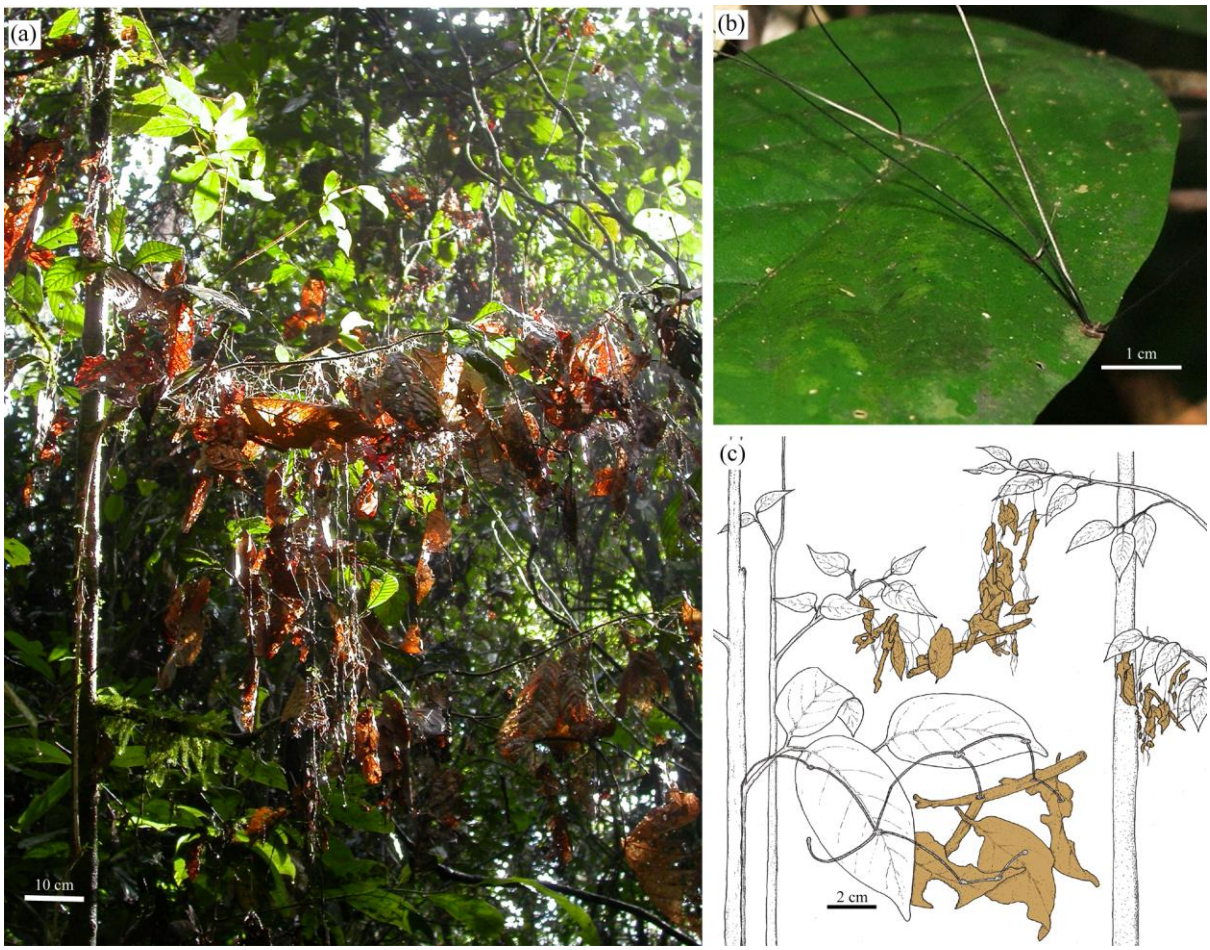
Supplementary Methods for

Biodiversity hanging by a thread: the importance of fungal litter-trapping systems in tropical rainforests

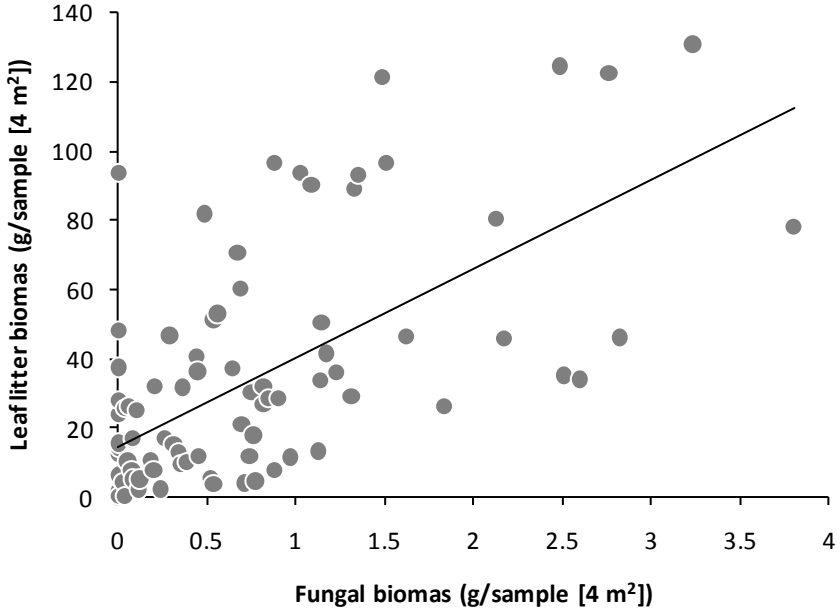
authored by Jake L. Snaddon, Edgar C. Turner, Tom M. Fayle, Chey V. Khen, Paul Eggleton, William A. Foster



Supplementary Figure 1: Litter-trapping fungal networks. *(a)* Photograph of a mass of suspended leaf-litter held by rhizomorph connections in the forest understory at Danum Valley Conservation Area (scale bar = 10 cm); *(b)* detail of adhesion zone with extending rhizomorphs (scale bar = 1 cm); *(c)* diagram of litter-trapping fungal networks, with detail of the rhizomorph connections between living vegetation and intercepted leaf litter (scale bar = 2 cm).

Amount of background canopy leaf litter

Not all of the leaf litter intercepted within the canopy is attached to the fungal networks. Apart from litter held within the other litter-trapping systems, i.e. epiphytes and shrubs, there is a percentage of ephemeral litter which is transient and not secured within the canopy [1]. Of the 100 sites surveyed to assess the distribution of fungal systems and quantity of suspended leaf litter, in twenty-one sites the fungal networks were not present, of which thirteen sites did contain leaf litter. To estimate the amount of background leaf litter and the quantity of litter actually held by the fungal networks we performed a linear regression with dry weight of the fungal systems against dry mass of leaf litter from the hundred sites (Supplementary Figure 2). We used Grubb's test to identify and remove seven outliers [2]. The intercept was then taken as the background quantity of suspended litter: 14.58 g per sample (four m^2) (3.64 g m^2), which matched closely the mean mass of leaf litter from the sites without fungal networks (14.3 g per sample (4 m^2) ± 5.0). This was then subtracted from the quantity of litter recorded for each of the sites before calculating the mean leaf litter held by the fungi.

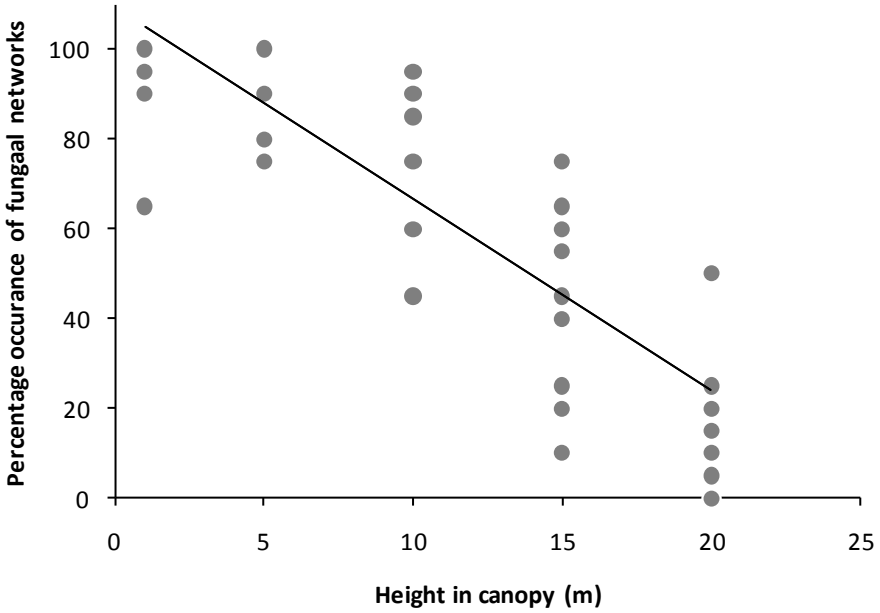


Supplementary Figure 2: Linear relationship between the biomass of fungal rhizomorphs and the biomass of leaf litter, recorded from 100 understory samples (4 m^2 areas to a height of three metres) ($y = 25.691x + 14.578$; $R^2 = 0.41$).

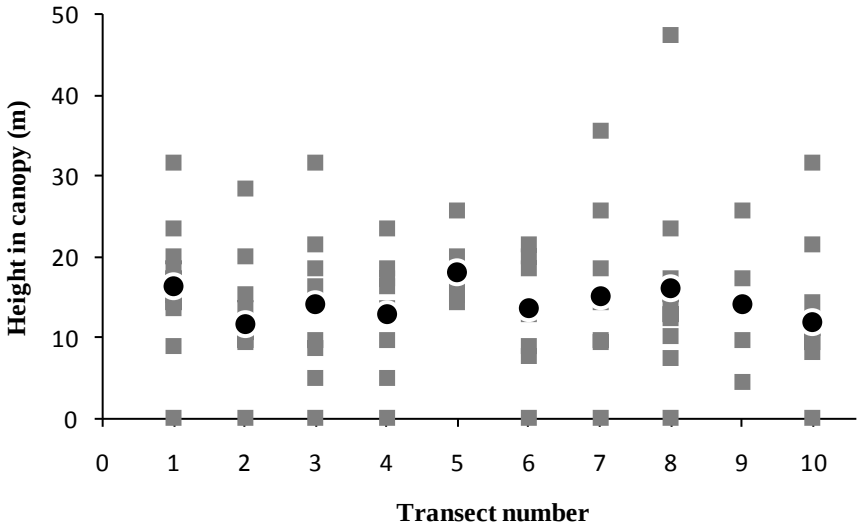
Relationship between canopy height and fungal networks

The vertical distribution of fungal litter-trapping systems was evaluated by recording the presence/absence of fungal systems with a clinometer in cardinal directions at heights of 1, 5, 10, 15 and 20 m, every 20 m along the transects, in 25 m^2 areas. The maximum height that the fungal systems were observed was also recorded every 10 m along the same transects. We used the relationship between canopy height and fungal occurrence (Supplementary Figure 3) to calculate the area below the fitted curve (extrapolated to zero occurrence) and estimate the percentage of total suspended litter held below three metres (21.9 %) and the percentage above three metres (78.1 %). From the collected litter samples, the calculated mass of

suspended leaf litter below three metres was 5.67 ± 1.01 g m^{-2}, assuming that there is no change in the relationship between the mass of leaf litter held by the fungal systems with height, the total litter held throughout the canopy amounts to 25.73 ± 4.58 g m^{-2}; which equates to 257.29 ± 45.77 kg ha^{-1}. The maximum observed height of the fungal networks was over 47 metres (Supplementary Figure 4), though the occurrence of fungal networks within the canopy declined with height (Supplementary Figure 3).



Supplementary Figure 3. Linear relationship between height in canopy and the percentage occurrence of fungi recorded from each of the ten transects; where the presence/absence of fungal systems recorded at the four cardinal directions at heights of 1, 5, 10, 15 and 20 metres in five sites (every 20 metres) along the transects (y = -4.26x + 109.15; R^2 = 0.7393).



Supplementary Figure 4. The grey squares mark the maximum observed heights of fungal networks for each of the sites (n= 10) along each transect. Black dots mark the mean maximum height for each of the ten transects.

Response of arthropod taxa to the fungal network removal

Supplementary Table 1: The effect of removing the fungal litter trapping networks on the abundance and morphospecies richness of arthropod separated by taxa, ± standard error of the mean.

	abundance		morphospecies richness	
	with fungi	without fungi	with fungi	without fungi
Formicidae	16.6 ± 2.8	2.4 ± 0.5	3.6 ± 0.3	1.7 ± 0.3
Araneae	6.3 ± 0.5	2.1 ± 0.4	5.5 ± 0.4	2.0 ± 0.3
Coleoptera	3.2 ±0.5	1.2 ± 0.3	2.5 ± 0.4	0.9 ± 0.2
Blattodea	2.8 ± 0.4	0.3 ± 0.1	1.4 ± 0.2	0.3 ± 0.1
Collembola	1.6 ± 0.4	1.0 ± 0.3	0.7 ± 0.1	0.7 ± 0.2
Isopoda	1.9 ± 0.9	0.2 ± 0.1	0.5 ± 0.1	0.1 ± 0.1
Orthoptera	1.4 ± 0.3	0.4 ± 0.1	1.3 ± 0.3	0.4 ± 0.1
Opiliones	1.3 ±0.2	0.2 ± 0.1	1.1 ± 0.2	0.2 ± 0.1
Diplopoda	1.3 ± 0.3	0.1 ± 0.1	0.8 ± 0.2	0.1 ± 0.1
Acari	1.0 ± 0.2	0.3 ± 0.1	0.8 ± 0.2	0.3 ± 0.1
Hemiptera	1.0 ± 0.3	0.3 ± 0.1	0.8 ± 0.2	0.3 ± 0.1
Diptera	0.6 ± 0.2	0.5 ± 0.2	0.6 ± 0.2	0.5 ± 0.2
Larvae	0.5 ± 0.2	0.2 ± 0.1	0.5 ± 0.1	0.2 ± 0.1
Others	1.9 ± 0.3	0.5 ± 0.2	1.8 ± 0.2	0.6 ± 0.2

Supplementary Table 2: Numbers of orders recorded in the four habitats and morphospecies for the fungal treatments. Total number of orders, shared orders and levels of similarity between the habitats, and equivalent morphospecies data for the fungal treatments. Similarity indices used are S_{class} (Sørenson's classic similarity index) and S_{inc} (Chao's incidence-based measure with a correction for unseen shared species) [3]. The turnover between forest floor litter and fungus layer and between the latter and the canopy was very low.

Habitat	# orders	# species
Canopy	29	-
Litter	27	-
With fungi	24	338
Without fungi	19	176

Habitat Comparisons	Total orders	Shared orders	S_{class}	S_{inc}
Canopy vs litter	31	25	0.893	0.997
Canopy vs with fungi	31	22	0.83	0.985
Canopy vs without fungi	29	19	0.792	0.966
Litter vs with fungi	31	20	0.784	0.973
Litter vs without fungi	28	18	0.783	0.952
With fungi vs without fungi	25	18	0.837	0.99
	Total morphospecies	Shared morphospecies		
With fungi vs without fungi	399	115	0.447	0.652

References

1. Nadkarni N.M., Matelson T.J. 1991 Fine Litter dynamics within the tree canopy of a tropical cloud forest. *Ecology* **72**(6), 2071-2082.
2. Sokal R.R., Rohlf F.J. 2001 *Biometry*. 3rd ed. New York, W. H. Freeman and Company.
3. Colwell R.K. 2009 EstimateS: Statistical estimation of species richness and shared species from samples, Version 8.2. User's Guide and application published at: http://purl.oclc.org/estimates.