# ECOLOGICAL STUDY OF *Saara Hardwickii* IN CENTRAL GUJARAT

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# INTRODUCTION

Herpetology is a branch of Zoology that deals with study of Amphibians (frogs, toads, salamanders, newts and caecilians) and Reptiles (snakes, lizards, turtles, tortoise, crocodiles and terrapins), both clades arose within the tetrapod. Tetrapods are the fishes who has undergone transition from fin to limbs i.e. water to land, and one of their earliest divergent group developed into the amphibians. These amphibians successfully explored humid environment, remained closely tangled to the water and moist microhabitat for their propagation. Another divergent group of Tetrapods, the Anthracosaurs, modified and propagated on land without water and circumstantially, developed an effective skin barrier to reduce excessive and rapid water loss and are represented as “Reptile”.

Amphibians and reptiles are better suited than birds and mammals in different ecological situations characterized by periodic shortages of food, water, or oxygen (Harvey, 1980). Physiological differences in reptiles are significantly important from environmental perspectives. For example, their low metabolic rates (Bennett & Dawson, 1976) allow reptiles to conserve various resources as compared to birds and mammals. Reptiles are ectothermic as they obtain heat solely from the external environments whereas birds and mammals are endothermic and heat is generally produced through oxidative metabolism. Amphibians have certain advantages under the harsh unpredictable conditions that help them to live even in deserts. Range of body temperature is inversely proportional to the length of activity period and it differs from species to species (Pianka, 1977). Foraging behavior can also be very well correlated with activity temperature: active foragers have higher mean body temperatures than inactive predators. Thermoregulation helps them to conserve energy and water resources in extreme conditions.

The reptiles consist of three clades: Testudines, Archosaurs and Lepidosaurs. The Lepidosaurs includes snakes, lizards and tuataras.

Lizards are widespread order of Squamata reptiles with over 6,000 species worldwide except in Antarctica. They occupy all terrestrial biotopes in India, from deserts to evergreen forest and from plains to Himalayas. Nine families – Gekkonidae, Eublepharidae, Agamidae, Chamaeleonidae, Scincidae, Lacertidae, Anguidae, Varanidae and Dibamidae are found in India (The Book of Indian Reptiles and Amphibians, 2008). They are the largest and the most diverse group of land vertebrates. They range in size from tiny geckos that could completely curl up on the thumbnail to 10-foot giants (Guide to lizards, 2010). The largest known lizard is Komodo dragon of Varanid and the smallest being *Sphaerodactylus parthenopion* and *Sphaerodactylus ariasae* . Schoener considered lizards as model animal than birds in general as they are terrestrial, quadrupedal, poikilothermic, grow slowly and lacks parental care.

The suborder Lacertilia of order Squamata includes about 421 species belonging to two families: family Agamidae including 50 genera and 400 species and family Leiolepidinae which contains two genera with 21 species. The latter subfamily contains genus Leiolepis (7 species) and genus Uromastyx (14 species) (Zug et al., 2001)

Agamidae is a family of Iguanian lizards indigenous to Africa, Asia, Australia and a few in Southern Europe. Many species are known as Dragons or Dragon lizards. Most Agamids are insectivorous and few are herbivorous. Agamid lizards are predominantly oviparous; only two genera (Phrynocephalus and Cophotes) are viviparous (Goin et al., 1978). Agamids have well-developed strong legs and their tails do not have regeneration potential (Thompson, 1993). Many agamid species are capable of limited camouflage to regulate their body temperature (Velasco *et al.*,2005). In some species, males are more brightly colored than

females, and colors play a vital role in signaling and reproductive behaviors. Large number of chromatophores are present in the skin that enables them for camouflage according to the external stimuli.

The Uromasticinae, the subfamily of our interest, comprises of two genera - Saara and Uromastyx. Lizards of genus Uromastyx occur in the desert belt of the old world between 5°N and 35°N. Their range cover an enormous land mass including the Northern Africa, the Middle East Arabia, Iran and Iraq. Uromastyx comprises of 15 species.

Saara and Uromastyx, are differentiated by the presence or absence of intercalaries between the tail whorls respectively (Wilms, 2005; Wilms *et al.,* 2009).

| | |
|---|---|
| **Kingdom** | Animalia |
| **Subkingdom** | Bilateria |
| **Infrakingdom** | Deuterostomia |
| **Phylum** | Chordata |
| **Subphylum** | Vertebrata |
| **Infraphylum** | Gnathostomata |
| **Superclass** | Tetrapoda |
| **Class** | Reptilia |
| **Order** | Squamata |
| **Suborder** | Iguania |
| **Family** | Agamidae |
| **Subfamily** | Uromastycinae |
| **Genus** | Saara |
| **Species** | *S. hardwickii* |

**Table 1: Classification of *Saara hardwickii***

**BURROW:**

Saara and Uromastyx are desert lizards found primarily in deserts, both in sandy and rocky regions. The adults vary in size reaches to half meters of their total body length. They dig out the large spiral burrows to reside with their powerful claws.

Saara is a genus of Agamid lizards found prominently in Asia. The genus Saara is characterized by 3 species worldwide (Wilms *et al*., 2009) –

*Saara asmussi* (Strauch, 1863) – Persian spiny tailed lizard,

*Saara loricata* (Blanford, 1874) – Iraqi spiny tailed lizard, and

*Saara hardwickii* (Gray, 1827) – Indian spiny tailed lizard. (The taxonomic position of the species is given in table 1)

## 1. *Saara asmussi* (Figure. 1)

**Differential diagnosis:** The species asmussi belongs to the genus Saara. This taxon is distinguished from *Saara hardwickii* by 1–2 rows of unkeeled intercalary scales separating each tail whorl dorsally (2–6 keeled intercalary scales in S. hardwickii). The *S. asmussi* is distinguished from S. loricata in having fewer preanofemoral pores (8–13 in vs. 14–20 in S. loricata).

**Description**: Maximum length 475 mm, maximum SVL (snout- vent-length) 265 mm. 170–201 scales around mid-body, 94–103 scales between gular- and inguinal fold, 40–53 gular scales, 21–27 scales counted from the mid of the lower end of the ear opening to the mental scale. On both sides 5–7 scales between supralabial and enlarged sub ocular scale. 25–30 scales around 5th whorl. 23–26 tail whorls. 11–13 scales beneath 4th left toe. 8–13 preanofemoral pores on either side.

**Coloration**: Head, shoulders and forelegs are light grey to bluish in color, hind legs yellowish grey to blue. Tail dull grey-olive with yellowish spines or completely blue. Backside light ocker yellow up to the tail root; some tubercules on the back are colored orange. The belly is yellowish white with dark spots on the breast. At low temperatures the back is blackgrey

**Distribution**: Saara asmussi lives in the dry areas of Iran, Afghanistan and Pakistan.

**Tail:** Tail with less than 28 primary whorls; 1–2 rows of unkeeled intercalary scales between tail whorls on dorsal surface of tail; dorsal scalation with transverse rows of conspicuously enlarged tubercular scales.

## 2. S*aara loricata* (Figure. 2)

**Differential diagnosis**: This taxon is distinguished from *Saara hardwickii* by 1–2 rows of unkeeled intercalary scales separating each tail whorl dorsally (2–6 keeled intercalary scales in *S. hardwickii*). *S. loricata* is distinguished from S. asmussi in having more preanofemoralpores (8–13 in S. asmussi vs. 15–20 in S. loricata).

**Description**: Maximum total length 520 mm, maximum SVL 290 mm. 183–234 scales around mid-body, 101–110 scales between gular- and inguinal fold, 32–45 gular scales, 24–36 scales counted from the mid of the lower end of the ear opening to the mental scale. On both sides 4–8 scales between supralabial and enlarged subocular scale. 23–33 scales around 5th whorl. 22–26 tail whorls. 11–13 scales beneath 4th left toe. 15–20 preanofemoral pores on each side.

**Colouration**: Head, limbs, back and tail brown, yellow-grey or crème coloured with small intermixed brown dots. Back sometimes vividly red coloured. The belly is yellowish brown or yellowish white (Kalaf 1959; Haas & Werner 1969).

**Tail:** Without enlarged scales at the front edge of the ear opening; 15–20 preanofemoral pores on either side; 12 scales in a transverse row on the dorsal surface of the tail base.

### 3. *Saara hardwickii* (Figure. 3)

**Differential diagnosis**: This taxon is distinguished from S. asmussi and S. loricata by having 2–6 keeled intercalary scales separating each tail whorl dorsally (1–2 rows of unkeeled intercalary scales in S. asmussi and S. loricata).

**Description**: Maximum total length 438 mm, maximum SVL 233 mm. 190–275 scales around mid-body, 112–157 scales between gular- and inguinal fold, 32–46 gular scales, 24–42 scales counted from the mid of the lower end of the ear opening to the mental scale. On both sides 6-9 scales between supralabial and enlarged subocular scale. 40–52 scales around 5th whorl. 28–39 whorls. 15–21 scales beneath 4th left toe. 12–19 preanofemoral pores on either side.

**Colouration**: The colouration of the back is yellow brown, with dark dots or with a vermiculation with whitish belly portion. The throat is scattered with dark dots. The front sides of the upper thighs on both sides show a black spot at the base of the frontlegs. The pattern of the juveniles consists of uniformly spaced black dots on the back.

**Distribution**: *Saara hardwickii* is widely distributed in the dry areas of northwest India and Pakistan. In Afghanistan this species lives at least in the border area with Pakistan, near Jalalabad (Wilms. 2001).

**Tail:** Tail with 29–36 primary whorls; 2–6 rows of keeled intercalary scales between whorls on dorsal surface of tail; dorsal scalation interspersed with irregular and slightly enlarged, tubercular scales.

Figure. 1 *Saara asmussi*

*Figure. 2 Saara loricata*

Figure. 3 *Saara hardwickii*

**SKULL:**

Siebenrock (1895) recognized two major skull types amongst Agamids: laterally compressed skull is found mostly in arboreal genera and wider and flattened type is seen mainly in terrestrial taxa like *Uromastyx* and *Saara*.

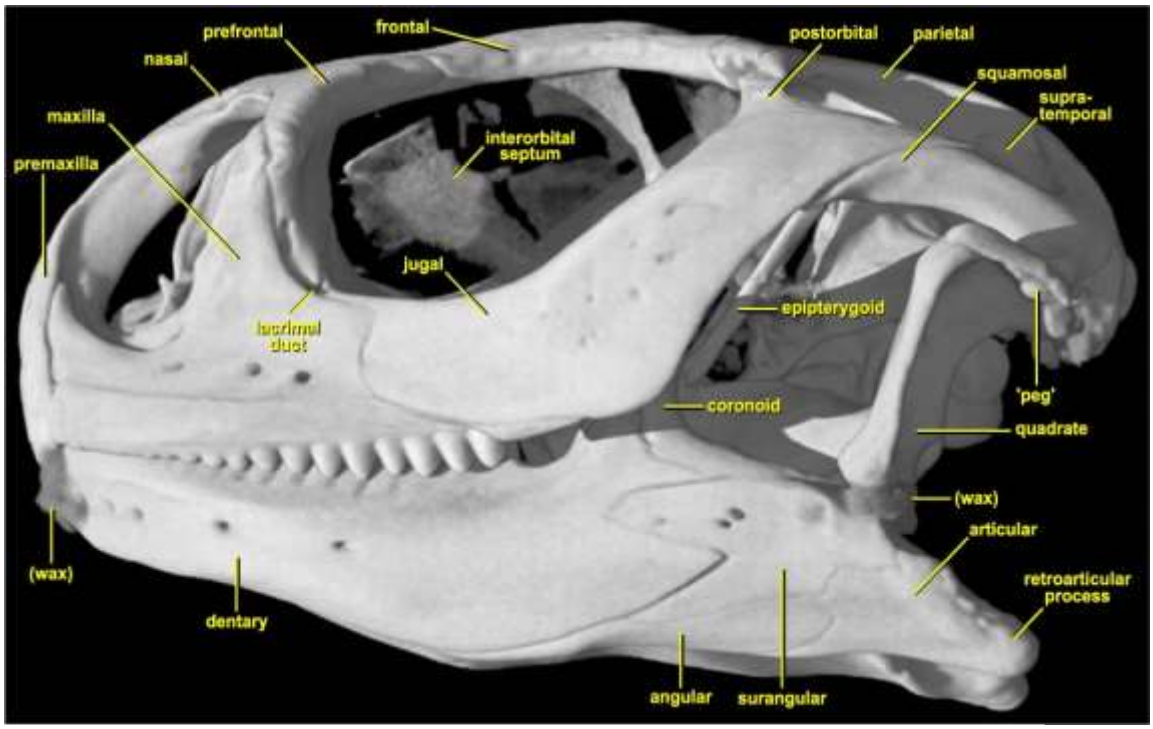


**Figure. 4 Lateral view of skull of *Saara hardwickii***

The skull (Figure. 4) presents a tall anterior premaxilla, relatively short tall maxilla with larger prefrontal, and massive jugal. Together, the premaxilla, maxilla and nasal border forms the large external naris. The anterior processes of the maxillae meet behind the premaxilla. The facial process is narrow and lies against the expanded prefrontal. The latter forms a strong flange in the orbital margin as it separates orbits from the nasal chamber and bracing the antorbital margin. The lacrimal duct runs between the prefrontal and maxilla. The orbit is

dorsolaterally directed and framed by the frontal and (briefly) parietal dorsally, the postorbital and jugal posteriorly, the jugal and maxilla ventrally, and the prefrontal anteriorly (Susan Evans, 2003).

All maxillary teeth are acrodont, the anterior teeth being worn down almost to the alveolar margin while the posterior teeth are fairly pristine. Dorsally, the jugal meets the postorbital and the squamosal. The postorbital abuts the parietal directly without an intervening postfrontal. The squamosal is sigmoid and bears a strong posterodorsal process that contacts the postparietal process of the parietal, and a smaller ventral 'peg' for the quadrate. This 'peg' is accommodated within a foramen in the expanded cephalic condyle of the quadrate. The dorsal quadrate articulation is thus provided by the squamosal, and also by the supratemporal and the paroccipital process of the otooccipital. The quadrate is a large bone that provides the articulation between the skull and the lower jaw (and is equivalent to the incus in the mammalian skull). Its raised anterolateral margin forms the frame to which the tympanic membrane is attached (the other borders being the retro articular process of the lower jaw and a muscle [the depressor mandibulae] that runs from the skull to the back of the jaw). Accordingly, the rod-like epipterygoid is also visible medial to the jugal, as is the dense interorbital septum. (Susan Evans, 2003)

The lower jaw is deep and robust. The dentary ends posteriorly in a bifurcate suture, meeting the surangular dorsally and the angular.

**HOME RANGE:**

Home range (HR) was originally defined by Burt (1943) as the area traversed during the natural activities of food gathering, mating, and caring for young. Most home range studies deal with

interactions of: (1) a lizard's social organization and orientation; (2) home range size and functionality; (3) HR size, productivity of the environment, and population density; (4) HR size, mating success and survival. HR size is considered as an important indicator of the behavioral and resource requirements of an animal with reference to available resources.

**Factors affecting HR:**

1. **Body size:** Larger body sized animals have larger HR due to increased food requirements and accumulation of food.
2. **Diet:** According to trophic level distribution, larger carnivores require larger home range as compared to herbivore for their survival.
3. **Selection of food or foraging style:** frugivorous primates have relatively larger HRs than do foliage eaters (Milton and May 1976). Besides, browsing ungulates have relatively larger HRs than do grazers (Mysterud et.al, 2001).
4. **Other factors:** climatic factors, weather, age, sex, habitat quality, and activity patterns (Stickel 1968, Mysterud et al.,. 2001). Some of the aforementioned factors might be mediated by dietary needs and food availability.

# Review of literature

Gujarat is one of the most biodiverse state in India. The habitat varies from dry deserts in the parts of Kutch and Saurashtra to moist deciduous forest in the southernmost part of the State in the district of Surat, Valsad and Dang to coastal area along the 15 districts of Gujarat. This provides a very conducive environment for the survival of several micro and macro organisms. A total of 107 reptile species from 62 genera in 23 families have been recorded in Gujarat state. Contradictory, addition of 23 species of reptiles dubiously or erroneously reported in the literature are discussed and recommended for removal from the Gujarat reptiles list (Patel, Harshil & Vyas, Raju, 2019).The genus name Uromastyx was coined by Merrem (1820) in his work '*Versuch eines Systems der Amphibien – Tentamen Systematis Amphibiorum*'. Wilms, *et.al.* (2009) assessed the taxonomic relationships within the genus Uromastyx using morphological and genetic methods, resulting in the resurrection of the genus Saara (Gray, 1845) for *Saara hardwickii, S. asmussi* and *S. loricata*.

*Saara hardwickii* has been listed as Data Deficient in India (Molur & Walker, 1998) due to lack of information. Earlier, Spiny-tailed lizard (Uromastyx hardwickii) has been recorded in India from Andhra Pradesh, Orissa, Gujarat, Uttar Pradesh and Rajasthan (Joseph, 1988; Sharma, 2002). The largest population of Indian spiny-tailed lizards is found in the Thar Desert of Rajasthan chiefly within the western districts whereas smaller populations have been reported from western Gujarat (Ramesh M. & Sankaran R., 2013). Gujarat has a less known distribution – The STL are majorly found in Kutch, Surendranagar, Rajkot, Patan and Amreli districts of Gujarat.

Several studies were conducted in order to isolate DNA and sequencing procedures from muscle tissue of S. hardwickii. (Amer & Kumazawa, 2005). It is observed that activation of thyroid gland is proportional to active or inactive state of thyroid gland (Sinha Choubey, 1981).

Progesterone, testosterone, and estradiol-17β were measured by radioimmunoassay in the plasma and ovarian tissues of preovulatory and gravid spiny-tailed lizards (Uromastix hardwickii). Plasma titers of all three steroids were significantly higher in females carrying the oviductal eggs as compared to the values obtained in the preovulatory animals. The rise in plasma levels of steroids during gravidity is mainly due to the steroidogenic activity of the corpus luteum and that the functions generally attributed to the reptilian luteal tissue may be mediated not only by progestins alone but also by other steroids synthesized by the corpus luteum in this reproductive phase (Arslan *et.al*, 1977)

In other studies, monthly changes in plasma and testicular androgen concentrations of the spiny-tailed lizard, *Uromastix hardwickii*, were measured using a specific testosterone radioimmunoassay. A rise in plasma testosterone levels (22.4 ± 2.6 ng/ml) was associated with maximal testicular weights in late March, preceding the mating period in April. In May, there was a marked drop in plasma testosterone values. From June to January, plasma testosterone levels remained more or less uniform, and the mean monthly estimations made during this period ranged between 4.6 and 7.2 ng/ml. Plasma testosterone concentrations tended to increase again in February. In June, tissue testosterone levels began to rise, reaching a peak by late August or early September, just prior to the fall recrudescence of the testis. There was a marked fall in tissue testosterone levels during October and November and a more gradual decrease was recorded from January to May. Tissue testosterone content calculated per testis had two peaks, one coinciding with the recrudescent phase of the testis and the second larger peak coinciding with the breeding period when the testicular weights were maximal (M. Arslan, J. Lobo, et.al, 1978).

The pocket population of S. hardwickii in India points toward an immediate genetic assessment of the species in order to understand the genetic variation among populations of this species so as to know the exact nature of evolutionary pressure on it. Sequencing the 16S rRNA gene of *S. hardwickii* have been attempted for the first time in Indian isolates, considering fecal pellets as the DNA source material to understand underlying genetic variation of this species. The study revealed monomorphic nature of Indian isolates suggesting urgent conservation of the species in India. Further research studies are needed to provide better picture on genetic variation and ancestral information of this species (C Sharma *et.al*, 2018).

The impact of heavy urbanization and trade has shown drastic increase in the mortality of this species across rural Kutch and other areas. Although various government agencies and NGOs have done environmental impact assessments, scanty details on the survival threats facing local fauna and flora are available. In spite of this, local NGOs and other conservationist have locked into a debate recently, when the state asked for clearance from the Centre (Ministry of Environment and Forests) to build a road through the Kutch Desert Wildlife Sanctuary. The road may run over some patchy territories displacing the spiny-tails along the Harappan site of Dholavira. The Indian wildlife conservation efforts have a history of promoting only 'glamorous' wildlife and so the threats facing the often ignored spiny-tailed lizards in the Kutch frontier may sadly go unnoticed (Pratiksha Patel, 2011). Very recently, Activist Ritesh Poker told 'India Today Mail' that during his research work on desert animals revealed that Sandha lizards were poached in Bhuj - Banni area. More than 300 Indian spiny tailed lizards were killed allegedly in Banni, Kutch to extract oil from its tail which is being used to heal bone diseases and boost stamina.

# METHODOLOGY

### 3.1 STUDY SITE

Lakhtar taluka of Surendranagar district in Gujarat has typical arid climate recognized by hot, long and dry summer, short winter and wide range of temperature. The precipitation rate is very low.

The study was conducted in Vadla, a small village in Lakhtar taluka of Surendranagar district (22°55'38"N 71°59'56"E), 80Kms from Ahmedabad (Figure. 4). The main site was in the outskirts of the village providing it the suitable habitat for its survival (Figure. 6). In the middle of the study area, lies a small temple of Goddess. It is an unknown and less explored area, known only to the locals. The area covers less than a square kilometer and was bounded by the agriculture field and to a little extent by human settlement. It is known as the 'Vadla dam bird point' by the locals. The site is a flat saline terrain which turns into marshy wetland during monsoon. The surrounding wetland gets occupied by large number of migratory birds. The annual rainfall varies from 400mm to 700mm. The monsoon allows the local to encroach the land for cultivation. The total human population was 1722 during 2011 survey. The maximum mortality of STL was observed by the local people during monsoon. The maximum temperature reaches up to 45°C during summer and drops up to 22°C in winter.

From the local survey of the villagers, it was known that the site was a private land owned by the Bharwads. The land was predominantly used as grazing land by the Gauchars. On holidays, the land was also used by the villagers for playing. Since, the area of study doesn't fall under the legislative category of protection, it faces punishing human disturbance.


**Figure. 5 Location of Vadla**


**Figure 6 Map view of Vadla village and study site**


**Figure. 7 Study area**


**Figure. 8 Waypoints for the location STL**

### 3.2 SIGHTINGS

Sightings of Active burrow were considered as evidence of presence of STL in location (Figure. 8) and alone alive couch acclimated to appraise population density of *S.hardwicki* (Safi, *et. al*).

### 3.3 STUDY PERIOD

The study was conducted in winter months from December, 2019 to February, 2020. The data was collected in two days per week yielding to minimum nine visits per month. The initial two weeks were assigned for locating and identifying the active burrows. For the ease of collecting data, the day was divided into two phases:

Phase 1 – 1100 hours to 1400 hours;

Phase 2 – 1430 hours to 1700 hours.

### 3.4 POPULATION AND BURROW ESTIMATION

The biological population estimation was carried out by - The belt transect method. The belt transects were placed 20m from the roadside. Each belt was of 100m X 100m. A total of 8 belt transects were laid and subsequently, the number of burrows and individuals were noted. The burrows were mapped with GPS essential android application. The average time taken to traverse the belt was 9 minutes. The identified burrows were categorized as:

1. Active burrows- Open and closed

2. Inactive burrows

3. Eroded burrows

The number of active burrows was enumerated in the same belt on the same day by spotting their trails or fresh pellets in adjacent ranges when lizards would be resting during the day in order to avoid any type of conflicts with them (Wilms et al., 2009).

### 3.5 TIME CONSTRAINED ACTIVITY BUDGETING

All the activities-based observations were taken from a distance of 10-15m from the targeted burrow. The activity was observed by 8 X 50 Vanguard binoculars.

The temperature dependent activity was noted by Scan animal sampling (Altmann, 1974). Behavior of all the individuals in a group were noted at a predominant time period. A time interval of 20 minutes was used for the activity pattern from 1400 hours to 1600 hours in December, 2019 and 1100 hours to 1600 hours in January and February, 2020 based on the ambient temperature conditions. The time of emergence and disappearance in their respective burrow was also noted.

The focal animal sampling (Altmann, 1974) was used to note the particular activities of an individual for 30 minutes. The focal individual was randomly selected from each quadrate and its activity pattern was noted. The activity was chiefly categorized into: Scanning, Basking, Moving and Foraging. The activity pattern was enumerated as the count of active lizards at any time stated as percentage of the maximum lizard count for the day.

The ambient and ground temperature was noted by Philips thermometer. The temperature was recorded hourly. The number of active lizards were noted parallel to different temperature range. Lizard body color was noted with reference to temperature: Dark brown, dark olive and pale white.

Bite counts of individuals in vicinity to hide were recorded by focal sampling of individual lizards. The area sampled of bite counts was having the same vegetative composition. Tally counter was used to record feeding bites. The diet composition was noted by plucking the feeder plant species. The plant species were collected in zip lock bags and sent for identification.

The fecal matter was collected in a zip-lock bag and studied. The average distance between the burrow and the pellets was noted for 20 selected individuals. The number of pellets near the burrow was recorded. Physical parameters of the pellets such as dry weight, size, shape, color and texture was studied.

### 3.6 SOIL ANALYSIS

The physical parameters of soil were studied:

#### 3.6.1 Soil color

Color of soil serves as an important characteristic of soil. Soil color was considered as an identity based on International method by Munsell soil colour chart.

The soil sample was collected from the study site, some amount of soil was kept in petri dish and observed under the direct sunlight. It was then compared with the Munsell soil color chart.

#### 3.6.2 Soil texture:

Soil texture refers to the composition of the soil in terms of the amounts of small (clays), medium (silts), and large (sands) size particles (Hayakawa, 1895: Hillel, 2004). The soil investigated was classified with respect to the three major soil texture classes - coarse, medium, and fine (Helmut Dorr, Luisa Kat ruff, *et al.,* 1993). It was identified by different mesh size, by rubbing the soil in between the fingers.

### 3.6.3 pH:

Soil pH is the measure of the acidity and the alkalinity of the soil (E.O.Mclean, 1982). It was tested by pH meter (ANALAB SI Pvt. Ltd., Vadodara, Gujarat). About ¾ jar was filled with sample soil and distilled water was added to the jar. It was capped and was shaken vigorously for few minutes. The sample was allowed to stand for 10 minutes so that the salts gets dissolved. The pH tester was calibrated with pH 7 buffer solution. Removing the cap, the pH tester was placed into the wet soil slurry and the pH was recorded.

### 3.6.4 Moisture:

Soil moisture is one of the determining variables of the health or stress on land surface ecosystems and managed systems such as those in agriculture. It is a key element of the surface water budget (Unninayar & Olsen, 2015). The soil moisture content was measured by Gravimetric method. The fresh soil was collected once every month from the desired depth and weighed. It was then transferred to the oven in 100°C for 24 hours and was immediately transferred to desiccator containing $CaCl_2$ (Bandyopadhyay *et al.*, 2012). Soil moisture content was calculated with the given formula:

$$Soil\ moisture = \frac{Weight\ of\ wet\ soil - Weight\ of\ dry\ soil}{Weight\ of\ dry\ soil}$$

## 3.7 VEGETATION SURVEY

Vegetation survey was carried out in December, 2019 and January, 2020. A total of 20 plots were studied, each plot of 1m x 1m were laid near the selected active burrow and 20m far from

the burrow. At each plot, the number of plant species, density and number of individuals of each species was calculated.

The density of plant species was calculated by the equation (Henderson, 2003):

$$Density\ (D) = \frac{N}{A};$$

Relative density of each species was calculated according to the given equation:

$$Relative\ density\ (R.D) = \frac{D}{Total\ density} \times 100$$

The frequency was calculated by the formula:

$$Frequency\ (F) = \frac{A}{B} \times 100$$

The abundance of the identified floral species was calculated by:

$$Abundance\ (Ab.) = \frac{N}{A}$$

Identification, nomenclature and growth form (annual herb, annual grass, perennial herb, sub-shrub, and shrub) of plant species were designated. Human disturbance intensities were also recorded. The quantitative grazing was rated: 1 = very low grazing; 2 = low grazing, 3 = medium grazing, and 4 = high grazing (overgrazing).

### 3.8 FAUNAL DIVERSITY

Other than *Saara hardwickii*, available faunal diversity was also observed frequently on a regular basis. For the evaluation of avian faunal diversity, a checklist of resident and migratory birds was prepared. For creating the checklist of birds, “The ebird” application by The Cornell

lab ornithology was used. Correct identification of the avian species was done with the help of "Birds of the Indian subcontinent" by Carol Inskipp, Richard Grimmet and Tim Inskipp.

The population estimation was carried out by Grid method and Individual count method. Grid, also called as blocking, was used for the population estimation wherein field view was divided into a grid of even units, and the birds in one section were counted as close to individually as possible. Multiplying this count by the number of grid sections in the flock gives a reasonable estimate of the total number of birds.

### 3.9 CONSERVATION OF EXPERIMENTAL SUBJECT

The engagement of local communities served a greater impact for the protection of *Saara hardwickii*. The selected locals were targeted and were trained. For the survey on analysis of local community attitude towards STL, a questionnaire (Figure. 9) was prepared and their opinion about the species was interviewed. Interview was restricted to one respondent per house. The questionnaire included both open ended and fixed response questions. The responses were noted in the data sheet.

# QUESTIONNARE SURVEY

1. Name of the respondent:-
2. Occupation:-
3. Age: - Sex:-
4. Have you seen STL: - YES.

   NO.

   If yes, where and when:-

   Size:-

   Number:-

   Behavior:-
5. Does he/she likes the animal being around?
6. Does the animal pose any threat to the local?
7. If so, how do they think this can be minimized?
8. How is the animal helpful to the surroundings?
9. Does he/she thinks the animal needs to be conserved?
10. How can he/she contribute to the conservation?

**Figure. 9 Questionnaire survey**

# RESULT AND DISCUSSION

## 4.1 BIOLOGICAL POPULATION AND BURROW ESTIMATION

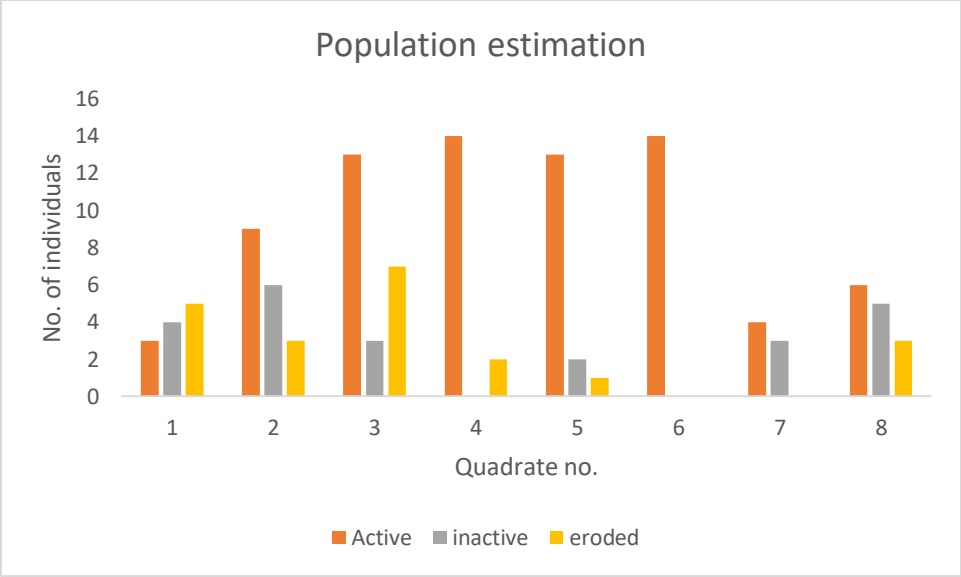


**Figure. 10 Graphical representation of number of active, inactive and eroded burrows.**

The active burrow was defined as the burrows in which the individuals reside. STL are burrow dwelling lizards, solitary and diurnal in nature. The individuals dig their own burrow with their powerful claws. Zigzag pattern burrow terminates into a small chamber indicates active burrow. From the current study, the number of active burrows including open (Figure. 12) and closed were 86, Inactive burrows (Figure. 13) were 23 and eroded burrows were 21.

Burrow entrance laden with soil is considered as active closed burrow and helps in avoiding invasion of the predators (Figure. 11). During activity period, they remove the soil and slide themselves out of the burrow. Throughout the basking period lizard generally sits at the entrance of the burrow facing the direction of the burrow inlet. This allows them to escape from predator or any dangerous conditions. Upon receiving any threat signals, lizard would rush towards their own burrows instead of hiding into the possible adjacent burrows.

**Figure. 11 Active – Closed type**

**Figure. 12 Active – Open type**

**Figure. 13 Inactive burrow**

**Figure.14 Unusual burrow**

This shows strong homing ability of STL. The entrance diameter of the burrow varies from 6 cm to 10 cm. The diameter of the adult STL burrow are larger than that of the sub-adults.

In contrast to their general tendency of occupying individual burrows, during present study three unusual burrows were discovered where two individuals used to share the burrows (Figure. 14)

According to Wilms *et al.*, (2009), the age group of spiny-tailed lizards can be identified based on their total length. Juveniles were identified based on their size as well as dark blotches on their skin, while subadults and adults were distinguished based on size difference only. In the earlier studies, the density recorded in Tal Chappar wildlife sanctuary of active burrows was 324/ha (Das, Dookia, *et al.*,2012), 28.85 burrows/ha in Jaisalmer, 51.59 burrows/ha in Thalur substrate (Ramesh & Ishwar, 2008) and 30.85 burrows/ha in Abdasa tehsil of Kutch (Jhala *et.al.*, 2012)

**4.2 PROPERTIES OF FECAL PELLETS**

The pellets of STL were spindle shaped and their size varied from 3cm to 5cm (Figure. 16). Fresh pellets are dark green in color changing to straw color or pale white upon drying. They lay pellets in clusters proximate to their burrow. On an average, the number of pellets laid were 5-7. The average distance of laying from the burrow was 15.98cm (Figure. 15).

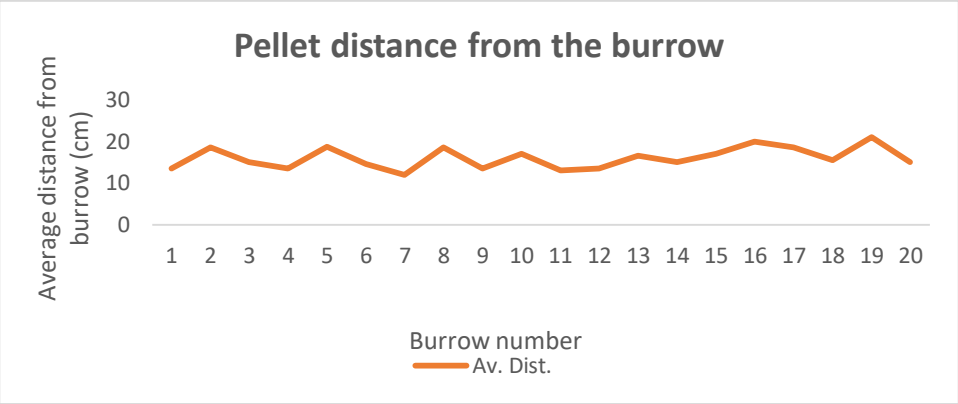


**Figure. 15 Graphical representation of the pellet distance from the burrow.**

**Figure. 16 Fresh pellets of STL**

## 4.3 TIME DEPENDENT ACTIVITY BUDGETING

STL are diurnal species that show majority of activities during day. Minimal activities were recorded during winter months and then bimodal to higher activity patterns were observed in summer season. Activity showed a major peak between 0900 to 1100 hours and minor peak around 1500 hours. As summer progressed, major peak increased in height and the minor peak declined with duration of activity unaltered. Bimodality changed to unimodality during monsoon with the peak of activity between 1200 to 1500 hours (Dutta & Jhala, 2007).

STL initiated its activities in later hours from 1200 to 1400 hours in the months of November to February. Emergence time of STL from their respective burrows is depicted in Figure. 17. Various activity patterns are directly proportional to the ambient temperature and for temperatures below 28°C, very low or no activity was observed. Maximum activity was recorded above 30°C temperature. In the course of study, ambient and land surface temperatures ranged from 26°C to 34°C and 26.5°C to 34°C respectively.

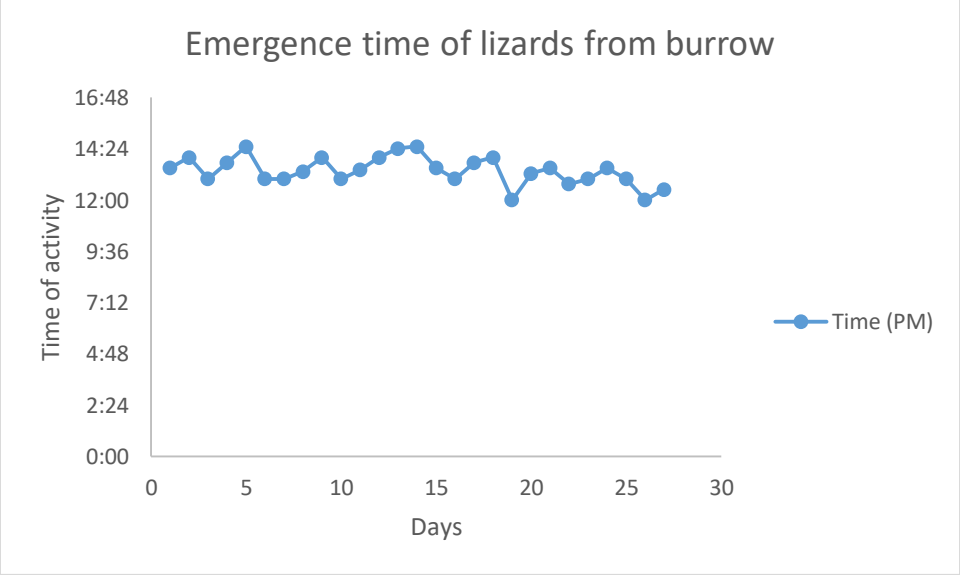


**Figure. 17 Graphical representation of emergence time of lizards from the**

**Figure. 18 Scanning**

**Figure. 19 Basking**

**Figure. 20 Alarmed**

**Figure. 21 Escape**

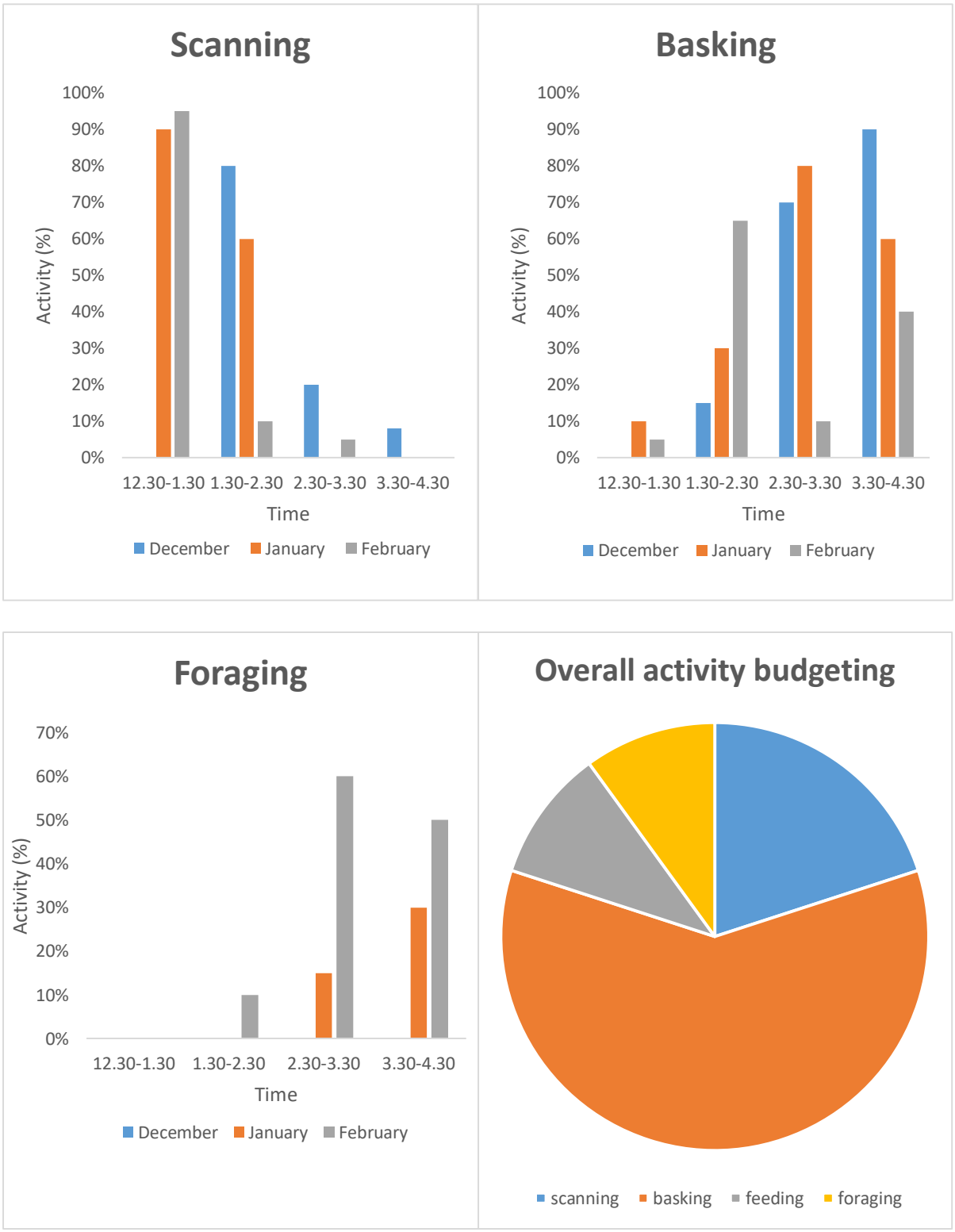


**Figure. 22 Time based activity budgeting**

The activities were chiefly categorized into – Scanning, Basking and Foraging (Figures 18-21). Scanning is exhibited through protruded head outside the burrow and stays in that position for quite long time period before completely emerging out of the burrow. Initially, they scan the outer environment to detect the danger outside. Thereafter, they gradually emerge out of the burrow and orient themselves towards sunlight. Once basking is over, few individuals may explore feeding possibilities in their surrounding area with intermittent rest. Observations from the present study revealed that any individual takes on an average 14 bites per minutes.

They moved around 8-10m from their burrows. While feeding, they remain in alert state and runs immediately when threatened. When in alert state, they lift up their spiny tail.

STL shows color dimorphism. A gradual and serial change in body color was observed. In the initial phase of activity, the body color was dark brown. In later hours, after severe basking, the color changed to light brown or pale white color making them completely camouflaged. During monsoon, the lizard appear much darker than in summer and retained dark brown colouration throughout the day (Dutta & Jhala, 2007).

A case of poaching was reported during the study period. The morphometric characters were recorded and the individual was released.

1. Head – Tail length: 31cm
2. Snout – eye length: 2.1cm
3. Snout – Head length: 4.5cm
4. Diameter of head, abdomen and tail: 8.4cm, 12.5cm and 7.5cm
5. Diameter of tail tip: 2.5cm

6. Length of forelimb and hindlimb: 5cm and 8cm
7. Distance between two limbs: 9.5cm
8. Tail length: 13.5cm
9. Number of whorls: 36

## 4.4 SOIL ANALYSIS

### 4.4.1 Soil colour

The soil color when compared with Munsell soil color chart was found to be as mentioned in below table:

| Sample no. | Soil formula | Colour | Soil fertility |
|---|---|---|---|
| 1 | 7.5YR 7/4 | Light brown | Less |

**Table. 2 Soil Analysis**

The above table showed that the Vadla study site is less fertile soil and thus the land has scanty vegetation.

### 4.4.2 Soil texture

Soil particle size ranged between 0.002mm to 0.02mm which indicates higher absorption potential of soil and reptiles could easily prepare burrows in such moist soil.

### 4.4.3 Soil pH

pH was found to be in the range of 5.5 to 7.5 suggests that there are sufficient pH is present for the plant growth.

### 4.4.4 Soil moisture

Weight of fresh soil = 50gm

Weight of air dried soil after 24 hours = 43.78gm

$$Soil\ moisture = \frac{Weight\ of\ wet\ soil - Weight\ of\ dry\ soil}{Weight\ of\ dry\ soil}$$

$$= 50 - 43.78 \div 43.78$$

$$= 14.2\%$$

The moisture content of the soil was 14.2%. This suggest that the soil was very dry.

## 4.5 VEGETATION ANALYSIS

The area has a very scanty distribution of floral diversity. The major plant species in and around the study area included:

| Sr. No. | Scientific Name | Growth form |
|---|---|---|
| 1. | *Paspalidium flavidum* | Perennial grass |
| 2. | *Desmostachya bipinnata* | Perennial grass |
| 3. | *Digitaria adscendens* | Grass |
| 4. | *Borreria articularis* | Herb |
| 5. | *Euphorbia hirta* | Herb |
| 6. | *Setaria intermedia* | Herb |
| 7. | *Ziziphus Nummularia* | Shrub |
| 8. | *Prosopis julifera* | Shrub |
| 9. | *Barleria prionitis* | Shrub |
| 10. | *Acacia nilotica* | Tree |

| | | |
|---|---|---|
| 11. | *Azadiracta indica* | Tree |

**Table: 3 Checklist of the floral species**

On studying the floral species near the burrow and 20m from the burrow, it was noted that *Paspalidium flavidum* showed highest density cover, followed by *Azadiracta indica* and *Setaria intermedia.* The human disturbance has been represented graphically (Figure. 24).

| **Plant sp.** | **No. of individuals per quadrate** | | | | | | | | | | **N** | **A** | **B** | **D** | **F** | **Ab.** | **R.D** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | | | | | | | |
| I | 7 | 5 | 6 | 3 | 5 | 6 | 8 | 0 | 1 | 2 | 43 | 9 | 10 | 4.3 | 90% | 4.7 | 61.42% |
| II | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 6 | 6 | 10 | 0.6 | 60% | 1 | 8.57% |
| III | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 4 | 0 | 3 | 10 | 5 | 10 | 1 | 50% | 0.4 | 14.28% |
| IV | 2 | 0 | 2 | 1 | 0 | 2 | 4 | 0 | 0 | 0 | 11 | 6 | 10 | 1.1 | 60% | 2.2 | 15.71% |
| **Vegetation of floral species 20m from the burrow** | | | | | | | | | | | | | | | | | |
| I | 5 | 6 | 4 | 4 | 7 | 5 | 2 | 6 | 7 | 0 | 46 | 9 | 10 | 4.6 | 90% | 5.1 | 56.79% |
| II | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 5 | 5 | 10 | 0.5 | 50% | 1 | 6.17% |
| III | 3 | 0 | 0 | 1 | 0 | 2 | 0 | 2 | 0 | 0 | 8 | 5 | 10 | 0.8 | 40% | 2 | 9.87% |
| IV | 3 | 2 | 1 | 4 | 0 | 2 | 5 | 3 | 2 | 0 | 22 | 8 | 10 | 2.2 | 80% | 2.75 | 27.16% |

**Table: 4 Vegetation analysis of the floral species by quadrate method.**

Aberration: I - *Paspalidium flavidum;* II - *Acacia nilotica;* III - *Ziziphus Nummularia;* IV - *Setaria intermedia*; N - Total number of individuals in all the quadrate; B - Total number of quadrates studied; A - Total number of quadrates in which each species occurred; D - Density; F – Frequency; Ab. – Abundance; R.D – Relative density.

## 4.6 FAUNAL DIVERSITY

| Sr. No. | Common Name | Scientific name | Family |
|---|---|---|---|
| 1 | Marsh harrier | *Circus aeruginosus* | Accipitirdae |
| 2 | Black shoulder kite | *Elanus axillaris* | Accipitirdae |
| 3 | Oriental honey buzzard | *Pernis ptilorhynchus* | Accipitirdae |
| 4 | Indian spotted eagle | *Clanga hastata* | Accipitirdae |
| 5 | Crested lark | *Galerida cristata* | Alaudidae |
| 6 | Ashy crowned sparrow lark | *Eremopterix griseus* | Alaudidae |
| 7 | White throated kingfisher | *Halcyon smyrnensis* | Alcedinidae |
| 8 | Common kingfisher | *Alcedo atthis* | Alcedinidae |
| 9 | Pied kingfisher | *Ceryle rudis* | Alcedinidae |
| 10 | Bar headed Goose | *Ansur indicus* | Anatidae |
| 11 | Northern Shoveler | *Spatula clypeata* | Anatidae |
| 12 | Grey lag goose | *Anser anser* | Anatidae |
| 13 | Indian spot billed duck | *Anas poecilorhyncha* | Anatidae |
| 14 | Ruddy shelduck | *Tadorna ferruginea* | Anatidae |
| 15 | Northern pintail | *Anas acuta* | Anatidae |
| 16 | House swift | *Apus nipalensis* | Apodidae |
| 17 | Greater egret | *Ardea alba* | Ardeidae |
| 18 | Little egret | *Egretta garzetta* | Ardeidae |
| 19 | Pond heron | *Ardeola grayii* | Ardeidae |
| 20 | Grey heron | *Ardea cinerea* | Ardeidae |

| | | | |
|---|---|---|---|
| 21 | Eurasian thick knee | *Burhinus oedicnemus* | Burhinidae |
| 22 | Red wattled lapwing | *Vanellus indicus* | Charadriidae |
| 23 | White tailed lapwing | *Vanellus leucurus* | Charadriidae |
| 24 | Kentish plover | *Charadrius alexandrinus* | Charadriidae |
| 25 | Open bill stork | *Anastomus oscitans* | Ciconiidae |
| 26 | Woolly neck stork | *Ciconia episcopus* | Ciconiidae |
| 27 | Painted stork | *Mycteria leucocephala* | Ciconiidae |
| 28 | Plain prinia | *Prinia inornata* | Cisticolidae |
| 29 | Ashy prinia | *Prinia socialis* | Cisticolidae |
| 30 | Spotted dove | *Spilopelia chinensis* | Columbidae |
| 31 | Collared dove | *Streptopelia decaocto* | Columbidae |
| 32 | laughing dove | *Spilopelia senegalensis* | Columbidae |
| 33 | Rock Pigeon | *Columba livia* | Columbidae |
| 34 | Indian roller | *Coracias benghalensis* | Coraciidae |
| 35 | Red headed bunting | *Emberiza bruniceps* | Emberizidae |
| 36 | Indian silver bill | *Euodice malabarica* | Estrildidae |
| 37 | demoiselle crane | *Grus virgo* | Gruidae |
| 38 | common crane | *Grus grus* | Gruidae |
| 39 | Wire tailed swallow | *Hirundo smithii* | Hirundinidae |
| 40 | Common house martin | *Delichon urbicum* | Hirundinidae |
| 41 | Barn swallow | *Hirundo rustica* | Hirundinidae |
| 42 | Long tailed shrike | *Lanius schach* | Laniidae |

| | | | |
|---|---|---|---|
| 43 | Rufous shrike | *Lanius schach* | Laniidae |
| 44 | Isabeline shrike | *Lanius isabellinus* | Laniidae |
| 45 | River tern | *Sterna aurantia* | Laridae |
| 46 | Caspian tern | *Hydroprogne caspia* | Laridae |
| 47 | Large grey babbler | *Turdoides malcolmi* | Leiothrichidae |
| 48 | Green bee-eater | *Merops orientalis* | Meropidae |
| 49 | White wagtail | *Motacilla alba* | Motacillidae |
| 50 | Yellow wagtail | *Motacilla flava* | Motacillidae |
| 51 | Paddy field pipit | *Anthus rufulus* | Motacillidae |
| 52 | Citrine wagtail | *Motacilla citreola* | Motacillidae |
| 53 | Common stonechat | *Saxicola maurus* | Muscicapidae |
| 54 | Pied bushchat | *Saxicola caprata* | Muscicapidae |
| 55 | Black redstart | *Phoenicurus ochruros* | Muscicapidae |
| 56 | Indian robin | *Saxicoloides fulicatus* | Muscicapidae |
| 57 | Magpie robin | *Copsychus saularis* | Muscicapidae |
| 58 | Purple sunbird | *Cinnyris asiaticus* | Nectariniidae |
| 59 | Ashy drongo | *Dicrurus leucophaeus* | Passeriformes |
| 60 | Black drongo | *Dicrurus macrocercus* | Passeriformes |
| 61 | Rosy pelican | *Pelecanus onocrotalus* | Pelecanidae |
| 62 | Little cormorant | *Microcarbo niger* | Phalacrocoracidae |
| 63 | Grey francolin | *Francolinus pondicerianus* | Phasianidae |
| 64 | Lesser flamingo | *Phoeniconaias minor* | Pheonicoptidae |

| | | | |
|---|---|---|---|
| 65 | Greater flamingo | *Phoenicopterus roseus* | Pheonicoptidae |
| 66 | Common chiffchaff | *Phylloscopus collybita* | Phylloscopidae |
| 67 | Streaked weaver | *Ploceus manyar* | Ploceidae |
| 68 | Baya weaver | *Ploceus philippinus* | Ploceidae |
| 69 | Little grebe | *Tachybaptus ruficollis* | Podicipedidae |
| 70 | White eared bulbul | *Pycnonotus leucotis* | Pycnonotidae |
| 71 | Red vented bulbul | *Pycnonotus cafer* | Pycnonotidae |
| 72 | Common coot | *Fulica atra* | Rallidae |
| 73 | White breasted water hen | *Amaurornis phoenicurus* | Rallidae |
| 74 | Common moorhen | *Gallinula chloropus* | Rallidae |
| 75 | Pied avocet | *Recurvirostra avosetta* | Recurvirostridae |
| 76 | Black winged stilt | *Himantopus himantopus* | Recurvirostridae |
| 77 | Wood sandpiper | *Tringa glareola* | Scolopacidae |
| 78 | Green sandpiper | *Tringa ochropus* | Scolopacidae |
| 79 | Bar tailed godwit | *Limosa lapponica* | Scolopacidae |
| 80 | Red shank | *Tringa totanus* | Scolopacidae |
| 81 | Ruff | *Calidris pugnax* | Scolopacidae |
| 82 | Little stint | *Calidris minuta* | Scolopacidae |
| 83 | Marsh sandpiper | *Tringa stagnatilis* | Scolopacidae |
| 84 | Rosy starling | *Pastor roseus* | Sturnidae |
| 85 | Indian spoonbill | *Platalea leucorodia* | Threskiornithidae |
| 86 | Glossy ibis | *Plegadis falcinellus* | Threskiornithidae |

| | | | |
|---|---|---|---|
| 87 | Red nape ibis | *Pseudibis papillosa* | Threskiornithidae |
| 88 | Eurasian spoonbill | *Platalea leucorodia* | Threskiornithidae |
| 89 | Bluethroat | *Luscinia svecica* | Turdidae |
| 90 | Eurasian hoopoe | *Upupa epops* | Upupidae |

**Table. 5 Checklist of avian species**

| **Sr. No.** | **Common name** | **Scientific name** | **Family** |
|---|---|---|---|
| 1 | Red sand boa | *Eryx johnii* | Boidae |
| 2 | Russel's viper | *Daboia russelii* | Viperidae |
| 3 | Indian cobra | *Naja naja* | Elapidae |
| 4 | Indian rat snake | *Ptyas mucosa* | Colubridae |
| 5 | Common monitor lizard | *Varanus bengalensis* | Varanidae |

**Table. 6 Checklist of reptiles**

| **Sr. No.** | **Common name** | **Scientific name** | **Family** |
|---|---|---|---|
| 1 | Desert fox | Vulpes vulpes pusilla | Canidae |
| 2 | Stray dogs | - | Canidae |

**Table. 7 Checklist of mammals**

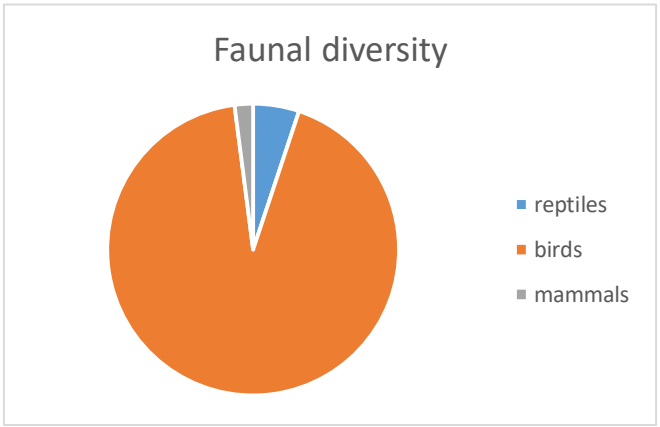


**Figure. 23 Faunal diversity of the study site**

## 4.7 THREATS:

Indian spiny tailed lizard is listed in CITES (Appendix II) and in Indian Wildlife (protection) Act 1972 (Schedule II). The major threats to this species are listed below:

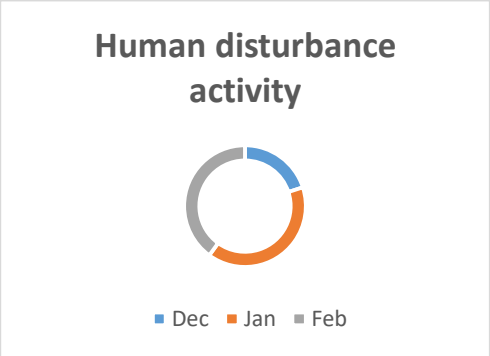


**Figure. 24. Human disturbance activity from December, 2019-January, 2020**

### 4.7.1 Trade and exploitation:

*Saara hardwickii* are predominantly reported in India and Pakistan with higher trade rate. The lizard has been largely poached for the extraction of oil from the fat and known as *sandhe ka tel*. The oil is often sold by the roadside quacks and is claimed to cure impotency and used as a massage oil. The flesh is eaten by some tribal people and has been considered a food delicacy. The powder of its fecal matter is often mixed with kajal and is believed to cure the corneal opacity. The skin is used to prepare the leather articles. Lizard density is declining due to such unethical, non-scientific and unhealthy practices at many places.

However, the strict enforcement of Wildlife Protection Law and continuous awareness by the Forest department has controlled the trade up to certain extent. Unfortunately, very few local communities consistently chase this lizard and sacrifice them for their immediate consumption purpose.

### 4.7.2 The anthropogenic factors:

Many youngsters play variety of games onto the current study area and thereby disturb the social activity patterns. Besides, burrow gets greatly destroyed due to car driving and other disturbances (Figures 25-27).

This study site is used for agricultural purpose by local community during monsoon. Agricultural expansion, habitat destruction and road construction activities also leads to reduction in lizard density.

### 4.7.3 Predation by raptors and stray dogs:

Predators of STL included the raptors such as steppe eagle (*Aquila nipalensis*) and black shoulder kite (*Elanus axillaris)*. They were found to eat only head and body region of STL excluding the tail region. Burrow excavation is observed due to other predators include Desert foxes (*Vulpes vulpes pusilla*) and stray dogs. Additionally, common monitor (*Varanus benghalensis*) and common sand boa (*Eryx johnii*) were also seen to prey on the Spiny Tailed Lizards.

**Figure. 25 Blockage of burrow due to waste disposal**

**Figure. 26 Study area used by locals for playing**

**Figure. 27 Area used for Photography purpose**

# CONSERVATION MANAGEMENT

Wildlife trade is the major cause of human animal conflicts and perhaps could be due to certain cultural practices, age old customs and socioeconomic status in majority of the developing countries. Community outreach programs and campaigns are necessary for spreading awareness about ecological importance of spiny tailed lizard and ground level interactions should make the community realize about coexistence, conservation and wildlife management strategies. Survey questionnaire was to be prepared with active participation of representative individuals from the society for better understanding of species well-being and conservation. Additionally, researchers should attempt to identify the real problems faced by local community members.

As a part of my dissertation work, an attempt was made to prepare survey questionnaire and 30 households of Padhar community were interviewed. From the interactions with local community members, I gathered that around 800 individuals of *Saara hardwickii* were seen few years ago in the same patch. Various dubious and outrageous methods for encroaching the burrows are used including noosing, smashing, trapping leading to significant decline in lizard density over a period of time largely due to trade and land exploitations.

Youngsters in the surrounding area showed willingness to contribute in species conservation. They displayed higher degree of enthusiasm in learning various components of the conservation strategies and different behavior patterns of several faunal species.

# CONCLUSION

The present study focused on population estimation and time based activity budgeting of STL in winter grounds. My study revealed that in just one acre of land, there were 84 burrows. The winter ground had less activity as compared to summer and monsoon. The individuals changed and aligned their behavior according to the environment temperature. Rich vegetation provide safe place for the STL to exist.

Environmental degradation and its causes has been a major concern and also under debate. The study concluded that the species needs immediate conservation. The causes of the loss of the lizard are Expansion of agriculture land and habitat loss. Also the off-road use of land, over-grazing and use of land for picnic spot are contributing to the causes of decreasing population of STL.

Ecosystem management involves processing and conserving the species and maintaining the habitat accordingly to increase the species diversity. The protection of habitat is the initiation for the conservation of Indian STL and its ecosystem management. The govt. and non-govt. staff must get involved in raising the awareness of this species. Various models of conservation and laws are the best means of conserving wildlife, yet their implementation and success depends on thorough understanding of the ecology of the targeted species.

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