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Abundance and stratification of foliage arthropods in a lowland rain forest of Cameroon

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Abstract. 1. Arthropod densities and apparent leaf damage were compared within the canopy ecotone and the shrub layer of a lowland rain forest in Cameroon, using a branch clipping method.

2. Most of the individuals collected consisted of ants (average 44%) and various herbivores (31%). Overall arthropod densities amounted to 17 individuals per sample, which, on average, consisted of 0.85 m^2 of foliage area. Arthropod densities were lower than on temperate foliage.

3. Arthropod densities were about 3 times higher in the canopy than within the shrub layer. In particular, ants and herbivores were significantly more abundant in the canopy than within the shrub layer. Usually, layer effects rather than site effects appeared to cause greater variance in arthropod abundance.

4. Arthropod species-richness, as estimated by the number of operational taxonomic units sorted, was higher in canopy samples than in samples obtained from the shrub layer. However, apparent leaf damage was higher within the shrub layer (10.9%) than on the canopy (5.2%).

5. Possible factors responsible for the high densities of ants and herbivores on the canopy and for the high leaf damage within the shrub layer are discussed.

Key words. Canopy raft, foliage arthropods, herbivores, leaf damage, rain forest.

Introduction

In recent years there has been much controversy about the magnitude of animal species richness on earth (e.g. Gaston, 1991; Erwin, 1991). Many authors agree that, notwithstanding micro-organisms, this is virtually the equivalent of discussing arthropod species richness in tropical rain forests (see Wilson, 1988), and, perhaps to some extent, that of arthropods associated with the crowns of rainforest trees (Erwin, 1983; Stork, 1988). However, our understanding of the organization of arboreal arthropod communities in rain forests is still fragmentary and few studies go beyond the description of faunal composition and guild structure (e.g. Farrell & Erwin, 1988; Morse *et al.*, 1988; Basset, 1991a). In particular, few quantitative and readily-comparable data about the population levels and the density of rainforest arthropods above ground level are available (e.g. Nadkarni & Longino, 1990; Basset & Arthington, 1992). Furthermore, few data are available about the vertical and spatial distribution of arthropods within rainforest trees (e.g. Basset, 1992). This results from technical difficulties in tree-crown access and in arthropod sampling.

Insecticide fogging has often been used to survey the arthropod fauna foraging within tree crowns (e.g. Erwin, 1988; Stork, 1988). Arthropod abundance is usually expressed per m^2 of collecting surface and the interpretation of these data may not be straightforward. For example, since catches may depend on the amount of foliage above collecting trays (Barnard *et al.*, 1986) it may be difficult to estimate arthropod densities per leaf area and to compare them between individual trees and tree species. Furthermore, the actual sampling procedures do not allow distinction between the fauna residing on the uppermost foliage from that on the lower strata of vegetation.

In botany the term 'canopy' is sometimes defined as the ecotone represented by the interface between the uppermost layer of leaves and the atmosphere (Hallé & Blanc, 1990). For practical purposes, this layer is only

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1 or 2 m deep (see Hallé & Blanc, 1990). Many of the biotic processes occurring within the canopy ecotone (i.e. flowering, fruiting, leaf flush, photosynthesis, evapotranspiration, etc.) may be of crucial importance to the whole of the rain forest ecosystem (see Hallé & Blanc, 1990). However, to date, entomologists have not succeeded in sampling selectively the canopy ecotone and in discovering its main entomological features.

Recently the canopy ecotone (hereafter termed 'canopy') of rain forests has become accessible to scientists (see Hallé & Blanc, 1990). Not unexpectedly, Blanc (1990) showed that the microclimate of the canopy is quite different from that within the subjacent vegetation. Microclimate, along with illumination, food resources and many other factors, can promote the stratification of certain arthropod groups on the foliage of rainforest trees (Basset, 1992). This may result in differences between the canopy and the lower vegetational strata in (a) arthropod faunal composition and species-richness; (b) arthropod activity; (c) arthropod density; and (d) apparent grazing pressure of herbivores. Although Sutton (1983) studied the flight activity of nocturnal insects below the canopy, these assumed differences have not been investigated to date. During a short field study we tested whether items (c) and (d) were true for sedentary and poorly-active arthropods inhabiting the shrub layer and the canopy of a lowland rain forest in Cameroon.

Material and Methods

Study site and canopy access. Sampling was performed in the Reserve of Campo, South of Kribi, Cameroon (2°38′59″N, 9°54′21″E), during 3 weeks in October–November 1991, at the end of the rainy season. Much of the reserve consists of primary lowland and evergreen rain forest, which has been logged over, with some unlogged remnants. Canopy access was achieved with the logistical assistance of 'Opération Canopée', as follows. An air-inflated dirigible of 7500 m^3 (Cleyet-Marrel, 1990) was used to lift up and to set down upon the canopy a 580 m^2 platform of hexagonal shape (the 'canopy raft'). The raft, which consisted of air-inflated beams and Aramide netting (Ebersolt, 1990), was positioned on particular sites upon the canopy and moved every week by the dirigible (Hallé & Blanc, 1990). Access to the raft was provided by single rope techniques. A second set of canopy samples was obtained when one of us (Y.B.) was sampling the foliage from the 'luge', a triangular platform of about 16 m^2 which was suspended below the dirigible and which 'glided' over the canopy at low speed (Ebersolt, 1990).

Arthropod sampling and guild assignment. Arthropods were sampled with the branch clipping method within the shrub layer (foliage within the reach of hands, up to 2.5 m above the ground) and on the canopy (see discussion of methodology in Majer & Recher, 1988; Blanton, 1990). A few branches or branchlets were enclosed within a plastic bag (heavy duty garbage bag of 110 litres). The aperture of the bag was clipped to a circular and metallic frame, which was connected to a stick. With the aid of the stick, the foliage was quickly enclosed within the bag. The frame maintained the aperture of the bag open during this operation and this reduced foliage disturbance and arthropod escape. The bag was closed, the branches cut and a cotton ball saturated with ethyl acetate was dropped into the bag. The anaesthetized arthropods were recovered a few hours later after shaking the bag twenty times, removing the branches and turning the bag upside down into a funnel connected to a collecting vial with ethanol 70°. The foliage and the bag were inspected for any remaining arthropods. Active and inactive mines and galls were also recorded, but no attempt was made to recover insects inside stems. Sampling was performed during day-time, usually in the morning, and we attempted to sample as many plant species as possible. The procedure appeared to be efficient for most sedentary, apterous and/or poorly-active arthropods but not for active fliers which were easily dislodged from the foliage (e.g. most Diptera, Hymenoptera). We restricted our sampling to the foliage of trees, vines and, in the shrub layer, of shrubs, treelets and saplings. Four sites were sampled at random within the shrub layer, where foliage situated in deep shade was collected only. In contrast, sampling on the canopy was limited by technical requirements. Three raft sites were visited and samples consisted of accessible foliage from the raft, in full sunlight. These were taken immediately after a 12 h observation period which followed setting up on a new site and during which no scientific activity and little disturbance occurred on the raft. Foliage samples obtained with the luge were cut and then enclosed in plastic bags. Table 1 summarizes the number of samples collected at the different sites.

Arthropods were sorted by the senior author to Operational Taxonomic Units (OTUs or morphospecies). OTUs sorted within a certain sample were not cross-referenced with OTUs from other samples. Arthropods were counted and assigned to six broad feeding guilds, whose choice ensured consideration of enough individuals within each guild for sound statistical analysis. These guilds were the following: (a) ants (various feeding habits); (b) spiders (predators); (c) parasitoids; (d) herbivores; (e) scavenging fauna (scavengers, fungal-feeders, epiphyll grazers, dead wood eaters, etc.); and (f) others. In the absence of precise biological information, some assumptions had to be made about the guild assignment (e.g. all individuals from a certain family belong to the same guild), and these are detailed in the Appendix.

Evaluation of sample size and leaf damage. All the leaves from the sample were counted and the leaf areas (double-sided) of five leaves randomly selected from within the sample were estimated using squared paper. Precision of measurement was in the order of 1 cm^2. This procedure was applied separately for mature and young leaves (i.e. not fully pigmented and of tender taxture). Overall sample size was estimated as:

sample size = mean leaf area of young leaves × no. of young leaves + mean leaf area of mature leaves × no. of mature leaves.

Table 1. Characteristics and number of samples obtained in different sites, number of plant species sampled and height at which samples were taken.

Site	Rain forest type	Samples	Plants	Height (m)
Shrub layer, site 1	Primary, logged	7	6	0–2.5
Shrub layer, site 2	Primary, logged	14	12	0–2.5
Shrub layer, site 3	Primary, logged	20	18	0–2.5
Shrub layer, site 4	Primary, logged	20	20	0–2.5
Raft, site 1	Primary, logged	34	4	40
Raft, site 2	Primary, logged	16	7	37
Raft, site 3	Primary, unlogged	12	4	42
Luge	Primary, unlogged	15	13	35–40

Since no obvious correlation existed between total sample area and total number of arthropods recovered from the sample, arthropod numbers were not corrected accordingly to sample area (see Results section). Leaf damage was measured as percentage of apparent leaf damage (ALD), not as absolute loss of area. ALD was estimated visually for all young and mature leaves of the sample (Basset, 1991b), using the following score categories:

0%, 1%, <5%, 5–10%, 10–20%, 20–50%, 50–80%, and 80–100%.

The average ALD of the sample was calculated as the average percentage damage per leaf, obtained in summing the mid-point value of corresponding class scores and dividing this sum by the number of leaves. Usually, bunches of five to ten leaves were scored, instead of individual leaves, unless their scores differed greatly.

Results

Influence of sample size

We sampled about 117 m^2 of foliage and, when samples were pooled, mean sample size averaged 0.849 ± 0.03 m^2 (mean ±SE). There was no correlation between total sample area and total number of arthropods recovered from the samples (Fig. 1a). This observation was similar for relationships between the number of individuals belonging to different guilds and (a) total sample area and (b) young foliage area. Log-transformation of the data did not improve the relationships between guilds and sample area. Therefore, arthropod numbers were expressed per unit sample, which roughly translated to 0.85 m^2 of foliage. However, there was a positive correlation between total sample size and number of OTUs sorted within the samples (Fig. 1b).

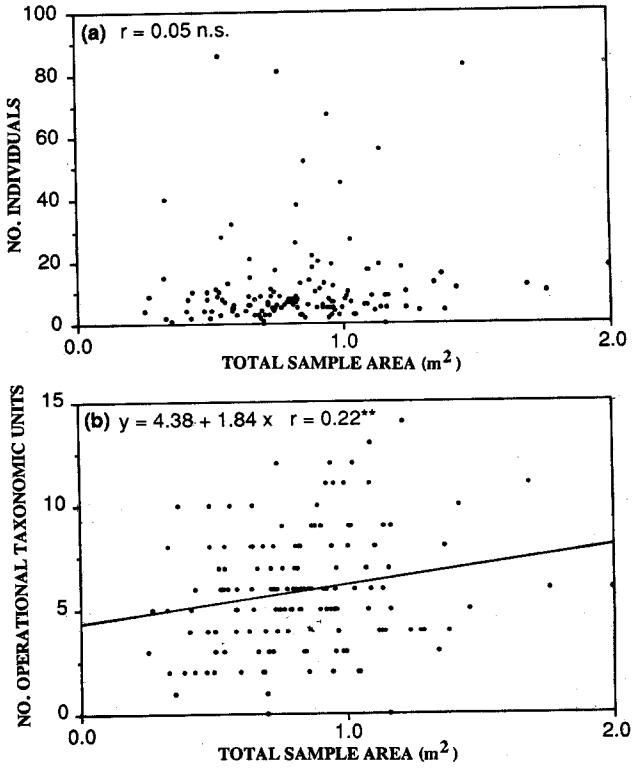

Fig. 1. Relationships between the total sample area and (a) the number of individuals recovered from the samples and (b) the number of Operational Taxonomic Units sorted from the samples (a few points distant to the cloud are not figured).

Arthropod abundance

A total of 2271 arthropods, which were distributed in eighty-eight families (see Appendix), were recovered from the samples. The uniformity of the distribution of arthropods within the guilds recognized was investigated by table contingency analysis. First, the distribution was non-uniform when all canopy samples (raft and luge samples) were compared with all samples obtained from the shrub layer (2×6 table, $G = 350.0$, $P < 0.001$). Second, the distribution was non-uniform when the three raft sites were compared (3×6 table, $G = 210.7$, $P < 0.001$). Third, the distribution was non-uniform when we compared raft samples with luge samples (2×6 table, $G = 70.3$, $P < 0.001$). Last, the distribution was also non-uniform when the four sites of the shrub layer were compared (4×6 table, $G = 64.7$, $P < 0.001$).

When samples were pooled, arthropod density amounted to 16.6 individuals per sample (Table 2). Ants represented

Table 2. Mean number of individuals (SE) sorted from all samples, from samples of the shrub layer and from canopy samples. The last entry refers to the mean number (SE) of operational taxonomic units sorted from the samples. *t*-tests indicate significant differences between samples from the shrub layer and from the canopy.

Variable	Pooled samples	Shrub layer	Canopy	*t*-tests
All arthropods	16.56 (2.85)	7.00 (0.91)	24.13 (4.91)	3.43 ***
Ants	7.35 (1.65)	1.31 (0.35)	12.13 (2.84)	3.79 ***
Spiders	1.27 (0.26)	1.75 (0.57)	0.88 (0.11)	1.51 n.s.
Parasitoids	0.17 (0.04)	0.18 (0.07)	0.17 (0.05)	0.14 n.s.
Herbivores	5.10 (1.32)	1.48 (0.38)	7.97 (2.30)	2.79 **
Scavengers	1.90 (0.15)	1.49 (0.17)	2.22 (0.23)	2.56 *
Others	0.76 (0.10)	0.77 (0.17)	0.75 (0.12)	0.08 n.s.
No. OTUs	5.81 (0.23)	4.80 (0.28)	6.61 (0.33)	4.16 ***

* $P<0.05$, ** $P<0.01$, *** $P<0.001$.

in average 44% of individuals, herbivores 31%, scavenging fauna 11%, spiders 8%, others 5% and parasitoids 1% (Table 2). Canopy samples yielded significantly more individuals (all arthropods considered), ants, herbivores, scavenging fauna and number of OTUs sorted than did samples from the shrub layer (Table 2). When the respective effects of site location and of layer (shrub layer and canopy) were tested by two-way ANOVA (Table 3), more variance was explained by layer effect than by site effect for all arthropods, ants, and herbivores. In contrast, site effect was prevalent for parasitoids, scavengers and others. The number of OTUs sorted appeared to be equally dependent on layer and site effects. When canopy samples alone were considered (Table 4), there were significant differences in the abundance of some arthropod guilds. In particular, the second raft site yielded more individuals and ants, the third raft site more parasitoids and the luge less scavengers and number of OTUs sorted.

Foliage characteristics

Despite small differences in sample size, the total leaf area collected per sample was relatively similar in all sites, and, in particular, there was no statistical difference between samples in the shrub layer and those in the canopy (Table 5). Slightly more young foliage was collected from the canopy than from the shrub layer (Table 5) and this was consistent with our general impression that young leaves were more common on the former than within the latter. The average leaf area was larger in the shrub layer than on the canopy (Table 5). Overall apparent leaf damage, as estimated crudely, amounted to $7.7 \pm 0.6\%$. It was significantly higher in the shrub layer than on the canopy, both for young and mature foliage (Table 5). ALD was slightly higher on mature foliage than on young foliage but this was not significant (paired *t*-test, $t = 0.864$, $P < 0.391$). Significantly more mines were recovered from canopy samples than from samples of the shrub layer, whereas this trend did not exist for galls (Table 5).

Discussion

Our methodology was strongly biased towards poorly-active arthropods. In every part of the sampling procedure it is probable that some specimens were lost. However, there is no reason to believe that the bias was different between samples from the shrub layer and from the canopy, and, in particular, average sample sizes were similar in these layers. The only potential source of bias between these two sets of samples is the number of plant species sampled, which was higher within the shrub layer than in the canopy. This is a logistic limitation of the raft, which may be avoided in using the luge (Table 1). It appeared that there were no sharp differences between raft and luge samples regarding arthropod abundance and foliage characteristics. This suggests that the biases inherent in our sampling methodology were larger than those originating from any foliage disturbance after the raft has been set up on the canopy. However, there were differences between raft sites, particularly at the third site where far fewer ants

Table 3. Results of two-way ANOVA testing the effects of layer (shrub layer and canopy) and of site (four sites within the shrub layer; three raft sites and luge site on the canopy) on arthropod abundance and number of OTUs sorted.

Variable	Interaction	MS	F-ratio	*P*
All arthropods	Layer	9742.6	10.11	0.002
	Site	2331.8	2.42	0.069
	Site*layer	3463.1	3.60	0.015
	Error	963.3		
Ants	Layer	4186.3	13.53	0.000
	Site	1119.2	3.62	0.015
	Site*layer	1172.2	3.79	0.012
	Error	309.3		
Spiders	Layer	18.5	2.03	0.157
	Site	10.2	1.12	0.345
	Site*layer	3.94	0.43	0.730
	Error	9.12		
Parasitoids	Layer	0.09	0.45	0.503
	Site	0.57	2.78	0.044
	Site*layer	1.60	7.81	0.000
	Error	0.21		
Herbivores	Layer	1502.7	6.93	0.009
	Site	398.1	1.84	0.144
	Site*layer	534.7	2.46	0.065
	Error	216.8		
Scavengers	Layer	2.53	0.94	0.334
	Site	17.6	6.55	0.000
	Site*layer	2.68	1.00	0.397
	Error	2.69		
Others	Layer	2.82	2.20	0.140
	Site	7.00	5.47	0.001
	Site*layer	4.56	3.56	0.016
	Error	1.28		
No. OTUs	Layer	48.69	7.84	0.006
	Site	26.74	4.31	0.006
	Site*layer	12.48	2.01	0.116
	Error	6.21		

were recorded. This accounts for the difficulty of studying rainforest ecosystems, whose spatial heterogeneity is prominent. Another potential problem was the relatively short duration of the sampling period and it is not known if our conclusions apply to different times of the day, especially night-time, or to different periods of the year.

When samples from the shrub layer and from the canopy were pooled, we estimated arthropod densities to average seventeen individuals (all arthropods), including seven ants and five herbivores, per 0.85 m^2 of foliage area. As emphasized previously, it is probable that these figures are underestimated, but they provide a guide for comparison with other studies. Our values appear low, particularly the herbivore figure, in comparison with similar data and also biased towards poorly-active insects, as recorded for various temperate trees (19–78 herbivores per m^2 of foliage; Basset & Burckhardt, 1992) and for a subtropical tree (11 herbivores per m^2; Basset & Arthington, 1992). Thus, our estimates tend to confirm the impression that arthropod densities are lower on tropical foliage than on temperate foliage (Elton, 1973). The predominance of ants in vegetation samples is also consistent with data reported in neotropical forests (Wilson, 1987; Tobin, 1991).

Arthropod densities were about 3 times higher on the canopy than within the shrub layer. Despite myrmecophilous plants being relatively common in the shrub layer, foraging by ants appeared to be more common in the canopy than within the shrub layer. However, our data did not account for twig-dwelling ants. Ants of the genus *Crematogaster* were often tending coccoids, which represented a substantial proportion of herbivores on the canopy. Removing coccoids from analyses did not suppress the trend of herbivores being significantly more abundant in the canopy than within the shrub layer. In fact, without accounting for ants and coccoids, arthropod abundance was still more than 2 times greater in the canopy as within the shrub layer. Thus, the high foraging activity of ants in the canopy may be explained partly as a result of the high arthropod productivity of the canopy (as measured by the number of individuals) and the concomitant presence of potential prey. In addition, the canopy may represent an optimal habitat for certain ant species to tend coccoids.

It was first hypothesized that the scavenging fauna should be more abundant near ground level than in the canopy, because of the higher number of adequate habitats in the former layer. Surprisingly, the situation was reversed. Perhaps our classification of functional guilds was too crude to account for possible differences within this 'guild'. Spider abundance was higher near ground level than in the canopy, but not significantly so. Arthropod species-richness, as estimated by the number of OTUs sorted, appeared higher in canopy samples than in the samples obtained in the shrub layer. However, these data should be interpreted with caution, particularly because the number of species was more dependent upon sample size than was the number of individuals.

Different factors may account for the high abundance of herbivores on the canopy. First, as partly suggested by the present study, the productivity of the canopy is higher than that of the light-limited understorey. There is a higher supply of young foliage, which is often more nutritious for herbivores than mature foliage (Mattson, 1980), on the canopy than within the shrub layer. However, there was no obvious correlation between the amount of young foliage and the number of herbivores recovered from the samples. Second, the high illumination and temperature experienced by the canopy may enhance foraging by adult herbivores, oviposition and subsequent high herbivore densities in this layer (see Moore *et al.*, 1988). Third, the smaller leaves of the canopy and the generally high foliage compactness there, in comparison with the larger and fewer leaves of the shrub layer, may protect herbivores from predators. Last, leaf biochemistry of deep shade and sun leaves may differ to such an extent that canopy leaves may be nutritionally more rewarding than leaves within the shrub layer. This was not supported by our estimates of apparent leaf damage, which were significantly higher

Table 4. Mean number of individuals (SE) and mean number of OTUs recovered per sample for the four canopy sites. Significantly different means are followed by different letters (one-way ANOVA and Tukey tests, $P < 0.05$).

Variable	Raft 1	Raft 2	Raft 3	Luge	ANOVA, *F*
All arthropods	13.53[a] (1.45)	50.50[b] (19.84)	9.25[a] (1.50)	31.93[ab] (10.99)	3.68 *
Ants	5.79[a] (1.14)	29.50[b] (11.54)	3.00[a] (1.05)	15.27[ab] (5.45)	4.49 **
Spiders	0.94 (0.16)	0.75 (0.23)	1.25 (0.33)	0.60 (0.21)	1.17 n.s.
Parasitoids	0.12[a] (0.06)	0.06[a] (0.06)	0.58[b] (0.23)	0.07[a] (0.07)	4.92 **
Herbivores	2.97[a] (0.51)	17.19[a] (9.12)	2.00[a] (0.37)	14.27[a] (5.95)	2.84 *
Scavengers	2.82[a] (0.42)	2.56[ab] (0.42)	1.67[ab] (0.40)	0.93[b] (0.29)	3.91 *
Others	0.88 (0.13)	0.44 (0.16)	0.75 (0.35)	0.80 (0.44)	0.67 n.s.
No. OTUs	7.35[a] (0.47)	6.62[ab] (0.68)	7.17[ab] (0.92)	4.47[b] (0.59)	4.11 **

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 5. Characteristics of foliage samples (mean and SE), detailed for the shrub layer and for the four canopy sites. *t*-tests indicate significant differences between the shrub layer and the canopy.

Variable	Shrub layer	Raft 1	Raft 2	Raft 3	Luge	*t*-tests
Foliage area (cm^2) (1)	8086 (298)	9619 (841)	8492 (968)	8883 (869)	7260 (917)	1.28 n.s.
Foliage area (cm^2) (2)	411 (128)	886 (159)	205 (120)	491 (223)	1210 (345)	1.98 *
Leaf area (cm^2)	68 (5.8)	18 (0.3)	38 (5.3)	32 (11.0)	88 (60.1)	2.28 *
Leaf damage (%) (1)	10.9 (0.89)	2.9 (0.35)	6.6 (0.80)	8.9 (2.92)	6.2 (0.69)	739.5 *(3)
Leaf damage (%) (2)	10.4 (2.28)	3.7 (0.65)	2.4 (0.55)	5.4 (2.40)	5.6 (1.33)	3700.5 ***(3)
Mines (no.)	0.15 (0.08)	0.62 (0.39)	2.06 (1.07)	0.58 (0.23)	2.40 (1.04)	3.07 **
Galls (no.)	0.93 (0.82)	0.50 (0.28)	0.44 (0.20)	0.50 (0.29)	4.07 (3.20)	0.24 n.s.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.
(1) Young and mature leaves, (2) Young leaves only, (3) Non-parametric test, Mann-Whitney *U*.

in the shrub layer than in the canopy. However, estimates of ALD are plagued with problems of interpretation (see Lowman, 1984; Landsberg, 1989; Basset, 1991b) and therefore our data should be interpreted with caution. The following factors probably account for the difference reported: (a) a high grazing pressure of herbivores within the shrub layer, since young leaves are rare per unit volume near ground level (Basset, 1991b); (b) compensatory grazing rates to overcome less nutritious leaves within the shrub layer (e.g. Moore & Francis, 1991); (c) when intraspecific leaves are compared, lower defensive characteristics of shade leaves than sun leaves (Lowman, 1985; Coley, 1988); (d) greater lifetime of shade leaves than that of sun leaves, which may increase discrete estimates of

apparent leaf damage within the shrub layer (Coley, 1988; Greenwood, 1990; some understorey damage may also result from the steady rain of falling branches); (e) higher hole expansion rates within leaves of the shrub layer than within leaves of the canopy (see Landsberg, 1989); and (f) high predatory pressure of ants upon the canopy, which may depress population levels of free-living herbivores such as caterpillars (Fowler & Macgarvin, 1985), usually responsible for high apparent leaf damage (Basset, 1991b).

To summarize, this simple field study confirmed that during day-time arthropod abundance on the canopy may be much higher than that within the shrub layer. We are aware of the methodological limitations of our study, but the paucity of information relevant to canopy arthropods confers a particular interest to our data. Other comparative studies are needed in order to establish whether arthropod activity, species-richness and biomass follow the same trend reported for arthropod abundance and whether this situation is widespread and occurs during other periods of the day, of the year, and in other rain forest types.

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Appendix

Distribution per family of the number of arthropods collected in foliage samples. Numbers refer to individuals collected from samples of the four sites within the shrub layer, of the three raft sites and of the luge, respectively (samples from the shrub layer and the canopy are separated by a '/'). Guild assignment is given in parentheses, as follows: a = ants, s = spiders, p = parasitoids, h = herbivores, c = scavenging fauna, o = others (j = juveniles).

Acari	
Unknown (o)	10, 1, 2, 3 / 3, 5, 1, 0
Araneae	
Anapidae (s)	0, 3, 0, 0 / 0, 0, 0, 0
Araneidae (s)	1, 1, 0, 2 / 0, 0, 0, 1
Barychelidae (s)	2, 0, 0, 2 / 0, 0, 0, 0
Clubionidae (s)	1, 1, 1, 0 / 6, 1, 1, 2
Heteropodidae (s)	0, 0, 1, 35 / 1, 0, 1, 0
Linyphiidae (s)	0, 2, 1, 4 / 0, 0, 0, 0
Pholcidae (s)	0, 1, 2, 3 / 0, 0, 0, 0
Salticidae (s)	4, 5, 2, 3 / 4, 3, 3, 2
Thomisidae (s)	0, 0, 1, 2 / 2, 0, 0, 1
Unknown (s)	2, 9, 8, 8 / 19, 0, 10, 3
Blattodea	
Blattidae (c)	0, 1, 1, 0 / 1, 0, 0, 0
Unknown (j) (c)	0, 0, 0, 0 / 0, 0, 1, 0
Collembola	
Entombryidae (c)	13, 7, 9, 9 / 15, 5, 4, 2
Isotomidae (c)	0, 0, 0, 0 / 0, 1, 0, 0
Sminthuridae (c)	2, 0, 0, 0 / 0, 0, 0, 0
Coleoptera	
Aderidae (c)	1, 0, 0, 0 / 0, 0, 0, 0
Anobiidae (c)	0, 0, 0, 0 / 0, 0, 1, 0
Anthicidae (c)	0, 0, 1, 0 / 0, 0, 0, 0
Brenthidae (c)	1, 0, 0, 0 / 0, 0, 0, 0
Cantharidae (o)	0, 0, 1, 0 / 0, 0, 0, 0
Carabidae (o)	0, 0, 0, 0 / 2, 0, 0, 0
Cerambycidae (c)	0, 1, 0, 0 / 0, 0, 0, 0
Chrysomelidae (h)	0, 0, 3, 5 / 2, 1, 4, 1
Coccinellidae (o)	0, 0, 0, 0 / 0, 0, 1, 0
Corylophidae (c)	1, 1, 0, 0 / 6, 2, 0, 0
Curculionidae (h)	3, 2, 6, 5 / 5, 4, 0, 1
Elateridae (o)	0, 0, 0, 0 / 1, 0, 1, 0
Endomychidae (c)	0, 0, 1, 0 / 0, 0, 0, 0
Hydrophilidae (c)	0, 0, 0, 0 / 1, 0, 0, 0
Lathridiidae (c)	0, 0, 0, 0 / 1, 0, 0, 0
Lycidae (o)	0, 1, 0, 0 / 0, 0, 0, 0
Nitidulidae (c)	0, 2, 1, 1 / 12, 2, 0, 0
Platypodidae (c)	0, 0, 0, 0 / 0, 0, 1, 0
Ptiliidae (c)	1. 0, 1, 0 / 13, 3, 0, 1
Salpingidae (c)	0, 0, 0, 0 / 1, 0, 0, 0
Scolytidae (c)	1, 1, 2, 2 / 18, 6, 0, 0
Scydmaenidae (o)	0, 1, 2, 0 / 0, 0, 0, 0
Silvanidae (c)	0, 0, 0, 0 / 4, 4, 1, 1
Staphylinidae (c)	0, 0, 4, 0 / 12, 5, 1, 3
Tenebrionidae (c)	0, 0, 0, 1 / 0, 0, 2, 0
Unknown (j) (c)	0, 0, 1, 0 / 2, 0, 1, 1
Dermaptera	
Labiidae (o)	0, 0, 0, 1 / 1, 2, 1, 0
Diptera	
Agromyzidae (h)	0, 0, 0, 0 / 1, 0, 0, 0
Bibionidae (o)	0, 2, 0, 0 / 0, 0, 0, 0
Cecidomyiidae (o)	3, 2, 1, 0 / 2, 0, 0, 1
Ceratopogonidae (o)	1, 0, 0, 0 / 0, 0, 0, 0
Chironomidae (o)	1, 0, 0, 0 / 3, 0, 0, 0
Chloropidae (o)	0, 0, 0, 1 / 1, 0, 1, 0
Dolichopodidae (o)	0, 1, 0, 0 / 0, 0, 0, 1
Drosophilidae (o)	0, 0, 0, 0 / 3, 0, 0, 2
Phoridae (o)	0, 0, 0, 0 / 1, 0, 0, 0
Sciaridae (o)	0, 0, 0, 0 / 4, 0, 1, 0
Unknown (o)	1, 0, 0, 0 / 0, 1, 0, 0
Diplopoda	
Polydesmida (c)	0, 0, 1, 0 / 0, 0, 0, 0
Hemiptera	
Cicadellidae (h)	1, 2, 1, 1 / 9, 5, 4, 0
Cixiidae (h)	0, 1, 1, 0 / 0, 0, 0, 0
Coccoidea (h)	22, 1, 2, 0 / 45, 247, 0, 195
Cydnidae (h)	0, 0, 0, 0 / 3, 0, 0, 0
Dipsocoridae (o)	1, 0, 1, 0 / 1, 0, 0, 0
Flatidae (h)	0, 0, 0, 0 / 1, 0, 0, 0
Fulgoroidea (j) (h)	0, 0, 1, 1 / 1, 1, 1, 0
Lygaeidae (h)	0, 2, 0, 0 / 4, 4, 1, 2
Membracidae (h)	0, 2, 0, 0 / 6, 5, 0, 2
Miridae (o)	0, 0, 0, 0 / 0, 0, 1, 0

Plataspidae (h)	0, 0, 0, 0 / 0, 0, 1, 1
Psylloidea (h)	0, 1, 0, 0 / 2, 0, 0, 2
Reduviidae (o)	0, 0, 2, 1 / 0, 0, 0, 0
Unknown (j) (h)	0, 1, 1, 0 / 0, 1, 5, 3
Hymenoptera	
Agaonidae (h)	0, 0, 0, 1 / 0, 0, 3, 0
Aphelinidae (p)	2, 0, 0, 0 / 0, 0, 1, 0
Braconidae (p)	0, 0, 0, 0 / 1, 0, 0, 0
Ceraphronidae (p)	0, 0, 0, 0 / 0, 1, 0, 0
Chrysididae (p)	0, 1, 0, 0 / 0, 0, 0, 0
Diapriidae (p)	1, 0, 0, 0 / 0, 0, 0, 0
Encyrtidae (p)	0, 0, 0, 0 / 0, 0, 1, 0
Eupelmidae (p)	0, 0, 0, 0 / 2, 0, 0, 0
Formicidae (a)	9, 22, 21, 28 / 197, 472, 36, 229
Mymaridae (p)	0, 1, 0, 0 / 0, 0, 0, 0
Platygasteridae (p)	1, 0, 3, 0 / 0, 0, 1, 1
Pteromalidae (p)	0, 0, 0, 0 / 0, 0, 1, 0
Scelionidae (p)	0, 0, 0, 0 / 0, 0, 1, 0
Torymidae (p)	0, 0, 1, 0 / 0, 0, 0, 0
Trichogrammatidae (p)	1, 0, 0, 0 / 0, 0, 1, 0
Isopoda	
Oniscoidea (c)	1, 0, 0, 0 / 0, 0, 1, 0
Isoptera	
Unknown (c)	0, 0, 0, 0 / 0, 0, 1, 0
Lepidoptera	
Geometridae (h)	0, 0, 1, 0 / 0, 0, 0, 0
Unknown (j) (h)	0, 2, 5, 3 / 8, 3, 2, 5
Unknown (o)	0, 0, 0, 0 / 0, 0, 0, 1
Mantodea	
Mantidae (o)	0, 0, 0, 0 / 0, 0, 0, 6
Opiliones	
Unknown (o)	0, 0, 0, 2 / 0, 0, 0, 0
Orthoptera	
Acrididae (h)	1, 0, 0, 0 / 1, 0, 0, 0
Gryllidae (c)	0, 1, 0, 3 / 0, 0, 2, 0
Tettigoniidae (o)	0, 0, 3, 1 / 0, 0, 2, 0
Phasmoptera	
Phasmatidae (h)	0, 0, 0, 0 / 0, 1, 0, 0
Psocoptera	
Archipsocidae (c)	0, 0, 0, 0 / 3, 0, 0, 0
Caeciliidae (c)	0, 0, 1, 1 / 1, 0, 0, 1
Ectopsocidae (c)	0, 0, 0, 0 / 1, 0, 0, 1
Hemipsocidae (c)	1, 0, 0, 0 / 0, 0, 0, 0
Lachesillidae (c)	0, 0, 0, 1 / 0, 2, 0, 1
Lepidopsocidae (c)	0, 0, 0, 0 / 0, 0, 2, 0
Pachytroctidae (c)	0, 0, 4, 2 / 2, 8, 0, 1
Psoquillidae (c)	0, 0, 0, 0 / 1, 0, 0, 0
Unknown (j) (c)	0, 1, 1, 5 / 2, 2, 0, 3
Thysanoptera	
Phlaeothripidae (h)	0, 0, 1, 1 / 0, 0, 1, 0
Unknown (h)	2, 1, 5, 3 / 15, 3, 1, 1
Thysanura	
Lepismatidae (c)	0, 0, 1, 0 / 0, 1, 0, 0