Ecography

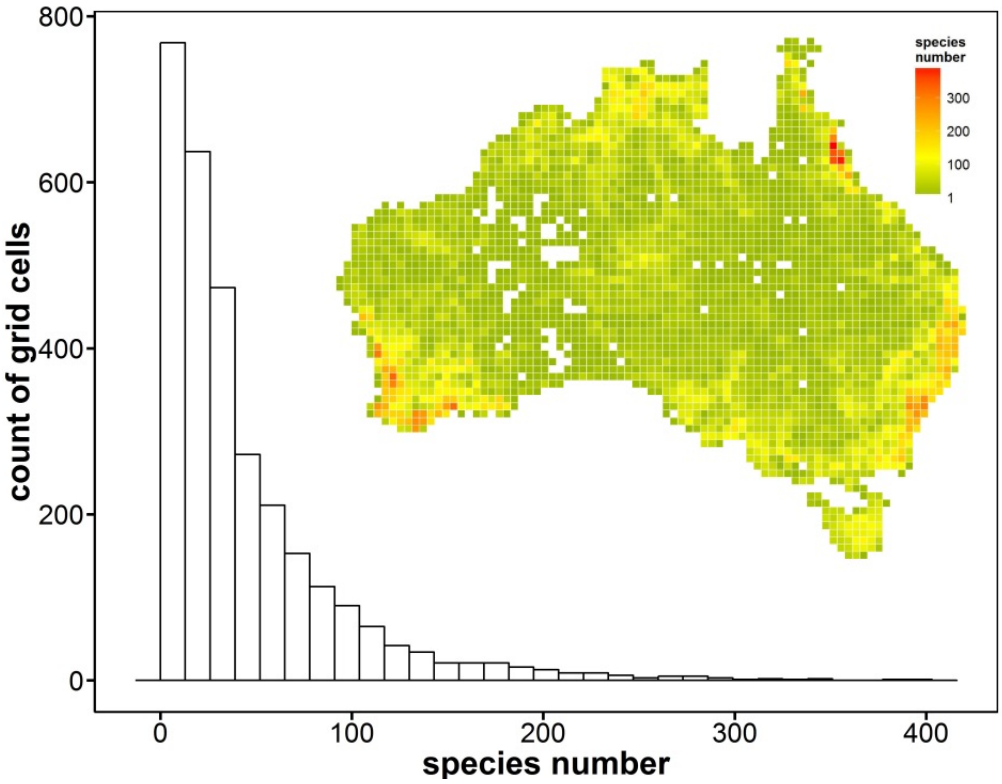
ECOG-02010
Chen, S.-C., Cornwell, W. K., Zhang, H.-X. and moles, A. T. 2016. Plants show more flesh in the tropics: variation in fruit type along latitudinal and climatic gradients. – Ecography doi: 10.1111/ecog.02010

Supplementary material

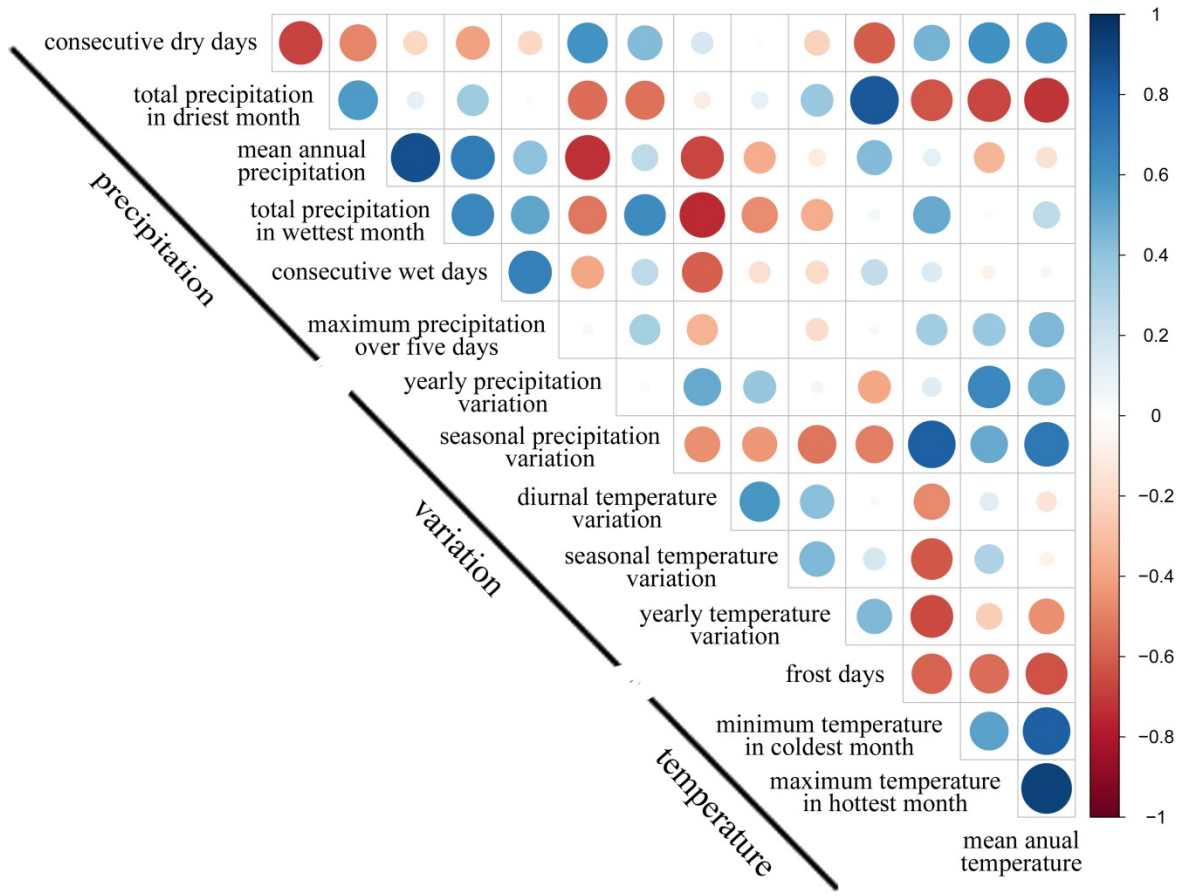
Appendix 1. Logistic regressions of 15 climatic variables and latitude against the proportion of Australian fleshy-fruited species per 50 km grid cell.

Variable	***β* coefficient**	***p*-value**	**McFadden's R^2**
maximum precipitation over five days (mm)	0.009	< 0.0001	0.389
total precipitation in wettest month (mm)	0.004	< 0.0001	0.241
minimum temperature in coldest month (°C)	0.070	< 0.0001	0.238
yearly temperature variation (CV)	-62.353	< 0.0001	0.204
mean annual temperature (°C)	0.061	< 0.0001	0.201
consecutive wet days (days)	0.226	< 0.0001	0.154
diurnal temperature range (°C)	-0.124	< 0.0001	0.136
seasonal temperature variation (CV)	-3.256	< 0.0001	0.126
mean annual precipitation (mm)	0.001	< 0.0001	0.118
maximum temperature in hottest month (°C)	0.045	< 0.0001	0.116
seasonal precipitation variation (CV)	0.562	< 0.0001	0.114
frost days (days)	-0.010	< 0.0001	0.013
total precipitation in driest month (mm)	-0.004	< 0.0001	0.011
consecutive dry days (days)	-0.001	< 0.0001	0.002
yearly precipitation variation (CV)	-0.011	0.835	< 0.001
latitude	0.041	< 0.0001	0.260
longitude	0.020	< 0.0001	0.150

Appendix 2. Histogram of studied species number per 50 km grid cell within Australia. The embedded map shows the species number in 50 km grid cells.



Appendix 3. The correlation matrix of the Pearson's correlation coefficients between climatic variables. Positive correlations are displayed in blue and negative correlations in red. Colour intensity and circle size are proportional to the Pearson's correlation coefficients. The legend on the right side of the correlogram shows the correlation coefficients and the corresponding colours.



Appendix 4.

We matched the species in our fruit type dataset to a large recent time-tree (Zanne et al. 2013, Zanne et al. 2014) for vascular plants, using "Taxonstand" to standardize names (Cayuela and Osanaen 2014) and phyndr to maximize overlap (Pennell et al. 2015). This led to 891 species in the resulting time-tree with trait values.

We then used a phylogenetic logistic regression approach developed by Ives and Garland (2010) and implemented in R by Ho and Ane (2014). This can estimate a metric of phylogenetic signal for binary traits and also test for the association of two traits after first accounting for phylogenetic correlation.

Ives and Garland (2010) show that for the binary case, their statistic α is a measure of phylogenetic signal with $\alpha = 1$ representing the phylogenetic correlation equivalent to a continuous trait evolving under Brownian motion; $\alpha = \infty$ represents no phylogenetic signal. The estimated value was $\alpha = 0.021$ for the trait of fleshy fruit (see Ives and Garland 2010).

Variable	β coefficient	p-value	AIC
maximum precipitation over five days (mm)	0.594	< 0.0001	524.4
consecutive wet days (days)	0.434	< 0.0001	530.1
frost days (days)	-0.324	< 0.0001	692.1
consecutive dry days (days)	0.340	< 0.0001	759.6
total precipitation in wettest month (mm)	0.538	< 0.0001	761.4
mean annual precipitation (mm)	0.615	< 0.0001	773.9
diurnal temperature range (℃)	-0.593	< 0.0001	782.4
maximum temperature in hottest month (℃)	0.278	< 0.0001	839.1
yearly precipitation variation (CV)	0.212	< 0.0001	840.2
seasonal precipitation variation (CV)	0.310	< 0.0001	843.3
mean annual temperature (℃)	0.398	< 0.0001	853.2
seasonal temperature variation (CV)	-0.497	< 0.0001	856.1
minimum temperature in coldest month (℃)	0.461	< 0.0001	863.1
total precipitation in driest month (mm)	0.387	< 0.0001	872.6
yearly temperature variation (CV)	-0.220	< 0.0001	879.0
latitude	0.438	< 0.0001	862.8
longitude	0.487	< 0.0001	893.9

References

Cayuela, L. and Osanaen, J. 2014. Taxonstand: Taxonomic Standardization of Plant Species Names. R package version 1.7. http://CRAN.R-project.org/package=Taxonstand.

Ho, L. s. T. and Ané, C. 2014. A linear-time algorithm for Gaussian and non-Gaussian trait evolution models. — Syst. Biol. 63: 397-408.

Ives, A. R. and Garland, T. 2010. Phylogenetic logistic regression for binary dependent variables. — Syst. Biol. 59: 9-26.

Pennell, M. W. et al. 2015. A simple approach for maximizing the overlap of phylogenetic and comparative data. — bioRxiv 024992.

Zanne, A. E. et al. 2013. Data from: Three keys to the radiation of angiosperms into freezing environments. Dryad Digital Repository. http://dx.doi.org/10.5061/dryad.63q27.2.

Zanne, A. E. et al. 2014. Three keys to the radiation of angiosperms into freezing environments. — Nature 506: 89-92.

Appendix 5.

The growth form of each species was categorized into tree, shrub or herb, according to species descriptions in the *Flora of Australia Online* database (Flora of Australia Online 2009). For species that lacked growth form information in *Flora of Australia Online*, we referred to descriptions in other sources, including FloraBase (Western Australian Herbarium 1998), PlantNET (The Royal Botanic Gardens and Domain Trust 1999) and the database of Australian Tropical Rainforest Plants (Centre for Australian National Biodiversity Research 2010). Climbers and species with ambiguous growth forms were not included in the analysis. The final dataset consisted of 629 tree species (100260 geographic occurrences), 2071 shrub species (420553 geographic occurrences), and 881 herb species (188685 geographic occurrences).

The species list and their occurrence data were mapped onto 50 km grid cells using *Biodiverse v0.18* (Laffan et al. 2010). The count and proportion of tree species was exported for each grid cell using label property analyses (2983 grid cells in total).

There was a significant latitudinal gradient in the proportion of tree species in Australia (β coefficient = 0.102, $p < 0.0001$, $R^2 = 0.42$). Tree species were more frequent towards the tropics and at the northeast coastal fringes (Fig. A5.1). This result is consistent with previous studies on the global pattern in plant growth form that the proportion of trees increases and the proportion of herbs decreases towards the tropics (Moles et al. 2007; Moles et al. 2009).

The proportion of fleshy-fruited species was fitted against latitude, growth form and their interaction, using logistic regression in R version 3.0.3 (R Core Team 2014).

The proportion of fleshy-fruited species was significantly with latitude, growth form and their interactions ($p < 0.0001$ for each term in the logistic regression model). Towards the low latitudes, trees were more likely to present fleshy fruits than do either shrubs or herbs, while the proportion of fleshy-fruited species with each growth form approached to be similar at high latitudes (Fig. A5.2).

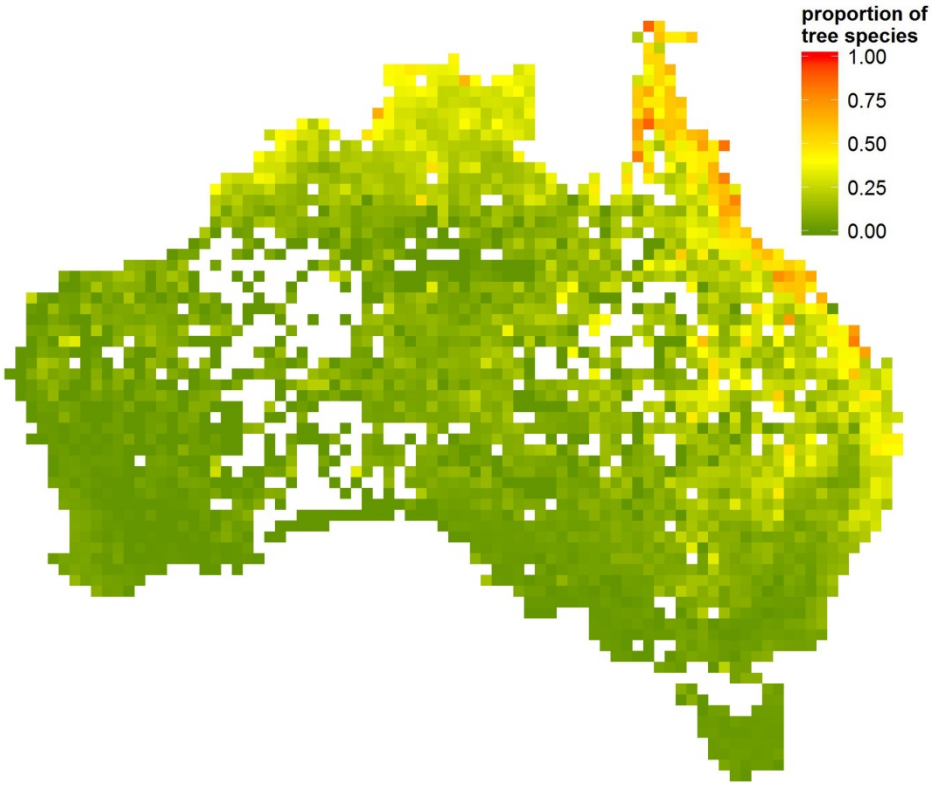


Figure A5.1. The proportion of tree species in 50 km grid cells within Australia (9.25°S – 43.75°S). Cells with fewer than five species were removed for visual purpose.

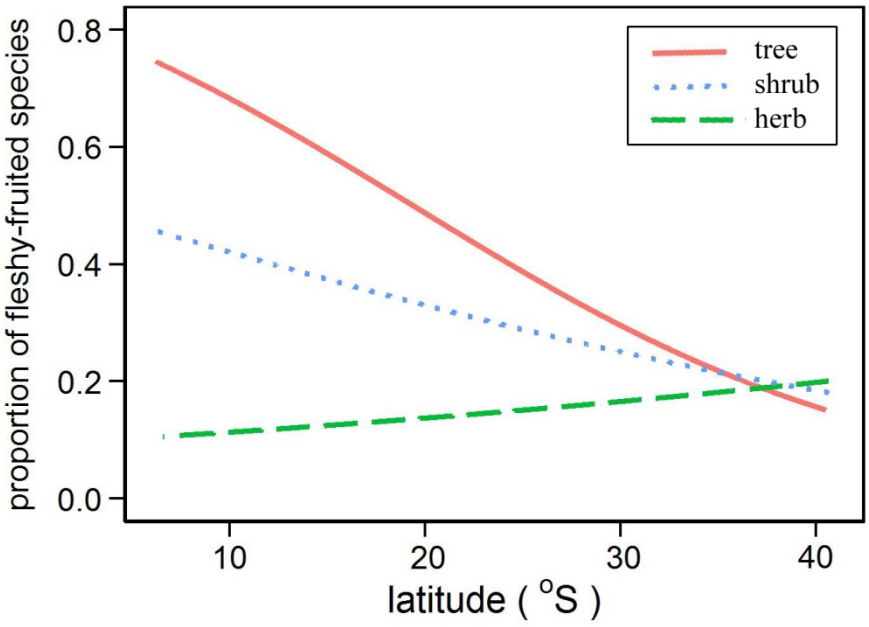


Figure A5.2. Predicted proportion of fleshy-fruited species against latitude for each growth form.

References

Centre for Australian National Biodiversity Research 2010. Australian Tropical Rainforest Plants [online version 6.1]. Available: http://www.anbg.gov.au/cpbr/cd-keys/rfk/index.html.

Laffan, S. W. et al. 2010. Biodiverse, a tool for the spatial analysis of biological and related diversity. — Ecography 33: 643-647.

Moles, A. T. et al. 2007. Global patterns in seed size. — Global Ecol. Biogeogr. 16: 109-116.

Moles, A. T. et al. 2009. Global patterns in plant height. — J. Ecol. 97: 923-932.

R Core Team 2014. R: a language and environment for statistical computing. R Foundation for Statistical Computing.

The Royal Botanic Gardens and Domain Trust 1999. PlantNET - The Plant Information Network System of The Royal Botanic Gardens and Domain Trust, Sydney, Australia (version 2.0). Available: http://plantnet.rbgsyd.nsw.gov.au.

Western Australian Herbarium 1998. FloraBase—the Western Australian Flora (version 2.8). Department of Parks and Wildlife. Available: http://florabase.dpaw.wa.gov.au/.