

Ecography

E4802

Fu, C., Hua, X., Li, J., Chang, Z., Pu, Z. and Chen, J. 2006. Elevational patterns of frog species richness and endemic richness in the Hengduan Mountains, China: geometric constraints, area and climate effects. – *Ecography* 29: 919–927.

Appendix 1. Literature sources (in Chinese) for secondary data on frog distributions in the Hengduan Mountains, China.

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	Elevational distribution (m)	
	Minimum	Maximum
Bombinatoridae		
<i>Bombina microdeladigitora</i> Liu, Hu, and Yang, 1960	1200	2600
<i>Bombina maxima</i> (Boulenger, 1905)*	1400	3500
Megophryidae		
<i>Oreolalax popei</i> (Liu, 1947)*	970	2000
<i>Oreolalax granulatus</i> Fei, Ye, and Huang, 1991*	2350	2400
<i>Oreolalax jingdongensis</i> Yang, Ma, Chen, and Li, 1983*	1950	2600
<i>Oreolalax schmidti</i> (Liu, 1947)*	2500	3100
<i>Oreolalax major</i> (Liu and Hu, 1960)*	2000	3100
<i>Oreolalax pingii</i> (Liu, 1943)*	2700	3270
<i>Oreolalax rugosus</i> (Liu, 1943)*	2000	3550
<i>Oreolalax xiangchengensis</i> Fei and Huang, 1983*	950	3570
<i>Scutiger chintingensis</i> Liu and Hu, 1960	2500	3160
<i>Scutiger maculatus</i> (Liu, 1950)*	3300	3500
<i>Scutiger jiulongensis</i> Fei, Jiang, Ye, and Cheng, 1995*	3120	3750
<i>Scutiger tuberculatus</i> Liu, Hu, and Fei, 1979*	2600	3750
<i>Scutiger gongshanensis</i> Yang, Su, and Li, 1979*	2700	4000
<i>Scutiger glandulatus</i> (Liu, 1950)*	2250	3700
<i>Scutiger mammatus</i> (Günther, 1896)*	2800	4200
<i>Scutiger muliensis</i> Fei and Ye, 1986*	2900	3500
<i>Scutiger boulengeri</i> (Bedriaga, 1898)	2700	5000
<i>Brachytarsophrys feae</i> (Boulenger 1887)	800	1402
<i>Brachytarsophrys carinensis</i> (Boulenger, 1889)	940	2600
<i>Xenophrys major</i> (Boulenger, 1908)	700	2100
<i>Xenophrys glandulosa</i> (Fei, Ye, and Huang, 1991)*	2000	2500
<i>Xenophrys omeimontis</i> (Liu, 1950)	1100	2500
<i>Xenophrys minor</i> Stejneger, 1926	700	2850
<i>Leptobranchium chapaense</i> (Bourret, 1937)	800	2030
<i>Atympanophrys gigantea</i> (Liu, Hu, and Yang, 1960)*	1250	2600
<i>Atympanophrys shapingensis</i> (Liu, 1950)*	1970	3320
<i>Leptolalax pelodytoides</i> (Boulenger, 1893)	790	1600
<i>Vibrissaphora ailaonica</i> Yang, Ma, Chen, and Li, 1983*	1700	2600
Bufonidae		
<i>Bufo melanostictus</i> Schneider, 1799	400	2100
<i>Bufo himalayanus</i> Günther, 1864	700	2100
<i>Bufo ailaonanus</i> Kou, 1984*	2550	2600
<i>Bufo tuberculatus</i> Zarevskij, 1926*	2600	2700
<i>Bufo gargarizans</i> Cantor, 1842	750	3650
<i>Bufo tibetanus</i> Zarevskij, 1926	2300	4240
<i>Bufo aspinius</i> (Yang, Liu, and Rao, 1996)*	1800	2100
<i>Bufo burmanus</i> Andersson, 1939	1400	2600
Rhacophoridae		
<i>Rhacophorus bipunctatus</i> Ahl, 1927	680	2100
<i>Polypedates chenfui</i> (Liu, 1945)	900	1300
<i>Polypedates puerensis</i> He, 1999*	1990	2000
<i>Polypedates gongshanensis</i> (Yang and Su, 1984)*	1400	2000
<i>Polypedates omeimontis</i> Stejneger, 1924	990	1400
<i>Polypedates mutus</i> (Smith, 1940)	500	2060
<i>Polypedates nigropunctatus</i> (Liu, Hu, and Yang, 1962)	600	2134
<i>Polypedates megacephalus</i> Hallowell, 1860	400	2150
<i>Polypedates dugritei</i> David, 1872	1250	3200
<i>Chirixalus doriae</i> Boulenger, 1893	1000	1620
<i>Philautus longchuanensis</i> Yang, Su, and Li, 1979	1200	1600
<i>Philautus odontotarsus</i> Ye, Fei, and Hu, 1993	1000	1200

Ranidae		
<i>Rana nigromaculata</i> Hallowell, 1861	770	900
<i>Rana pleuraden</i> Boulenger, 1904	700	3000
<i>Rana shuchinae</i> Liu, 1950*	3000	3800
<i>Rana livida</i> (Blyth, 1856)	500	1600
<i>Rana margaretae</i> Liu, 1950	1090	1500
<i>Rana jingdongensis</i> (Fei, Ye, and Li, 2001)*	1580	1900
<i>Rana andersonii</i> Boulenger, 1882	750	2600
<i>Rana grahami</i> Boulenger, 1917	960	3200
<i>Rana nigrovittata</i> (Blyth, 1856)	450	1100
<i>Rana chaochiaensis</i> Liu, 1946*	700	3640
<i>Rana chensinensis</i> David, 1875	1280	4000
<i>Rana weiningensis</i> Liu, Hu and Yang, 1962	1920	3200
<i>Amolops marmoratus</i> (Blyth, 1855)	800	1700
<i>Amolops chunganensis</i> (Pope, 1929)	700	1800
<i>Amolops viridimaculatus</i> (Jiang, 1983)*	800	2300
<i>Amolops monticola</i> (Anderson, 1871)	850	2350
<i>Amolops loloensis</i> (Liu, 1950)*	1890	3200
<i>Amolops lifanensis</i> (Liu, 1945)*	1400	1400
<i>Amolops liangshanensis</i> (Wu and Zhao, 1984)*	2000	3470
<i>Amolops mantzorum</i> (David, 1872)	1000	3500
<i>Limnonectes kuhlii</i> (Tschudi, 1838)	500	2200
<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	500	2096
<i>Chaparana unculuanus</i> (Liu, Hu and Yang, 1960)*	1250	2600
<i>Paa boulengeri</i> (Günther, 1889)	800	2100
<i>Paa arnoldi</i> (Dubois, 1975)	1000	2500
<i>Paa yunnanensis</i> (Anderson, 1879)	950	3100
<i>Paa maculosa</i> (Liu, Hu and Yang, 1960)*	1250	2600
<i>Paa liui</i> (Dubois, 1987)*	1000	2650
<i>Paa feae</i> (Boulenger, 1887)	–	–
<i>Fejervarya multistriata</i> (Hallowell, 1861)	450	3000
<i>Nanorana ventripunctata</i> Fei and Huang, 1985*	2200	3600
<i>Nanorana pleskei</i> Günther, 1896	3260	3700
<i>Nanorana parkeri</i> (Stejneger, 1927)	3200	4700
<i>Ingerana liui</i> (Yang, 1983)	760	780
<i>Occidozyga martensii</i> (Peters, 1867)	500	1240
Microhylidae		
<i>Microhyla butleri</i> Boulenger, 1900	500	1200
<i>Microhyla heymonsii</i> Vogt, 1911	450	1800
<i>Microhyla ornata</i> (Duméril and Bibron, 1841)	400	2200
<i>Kalophrynus menglienicus</i> Yang and Su, 1980*	1040	1040
<i>Kaloula rugifera</i> Stejneger, 1924	500	1200
<i>Kaloula pulchra</i> Gray, 1831	450	1700
<i>Kaloula verrucosa</i> Boulenger, 1904	960	2300
<i>Calluella yunnanensis</i> Boulenger, 1919	980	3100
Hylidae		
<i>Hyla annectans</i> (Jerdon, 1870)	800	3000

Nomenclature follows Frost (2006).

Frost, D. R. 2006. Amphibian species of the World: an online reference. Ver. 4 (17 August 2006). – Electronic Database accessible at <<http://research.amnh.org/herpetology/amphibia/index.php>>, American Museum of Natural History, New York, USA.

Appendix 3. Species accumulation curves and species richness estimates.

Methods: 25 data sets from secondary sources (Appendix 1) were compiled in this study. For each data set, we divided the range of elevation into 200-m bands, and calculated the total number of species in each band. Species accumulation curves were generated based on incidence functions (Colwell et al. 2004), and a species estimator, Chao2 was used to estimate the total richness (Colwell and Coddington 1994). Species accumulation curves and species richness estimates were performed with EstimateS version 7.5 (Colwell 2004).

Results: the sample times in the 1000 km² area for each 200-m elevational zones decreased with increasing elevation (Fig. S1). The sample efforts at all 200-m elevational zones varied from 6 to 23 times (Fig. S2). Species accumulation curves were shown at Fig. S2. Culver et al. (2006) thought that for species richness estimates, the most appropriate comparisons was not the final point on the

curve but rather at a point of equal number of samples. Species richness estimates based on six samples were shown at Fig. S3. The results of species accumulation curves and species richness estimates showed that sampling was adequate.

References

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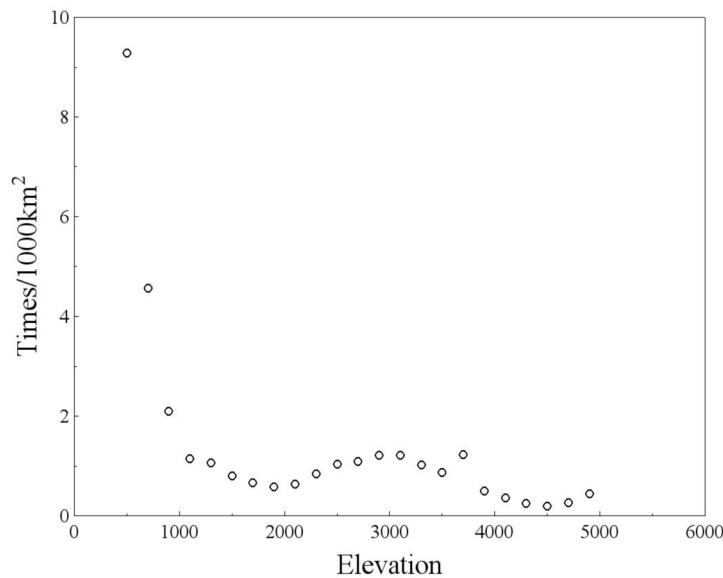


Fig. S1. The relationship between elevation and sample times 1000 km².

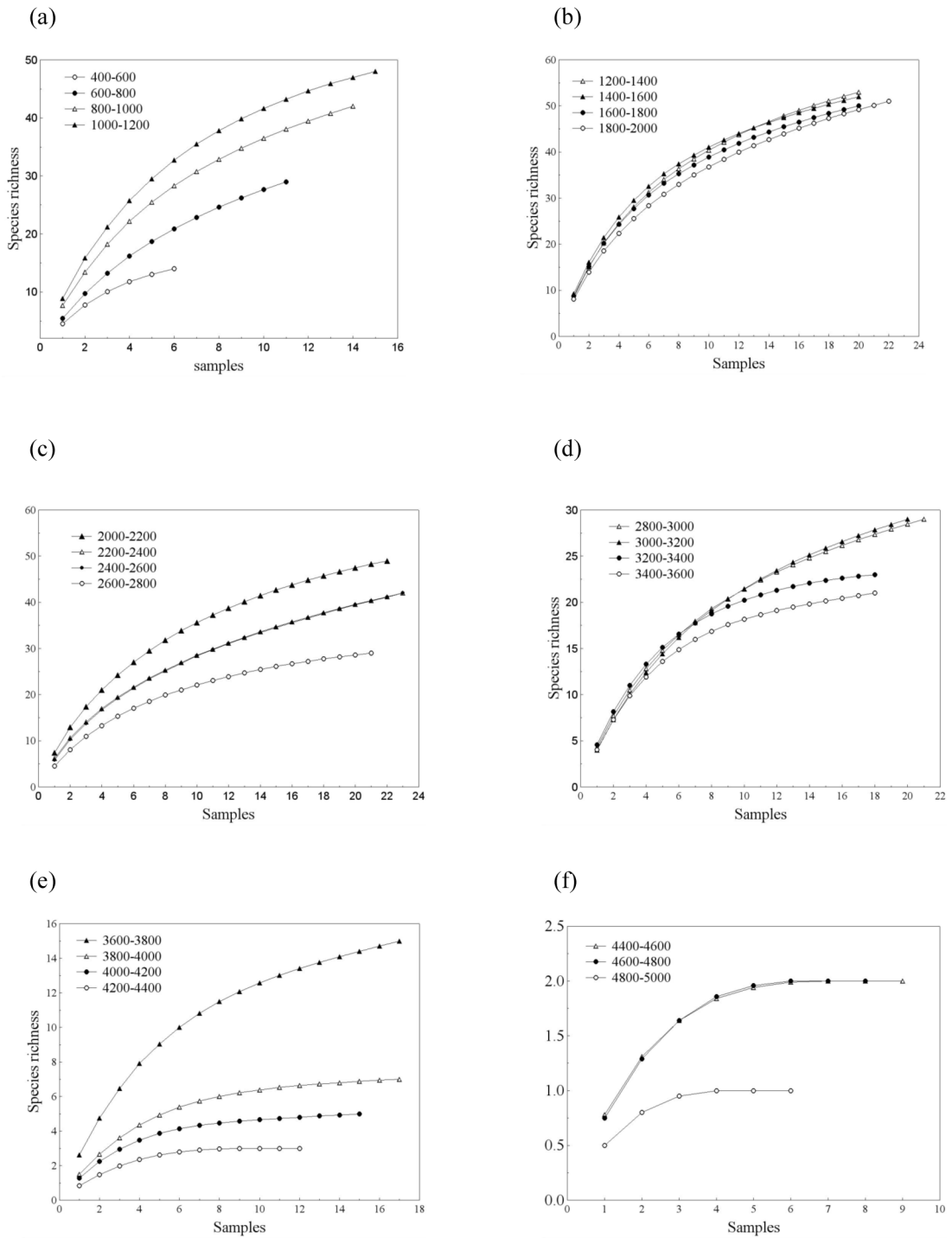


Fig. S2. Species accumulation curves of all 200-m elevational bands, (a) 400–1200; (b) 1200–2000; (c) 2000–2800; (d) 2800–3600; (e) 3600–4400; (f) 4400–5000.

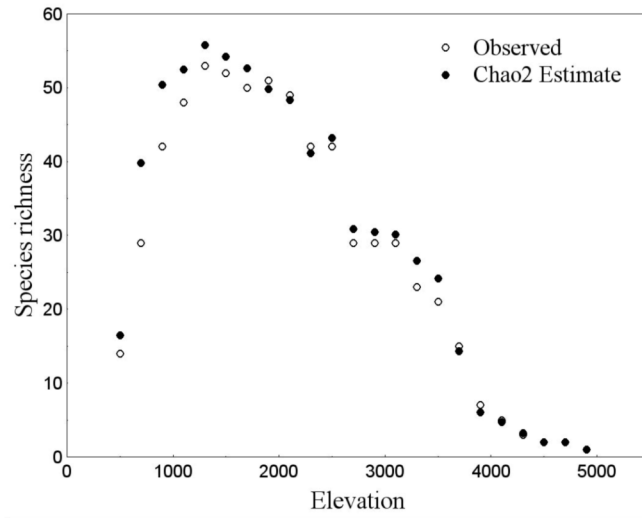
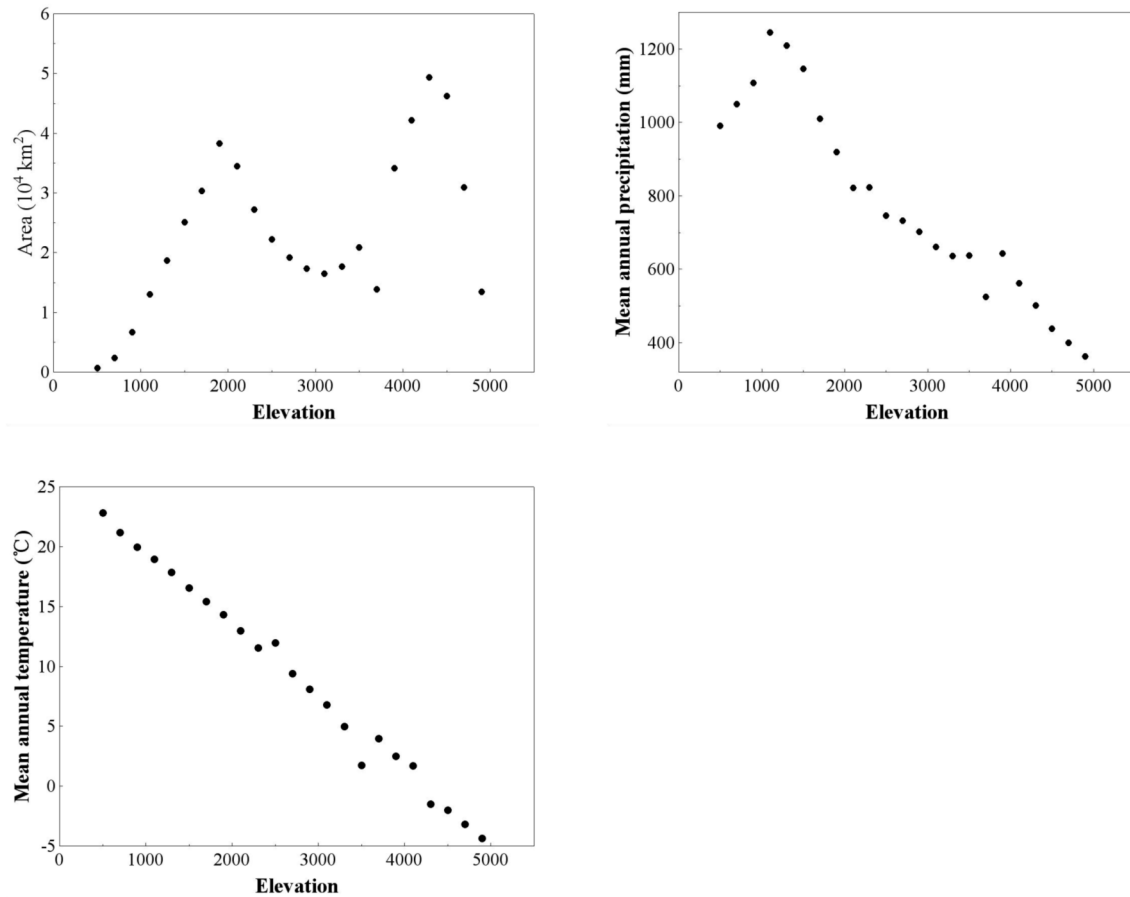


Fig. S3. The relationship between elevation and species richness of observation or mean of Chao2 estimate for six samples.

Appendix 4. The relationships between elevation and area or climatic variables in the Hengduan Mountains, China.



Appendix 5. Second order polynomial regressions for explained variables and species richness of total frogs, endemics and non-endemics including overall species and separated for large-ranged and small-ranged species in the Hengduan Mountains using generalized linear models (GLM).

		Variable	GLM order	DF	RP ^{2P}	P (F)
Total	Overall species	MDE	2	20	0.22	0.2972
		Area	2	20	0.21	0.0529
		MAP	2	20	0.72	<0.0001
		MAT	2	20	0.78	<0.0001
	Large-ranged species	MDE	2	20	0.32	0.2340
		Area	2	20	0.24	0.0253
		MAP	2	20	0.64	<0.0001
		MAT	2	20	0.77	<0.0001
	Small-ranged species	MDE	2	20	0.08	0.3647
		Area	2	20	0.20	0.2458
		MAP	2	20	0.84	<0.0001
		MAT	2	20	0.73	<0.0001
Endemics	Overall species	MDE	2	20	0.90	<0.0001
		Area	2	20	0.42	0.0010
		MAP	2	20	0.48	0.0004
		MAT	2	20	0.77	<0.0001
	Large-ranged species	MDE	2	20	0.91	<0.0001
		Area	2	20	0.46	0.0006
		MAP	2	20	0.47	0.0004
		MAT	2	20	0.80	<0.0001
	Small-ranged species	MDE	2	20	0.62	<0.0001
		Area	2	20	0.33	0.0056
		MAP	2	20	0.43	0.0009
		MAT	2	20	0.61	<0.0001
Non-endemics	Overall species	MDE	2	20	0.09	0.1678
		Area	2	20	0.09	0.4191
		MAP	2	20	0.87	<0.0001
		MAT	2	20	0.72	<0.0001
	Large-ranged species	MDE	2	20	0.13	0.1547
		Area	2	20	0.11	0.1928
		MAP	2	20	0.76	<0.0001
		MAT	2	20	0.74	<0.0001
	Small-ranged species	MDE	2	20	0.15	0.0835
		Area	2	20	0.12	0.7082
		MAP	2	20	0.96	<0.0001
		MAT	2	20	0.68	<0.0001

DF, degree of freedom; P (F), probability in F-test. Abbreviations expressed as in Table 1.