

## DIVERSITY AND ECOLOGY OF SPIDERS (ARANEAE) IN THE BUFFER ZONES OF THREE NATIONAL PARKS IN NORTHERN VIETNAM

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**Abstract.** The diversity and ecology of spiders were studied in the Ngoc Thanh buffer zone of Tam Dao National Park, the Cuc Phuong buffer zone of Cuc Phuong National Park, and the Ba Trai buffer zone of Ba Vi National Park. Spiders were collected by five methods: pitfall traps, litter sampling, tree beating, sweep netting, and visual searches in four types of habitats including secondary forests, artificial forests, shrublands, and home gardens. A total of 70 species were recorded from three study sites with 68 species in Ngoc Thanh, 49 species in Cuc Phuong, and 47 species in Ba Trai. There were 56 spider species called *singleton status* species or *rare* species (collection of only one individual) including 13 species in Ngoc Thanh, 19 species in Cuc Phuong, and 24 species in Ba Trai. This study has used a new method in ecology research on the occurrence of rare species to assess the degrees of disturbance in the ecosystem. The results of cluster analysis showed that habitat types with different vegetation structures and habitat disturbances affect the distribution of spider species. The research results are presented for the first time, as a scientific basis for the conservation and sustainable use of spider species in the buffer zone of National Parks in Northern Vietnam.

**Keywords:** spiders, rare species, vegetation structure, disturbance, buffer zone.

### 1. Introduction

Spiders (Arachnida: Araneae) are very large in number of species and population. Spiders currently comprise more than 48,000 species, placed in more than 4,000 genera and 115 families [1]. There are 491 spider species belonging to 219 genera and 43 families known from Vietnam [2].

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Studies have shown that spiders play a major role as natural enemies in fighting insect pests in agro-forestry ecosystems or farmlands. It seems strange that spiders are largely ignored since these are of great scientific significance and great economic value in the biological control of insect pests and indicators of habitat diversity and pollution [3]. In Vietnam, studies on the use of natural enemies in the control of pest populations have only focused on insects [4, 5].

In addition, spiders can be chosen as very good environmental indicators to monitor the status of tropical rainforest management, and the specific biodiversity situation in different recovery periods of destroyed tropical rainforests.

This study aims to document the community structure, diversity, species composition, and abundance of spiders in habitats in buffer zones of three national parks with various degrees of disturbance.

## 2. Content

### 2.1. Material and methods

#### \* *Study sites*

The study was conducted in the buffer zones of three national parks: Ngoc Thanh commune in the buffer zone of Tam Dao National Park, Cuc Phuong commune in the buffer zone of Cuc Phuong National Park, and Ba Trai commune in the buffer zone of Ba Vi National Park. These national parks are popular tourist destinations.

Some forests near villages have been clear-cut to provide land for growing teas, vegetables, and crops. Small-scale logging also occurs in the forests to obtain materials for construction and firewood. These human activities generate various degrees of disturbance to the forest ecosystem.

Ngoc Thanh is subjected to a low level of disturbance. This area is strictly protected by Me Linh Station for Biodiversity. Cuc Phuong is more severely disturbed than Ba Trai but is less altered than Ngoc Thanh.

Four habitats were studied at each site, including a secondary forest, artificial forest, shrubland, and gardens around the home.

#### \* *Sampling methods*

Five collecting methods were used in all sites to sample the spiders: pitfall traps, litter sampling, tree beating, sweep netting, and visual searches. Using *pitfall traps*, spiders were collected from ten traps in each site with parallel lines of traps set 10 m apart and each line with five traps 3 m apart. The traps consisted of a 180 mm length and 80 mm diameter PVC pipe sunk vertically in the ground so that the rim is flushed with the ground. A 120 mm deep and 70 mm diameter plastic cup was fitted inside the pipe. In *litter sampling* (sieving), samples were taken every 2 weeks with 8 litter samples every collection time in each site. The area of each litter sample is 1 m<sup>2</sup> (1 m x 1 m). Litter samples were placed in a sieve and shaken for 2 minutes into a large plastic container. In *tree beating*, a beating tray of 0.9m x 0.9m and a stick of about one meter long was used to beat the lower branches for 10 minutes at each site. In *sweep netting*, two types of sweep nets were used. A sweeping net with a 40 cm mouth width was used to sweep grasses and bushes with 10 minutes duration in each site. A net mounted on

the eight-meter-long fishing pole was used to collect spiders in the canopy and swept for 10 minutes to take samples at each site. *Visual searches* simply looked for spiders that dwell on the web for 10 minutes on each site. All specimens were preserved in 70% ethanol. Every collected spider individual was identified under a stereomicroscope concerning the morphological keys in Platnick [1] Pham Dinh Sac [2], and Song et.al. [3].

**\* Statistical analyses**

The similarity between the various sites was assessed using a clustering technique contained in the software PRIMER Version 6.

**2.2. Results and discussion**

**2.2.1. Spider fauna in the buffer zones of Tam Dao, Cuc Phuong, and Ba Vi National Parks**

A total of 1773 individuals were collected from the three study sites. They belong to 70 species, 11 families (Table 1). Salticidae made up the largest portion of individual spiders collected (31.40%), followed by Araneidae (23.29%), Agelenidae (11.22%), Hexathelidae (8.46%), Oxyopidae (7.78%), Tetragnathidae (6.12%). Salticidae also has the highest number of species (20), followed by Araneidae (16), Tetragnathidae (8), Lycosidae (7), and Thomcidae (5).

**Table 1. The composition of spider species recorded in the habitats of study sites**

Species	Study sites	Number of individuals
Family Araneidae		
<i>Araneus inustus</i> (C.L. Koch)	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	54
<i>Argiope bruennichii</i> (Scopli)	NT (SC,AF), BT (SC,AF)	5
<i>Argiope minuta</i> Karsch	NT (SC,AF), CP (SC,AF), BT (GD)	13
<i>Argiope catenulata</i> (Doleschall)	NT (SC), CP (SH), BT (AF)	3
<i>Cyclosa bifida</i> (Doleschall)	NT (SH), CP (GD), BT (GD)	3
<i>Cyclosa insulana</i> (Costa)	NT (SC, AF), CP (SC), BT (SC)	9
<i>Cyrtophora muluccensis</i> (Doleschall)	NT (SC,AF,GD), CP (SC,AF,GD)	40
<i>Eriovixia laglaizei</i> (Simon)	NT (AF,GD), CP (GD)	8
<i>Hypsosinga alboria</i> Yin et al.	NT (SH), BT (SH)	3
<i>Hypsosinga pygmaea</i> (Sundevall)	NT (SC), CP (SC)	4
<i>Hypsosinga sanguinea</i> (C.L.Koch)	NT (SC)	1
<i>Gea subarmata</i> Thorell	NT (AF)	1
<i>Gasteracantha diadesmia</i> Thorell	NT (SC, SH, GD), CP (SC, AF,	19

	SH), BT (SC, SH, GD)	
<i>Gasteracantha kuhli</i> C.L.Koch	NT (SC,AF,GD), CP (SC,GD), BT (SC,GD)	21
<i>Neoscona theisi</i> (Walckenaer)	NT (SC, AF, SH, GD), CP (SC, SH, GD), BT (SH, GD)	28
<i>Nephila maculata</i> (Fabricius)	NT (SC,AF,GD), CP (SC,AF,GD), BT (SC,AF,GD)	201
Total		413
Family Agelenidae		
<i>Agelena sublimbata</i> Wang	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	199
Total		199
Family Clubionidae		
<i>Castianeira tiraglupa</i> Barrion & Litsinger	NT (SH, GD), CP (GD)	9
<i>Cheracanthium catindigae</i> Barrion & Litsinger	NT (SC, AF), CP (SC, AF)	7
<i>Clubiona japonicona</i> Bösenberg & Strand	NT (SC,AF,GD), CP (SC,GD)	27
Total		43
Family Hexathelidae		
<i>Macrothele holsti</i> Pocock	NT (SC, AF,SH, GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	150
Totals		150
Family Linyphiidae		
<i>Atypena adelinae</i> Barrion & Litsinger	NT (SC,AF,SH,GD), CP (SC,AF,SH), BT (SC,AF,GD)	20
<i>Erigone</i> sp.	CP (SC), BT (SC)	2
<i>Hylyphantes graminicola</i> (Sundevall)	NT (SH)	1
<i>Ummeliata insecticeps</i> (Bösenberg & Strand)	NT (SC), CP (SC, SH), BT (SC, SH)	10
Total		33
Family Lycosidae		
<i>Hippasa holmerae</i> Thorell	NT (SH, GD), CP (SH), BT (SH)	5

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<i>Lycosa</i> sp.	CP (SH), BT (GD)	5
<i>Pardosa birmanica</i> Simon	NT (AF,SH,GD), CP (GD), BT (AF,SH)	9
<i>Pardosa pseudoanulata</i> (Bösenberg & Strand)	NT (AF,SH,GD), CP (SH,GD), BT (GD)	31
<i>Pardosa sumatrana</i> (Thorell)	NT (SC,AF,SH,GD), CP (SC,AF)	6
<i>Pirata blabakensis</i> Barrion & Litsinger	NT (SC)	1
<i>Pirata suppiraticus</i> Bösenberg & Strand	NT (AF,SH), CP (AF), BT (AF, GD)	4
Total		61
Family Oxyopidae		
<i>Oxyopes lineatipes</i> (C.L. Koch)	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD)	14
<i>Oxyopes javanus</i> Thorell	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	121
<i>Oxyopes birmanicus</i> Thorell	NT (SC, SH), CP (SH)	3
Total		138
Family Salticidae		
<i>Bianor anguilosus</i> (Karsch)	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	70
<i>Burmattus sinicus</i> Proszynski	NT (SC, SH), CP (SH)	6
<i>Carrhotus sannio</i> (Thorell)	NT (SH)	1
<i>Epeus gloriatus</i> Zabka	NT (SC), CP (AF), BT (SC)	6
<i>Evarcha flavocincta</i> (C.L. Koch)	NT (SC,AF,GD), CP (AF), BT (GD)	6
<i>Epocilla cancarata</i> (Karsch)	NT (SC,AF,SH,GD), CP (SC,AF,SH,GD), BT (SC,AF,SH,GD)	93
<i>Harmochirus brachiatus</i> (Thorell)	NT (SC, SH)	2
<i>Hasarius adansoni</i> (Audouin)	NT (AF,SH,GD), CP (GD), BT (GD)	10
<i>Marpissa magister</i> (Karsch)	NT (SH,GD), CP (AF), BT (GD)	8
<i>Myrmaracha legon</i> Wanless	NT (GD), CP (AF), BT (SH)	16
<i>Phintella versicolor</i> (C.L. Koch)	NT (SC,AF,SH,GD), CP	269

	(SC,AF,SH,GD), BT (SC,AF,SH,GD)	
<i>Phintella lucai</i> Barrion & Litsinger	NT (SC,GD), CP (SC), BT (AF)	3
<i>Phintella vittata</i> (C.L. Koch)	NT (AF,SH,GD), CP (SC,AF), BT (GD)	11
<i>Plexippus paykulli</i> (Audouin)	NT (SC,AF,GD), CP (SC), BT (AF)	14
<i>Plexippus petersi</i> (Karsch)	NT (SC, SH), CP (SC, SH), BT (SC)	13
<i>Plexippus setipes</i> Karsch	NT (AF,SH,GD), CP (SH), BT (GD)	6
<i>Rhene flavigera</i> (C.L. Koch)	NT (SH)	1
<i>Siler</i> sp.	NT (SC, SH)	6
<i>Telamonia festiva</i> Thorell	NT (GD)	1
<i>Thiania bhamoensis</i> Thorell	NT (SC,AF,GD), CP (SC,AF, GD), BT (SC, GD)	14
<i>Total</i>		556
Family Tetragnathidae		
<i>Dyschiriognatha tenara</i> Karsch	NT (GD)	4
<i>Leucauge decorata</i> (Blackwall)	NT (SC,AF,SH,GD), CP (AF, GD), BT (SC,GD)	22
<i>Tetragnatha mandibulata</i> Walckenaer	NT (SH, GD), CP (GD), BT (SH,)	6
<i>Tetragnatha maxillosa</i> Thorell	NT (SC,AF,GD), CP (SC), BT (GD)	17
<i>Tetragnatha nitents</i> (Audouin)	NT (AF, GD), CP (AF, GD), BT (GD)	18
<i>Tetragnatha javana</i> (Thorell)	NT (SC,AF,SH,GD), CP (AF,SH,GD), BT (SC,AF, GD)	32
<i>Tetragnatha vermiformis</i> Emerton	NT (SC), CP (SC), BT (SC)	7
<i>Tetragnatha virescens</i> Okuma	NT (AF,SH,GD), BT (SC)	3
<i>Total</i>		109
Family Therididae		
<i>Coleosoma blandum</i> Cambridge	NT (SC, AF), CP (SC), BT (AF)	7
<i>Theridium octomaculatum</i> Bösenberg & Strand	NT (SC, SH, GD), BT (AF, SH)	4
<i>Total</i>		11

Family Thomcidae		
<i>Oxytate virens</i> (Thorell)	NT (SC)	2
<i>Runcinia acuninata</i> (Thorell)	NT (AF, GD)	3
<i>Misumenoides matinkus</i> Barrion & Litsinger	NT (SC,AF), BT (SC)	3
<i>Thomisus italongus</i> Barr & Lits	NT (SH)	1
<i>Xysticus palawanicus</i> Barrion & Litsinger	NT (SH), BT (SH)	2
Total		11

(NT: Ngoc Thanh, CP: Cuc Phuong, BT: Ba Trai, SC: secondary forest, AF: artificial forest, SH: shrubland, GD: home garden)

Five species of spiders were common at four habitats of all three studied sites, namely, *Araneus inustus*, *Macrothele holsti*, *Oxyopes javanus*, *Epocilla cancarata*, and *Phintella versicolor*. Seven species were collected in only one habitat and a single study site: *Hypsosinga sanguinea* (secondary forest, Ngoc Thanh), *Hylyphantes graminicola* (shrubland, Ngoc Thanh), *Pirata blabakensis* (secondary forest, Ngoc Thanh), *Carrhotus sannio* (shrub-land, Ngoc Thanh), *Dyschiriognatha tenara* (garden around home, Ngoc Thanh), *Oxytate virens* (secondary forest, Ngoc Thanh), *Thomisus italongus* (shrub-land, Ngoc Thanh).

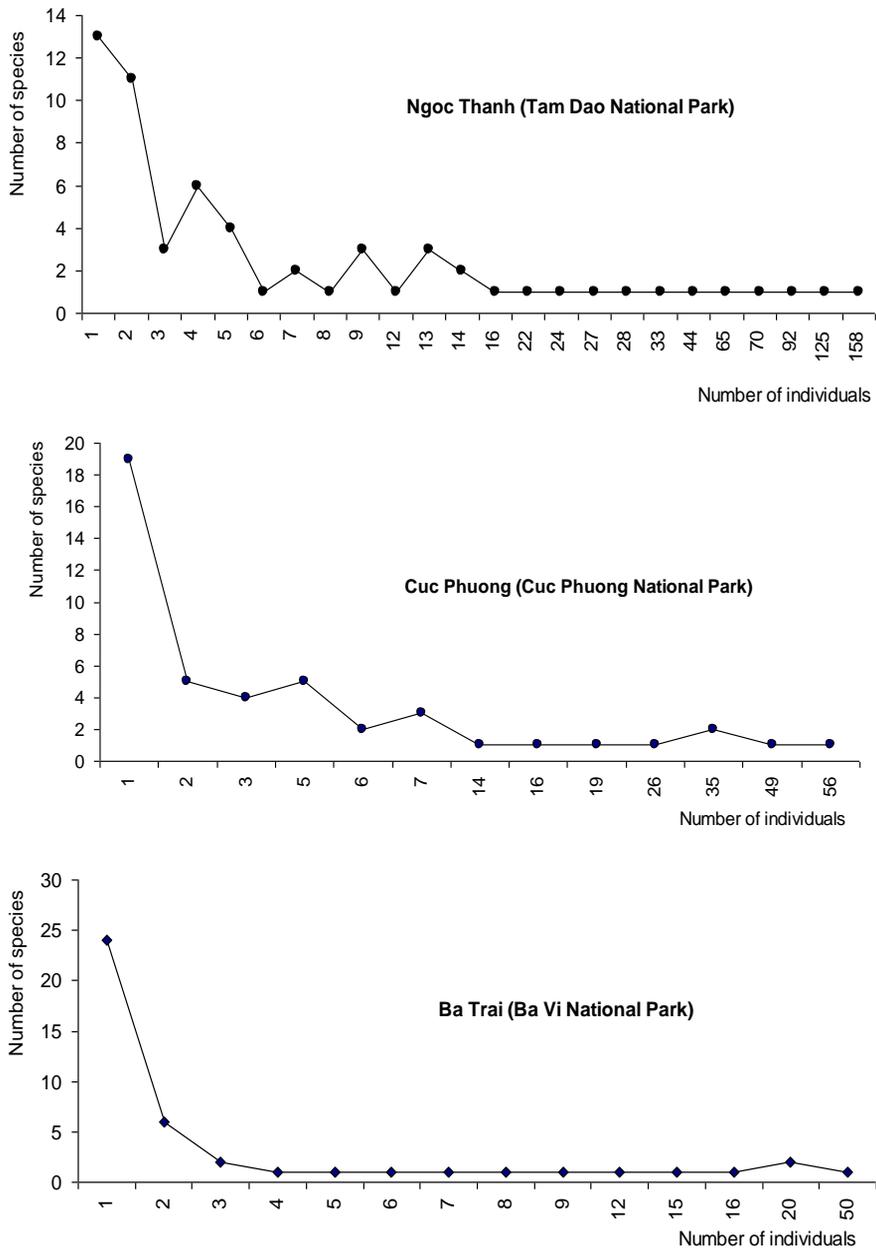
A total of 70 species were recorded from three study sites. Of these, 68 species were found in Ngoc Thanh, 49 in Cuc Phuong, and 47 in Ba Trai. Five species were common with over 100 individuals per species collected (Table 2).

**Table 2. Dominant species recorded from the study sites**

No.	Species	Number of individuals				
		Ngoc Thanh	Cuc Phuong	Ba Trai	Total	Percent (%)
1	<i>Phintella versicolor</i>	184	35	50	269	15.17
2	<i>Nephila maculata</i>	125	56	20	201	11.34
3	<i>Agelena sublimbata</i>	158	26	15	199	11.22
4	<i>Macrothele holsti</i>	92	49	9	150	8.46
5	<i>Oxyopes javanus</i>	70	35	16	121	6.83
The rest (65 species)		554	166	113	833	46.98
Totals		1183	367	223	<b>1773</b>	<b>100.00</b>

The most dominant species was *Phintella versicolor*, with a total of 269 individuals (15.17%) found. The second dominant species was *Nephila maculata* (11.34%), followed by *Agelena sublimbata* (11.22%), *Macrothele holsti* (8.46%), and *Oxyopes javanus* (6.83%). All the rest comprised of 65 species had an average ratio of 0.72% per species.

### 2.2.2. The relation between recorded species and captured individuals



**Figure 1. The relation between recorded species and captured individuals**

The analyses of spider diversity have shown that there were 56 spider species collected with only one individual in the study sites. They were regarded as *singleton status* species or *rare* species.

According to Coddington [6], the occurrence of rare species is caused by a variety of edge effects, of which the most important are habitat, time, and method. Habitat edge effects explain the singleton status of canopy species in subcanopy samples, or of

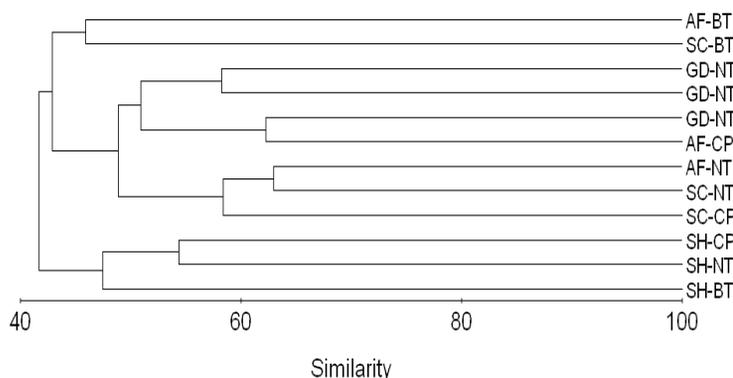
species not usually found in mature hardwood forests, but known to be more common elsewhere. Time edge effects explain why the species were common at the site, but were out of season at sampling time. Finally, method edge effects may explain why some of the species are not known to be anywhere common in the region. It is an ecological truism that all species must be common somewhere, or, alternatively, that breeding populations have a species-specific spatial structure. More likely, these rare species occur in the area we sampled, but have natural histories that make them difficult to collect by the methods we used.

Nevertheless, although edge effects may explain the occurrence of rare species to some extent, they still are valid indicators that an inventory is incomplete. A total of 56 rare species were collected in study sites, which included 13 species in Ngoc Thanh, 19 species in Cuc Phuong, and 24 species in Ba Trai. This pattern corresponded to the different disturbance levels in the study sites arranged in descending order: Ngoc Thanh, Cuc Phuong, and Ba Trai. This result suggested that the occurrence of rare species is affected by degrees of disturbance in the ecosystem.

According to Figure 1, the diversity of spiders in studied sites can be divided into three groups: *Group 1* with high species diversity consisting of from 5 to 24 species and a small population size (with only 1 or 2 individuals collected per species); *Group 2* with medium species diversity consisting of from 2 to 4 species and medium population size; and *Group 3* with low species diversity containing only one species and large population size. From a conservation perspective, species in Group 1 should be given priority over those in Groups 2 and 3.

### 2.2.3. Similarity of spider species composition in study sites

Cluster analysis was used to examine the species composition similarity between the studied sites. The results showed that the species could be clustered into three main groups (Figure 2). The first group is comprised of shrub-land habitats in three study sites, the second group included most study sites in three habitats, and the third group included secondary and artificial forests in Ba Trai.



**Figure 2.** The similarity of spider species composition in the study habitats (AF: artificial forest, SH: shrubland, GD: home garden, NT: Ngoc Thanh, CP: Cuc Phuong, BT: Ba Trai)

The result suggested that the structure of vegetation in different habitats affects the distribution of spider species. The first group is characterized by shrub vegetation in all study sites. The second group, with three types of habitats, had similarities in the structure of vegetation with big trees. This structure is very important to web-making spider species. For example, web-making spider species *Cyrtophora muluccensis* and *Nephila maculata* are making their web between big trees, at a height of over 2 meters above ground level. However, in the third group, two types of habitats (secondary forest and artificial forest) in Ba Trai were clustered together and significantly different from other studied sites. In the three study sites, Ba Trai had the highest level of disturbance, followed by Cuc Phuong, and lastly Ngoc Thanh. Sites having similar habitat structures but receiving different levels of disturbance were not similar in species composition and abundance pattern. Therefore, the disturbances of habitats did not affect biodiversity at the species level.

### 3. Conclusions

A total of 70 species were recorded from three study sites: 68 species in the Ngoc Thanh buffer zone of Tam Dao National Park, 49 species in the Cuc Phuong buffer zone of Cuc Phuong National Park, and 47 species in the Ba Trai buffer zone of Ba Vi National Park. Fifty-six spider species were regarded as *singleton status* species or *rare* species including 13 species in Ngoc Thanh, 19 species in Cuc Phuong, and 24 species in Ba Trai. The occurrence of rare species is affected by degrees of disturbance in the ecosystem. The habitat types with different vegetation structures and habitat disturbances affect the distribution of spider species. The research results are presented for the first time, as a scientific basis for conservation and sustainable use of spider species in the buffer zone of National Parks in Northern Vietnam.

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