Supplementary Information

Supplementary Materials and Methods

Study area

This study was conducted on Tianping Mountain, northwest Hunan Province, China (N29.714072°–29.787100°, E109.906154°–110.170800°), which includes a core region of the Badagongshan National Nature Reserve. This area supports a rich biodiversity, including approximately 1 500 animal species and 2 300 plant species (Zhu et al., 2020a). Therefore, it is considered a "natural museum" and a "world rare species gene pool". The study area is ~20 000 ha, three quarters of which is covered by forests (Qiao et al., 2015). The elevation of this region is between 200 to 2 700 m, with the main vegetation changing from crops, evergreen broadleaf forests, to evergreen deciduous broadleaf forests from low, mid, to high elevations (Xiong et al., 1999). This region belongs to the north subtropical monsoon climate. The mean annual temperature is 11.5 °C, and the mean annual precipitation ranges from 2 105 to 2 840 mm (Chen & Li, 2003).

Data acquisition

Ten transects along an elevational gradient were randomly selected (Supplementary Figure S1). These transects were 200 m long and 2 m wide and were placed near stream tributaries. To reduce spatial correlation, all transects were separated by a minimum distance of 1.5 km, and by a deep mountain gorge, stream, or other prominent landmark.

We used nocturnal time-constrained visual encounter surveys based on distance sampling, which is considered effective for sampling anurans (Dodd, 2010; Funk et al., 2003). Field work was performed in April, June, August, and October in 2017. These four sampling events were conducted in accordance with spring, early summer, midsummer, and autumn, covering the anuran breeding, foraging, and migration seasons in the study area. Four people systematically walked at a slow pace (about 4 m/min) and intensively searched for anuran species by turning over stones, logs, leaf litter, tree branches, shrubs, and bushes along the transects using 220 lm torches after sunset, with two transects being sampled per night (Khatiwada et al., 2019; Zhu et al., 2020b). In each transect, all individuals encountered were captured and stored in cotton bags (38 cm×21 cm), with one cotton bag containing one individual. Amphibian sampling was conducted in accordance with the Law of the People's Republic of China on the Protection of Wildlife and approved by the Chengdu Institute of Biology Animal Care Committee [CIB2015003]. We took all captured individuals to a nearby dry place, where they were photographed and identified to species and sex following Fei et al. (2009, 2012). All anurans were measured for a set of 15 external morphological traits using a digital caliper to the nearest 0.01 mm, including snout-vent length (SVL), head length (HEL), head width (HW), snout length (SL), eye diameter (ED), nose eye distance (NED), upper eyelid width (UEW), interorbital space (IOS), internasal space (INS), lower arm and hand length (LAL), hand length (HAL), hindlimb length (HIL), tibia length (TL), tibia width (TW), and foot length (FL) (Supplementary Figure S2). The mass of each individual was measured using a digital scale to the nearest 0.01 g. After measurement, all individuals were released back to their original habitats.

A set of 16 microhabitat variables were measured in each transect during the sampling events in April, June, August, and October, separately. These environmental variables (i.e., air temperature, air humidity, altitude, water depth, water width, leaf litter depth, canopy cover, number of trees, shrub cover, leaf litter cover, rock cover, soil pH, water temperature, water pH, water conductivity, and water velocity) play important roles in shaping anuran assemblages (Grundel et al., 2015; Keller et al., 2009; Khatiwada et al., 2019; Wyman, 1988; Wyman & Jancola, 1992). They were thus considered to have potential effects on anuran functional diversity patterns. Details on measurement methodologies are provided in Zhu et al. (2020b).

Functional traits

Typically, animals display five main ecological functions (e.g., food acquisition, defense against predation, nutrient processing, reproduction, and mobility) in ecosystems, which can be described using relevant functional traits (Villéger et al., 2017). In the present study, we focused on three main functions of amphibians (i.e., food acquisition, defense against predation, and mobility) and profiled them through ecomorphological functional traits based on published literature (e.g., Dalmolin et al., 2020; Trochet et al., 2014; Tsianou & Kallimanis, 2016). Specifically, the mass of each individual was log-transformed and other external morphological traits (except SVL) were scaled by SVL (Supplementary Table S3). These 15 ecomorphological traits were unitless ratios that were *a priori* independent of anuran SVL, thus avoiding the effects of animal body size (Winemiller, 1991; Villéger et al., 2010). Therefore, these traits can reflect the main functions that anurans display in ecosystems. Specifically, scaled mass, scaled head length, scaled head width, scaled snout length, and scaled eye diameter were related to anuran food acquisition. Scaled mass, scaled eye diameter, scaled nose eye distance, scaled upper eyelid width, scaled interorbital space, and scaled internasal space reflected anuran ability to defend against predation. Scaled mass, scaled lower arm and hand length, scaled hand length, scaled hindlimb length, scaled tibia length, scaled tibia width, and scaled foot length were related to anuran mobility (Dalmolin et al., 2020; Trochet et al., 2014; Tsianou and Kallimanis, 2016; Supplementary Table S3).

Statistical analyses

All functional traits were scaled (mean of 0 and standard deviation of 1) (Villeger et al., 2008) and used for principal component analysis (PCA). The eigenvalues of the first four synthetic principal components were >1 (PC1=5.94, PC2=3.86, PC3=2.61 and PC4=1.74, respectively), and were used to create a four-dimensional functional space (PC1=37.15%, PC2=24.12%, PC3=16.32% and PC4=10.85%, respectively; Supplementary Figure S3).

Accounting for functional entity relative biomass in transects, four functional diversity indices, including functional richness, functional evenness, functional divergence, and functional specialization, were selected to describe the complementary components that filled functional space (Mouillot et al., 2013). Specifically, functional richness reflected the proportion of functional space occupied by functional entities. Functional evenness measured the regularity of the distribution of functional entity relative biomass in functional space. Functional divergence reflected the proportion of relative biomass supported by functional entities with extreme functional traits. Functional specialization was the proportion of the relative biomass of functional entities with extreme functional traits in functional space (Mouillot et al., 2013; Schleuter et al., 2010; Villeger et al., 2008). All functional diversity indices were first calculated in each transect for each sampling event. The data from the four sampling events were then pooled to calculate the whole year's functional diversity indices in each transect.

Spatial variation of anuran functional diversity was tested along the elevational gradient using linear regression models with a quadratic term, which was subsequently removed if it was not significant ($P>0.05$) (Crawley, 2007). Functional diversity indices were log-transformed prior to analyses if needed. We only tested the response of anuran functional diversity indices to elevation after pooling the data from the four samplings. This is because most transects did not contain sufficient functional entities for calculation in each season (at least five functional entities should be included in the calculation as we used four-dimensional functional space). To identify the potential differences in functional diversity indices among seasons (i.e., four months), Kruskal-Wallis and Wilcoxon rank sum tests were conducted for each index, separately.

A total of eight microhabitat variables, including air humidity, water temperature, number of trees, canopy cover, shrub cover, leaf litter cover, leaf litter depth, and water conductivity, were selected based on our previous study showing that these variables have significant effects on amphibian distribution and species richness (Zhu et al., 2020b). To explore the determination of environmental variables on functional diversity indices, we first constructed generalized linear models (GLMs), including all microhabitat variables for each index. A normal distribution with an identity link function was applied to each index. We compared different GLMs by removing variables one by one from the global model based on Akaike information criterion (AIC) values. The best model was determined based on the lowest AIC value. After that, hierarchical partitioning analyses were used to calculate the relative contribution of each selected environmental variable to the variations in different diversity indices.

All statistical analyses were conducted in R 3.6.1 (R Development Core Team, 2020). Functional diversity indices were calculated based on the *FD* package (Villeger et al., 2008). Linear regression and GLMs were performed using the *lme4* package

(Bates et al., 2015). Hierarchical partitioning was undertaken using the *hier.part* package (Walsh et al., 2004).

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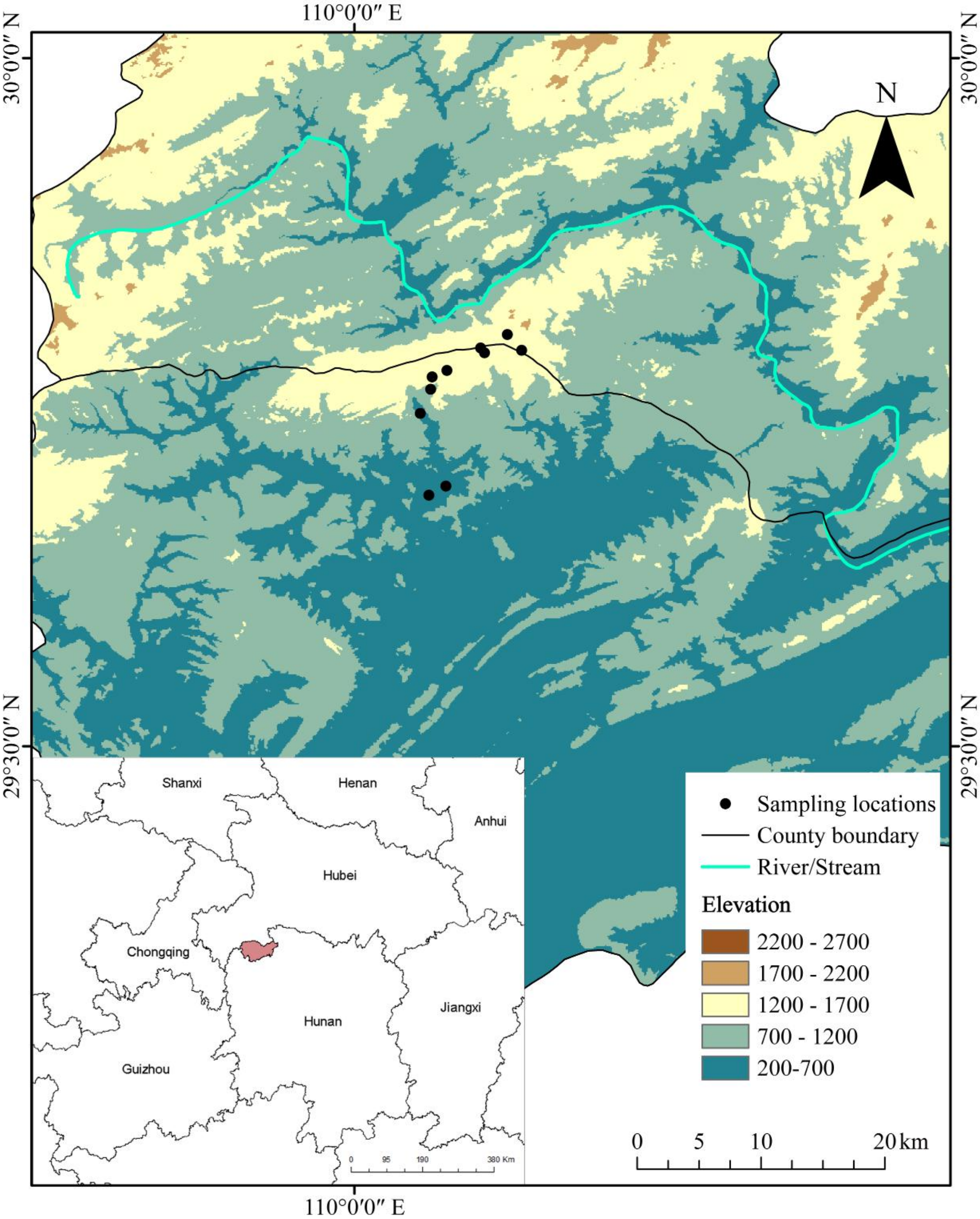
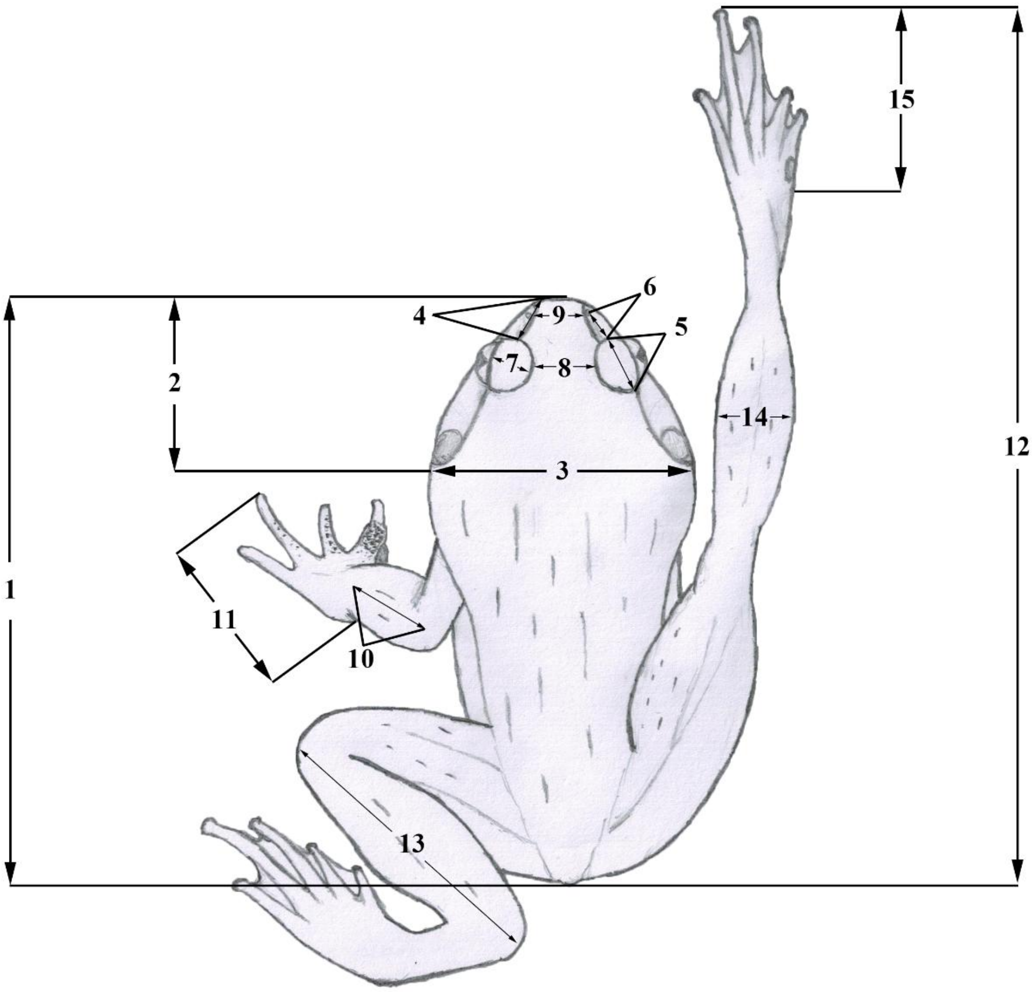
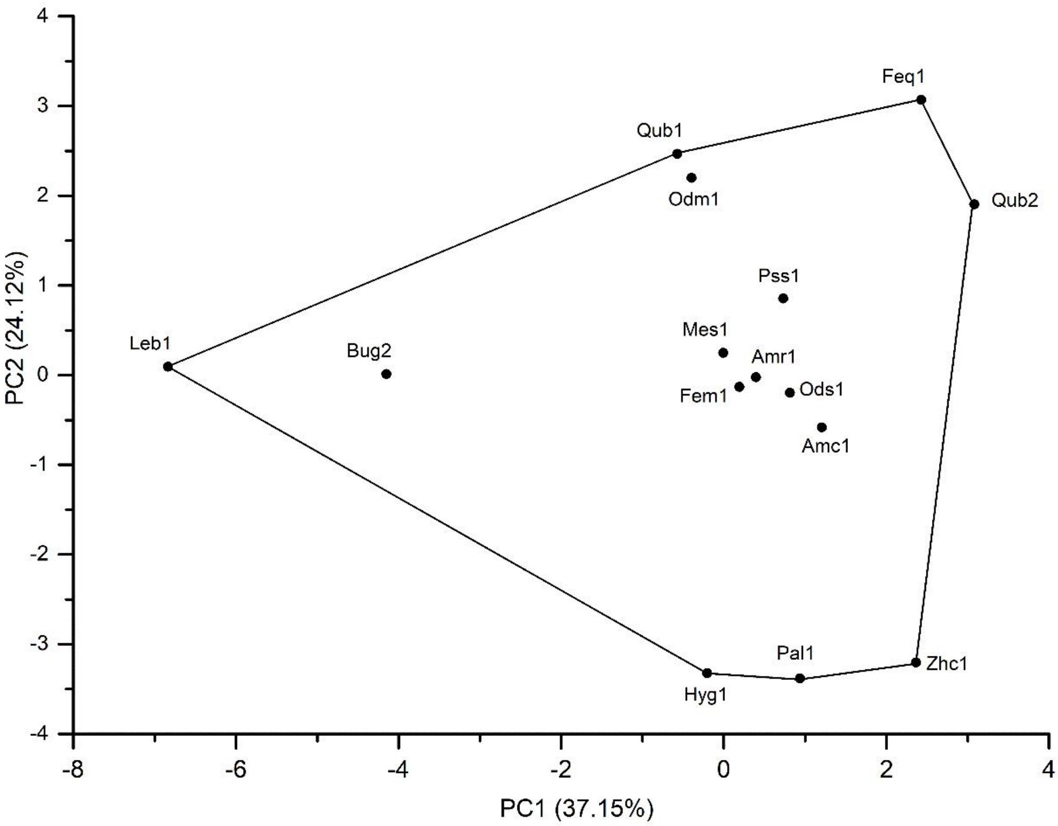
Supplementary Figures



Supplementary Figure S1 Map showing study area on Tianping Mountain, China. Black dot denotes transects used in present study.



Supplementary Figure S2 Measurement of 15 external morphological traits: 1: snout-vent length (SVL); 2: head length (HEL); 3: head width (HW); 4: snout length (SL); 5: eye diameter (ED); 6: nose eye distance (NED); 7: upper eyelid width (UEW); 8: interorbital space (IOS); 9: internasal space (INS); 10: lower arm and hand length (LAL); 11: hand length (HAL); 12: hindlimb length (HIL); 13: tibia length (TL); 14: tibia width (TW); 15: foot length (FL).



Supplementary Figure S3 Species distribution in two-dimensional functional space. Abbreviations are available in Supplementary Table S1.

Supplementary Tables

Supplementary Table S1 Species and functional entities (and abbreviations) captured on Tianping Mountain.

Oder	**Family**	**Species**	**Functional entities**	**Abbreviation**
Anura	Bufonidae	*Bufo gargarizans*	Juvenile *Bufo gargarizans*	Bug2
	Ranidae	*Amolops chunganensis*	Adult *Amolops chunganensis*	Amc1
		Amolops ricketti	Adult *Amolops ricketti*	Amr1
		Odorrana margaretae	Adult *Odorrana margaretae*	Odm1
		Odorrana schmackeri	Adult *Odorrana schmackeri*	Ods1
		Pseudorana sangzhiensis	Adult *Pseudorana sangzhiensis*	Pss1
	Dicroglossidae	*Fejervarya multistriata*	Adult *Fejervarya multistriata*	Fem1
		Feirana quadranus	Adult *Feirana quadranus*	Feq1
		Quasipaa boulengeri	Juvenile *Quasipaa boulengeri*	Qub2
			Adult *Quasipaa boulengeri*	Qub1
	Rhacophoridae	*Zhangixalus chenfui*	Adult *Zhangixalus chenfui*	Zhc1
	Hylidae	*Hyla gongshanensis*	Adult *Hyla gongshanensis*	Hyg1
	Megophryidae	*Paramegophrys liui*	Adult *Paramegophrys liui*	Pal1
		Leptobrachium boringii	Adult *Leptobrachium boringii*	Leb1
		Megophrys sangzhiensis	Adult *Megophrys sangzhiensis*	Mes1

Supplementary Table S2 Best model selected by GLMs. Significant *P*-values are in bold. Abbreviations of microhabitat variables are: WT: water temperature; TN: number of trees; CC: canopy cover; SC: shrub cover; LLC: leaf litter cover; LLD: leaf litter depth; WCON: water conductivity.

Functional diversity indices		Estimate	Std.Error	*P*
FRic	**Intercept**	-0.653	1.014	0.566
	WT	0.065	0.075	0.447
	TN	0.005	0.004	0.249
	CC	-0.011	0.008	0.279
	SC	-0.019	0.019	0.389
	LLC	0.080	0.057	0.254
	WCON	-0.003	0.003	0.415
FEve	**Intercept**	2.491	0.405	**0.003**
	WT	-0.112	0.021	**0.006**
	TN	-0.005	0.001	**0.009**
	CC	0.005	0.002	0.057
	SC	0.007	0.006	0.318
	LLC	-0.042	0.018	0.087
FDiv	**Intercept**	0.957	0.098	**< 0.001**
	WT	-0.057	0.006	**< 0.001**
	CC	0.013	0.001	**< 0.001**
	SC	0.019	0.005	**0.016**
	LLD	-0.363	0.071	**0.007**
	WCON	0.004	< 0.001	**< 0.001**
FSpe	**Intercept**	0.153	0.163	0.417
	WT	0.023	0.012	0.153
	TN	0.003	< 0.001	**0.022**
	CC	-0.004	0.001	0.051
	SC	-0.013	0.003	**0.022**
	LLC	0.039	0.009	**0.023**
	WCON	-0.002	< 0.001	**0.030**

Supplementary Table S3 List of 15 functional traits and their related ecological functions

Functional traits	Measure	Ecological functions
Mass	log(M)	Food acquisition, defense against predation, and mobility
Scaled head length	HEL/SVL	Food acquisition
Scaled head width	HW/SVL	Food acquisition
Scaled snout length	SL/SVL	Food acquisition
Scaled eye diameter	ED/SVL	Food acquisition and defense against predation
Scaled nose eye distance	NED/SVL	defense against predation
Scaled upper eyelid width	UEW/SVL	defense against predation
Scaled interorbital space	IOS/SVL	defense against predation
Scaled internasal space	INS/SVL	defense against predation
Scaled lower arm and hand length	LAL/SVL	mobility
Scaled hand length	HAL/SVL	mobility
Scaled hindlimb length	HIL/SVL	mobility
Scaled tibia length	TL/SVL	mobility
Scaled tibia width	TW/SVL	mobility
Scaled foot length	FL/SVL	mobility

Abbreviations: SVL: snout-vent length, HEL: head length, HW: head width, SL: snout length, ED: eye diameter, NED: nose eye distance, UEW: upper eyelid width, IOS: interorbital space, INS: internasal space, LAL: lower arm and hand length, HAL: hand length, HIL: hindlimb length, TL: tibia length, TW: tibia width, FL: foot length. Details of the measurement are provided in Figure 2.