

# 私立東海大學生物學系碩士論文

指導教授：卓逸民 博士 Dr. I-Min Tso

蘭嶼蜘蛛多樣性：不同干擾程度棲地間之比較

Spider diversity on Orchid Island, Taiwan: A comparison  
between habitats receiving different aboriginal activities

陳冠州 Kuan-Chou Chen

學號：G882314

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## 摘要

熱帶森林擁有豐富的蜘蛛多樣性，但相關研究大多針對溫帶地區的農地生態系，並著重在調查底棲性的蜘蛛群落。位於台灣東南的蘭嶼島，是東亞地區熱帶森林分佈之北限。本研究旨在探討蘭嶼熱帶森林的蜘蛛多樣性，並以原住民之各種棲地利用所形成不同棲地類型間之比較為主軸，針對蘭嶼森林生態系中森林內部、草原以及兩者的過渡區域(森林邊緣)三種不同棲地類型，選定四個重複樣區(永興、永興外、野銀、中興)作為比較。我們在每個樣區設置四個 5m × 5m 的採樣點共 48 個，另於較原始的天池森林，設置兩個樣區共 8 個採樣點。其中，天池以外的樣區因離部落較近，受到相當程度的人為干擾，而天池所受干擾則相對低上許多。採集共使用掉落式陷阱、玻利式漏斗、灌叢掃網、徒手日、夜間採集及樹冠層撈網等六種方法，在每個採樣點系統性採集由地表至 10 公尺高度樹冠層之所有蜘蛛。在 2000 及 2001 年之間所進行的三次採集共獲得蜘蛛共 5406 隻個體，包含 2845 隻成體，分屬 19 科 150 個種。以 ANOVA 分析四種類型棲地間之群落結構之結果顯示不同棲地間之蜘蛛群落結構有相當顯著之差異；而種類組成及功能群之比較之分析結果亦是如此。這些結果顯示在森林內部、邊緣及天池之採樣點無論在物種數及多樣性指數皆顯著高於草原採樣點。而有小尺度原住民砍伐之森林採樣點之物種數及部分多樣性指數反高於位於天池原始林之採樣點。比起前者，後者之優勢物種所佔比例高出許多。利用兩兩採樣點間之 Euclidean distance 所進行之 Clustering analysis 顯示所有採樣點可區分為森林及草原等兩大類型，顯示兩種棲地類型之物種組成有極大差異。此外，樹冠層較茂密的林邊樣點被歸在森林類型，而樹冠較稀疏的樣點則被歸在草原類型，顯示蜘蛛群落對棲地有一定的偏好，並隨棲地品質有所變化。在分層比較樹冠、灌叢與地表之蜘蛛

蛛多樣性時發現，灌叢之種豐富度與數量最為豐富；而且三者的群落結構與功能群組成均有顯著差異，顯示蜘蛛群落主要的分佈範圍在兩公尺以下的區域且受微棲地所影響。研究結果顯示，蘭嶼熱帶森林生態系擁有相當高且獨特的蜘蛛多樣性，雅美人對森林內部之傳統利用模式似乎可藉降低優勢種之比例而維持較高之蜘蛛多樣性。但若將森林完全砍伐形成草原後，蜘蛛之多樣性將降低，且其種類組成與群落結構將完全改觀。

關鍵字：生物多樣性、蜘蛛、熱帶森林、蘭嶼、原住民

## **Abstract**

Tropical forests exhibit very high spider diversity, but most related studies examined a particular functional group or layer of the habitat and few assessed the impacts of disturbance on tropical Araneae diversity. Orchid Island is 92 kilometers off the southeast coast of Taiwan and her forests are the northern most tropical forests in East Asia. In this study, the spider diversity of Orchid Island was studied and those from three types of habitats generated by various kinds of aboriginal activities were compared. Habitat types examined in this study included the forest, the meadow and the forest edge. All habitat types had four replicates each containing four 5m×5m sampling plots. In addition, we also set up another 8 plots in the relatively undisturbed primary forest in Tienchi for comparison. Spiders from the ground, understory shrubs and canopy were collected to have a comprehensive representation of diversity from all microhabitats in the sampling plots. From the 2845 adult specimens obtained, a total of 150 species from 19 families were identified. The composition and structure of spider communities were significantly different between different habitats. Plots in the forest, forest edge and Tienchi habitats exhibited significantly higher species richness and diversity than those in the meadow. Compared with plots in the forest habitats, those in the Tienchi primary forest had lower species richness and diversity due to high relative abundance of dominant species. Result of a UPGMA analysis using pair-wise Euclidean distance showed that most of the sampling plots could be clustered into two major groups, Forests and Meadows. Plots of forest edge habitats exhibiting less canopy cover were grouped with the meadow plots and those with more canopy cover were grouped with the forest plots. Foraging guild composition also differed significantly among different types and layers of the habitats. Results of this study suggested that while clear-cutting of the forest generated a distinct spider

community, limited scale of logging by local people seemed to increase the diversity of spiders by suppressing the dominant species.

Keywords: biodiversity, spider, tropical forest, Orchid Island, aboriginal activities

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## **Introduction**

Although spider diversities in temperate regions have been relatively well studied, those in the tropic areas have received only little investigation. Spiders are the most diverse and abundant invertebrate predators of terrestrial ecosystems (Wise 1993, Nyffeler 2000), which forage primarily on insects. Because of their high abundance and insectivorous foraging, spiders are considered the major agent controlling the insect communities in terrestrial ecosystems (Riechere & Lockley 1984, Topping & Lövei 1997, Marc et al. 1999, Nyffeler 2000). These properties make spiders a good indicator for comparing the biodiversity of various environments and for assessing the effects of disturbances on biodiversity (Clauseu 1986, Nyffeler & Benz 1987, Churchill 1997, Churchill 1998, Maelfait & Hendrickx 1998, Riecken 1999). However, most studies focused on agricultural ecosystems in temperate areas such as United State and Europe (Young & Edward 1990, Carter & Rypstra 1995, Topping & Lövei 1997, Marc et al. 1999, Tóth & Kiss 1999, Uetz et al 1999); studies of spider diversity in tropical areas were rare. Although the effects of various disturbances on spider diversity were well known in temperate regions (Bultman & Uetz 1982, Maelfait & Keer 1990, Gibson et al. 1992, Pettersson 1996, Topping & Lövei 1997, Zulka et al. 1997, Feber et al. 1998, Downie et al. 1999), studies on effects of environmental impacts on tropical fauna are extremely few. Robinson and Robinson (1974) studied the abundance and composition of orb-weavers in Wau, New Guinea. Lubin (1978) studied the relationship between habitat structure and web spider diversity in Barro Colorado Island, Panama. Greenstone (1984) conducted a similar study in Costa Rica and found that vegetation structures but not prey availability significantly determined the diversity of web spiders. Coddington et al. (1991) analyzed the species richness in a Peruvian tropical forest. Pfeiffer examined the



diversity of ground spiders (1996 a) and arboreal spiders (1996 b) in Puerto Rico. By using canopy fogging, Russel-Smith and Stork (1994) compared the abundance and diversity of canopy spiders in different elevations in Sulawesi and found that both attributes correlated positively with altitude. This short review demonstrated that most studies examined a particular functional group or layer of the habitat and few of them focused on the impacts of disturbances on tropical Araneae diversity.

Orchid Island (Lanyu in Chinese) is a tropical island 92 kilometers off the southeast coast of Taiwan. The forest on Orchid Island is the northern most tropical forest in East Asia (Chen et al. 1982). The aboriginals inhabiting this island are Yami people. Yami people were of Malay-Polynesian origin and were migrated from Batan Islands, Philippine about 800 years ago (de Beauclair 1959), whose culture and resource utilization of are closely associated with the sea (Wang 1984). However, they also conducted several forms of land utilization, which occurred primarily on the island's forest. Some forests near the villages were clear-cut to provide lands for yam or taros plantation. Small scales of logging also occurred in the forests to obtain material for canoe and hut construction. Both activities generated disturbances to the forest ecosystem. Recently, Tso and Tanikawa (2000) and Yoshida et al. (1998, 2000) had conducted some taxonomic studies on spider diversity on Orchid Island, however, so far there is no information about how the traditional activities of Yami people affect the spider diversity of this island. In this study, the impacts of Yami people's forest utilization on spider diversity were assessed by comparing the spider diversities in forests, meadows and the areas between (forest margin). Spiders from the litter to up to 10m in the canopy were systematically collected to have a more comprehensive realization of the spider diversity and impacts of disturbances.

## Materials and Methods

### *Orchid Island tropical forest:*

Orchid Island is a tropical island 92 kilometers off the southeast coast of Taiwan (121.32° E, 22.03° N) with a total area about 45.74 km<sup>2</sup> (Chen et al. 1982). It was formed by the eruption of volcano and was located on the Luzon sill between Taiwan and Philippine (Richard et al. 1986). On this small island there are ten mountains with elevations were over 400 m; two of them were even over 500 m. Most areas on the island are mountainous regions, with few alluvial plains scattered along the coast. The features of its climate are high temperature (averages 22.4 °C) and plentiful rainfall (annual rainfall > 2600 mm). Between May and September the temperature exceeds 25 °C and during this time typhoons frequently occur (Wang 1984). Orchid Island receives strong wind all year round, especially during the winter months. Due to the impact of strong wind, the forest on this island is different from typical tropical rain forest. It is classified as mountain rain forest and is the northern most tropical forest in East Asia (Chen et al. 1982). We selected three types of habitats, which were quite typical of this island. The first type are the meadows, which usually locate near the margins of the forest. Meadows are generated from the clear-cutting of the forest and they receive the most disturbances. The second type are the forests, which receive small scale of logging by local people and compared with those received by meadows disturbances are relatively small. The third type are the forest edges situated between the former two habitats. All the three habitat types had four replicates located in Yonsing Farm, Yeying village and Chungshing Farm (Figure 1). Besides, two replicates were established in Tienchi, which was a primary forest with the elevation of 300m and received the lowest level of aboriginal activities. In each replicate four 5m×5m sampling plots were established and in the center of each plot a pitfall trap

was set up to collect ground spiders.

*Descriptions of four types of habitats:*

(1) Forest:

(I) Chungshing Farm: *Acalypha grandis* and *Macaranga tanarius* were the dominant trees here. Canopy height was approximately 8-9 m and ground layer vegetation was composed mostly of *Alocasia macrorrhiza*, *Elatostema edule* and *Xanthosoma nigrum*.

(II) Yeying village: *Melanolepis multiglandulosa* and *Macaranga tanarius* were the most dominant with canopy height approximately 10 m. Bushes layer was composed of *Artocarpus incisus* and *Ficus ruficaulis*, and ground layer vegetation was composed mostly of *Alocasia macrorrhiza*.

(III) Yonsing Farm: *Pometia pinnata* were the dominant trees in the first layer of forest with canopy height approximately 20 m. Second layer were composed of *Artocarpus incisus*, *Dendrocnide meyeniana* and *Pometia pinnata* with canopy height about 6-8 m. Bushes layer was composed mostly of *Melanolepis multiglandulosa* and *Nothapodytes mimoniana* with a height of 4-5m. *Donax connaeformis* and *Piper philippinum* comprised most of the ground layer vegetation.

(IV) Yonsing Farm Outside: *Acalypha grandis* and *Ficus ruficaulis* were the most dominant trees here and the canopy height was approximately 8-9 m. Ground layer vegetation was composed mostly of *Ipomoea pes-caprae*.

(2) Forest edge:

(I) Chungshing Farm: Similar to forest habitat of this site, *Acalypha grandis*

and *Macaranga tanarius* were also the dominant trees here. Canopy height was approximately 8-9 m and ground layer vegetation was composed mostly of *Alocasia macrorrhiza*, *Elatostema edule* and *Xanthosoma nigrum*.

(II) Yeying village: *Melanolepis multiglandulos* and *Ficus ruficaulis* were predominant trees here and the canopy height was approximately 10 m. Bushes layer was dominated by *Artocarpus incisus* and ground layer vegetation was composed mostly of *Alocasia macrorrhiza* and *Schismatoglottis calyptrata*.

(III) Yonsing Farm: Compared with that of other plots the canopy was more broken here and *Artocarpus incisus* and *Macaranga tanarius* were the predominant trees with approximately 6-7 m canopy height. There were many small *Nothapodytes mimoniana*, *Artocarpus incisus*, *Pometia pinnata* and *Macaranga tanarius* in the bushes layer here because of sufficient light. Ground layer vegetation was dominated by *Alpinia speciosa* and *Oplismenus compositus*.

(IV) Yonsing Farm outside: Compared with plots in Chungshing and Yeying village the canopy here was also more broken. *Acalypha grandis* and *Ficus ruficaulis* were predominant trees here with the height of canopy approximately 8-9 m. Ground layer vegetation was composed mostly of *Ipomoea pes-caprae*.

(3) Meadow:

(I) Chungshing Farm: Ground layer vegetation was composed mostly of *Alocasia macrorrhiza*, *Elatostema edule* and *Xanthosoma nigrum*.

- (II) Yeying village: The sampling plots were located near the edge of a plantation area composed of *Ipomoea batatas* and *Xanthosoma nigrum*.
- (III) Yonsing Farm: Ground layer vegetation was dominated by *Imperata cylindrical var. major* and *Miscanthus sinensis var. condensatus*. In addition, few bushes of *Ficus cumingii* also existed.
- (IV) Yonsing Farm outside: Ground layer vegetation was composed mostly of *Ipomoea pes-caprae*. Few bushes composed of *Pipturus arborescens* and *Palaquium formosanum* also existed.
- (4) Tienchi primary forest: *Bischofia javanica* and *Ficus benjamina* were predominant trees here and the canopy height was approximately 25 m. Ground layer vegetation was composed mostly of *Elatostema edule* and *Cyathea fenicis*.

#### *Sampling methods:*

Many previous studies on spider diversity focused on fauna from a subset of the habitat, such as ground (Uetz & Unzicken 1976, Curtis 1980, Topping & Sunderland 1992, Merwe et al. 1996, Oliver & Beattie 1996, Draney 1997, Corey et al. 1998), bushes (Johnson 1996, Kampichler et al. 2000), canopy or foliage (Mason 1992, Russel-Smith & Stork 1994, Peterson 1996). In this study we collected spiders from grounds, shrubs and canopy to have a comprehensive representation of diversity from all microhabitats in the plot. Three field trips were conducted in August 2000, February and April 2001. To collect ground spiders, one trap was established in each sampling plot and the traps were opened for five days in each field trip. Besides, at the end of each field trip we collected litter from a 0.25 m<sup>2</sup> area in each sampling plot. The litter was brought back to the laboratory in Department of Biology, Tunghai

University and was processed by Berlese funnels for 48 hours. The third and fourth methods were hand collections during daytime and nighttime because Green (1999) demonstrated that identical sampling methods conducted diurnally or nocturnally might obtain quite different results. In each 5m×5m plot we collected all spiders from the ground to 2 meters in height by hand for 20 minutes. When the hand collection were completed, in each plot we collected spiders in the vegetation with a sweeping net for 10 minutes and data from all three methods were combined in the subsequent analysis. As the last method we used canopy sweeping-net to collected spiders in the canopy up to 10 m above the ground. A sweeping-net was mounted on a eight-meter-long retractable fishing pole. To sample the spiders in the canopy above the sampling plots, four persons each with a sweeping-net stood at four corners of the sampling plot then shook the tree branches vigorously for five minutes. Spiders collected from all four sweeping nets were pooled together for further analysis. Voucher specimens were deposited in National Museum of Natural Science, Taichung, Taiwan.

*Community structure:*

The traditionally-used Margalef Species Richness, Shannon-Weaver Function, Simpson and Evenness indices were used to describe the community structures of spiders among different habitats and different layers of the forests. One-way analysis of variance (ANOVA) tests and LSD mean comparisons were used to compare the values of all indices derived from all the plots of four habitats. Most previous studies only sampled spiders from a particular layer of the habitat. Therefore in this study we evaluated if diversity indices estimated from particular layer of the habitat could represent those of all the layers combined. Only specimens collected from habitats

exhibiting all three layers (canopy, bushes and ground) were use in this part of the analysis. We first calculated the aforementioned indices from all the specimens collected from forest, forest edge and Tienchi plots. Then from this subset of sample we calculated the aforementioned indices based on canopy, bushes and ground spiders respectively. One-way ANOVA tests and LSD mean comparisons were used to compare whether the indices calculated from overall specimens or those from different layers of the habitats different among forest, forest edge and Tienchi habitats. Results of ANOVA tests on data of three layers combined and on data of each layer alone were then compared. Besides, for each layer of the habitat (canopy, bushes and ground) we also calculated the aforementioned diversity indices from specimens of forest, forest edge and Tienchi combined. One-way ANOVA tests and LSD mean comparisons were used to compare values derived from each layer to see if community structures different among different layers of the habitat.

*Guild composition analyses:*

Guild compositions of spiders in four different habitats and in three layers of the habitats were compared to have another way of examining how community structures varied with environments. A comparison of guild composition can provide insights about the effects of habitat alternation and disturbances on arthropod biodiversity (Stork 1987). Spiders collected from this study were divided to the following eight guilds according to the classification proposed by Uetz et al. (1999): (1) Foliage Runners: such as Scytodidae, Heteropodidae and Clubionidae (except *Phrurolithus lynx*); (2) Ground Runners: such as Lycosidae, Tetrablemuina, Oonopidae, Gnaphosidae and Clubionidae (*Phrurolithus lynx*); (3) Stalkers: such as Oxyopidae and Salticidae; (4) Ambushers: such as Philodromidae and Thomisidae; (5) Sheet

Web-Builders: such as Hahniidae; (6) Wandering Sheet/Tangle Weavers: such as Linyphiidae, and Theraphosidae; (7) Orb Weavers: such as Araneidae, Tetragnathidae and Uloboridae; (8) Space Web Builders: such as Pholcidae, and Theridiidae.

Chi-square tests of homogeneity were used to compare the individuals of each guild between each pair of habitats and between each pair of layers.

*Similarity between sampling plots:*

Habitats having totally different species composition but similar abundance pattern might have identical diversity index values. Therefore in addition to investigating the spider community structures with the popularly-used indices; we also calculated the quantitative Euclidean distance (Krebs 1989) between each pair of sampling plots then used a UPGMA clustering analysis to visualize the association pattern of specimens collected from the sampling plots. When the sample size is large enough, analysis using Euclidean distance can assess the similarity between sampling plots when considering both species composition and relative abundance.

*Habitat preference analyses:*

The distribution of a particular species of spiders among different habitats can be used to assess its habitat preference pattern (Draney 1997). Judged from the abundance patterns of the specimens 18 dominant species were designated in this study. We used one-way ANOVA tests to compare the relative abundance of them among four types of habitats. Fisher's Least-Significant- Difference (LSD) tests were used to perform pair-wise comparisons between habitats. All the analyses were performed using SPSS 8.0 for Windows.



## Results

### *Diversity of spiders in Orchid Island tropical forest:*

A total of 5406 individuals including 2845 adults were collected from three field trips and 150 species from 19 families were identified. Most of the species obtained were previous undescribed thus might be new or newly record species to Taiwan.

Among those species that could be identified to species, 25 were found on this island but not in Taiwan. A list of all the species with the abundance in each habitat was given in the appendix. The three most abundant families were Theridiidae, Tetragnathidae and Araneidae. Among them, Theridiidae was the most diverse family and a total of 35 species were found. Spider community in Orchid Island tropical forests was consisted of few dominant and many rare species (Figure 2), which was similar to most studies on spider diversity.

### *Comparison between habitats based on specimens from all the layers combined:*

The number of total species and abundance were the highest in Forest Edge and the lowest in Tienchi (Table 1). The lower total species number and abundance of Tienchi plots found in forest edge plots might result from the fact that only eight sampling plots were established in Tienchi but 16 were established in other sites. Because, when we transformed the data to density (adults per 100m<sup>2</sup>), Tienchi become the highest and meadow the lowest. Among species found in forest edge plots, 40 species were found from Forest, Forest Edge and Meadow; 17 species were found only in Forrest and Forest Edge and another 13 species were found only in Forest Edge and Meadow. This species distribution pattern suggested that the Forest Edge habitats exhibited species from both Forest and Meadow habitats. Shannon index, Simpson index and Evenness were all significantly different among four habitat types

(Table 1). The Richness and Shannon indices were both highest in Forest and Tienchi, but the Simpson and Evenness indices in Tienchi were significantly lower than those in Forest. Two dominant species, *Mesida gemma* (28%) and *Leucauge argentina* (19.4%), had accounted for almost 50% of the total spider community in Tienchi. The Forest Edge had significantly lower Richness and Shannon indices than those of Forest. However, these two habitats did not differ significantly in Simpson and Evenness indices. Meadows exhibited the lowest Richness, Shannon and Simpson indices, but the highest Evenness.

*Comparison between habitats based on specimens from different layer of habitats:*

Results of ANOVA tests on indices calculated from specimens of forest, forest edge and Tienchi plots were similar to those generated from all four habitats combined (Table 2). Again, the Richness and Shannon indices of forest and Tienchi were significantly higher than those of forest edge, and Simpson index and Evenness of Tienchi were the lowest among three habitats. However, patterns of diversity indices calculated from specimens of different layer of habitats alone differed considerably from those of all specimens combined. Except evenness, all indices estimated from canopy spiders alone showed no significant difference between habitats (Table 3). Opposite to the results of all three layers combined, Evenness of forest edge was significantly lower than those of Forest and Tienchi. Except Richness, indices estimated from bush spiders were significantly different among habitats (Table 4). Similar to those of all layers combined, Simpson and Evenness of Tienchi were significantly lower. However, Shannon index of Tienchi exhibited opposite patterns when different data sets were used. Most of the indices estimated from ground spiders showed no significant difference among habitats. The only index that was

significantly different among habitats was Shannon index, but the pattern was significantly different (Table 5). Therefore, diversity indices calculated from canopy or ground spiders deviated considerably from those generated from whole data set. Only patterns of Simpson and Evenness calculated from bush spiders approximated those calculated from whole data set.

#### *Comparison between layers:*

Among the 150 species of spiders found in Orchid Island, more than two third could be found from bushes. Moreover, more than 70% of the adult specimens were collected from bushes (Table 6). Species richness, Shannon and Simpson indices estimated from bush spiders were the highest and those from ground spiders were the lowest (Table 6). However, the Evenness estimated from bush spiders were significantly lower than that from canopy and ground spiders. Except Evenness all the indices calculated showed significant difference between ground and canopy spiders. The most dominant species in canopy were *Chryso orchis* (24.5%) and *Anelosimus taiwanicus* (15.9%) (both Theriidae). The most dominant species in bushes were *Leucauge argentina* (11.3%) and *Mesida gemma* (10.2%) (both Tetragnathidae). The most dominant species in ground were *Pardosa tschekiangensis* (16.8%) (Lycosidae) and *Phrurolithus lynx* (16.8%) (Clubionidae).

#### *Comparison of guild composition between habitats and between layers:*

Spider guild compositions of four habitats were given in figure 3. Results of Chi-square tests between each pair of habitats showed that percentages of guilds differed significantly among habitats (Table 7). All habitats were dominated by orb weavers and space web builders (Figure 3). In all habitats except the meadows,

weavers comprised around 80% of the total catch. Especially in the primary forest site Tienchi, orb weavers comprised almost 70% of the specimens collected. However, more than 40% of the specimens found in meadow were other guilds such as ground runners, stalkers or wandering sheet weavers (Figure 3). This result might be due to that meadow habitat had little bush layer and no canopy cover, so the percentages of hunters and ground level web builders were higher. The composition of guilds of different layers of the habitats was given in figure 4. Guild composition differed significantly among different layers (Table 8). More than 80% of the fauna in canopy and bushes were composed of orb weavers and space web builders. However, the relative dominance pattern of these two guilds differed between canopy and bushes. Canopy was dominated by space web builders, but bushes were dominated by orb weavers. The ground layer spider community was composed mostly of ground runners and wandering sheet weavers.

*Similarity between sampling plots:*

Originally we established 56 sampling plots, but the forest habitat in Chungshing Farm was destroyed after the first field trip due to activities of local people so that we removed it from the analysis. Result of a UPGMA analysis using Euclidean distances estimated from the remaining 52 sampling plots was given in figure 5. Result of this analysis showed that the similarities of the plots located in same habitats were very high. The specimens of 52 sampling plots could be divided into seven groups. All except one group (Meadow IV cluster, Figure 5) could be further clustered into two major groups, Forests and Meadows (Figure 5). All the plots of the forest habitats were grouped together so did most plots of the meadow habitats. The eight plots of Tienchi primary forest were grouped together and were separated from other plots of

forest. Some plots of the forest edge were grouped with the forest plots but the others were grouped with the meadow plots. Plots of forest edge habitats exhibiting less canopy cover, such as those in Yonsing Farm, were grouped with the meadows plots (Meadow II cluster, Figure 5). On the other hand, those with more canopy cover, such as those in Yeying village and Chungshing Farm, were grouped with the forest plots (Forest III cluster, Figure 5).

*Habitat preference:*

Results of ANOVA tests examining habitat preference of 18 dominant species were given in table 9. Except three species, all species showed significant difference in their distribution among different habitats. The species that specialized in only one habitat were: *Hahnia corticicola* (forest); *Chryso orchis*, *Leucauge decorata*, *Thelacantha brevispina* and *Achaearanea japonica* (forest edge); *Pardosa tschekiangensis* and *Cyclosa mulmeinensis* (meadow); *Mesida gemma* and *Gea zaragosa* (Tienchi). The species that preferred two or three habitats but not all habitats were: *Leucauge argentina* (forest, Tienchi); *Anelosimus taiwanicus*, Thomisidae A (forest, forest edge); *Tylorida striata* (forest edge, meadow); *Cyclosa confusa* and *Eriovixia sakiedaorum* (forest, forest edge, Tienchi). Species that distributed more or less evenly in all the four habitats were *Argyrodes lanyuensis*, *Neoscona puntigera* and *Phrurolithus lynx*.

## Discussion

The spider fauna of the tropical forest ecosystem on Orchid Island was quite diverse and unique and a total of 150 species from 19 families were found from adult specimens. Considering the small area of this island (45.74 km<sup>2</sup>), the diversity was quite high. In the island of Taiwan with an area of 36,000 km<sup>2</sup>, only around 300 species were documented thus far (Chen 1996). Among the specimens obtained in this study, 107 species were previously undescribed thus might be new or newly recorded species to Taiwan. Many of the newly recorded species were reported from Philippine but not seen in Taiwan (Barrion & Litsinger 1995). A close look at the composition of the described species on Orchid Island indicated that it exhibited fauna from Taiwan and Philippine, which pattern was similar to other studies on plant and insect diversity of Orchid Island (Chen et al. 1982). For example, among the described species 11 were distributed in both Taiwan and Philippine, 4 were currently only known from Philippine and six were currently only known from Orchid Island.

Although the area of Orchid Island is quite small, the composition and structure of spider communities are significantly different between different habitats. Both number of species and abundance of adults were the lowest in the primary forest site Tienchi, but the density of spiders and Margalef Species Richness were rather high in this site (Table 1). A lower number of total species and abundance in Tienchi might result from smaller number of sampling plots. Because, when the diversity and abundance of individual sampling plots were averaged and compared, Tienchi exhibited the highest density and richness. A close examination of Table 1 indicated that plots in forest habitats exhibited high Shannon, Simpson and Evenness index. Shannon index of the primary forest site Tienchi was not significantly different from that of the forest, but its Simpson and Evenness indices were significantly lower than

those of forest. Nevertheless, the Evenness index of Tienchi was significantly lower than that of the meadow. These results could be explained by the structure of spider communities in different habitats and the nature of indices used. Compared with plots in other habitats, those in Tienchi exhibited higher Richness. However, in Tienchi plots two dominant species *Mesida gemma* and *Leucauge argentina* had accounted for almost 50% of the spider community. The percentages of two most dominant species in spider communities of other three types of habitats were never over 30% (21% in forest; 28.5% in forest edge and 20% in meadow). Therefore, compared with plots in other habitats those in Tienchi exhibited more species but much higher relative abundance of dominant species. On the other hand, the three diversity indices used in this study responded quite differently to species richness and relative abundance of the sample. Shannon index was more sensitive to the presence of rare species in the sample. However, Simpson index would be more affected if there were few dominant species with rather high relative abundance in the sample. Evenness was not that affected by the richness in the sample but was quite sensitive to the degree of homogeneity among species. Therefore, the higher number of species in Tienchi plots generated Shannon index values similar to those of forest plots. Tienchi plots' unequal abundance pattern and higher species number generated Simpson index values significantly smaller than that of forest plots but larger than that of the species-poor meadow plots. However, when Evenness index that was most sensitive to relative abundance of the sample was used, the values of the heterogeneous Tienchi plots became the smallest among all habitats.

Forest and Tienchi plots differed significantly in Simpson and Evenness indices and one of the possible reasons might be different degree of disturbances from aboriginal activities received by these two habitats. The forest habitats received a

small degree of disturbances, however, their Simpson and Evenness indices were significantly higher than those of the Tienchi primary forest. The lower index values of Tienchi were generated by a very high abundance of dominant species in the sample collected. Small scale of clearing and logging in the forest did not seem to be a heavy pressure to the spider community on Orchid Island because the species richness and diversity of the forest habitats were not significantly smaller. Small level of disturbances generated by activities of Yami people may have a greater influence on the dominant species. Small scale of disturbances generated by logging and clearing conducted by Yami people seemed to reduce the abundance of the dominant species thus increased the diversity of the spider community. This pattern was consistent with the predictions of the intermediate disturbance hypothesis (Connell 1979). The proposed explanation for the lower Simpson and Evenness indices in Tienchi could be supported by the results of habitat comparison using spiders from different layers of the forest. In this study we also examined whether diversity indices generated from particular layer of forest different among habitats. Results showed that indices calculated from canopy spiders did not differ between forest and Tienchi (Table 3), but those calculated from bush spiders differed significantly (Table 4). Except Richness, Tienchi plots exhibited the lowest values in indices examined. Such distinct index pattern generated when spiders from different layers of the habitat were used was consistent with the characteristic of activities generated by Yami people in the forest. Except logging (which were relatively rare events), most of the activities conducted by Yami people were confined to the understory of the forest. The activities included gathering, clearing the understory growth of selected tree, moving of people and domestic animals (pigs and goats)(Yu 1994); almost all of them impacted directly on bush layers. Compared with forest plots, those activities were considerably rare in



the primary forest Tienchi plots. Therefore, because canopies in Tienchi and forest plots both received little disturbances, so diversity indices did not differ between them. However, bush layer of these two habitats received different degree of disturbances, thus differed significantly in structure of spider communities.

Results from UPGMA analysis showed that spider community in primary forest site Tienchi was quite different from that of forest habitat. In figure 5, all plots from Tienchi were clustered together and were separated from forest and forest edge plots. A close examination of spider communities of Tienchi and forest plots indicated that relative abundances of space web builders and orb weavers between these two habitats might be responsible for the observed clustering pattern. Spider communities in Tienchi and forest were both dominated by space web builders and orb weavers (figure 3). The most abundant species in Tienchi was *Mesida gemma*. A total of 156 adults were found in eight Tienchi plots but only 30 were recorded from the 16 forest plots. On the other hand, the second most abundant species in forest was *Chryso orchis*. Eighty-four adults were collected from the forest plots but only 2 were found in Tienchi (Appendix). Since the Euclidean distance method used in this study considered both specie composition and relative abundance, the dramatic differences in abundances of dominant species between Tienchi and forest plots might be responsible for the separation of these plots in figure 5. Therefore, in Orchid Island tropical forest ecosystem orb weavers and space web builders seemed to be the major determinants of spider community structures and non-weaving spiders seemed to play a less important role. Similar result was also found by Pfeiffer (1996 b) in Luquillo Experimental Forest in Puerto Rico.

Compared with those of other habitats, the species richness and diversity indices of meadow habitats were both the lowest. Due to large scale of disturbances generated

by clear-cutting and periodical burning, the vegetation architecture of this habitat was quite simple and was composed mostly of grasses and few bushes. Species needing more complex architecture to build their web such as Theridiidae or Araneidae were less abundant in the meadow plots. A close examination of the guild composition showed that the percentages of hunters and ground level web builders were quite high thus made meadow habitats differ significantly from others (figure 4). The other thing we should pay attention was that the value of Evenness of meadow plots was higher than that of Tienchi plots. This might also result from the high disturbances generated by aboriginal agriculture activities, which reduced the advantages of dominant species. The most dominant species in meadow habitats was *Pardosa tschekiangensis*, it was also one of the two dominant species that preferred to inhabit meadow habitats.

While the plots in forest and Tienchi were more homogenous in species composition, those in the forest edge habitats were much more heterogeneous and their spider diversity exhibited more variation. Compared with forest habitat, the total number of species and abundance were both higher in forest edge (Table 1). Among the species found in forest edge, 40 species could also be found in forest and meadow. Besides, 17 species were found only in forest and forest edge and another 13 species were found only in forest edge and meadow (Appendix). This pattern suggested that forest edge habitat had species originated from both forest and meadow habitats, thus exhibited the highest total number of species. However, the Richness and Shannon indices of forest edge were significantly lower than those of Forest plots. The higher total number of species but lower Richness and Shannon index values of forest edge habitats might have resulted from their vegetation structures. Results of the clustering analysis showed that the forest edge plots that having more canopy cover (such as those eight plots from Yeying village and Chungshing Farm) were grouped with forest

plots; those having less canopy cover (such as the others from Yonshing Farm and Yonshing Farm outside) were grouped with the meadow plots. Those forest edge plots having less canopy cover had a more meadow-like vegetation structure thus exhibited a considerable portion of meadow spider community. Since spider communities in meadows were characterized by low richness and diversity (Table 1) and half of the forest edge plots exhibited a meadow-like spider community, so various diversity indices of forest edge plot fell between those of forest and meadow plots. This result indicated that spider communities were in close association with the vegetation structure and thus were a good indicator of the changes of the environment.

A comparison of spider diversity between different layers of the tropical forest on Orchid Island indicated that their species composition and community structures were quite different. In addition to species number and abundance, bushes also had the highest Species Richness, Shannon and Simpson indices, but the lowest Evenness. This result suggested that most Araneae species in Orchid Island forest ecosystem were distributed in areas under two meters in height. A more abundant and diverse spider community in bush layer might also result from higher sampling intensity received by this layer of habitat. In this study bushes in forest understory had received the most intensive collection. However, due to the limitation of landscapes more comprehensive sampling methods of canopy such as fogging (Stork 1987; Russel-Smith and Stork 1994) were not feasible in Orchid Island forest. However, similar vertical abundance pattern was also found in a more comprehensive study conducted by Pfeiffer (1996) in Luquillo Experimental Forest in Puerto Rico. Therefore, a more abundant and diverse spider community in bushes than that in canopy might be a general pattern in tropical forests. Although the architecture of canopy was quite complex, its community structure and guild composition were

different from those of bushes. The most dominant guild in canopy was space web builders of the species *Chrysso orchis* and *Anelosimus taiwanicus* (both Theridiidae). However, the most dominant guild in bushes was orb weavers of the species *Leucauge argentina* and *Mesida gemma* (both Tetragnathidae) (figure 4). The body sizes of the bush-dwelling orb weavers were larger than those of the canopy-dwelling theridiids (Tso & Tanikawa 2000, Yoshida et al. 2000) and the orb weavers needed larger open space for orb construction. Compared with canopy, bush layer might exhibit more suitable microhabitats for orb web construction thus was inhibited by more orb-weavers.

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Table 1. Results of ANOVA tests examining Density, Margalef Richness, Shannon index, Simpson index and Evenness estimated from specimens collected from four habitats. (F: forest, FE: forest edge, M: meadow, T: primary forest in Tienchi; significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ , NS : Non significant at  $\alpha = 0.05$  level)

| Habitats                  | Species | Adult Abundance | Density (Adults/100m <sup>2</sup> ) | Richness      | Shannon index | Simpson index | Evenness     |
|---------------------------|---------|-----------------|-------------------------------------|---------------|---------------|---------------|--------------|
| T                         | 60      | 557             | 278.50±26.61                        | 5.37±0.40     | 2.54±0.13     | 0.86±0.024    | 0.80±0.033   |
| F                         | 84      | 843             | 250.33±80.37                        | 5.09±0.60     | 2.72±0.18     | 0.91±0.019    | 0.88±0.032   |
| FE                        | 89      | 939             | 234.75±88.01                        | 4.45±0.92     | 2.50±0.25     | 0.88±0.031    | 0.86±0.059   |
| M                         | 84      | 506             | 120.75±63.82                        | 3.74±1.01     | 2.26±0.33     | 0.85±0.054    | 0.89±0.063   |
| <b>Significance level</b> | -       | -               | ***                                 | ***           | ***           | **            | **           |
| <b>LSD comparison</b>     | -       | -               | T, F, FE > M                        | T, F > FE > M | F > FE > M    | F > T, M      | M, FE, F > T |
|                           |         |                 |                                     |               | T > M         | FE > M        |              |

Table 2. Results of ANOVA tests examining Density, Margalef Richness, Shannon index, Simpson index and Evenness estimated from specimens collected from three habitats. (F: forest, FE: forest edge, T: primary forest in Tienchi; significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ )

| <b>Habitats</b>           | <b>Richness</b>     | <b>Shannon index</b> | <b>Simpson index</b> | <b>Evenness</b>     |
|---------------------------|---------------------|----------------------|----------------------|---------------------|
| <b>T</b>                  | 5.37±0.40           | 2.54±0.13            | 0.86±0.024           | 0.80±0.033          |
| <i>F</i>                  | 5.09±0.60           | 2.72±0.18            | 0.91±0.019           | 0.88±0.032          |
| <b>FE</b>                 | 4.45±0.92           | 2.50±0.25            | 0.88±0.031           | 0.86±0.059          |
| <i>Significance level</i> | *                   | *                    | **                   | **                  |
| <i>LSD comparison</i>     | <b>T, F &gt; FE</b> | <b>F &gt; FE</b>     | <b>F &gt; FE, T</b>  | <b>F, FE &gt; T</b> |

Table 3. Results of ANOVA tests examining Margalef Richness, Shannon index, Simpson index and Evenness estimated from canopy spiders of three habitats. (F: forest, FE: forest edge, M: meadow, T primary forest in Tienchi; significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ , NS : Non significant at  $\alpha = 0.05$  level)

| <b>Habitats</b>           | <b>Richness</b> | <b>Shannon index</b> | <b>Simpson index</b> | <b>Evenness</b>    |
|---------------------------|-----------------|----------------------|----------------------|--------------------|
| <b>T</b>                  | 2.51±0.95       | 1.66±0.56            | 0.77±0.15            | 0.96±0.03          |
| <b>F</b>                  | 2.64±0.66       | 1.77±0.43            | 0.79±0.10            | 0.94±0.66          |
| <i>FE</i>                 | 2.02±0.67       | 1.50±0.37            | 0.69±0.11            | 0.82±0.08          |
| <i>Significance level</i> | <b>NS</b>       | <b>NS</b>            | NS                   | <b>***</b>         |
| <i>LSD comparison</i>     | -               | -                    | -                    | <b>T, F &gt;FE</b> |

Table 4. Results of ANOVA tests examining Margalef Richness, Shannon index, Simpson index and Evenness estimated from bushes spiders of three habitats. (F: forest, FE: forest edge, T: primary forest in Tienchi; significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ , NS : Non significant at  $\alpha = 0.05$  level)

| <b>Habitats</b>           | <b>Richness</b> | <b>Shannon index</b> | <b>Simpson index</b> | <b>Evenness</b>     |
|---------------------------|-----------------|----------------------|----------------------|---------------------|
| <b>T</b>                  | 3.52±0.44       | 2.04±0.14            | 0.80±0.029           | 0.75±0.040          |
| <i>F</i>                  | 3.77±0.78       | 2.38±0.23            | 0.88±0.031           | 0.88±0.037          |
| <b>FE</b>                 | 3.39±0.64       | 2.23±0.19            | 0.86±0.03            | 0.86±0.055          |
| <i>Significance level</i> | <b>NS</b>       | <b>**</b>            | <b>***</b>           | <b>***</b>          |
| <i>LSD comparison</i>     | <b>-</b>        | <b>F, FE &gt; T</b>  | <b>F, FE &gt; T</b>  | <b>F, FE &gt; T</b> |

Table 5. Results of ANOVA tests examining Margalef Richness, Shannon index, Simpson index and Evenness estimated from ground spiders of three habitats. (F: forest, FE: forest edge, T: primary forest in Tienchi; significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ , NS : Non significant at  $\alpha = 0.05$  level)

| <b>Habitats</b>           | <b>Richness</b> | <b>Shannon index</b> | <b>Simpson index</b> | <b>Evenness</b> |
|---------------------------|-----------------|----------------------|----------------------|-----------------|
| <b>T</b>                  | 2.06±0.50       | 1.50±0.29            | 0.75±0.07            | 0.94±0.042      |
| <i>F</i>                  | 1.61±0.47       | 0.88±0.54            | 0.50±0.26            | 0.91±0.100      |
| <b>FE</b>                 | 1.63±0.57       | 1.02±0.57            | 0.55±0.28            | 0.95±0.053      |
| <i>Significance level</i> | <b>NS</b>       | <b>*</b>             | NS                   | <b>NS</b>       |
| <i>LSD comparison</i>     | -               | <b>T &gt; F, FE</b>  | -                    | -               |

Table 6. Results of ANOVA tests examining Margalef Richness, Shannon index, Simpson index and Evenness estimated from specimens collected from forest, forest edge and Tienchi. (C: canopy, B: bushes, G: ground Significance level: \*: p< 0.05, \*\*: p<0.01, \*\*\*: p<0.001)

| <b>Layers</b>             | <b>Species</b> | <b>Adults</b> | <b>Richness</b>        | <b>Shannon index</b>   | <b>Simpson index</b>   | <b>Evenness</b>    |
|---------------------------|----------------|---------------|------------------------|------------------------|------------------------|--------------------|
| <b>Canopy</b>             | 46             | 477           | 2.37±0.78              | 1.64±0.45              | 0.75±0.120             | 0.90±0.092         |
| <b>Bushes</b>             | 111            | 1999          | 3.60±0.63              | 2.24±0.24              | 0.85±0.044             | 0.84±0.066         |
| <b>Ground</b>             | 47             | 369           | 1.79±0.47              | 1.10±0.55              | 0.59±0.250             | 0.93±0.072         |
| <i>Significance level</i> | -              | -             | ***                    | ***                    | ***                    | ***                |
| <i>LSD comparison</i>     | -              | -             | <b>B &gt; C &gt; G</b> | <b>B &gt; C &gt; G</b> | <b>B &gt; C &gt; G</b> | <b>C, G &gt; B</b> |



Table 7. Chi-Square tests of guild homogeneity between each pair of habitats. (F: forest, FE: forest edge, M: meadow, T: primary forest in Tienchi; significance level: \*: p< 0.05, \*\*: p<0.01, \*\*\*: p<0.001)

| <b>Habitats</b> | <b>T</b>   | <b>F</b>  | <b>FE</b>  | <b>M</b> |
|-----------------|------------|-----------|------------|----------|
| <b>T</b>        |            |           |            |          |
| <b>F</b>        | 110.926*** |           |            |          |
| <b>FE</b>       | 80.295***  | 41.221*** |            |          |
| <b>M</b>        | 109.205*** | 183.12*** | 144.446*** |          |

Table 8. Chi-Square tests of guild homogeneity between each pair of layers in the habitat.( significance level: \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ )

| <b>Layers</b> | <b>Canopy</b> | <b>Bushes</b> | <b>Ground</b> |
|---------------|---------------|---------------|---------------|
| <i>Canopy</i> |               |               |               |
| <b>Bushes</b> | 225.152***    |               |               |
| <b>Ground</b> | 651.566***    | 1174.291***   |               |

Table 9. Results of ANOVA tests examining habitat preference of 18 dominant species between different habitats. (F: forest, FE: forest edge, M: meadow, T: primary forest in Tienchi ; significance levels : \* :  $p < 0.05$  ; \*\* :  $p < 0.01$  ; \*\*\* :  $p < 0.001$  ; NS : Non significant at  $\alpha = 0.05$  level)

| Species Name                   | Abundance | Percentage (%) | Adults in each habitats |    |     |    | F ratio | LSD mean comparison | Significance levels |
|--------------------------------|-----------|----------------|-------------------------|----|-----|----|---------|---------------------|---------------------|
|                                |           |                | T                       | F  | FE  | M  |         |                     |                     |
| <b>Chryso orchis</b>           | 259       | 9.1            | 2                       | 84 | 161 | 12 | 13.85   | FE > F > M, T       | ***                 |
| <i>Leucauge argentina</i>      | 230       | 8.1            | 108                     | 98 | 18  | 6  | 46.98   | T > F > FE, M       | ***                 |
| <i>Mesida gemma</i>            | 219       | 7.7            | 156                     | 30 | 33  | 0  | 148.68  | T > F, FE > M       | ***                 |
| <i>Leucauge decorata</i>       | 154       | 5.4            | 0                       | 2  | 108 | 44 | 5.69    | FE > M, F, T        | **                  |
| <i>Cyclosa confusa</i>         | 143       | 5.0            | 20                      | 65 | 51  | 7  | 8.96    | F, FE, T > M        | ***                 |
| <i>Thelacantha brevispina</i>  | 140       | 4.9            | 1                       | 44 | 89  | 6  | 6.72    | FE > F, M, T        | **                  |
| <i>Argyrodes lanyuensis</i>    | 116       | 4.1            | 25                      | 37 | 43  | 11 | 2.77    | T, FE, F, M         | NS                  |
| <i>Eriovixia sakiedaorum</i>   | 93        | 3.3            | 19                      | 56 | 17  | 1  | 5.59    | F, T, FE > M        | **                  |
| <i>Anelosimus taiwanicus</i>   | 92        | 3.2            | 8                       | 46 | 38  | 0  | 4.52    | F, FE, T, M         | **                  |
| <i>Neoscona puntigera</i>      | 77        | 2.7            | 12                      | 12 | 25  | 28 | 1.63    | FE, M, T, F         | NS                  |
| <i>Achaearanea japonica</i>    | 75        | 2.6            | 4                       | 14 | 45  | 12 | 2.83    | FE > F, M, T        | *                   |
| <i>Pardosa tschekiangensis</i> | 65        | 2.3            | 0                       | 2  | 6   | 57 | 3.75    | M > FE, F, T        | *                   |
| <i>Gea zaragosa</i>            | 63        | 2.2            | 21                      | 16 | 10  | 16 | 3.01    | T > M, F, FE        | *                   |
| <i>Phrurolithus lynx</i>       | 63        | 2.2            | 9                       | 22 | 21  | 11 | 0.42    | F, FE, T, M         | NS                  |
| <i>Tylorida striata</i>        | 59        | 2.1            | 0                       | 0  | 25  | 34 | 8.06    | M, FE > T, F        | ***                 |
| <i>Cyclosa mulmeinensis</i>    | 58        | 2.0            | 0                       | 0  | 15  | 43 | 3.88    | M > FE, T, F        | **                  |
| <i>Hahnia corticicola</i>      | 54        | 1.9            | 3                       | 42 | 8   | 1  | 5.65    | F > FE, T, M        | **                  |
| Thomisidae A                   | 50        | 1.8            | 5                       | 30 | 13  | 2  | 2.96    | F, FE, T, M         | *                   |

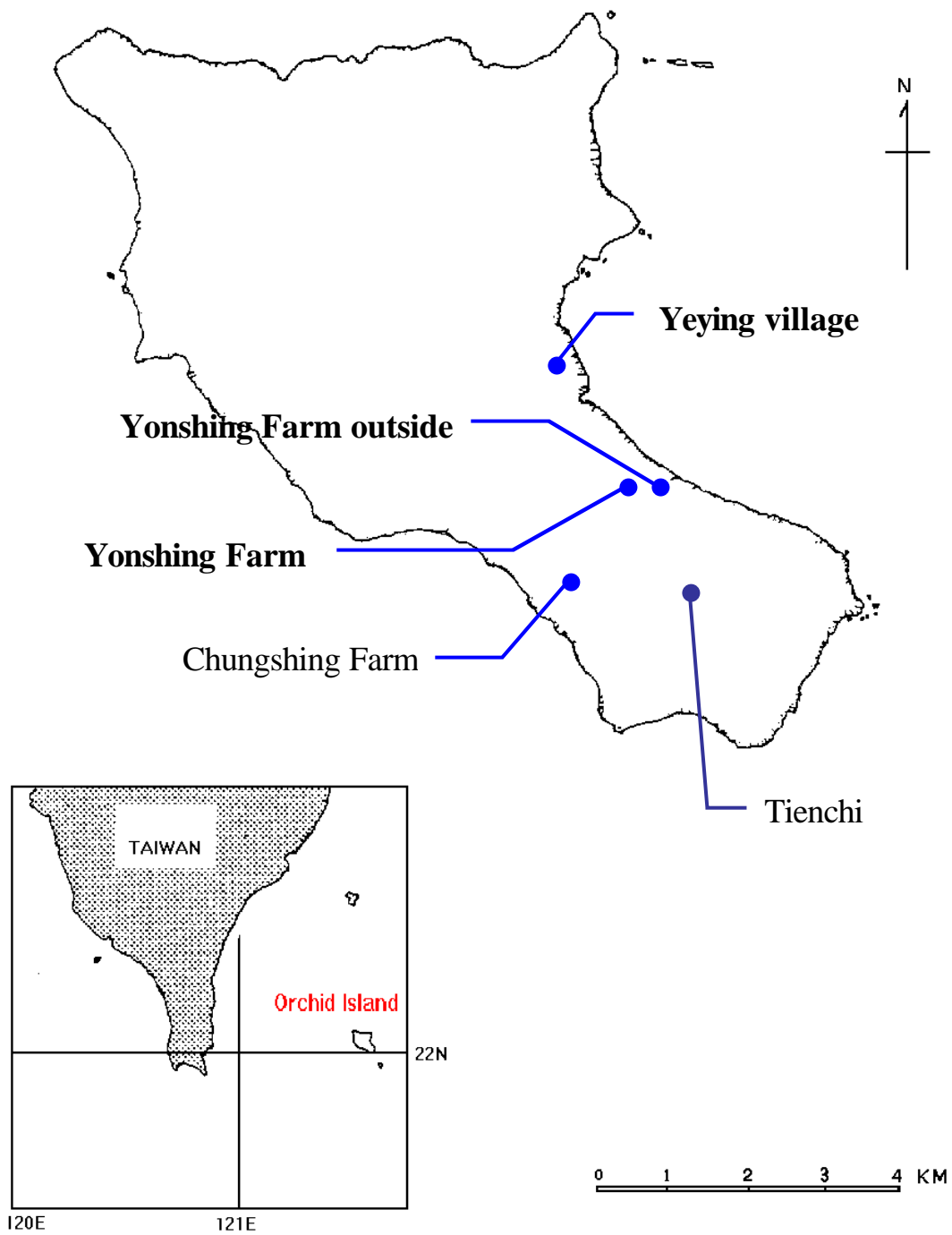


Figure 1. The map of Orchid Island and the location of five study sites.

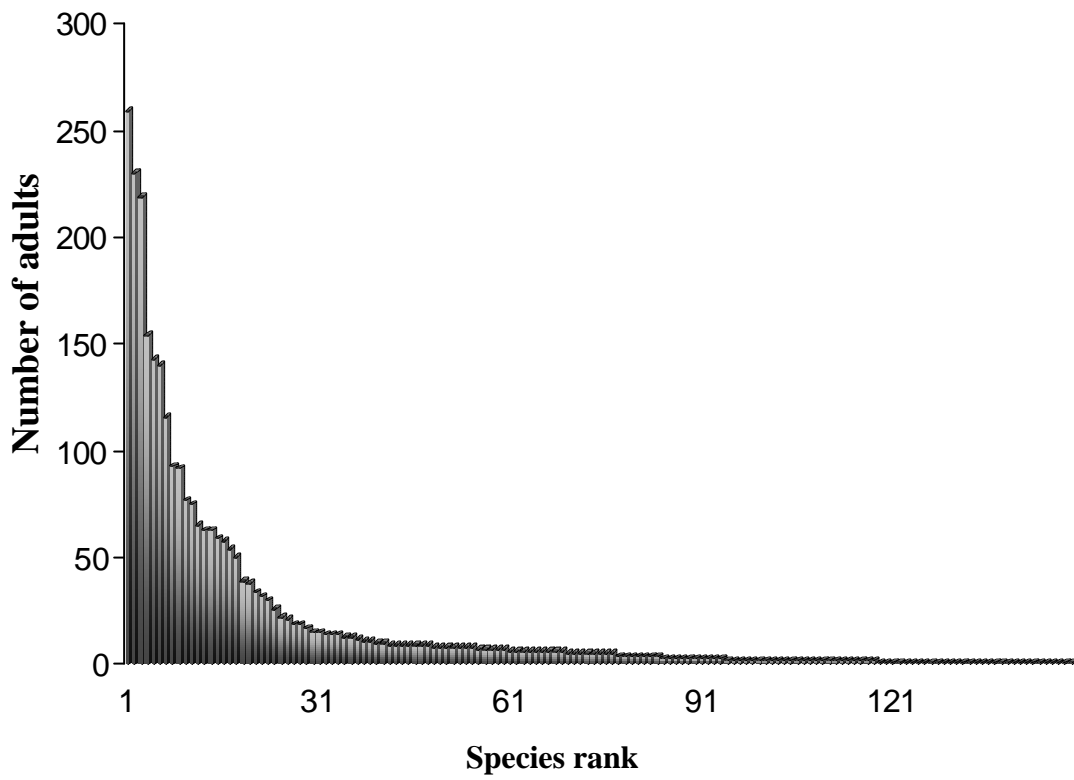


Figure 2. The abundance of each species ranked according to number of adult specimens collected.

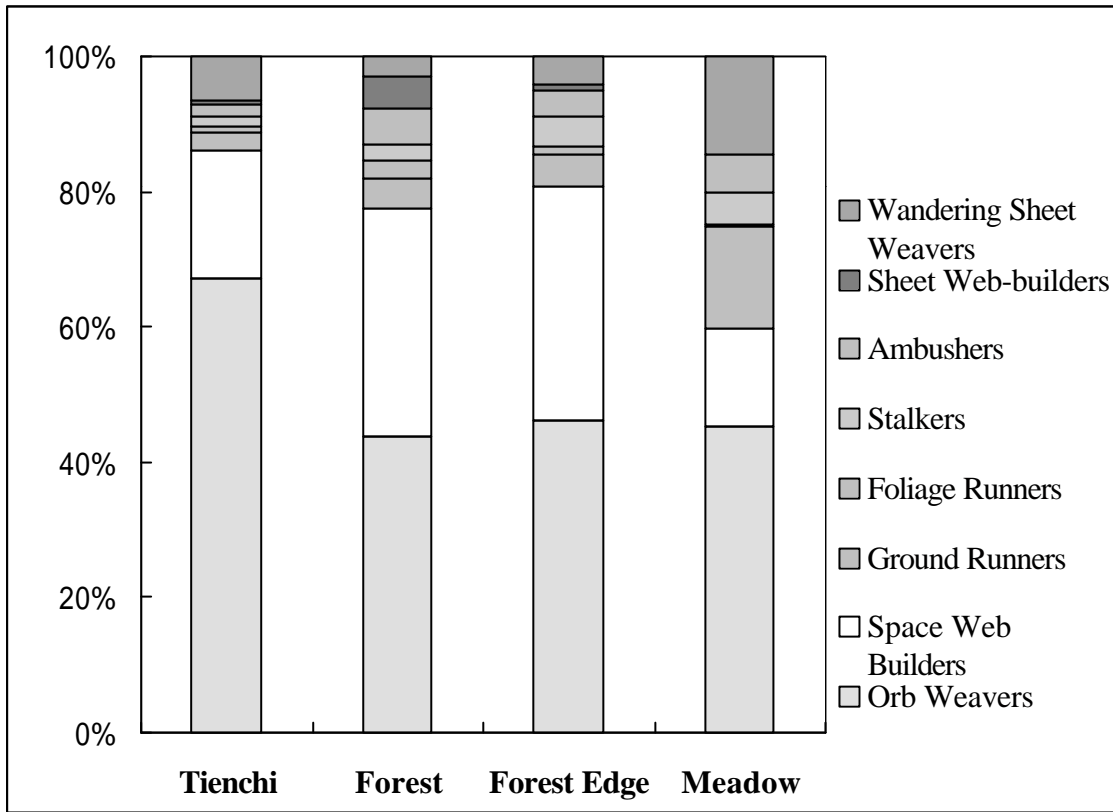


Figure 3. Guild composition of spider collected from four different habitats. (F: forest, FE: forest edge, M: meadow, T: primary forest in Tienchi)

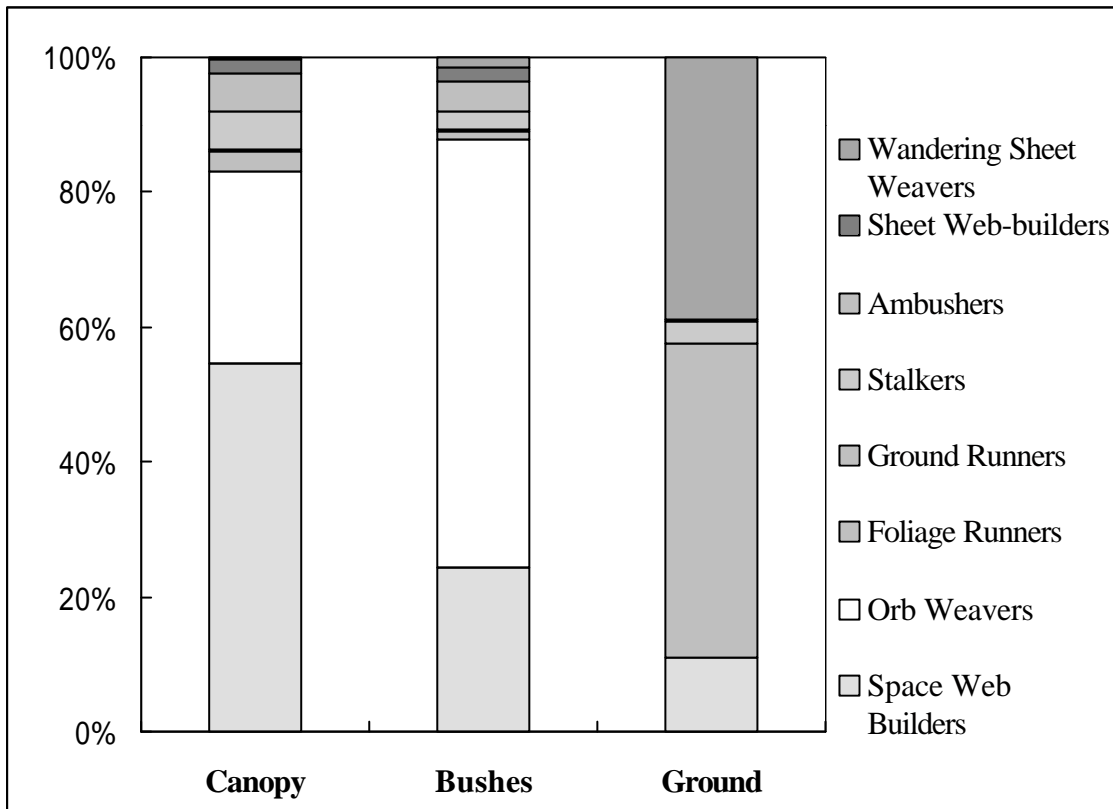


Figure 4. Guild composition of spider collected from different layers of the habitats.

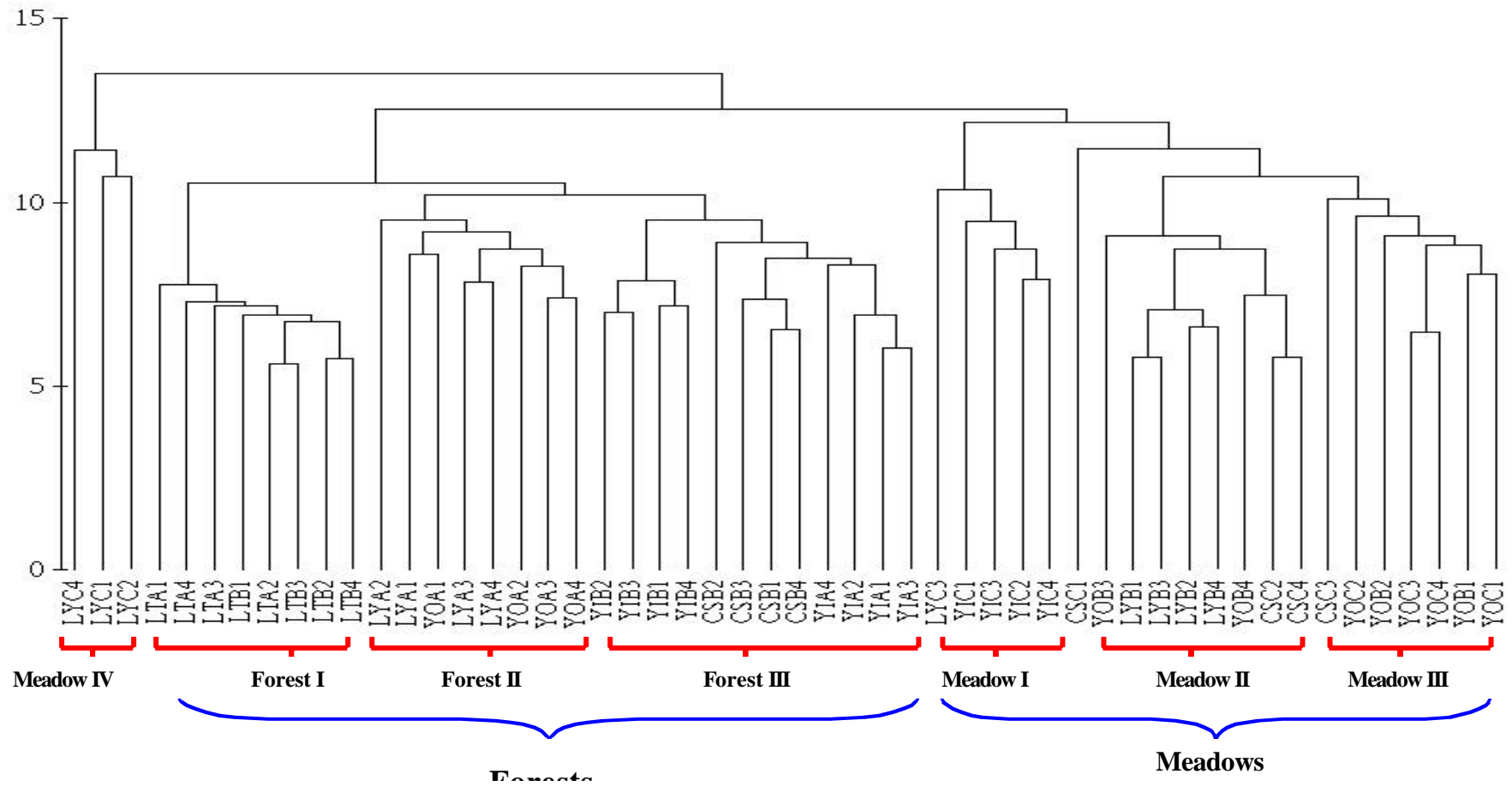


Figure 5. Result of a UPGMA analysis using Euclidean distance estimated from 52 sampling plots in Orchid Island. (LY: Yonsing Farm, YO: Yonsing Farm outside, YI: Yeying village, CS: Chungshing Farm, A: forest, B: forest edge, C: meadow; LTA, LTB: primary forest in Tienchi)



Appendix

List of spider species collected from the Orchid Island and their abundance ( / ) in different habitat types. (F: forest, FE: forest edge, M: meadow, T: primary forest in Tienchi)

| Species                         | Habitats |         |         |         | Total |
|---------------------------------|----------|---------|---------|---------|-------|
|                                 | T        | F       | FE      | M       |       |
| <b>Araneidae</b>                |          |         |         |         |       |
| <i>Arachnura melanura</i>       | 2 / 0    | 0 / 0   | 0 / 0   | 0 / 0   | 2     |
| <i>Cyclosa confusa</i>          | 10 / 10  | 39 / 26 | 27 / 24 | 2 / 5   | 143   |
| <i>Cyclosa mulmeinensis</i>     | 0 / 0    | 0 / 0   | 12 / 3  | 28 / 15 | 58    |
| <i>Cyrtophora exanthematica</i> | 4 / 1    | 6 / 1   | 1 / 3   | 1 / 4   | 21    |
| <i>Cyrtophora unicolor</i>      | 6 / 0    | 2 / 0   | 0 / 0   | 0 / 0   | 8     |
| <i>Eriovixia sakiedaorum</i>    | 8 / 11   | 26 / 30 | 7 / 10  | 0 / 1   | 93    |
| <i>Thelacantha brevispina</i>   | 0 / 1    | 34 / 10 | 63 / 26 | 4 / 2   | 140   |
| <i>Gea zaragosa</i>             | 11 / 10  | 11 / 5  | 7 / 3   | 13 / 3  | 63    |
| <i>Neoscona puntigera</i>       | 6 / 6    | 8 / 4   | 13 / 12 | 19 / 9  | 77    |
| <i>Neoscona theisi</i>          | 0 / 0    | 0 / 0   | 4 / 4   | 17 / 9  | 34    |
| <i>Neoscona vigilans</i>        | 0 / 0    | 0 / 0   | 5 / 1   | 3 / 0   | 9     |
| Araneidae A                     | 0 / 0    | 0 / 3   | 0 / 0   | 0 / 0   | 3     |
| Araneidae B                     | 0 / 2    | 0 / 1   | 0 / 0   | 0 / 0   | 3     |
| <i>Cyphalonotus</i> sp.A        | 1 / 1    | 0 / 0   | 0 / 0   | 0 / 0   | 2     |
| <i>Larinia</i> sp.A             | 0 / 0    | 0 / 0   | 0 / 0   | 4 / 1   | 5     |
| <i>Larinia</i> sp.B             | 0 / 0    | 0 / 0   | 1 / 1   | 0 / 0   | 2     |
| <i>Poltys</i> sp.A              | 0 / 0    | 0 / 0   | 0 / 2   | 0 / 0   | 2     |
| Juvenile                        | 79       | 122     | 218     | 235     | 654   |
| <b>Total</b>                    |          |         |         |         | 1319  |
| <b>Clubionidae</b>              |          |         |         |         |       |
| <i>Clubiona charleneae</i>      | 0 / 0    | 2 / 1   | 1 / 0   | 0 / 0   | 4     |
| <i>Phrurolithus lynx</i>        | 3 / 6    | 9 / 13  | 2 / 19  | 1 / 10  | 63    |
| Clubionidae A                   | 0 / 0    | 8 / 3   | 2 / 0   | 0 / 1   | 14    |
| Clubionidae B                   | 0 / 0    | 1 / 0   | 0 / 1   | 0 / 0   | 2     |
| Clubionidae C                   | 0 / 0    | 0 / 1   | 0 / 0   | 0 / 0   | 1     |
| Juvenile                        | 10       | 28      | 28      | 11      | 77    |
| <b>Total</b>                    |          |         |         |         | 161   |
| <b>Gnaphosidae</b>              |          |         |         |         |       |
| <i>Gnaphosa kompimensis</i>     | 0 / 0    | 1 / 0   | 1 / 0   | 0 / 0   | 2     |
| Gnaphosidae A                   | 0 / 0    | 0 / 0   | 0 / 0   | 0 / 1   | 1     |
| Gnaphosidae B                   | 0 / 0    | 0 / 0   | 0 / 0   | 0 / 1   | 1     |
| Juvenile                        | 0        | 0       | 0       | 0       | 0     |
| <b>Total</b>                    |          |         |         |         | 4     |

Appendix continued

| Species            | Habitats |         |       |       | Total     |
|--------------------|----------|---------|-------|-------|-----------|
|                    | T        | F       | FE    | M     |           |
| <b>Hahniidae</b>   |          |         |       |       |           |
| Hahnia corticicola | 2 / 1    | 32 / 10 | 6 / 2 | 1 / 0 | 54        |
| juvenile           | 1        | 20      | 0     | 0     | 21        |
| <b>total</b>       |          |         |       |       | <b>75</b> |

**Heteropodidae**

|                         |       |       |       |       |           |
|-------------------------|-------|-------|-------|-------|-----------|
| Micrommata nanningensis | 0 / 0 | 0 / 0 | 0 / 2 | 0 / 0 | 2         |
| Heteropodidae A         | 0 / 1 | 2 / 1 | 0 / 0 | 0 / 0 | 4         |
| Heteropodidae B         | 0 / 0 | 2 / 0 | 0 / 1 | 0 / 0 | 3         |
| juvenile                | 13    | 15    | 5     | 2     | 35        |
| <b>total</b>            |       |       |       |       | <b>44</b> |

**Linyphiidae**

|               |       |       |        |        |    |
|---------------|-------|-------|--------|--------|----|
| Linyphiidae A | 8 / 4 | 4 / 5 | 1 / 2  | 2 / 4  | 30 |
| Linyphiidae B | 1 / 1 | 1 / 0 | 1 / 9  | 4 / 9  | 26 |
| Linyphiidae C | 0 / 1 | 0 / 0 | 0 / 0  | 0 / 0  | 1  |
| Linyphiidae D | 0 / 3 | 0 / 8 | 0 / 15 | 0 / 12 | 38 |
| Linyphiidae E | 2 / 6 | 0 / 0 | 0 / 0  | 0 / 0  | 8  |
| Linyphiidae F | 0 / 0 | 0 / 0 | 0 / 0  | 1 / 1  | 2  |
| Linyphiidae G | 0 / 1 | 0 / 1 | 0 / 1  | 0 / 3  | 6  |
| Linyphiidae H | 0 / 0 | 0 / 0 | 0 / 0  | 0 / 5  | 5  |
| Linyphiidae I | 0 / 0 | 0 / 0 | 0 / 0  | 1 / 0  | 1  |
| Linyphiidae J | 0 / 0 | 0 / 0 | 0 / 0  | 0 / 5  | 5  |
| Linyphiidae K | 0 / 0 | 0 / 0 | 0 / 2  | 0 / 1  | 3  |
| Linyphiidae L | 0 / 5 | 0 / 1 | 0 / 0  | 0 / 0  | 6  |
| Linyphiidae M | 0 / 0 | 0 / 0 | 0 / 1  | 0 / 1  | 2  |
| Linyphiidae N | 3 / 0 | 0 / 0 | 1 / 0  | 0 / 0  | 4  |
| Linyphiidae O | 0 / 0 | 0 / 0 | 0 / 0  | 8 / 0  | 8  |
| Linyphiidae P | 0 / 0 | 0 / 0 | 3 / 0  | 6 / 0  | 9  |
| Linyphiidae Q | 0 / 0 | 1 / 0 | 1 / 0  | 1 / 0  | 3  |
| Linyphiidae R | 0 / 0 | 0 / 0 | 0 / 0  | 0 / 2  | 2  |
| Linyphiidae S | 0 / 0 | 1 / 0 | 0 / 0  | 0 / 0  | 1  |
| Linyphiidae T | 0 / 0 | 0 / 0 | 0 / 0  | 0 / 3  | 3  |
| Linyphiidae U | 0 / 0 | 0 / 1 | 0 / 0  | 0 / 0  | 1  |
| Linyphiidae V | 0 / 0 | 0 / 1 | 0 / 0  | 0 / 0  | 1  |

Appendix continued

| Species       | Habitats |       |       |       | Total      |
|---------------|----------|-------|-------|-------|------------|
|               | T        | F     | FE    | M     |            |
| Linyphiidae W | 0 / 0    | 0 / 0 | 0 / 0 | 1 / 0 | 1          |
| juvenile      | 8        | 13    | 11    | 23    | 55         |
| <b>total</b>  |          |       |       |       | <b>221</b> |

## Lycosidae

|                        |     |     |     |       |            |
|------------------------|-----|-----|-----|-------|------------|
| Arctosa meitanensis    | 0/3 | 0/0 | 0/0 | 0/0   | 3          |
| Pardosa tschekiagensis | 0/0 | 0/2 | 3/3 | 26/31 | 65         |
| Trochosa ruricoloides  | 0/0 | 0/0 | 0/2 | 2/1   | 5          |
| Lycosidae A            | 0/0 | 0/0 | 3/2 | 0/0   | 5          |
| Lycosidae B            | 0/0 | 0/0 | 1/0 | 0/0   | 1          |
| Lycosidae C            | 0/0 | 0/0 | 1/0 | 0/0   | 1          |
| juvenile               | 1   | 3   | 10  | 18    | 32         |
| <b>total</b>           |     |     |     |       | <b>112</b> |

## Oonopidae

|                           |     |     |     |     |           |
|---------------------------|-----|-----|-----|-----|-----------|
| <i>Gamasomorpha</i> sp.A  | 1/1 | 2/2 | 0/1 | 0/0 | 7         |
| <i>Ischnothyrens</i> sp.A | 0/0 | 1/1 | 0/1 | 0/2 | 5         |
| Oonopidae A               | 0/0 | 1/0 | 0/1 | 0/0 | 2         |
| Oonopidae B               | 0/0 | 0/0 | 0/1 | 0/0 | 1         |
| Oonopidae C               | 0/0 | 3/0 | 2/0 | 1/0 | 6         |
| Oonopidae D               | 0/0 | 0/0 | 0/0 | 1/0 | 1         |
| juvenile                  | 1   | 3   | 0   | 2   | 6         |
| <b>total</b>              |     |     |     |     | <b>28</b> |

## Oxyopidae

|                  |     |     |     |     |           |
|------------------|-----|-----|-----|-----|-----------|
| Oxyopes sertatus | 0/0 | 1/0 | 8/2 | 6/5 | 22        |
| juvenile         | 0   | 1   | 31  | 11  | 43        |
| <b>total</b>     |     |     |     |     | <b>65</b> |

## Philodromidae

|                         |     |     |     |     |          |
|-------------------------|-----|-----|-----|-----|----------|
| Philodromus subaureolus | 0/0 | 1/1 | 1/1 | 0/0 | 4        |
| juvenile                | 0   | 0   | 0   | 0   | 0        |
| <b>total</b>            |     |     |     |     | <b>4</b> |

Appendix continued

| Species          | Habitats |     |     |     | Total     |
|------------------|----------|-----|-----|-----|-----------|
|                  | T        | F   | FE  | M   |           |
| <b>Pholcidae</b> |          |     |     |     |           |
| Pholcidae A      | 1/1      | 6/1 | 0/0 | 0/0 | 9         |
| juvenile         | 2        | 4   | 2   | 1   | 9         |
| <b>total</b>     |          |     |     |     | <b>18</b> |

## Salticidae

### Phintella versicolor

|                         |       |       |       |       |            |
|-------------------------|-------|-------|-------|-------|------------|
|                         | 0 / 0 | 0 / 0 | 0 / 0 | 0 / 1 | 1          |
| <i>Marpissa</i> sp.A    | 1 / 0 | 4 / 2 | 3 / 4 | 1 / 0 | 15         |
| <i>Myrmarachne</i> sp.A | 0 / 0 | 1 / 0 | 0 / 1 | 0 / 0 | 2          |
| <i>Myrmarachne</i> sp.B | 0 / 0 | 0 / 0 | 0 / 1 | 0 / 0 | 1          |
| <i>Myrmarachne</i> sp.C | 0 / 0 | 1 / 0 | 0 / 0 | 0 / 0 | 1          |
| <i>Myrmarachne</i> sp.D | 0 / 0 | 1 / 0 | 1 / 0 | 0 / 0 | 2          |
| <i>Phintella</i> sp.A   | 0 / 2 | 0 / 0 | 0 / 1 | 0 / 0 | 3          |
| <i>Phintella</i> sp.B   | 0 / 0 | 0 / 0 | 0 / 0 | 1 / 0 | 1          |
| <i>Rhene</i> sp.A       | 0 / 0 | 1 / 0 | 0 / 0 | 0 / 0 | 1          |
| Salticidae A            | 0 / 0 | 0 / 0 | 5 / 1 | 1 / 3 | 10         |
| Salticidae B            | 1 / 0 | 1 / 3 | 6 / 3 | 1 / 0 | 15         |
| Salticidae C            | 0 / 0 | 0 / 1 | 0 / 1 | 0 / 0 | 2          |
| Salticidae D            | 1 / 3 | 3 / 1 | 2 / 0 | 0 / 1 | 11         |
| Salticidae E            | 0 / 0 | 0 / 0 | 0 / 0 | 1 / 0 | 1          |
| Salticidae F            | 0 / 0 | 0 / 0 | 0 / 0 | 2 / 1 | 3          |
| Salticidae G            | 0 / 0 | 0 / 0 | 1 / 0 | 0 / 0 | 1          |
| Salticidae H            | 0 / 0 | 0 / 0 | 0 / 1 | 0 / 0 | 1          |
| juvenile                | 2     | 36    | 37    | 12    | 87         |
| <b>total</b>            |       |       |       |       | <b>158</b> |

## Scytodidae

|              |       |       |       |       |           |
|--------------|-------|-------|-------|-------|-----------|
| Scytodidae A | 3 / 0 | 0 / 0 | 3 / 1 | 0 / 0 | 7         |
| juvenile     | 5     | 1     | 3     | 1     | 10        |
| <b>total</b> |       |       |       |       | <b>17</b> |

## Tetrablemmidae

|                  |       |       |       |       |          |
|------------------|-------|-------|-------|-------|----------|
| Tetrablemmidae A | 0 / 2 | 2 / 2 | 1 / 1 | 0 / 0 | 8        |
| Juvenile         | 0     | 0     | 0     | 0     | 0        |
| <b>Total</b>     |       |       |       |       | <b>8</b> |

Appendix continued

| Species                      | Habitats |         |         |         | Total       |
|------------------------------|----------|---------|---------|---------|-------------|
|                              | T        | F       | FE      | M       |             |
| <b>Tetragnathidae</b>        |          |         |         |         |             |
| <i>Leucauge argentina</i>    | 80 / 28  | 75 / 23 | 13 / 5  | 4 / 2   | 230         |
| <i>Leucauge decorata</i>     | 0 / 0    | 0 / 2   | 70 / 38 | 21 / 23 | 154         |
| <i>Mesida gemma</i>          | 80 / 76  | 15 / 15 | 18 / 15 | 0 / 0   | 219         |
| <i>Nephila pilipes</i>       | 8 / 2    | 11 / 7  | 7 / 2   | 1 / 1   | 39          |
| <i>Tetragnatha praedonia</i> | 1 / 0    | 2 / 2   | 3 / 4   | 1 / 1   | 14          |
| <i>Tylorida striata</i>      | 0 / 0    | 0 / 0   | 17 / 8  | 29 / 5  | 59          |
| Juvenile                     | 257      | 158     | 303     | 114     | 832         |
| <b>Total</b>                 |          |         |         |         | <b>1547</b> |

## Theraphosidae

### Yamia watase

|              |       |       |       |       |          |
|--------------|-------|-------|-------|-------|----------|
|              | 0 / 1 | 0 / 0 | 0 / 2 | 0 / 3 | 6        |
| Juvenile     | 0     | 1     | 0     | 1     | 2        |
| <b>Total</b> |       |       |       |       | <b>8</b> |

## Theridiidae

### Achaearanea japonica

|                                   |         |         |         |        |     |
|-----------------------------------|---------|---------|---------|--------|-----|
|                                   | 2 / 2   | 6 / 8   | 35 / 10 | 11 / 1 | 75  |
| <i>Achaearanea lanyuensis</i>     | 1 / 9   | 4 / 0   | 0 / 0   | 0 / 0  | 14  |
| <i>Achaearanea quadrimaculata</i> | 0 / 0   | 1 / 2   | 2 / 1   | 0 / 1  | 7   |
| <i>Achaearanea tepidariorum</i>   | 4 / 0   | 15 / 0  | 0 / 0   | 0 / 0  | 19  |
| <i>Anelosimus taiwanicus</i>      | 4 / 4   | 27 / 19 | 14 / 24 | 0 / 0  | 92  |
| <i>Argyrodes cylindrogaster</i>   | 0 / 0   | 0 / 2   | 2 / 1   | 0 / 1  | 6   |
| <i>Argyrodes fissifron</i>        | 4 / 2   | 5 / 1   | 0 / 0   | 0 / 0  | 12  |
| <i>Argyrodes labiatus</i>         | 0 / 0   | 0 / 0   | 3 / 0   | 1 / 0  | 4   |
| <i>Argyrodes lanyuensis</i>       | 14 / 11 | 25 / 12 | 26 / 17 | 8 / 3  | 116 |
| <i>Argyrodes nigroris</i>         | 0 / 0   | 1 / 0   | 0 / 0   | 0 / 0  | 1   |
| <i>Argyrodes sinicus</i>          | 0 / 1   | 0 / 0   | 0 / 0   | 1 / 0  | 2   |
| <i>Chrosiothes fulvus</i>         | 0 / 0   | 1 / 4   | 0 / 1   | 0 / 0  | 6   |
| <i>Chryso argyrodiformis</i>      | 0 / 0   | 0 / 0   | 1 / 2   | 1 / 3  | 7   |
| <i>Chryso orchis</i>              | 1 / 1   | 43 / 41 | 71 / 90 | 2 / 10 | 259 |
| <i>Chryso spiniventris</i>        | 0 / 0   | 2 / 1   | 6 / 2   | 1 / 1  | 13  |
| <i>Chryso vesiculosa</i>          | 0 / 0   | 2 / 0   | 0 / 0   | 0 / 0  | 2   |
| <i>Coleosoma blandum</i>          | 0 / 0   | 0 / 0   | 1 / 0   | 1 / 0  | 2   |
| <i>Coleosoma floridanam</i>       | 0 / 1   | 3 / 7   | 2 / 6   | 2 / 11 | 32  |
| <i>Dipoena mustelina</i>          | 4 / 4   | 0 / 0   | 0 / 3   | 0 / 2  | 13  |

Appendix continued

| Species                 | Habitats |       |       |       | Total |
|-------------------------|----------|-------|-------|-------|-------|
|                         | T        | F     | FE    | M     |       |
| Moneta mirabilis        | 4 / 3    | 0 / 0 | 1 / 0 | 0 / 0 | 8     |
| Theridion xianfengensis | 0 / 6    | 0 / 3 | 0 / 0 | 0 / 0 | 9     |
| <i>Dipoena</i> sp.A     | 0 / 1    | 0 / 4 | 0 / 0 | 0 / 0 | 5     |
| <i>Phoroncidia</i> sp.A | 0 / 0    | 0 / 0 | 0 / 0 | 1 / 0 | 1     |
| Theridiidae A           | 2 / 0    | 2 / 0 | 1 / 0 | 1 / 0 | 6     |
| Theridiidae B           | 1 / 0    | 3 / 0 | 0 / 0 | 0 / 0 | 4     |
| Theridiidae C           | 6 / 0    | 9 / 0 | 1 / 0 | 0 / 1 | 17    |
| Theridiidae D           | 0 / 0    | 0 / 9 | 0 / 0 | 0 / 0 | 9     |
| Theridiidae E           | 3 / 1    | 1 / 3 | 1 / 1 | 0 / 0 | 10    |
| Theridiidae F           | 0 / 1    | 0 / 1 | 0 / 0 | 0 / 0 | 2     |
| Theridiidae G           | 0 / 1    | 0 / 1 | 0 / 0 | 0 / 0 | 2     |
| Theridiidae H           | 0 / 0    | 0 / 0 | 0 / 0 | 1 / 0 | 1     |
| Theridiidae I           | 4 / 1    | 4 / 3 | 0 / 1 | 4 / 2 | 19    |
| Theridiidae J           | 0 / 0    | 2 / 0 | 0 / 0 | 0 / 0 | 2     |
| Theridiidae K           | 0 / 0    | 0 / 0 | 0 / 0 | 0 / 1 | 1     |
| Theridiidae L           | 0 / 0    | 0 / 0 | 0 / 0 | 1 / 0 | 1     |

|              |    |     |     |    |             |
|--------------|----|-----|-----|----|-------------|
| juvenile     | 83 | 147 | 203 | 61 | 494         |
| <b>total</b> |    |     |     |    | <b>1273</b> |

### Thomisidae

|                             |       |         |       |       |    |
|-----------------------------|-------|---------|-------|-------|----|
| Diaea subdola               | 0 / 1 | 1 / 1   | 0 / 3 | 0 / 1 | 7  |
| <i>Runcinia acuminata</i>   | 0 / 0 | 1 / 0   | 3 / 0 | 4 / 0 | 8  |
| <i>Runcinia albostriata</i> | 0 / 0 | 1 / 1   | 0 / 1 | 1 / 5 | 9  |
| <i>Thomisus okinawensis</i> | 0 / 0 | 1 / 0   | 4 / 2 | 1 / 0 | 8  |
| Xysticus ephippiatus        | 0 / 0 | 0 / 0   | 0 / 0 | 1 / 0 | 1  |
| Thomisidae A                | 4 / 1 | 14 / 16 | 9 / 4 | 1 / 1 | 50 |
| Thomisidae B                | 0 / 0 | 0 / 0   | 0 / 0 | 0 / 1 | 1  |
| Thomisidae C                | 0 / 0 | 0 / 0   | 0 / 0 | 0 / 4 | 4  |
| Thomisidae D                | 0 / 0 | 0 / 0   | 0 / 0 | 3 / 0 | 3  |
| Thomisidae E                | 0 / 0 | 0 / 0   | 0 / 0 | 2 / 0 | 2  |
| Thomisidae F                | 0 / 0 | 4 / 1   | 4 / 2 | 0 / 0 | 11 |
| Thomisidae G                | 0 / 0 | 0 / 0   | 1 / 0 | 1 / 0 | 2  |
| Thomisidae H                | 3 / 2 | 0 / 0   | 0 / 0 | 0 / 0 | 5  |
| Thomisidae I                | 0 / 0 | 1 / 0   | 0 / 1 | 0 / 0 | 2  |
| Thomisidae J                | 0 / 0 | 0 / 0   | 0 / 0 | 1 / 0 | 1  |

Appendix continued

| Species      | Habitats |       |       |       | Total      |
|--------------|----------|-------|-------|-------|------------|
|              | T        | F     | FE    | M     |            |
| Thomisidae K | 0 / 0    | 0 / 0 | 0 / 0 | 1 / 0 | 1          |
| juvenile     | 52       | 57    | 40    | 31    | 180        |
| <b>total</b> |          |       |       |       | <b>295</b> |

### Uloboridae

|                                 |       |       |       |       |           |
|---------------------------------|-------|-------|-------|-------|-----------|
| Philoponella nasutus            | 0 / 0 | 5 / 3 | 0 / 0 | 0 / 1 | 9         |
| <i>Philoponella prominensis</i> | 3 / 0 | 2 / 0 | 1 / 0 | 0 / 0 | 6         |
| Uloboridae A                    | 4 / 2 | 0 / 0 | 0 / 0 | 0 / 0 | 6         |
| Uloboridae B                    | 0 / 0 | 0 / 0 | 0 / 1 | 0 / 0 | 1         |
| Uloboridae C                    | 0 / 0 | 0 / 0 | 2 / 0 | 0 / 0 | 2         |
| Uloboridae D                    | 0 / 0 | 1 / 0 | 0 / 0 | 0 / 0 | 1         |
| juvenile                        | 5     | 2     | 3     | 1     | 11        |
| <b>total</b>                    |       |       |       |       | <b>36</b> |

|                       |             |             |             |             |             |
|-----------------------|-------------|-------------|-------------|-------------|-------------|
| <b>TOTAL adult</b>    | 557         | 843         | 939         | 506         | 2845        |
| <b>TOTAL juvenile</b> | 526         | 614         | 897         | 524         | 2561        |
| <b>TOTAL</b>          | <b>1083</b> | <b>1457</b> | <b>1836</b> | <b>1030</b> | <b>5406</b> |