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Crab spiders, tree canopy, and biodiversity in tropical East Asia (Araneae: Thomisidae)

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Abstract
In an extended tree canopy fogging project in northern Borneo, East Malaysia, 160 trees were fogged. 86 species of Thomisidae were identified to described species or to morphospecies and compared with the unidentified material (appr. 150 species) of the Deeleman General SE Asian Spider Collection (Naturalis Museum Leiden). The compiled data give a first glimpse of insight into the approximate species number and the overlaps between forest types, the percentage of new species and their distribution ranges. The fauna of the ground and understorey probably shelters a larger amount of species than the canopy because the former includes more poor dispersers with smaller ranges.

Key words: crab spiders, South East Asia, Borneo, canopy fauna, biodiversity.

INTRODUCTION

Through 1992–2001 a canopy fogging project was carried out by AF, fogging 160 tree crowns in 12 different types of primary and secondary forest in northern Borneo, East Malaysia (Floren & Deeleman-Reinhold 2005). Among other things, differences in composition of arthropod species between forest types were studied and impact of human activities on species diversity was assessed.

Where do canopy species come from, what proportion of the species is new and how many species are found in the canopy only? We selected the thomisids for this study: they rank fourth family regarding species richness, their number is manageable, and they are widely diversified. Also they are known to be good dispersers.

Only one crab spider species (*Thomisus persipicillatus* Thorell, 1890) has hitherto been described from a type locality in Borneo, in all, around 11 known, widespread species are known to occur with high probability on Borneo. Approximately 185 species of crab spiders have been recorded from SE Asia including tropical China and Japan till the year 2003, excluding New Guinea (Platnick, 2008).

METHODS

We sorted the spiders to morphospecies and compared species composition between primary and several adjacent and isolated secondary forest types. The thomisid species were identified by CD-R. More than half of the described species belong to "old cryptic" species: described before 1900 from the Malay region, in Latin and most often not or inadequately illustrated. Identification of these species was as much as possible done by comparing types of Simon (Paris) and Thorell (Genova, Stockholm and London). We used recent publications a.o.

from China, Japan and the Philippines and that of Lehtinen (2005). We compared each of the canopy species with the ground level species ("understorey") from primary and evergreen secondary forests in the southeast Asian collection of CD-R., now in Naturalis, Leiden, encompassing all large Indonesian islands, the Moluccans and the Lesser Sunda islands as well as a.o. southern Thailand and Malay Peninsula. This collection contains currently around 500 adult individuals in 150 thomisid species, 28 (19%) of which were identified as named species.

The canopy material stems from three areas:

(1) Poring, part of the Mt. Kinabalu National Park, West Sabah, Borneo.
(2) Sorinsim, Kinabalu area, West Sabah, Borneo.
(3) Crocker Range, several hundred kilometres west of Kinabalu, West Sabah, Borneo.

Abbreviations of finding localities:

PHS: Poring, Kinabalu Hot Springs, approximately 700 m, primary rainforest, canopy of three different tree species, 1992–1998, leg. A. Floren.
S: Sorinsim, 5–40 years old secondary forest adjacent to primary forest, 1997, canopy fogging, leg. A. Floren.
CR: Outskirts of Crocker Range, small isolated patches of 10, 25 and 50 years old forest, separated by lowland, mainly agricultural land, much degraded; canopy fogging, leg. A. Floren.

RESULTS

Counting genera and species; overlaps of canopy with understorey fauna

Our canopy project yielded 1615 individual crab spiders in 86 species; 23 (27%) species could be identified to named species (table 1). Several old, "cryptic" genera were encountered, such as *Cerinius* Thorell, *Demogenes* Simon, *Domatha* Simon, *Nyctimus* Thorell, *Pycnaxis* Simon, *Pothaeus* Thorell and *Zametopina* Simon. One canopy species was clearly related to the litter-dwelling genus *Cebrenninus* but not congeneric. Typically, *Cebrenninus* species are ground-living; five species have been described from leaf litter in the forests of Java, Sumatra and Borneo at the end of the nineteenth century, several of which indeed we recognized in our understorey collection. All eight specimens of the canopy-dwelling species were fogged from the oldest secondary forest merging into the primary forest in Sorinsim, lowland Kinabalu. That forest type proved to be the richest in species of all studied habitats, for most spider families.

Most thomisid genera were represented both in the ground layer and in the canopy (see table 2). The most common genus we found in the canopy was *Cerinius* Thorell (synonymy with the Australian genera *Tharrhalea* and *Hedana* is unjustified) with 9 species (Fig. 1), mostly in the younger secondary forests. Three named species which were described from localities outside Borneo are widespead so presumably occur also in Borneo, all other *Cerinius* species were either found only in the canopy or in one locality in the general collection. (The species illustrated in Murphy & Murphy (2000) on p. 434 looks like *Cerinius*). An important element in the canopy were the Dietinae, with seven genera including *Alcimochthes* and *Scopticus*. *Oxytate*, with 5 species in the canopy and 10 in the general collection, with an overlap of 2 species was the most species-rich genus (Figs. 3, 4). Many species are listed under *Tmarus*; the genus is not monophyletic and several species should be split off, such as *Tmarus loriae* and related undescribed species. The genus *Domatha* is represented in the canopy with the single species known in the area *Domatha vivida*, and additionally with 3 other undescribed species in the canopy and three other, also undescribed species in the general collection. Another poorly known genus, *Demogenes* proved to be represented both in the canopy and the ground and understorey collection in a variety of species. The genus *Zametopina* was hitherto known from the type species

region:	Poring PHS	Sorinsim S	Crocker Range CR	Known distribution	Deeleman General SE Asian Spider Collection
forest type:	Primary	Secondary adjacent	Secondary isolated		
samples:	32	48	24		
Amyciaea forticeps (O.P.-C.)	1	0	0	Widespread	
* *Cerinius mariae* (B. & L.)	5	23	0	Luzon	W. Sarawak
* *Cerinius ocellatus* (Thor.)	1	7	2	Myanmar, Java Sumatra	Malaysia, Thailand Sumbawa
Cerinius magkalapitus (B. & L.)	0	16	0	Mindanao	
* *Pycnaxis guttata* Simon	0	6	8	Luzon	Sarawak
* *Boliscus tuberculatus* (Simon)	1	9	0	Myanmar-Japan	Malaysia
* *Domatha vivida* Simon	20	3	0	Luzon	Brunei (canopy), Sumatra
* *Loxobates daitoniensis* Ono	1	6	1	Japan	
* *"Loxobates" masapangensis* B. & L.	11	31	26	Luzon	Sumatra
Lycopus edax Thor.	2	0	0	Myanmar	
Oxytate striatipes L. Koch	0	0	29	Widespread is SE Asia	
* *Pasias luzonus* Simon	1	14	0	Luzon	Sumatra, Sulawesi
Talaus nanus Thor.	0	297	0	Myanmar-Java	W. Sabah, Malaysia
* *Talaus triangulifer* Simon	0	1	1	Sumatra	Kalimantan, Sarawak
* *Philodamia variata* Thor.	0	8	1	Singapore	
Thomisops sanmen Song, Zhang & Zheng	28	0	0	China	
Nyctimus bistriatus Thor.	4	0	0	Sulawesi	Sumatra, Borneo Sumbawa
Tmarus loriae Thor.	0	0	1	Pineng Malaysia	
* *Zametopina calceata* Simon	15	4	0	Vietnam	Brunei Sabah, Suma
Ebrechtella fruehstorferi Dahl	0	41	0	Widespread	Thailand: Krabi, mangrove
Ebrechtella concinna (Thor.)	0	1	0	Widespread West Pacific	
Thomisus perspicillatus (Thor.) (Fig. 2)	0	23	0	Sarawak	Poring canopy walk
* *Mastira maputiyana* (B. & L.)	0	25	1	Luzon	

Table 1. List of identified thomisid species from the canopy project, with distribution across forest types and range size. Left columns: number of specimens in three fogging series in primary forest (Poring), three secondary forests of different age merged into primary forest and into one another (Sorinsim, 5-15-40yr) and three patches of isolated secondary forest of 3 different ages (Crocker Range, 10-20-50yr). Right columns: distribution according to published data, and unpublished records based on the Deeleman general collection Naturalis, Leiden. The overlapping species are marked with *.

Genus	described species in SE Asia excluding New Guinea	species in general collection	species in Borneo canopy	shared (overlapping) species
Cebrenninus	5	5	1	0
Epidius	5	1	2	1
Pycnaxis	1	1	1	1 *
Cerinius ("Hedana")	3	5	9	3 *
Demogenes	2	4	2	1
Lycopus	4	1	4	2
Oxytate	12	10	5	2
Domatha	1	4	4	1 *
Zametopina	1	6	2	1 *
Nyctimus	1	1	1	1 *
Tmarus	12	10	5	2 *

Table 2. Species numbers in the general collection and in the canopy project in some genera. Overlapping species with asterix are named species.

Z. calceata only; this and another, new species were found in the canopy, both in the primary lowland forest; 5 other undescribed species from widely scattered localities figured in the understorey. One strongly camouflaged spider species with bizarre excrescences on the carapace proved to be a new species of *Smocidinodes* Ono, all four specimens were found in one of the 5 primary forest types only. Other thomisid genera seem to be absent in the canopy altogether, such as *Camaricus* and *Pagida.*

Our examination of the thomisid species from 10 canopy fogging samples in Brunei (Russell-Smith & Stork 1995) revealed that 8 thomisid species were shared with those from Kinabalu, including *Cerinius ocellatus.*

Exclusivity of the canopy fauna

How many spider species in the canopy of tropical rainforest are more or less exclusive for tree canopy, and what distribution data can be added from what we found in the general collection? In the understorey material we found 19 species shared with the canopy, 11 of which are named (described species) (see table 1) and 8 allegedly undescribed.

One species of an unnamed genus ("Thom A") was absolute champion in density in the primary forest (346 specimens) but absent in all secondary forests and in the collection from the understorey, an exception to the rule that in the primary rainforest there are no clearly dominant species.

The second abundant species in the canopy after Thom A is *Talaus nanus*, a widespread species which was found in secondary forest of different ages merging into the primary forest in 297 individuals. This species was represented with a mere 7 specimens in the general collection. No other species had more than 70 specimens in all samples together.

From our 86 canopy species, 55 species or 63% were not found at ground level. Or these, 19 species (22%) were represented with more than 5 individuals, and 14 species (16%) with 10 specimens or more. This suggests that in SE Asia, probably in the majority of species of the canopy fauna, individuals descend occasionally to the ground level. Exceptionally, "Thom A" and a few other species in other families they appear to be strictly limited to the canopy.

CONCLUSIONS

The lower percentage of identified species in the understorey (19%, against 27% in the canopy) may reflect a real situation: ground-living species often have lower dispersal capacitiy and smaller ranges. They are more susceptible to population splitting followed by geographic speciation and form a reservoir of new species, much more than do canopy species. This again suggests that the great majority of SE Asian spiders is still undescribed. Furthermore, the high percentage of singletons (20%) of thomisids in the canopy material are evidence that the species pools, in particular of the primary and adjacent secondary forests in N. Borneo have not yet been sampled representatively. Fifty-six additional samples, fogged in 2006 in 4 unsampled habitats of the same primary forest in the same area yielded 8 extra species (9%) of thomisids, all unnamed and not found in previous samples. This shows that further collecting in the canopy in different localities, even of the same forest, guarantees more new species.

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Fig. 1. *Cerinius* n. sp., very common spider in the canopy of light forests in Borneo. Photo: Flip Stoutjesdijk.

Fig. 2. *Thomisus perspicillatus*, from lower Kinabalu, roadside, probably endemic; the only thomisid ever described in the 19th century from a type locality in Borneo. Photo: Paul Zborowski.

Fig. 3. *Oxytate* n. sp., male from Mt. Kinabalu. Photo: Paul Zborowski.

Fig. 4. *Oxytate* n. sp., same individual as in Fig. 3, preserved in alcohol. Photo: Flip Stoutjesdijk.