Chapter III

MATERIALS AND METHODS

3.1. Study Area:

The state of Kerala is on the southernmost tip of India. It stretches along the coast of the Arabian Sea and is separated from the rest of the subcontinent by the steep Western Ghats. The state lies between 8° 17' 30" and 12° 47' 40" north latitudes and 74° 52' and 77° 22' 47" east longitudes. The breadth of the state varies from 32 kms in the extreme north and south to over 120 kms in the middle.

Physiographically four geographic regions are delimited in Kerala: High ranges: With elevation over 600 mts; this strip of land on the eastern edge, close to the Ghats, comprises of steep mountains and deep valleys, covered with dense forests. Almost all the rivers of the state originate here. Tea and coffee estates have cropped up in the high ranges during the last two centuries. Mid lands: The elevation of central region lies between 300 and 600 mts, the hills are not very steep and the valleys are wide. The valleys have been developed as paddy fields and the elevated lands and hill slopes, converted into estates of rubber, fruit trees and other cash crops like pepper, tapioca, etc. Plains: With elevation between 30-300 mts. Low lands: With elevation below 30 mts. Extensive paddy fields, thick groves of coconut trees and picturesque backwaters, interconnected with canals and rivers, are the features of this region. In the southern and northern parts of the state, the coastal belt also has some hills and valleys. Majority of the areas in Kerala lies below an elevation of 300 meters. At the eastern border of the state lies the Western Ghats. The highest peak in Western Ghats, the Anamudi (2817 mts) is situated at Eravikulam range. About 14 peaks in Kerala have an altitude of over 2000 mts. Palakkad gap with a width of 30 kms is an important pass across Western Ghats, it spreads to a length of 80 kms; Aryankavu pass in Kollam district is another important pass across the Western Ghats; Kumili-Kambam pass, Udamanchola-Tamil Nadu pass, Munnar-Bodinayakanoor pass are some of the other important passes across the state.
3.1.1. **Rivers:** There are 44 rivers in the state, of which 41 originate from the Western Ghats and flow towards west into the Arabian Sea. Three tributaries of the river Cauvery, namely Kabani, Bhavani, Pambar originate in Kerala and flow east into the neighbouring states. These rivers and streams flowing down from the Western Ghats either empty themselves into the backwaters in the coastal area or directly into the Arabian Sea. The important rivers from north to south are; Valapattanam (110 kms.), Chaliar (69 kms.), Kadalundipuzha (130 kms.), Bharathapuzha (209 kms.), Chalakudy (130 kms.), Periyar (244 kms), Pamba (176 kms), Achenkovil (128 kms.) and Kalladayar (121 kms.). Other than these, there are 35 more small rivers and rivulets flowing down from the Ghats.

3.1.2. **Backwaters:** The backwaters are a unique feature of the state. Canals link the lakes and backwaters to facilitate an uninterrupted inland water navigation system from Thiruvananthapuram to Vadakara, a distance of 450 kms. The Vembanad Lake stretching from Alappuzha to Kochi is the biggest water basin and is over 200 sq. kms. in area. Water-logged Kuttanad alone forms more than 20 % of India's total length of waterways.

3.1.3. **Climate:** Four different climatic seasons exist; winter season (Jan-Feb), summer (March-May), south west monsoon season (June-Sept), north east monsoon (Oct-Dec). Precipitation is below 50 mm in winter. More rain is received in Kanjirapilly region of Kottayam district during summer. During this season, 300-400 mm of rain is received in north Kerala and 50-200 mm in south Kerala. South West monsoon brings 2500 mm of rain in north Kerala and 70m mm in south Kerala. During north east monsoon season, more rain is received in south Kerala. Kozhikode district gets more rain than other districts (3750 mm), while Thiruvananthapuram district gets the lowest rainfall (1810 mm). The maximum temperature in coastal areas is around 32°C, while minimum temperature comes to around 22°C; in interior lands, summer temperature some times raises to 38°C. Kerala receives a fairly good annual rainfall varying from 1250 to 5000 mm. The normal annual rainfall of Kerala is 3107 mm. (national average is 1197mm). On an average, the number of rainy days is in the range of 120-140 in a year. The annual yield of water in Kerala in a normal year is around 7030 crores cubic metres. The utilizable water resource is around 4200 crore cubic meters. The highest rainfall occurs in the high ranges of Idukki district where it exceeds 5000 mm.
3.1.4. Flora and fauna: Kerala exhibits high diversity of plants and animals. It has over 25% of India's 15,000 plant species. The state's forest wealth includes tropical wet evergreen, semi-evergreen and tropical moist deciduous. Coastal plains are ideal for the cultivation of paddy and coconut; cashew, tapioca, plantain, jack fruit, tamarind and mango also grow well in Kerala. Rubber, coffee, tea, and cardamom plantations exist in high ranges. Teak, rosewood, ebony, artocarpus, sandalwood, Hoppea parviflora and Pterocarpus marsupium grow in eastern regions of the state. Kerala is well known as a land of medicinal plants. Animal population also exhibits high diversity. Lion tailed macaque, nilgiri langur, civets and mongoose which are endemic to Western Ghats are found in Kerala. Loris, mouse deer and wild goat which are found in eastern Himalayas are also found in Kerala. Jackal, tiger, leopard, black leopard, wild cat, gaur, spotted deer, boar, elephants, pangolin, several species of rodents like squirrels, hares, rats, reptiles and birds also exist in the forests of Kerala. Silent valley National Park and Eravikulam National Park are the two national parks in Kerala; besides 11 wildlife sanctuaries also exist in Kerala.
Location of study sites

Plate: 1

3.2. Sites selected for studying spider diversity in Kerala.

In order to get a good sampling, the collection sites were planned to cover northern, central and southern regions of Kerala, as well as low lands and high lands. The main collecting centre was Ernakulam district, located in central Kerala. Studies were also carried out in Parambikulam Wildlife Sanctuary in Palakkad district in central Kerala. In southern Kerala, Kollam and Pathanamthitta districts were selected for study. In northern Kerala, spiders were collected from Wayanad, Mallapuram, Kozhikode and Kannur districts. Kuttanad area was selected to represent low lands and Idukki district to represent high lands.

Ernakulam district: Kochi city is located between 76° 15' E longitude and 9° 57'N latitude. It lies at sea level with average temperature ranging from 22°C to 35°C. The mean rainfall is 3100 mm per year. Although Kochi is mostly urban in its habitats unlike other Indian cities it has a fairly good amount of vegetation. Another main centre of collection was Bhoothathankettu forest areas. A bulk of my collection was made from this area which is easily accessible by bus. Edamlayar, on the eastern border of the district at an elevation of more than 500 mts MSL was another site of collection. Thattakkad Bird Sanctuary, located near to this region, was also an important study area.

Palakkad district: An intensive study on the diversity of spiders was carried out in Parambikulam Wildlife Sanctuary also during the training program on the taxonomy and natural history of theraphosid spiders by Zoo Outreach Organization, Coimbatore.

Wayanad district: Collections were carried out in the forest area around Pookkote Lake in Kalpetta, located at an altitude of 650 mts. The Edakkal caves located at an altitude of more than 900 mts MSL was another study site. The purpose of the study was to bring out the differences in the diversities of spider fauna at high altitude regions; but the spider fauna were found to be basically similar to that found in Ernakulam district.

Kollam and Pathanamthitta districts: The area around Aryankavu, Palaruvi waterfalls and Tenmali in Kollam districts and Achenkovil forests located far in the
interior forest in Pathanamthitta were explored for spiders. These field visits helped familiarizing with the habitats and the nests of a few large theraphosid spiders like Poecilotheria, Thrigmopoeus and Plesiophrictus. The average altitude of Achenkovil is over 1000 mts and that of Aryankavu-Palaruvi region is around 256 mts above MSL. A limited collection was carried out at Thiruvalla also.

**Alappuzha district:** Kuttanad area of Alappuzha, one of the rice bowls of Kerala was a major collection site. A good number of photographs of spiders are included from this area. They were photographed under Stereozoom microscope in live condition. Even after three years of study, I have numerous unexamined spider specimens from these regions which may contain several unrecorded species.

**Idukki district:** In Idukki, a good number of spiders were collected from Adimali region and from the high ranges of Marayoor and Mannavan shola. Marayoor is a dry deciduous forest area in Kerala. This rain shadow region of Kerala has a strikingly different habitat from the rest of Kerala. Its altitude is around 1200 mts above MSL. Similarly, Mannavan shola is another characteristically different ecosystem with temperate character in its flora. A good collection was also made from Vagamon, a grass land area located at a higher altitude with comparatively cooler climate.

**Mallapuram district:** Several specimens of ground dwelling families like Corinnidae, Liocrannidae, Clubionidae and Miturgidae were collected from Nilambur forest areas.

**Kannur and Kozhikode districts:** Several species of mygalomorph spiders were collected from these districts. Mukkam area in Kozhikode yielded a few larger species of mygalomorphs during the study.

### 3.3. Collection Methods:

Methods suggested by Barrion & Litsinger (1995), Tikader (1976e, 1987), Subrahmanyam (1968) and Koh (1989) were mainly employed for the collection and preservation of spiders. These methods are described below:
1) **Sedentary spiders** resting on walls, leaf blades, tree trunks or in the webs can be caught in a jar by holding it open beneath them and by tapping the spider into it with the lid.

2) **Sweep net:** This is an old method usually used for collecting insects and butterflies. An insect net is swept through tall grass and weeds and the spiders caught in it are collected in a small glass vial containing some spirit.

3) **Inverted Umbrella:** Here, an inverted umbrella is placed below flowering shoots or bushes and when the tree or branch is thoroughly shaken, spiders along with insects fall to the inverted umbrella. After removing leaves, spiders can be transferred into collecting tubes containing ethyl alcohol with the help of a fine water brush.

4) **Small spiders** which live under the bark of trees, in debris or in the corners of walls are collected with a fine water brush dipped in alcohol.

5) **Spiders of the family Theraphosidae** are quite large and usually live in burrows in the ground. These are collected by keeping a large glass bottle against the burrow and allowing the spiders to crawl into it. The spider is then killed in a cyanide bottle before transferring it to 75% ethyl alcohol.

6) **Kerchief method:** This method is used for collecting running and wandering spiders, especially those belonging to the families Lycosidae and Salticidae. An open kerchief will be thrown over the running spider, which is then carefully caught in the folds of kerchief.

### 3.4. Preservation:

Before the spiders were permanently preserved, they were arranged properly. For this, collected specimens were transferred into petridish containing Isopropyl alcohol. It was kept covered undisturbed for about two or three hours in order to allow the relaxation of body muscles. The body parts like legs, abdomen, and palps were then arranged in a life like manner with the help of forceps and brush. Spiders were then kept in alcohol in a closed pair of petridishes overnight before
transferring to tubes for permanent preservation. The glass vials containing preserved specimens were stoppered by a rubber cork to prevent evaporation of alcohol. Alternatively, glass vials were plugged by cotton and group of these tubes were then placed in large bottle containing alcohol. This was the method used for preserving most specimens. Each collecting tube enclosed a label indicating the collection data. Collection data includes the name of the collector, place of collection, date of collection and habitat of collection.

Internal genitalia was dissected out with the help of sharp scalpel or pointed tipped razor blade. After dissection, the epigynum was cleared in 10% KOH or clove oil. It was then studied with the help of Stereomicroscope. The dissected out epigynum were put in a separate small microvial and corked with cotton and placed in the same bottle containing the specimen.

3.5. Photography:

Photos of all important spiders were taken with Canon digital camera attached to Leica S4E Stereoscopic microscope. Generally, major diagnostic features such as dorsal view, ventral view, ocular area, cheliceral area and side view were taken for the study. Photographs of live specimens were taken with photomicrographic attachment by mildly anesthetizing them with chloroform.

**Scanning Electron Images (SEI)** were taken at SSCU (Solid State and Structural Chemistry) Department of Indian Institute of Science (IISC), Bangalore. SEI was taken using JEOL- JSM-5600 Scanning Electron Microscope at an accelerating voltage of 4-10V. In order to enhance electron scanning, specimens were gold coated before imaging. SEI shows more depth and resolution even at the same magnification compared with Stereomicroscopes.

**Illustration:** Diagrams were drawn mostly with the help of Camera Lucida (Leica) attached to Stereomicroscope. Alternately, specimens were photographed with camera attachment and an outline is drawn on the print out as suggested by Mayer and Simpson (2000). All measurements are in mm taken with an eyepiece graticule. Scale mentioned in diagrams indicates one mm unless otherwise mentioned.
3.6. Identification: Three methods were mainly used for identification:

a) With the help of literature. Almost all the papers published on Indian spiders were collected during the study. Specimens were mostly identified by comparing with the original description and illustrations available in these works.

b) Comparison with the holotypes or paratypes available at National Collection, ZSI, Kolkata.

c) With the help of experts in the field like Dr. Jerzy Prosynski, Dr. Andrew Smith, Dr. B. K. Biswas and Dr. B.H. Patel.

3.7. References and Citations: All references and citations are followed after Platnick (2003-05) available in the internet. Only citations relevant to Indian region are mentioned in the work.

3.8. Remarks

Though more than 400 species were collected during the study, a detailed treatment is provided of only 100 species, while the remaining are mentioned only with their names. Wherever a good description and illustration is available to a species, its report is limited to giving locality, distribution and previous references. However, regarding many species, no adequate description or illustration was available. In such cases, species are fully redescribed by providing detailed diagnostic drawings. In a few cases, species are identified only up to the genus level. Many of these species may be new to science, but unfortunately their new identity can’t be confirmed without getting full literature from other parts of the world. Hence for such species, a brief listing of their main characters is included.

One salient achievement of the study is taking photographs of more than 350 species of spiders using digital camera attached to stereoscopic microscope. Though photos of all important diagnostic features were taken, photos of many species are limited to dorsal view in the thesis due to lack of space. These photographs will prove to be useful assets to future workers in the field, as no or a few photographs exist on Indian spiders.
The literature included in the thesis is limited to those works which have helped in the identification of the species. Indian distribution sites are mentioned in the case of each species with name of the state abbreviated in parenthesis.

Many of the species collected during the study were found to be new; many specimens were also taken to ZSI, Kolkata for confirmation. The major problem that frequently haunts the researchers is the unavailability of old literature such as those of Simon, Thorell, Karsch, Strand etc. Even when literature is available in certain cases, it creates much confusion while identifying some species, as their description in most cases is so brief and vague and without illustrations. These problems make it impossible to confirm species identity without examining the original type. Here also Indian workers face substantial difficulties since type of most Indian species are at BMNH, London, MNHN, Paris or in Museum of Genova. Many of the new species described by earlier Indian workers based only on Indian literature are now found to be synonyms. For example, majority of salticids identified as new by Tikader are found to synonyms of already described species. This problem exists all over the world. Existence of synonyms are so great that if a complete revision is made, the total number of world species may get reduced to some 30000 from the present number of 38663 (Platnick, 2004). Even after much effort, if we find it impossible to identify a species the only thing one can resort to is to describe it as new, as done by our earlier Indian workers.

3.9. Abbreviations