Appendix S1: Supporting Tables and Figures.

Contents

Table S1:

Site information. MAT: mean annual temperature, MAP: mean annual precipitation, CV: coefficient of variation.

	Bubeng	Ailao-shan	Yuanjiang	Yakushima
Site name	Yunnan	Yunnan	Yunnan	Yakushima
Vegetation	Tropical forest (TRF)	Subtropical evergreen wet forest (STF)	Hot-dry savanna (HDS)	Warm-temperate forest
Elevation (m)	780	2500	480	14 - 1748
Location	21°37'N, 101°35'E	24°32'N, 101°01'E	23°28'N, 102°10'E	30°38'N, 130°62'E
MAT (°C)	21	11.7	24.7	8.1 - 19.4
MAP (mm)	1532.0	1931.0	732.8	4477.0
Dry period (month)	6	-	6	-
Canopy height (m)	35-45	25	4-6	-
Leaf thickness	Measured	Measured	Measured	Measured
Leaf disc thickness	Measured	Measured	Measured	Not-measured
Leaf punch diameter (cm)	0.6	0.6	0.6	1.0
Number of species for species means	60	47	34	193
Number of individuals for individuals means	366	282	204	607
Number of species for CV	60	47	33	5
Number of individuals for CV	366	282	203	26

The site information and climate data in Yunnan, referred to Fei et al. (2018), and Song et al. (2017). MAT and MAP of Yakushima were obtained from the Yakushima meteorological station and Eguchi (2006).

Table S2:

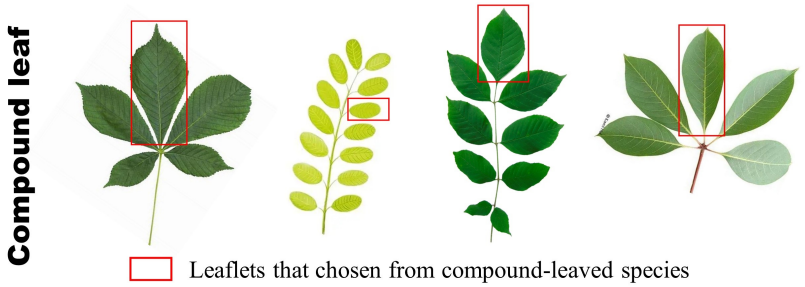
Summary of a linear mixed model for log-transformed total dry mass of leaf discs for each tree individual. Species was used as a random intercept. The small disc is described as an effect of '0.6 cm diameter' compared with '1.0 cm diameter'.

Predictors	Estimate	SE	DF	t-value	*P* value
(Intercept)	-4.410	0.013	1030	-333.00	< 0.001
log(Leaf tissue density)	0.240	0.007	1030	33.20	< 0.001
log(Leaf area)	-0.061	0.009	1030	-6.94	< 0.001
log(Leaf thickness)	0.277	0.008	1030	34.90	< 0.001
Small disc	-0.500	0.020	332	-25.60	< 0.001

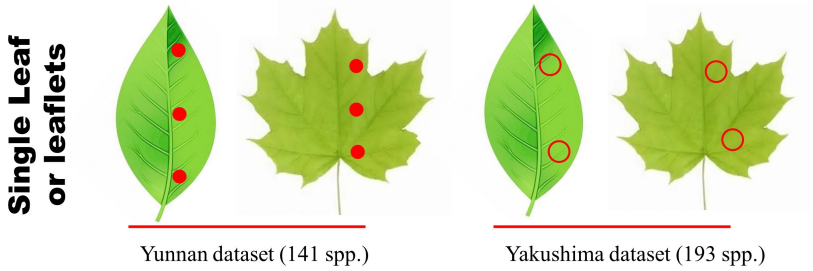
Figure S1:

Detailed sampling protocol for whole-leaf and leaf disc LMA.

Step 1: In case of single-leaved species, then directly move to Step 2. For compound-leaved species, a leaflet was used to represent the whole compound leaf. We chose the biggest leaflets in the compound leaf, normally it was the apex leaflet in imparipinnate and the third or forth leaflet in even-pinnately compound leaf.



Step 2: Entire single leaves or leaflets were used for whole-leaf and disc-LMA determinations. (1) To determine disc-LMA, we punched leaf discs at the different positions from each leaf/leaflet and determined thickness using a micrometer; (2) To determine whole-leaf LMA, we scanned fresh leaf area firstly then determined the thickness at the corresponding positions as did for disc-LMA. Note: In Yunnan dataset, we used a 0.6-cm-diameter puncher and punched three discs from each leaf. In Yakushima dataset, we used a 1-cm-diameter puncher and punched two leaf discs from each leaf.



Step 3: In case of species with small-sized leaves, *e.g.,* length < 3 cm for single leaf , or small compound leaf (*e.g.,* length <10cm), we punched only one disc from each leaf/leaflet for disc-LMA determinations. Specifically: (1) For single-leaved species, we punched one disc from each leaf; (2) For compound-leaved species, we used three leaflets from different positions and obtained one disc from each leaflet. Finally, the mean value of three discs was used. Differently, we used whole compound leaf but not leaflet as did for large compound-leaved species to estimate the whole-leaf LMA for species with small-sized compound leaf. Whole-leaf thickness was calculated as the mean thickness of the three leaflets.

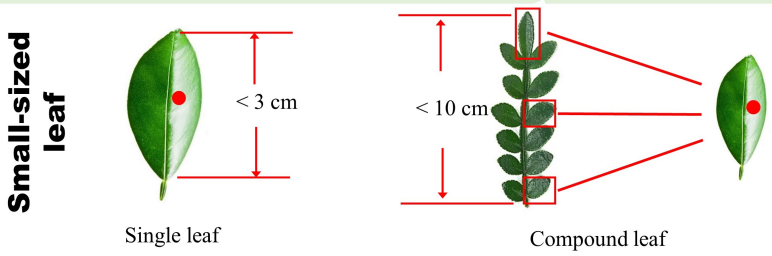


Figure S2:

Generalization for a relationship between ratios of disc-based and whole-leaf-based estimates of leaf mass per area (LMA), leaf tissue density (LD), and leaf thickness (LT). For the *i* tree individual or species, the relationship between ratios of disc-based and whole-leaf estimates of LMA, LD, and LT is:

$$\frac{\mathrm{LD}_{\mathrm{d}i}}{\mathrm{LD}_{\mathrm{w}i}} = \frac{\mathrm{LMA}_{\mathrm{d}i}}{\mathrm{LMA}_{\mathrm{w}i}} \frac{\mathrm{LT}_{\mathrm{w}i}}{\mathrm{LT}_{\mathrm{d}i}}$$

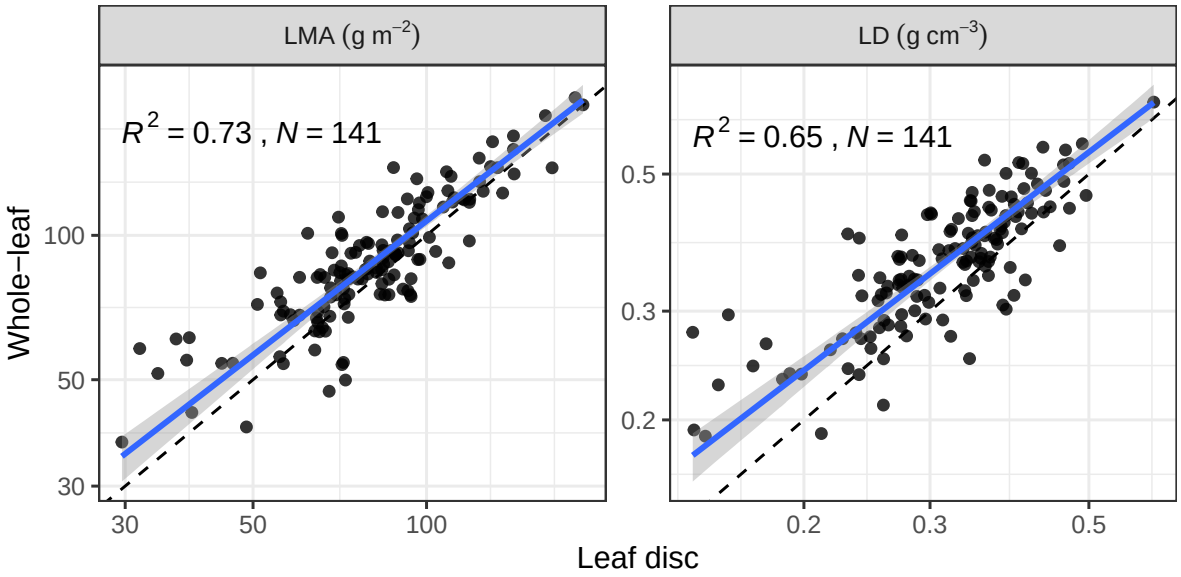
where *d* indicates disc-based estimates, *w* indicates whole-leaf based estimates.

Because thickness is measured on leaf lamina whether one uses a leaf disc or a whole-leaf, the expected ratio between thickness for a leaf disc and a whole-leaf should be 1. The above relationship, therefore, can be rewritten using lognormally distributed multiplicative error (ϵ_i) on the arithmetic scale:

$$\frac{\mathrm{LD}_{\mathrm{d}i}}{\mathrm{LD}_{\mathrm{w}i}} = \frac{\mathrm{LMA}_{\mathrm{d}i}}{\mathrm{LMA}_{\mathrm{w}i}} exp(\epsilon_i) \quad \epsilon_i \sim \mathcal{N}(0, \sigma^2).$$

LMA requires two times measurements (mass and area) and LD requires three time measurements (mass, area and thickness), and thus variance in the ratio of whole-leaf LD and leaf disc LD should be greater than that of LMA.

As we expected LD, showed the slightly smaller R^2 value than LMA (Figure below) in the Yunnan dataset. We have independent measurement for thickness for leaf discs and whole-leaves in the Yunnan dataset. If we use the same leaf thickness values for leaf discs and whole-leaves (i.e., $\mathrm{LT}_{wi}/\mathrm{LT}_{di} = 1$), the scatter plots will be identical for LMA and LD. Consequently, we do not perform further analyses for LD, because differences between whole-leaf LD and leaf disc LD only depends on the ratio between whole-leaf LMA and leaf disc LMA and measurement errors of leaf thickness.

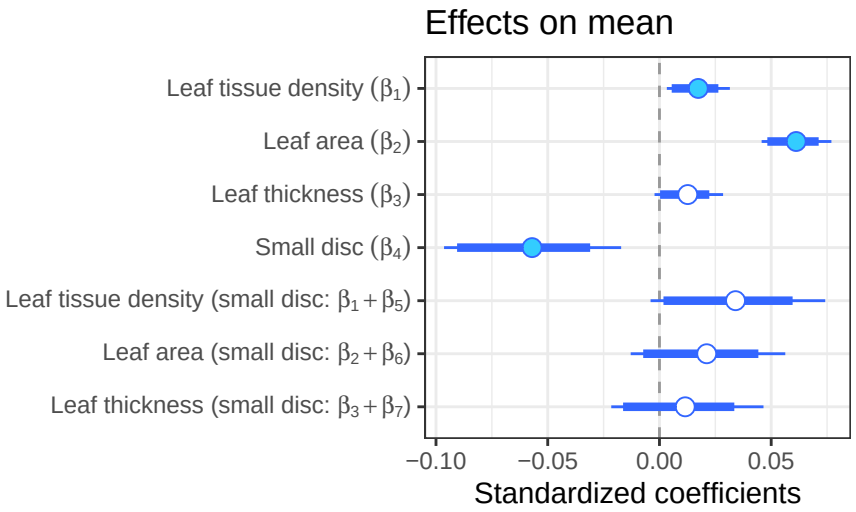


Relationships between species mean leaf mass per area (LMA) and leaf tissue density (LD) determined by using whole leaves and leaf discs for the Yunnan dataset that has both leaf thickness for leaf discs and whole leaves. Dashed lines indicate 1:1 lines. Blue solid lines indicate standardized major axis regressions. The 95% confidence intervals are presented as the shaded area. All the correlations are significant ($P < 0.001$).

Figure S3:

Standardized regression coefficients modeling the effects of leaf tissue density, leaf area, leaf thickness, punch size, and their interactions on (a) the mean estimates of whole-leaf-based leaf mass per area (LMA) and (b) the estimated variance of whole-leaf LMA. The leaf disc LMA was used for the baseline mean of the whole-leaf LMA. Thick and thin lines indicate 90% and 95% credible intervals, respectively. Circles show posterior means of coefficients. Circles filled with blue indicate significant effects and white indicate non-significance effects.

a



b

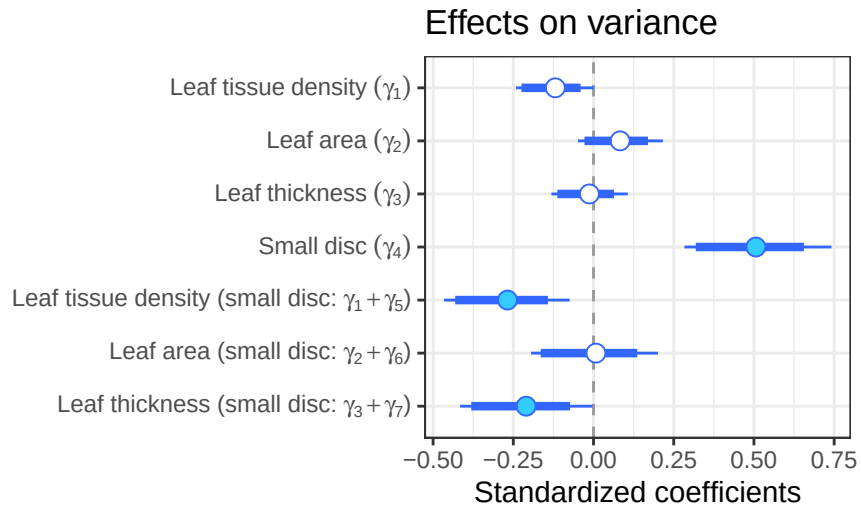


Figure S4:

Relationships between species mean leaf mass per area (LMA) determined by using whole leaves and leaf discs obtained with leaf punches of different diameters. Dashed lines indicate 1:1 lines. Blue solid lines indicate standardized major axis (SMA) regressions. The 95% confidence intervals are resented as the shaded area. The correlation is significant ($P < 0.001$).

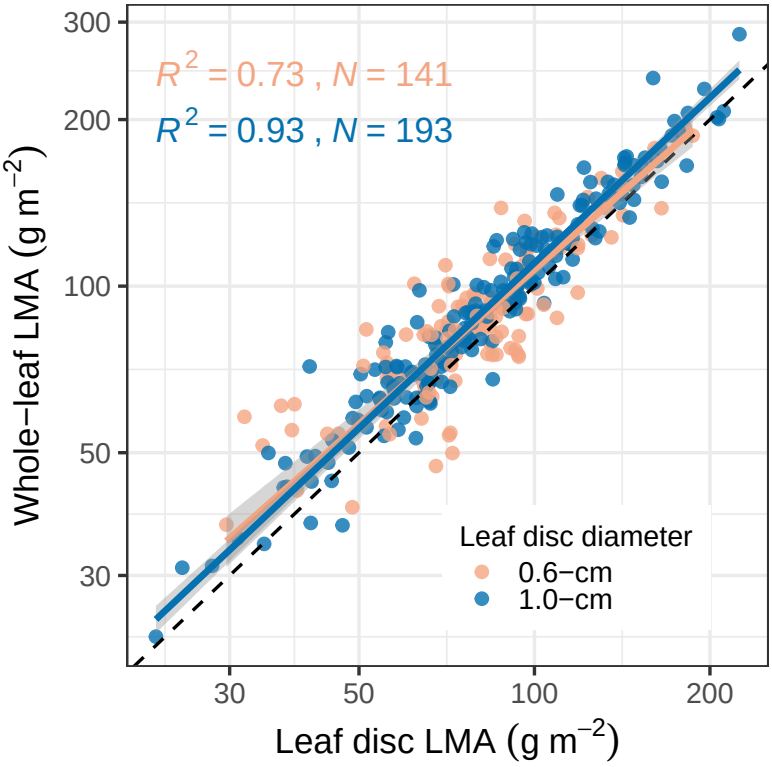
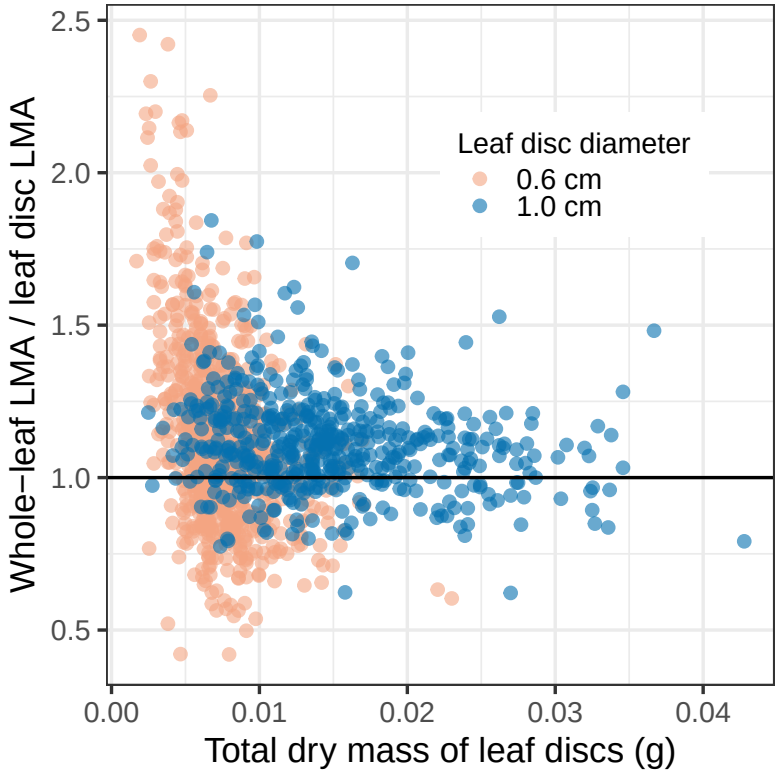


Figure S5:

Relationships between the ratio of whole-leaf leaf mass per area (LMA) to disc leaf LMA and total dry mass for the leaf disc. The relationships was heteroscedastic (unequal variance, $p < 0.001$; all the samples were analyzed together). Samples with small total dry mass tended to show greater variance.



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