Diversity of Spider Assemblages in Sacred Groves of Ratnagiri, Maharashtra: Implications for Conservation Management in the Landscape

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SUBMITTED TO THE
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For
THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY IN FORESTRY
(Wildlife Science)

By

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Wildlife Institute of India, Dehradun

2016

DECLARATION

I hereby declare that the thesis entitled "**Diversity of Spider Assemblages in Sacred Groves of Ratnagiri, Maharashtra: Implications for Conservation Management in the Landscape**" submitted by Mr. Vinayak Krishna Patil (Reg. no. 12Ph.D259) to Forest Research Institute University, Dehradun, for the award of the degree of Doctor of Philosophy in Forestry (Wildlife Science), is a record of original research work carried out by me under the supervision of Dr. V. P. Uniyal, Scientist-F, Wildlife Institute of India, Dehradun and Shri. Mukul Trivedi (IFS), Joint Director Forest Survey of India, Dehradun and it is not formed the basis for the award of any other degree or diploma. I also declare that the thesis embodies my own work, observation and analysis and in that respects the investigation appears to advance knowledge in the subject.

Place: Dehradun
Date: 18/04/2016

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Supervisor

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To

my Mother

who, despite unbearable suffering,

let go of her ailing body

only after she saw me once last time

ACKNOWLEDGEMENTS

"Dreams…are a form of wish fulfillment in the psychic space"

-Sigmund Freud, *The Interpretation of Dreams,* 1899

Yes, but I have been so lucky that my wishes have been fulfilled not in my psychic space but in reality. An entire century after Freud declared this in his original German volume, I finished my undergraduate studies and was disappointed to notice that there were no admissions to the Wildlife Institute of India (WII) that year. I had to make do with the Forest Research Institute (FRI) course. But my wish was fulfilled when Dr. Jhala of WII gladly accepted me in his team to work on jackals for my dissertation. The stint was foundation for my professional career as teacher of ecology. Throughout my much-fulfilled 10-year-long career, though, there was an unexplained nagging from within.

Different parts of a dream-puzzle were getting in place during those ten years including my taking interest in spiders, noticing WII scientist Dr. V. P. Uniyal's supervision of spider studies and completing an employer-blocked period before I could register for my PhD. And then, in 2012, I landed my admission in FRI once again with WII as research centre. Do I need any dreams for wish-fulfillment?!

But just like dreams, wish fulfillment is also momentary. The real tasks can never be completed without real encouragement, sound advice and sincere help. I have received ample of all these in the last four years and would like to express my gratitude here.

Dr. Jhala introduced Dr. Uniyal as a 'nice man'. And both men have been really nice for me. Regardless their different approaches to science both have encouraged me in their own little ways. Waves from both these men have reached my heart and I would never stop thanking them in my own little ways. I also thank Shri. Mukul Trivedi, IFS - my co-supervisor for constant support despite his busy schedule.

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I had to consult several experts for my taxonomic investigations. And I was always encouraged by those whom I contacted. They include Dr. U. A. Gajbe, Dr. Ganesh Vankhede, Dr. Manju Siliwal, Siddharth Kulkarni, Dr. R. V. Hipparagi, Dr. Atul Bodkhe, Dr. Sunil Jose, Dr. John Caleb, Dr. Karthikeyani, Shripad Manthen. Besides them, some experts from other countries like Dr. Charles Haddad, Dr. Deeleman-Reinhold, Dr. Ansie Dippenaar-Schoeman, Dr. Wanda Wesolovska, Dr. Suresh Benjamin, Dr. Sergei Zonstein, Dr. Yuri Marusik, Dr. Akio Tanikawa, Dr. Joseph Koh, Dr. Xiao-Qi Mi always responded quickly and crisply to keep me on right track.

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I can not forget the sacrifices that my family – my parents, my brother and his family, my wife and kids - had to make so that I could give enough time for this study. It is difficult to put their contribution in words. Rather than Doctor, I shall be happier called a 'Doctor of Spiders' as my kids do!

I lack interpersonal skills but I try to fill this gap by connecting with inspiring personalities. And Rebecca Stott gave me a bunch of them recently through her Darwin's Ghosts. Thanks to her too.

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Vinayak Patil

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SUMMARY

The present study was conducted in Dapoli Taluka of Ratnagiri district in Maharashtra (India) with the objectives to document spiders in the sacred groves. The first objective was to comprehensively document the sacred groves in the study area because it is a high concentration sacred-groves region but very little documentation has been done so far. The other objective was to explore the spider diversity in sacred groves and compare it with some other habitats in the study area. These habitats included reserved forests, mango orchards and cashew orchards. Lastly, it was sought to find out if the habitats, seasonality, disturbance etc. had any influence on the diversity and composition of spider assemblages in the study sites.

A expected, a wide range of characteristics have been documented for the 102 sacred groves which could be located in the study area. A considerably comprehensive documentation of sacred groves has been done in this study. Dapoli Taluka can be considered comparable to similar high-sacred grove concentration areas like Kodagu district of Karnataka. It was noted that there was a wide range of sizes of sacred groves was present (0.03-40 ha). More than 50 different deities were noted as being worshipped in these sacred groves. Several festivals were celebrated in the sacred groves but *Holi* and Navratra held special importance.

It was observed that only a few large sacred groves retained their grove characteristics in terms of forest vegetation. Others were suffering destruction in terms of tree-felling, temple construction, plantation activity etc. Larger groves were noted to hold rare and threatened plants like *Saraca asoca*, *Mammea suriga*, *Antiaris toxicaria* etc. However, smaller groves were most vulnerable to destructive forces. A subjective disturbance ranking based on nine threat categories revealed that most of the sacred groves faced challenges in terms of shifting belief system.

Explorations into spider diversity revealed that the study area holds a rich diversity of spiders with 377 species belonging to 39 families of Araneomorph spiders being recorded. Although many of these have been identified as morphospecies, there is a potential for diagnosing them and putting them in proper taxonomic perspective. Nonetheless, 31 genera and 71 species belonging to different families have been reported here as new to India. Out of these identity of at least 52 species has been confirmed by referring to relevant literature and consulting experts. Diagnostic photographs of some of the genera and species are presented in this thesis. Non-parametric species richness estimators were computed using EstimateS and it was found that the spider surveys at regional level were highly complete with reaching upto 95 per cent completion.

The spider sampling was done in two distinct strata of vegetation – foliage by vegetation beating and ground by litter search. It was found that the two strata held distinctly different assemblages of spiders. Although there was considerable overlap in terms of families, in the two assemblages, the ground-dwelling assemblage contained 36 families whereas foliage dwellers contained 34 families. Salticidae family was abundant in both assemblages. Yet it contributed maximum to the dissimilarity between the two assemblages indicting that the Salticid species in foliage and ground assemblages are quite different. Other typical foliage dwellers and ground dwellers followed the Salticidae in creating dissimilarity between the two assemblages.

There was apparent seasonal fluctuation in spider abundance and diversity across seasons. Although there was significant increase in spider abundance in 2nd year sampling than 1st year sampling, the rise was almost uniform across seasons, and hence could be attributed to increased practice of the collector. But for the pooled data of both years, winter season was found to yield markedly higher spider abundance and marginally higher diversity compared with post-monsoon and summer seasons. This is in line with most of the spider species starting their life cycle in monsoon season, reaching their peak densities in winter and remaining dormant or dying out in the summer season.

There was no significant compositional difference between mango or cashew orchards; nor was there such difference between sacred groves and reserved forests. However, mango orchards were clearly different from reserved forest and somewhat so from sacred groves. It was also noted that *Oedignatha scrobiculata* and *Angaeus pentagonalis* were contributing most to the dissimilarity. *O. scrobiculata* – a ground dweller could be considered as an indicator of typical orchard conditions like compact ground, slow decomposing litter and less ground vegetation - all features of management-intensive habitat.

But clearly, the diversity in terms of species richness was higher in sacred groves. Even the diversity when compared in terms of effective number of species i.e. exponential of Shannon entropy, it was observed that the orchards differed only slightly from sacred groves but reserved forests were markedly low. However, the habitat variables recorded in this study did not reveal any clear associations with species distribution.

There was a simple linear relationship between species richness and genus richness. And this relationship was not affected by habitat, patch size, sampling effort or disturbance level. Therefore, it could be concluded that generic richness was a good predictor of species richness in spiders and may be relied upon when studies need to be quick and involve non-experts.

The indicator species identified for sacred groves were Philodromidae sp1 (cf *Philodromus margaritatus*) and *Nephila pilipes* which appeared to prefer undisturbed habitats. Similarly, *Amyciaea forticeps* came up as an indicator of mango orchards probably because this species is associated with weaver ants (*Oecophylla* sp.) that colonize fruit trees. On the other hand, *Leptopholcus podophthalmus* identified as an indicator of reserved forests seems actually an indicator of mango-less vegetation because it never appeared in collection from mango orchards (not even cashew orchards) and even the sacred groves which were dominated by natural or planted mango trees.

Prioritization of sites for spider conservation was attempted using two approaches – plain scoring based on species richness and iterative scoring taking into consideration complimentarity in species composition. It was observed that first approach was easy and ranked most of the larger sacred groves on priority. However, the second approach seemed more inclusive in terms of conserving more species in the entire landscape weighing other habitats also. It was noticed that the second approach was also useful if genus richness was used as a surrogate of species richness.

^^*^*^*^*^*^*^*^*^*

Chapter 1: INTRODUCTION

1.1 Sacred Groves

Sacred groves are a typical feature of several cultures throughout the world in general and India in particular. Kosambi (1962) traced the pre-Aryan aboriginal origin of sacred groves dedicated to the mother goddesses in India. Their presence has been noted, recorded and studied in most of the states of India (Malhotra et al. 2001a, 2001b). In Maharashtra, too, the forested regions typically show the presence of sacred groves (Deshmukh et al. 1998). Maharashtra's sacred groves have been studied quite extensively from floristic, cultural and conservation points of view (Gadgil and Vartak 1975, 1976, 1981; Vartak, 1983, Vartak et al. 1986, Gadgil 1989, Nipunage et al. 1993, Kumbhojkar et al. 1996, Roy Burman 1996, Deshmukh et al. 1998, Godbole et al. 1998, Raddi 1998, Untawale 1998, Nipunage and Kulkarni 2010, Patil 2011).

The social context of sacred groves derives from a history of hunting-gathering times. The sites dedicated to ferocious mother goddesses, immolated widows and such others have retained their forbidden status through centuries. In the meantime, the Sanskritization and Aryanization of local deities led to name-changes, worship patterns and temple-building (Kosambi 1962, Roy Burman 1996; Chandrakanth et al. 2004). However, the patches of forest around the site were maintained as inviolable gardens *mangal-vanas*.

In their present context, sacred groves are community-protected sites by tradition; the protection being afforded through various taboos sometimes called as social fencing. Malhotra et al. (2001a) estimated that there could 1-1.5 lakh sacred groves in India. Despite their often small size, this number, if confirmed, makes sense for a targeted conservation action. Every study that has been conducted on sacred groves has stressed the need for conservation of sacred groves because, like all natural resources, they are also under tremendous pressure for exploitation.

Sacred groves represent "antique ecosystems" in the sense that their structural and functional integrity is maintained over an unknown period of history. They are islands of rich biodiversity in a landscape dominated by human manipulations (Dudley et al. 2010). Despite multiple speculations about their origin, their present-day function seems to be utilitarian and preservative (Gadgil and Vartak 1975). They provide fuelwood and litter in addition to medicinal plants. But more importantly, they are a storehouse of rare and threatened flora (Boraiah et al. 2003; Page et al. 2009). Although, there are few studies explicitly quantifying faunal elements, they have been shown to conserve this biodiversity efficiently (Bhagwat and Rutte 2006) and thus providing an important ecosystem service.

It is also presumed that when a sacred grove exceeds the size of half a hectare, it usually represents the primeval vegetation of its region (Gadgil and Vartak, 1976). In the Western Ghats of India - one of the hottest hotspots of biodiversity (Myers et al. 2000) - where most of the primary vegetation has been lost, such remnants are indeed important. Sacred groves, one can imagine, were once part of extensive forests. Their present day existence is largely as islands surrounded by agricultural, settled or barren lands. Their structure climax woody vegetation and function as reservoirs of water sources and biodiversity are both under attack. Erosion of traditional taboos, shifting of cultural values and commercial intent behind every action have all led to the degradation – even complete annihilation – of several sacred groves.

Sacred groves are community-managed. But ownership pattern is different from place to place. Therefore, and in the post-'Western Ghats Expert Ecology Panel (WGEEP)' era, the way to go ahead with the task of conservation of sacred groves is through participatory incentivized management. Although the approach has been successful in some places and is faltering in others (Puyravaud and Davidar 2014), the still-strong attachment of village people to their sacred groves can be harnessed for protecting the groves. Successful management of these informal protected areas can ensure long-term conservation of biodiversity at landscape scale (Bhagwat et al. 2005a).

Although all sacred groves are important, there is a need for prioritization of conservation effort. This further necessitates evolution of simple and effective monitoring criteria, indicators and protocols. One of the faunal groups which has been identified as a good bioindicator is Araneidae i.e. spiders (Majer et al. 2007).

1.2 Spiders

Spiders belong to the world's sixth largest order of organisms i.e. Araneae. Presently, there are 45,888 nominate species of spiders known from 3,981 genera under 114 families (World Spider Catalogue 2016 accessed 13.iv.2016). One recent review showed that rate of discovery of spider species has accelerated in the recent decades (Agnarsson et al. 2013). They also predicted that there could be around 1,20,000 spider species in the world. As in most other organisms, spider species richness, too, is highest towards tropics and decreases towards poles. Tropical forests are especially rich in spider species with even close to 500 species being recorded in 1-ha plots in Peruvian forests (Coddington et al. 2009; Agnarsson et al. 2013).

In India, there have been few attempts at collating the checklists of known spider species (Tikader 1987, Siliwal et al. 2005, Keswani et al. 2012). The latest one by Keswani et al. (2012) has put the number at 1686 known species of spiders from 438 genera of 60 families. This number of known spider species is comparatively very less, especially in a country that boasts of 4 biodiversity hotspots. In comparison, small countries like Japan situated away from tropical region have a disproportionately large number of spider species. Thus, one can speculate that the tremendous diversity of spiders is largely unexplored in India. Certainly there is undersampling bias behind this (Coddington et al. 2009, Agnarsson et al. 2013).

Spiders are ubiquitous and abundant. They are predators and feed on several insects, other invertebrates, rarely small vertebrates and sometimes on plant products for supplement. In turn, the spiders are predated upon by numerous other insects – especially wasps – and birds etc. In any ecosystem, owing to their high species richness, they form critical links in the food chains. Their importance in agriculture as biological control agents is unparalleled and largely unknown (Uetz et al. 1999).

Spiders have been found to be the best indicators of habitat condition among several plant, vertebrate and invertebrate taxa (Majer et al. 2007). Spider assemblages are intimately linked with habitat features at different landscape scales (Batáry et al. 2008). Being ubiquitous, numerous and sensitive to environmental changes qualifies spiders for being used in conservation monitoring protocols (Hore and Uniyal 2008; Kapoor 2006). So far, there has been not much progress in using spiders as biodiversity indicators. However, a thorough understanding of spider assemblages in sacred groves and their relationships with innate and modified habitat features would make it possible to use them as indicators of their conservation status.

Global database of spiders – or any group of organisms, for that matter – is built up on localized descriptions of new species and new reports arriving from local inventories (World Spider Catalog 2016). The descriptions form a part of taxonomic exercise whereas local inventories could only be parataxonomic for groups like spiders. However, Agnarsson et al. (2013) have argued that local inventories, semi-diagnostic as they may be, are important in spider studies especially in the times of crunch of manpower and other resources for biodiversity studies (Derraik et al. 2002).

In the wake of such difficulties, many biodiversity rich areas have remained unexplored for spiders as well as other lower organisms. The Konkan region of Maharashtra which is part of Western Ghats – Sri Lanka biodiversity hotspot has likewise remained unexplored for spider diversity.

1.3 Context of Present Study

With this background, present study was carried out in Dapoli taluka of Ratnagiri district in Konkan region of Maharashtra. Konkan is one of the highest sacred grove concentration regions in India (Deshmukh et al. 1998). And being a part of the Western Ghats makes it a biodiversity hotspot. Considerable research effort has been invested in floral investigations in the sacred groves of this district. Some studies have looked at socioeconomic and perspective aspects of these sacred groves (Patil 2011).

Sacred groves in this region have been found to fulfil High Conservation Value Forest (HCVF) criteria (Punde 2007a). Similarly, peer-recognized and widely funded conservation activities in sacred groves are under way in parts of this district for over two decades (Godbole et al. 1998). On the behest of the Western Ghats Expert Ecology Panel (WGEEP), Bharati Vidyapeeth Institute of Enivronmental Education and Research, Pune carried out an exercise to identify potential ecologically sensitive areas (ESAs) in the Northern Western Ghats (BVIEER 2010). This exercise has identified sacred groves as an important category of ESAs. The report goes ahead and mentions that sacred groves 'form benchmarks of what the ESAs should look like in the future'. In fact, two sacred groves from the present study area were identified as ESAs.

However, faunal components of sacred groves of the proposed study area have not been investigated. The ones conducted like Ulman et al. (2009) and presenting information on birds do not present convincing information. Still less studies have been conducted on spiders in this region (Bhuvad et al. 2012). To fill this gap in knowledge and to utilize the opportunity to investigate the conservation status and value of sacred groves keeping spiders as a focal taxon, the present study was conducted with following objectives.

1.4 Objectives

1 To prepare inventory and to map sacred groves in Dapoli Taluka of Ratnagiri district

2 To assess spider diversity in sacred groves and other wooded land-uses

3 To assess the impact of disturbance and management interventions in wooded land-uses including sacred groves on the spider assembalges

1.5 Key Research Questions

With data collected under these objectives, answers to following and several other questions were attempted.

1. Do large sacred groves hold more diverse spider assemblages?
2. Do sacred groves hold significantly different and diverse assemblages than other wooded landuses?
3. Can spiders be used as indicators of disturbance and management in wooded landuses including sacred groves?

1.6 Organization of Thesis

This thesis is organized into chapter. Chapters 1, 2 and 3 describe the background of the study, review of relevant literature and study area respectively. Chapter 4 deals with the methodology adopted for collecting and analyzing data for the proposed objectives.

Chapter 5 deals with results obtained in the investigations conducted. The results are arranged in sequence of the objectives. Section 5.1 of this chapter presents results for the first objective i.e. inventory of sacred groves in Dapoli taluka. The results are discussed in the light of contextual references and future outlook. The datasheet prepared for the surveys is placed at Annexure I. The exhaustive data on sacred groves is presented as Annexures II-VI.

Section 5.2 deals with the taxonomic aspect of the second objective i.e. assessment of spider diversity in sacred groves and other wooded landuses. Methodology adopted for field surveys and taxonomic work is described. The results are presented in the form of an account of each family recorded alongwith its diagnostic life history and morphological traits, the genera and families recorded in the present study and their context in terms of known global and Indian spider diversity. The taxa which are potential new records to India are highlighted. The exhaustive list of spider species (and morphospecies) is presented as Annexure VII. Photographs of some representative spider species of common families are presented in Plates 11-13 and diagnostic photographs of some species/genera newly reported from India are shown in Plates 14-30. The results are discussed from taxonomic and parataxonomic prespective.

Section 5.3 contains the ecological aspects of the second and third objectives i.e. spider assemblage structure and impact of disturbance and management on it. The methodology for fieldwork and statistical analyses is described and results presented so as to understand the underlying differences in spider assemblages at a given site, and across sites. The results on observed taxon richness, species-individuals relationships, estimators of taxon richness, indicative completeness of surveys, distinctness of foliage-dweller and ground-dweller assemblages, influence of habitat type and disturbance levels on assemblage composition etc. are presented. In addition, a section is presented on higher taxa surrogacy and indicator species for habitats to address the problems of lack of taxonomic expertise, taxonomic upheavals and intensive and cumbersome surveys. Lastly, as a management intervention, the prioritization of sites based on spider diversity is attempted. The results are discussed in the light of similar studies on spiders.

Chapter 6 discusses briefly the highlights of the entire study and presents conclusions. Thereafter follow the list of references cited and Annexures. The plates are numbered in sequence for the entire thesis without reference to chapters. However, the tables and figures are divided into sequences within chapters.

^^*^*^*^*^*

Chapter 2: LITERATURE REVIEW

2.1 Sacred Groves and their Importance

Sacred natural sites are found throughout the world in the form of sacred forests, mountains, waters etc. but are concentrated in the tropical forested regions of Asia and Africa (Dudley et al. 2010). Sacred groves are a subset of these sites and comprise of forest patches. India holds, perhaps, the highest estimated number of sacred groves i.e. 1.5 lakh (Malhotra et al. 2001a). Maharashtra is one of the states in India where a large number of sacred groves have been documented (Deshmukh et al. 1998). Origins of sacred groves in India have been variously traced to the vedic or tribal traditions and dated from shifting cultivators to the pre-agrarian hunter-gatherers (Kosambi 1962, Gadgil and Vartak 1981, Nipunage and Kulkarni 2010).

Sacred groves are essentially informal protected areas. Protection is enforced in the form of religious beliefs and taboos rather than any written code. Felling and lopping of trees, hunting of animals and grazing livestock inside sacred groves is strongly restricted (Singh 2006; Bhagwat and Rutte 2006; Ganesan et al. 2009; Patil 2011). There are instances where permissions are taken in the form of *koul* before extracting any produce from sacred grove (Nipunage and Kulkarni 2010). On the other hand, there seems to be no restriction on removal of medicinal plants by the local *vaidyas* (Patil 2011; Singh 2006). They provide numerous other ecosystem services including conservation of biodiversity.

2.2 Conservation in Sacred Groves

Sacred groves are considered an important in-situ conservation method with huge potential for biodiversity conservation (Bhagwat and Rutte 2006; Dudley et al. 2010). Despite their small size, they are important sources of ecosystem services including biodiversity conservation (Ray and Ramachandra 2010). In their region, they are remnants of primary vegetation which carries so much weight in the all-so-important approach to conservation – biodiversity hotspots (Myers et al. 2000). They support large number of species of both plants and animals. More importantly, they hold numerous endemic and threatened species.

Several studies in Western Ghats, Himalayas and North-East India have documented the rich biodiversity in terms of floristic compositions (Khan et al. 2008; Ormsby and Bhagwat 2010). In comparison, only a few studies have documented the faunal components of sacred groves (e.g. Bhagwat et al. 2005a in Kodagu, Karnataka; Jayarajan 2004 in Kannur and Kasaragod, Kerala, Patil 2011 in Maharashtra, Gaude and Janarthanam 2015 in Goa). Even less documented is the spider fauna of sacred groves (Jayarajan 2004; Patil 2011; Sivaperuman 2008).

2.3 Sacred Groves in Landscape Context

Conservation function as well as the structural diversity of any forest patch is highly influenced by its landscape parameters. Therefore, landscape parameters like size, shape, isolation, edges, interspersion, juxtaposition etc. of the sacred groves could be studied and given as a valuable input into management actions. The major influence is fragmentation which results in reduction in size of fragements, isolation of patches, increased edge effect, habitat degradation, microclimate change leading to drastic effects on structural diversity (Tilman et al. 1997, Mishra et al. 2004, Jha et al. 2005).

Ray and Ramachandra (2010) asked whether small sacred groves were efficient in conservation and found the answer in affirmative. But other landscape criteria apart from size were not discussed in detail, perhaps, because literature was scanty on them. On the other hand, Laurance et al. (2002) could not find a “minimum critical size” for forest fragments as reserves but concluded that they should be large and numerous. Sacred groves present the most astonishing size range starting from single trees to hundreds of hectares of forest. Tripathi and Reynald (2010) found that the tree species richness increased significantly with increase in size of the forest fragment. They quantified several measures of diversity and all indicated higher diversity in larger forest fragment. Further, they calculated measures of β diversity which showed maximum difference between the fragments at the two ends of the size-range.

Laurance et al. (2002) over a long term study in Amazonian forest fragments recorded that fragmentation even at a very small scale critically determined the presence and abundance of several plant species. Gascon and Lovejoy (1998) showed that edge effect was species specific yielding negative effects on the diversity of birds and ants and positively affecting diversity of frogs, small mammals and butterflies. Page et al. (2009) in their work in Kodagu region in Karnataka found little evidence suggesting the influence of isolation on species richness for trees and lianas. Instead, they found size of patches was more strongly correlated.

Contrary to these observations, Bhagwat et al. (2005b) found that biodiversity within sacred groves was least affected by their size or distance from nearest forest reserve. They reported landscape structure in terms of tree cover in the surroundings and stand structure in terms of variability in canopy height as factors responsible for variation in species richness of the sacred groves. Similarly, (Brown et al. 2005) concluded that habitat degradation was a more serious threat than fragmentation to fungal diversity in the Western Ghats.

Laurance et al. (2002) found a strong influence of forest fragmentation on several ecological and ecosystem processes through edge effect and matrix dynamics. Effect of these influences was multiplied by their synergy with adverse social influences. Conversely, fragmentation or isolation can be overcome by corridors. According to Macdonald (2003) corridors can reduce the isolation of spatially separated populations and potentially increase the total area of habitat available. The effectiveness of corridors for dispersal by single animals depends upon the distance to be traversed. Bennett (1990) in his study found corridors facilitating continuity between otherwise-isolated populations of small mammals in study locality by providing a pathway for the dispersal of single animals.

Tambat et al. (2005) studied the effect of grove area on seedling mortality of *Artocarpus hirsutus* and *Canarium strictum.* They found that seedling fitness decreased as the grove area reduced and distance between the groves increased possibly as a result of inbreeding depression.

In a given area, available faunal diversity is crucial for ecological services like pollination and seed dispersal and survival of this fauna is controlled by availability of favourable habitat which according to Ray and Ramachandra (2010) was enhanced by strategic locations of small fragments and their connectivity in landscape. Bodin et al., (2006) modelled importance of small patches and the consequences of their sequential removal on pollination and seed dispersal in agricultural fields of southern Madagascar. These models showed that removal of small patches (≤3 ha) would affect overall pollination activity and seed dispersal by ring-tailed lemurs.

2.4 Spiders: Global and Local Diversity

Spiders (Order Araneae) are a group of highly diversified organisms with the world's sixth largest count (≈46,000 species) of named species. To be precise, there are 114 extant families of spiders in the world and 45,881 species belonging to 3,981 genera have been described so far (World Spider Catalogue 2016). Currently, the rate of discovery of spider species is about 900 species per year (World Spider Catalogue 2016). At this rate and boosting it with platoon of active arachnologists and sufficient funding, it is expected that documentation of the entire spectrum of spider diversity (≈1,20,000 species) is not too far away (Platnick and Raven 2013, Agnarsson et al. 2013, Huber 2014).

Spiders have been around on the Earth for more than 380 million years (Garrison et al. 2016). Their taxonomic diversity is buttressed with enormous diversity of life strategies including that in predation, reproduction, web-building and so on. These adaptations have enabled them to occupy similarly diverse range of habitats.

Spiders are also a rare group of organisms which have a dedicated online real-time catalogue (World Spider Catalogue http://www.wsc.nmbe.ch/) that has incorporated almost the entire taxonomic knowledge and continues to do so. For years it was maintained by the legendary Norman Platnick of American Museum of Natural History, New York until his retirement in 2014. Currently it is being maintained by Natural History Museum, Bern, Switzerland.

The checklists of spider taxa of India published in last 3 decades are summarized in Table 2.1. A look at the table and Figure 2.1 will illustrate that there is a clear increasing trend in the numbers of species and genera whereas the number of families is stabilizing. This is in line with the global trends noted by Agnarsson et al. (2013) where they found that while discovery of species showed no slowing down, the higher taxa like families have, perhaps, reached asymptote.

Table 2.1 Spider diversity summarized at different times over the last three decades.

Source	Species	Genera	Families
Tikader 1987	1067	249	43
Siliwal et al. 2005	1442	361	59
Keswani et al. 2012	1686	438	60

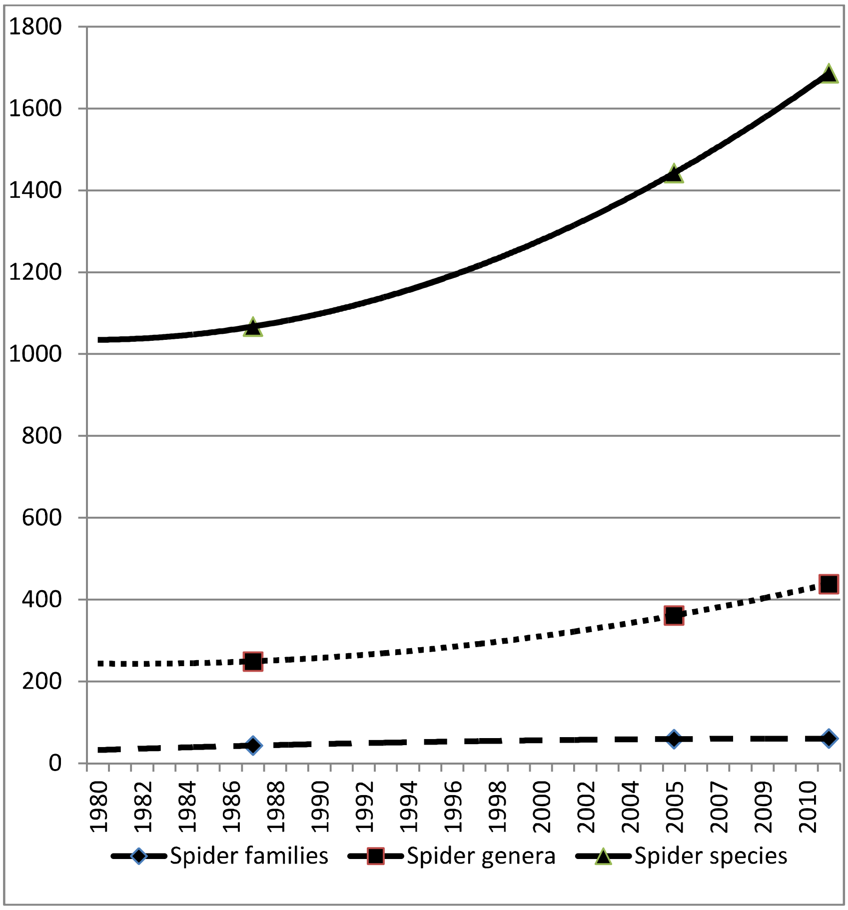

Figure 2.1 Progression of documentation of spider fauna in India since 1987 to 2012.

Documentation of global diversity of spiders is built upon localized descriptions of new species and local spider assemblage inventories which also invariably tend to include new descriptions. More often, the local inventories turn into parataxonomy – the incomplete taxonomic description of available material. The specimen are labeled as morphospecies when it is not possible to assign them to a known species. However incomplete this approach maybe, its importance for alpha taxonomy has been outlined by Agnarsson et al. (2013) in following words -

"*Most species could not be named, either because they were new to science or because existing descriptions of known species were inadequate to identify specimens. Given that species are best described in the context of revisions, formally naming and describing rich tropical faunas as a byproduct of biodiversity research is effectively impossible. On the other hand, local inventories can publish images of the habitus and some aspects of diagnostic sexual morphology of observed 'morphospecies' on websites. Perhaps, these semi-diagnosed informal taxa will help to accelerate alpha taxonomy.*"

In the last decade, an average of 14 papers was published per year describing spider species from India (World Spider Catalogue 2016). However, studies dealing with near-complete documentation of spider fauna of a small geographical area like Kapoor (2006) or Sen et al. (2015) as envisaged by Agnarsson et al. (2013) are rare. Further, several theses like Hore (2009), Quasin (2011), Uniyal et al. (2011) etc. contain intensive information on spiders of small areas but are also rare.

2.5 Studies on Spiders in India

Spider systematics is nearly 250 years old and is considered slightly older than *Systema naturae* of Linnaeus (Platnick and Raven 2013). India, too, has a fairly long history of spider systematics which, perhaps, dates back to 1867 with John Blackwall's description of few species from India (Blackwall 1867). There have been attempts to summarize the history of spider studies in India (Siliwal et al. 2005, Hore 2009, Quasin 2011, Keswani et al. 2012). Even though numerous studies have documented spider fauna of different regions and groups of spiders, our knowledge of Indian spiders remains extremely fragmentary (Quasin 2011). A brief historical sketch of spider studies in India is provided here

The so called 'Age of Enlightenment' in Europe led by Britain and France was still on when spider systematics of India began. Most of the spiders were described by taxonomists working in Europe in natural history museums based on collections made by officials serving in the tropical colonial countries. For example, Major Julian Hobson of 9th Regiment Bombay Native Infantry was a botanist who sent his spider collections to Rev. Octavius Pickard-Cambridge – one of the prolific arachnologists who described many species from oriental region – who examined them and described several species (Pickard-Cambridge, 1974). Pickard-Cambridge himself considered these collections interesting and valuable (Pickard-Cambridge O. 1870). A glimpse into the working life of arachnologists like O. Pickard-Cambridge can be obtained through their memoirs (Pickard-Cambridge A. W. 1918).

In the second half of the nineteenth century, several contributions on Indian spiders were made by Ferdinand Stoliczka, O. Pickard-Cambridge, Ferdinand Karsch, Eugene Simon, Tamerlan Thorell, and Reginald Innes Pocock. The culmination was Pocock publishing the Arachnida volume of the Fauna of British India including Ceylon and Burma (Pocock 1900). His book provided the first list of spiders, along with new descriptions in British India based on spider specimen at the Natural History Museum, London. But all these arachnologists worked from Europe and spiders they reported from India was part of their overall arachnological studies.

In the first half of the twentieth century, major contributions to the knowledge of Indian regions came from Gravely from 191 to 1935 and Sheriffs from 1919 to 1931. Some sporadic reports also came from other researchers. But the real impetus to spider taxonomy in India was provided with the arrival of Dr. B. K. Tikader. He made more than 100 contributions to the knowledge of Indian spiders from 1960 to 1987. Tikader was the one who unified the knowledge on Indian spiders apart from describing numerous spider species new to science. Alone and along with colleagues and students in Zoological Survey of India (ZSI), he published monographs on several families and for several regions (Tikader, 1980, 1982a, 1982b, Tikader and Malhotra 1980, Majumder and Tikader 1991, Sethi and Tikader 1988). He also published the Handbook of Indian spiders (Tikader 1987), which included 1067 species belonging to 249 genera in 43 families.

With the spread of ZSI through regional centres, the spider studies also diverged into various regions of India. Several parts of India have been covered by ZSI for arachnological explorations through B. K. Tikader (Maharashtra, West Bengal, Andaman, Nicobar etc.), M. S. Malhotra (Maharashtra), B. Biswas (North-East India), U. A. Gajbe (Central India), B. H. Patel and T. S. Reddy (Gujarat, Andhra Pradesh and H. K. Patel (Gujarat) etc. The information on spider diversity of Northern parts of India especially, the western Himalayan and Sivalik regions was far from complete (Quasin 2011). However, attempts have been made by researchers at Wildlife Institute of India (Hore 2009, Quasin 2011).

Spiders of protected areas in India have received some attention. The earlier studies were typically less intensive and reported few species (Patel 2003, Bastawade and Khandal 2006, Sunil Jose et al. 2008 etc.). Uniyal et al. (2011) and Quasin and Uniyal (2010) attempted comprehensive documentation of spiders of Nanda Devi biosphere reserve and Kedarnath wildlife sanctuary. Uniyal (2004, 2006) and Hore and Uniyal (2008) propounded spiders as conservation monitoring tools for protected areas. Studies on spiders are also conducted in agro ecosystems mainly in rice fields and coffee plantations (Sebastian et al. 2005, Kapoor 2008, Bhuvad et al. 2013).

M. Siliwal has made numerous contributions from 2001 till date to the Indian spider fauna especially the Mygalomorphae. But one of her main contributions was preparing an updated checklist of Indian spiders (Siliwal et al. 2005). This checklist was based on Platnick’s catalogue of spiders. It is still a relevant benchmark for Indian spider fauna despite arrival of books like Sebastian and Peter (2009) and further checklists (Keswani et al. 2012). Sebastian and Peter (2009) came at a good time when many Indian researchers are exploring spider diversity in different parts of India. The spider exploration has gone much beyond the scope of ZSI and has witnessed a spurt in taxonomic activity (average 14 papers per year in the last decade). The group of researchers based in Sacred Heart College, Kochi led by P. A. Sebastian is doing active research in spider taxonomy. Also a recently published monograph on spiders of reserved forests of Dooars has been a culmination of long term research (Sen et al. 2015). Thus, there have been several studies on spiders in India and in recent past they have gained momentum. But still our knowledge of Indian spider fauna needs to be advanced to bring to the level of other Asian countries like China, Japan, Taiwan etc.

2.6 Spiders in Sacred Groves

Spiders are generalist predators and have the world's most abundant taxon – Insecta – as their main food (Maloney et al. 2003). They can be found in almost all terrestrial habitats in natural settings. In fact, they can be found in most anthropogenic habitats too (Wise 1993). Most spider species occur as high-density populations in diverse communities. With all these properties, they have been hailed as an ideal group for studying metacommunity dynamics (Schmidt et al. 2007).

Documenting and understanding spider assemblages in tropical forests in the present context of rapid loss is an important task (Kapoor 2006). Sacred groves are supposed to be relics of ancient vegetation and remnants of larger forest tracts (Chandran et al. 1998). And they have been shown to hold rare and endemic species of plants (e.g. Jayarajan 2004; Sukumaran and Jeeva 2008; Sukumaran and Raj 2007; Bhagwat et al. 2005a; Khumbongmayum et al. 2005; Punde 2007; Tambat et al. 2005; Page et al. 2009), birds (Bhagwat et al. 2005b; Jayarajan 2004), mammals (Jayarajan 2004), and butterflies (Barua 2007, Gaude and Janarthanam 2015). But rarely anyone has even attempted to record the spider fauna of sacred groves.

I could trace only two studies which looked at spiders in sacred groves. One was carried out in Kerala during 1997-1998 over a period of 4 months in 3 sacred groves (Sivaperuman 2008). This study recorded only 14 species with visual search method. A correlation between size of sacred grove and spider species richness was expected but not found. Another study was conducted in the South-Western Maharashtra (Patil 2011). Seven sacred groves were surveyed once each for spiders among other potential indicator taxa. I could record 59 species of spiders and found that the general indices of assemblage diversity were not reflecting disturbance levels in these sacred groves.

Kapoor's (2006) study comes closer to sacred groves in terms of nature of habitat sampled. She recorded 156 spider morphospecies in her sampling effort. However, most of the forest fragments she sampled were huge in size. She found substantial changes in species composition in response to altitude and habitat alteration. However, a meta-analysis of studies on effect of land management on spider abundance and richness revealed that spider assemblages in forest ecosystems are relatively more resilient to disturbing land management practices (Prieto-Benítez and Méndez 2011).

Let alone sacred groves, even the checklists of spiders for protected areas from this region are nowhere near to complete (e.g. 60 species in Bastawade and Khandal 2006 for Sanjay Gandhi National Park, Borivali). This is quite an underestimate given the Coddington et al.'s (1991) estimate of 300 to 800 spider species per hectare in tropical forests. Even a small-scale study in fieldcrops and orchards in this region resulted in recording 141 species and morphospecies (Bhuvad et al. 2013). Thus, there exists considerable scope to record diversity of spiders from this region.

The taxonomic treatment of specimen collected in the present study involved review of literally hundreds of taxonomic papers, books and monographs. A detailed review of these can not be provided here and is not desirable also. That will be included in the taxonomic papers as and when they are published (e.g. Patil et al. 2015 and several in review).

2.7 Spiders as Bio-Indicators

Samways et al. (2010) have defined a bioindicator as a species or group of species that (i) readily reflects the abiotic or biotic state of an environment, (ii) represents the impact of environmental change on a habitat, community or ecosystem, or (iii) is indicative of the diversity of a subset of taxa, or of wholesale diversity, within an area. One of the major challenges to conservation of biodiversity is our often poor knowledge of species-rich groups of organisms and areas of world. With the limited resources, it is necessary to collect information with efficient approaches. Use of bioindicators is one such approach. Bioindicators can be grouped into environmental indicators, ecological indicators or biodiversity indicators (McGeoch 2013). The bioindicator response is usually measured in terms of species abundance and distribution.

Many arthropod groups are considered promising bioindicators because of their high species richness, large biomass, the importance and diversity of their functional roles, and their responsiveness to environmental change (Samways et al. 2010). Kremen (1992) had much earlier suggested that terrestrial arthropods could be used for virtually any monitoring programme, so long as the goals are well defined. Bisevac and Majer (2002) concluded that certain invertebrates were much better and cost-effective bioindicators than vertebrates.

Community Based Natural Resource Management (CBNRM) is perceived as a potential approach to management of sacred groves (Bhagwat and Rutte, 2006). CBNRM programs envisage development of specific indicators to monitor the progress towards goals and objectives (Gruber 2011). Similar indicators can be devised for monitoring ecosystem health or conservation status.

Very often species or other taxa are used as indicators of changes in natural areas. In 1970s and 1980s, single species were typically used to indicate contamination levels. But with Kremen's (1992) paper, the approach changed to species assemblages and ordination. Later on (Dufrene and Legendre 1997) proposed the IndVal measure to determine indicator potential species in an assemblage. It was and still is a very famous method to identify indicator species. However, supposedly better measures like *phi coefficient of association* are being proposed (Tichy and Chytry 2006). Spiders, too, are considered useful indicators of environmental conditions and they are gaining importance even in Indian context (Uniyal et al. 2011). In fact, they were found to be the best indicators among as diverse groups as beetles, Hemiptera, ants, springtails, birds and other terrestrial vertebrates (Majer et al. 2007). Kapoor (2006) has nicely summarized the properties of spiders to be good ecological indicators as them being conspicuous; amenable to relatively cheap, easily deployable and replicable methods of sampling; predators with short life cycle; equipped with varied dispersal systems; and having sensitivity to change in vegetation structure.

Landscape parameters and habitat features determine the environment of a sacred grove. Habitat features, in turn, are in a state of flux. They are influenced by management interventions and disturbances. Sacred groves are ideally areas with minimum management and interference. But all researchers and conservationists have expressed concern over the violation of this ‘minimum’ rule (Gadgil and Vartak 1975;

Mishra et al. 2004; Dudley et al. 2010). It is an accepted principle of landscape ecology that a certain low level of disturbance is helpful in increasing diversity of any given ecosystem (Meine 2010). But often this threshold level is poorly known and by the time managers realize, disturbance increases unchecked only to deteriorate the ecosystem. Indicators like spiders can come handy in these situations to warn the managers at an early stage.

Presence and abundance of spiders is connected with the environment in a sacred grove. Slope, aspect, soil and rock types are important in determining spiders in the burrowing guild. Vegetation composition and stratification are important for the web-building as well as bark and canopy dwelling spiders. It also indirectly affects the litter-dwelling spiders. Most of the spiders are sedentary predators. Even some moving spiders also become sedentary during breeding time i.e. from egg-laying to hatching. As a result, they respond to a very close microclimatic zone than many other groups of organisms. These microhabitats are altered by management interventions and disturbances - either as gradients or discrete events. Various management operations like clearing, plantation, thinning, litter removal influence spiders in almost all guilds. Disturbances like excessive felling, intensive grazing, recurring fires and construction activities also reduce availability of niches, fragment habitat and destroy populations. So, spiders can indicate environmental conditions at different scales.

Although not in sacred groves, several studies have proved this in case of natural gradients. Churchill (1998) found that dominant spider families sufficiently indicated environmental change along rainfall and grazing gradients in Australian tropical savannas. Structural changes in vegetation were successfully indicated by certain spider families in grasslands of New Zealand (Olarte 2010). Open and closed canopy forest specialist spiders showed significantly different responses to ground vegetation and litter characteristics respectively (Oxbrough et al. 2005). Quasin and Uniyal (2010, 2013) have found interesting relationship between elevation grandient and spider diversity in high altitude Himalayas.

Similar results have been recorded for management and disturbance regimes. Spiders were also found to reflect mammalian grazing impacts (Warui et al. 2005). Kapoor (2006) also identified certain spiders as indicators of habitat alteration in rainforest fragments of the Western Ghats. Spider guilds specific to micro-habitats like bark, foliage and ground did also show strong association levels with potential to indicate changes in these micro-habitats (Pinzón and Spence 2010).

Page et al. (2009) have, however, advised against using only one life form (trees in their case) as indicators of effects of fragmentation in sacred groves. But, it is nonetheless practical to explore indicators across life forms separately and then combine them into efficient monitoring protocols. That is why one of the popular approaches to short-cut the inventories is using higher taxa surrogates. Genus was found to be a promising surrogate for spider species richness in Mediterranean forests (Cardoso et al. 2004). This also helps in overcoming the taxonomic burden of morphospecies versus alpha taxonomy conflict (Coddington et al. 1991). Even within spider assemblages of Hungarian agricultural fields and pastures, rare species were found to respond particularly well to smaller ecological changes (Batáry et al. 2008; Samu and Szinetar 2002).

2.8 Spiders in Landscape Context

This part of the literature review was made with an objective which was subsequently dropped from the proposed study on suggestion of the RAC. However, this was published as a review paper (Patil and Uniyal 2013) and contains important references that are used while interpreting results of this study. Therefore, this review is presented here.

Spiders, like most other organisms, live in a hostile world in which they have to keep predators at bay while obtaining enough food to survive and reproduce (Helsdingen 2011). Most spiders except active hunters are sedentary over a large part of their life-span. But all of them possess the defining ability to move (Biewener 2003) especially from place to place. Their movements are inspired by motives of self-preservation by avoiding mortality from various factors, acquisition of essential resources and avoidance of competition in doing so (Fahrig 2007).

Dingle (1996) has classified animal movements into three broad categories - station keeping (within home range), ranging (in pursuance of alternate home range) and migratory (beyond the ambit of home range) movements. These depend on organism's size, life history traits, power of movement, geographical range, and habitat. Dingle further argues that natal dispersal wherein the juveniles move away from their natal home range to establish their own home range is different from exploratory beyond-home-range ranging movements. But most spider studies, and hence this review calls both these movements as dispersal. Spiders have been known to perform all these movements.

Spider assemblages of any habitat are shaped by landscape-level and local factors. Landscape-level factors include landscape diversity, proportion of different habitats in the matrix, patch size, isolation etc. Local factors include plant cover, litter cover, bare ground proportion etc. Habitats can be of two types- natural and managed. Of course, there could be a range of levels between entirely natural and intensively managed.

It is understood that even intensively managed habitats often support diverse spider assemblages. It has also been proven that in managed habitats, the assemblages are maintained by landscape-level factors. This is mainly because management actions lead to disturbance and frequent changes in species richness and abundances. To maintain these components of diversity, frequent recolonization of habitat by spiders is essential. And the source for these recolonizations is surrounding landscape. Hence, the nature of the landscape i.e. landscape-level factors assume great importance in such situations. On the contrary, unmanaged or natural habitats experience less disturbance and consequently more stable spider assemblages. These do not need frequent recolonizations and this phenomenon appears to be subdued. Thus, the spider assemblage is shaped mostly by local factors in the habitat.

The spider populations and assemblages are always in a state of flux. The landscape-scale processes that contribute to this flux are dispersal and colonization (Shmida and Wilson 1985; Bullock et al. 2002). Colonization is a result of dispersal. Incidentally, dispersal is at the base of two major ecological theories - metapopulation dynamics and metacommunity dynamics (Wilson 1992). More physically, and simply put, metapopulations or metacommunities are nothing but occupied patches in a landscape. Metapopulation dynamics is run by architecture of populations and density-dependence in addition to dispersal (Hanski 1991). Similarly, metacommunity dynamics is run by patch dynamic, species sorting, and niche partitioning in addition to dispersal (Leibold et al. 2004). It is worth noting here that metacommunity dynamics has attained unprecedented levels of popularity amongst ecologists. This is clear from the enthusiastic reviews received by the book 'Metacommunities: Spatial Dynamics and Ecological Communities' (Holyoak et al. 2005) (e.g. Gaston 2006). It is also evident from the way a comprehensive review of this theory (Leibold et al. 2004) got cited in over 1000 papers in just 8 years!

Thus, dispersal is the key mechanism behind occupancy of habitat patches in a landscape and it invariably involves travel across landscape. Dispersal movements across landscape depend on the heterogeneity of landscape as well as the organism concerned (Turner 1989). She, however, contended that in landscape ecological studies, all landscape scales must be organism-centric. In such a case, important factor is the ability and tendency of the species to cover distances. Mobility categories of butterflies like sedentary, intermediate, and wide ranging have been identified (see Thomas 2000). Similar categories based on mobility can be construed in spiders too.

From a different perspective, dispersal is triggered by resource- and density-dependent factors working at population levels which are, in turn, influenced by the configuration of the landscape. The landscapes are inherently heterogeneous comprising of several types of habitats arranged in patches. Some patches correspond to the suitable habitat while others unfavorable. Dispersal is thus, kicked off as a response to a forcing event causing 'changes in the quality, size, density and connectivity of suitable habitat patches' (Jackson and Sax 2010). Dispersing individuals face the problem of covering the distance between suitable patches (Opdam 1991). And anthropogenic fragmentation of habitats has increased these distances substantially. Lower dispersal success is often connected with decline in population in fragmented habitats (Schumaker 2007).

But there is little doubt that spiders are successful dispersers given their extremely diverse assemblages, high abundances and numerous habitats occupied (Turnbull 1973). Different spider species, albeit related, showed differential colonization abilities in the studies of Marshall et al. (2000). This could be a result of level of association with the habitat as Wiens (1989) had found in case of birds which would be affected differently by the fragmentation of habitat. On one hand, habitat generalists and edge lovers can be benefitted by a certain degree of fragmentation. On the other, for habitat specific species, the area between habitat patches acts as a barrier or sink (Opdam 1991). In habitat specialist spiders, the propensity for dispersal was found to be declining with increasing fragmentation of habitat (Bonte et al. 2003). Samu et al. (1999) have advised to study spiders at 3 scales of spatial hierarchy – micro-habitat, habitat and landscape. For spiders, landscape composition at the scale of 500 m radial area has been found to be appropriate (Clough et al. 2005, Schmidt et al. 2005).

In spiders, some studies have used indirect evidence of dispersal and mark-recapture set ups. Still, there have been very few studies which focused exclusively on dispersal in spiders (e.g. Bishop and Riechert, 1990; Blandenier and Fürst, 1998; Nicholls et al., 2001; Schneider et al., 2001; Bonte et al., 2004; Bonte et al., 2006; Bonte et al., 2003; Reynolds et al., 2007; Hibbert and Buddle, 2008). Modelling dispersal is another approach not used in spiders. Dispersal success rate of organisms is predicted through numerous spatially explicit grid-based or patch-based demographic models (see Vuilleumier and Metzger 2006 for a review); Alternatively, dispersal success is predicted on the basis of indices of landscape fragmentation assessing the connectivity. But they all are inefficient and unrealistic in the absence of life history data of the target species (Schumaker, 2007). Schumaker (2007) also showed that of several landscape indices, only those that combined patch area and perimeter were able to predict dispersal success adequately.

Spider colonization takes place through two processes – natal dispersal and cyclic dispersal. In natal dispersal, young spiderlings move away from their mother's habitat patch and get established elsewhere. However, there has been evidence of natal dispersal being performed by adults especially those of social spiders of the genus *Stegodyphus* (Schneider et al., 2001). The cyclic dispersal results into what is known as 'cyclic colonization' in which the spiders colonize a resource-rich habitat for a certain period of year and then return to their original habitat (Wissinger, 1997). Again, in this case the individuals involved could be spiderlings and adults both and the colonization is short-term.

Deprived of wings, spiders disperse relying on their legs and their extraordinary ability to produce silk. Thus, whether natal or adult, spiders disperse in two modes – cursorial and aerial. Aerial dispersal takes place by a mechanism of ballooning which is known for over a century (see LaPersonne, 1929 and editor's note alongwith). It is known to carry spiders to heights of 5 km above ground and upto 300 km across landscape (see Ehmann, 1994).

Ballooning is a passive mode of dispersal dependent on air currents, wind direction, and body mass and wherein the spider has no control on the flight direction (Thomas and Jepson, 1999). Bishop (1990) speculated a difference between initiation of ballooning and maintenance of flight. She sticky-trapped ballooning spiders at different heights above ground and found that less fluctuation in wind velocity was important for successful flight maintenance. In a fitting proof, Reynolds et al. (2007) have found that the silken dragline is only of as much importance as to launch the spider into the air current. Thereafter, the distance travelled by the spider is determined by the meteorological conditions rather than the properties of the dragline. Spiders initiated ballooning at appropriate meteorological conditions that maximized the dispersal distance.

Tiptoeing is a prelude to the ballooning. A tiptoeing spider stands on raised legs and points abdomen upwards. In this position, it releases tens to hundreds strands of silk using which as parachute, the spiders ride the wind currents (Schneider et al., 2001 in *Stegodyphus dumicola*). They concluded that use of multiple strands of silk to balloon can help even large-sized adults in dispersing to remote locations.

Ballooning was found to be a major mode of dispersal for certain spiders in high-Arctic glacial ecosystems (Coulson et al. 2003). Bishop and Riechert (1990) found that spiders arriving in their garden plots via ballooning were significantly more than those via cursorial mode. The familial composition of both modes was also significantly different. They also observed that nearly 50% of all immigrant species arrived from far-away areas via aerial dispersal. Ehmann (1994) controlled - by means of exclosures - the access of cursorial and ballooning spiders to individual shrubs within plots. He found that control shrubs received over 75% of their individuals via ballooning. But the mode of dispersal did not influence the guild structure in either treatment. Hibbert and Buddle (2008) conducted similar studies in cornfields and adjacent natural forest in Canada. They used circular aluminium enclosures that allowed only ballooning spiders or both ballooning and cursorial spiders. They found that cursorial mode of dispersal significantly contributed to the colonization of spiders in cornfields. Their other observation was that several spider species were common to both habitats indicating that the natural forest could play an important role in maintaining spider populations in cornfields.

Habitat quality is also known to initiate dispersal. Ballooning away from a deteriorating agricultural habitat was also found to be a major mode of dispersal of Linyphiid spiders (Thomas and Jepson, 1999). Buddle and Rypstra (2003) trapped emigrating spiders in pit-fall traps in a two-species system of wolf spiders in soybean fields. They found that one species showed very high propensity to emigrate from low-quality habitat showing its specialization on high-quality habitat. The other species showed generalist behaviour. This goes on to show that even exclusively cursorial spiders exhibit variable tendencies of dispersal.

Presence of refuge vegetation does influence the colonization of croplands by generalist predators (Hibbert and Buddle, 2008). It is also important as escape zone for the agrobiont spiders during periods of excessive disturbance viz. pesticide application (Marc et al., 1999). But the zone of this influence of colonization was found to be very limited. In addition, effect of corridors of refuge vegetation running through extensive monocultures has also been studied. The population and, hence, the pest control potential of natural enemies was found to be amplified by a riparian corridor in extensive vineyards (Nicholls et al., 2001). Interestingly, among the complex of arthropod natural enemies they recorded, the second most abundant predators were Thomisiid spiders!

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Chapter 3: STUDY AREA

3.1 Konkan region

Konkan is the coastal region of Maharashtra (Plate 1). It is a narrow North-South strip of nearly 700 km length and 40 km width. The total geographical area of Konkan region is 30,728 km^2. It includes districts of Thane, Mumbai, Mumbai suburban, Raigad, Ratnagiri, Sindhudurg and the newly carved out Palghar. Geographical area and population of districts of Konkan region as compared with that of Maharashtra state is summarized in Table 3.1. These figures indicate that Konkan region forms 10 per cent of the geographical area of Maharashtra but supports 25 per cent of its population. The swollen proportion of population compared with area is largely attributable to the dense population in Mumbai, Mumbai suburban and Thane mega-cities.

Table 3.1 Area and Population of districts of Konkan region.

District	Geographical area (km^2)	Population (no.)*
Thane#	9,558	11,060,148
Mumbai City	157	3,085,411
Mumbai Suburban	446	9,356,962
Raigad	7,152	2,634,200
Ratnagiri	8,208	1,615,069
Sindhudurg	5,207	849,651
Total	*30,728*	*2,86,01,441*
Maharashtra state	3,07,713	11,23,74,333

* www.censusindia.gov.in

The stats for Thane district here and elsewhere in this document include those of Palghar district which was recently split from the earlier one.

Konkan region is bounded by the Arabian sea on the West and the crest of Sahyadri hills on the East. Thus, altitude ranges from mean sea level to nearly 1200 m above msl. The Sahyadri hill-side is mostly precipitous and famous for its ghats. The terrain throughout the region is mostly hilly, broken by several small river-valleys. Rivers origin in the Sahyadri hills and run through deep valleys before reaching quickly their estuaries. The major rock formations are laterite and Deccan trap. The soils are lateritic and acidic. Some coastal areas also have low-lying plains and hilltop plateaus.

Throughout the region, climate is typically tropical characterized by moderate temperatures (7-38°C) and high humidity throughout year (55-100 %). The annual rainfall exceeds 4000 mm in places.

Konkan region, being largely hilly, exhibits a variety of landuses. These include forests, agriculture, built-up area, marshy lands, barren and rocky outcrops, grasslands etc. A summary of area under different landuse categories in presented in Table 3.2.

The landcover is dominated by forest with over 50% of geographical area under forest cover (FSI, 2015). The forest types recorded are semievergreen, tropical moist deciduous and tropical dry deciduous in that sequence of occurrence from South to North. But as Kanade et al. (2008) have remarked, these forest types are mixed up at very small scales under the constant felling, grazing, burning and such other pressures. In addition, mangrove forests are also found in Ratnagiri, Raigad and Thane districts. However, much of this forest is owned privately. Most of it is also in a highly disturbed state. Panigrahy et al. (2010) interpreted a rapid decline in overall forest cover and conversion of dense forest to open forest in this region over last three decades. The other vegetation includes grasslands on plateaus. The entire region is dotted with small sacred groves (Deshmukh et al. 1998). Almost all area of this region comes under the definition of Western Ghats as per the boundaries drawn by the Western Ghats Ecology Expert Panel (Gadgil et al 2011).

Major agricultural crops are rice and finger-millet. Paddy is usually cultivated in the valleys and lowland plains; finger-millet on slopes. Over the last three decades, mango and cashew orchards have replaced forests on slopes and grasslands on plateaus on a large scale. Coconut and arecanut orchards are also a typical feature of valleys closed to the coastline. Konkan region holds two agroclimatic zones viz. AZ90-South Konkan coastal and AZ91-North Konkan coastal as per Indian Meteorological Department. The region’s major crops include rice, some millets and pulses. A large proportion of land has been brought under tree orchards of mango, cashew, sapota, coconut, arecanut etc. A summary of major crops is presented in Table 3.3.

Table 3.2. Area (km^2) under different landuse categories in large districts of Konkan region (source: Department of Statistics, Govt. of Maharashtra)

District	Forest	Net area sown	non-agriculture land	Barren and uncultivable land
Thane	3964	2446	946	566
Raigad	1500	1886	589	1284
Ratnagiri	54	2444	145	2333
Sindhudurg	331	1403	205	998
Total	5849	8179	1885	5181

District	Culturable wasteland	Permanent pasture	Misc. Trees and groves	Current fallow	Other fallow
Thane	342	540	249	94	190
Raigad	380	401	226	144	459
Ratnagiri	1326	139	70	278	1375
Sindhudurg	661	20	256	144	1022
Total	2709	1100	801	660	3046

Table 3.3. Major crops and their acreage in Konkan region for 2013-14 (source: Department of Agriculture, Govt. of Maharashtra).

Crop		Acreage (km^2)
Fruit orchards		
1	Mango	1750
2	Coconut	350
3	Cashew	1750
4	Sapota	120

Crop		Acreage (km^2)
Field crops (kharif)		
1	Rice	4079
2	Ragi	445
3	Total pulses	88
4	Total oilseeds	72

3.2 Ratnagiri district

Ratnagiri is a coastal district with hilly terrain representing typical climate and vegetation of Konkan region. It comes under the Western Ghats biogeographic zone and is part of Western Ghats-Sri Lanka global biodiversity hotspot. It is characterized by extremely humid weather with average 3500 mm annual rainfall. The prominent landforms of the district include coastline, estuarine plains and river basis, lateritic plateaus, residual hills and scarp faces of the Sahyadri proper (CGWB, 2014). Natural vegetation of the district comprises of moist deciduous forests on hills and in valleys, grasslands on plateaus, mangroves along coastline.

In 2011 cenus, Ratnagiri had population of over 16 lakh which was 1.44 per cent of total Maharashtra population. The anthropogenic pressures in this district are on rise as industrialization and urbanization are increasing.

3.3 Intensive study area: Dapoli

This study was carried out in Dapoli Taluka (17°34' to 17°56'; 73°03' to 73°20') of Ratnagiri district (Plate 1). Total geographical area of Dapoli is 846 km^2. In 2011 cenus, population recorded for Dapoli taluka was 1.9 lakh. Population is distributed in villages comprising of several hamlets each. Dapoli taluka has176 villages.

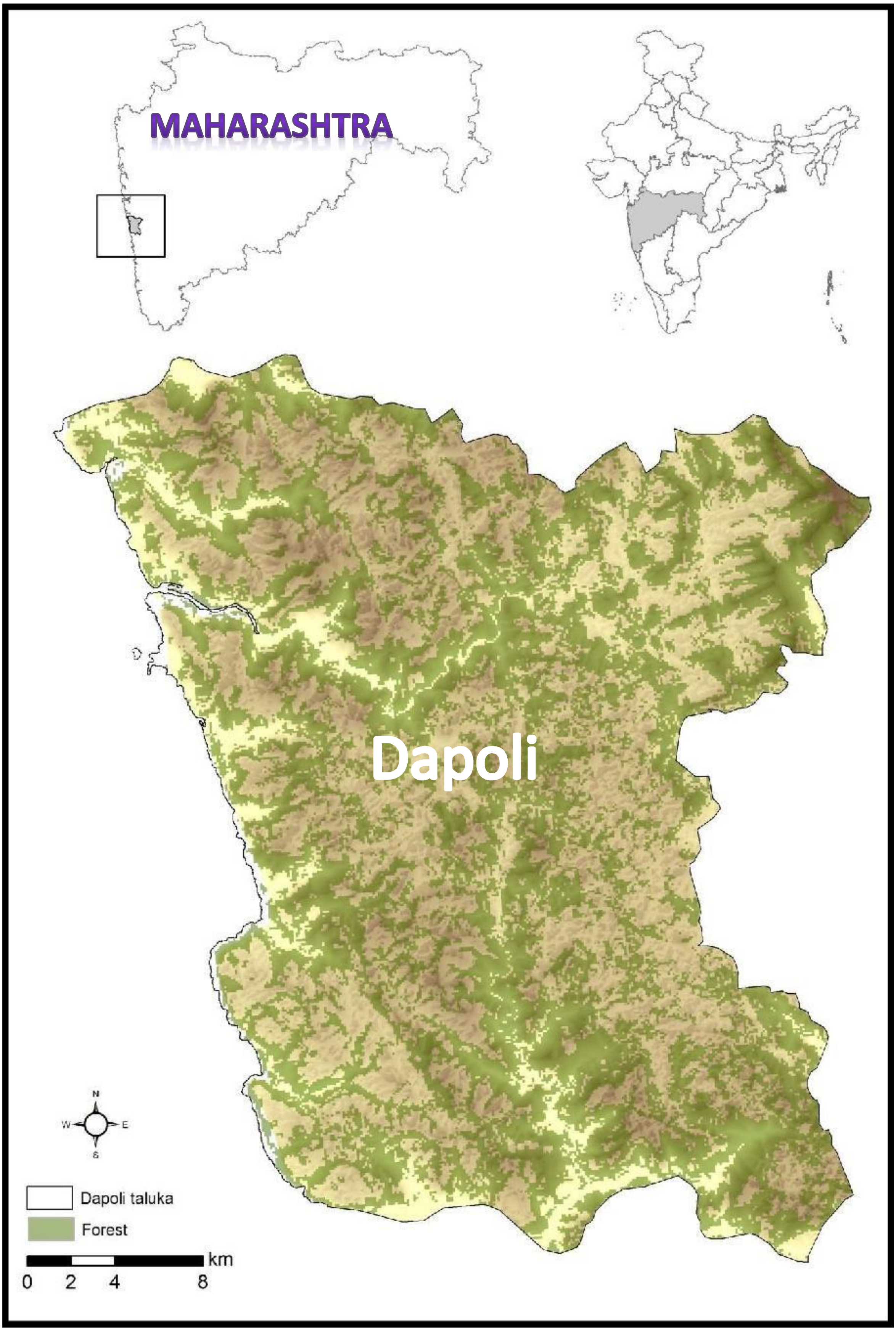
The landscape of Dapoli is dominated by forests, plateaus, agricultural patches and fruit orchards. For the present investigation, four wooded landuses were selected – Sacred groves, reserved forests, mango orchards and cashew orchards.

3.3.1 Sacred Groves

Sacred groves are an age-old institution here. They are known as *Dev-rahati* meaning the abode of the deity. There are 110 sacred groves in Dapoli as per the records of the revenue department. They range in size from 0.05 to 40 ha.

Sacred groves in their large forms exhibit the primary forest vegetation of this region. They invariably associated with an ancient deity whose origins were difficult to trace during interactions with the villagers. Only detailed anthropological studies on the

Plate 1: Location and Map of Dapoli taluka



lines of Kosambi (1962) could reveal the origins and history of sacred groves of the study area. However, the grove – the forest renders itself for interpretation. These groves bear huge specimen of the species such as *Terminalia bellirica*, *Ficus bengalensis* or other *Ficus* spp., *Mangifera indica*, *Lagerstroemia microcarpa* etc. In sacred groves with small evergreen patches along watercourse, congregations of *Mammea suriga and Saraca asoca* are found. Similarly, in large sacred groves, the rare woody lianas of *Entada scandens* and *Gnetum ula* are still found with their vine length totaling kilometers of distance. Although sacred groves are in existence for unknown periods of time, only a few of them have been able to retain their original forest structure. It is result of combination of several factors including size of the sacred groves, increasing importance of the temple and decreasing significance of the grove as such. Thus, there is a visible gradient of disturbance in the sacred groves. Some groves are intact to a high degree with minimum disturbance whereas on the other extreme there are groves which have been almost completely felled to carry out plantations of other species or for temple-building.

3.3.2 Reserved forests

The reserved forest which is very limited in extent in this taluka is degraded forest comprising of not very old growth of Teak and other associated species. Dominant associate trees include *Terminalia tomentosa, T. paniculata, T. bellerica, T. chebula, Lagerstroemia parviflora, L. microcarpa, Memecylon umbellatum, Syzigium cumini, Bombax ceiba, Zanthoxylum rhetsa, Dillenia pentagyna* etc. The shrubs include *Grewia tiliaefolia, Carissa karonda, Zizyphus rugosa, Atlantia monophylla, Rauwolfia serpentina, Clerodendron* sp., *Leea* spp. etc.

The reserved forest patches are overgrown with *Carissa* and *Zizyphus* bushes. Historically, it is reported in the Gazette of the Ratnagiri district that in 1829, on the recommendation of the then collector Mr. Dunlop, the forests of this region were placed at the disposal of the people. Therefore, the privately owned forests are nothing but secondary degraded forests not resembling the forest of large sacred groves. But even the reserved forests also have become secondary forests due to heavy fellings carried out before 25-30 years. Structurally it is very simplified with absence of typical forest strata.

3.3.3 Mango and Cashew orchards

In recent decades, the private forests have been rapidly converted to horticultural plantations of mango *Mangifera indica* and cashew *Anacardium occidentale* on large scale under the horticulture development programme. These plantations are typically raised from grafts and are usually intensively managed. The trees are widely spaced (10 x 10 m) and the ground is rarely grown with anything but grasses. The trees are not allowed to grow very tall. The canopy of mango trees is usually very compact whereas that of cashew trees is relatively open with straggling branches. The leaf litter of both these species is extensive but that of cashew is relatively slow to decompose. Therefore usually the ground in cashew orchards is compact and rarely grown with herbaceous vegetation. These represent the most recent modified and managed wooded landuses in the study area.

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Chapter 4: METHODOLOGY

4.1 Inventory of Sacred Groves

Although numerous studies have documented social, cultural, ecological and economical aspects of sacred groves, the systematic inventorization in broad geographic context of sacred groves is far from complete (Dudley et al. 2010). The first step of this study was proper documentation of sacred groves in Dapoli taluka. Most of the sacred groves in the study area are under the Revenue department. According to the land records of revenue department, there are 110 sacred groves in Dapoli taluka. The department has not crystallized the information as individual sacred groves. Rather, there is a listing of survey numbers by village recorded as *dev-rahati*. The above figures are arrived at by assuming that all survey numbers form a single sacred grove in each village. However, a preliminary survey and a previous study (Patil 2011) have indicated that these survey numbers can lie adjacent to each other forming a single sacred grove in a village or be located separately to form distinct sacred groves within same village. Some are not listed in the records of the Revenue department. Moreover, all the sacred groves are not in a state of total protection. Some are partly or fully destroyed. Therefore, it is necessary to visit all sacred groves, ascertain their current extent as a forest habitat, and assess their status.

'The importance of small size' is adequately recognized in the context of role of forest fragments in the landscape processes (Bodin et al. 2006; Punde 2007; Ray and Ramachandra 2010). Therefore, all sacred groves irrespective of their size were documented and described. But the landscape context of all sacred groves was much varied by means of which it might mask the effects of size. Therefore, for the purposes of this study a sacred grove was defined as a patch of forest that is recorded as sacred groves but may or may not stand out in its landscape by its isolation from other and larger patches of forest.

A list of villages of Dapoli taluka where at least some land parcels are assigned as *dev-rahati* or *sahan* was obtained from the local revenue department office. These villages were visited during August to October 2013 to locate the sacred groves. Enquiries were made with the residents of the village and some responsible person like village-head Sarpanch, Police-patil, temple priest or mankari was contacted. They were requested to show the sacred grove. At each sacred grove, a location was either recorded with a Garmin GPS unit or marked on a handy map to locate later from GoogleEarth.

A datasheet (Annexure 1) was developed in which information on various aspects of the sacred grove was included. These included size of the grove, deities, temple, priests, festivals apart from the structure and population of the village. These also included habitat features of the grove like prominent vegetation, special features etc.

In the third part, after visiting and understanding the context of the sacred grove, a disturbance rating was recorded for each sacred grove using the threats mentioned by Malhotra et al. (2001a) and as applied by Patil (2011). The threats – commercial forestry, developmental projects, shift in belief system, sanskritization, pilgrimage and tourism, removal of biomass, encroachment, modernization and market forces, fragmentation and perforation – were qualitatively assessed by the researcher into three categories mild, moderate, severe. These were then quantified for each element by weighting to assign a threat index to them. This threat index was used as one base of hierarchy for further analysis.

4.2 Study Sites for Spider Sampling

After the inventory of sacred groves, 22 were selected for detailed study of their spider assemblages. An effort was made to cover all parts of the Dapoli taluka, the entire range of sizes of sacred groves and their landscape context in terms of altitude and immediately surrounding landscape.

To compare the spider assemblages with other wooded lanuses three patches of reserved forest, four mango orchards and three cashew orchards were also selected. Since there are not many reserved forests, sampling sites sufficiently separated from each other were selected in larger patches of reserve forest. In case of orchards, effort was made to have representation of different sizes.

Across all the identified sampling sites (n = 32), a total of 56 permanent quadrats of dimension 20 x 20 m were marked. The quadrats were distributed in the sampling sites in proportion to the size of the patch at each site. For patches less than two ha, only one quadrat was marked; for sites ranging in size from two to five ha, there were two quadrats; and for patches larger than that three quadrats were marked. The details of each selected site are presented in Table 4.1. Locations of these sites and samplings plots are shown in Plate 2. The typical habitats sampled in this study are shown in Plate 3.

At each sampling site, care was taken to mark the quadrat away from the edge and as close as possible to the centre of the selected site. At the sites where multiple quadrats were marked, they were marked at least 100 m away from each other. However, no effort was made to construct zones within larges patches as was done by Page et al. (2009). Therefore, for analysis purpose, the quadrats are treated as if they were independent sampling locations, perhaps, influenced by the size of the patch in which they were located.

Plate 2: Location of Spider Sampling Sites in Dapoli taluka

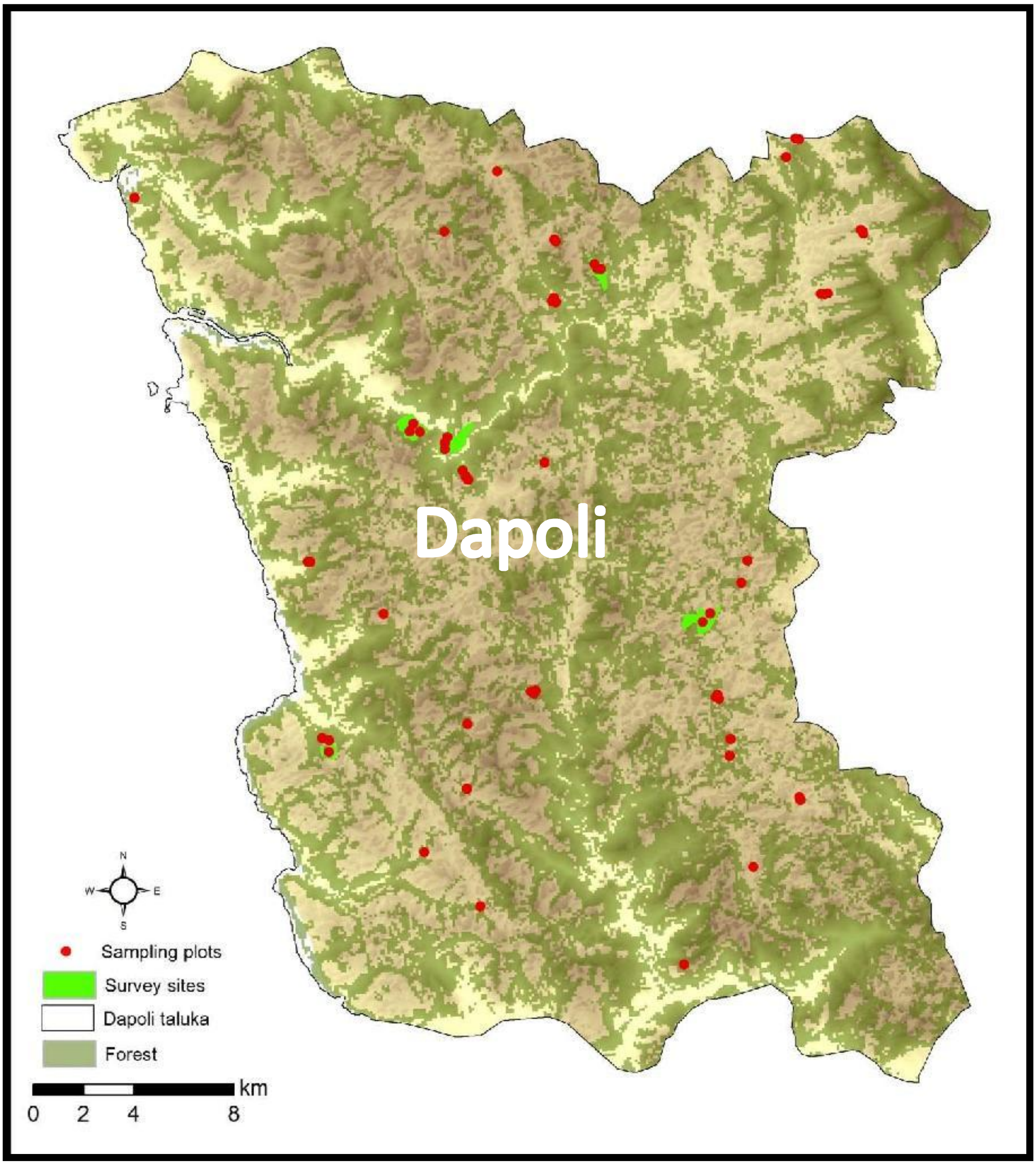


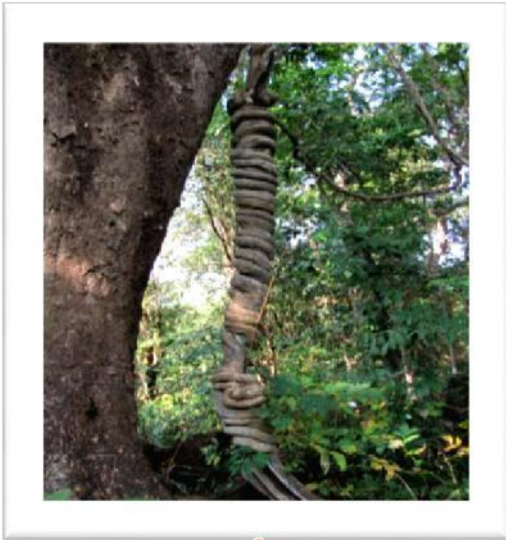
Table 4.1 Details of sites covered for spider inventory in Dapoli taluka of Ratnagiri district. The village names indicate sacred groves whereas orchards and reserved forest patches are numbered sequentially.

Site	Code	Latitude Degree decimals	Longitude Degree decimals	Area (ha)	No. of quadrats
Degaon	DG	17.6449	73.2996	0.26	1
Pichdoli	PD	17.8728	73.1887	0.26	1
Pangari	PN	17.6096	73.2744	0.53	1
Nanate	NT	17.6727	73.1966	0.63	1
Aade	AD	17.8850	73.0776	0.74	1
Agarvayangani	AW	17.6310	73.2018	1.14	1
Umbarle	UM	17.6966	73.1973	1.38	1
Bhatghar	BG	17.9024	73.3129	1.60	1
Male	ML	17.6502	73.1815	1.71	1
Kherdi	KH	17.7902	73.2247	1.76	1
Kadivali	KD	17.8698	73.2289	2.00	2
Wakavali	WK	17.7545	73.2970	2.43	1
Soveli	SO	17.9066	73.3148	2.47	2
Kangvai	KG	17.8945	73.2074	2.75	1
Kondhe	KN	17.6697	73.3165	3.75	2
Karde	KR	17.7547	73.1398	3.77	2
Jamge	JM	17.8729	73.3395	4.45	3
Gavtale	GT	17.7062	73.2872	5.00	3
Dhankoli	DN	17.8489	73.2272	7.77	3
Shirkhal	SK	17.8503	73.3234	9.14	3
Sadavali	SD	17.7096	73.2224	12.14	3
Kudavale	KU	17.8606	73.2438	>40.00	3
Mango1	MN1	17.7359	73.1655	1.3.	1
Mango2	MN2	17.7359	73.2823	>60.00	2
Mango3	MN3	17.7471	73.2949	4.8.	1
Mango4	MN4	17.6894	73.1478	>40.00	2
Cashew1	CS1	17.6877	73.2887	2.00	1
Cashew2	CS2	17.6851	73.2911	1.80	1
Cashew3	CS3	17.6920	73.1447	1.10	1
Res. Forest1	RF1	17.8037	73.1765	>40	3
Res. Forest2	RF2	17.7997	73.1922	>40	3
Res. Forest3	RF3	17.7861	73.1969	>40	3

Plate 3: Typical habitats studied for spider diversity in Dpaoli taluka

Sacred Grove (a,b), Mango orchard (c), Cashew orchard (d), Reserved forest (e)

a



b

c

d

e

4.3 Spider Sampling

Spiders are numerous and ubiquitous and there is no single method that can sample all different types of spiders. There are several methods and each caters for a specific group of spiders. For example, pitfall traps collect ground-dwelling spiders, litter sampling extracts ground and litter-dwellers, beating dislodges understory-dwellers. Visual search is a method that can record spiders across these strata as well as web-builders and bark-dwellers etc. These methods, in addition, have variable sampling efficiencies and need to be carefully chosen based on the objective of the sampling exercise (Sørensen et al. 2002). One of the objectives of this study was to record the maximum possible diversity of spiders in the study area. The spiders are largely grouped into two infra-orders –Araneomorphae and Mygalomorphae. The two infra-orders are very different groups of organisms and methods to study their diversity and taxonomy are quite different. The scope of the present study was limited to Araneomorph spiders.

It is observed over the years that even intensive surveys fail to sample the entire spider fauna of any given site (Sørensen et al. 2002, Coddington et al. 2009). Hence, a compromise between resource availability and inventory completeness is advised regularly. Therefore, a protocol combining visual search, pitfall traps, litter extraction, sweeping net and vegetation beating was proposed to be used in this study. However, in pilot studies, it was observed that pitfall traps captured a large proportion of by-catch which was undesirable. Similarly, visual search resulted in collection of too few individuals compared to other methods and sweeping net was only good for open, herb-dominant habitats. Hence, it was decided to concentrate only on vegetation beating and litter sorting. Thus, effectively each of these methods is sampling foliage-dwellers assemblage (vegetation beating) and ground-dwellers assemblage (litter sorting). It must, however, be noted that the entire spider assemblage is not sampled by use of these two methods. In the foliage-dwellers assemblage, very small representation of bark dwelling spiders (Hersiliidae, some Salticidae, *Herennia multipuncta* etc.) was observed. Similarly, Nephila pilipes was not collected so often as it occurred. Similarly, in ground-dwellers assemblage, spiders hiding below large boulders and those burrowing deep in the soil were not collected effectively with the litter sorting method. And, therefore, there may be an underestimation of abundance and species richness of these taxa could be seen in the data.

Samways et al. (2010) pointed out that occurrence data is preferable in case of social insects because abundance data is due to non-independence of individuals from same colony and that catches are strongly affected by the sample location from the colony location. Same could be true in case of spiderlings of most species because they stay together for some initial moults. In the present study too, on a few occasions, such groups of spiderlings of same species were captured. Because such instances were few and no rule could be formed to discard individuals, all individuals were counted in the given sample. This might have introduced a slight bias but as has been already pointed out, such instances were very few. Thus, the data structure used for analysis from this study is of the form abundance matrix. This matrix is readily convertible to occurrence matrix.

Technical details of the sampling methods are described below-

4.3.1 Vegetation Beating (Plate 4)

Vegetation beating results into collection of more individuals per sample than other methods (Sørensen et al., 2002). In this method, an open umbrella was placed or held upside down on the ground and shrubs or branches of trees directly above the umbrella were tapped vigorously with a stick. The dislodged spiders were collected in separate vials. The strata of vegetation covered ranged from knee-height to just above the head of the researcher. This was so for ease of reach and operation.

4.3.2 Litter Sorting (Plate 4)

Litter sorting, too, has been found to be complementary with other methods (Sabu et al., 2011; Sørensen et al., 2002). Litter was hand-collected from a small area within the quadrat. All the debris, leaves, humus and top soil was collected and transferred to a clean white sheet. Immediately, search for spiders was started and the litter was hand-crushed and sorted so that spiders move away from litter. They were spotted on the sheet and collected in separate vials. The litter was progressively reduced from the sheet so that more cryptic spiders and those feigning dead could be collected.

From each quadrat two samples each of vegetation beating and litter sorting of 20

Plate 4: Methods of spider sampling used in the study of spiders in Dapoli taluka

Vegetation Beating

Litter Sorting

minutes each were collected. This study was temporally replicated for two years covering three seasons – post-monsoon, winter and summer. Monsoon months were avoided as there are heavy showers in the study area and the proposed methods were not suited for this season. However, it is expected that Post-monsoon season covers the diversity of monsoon spiders. The periods of seasons covered in this study are presented in Table 4.2.

Table 4.2 Seasons covered in spider sampling in Dapoli taluka of Ratangir district.

Season/Year	2013	2014	2015	2016
Winter	-	12.i.2014-28.ii.2014	-	4.i.2016-3.ii.2016
Summer	-	17.v.2014-5.vi.2014	10.v.2015-6.vi.2015	-
Post-monsoon	1.x.2013-20.xi.2013	12.x.2014-10.xi.2014	1.xi.2015-5.xi.2015	-

All specimens were kept in separate vials and all vials of a sample were kept separately in sample bags with proper labeling. After sampling was over, the collected specimens were brought to the lab. They were sorted and an effort was made to identify the live specimen using reference books like Sebastian and Peter (2009). Those which could be identified with certainty were recorded and kept away for releasing back. The individuals difficult to identify were checked if they were adult. If they were juveniles, they were attempted to identify upto at least family or genus and were recorded. The adults were immediately killed using alcohol and were examined under the microscope. The killed individuals were preserved in 70% ethanol. As the study progressed, the proportion of specimen killed decreased with my increased confidence to identify them. Some adults of each species or morphospecies were preserved as voucher specimen with proper cataloguing. They were subjected to detailed taxonomic examination for identification.

They were identified properly with the help of available keys and expert advice. They will be retained for future reference and will be deposited in appropriate collections.

4.4 Spider Taxonomy

The specimens were examined under LABOMED stereo-zoom microscope at College of Forestry, Dapoli. Wherever necessary and congruent with availability of time and other resources, the genitalic organs of male and female adult spiders were dissected and cleared using 10% KOH. As per the standard protocol for confirming identities of spiders, these cleared genitalia were compared with illustrations and descriptions available in the literature. In several cases expert advice was sought from scientists working on a particular family or genus. Most of the literature for this purpose was sourced from World Spider Catalog (http://www.wsc.nmbe.ch/) which has an almost complete global repository of taxonomic literature on spiders. Similarly, websites such as Spiders of Europe (http://www.araneae.unibe.ch/), Spiders of Belgium and France (www.arachno.piwigo.com) etc. were found of immense help.

However, it must be noted that I am not a professionally trained spider taxonomist and most of the taxonomic work done here falls in the category of parataxonomy. Nevertheless, one species (Corinnidae: *Echinax panache*) has already been reported for the first time from India with its genus also new for India (Patil and Uniyal 2015). Several other taxonomic manuscripts are in various stages of publication. Therefore, information presented here must be viewed from a perspective of transition from parataxonomy to alpha taxonomy. The identified specimen will be retained for future reference and deposited in recognized national repositories.

4.5 Habitat Conditions

Dufrene and Legendre (1997) provided a framework for identifying indicator species or groups of species for sites. Their measure IndVal has been widely used and subsequently modified for fuller utilization of this well-known measure (Podani and Csányi 2010). It has been used for butterflies (Barua 2007) and also extensively for spiders (Bonte et al. 2003, Hore and Uniyal 2008, Olarte 2010, Pinzón and Spence 2010). More advanced measures of habitat fidelity like *phi coefficient of association* (Φ) have been proposed lately (Tichy and Chytry 2006).

To use these, the sampling locations must be hierarchically organized based on some distinguishing parameters. In the proposed study, size of the patch and typology of landuse have been proposed to be used to organize sampling sites in a basic hierarchy.

In addition, different habitat variables, disturbance variables, management variables and landscape variables were proposed to be quantified at different scales i.e. quadrat, site and landscape. The variables to be recorded at quadrat and site scales were recorded only once in the winter season. A datasheet was prepared to record each of these variables.

Data was recorded on tree density by counting number of trees above 10 cm DBH in the marked quadrat. The litter depth was measured randomly at 10 points within the quadrat. Litter cover was visually estimated as per cent of area covered with litter. Signs of disturbance i.e. number of stumps of felled trees and dung-piles of livestock were counted within quadrat. Removal of ground vegetation along with litter was also recorded as per cent area of the quadrat. Fire history and extent of fire was also recorded. However, there were no fire incidences at the sampled sites. Similarly per cent encroachment at the level of site was proposed to be estimated but there were no instances of encroachment. Data was also recorded on plantation activity at the sampling sites in terms of history, species involved and area covered.

In addition, a perception-based threat index at each selected sacred grove was worked out using the threats mentioned by Malhotra et al. (2001a) and as applied by Patil (2011). The threats – commercial forestry, developmental projects, shift in belief system, sanskritization, pilgrimage and tourism, removal of biomass, encroachment, modernization and market forces, fragmentation and perforation – were qualitatively assessed by the researcher into three categories mild, moderate, severe. These were then quantified for each element by weighting to assign a threat index to them. This threat index was used as one base of hierarchy for further analysis.

4.6. Data Analysis

Data was organized into species/genera/family x sites (community) and environment x sites (environment) matrices. Community matrices were maintained separately for each sampling method. They had abundance values of each species in each sample.

Environment matrix contained values for all quantitative and qualitative variables and also for classifying variables (date, season, other categories etc.). These matrices could be transposed whenever necessary as per the requirement of the software being used. One characteristic feature of such a dataset is a large number of zeros in the community matrix. But this has been well-recognized (Dufrene and Legendre 1997) and overlooked subsequently. The overall analysis outlook in this study followed that of Cardoso et al. (2007) and Hore (2009).

4.6.1 Spider Diversity in Study Area

For assessment of diversity of the regional spider assemblages, the abundance data of all sampling sites separately for each assemblages and also in the pooled form was subjected to analysis in EstimateS 9.1 (Colwell 2013). EstimateS computes several parametric and nonparametric estimators of diversity in assemblages. However, for valid comparison among different assemblages, the nonparametric Chao1 and Jackife2 are recommended. Chao1 estimates absolute number of species in an assemblage based on number of rare species (singletons and doubletons) in a sample. It is one of the most recommended species richness estimators for computing inventory completeness values which are nothing but proportion that the observed species richness forms of the estimated species richness (Sorenson et al. 2002; Coddington et al. 2009). Similarly, Jacknife2 has been found to be a precise, unbiased species richness estimator with little dependence on sample size compared with other numerous estimators(Colwell 2013). These estimated values of taxon richness provide a basis for computing the completeness of surveys conducted. The observed richness values can be seen as a proportion of the estimated richness values discovered by the sampling effort invested in a particular survey. This proportion indicates the extent to which the surveys have been complete.

Apart from these, curves of taxon accumulation were generated by using the richness values computed by EstimateS after 100 randomizations. These make possible a visual assessment of the effort invested in sampling either in terms of numbers of samples taken or number of individuals collected and the corresponding results in terms of taxon richness achieved. The curves have an asymptotic nature and they provide an idea as to the adequacy or inadequacy of the sampling effort.

This analysis also produced numbers of singletons (species with only one individual) and doubletons (species with only two individuals). Along with these, the average number of individuals per sample and the average number of species per sample were calculated. Sampling intensity i.e. the ratio of individuals to species is also considered a measure of effort (Coddington et al., 1996). They have asked for larger sampling intensities in high diversity sites which we perceive the present sampling sites are. But the study from same area (Bhuvad et al. 2013) ranged in sampling intensity from 10 to 24 resulting in acceptable levels of estimates (>80%) most of the times across agroecosystems.

4.6.2 Distinct Spider Assemblages within Habitat

It was intuitive to treat the spider collections obtained by vegetation beating and litter sorting as two distinct spider assemblages – foliage dwellers and ground dwellers - within any given habitat. Therefore, the two assemblages were assessed for their diversity and composition separately. But since they form parts of the same overall spider assemblage of a habitat, the data from both collection methods at a given sampling location was also pooled for assessing the diversity and composition of the entire spider assemblage. Nevertheless, the question of distinctness of the aforementioned two assemblages was approached from the angle of taxonomic composition of the respective assemblages. NMDS (Non-metric Multidimensional Scaling) module of PAST 3.08 (Hammer et al. 2001) was used to perform this task. The NMDS is based on a distance matrix computed with an appropriate distance measure. In the present case Bray-Curtis distance often used in analysis of ecological communities was used.

4.6.3 Spider Diversity across Habitats

One of the major questions to be answered by this study was whether sacred groves held diverse and distinct spider assemblages compared to other land-uses under study. To answer this, the data for sampling locations was analyzed separately and in the pooled form as detailed and justified earlier. The sampling locations were grouped by habitat types (Sacred groves, Reserved forests, Cashew orchards and Mango orchards).

The diversity estimation in EstimateS was run separately for samples in each habitat category as described above. One of the advantages of the latest version of EstimateS is that it accepts batch input of grouped datasets and provides results in a single file. The same was used for these analyses.

More relevant here than in the earlier section, the diversity indices and parametric and non-parametric estimators of taxon richness are used compare diversity across samples, sites, habitats and regions (Magurran, 2004). One of the common diversity indices applied to arthropod assemblage studies is the log series Fisher's alpha because it fits the natural log-series distributions of many assemblages (Jost 2004). However, as Jost (2007) later argued the best diversity index for comparison across sites was Shannon entropy or rather its exponential form. Kruskal-Wallis test was used to compare the differences in diversity indices of sites and habitats.

EstimateS 9.1 also provides opportunity to obtain rarefaction curves which are used to when entities being compared have not been equally sampled in terms of either samples or individuals. However, comparing richness at smallest available sample size was like having an apple not being able to eat it. A further advance is in terms further extrapolation (Colwell, 2013). Because sites and habitats had unequal sampling efforts, the rarefaction procedure rarefies the larger samples to the smallest sample size in the dataset. In addition, the new feature of extrapolation based on rarefaction was also used to predict the species richness at the sample size of the largest sample (Colwell 2013). Thus, the comparisons between unequally sampled sites or habitats are rendered valid.

4.6.4 Dissimilarity Analysis and Indicator Species

Bray-Curtis similarities were computed across sites and habitats using species composition. Multidimensional scaling (MDS) plots were constructed based upon similarity values of species composition across sites and habitats in program **PAST 3.08** (Hammer et al. 2001). Analysis of similarities (ANOSIM) was performed between each pair of sites and habitats to determine whether there were significant differences between the spider assemblages across the sites or habitats. The data were fourth-root transformed before analysis to reduce the weight of common species (Clarke and Warwick, 1998, Hore, 2009).

SIMPER analysis was performed to identify those taxa which contributed most to the observed assemblage differences

Spider assemblages and therefore sampling sites were grouped on the basis of species composition using ordination methods especially canonical community ordination (Ter Braak, 1994). Similarly, IndVal (Dufrene and Legendre, 1997) was used to estimate the percentage indicator potential of species and/or higher taxa for different landscape elements and by creating typologies using different environmental variables. Conversely, groupings created by ordination were explored with environmental variables to find out typologies. For this purpose, the Indicator Value module of PC-ORD 4.20 (McCune and Mefford 1999).

4.6.5 Conservation Priority Ranking

For determining conservation priority among the studied sites, the first approach used was scoring of the sites based on the taxon richness (family, genus, species) recorded in each site (Cardoso et al. 2004). The data for vegetation beating, litter sorting and pooled data for both methods were analyzed separately. The site with highest taxon richness was given first rank, the next the second and so on. Rank correlation analysis was performed across various combinations of taxa and sampling methods. Assuming that species-based ranking of sites was the best criteria for prioritizing sites, the potential of higher taxa to do the same was tested using scatte-plots and Spearman's rank correlation values.

Samways et al. (2010) have maintained that there is sometimes merit in using more than one form of analysis. Second approach used for prioritizing sites for conservation was Iterative accumulation of taxa (Cardoso et al. 2004, Hore 2009). For each taxon, site with highest richness was ranked first. Second rank was assigned to the site which added maximum number of additional taxa to the tally and so on. In case of a tie, the site with highest richness was given priority. This step-by-step iterative ranking was used to plot accumulation curves of taxa versus sites as proportions. All three taxa were plotted together. The data for vegetation beating, litter sorting and pooled data for both methods were analyzed separately.

^^*^*^*^*^*

Chapter 5: RESULTS

5.1 Inventory of Sacred Groves Of Dapoli

> "As interested, discerning readers, students and researchers we request you to participate and create an online open collaborative system for sharing biodiversity information"
>
> \- Founders, the Western Ghats Biodiversity Portal

5.1.1 Background of the Investigation

Sacred groves are important traditional practice of conserving biodiversity and ensuring many ecosystem services. However, knowledge on sacred groves is very fragmentary with studied covering one or few sacred groves and concentrating on one or few taxa of organisms. A need to prepare a catalogue – at least a prototype – was felt and therefore this investigation was carried out in Dapoli Taluka of Ratangiri district in Maharashtra to record information on various aspects of sacred groves of one of the sacred grove concentration area.

5.1.2 Sacred groves in Dapoli

A total of 102 sacred groves were recorded from Dapoli taluka. Few of the land parcels, perhaps identified as sacred groves, could not be located either due to their very small size, unavailability of proper informant etc. A detailed matrix giving information on sacred groves and their various parameters recorded in this study is provided as Annexures II-VI. In the abovesaid matrix, for reporting purpose, usually the co-ordinates of the temple are presented. Wherever prominent temple is not available, co-ordinates of approximate centre of the grove are provided. Plate 5 show point locations of all surveyed sacred groves. Plates 6 to 9 show the actual areas of these sacred groves mapped. For clarity the map of Dapoli Taluka is divided in four quadrants in successive plates. Plate 10 shows some typical sacred groves of the study area. One of the pictures shows rampant destruction of relict forest for temple construction.

Most of the data collected in this exercise is descriptive and with an object to prepare a catalogue of sacred groves. Hence, it must be read in the context in the annexure.

Plate 5: Locations of Sacred Groves located in Dapoli taluka

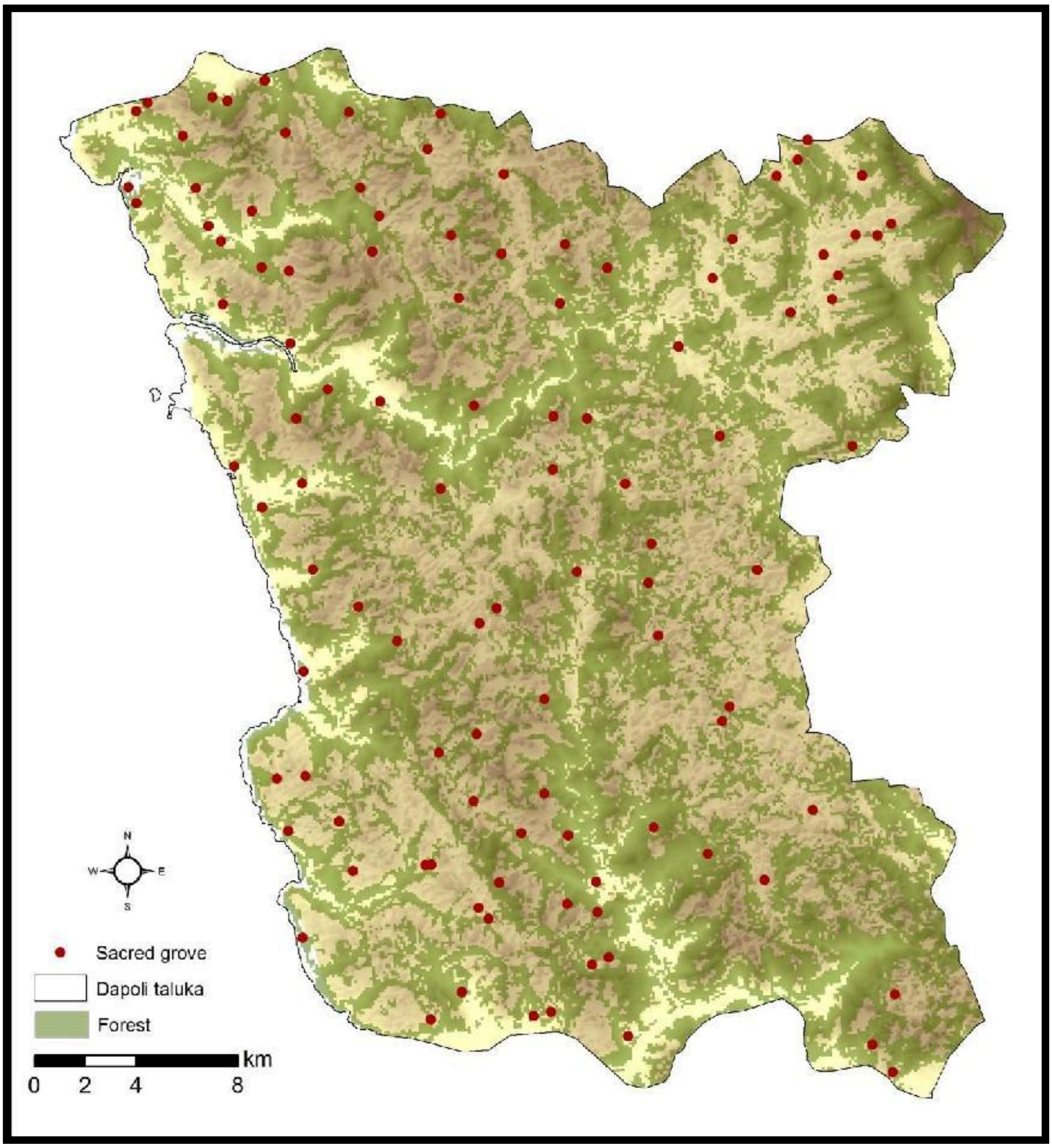


Plate 6: Mapping of Sacred Groves located in Dapoli taluka (North-West quadrant)

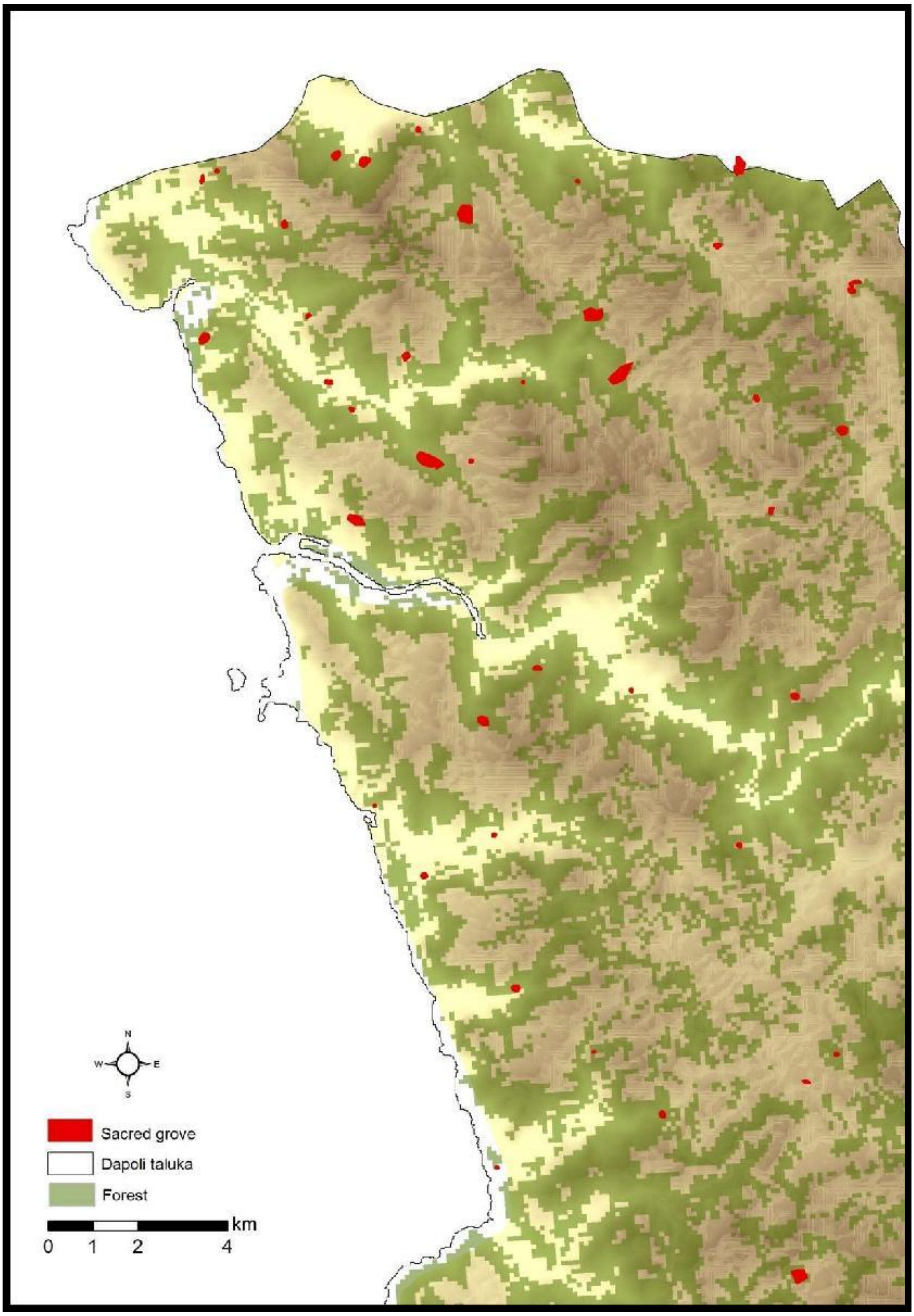


Plate 7: Mapping of Sacred Groves located in Dapoli taluka (South-West quadrant)

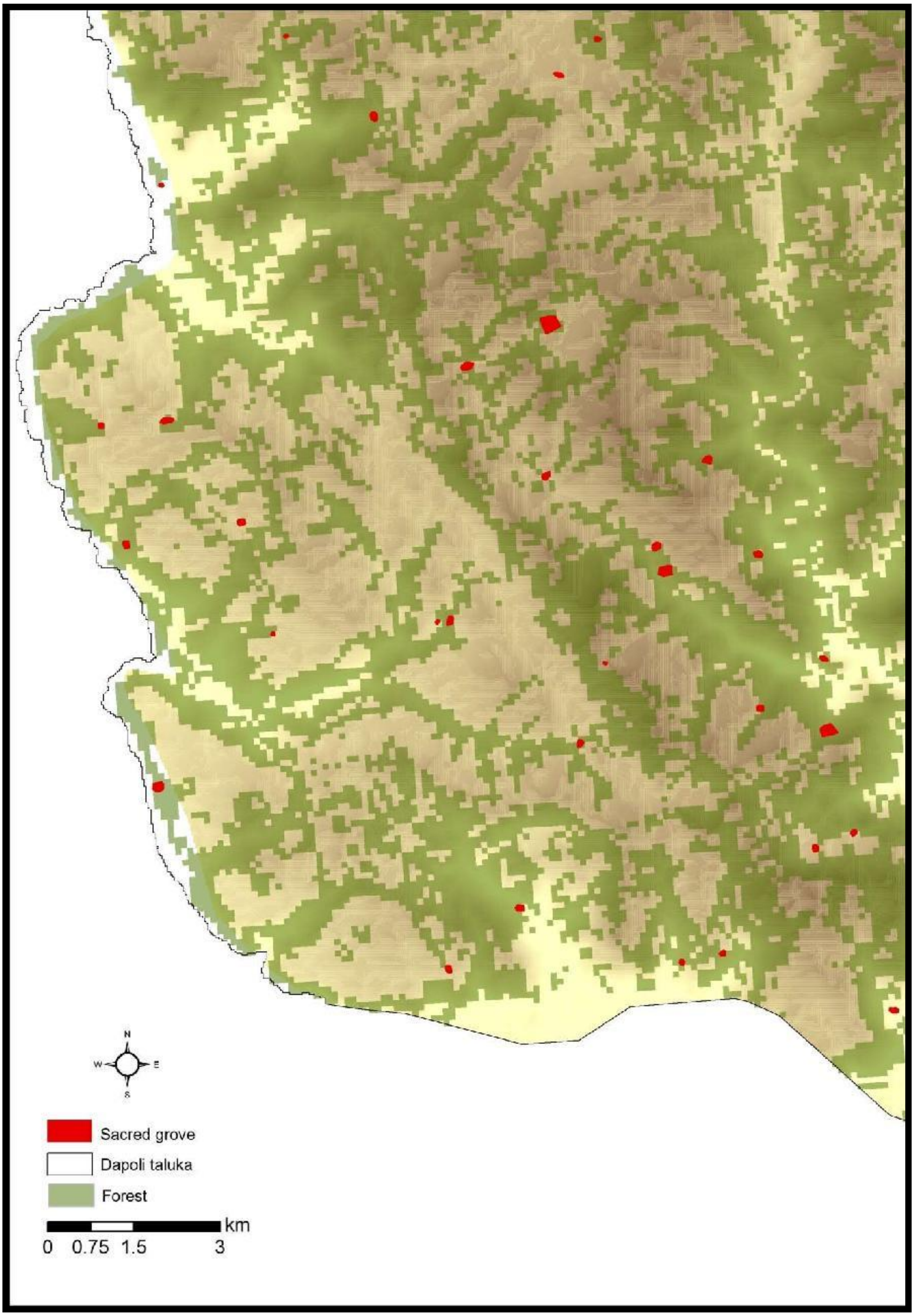


Plate 8: Mapping of Sacred Groves located in Dapoli taluka (North-East quadrant

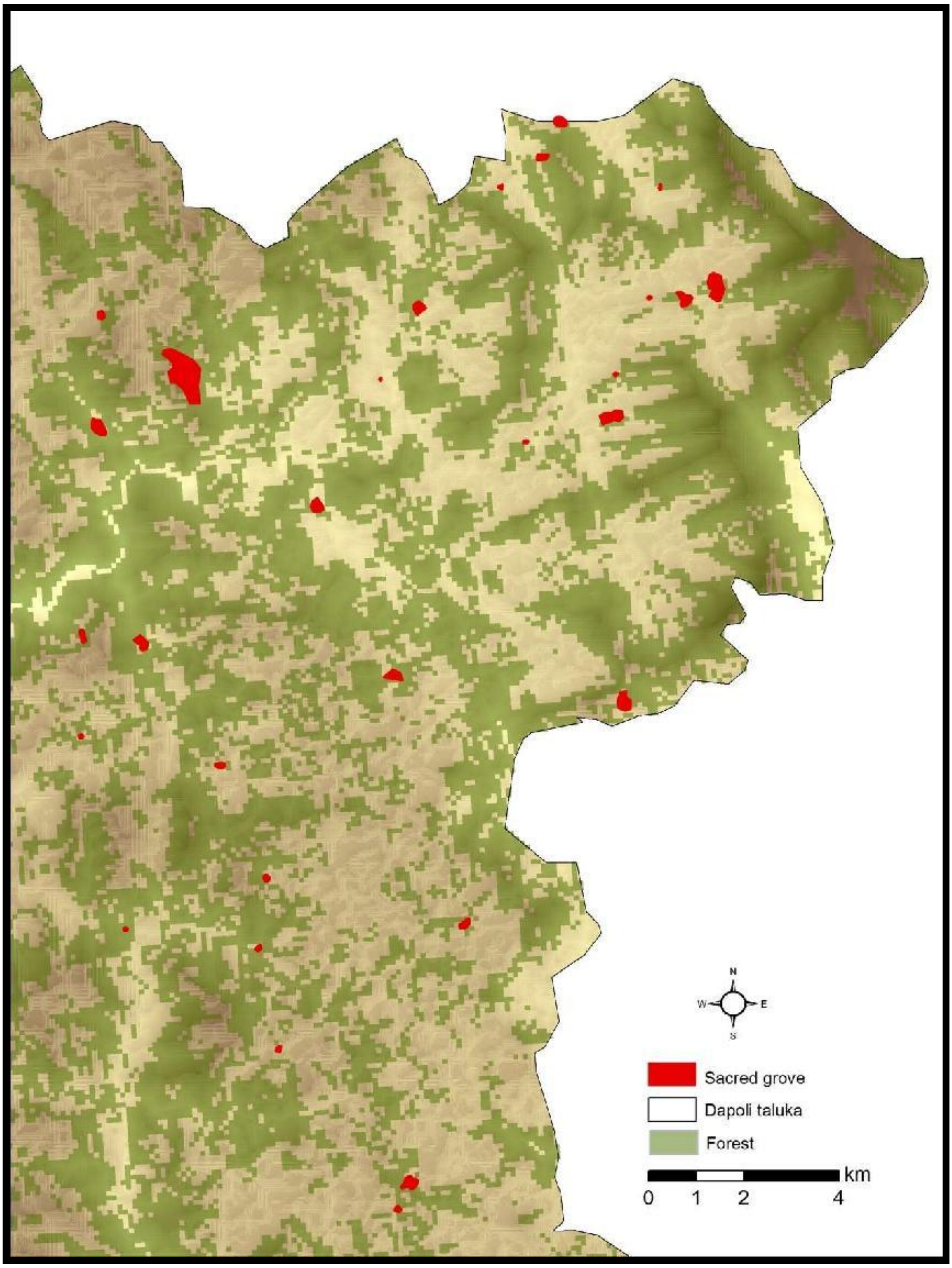


Plate 9: Mapping of Sacred Groves located in Dapoli taluka (South-East quadrant)

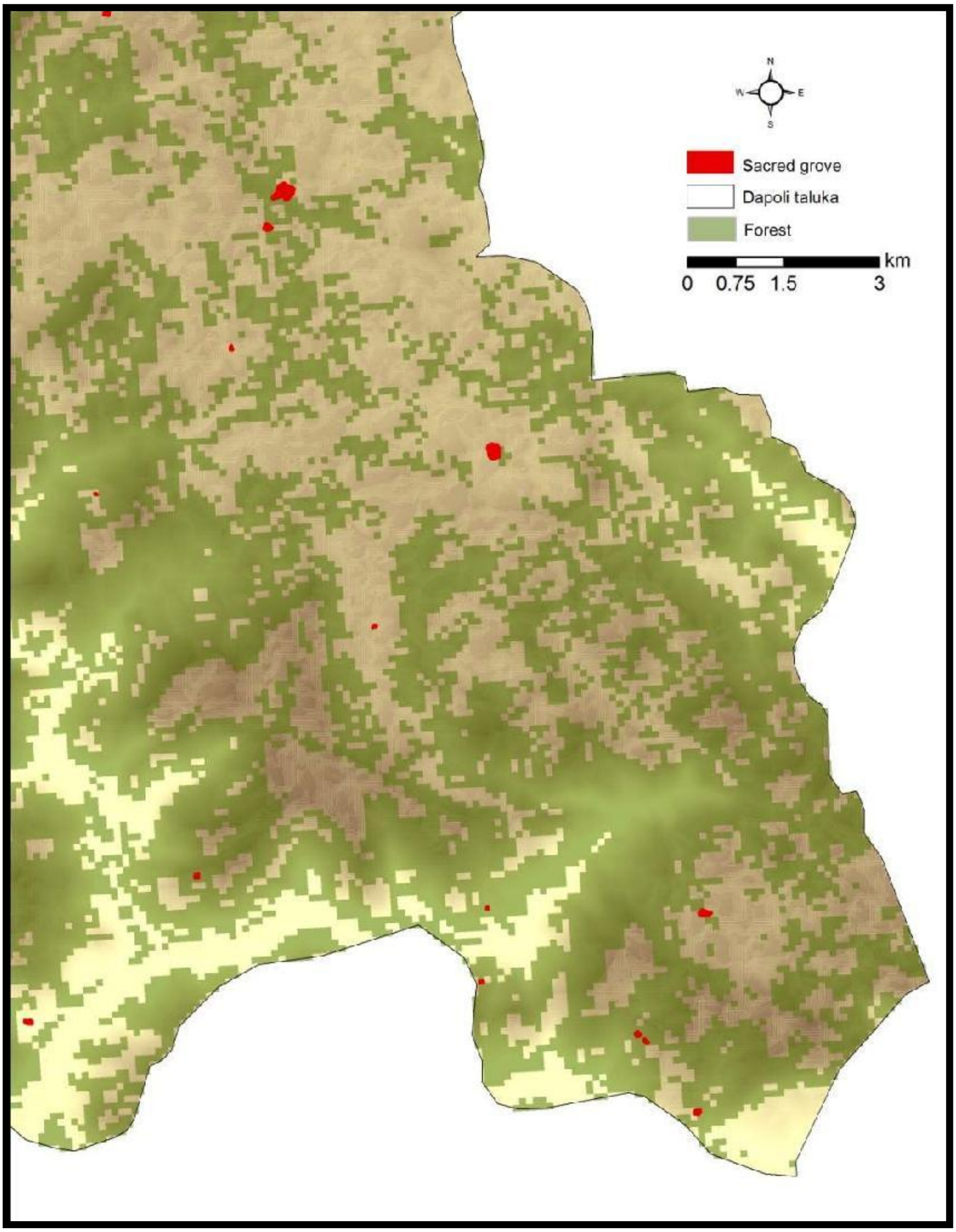
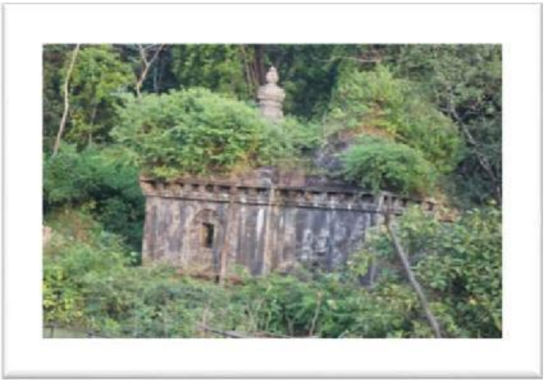


Plate 10: Photographs of some Sacred Groves

Karde (a), Kudavale (b), Aade (c), Dhankoli (d), destruction in Kadivali (e)



a

b

c

d

e

However, some parameters on which quantitative data is available are analysed and the results are presented here.

5.1.3 Geography of Sacred Groves

A total of 102 sacred groves were recorded from 99 villages. Ninety six villages had only a single sacred grove for the given village. In the remaining 3 villages (Bhopan, Male and Sukondi), there were 2 sacred groves each. Whereas in Bhopan, both the sacred groves were of similar size, in other two villages, one of the sacred groves was larger than the other.

The size of sacred groves in Dapoli taluka ranges from 0.03 to 40 ha. Figure 5.1 reveals that most of the sacred groves are small sized whereas only few are large sized. Kudavale sacred grove was the largest with approximately 40 ha area and no clear boundaries reckoned because most of it is a kind of private land issued to the deity by the reigning family of the village.

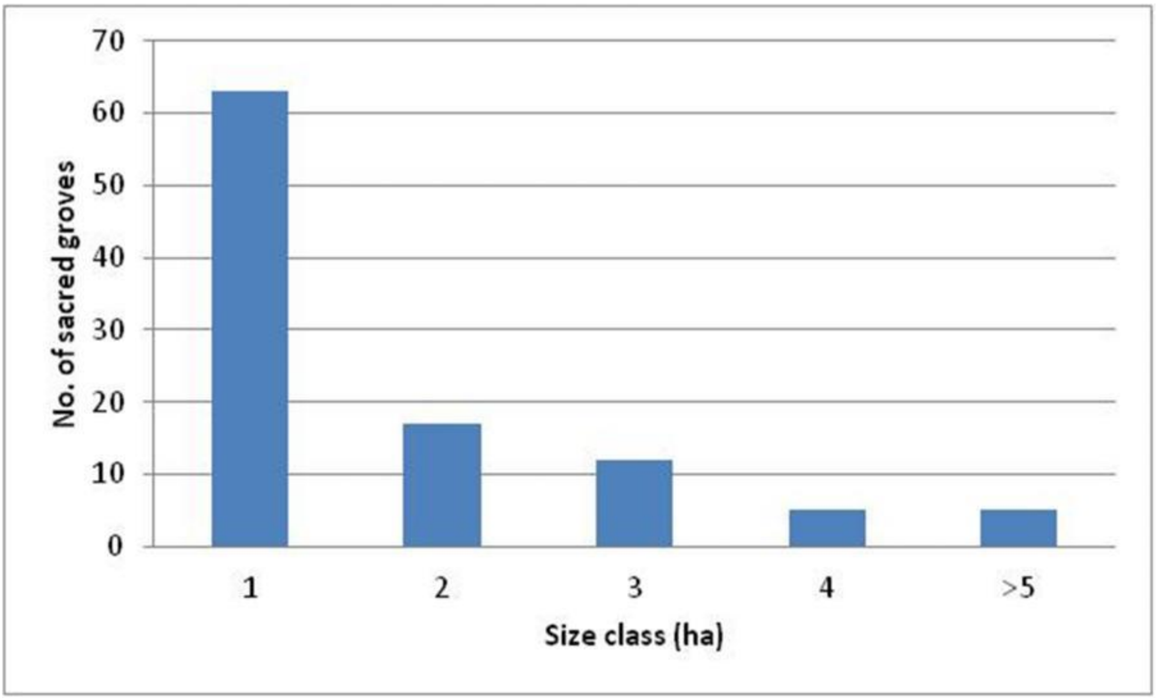


Figure 5.1 **Frequency distribution of sacred groves in different size classes. The first four classes on x-axis represent sacred groves of indicated or smaller size.**

The sacred groves were found to be located from an elevation of 8 to 240 msl. This, perhaps, covers the entire range of elevations available in Dapoli taluka. This range was converted into 5 elevation classes of 50 m each. Figure 5.2 shows that most of the sacred groves were located at elevation from 100 to 200 msl. However, there was no correlation between altitude and the size of the sacred groves (r = 0.124).

More than 60 per cent of the groves were approachable by dirt road while rest were approachable by a tar road. As per the informants, 94 sacred groves were recorded in the name of the revenue department. But 7 sacred groves were retained on privately owned land. Ownership of one sacred grove could not be ascertained.

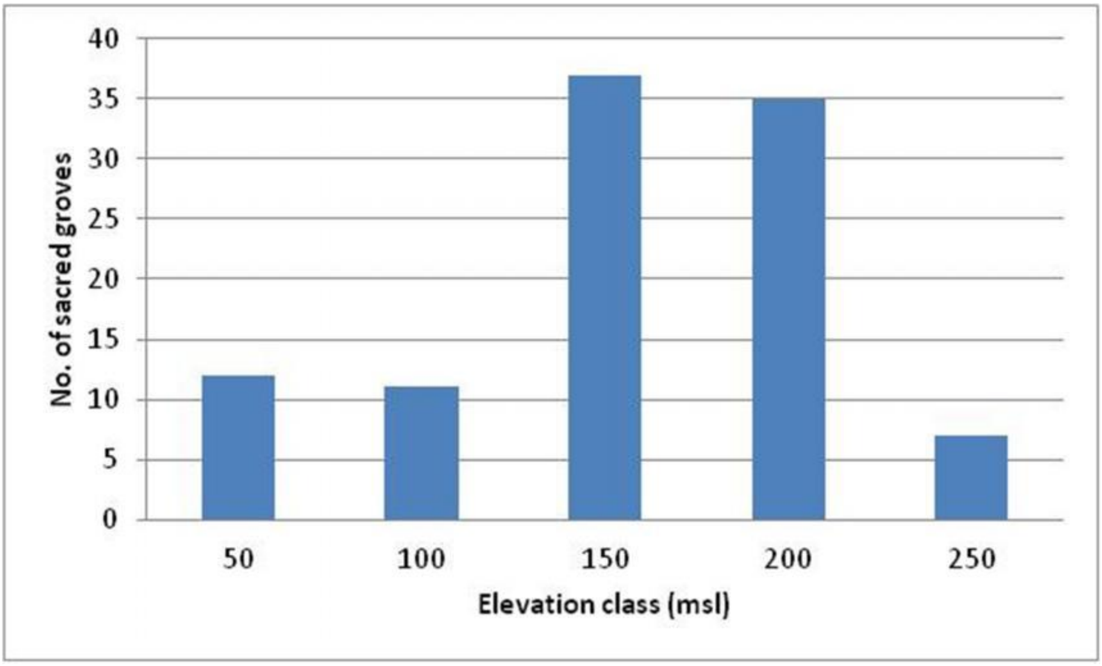


Figure 5.2 Frequency distribution of sacred groves in different elevation classes. The classes on x-axis are indicated by the maximum limit of each class.

5.1.4 Cultural Aspects of Sacred Groves

There was a large variety of deities worshipped in the sacred groves of Dapoli. The most common ones were Bhairi, Kalkai, Mahamai, Khem, Zolai and Chandika. A list of major deities of sacred groves is presented in Table 5.1. But apart from these, most of the sacred groves had associated deities also. Temples and their progression in the history indicate many things from anthropological point of view. For facility, temples in studied sacred groves were categorized into two categories 'simple' and 'elaborate'. A simple temple generally indicates historical construction whereas an elaborate temple is a modern one. Nearly 75 per cent of the temples were elaborate and remaining were simple with one sacred grove having no built-up temple.

Mankari and priest are associated institutions of sacred groves. Whereas *Mankari* are persons holding certain deity related privileges like carrying the palanquin during festivals, the priests are entrusted with the routine worship and maintenance of the deity and temple. It was found that the institution of *Mankari* was inherited by one or more families in more than 80 per cent of the villages. However, instilling of democratic values and resolution of age-old conflicts have also resulted in a few villages adopting an elected committee for management and the members are hailed as *Mankaris*. An equivalent proportion of villages are divided into categories where sacred groves are managed by community or a family and where the management is taken up by an informally elected committee. Most of the priests, however, are by inheritance for several generations.

The common festivals celebrated in the sacred groves include Holi and Navaratra. Apart from these, several other festivals are celebrated in many sacred groves. There are few villages where these main festivals or none of them are not celebrated in the sacred groves.

5.1.5 Vegetation Composition of Sacred Groves

The larger undisturbed sacred groves have retained their original vegetation to some extent. This includes a large variety of trees, shrubs and climbers. The following species were recorded during this study-

Trees: *Acacia catechu, Aegle marmelos, Albizia* sp.*, Bauhinia* sp.*, Antiaris toxicaria, Artocarpus heterophyllus, Bombax ceiba, Bridelia retusa, Butea monosperma, Careya arborea, Caryota urens, Dillenia pentagyna, Erythrina variegate, Ficus bengalensis, Ficus glomerata, Garcinia indica, Gmelina arborea, Lagerstroemia lanceolata, Lagerstroemia parviflora, Mammea suriga, Mangifera indica, Mcaranga peltata,* *Memecylon umbellatum, Mesua ferrea, Michelia* sp., *Mimusops elengi, Saraca asoca, Semecarpus anacardium, Syzigium cumini, Tectona grandis, Terminalia bellerica, Terminalia chebula, Terminalia elliptica, Terminalia paniculata, Terminalia tomentosa, Zanthoxylum rhetsa* etc.

Apart from these, following tree species were found planted in some sacred groves - *Acacia auriculiformis, Anacardium occidentale, Casuarina equisetifolia, Ceiba pentandra, Delonix regia, Eucalyptus* sp., *Tamarindus indica*. In some sacred groves, especially smaller ones like Degaon, Chandikanagar, Umbarshet, have been planted with mango or cashew and one in Talsure with *Casuarian equisetifolia*.

Shrubs: *Ixora spp., Carrissa karonda, Grewia tiliaefolia, Zizyphus rugosa, Atlantia racemosa, Holarrhena antidysenterica, Strobilanthes* sp., *Clerodendrum* sp., *Leea* spp. It was observed that several smaller sacred groves have already been infested by invasive weeds like *Lantana* and *Chormolaena*.

Lianas: The dominant liana in most large groves was *Gentum ula*. But in few sacred groves like Kudavale, Dhankoli, the omnipresence of *Entada scandens* was very striking.

5.1.6 Disturbance ranking

The subjective categories of mild, moderate and severe under nine threat categories were converted into scores of 1, 2 and 3 respectively (see Annexure VI). The sacred groves were ranked based on totals of the scores. Sacred groves of Bhomdi, Jalgaon, Kavdoli, Kharavate, Ravtoli, Rovale received a zero score indicating that they were least disturbed sacred groves. On the other hand, sacred groves of Dabhol, Umbarle, Karanjani, Saldure, Chandikanagar, Usgaon etc. received high scores meaning that they were being threatened by many of these disturbance categories.

Figure 5.3 illustrates that these threats were all pervasive with shift in belief system the most common and dominant threat overall followed by removal of biomass and modernization.

Table 5.1 Main deities worshipped in sacred groves of Dapoli. Deities. The variants of same name are clubbed together.

Deity	No. of sacred groves
Annapurna	1
Apatoba	1
Bhairi, Bhairidevi, Bhairi-dhawaji, Bhairi-manai, Bhairi-ravalnath, Bhairavnath	17
Bhanoba	1
Bhargavram	1
Chandika	4
Chokaran	1
Darvinkarin	1
Gadekarin	1
Gaodevi	1
Ghanekarin	1
Jakai, Jakhmata	3
Janai, Janai-padmavati, Janani, Janani-somaya	4
Jholai	5
Kaleshwari, Kalkai	13
Kalkoba	1
Khandoba-mhalsai	1
Khem, Khemdev, Khemeshwar, Khem-mahamai, Khem-manai, Khem-padmavati	7
Kherdoba	1
Koteshwari	1
Kudukdev	1
Kulkulai	1
Mahadeshwar	1
Mahalaxmi	1
Mahamai	8
Mariaai	1
Padmawati	1
Ramjai-kalkai	1
Ravalnath	1
Rhatoba	1
Satai, Satmai	4
Shankar, Shankar Parvati	3
Shipangankarin	1
Shridevi, Shridevi-manai	2
Simadevi	1
Somaya, Someshwari, Somjai	4
Valajai	1
Vyaghreshwar	1
Zarai	1

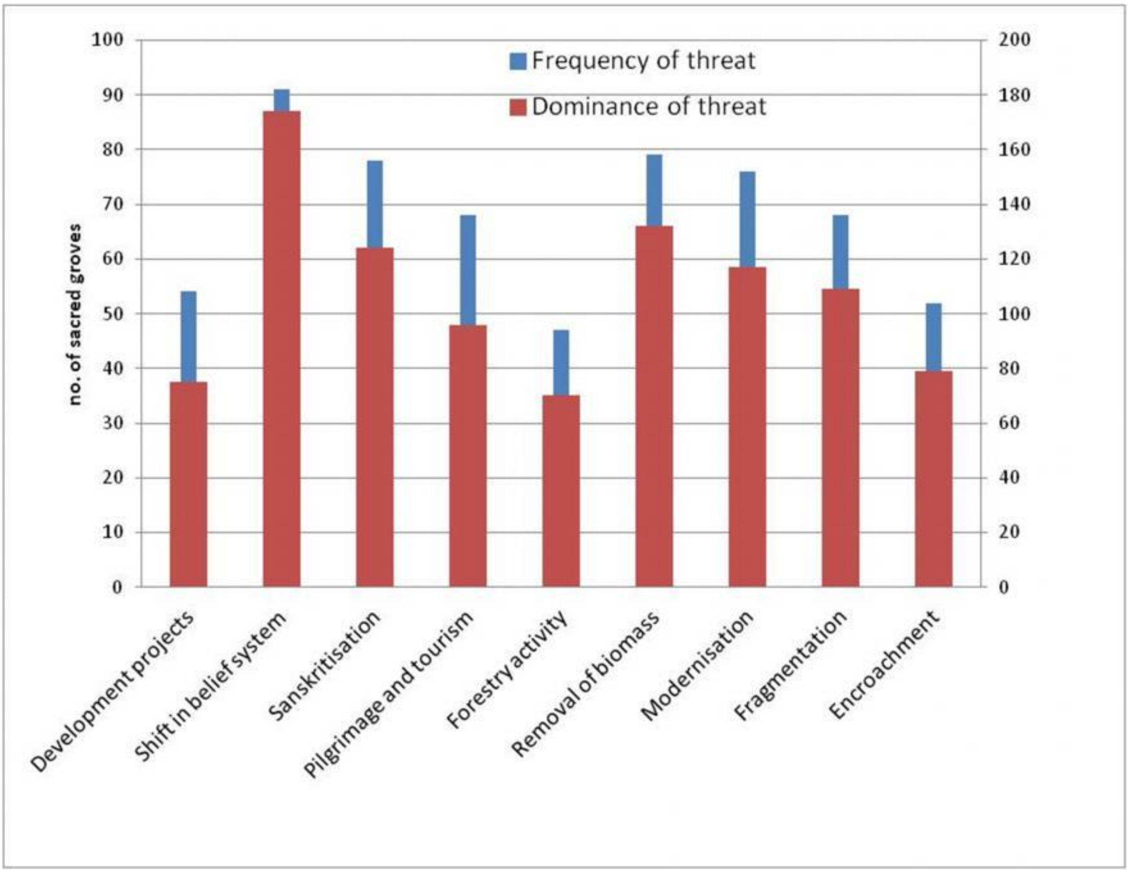


Figure 5.3 Occurrence and dominance of various threat categories in the sacred groves of Dapoli taluka. The wide columns refer to dominance of threat.

5.2 Inventory of Spiders of Dapoli

5.2.1 Background of the Investigation

Spiders form a very species-rich group of organisms and are poorly explored in most of the areas. Studies on spider systematic have rarely covered small areas intensively so that entire diversity of spiders could be explored. It is not possible to explore the entire spider fauna in any one investigation however intensive it may be. But it is still possible to record maximum number of species present in an area if sufficiently concentrated surveys are carried out. The present investigation was undertaken with a view to document maximum possible number of species in Dapoli Taluka. It was realized, however, that carrying out field collection expeditions and simultaneously examining the collected material with an aim to diagnose the species with taxonomic perfection was a very difficult task and could go beyond a doctoral study. Therefore, results presented here are based on full diagnosis for some groups of spiders whereas others have received only partial attention. Had there been a method to compute standard error in taxonomic diagnosis, it would have been very high given a large number of synonymies trailing even the most prolific spider taxonomists (Platnick and Raven, 2013). Therefore, for a non-specialist like me a large number of specimen remain attributed to morphospecies here.

5.2.2 Spider Diversity of Dapoli

Rich spider diversity has been documented in the present study with 377 species including morphospecies being recorded in a relatively small study area of <900 km^2. This is close to 25% of the known Araneomorph spider species from India (Keswani et al. 2012). These 377 species belong to 39 families and 282 genera which respectively comes to 75% and 58% of Araneomorph families and genera known from India (Keswani et al. 2012).

Figure 5.4 displays the taxonomic diversity in terms of genus and species richness in the 39 spider families recorded in this study. The same is also presented in Table 5.2. Figure 5.5 shows the relative abundances of spider families recorded by the two sampling methods. It was observed that Salticidae was the dominant family in terms of taxonomic richness (40 genera, 66 species) as well as in terms of number of individuals captured through systematic sampling. Interestingly, Salticidae was also the most dominant family collected by both the methods. It was closely followed by Theridiidae (37 genera, 63 families) and Araneidae (22 genera, 47 species).

A list of species (including morphospecies) recorded in this study with their abundances in different study sites is presented at Annexure VII. An account of the recorded families is provided below. The English names of the families have been sourced from Jocque and Dippenaar-Schoeman (2006); worldwide inventory figures are from World Spider Catalog (2016) and figures for India are taken from Keswani et al. (2012). Although, Keswani et al. (2012) has been outdated by fast developing spider taxonomy in the last four years, their figures used as a benchmark and wherever possible, updated figures from the World Spider Catalog (2016) are provided. Further, this account will show that a large number of species are being potential candidates for being reported for the first time from India. Photographs of representive species of common families reported in this study are presented in Plates 11 to 13.

Table 5.2 Number of genera and species recorded from study sites in Dapoli Taluka. A dash indicates non-identification at that taxonomic level.

Family	Foliage-dwellers		Ground-dwellers		Entire assemblage	
	genera	species	genera	species	genera	species
Araneidae	21	45	13	15	22	47
Clubionidae	4	7	0	0	4	7
Corinnidae	2	2	4	4	5	5
Ctenidae	1	-	2	3	2	3
Deinopidae	1	1	0	0	1	1
Dictynidae	2	2	3	3	4	4
Eutichuridae	2	8	1	1	2	8
Filistatidae	1	1	1	1	1	1
Gnaphosidae	2	3	5	9	5	10
Hahnidae	1	1	0	0	1	1
Hersiliidae	2	2	1	-	2	2
Linyphiidae	8	8	10	10	11	11
Liocranidae	1	3	4	5	4	6
Lycosidae	1	1	8	13	8	13
Mimetidae	1	1	1	1	2	2
Miturgidae	1	1	1	1	1	1
Mysmenidae	0	0	1	1	1	1
Nephiliidae	1	1	0	0	1	1
Oecobiidae	0	0	1	1	1	1
Oonopidae	5	6	9	14	9	14
Oxyopidae	4	11	3	5	4	11
Palpimanidae	1	1	1	1	2	2
Philodromidae	5	7	5	7	5	8
Pholcidae	2	2	2	2	2	2
Phrurolithidae	2	1	1	1	1	1
Pisauridae	4	5	2	2	5	6

Table 5.2 contd. **Number of genera and species (including morphogenera and morphospecies) in the entire spider assemblage (ESA) and in the foliage-dwelling assemblage (FDA) and ground-dwelling assemblage (GDA) in the study area. A dash indicates non-identification at that taxonomic level.**

Family	**Foliage-dwellers**		**Ground-dwellers**		**Entire assemblage**	
	genera	**species**	**genera**	**species**	**genera**	**species**
Prodidomidae	0	0	1	1	1	1
Salticidae	37	59	27	37	40	66
Scytodidae	2	4	2	3	2	5
Segestriidae	0	0	1	2	1	2
Sparassidae	5	5	3	3	5	6
Tetrablemmidae	1	1	3	3	3	3
Tetragnathidae	5	10	3	3	5	11
Theridiidae	34	59	22	26	37	63
Theridiosomatidae	1	1	1	1	1	1
Thomisidae	20	29	15	21	20	34
Trachelidae	0	0	2	2	2	2
Uloboridae	4	3	2	2	2	3
Zodariidae	1	3	7	11	7	11

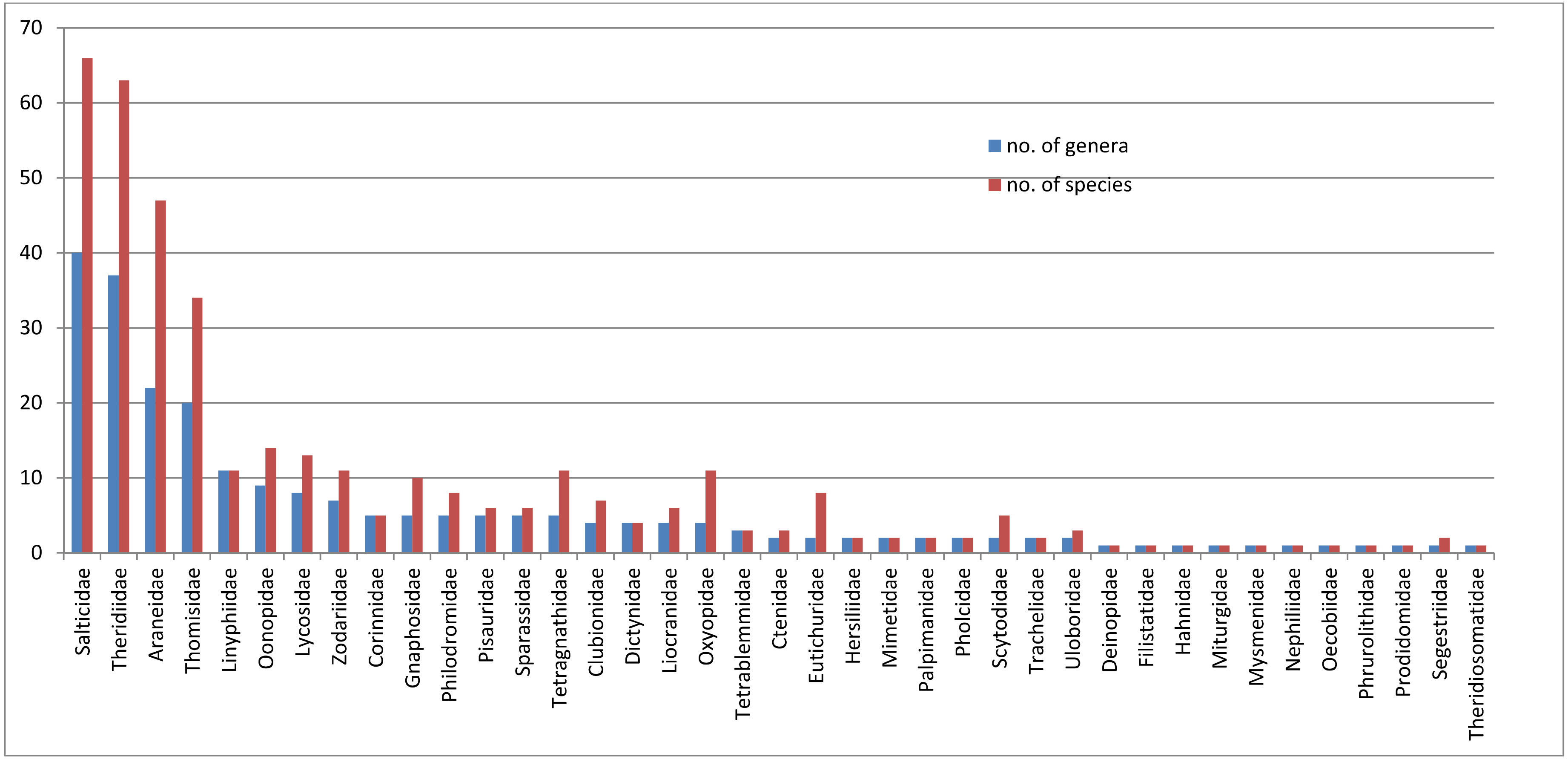


Figure 5.4 **Representation of genera and species in different spider families of the entire spider assemblage recorded in the study area.**

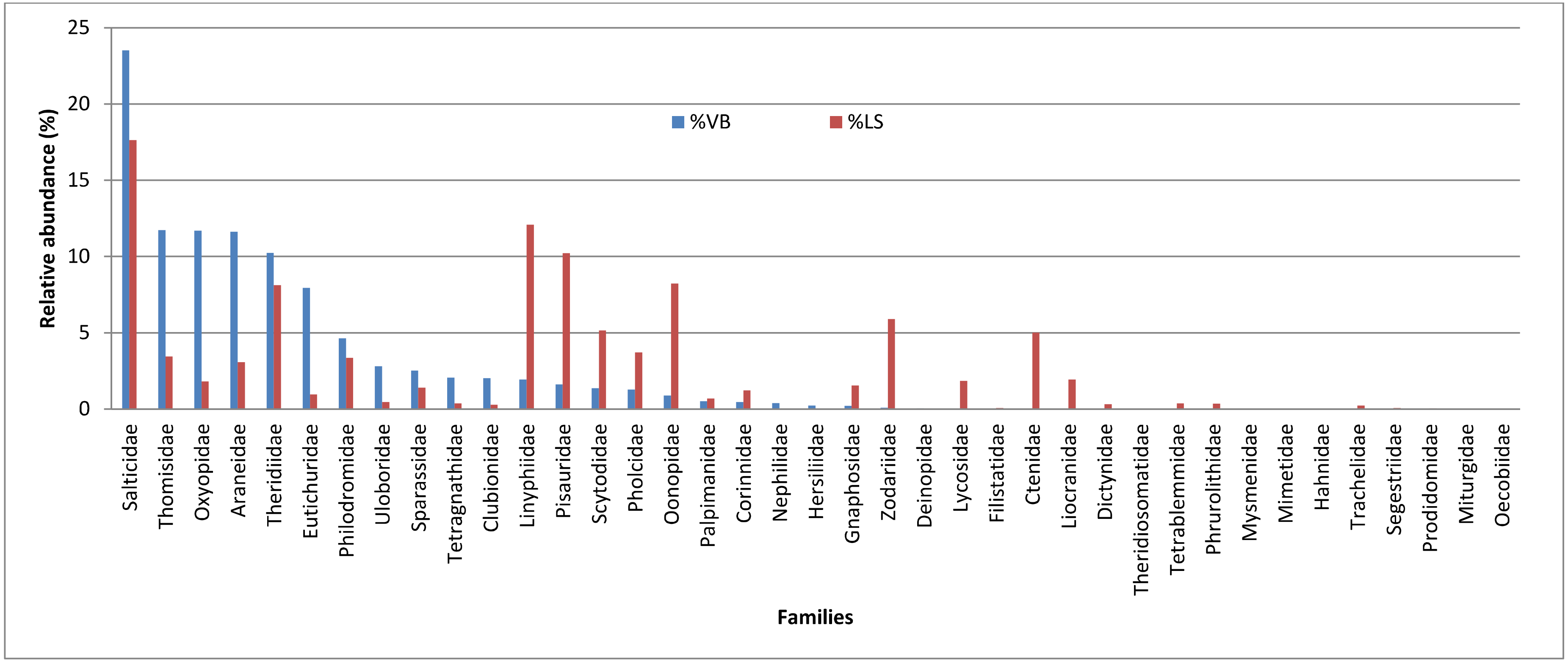


Figure 5.5 **Relative abundance of different spider families in the two sampled strata through the collection methods of vegetation beating (VB) and litter search (LS). Relative abundance is the proportion (%) of number of individuals of a family to the total number of individuals of all families under respective sampling method.**

Plate 11: Representatives of Common Spider Families Recorded in Dapoli

Arachnura angura **(a),** ***Araneus viridisomus*** **(b),** ***Gea spinipes*** **(c),**
Poltys columnaris **(d),** ***Hippasa agelenoides*** **(e),** ***Cheiracanthium murinum*** **(f)**

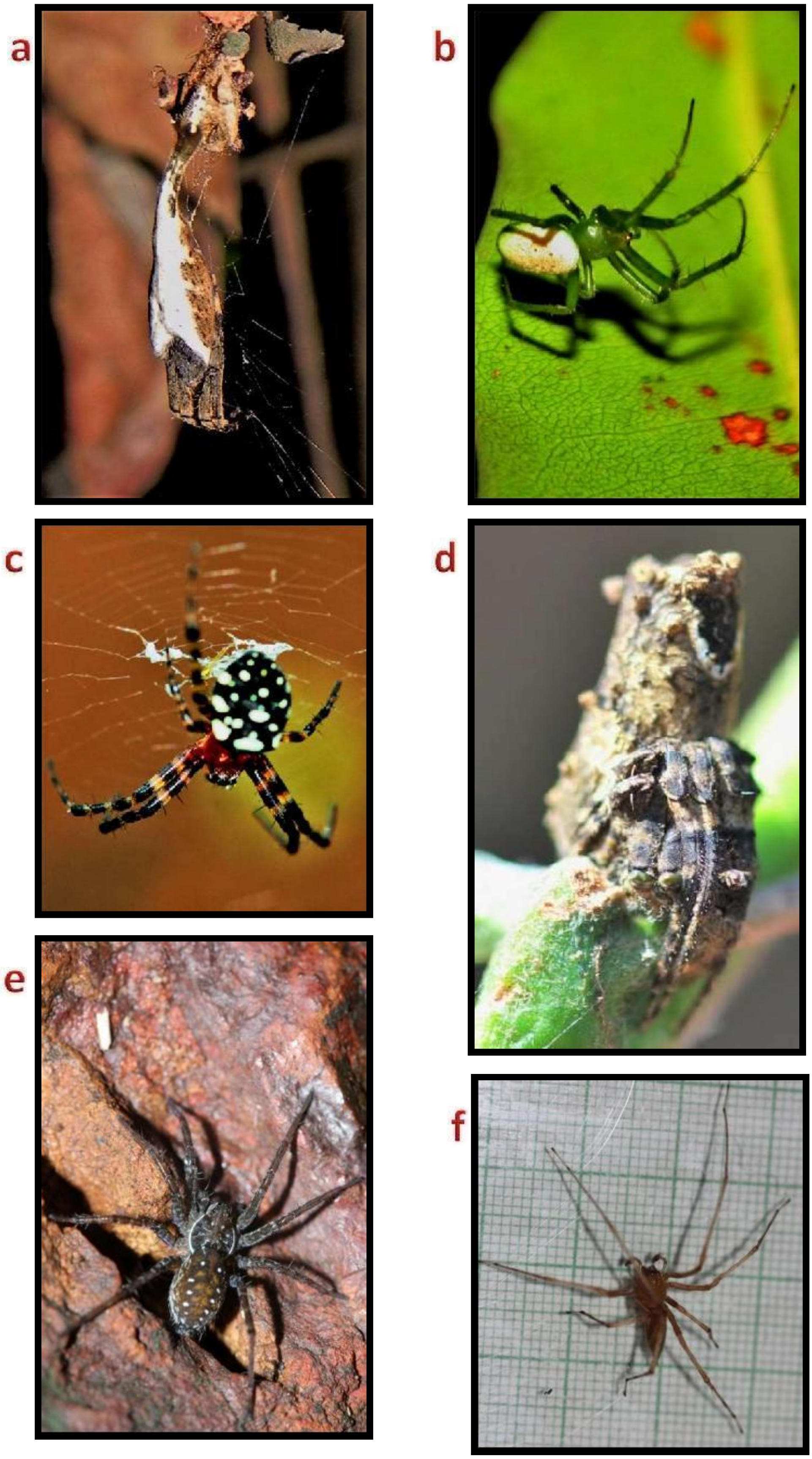


Plate 12: Representatives of Common Spider Families Recorded in Dapoli

Nephila pilipes **(a)*****,*** ***Herennia multipuncta*** **(b)*****,*** ***Opopaea apicalis*** **(c)*****,*** ***Oxyopes sp.*** **(d),** ***Hamadruas sikkimensis*** **(e)**

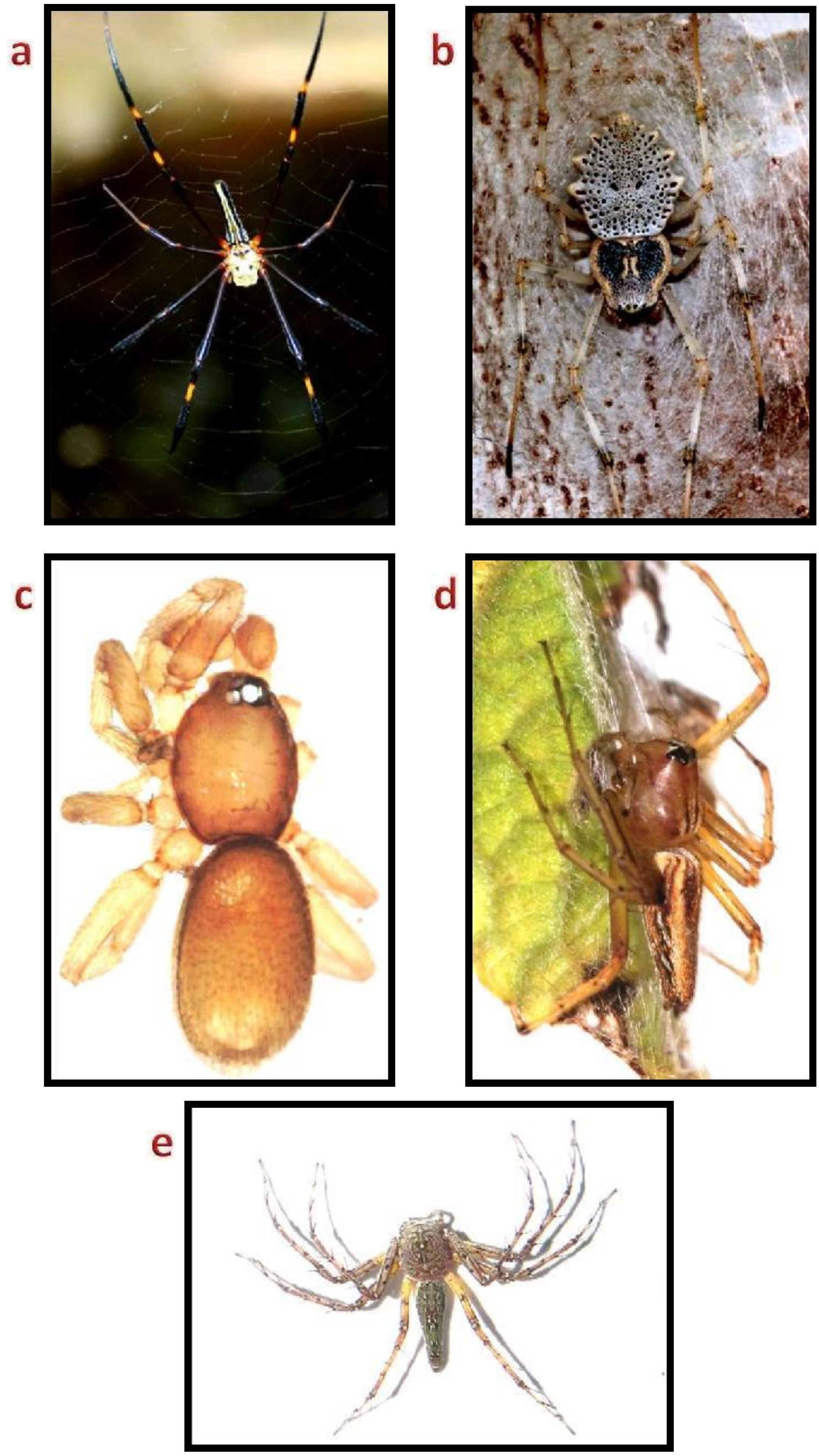
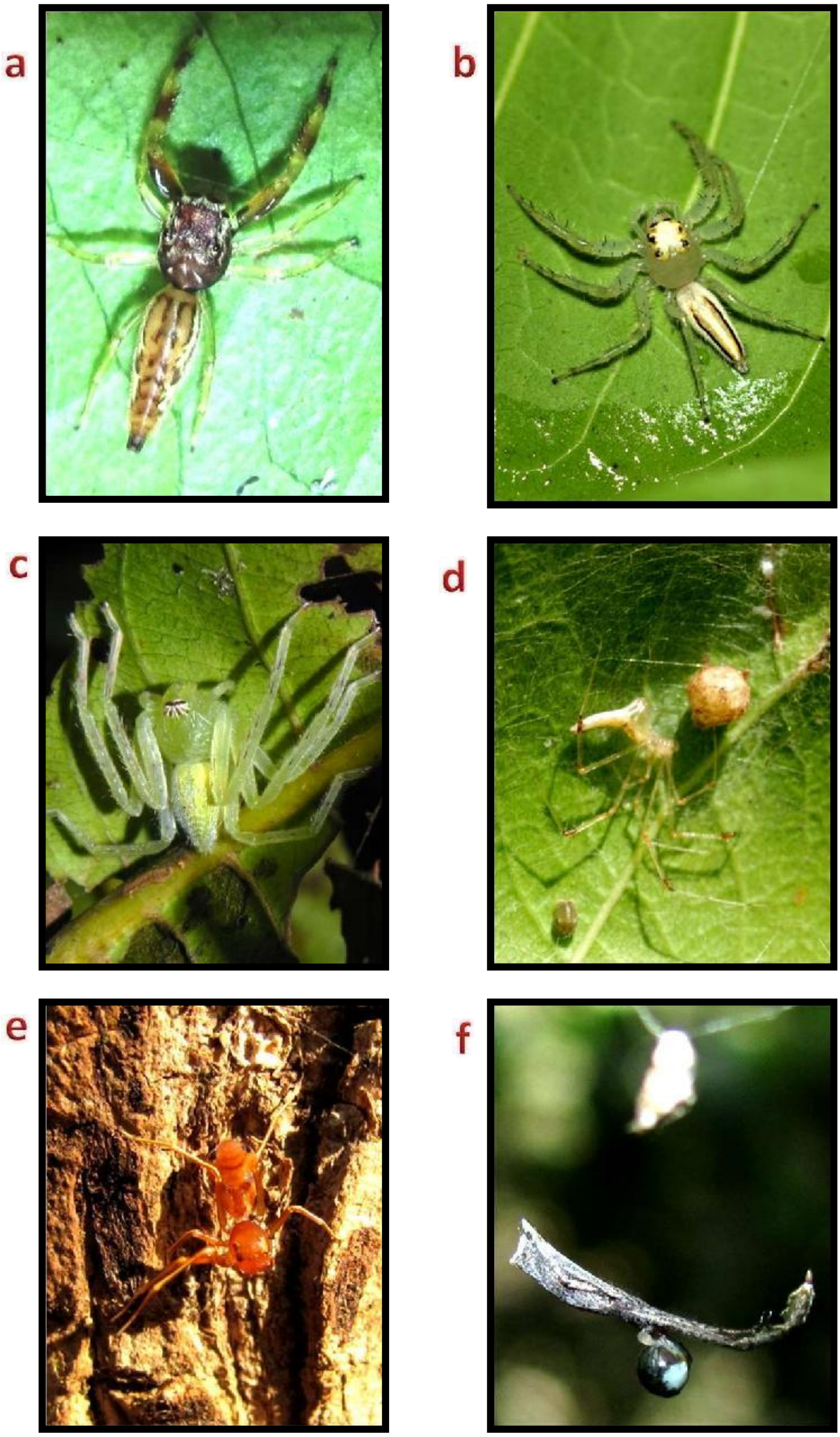


Plate 13: Representatives of Common Spider Families Recorded in Dapoli

Bavia annamita **(a),** ***Telamonia dimidiata*** **(b),** ***Gnathoplaystes*** **sp. (c),**
Meotipa picturata **(d),** ***Amyciaea forticeps*** **(e),** ***Miagrammopes thwaitesi*** **(f)**



5.2.3 Account of Recorded Spider Families

1. ARANEIDAE Simon, 1895

Orb web spiders

Araneidae is a worldwide distributed family whose members typically build orb web with a sticky spiral with several modifications. Their webs can be found right from pits in the ground to high branches of tree canopies.

This is the third largest family in the present study in terms of number of genera and species. It was found to occur in both the foliage dwelling as well as ground dwelling assemblages. However, most of the Araneids caught in the litter were juveniles. But genera like *Gea* build their webs very close to ground.

- Genera; species in world -169; 3114
- Genera; species in India – 28; 163
- Genera; species in present study – 22; 47

List of species in present study -

Arachnura melanura

Araneus ejusmodi

A. mitificus

A. viridisomus

Argiope aemula, A. pulchella

Chorizopes frontalis, *C. tikaderi*

Cyclosa confraga, C. hamulata, C. monticola, C. omonaga, C. quinqueguttata

Cyrtophora cicatrosa

Araneus sp2, *Araneus* sp3

Araniella sp1, , *Cyphalonotus* sp1

Eriovixia cavaleirie, E. excelsa, E. huwena, E. jianfengensis, E. laglaizei, E. nigrimaculata, E. pseudocentrodes, E. sakiedaorum

Gea spinipes, G. subarmata, Gea sp3

Hypsosinga sanguinea, Larinia bonneti, Lipocrea epeiroides

Neoscona bengalensis, N. mukerjei, N. nautica, N. punctigera, N. subpullata, N. vigilans

Ordgarius hobsoni, Parawixia dehaani, Pasilobus kotigeharus

Poltys columnaris, P. stygius

Singa sp1*, Thelacantha brevispina*

Araneidae sp1, Araneidae sp2

Taxonomic notes - The genera *Araniella*, *Cyphalonotus* and *Hypsosinga* are new to India. Similarly, *Araneus ejusmodi*, *Chorizopes frontalis*, *Eriovixia cavaleirie, E. huwena, E. jianfengensis, E. nigrimaculata, E. pseudocentrodes, E. sakiedaorum, Hypsosinga sanguinea, Larinia bonneti, N. subpullata Poltys stygius* are considered new to India.

2. CLUBIONIDAE Wagner, 1887

Sac spiders

Clubionidae is a worldwide distributed family whose members are free-living, nocturnal hunters. They can be found resting in their silken sac-like retreats on leaves during daytime. They are ecribellate, entelegyne spiders with 8 eyes.

Genera; species in world -15; 603

Genera; species in India – 3, 24

Genera; species in present study – 4, 7

List of species in present study -

Clubiona brevispina, C. pashabhaii, C. pteronetoides, C. viridula,

Matidia sp1, *Pristidia* sp1, *Pteroneta* sp1

Taxonomic notes – The genera *Pristidia* and *Pteroneta* and species *Clubiona brevispina, C. pteronetoides, C. viridula* are considered new to India.

3. CORINNIDAE Karsch, 1880

Dark sac spiders/Ant-like sac spiders

Corinnidae is a worldwide distributed family whose members are free-living typically ground spiders. But some genera are adapted to living in the foliage. Several of the ground-dwelling species mimic ants or mutillid wasps. They are ecribellate, entelegyne spiders with eight eyes.

Genera; species in world -67; 74

Genera; species in India – 9, 36

Genera; species in present study – 5, 5

List of species in present study -

Corinnomma severum, Echinax panache

Corinnidae sp1, *Corinnidae* sp2, *Corinnidae* sp3

Taxonomic notes – The genus *Echinax* and the species *Echinax panache* have been reported as new to India (Patil et al. 2015)

4. CTENIDAE Keyserling, 1877

Tropical wolf spiders

Ctenidae is a worldwide, except New Zealand, distributed family whose members are nocturnal, wandering spiders. They are predominantly ground spiders. They are ecribellate (raely cribellate), entelegyne spiders with eight eyes. The eyes are arranged in 3 rows of 2-4-2.

Genera; species in world -41; 503

Genera; species in India – 2, 14

Genera; species in present study – 2, 3

List of species in present study -

Ctenus sikkimensis, Ctenus sp2

Ctenidae sp1

Taxonomic notes – Not many adult individuals of this family could be collected during present study. And hence, the infra-familial diversity remains largely unexplored.

5. DEINOPIDAE C. L. Koch, 1850

Net-casting spiders/Ogre-faced spiders

Deinopidae is a family with tropical and subtropical distribution whose members live I low vegetation. They build a small expandable web which is held between the front legs. The spiders hang upside down and when a prey (usually ants) come in range, cast their web over it. They are cribellate, entelegyne spiders with eight eyes; the posterior median eyes are greatly enlarged.

Genera; species in world -2; 61

Genera; species in India – 1, 1

Genera; species in present study – 1, 1

List of species in present study -

Deinopis goalparaensis

Taxonomic notes – Only few juvenile/subadult individuals of this family were collected during present study. However, based on one adult male collected previously, the identity of the species is fixed as *D*. goalparaensis.

6. DICTYNIDAE O. P.-Cambridge, 1871

Meshweb spiders

Dictynidae is a worldwide distributed family but is more common in temperate reiongs. Its members are found both in foliage and on the ground. The foliage dwellers make a ladder or mesh-like retreat on the leave. They are cribellate, entelegyne spiders with six to eight eyes.

Genera; species in world -52; 578

Genera; species in India – 8, 12

Genera; species in present study – 4, 4

List of species in present study -

Dictyna sp1

Dictynidae sp1, *Dictynidae* sp2, *Dictynidae* sp3

Taxonomic notes – Unavailability of pertinent literature and lack of sufficient number of adult specimen has prevented detailed treatment of this family.

7. EUTICHURIDAE Lehtinen, 1967

Eutichuridae is a worldwide distributed family whose members are free-living spiders living in foliage. They are ecribellate, entelegyne spiders with eight eyes; the eye group wide and occupying almost the entire head-width.

This family has been recently re-elevated to the family status and relimited by Ramirez

(2014).

Genera; species in world -12; 344

Genera; species in India – 2, 26 (WSC, 2016)

Genera; species in present study – 2, 8

List of species in present study -

Cheiracanthium insigne, C. murinum, C. triviale, C. vorax

Cheiracanthium sp6, *Cheiracanthium* sp8*,*

Summacanthium sp2*, Summacanthium* sp4

Taxonomic notes – The genus *Summacanthium* is considered new to India – in fact anywhere away from its type locality i.e. Sulawesi. However, allocation of specimen to two species of this genus is only tentative because only few genitalic and somatic characteristics could be matched with original description.

8. FILISTATIDAE Ausserer, 1867

Crevice weavers

Filistatidae is a family distributed through tropical, subtropical and arid regions of the world. Its members live in silk-lines tubular retreats made in crevices in rocks and walls from where cribellate silk lines are spread in all directions. They are cribellate, haplogyne spiders with eight eyes and labium fused to sternum.

Genera; species in world -18; 126

Genera; species in India – 3,10

Genera; species in present study – 1, 1

List of species in present study -

Pritha poonaensis

Taxonomic notes – Despite the haplogyne, juvenile nature of specimen of this family, their assignment to *Pritha poonaensis* is quite justifiable due to vicinity of the type locality.

9. GNAPHOSIDAE Pocock, 1898

Flat-bellied ground spiders

Gnaphosidae is a worldwide distributed family whose members are free-living spiders found mainly on the ground. They are ecribellate, entelegyne spiders with eight eyes, posterior median eyes often deviate from round shape. Spinnerets, especially anterior ones, cylindrical, sclerotized and well separated.

Genera; species in world -124; 2183

Genera; species in India – 30, 146

Genera; species in present study – 5, 10

List of species in present study -

Hitobia sp1, *Hitobia* sp2, *Micaria* sp1, *Micythus* sp1

Setaphis sp1, *Setaphis* sp2

Zelotes sp1, *Zelotes* sp3, *Zelotes* sp4, *Zelotes* sp6

Taxonomic notes – The genus *Hitobia*, *Micythus* are considered new to India. *Micythus* was confirmed by personal correspondence with Dr. Deeleman-Reinhold. However, it can be seen that difficulties in obtaining sufficient number of adult individuals and pertinent literature have prevented a detailed treatment of this family.

10. HAHNIIDAE bertkau, 1878

Comb-tailed spiders

Hahniidae is a worldwide distributed family whose members construct delicate sheet webs near the soil surface in forested area. They are ecribellate, entelegyne spiders with eight eyes and spinnerets, unlike any other spiders, situated in a transverse row.

Genera; species in world -28; 249

Genera; species in India – 3, 4

Genera; species in present study – 1, 1

List of species in present study -

Hahnia mridulae

Taxonomic notes – Despite very few juvenile specimen, the overall appearance and somatic characteristics have led to assign these to *Hahnia mridulae*.

11. HERSILIIDAE Thorell, 1870

Long-spinnered spiders/Two-tailed spiders/Whirligig spiders

Hersiliidae is distributed through tropical and subtropical part of the world. Although most of the members are well-camouflaged tree-trunk-dwellers, some are also ground-dwelling web-builders. They are ecribellate, entelegyne spiders with eight eyes and posterior spinnerets extremely long and slender.

Genera; species in world -15; 179

Genera; species in India – 3,17

Genera; species in present study – 2, 2

List of species in present study -

Hersilia savignyi

Murricia cornuta

Taxonomic notes – Although only adult females were collected during this study, they were not difficult to assign to the two well-known genera. However, *M. cornuta* is considered new to India.

12. LINYPHIIDAE Blackwall, 1859

Hammock-web spiders/Dwarf spiders

Linyphiidae is one of the largest families distributed worldwide and particularly rich in temperate and cooler climates of the Northern Hemisphere. They spin delicate sheet webs in low vegetation and also in litter. Many do not even build webs. They are ecribellate, entelegyne spiders with eight eyes. Males often have their carapace strangely modified.

Genera; species in world -601; 4538

Genera; species in India – 36, 146

Genera; species in present study – 11, 11

List of species in present study -

Atypena sp2

Nasoona sp1, *Neriene birmanica, Nesioneta* sp1, *Paracymboides tibialis*

Linyphiidae sp1, *Linyphiidae* sp4, *Linyphiidae* sp5,
Linyphiidae sp6, *Linyphiidae* sp8, *Linyphiidae* sp9

Taxonomic notes – Although *Atypena* and *Nesioneta* are here identified and considered new genera to India, it is clear that the infra-familial diagnosis of Linyphiids in this study is not completely treated.

13. LIOCRANIDAE Simon, 1897

Spiny-legged sac spiders

Liocranidae is a worldwide distributed family whose members are free-living ground-dwelling spiders common in forests. Some genera are associated with ants and termites. They re ecrebillate, entelegyne spiders with eight eyes.

Genera; species in world -31; 271
Genera; species in India – 4, 10
Genera; species in present study – 4, 6
List of species in present study -
Oedignatha scrobiculata, Oedignatha sp2
Sphingius sp1, *Sphingius* sp2, *Sudharmia* sp1
Liocranidae sp1

Taxonomic notes – *Sudharmia* is considered a new report for India. *Oedignatha scrobiculata* is very well represented in the sampling.

14. LYCOSIDAE Sundevall, 1833

Wolf spiders

Lycosidae is a worldwide distributed family whose members are mostly free-living ground-dwelling hunters. Some of them live in burrows or make sheet webs with a funnel. Interestingly, egg sacs are carried by female attached to the spinnerets and even the young spiderlings are carried on the back by their mothers. They are ecribellate, entelegyne spiders with eight eyes; eyes arranged in 3 rows of 4-2-2.

Genera; species in world -123; 2415

Genera; species in India – 19, 133

Genera; species in present study – 8, 13

List of species in present study -

Evippa sp1, *Evippa* sp2, *Flanona* sp1

Hippasa agelenoides, H. olivacea

Lycosa chaperi, L. geotubalis, L. prolifica

Lysania sp cf prolixus

Pardosa sp6*, Pardosa* sp7, *Xerolycosa* sp1

Lycosidae sp1

Taxonomic notes – Although some species like *Hippasa agelenoides* have been clearly identified, the infra-familial diagnoses have not been complete.

15. MIMETIDAE Simon, 1881

Pirate spiders

Mimetidae is a worldwide distributed family whose members are mostly araneophagous and do not build a web. They live in low vegetation or litter or on the webs of other spiders. They are ecribellate, entelegyne spiders with eight eyes. The tibiae and metatarsi of leg I and II bear typical prolateral spination comprising of a row of long spines interspersed with several short ones.

Genera; species in world -13; 152

Genera; species in India – 2, 2

Genera; species in present study – 2, 2

List of species in present study -

Ero sp1

Mimetus sp1

Taxonomic notes – Only two juvenile specimen were collected and they could be determined only to the genus level. Still, *Ero* appears to be a new report for India.

16. MITURGIDAE Simon, 1885

Prowling spiders

Miturgidae is a widespread family whose members are free-living, nocturnal, cryptic spiders constructing a sac-like retreat. They are ecribellate, entelegyne spiders with eight eyes. However, recently, there have been significant changes with many genera from Miturgidae having been transferred to other newly elevated families. Hence, diagnostic somatic characters are still not clear. In the same revision, two Indian genera *Cheiracanthium* and *Eutichurus* from this family were recently transferred to the family Eutichuridae by Ramirez (2014).

Genera; species in world -32; 158

Genera; species in India – 3, 29 (1, 1 as per WSC, 2016)

Genera; species in present study – 1, 1

List of species in present study -

Systaria sp1

Taxonomic notes – The assignment of the only juvenile specimen to Miturgidae and *Systaria* is only tentative.

17. MYSMENIDAE Petrunkevitch, 1928

Minute clasping weavers

Mysmenidae is a worldwide distributed family whose members are found in humid habitats. They are minute spiders often kleptoparasitic on webs of other spiders and some build their own sheet webs in low vegetation. They are ecribellate, entelegyne spiders with eight eyes. Males typically bear a clasping spine metatarsus and sometimes tibia I.

Genera; species in world -13; 137

Genera; species in India – 1, 1

Genera; species in present study – 1, 1

List of species in present study -

Mysmenidae sp1

Taxonomic notes – Only few characters justify the placement of these 3 specimen into Mysmenidae and need a further detailed examination with high-end microscopy.

18. NEPHILIIDAE Simon, 1894

Giant orb-web spiders, Coin spiders

Nephilidae is a pantropically distributed family whose members build sticky orb-webs. They are often large spiders (some of the largest among the Araneomorphs), ecribellate, entelegyne, with eight eyes.

Genera; species in world -5; 61

Genera; species in India – 3, 7

Genera; species in present study – 1, 1

List of species in present study -

Nephila pilipes

Taxonomic notes – Clearly the one of the most common and un-cryptic species of the study area. Despite variations in body coloration, all collected specimen belonged to *N. pilipes*.

19. OECOBIIDAE Blackwall, 1862

Dwarf round-headed spiders/Star-legged spiders

Oecobiidae is a worldwide distributed family whose members are found on the rocks or walls under small mesh-webs made over crack or crevices. Like Hersiliidae, the prey is immobilized by circling around it and entangling with a band of silk. They are cribellate (sometimes ecribellate), entelegyne spiders with six or eight eyes.

Genera; species in world -6; 110

Genera; species in India – 2, 8

Genera; species in present study – 1, 1

List of species in present study -

Oecobius sp1

Taxonomic notes – Again a single juvenile specimen but could be placed in the family and genus correctly because of typical morphology.

20. OONOPIDAE Simon, 1890

Dwarf hunting spiders/ Dwarf armoured spiders/ Goblin spiders

Oonopidae is a worldwide distributed family with common occurrence in tropics. They are free-living, nocturnal ground-dwellers (although some genera are foliage dweller also) common in forests. They are ecribellate, haplogyne spiders with six eyes or none, many genera with variously sclerotized dorsal and ventral scuta on abdomen.

Genera; species in world -113; 1625

Genera; species in India – 10, 34

Genera; species in present study – 9, 14

List of species in present study -

Aprusia vestigator, Brignolia sp1, *Camptoscaphiella* sp1

Gamasomorpha sp1, *Gamasomorpha* sp3, *Gamasomorpha* sp4

Heteroonops sp1, *Ischnothyreus* sp1, *Ischnothyreus* sp3, *Opopaea apicalis*

Orchestina pilifera, Orchestina sp1*, Orchestina* sp2

Trilacuna sp1

Taxonomic notes – *Heteroonops* is probably misidentified or it is *H. spinimanus* which is pantropical. *Orchestina* is perhaps new to India. All its species show affinity to those species known from Sri Lanka.

21. OXYOPIDAE Thorell, 1870

Lynx spiders

Oxyopidae is a worldwide distributed family whose members are often colourful free-living plant-dwellers and active hunters. They are ecribellate, entelegyne spiders with eight eyes.

Genera; species in world -9; 455

Genera; species in India – 4, 71

Genera; species in present study – 4, 11

List of species in present study -

Hamadruas sikkimensis, Hamadruas sp3, *Hamadruas* sp4

Hamataliwa ovata,

Oxyopes ashae, Oxyopes birmanicus, Oxyopes naliniae, *Oxyopes shweta, Oxyopes* sp1, *Oxyopes* sp2

Peucetia sp1

Taxonomic notes – All the common genera are found in this study, But Peucetia was relatively very rare. And *Hamadruas* sp3 and *H.* sp4 are likely to be juveniles of *H. sikkimensis* or some *Hamataliwa*.

22. PALPIMANIDAE Thorell, 1870

Palp-footed spiders

Palpimanidae is a family with tropical and subtropical distribution; its members are free-living ground dwellers and appear to have a diet of other spiders. They are ecribellate, entelegyne spiders with eight eyes, leg I usually enlarged in all segments, carapace strongly sclerotized and spinnerets reduced in numbers.

Genera; species in world -16; 139

Genera; species in India – 3, 3

Genera; species in present study – 2, 2

List of species in present study -

Boagrius sp1

Steriphopus sp1

Taxonomic notes – Identification of both the genera was confirmed by Dr. Sergei Zonstein of Israel. Both *Boagrius* and *Steriphopus* are new to India.

23. PHILODROMIDAE Thorell, 1870

Small huntsman spiders

Philodromidae is a worldwide distributed family whose members are free-living, agile hunters commonly found in foliage or on ground. They are ecribellate, entelegyne spiders with eight eyes and slender laterigrade legs.

Genera; species in world -30; 540

Genera; species in India – 8, 48

Genera; species in present study – 5, 8

List of species in present study -

Philodromus bhagirathai, Philodromus devhutai

Tibellus sp1, *Tibellus* sp2, *Tibellus* sp3

Philodromidae sp1, *Philodromidae* sp3, *Philodromidae* sp4

Taxonomic notes – Identification in this family is largely based on available Indian literature and there is little clarity at infra-familial levels.

24. PHOLCIDAE C. L. Koch, 1851

Daddy-long-legs spiders

Philodromidae is a worldwide distributed family whose members construct sheet or spacewebs in foliage on in the litter. They also inhabit dark places like caves. Some species have become synanthropic. They are ecribellate, haplogyne spiders with six or eight eyes; legs very long. Females carry loosely bound eggmass in their chelicerae.

Genera; species in world -80; 1506

Genera; species in India – 9, 12

Genera; species in present study – 2, 2

List of species in present study -

Belisana dodabetta

Leptopholcus podophthalmus

Taxonomic notes – Interestingly two distinct genera and two species were recorded one each from foliage-dweller and ground-dwellers. *Leptopholcus* is considered a new report to India and a manuscript is in review for this report with Journal of Threatened Taxa.

25. PHRUROLITHIDAE Banks, 1892

Phrurolithidae is a widespread family whose members are characterized by reduced leg spination especially on posterior legs and dorsally on all femora. They are different from Trachelidae by having a long series of macrosetae on the anterior tibiae and lacking cusples. They are ecribellate, entelegyne spiders with eight eyes.

This subfamily was recently elevated to family status and relimited by Ramirez (2014)

Genera; species in world -14; 207

Genera; species in India – 1, 1 (WSC 2016)

Genera; species in present study – 1, 1

List of species in present study -

Orthobula impressa

Taxonomic notes – This is the only species of this family present in India and was recently reported from Maharashtra.

26. PISAURIDAE Simon, 1890

Nursery web spiders/ Fish-eating spiders

Pisauridae is a worldwide distributed family whose members are either free-living or web-bound. Their web is a sheet with a large funnel leading into a retreat in the tree stem or ground. They are ecribellate, entelegyne spiders with eight eyes.

Genera; species in world -47; 335

Genera; species in India – 11, 24

Genera; species in present study – 5, 6

List of species in present study -

Dendrolycosa robusta, Dendrolycosa yuka

Perenethis sp1, *Pisaura* sp1

Pisauridae sp1, *Pisauridae* sp2

Taxonomic notes – Perhaps, *D. robusta* ad *D. yuka* are new reports to India. But as is the case, the already described Indian species *D. gitae* and *D. bobbiliensis* have been considered inadequately described and possible synonymies suggested (including *D. robusta*) in a recent revision (Jager 2011). So, there is a need of revision of Indian species.

27. PRODIDOMIDAE Simon, 1884

Long-spinnered ground spiders

Prodidomidae is a family with worldwide distribution in tropical and subtropical regions. They are free-living nocturnal ground spiders. They are ecribellate, entelegyne spiders with eight eyes; anterior spinnerets located more towards the epigastric region.

Genera; species in world -31; 309

Genera; species in India – 2, 9

Genera; species in present study – 1, 1

List of species in present study -

Prodidomus sp cf rufus

Taxonomic notes – Only one adult male specimen and 2 juveniles were collected. Unfortunately, all species reported from India except *P. venkateswarai* are described with only females. And this male did not match with *P. venkateswarai*. But it resembled a widespread species *P. rufus*. This species probably has only Indian subcontinent as a gap in its circumtropical distribution.

28. SALTICIDAE Blackwall, 1841

Jumping spiders

Salticidae is a worldwide distributed family whose members are diurnal, cursorial (jumping) hunting spiders. It is one of the most speciose families of spiders. They are ecribellate, entelegyne spiders with eight eyes; anterior median eyes are greatly enlarged and placed in front of the carapace.

Genera; species in world -598; 5872

Genera; species in India – 73, 207

Genera; species in present study – 40, 66

List of species in present study -

Aelurillus sp1, *Aelurillus* sp2

Asemonea tenuipes, Bavia annamita

Bianor sp1, *Bianor* sp2

Brettus cingulatus, Bristowia heterospinosa

Carrhotus decorata, C. viduus

Chrysilla jesudasi

Cocalus sp1, *Curubis* sp1*, Curubis* sp2*, Curubis* sp3*,*

Curubis sp4, *Curubis* sp5, *Curubis* sp6, *Curubis* sp7

Cyrba ocellata, Epeus indicus,

Epocilla chimakothiensis, E. praetextata

Euophrys frontalis, Euophrys sp1, *Euophrys* sp2

Evarcha sp1, *Harmochirus brachiatus, Hasarius adansoni*

Hyllus semicupreus, H. sp1

Icius sp1, *Jerzego* sp1, *Langona sp cf goaensis*

Marengo inornata, Marengo sp1, *Marpissa singhi,*

Mendoza sp1, *Menemerus bivittatus*

Myrmarachne melanocephala, M. poonaensis, M. prava, M. spissa,

Myrmarachne sp4

Phintella cf bifurcata, P. debilis, P. versicolor, P. vittata, P. volupe

Plexippoides zhangi, Plexippus sp1, *Portia fimbriata*

Pseudicius daitaricus, P. nepalicus, Pseudicius sp2

Rhene albigera, R. flavicommans

Sitticus sp1, *Stenaelurillus* sp1, *Telamonia dimidiata*

Thyene bivittata, T. imperialis, Uroballus sp1

Salticidae sp1, *Salticidae* sp2, *Salticidae* sp3

Taxonomic notes – Taxanomy of Salticidae in this study has been clear in parts with relation to commonly known genera like *Asemonea, Epeus, Epocilla, Phintella, Portia, Rhene* etc. However, some genera like *Icius, Plexippoides* and species thereunder are considered new to India.

29. SCYTODIDAE Blackwall, 1864

Spitting spiders

Scytodidae is a pantropically distributed family whose members are wandering spiders found in varied habitats. They overpower the prey by spurting gluey silk secreted by glands in the prosoma. Females carry the eggmass in chelicerae. They are ecribellate, haplogyne spiders with six eyes in three diads.

Genera; species in world -5; 233

Genera; species in India – 1, 9

Genera; species in present study – 2, 5

List of species in present study -

Dictis sp1, *Dictis* sp3, *Dictis* sp4
Scytodes sp1, *Scytodes* sp2

Taxonomic notes – Owing to current confusion and spurt in reporting species of both the genera in this family, it was decided to identify them only to the genus level with possible morphospecies delineation.

30. SEGESTRIIDAE Simon, 1893

Tubeweb spiders

Segestriidae is a worldwide distributed family whose members occupy a variety of habitats hiding in silk-lined tubular retreats with trip-lines radiating from the opening. They are ecribellate, haplogyne spiders with six eyes.

Genera; species in world - 4; 120
Genera; species in India – 2, 2
Genera; species in present study – 1, 2
List of species in present study -
Ariadna sp1, *Ariadna* sp2

Taxonomic notes – Because of the haplogyne nature of the spiders, it was decided to delineate morphospecies based on morphological distinctions only.

31. SPARASSIDAE Bertkau, 1872

Huntsman spiders

Sparassidae is a worldwide distributed species in tropical and subtropical regions. Its members are nocturnal, wandering hunters living in foliage, on ground or in caves. Some species have become synanthropic. They are ecribellate, entelegyne spiders with eight eyes, laterigrade legs.

Genera; species in world - 86; 1210
Genera; species in India – 12, 93
Genera; species in present study – 5, 6
List of species in present study -

Gnathopalystes denticulatus

Heteoropoda sp1, *Micrommata* sp1,

Olios fuligineus, Olios sp3

Seramba sp1

Taxonomic notes – Another family with abundant representation but few adult specimen. Therefore only two species could be identified with certainty.

32. TETRABLEMMIDAE O. P.-Cambridge, 1873

Armoured spiders

Tetrablemmidae is distributed in tropical and subtropical regions. Its members are cryptozoic, living in the litter layer and under bark in forests, some construct a sheetweb. They are ecribellate haplogyne spiders with six, four eyes or none. Abdomen bears dorsal, ventral and lateral scuta.

Genera; species in world - 31; 161

Genera; species in India – 4, 9

Genera; species in present study – 3, 3

List of species in present study -

Brignoliella acuminata

Choiroblemma rhinoxunum

Tetrablemma deccanense

Taxonomic notes – Of the four genera known from India, three could be found in this study and each was represented by one species each. The genera are quite easy to distinguish but species level identification needs to be confirmed.

33. TETRAGNATHIDAE Menge, 1866

Water orb-weavers

Tetragnathidae is a worldwide distributed family whose members build orb-webs; some genera specialized to building webs over standing or running water. They are ecribellate entelegyne spiders with eight eyes, often prominent chelicerae.

Genera; species in world -48; 987

Genera; species in India – 8, 40

Genera; species in present study – 5, 11

List of species in present study -

Leucauge celebesiana, Leucauge decorata

Mesida gemmea, Opdaometa fastigata

Tetragnatha cochinensis, T. fletcheri, T. mandibulata,

T. maxillosa, T. vermiformis, T. viridorufa

Tylorida ventralis

Taxonomic notes – Many of the common species of this family were recorded in this study. *Mesida* is considered new to India.

34. THERIDIIDAE Sundevall, 1833

Cob web spiders, Gumfoot web spiders, Comb footed spiders

Theridiidae is a worldwide distributed family whose members construct irregular space webs or tangle webs. Some genera are kleptoparasitic on other web building spiders. They are ecribellate, entelegyne spiders with eight eyes, tarsi IV with a row of curved serrated bristles.

Genera; species in world -122; 2470

Genera; species in India – 26, 76

Genera; species in present study – 37, 63

List of species in present study -

Argyrodes bonadea, A. fissifrons

Ariamnes flagellum, Cephalobares globiceps

Chrysso sp1, *Chrysso* sp2

Coleosoma blandum, Coscinida tibialis, Crustulina sp1, *Cryptachaea* sp1

Dipoena sp1, *Dipoenura cyclosoides, Emertonella taczanowski*

Episinus nubilus, Euryopis elegans, E. episinoides, E. nubila

Faiditus xiphias, Faiditus sp1, *Hentziectypus* sp1

Janula germaini, Janula sp1, *Janula* sp3, *Lasaeola* sp1

Meotipa picturata, Moneta mirabilis

Neospintharus sp cf nipponicus, Neottiura sp2,

Parasteatoda japonica, P. tepidariorum

Pholcomma sp1

Phoroncidia nasuta, P. septemaculeata, Phoroncidia sp4, *Phoroncidia* sp5

Phycosoma gui, P. labialis, P. martinae, P. stellaris, P. wangi

Phylloneta sp1

Platnickina maculata, P. mneon, Platnickina sp1

Propostira quadrangulata,

Rhomphaea labiata, Rhomphaea projiciens, R. sagana, R. sinica,

Ruborridion musivum, Rugathodes sp1, *Spheropistha melanosoma*

Steatoda sp1, *Steatoda* sp2, *Theonoe* sp1

Theridion sp cf hannoniae, T. sp cf pinastri, T. theridioides, Theridion sp1,

Theridion sp4

Theridula gonygaster, Thwaitesia margaritifera, Thwaitesia sp1

Taxonomic notes – Intrinsically species rich family. Still many genera like Cephalobares, Janula, Ruborridion are certainly new to India. Several species too like those belonging to *Phoroncidia, Moneta, Dipoenura* are new to India. Although, *Hentziectypus* is an American genus, some juveniles resembling it have been found.

35. THERIDIOSOMATIDAE Simon, 1881

Ray spiders

Theridiosomatidae is worldwide distributed family whose members construct webs of variable shape in dark, shaded humid areas. They are minute ecribellate, entelegyne spiders with eight eyes distinguished by pits present on anterior margin of sternum.

Genera; species in world -18; 110

Genera; species in India – 1, 1

Genera; species in present study – 1, 1

List of species in present study -

Theridiosomatidae sp1

Taxonomic notes – A few very minute spiders although the pits on sternum character could not be confirmed were assigned tentatively to this family.

36. THOMISIDAE Sundevall, 1833

Crab spiders

Thomisidae is a worldwide distributed family whose members are wandering spiders found in foliage and on ground. They are ecribellate, entelegyne spiders with eight eyes, laterals usually on tubercels; laterigrade legs with first two pairs larger and stronger than other two.

Genera; species in world - 175; 2155

Genera; species in India – 40, 176

Genera; species in present study – 20, 34

List of species in present study -

Amyciaea forticeps, Angaeus pentagonalis, Boliscus tuberculatus

Bomis bengalensis, Epidius bazarus, Henriksenia hilaris

Misumenops sp1, *Monaeses sp cf israeliensis, Monaeses* sp2

Oxytate elongata,

Ozyptila sp1, *Ozyptila* sp2, *Ozyptila* sp3

Pasias puspagiri,

Pherecydes sp1

Phrynarachne tuberose,

Runcinia sp1

Sinothomisus sp1, *Strigoplus netravati*

Synema decorata, S. revolutum

Thomisus lobosus, T. projectus, T. viveki, Thomisus sp2, *Thomisus* sp5

Tmarus kotigeharus, Tmarus sp1, *Tmarus* sp2, *Tmarus* sp3, *Tmarus* sp5,

Tmarus sp6

Xysticus sp1, *Xysticus* sp2

Taxonomic notes – *Boliscus, Pherecydes* (confirmed by personal correspondence with Dr. Ansie Dippenaar-Schoeman who has last worked on this genus) and probably *Sinothomisus* are considered new to India.

37. TRACHELIDAE Simon, 1897

Trachelidae is a widespread family whose members are characterized by reduced leg spination especially on posterior legs and dorsally on all femora. However, they lack macrosetae on legs and males have cusples. They are ecribellate entelegyne spiders with eight eyes.

This subfamily was recently elevated to family status and relimited by Ramirez (2014).

Genera; species in world -16; 209

Genera; species in India – 2 (3 as per WSC 2016)

Genera; species in present study – 2, 2

List of species in present study -

Cetonana sp1

Trachelas sp1

Taxonomic notes – *Cetonana* is probably new to India but the identification is semi-diagnostic.

38. ULOBORIDAE Thorell, 1869

Hackled-orb spiders, Triangle-web spiders, Single-line web spiders

Uloboridae is a worldwide distributed family whose members construct complex orb webs or webs reduced even to a single line. They are cribellate, entelegyne spiders with eight eyes, venom glands are absent.

Genera; species in world -18; 281

Genera; species in India – 5, 23

Genera; species in present study – 2, 3

List of species in present study -

Miagrammopes thwaitesi

Uloborus bigibbosus, U. ferokus

Taxonomic notes – Although large variation could be seen in both the genera of this family recorded in this study, all specimen were assigned to one of the three species which could be tentatively identified.

39. ZODARIIDAE Thorell, 1881

Burrowing spiders, Ant-eating spiders

Zodariidae is a tropical and subtropical family with few Palearctic genera. They are free-living ground dwellers or foliage dwellers usually feeding on ants and termites. They are ecribellate, entelegyne spiders with six or eight eyes.

Genera; species in world -83; 1112

Genera; species in India – 9, 24

Genera; species in present study – 7, 11

List of species in present study -

Asceua cingulata, Cicynethis sp1, *Cryptothele collina*

Euryeidon sp1, *Mallinella* sp1, *Mallinella* sp2

Storena birenifer, Storena sp2

Zodarion sp1, *Zodarion* sp2, *Zodarion* sp3

Taxonomic notes – Although generic identification was fairly easier for this family, the species could not be assigned with certainty. Only a single adult of *Cryptothele collina* was collected near the end of fieldwork.

5.2.4 Spider Discoveries

A total of 51 species belonging to 34 genera are considered here as being reported for the first time from India. Overall, 29 genera are also being reported for the first time from India. One genus and its constituent species *Echinax panache* has already been reported in peer reviewed journal (Patil et al. 2015). Fifty one species have been identified in consultation with available literature and experts while 18 species could be assigned to genus only. A list of these genera and species is presented in table 5.3. Their known distribution is also indicated based on World Spider Catalog (2016). It could be seen that the known distributions of most of these species and genera were such that there is high probability of their occurrence in India. Some of these newly discovered spiders are shown with their diagnostic characters in Plates 14-30.

Table 5.3 List of genera and species considered as New to India based on taxonomic investigations carried out on spiders of Dapoli, India. Only the genera suffixed with * are new to India.

Family/Genus	Species	Known distribution
Araneidae		
Araneus Clerck, 1757	*Araneus ejusmodi* Bosenberg and Strand, 1906	China, Korea, Japan
Chorizopes O. Pickard-Cambridge, 1870	*Chorizopes frontalis* O. Pickard-Cambridge, 1870	Sri Lanka to Sumatra
Cyclosa Menge, 1866	*Cyclosa monticola* Bosenberg and Strand, 1906	Russia, China, Korea, Taiwan, Japan
	Cyclosa omonaga Tanikawa, 1992	China, Korea, Taiwan, Japan
Cyphalonotus Simon, 1895*	*Cyphalonotus* sp1	South and South-East Asia, Africa
Eriovixia Archer, 1951	*Eriovixia cavaleirie* (Schenkel, 1963)	China
	Eriovixia huwena Han and Zhu, 2010	China
	Eriovixia jianfengensis Han and Zhu, 2010	China
	Eriovixia nigrimaculata Han and Zhu, 2010	China
	Eriovixia pseudocentrodes (Bosenberg and Strand, 1906)	China, Laos, Japan
	Eriovixia sakiedaorum Tanikawa, 1999	Hainan, Taiwan, Japan
Hypsosinga Ausserer, 1871*	*Hypsosinga sanguinea* (C. L. Koch, 1844)	Palearctic
Larinia Simon, 1874	*Larinia bonneti* Spassky, 1939	Palearctic
Neoscona Simon, 1866	*Neoscona subpullata* (Bosenberg and Strand, 1906)	China, Korea, Japan
Poltys C. L. Koch, 1843	*Poltys stygius* Thorell, 1898	Myanmar to Queensland

Table 5.3 (contd.) List of genera and species considered as New to India based on taxonomic investigations carried out on spiders of Dapoli, India.

Family/Genus	Species	Known distribution
Clubionidae		
Clubiona Latreille, 1804	*Clubiona brevispina* Huang and Chen, 2012	Taiwan
	Clubiona pteronetoides Deeleman-Reinhold, 2001	Thailand
	Clubiona viridula Ono, 1989	China, Taiwan, Thailand, Ryukyu Islands, Lesser Sunda Islands
Pristidia Deeleman-Reinhold, 2001*	*Pristidia* sp1	South and South-East Asia
Pteroneta Deeleman-Reinhold, 2001*	*Pteroneta* sp1	South-East Asia, Astralia
Corinnidae		
Echinax Deeleman-Reinhold, 2001*	*Echinax panache* Deeleman-Reinhold, 2001	China, **India**, Thailand
Gnaphosidae		
Hitobia Kamura, 1992*	*Hitobia* sp1	South Asia, South-East Asia
Micythus Thorell, 1897*	*Micythus* sp1	South Asia, South-East Asia
Hersiliidae		
Murricia Simon, 1882	*Murricia cornuta* Baehr and Baehr, 1993	Singapore
Mimetidae		
Ero C. L. Koch, 1836*	*Ero* sp1	Cosmopolitan

Table 5.3 (contd.) List of genera and species considered as New to India based on taxonomic investigations carried out on spiders of Dapoli, India.

Family/Genus	Species	Known distribution
Oonopidae		
Aprusia Simon	*Aprusia vestigator* (Simon, 1893)	Sri Lanka
Orchestina Simon, 1882*	*Orchestina pilifera* Dalmas, 1916	Sri Lanka
Palpimanidae		
Boagrius Simon, 1893*	*Boagrius* sp1	Tanzania, Malaysia, Sumatra
Steriphopus Simon, 1887*	*Steriphopus* sp1	Myanmar, China, Seychelles, Sri Lanka
Pholcidae		
Leptopholcus Simon, 1893	*Leptopholcus podophthalmus* (Simon, 1893)	Sri Lanka to China, Singapore
Salticidae		
Myrmarachne MacLeay, 1839	*Myrmarachne spissa* (Peckham and Peckham, 1892)	Sri Lanka
Plexippoides Proszynski, 1984*	*Plexippoides zhangi* Peng et al. 1998	China
Uroballus Simon, 1902*	*Uroballus* sp1	Sri Lanka, Borneo, Vietnam
Tetragnathidae		
Mesida Kulczynski, 1911*	*Mesida gemmea* (Hasselt, 1882)	Myanmar to Java, Taiwan

Table 5.3 (contd.) List of genera and species considered as New to India based on taxonomic investigations carried out on spiders of Dapoli, India.

Family/Genus	Species	Known distribution
Theridiidae		
Coleosoma O. Pickard-Cambridge, 1882	*Coleosoma blandum* O. Pickard-Cambridge, 1882	Cosmopolitan
Dipoenura Simon, 1909	*Dipoenura cyclosoides* (Simon, 1895)	Sierra Leone, China, Laos
Episinus Walckenaer, in Latreille, 1809	*Episinus nubilus* Yaginuma, 1960	China, Korea, Taiwan, Japan, Ryukyu Islands
Euryopis Menge, 1868	*Euryopis elegans* Keyserling, 1890	Australia
	Euryopis episinoides (Walckenaer, 1847)	Mediterranean, China
Hentziectypus Archer, 1946*	*Hentziectypus* sp1	North and South America
Janula Strand, 1932*	*Janula nebulosa* (germaini) (Simon, 1895)	Brazil, Paraguay
Lasaeola Simon, 1881*	*Lasaeola* sp1	Cosmopolitan
Moneta O. Pickard-Cambridge, 1870	*Moneta mirabilis* (Bosenberg and Strand, 1906)	China, Korea, Laos, Malaysia, Taiwan, Japan
Neospintharus Exline, 1950*	*Neospintharus* cf *nipponicus* (Kumada, 1990)	China, Korea, Japan
Neottiura Menge, 1868*	*Neottiura* sp2	Cosmopolitan
Parasteatoda Archer, 1946	*Parasteatoda japonica* (Bosenberg and Strand, 1906)	China, Laos, Taiwan, Korea, Japan
Pholcomma Thorell, 1869*	*Pholcomma* sp1	Cosmopolitan
Phoroncidia Westwood, 1835	*Phoroncidia nasuta* (O. Pickard-Cambridge, 1873)	Sri Lanka, Taiwan, Japan
	Phoroncidia septemaculeata (O. Pickard-Cambridge, 1873)	Sri Lanka
Phycosoma O. Pickard-Cambridge, 1879*	*Phycosoma* (Dipoena) gui Zhu, 1998	China
	Phycosoma (Dipoena) wangi Zhu, 1998	China, Korea
	Phycosoma labialis (Zhu, 1998)	China
	Phycosoma stellaris (Zhu, 1998)	China

Table 5.3 (contd.) List of genera and species considered as New to India based on taxonomic investigations carried out on spiders of Dapoli, India.

Family/Genus	Species	Known distribution
Phylloneta Archer, 1950*	*Phylloneta* sp1	Mainly Holarctic but also in Karakoram
Platnickina Kocak and Kemal, 2008	*Platnickina maculata* (Yoshida, 2001)	Japan
Rhomphaea L. Koch, 1872	*Rhomphaea labiata* (Zhu and Song, 1991)	China, Korea, Laos, Japan
	Rhomphaea sagana (Donitz and Strand, 1906)	Russia, Azerbaijan to Japan, Philippines
	Rhomphaea sinica (Zhu and Song, 1991)	China
Ruborridion Wunderlich, 2011*	*Ruborridion musivum* Simon, 1873	Mediterranean
Spheropistha Yaginuma, 1957*	*Spheropistha melanosoma* Yaginuma, 1957	Korea, japan
Theonoe Simon, 1881*	*Theonoe* sp1	Cosmopolitan
Theridion Walckenaer, 1805	*Theridion* sp cf *hannoniae* Denis, 1944	Europe, North Africa, Turkey, Madeira, Canary Is.
	Theridion theridioides (Keyserling, 1890)	China, Queensland, New South Wales
Thomisidae		
Boliscus Thorell, 1891*	*Boliscus tuberculatus* (Simon, 1886)	China, Myanmar to Japan
Monaeses Thorell, 1869	*Monaeses* sp cf *israeliensis* Levy, 1973	Greece, Turkey, Israel, Lebanon, Central Asia
Pherecydes O. Pickard-Cambridge, 1883*	*Pherecydes* sp1	Africa
Zodariidae		
Cicynethus Simon, 1910*	*Cicynethus* sp1	Namibia, South Africa
Euryeidon Dankittipakul and Jocque, 2004*	*Euryeidon* sp1	Thailand
Zodarion Walckenaer, 1826	*Zodarion* sp1	Cosmopolitan

Plate 14: Discoveries

ARANEIDAE

Araneus ejusmodi **Bosenberg & Strand, 1906**

(a) female habitus, (b) epigyne, (c) male habitus, (d) male palp retrolateral, (e) ventral, (f) prolateral

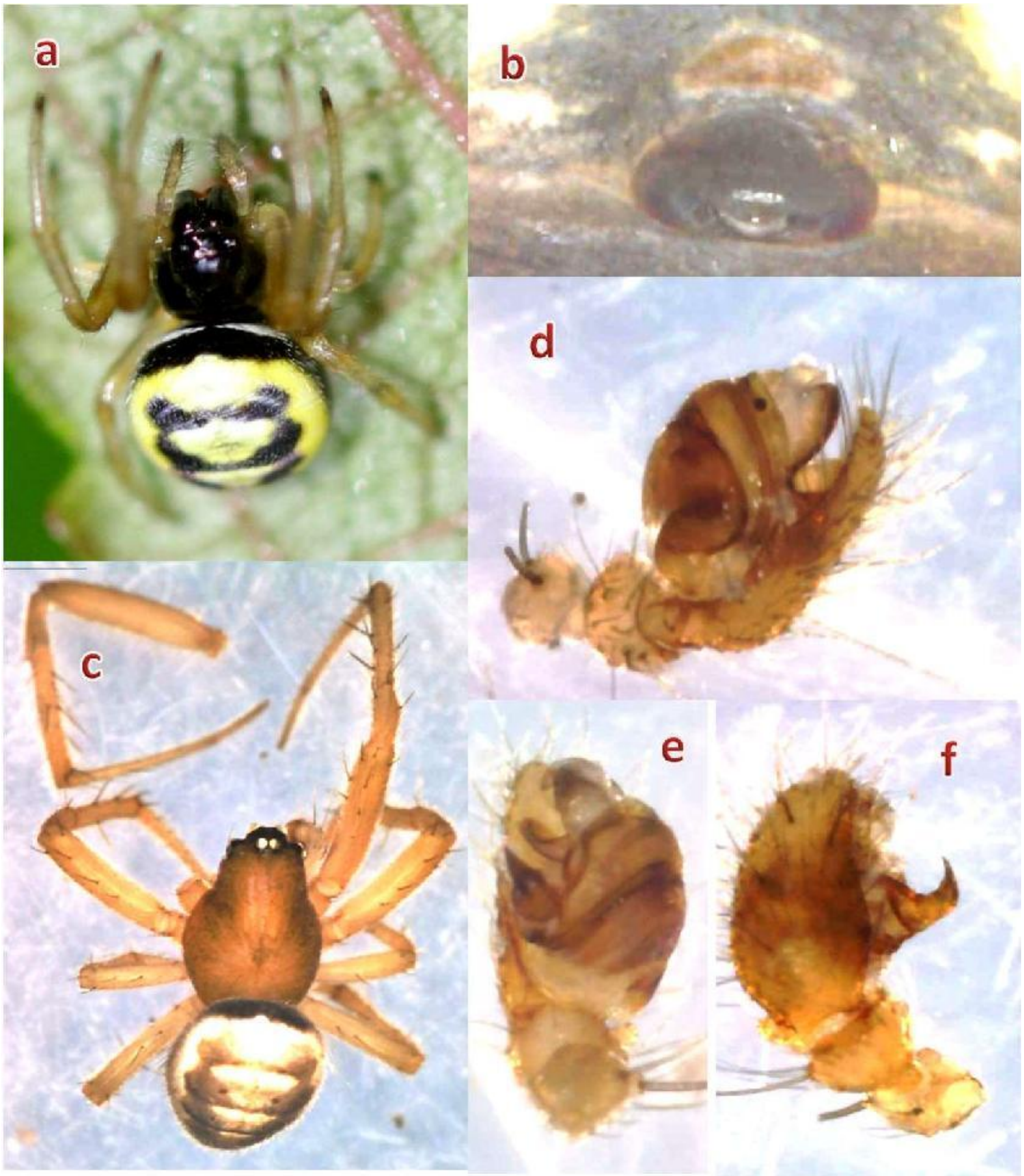


Plate 15: Discoveries
ARANEIDAE

***Chorizopes frontalis* O. P. -Cambridge, 1870**

Male habitus (a), palp prolateral (b), retrolateral (c), female eye arrangement (d), habitus (e)

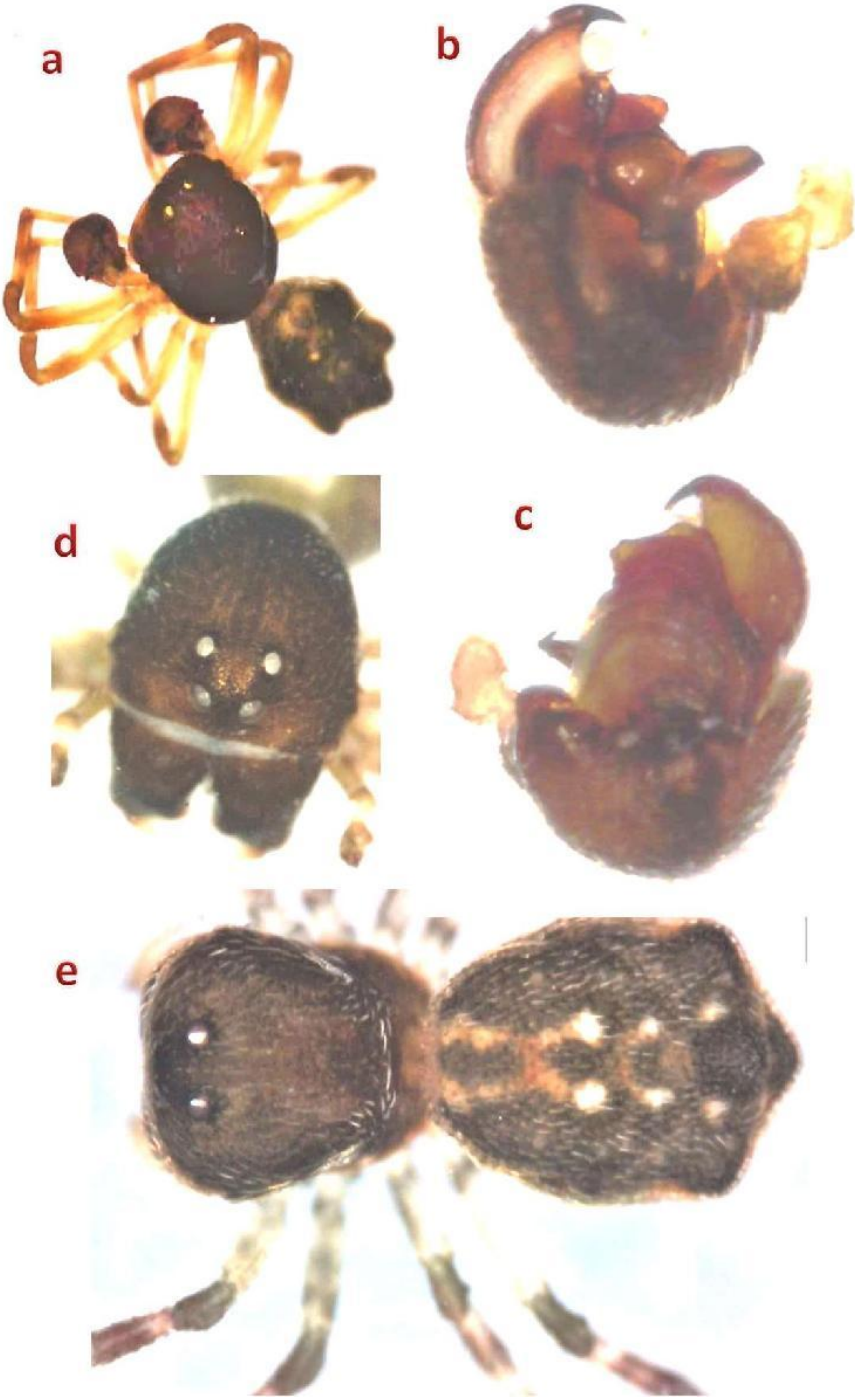


Plate 16: Discoveries
ARANEIDAE
***Cyclosa monticola* Bosenberg & Strand, 1906**
female habitus (a), epigyne (b)
***Cyphalonotus* sp1**
subadult habitus (c), lateral (d), eye arrangement (e)

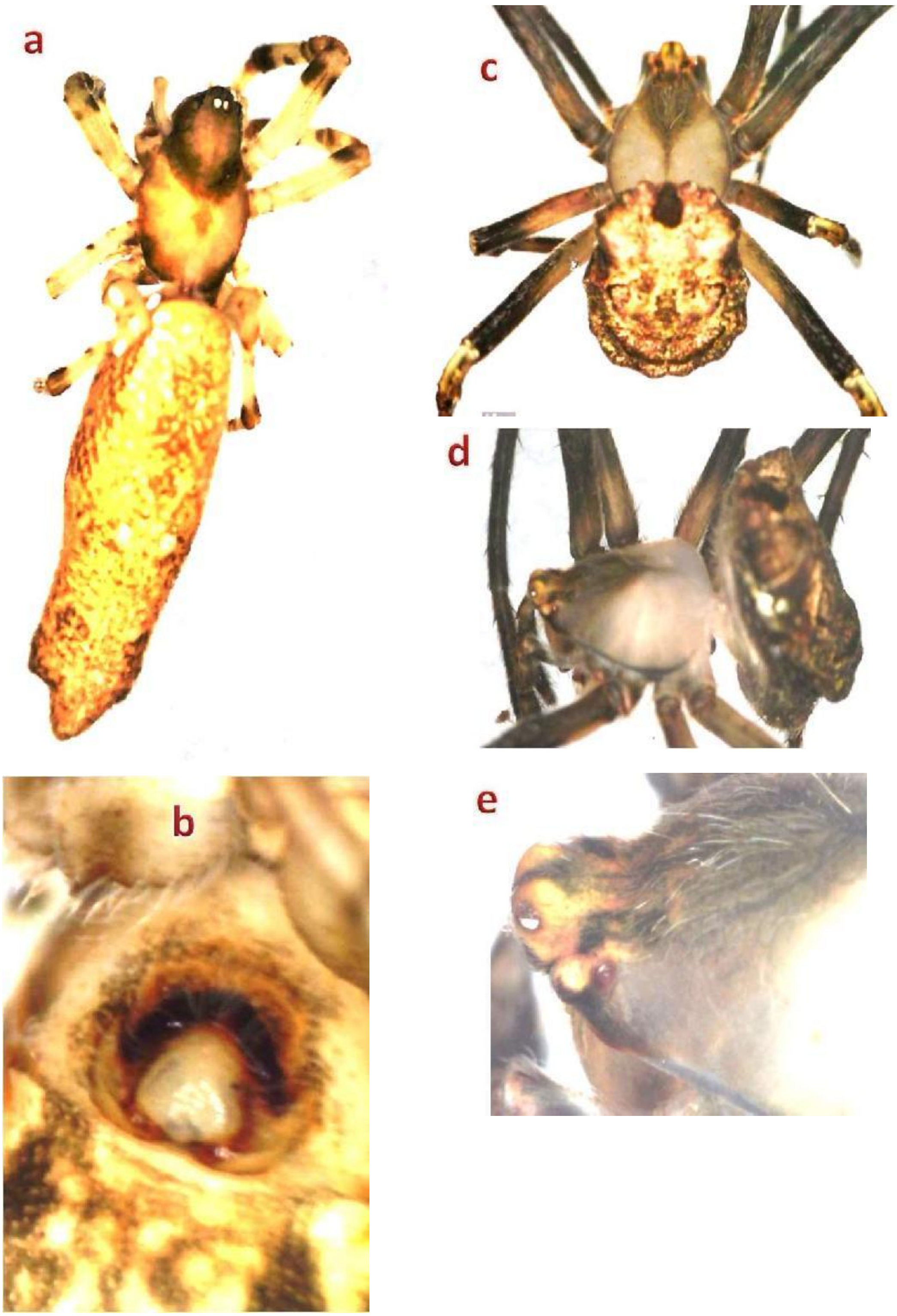


Plate 17: Discoveries

ARANEIDAE

***Eriovixia cavaleirie* (Schenkel, 1963)**

Female habitus (a), lateral (b), epigyne (c)

***Eriovixia pseudocentrodes* Bosenberg & Strand, 1906**

Female habitus (d), epigyne (e)

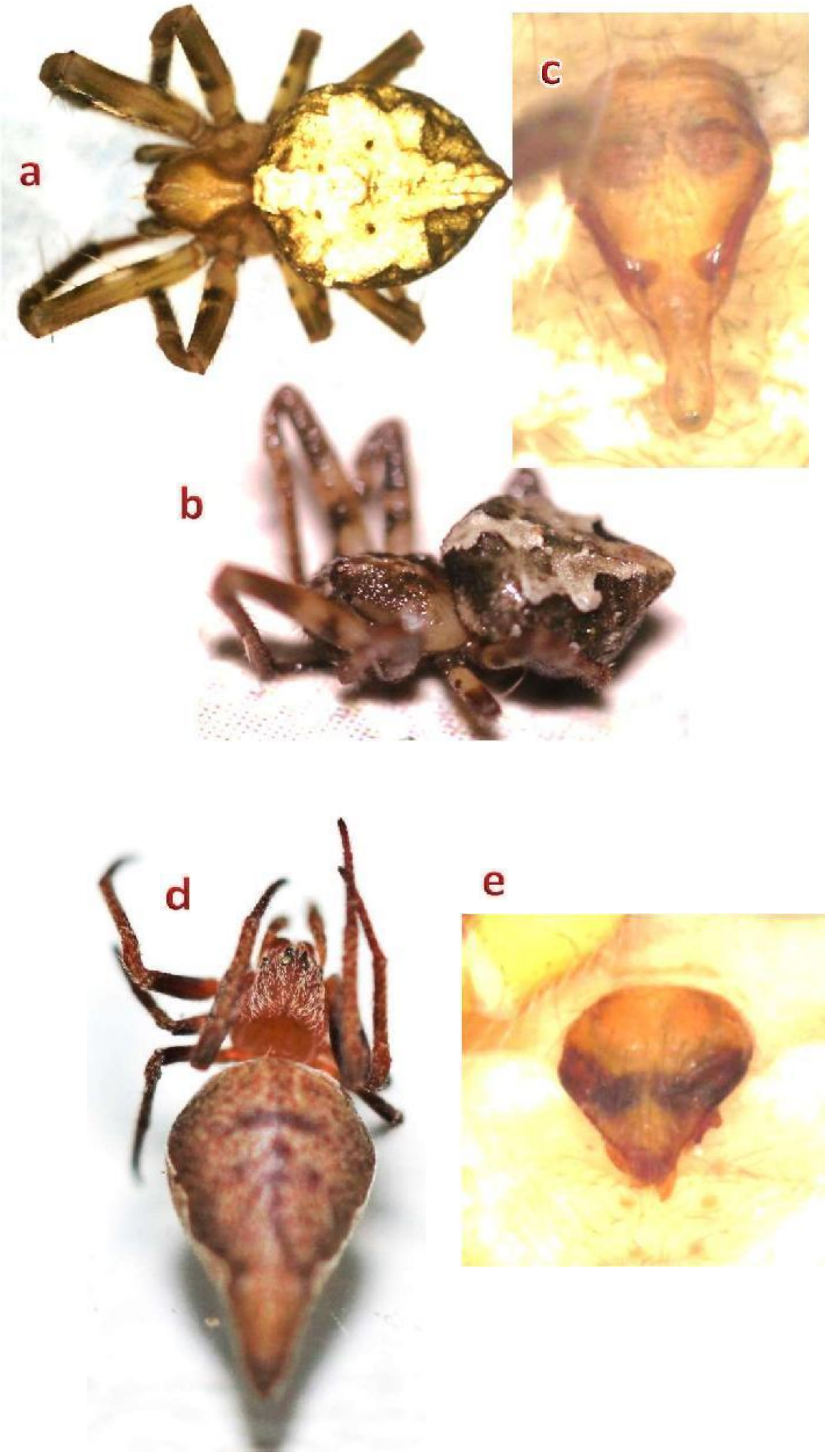


Plate 18: Discoveries

ARANEIDAE

***Eriovixia huwena* Han & Zhu, 2010**

Male habitus (a), clypeus (b), palp prolateral (c), retrolateral (d)

***Eriovixia nigrimaculata Han* & Zhu, 2010**

Juvenile habitus (e), carapace (f)

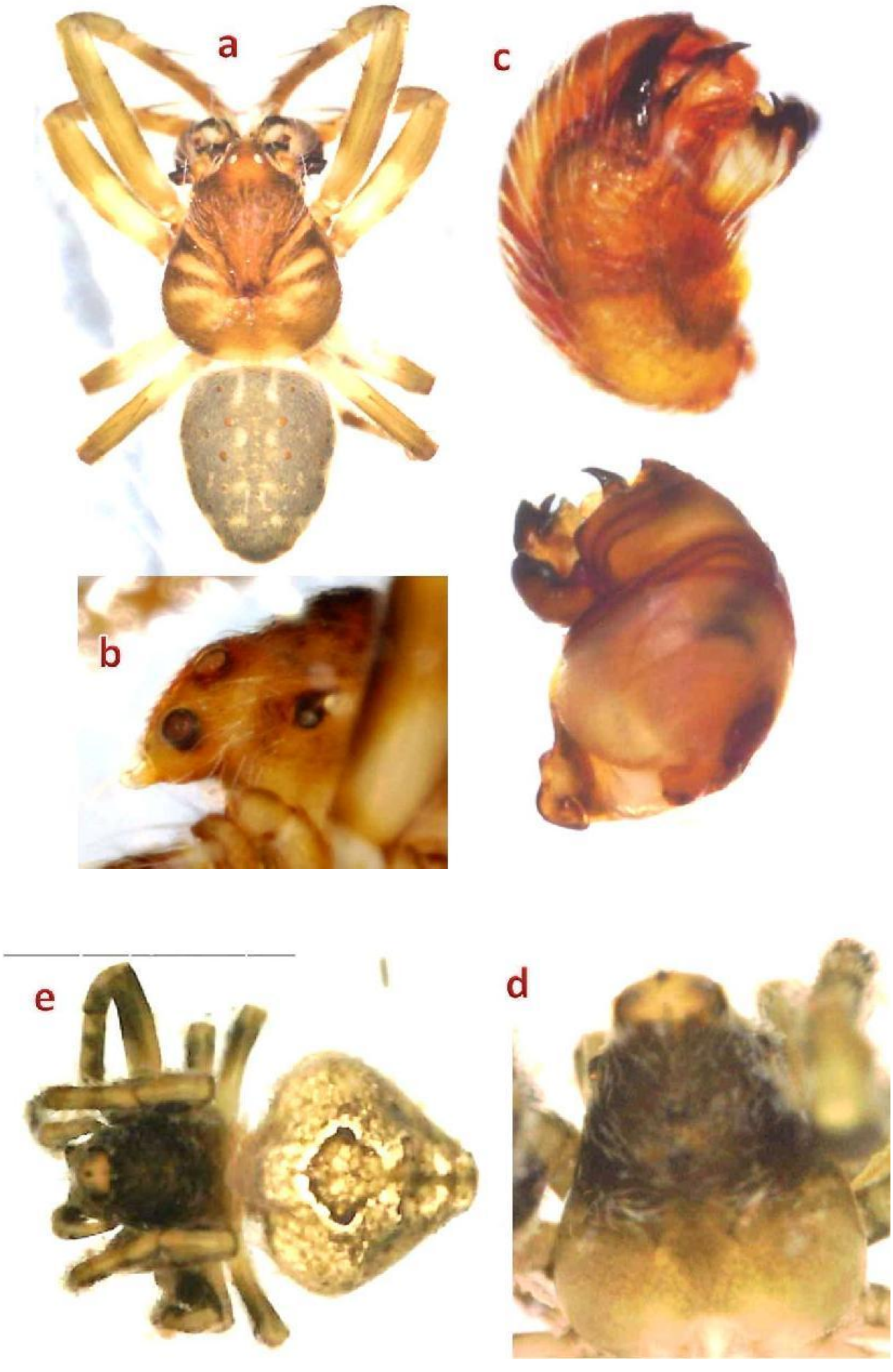


Plate 19: Discoveries

ARANEIDAE

***Eriovixia jianfengensis* Han & Zhu, 2010**

Male habitus(a), palp retrolateral (b), prolateral (c), female habitus (d)

***Eriovixia sakiedaorum* Tanikawa, 1999**

Female habitus (e), epigyne (f)

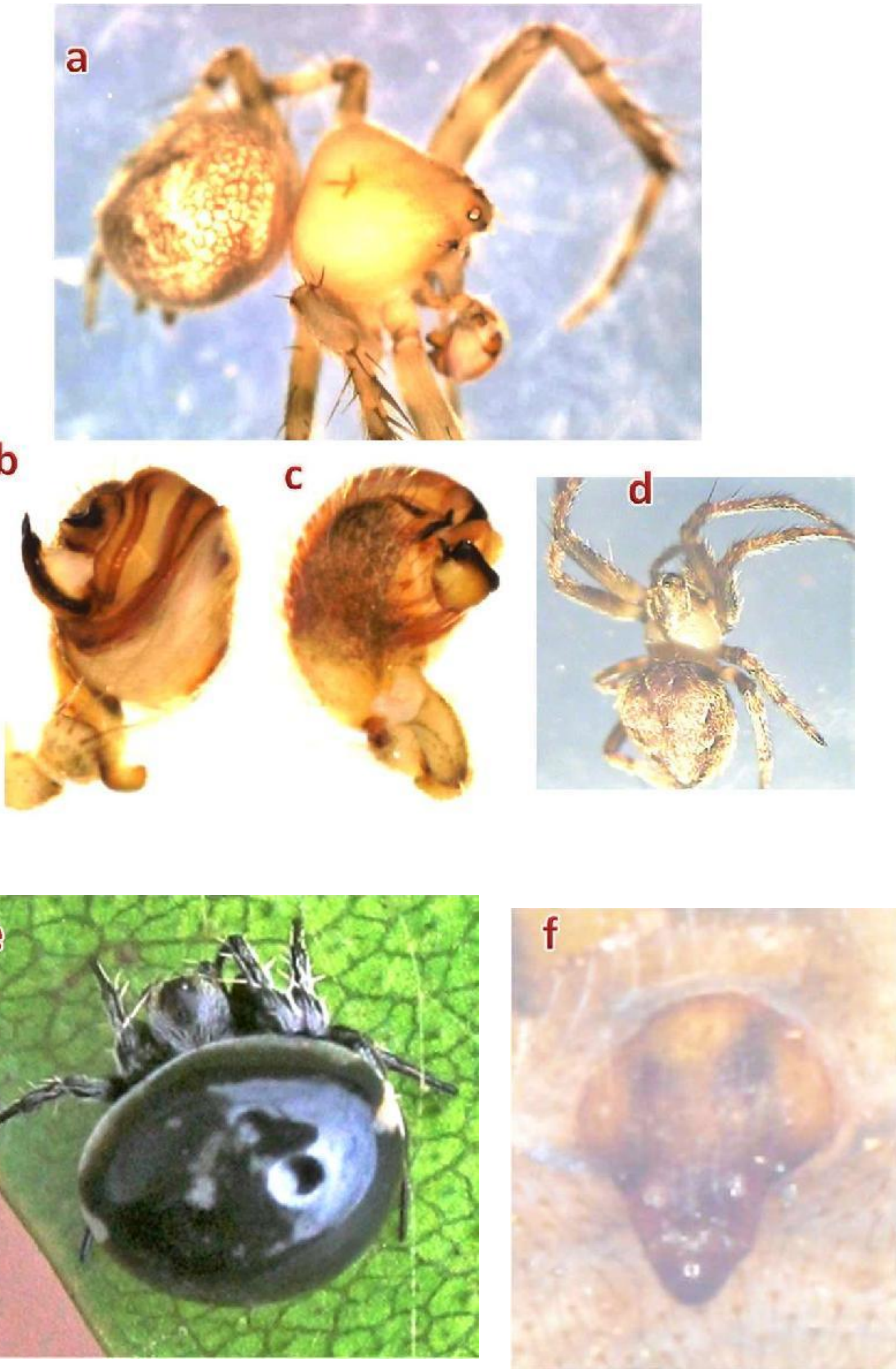


Plate 20: Discoveries
CLUBIONIDAE

***Clubiona brevispina* Huang & Chen, 2012**

Female habitus (a), epigyne (b), male palp dorsal (c), ventral (d)

***Clubiona viridula* Ono, 1989**

Female habitus (e), epigyne (f)

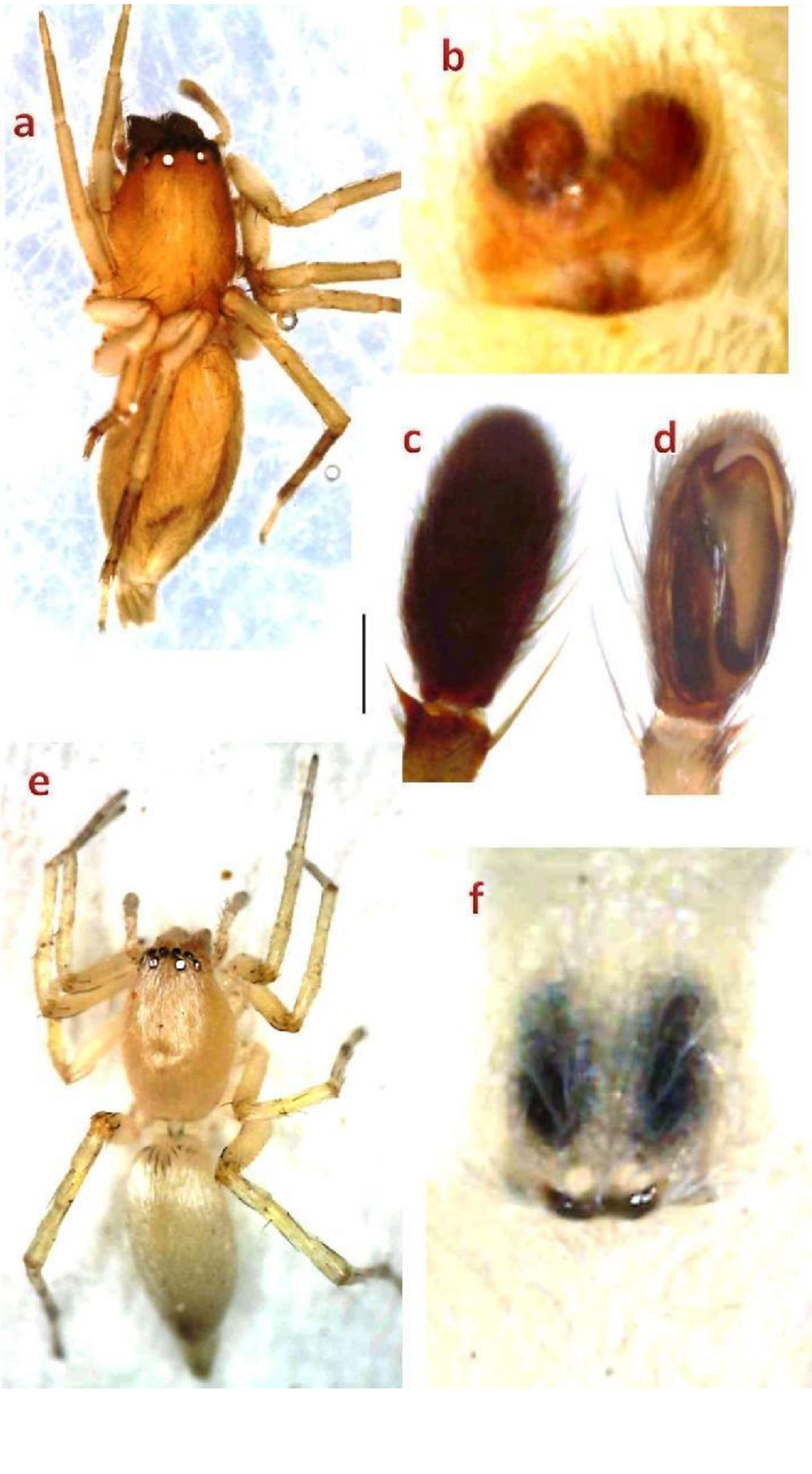


Plate 21: Discoveries

CLUBIONIDAE

***Pristidia* sp1**

Male habitus (a), palp ventral (b), prolateral (c)

***Pteroneta* sp1**

Female habitus (d), epigyne (e)

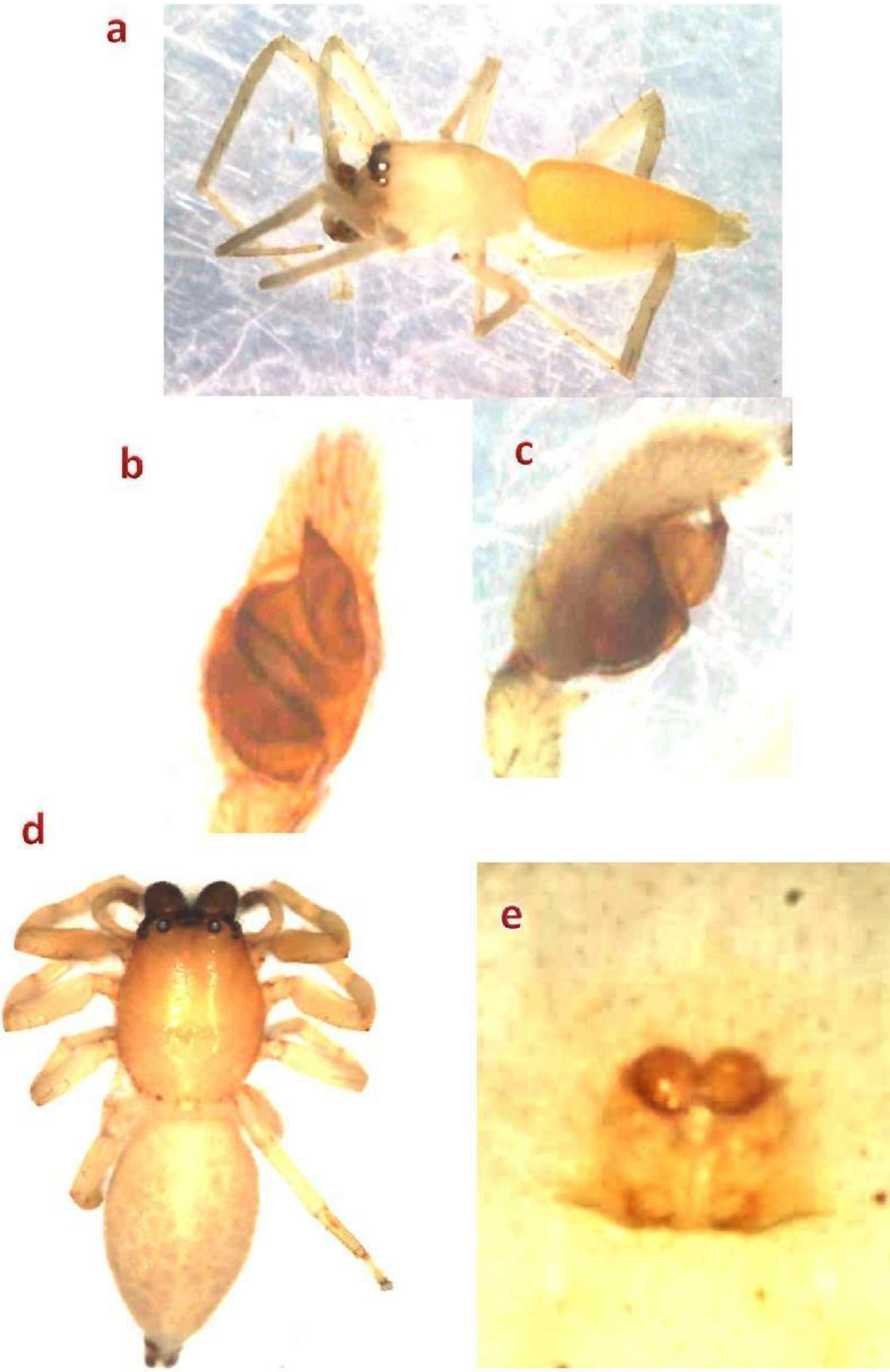


Plate 22: Discoveries

GNAPHOSIDAE

***Micythus* sp1**

Juvenile habitus (a), Male habitus (b)

HERSILIIDAE

***Murricia cornuta* Baehr & Baehr, 1993**

Female habitus (c), eye arrangment, (d), genitalia (e)

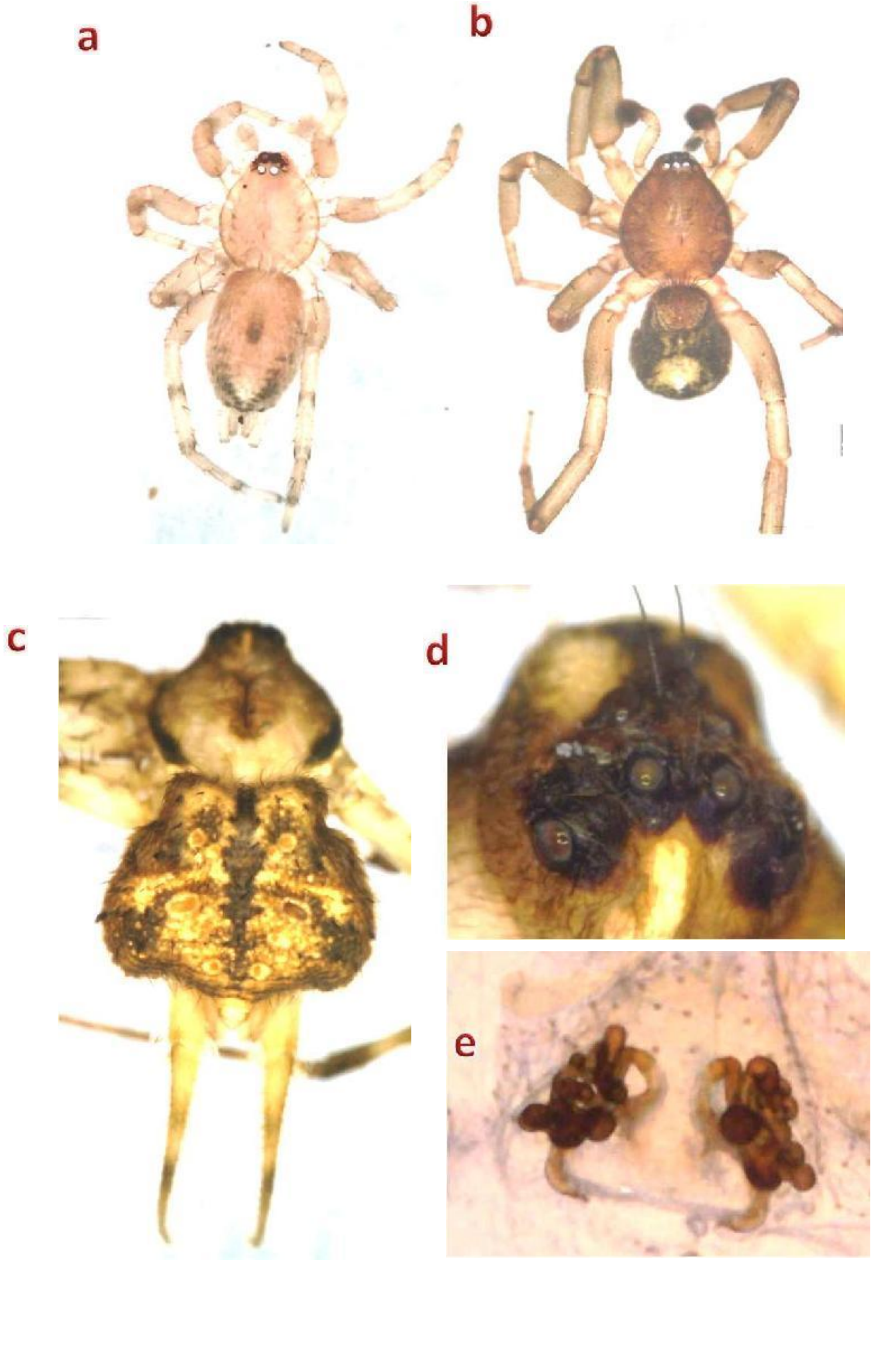


Plate 23: Discoveries

PALPIMANIDAE

***Boagrius* sp1**

Male habitus (a), palp retrolateral (b), prolateral (c), female habitus (d), epigyne (e)

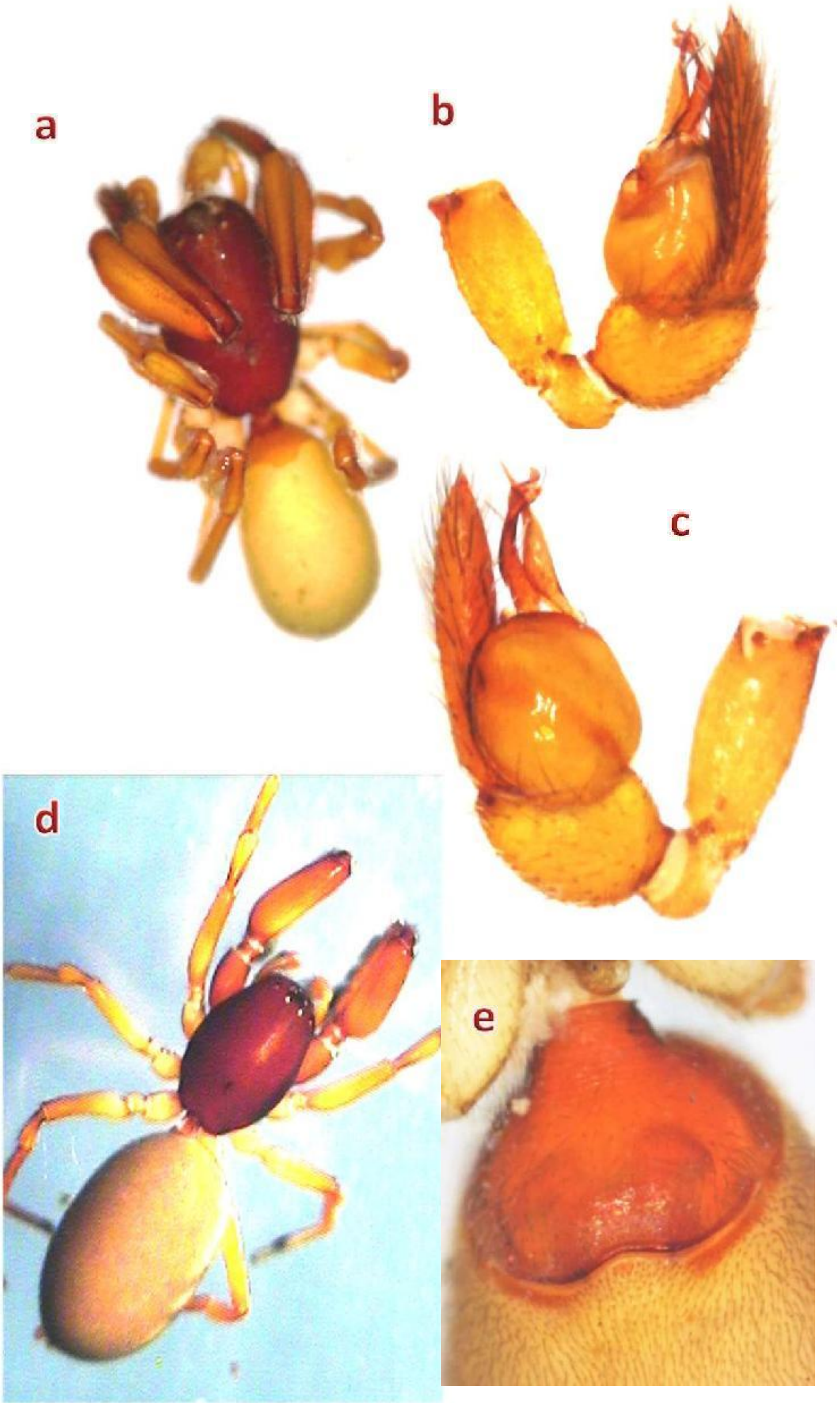


Plate 24: Discoveries
PALPIMANIDAE
***Steriphopus* sp1**

Male habitus (a), palp retrolateral (b), abdomen ventral (c), female habitus (d), epigyne (e)

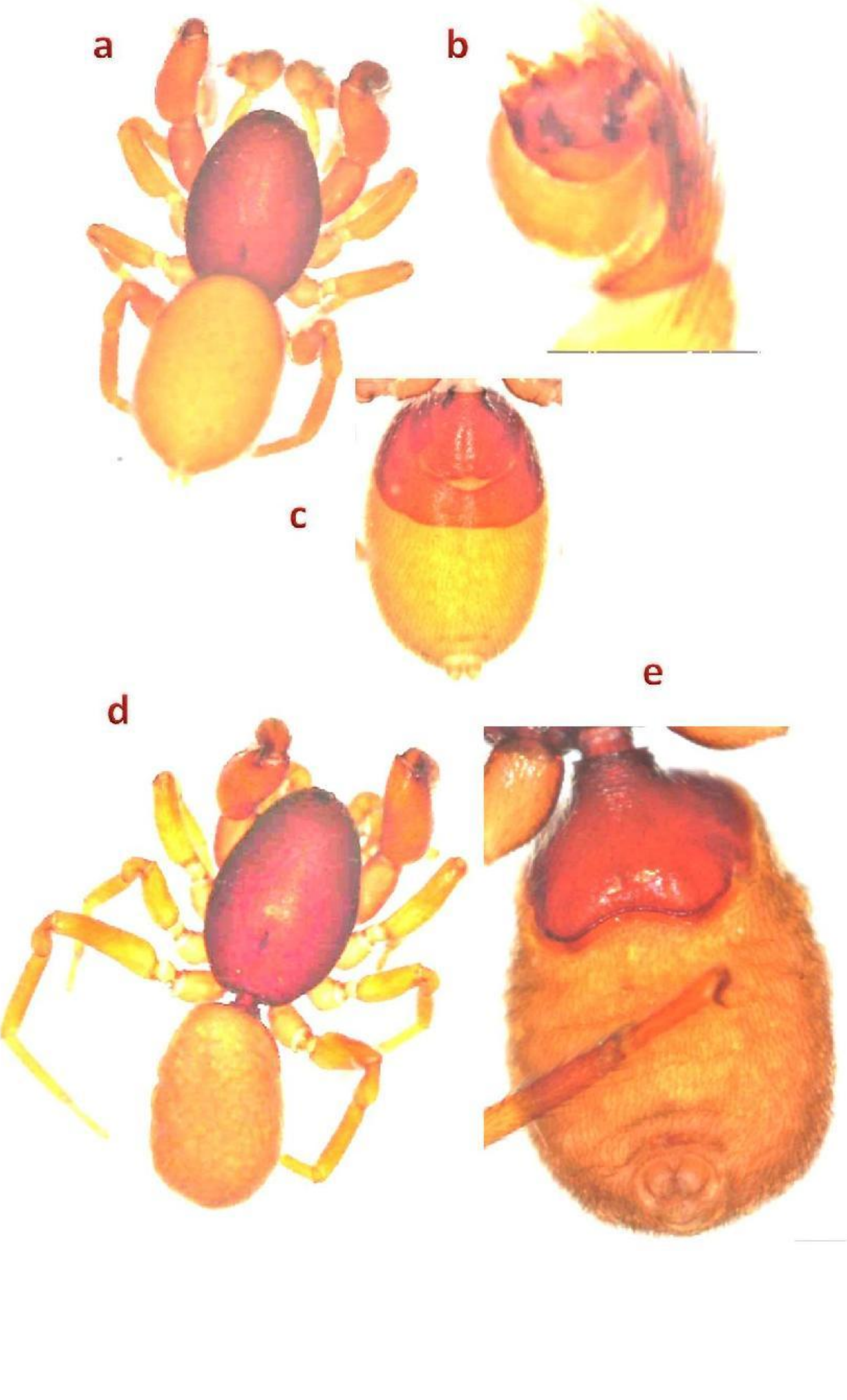


Plate 25: Discoveries
PHOLCIDAE
Leptopholcus podophthalmus **Simon 1893**

Female habitus (a), epigyne (b), genitalia (c), male eyes (d), palp retrolateral (e), prolateral (f)

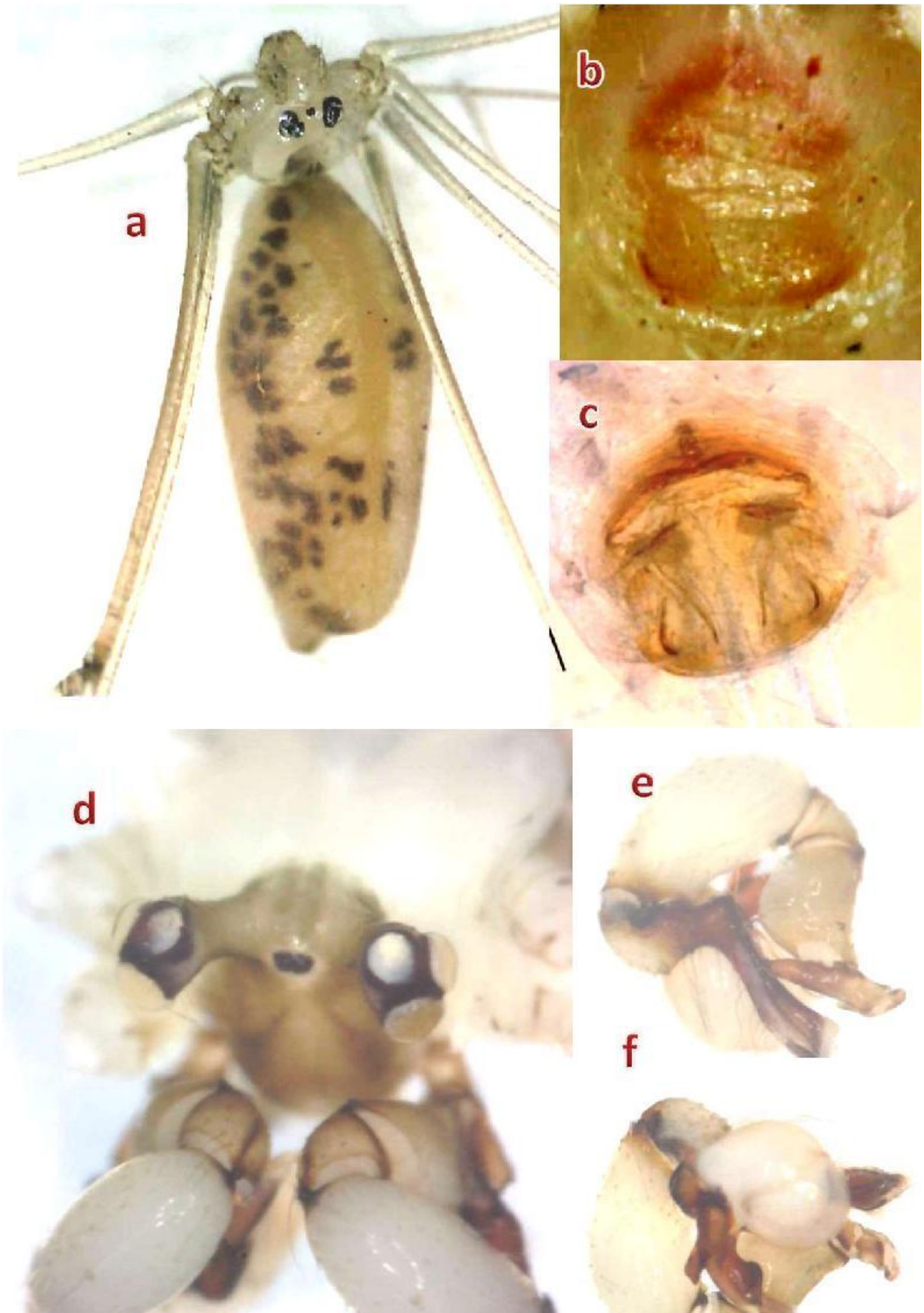


Plate 26: Discoveries

SALTICIDAE

***Plexippoides zhangi* Peng et al. 1998**

Female habitus (a), epigyne ventral (b), dorsal (c)

***Uroballus* sp1** Juvenile habitus (d)

Myrmarachne spissa Female habitus (e)

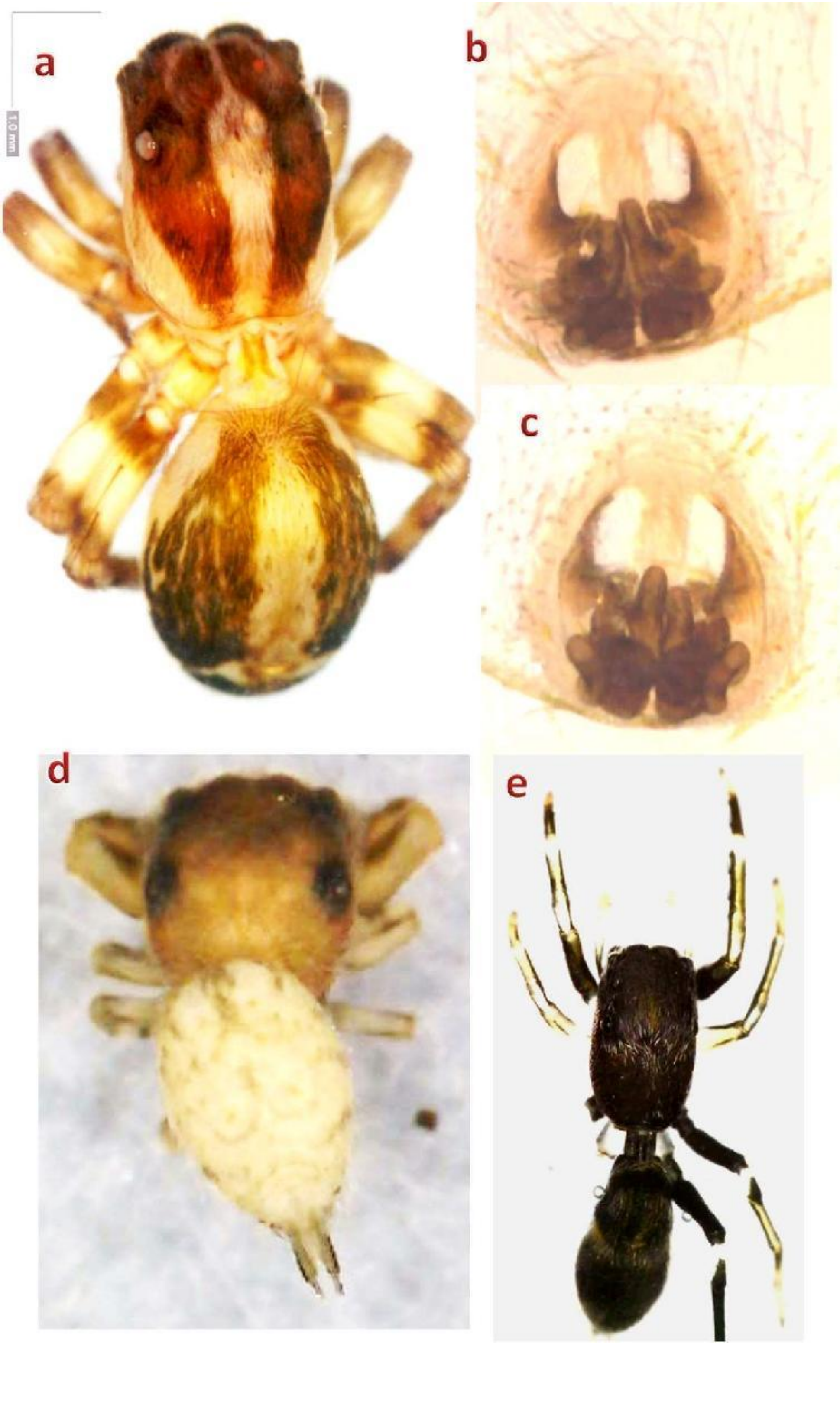


Plate 27: Discoveries

THERIDIIDAE

***Phycosoma stellaris* (Zhu, 1998)**

Male habitus (a), palp prolateral (b), retrolateral (c), female habitus (d), epigyne (e)

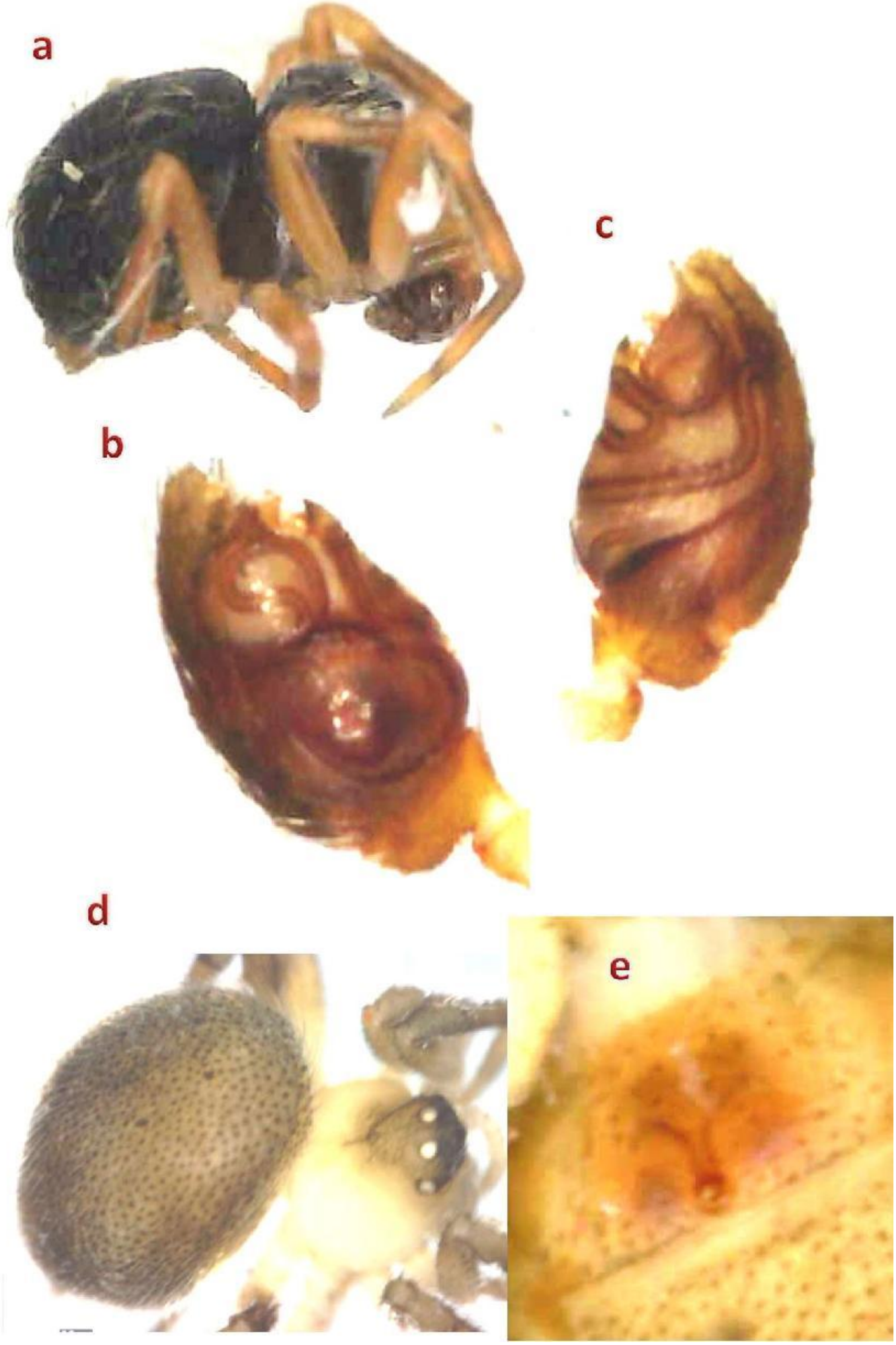


Plate 28: Discoveries

THERIDIIDAE

Rhomphaea sagana **(Donitz & Strand, 1906)**

Male habitus (a), palp prolateral (b), ventral (c), eye area (d)

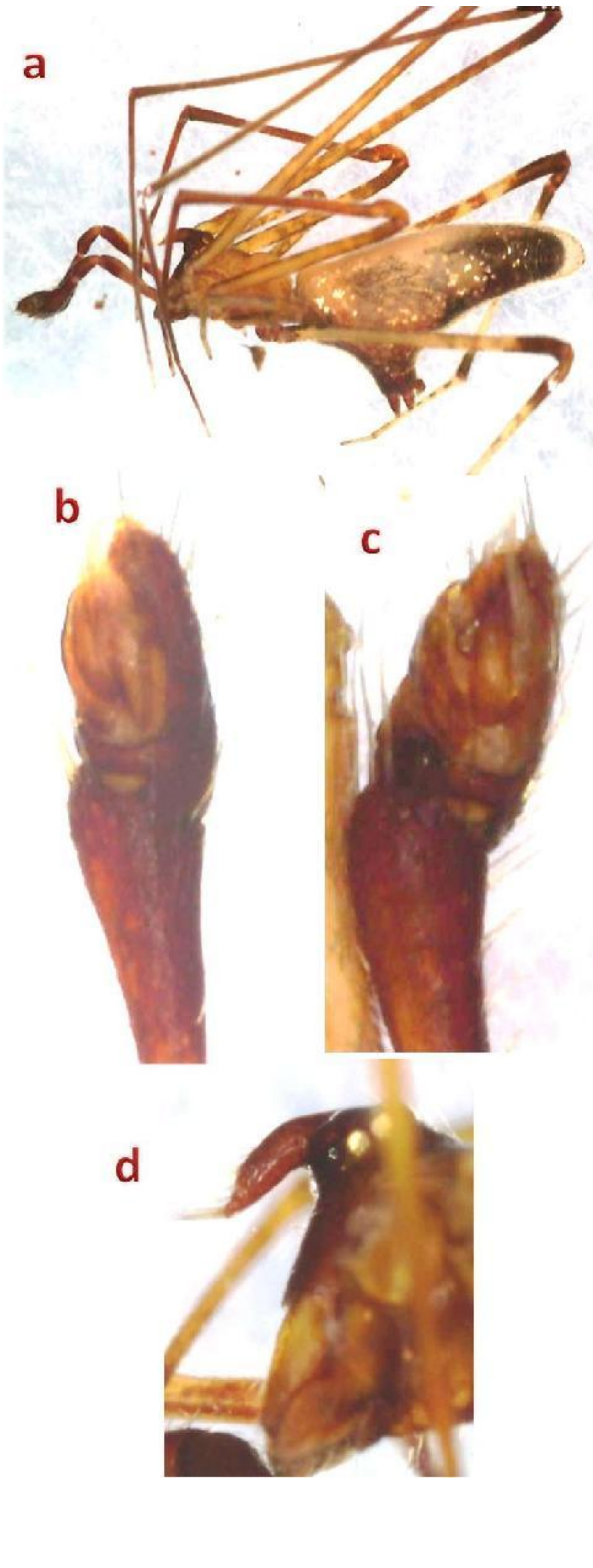


Plate 29: Discoveries
THERIDIIDAE
***Ruborridion musivum* Simon, 1873**

Female habitus (a), epigyne (b), genitalia (c)

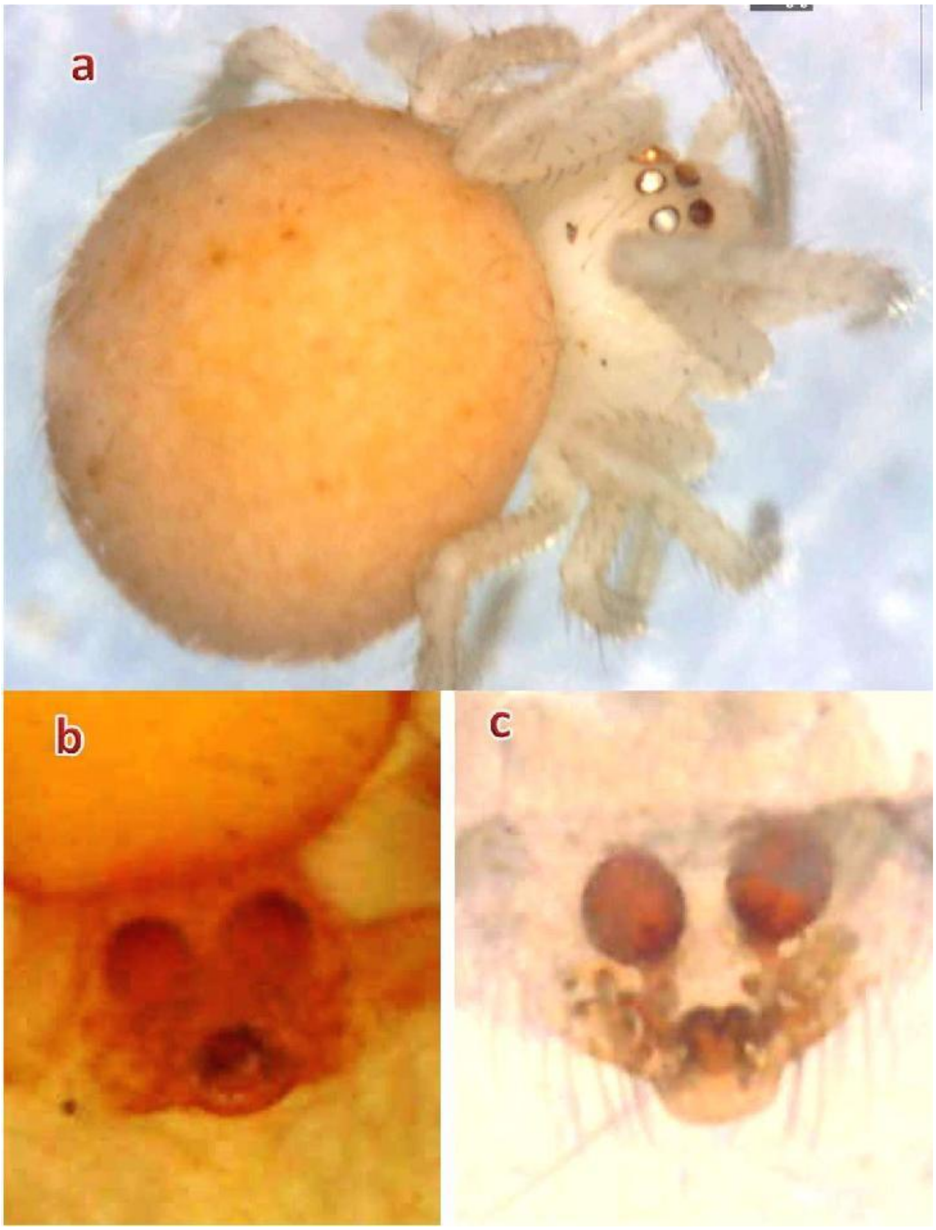


Plate 30: Discoveries
THOMISIDAE
***Boliscus tuberculatus* Simon, 1886**
Female habitus (a), sternum (b)
***Pherecydes* sp1**
Female habitus (c), carapace (d), epigyne (e)

5.3 Spiders: Diversity in Numbers

A total of 16,885 individual spiders were identified at least to family level. The rest were mostly juvenile - unidentifiable even to family - and were excluded from further analyses. Out of the spiders identified up to family level, 14,800 were identified to genus level and 13,895 to species level.

The data is presented separately for the entire spider assemblage and for its two sub-sets - the foliage-dwelling, ground-dwelling – depending on the collection method used. Refer Table 5.2 for the number of genera and species each spider family is represented by in the aforementioned spider assemblages in the study area.

Details of number of individuals collected and numbers of families, genera (including few morphogenera) and species (including morphospecies) identified based on them are given in Table 5.4. This table also gives the values of singletons (species/genera/families represented by single individuals in the dataset), doubletons (species/genera/families represented by two individuals in the dataset), estimated Chao1 and Jacknife2 estimators of species richness. The degree of completeness of the surveys is indicated by proportion that observed richness forms of the estimated richness. The range of completeness is the range from proportion with the value of highest estimator to the value of the lowest estimator. It can be seen that Chao1 was consistently the lower of the two estimators.

The foliage dweller assemblage yielded nearly double the number of individuals compared to ground-dwellers. This could have resulted due to the intrinsic difference in the method of sampling the two assemblages. The two methods were entirely different except for the effort in terms of time i.e. 20 minutes. Thus, it is difficult to infer whether the foliage dweller assemblage is intrinsically more abundant or it is an artifact of the collection method.

Again, the foliage dweller assemblage was found to be more diverse than ground dweller assemblage in terms of observed species richness (294 v/s 215). But, again, as it is a common observation that with the number of sampled individuals, the taxon richness goes on increasing. Therefore, it was difficult to infer whether the higher species richness of foliage dwellers was an intrinsic pattern or an artifact of the higher number of individuals collected owing to a different method.

Table 5.4 **Summary of Recorded abundances and taxa richness of spider assemblages (foliage-dwelling, ground-dwelling and entire) in the study area. Figures in parentheses indicate number of morphogenera and morphospecies.**

Taxa	Foliage-dwellers			Ground-dwellers			Entire assemblage		
	Fam.	Gen.	Spec.	Fam.	Gen.	Spec.	Fam.	Gen.	Spec.
No. of individuals	11,116	9,510	8,971	5,769	5,290	4,924	16,885	14,800	13,895
Observed taxon richness	34	185 (17)	294 (113)	36	168 (21)	215 (117)	39	232 (27)	377 (179)
No. of singletons	4	28	57	4	21	31	3	21	52
No. of doubletons	4	14	29	2	24	41	1	18	41
Chao1	36	210	347	40	176	226	41	243	409
Jacknife2	40	224	376	41	215	293	43	271	475
% completeness	85-94	83-88	78-85	88-90	78-95	73-95	91-95	86-95	79-92

It could be seen that a large number of morphogenera and morphospecies have been reported in this investigation. But it is also a common feature of surveys of speciose groups of organisms. It results because of inadequate literature and paucity of other resources including time. However, voucher specimen for these have been preserved and catalogued properly so that they will be diagnosed properly later on.

Another feature of such datasets is that they throw up a large number of singletons and doubletons. In the present case they are 52 and 41 respectively in the pooled dataset. These represent the rare species and many indices and estimators of species richness are sensitive to it. The non-parametric estimators indicate that there could be upto 43 families and 475 species in the study area. However, as suggested by most of its users, if Chao1 is taken as a robust estimator of species richness, 92% of the spider diversity has already been explored in this study.

Figure 5.6 depicts the species accumulation curves for the entire spider assemblage (a) foliage dwellers (b) and ground dwellers (c). The plots are of observed species richness, Chao1 and Jacknife2 species estimators. As recommended by Gotelli and Colwell (2001) to compare the sample-based abundance data, the accumulation curves are rescaled to numbers of individuals rather than numbers of samples.

The curves show increasing trends and indicate that there could be much more species that could be discovered in the study area with increased sampling intensity. There seem to be signs of these curves of observed and estimated species richness reaching an asymptote only in case of ground spiders.

Boxplots were plotted and Chi-squared test was conducted to test if there was any difference in the spider abundance and species richness across 6 seasonal sampling phases (PM1, WT1, SM1, PM2, WT2, SM2 for post-monsoon, winter and summer of 1^{st} year and 2^{nd} year respectively) and the three sampling seasons. There was an overall increase in the spider abundance and species richness from the first years's sampling phases to the second year's sampling phases. The rise was significant for abundance (Chi^2 = 687.57, p = 0.0001) but non-significant for species richness (Chi^2 = 277.28, p = 0.45) ((Figure 5.7, left boxplots). This systemic rise in capture of spiders could be attributed to the increased proficiency or practice of the collector.

However, when seasons were compared, there was significant increase in abundance (Chi^2 = 336.28, p = 0.0001) and species richness ((Chi^2 = 139.84, p = 0.03) in winter season compared to post-monsoon and summer (Figure 5.7, right boxplots). Similar patterns have been obtained by others (e.g. Lubin 1978 for web-builders, Mineo 2010 for ground dwellers). In the rice fields of Kuttanad, the ratio of juveniles to adults was high during initial crop stages i.e. towards the beginning of monsoon. It indicates that spiders multiply during the early monsoon from the adult breeding population of summers. That is wet seasons have higher species diversity and abundance of spiders. This is related with overwintering or cryptic life history stages and breeding phenology of spiders.

It was observed in the study area that spider density and diversity started increasing from mid-monsoon and reaching peak in mid-winter. Thereafter, the density and diversity started falling in summer. It was quite evident in *Nephila pilipes* and in many other orb-weavers. However, as Coddington et al. (2009) mentioned for aseasonal tropical climes, the differences were not drastic.

(a)

(b)

(c)

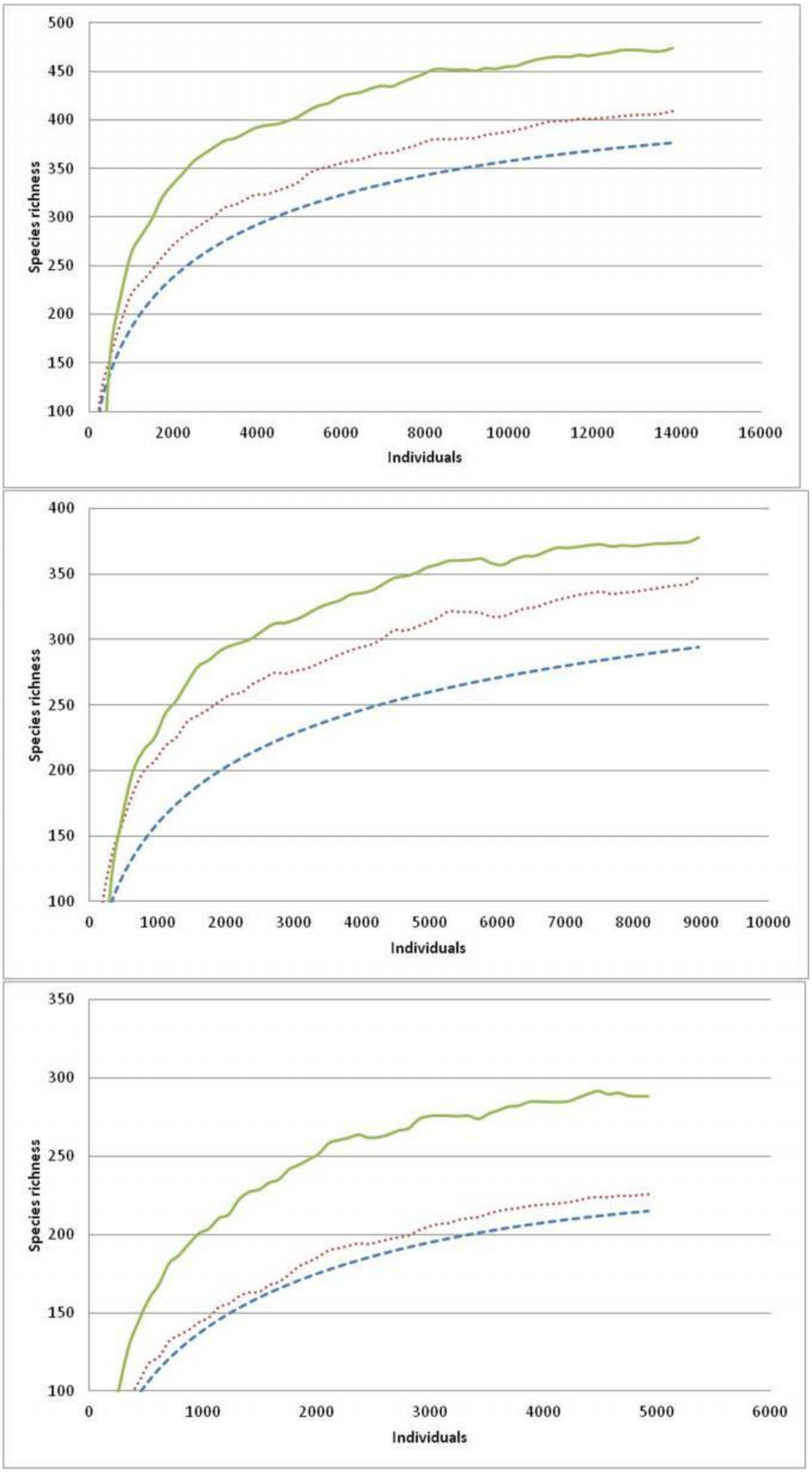


Figure 5.6 Accumulation curves of observed (dashed line) estimated Chao1 (dotted line) and estimated Jacknife2 (solid line) species richness of (a) entire spider assemblage (b) foliage dwellers and (c) ground dwellers in the study area.

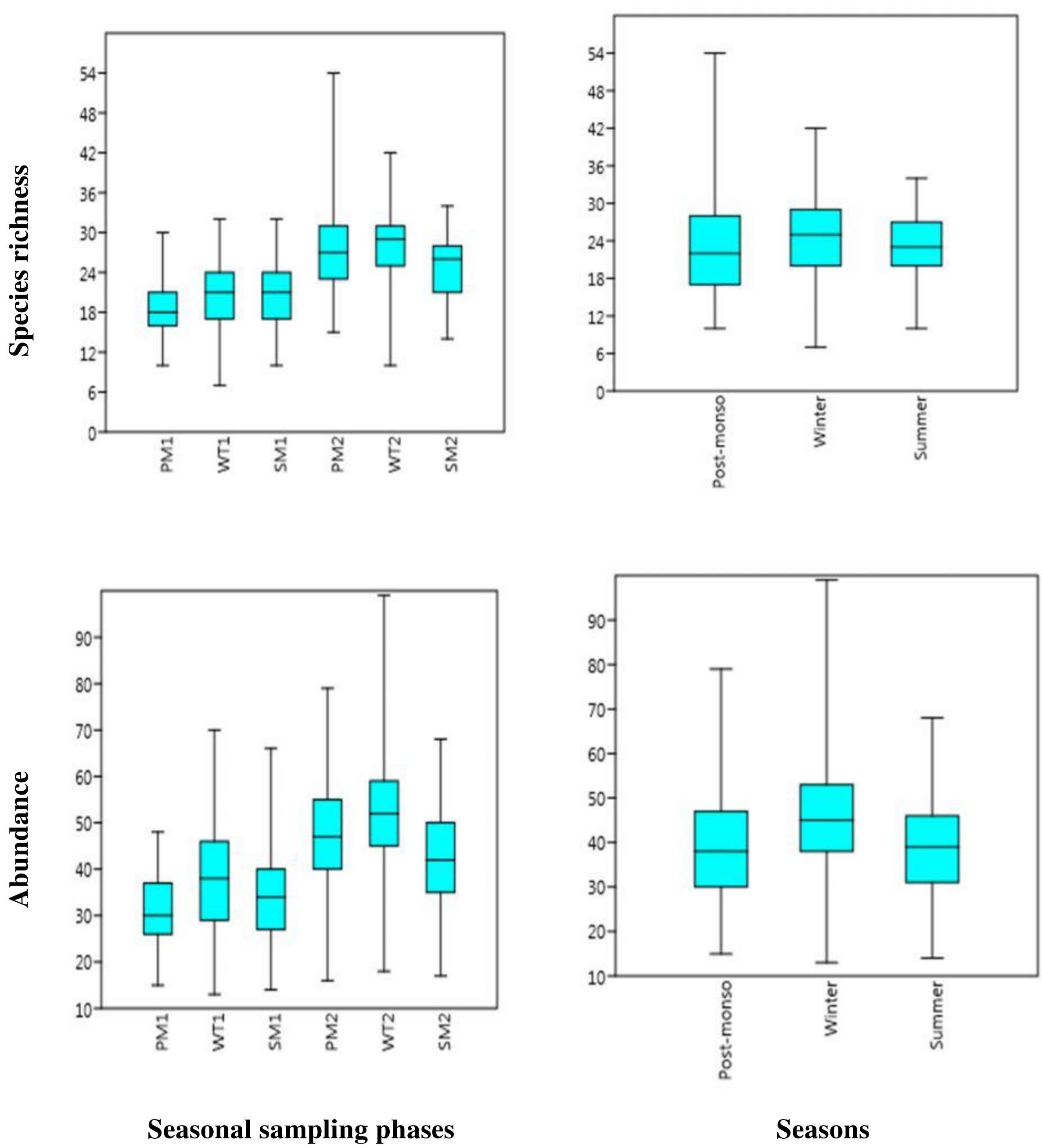


Figure 5.7 Comparison of species richness (top) and spider abundance (bottom) recorded across different seasonal sampling phases (left; PM = Post-monsoon, SM = Summer, WT = Winter) and seasons (right)

5.4 Spiders: Habitat Association

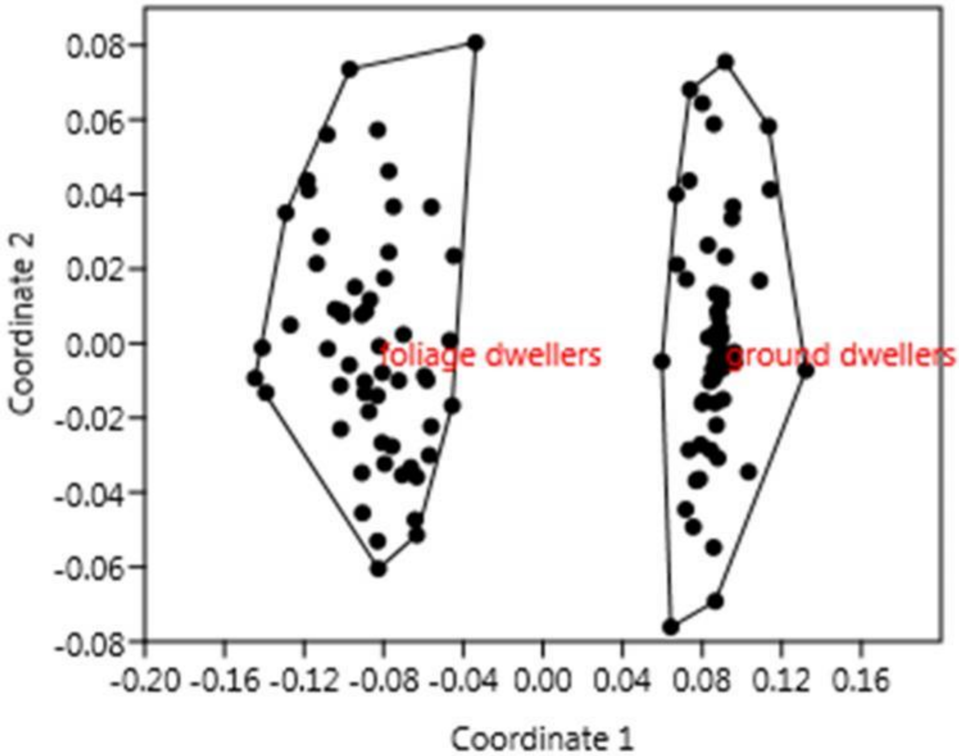
5.4.1 Distinct Spider Assemblages within Habitat

To test whether the two assemblages – foliage dwellers and ground dwellers were really distinct, NMDS was carried out in PAST using species composition and family composition separately.

NMDS plot generated by species composition clearly segregated the two spider assemblages (stress = 0.22) thus underlining their fundamentally different nature and justified the treatment of the two assemblages separately in this study (Figure 5.8a). ANOSIM resulted in significant difference between the two assemblages ($R = 0.62$, $p = 0.0001$). In SIMPER analysis, the overall dissimilarity between the assemblages based on Bray-Curtis distance was found to be 92.45 per cent. Only 25 out of 377 species contributed to over 50 per cent of the dissimilarity. These species, their mean abundances in the two assemblages and contribution to the dissimilarity are tabulated in Table 5.5. It can be seen that the species' contribution to the dissimilarity has come through their extremes of abundances in the two assemblages. But none of these main species is completely absent from any of the assemblages. It is also interesting to note that Salticidae – the dominant family in both assemblages – contributed only 5 species among these main dissimilarity-driving species. Pisauridae sp1 (which is probably a *Nilus* sp.) and Philodromidae sp1 (which is close to *Philodromus margaritatus*) were found to be the main drivers of dissimilarity between the two assemblages.

Even when the NMDS was conducted using family composition the two spider assemblages segregated even more clearly (stress = 0.16). ANOSIM also returned significant difference between the two assemblages ($R = 0.88$, $p = 0.0001$) (Figure 5.8b). Overall average dissimilarity, however, was reduced to 59.94 per cent in SIMPER using Bray-Curtis distance. Only six families contributed to more than 50 per cent of the dissimilarity (Table 5.6). As expected, Salticidae contributed maximum to the dissimilarity because of its abundance in both the assemblages. But Thomisidae, Araneidae and Oxyopidae marked out the foliage-dwellers whereas Linyphiidae and Pisauridae highlighted ground-dwellers. Thus, it could be inferred that the families contributing to the dissimilarity between these two assemblages apart from Salticidae could be targeted for monitoring protocols in the respective assemblages.

(a)



(b)

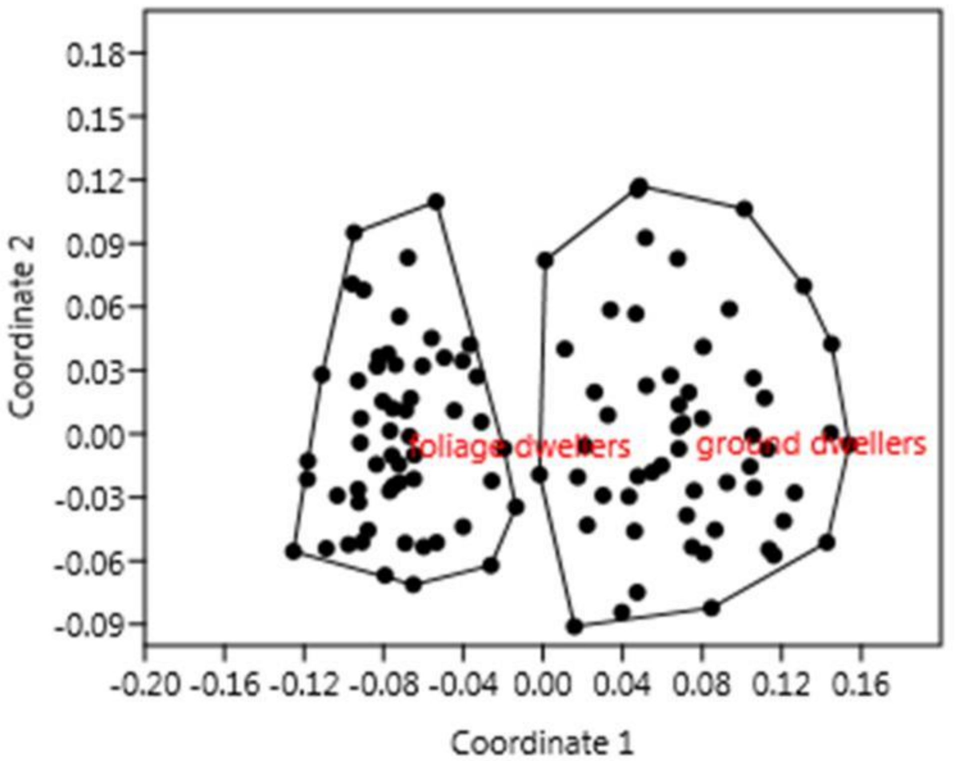


Figure 5.8 NMDS plots of sampling locations based on (a) species composition (b) family composition. Bray-Curtis distances were used.

Table 5.5 Species with major contributions to the dissimilarity between foliage dweller and ground dweller spider assemblages.

Taxon	Mean abundance in foliage dweller assemblage	Mean abundance in ground-dweller assemblage	Av. dissim	Cumulative contribution %
Pisauridae sp1	1.05	10.5	3.853	4.168
Philodromidae sp1	8.32	0.196	3.248	7.681
Asemonea tenuipes	8.27	0.268	3.212	11.16
Epeus indicus	6.91	0.0179	2.768	14.15
Hamadruas sp3	5.68	0.0714	2.224	16.56
Evarcha sp1	5.43	0.179	2.211	18.95
Brettus cingulatus	5.59	0.0179	2.178	21.3
Hamadruas sp4	5.68	0.161	2.177	23.66
Nasoona sp1	1.27	5.39	2.032	25.86
Angaeus pentagonalis	4.95	0.107	1.925	27.94
Eriovixia jianfengensis	4.45	0.232	1.767	29.85
Scytodes sp1	2.07	3.89	1.648	31.63
Asceua cingulata	0.125	3.88	1.523	33.28
Belisana dodabetta	0.125	3.75	1.513	34.92
Uloborus bigibbosus	4	0.411	1.5	36.54
Gamasomorpha sp1	0.214	3.75	1.472	38.13
Phintella vittata	3.38	0.0893	1.372	39.61
Cephalobares globiceps	3.46	0.232	1.368	41.09
Tmarus sp1	3.27	0.0357	1.311	42.51
Euophrys sp1	0.304	3.21	1.244	43.86
Micrommata sp1	2.95	1.41	1.228	45.19
Hamataliwa ovata	3.04	0.0714	1.193	46.48
Eriovixia laglaizei	3.11	0.214	1.186	47.76
Philodromus devhutai	0.25	2.98	1.12	48.97
Amyciaea forticeps	2.66	0.161	1.064	50.12

Table 5.6 Families with major contributions to the dissimilarity between foliage dweller and ground dweller spider assemblages.

Taxon	Mean abundance in foliage dweller assemblage	Mean abundance in ground-dweller assemblage	Av. dissim	Cumulative contribution %
Salticidae	0.478	0.333	5.972	9.964
Linyphiidae	0.043	0.237	5.55	19.22
Thomisidae	0.219	0.0334	5.45	28.32
Pisauridae	0.0358	0.214	5.079	36.79
Araneidae	0.214	0.0515	4.743	44.7
Oxyopidae	0.176	0.00979	4.656	52.47

5.4.2 Diversity of Spiders across Habitats

To test if the sacred groves hold diverse spider assemblages than other habitats, the diversity parameters were computed by sorting the sampling quadrats by habitat type. Table 5.7 shows the values of observed species richness, number of collected individuals, singletons, doubletons, Shannon entropy and its exponential form i.e. effective species number. It also shows values of a parametric diversity index Fisher alpha and nonparametric species richness estimators Chao1 and Jacknife2. The range of completeness of surveys was worked out by ratioing the observed species richness with the values of estimated species richness by two non-parametric estimators.

The habitats could be ranked from most species rich to least in the order of Sacred groves > Mango orchards > Reserved forests > Cashew orchards in terms of observed species richness. However, this could easily have been influenced by unequal sampling effort that was devoted to each habitat. The most effort was given to sacred groves and correspondingly higher number of spiders were collected from that habitat. Lowest effort was made in cashew orchards and correspondingly low numbers of individuals were recorded. However, in case of mango orchards, number of individuals collected was disproportionate to the amount of effort. Thus, the collection of spiders in mango orchards was more efficient compared other habitats which resulted in larger number of individuals being collected and therefore relatively large number of species being detected.

It is clear that inadequate sampling has resulted into partial exploring of the spider diversity in the orchards and even in the reserved forests. However, the results of diversity analysis provide some insights. It can be seen that at the scale of the entire assemblage the effective species numbers i.e. exponential form of Shannon's entropy gives a clue to the overall similar diversity in cashew orchards (99), mango orchards (100) and the sacred groves (100). On the other hand, he reserved forests are comparatively very low on this count. There could be many reasons behind this and some clues could be obtained by performing compositional analysis of the spider assemblages in these habitats.

The values of Fisher alpha were subjected to Kruskal-Wallis test for equality of medians. It revealed that there was no significant difference between Fisher alpha values of different habitats (chi^2 = 2.692, p = 0.44).

The so called 'rainbow' of Colwell et al (2012) is presented in Figure 5.9. This is comparison of extrapolation of species richness based on rarefaction. From the available reference sample, the richness is rarefied first and then extrapolated to a fixed number of samples that could be taken. Data used is pooled data grouped by habitat types. Compare this with the conventional accumulation curves rescaled by number of individuals (Figure 5.10).

This comparison informs us that in the orchards, the species richness reaches asymptote at a much faster rate than in sacred groves or reserved forests both in terms of number of individuals captured and number of samples collected. However, the trend is that at lower levels of sampling, the orchards tend to throw up relatively higher species richness compared to sacred groves and significantly higher species richness than in reserved forests.

Table 5.7 Observed species richness and other associated diversity measures in different habitat types in study area.

	FD	**GD**	**EA**	**FD**	**GD**	**EA**
	Cashew orchard			**Mango orchard**		
Observed Species richness	116	69	162	155	101	215
Individuals	374	254	628	1025	647	1672
Shannon_H	4.268	3.711	4.597	4.222	3.829	4.61
Effective Species number (ExpH)	71	41	99	68	46	100
Fisher_alpha	57.6	31.17	70.73	50.76	33.56	65.62
Chao-1	205	84	221	224	118	261
Jacknife2	190	112	255	242	164	317
Completeness%	57-61	62-82	64-73	64-69	62-86	68-82
	Reserved forest			**Sacred grove**		
Observed Species richness	142	84	181	260	180	334
Individuals	1405	544	1949	6167	3479	9646
Shannon_H	4.038	3.584	4.3	4.338	3.928	4.637
Effective Species number (ExpH)	57	36	74	77	51	103
Fisher_alpha	39.44	27.77	48.75	54.98	40.26	67.14
Chao-1	216	91	230	328	199	390
Jacknife2	221	133	276	352	253	449
Completeness%	64-66	63-92	66-79	74-79	71-90	74-86

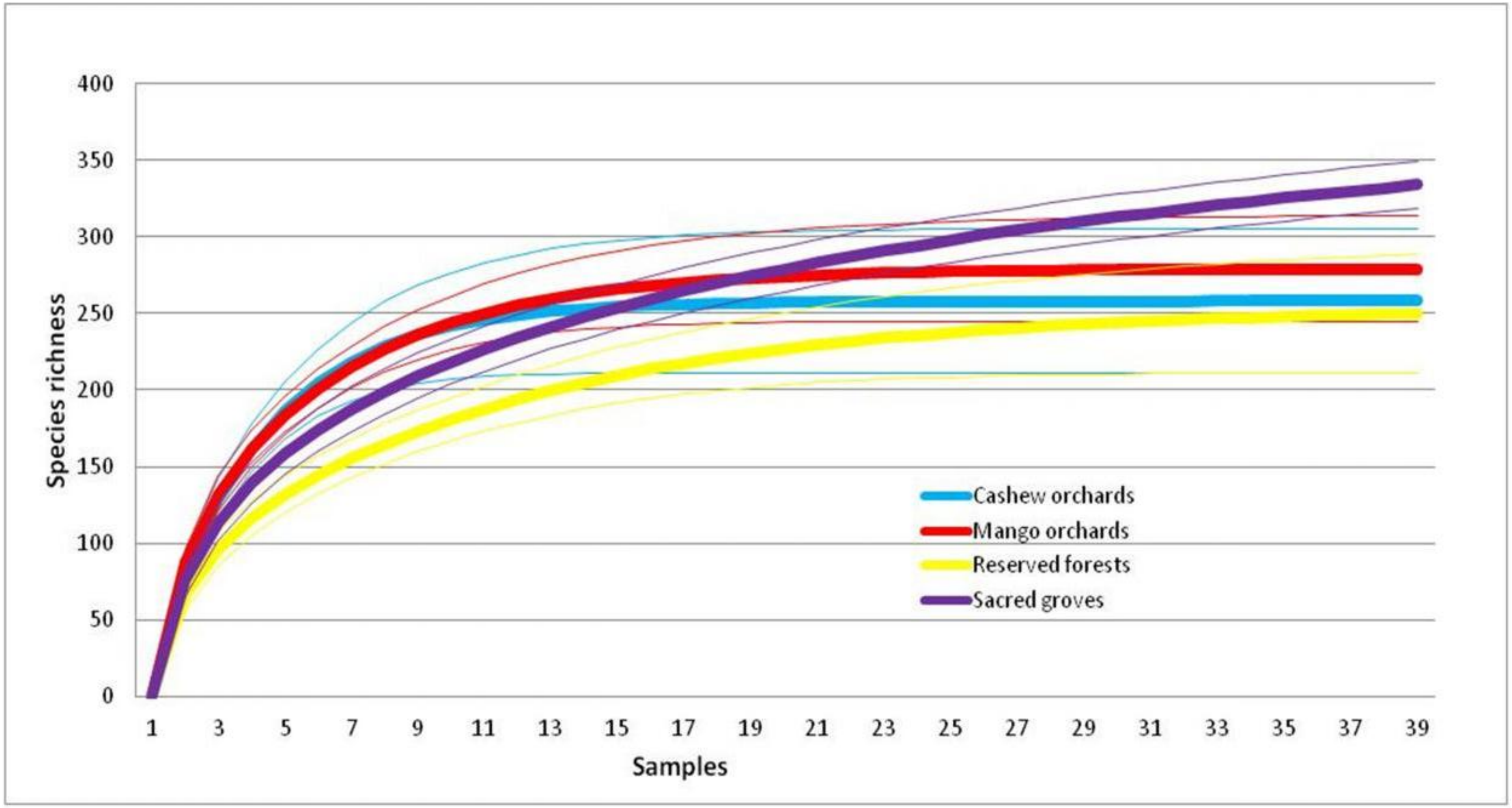


Figure 5.9 The so called 'rainbow' of Colwell et al (2012) constructed for the extrapolated species richness values based on rarefaction procedure. The thick lines show extrapolated accumulation curves, thin lines their corresponding 95% confidence intervals.

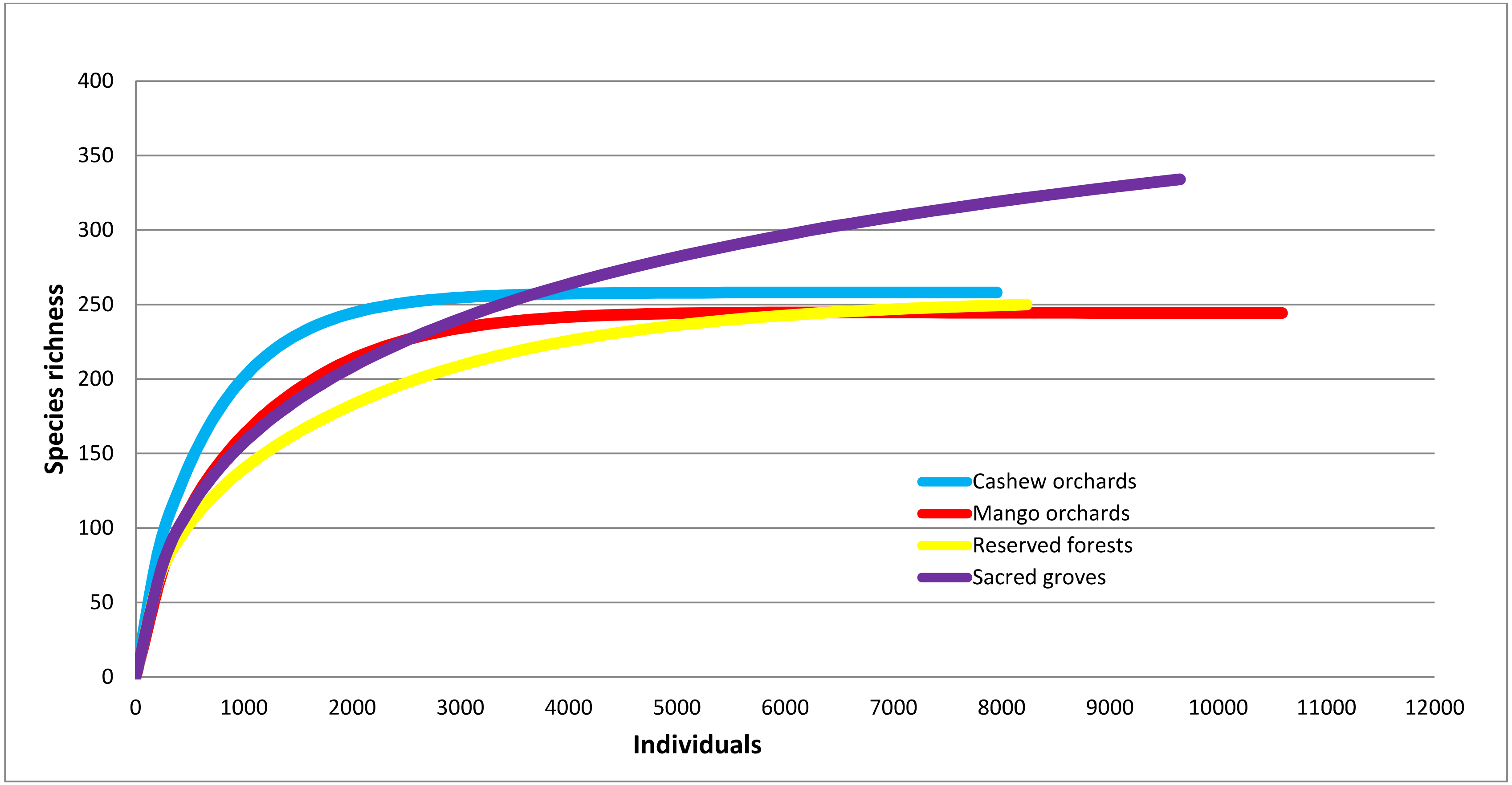


Figure 5.10 Species accumulation curves for habitat types rescaled to the number of individuals.

5.4.3 Compositional (Dis) Similarity of Spider Assemblages across Habitats

After testing the difference in numbers i.e. diversity indices of 0 and 1 order, it was decided to look at differences in the membership of the assemblages in different habitat types. In other words the compositional similarity or dissimilarity was assessed using NMDS in PAST. The raw abundances of species and families in quadrats were used to calculate Bray-Curtis dissimilarity based on which the quadrats were plotted in a 2D space (stress =21%). The quadrats were not segregated very much clearly (Figure 5.11) However, the orchards and the reserved forests appeared to be distinct. Therfore, ANOSIM was conducted to assess the differentiation between pairs of habitats. Although there was no overall dissimilarity among the habitats, the pairwise test revealed that mango orchards exhibited significant differeneces with sacred groves ($R = 0.47$, $p = 0.001$) and with reserved forests ($R = 0.65$, $p = 0.0003$).

Thus, the speculation in previous section that there could be compositional differences among the mango orchards and other habitat types seems to be vindicated. The enhanced collection of spiders in mango orchards could have been a result of predominance of gregarious and easy to collect species.

SIMPER revealed how much contribution each species made to the overall dissimilarity between significantly different pairs. In case of Sacred groves-Mango orchards pair, 50% dissimilarity was contributed by 35 species (Table 5.8). In the other pair i.e. Reserved forests-mango orchards, it was contributed by 31 species (Table 5.9).

The two species that made major contribution to this dissimilarity were *Angaeus pentagonalis* (Thomisidae) and *Oedignatha scrobiculata* (Liocranidae). Their presence was conspicuous in mango orchards compared with sacred groves or reserved forests. Interestingly, the earlier one comes from foliage-dweller assemblage whereas the later one is a ground-dweller.

A look at the species composition of cashew orchards reveals that O. *scrobiculata* is also abundant there. It could be that *O. scrobiculata* is a specialist of modified habitats and could possibly indicate disturbance.

(a)

(b)

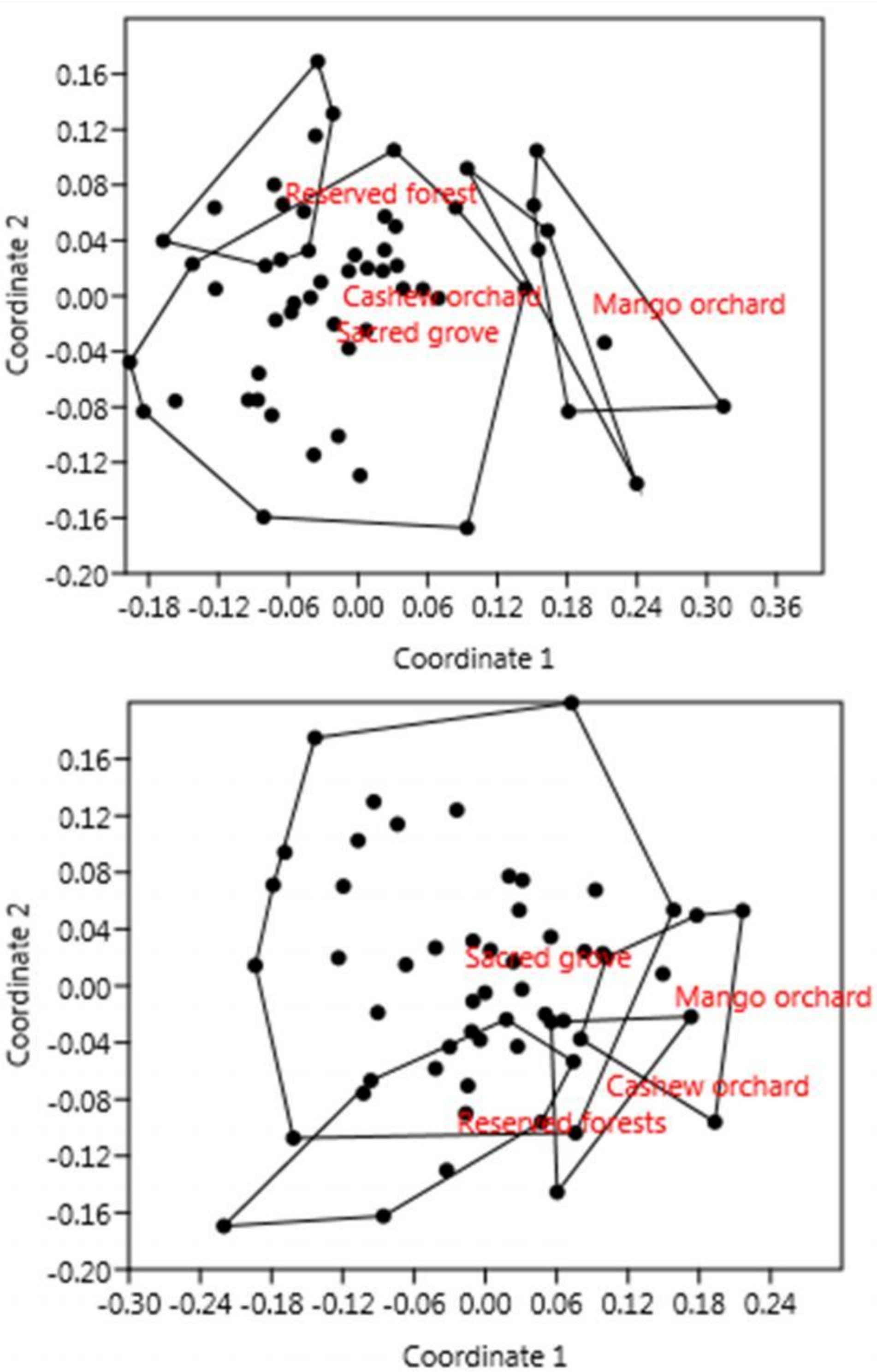


Figure 5.11 NMDS plot of sampling locations based on (a) species composition and (b) family composition grouped by habitat types.

Table 5.8 Species' contribution to the dissimilarity between sacred groves spider assemblage and mango orchards assemblage (Avg dissimilarity = 69 %)

Species	Contrib. %	Cumulative %	Mean abundance in	
			Sacred groves	Mango orchards
Oedignatha scrobiculata	**3.051**	**3.051**	**0.132**	**11.2**
Angaeus pentagonalis	**3.002**	**6.053**	**3.74**	**11.5**
Philodromidae sp1	2.659	8.712	11	1.33
Hamadruas sp4	2.411	11.12	5.21	10.3
Eriovixia laglaizei	2.335	13.46	2.47	9.67
Asemonea tenuipes	2.062	15.52	9.58	2.67
Epeus indicus	1.899	17.42	7.26	9.67
Brettus cingulatus	1.837	19.26	6.11	8.33
Scytodes sp1	1.764	21.02	7.21	1.83
Pisauridae sp1	1.754	22.77	10.9	14.3
Pseudicius nepalicus	1.697	24.47	0.263	6.33
Nasoona sp1	1.694	26.17	8.29	2.83
Hamadruas sp3	1.39	27.56	5.66	2
Eriovixia jianfengensis	1.366	28.92	5.26	0.5
Gamasomorpha sp1	1.359	30.28	5.24	0.333
Belisana dodabetta	1.346	31.63	5	0.5
Micrommata sp1	1.327	32.95	4.97	0.167
Philodromus devhutai	1.247	34.2	3.68	5.33
Evarcha sp1	1.24	35.44	5.95	1.83
Bristowia heterospinosa	1.214	36.65	1.42	5
Asceua cingulata	1.18	37.83	5.24	2.5
Phintella vittata	1.129	38.96	3.11	5.17
Phintella volupe	1.079	40.04	2.55	5.17
Tmarus sp1	1.065	41.11	4.18	0.333
Nesioneta sp1	1.051	42.16	2.32	4.17
Amyciaea forticeps	1.018	43.18	3.29	5.17
Uloborus bigibbosus	0.9907	44.17	5.37	2.83
Hamataliwa ovata	0.9573	45.12	3.32	2.83
Platnickina sp1	0.9363	46.06	0.368	3.67
Platnickina maculata	0.9217	46.98	0.579	3.67
Bomis bengalensis	0.8925	47.87	0	3
Parasteatoda tepidariorum	0.8783	48.75	2.74	3
Cephalobares globiceps	0.8663	49.62	3.29	0.167
Euophrys frontalis	0.8517	50.47	0.895	2.83

Table 5.9 Species' contribution to the dissimilarity between reserved forests spider assemblage and mango orchards assemblage (Avg dissimilarity = 72 %)

Species	Contrib. %	Cumulative %	Mean abundance in	
			Reserved forest	Mango orchards
Angaeus pentagonalis	**3.13**	**3.13**	**6.33**	**11.5**
Oedignatha scrobiculata	**3.08**	**6.21**	**0.333**	**11.2**
Hamadruas sp4	2.479	8.69	6.22	10.3
Cephalobares globiceps	2.439	11.13	8.89	0.167
Eriovixia laglaizei	2.419	13.55	2.67	9.67
Hamadruas sp3	2.369	15.92	10.2	2
Pisauridae sp1	2.297	18.21	13.8	14.3
Boliscus tuberculatus	2.128	20.34	8	0.167
Asemonea tenuipes	2.006	22.35	9	2.67
Brettus cingulatus	1.937	24.28	2.89	8.33
Epeus indicus	1.885	26.17	3.33	9.67
Pseudicius nepalicus	1.818	27.99	0	6.33
Eriovixia jianfengensis	1.685	29.67	6.56	0.5
Evarcha sp1	1.65	31.32	7.56	1.83
Leptopholcus podophthalmus	1.615	32.94	6.11	0.333
Micrommata sp1	1.612	34.55	6	0.167
Moneta mirabilis	1.503	36.05	5.33	0
Philodromus devhutai	1.397	37.45	0.556	5.33
Amyciaea forticeps	1.366	38.82	0.222	5.17
Bristowia heterospinosa	1.348	40.16	0.333	5
Phintella volupe	1.152	41.32	1.56	5.17
Philodromidae sp1	1.129	42.44	4.78	1.33
Platnickina maculata	1.054	43.5	0	3.67
Nesioneta sp1	1.045	44.54	1.22	4.17
Platnickina sp1	0.9993	45.54	0.111	3.67
Phintella vittata	0.9509	46.49	3.22	5.17
Hyllus sp1	0.9312	47.43	0.333	3.67
Bomis bengalensis	0.9244	48.35	0	3
Seramba sp1	0.9072	49.26	0.333	3.33
Hamataliwa ovata	0.8808	50.14	2.78	2.83

5.4.4 Effect of Effort and Habitat on Spider Assemblages

The patches that were selected for sampling varied in their size from 0.2 ha to >40 ha. In island biogeography, there is a great relevance of size of the patches in the dynamics of assemblages in the patches as well as in the landscape. Because the patches of reserved forest and two of the mango orchards were very extensive, and because initial explorations revealed that their size acted as outliers, it was decided to test the effect of size of patch in case of sacred groves only.

NMDS was again performed for testing the effect of size of the patch in which sampling quadrats were located. The range of size was divided into 3 categories (<2 ha small, 2-5 ha medium and more than 5 ha large). It was expected that the species and family composition of the assemblages was influenced by size of the patches. However, NMDS plots (Figure 5.12) for both the species and family composition could not segregate the sampling locations on the basis of size of the patches.

MRPP (Multi-response Permutations Procedure) test in PC-ORD also indicated that there was much variation in species composition within habitat types than between them with chance-corrected within group agreement A = 0.068.

One of the reasons behind the apparent similarity of the assemblages irrespective of size of the patches could be that the patches were not really patches. The entire landscape is a very heterogeneous one with nearly 50% of the geographical area possessing some kind of tree cover. This tree cover although much fragmented, perhaps, holds sufficient connectivity for small organisms like spiders which have extraordinary dispersal modes and abilities.

There was a very high concordance between genus richness and species richness with genus richness predicting species richness very efficiently. This fact was utilized to understand if any of the effort or habitat parameters were influencing this relationship between genus richness and habitat richness. The factors were grouped into discrete categories like effort (low, medium, high), type of habitat (orchard, reserved forest, sacred grove), degree of isolation of patch (isolated, part-contiguous, contiguous) and disturbance ranking based on threat category score sums (low disturbance, high disturbance). Figures 5.13 and 5.14 show the simple linear regressions of sampling sites (n = 32) between genus richness and species richness grouped by these various categories by factor. None of the factors shows any significant difference in the slope of the regression lines. The regressions equations, R^2 values are shown with the figures.

However, when the *a priori* groupings of sites into size classes was kept aside, and the NMDS ordination of sampling plots based on species composition was examined, there emerged some clear clues (Figure 5.15). Sadavali a very fine sacred grove with large area, minimum disturbance and 'relict forest' had all its plots (SD_1, SD_2, SD_3) clearly separated from even those in other sacred groves. Similarly, all reserved forest plots formed a group with some sacred groves included with them. These sacred groves have continuously received some level of disturbance in the past and their nature of sacred groves has retained only because of their extensive size. On the other hand, all mango and cashew orchards can be visualized as a loosely formed group along with sacred groves like Degaon and Kherdi which have been highly disturbed and even planted with mango varieties. It was interesting to note that the plot in Kondhe sacred grove where there are mainly mango trees aligned closely with this group. The other plot in the same grove where which resembles primary forest was well-separated. This perhaps necessitates reviewing the scale at which spiders' habitat association should be assessed.

(a)

(b)

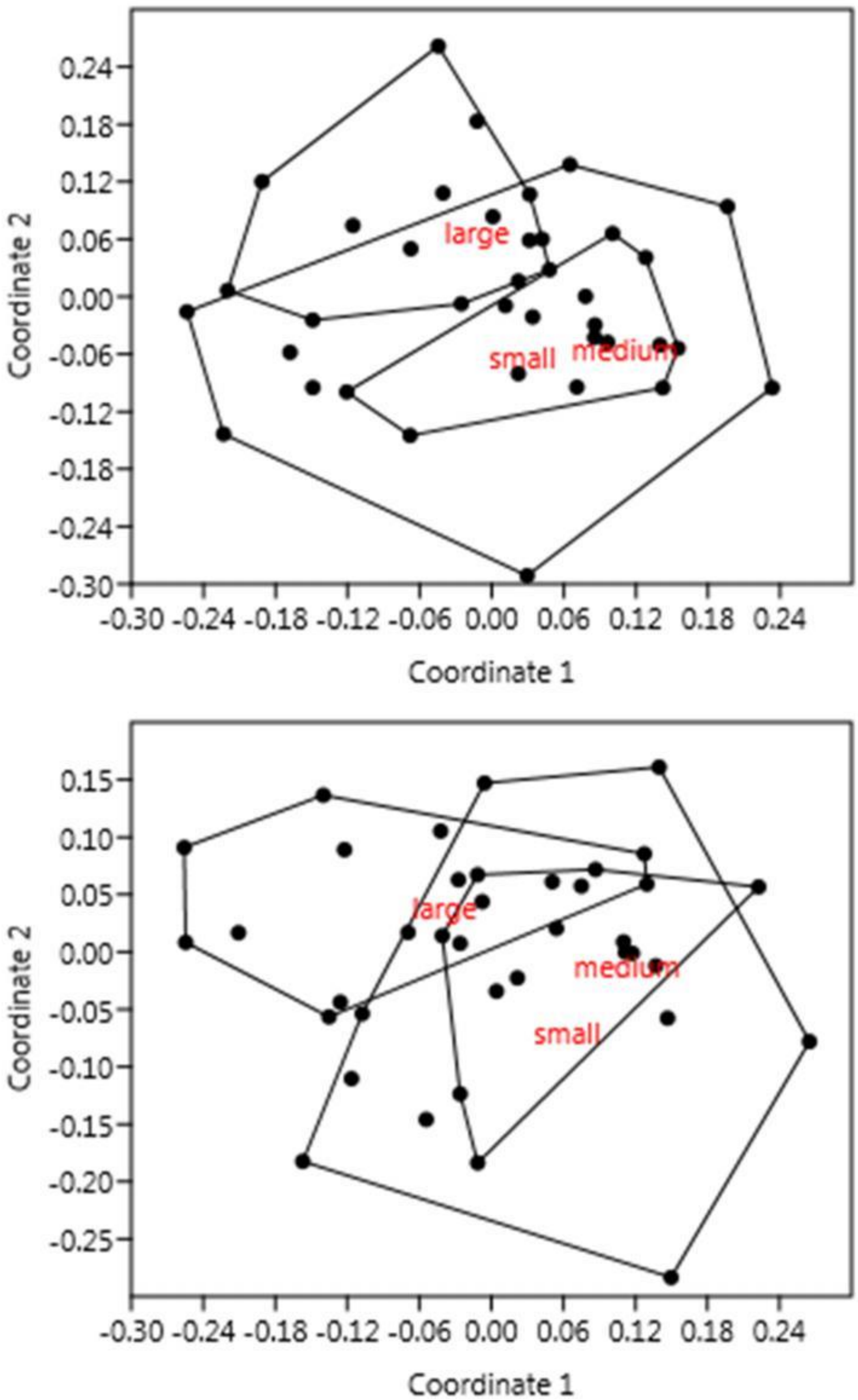


Figure 5.12 NMDS plots of sampling locations within sacred groves only grouped by size classes of the sacred groves.

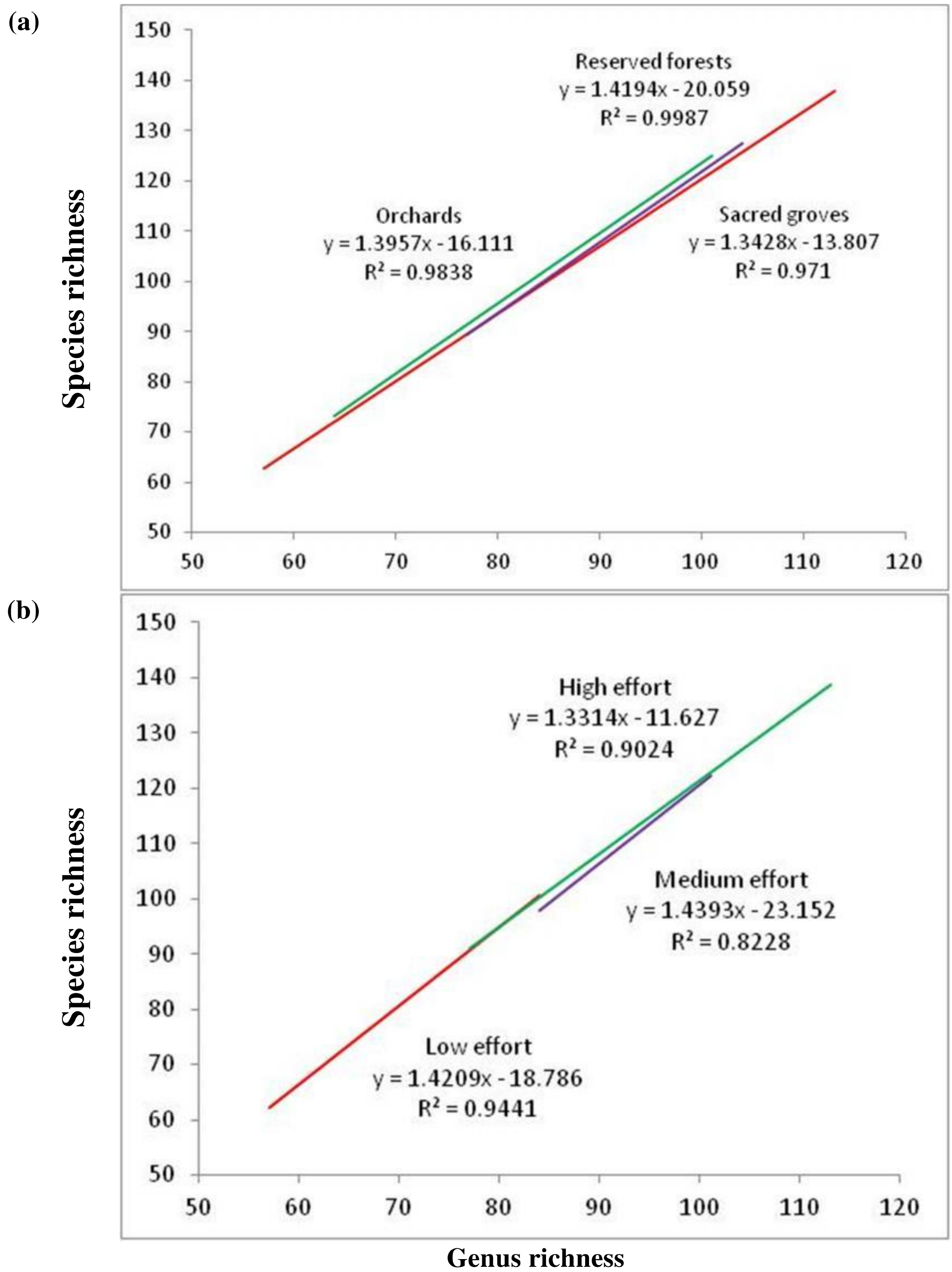


Figure 5.13 Comparison of genus richness and species richness in sites (a) within putative habitat types and (b) receiving different levels of sampling effort.

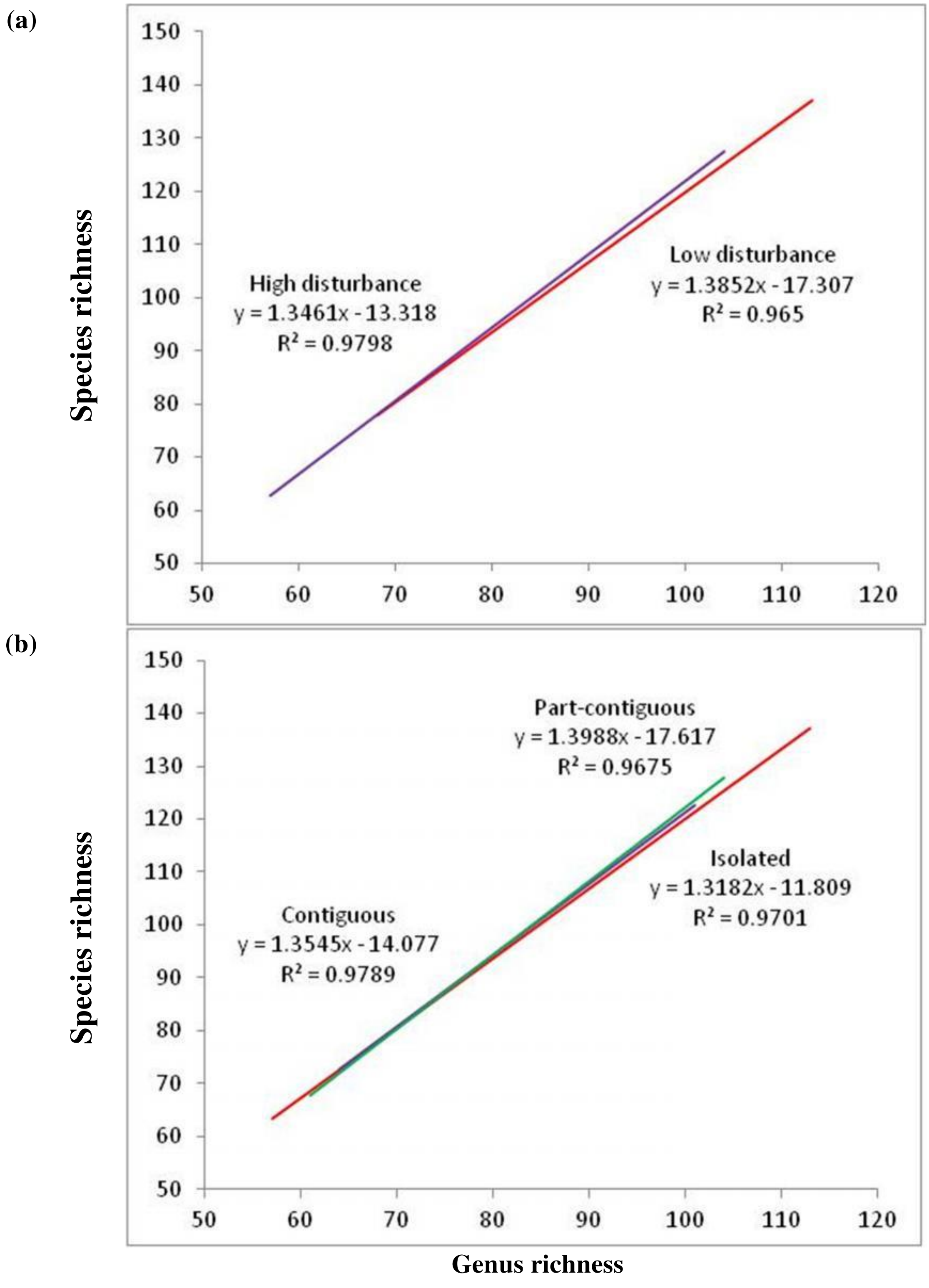


Figure 5.14 Comparison of species richness and genus richness in sites (a) classed on the basis of disturbance index (b) with different levels of isolation from surrounding forest.

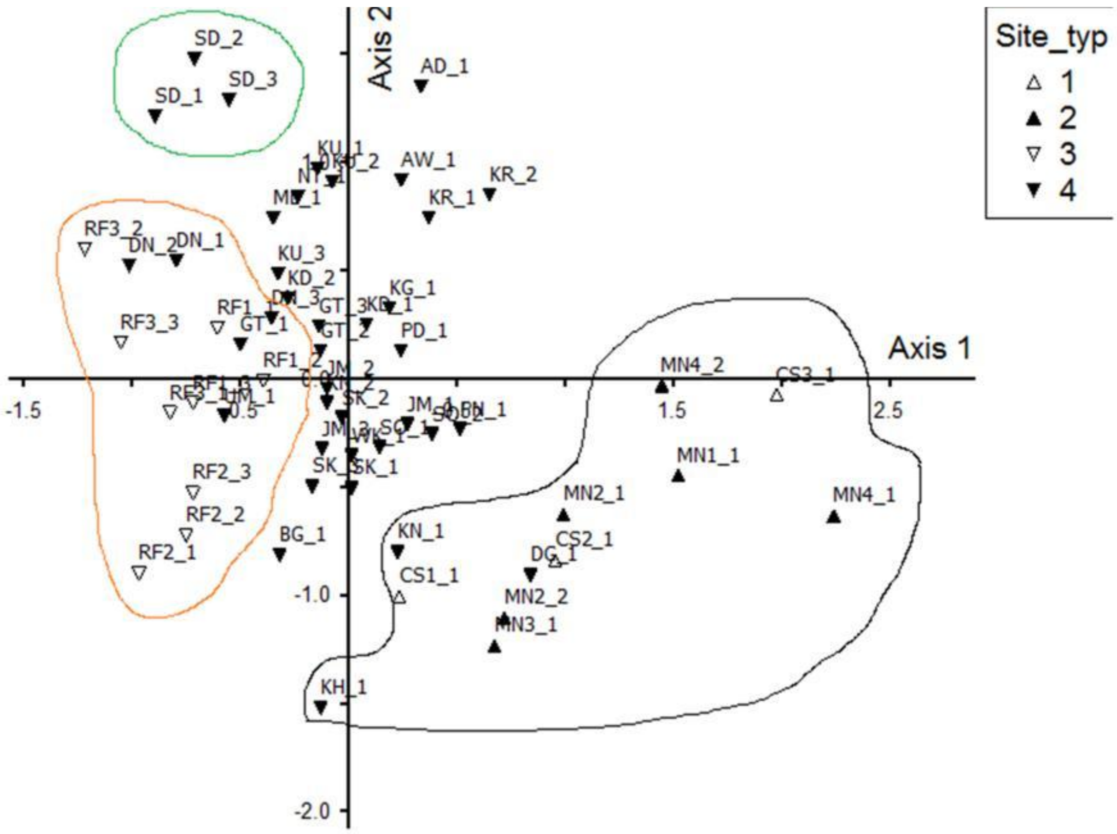


Figure 5.15 Post-hoc grouping of sites after ordination (NMDS) based on species composition. Green polygon highlights a very typical ancient sacred grove. Red polygon clusters all reserved forest patches along with some sacred groves. Black polygon contains all mango and cashew orchards orchards and groves with planted mango.

5.5 Spiders as Indicators

As illustrated in previous section, the habitats studied in this investigation varied greatly in terms of the spider diversity and species composition. For now, the spider assemblages in different habitats stand out as discrete entities in which a great degree of dissimilarity is introduced by a few representative species. This offered an opportunity to identify indicator species for these *a priori* identified habitat types which were confirmed to hold distinct spider assemblages.

Table 5.10 provides the list of species identified using Indicator Value module of proogram of PC-ORD. Only those species with high indicator value and extremely low *p* (<0.005) are listed.

Table 5.10 List of Indicator species identified based on the relative frequencies and relative abundances of the species (of the entire assemblage) at all sampling locations segregated by major habitat types.

Cashew orchards			**Mango orchards**		
species	**IV**	***p***	**species**	**IV**	***p***
Argyrodes bonadea	69.2	0.001	*Amyciaea forticeps*	59.5	0.001
Ordgarius hobsoni	69.7	0.003	*Hersilia savignyi*	67.6	0.002
Hypsosinga sanguinea	56.6	0.004	*Bomis bengalensis*	50	0.004
Synema revolutum	53.3	0.004			

Reserved forests			**Sacred groves**		
species	**IV**	***p***	**species**	**IV**	***p***
Leptopholcus podophthalmus	71.3	0.001	Philodromidae sp1	54.6	0.002
Cephalobares globiceps	70.1	0.001	*Nephila pilipes*	63.2	0.005
Boliscus tuberculatus	86.8	0.001			
Micrommata sp1	53.9	0.003			

Contrary to the intuition in earlier sections that *Oedignatha scrobiculata* might emerge as one of the indicator species or orchards, it does not feature in these lists. However, the indicator species identified for sacred groves i.e. Philodromidae sp1 and *Nephila pilipes* could be good indicators for this habitat. The fact that the later species has emerged as an indicator species itself is a proof of its preference of undisturbed habitat at least in early stages of its life. This is so because, as elaborated in the methodology chapter, *N. pilipes* was not collected in proportion to its adult abundance. The adults used to be in their huge webs and were not subjected to the vegetation beating as usually they would retreat to a very high point on their webs on slight disturbance. And to avoid confounding, even those that accidentally lodged in the umbrella were let go. So, the collected individuals were mostly juveniles which make smaller webs in lower strata of vegetation. Thus, although adult *N. pilipes* could be seen even in orchards, they are almost always only adults.

Similarly, *Amyciaea forticeps* came up as an indicator of mango orchards probably because this species is associated with weaver ants (*Oecophylla* sp.). And weaver ants have been seen to be partial to fruit trees especially mango (Peng and Christian 2007). On the other hand, *Bomis bengalensis* was recorded in large numbers in only one season and in only one mango orchard. So, there is a need to evaluate it further.

Boliscus tuberculatus emerged as a very strong indicator of reserved forests perhaps because it showed very high fidelity to this habitat along with sporadic presence in sacred groves and near-complete absence from orchards. *Leptopholcus podophthalmus* has already been tentatively identified as an indicator of mango-less vegetation because it never appeared in collection from mango orchards (not even cashew orchards) and even the sacred groves which were dominated by natural or planted mango trees (Patil and Uniyal, in review). Thus, the intuition has been proved by the statistical method and the species has emerged as an indicator of reserved forests which rarely had mango trees.

5.6 Conservation Site Prioritization

5.6.1 Scoring Approach

Site prioritization can be easily and quickly done using the scoring approach. The taxa are scored on the basis of their taxon richness starting from species, then genera and then families. This is because the ultimate targets of conservation are species. Accordingly, sites in this study were ranked. I used all sites and not just the sacred groves for two reasons. One, I thought that the purpose of this thesis, this would be an academic exercise. And two, there was considerable compositional variation at least between some habitats. So to capture diversity of spiders in its entirety it was necessary to include habitat sites other than sacred groves. Table 5.11 provides scoring of sites based on this criteria for pooled data. Similar rankings were obtained for foliage dwellers and ground dwellers separately but only entire assemblage rankings are shown. First 10 sites are italicized for comparison with iterative scoring (Table 5.12). Figures 5.15 to 5.17 show the scatterplots of site rankings based on species and family and species and genera for the three assemblages separately.

As expected, it was found that families have low predictive power for species-based ranking (Spearman's s_r = 0.55, 0.76 and 0.59 for foliage dwellers, ground dwellers and entire assemblage respectively). On the other hand, genus based ranking predicted the species-based ranking very well (Spearman's s_r = 0.97, 0.98 and 0.98 for foliage dwellers, ground dwellers and entire assemblage respectively). These results have automatically highlighted the usefulness of higher taxa surrogacy in case of spiders.

Table 5.11 Conservation prioritization ranking of studied Sites based on values of taxon richness for the entire spider assemblage.

	Taxon richness			Site rank		
Site	**Species**	**Genera**	**Families**	**Species**	**Genera**	**Family**
Shirkhal	134	113	29	1	1	1
Dhankoli	128	101	25	2	3	6
RF2	126	104	24	3	2	12
Mango2	125	100	26	4	7	3
Jamge	125	101	25	4	3	6
Sadavali	124	101	24	6	3	12
Mango4	121	101	27	7	3	2
Gavtale	119	96	24	8	10	12
RF1	117	96	25	9	10	6
Kondhe	112	90	24	10	12	12
Kudavale	110	97	24	11	8	12
Kadivali	109	97	26	12	8	3
Soveli	106	90	23	13	12	22
Mango1	104	84	22	14	14	24
Karde	95	84	24	15	14	12
Cashew1	94	77	21	16	17	28
Cashew2	91	77	26	17	17	3
Pichdoli	91	81	23	17	16	22
Pangari	90	77	20	19	17	30
RF3	89	77	25	20	17	6
Kangvai	87	74	25	21	21	6
Wakavali	86	74	24	22	21	12
Degaon	82	68	25	23	24	6
Kherdi	79	69	24	24	23	12
Nanate	77	68	22	25	24	24
Mango3	75	65	24	26	28	12
Aade	75	68	19	26	24	32
Bhatghar	74	68	20	28	24	30
Agarvayangani	73	64	22	29	29	24
Male	69	61	24	30	31	12
Cashew3	69	64	21	30	29	28
Umbarle	63	57	22	32	32	24

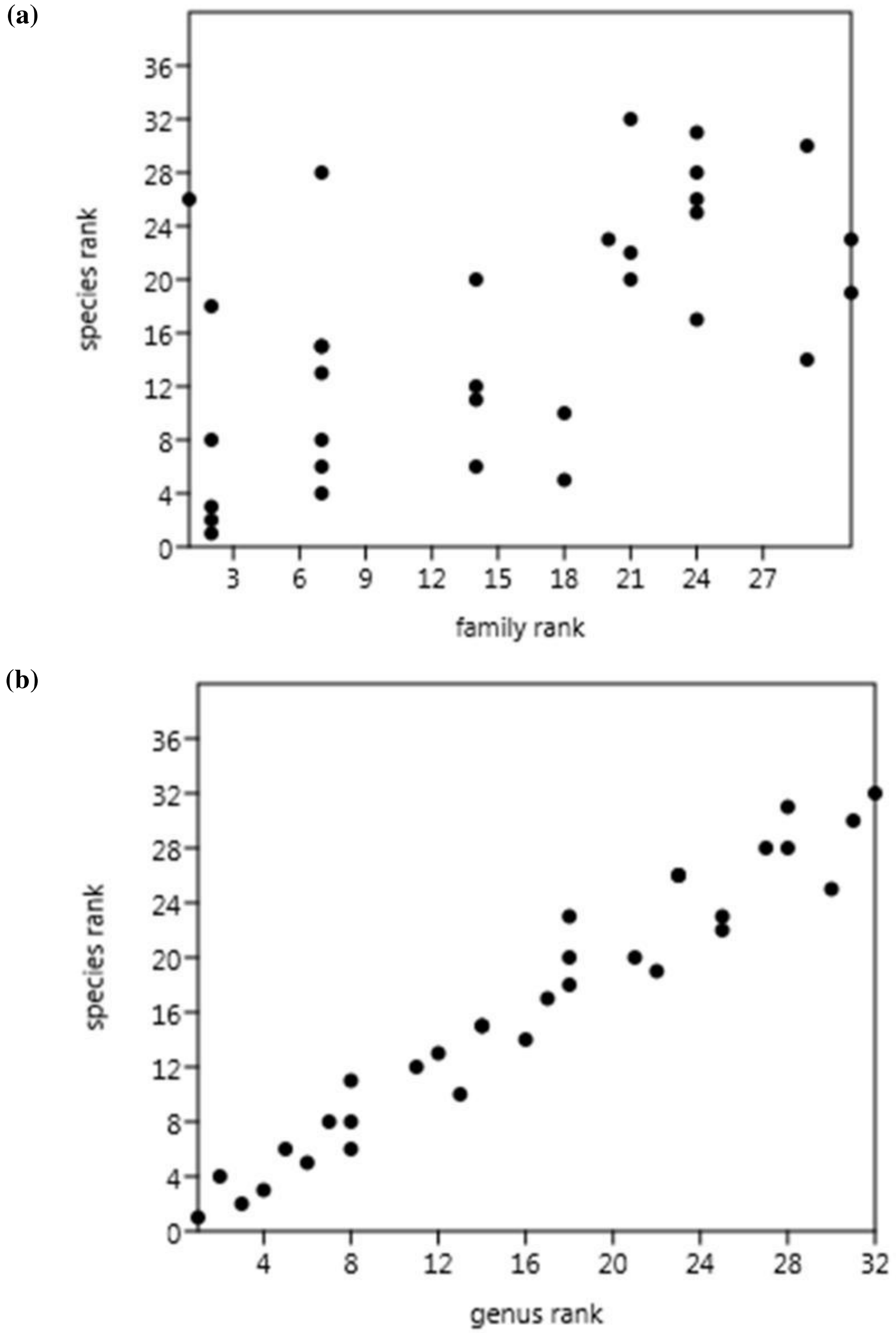
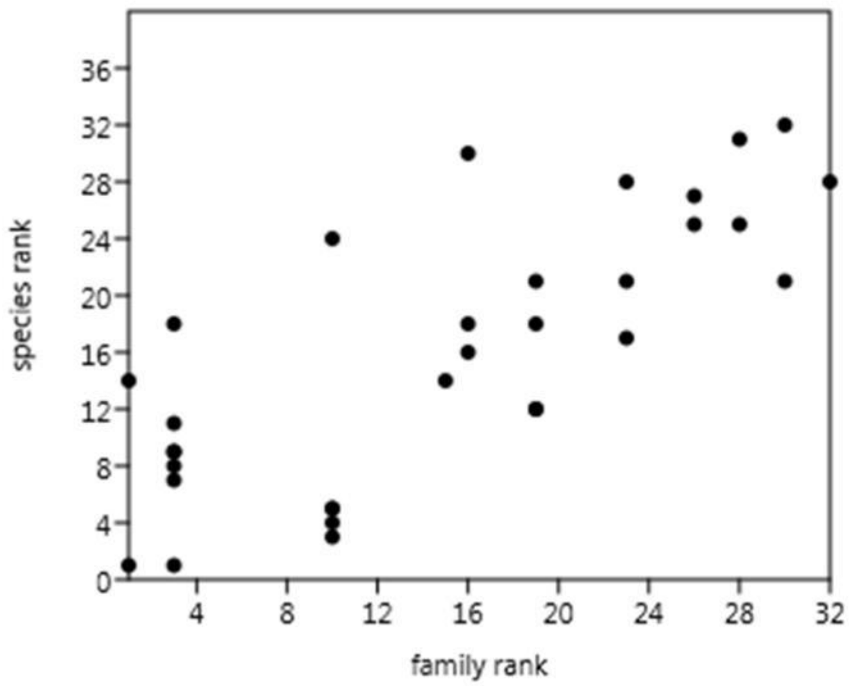


Figure 5.16 Comparison of site ranking based on foliage dwelling spider assemblage according to (a) family and species richness, and (b) genus and species richness.

(a)



(b)

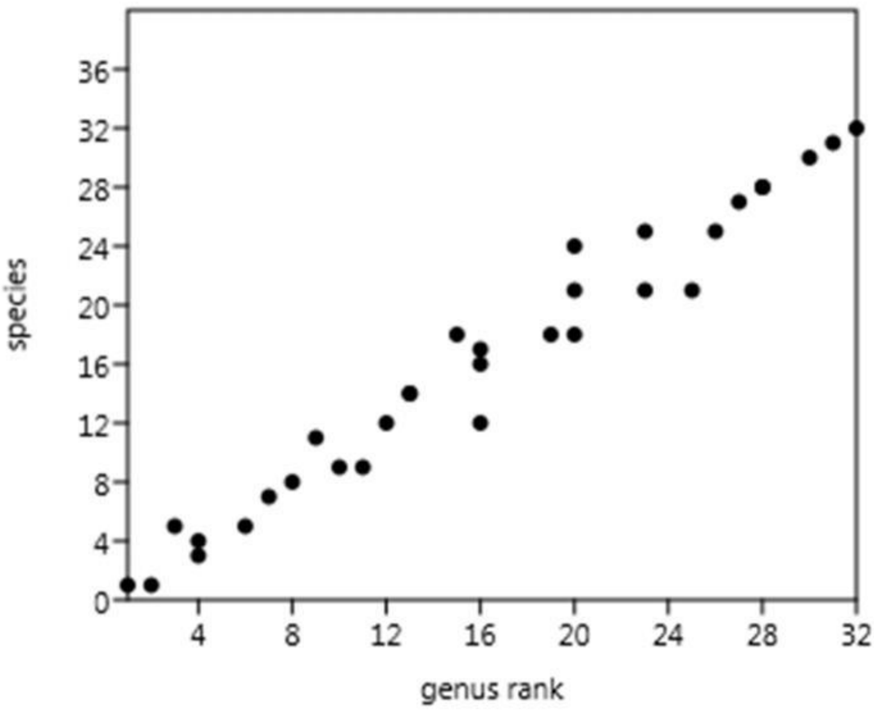
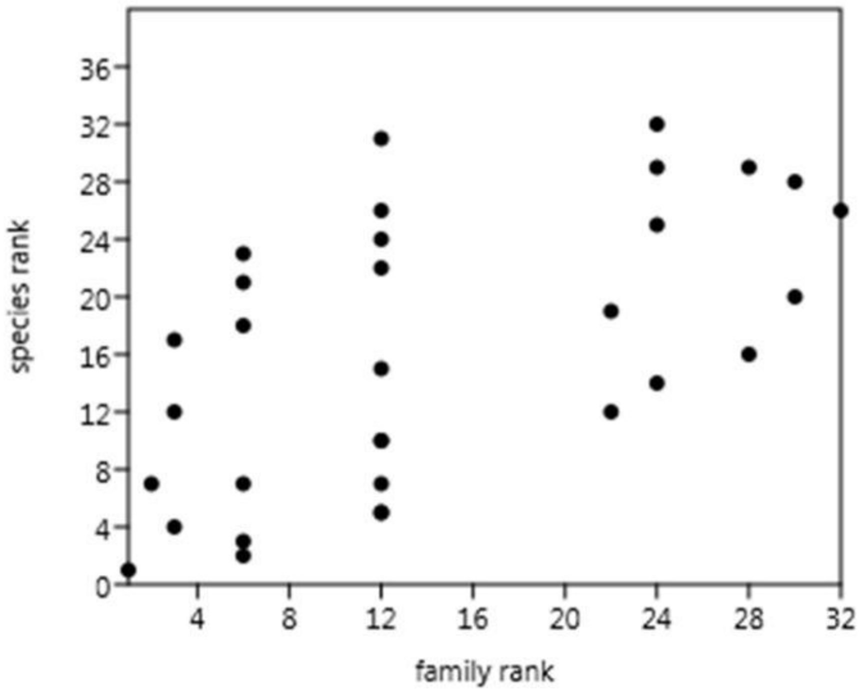


Figure 5.17 Comparison of site ranking based on ground dwelling spider assemblage according to (a) family and species richness, and (b) genus and species richness.

(a)



(b)

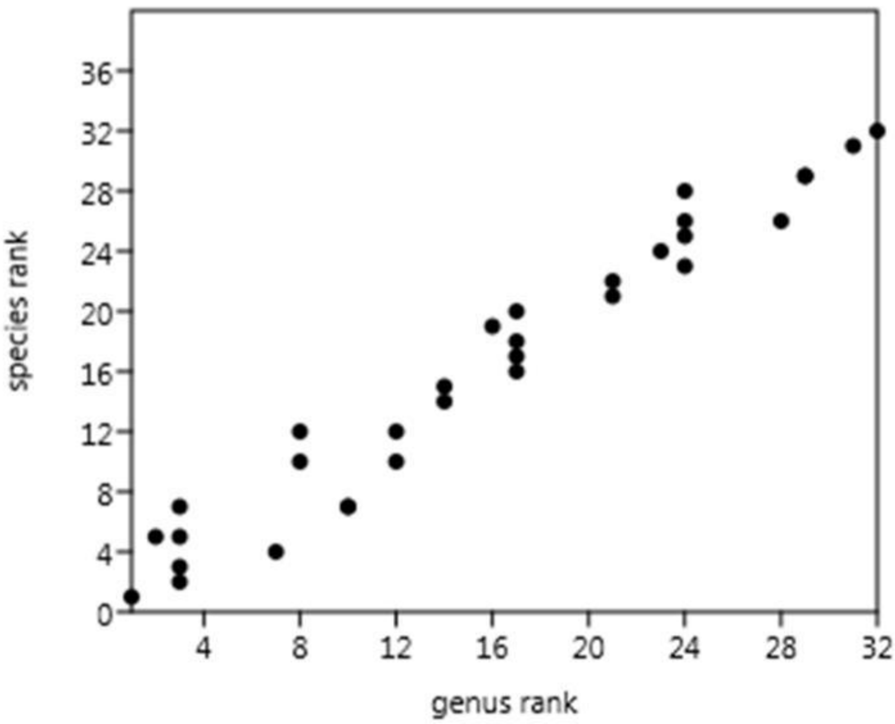


Figure 5.18 Comparison of site ranking based on entire spider assemblage according to (a) family and species richness, and (b) genus and species richness.

5.6.2 Iterative Ranking

Cardoso et al. (2004) have advised that although scoring approach is easy to work out and understand, due consideration must be given to the element of complimentarity among sites. Because sites always hold overlapping assemblages, some of the species conserved in one site will again be conserved in the second site. To maximize the number of species conserved within minimum possible number of sites, it is necessary to select sites in a step-by-step procedure. The first site is selected on the basis of maximum species richness. But after that, the next site should be selected such that it adds maximum number of additional species to the pool of conserved species. This way, the procedure is repeated till the point when satisfactory number of species can be assured of conservation.

The same approach was followed in this study. However, all sites were used because we considered this exercise as a tentative one and some of the habitats sampled had quite different assemblages of spiders. We selected first site on the basis of maximum species richness and then went on adding sites as described above. The procedure was performed separately for foliage dweller assemblage, ground dweller assemblage and the entire spider assemblage. Figure 5.19 reveals that ranking based on the entire spider assemblage required almost same number of steps as that for the separate assemblages to reach the level of 100% species conservation. This underlines the outcome that sites ranking can be done on the basis of any one assemblage and there is no need to invest resources in inventorying different assemblages at least in similar cases.

If the target were to use surrogate taxa approach and the study was limited to identification of genera of spiders. In that case 100 per cent conservation of genera would have needed at least 15 per cent less number of sites while still conserving 98 per cent of species on the basis of entire assemblage. Similarly, 12 per cent and 6 per cent less sites would have to be selected if foliage dweller and ground dweller assemblage information was used respectively. Sites ranked by this approach using entire assemblage information for conservation are shown in Table 5.12. The difference in sites selected by the two approaches can be seen by comparing the first ten sites in Table 5.11 and Table 5.12.

Table 5.12 Ranking of sites on the basis of number of species they add to the pool of species covered in already selected sites in a step-by-step manner for the entire spider assemblage.

Site	Species richness	New species	Accumulated species pool
Shirkhal	134	134	134
Dhankoli	129	54	188
Mango2	125	39	227
Mango1	104	28	255
RF2	127	20	275
Sadavali	124	15	290
Kondhe	112	13	303
Cashew1	94	10	313
Kangvai	87	10	323
Jamge	126	8	331
Mango4	121	8	339
Agarvayangani	73	6	345
Gavtale	119	5	350
RF1	117	5	355
Nanate	77	4	359
Degaon	82	3	362
Cashew3	70	3	365
Kudavale	110	2	367
Pangari	90	2	369
Kherdi	79	2	371
Mango3	75	2	373
Soveli	107	1	374
RF3	89	1	375
Wakavali	86	1	376
Aade	75	1	377
Umbarle	63	1	378

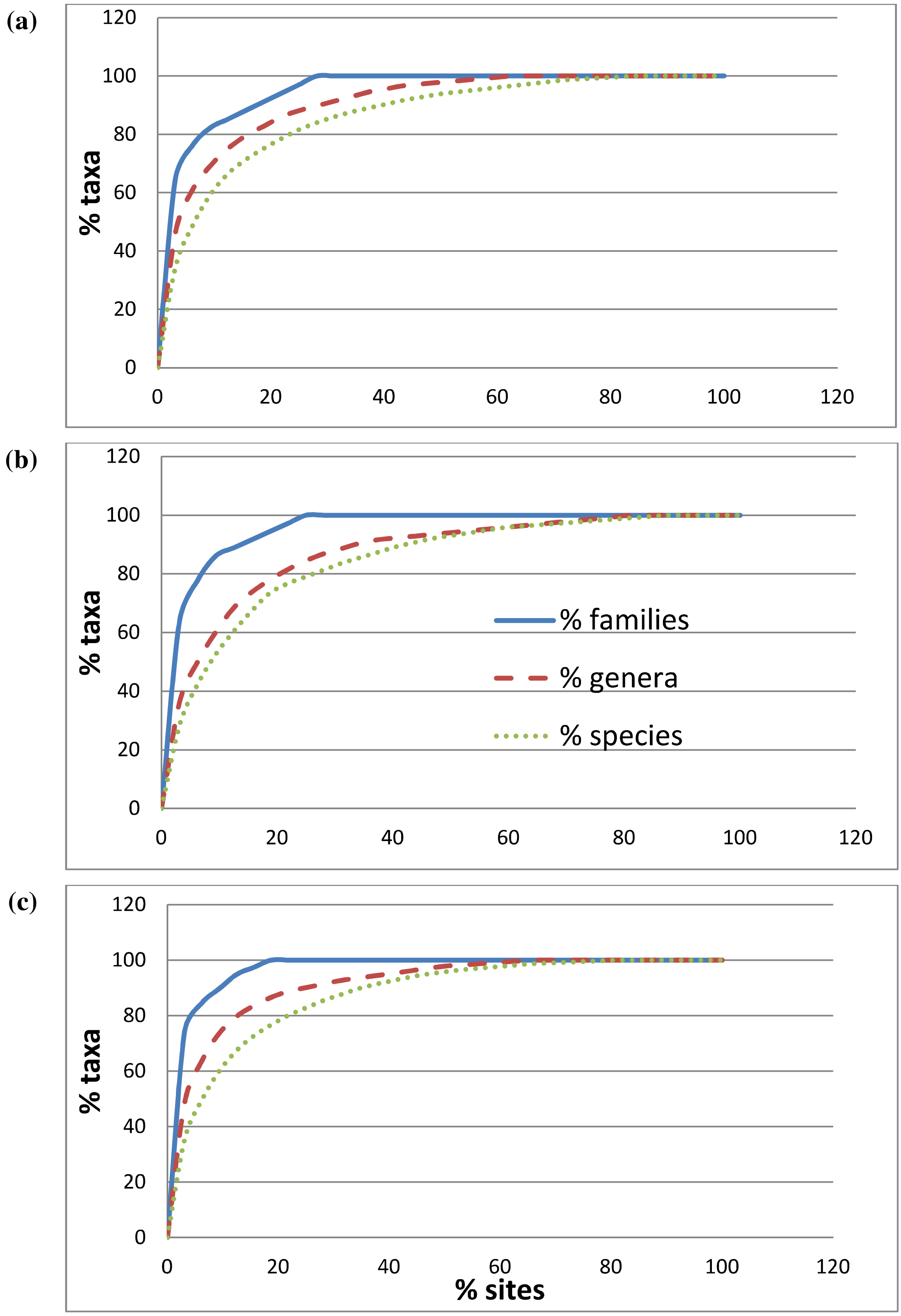


Figure 5.19 **Accumulation of taxa (%) that could be conserved by Stepwise addition of sites to be conserved based on (a) foliage dwellers, (b) ground dwellers, (c) entire assemblage**

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Chapter 6: DISCUSSION AND CONCLUSIONS

6.1 Sacred Groves in Dapoli

Gadgil and Vartak (1975) pleaded for continued conservation of sacred groves long ago. In the four decades since, there has not been much progress towards conservation of the sacred groves of India. Numerous studies have been taken up in India in different parts of the country (see the bibliographies in Malhotra et al. 2001a, Dudley et al. 2010). But still conservation of sacred groves faces daunting challenges (Ormsby and Bhagwat 2010) and sacred groves continue to be lost and degraded. One of the suggested measures is development of 'greater sensitivity towards these conservation traditions'. This needs awareness of sacred groves not only in the scientific fora but also in the popular domain. The stakeholders of the sacred groves are unaware of the importance and potential crusaders are unaware of the existence of sacred groves. This gap can be bridged by using latest technology to document information on sacred groves in internet-based open access archives.

Although the importance of sacred groves has been widely acknowledged, there are very few attempts at comprehensively documenting the sacred groves in a spatial domain which can be readily accessible to interested persons. The website of the C. P. R. Environmental Education Centre (www.cpreec.org) maintains a list of sacred groves by districts of different states. For Maharashtra it lists over 900 sacred groves. Although several sacred groves from Ratnagiri districts have been listed, the sacred groves of Dapoli taluka are conspicuous by their absence in this list except a few. Perhaps, it is an advance over Deshmukh et al. (1998) but the source is unknown and several villages are shown to have several sacred groves each. Perhaps, it is an artefact of the revenue records which are maintained by survey numbers. And each survey number assigned to sacred grove in revenue record has been counted there as a separate grove which, of course, is not the case. A sacred grove may comprise of several adjoining survey numbers. In fact, the present study has recorded only three villages which had more than one independent sacred grove.

A considerably comprehensive documentation of sacred groves has been done in this study. There are at least 102 sacred groves for 176 villages in this taluka. Based on this documentation, Dapoli can be considered as one of the highest sacred grove concentration regions comparable to similar others like Kodagu district of Karnataka (Page et al. 2009).

Information has been collected on demographic, cultural, management and vegetation parameters and summarized in this study. It was an interesting observation to note that during the interviews with people in these villages, the respondents were answering as if they were asked about the deity and the temple. Needless to say that I was interested more in the grove around the temple. This was, perhaps, because the cultural importance of sacred groves have diminished and the deities, the temple and the festivals have attained an increased status in the mindset of the stakeholders. This amounts to a sign of erosion of cultural values and weakening of taboos as noted by several researchers including Gadgil and Vartak (1976) long ago. But this observation provides another angle that cultural values are not only eroding but also shifting from primeval grove-centric to modern temple-centric.

Sacred groves everywhere are disappearing fast due to cultural change and pressure to use the natural resources within the groves (Ormsby, 2011). This phenomenon was observed in the study area too. They are disappearing in the sense that their integrity as "*antique forests*" is being lost. The most prominent expression of this disappearance is in the form of renovation of temples. Out of the 22 sacred groves that were visited regularly since 2013 for spider surveys, the renovation of temples was either completed, was in progress or was initiated during in at least five sacred groves. Several others had recently built modern temples. In the survey of recorded sacred groves too it was found that only 25 per cent had a basic simple temple of pre-historic form. Another expression of disappearance of identity of sacred groves was recorded in the form of upgradation of basic approach roads to tarred roads. I was always surprised on my later visits to almost all spider-survey sacred groves that the roads had been converted to tar-roads.

The management of sacred groves is also shifting from traditional taboo-based systems to modern democratic systems. In several villages, it was noted that the sacred groves and the deities were historically under the management of scheduled castes. But in almost all villages, the then lower castes migrated to Buddhism and since then other castes have taken over. The management is also slowly getting into the hands of local gram panchayats or other related civic bodies formed under various schemes (like *Tantamukti samiti*). Moreover, management itself is shifting towards neglect/exploitation of the grove and reverence of the deity. But it must be noted that there is still fervour at the times of festival. I was lucky to participate in some of the festivals like *Navaratra* in some sacred groves and also participated in their feasts. I have witnessed people in parties of two or three going for a night-watch in Dhankoli where sacred grove is at least two kilometres away and located in a forested valley. So, it seems the cultural erosion has not yet been complete and there is scope for the conservationists to exploit this attachment for the effective conservation of sacred groves.

The size of sacred groves is a matter of concern. Nonetheless, it is an inherent property of the sacred groves of this region to be small sized. In this study too the range of size of sacred groves ranged from 0.03 to 40 ha. Several of the sacred groves which had minuscule area were actually a small area surrounding the temple premises. This area contained few trees of ancient origin and few recently planted. The place is called sacred grove because the deity resides there and because old trees were retained. In Degaon which has one of the smallest sacred grove, there were only one *Terminalis bellirica* and one *Ficus bengalensis* tree in front of a considerably large temple. The rest of the area was cleared and 10 mango trees of Alphonso variety have been planted more than 10 years ago. Same situation was observed in Pangari village and in Kherdi village, the felling of natural vegetation took place even as this study was in progress. Similar observations were made by Gadgil and Vartak (1976) and many others. Nevertheless, Bodin et al. (2006) have proved that even small fragmented patches are capable of providing landscape-scale ecosystems service like pollination and seed dispersal by enhancing the habitat connectivity for the agents responsible for these services. Therefore, it is necessary to recognize the importance of sacred groves, however small, in the context of the landscape.

Most of the larger sacred groves, on the other hand, have actually retained their primary vegetation. As Gadgil and Vartak (1976) have pointed out, a sacred grove sufficiently large to accommodate a forest habitat actually resembles climax vegetation of that region in near-virgin condition. Similar observations were made in the present study wherein almost all large sacred groves – except those that have been destroyed recently or have been under pressure for exploitation – contain the primary vegetation of this region that is moist deciduous forest. A very good example is found in Sadavali village. This sacred grove has a perennial stream along which a profusion of *Saraca asoca* is found. This species is rare in Ratnagiri although common in semi-evergreen forests of adjoining Sindhudurg district. The habitat in such sacred groves is dominated by ancient trees and lianas. Trees like *Antiaris toxicaria*, *Terminalia bellirica*, Mammea *suriga*, *Ficus bengalensis, Dillenia pentagyna* and lianas like *Entada scandens* and *Gnetum ula* were observed only in large undisturbed sacred groves.

As already pointed out, the plight of sacred groves continues despite numerous studies, policies and action plans. In this study, too, it was observed that several sacred groves are actually facing threats which can be approximately quantified. The most common and dominant threat i.e. shift in belief systems is a real problem. The weakening of taboos and erosion of culture (Gadgil and Vartak, 1976) have played a major role in degradation and destruction of sacred groves. This is, perhaps, the root cause of sacred groves' plight. Traditional religious beliefs tend to decline as a society shifts from agrarian to industrial. And rise in pervasive insecurity can mark the return of traditional beliefs (Inglehart and Baker 2000). The challenge here is to make the weakened beliefs stronger without waiting for the insecurity to reign in. It is important to understand that the governments have little funds to spare for the effective conservation of these small patches of pristine forests. On the other hand, there have been no efforts to secure funding from international community as expected by Ormsby and Bhagwat (2010). So, the last resort is to urge the stakeholders into action.

Internet based multimedia has revolutionized the information sharing and outreach for even apparently smaller causes. In the era of digitalization and digitization, it is felt that there should be a database of sacred groves on the lines of the database of formal protected areas (www.wiienvis.nic.in) or more appropriately something participatory like India Biodiversity Portal (www.indiabiodiversity.org). This would result in better outreach and awareness about sacred groves, their geographical context and importance. However, no efforts in this direction have been noticed so far. The objective of this study was to prepare a catalogue of sacred groves of Dapoli taluka. For the purposes of this thesis, adequate data has been collected and presented. Indeed, this study would also become a mere scientific exercise. But the author intends to take this further and make available an online, interactive catalogue of sacred groves of Dapoli taluka. This catalogue can then grow to accommodate different regions through participation of people. This way, people interested in sacred groves will be able to access the information as well as add the information on more and more sacred groves. It is important that the stakeholders are aware of the importance of their sacred grove as an acknowledged resource. Then they might be spurred into converting their traditional taboos into more conscious regulations.

6.2 Spiders of Dapoli

Global database of spiders – the World Spider Catalog – is an excellent resource for spider taxonomists. It is built up on localized descriptions of new species and new reports arriving from local inventories. Although the first is expected to be taxonomically accurate, the later may not be so rigorous and may end up being only semi-diagnostic (Agnarsson et al. 2013). They are included in the catalog only if they carry detailed descriptions and/or illustrations of species. Nevertheless, the local inventories contribute to the understanding of the ranges of taxa at regional scale and are indicative of local richness which ultimately contributes to the global gamma diversity. And, hence, Agnarsson et al. (2013) have argued that local inventories, semi-diagnostic as they may be, are important in spider studies. This parataxonomy in spider systematic is certainly important in the times of crunch of manpower and other resources for biodiversity studies (Derraik et al. 2002).

As in many other tropical places, the diversity recorded in the present study was immense. A total of 377 species belonging to 282 genera and 39 families were recorded. This comparable with similar recent studies in India (Jose et al. 2008: 22 families, 82 genera, 147 species in Parambikulam wildlife sanctuary; Hore and Uniyal 2008a: 22 families, 60 genera, 160 species in Terai Conservation Area; Uniyal et al. 2011: 33 families, 108 genera, 244 families in Nanda Devi Biosphere reserve; Sen et al. 2015: 22 families, 81 genera, 148 species in reserve forests of Dooars).

However, it should be noted that a considerable proportion of the 377 recorded species are morphospecies – semi-diagnosed morphs which may later be diagnosed properly. But the morphospecies also are based mostly on adult specimen and can be subjected to proper examination. And even in the above mentioned studies, except

Sen et al. (2015) a considerable number of morphospecies were recorded. At this juncture, the number of fully identified species in the present study is 198. This pattern is quite common in studies of speciose arthropod groups like spiders. Similarly, it can be observed that the proportion of morphospecies was higher in litter sorting (54%) compared to vegetation beating (38%). It is so because alpha-taxonomy of ground-dwelling spiders of the study Indian region is not very much clear and extensively available. A similar but rather subdued trend can be seen in terms of morphogenera because higher spider taxa are comparatively easier to identify. Imperfect identification of taxa in the form of morphospecies/morphogenera in ecological surveys is termed para-taxonomy. The problem of numerous un-described species is compounded by non-availability of taxonomic expertise and literature. However, still, the para-taxonomic approach could be useful in advancing alpha-taxonomy (Agnarsson et al. 2013) and adequately used for ecological analyses (Cardoso et al. 2004).

Salticidae was the dominant family in both the assemblages. And it was represented by comparable abundance in both assemblages. It was also the largest family in terms of number of genera and species. This was found to be in line with the global and Indian trends in species and genus richness in which Salticidae is the undoubted leader (World Spider Catalog 2016, Keswani et al. 2012). Similarly, families Theridiidae, Philodromidae, Sparassidae and Palpimanidae are represented by comparable abundances in both the assemblages thereby implying that these families are distributed in both the sampled strata fairly evenly. But compositionally they may be quite different. For example, only two species of Palpimanidae were found to be distributed one each in each assemblage. Similarly only two species of Pholcidae were found to be distributed one each in each assemblage. The data also indicated predominantly foliage-dwelling (Thomisidae, Oxyopidae, Araneidae, Eutichuridae, Uloboridae, Tetragnathidae and Clubionidae) and predominantly ground-dwelling (Linyphiidae, Pisauridae, Scytodidae, Pholcidae, Oonopidae, Gnaphosidae, Zodariidae, Lycosidae, Ctenidae, Tetrablemmidae, Liocranidae etc.) families quite clearly.

However, it must be noted that in case of less abundant and less well-known families like Mysmenidae, Theridiosomatidae, it was difficult to conclude similarly and exclusively on the basis of present data. Further, inclusion of Pisauridae in predominantly ground-dwelling families is an artifact of the fact that juveniles of one of its unidentified species were found in large numbers in the litter. It is also true that juveniles of many foliage-dwelling families like Clubionidae, Eutichuridae, Oxyopidae, Pisauridae etc spend early stages of their life in litter (Pers. Obs.).

At least 31 genera and 71 species recorded in this study have been tentatively considered and proposed as new to Indian spider fauna. One genus *Echinax* (Corinnidae) and its constituent species *Echinax panache* have already been published as a new record for India (Patil et al. 2015). Some of these have been identified in consultation with experts in concerned groups of spiders. For example, the genus *Micythus* (Gnaphosidae) was confirmed in consultation with Dr. Deeleman-Reinhold from the Netherlands; genus *Pherecydes* (Thomisidae) with Dr. Ansie Dippenaar-Schoeman, Extraordinary Professor, University of Pretoria. Similarly, the two genera of Palpimanidae were identified in consultation with Dr. Sergei Zonstein of Tel Aviv University who conceded that even the two species may be new to science.

A look at the potential new records tells that they are presently known mostly from the South-East Asian countries. But some genera like *Echinax* are with an Oriental plus Afrotropical distribution. *Pherecydes* is so far known only from Afrotropical region. Thus, as the knowledge on spider fauna of Indian region expands, there will be better clues available for the historical biogeography and recent anthropogenic movements of spiders. The present study is a small piece of work in the larger quest of exploring spider diversity in India which is recently joined by many other enthusiastic researchers.

However, despite detailed descriptions in even purely taxonomic thesis would not be considered and recognized for their inclusion in global database or the species described would not be accepted (e.g. Davis 2012). Therefore, it was decided to provide only indication here and publish detailed descriptions and illustrations in peer-reviewed journals later. Nevertheless, it is an indication and conviction of the fact that spider diversity in India is poorly explored.

6.3 Spider Diversity in Numbers

Two methods i.e. vegetation beating and litter search were used for sampling spiders in this study. As such, the two methods can not be compared for their performance because both sample different strata of the habitat. Vegetation beating targeted lower stratum of vegetation approximately from knee height to just above the head of the collector. This included mostly the large herbs, shrubs and lower branches of trees. Litter search, on the other hand, targeted the ground floor including various layers of litter including the topsoil. Both the sampled micro-habitats were entirely different and have been studied separately in different studies (e.g. foliage spiders: Rubio and Moreno 2010; Sorenson et al. 2002 etc. and ground spiders: Chatzaki et al. 2005; Monzo et al. 2011; Sabu et al. 2011; Schmidt et al. 2005 etc.).

The two methods sampled two spider assemblages – foliage dwellers and ground dwellers respectively. Nonetheless, the two nominate assemblages are much wider than covered in the present study. For example, foliage dwellers include spiders occupying higher canopy strata and ground dwellers include spiders that burrow deep in the soil or have retreat under stones. The collection methods used here may have collected some of these but were not targeted particularly. Therefore, it was considered appropriate to present and discuss results separately for each method. However, as the two spider assemblages are part of the same spider community, some of the analyses were conducted also by pooling the data obtained by the two methods at each sampling plot.

It is not advisable to compare the two methods because they are intrinsically different in the micro-habitat and spiders they sample, and their methodological approach. The only common factor - the effort - was same i.e. 20 minutes for each sample. Still it can be seen that the output from vegetation beating was almost double in terms of individuals and species collected per sample. Thus, when choice is available, vegetation beating can be used as a preferred method to obtain more number of individuals and species per unit of effort invested.

Although clear trends towards higher abundance and species richness in foliage dweller assemblage were seen in the raw numbers, it was difficult to interpret whether it was an inherent trend or an artifact of the collection efficiency of vegetation beating over litter sorting. A large number of singletons (species represented by only one individual) and doubletons (species represented by only two individuals) was observed as defined by Gotelli and Colwell (2001). This could be inferred as having two reaons. One, a result of true rarity of these species (e.g. *Crytpothele collina*, *Prodidomus rufus* etc.). Two, a result of taxonomic jumbles where only one or two adults were found, identified and recorded as species but the juveniles of same species could have gone into the unidentified members of the concerned genus of family. The later happened for many species of Clubionidae and Eutichuridae where even sub-adults individuals were difficult to assign to a particular species. This problem, however, was not faced in other families like Araneidae where in most genera even juveniles could be assigned to a particular species. Still, the problem of singletons was not as high as reviewed by Coddington et al. (2009) who found that in most arthropod studies the proportion of singletons was 36 per cent. In the present case it was only 14 per cent.

The asymptotic species richness estimators and their plotted curves revealed that there were many more species waiting to be described in this study area. The surveys were fairly complete reaching even 95 per cent level if the conservative estimates of species richness are considered (i.e. Chao1 values). But the higher estimate for species richness was more than 450 species. These figures are very commensurate with those predicted by Coddington et al. (2009) for reasonably intact moist tropical ecosystems.

There was apparent seasonal fluctuation in spider abundance and diversity across seasons. Although there was significant increase in spider abundance in 2nd year sampling than 1st year sampling, it was almost uniform across seasons, and hence could be attributed to increased practice of the collector. But for the pooled data of both years, winter season was found to yield markedly higher spider abundance and marginally higher diversity compared with post-monsoon and summer seasons. For some species like Nephila pilipes and many other orb-weaver species, this pattern is quite evident. Similar patterns have been obtained by others (e.g. Lubin 1978 for web-builders, Mineo 2010 for ground dwellers). In the rice fields of Kuttanad, the ratio of juveniles to adults was high during initial crop stages i.e. towards the beginning of monsoon. It indicates that spiders multiply during the early monsoon from the adult breeding population of summers. That is wet seasons have higher species diversity and abundance of spiders. This is related with overwintering or cryptic life history stages and breeding phenology of spiders. However, as Coddington et al. (2009) mentioned for aseasonal tropical climes, the differences were not drastic.

6.4 Spiders and Habitat

Spiders as individuals are associated with their habitat at a very fine scale, the higher taxonomic levels getting broader and broader in their habitat selection. The microclimate rather than landscape affects the species richness and abundances of spiders at least in pasture ecosystems (Batary et al. 2008) and grasslands (Uniyal and Hore 2008).

The two assemblages sampled in the present study suggested that they were clearly distinct in any habitat sampled. This was intuitive to believe as the foliage dweller and ground dweller spiders have evolved many different life history traits which make them distinct (Entling et al. 2007, Bowlin et al. 2014). The results based on compositional analysis at the levels of both species and families showed this pattern. Some families like Nephilidae, Clubionidae were found to be exlusively foliage dwellers whereas some like Trachelidae, Segestriidae, Prodidomidae etc. were found to be exclusively ground dwellers. However, the later families were represented by few individuals each and therefore conclusive remarks can not be offered at this point. Most of the families, on the other hand, were represented in both the assemblages with the Salticidae being almost equally present in both. Families of orb-weavers like Araneidae and Tetraganthidae and other like Eutichuridae were supposed to be exclusively foliage dwellers and they were more or less so. But several juvenile individuals of these families were collected from litter indicating that some early stages of life of these spiders are spent on ground in litter.

The dissimilarity was mostly contributed by Thomisidae, Araneidae and Oxyopidae being abundant in foliage dwellers and relatively very less so in ground dwellers. Similarly, Linyphiidae and Pisauridae were relatively more abundant in ground dweller assemblage.

This compositional diversity was, although, not evident among different putative habitat categories. The habitats selected for this study included sacred groves, reserved forests, mango orchards and cashew orchards. There was no significant compositional difference between mango or cashew orchards; nor was there such difference between sacred groves and reserved forests. However, mango orchards were clearly different from reserved forest and somewhat so from sacred groves. But clearly, the diversity in terms of species richness was higher in sacred grove plots. Even the diversity when compared in terms of effective number of species i.e. exponential of Shannon entropy as suggested by Jost (2006, 2007), it was observed that the habitats differed only slightly. This goes to tell that spiders being ubiquitous can attain very high species richness in apparently vey distinct habitats. But the composition of assemblages in these habitats may be different depending on the properties of the habitats. However, the habitat variables recorded in this study did not reveal any clear associations with species distribution. So, it seems that either the variables selected were perhaps broad scale and the spiders select their habitats at a much finer scale (Hore and Uniyal 2010).

The richness of species versus richness of genera was compared for two purposes – testing for higher taxa surrogacy (Cardoso et al 2004, Hore and Uniyal 2013) and for looking at whether different factors like habitat, size of patch, effort, disturbance etc. affected these trends. It was observed that there was a clear linear relationship between species richness and species richness which was predictable as similar results have been found in Cardoso et al. (2004) and Hore (2009). Thus, spider genera could be used as surrogates for spider species. This is a very useful inference for studies which do not intend taxonomic work but are targeting impact assessments of either disturbance or conservation efforts. The non-specialist parataxonomists can very well take up such work with basic training where the identification of spiders upto genus level is comparatively much easier that at the species level (Derraik et al. 2002, 2010, Agnarsson et al. 2013).

On the other hand the discrete categories of either effort, habitat type, size of patch studied or disturbance ranking did not yield any significant effect on the relationship between species richness and genus richness. In all categories the relationships aligned with each other almost perfectly. This again supported the use of spider genera as surrogates for spider species as the underlying diversity of spider species could very well be understood using generic level information without being influenced by above mentioned factors which always tend to be part of monitoring programs especially when minimal-trained personnel are involved.

6.5 Conservation Management of Sacred Groves and Spiders

Indicator species

Samways et al. (2010) have outlined the steps in developing a bioindicator system – (i) a-priori selection of a one or more potential bioindicator taxa, (ii) identifying sensitive and suitable species from the assemblage of potential taxa using field sampling and quantitative techniques, (iii) testing the proposed bioindicator on an independent data set, and (iv) further developing the bioindicator for use by managers and practitioners. It has often been seen that the first two steps are completed by academicians and then the recommended bioindicators are neither tested on independent data sets nor developed into a bioindicator system. The present study has also completed the first two steps. And it is hoped that the author will continue the work into further steps to develop a bioindicator system.

The indicator species identified for sacred groves i.e. Philodromidae sp1 and *Nephila pilipes* could be good indicators for this habitat. The fact that the later species has emerged as an indicator species itself is a proof of its preference of undisturbed habitat at least in early stages of its life. This is so because *N. pilipes* was not collected in proportion to its adult abundance. The adults used to be in their huge webs and were not subjected to the vegetation beating as usually they would retreat to a very high point on their webs on slight disturbance. And to avoid confounding, even those that accidentally lodged in the umbrella were let go. So, the collected individuals were mostly juveniles which make smaller webs in lower strata of vegetation. Thus, although adult *N. pilipes* could be seen even in orchards, they are almost always only adults.

Similarly, *Amyciaea forticeps* came up as an indicator of mango orchards probably because this species is associated with weaver ants (*Oecophylla* sp.). And weaver ants have been seen to be partial to fruit trees especially mango (Peng and Christian 2007). On the other hand, *Bomis bengalensis* was recorded in large numbers in only one season and in only one mango orchard. So, there is a need to evaluate it further.

Boliscus tuberculatus emerged as a very strong indicator of reserved forests perhaps because it showed very high fidelity to this habitat along with sporadic presence in sacred groves and near-complete absence from orchards. *Leptopholcus podophthalmus* has already been tentatively identified as an indicator of mango-less vegetation because it never appeared in collection from mango orchards (not even cashew orchards) and even the sacred groves which were dominated by natural or planted mango trees (Patil and Uniyal, in review). Thus, the intuition has been proved by the statistical method and the species has emerged as an indicator of reserved forests which rarely had mango trees.

Thus, although the set of spiders statistically identified in this investigation as indicators of sacred grove habitat need further assessment, there is one set available which is actually highly correlated positively or negatively with the presence or absence of mango trees. Mango is a natural tree of the moist deciduous forest of this tract. However, presence of natural mango in reserved or private forests which cover close to 50% of this district is quite negligible. The reason is, perhaps, its utility as valuable timber. But significance presence of natural mango is found in sacred groves (annexure VI). Huge old mango trees were noticed in larger sacred groves some of which were unfortunately felled recently (Kadivali). But on the other hand, some smaller sacred groves are being cleared of their natural vegetation and being planted with mango variety grafts (Kherdi, Degaon). Similarly, large tracts of secondary natural forest are being converted to plantations of mango variety grafts. This is a situation where the set of identified indicator species could possibly be developed into a bioindicator system.

Such a system could either be a part of Community Based Natural Resource Management (CBNRM) as perceived Bhagwat and Rutte (2006) for management of sacred groves.

Although not in sacred groves, several studies have proved this in case of natural gradients (e.g. Churchill 1998 - rainfall and grazing gradients sufficiently indicated by some families in Australian tropical savannas; Olarte 2010 - structural changes in vegetation by certain spider families in grasslands of New Zealand; Kapoor 2006 - habitat alteration in rainforest fragments of the Western Ghats indicated by certain spiders, Hore & Uniyal 2008b,c, 2010, 2013) – fire regimes in grasslands well indicated by certain spider species). Thus, evidence is all over to suggest that spiders can be built into a successful bioindicator system. There is a need to take this approach forward.

6.6 Conservation Prioritization

Prioritization of sites and species has been the cornerstone of twenty-first century conservation research and conservation and even indices like Average optimacity have been worked out (Wilhere et al. 2008). There has been a long-pending plea for inclusion of sacred groves in the conservation area network (Gadgil and Vartak 1976). It has not been heeded and even though there has been a provision in the Wildlife (Protection) Act, 1972 for declaration of community reserved, the sacred groves have not been represented in this category proportionate to their immense numbers. The organizations like Applied Environment Research Foundation (AERF) in Maharashtra and C.P. R. Environmental Education Centre (CPREEC) in Tamil Nadu have been left with the task of restoring and protecting sacred groves on a small scale in non-government participatory mode.

The discussion here will be meaningful if at all there will be a strategy to include sacred groves in the conservation network and spiders will be used for prioritizing them. As has been found out by several studies including the present one, spiders are good indicators of local biodiversity. Therefore, conservation of maximum number of spiders would actually be trailed by conservation of most of the biodiversity. It is also an easy criteria to apply and easy and quick to work out. Two approaches as suggested by Cardoso et al. (2004) and Hore and Uniyal (2013) were used in this study to rank studied sites for conservation prioritization. The first approach was based on raw species richness values which indicated that most of the large sacred groves should be included in the sacred grove conservation network.

The other approach included factoring in the complimentarity concept. It means when identifying and prioritizing sites for conservation, some species will be already conserved in previously selected sites and emphasis should be on adding more new species than going for overall high species richness. Thus, if first site is selected on the basis of maximum species richness, the next site should be selected such that it adds maximum number of additional species to the pool of already conserved species. It became evident on applying this approach that some of the larger sacred groves prioritized using earlier approach were ranked lower than some other habitats like mango orchards and reserved forests.

The other habitat sites were also included in the analysis because they contribute to the gamma diversity of the landscape. And it has been highlighted by several researchers that overall habitat heterogeneity of the landscape contributes more to the diversity of at least arthropods (Oberg et al 2008, Batary et al. 2008). Thus, although sacred groves are important landscape elements from cultural and ecological point of view, other landscape elements can also contribute substantially to the spider diversity and need to be maintained as ecological as well as social imperatives. It was found that the site prioritization based on plain scoring was easy. But a comparison of the first 10 sites selected by the two approaches revealed that the iterative ranking approach included more number of non-sacred grove habitats because they contributed newer species to the pool of already conserved species in species rich sacred groves. Thus, it was seen that this approach was especially useful in landscapes where there are variety of habitats are intermixed and there is a need to conserve many of them to protect the entire spectrum of biodiversity.

6.7 Conclusions

It could be concluded based on the findings of the present investigation that sacred groves of Dapoli Taluka range from very small patches to reasonably large patches with varies matrix around them. They were found to be culturally and traditionally a varied. But they were also highly threatened major of which was shift in belief system.

It could also be concluded that sacred groves of Dapoli Taluka held important and rare floristic elements like *Entada scandens*, *Antiaris toxicaria*, *Saraca asoca* (locally rare) and *Mammea suriga* (locally rare) and also threatened species like *Cryptocoryne cognata*. Because these were not found in other studied habitats, the immense importance of sacred groves is highlighted.

Spider diversity in Dapoli Taluka was found to be very high with 377 species being recorded in this study and statistical estimates reaching close to 500 species. Despite high estimated completeness surveys, it was observed that large number of species could not be identified with existing species. Although this could have many reasons, one of the reasons could be that there are species which are yet to be described.

Another conclusion from spider diversity data was that there were several singletons and doubletons which can not be actually so rare from ecological and biological considerations. Hence, the design and intensity of the spider collection methods and surveys was still inadequate to detect rare species.

Nearly 29 genera and 73 species were found to be new reports for India. It could be concluded that spider diversity of not only the study area but also at country level was poorly explored to allow such high number of new reports.

Spider diversity in terms of species richness and diversity indices was not found to be affected by size of the habitat patches studied. This was probably because these patches are not islands and they are connected with other smaller or larger patches in the habitat. Similarly, for organisms like spiders who show excellent dispersal propensities, the connectivity of habitats should be more functional than physical.

Similarly, the diversity in terms of species richness and diversity indices was not found to be influenced by habitat type. The effective number of species was found to be similar in the two types of orchards and sacred groves. However, it was considerably less in reserved forests.

However, spider assemblages differed considerably in their species composition. The foliage-dweller and ground-dweller assemblages were found to be well-defined and the dissimilarity was found to be contributed by few families like (Linyphiidae, Pisauridae dominant in ground-dwellers and Araneidae, Thomisidae, Oxyopidae dominant in foliage-dwellers). Salticidae was found to be equally abundant in both the assemblages but still it contributed maximum to the diversity of the two assemblages. This was because the species of Salticidae which were in foliage-dwellers were completely different from ground-dwellers.

The spider assemblages of mango orchard were significantly different from those of reserved forest and fairly different from those of the sacred groves. However, they were at par with those of the cashew orchards on the basis of species composition.

Oedignatha scrobiculata and *Angaeus pentagonalis* were found to be the main drivers behind this dissimilarity. *O. scrobiculata* was found high abundance in the orchards, and almost absent from sacred groves and reserved forests. Thus, this ground-dwelling species seemed to prefer relatively open habitats with little ground vegetation except grasses.

There was a simple linear relationship between species richness and genus richness. This relationship was observed to be not affected by size of the habitat patch, habitat type, amount of effort and disturbance status of the site. This enabled to conclude that genus richness could be used as surrogate taxa in rapid spider diversity studies.

Site prioritization based on plain scoring on the basis of species richness was found to be easy. However, when compared with iterative ranking, the top ranked sites remained similar but there were changes in lower sites. And this approach was probably favouring rare species because for rare species the complimentarity between sites should be less. Thus, iterative site ranking approach was found to be better for conserving rare species.

There was not much difference in proportion of sites selected using foliage-dweller assemblage, ground-dweller assemblage thus implying that any one of these assemblages could be used for rapid assessment and prioritization studies. Similarly, it was found that even if generic level was used for such rapid assessments and the decisions were based on 100 per cent conservation of genera, automatically more than 90 per cent species were getting protection.

Finally it could be concluded that these findings can be utilized for conducting further refinement studies and also directly for incorporation into spider-inventory based conservation decision-making processes.

6.8 Recommendations

The following recommendations are proposed based on the findings of the present investigation-

Sacred groves are important but threatened elements of our cultural and ecological heritage. Therefore, they need to be conserved against all odds. For this purpose 'greater sensitization' towards them can be achieved through using informal educational avenues like online catalogues. It can also be achieved through introduction of sacred groves in the formal education syllabi at school level. Thus, at least the students in the villages where sacred groves are present can relate to them much more intimately.

Spiders are a neglected group of organisms and there is much to be explored for taxonomists, ecologists and even for the laymen. Hundreds of species of spiders remain to be discovered from Indian region. Spider taxonomy should be advanced to document the full spectrum of spider diversity present in India through local research initiatives. The number of researchers involved in spider research and their output has been found to be increasing in the recent times. Initiative should now come from government and academia to support these enthusiastic persons in their ventures through financial and infra-structural support.

A large number of student volunteers were involved in this investigation and I found that they were full of queries and doubts about spiders. It is realized that like other well-known groups like birds and butterflies, there is a need of bringing the information in public domain in the form of popular books and websites.

Spiders were found to be good indicators of their own diversity at different taxonomic level and were also found to be of good indicator value for different habitats. Therefore, their inclusion in conservation site prioritization protocols and in subsequent monitoring programmes is essential. They can also be included in environmental impact assessment (EIA) studies.

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Annexure I:

Inventory of Sacred Groves in Dapoli Taluka

Village name		Lat		N
Taluka		Long		E
No. and names of wadis		Alt		m
		Pop		
Nearest wadi		Dist		
Approach road	Dirt/Tar/Concrete			

Ownership	Govt./Malki	If Malki, Name	
Area			
Main Deity		Other Deities	
Temple	Simple/Elaborate	Year built	
Mankari	Inherited/Elected	Name(s) and contact	
Priest name		No. of generation	
Management	Single/committee/Communal		

Rituals: Holi Navratra Any others

Status of Vegetation (Study this in a plot of 10 x 10 m at the centre of grove)

Strata	Emergents	canopy	climbers	shrubs	Stem density
Dominance				100%	/100 m^2

Dominant tree species

Dominant shrubs

Dominant climbers

Avg. Canopy closure		%	Litter cover	%
Ground cover	Herbaceous	Yes/No	Litter depth	cm

Surrounding landscape: Write in detail about surrounding vegetation, habitation, agriculture etc. Also draw a rough map of SG on backside of this sheet.

Disturbance Rating (Write whether slight(1)/moderate(2)/heavy(3))

Development projects		Pilgrimage and tourism		Modernisation	
Shift in belief system		Forestry activity		Fragmentation	
Sanskritisation		Removal of biomass		Encroachment	

Ecotourism rating (Give a score from 0-10 for ecotourism potential) .

Check if any of these features are present and mention any others for ecotourism.

Waterfall ☐ Caves ☐ Threatened species ☐ Ancient temple ☐

Congregation ☐

Annexure II: Demographic aspects of Sacred Groves of Dapoli

Village	No. and names of hamlets (*wadis*)		House-holds	Popu-lation
Aade	13	muslim, vitthal, chambhar, shivaji nagar (1,2,3,4), brahman ali, padale khond, guhagar ali	423	2189
Aaghari	7	kansewadi, kashtewadi, morewadi, khalchiwadi, rahatewadi, tiware rahatewadi	177	654
Aasud	27	navendrawadi, bandrewadi, dapkewadi, rewalewadi, utkarshwadi, tambadicha kond (A,B,C), ghodsanwadi, shirkewadi, shirkewadi A, kajarewadi, phansewadi, joshi aali, budhhawadi, tulsi mohla, kanche-tiliwadi, biwalkarwadi, aadarshwadi, guravwadi, yedrewadi, vadachiwadi, kaduwadi, magechiwadi, aavalechiwadi	565	2490
Aatgaon	2	Gavthavwadi, bhatwadi	176	678
Agarwayangani	10	govalwadi, budhawadi, pawarwadi, nigudbhaumwadi, ghevadwadi, madhliwadi, ramanewadi, khoparwadi, telewadi, brahmanwadi	381	1526
Bandhtivare	2	gavthanwadi, buddhawadi	186	656
Bhadavale	7	baudgawadi, shindewadi, guravwadi, devulwadi, usswadi, kolabewadi, sheriwadi	212	869
Bhatghar	1	Bhatghar	52	169
Bhomadi	5	nikamwadi, ramwadi, baudhawadi, mhabdewadi, gawalwadi	104	438
Bhopan_1	8	gharakarwadi, baudhwadi, vithalwadi, ambokarwadi, harekarwadi, shipanganwadi, mauhala	315	1199
Bhopan_2	-	-	-	-
Bondivali	6	khotwadi, budhhawadi, brahmanwadi, sutarwadi, thorala kond, satarachiwadi	164	645
Borivali	2	adiwadi, borivale wadi	173	616
Brahmnwadi	3	misalwadi, laxmiwadi, brahmanwadi	236	1032
Chandikanagar	2	ainoli, gomrai	199	737
Chandranagar	9	digiwadi, bagwadi1, bagwadi2, mulukwadi, varachiwadi, gorulewadi, malewadi (A,B,C)	270	1152
Chinchali	3	rohidaswadi, baudhwadi, marathwadi	131	531
Dabhol	1	Dabhol	1508	7929
Damame	7	guravwadi, vadachiwadi, madhaliwadi, baudhwadi, holambi, makardi, mywadi	173	724
Degaon	5	Kondwadi, marathwadi, barewadi, katalwadi, bamnewadi.	227	956
Dehen	5	degola, kansowadi, talwatkarwadi, dhepoli, jadhavwadi	173	647
Derde	2	Thombarewadi, bhoiwadi, khotwadi	131	494
Devake	3	varchiwadi, baudhwadi, datt wadi	122	450

Village	**No. and names of hamlets (*wadis*)**		**House-holds**	**Popu-lation**
Dhankoli	3	yadavwadi, baudhwadi, kunbiewadi	86	345
Douli	3	gavthanwadi, hanumanwadi, dhanarajwadi, baudhawadi	151	515
Ganpatipule	3	Purvwadi, Madaliwadi, Pashimwadi	184	712
Gavhe	7	pulekarwadi, pawarwadi, budhhawadi, gharatewadi, talewadi, guravwadi, brahmanwadi	313	1340
Gavrai	4	gavthanawadi, bauthwadi deulwadi, kalakwadi	114	460
Gavtale	3	Dattawadi ,hanumanwadi, buddhawadi	169	834
Hatip	5	Telwadi, Baudhwadi, Shedagewadi, Chalichakond, Dattwadi	152	646
Ilane	2	Gavthan, charmakarwadi	127	438
Jalgaon	13	Brahmanwadi, Lashkarwadi, Bouddhwadi, Shigvanwadi, Sutarwadi, gavalwadi	1258	5449
Jamage	7	baudh wadi, devacha kond, mahullatalacha kond, somjai wadi, jolwadi	328	1542
Kadivali	5	gavthan, jambhul khond, hanuman nager,	234	900
Kalambat	7	khotwadi, madhaliwadi, rajpurewadi, zimanwadi, gavalwadi, dabhilkarwadi, buddhawadi	159	559
Kalki	6	khotwadi,nacharewadi,patewadi,gavthanwadi,shivganwadi,depolwadi	216	769
Kangavai	5	baudhwadi,gavthanwadi, wayanganwadi, pedhekarwadi, durgaiwadi,	239	982
Karanjani	7	darbhachiwadi,brahmanwadi,ugavatwadi,mavalatwadi,katalwadi,bigiwadi,budhhawadi	283	1257
Karde	8	khairyachiwadi,khambewadi,jadhavwadi,danda mohalla,budhhawadi,teliwadi,madhaliwadi,sakadewdi	349	1250
Kavdoli	1	Kavdoli	127	545
kelil	2	ganeshwadi,bhavaniwadi	101	383
Kharavate	4	kulbiwadi, three baudhwadi	81	332
Kherdi	12	Brahmanwadi, Bouddhwadi, Sutarwadi, Shigwanwadi	485	2027
Kondhe	11	Goralewadi, Ghevadwadi, kadamwadi, patilwadi, shigavanwadi, baudhwadi(2), ghadavalewadi, kolambewadi, telwadi.	331	1511
Kongale	2	krantiwadi, buddhawadi	136	468
Kudavale	12	Dewkhal, borichi, sutar, karanjkar, katkar, tele, budhha, gavthan, yadav, govindnagar, kadam, varjai.	383	1648
Kumbhave	7	gorivale, nimbar, makhewadi, shigwan wadi, sytar wadi, budh wadi, sutar wadi	268	1153
Ladghar	3	shrahanewadi, parthdeviwadi, shankarwadi	399	1604
Lonvadi	2	gavthan, baudha wadi	76	271

Village	No. and names of hamlets (*wadis*)		House-holds	Popu-lation
Mahamainagar	1	Mahamainagar	70	256
Male	6	mahadikwadi, philasewadi, telapwadi, tilakwadi, srinagar, pandewadi	175	779
Male_1		-	-	-
Malvi	2	gavthan, baudha wadi	110	346
Mandivali	7	baudhwadi, musalmanwadi, bamanwadi, sawantwadi, anatwadi, bayitwadi, nawawadi	316	1434
Mathegujar	3	sutarwadi, pawarwadi, baudhwadi	82	365
Matwan	3	gavthan, morewadi, budhhawadi	139	529
Mugij	8	Waniwadi, Jadhavwadi, Madavkarwadi, Bhandiwadi, Gomalewadi, Thomarewadi, Baudhwadi, Kalmpethwadi	171	738
Murdi	4	chachval, teliwadi, brahmanwadi, kondwadi	243	966
Murud	9	varachi pakhadi, bhandarwada, navanagar, shipwadi, harijanwadi, bovanewadi, tambadicha kond, bhairavicha kond, khalachi pakhadi	419	1645
Nanate	6	jambhulkhand, dingandwadi, khotwadi, baudhwadi, chinchwadi, kamblewadi	184	836
Navashi	9	sutarwadi, pawarwadi, baudhwadi	218	994
Olgaon	3	varchiwadi, khalchiwadi, deol wadi	146	541
Onnavase	5	patilwadi, baudhwadi, engalewadi, khaiewadi, mamtulewadi,	255	1016
Pachavali	5	Marathwadi, Desaiwadi, Walmikiwadi, Baudhwadi, Sarodewadi, Walanwadi	153	560
Palgad	23	Belosewadi, Pawarwadi, Sutarwadi, Bajarpeth, Sambhajinagar, Ranimachi, Pawarwadi, Baudhwadi, Rohidaswadi, Kumbharwadi, Bhowalwadi, Patilwadi, Kondwadi, Malekarwadi, Mahadikwadi, Gujarwadi, Bramhanwadi, Belwadi, Shigawanwadi,Katalwadi, Fanaswadi	762	3531
Panderi	5	gharavewadi, gayakwadwadi, kavankarwadi, baudhwadi, bhuiwadi	186	785
Panhalekaji	12	gavanwadi, bholwadi, bhatiwadi, kalwadi, durbhwadi, vilewadi, bagwadi, pipalwadi, khepwadi, jambhulwadi, gandhwadi, banewadi, devaranwadi	231	847
Phanasu	8	patilwadi, mavwalathwadi, ugavatwadi, bhandawadi, katalwadi , maharwadi.	298	1236
Pichdoli	4	gawalwadi, teliwadi, baudhwadi, sawantwadi	107	419
Ravtoli	3	gavthanwadi, kondwadi, kalkondwadi	109	400
Revali	2	bhaudhawadi, shedgewadi,	68	245
Rovale	4	gavthanwadi, buddhawadi, vijaywadi, rohidaswadi	99	442

Village	No. and names of hamlets (*wadis*)		House-holds	Popu-lation
Sadavali	6	marathwadi, baudha wadi, dhangar wadi, hanuman wadi, pawar wadi	46	144
Sakhloli	9	ganeshwadi, kisanwadi, hanumanwadi, sutarwadi, gorivalewadi, adarshwadi, baudhwadi	280	1234
Saldure	4	bhuvadwadi, sawantwadi, gudekarwadi, bhandarwadi	89	342
Sarang	5	brahmanwadi, gavalwadi, moholla, talewadi, buddhawadi	203	918
Satere T. Haveli	3	kotwadi, agrewadi, khokharwadi	151	697
Satere T. Natu	4	Marathwadi, Kumbiwadi, Mohalla, Baudhwadi	71	250
Shirkhal	7	gav wadi, sutar wadi, dev bhavane wadi	206	1021
Shirsadi	5	Baudhwadi, Vikaswadi, Bhuwadwadi, Gavalwadi, Bolavanwadi	124	555
Shirsoli	4	Devwadi, Madhaliwadi, Baudhwadi, Pashimwadi	135	566
Shitalnagar	1	Shitalnagar	125	407
Shivajinagar	12	ainkarwadi, mehengewadi, pagalewadi, jagrutiwadi, ghadavlewadi, pimpaleshwarwadi, lanjekarwadi, ganeshwadi, padvekarwadi, navjivanwadi, hanumanwadi, ilamkarwadi	302	1219
Shivnari	3	adarshwadi, ganeshwadi, sutarwadi	97	407
Soveli	7	Bhoitewadi, Sawantwadi, Sutarwadi	214	988
Sukondi	11	mahadik, gaval, baudha, humne, jadhav, chandivane, masekar, batavle, navanagar	192	721
Sukondi_1	-	-	-	-
Talsure	13	shelarwadi, lalewadi, khotwadi, ashtachiwadi purv, ashtachiwadi pashchim, budhhawadi, telewadi, choganewadi, turewadi, vikaswadi, sanaswadi no.1, vikaswadi no.2, khorewadi	380	1624
Terevayangani	4	pahili wadi, parva wadi, madhli wadi, budh wadi	217	944
Umbarle	7	gavwadi, brahmanwadi, gotanwadi, kashtewadi, khopwadi, baudhwadi, rohidaswadi	217	939
Umbarshet	4	gavthawadi, buddhawadi, navanagar, nabib moholla	193	848
Urfi	5	baudhwadi(2), phalatewadi, khalewadi, borichakhond	127	562
Usgaon	6	madhliwadi, ramanewadi, ganeshwadi, baudhwadi, sutar wadi, dhopatwadi	223	930
Vaghave	2	budhawadi, gavthan	107	392
Vaghivane	2	Gavthan, charmakarwadi	113	335
Velavi	3	marathwadi, kalanagar, gawalwadi	108	439

Village	No. and names of hamlets (*wadis*)		House-holds	Popu-lation
Virsai	5	varchiwadi, ranewadi. mestriwadi, kondwadi, bhuvadwadi, phanaswadi	185	780
Visapur	3	budhwadi, patrichwadi, more wadi	166	729
Vishrantinagar	3	Baudhwadi, Savardekarwadi, morewadi	132	567
Wakavali	7	marathwadi, baudhwadi, kaundwadi, gavalwadi, malwadi, navanagarwadi, charamkarwadi	456	2066
Wanzloli	3	gawthanwadi, hanumanwadi, baudhwadi	220	746
Wavghar	1	guravwadi	234	943

Annexure III: Geographic aspects of Sacred Groves of Dapoli

Village	Latitude (degree decimal)	Longitude (degree decimal)	Altitude (msl)	Area (ha)	Approach road	Ownership
Aade	17.884	73.077	35	0.4	Tar	Government
Aaghari	17.624	73.136	42	0.85	Dirt	Government
Aasud	17.785	73.136	21	0.2	Dirt	Government
Aatgaon	17.917	73.077	59	0.8	Dirt	Government
Agarwayangani	17.631	73.202	140	0.91	Dirt	Government
Bandhtivare	17.813	73.197	179	0.4	Dirt	Government
Bhadavale	17.577	73.345	124	1	Dirt	Government
Bhatghar	17.900	73.311	150	1.88	Dirt	Government
Bhomadi	17.880	73.163	180	2.4	Dirt	Government
Bhopan_1	17.615	73.239	139	0.4	Dirt	Government
Bhopan_2	17.617	73.244	144	0.4	Dirt	Government
Bondivali	17.808	73.237	123	2.4	Dirt	Government
Borivali	17.648	73.154	109	0.3	Tar	Government
Brahmnwadi	17.741	73.205	192	0.44	Tar	Government
Chandikanagar	17.665	73.149	136	0.03	Tar	Government
Chandranagar	17.742	73.156	168	0.4	Tar	Government
Chinchali	17.859	73.326	142	0.3	Tar	Government
Dabhol	17.595	73.181	128	10.8	Tar	Private
Damame	17.604	73.346	209	1.5	Tar	Government
Degaon	17.644	73.300	180	0.07	Dirt	Government
Dehen	17.867	73.161	233	0.4	Dirt	Government
Derde	17.597	73.218	60	0.13	Dirt	Government
Devake	17.682	73.137	127	0.4	Dirt	Private
Dhankoli	17.849	73.227	117	2.8	Dirt	Government
Douli	17.890	73.157	164	10.8	Dirt	Government
Ganpatipule	17.858	73.281	111	0.1	Tar	Government
Gavhe	17.729	73.170	156	1.6	Tar	Government
Gavrai	17.661	73.230	22	0.6	Dirt	Government
Gavtale	17.706	73.287	181	2.4	Dirt	Private
Hatip	17.846	73.309	123	1.2	Tar	Government
Ilane	17.876	73.103	11	0.4	Dirt	Government
Jalgaon	17.736	73.199	183	3	Tar	Government
Jamage	17.873	73.340	143	2	Tar	Government
Kadivali	17.870	73.229	198	1.5	Dirt	Government
Kalambat	17.818	73.145	144	0.4	Tar	Government
Kalki	17.644	73.206	240	1.2	Dirt	Government
Kangavai	17.895	73.207	171	0.6	Tar	Government
Karanjani	17.785	73.250	169	0.28	Tar	Government
Karde	17.755	73.140	72	3.77	Dirt	Government
Kavdoli	17.920	73.109	60	2.8	Dirt	Government
kelil	17.634	73.241	115	0.39	Dirt	Government
Kharavate	17.903	73.150	182	0.2	Dirt	Government
Kherdi	17.790	73.225	176	2	Tar	Government

Village	Latitude (degree decimal)	Longitude (degree decimal)	Altitude (msl)	Area (ha)	Approach road	Ownership
Kondhe	17.670	73.317	137	3.6	Dirt	Government
Kongale	17.809	73.225	193	0.8	Tar	Unknown
Kudavale	17.861	73.244	186	40	Dirt	Government
Kumbhave	17.750	73.258	166	0.92	Tar	Government
Ladghar	17.719	73.136	12	0.4	Tar	Government
Lonvadi	17.871	73.107	68	0.03	Dirt	Government
Mahamainagar	17.662	73.131	93	0.08	Dirt	Private
Male	17.650	73.180	115	0.4	Dirt	Government
Male_1	17.650	73.182	130	1.21	Dirt	Government
Malvi	17.890	73.098	75	0.4	Dirt	Government
Mandivali	17.937	73.120	8	0.35	Tar	Government
Mathegujar	17.661	73.214	162	0.4	Dirt	Government
Matwan	17.834	73.269	112	2.75	Tar	Government
Mugij	17.894	73.304	129	0.45	Tar	Government
Murdi	17.848	73.108	98	0.8	Dirt	Government
Murud	17.777	73.122	25	0.69	Tar	Government
Nanate	17.673	73.197	173	0.43	Dirt	Government
Navashi	17.764	73.260	192	1.98	Dirt	Government
Olgaon	17.690	73.184	189	0.55	Dirt	Government
Onnavase	17.598	73.224	94	0.4	Dirt	Government
Pachavali	17.802	73.284	138	2	Dirt	Government
Palgad	17.785	73.336	103	3.88	Tar	Government
Panderi	17.590	73.251	19	3.44	Dirt	Government
Panhalekaji	17.644	73.240	88	0.53	Dirt	Government
Phanasu	17.654	73.279	202	0.4	Dirt	Government
Pichdoli	17.969	73.273	218	0.8	Dirt	Government
Ravtoli	17.922	73.104	105	1.2	Dirt	Government
Revali	17.851	73.191	200	1.6	Dirt	Government
Rovale	17.908	73.094	142	2.2	Dirt	Government
Sadavali	17.709	73.222	158	13.2	Dirt	Government
Sakhloli	17.734	73.256	189	5.54	Dirt	Government
Saldure	17.791	73.112	22	0.8	Dirt	Government
Sarang	17.814	73.163	25	0.4	Tar	Government
Satere T. Haveli	17.636	73.230	215	0.15	Dirt	Government
Satere T. Natu	17.877	73.344	156	2.8	Dirt	Government
Shirkhal	17.851	73.324	129	3.6	Tar	Government
Shirsadi	17.894	73.334	133	0.05	Dirt	Government
Shirsoli	17.872	73.288	108	0.51	Tar	Private
Shitalnagar	17.681	73.127	132	0.5	Tar	Government
Shivajinagar	17.783	73.185	185	0.35	Dirt	Government
Shivnari	17.701	73.284	184	0.74	Dirt	Private
Soveli	17.907	73.315	130	1.6	Tar	Government
Sukondi	17.862	73.122	73	0.19	Tar	Government
Sukondi_1	17.860	73.131	183	0.53	Tar	Government
Talsure	17.754	73.233	144	0.34	Tar	Government

Village	Latitude (degree decimal)	Longitude (degree decimal)	Altitude (msl)	Area (ha)	Approach road	Ownership
Terevayangani	17.675	73.222	200	0.7	Dirt	Government
Umbarle	17.696	73.198	205	1.38	Tar	Government
Umbarshet	17.924	73.080	127	0.4	Tar	Government
Urfi	17.664	73.260	138	2.55	Dirt	Government
Usgaon	17.605	73.192	23	0.36	Dirt	Private
Vaghave	17.808	73.134	180	0.34	Dirt	Government
Vaghivane	17.881	73.118	134	0.78	Dirt	Government
Velavi	17.866	73.207	195	0.6	Tar	Government
Virsai	17.903	73.180	171	1.2	Tar	Government
Visapur	17.866	73.320	112	2	Tar	Government
Vishrantinagar	17.873	73.332	138	0.25	Tar	Government
Wakavali	17.755	73.297	178	2.43	Dirt	Government
Wanzloli	17.909	73.130	164	2.4	Dirt	Government
Wavghar	17.587	73.338	188	0.32	Dirt	Government

Annexure IV: Cultural aspects of Sacred Groves of Dapoli

Village	Main Deity	Other Deities	Main festival 1	Main festival 2	Other festivals
Aade	Bhargavram	shani, rameshwar, maruti	Holi	Navaratra	akshay trutiya, janmashtami
Aaghari	Mahamai		no	no	Borivsa
Aasud	Vyaghreshwar	zolai devi	Holi	Navaratra	mahashivratra, shravan, tripur pornima, dattsjayanti, yatra
Aatgaon	Bhairi		Holi	Navaratra	
Agarwayangani	Bhairi-ravalnath	Maruti	Holi	Navaratra	
Bandhtivare	Bhairi		Holi	Navaratra	
Bhadavale	Someshwari	jakmata, kanthekarin	Holi	Navaratra	mahashivratri
Bhatghar	Janai-padmavati	Shankar	Holi	Navaratra	
Bhomadi	Mariaai	gaopandhri	Holi	No	
Bhopan_1	Shipangankarin	bhairi, kalkai, vaghjai, vardai	Holi	Navaratra	
Bhopan_2	Rhatoba		no	no	
Bondivali	Apatoba	shankar, gavrakhya	Holi	Navaratra	govinda
Borivali	Satmai	navavankari	no	no	gokulashtami, dasera
Brahmnwadi	Mahalaxmi	shankar	Holi	Navaratra	sankrant,
Chandikanagar	Chandika	kalika	Holi	no	falgun panchami
Chandranagar	Ghanekarin		Holi	Navaratra	kojagiri, govinda
Chinchali	Janai	kalkai, someshwar, hanuman	Holi	Navaratra	
Dabhol	Chandika		Holi	Navaratra	
Damame	Zarai	Jakhmata	Holi	Navaratra	hanuman jayanti
Degaon	Jholai	mahamai, shankar	Holi	Navaratra	No
Dehen	Bhairi	kalkai, chewalkarin, matwankarin	Holi	Navaratra	dasara, diwali
Derde	Satmai	jakai, manai, zolai	Holi	Navaratra	
Devake	Mahamai	kalkai	Holi	no	
Dhankoli	Somaya	janai, kelaskarin, dhankarin, kalkai	Holi	Navaratra	dasra, gondhal, diwali

Village	Main Deity	Other Deities	Main festival 1	Main festival 2	Other festivals
Douli	Janani-somaya	sateri, shankar, kumbaljai	Holi	Navaratra	jagar, dasara, diwali, shimga
Ganpatipule	Somjai	Ganpati, Manai	Holi	Navaratra	
Gavhe	Bhairi	ganpati	Holi	Navaratra	yatra, dasra
Gavrai	Kalkai		Holi	no	
Gavtale	Zolai	navalai, manai, vaghjai, mahadev	Holi	Navaratra	
Hatip	Shankar	Maruti, Kalbhairi	Holi	Navaratra	Maruti Utsav, Mahashivratra
Ilane	Annapurna	bhairi, ganpati, vetal, narayan, mahapurush	Holi	Navaratra	annapurna yatra
Jalgaon	Mahamai		no	no	
Jamage	Somjai		Holi	Navaratra	rakhan
Kadivali	Bhairi	joeshwari, shankar	Holi	Navaratra	diwali, dasara
Kalambat	Dhavaji	Chaitrapal, bhairi, dhakarkarin, jakhmata, kaleshri	Holi	Navaratra	
Kalki	Kherdoba	maruti, salekarin, kalkai	Holi	Navaratra	
Kangavai	Mahamai		no	no	chaitravali
Karanjani	Shankar	dhakati dvi	Holi	Navaratra	ganpati
Karde	Khem-mahamai	shankar	Holi	no	mahashivaratra, jagran
Kavdoli	Jakhmata	chandhavkarin, potfidya, nalavkarin	Holi	Navaratra	diwali, paledatra
kelil	Kalkai	Vaghjai, ganesh	Holi	Navaratra	
Kharavate	Kaleshwari	somaya, jakmata	Holi	Navaratra	Diwali
Kherdi	Chandika	shankar, zolai, kaluaai	Holi	Navaratra	dasara, dipawali, gondhal
Kondhe	Ramjai-kalkai	Hanuman, saimandir, vithal, datta, Krishna	Holi	Navaratra	No
Kongale	Satai		Holi	Navaratra	Saptah
Kudavale	Valajai	maruti, shankar, bhairi	Holi	Navaratra	Hanuman jayanti, Mahashivratri

Village	Main Deity	Other Deities	Main festival 1	Main festival 2	Other festivals
Kumbhave	Khemeshwar	Kalkai	Holi	no	jagar pornima
Ladghar	Chandika		Holi	Navaratra	
Lonvadi	Kaleshwari		Holi	Navaratra	
Mahamainagar	Mahamai		Holi	no	
Male	Chokaran		no	no	
Male_1	Mahamai	Varebuva	Holi	no	
Malvi	Mahamai		Holi	Navaratra	
Mandivali	Bhairi-dhawaji	jogeshwari, kateshwari, mahdev	Holi	Navaratra	chaitri
Mathegujar	Ravalnath		Holi	no	
Matwan	Zolai	Shankar	Holi	Navaratra	Dasara
Mugij	Shridevi	Salubai, Kalkai, Someshwar	Holi	Navaratra	Chaitrapornima, Palejatra
Murdi	Kalkai	Ram, mahadev	Holi	Navaratra	Saptah
Murud	Mahadeshwar	ganesh, hanuman	no	no	hanuman jayanti, shravan
Nanate	Bhairi-manai	ganapati, maruti	Holi	Navaratra	
Navashi	Khemeshwar		Holi	Navaratra	borivasa, chaitavali, palav jatra
Olgaon	Khemdev	mahamai, somaya, bhairi	Holi	Navaratra	
Onnavase	Satmai	maruti, zolai	Holi	Navaratra	
Pachavali	Bhanoba	Manai, Kalkai	Holi	Navaratra	No
Palgad	Zolai	Kalkai	Holi	Navaratra	Rakhan
Panderi	Jakai	chandkai, vaghjai, zolai, somaya, sakalil	Holi	no	
Panhalekaji	Zolai	Maruti, sai	no	no	Jatra
Phanasu	Khem-manai	sai, ganpati	Holi	Navaratra	No
Pichdoli	Kalkai	manai, jakmata	Holi	no	
Ravtoli	Kaleshwari	bhavatkarin, dayetkarin, khalyabua	Holi	Navaratra	diwali, paledatra
Revali	Mahamai	somyya, bhaswaraj, rawalnath, kalkai, jakmata, ganpati, chadda	Holi	Navaratra	gondhal, dasara
Rovale	Bhairi		Holi	Navaratra	chaitrayatra
Sadavali	Koteshwari	kalkai, vaghjai	Holi	Navaratra	

Village	Main Deity	Other Deities	Main festival 1	Main festival 2	Other festivals
Sakhloli	Gaodevi		Holi	Navaratra	Dasera
Saldure	Simadevi		Holi	Navaratra	nagpanchami, naralipornima,diwali
Sarang	Bhairi	kumbheshwar	Holi	Navaratra	
Satere T. Haveli	Khem-padmavati	ganpati, padmawati	Holi	Navaratra	
Satere T. Natu	Janani		Holi	Navaratra	Diwali, Chaitrapornima
Shirkhal	Shridevi-manai	kalmbha, shankar, ganpati	Holi	Navaratra	chaitri palkhi jatra
Shirsadi	Kalkai		Holi	Navaratra	Chaitrapornima, Palejatra
Shirsoli	Shankar Parvati		Holi	Navaratra	
Shitalnagar	Darvinkarin		Holi	Navaratra	
Shivajinagar	Kudukdev		Holi	no	
Shivnari	Kalkai	Pedjai, mahadev	Holi	Navaratra	
Soveli	Bhairidevi		Holi	Navaratra	
Sukondi	Kalkai		Holi	Navaratra	
Sukondi_1			Holi	Navaratra	funeral
Talsure	Manai	shankar, durgadevi	Holi	Navaratra	jatra and rakhipornima
Terevayangani	Gadekarin	govalkarin	no	no	
Umbarle	Kulkulai		Holi	no	
Umbarshet	Bhairi	kalkai, jakhmata	Holi	Navaratra	Narali paurnima, Gokulashtamisaptah
Urfi	Kalkoba	chankai, kalkai, degoba, aheral	Holi	Navaratra	diwali
Usgaon	Khandoba-mhalsai		Holi	Navaratra	shimga, gauri
Vaghave	Bhairavnath	Kalkai, Mahamai	Holi	Navaratra	
Vaghivane	Bhairi		Holi	Navaratra	
Velavi	Padmawati	Kalkai	Holi	Navaratra	Dasara, Pooja
Virsai	Khem	ganpati, jakmata, bhairi, vaghbir, kalkai, shankar,	Holi	Navaratra	shivaratri
Visapur	Kalkai		Holi	Navaratra	
Vishrantinagar	Bhairidevi	kalkai, Gogeshwari, sidheshwari	Holi	Navaratra	

Village	Main Deity	Other Deities	Main festival 1	Main festival 2	Other festivals
Wakavali	Kalkai		Holi	Navaratra	Dasera
Wanzloli	Jakhmata	mahadev	Holi	Navaratra	
Wavghar	Kalkai		Holi	Navaratra	

Annexure V: Management aspects of Sacred Groves of Dapoli

Village	Temple type and year of construction		Mankari	Management type
Aade	Elaborate	1995	Inherited	Committee
Aaghari	Simple		Inherited	Committee
Aasud	Elaborate		elected	Community
Aatgaon	Elaborate	2005	Elected	Community
Agarwayangani	Elaborate	1975	Inherited	Community
Bandhtivare	Simple	1992	Inherited	Community
Bhadavale	Elaborate		Inherited	Committee
Bhatghar	Elaborate		Inherited	Community
Bhomadi	No		Inherited	Community
Bhopan_1	Simple	1993	Inherited	Committee
Bhopan_2	Simple		-	
Bondivali	Elaborate		Inherited	Community
Borivali	Elaborate		Elected	Community
Brahmnwadi	Elaborate		Elected	Community
Chandikanagar	Elaborate	1983	Inherited	Committee
Chandranagar	Elaborate		Elected	Community
Chinchali	Elaborate		Inherited	Family
Dabhol	Simple		Inherited	Family
Damame	Elaborate		Inherited	Committee
Degaon	Elaborate	1990	Inherited	Community
Dehen	Elaborate	1986	Inherited	Community
Derde	Elaborate	2001	Inherited	Community
Devake	Simple	1986	Elected	Community
Dhankoli	Simple		Inherited	Committee
Douli	Simple	1983	Inherited	Committee
Ganpatipule	Simple		Inherited	Community
Gavhe	Elaborate	1800	Inherited	Community
Gavrai	Elaborate	2000	Inherited	Community
Gavtale	Elaborate	2000	Inherited	Community
Hatip	Elaborate	2000	Inherited	Community
Ilane	Elaborate		Inherited	Community
Jalgaon	Elaborate		Inherited	Community
Jamage	Elaborate		Inherited	Committee
Kadivali	Simple		Inherited	Committee
Kalambat	Elaborate	2011	Elected	Community
Kalki	Elaborate		Inherited	Community
Kangavai	Simple	1600	Inherited	Community
Karanjani	Elaborate		Inherited	Community
Karde	Elaborate		Inherited	Community
Kavdoli	Simple		Inherited	Community
kelil	Elaborate	2013	Inherited	Community
Kharavate	Simple	2008	Inherited	Community
Kherdi	Elaborate		Inherited	Community
Kondhe	Elaborate	2006	Inherited	Community

Kongale	Elaborate	2012	Inherited	Community
Kudavale	Elaborate		Inherited	Community
Kumbhave	Elaborate		Inherited	Family
Ladghar	Elaborate		Inherited	Community
Lonvadi	Elaborate	1990	Inherited	Community
Mahamainagar	Elaborate		Elected	Community
Male	Simple	2000	Inherited	Community
Male_1	Elaborate	1985	Inherited	Community
Malvi	Elaborate		Inherited	Community
Mandivali	Elaborate	2003	Inherited	committee
Mathegujar	Elaborate	2004	Inherited	Community
Matwan	Elaborate	1974	Elected	Community
Mugij	Elaborate		Inherited	Committee
Murdi	Elaborate	2008	Elected	Community
Murud	Elaborate	1868	Inherited	Community
Nanate	Elaborate	1972	Inherited	Community
Navashi	Elaborate		Elected	Community
Olgaon	Simple	1982	Elected	Community
Onnavase	Elaborate		Inherited	Community
Pachavali	Elaborate	2003	Inherited	Family
Palgad	Elaborate	2012	Inherited	Committee
Panderi	Elaborate	2007	Inherited	Community
Panhalekaji	Elaborate	2004	Inherited	Committee
Phanasu	Elaborate	2009	Inherited	Community
Pichdoli	Simple		Inherited	Family
Ravtoli	Simple		Inherited	Community
Revali	Elaborate	1993	Inherited	Family
Rovale	Elaborate	2008	Inherited	Community
Sadavali	Elaborate		Elected	Community
Sakhloli	Simple		Elected	Community
Saldure	Elaborate	1950	Inherited	Community
Sarang	Elaborate	1970	Elected	Community
Satere T. Haveli	Elaborate	2001	Inherited	Community
Satere T. Natu	Elaborate	1991	Inherited	Community
Shirkhal	Elaborate		Inherited	Committee
Shirsadi	Elaborate		Inherited	Community
Shirsoli	Elaborate		Inherited	Community
Shitalnagar	Simple		Inherited	Family
Shivajinagar	Simple		Inherited	Community
Shivnari	Elaborate	1967	Elected	Community
Soveli	Elaborate		Inherited	Committee
Sukondi	Simple		Inherited	Community
Sukondi_1	Elaborate		Inherited	Community
Talsure	Elaborate	2008	Inherited	Community
Terevayangani	Simple		Inherited	Community
Umbarle	Elaborate		Elected	Committee
Umbarshet	Elaborate	1990	Elected	Community
Urfi	Simple		Inherited	Committee

Usgaon	Simple	1974	Inherited	Family
Vaghave	Elaborate		Inherited	Community
Vaghivane	Elaborate	2010	Inherited	Committee
Velavi	Elaborate	2010	Inherited	Committee
Virsai	Elaborate	1800	Inherited	Committee
Visapur	Elaborate		Inherited	Committee
Vishrantinagar	Elaborate		Inherited	Family
Wakavali	Simple		Inherited	Committee
Wanzloli	Simple		Inherited	Committee
Wavghar	Elaborate		Inherited	Committee

Annexure VI: Floristic aspects and Disturbance scoring of Sacred Groves of Dapoli

#Disturbance categories: 1 – development projects, 2 – shift in belief system, 3 – sanskritisation, 4 – pilgrimage and tourism, 5 - forestry activities, 6 – removal of biomass, 7 – Modernization, 8 – Fragmentation, 9 - Encroachment

Village	**Tree density /100m2**	**Common trees**	**Disturbance categories scoring**								
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Aade	8	*Mimusops elengi, Ficus spp., Tectona grandis, Caryota urens, Mangifera indica*	0	1	3	3	0	1	3	2	0
Aaghari	10	*T. grandis, Mesua ferrea, Ficus spp.*	1	2	2	3	1	2	2	1	2
Aasud	2	*M. indica, Anacardium occidentale, Delonix regia, Aegle marmelos, Bauhinia sp., Artocarpus heterophyllus*	1	1	2	3	1	1	1	1	1
Aatgaon	10	*Ficus spp., Mangifera indica, Terminalia chebula*	0	1	1	0	0	1	1	0	0
Agarwayangani	7	*Memecylon umbellatum, Mangifera indica, Terminalia paniculata*	1	1	1	2	1	2	1	2	2
Bandhtivare	10	*Mangifera indica, Ficus spp.*	0	1	1	1	0	1	1	3	0
Bhadavale	2	*Ficus spp., Tectona grandis,*	0	2	2	0	0	3	3	0	0
Bhatghar	4	*Mangifera indica, Terminalia bellerica,*	0	0	0	0	0	0	0	1	2
Bhomadi	6	*Terminalia chebula, Terminalia bellerica, Terminalia tomentosa, Mangifera indica*	0	0	0	0	0	0	0	0	0
Bhopan_1	0	-	1	3	1	1	1	1	1	1	1
Bhopan_2	12	*Terminalia bellerica, Syzigium cumini, Terminalia paniculata, Tectona grandis*	1	1	1	1	1	1	1	1	1
Bondivali	20	*Terminalia bellerica, Terminalia paniculata, Tectona grandis, Syzigium cumini, Bombax ceiba, Mangifera indica*	1	2	2	1	1	1	2	1	1
Borivali	6	*Tectona grandis, Terminalia tomentosa, Terminalia paniculata*	1	3	2	1	0	3	3	2	1
Brahmnwadi	5	*Mangifera indica, Mimusops elengi*	3	1	3	2	3	1	3	1	0
Chandikanagar	2	*Mangifera indica*	1	3	2	2	0	2	3	3	2
Chandranagar	2	*Mangifera indica, Casuarina equisetifolia*	1	1	2	1	2	1	1	1	1
Chinchali	4	*Mangifera indica, Terminalia spp.*	0	3	0	0	0	0	0	1	0
Dabhol	2	*Mangifera indica, Ficus spp. Tectona grandis*	3	3	2	3	1	2	3	3	3
Damame	4	*Terminalia bellerica, Syzigium cumini, Terminalia paniculata, Tectona grandis*	0	1	1	0	0	2	2	0	0

Degaon	4	*Terminalia bellerica, Mangifera indica*	1	1	2	1	3	3	2	1	1
Dehen	6	*Mangifera indica, Aegle marmelos,*	1	3	2	0	0	3	3	0	0
Derde	12	*Acacia catechu, Tectona grandis, Terminalia bellerica, Gmelina arborea,*	1	1	1	1	1	1	1	1	1
Devake	30	*Mcaranga peltata, Tectona grandis*	1	3	2	2	1	2	1	3	0
Dhankoli	8	*Terminalia bellerica, mangifera indica, Lagerstroemia parviflora, Terminalia tomentosa, Butea monosperma, Ficus spp.*	0	1	1	0	0	1	0	0	0
Douli	5	*Mangifera indica, Terminalia tomentosa, Memecylon umbelatum, Terminalia bellerica*	0	0	0	0	1	0	0	0	0
Ganpatipule	4	*Terminalia spp., Terminalia bellerica,*	0	3	0	0	0	1	0	0	0
Gavhe	10	*Mangifera indica, Artocarpus heterophyllus, Terminalia spp.*	1	1	3	3	2	2	2	1	1
Gavrai	2	*Mangifera indica, Caryota urens, Michelia sp.*	1	1	1	1	3	3	1	2	3
Gavtale	30	*Mangifera indica, Mimusops elengi, Bauhinia sp., Ficus spp., Gmelina arborea, Bombax ceiba, Tectona grandis, Terminalia paniculata*	0	1	1	2	0	1	1	1	0
Hatip	2	*Mangifera indica, Syzigium cumini, Gmelina arborea, Erythrina variegata, Terminalia spp.*	1	3	0	1	0	1	0	1	0
Ilane	15	*Mangifera indica, Garcinia indica, Ficus bengalensis, Mimusops elengi*	0	1	1	1	0	1	1	0	0
Jalgaon	20	*Mangifera indica, Garcinia indica*	0	0	0	0	0	0	0	0	0
Jamage	14	*Mangifera indica, Terminalia bellerica, Bombax ceiba*	0	3	0	0	0	3	0	0	1
Kadivali	16	*Terminalia bellerica, Mimusops elengi, Memecylon umbelatum, Mangifera indica, Acacia catechu, Ficus spp.*	0	2	2	0	1	2	0	0	0
Kalambat	5	*mangifera indica, Tectona grandis, Casuarina equisetifolia*	0	2	2	1	0	0	1	3	0
Kalki	7	*Macaranga peltata, Terminalia tomentosa, mangifera indica,*	1	1	1	1	1	1	1	1	1
Kangavai	8	*Terminalia elliptica, Lagerstroemia spp., Syzigium cumini*	0	3	0	0	1	0	0	0	0
Karanjani	5	*Terminalia bellerica, Mangifera indica*	3	1	2	1	3	3	3	1	2
Karde	10	*Tectona grandis, mangifera indica, Mimusops elengi, Garcinia indica, Mammea suriga, Artocarpus heterophyllus, Dillenia pentagyna*	1	1	2	1	1	1	1	1	1
Kavdoli	9	*Tectona grandis, Mimusops elengi, Garcinia indica, Terminalia bellerica, Terminalia chebula*	0	0	0	0	0	0	0	0	0

kelil	7	*Dillenia pentagyna, Macaranga peltata, Terminalia tomentosa, mangifera indica, Terminalia paniculata, Zanthoxylum rhetsa, Tectona grandis*	2	3	2	1	1	2	1	1	2
Kharavate	4	*Tectona grandis, Terminalia bellerica, Mangifera indica, Memecylonn umbelatum*	0	0	0	0	0	0	0	0	0
Kherdi	5	*Aegle marmelos, Anacardium occidentale, Garcinia indica*	0	1	3		1	2	1	0	0
Kondhe	8	*Terminalia bellerica, Ficus spp., Bombax ceiba, Terminlia tomentosa, Eucalyptus, Acacia catechu, Mangifera indica, Gmelina arborea*	1	2	1	1	1	1	1	1	1
Kongale	5	*Mangifera indica, Memecylon umbelatus*	0	0	1	0	0	1	2	0	1
Kudavale	30	*Terminalia tomentosa, Terminalia paniculata, Mangifera indica, Terminalia chebula, Lagerstroemia parviflora, Lagerstroemia lanceolata, Bauhinia sp., Garcinia indica, Ficus bengalensis, Ficus religiosa, Saraca asoca*	1	2	2	3	1	1	1	1	1
Kumbhave	8	*Mangifera indica, Artocarpus heterophyllus, Terminalia spp., Syzigium cumini, Aegle marmelos, Macaranga peltata*	0	1	3	2	2	1	1	1	0
Ladghar	4	*Mangifera indica, Anacardium occidentale*	1	1	2	2	3	2	1	1	1
Lonvadi	20	*Mangifera indica, Anacardium occidentale, Ficus bengalensis, Terminalia chebula, Artocarpus heterophyllus, Mimusops elengi*	0	1	1	1	0	0	2	2	0
Mahamainagar	4	*Terminalia tomentosa, Terminalia paniculata, Terminalia chebula, Terminalia bellerica, Semecarpus anacardium, Michelia sp.*	2	2	1	1	0	3	2	3	2
Male	10	*Terminalia paniculata, Terminalia tomentosa, Memecylon umbelatum, Mangifera indica, Tectona grandis, Syzigium cumini*	1	1	1	1	1	1	1	1	1
Male_1	12	*Tectona grandis, Mimusops elengi, Memecylon umbelatum, Caryota urens, Syzigium cumini,*	1	1	1	1	1	1	1	1	1
Malvi	7	*Terminalia bellerica, Mangifera indica, Tectona grandis, Acacia catechu*	0	1	0	0	0	0	1	0	0
Mandivali	2	*mangifera indica, Tamarindus indica*	0	0	1	0	1	1	0	0	0
Mathegujar	8	*Memecylon umbelatum, Bombax ceiba, Casuarina equisetifolia, Macaranga peltata*	1	1	1	1	1	2	1	2	2
Matwan	10	*Artocarpus heterophyllus, Mangifera indica, Terminalia spp., Acacia catechu*	1	2	2	1	2	1	1	1	2
Mugij	5	*Tectona grandis, Acacia catechu, Terminalia spp., Dillenia pentagyna*	1	3	0	1	0	1	1	3	0
Murdi	25	*Mangifera indica, Mimusops elengi, Ficus religiosa, Terminalia chebula, Mammea suriga*	0	1	1	1	0	0	1	0	0

Murud	5	*Tectona grandis, Mesua ferrea, Garcinia indica, Mangifera indica, Ficus bengalensis*	1	2	2	1	1	2	1	1	2
Nanate	10	*Mimusops elengi, Mangifera indica, Memecylon umbelatum,*	1	2	1	1	1	2	1	1	1
Navashi	6	*Mangifera indica, Terminalia chebula, Terminalia bellerica, Terminalia tomentosa, bauhinia sp., Anacardium occidentale, Ficus glomerata*	1	2	2	1	3	3	1	1	1
Olgaon	8	*Tectona grandis*	1	2	2	1	0	2	1	2	2
Onnavase	5	*Mangifera indica, Tectona grandis, Acacia catechu*	1	2	1	1	1	1	1	1	1
Pachavali	7	*Mangifera indica, Terminalis bellerica,*	0	2	2	1	0	0	0	0	0
Palgad	8	*Tectona grandis, Syzigium cumini, Albizia sp., Terminalia spp.*	0	3	0	3	0	0	2	0	0
Panderi	12	*Terminalia chebula, Erythrina variegata, Careya arborea, Ficus spp., Mangifera indica, Garcinia indica*	1	2	1	1	1	1	1	1	1
Panhalekaji	1	*Mangifera indica, Tectona grandis*	1	3	1	1	1	1	1	1	1
Phanasu	7	*Tectona grandis, Careya arborea, Terminalia bellerica, mangifera indica*	1	3	1	1	2	2	1	1	1
Pichdoli	6	*memecylon umbelatum, Bauhinia sp., Bridelia retusa, Terminalia tomentosa*	0	1	0	0	0	1	0	0	0
Ravtoli	12	*Terminalia bellerica, Tectona grandis, Mangifera indica*	0	0	0	0	0	0	0	0	0
Revali	7	*Mangifera indica, Lagerstroemia lanceolata, Dillenia pentagyna, Bombax ceiba, Ficus spp, Syzigium cumini, Mimusops elengi, Caryota urens*	3	2	2	0	0	2	2	2	3
Rovale	14	*Mangifera indica, Terminalia tomentosa, Terminalia bellerica*	0	0	0	0	0	0	0	0	0
Sadavali	18	*Tectona grandis, Terminalia spp.*	0	2	1	1	0	2	1	0	1
Sakhloli	5	*Ficus spp., Tectona grandis, Bauhinia sp., Casuarina equisetifolia, Acacia auriculiformis*	1	2	2	1	0	3	2	3	2
Saldure	1	*Anacardium occidentale, Ficus religiosa, mangifera indica*	3	2	2	2	3	2	2	1	2
Sarang	5	*Mangifera indica, Mimusops elengi, Ficus religiosa, Terminalia chebula, Mammea suriga*	0	1	3	2	1	1	3	3	0
Satere T. Haveli	2	*Memecylon umbelatum, Bauhinia sp., Caryota urens, Terminalia tomentosa*	1	3	1	1	2	3	1	2	3
Satere T. Natu	6	*Mangifera indica, Acacia catechu, Terminalia bellerica, Erythrina variegata*	0	3	0	0	0	0	0	0	0
Shirkhal	4	*Mangifera indica, Erythrina variegata*	0	3	0	1	0	0	2	0	0
Shirsadi	1	*Mangifera indica*	3	3	0	1	0	0	1	1	3
Shirsoli	4	*Terminalia spp., Mangifera indica, Syzigium cumini*	2	2	0	2	2	2	2	1	0

Shitalnagar	7	*Tectona grandis, Mangifera indica, Artocarpus heterophyllus*	1	3	1	1	0	1	1	2	1
Shivajinagar	15	*Mangifera indica, Artocarpus heterophyllus, Ficus religiosa*	0	2	2	0	0	3	2	3	2
Shivnari	8	*Mangifera indica, Bauhinia sp., Anacardium occidentale, Terminalia paniculata*	0	1	1	0	0	1	1	2	0
Soveli	5	*Mangifera indica, Dillenia pentagyna, Terminalia bellerica*	0	3	1	0	0	1	0	3	0
Sukondi	30	*Terminalia elliptica, Tectona grandis, Mangifera indica, Syzigium cumini,*	0	3	0	0	0	0	0	0	0
Sukondi_1	12	*Mangifera indica, Ficus spp., Terminalia spp. , Ceiba pentandra*	0	1	1	2	2	1	0	1	0
Talsure	1	*Casuarina equisetifolia*	1	2	2	0	2	2	1	1	1
Terevayangani	10	*Mimusops elengi, Caryota urens, Terminalia elliptica, Macaranga peltata*	0	1	1	1	1	1	1	2	2
Umbarle	15	*Tectona grandis, Terminalia chebula, Terminalia bellerica*	2	3	2	3	1	2	3	2	2
Umbarshet	0	*Anacardium occidentale*	3	2	1	0	0	2	1	1	1
Urfi	4	*Mangifera indica, Tectona grandis, Garcinia indica, Ficus spp. Terminalia chebula*	1	3	1	1	1	1	1	1	1
Usgaon	10	*Tectona grandis, Terminalia tomentosa, Terminalia paniculata, Mangifera indica*	3	2	1	2	0	2	3	3	2
Vaghave	25	*Ficus spp., Mangifera indica, Terminalia chebula*	0	1	1	1	0	0	1	2	0
Vaghivane	6	*Mangifera indica, Tectona grandis, Dillenia pentagyna*	1	1	1	0	0	2	1	1	0
Velavi	8	*Terminalia bellerica, Mangifera indica, Lagerstroemia parviflora, Terminalia tomentosa, Careya arborea, Acacia auriculiformis, Syzigium cumini, Caryota urens*	0	2	3	1	0	2	3	0	0
Virsai	3	*Anacardium occidentale, Mangifera indica, Memecylon umbelatum*	0	1	2	0	0	0	0	2	0
Visapur	3	*Mangifera indica, Erythrina variegata*	0	3	0	1	0	3	0	0	0
Vishrantinagar	6	*Terminalia bellerica, Mangifera indica, Terminalia spp.*	1	3	0	1	0	1	0	0	0
Wakavali	8	*Tectona grandis, Mangifera indica, Artocarpus heterophyllus*	2	3	2	1	0	2	3	3	1
Wanzloli	7	*Mangifera indica, Syzigium cumini, Terminalia chebula, Memecylon umbelatum, Careya arborea*	0	0	1	0	0	1	0	0	0
Wavghar	3	*Tectona grandis, Mimusops elengi, Bombax ceiba, Bridelia retusa*	0	2	2	1	0	0	1	0	0

Annexure VII: List of species (morphospecies) by sites in the study area. A '0' indicates absence of the species in samples collected from that site and a number indicates the abundance of that species found in all samples from that site.

(The cordes refer to sites as follows: ML Male, AW Agarvayangani, NT Nanate, UM Umbarle, PN Pangari, DG Degaon, KN Kondhe, PD, Pichdoli, KH Kherdi, DN Dhankoli, KD Kadivali, KG Kangavai, KU Kudavale, SO Soveli, BG Bhatghar, JM Jamage, SK Shirkhal, AD Aade, SD Sadavali, WK Wakavali, GT Gavtale, KR Karde, MN2 Mango2, MN3 Mango3, CS1 Cashew1, CS2 Cashew2, MN1 Mango1, MN4 Mango4, CS3 Cashew3, RF1 Reserved forest1, RF2 Reserved forest2, RF3 Reserved forest3)

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Araneidae																																	
Arachnura melanura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2
Araneidae sp1	0	0	0	0	0	0	4	0	1	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	9
Araneidae sp2	0	0	0	0	1	1	0	0	0	0	0	0	3	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	9
Araneus ejusmodi	0	0	0	0	1	0	2	0	1	0	0	0	0	2	2	1	1	0	0	1	0	3	0	0	1	0	1	1	0	0	1	0	18
Araneus mitificus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3
Araneus sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	3
Araneus sp3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	4
Araneus viridisomus	11	4	9	3	1	2	3	5	2	6	4	5	0	8	2	7	17	7	1	5	3	3	7	3	4	0	4	6	0	7	15	2	156
Araniella sp1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	9
Argiope aemula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Argiope pulchella	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	3	0	1	3	0	0	0	0	0	0	0	3	13
Chorizopes frontalis	0	0	0	0	0	0	1	0	0	0	0	0	0	6	6	7	21	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	45
Chorizopes tikaderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	3
Cyclosa confraga	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	3	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	11
Cyclosa hamulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Cyclosa monticola	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Cyclosa omonaga	0	0	0	5	0	0	0	1	0	3	1	0	0	3	0	2	2	0	5	0	4	1	2	2	1	1	1	4	0	3	4	0	45
Cyclosa quinqueguttata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
Cyphalonotus sp1	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	2	1	4	0	0	1	16
Cyrtophora cicatrosa	0	0	0	0	1	4	0	0	1	0	0	0	0	2	0	0	3	1	0	1	0	1	0	0	1	1	0	0	0	1	5	1	23
Eriovixia cavaleirie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Eriovixia excelsa	0	1	0	0	1	1	1	1	1	4	0	1	0	3	0	3	2	2	0	1	2	1	0	0	1	1	4	5	1	1	2	0	40
Eriovixia huwena	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	3
Eriovixia jianfengensis	3	14	9	3	0	0	6	0	0	28	30	11	1	5	0	8	5	0	53	1	20	3	2	0	0	0	0	1	0	28	9	22	262
Eriovixia laglaizei	0	2	4	4	2	3	4	3	1	5	3	7	2	10	8	5	11	0	3	7	7	3	36	19	5	5	1	2	0	6	9	9	186
Eriovixia nigrimaculata	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	4	0	0	0	0	0	0	0	0	1	0	0	0	3	1	3	16
Eriovixia pseudocentrodes	0	0	0	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	5	1	2	0	0	0	0	1	0	16
Eriovixia sakiedaorum	0	2	0	0	3	4	1	1	2	5	3	2	0	1	2	3	0	0	2	1	4	4	3	1	1	1	0	3	0	1	1	3	54
Gea sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Gea spinipes	2	4	1	0	0	4	0	0	0	1	2	0	3	3	2	1	0	7	4	2	2	2	0	0	0	0	2	2	0	0	0	2	46
Gea subarmata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	2	0	7
Hypsosinga sanguinea	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	2	2	0	0	0	2	0	0	2	2	0	0	0	0	0	0	13
Larinia bonneti	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Lipocrea epeiroides	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Neoscona bengalensis	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	1	0	1	1	1	2	0	5	1	0	2	1	0	2	0	0	22
Neoscona mukerjei	0	0	0	0	0	1	2	0	2	2	1	0	2	0	0	3	2	0	2	0	2	0	3	5	3	1	2	1	0	0	1	0	35
Neoscona nautica	0	0	0	0	3	0	1	0	1	0	2	0	1	1	0	5	0	0	1	1	0	0	0	0	2	0	0	2	0	0	0	0	20
Neoscona punctigera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Neoscona subpullata	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Neoscona vigilans	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
Ordgarius hobsoni	0	0	0	0	0	0	4	0	0	0	1	1	0	3	0	4	0	0	0	1	0	0	0	0	2	3	2	1	1	0	0	0	23
Parawixia dehaani	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Pasilobus kotigeharus	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	2	0	2	0	0	0	1	0	0	2	0	0	0	0	11
Poltys columnaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	1	1	1	0	3	1	0	0	0	1	0	12
Poltys stygius	0	0	1	0	0	1	3	1	1	0	1	0	0	0	0	0	0	0	2	0	0	4	0	0	0	1	2	0	1	1	2	2	23
Singa sp1	2	0	0	0	0	6	1	0	1	1	1	1	0	1	0	1	1	0	0	1	0	1	0	2	1	1	5	0	0	1	5	0	33
Thelacantha brevispina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2
Clubionidae																																	
Clubiona brevispina	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Clubiona pashabhaii	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
Clubiona pteronetoides	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4
Clubiona viridula	0	1	0	0	0	0	1	0	0	0	0	0	0	2	1	0	2	3	1	0	0	8	0	0	0	0	0	0	0	0	5	0	24
Matidia sp1	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Pristidia sp1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pteroneta sp1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	7
Corinnidae																																	
Corinnidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	2	0	0	0	0	2	0	9
Corinnidae sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	4
Corinnidae sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Corinnomma severum	2	2	0	0	0	4	5	3	1	2	2	3	2	0	2	4	3	1	5	5	12	0	1	0	3	4	4	11	0	1	2	1	85
Echinax panache	3	0	1	0	0	1	0	1	0	4	0	0	0	0	0	0	1	0	0	1	3	0	1	0	0	0	0	0	0	0	1	0	17

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Ctenidae																																	
Ctenidae sp1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	9
Ctenus sikkimensis	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Ctenus sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Deinopidae																																	
Deinopis goalparaensis	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	5
Dictynidae																																	
DIctyna sp1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	7
Dictynidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Dictynidae sp2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	2	0	4	0	10
Dictynidae sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
Eutichuridae																																	
Cheiracanthium insigne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Cheiracanthium murinum	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	2	0	0	0	1	0	4	0	0	0	0	0	0	0	1	0	11
Cheiracanthium sp6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	4
Cheiracanthium sp8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	1	0	1	0	0	0	0	7
Cheiracanthium triviale	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Cheiracanthium vorax	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Summacanthium sp2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3
Summacanthium sp4	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	7
Filistatidae																																	
Pritha poonaensis	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	2	8

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Gnaphosidae																																	
Hitobia sp1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	2	1	2	0	0	1	0	10
Hitobia sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Micaria sp1	0	0	2	1	0	1	0	1	0	0	0	0	2	0	0	0	4	0	0	0	4	3	0	1	0	3	3	0	0	1	3	1	30
Micythus sp1	0	0	0	0	1	1	1	1	0	4	0	0	1	0	0	2	0	0	0	1	0	2	2	2	0	1	0	1	0	0	0	0	20
Setaphis sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	3
Setaphis sp2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	4
Zelotes sp1	0	0	0	0	0	1	0	0	0	0	1	2	2	0	0	2	0	0	0	0	1	0	1	1	2	0	0	0	0	4	0	0	17
Zelotes sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Zelotes sp4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Zelotes sp6	0	0	1	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	9
Hahnidae																																	
Hahnia mridulae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hersiliidae																																	
Hersilia savignyi	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	1	0	2	1	4	0	0	2	2	0	0	0	1	19
Murricia cornuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	2	2	0	0	0	7
Linyphiidae																																	
Atypena sp2	1	4	0	0	0	0	2	13	0	0	7	3	6	5	1	3	1	3	18	0	1	4	0	3	1	0	5	0	0	1	2	1	85
Linyphiidae sp1	0	0	0	0	0	0	2	5	0	15	9	11	15	10	2	8	6	0	2	0	8	0	6	0	0	2	0	0	0	4	2	7	114
Linyphiidae sp4	0	0	0	2	2	1	0	7	1	0	0	0	3	2	0	11	8	2	1	2	1	3	9	0	1	0	0	0	0	1	9	1	67
Linyphiidae sp5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3
Linyphiidae sp6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Linyphiidae sp8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	0	9	0	0	0	0	0	1	0	0	0	0	0	0	0	15
Linyphiidae sp9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Nasoona sp1	7	15	6	2	12	25	16	2	0	19	9	14	17	15	7	34	17	14	18	0	36	30	9	0	2	2	2	6	2	14	9	12	373
Neriene birmanica	1	0	3	0	1	0	1	1	0	1	4	0	9	4	0	3	0	4	6	0	1	5	0	0	0	0	0	4	1	1	4	3	57
Nesioneta sp1	0	3	7	0	2	7	1	1	3	3	3	1	4	17	2	16	11	0	0	1	6	0	10	1	2	0	0	14	3	3	4	4	129
Paracymboides tibialis	0	0	0	0	0	2	2	0	0	2	0	0	0	0	0	2	2	0	3	1	0	1	2	4	0	0	1	1	0	0	0	0	23
Liocranidae																																	
Liocranidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Oedignatha scrobiculata	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	2	0	20	5	1	15	15	27	10	0	3	0	101
Oedignatha sp2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	6
Sphingius sp1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sphingius sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Sudharmia sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
Lycosidae																																	
Evippa sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	5
Evippa sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
Flanona sp1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hippasa agelenoides	7	0	1	0	0	0	2	2	0	0	0	2	2	0	0	5	2	0	0	0	1	0	8	3	0	2	2	0	0	0	2	0	41
Hippasa olivacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Lycosa chaperi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Lycosa geotubalis	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
Lycosa prolifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Lycosidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Lysania sp cf prolixus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Pardosa sp6	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Pardosa sp7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Xerolycosa sp1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mimetidae																																	
Ero sp1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mimetus sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Miturgidae																																	
Systaria sp1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mysmenidae																																	
Mysmenidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	3
Nephiliidae																																	
Nephila pilipes	1	0	0	4	0	1	0	0	0	1	2	1	3	3	0	8	6	0	4	0	7	2	0	0	0	0	0	0	0	0	0	0	43
Oecobiidae																																	
Oecobius sp1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Oonopidae																																	
Aprusia vestigator	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Brignolia sp1	0	0	0	0	1	0	0	2	2	4	8	6	1	3	2	1	6	2	20	0	8	0	3	0	1	1	2	7	9	2	0	4	95
Camptoscaphiella sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gamasomorpha sp1	2	0	2	0	0	0	1	3	0	73	32	2	18	4	1	10	22	0	13	5	7	4	1	1	0	1	0	0	0	15	5	0	222
Gamasomorpha sp3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
Gamasomorpha sp4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Heteroonops sp1	0	2	2	0	1	0	6	0	0	15	5	1	6	5	4	6	5	1	3	2	7	3	3	0	3	2	1	2	0	8	6	19	118
Ischnothyreus sp1	0	0	1	0	0	0	1	3	0	0	0	0	0	2	0	1	3	0	0	3	4	0	0	0	0	0	1	2	0	3	2	0	26
Ischnothyreus sp3	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	6
Opopaea apicalis	0	0	0	0	0	1	0	2	4	0	0	0	1	0	2	0	2	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	15

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Orchestina pilifera	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	2	8
Orchestina sp1	1	1	3	2	2	0	4	0	3	4	1	1	3	4	0	2	3	3	5	1	0	0	2	0	4	0	0	1	0	2	3	6	61
Orchestina sp2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Trilacuna sp1	0	0	0	0	0	0	0	0	2	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	8
Oxyopidae																																	
Hamadruas sikkimensis	0	0	1	0	0	1	2	1	0	0	1	0	0	1	0	3	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	13
Hamadruas sp3	0	0	0	5	2	2	8	2	0	79	8	5	21	8	0	39	17	1	4	4	8	2	9	2	1	2	0	1	0	38	15	39	322
Hamadruas sp4	4	1	2	2	13	12	9	13	2	13	3	7	8	18	0	51	12	1	1	4	18	4	37	20	0	0	2	3	11	32	7	17	327
Hamataliwa ovata	7	1	6	6	2	1	7	0	2	22	3	4	6	15	8	10	15	1	0	2	8	0	6	9	4	0	1	1	2	14	5	6	174
Oxyopes ashae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
Oxyopes birmanicus	0	1	1	2	0	0	13	1	2	2	0	0	0	0	0	4	11	0	1	4	6	0	7	0	2	5	0	1	1	0	0	0	64
Oxyopes naliniae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Oxyopes shweta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	6
Oxyopes sp1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Oxyopes sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Peucetia sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Palpimanidae																																	
Boagrius sp1	5	3	0	3	0	0	0	0	3	12	5	2	4	0	0	0	0	0	6	0	2	3	0	0	0	0	0	1	0	2	4	2	57
Steriphopus sp1	0	0	0	1	0	0	2	1	0	5	4	0	4	0	0	0	2	2	3	4	1	2	0	0	0	0	0	3	0	2	2	2	40
Philodromidae																																	
Philodromidae sp1	33	16	23	5	9	3	10	15	2	28	19	2	76	11	1	26	15	30	35	2	15	41	0	4	5	2	2	2	2	24	3	16	477
Philodromidae sp3	0	0	1	0	1	0	1	1	0	0	0	0	0	2	0	1	2	0	0	0	0	1	3	0	1	0	0	1	0	0	0	1	16
Philodromidae sp4	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	12

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Philodromus bhagirathai	1	0	0	0	0	0	2	0	0	1	3	1	0	2	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	15
Philodromus devhutai	14	4	23	5	3	4	10	8	4	6	3	13	4	4	1	9	7	1	3	6	7	1	11	1	2	1	11	9	1	1	4	0	181
Tibellus sp1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Tibellus sp2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Tibellus sp3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pholcidae																																	
Belisana dodabetta	3	16	1	0	2	0	2	2	9	3	2	0	26	15	2	19	26	11	0	6	2	43	0	3	2	3	0	0	15	0	4	0	217
Leptopholcus podophthalmus	8	2	12	0	0	0	0	2	0	8	0	2	15	0	0	0	0	14	4	0	12	2	0	0	0	0	0	2	0	13	14	28	138
Phrurolithidae																																	
Orthobula impressa	0	0	1	2	0	2	1	0	1	0	2	0	0	1	0	2	1	0	0	0	0	0	0	0	0	2	0	3	2	1	0	0	21
Pisauridae																																	
Dendrolycosa robusta	0	0	0	0	1	0	3	2	0	2	1	1	1	1	0	1	1	0	0	2	1	1	0	0	0	0	0	0	0	1	1	2	22
Dendrolycosa yuka	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3
Perenethis sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Pisaura sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Pisauridae sp1	9	10	7	4	8	10	28	14	4	17	20	11	36	38	21	35	35	3	20	10	61	14	26	22	6	10	18	20	6	42	16	66	647
Pisauridae sp2	1	3	0	1	2	0	0	2	0	3	15	2	9	0	3	6	1	0	11	0	1	15	1	0	0	0	1	1	1	5	3	7	94
Prodidomidae																																	
Prodidomus sp cf rufus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
Salticidae																																	
Aelurillus sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
Aelurillus sp2	0	0	1	0	0	0	5	0	0	4	3	0	4	2	0	1	1	2	4	0	1	3	1	2	0	0	0	4	0	0	0	2	40

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Asemonea tenuipes	10	4	5	9	7	7	19	3	2	25	16	12	27	32	4	62	37	7	13	14	26	23	8	7	9	7	1	0	1	21	44	16	478
Bavia annamita	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Bianor sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Bianor sp2	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Brettus cingulatus	4	1	4	2	9	18	9	3	0	17	21	5	22	25	4	16	7	10	14	5	23	13	19	22	1	4	8	1	1	11	5	10	314
Bristowia heterospinosa	1	0	4	2	8	6	7	0	0	0	1	3	1	3	1	8	3	0	1	2	1	2	9	1	4	9	10	10	1	1	0	2	101
Carrhotus decorata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	2	1	0	0	0	0	0	9
Carrhotus viduus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	4	0	0	0	0	8
Chrysilla jesudasi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Cocalus sp1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	1	0	6	1	15
Curubis sp1	1	1	3	0	8	0	14	1	1	4	5	2	1	0	1	12	7	4	4	1	0	1	7	1	0	4	2	1	1	3	0	6	96
Curubis sp2	1	0	0	0	0	0	0	1	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Curubis sp3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Curubis sp4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Curubis sp5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Curubis sp6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Curubis sp7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cyrba ocellata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Epeus indicus	1	1	1	6	20	32	13	10	4	8	17	17	7	35	9	40	18	1	3	5	12	16	26	8	9	9	16	8	6	7	11	12	388
Epocilla chimakothiensis	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Epocilla praetextata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3
Euophrys frontalis	0	2	0	0	1	0	1	2	3	4	3	0	7	1	0	2	0	2	0	2	2	2	0	0	0	0	1	16	10	1	0	2	64

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Euophrys sp1	9	5	2	6	9	0	6	8	2	15	8	0	17	3	3	6	7	3	27	5	14	3	3	2	0	2	1	6	0	6	12	7	197
Euophrys sp2	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	5	0	0	0	0	0	0	0	0	4	3	0	20
Evarcha sp1	5	19	7	7	5	5	8	10	22	12	12	4	16	11	7	28	18	2	5	7	4	12	4	0	5	4	4	3	0	22	33	13	314
Harmochirus brachiatus	0	0	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	3	0	0	11
Hasarius adansoni	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	2	0	0	2	2	0	1	0	0	10
Hyllus semicupreus	0	1	2	0	0	1	3	3	1	1	0	0	0	4	1	3	8	7	1	0	0	1	3	3	6	3	5	5	6	8	13	0	89
Hyllus sp1	1	0	0	0	1	1	4	1	0	1	7	1	1	3	0	5	4	4	1	3	3	0	8	4	0	4	3	7	0	0	0	3	70
Icius sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1	1	0	0	0	0	6
Jerzego sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	1	1	0	7
Langona sp cf goaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Marengo inornata	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	5
Marengo sp1	2	2	4	8	0	0	0	0	0	4	0	9	6	0	0	0	0	0	7	0	4	0	0	0	0	0	0	0	1	0	0	0	47
Marpissa singhi	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2	0	0	0	0	0	8
Mendoza sp1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Menemerus bivittatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
Myrmarachne melanocephala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	2	5	1	0	0	0	13
Myrmarachne poonaensis	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
Myrmarachne prava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
Myrmarachne sp4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Myrmarachne spissa	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Phintella cf bifurcata	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4	3	0	0	0	13
Phintella debilis	0	0	1	0	1	0	17	1	2	1	5	1	1	0	1	3	5	0	1	4	3	0	3	1	1	0	0	0	0	2	5	2	61

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Phintella versicolor	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3
Phintella vittata	1	2	2	2	5	1	22	4	17	11	1	1	1	7	1	4	11	0	5	3	14	3	13	7	5	8	2	9	3	16	9	4	194
Phintella volupe	3	0	2	5	2	4	9	5	1	7	8	10	3	1	3	3	1	1	2	0	10	17	10	12	3	4	6	3	0	7	1	6	149
Plexippoides zhangi	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Plexippus sp1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Portia fimbriata	1	1	0	1	0	0	0	0	0	0	1	2	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Pseudicius daitaricus	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	3	8	2	0	0	0	20
Pseudicius nepalicus	0	0	0	0	1	2	1	0	3	0	0	0	0	0	0	2	1	0	0	0	0	0	4	5	3	1	11	18	2	0	0	0	54
Pseudicius sp2	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
Rhene albigera	1	1	0	0	1	0	4	2	2	1	1	3	4	2	0	5	4	1	0	4	6	1	13	2	4	3	0	3	4	3	1	4	80
Rhene flavicommans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Salticidae sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Salticidae sp2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Salticidae sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sitticus sp1	0	0	0	0	1	2	0	0	1	1	1	0	0	0	0	2	0	0	0	0	0	0	6	0	0	1	1	1	0	0	0	1	18
Stenaelurillus sp1	1	0	1	6	10	5	12	6	4	0	1	3	2	2	1	0	4	2	4	3	2	2	9	2	2	8	2	7	3	20	17	2	143
Telamonia dimidiata	0	1	1	1	5	0	2	5	4	1	5	4	6	1	1	3	0	7	2	5	10	11	11	4	6	1	1	2	3	2	10	5	120
Thyene bivittata	0	0	0	0	0	0	1	0	0	2	4	1	1	1	4	9	16	0	11	4	2	0	1	0	0	0	0	0	0	1	0	2	60
Thyene imperialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Uroballus sp1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	8
Scytodidae																																	
Dictis sp1	7	1	1	0	0	0	0	0	4	0	0	0	7	0	0	0	0	0	23	1	0	0	0	0	1	0	2	0	0	0	4	0	51
Dictis sp3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Dictis sp4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Scytodes sp1	22	19	13	4	3	2	5	0	26	17	11	24	21	9	1	0	6	18	39	0	0	34	5	2	7	5	2	2	0	21	3	13	334
Scytodes sp2	0	0	0	0	0	0	1	0	4	17	3	7	0	1	0	0	0	0	0	2	0	0	2	0	3	0	1	5	0	6	1	8	61
Segestriidae																																	
Ariadna sp1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ariadna sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	3
Sparassidae																																	
Gnathopalystes denticulatus	0	0	0	1	2	0	1	1	1	3	1	0	1	6	6	3	3	0	0	1	0	0	0	2	2	1	0	2	1	4	11	1	54
Heteropoda sp1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Micrommata sp1	11	0	3	12	0	1	9	6	0	21	6	7	17	0	1	7	8	2	27	13	34	4	1	0	0	0	0	0	0	22	5	27	244
Olios fuligineus	0	0	0	0	2	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	9
Olios sp3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Seramba sp1	0	0	4	1	1	0	0	2	0	0	0	0	1	3	0	2	4	0	0	2	1	5	2	1	1	0	7	10	3	1	2	0	53
Tetrablemmidae																																	
Brignoliella acuminata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Choiroblemma rhinoxunum	0	0	0	0	0	0	0	0	3	3	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	16
Tetrablemma deccanense	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
Tetragnathidae																																	
Leucauge celebesiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	4
Leucauge decorata	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	1	0	1	1	1	1	2	0	0	1	0	14
Mesida gemmea	0	0	0	0	1	0	0	1	0	1	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Opdaometa fastigata	1	0	0	0	0	0	0	0	2	4	1	1	10	7	8	11	4	0	1	2	4	0	0	0	0	0	0	0	2	11	1	1	71

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Tetragnatha cochinensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	1	0	7
Tetragnatha fletcheri	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Tetragnatha mandibulata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tetragnatha maxillosa	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	7
Tetragnatha vermiformis	0	0	0	0	0	5	7	0	0	0	1	0	2	2	0	6	7	0	1	0	3	0	2	0	1	0	3	1	2	0	1	0	44
Tetragnatha viridorufa	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	2	0	0	2	0	1	1	1	1	0	0	0	0	1	0	2	15
Tylorida ventralis	1	3	0	0	2	0	0	1	1	6	5	0	2	1	0	0	1	2	21	2	0	0	0	0	0	0	0	0	0	4	3	21	76
Theridiidae																																	
Argyrodes bonadea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	1	0	1	0	6
Argyrodes fissifrons	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	6
Ariamnes flagellum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	6
Cephalobares globiceps	9	1	5	0	0	0	8	3	0	16	10	1	3	5	5	16	13	3	4	3	18	2	0	0	1	0	0	1	0	27	25	28	207
Chrysso sp1	0	1	1	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	3	5	18
Chrysso sp2	1	0	0	0	0	0	0	2	0	0	0	2	0	0	3	1	0	4	1	0	1	0	0	1	0	2	0	0	0	2	3	3	26
Coleosoma blandum	0	1	0	4	1	2	1	2	0	1	3	5	3	0	0	4	3	4	1	0	7	5	0	1	0	0	0	1	0	1	1	6	57
Coscinida tibialis	0	0	0	0	1	1	0	1	2	6	1	0	4	2	0	4	6	1	1	2	0	2	1	0	0	0	0	1	0	1	0	0	37
Crustulina sp1	0	0	0	0	0	0	0	2	0	4	0	1	1	0	0	1	2	0	2	0	1	0	0	0	0	2	0	0	4	0	1	0	21
Cryptachaea sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	2	0	0	3	0	0	0	0	0	0	0	0	0	0	16
Dipoena sp1	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	3	0	1	1	4	0	0	0	0	0	0	0	0	0	0	13
Dipoenura cyclosoides	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	9	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	13
Emertonella taczanowski	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	3

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Episinus nubilus	0	0	0	1	0	0	4	0	2	0	1	0	2	0	4	0	0	0	3	0	10	0	3	0	1	0	0	0	0	5	5	0	41
Euryopis elegans	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4
Euryopis episinoides	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	4
Euryopis nubila	0	0	0	0	1	0	1	0	0	0	2	0	0	1	0	0	6	0	1	0	2	0	3	0	1	2	0	2	2	1	0	0	25
Faiditus sp1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Faiditus xiphias	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	4	0	1	0	0	0	0	2	3	3	15
Hentziectypus sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	15
Janula germaini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Janula sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	8	0	0	0	0	0	0	0	0	1	0	0	1	0	11
Janula sp3	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Lasaeola sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	3
Meotipa picturata	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	3	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	12
Moneta mirabilis	1	0	1	2	0	0	0	0	0	25	1	0	6	0	0	0	0	8	44	0	1	0	0	0	0	0	0	0	0	8	5	35	137
Neospintharus sp cf nipponicus	0	1	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	2	0	1	2	0	0	0	0	0	0	0	0	0	0	11
Neottiura sp2	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Parasteatoda japonica	1	0	0	1	0	0	2	0	0	2	0	2	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	3	0	1	16
Parasteatoda tepidariorum	2	1	0	1	2	1	3	5	0	21	1	6	24	0	0	3	3	4	7	2	16	2	4	1	0	2	3	10	2	4	2	7	139
Pholcomma sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Phoroncidia nasuta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	4
Phoroncidia septemaculeata	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phoroncidia sp4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
Phoroncidia sp5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Phycosoma gui	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	7
Phycosoma labialis	5	2	0	1	10	5	8	2	2	6	9	0	13	15	2	7	12	6	2	4	3	6	4	3	0	0	1	11	5	14	5	6	169
Phycosoma martinae	0	0	0	0	0	0	3	0	0	0	0	1	0	3	0	0	3	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	13
Phycosoma stellaris	0	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0	1	1	1	0	6	1	0	0	2	0	1	0	0	1	1	0	20
Phycosoma wangi	0	0	0	2	0	0	0	8	0	0	3	6	4	0	0	12	4	0	2	2	5	0	0	0	0	0	0	0	0	6	1	0	55
Phylloneta sp1	0	0	0	0	0	0	0	1	0	0	1	0	10	0	0	0	0	1	5	0	2	0	0	0	0	0	0	0	0	0	0	0	20
Platnickina maculata	0	1	0	0	2	1	0	0	0	4	0	0	6	2	1	3	1	1	0	0	0	0	4	2	1	0	5	11	0	0	0	0	45
Platnickina mneon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
Platnickina sp1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	3	3	0	1	1	3	12	0	2	2	4	6	4	0	1	0	45
Propostira quadrangulata	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Rhomphaea labiata	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	0	7
Rhomphaea projiciens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	1	4
Rhomphaea sagana	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Rhomphaea sinica	1	1	0	1	0	1	2	0	1	1	0	1	3	3	3	3	5	0	1	0	1	0	0	0	0	0	0	0	0	3	4	5	40
Ruborridion musivum	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	1	5	0	1	0	2	4	0	0	1	1	2	1	0	1	7	0	30
Rugathodes sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Spheropistha melanosoma	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Steatoda sp1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Steatoda sp2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Theonoe sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Theridion sp cf hannoniae	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Theridion sp cf pinastri	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	6	0	0	0	0	1	2	0	0	1	0	16

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Theridion sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Theridion sp4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Theridion theridioides	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	2	0	0	8
Theridula gonygaster	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	4
Thwaitesia margaritifera	0	2	0	1	1	0	2	0	3	0	5	0	0	7	1	6	2	0	1	3	11	2	4	0	4	1	0	0	0	4	1	0	61
Thwaitesia sp1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Theridiosomatidae																																	
Theridiosomatidae sp1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	4
Thomisidae																																	
Amyciaea forticeps	4	8	1	8	0	0	0	5	3	5	14	7	0	9	3	16	10	1	1	5	12	13	13	8	0	0	2	8	0	0	2	0	158
Angaeus pentagonalis	8	0	2	7	8	16	13	1	2	8	4	1	15	11	4	6	18	0	2	5	10	1	30	38	8	6	1	0	1	13	28	16	283
Boliscus tuberculatus	1	1	1	4	2	0	1	1	0	13	3	1	0	0	0	7	0	0	2	1	2	0	0	0	0	0	0	1	0	32	12	28	113
Bomis bengalensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	0	0	0	0	18
Epidius bazarus	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	0	2	0	12
Henriksenia hilaris	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	7
Misumenops sp1	0	1	1	0	1	0	0	1	0	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	0	2	9	5	0	0	0	24
Monaeses sp cf israeliensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Monaeses sp2	0	0	0	0	0	0	2	0	1	0	0	0	0	6	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	5	2	19
Oxytate elongata	0	1	1	0	7	10	9	0	1	2	4	0	0	7	2	6	14	0	0	3	2	0	2	0	1	0	1	5	0	2	3	0	83
Ozyptila sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	4
Ozyptila sp2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5
Ozyptila sp3	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	7
Pasias puspagiri	0	1	1	0	4	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	1	2	0	2	1	0	18

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Pherecydes sp1	0	0	1	0	1	0	0	1	0	0	0	1	4	0	0	2	6	5	0	1	6	5	0	0	0	1	1	3	0	4	0	0	42
Phrynarachne tuberosa	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
Runcinia sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Sinothomisus sp1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	6	3	2	0	0	0	16
Strigoplus netravati	0	0	0	0	0	0	0	3	0	1	1	1	0	1	1	0	1	0	1	2	0	0	1	0	3	0	0	0	0	0	5	0	21
Synema decorata	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	7	0	13
Synema revolutum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	4	0	0	0	0	0	0	9
Thomisus lobosus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	4
Thomisus projectus	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	5
Thomisus sp2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	4
Thomisus sp5	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	3	0	0	0	1	2	0	1	1	2	6	1	1	0	1	25
Thomisus viveki	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	6
Tmarus kotigeharus	4	0	0	1	2	1	3	1	1	4	1	0	2	1	0	2	4	0	4	0	8	2	0	0	3	0	3	9	7	5	2	0	70
Tmarus sp1	12	1	8	3	2	0	4	6	0	13	9	3	17	4	2	3	5	1	15	1	29	21	0	0	2	1	0	2	1	12	5	3	185
Tmarus sp2	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Tmarus sp3	1	0	0	0	1	0	0	0	0	5	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Tmarus sp5	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Tmarus sp6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Xysticus sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	0	1	0	0	0	0	6
Xysticus sp2	0	0	2	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Trachelidae																																	
Cetonana sp1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6
Trachelas sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	3	0	1	1	0	0	0	0	0	0	7
Uloboridae																																	

Family, species	ML	AW	NT	UM	PN	DG	KN	PD	KH	DN	KD	KG	KU	SO	BG	JM	SK	AD	SD	WK	GT	KR	MN2	MN3	CS1	CS2	MN1	MN4	CS3	RF1	RF2	RF3	Total
Miagrammopes thwaitesi	7	0	5	2	0	1	0	1	0	10	2	2	15	2	0	0	1	6	10	0	3	0	0	0	0	0	2	0	0	11	1	4	85
Uloborus bigibbosus	4	2	1	2	3	1	6	4	1	13	7	4	42	7	2	13	16	21	28	3	17	7	5	1	2	1	5	6	3	8	5	7	247
Uloborus ferokus	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
Zodariidae																																	
Asceua cingulata	2	9	5	4	2	1	6	5	6	22	8	4	12	2	18	19	16	3	22	18	12	3	6	7	0	1	2	0	1	0	0	8	224
Cicynethis sp1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Cryptothele collina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Euryeidon sp1	0	0	0	0	0	0	0	2	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	7
Mallinella sp1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	6	0	0	0	2	0	0	0	0	3	0	0	0	0	16
Mallinella sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Storena birenifer	1	0	0	0	0	0	4	1	1	3	1	0	16	0	0	0	0	1	6	0	3	1	4	0	0	1	0	8	8	2	0	4	65
Storena sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	12
Zodarion sp1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	1	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	9
Zodarion sp2	0	0	0	1	2	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	8
Zodarion sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2

REVIEW OF DISPERSAL IN SPIDERS: MODES, FATE AND IMPLICATIONS

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ABSTRACT

Spiders thrive in a hostile world as a successful group of organisms. One of the reasons for this has been speculated to be their ability to colonize almost every terrestrial habitat. Successful colonization is a result of persistent dispersal. Spiders have evolved two modes of dispersal – cursorial and aerial. Spiders adopt any or a combination of these two depending on developmental stage, body mass, membership of certain guilds, habitat structure and certain other environmental conditions. Both these modes have been found to be successful in carefully manipulated experimental setups as well as indirect observational records. However, contradictory results regarding relative success of each have been reported. Spider dispersal is an important landscape-scale process especially in agrarian landscapes. It has implications for the natural pest control and maintenance of natural habitats. Here, we review important studies on modes, fate and implications of spider dispersal to facilitate formulation of further studies.

Keywords: spider, colonization, ballooning, cyclic dispersal, metapopulation

Colonialist Spiders:

A number of well-known facts amply establish that spiders are successful colonizers. Spiders (Araneae) are a group of highly diversified organisms with the world's third largest count of species (Platnick, 2013). They are generalist predators and have the world's most abundant taxon – Insecta – as their prime food (Maloney, *et al.* 2003). They can be found in almost all terrestrial habitats in natural settings. In fact, they can be found in most anthropogenic habitats too (Wise, 1993). Most spider species occur as high-density populations in diverse communities. With all these properties, they have been hailed as an ideal group for studying metacommunity dynamics (Schmidt, *et al.* 2007) one major process in which is colonization. Indeed, spiders are true colonialists. But spiders, like most other organisms, live in a hostile world (Helsdingen, 2011). And colonization is fraught with numerous challenges as we know in the context of humans-

'…Send forth the best you breed
Go bind your sons to exile…
…Go mark them with your living
And mark them with your dead…'

– Rudyard Kipling, *The White Man's Burden*, 1899

Colonization is the establishment of a species in new area. Community of organisms at any given locality is built up by niche relations, habitat diversity, ecological equivalency and mass effects (Shmida & Wilson, 1985). Mass effect is immigration and establishment of some individuals of a species in an area previously unoccupied by that species (Shmida & Wilson, 1985). Immigration is the result of dispersal and has been conceived as a response to a forcing event causing 'changes in the quality, size, density and connectivity of suitable habitat patches' (Jackson & Sax, 2010). Successful colonization requires a well developed dispersal capacity (Bullock *et al.* 2002).

Thus, dispersal is the key to colonization. And dispersal has certainly gained central position in ecological studies (Bullock *et al.* 2002).

Dispersal

All animals possess the defining ability to move (Biewener, 2003) especially from place to place. Movements are inspired by motives of self-preservation by avoiding mortality from various factors, acquisition of essential resources and avoidance of competition in doing so (Fahrig, 2007). Animals perform several types of movements to accomplish these tasks. These types vary by organism's size, life history traits, power of movement, geographical range, and habitat. Considering these parameters, Hugh Dingle (Dingle, 1996) has classified movements into three broad categories - station keeping, ranging and migratory movements. The station keeping movements are contained within home range of an individual; ranging movements are in pursuance of an alternate home range; and migratory movements extend beyond the ambit of home range. Dingle argues that migration is distinct from ranging in behavioural and physiological aspects and response of organism to the environment. He includes the conventional concept of dispersal in ranging movements. He calls it a population level phenomenon in which a group of individuals breaks up progressively increasing distance between them. The individuals explore resources while on move and make decision to stop and settle. The more popular connotation of this type of movement is natal dispersal wherein the juveniles move away from their natal home range to establish their own home range.

Although Dingle (1996) has advised to use the term dispersal strictly in the context of natal or breeding dispersal and to use ranging, instead, for exploratory beyond-home-range movements, most spider studies do not distinguish between dispersal and ranging. Hence, we would continue calling all movements across landscape as dispersal in this review.

Nevertheless, dispersal invariably involves travel across landscape. But landscapes are inherently heterogeneous comprising of several types of habitats arranged in patches. Some patches correspond to the suitable habitat while others unfavorable. Dispersing individuals face the problem of covering the distance between suitable patches (Opdam, 1991). And anthropogenic fragmentation of habitats has increased these distances substantially.

Dispersal is at the base of two major ecological theories - metapopulation dynamics and metacommunity dynamics. Metapopulation Dynamics was initially propounded by Richard Levins in 1969 in the context of demographics of agricultural pests. It subsequently outgrew the original context and assumed a central place in ecological paradigms. On the other hand, metacommunity dynamics emerged from the realization of inadequacy of metapopulation dynamics (Wilson, 1992). It has attained unprecedented levels of popularity amongst ecologists. This is clear from the enthusiastic reviews received by the book 'Metacommunities: Spatial Dynamics and Ecological Communities' (Holyoak *et al.* 2005) (e.g. Gaston 2006). It is also evident from the way a comprehensive review (Leibold *et al.* 2004) got cited in over 1000 papers in just 8 years!

More physically, and simply put, metapopulations or metacommunities are nothing but occupied patches in a landscape. Metapopulation dynamics is run by architecture of populations and density-dependence in addition to dispersal (Hanski, 1991). Similarly, metacommunity dynamics is run by patch dynamic, species sorting, and niche partitioning in addition to dispersal (Leibold and Miller, 2004). Lower dispersal success is often connected with decline in population in fragmented habitats (Schumaker, 1996). Thus, dispersal remains the key mechanism behind the occupancy of a habitat patch by a species.

Dispersal is a prime process in landscape ecology and its parameters – especially the scale – depend on the heterogeneity of landscape as well as the organism concerned (Turner, 1989). It is triggered by resource- and density-dependent factors working at population levels. Samu *et al.* (1999) have advised to study spiders at 3 scales of spatial hierarchy – micro-habitat, habitat and landscape. For spiders, landscape composition at the scale of 500 m radial area has been found to be appropriate (Clough *et al.* 2005, Schmidt *et al.* 2005).

Scale of dispersal, however, varies with species and must be parameterized to get correct interpretation of the colonization process. In her review, Turner (1989) has also emphasized that in landscape ecological studies, all landscape scales must be organism-centric. Wiens (1989) had opined that different types of species of birds would be affected differently by the fragmentation of habitat. On one hand, habitat generalists and edge lovers can be benefitted by a certain degree of fragmentation. On the other, for habitat specific species, the area between habitat patches acts as a barrier or sink ((Opdam, 1991). Another factor is the ability and tendency of the species to cover distances. Mobility categories of butterflies like sedentary, intermediate, and wide ranging have been identified (Thomas, 2000). Similar categories based on habitat preferences and mobility can be construed in spiders too. Different species, albeit related, showed differential colonization abilities in the studies of Marshall *et al.* (2000). In habitat specialist spiders, the propensity for dispersal was found to be declining with increasing fragmentation of habitat (Bonte *et al.* 2003).

Studying Dispersal

Advances in telemetry have made real-time tracking of dispersing individuals and their fate. But this technology is restricted in its application to vertebrates only. Arthropod dispersal has been traditionally interpreted indirectly from the monitoring of populations and communities in target habitats. Even capturing dispersing individuals, marking them and releasing back have been attempted. In spiders, several studies have used indirect evidence of dispersal and mark-recapture set ups. Still, there have been very few studies which focused exclusively on dispersal in spiders (e.g. Bishop & Riechert 1990, Blandenier & Fürst 1998; Nicholls *et al.* 2001; Schneider *et al.* 2001; Bonte *et al.*2003,2004, 2006; Reynolds *et al.* 2007, Hibbert & Buddle, 2008).

Dispersal has also been extensively modeled. One way is to model the dispersal success rate of organisms through spatially explicit demographic models. Spatially explicit models are either grid based or patch based. Numerous models exist (Vuilleumier & Metzger 2006). But they all are inefficient and unrealistic in the absence of life history data of the target species (Schumaker, 1996). Each approach has its own advantages and disadvantages over and above the loss of complexity of animal behavior. The other way is to predict dispersal success on the basis of indices of fragmentation pattern in the landscape. These are supposed to estimate the habitat connectivity. They have been continuously under scrutiny (Schumaker, 1996). Schumaker showed that of several landscape indices, only those that combined patch area and perimeter were able to predict dispersal success adequately. Even less attempts have been made to model dispersion in spiders.

Colonization and Dispersal in Spiders

Spider colonization takes place through two processes – natal dispersal and cyclic dispersal. In natal dispersal, young spiderlings move away from their mother's habitat patch and get established elsewhere. However, there has been evidence of natal dispersal being performed by adults especially those of social spiders of the genus Stegodyphus (Schneider *et al.* 2001).

The cyclic dispersal results into what is known as 'cyclic colonization' in which the spiders colonize a resource-rich habitat for a certain period of year and then return to their original habitat (Wissinger, 1997). Again, in this case the individuals involved could be spiderlings and adults both and the colonization is short-term.

Deprived of wings, spiders disperse relying on their legs and their extraordinary ability to generate silk. Thus, there are two modes of dispersal in spiders – ground and aerial. Aerial dispersal takes place by a mechanism of ballooning. It is known to carry spiders to heights of 5 km above ground and upto 300 km across landscape (,Ehmann, 1994). It has been considered a passive mode of dispersal dependent on air currents, wind direction, and body mass and wherein the spider has no control on the flight direction (Thomas and Jepson 1999, Compton 2002). It was seen as a means of dispersal of small young spiders post their emergence from eggsacs. Tiptoeing is a prelude to the ballooning. A tiptoeing spider stands on raised legs and points abdomen upwards (Schneider *et al.,* 2001). In this position, it releases several strands of silk.

Bishop & Riechert (1990) found that spider families arriving in their garden plots via cursorial mode and via ballooning were significantly different. They also observed that nearly 50% of all immigrant species arrived from far-away areas via aerial dispersal. Ehmann (1994) manipulated the access of cursorial and ballooning spiders to individual shrubs. He found that control shrubs received over 75% of their individuals via ballooning. But the mode of dispersal did not influence the guild structure in any treatment. It is therefore commonly assumed that the ballooning is used by spiders for natal dispersal as it is usually long distance dispersal (LDD) and walking is used for cyclic dispersal as it is usually short distance dispersal (SDD).

Buddle and Rypstra (2003) trapped emigrating spiders in pit-fall traps in a two-species system of wolf spiders in soybean fields. They found that one species showed very high propensity to emigrate from low-quality habitat showing its specialization on high-quality habitat. The other species showed generalist behaviour. This goes on to show that exclusively cursorial spiders exhibit variable tendencies of dispersal.

Hibbert and Buddle (2008) conducted studies in cornfields and adjacent natural forest in Canada. They used circular aluminium enclosures that allowed only ballooning spiders or both ballooning and cursorial spiders. They found that cursorial mode of dispersal significantly contributed to the colonization of spiders in cornfields. Their other observation was that several spider species were common to both habitats indicating that the natural forest could play an important role in maintaining spider populations in cornfields.

Bishop (1990) reviewed the earlier studies of ballooning and concluded that initiation of ballooning and maintenance of flight were two different aspects influenced by different factors. To fill the gap in information on flight maintenance, she sticky-trapped ballooning spiders at different heights above ground. She found that there was seasonal variation in both the height of ballooning and ballooning taxa. She also found that ballooning took place from just above canopy i.e. 22 m to even 44 m. She recorded the importance of less fluctuation in wind velocity for successful flight maintenance.

Dr. James Bell of Cardiff University, UK and his colleagues have extensively studied ballooning behavior in spiders and other arthropods and its evolutionary consequences (Reynolds, *et al.* 2007). They have found that the silken dragline is only of as much importance as to launch the spider into the air current. Thereafter, the distance travelled by the spider is determined by the meteorological conditions rather than the properties of the dragline. And that ballooning spiders initiate ballooning at appropriate meteorological conditions that would maximize the dispersal distance. Ballooning was found to be a major mode of dispersal for certain spiders in high-Arctic glacial ecosystems (Coulson *et al.* 2003).

Schneider *et al.* (2001) studied ballooning in adult *Stegodyphus dumicola* spiders. They reported, for the first time, ballooning on multiple – tens to hundreds - strands. They concluded that use of multiple strands of silk to balloon can help even large-sized adults in dispersing to remote locations.

Most spider dispersal and colonization studies have been conducted in agricultural habitats and their surrounding landscape context. One of the limitations of biocontrol by spiders in croplands is that they fail to colonize the crop in advance to the pests. Most studies have targeted at altering the in-field-habitat structure to facilitate colonization by dispersing spiders. Similarly, few studies have also looked at the adjacent non-crop habitats and their role in colonization.

Contrary to the results of Bishop & Riechert (1990), Schmidt *et al.* (2007) have showed that the non-crop habitat is important for colonization of most spiders in wheat-fields. At the same time, some spiders specializing in arable habitats were not influenced by non-crop habitats.

Presence of refuge vegetation does influence the colonization by generalist predators. But the zone of this influence of colonization was found to be very limited. In addition, effect of corridors of refuge vegetation running through extensive monocultures has also been studied. Clara Nicholls and her colleagues (2001) undertook such a study in Northern California in two vineyard blocks of 2.5 ha each and surrounded by riparian vegetation on one side. They used the experiment like presence of a vegetation corridor bisecting one of these vineyards They tested if this corridor was a ‘consistent, abundant and well-dispersed source of food and habitat’ for the natural predators to act as a source population for colonization in the vineyard and whether it also acted as a ‘conduit for the dispersion of natural enemies’. They estimated populations of pests of grapes along with their generalist predators.

Their main finding was that the population and, hence, the pest control potential of natural enemies was amplified by the corridor in addition to the riparian vegetation edge. They did find lower incidence of pests in the area of influence of the corridor i.e. the pest populations increased gradually away from the corridor. Interestingly, among the complex of arthropod natural enemies they recorded, the second most abundant predators were Thomisid spiders!

Concluding Remarks

Spiders are capable of both local, short distance ground dispersal and distant, long distance aerial dispersal. Both these propensities play a major role in their colonization of unoccupied habitats. Colonization itself can be permanent or cyclic. While aerial dispersal is influenced by meteorological conditions, ground dispersal is affected by habitat configuration. The landscape architecture in terms of habitat-matrix compositions, juxtapositions and corridors determine the success of dispersal events. An understanding of these landscape level phenomena is especially important in heterogenous landscapes for conservation of spider diversity. It is also important to apply spiders as potential biocontrol agents in agroecosystems. It also certainly has implications for maintenance of natural habitats in predominantly anthropogenic landscapes.

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FIRST REPORT OF GENUS *Echinax* DEELEMAN-REINHOLD, 2001 (ARANEAE: CORINNIDAE) FROM INDIA

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ABSTRACT

Echinax Deeleman-Reinhold, 2001 is a relatively new genus of foliage dwelling Corinnid spiders. Although not very species-rich, it is widely distributed in South-East Asia and Africa. We present here, probably, the missing link in the wide distribution of this genus by reporting its occurrence in India. *Echinax panache* Deeleman-Reinhold, 2001 is reported from Konkan- the western coastal region of Maharashtra state thereby extending its range considerably to the west.

Keywords: Spider, *Echinax panache*, Konkan, Maharashtra

INTRODUCTION

Echinax Deeleman-Reinhold, 2001(Corinnidae: Castianeirinae) is a genus of foliage dwelling spiders inhabiting tropical forests of the old-world. Deeleman-Reinhold (1995) had described 3 species under *Copa* Simon, 1886 from South-East Asia. But subsequent investigations prompted her to erect this new genus for those species with *Echinax oxyopoides* (Deeleman-Reinhold 1995) as type species and describe another new species from the same region (Deeleman-Reinhold 2001). Later, another new species *E. anlongensis* Yang, Song & Zhu, 2004 was described from China and presence of 2 other species was also reported. Thereafter, Marusik *et al*. (2008) described female of *E. panache* from China and clarified the difference between females of *E. panache* and *E. oxyopoides*. Very recently, *E. longespina* (Simon, 1910) was similarly separated from *Copa* to include in *Echinax* and 6 new species were also described from Afrotropical region (Haddad, 2012). Thus, presently there are 12 species in the genus *Echinax* (World Spider Catalog, 2015).

We report here the occurrence of genus *Echinax* in India for the first time thereby providing a link in the *hitherto* disjunct looking range of this genus. This report also extends the range of *E. panache* (Deeleman-Reinhold, 1995) further west.

MATERIALS AND METHODS

This species was collected during fieldwork carried out in Dapoli taluka of Ratnagiri district in Maharashtra state of India during October 2013. The collection localities are sacred groves in the village Male (17°45'16.37"N, 73°17'49.15"E) and

Pichdoli (17°52'22.20"N, 73°11'19.40"E). These small sacred groves are surrounded by settlements, agriculture and forest. At both these places, the forest is mixed semi-evergreen. The middle story is dominated by *Memecylonum bellatum*. The spiders were collected, photographed and preserved in 75% alcohol. They were examined with the help of a Labomed stereo microscope. Photographs were taken with a Dinolite digital microscope and measurements were taken with the help of Dinocapture 2.0 software. All measurements are expressed in mm. The specimens are presently held in the spider collection of College of Forestry, DBSKKV, Dapoli. Subsequent to the publication of this paper, they will be deposited in a national repository. Abbreviations used are –AER = anterior eye row, AL = abdomen length, ALE = anterior lateral eye, AW = abdomen width, CL = carapace length, CW = carapace width, PER = posterior eye row, ST = spermatheca.

Echinax Deeleman-Reinhold, 2001

Echinax panache Deeleman-Reinhold, 2001(figures 1-4)

E. p. Deeleman-Reinhold, 2001; *E. oxyopoides* Yang, Song & Zhu, 2004 (females misidentified as per Marusik, Zheng& Li, 2009); *E. p.* Yang, Song & Zhu, 2004; *E. p.* Marusik, Zheng & Li, 2009.

Diagnosis:

Deelemen-Reinhold (2001) while erecting the genus and Haddad (2012) while revising it have given detailed distinguishing characters which set apart *Echinax* from similar lycosiform Castianeirinae genera like *Copa*, *Humua* Ono, 1987 and *Medmassa* Simon, 1887. *Echinax* can be distinguished from all these by its smaller size, thinner teguments, long deviant spines on all leg segments except tarsi, and posterior eye row strongly procurved.

Material examined:

1 Female, 1.X.2013, Male (Taluka Dapoli, District Ratnagiri, Maharashtra), India, by beating vegetation, Vinayak Patil & Mayur Naik (CFOR-S377); 1 Female, 6.X.2013, Pichdoli (Taluka Dapoli, District Ratnagiri, Maharashtra), India, by beating vegetation, Vinayak Patil & Mayur Naik (CFOR-S393).

Diagnosis:

The present specimen possess the key character of insemination ducts entering the ST II anteriorly (see Haddad, 2012) which is shared by all known females of Asian and one African species. They resemble *E. panache*in the respect of insemination ducts and copulatory pockets. Also in having longitudinal grey bands on carapace formed by prostrate hairs as against tegumental pigments in all other Asian species (Deeleman-Reinhold, 2001, Marusik *et al.*, 2008). We must also note that our specimen also resemble the African *E. scharffi* Haddad, 2012 in respect of pattern on the carapace and abdomen (Haddad, 2012).

Description:

TL5.10, CL2.15, CW1.62, AL3.12, AW1.56

Carapace cream colored with broadest in the middle and narrowing anteriorly. A deep brown longitudinal thoracic fovea. Lateral margins with irregular broad patches formed by black prostrate hair. A similar broad patch running midlongitudinally from eyes to almost posterior margin of carapace. This patch is broken by hairless areas forming a pattern. A prominently black eye area with eyes arranged in a compact circle on a slightly elevated cephalic area. AER slightly procurved; PER strongly procurved and slightly wider than AER.ALE the smallest; ocular quad slightly longer than wide and wider behind. All eyes circled by black rings.

All mouthparts uniform cream colored with dense scapulae and sparse short hairs throughout. Chelicerae with 2 teeth each on prolateral and retrolateral margins. Maxillae longer than wide; labium longer than wide and like a hemi-circle. Sternum as long as wide and roundish uniform cream colored with sparse short hairs.

Legs medium and strong, yellowish cream colored with brown mottling on most segments; Leg formula: 4123; leg lengths as in table 1. The ventral side of all femora uniformly cream colored with just a distal black ring on leg III & IV. All legs have 3 dorsal, 2 prolateral and 2 retrolateral erect long spines on femora. All patellae have a very long dorso-distal spine. All other segments of legs possess whorls of very long erect spines.

Figures-1-4, *Echinax panache* Deeleman-Reinhold, 2001 female; habitus (1), carapace (2), genitalia ventral (3) and genitalia dorsal (4).

Abdomen is oval with cream color of the tegument on which a pattern of light to dark brown created by prostrate hairs. Venter cream colored with a broad mid-longitudinal light brown band.

Table 1: Leg lengths of *Echinax* panache female from Konkan region of Maharashtra.

	F	P+T	MT	T	Total
Leg I	2.02	2.17	1.60	0.95	**6.74**
Leg II	1.91	2.00	1.56	0.85	**6.33**
Leg III	1.77	2.04	1.51	0.82	**6.14**
Leg IV	2.17	2.55	2.37	1.03	**8.12**

Epigyne: A broad sclerotized plate with copulatory openings on the lateral sides. These are guarded by 6-shaped ridges forming copulatory pockets. In ventral view, the spermathecae give impression of a broad X. Each spermatheca is elongated and convoluted; with anterior part termed ST II and posterior ST I (Haddad, 2012). The insemination ducts lead internally in a curved manner to enter ST II anteriorly.

Remarks

This is the first report of the genus *Echinax* from South Asia. Haddad (2012) had predicted that South Asian forests with similar habitat in South-East Asia and Africa could hold this genus. However, we must remark that a specimen similar to ours in most aspects was described as *Mimetus tikaderi* by Gajbe (1992) and it has already been placed *incertae sedis* in the World Spider Catalog (Platnik, 2014). It is also likely that not only *Echinax* but also *Medmassa* could be present in South Asia given its presence in Africa and South-East Asia. It is also possible that *Copa* is an exclusively African genus and two species reported from Sri Lanka might be from other genus. This question was, however, left unresolved by Deeleman-Reinhold (2001) for want of type specimen.

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