CHAPTER II

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2.1. STUDY AREA

2.1.1. Location

Jeypore Reserve Forest is located in the Dibrugarh District of eastern Assam. The study area lies within 95°21'28.3'' to 95°29'51.1'' E latitudes and 27°05'35.2'' to 27°16'11.2'' N longitudes. In the north side it shares boundary with Dihing-Patkai Wildlife Sanctuary and in the south Disang (Dilli) river forms boundary between Jeypore Reserve Forest and Sibsagar District. In the east side Namsang river separated it from Arunachal Pradesh. In the western part of the boundary Jaipur town is located.

2.1.2. Brief description and history

Jeypore Reserve Forest (Figure-2.1) is a part of Patkai Hills which runs south-westernly in Tirap District of Arunachal Pradesh and located in Dibrugarh district of Assam. The study area was notified as Reserve Forest in the year 1888. The total area of Jeypore Reserve Forest is 108.68 km$^2$ of which, 20 km$^2$ falls under the Dihing Patkai Wildlife Sanctuary and mainly covers the low to medium elevated hills. Three rivers namely Burhi Dehing, Namsang and Disang surrounded the reserve forest from east, south and west side. The main river Burhi Dehing flows all the way the eastern boundary of Jeypore Reserve Forest from Namsang Mukh to Naga Ghat and merges with Brahmaputra River at Jokai. The river Namsang runs through southern boundary and merges with river Burhi Dehing at Namsang. Another river Disang runs through western boundary of Jeypore Reserve Forest and falls into the river Brahmaputra at Disangmukh. The whole Jeypore Reserve Forest area is drained by a matrix of small rocky streams which flows through small ravines and valleys and falls into the Burhi Dehing, Namsang and Disang rivers. The main stream the Tipum Nullah runs west-easterly and falls into Burhi Dehing River at the Tipum Mukh. Except the main stream, other small network of streams are
remains dry from winter till pre-monsoon (February-March) season. However during rainy periods the major streams of Jeypore Reserve Forest becomes uncrossable. During that periods, extensive riparian vegetation develops all along stream sides. Large patches of wild banana occur in the openings of moist forest and along the waterways.

Jeypore Reserve Forest has records of logging operations as far back as 1921 (Das, 1965). Throughout the last century, the reserve forest was widely exploited to supply the demand for construction material both for household use and as well as for the industries in this tract including the Assam Oil Company, Oil India Ltd., Fertilizer Corporation of India, railway sleeper treatment plants and saw mills etc. The largest consumer of timber was the plywood industry, which mainly manufactured tea chests. Cane, bamboo, thatch and firewood are needs of the local populace, including a substantial amount for the tea estates were also met by these reserves (Das, 1965).

The time of fragmentation of the intact forests could be deduced for some of the sites from the establishment history of British-owned tea estates in the vicinity, starting from the 1840s. The histories of human settlements near the forests however are not well documented. In anecdotal notes, a tea planter by the name of J.W. Tweedie (unpublished), describes the area around the present Jeypore Reserve Forest in the year 1896 as follows: "Jaipur was the only garden in that part (Hapjan Parbut) and the nearest being Tingrai to the North, Tinkong to the West and Sonari to the South and miles of virgin forest inbetween were inhabited by elephants, buffalo, tiger and even rhino. There were only small patches of rice land cultivated by Assamese" (Kakati, 2004).

The Supreme Court of India imposed a ban on tree-felling without approved working plans in all forests in north-east India in the year 1996. The transport of timber outside the region was also prohibited. Before the ban, the north-eastern region comprising 7% of India's land area accounted for over 60% of the timber supplied (Dutta and Kohli, 2005). Unfortunately, illegal tree-fellings and timber trafficking is continued though the ban order is placed. Lack of forest staff, lack of cooperation of local people, poor implementations of existing forest laws, political interference and a lack of ecological responsibility of the
main industries in this area have been largely responsible for the extensive degradation of the forests in Jeypore. Armed insurgent groups of Assam, Arunachal Pradesh and Nagaland have been active in the boarders of Jeypore Reserve Forest. The law and order problems created by these insurgency groups have further facilitated the deforestation of the reserves through tree felling and land encroachments (Kakati, 2004). The Jeypore Reserve Forest (Jeypore RF), is now relatively undisturbed in terms of intrusions and disruptions by humans, although logging activities have taken place in the past.

2.1.3. Topography and soil type

Jeypore Reserve Forest is undulating to hilly with altitude ranges from 113 - 350 msl. Soil type is old alluvium of the Brahmaputra and Burhi Dehing rivers, the former being almost neutral while the latter is acidic soil. Shallow soils are common with underlying rocks and boulders. Sub-soils in the foothills consist of mostly boulders and pebbles, under a layer of sandy loam over which lies a layer of humas. The foothills along the Burhi Dehing River in the south are made up of Upper Tertiary rocks, the Tipam sandstone, rich in oil deposits (Das, 1965; Chand, 1990 and Choudhury, 1995).

2.1.4. Forest vegetation

The original forest types in this reserve forest was Assam Valley Tropical Wet Evergreen Forest (category 1B/C1) (Champion and Seth, 1968) also called the Upper Assam *Dipterocarpus - Mesua* forest. These forests are characterized by a top canopy dominated by *Dipterocarpus macrocarpus* reaching heights of 50 m, a middle canopy dominated by *Mesua ferrea* and *Vatica lanceaeofolia* and undergrowth consisting of woody shrubs such as *Saprosma ternatum, Alpinia allugas* and *A. moluccensis*. Palms such as *Pinanga gracilis* and *Livistona jenkinsiana* and canes *Calamus erectus, C. flagellum* and *C. latifolius* are common (Kakati, 2004). Bamboos species like *Dendrocalamus hamiltonii, Telnostachyum dullooa* and *Pseudostachyum polymorphum* and climbers such as *Derris oblonga, Tapiria hirsuta* and *Thunbergia* sp. grows in areas where the canopy is relatively open. Swamps and grassland patches occur in these forests (Chand, 1990). Forestry operations
Figure- 2.1: Vegetation Map of Jeypore Reserve Forest with rivers, roads and forest camps.
Plate-2.1: Assam Valley Tropical Wet Evergreen Forest, A- Canopy view of the forest; B- inside the forest.
Plate-2.2: Assam Valley Tropical Wet Evergreen Forest, C- the forest bisected by the road as Dihing Patkai WLS (right) and Jeypore Reserve Forest (left); D- grassland inside the forest.
Plate-2.3: Assam Valley Tropical Wet Evergreen Forest, E- secondary bamboo forest inside the forest; F- fern, inside the forest.
Plate-2.4: Assam Valley Tropical Wet Evergreen Forest, G- Seasonal water body; H- Hatimuta waterfall inside the forest.
Plate-2.5: Assam Valley Tropical Wet Evergreen Forest, I- perennial hill stream inside the forest; J- Disang (Dilli) river, western boundary of the forest.
in the reserves over the last century have resulted in the reserves also having areas of old mixed tree plantations (Plate-2.1, 2.2, 2.3, 2.4, 2.5).

2.1.5. Climate

The climate of the study area is tropical monsoon characterised by high humidity and rainfall (2226 - 3644 mm). It receives rainfall from the south-west monsoon (May-September) and north-east monsoon (December-April). Heavy rainfall last till September, but occasional rainfall occurs throughout the year. There is a relatively dry period between November and February. Average temperature ranges from a minimum of 6°C in winter to a maximum of 38°C in the summer. There was an evidence of 119 to 164 rainy days per year (Das, 1965; Chand, 1990).

2.2. METHODS OF STUDY

2.2.1. Study period

The study had been carried out in Jeypore Reserve Forest to collect the lizard’s data from January 1, 2009 to 31st December, 2011. The intensive study was conducted round the year covering all the months of a year.

2.2.2. Preliminary field work: Site selection and habituation

The study site was mainly woodlands of *Dipterocarpus-Mesua* combination with bamboo growths and cane brakes and from small to large streams was flowing through the bases of hills. The area was uniform with undulating terrain but only the difference was the altitudinal variations.

2.2.3. Study design and data collection

For convenient of study the entire study area was divided into five different sites viz. Nagaghat, Namsang, Kothalguri, Hukanjuri and Dillighat. The study was conducted on the basis of two seasons’ viz., dry season and wet season. Species richness, species abundance,
species density and distribution were analysed from the collected data. The following methods were used for the study.

a. Inventory and natural history

For inventory and natural history observations, regular walking was made along forest trails and streams during daytime following different standard methods (Crump and Scott, 1994). Lizards were recorded while observing on the ground or trees or potential microhabitats like leaf litters, crevices, beneath the bark, among the base of trees and dead trees lying on the ground, holes in the base of the hill slope, wetlands, river beds which were abundant around the study area and provide shelters for the lizards. The lizards were caught, identified, photographed, measured the SVL (Snout to Vent Length) and TL (Tail Length) and released in the same location afterwards. GPS locations of every species encountered during the survey were recorded.

2.2.4. Taxonomy of skink species

The present study focused on five species of skink representing three genera from the Scincidae sub-family Lygosominae, including *Eutropis*, *Sphenomorphus* and *Lygosoma*. Many of these genera were predominantly sub-tropical; however, they were also tropical to temperate in distribution. Only those species were included which have found in Jeypore Reserve Forest during pilot study period.

2.2.5. Survey and data collection

Data collected included the parameters such as locality of the species, date and time of collection, weather condition, habitat types, microhabitats condition, gender and life stages (if possible) of each individual, morphometric measurements of the species, scale counting, species compositions and behavioural notes etc. were recorded at field data sheets (see data sheet in Appendix- I). Local residents living at the fringe village areas were interacted with the aid of field guides regarding whether they have any experience of
hunting the monitor lizards and also collection of eggs in the past. The following methods were used to survey and collects data from the study area.

i) **Active search and opportunistic methods**

During active search methods, the animals were searched actively under the logs, leaflitters, in the tree cavity, caves, under the rocks, in the trees *etc.* to uncover the lizard's information. In the opportunistic survey, data were recorded when an animal was found dead or caught by villagers or poachers.

ii) **Visual Encounter Surveys (VES)**

A visual encounter survey method of Crump and Scott (1994) was used to conduct field survey to collect the lizard's data from the study area. During visual encounter survey (VES) two field worker were walked through the habitat with a speed of 10 meters/10 minutes and searched systematically for any lizards existed within a reach of six meters in width. The VES method was done in 30 fixed line transects and each of them were 1 km in length.

iii) **Roadkill and basking surveys**

The existing roads were serving as basking surface for lizards. Lizards basking on the roads or crossing the roads were often killed by vehicles. For inventory of local reptiles, surveys along roads were commonly used. A roadkill and basking survey was done primarily for inventory of species present in the Jeypore Reserve Forest. Thus the surveys were targeted in different types of roads *viz.* paved, gravel, *etc.* near or adjacent to the tea gardens, paddy fields, woodlands, grasslands or water bodies.

Roadkill and basking surveys were done along four 2 km long fixed stretches of roads. Lizards found were photographed and location was recorded. In addition to fixed roadkill surveys, all incidental sightings of dead or basking lizards found were also noted down while driving between survey sites.
iv) **Microhabitat study**

For microhabitat study, the method of Clemann *et al.* (2008) was followed. When an individual of skink was sighted, 8 structural characteristics of the microhabitat were recorded in a 3 m radius surrounding the skink. The recorded 8 structural characteristics pattern of microhabitat variables were such as i) visual estimate of the percentage of shrub cover ii) visual estimate of the percentage of grass cover iii) visual estimate of the percentage of leaf litter cover iv) visual estimate of the percentage of open ground v) visual estimate of percentage rock cover vi) visual estimate of percentage log cover vii) visual estimate of percentage water cover and viii) visual estimate of percentage tree cover.

v) **Rainfall and temperature**

The daily rainfall and temperature data were collected from Namsang Tea Estate, which was just outside the boundary of Jeypore Reserve Forest. The daily rainfall and temperature data were collected from January 2009 to December 2011.

vi) **Morphometric measurements**

Morphometric measurements of various body parts and scales were done using digital Mitutuyo diel caliper to the nearest 0.1 mm. Body and tail lengths were measured by using measuring tape. Minimum of three to five (3-5) individuals of each species were taken for the morphometric measurements. Live specimens were taken to measure the morphometric characters in Jeypore Reserve Forest during field survey (as per Zug, 1998; Das *et al.*, 2008). Each morphometric characters and its abbreviation term with definition were described in Appendix- II. All the characters were measured in millimeters except snout to vent length and body length and abbreviations were used as per Das *et al.* (2008).

The following parameters were taken to measure the lizards immediately after capture such as snout-vent length (SVL), tail length (TL), axilla to groin distance (AG), head length (HL), head width (HW), head depth (HD), eye diameter (ED), eye length (EL), eye to tympanum distance (ET), eye to nostril distance (ENs), eye to snout distance (ESn),
tympanum length (TmL), tympanum width (TmW), internarial distance (IND), interorbital distance (IOD), forelimb length (FLL), hindlimb length (HLL), frontal length (FL). Means measurements and ± standard errors (SE) were calculated for all measurements.

vii) Scalation

For nomenclature of scales and scale counts, the characters used by Smith (1935a; Figure-2.2), Greer and Broadley (2000) and Das et al. (2008) were followed such as, number of postnasal scales (PN), loreals (L), preoculars, presubocular, postocular, number of supralabials (SL), number of infralabials (IL), number of frontoparietals (FP), number of nuchals (N), number of supraoculars (SO), number of supracillaries (SC), number of primary temporal (1º) and secondary temporal (2º) scales, number of pretemporal (PT) scales, number of preanal scales, number of keels on dorsal scales, number of midbody scales (MBSR), number of subdigital lamellae on forth toe (SDL).

Other useful characters relevant to the generic diagnosis of *Eutropis* were done as per Greer and Broadley, 2000. The reduction in the contact between the first supraocular and the frontal; the most posterior supraocular contacted by the frontal; the number of pretemporals; the number of temporal scales and their configuration; and the number of small rows of scales dorsal to the window of the lower eyelid, and the fragility of the skin when the animal is grasped or struck were also examined in *Sphenomorphus* and *Lygosoma* species.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>F-</td>
<td>Frontal</td>
</tr>
<tr>
<td>FN-</td>
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</tr>
<tr>
<td>FP-</td>
<td>Fronto-parietal</td>
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<td>IP-</td>
<td>Interparietal</td>
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<td>Supraoculars</td>
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<td>N-</td>
<td>Nuchal</td>
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</table>

**Figure-2.2:** Schematic diagram of skink showing the different head scales with their nomenclature (source Smith, 1935a).

Colour notes of live specimens were recorded digitally using Canon SX110IS. Colour nomenclature was followed the swatches of Smith (1935a). Other sources of information on body characters were include Boulenger (1890), Taylor (1963), Sharma (1971, 1973), Inger et al. (1984), Yamasaki et al. (2001) and Das (2002).

**viii) Photographic documentation**

Individual of each species encountered in the field was documented with colour photographs. Photographs were taken using a Canon SX100IS digital point and shoot camera. Photographs were taken from dorsal, dorsolateral, ventral and lateral aspects. Important characters such as eye colour, head pattern, special markings on the body were photographed in detailed.

**ix) Identification and nomenclature**

Identification of lizards was done by examining the scalation pattern and obtaining morphometric measurements as per the standard identification guide. Species were identified by using the identification key of Günther (1864), Boulenger (1890), Smith (1935a), Taylor (1963), Das (2003) and Ahmed et al. (2009). However, few detailed literatures dealing with particular group or species were also used for identification purpose e.g. *Varanus* was followed as per Auffenberg (1986, 1994) and Auffenberg et al.

### 2.2.6. Data analysis

#### 2.2.6.1. Diversity and evenness

Species diversity is composed of species richness and evenness. Diversity index takes account the number of species present and as well as the abundance of each species. There are many methods to measure the diversity of a community. The following methods were used to analyse the diversity index and evenness.

(i) **Simpson's diversity index (D)**

Simpson's diversity index (D) was calculated as proportion of species $i$ relative to the total number of species ($p_i$) and their square. Then the squared proportions for all the species were summed, and reciprocal was taken.

$$D = \frac{1}{\sum_{i=1}^{S} p_i^2}$$

Equitability ($E_D$) was calculated by dividing Simpson’s diversity index (D) by $D_{\text{max}}$ ($D_{\text{max}} = S$; where, $S$ is number of species encountered). Equitability assumes value between 0 and 1, with 1 being complete evenness.

$$E_D = \frac{D}{D_{\text{max}}} = \frac{1}{\sum_{i=1}^{S} p_i^2} \times \frac{1}{S}$$

(ii) **Shannon index**

Shannon's diversity index of lizard community was calculated by the following formula.
\[ H' = - \sum_{i=1}^{S} p_i \ln p_i \]

Where, \( H' \) = the Shannon diversity index; \( p_i \) = fraction of the entire population made up of species \( i \) (proportion of a species \( i \) relative to total number of species present, not encountered) and \( S \) = number of species encountered. Here, high value of \( H' \) represents diverse and equally distributed community and low values represents less diverse community.

(iii) Shannon's equitability \((E_H)\)

To measure the evenness of lizard community Shannon's equitability \((E_H)\) was used. It was measured by dividing \( H' \) (Shannon's index) by \( H_{\text{max}} \) \((H_{\text{max}} = \ln S; \) where, \( S \) is number of species encountered). Shannon's equitability assumes value between 0 and 1, with 1 being complete evenness.

\[ E_H = \frac{H'}{H_{\text{max}}} = \frac{H'}{\ln S} \]

2.2.6.2. Niche breadth and niche overlap

Niche breadth and niche overlap was calculated from the quantitative data of the habitat and its resources used types. Niche breadth was measured by observing the distribution of individual organisms within a set of resource states. Levins' measure was used to calculate the niche breadth of skink community. Table-3.2 illustrates a resource matrix for lizards in the Jeypore Reserve Forest in which microhabitats were divided into 7 resource states.

Niche overlaps was the measured on the basis of the overlaps of the resource used among the different species in the community guild. A number of indices were available
to measure niche overlap such as utilization of dietary components or microhabitats. Pianka’s index of niche overlap was followed to calculate overlap of microhabitats in skink community of Jeypore reserve Forest. The index is symmetrical and assumes values between 0 (no resources used in common between two species) 1.0 (complete overlap in resource use).

i) Levins' measure

The formula of Levin (1968) niche breadth was used to estimate the niche breadth. It can be measured by the following formula.

\[ B = \frac{1}{\sum p_i^2} \]

Where, \( B \) = Levins' measure of niche breadth and \( p_i \) = Proportion of individuals found in or using resource state \( i \).

In Levins' niche breadth \( B \) is maximum when individuals of a species use different resource state and minimal when all the individuals of a species use only one resource state (minimum niche breadth, maximum specialisation). The range of \( B \) was from 1 to \( n \), where \( n \) was the total number of resource states.

ii) Pianka's index

Pianka’s niche overlap equation was used to calculate the niche overlap of the lizard species in Jeypore Reserve Forest. The formulae used for the purpose was such as-

\[ O_{ij} = \frac{\sum_{l=1}^{n} p_{lj} p_{lk}}{\sqrt{\left(\sum_{l=1}^{n} p_{lj}^2 p_{lk}^2\right)}} \]
Where, $O_{jk}$ is Pianka’s index. $P_{ji}$ and $P_{ki}$ were the proportions of the resource $i$ used by species $j$ and $k$, respectively; $n$ was the total number of resources states.

2.2.6.3. Microhabitat data analysis

To determine, if rainfall and temperature have any impact on specie occurrence simple linear regressions were performed. Finally, encounters of species in different microhabitats were examined graphically to determine if one or all species were more common in their habitat preferences.

2.2.6.4. Morphological analysis

Nineteen measurements (Table-3.5) were used to analyse the distance between the species. The mean with standard deviation of the data of each individuals/species were calculated. The mean value was used for analysis. To correct (relative) differences in size all the measurements were standardized (express as proportion of SVL vs other measurements). The standardized data were used in the multivariate cluster analysis using Ward’s method with nearest distance in software SPSS 16. In cluster analysis the distance was calculated using Euclidean distance.