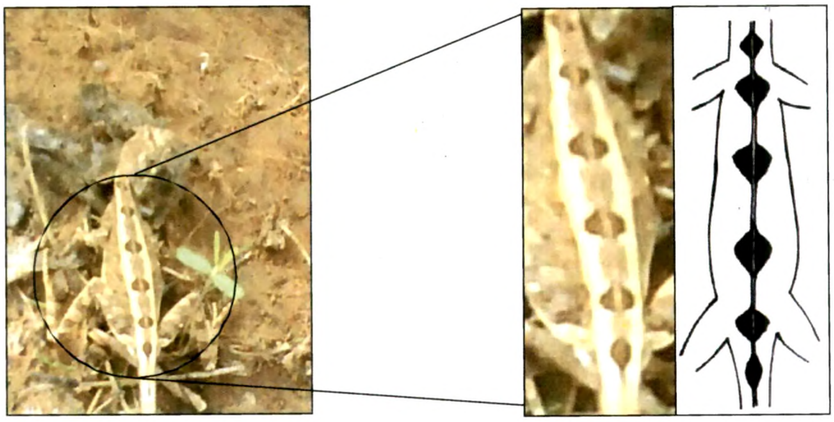

Figure 6.4d Uniformed paired pattern with blunt tips (Female)

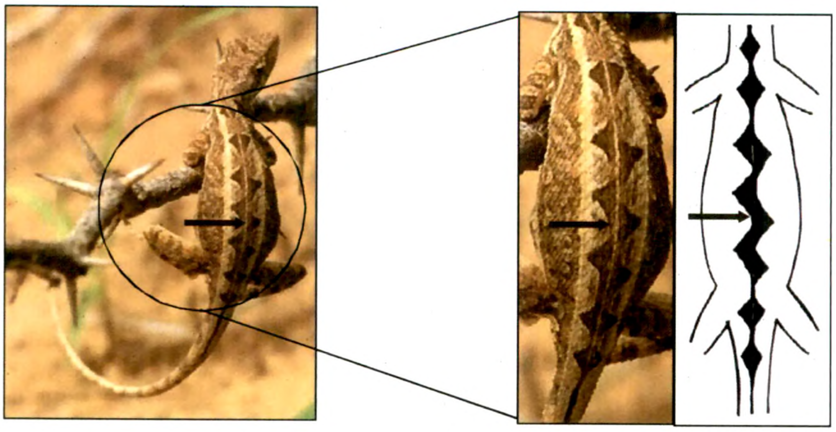

Figure 6.4e Uniformed paired pattern with complete misalignment (→) leading to increase in a number of diamond patches (Female)

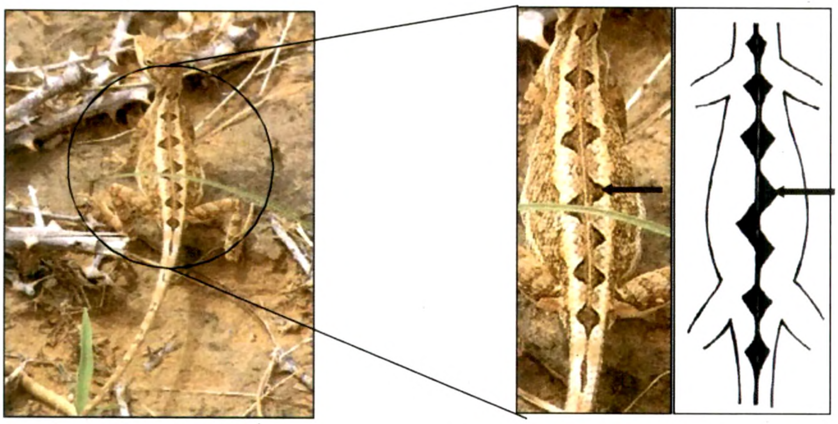

Figure 6.4f Uniformed unpaired pattern (→)(Female)

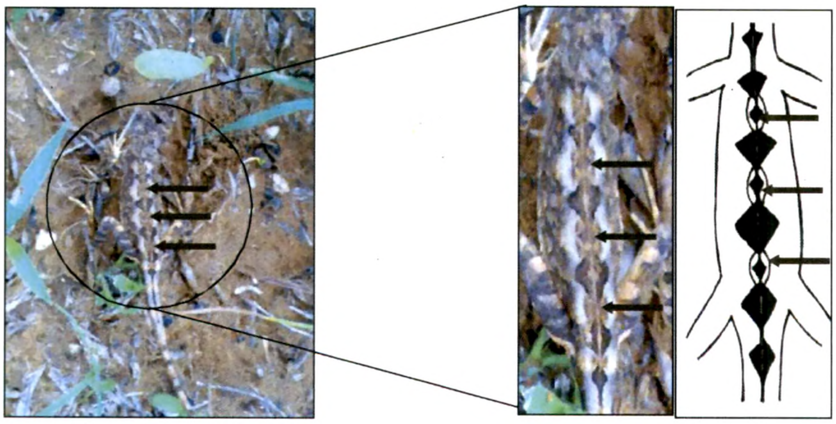

Figure 6.4g Uniformed paired pattern with blunt tips and additional small diamonds in between the main patches; 2nd and 3rd, 3rd and 4th, 4th and 5th (Female)

Figure 6.11 *Sitana ponticeriana* Male in breeding colouration - showing blue coloured path on neck(→) and a blue streak along the mid ventral edge of the gular flap(→)

Figure 6.12 *Sitana ponticeriana* (Male) selecting a suitable perch to begin with the fanning activity

Figure 6.13 *Sitana ponticeriana* (Gravid Female) initially perching on the shrub

Figure 6.14 Male assuming a higher than female on the perch

Figure 6.15 Male performing its peculiar courtship display of fanning from the perch

Figure 6.16 Male performing the courtship display of fanning from the ground along with fore leg push-ups

Figure 6.17 Approach by the courting male while the receptive female expresses the submissive behaviour

Figure 6.18 Male and female locked in a copulatory plug

Figure 6.23a ISA - 2: Sindhrot Village Scrubland/Vadodara Rural
The undisturbed habitat of *Sitana ponticeriana* during the study period from 2006 - 2007

Figure 6.23b ISA - 2: Sindhrot Village Scrubland/Vadodara Rural
Beginning of habitat degradation in March 2008

Figure 6.23c ISA - 2: Sindhrot Village Scrubland/Vadodara Rural
Further degradation of habitat as observed in April 2008

Figure 6.23d ISA - 2: Sindhrot Village Scrubland/Vadodara Rural
Summit of Habitat degradation - May 2008