Oikos

OIK-03670

Szefer, P., Carmona, C. P., Chmel, K., Konečná, M., Libra, M., Molem, K., Novotný, V., Segar, S. T., Švamberková, E., Topliceanu, T.-S. and Lepš, J. 2017. Determinants of litter decomposition rates in a tropical forest: functional traits, phylogeny and ecological succession. – Oikos doi: 10.1111/oik.03670

Appendix 1

Correlations between input variables

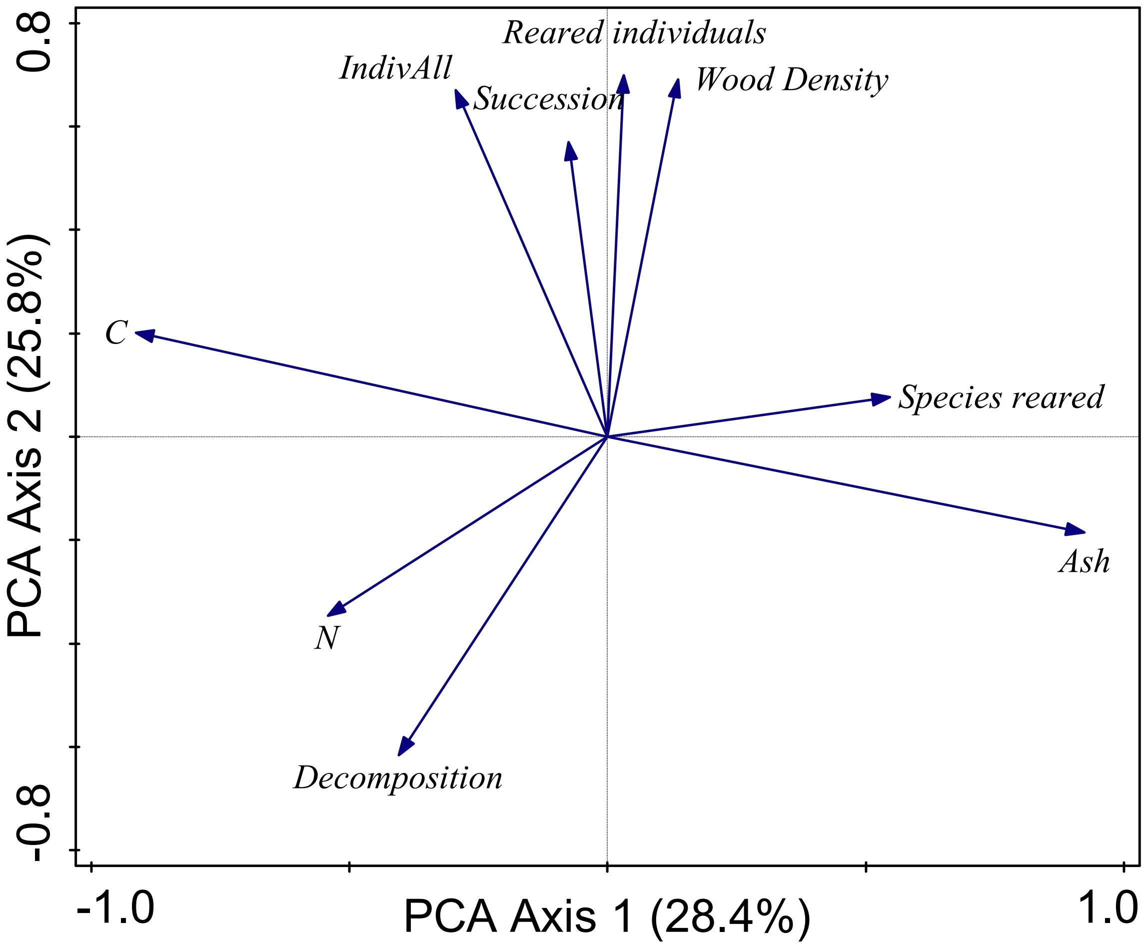

Figure A1. Principal component analysis (PCA) of response variable (decomposition rate) and explanatory variables (physiochemical properties of plant species – nitrogen (N), carbon (C), wood density, ash; plant successional status (succession) and associated insects herbivory rate (recorded individuals of insect – number of externally feeding individuals collected (All individuals), species reared and reared individuals. First two canonical axes explained 54,2 % of variability.

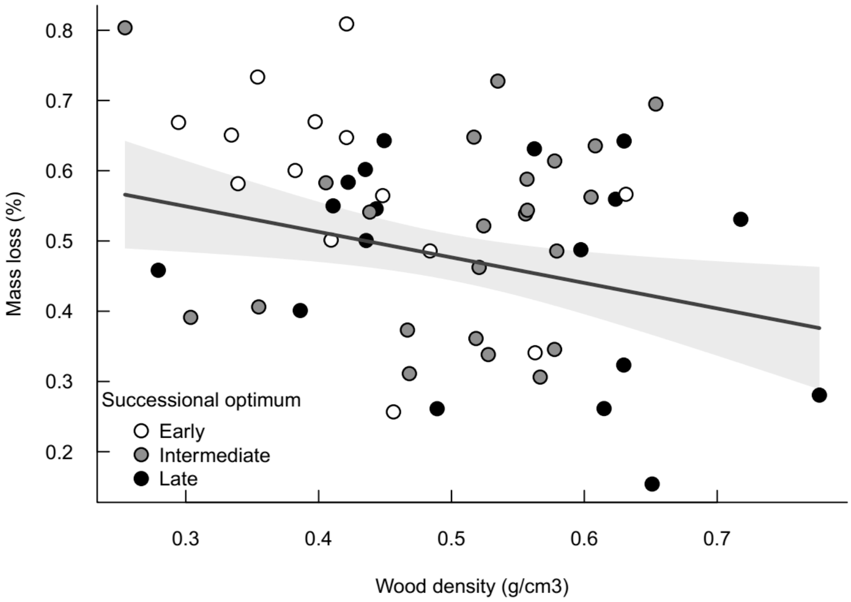

Figure A2. Negative linear relationship between leaves decomposition (the mass loss in %) and wood density of individual tree species (y = 0.659–0.366x, p = 0.015, R^2 = 0.085).

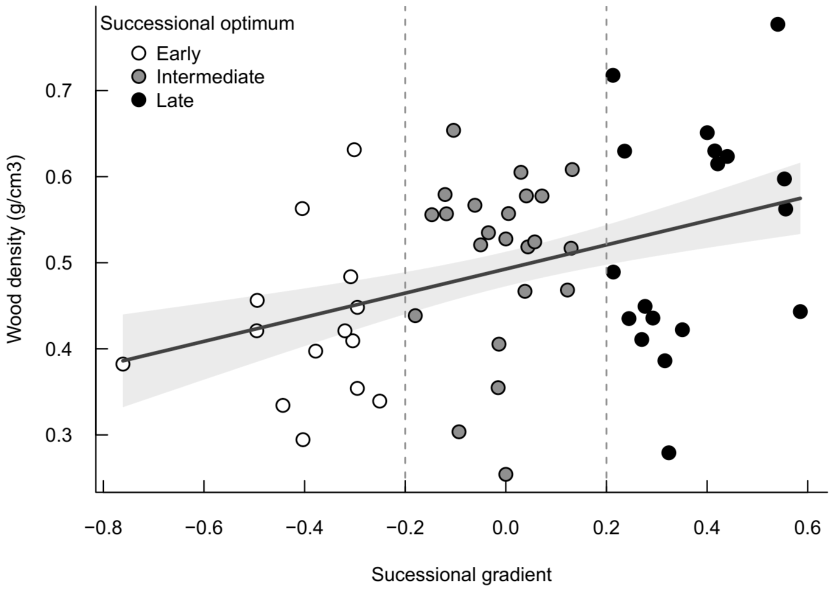

Figure A3. Positive relationship between wood density and plant successional status (y = 0.494 + 0.136x, p <0.001, R^2 = 0.147). The colours represent: early (blank circle), intermediate (grey circles) and late (black circles) successional optimum

Table A1. Correlation coefficients between decomposition rate, physicochemical properties of leaves and focal plant species, plant successional status and associated insects herbivory rate (Individuals recorded - number of externally feeding individuals collected, Species and Individuals reared – number of species and individuals that reared while they were fed by individual plant species). Significantly correlated parameters are shown in bold.

Correlation	N	r	p
Decomposition × N	**56**	**0.56**	**<0.001**
Decomposition × C	56	0.13	0.337
Decomposition × Ash	56	-0.19	0.165
Decomposition × Success	**56**	**-0.30**	**0.024**
Decomposition × Wood density	**57**	**-0.31**	**0.021**
Decomposition × Individuals recorded	56	-0.18	0.190
Decomposition × Species reared	56	-0.10	0.466
Decomposition × Individuals reared	56	-0.25	0.066
N × C	**56**	**0.27**	**0.044**
N × Ash	**56**	**-0.29**	**0.031**
N × Success	**55**	**-0.41**	**0.002**
N × Wood density	56	-0.20	0.147
N × Individuals recorded	55	0.17	0.221
N × Species reared	55	-0.11	0.433
N × Individuals reared	55	0.07	0.633
C × Ash	**56**	**-0.96**	**<0.001**
C × Success	55	0.20	0.134
C × Wood density	56	-0.06	0.669
C × Individuals recorded	**55**	**0.31**	**0.023**
C × Species reared	**55**	**-0.41**	**0.002**
C × Individuals reared	55	0.02	0.873
Ash × Success	**55**	**-0.22**	**0.101**
Ash × Wood density	56	0.03	0.848
Ash × Individuals recorded	**55**	**-0.28**	**0.037**
Ash × Species reared	**55**	**0.41**	**0.002**
Ash × Individuals reared	55	-0.01	0.960
Success × Wood density	**56**	**0.42**	**0.001**
Success × Individuals recorded	55	0.05	0.700
Success × Species reared	55	-0.21	0.117
Success × Individuals reared	55	0.06	0.668
Wood density × Individuals recorded	**56**	**0.27**	**0.044**
Wood density × Species reared	56	0.00	0.972
Wood density × Individuals reared	**56**	**0.37**	**0.005**
Species reared × Individuals recorded	56	0.07	0.606
Species reared × Individuals reared	**56**	**0.32**	**0.015**
Individuals reared × Individuals recorded	**56**	**0.72**	**<0.001**

Appendix 2

Comparison of leaf-litter water content between primary and secondary forest sites

Humidity of forest understorey and related values of leaf litter moisture has been reported to have profound effect on litter decaying rate . Therefore we carried out additional measurements of the litter water content in two focal habitat types: primary and young secondary forest.

Samples of leaf litter were collected from 12:00 to 13:15 on a sunny day on 14 December 2015 near Ohu village in Papua New Guinea. It is noteworthy that a heavy rainfall was recorded during the preceding night. A handful of leaf litter was collected from 20 sites (located within a ~1 km radius) in each of the habitat type: primary and young secondary forest (3–4 years old abandoned gardens). Samples of litter contained exposed particles from a top layer as well as more damp covered parts of litter. This was stored in plastic zip-lock bags while only bags without an air leak were used in order to prevent any litter desiccation. Each bag containing leaf-litter was weighted shortly after the collection finished. After first weighing, bags were cut opened and placed into a drier for 5 days and samples of leaf-litter were reweighed again afterwards. Once dry each empty plastic bag was also weighted and its mass was deducted from a litter mass. The mass differences between fresh and dried leaf-litter provided a percentage water content of each collected litter samples. Difference in water litter content between primary and secondary forest was analysed by one-way ANOVA test. Data were visualised with package ggplot2 (Wickham 2009) using again RStudio.

We found significant difference in leaf litter water content between samples collected in primary and secondary forest (ANOVA, $F_{19,19} = 19.2578$, $p<0.001$). Evidently leaf-litter in secondary forest sites was more exposed to the direct sunlight having lower values of water content compared with leaf-litter in primary forest (Fig. A4)

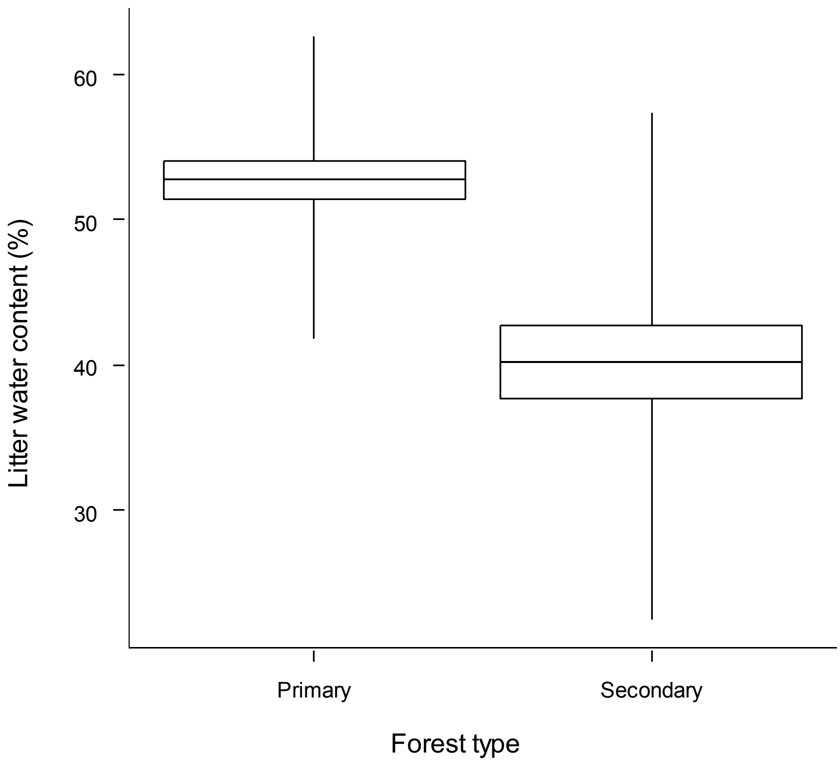

Figure A4. Percentage values of water content (mean ± SE, min. and max.) in leaf-litter collected in primary and secondary forest sites.

Reference

Wickham H. 2009. ggplot2: elegant graphics for data analysis. – Springer.

Appendix 3
List of tree species used in the analysis

Table A2. List of plant species that were used in analysis of leaf-litter decay. Successional status with negative values indicate to early-successional species while high positive values indicate to climax species. Values of relative weight loss obtained during leaf decay experiment in primary and secondary forest are listed for individual plant species.

Plant species	Family	Plant successional status	Weight loss (secondary)	Weight loss (primary)
Artocarpus communis J.R.Forst. & G.Forst.	Moraceae	-0.014	0.559	0.607
Breynia cernua (Poir.) Mull.Arg.	Euphorbiaceae	-0.147	0.478	0.599
Casearia erythrocarpa Sleumer	Flacourtiaceae	0.213	0.518	0.543
Celtis philippensis Blanco	Ulmaceae	0.541	0.228	0.333
Dolicholobium oxylobum K.Schum. & Lauterb.	Rubiaceae	-	0.276	0.401
Dracaena angustifolia Roxb.	Agavaceae	0.277	0.609	0.677
Endospermum labios Schodde	Euphorbiaceae	-0.295	0.723	0.743
Eupomatia laurina R.Br.	Eupomatiaceae	0.044	0.314	0.408
Ficu bernaysii King	Moraceae	0.038	0.390	0.356
Ficus botryocarpa Miq.	Moraceae	-0.180	0.556	0.527
Ficus conocephalifolia Ridl.	Moraceae	0.030	0.533	0.592
Ficus copiosa Steud.	Moraceae	-0.118	0.540	0.636
Ficus dammaropsis Diels	Moraceae	-0.301	0.551	0.582
Ficus hispidioides S.Moore	Moraceae	-0.304	0.431	0.571
Ficus nodosa Teijsm. & Binn.	Moraceae	-0.015	0.374	0.439
Ficu phaeosyce K.Schum. & Lauterb.	Moraceae	0.072	0.260	0.432
Ficus pungens Reinw. ex Blume	Moraceae	-0.308	0.423	0.548
Ficus septica Burm.f.	Moraceae	-0.295	0.529	0.600
Ficus trachypison K.Schum.	Moraceae	-0.056	0.523	0.525
Ficus variegate Blume	Moraceae	-0.093	0.329	0.454
Ficus wassa Roxb.	Moraceae	-0.121	0.464	0.507
Gardenia hansemannii K.Schum.	Rubiaceae	-0.104	0.630	0.760
Gnetum gnemon L.	Gnetaceae	0.415	0.626	0.658
Homalanthus novoguineensis (Warb.) K.Schum.	Euphorbiaceae	-0.319	0.730	0.877
Hydriastele microspadix Burret	Arecaceae	0.324	0.415	0.501
Kibara cf. coriacea Hook.f. & Thoms.	Monimiaceae	0.554	0.468	0.508
Leucosyke capitellata Wedd.	Urticaceae	-0.494	0.218	0.295
Macaranga aleuritoides F.Muell.	Euphorbiaceae	-0.403	0.619	0.719
Macaranga bifoveata J.J.Sm.	Euphorbiaceae	-0.023	0.466	0.617
Macaranga brachytricha Airy Shaw	Euphorbiaceae	-0.443	0.591	0.711
Macaranga densiflora Warb.	Euphorbiaceae	-0.320	0.601	0.694
Macaranga novoguineensis J.J.Sm.	Euphorbiaceae	0.316	0.321	0.481
Macaranga quadriglandulosa Warb.	Euphorbiaceae	-0.378	0.624	0.715
Mallotus mollissimus (Geiseler) Airy Shaw	Euphorbiaceae	-0.251	0.563	0.600
Melanolepis multiglandulosa Rchb. & Zoll.	Euphorbiaceae	-0.495	0.772	0.846
Morinda bracteata Roxb.	Rubiaceae	0.130	0.628	0.667
Mussaenda scratchleyi Wernham	Rubiaceae	-0.035	0.703	0.752

Nauclea orientalis (L.) L.	Rubiaceae	-0.050	0.449	0.476
Neonaclea clemensii Merr. & L.M.Perry	Rubiaceae	0.236	0.308	0.339
Neuburgia corynocarpa (A.Gray) Leenh.	Loganiaceae	0.270	0.520	0.580
Osmoxylon sessiliflorum (Lauterb.) Philipson	Araliaceae	0.351	0.530	0.637
Pavetta platyclada K.Schum. & Lauterb.	Rubiaceae	0.132	0.625	0.645
Pimelodendron amboinicum Hassk.	Euphorbiaceae	0.556	0.579	0.684
Piper aduncum L.	Piperaceae	-0.761	0.627	0.574
Pometia pinnata J.R.Forst. & G.Forst.	Sapindaceae	0.421	0.243	0.280
Premna obtusifolia R.Br.	Verbenaceae	-0.405	0.349	0.332
Psychotria leptothyrsa Miq.	Rubiaceae	0.245	0.630	0.573
Psychotria micralabastra Valeton	Rubiaceae	0.292	0.443	0.558
Psychotria micrococci Valeton	Rubiaceae	0.123	0.235	0.388
Psychotria ramuensis Sohmer	Rubiaceae	0.214	0.231	0.292
Pterocarpus indicus Willd.	Fabaceae	0.005	0.517	0.570
Randia schumanniana Merr. & L.M.Perry	Rubiaceae	0.440	0.517	0.602
Sterculia schumanniana (Schltr.) Guillaumin	Malvaceae	0.585	0.492	0.599
Tabernaemontana aurantiaca Gaudich.	Apocynaceae	0.041	0.622	0.606
Tarenna buruensis Merr.	Rubiaceae	0.057	0.477	0.566
Timonius timon(Spreng.) Merr.	Rubiaceae	-0.062	0.233	0.379
*Versteegia cauliflora*Valeton	Rubiaceae	0.400	0.127	0.181

Appendix 4

Table A3. Results of model fitting tests on the evolution of initial nitrogen content (NITRO), successional optima (OPTIMA) and wood density (WOOD) under eight common models of evolution: white noise model (White); Pagel's (1999) lambda transformation (Lambda); Ornstein-Uhlenbeck model (OU); punctuational (speciational) model of trait evolution (Kappa); a time-dependent model of trait evolution (Delta); diffusion model with linear trend in rates through time (Trend); brownian motion model (BM); early burst model (EB).P-values correspond to likelihood ratio test of a given model and the white noise model.

Model	NITRO	OPTIMA	WOOD	NITRO	OPTIMA	WOOD
	AICc			p-values		
"BM"	120.474	88.827	-66.791	ns	ns	ns
"delta"	110.433	75.509	-76.918	ns	ns	ns
"lambda"	101.544	24.724	-85.639	0.035	0.004	0.002
"kappa"	108.231	41.010	-82.351	ns	ns	ns
"EB"	122.715	91.069	-64.550	ns	ns	ns
"OU"	98.172	32.219	-90.704	0.005	ns	<0.001
"white"	103.741	30.946	-78.497	ns	ns	ns
"trend"	115.430	82.172	-71.870	ns	ns	ns

Appendix 5

Table A4. Results of model fitting tests on the evolution of mass loss under 8 common models of evolution: white noise model (White); Pagel's (1999) lambda transformation (Lambda); Ornstein-Uhlenbeck model (OU); punctuational (speciational) model of trait evolution (Kappa); a time-dependent model of trait evolution (Delta); diffusion model with linear trend in rates through time (Trend); brownian motion model (BM); early burst model (EB).

Model	AICc	lnL	Parameters
White	-50.072425	27.151597	-
Lambda	-49.413308	27.941948	$\lambda = 0.303$
OU	-47.970181	27.220385	$\alpha = 0.526$
Kappa	-37.191620	21.831104	$\kappa = 0.119$
Delta	-4.148924	5.309756	$\delta = 2.999$
Trend	2.730168	1.870210	Slope = 100
BM	9.357964	-2.678982	-
EB	11.830010	-2.679711	$a = -1 \times 10^{-06}$

Appendix 6

Table A5. Values and statistical significance of various measures of phylogenetic signal for mean decomposition values (DECO Mean), decomposition values from secondary (DECO S) and primary (DECO P) forest, initial nitrogen content (NITRO), successional optima (OPTIMA) and wood density (WOOD). C mean - Abouheif's Cmean ; I – Moran's I; K – Bloomberg's K; K* - Bloomberg's K*; Lambda – Pagels lambda. All calculations were performed in R using phyloSignal function from 'phylosignal' package (Keck 2015).

Trait	Cmean	I	K	K*	Lambda
DECO Mean	0.136	0.037	0.069	0.094	0.303
DECO S	0.100	0.021	0.073	0.097	0.169
DECO P	0.160	0.051	0.064	0.088	0.384
NITRO	0.052	0.034	0.156	0.206	0.912
OPTIMA	0.107	0.089	0.085	0.098	0.751
WOOD	0.237	0.143	0.166	0.226	0.823
p-values					
DECO Mean	0.054	0.099	0.150	0.116	0.209
DECO S	0.087	0.164	0.127	0.099	0.635
DECO P	0.024	0.056	0.239	0.155	0.082
NITRO	0.220	0.098	0.010	0.008	0.035
OPTIMA	0.070	0.011	0.057	0.106	0.004
WOOD	0.008	0.002	0.003	0.001	0.002