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The boundary of palaearctic and oriental realms in western China

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Abstract

In the world-wide zoogeographic division, there has been no consentaneous understanding about the delimitation between palaearctic and oriental realms in western China. In this study, we will discuss the division based on amphibian distribution in Shaanxi, Gansu, Sichuan, Yunnan, and Tibet according to species coefficient similarity between each zoogeographic province. The results show that the northern border lies from Qinling Mountains–Feng Xian (Shaanxi)–Debu (Gansu)–Aba (Sichuan)–Batang–Bomi (Tibet), to Linzhi districts, and the southern border is from Taibai–Feng Xian in Shaanxi–Wen Xian (Gansu)–Songpan–Kangding–Daocheng (Sichuan), to Zhongdian–Gongshan in Yunnan, and westward to Motuo and Bomi district in Tibet.

Keywords: Amphibian; Zoogeography; Palaearctic; Oriental; Hengduan Mt.

1. Introduction

China covers the oriental and palaearctic zoogeographic realms [1–6]. On the issue of the boundary between the two zoogeographic realms in China, there is an agreement in eastern part of China [4,6]. However, for the border in west China, from Qinling Mountains to Himalayan area, no agreement has been obtained. Due to the complicated landform and climate, fauna of palaearctic and oriental realms mixed up in the Hengduan Mt. region between Qinling and Himalayas in a broad transition. The geographic location, as well as the south–north direction of the Hengduan Mt., provides traveling channels in the valleys to animals. Therefore, the animal component belonging to either oriental or palaearctic realm is penetrative and interlaced in this region on a large scope [7].

In general, the boundary between the two realms in the eastern part of China to the east of Qinling Mountains is coinciding with the 0 °C isotherm of the average temperature in January and with the 800 mm isohyet line yearly. Geographically, it is the border of the subtropical and temperate zones, as well as the border of the south and the north of China. In the west of China the border is considered as the boundary of subtropical zone and the plateau. However, there is argument on locations of the boundary in specific regions or for specific species [8] due to the locally special landform and climate. For example, there are different opinions on which area should be included in the oriental realm in Gansu province [9–11].

Efforts have been made to resolve this problem. Chen et al. discussed the eastern circumscription in the Tibet plateau geographic zone based on the fish distribution data and the geographical events there [12]. Hoffmann proposed a broad transition zone in China and adjacent countries as the southern circumscription of the palaearctic realm by analyzing the

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data of mammalian faunas in those nations [13]. His conclusion is different from traditional conception and has been queried by biogeographic researchers of China [14].

The determination of zoogeographical division, especially on the specific boundary, depends on the distribution of animals to be discussed. Mammals and birds, due to their high adaptation to environment diversity and higher locomotion ability, are not appropriate to discuss the division issue generally. However, the amphibian, as cold-blooded animals, need both aqueous and terrene environment to accomplish their life history and their distribution range is limited by water and heat. This feature makes them a better indicator to discuss the definite zoogeographic division compared with mammals and birds. In this study, we use amphibians as an objective to explore the zoogeographic division of palaearctic and oriental realms in west China.

2. Materials and methods

2.1. Materials

All the amphibian distribution data used in this study are from published literatures [9,15–21]. We only consider those zoogeographical regions related to the boundary issue of palaearctic and oriental realms. The amphibians in the west districts are listed in Fig. 1 and Table 1.

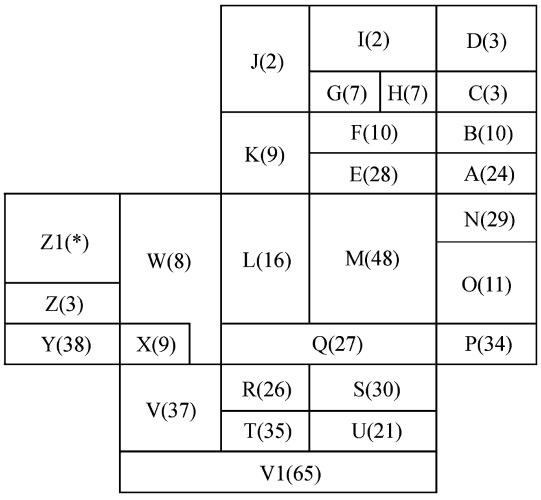

Fig. 1. Distribution diagram of amphibians in west China. (A) Southern Qinling hilly province; (B) northern Qinling hilly province; (C) loess plateau province; (D) desert province of northern Shaanxi; (E) southern Longnan hilly province; (F) northern Longnan hilly province; (G) central loess plateau province of Gansu; (H) loess plateau province of Longdong; (I) Gansu corridor province; (J) Qilian Mt. province; (K) Gannan plateau and grassland province; (L) northwestern Sichuan plateau province; (M) western basin province; (N) Daba province northeast of Sichuan basin; (O) central basin province; (P) southeastern basin province; (Q) southwestern plateau province of Sichuan; (R) Hengduan high mountain gorge province northwest of Yunnan; (S) high mountain and gorge province northern and northeastern of Yunnan; (T) southeast mountainous province; (U) plateau of central and east Yunnan; (V) western mountainous province of Yunnan; (V1) tropic mountainous province southern Yunnan; (W) Sanjiang Hengduan province; (X) Cha-yu province southeast of Tibet; (Y) Himalayas province; (Z) valley province of southern Tibet; (Z1) Fioeld-mark province of Qiang-Tang. *Species number undetermined.

2.2. Methods

We analyzed the components and the distribution pattern of amphibians in each zoogeographic province based on the zoogeographic division of amphibian in west China [15]. For a given zoogeographic province, if it only contains species to one realm (either oriental or palaearctic), it is regarded as the specific realm. If it contains species that occurs in the two realms and is located between the subtropical and warm zones or plateau, it is regarded as the permeation district of the two realms. In addition, we calculated the coefficient of similarity between each zoogeographic province concerned to discuss the relation of amphibians with those adjacent provinces. The coefficient of similarity basically reflects the genetic relationship and diversities of different zoogeographic provinces. The more identical the species components of the two regions are, the closer they are in geology and evolution [22]. Comparing the similarity of one district to the others, we can affirm the relationship of every zoogeographic province, and then draw the validated border of palaearctic and oriental in western China.

Similarity coefficient (S) is calculated by

$$S = (2n/(N_1 + N_2))\%.$$

Here, n is the number of identical species in both A and B regions, N_1 is the number of species in region A, N_2 is the number of species in region B [23]. We consider the relationship of two given provinces with a coefficient (S) value. The similarity is considered to be low for $S < 0.4$, general for $0.4 \leqslant S < 0.6$, significant for $0.6 \leqslant S < 0.8$, and very significant for $S \geqslant 0.8$, respectively.

3. Results and analyses

For convenience in discussion we simplified the diagram to show the relative location of zoogeographic division in administrative provinces concerned in western China (Fig. 1). Each square represents a specific zoogeographic province and the number in each square is the total species recorded there. The name list of amphibians in western China is given in Table 1, and the matrix of coefficient similarity between zoogeographic provinces is provided in Table 2.

3.1. Shaanxi

Shaanxi is divided into four zoogeographical provinces (Fig. 1), i.e. southern Qinling hilly province (A), northern Qinling hilly province (B), loess plateau province (C), and desert province of northern Shaanxi (D). The northern Qinling hilly province includes actually the region along both sides of the major ridge. Traditionally, the southern side of the ridge was regarded as the south circumscription of this province. It is also believed to be the boundary of south and north China, as well as the south border of

Table 1
The amphibian species and distribution in western China (1, exist; blank, absent)

Species	A	B	C	G	K	F	E	L	M	N	O	Q	R	W	X	Y	Z
Batrachuperus karlschmidti Liu								1									
Batrachuperus pinchonii (David)	1							1	1			1	1				
Batrachuperus tibetanus Schmidt	1	1		1	1	1	1	1	1	1				1			
Batrachuperus yenyuanensis Liu												1					
Liua shihi (Liu)	1									1							
Ranodon tsinpaensis Liu and Hu		1								1							
Andrias davidianus (Blanchard)	1	1		1		1	1		1	1	1						
Echinotriton asperrimus (Unterstein)							1		1								
Tylototriton taliangensis Liu									1			1					
Tylototriton verrucosus Anderson													1				
Bombina maxima (Boulenger)									1			1					
Atympanophrys shapingensis (Liu)									1			1					
Brachytarsophrys carinensis (Boulenger)												1					
Brachytarsophrys feae (Boulcnger)													1				
Leptolalax pelodytoides (Boulenger)							1		1	1			1				
Megophrys boettgeri (Boulenger)	1						1			1							
Megophrys kempii (Annandale)																1	
Megophrys minor Stejneger	1						1		1	1		1	1			1	
Megophrys nankiangensis Liu and Hu							1			1							
Megophrys omeimontis Liu									1							1	
Megophrys pachyproctus Huang																1	
Oreolalax chuanbeiensis Tian							1		1								
Oreolalax granulosus Fei, Ye, and Chen													1				
Oreolalax lichuanensis Hu and Fei							1										
Oreolalax major (Liu and Hu)									1			1					
Oreolalax multipunctanus Wu, Zhao, Inger, and shaffer									1								
Oreolalax omeimontis (Liu and Hu)									1								
Oreolalax pingii (Liu)												1					
Oreolalax popei (Liu)	1						1		1								
Oreolalax rugosus (Liu)												1	1				
Oreolalax schmidti (Liu)									1			1					
Oreolalax xiangchengensis denqinicus (Yang)													1				
Oreolalax xiangchengensis Fei and Huang												1	1				
Scutiger boulengeri (Bedriaga)				1	1		1	1	1					1	1	1	1
Scutiger chintingensis Liu and Hu									1								
Scutiger glandulatus (Liu)								1					1				
Scutiger gongshanensis Yang an Su													1				
Scutiger maculatus (Liu)								1						1			
Scutiger mammatus (Günther)								1					1	1	1		
Scutiger ningshanensis Fang	1																
Scutiger nyingchiensis Fei															1	1	1
Scutiger pingwuensis Liu and Tian							1		1								
Scutiger ruginosus Zhao and Jiang								1									
Scutiger sikimmensis (Blyth)																1	
Scutiger tuberculatus Liu and Fei								1									
Scutiger weigoldi (Vogt)									1								
Vibrissaphora boringii Liu									1								
Bufo andrewsi Schmidt	1					1	1	1	1	1		1	1				
Bufo cyphosus Ye															1	1	
Bufo gargarizans Cantor	1	1	1	1	1	1	1		1	1	1						
Bufo himalayanus Günther																1	
Bufo melanostictus Schneider												1					
Bufo minshanicus Stejneger					1	1		1									
Bufo raddei Strauch				1	1	1											
Bufo tibetanus Zarevski								1					1	1	1		
Bufo tuberculatus Zarevsky								1						1			
Bufo viridis Laurenti																1	
Torrentophryne aspinia Yang and Rao													1				
Torrentophryne tuberospinia Yang and Liu													1				
Hyla annectans (Jerdon)									1			1	1				
Hyla annectans gongshanensis Yang, Su, and Li													1				
Hyla japonica Günther										1							
Hyla tsinlingensis Liu and Hu	1	1			1	1				1							

(*continued on next page*)

Table 1 (*continued*)

Species	A	B	C	G	K	F	E	L	M	N	O	Q	R	W	X	Y	Z
Calluella yunnanensis Boulenger												1					
Kaloula borealis (Barbour)	1	1															
Kaloula rugifera Stejneger							1		1		1						
Kaloula verrucosa (Boulenger)												1	1				
Microhyla mixture Liu and Hu	1									1							
Microhyla ornata (Dumeril and Bibron)	1	1					1		1	1	1						
Microhyla pulchra (Hallowell)							1										
Amolops afghanus (Günther)																1	
Amolops chunganensis (Pope)	1						1		1	1							
Amolops granulosus (Liu and Hu)									1	1							
Amolops kangtingensis (Liu)								1									
Amolops liangshanensis Wu an Zhao												1	1				
Amolops lifanensis (Liu)									1								
Amolops loloensis (Liu)									1			1					
Amolops mantzorum (David)							1		1								
Amolops monticola (Anderson)															1	1	
Amolops viridimaculatus (Jiang)													1				
Micrixalus borealis Annandale																1	
Micrixalus reticulatus (Zhao and Li)																1	
Micrixzlus xizangensis (Hu)															1	1	
Nanorana parkeri (Stejneger)														1	1	1	1
Nanorana pleskei Günther					1			1	1								
Nanorana ventripunctata Fei and Huang													1				
Rana amurensis Boulenger			1														
Rana arnoldi Dubosis													1				
Rana boulengeri Günther	1						1		1	1	1						
Rana chaochiaoensis Liu									1			1	1				
Rana chensinensis David	1	1		1	1	1	1	1	1	1				1			
Rana chevronta Hu and Ye									1								
Rana conaensis (Fei and Huang)																1	
Rana daunchina Chang									1								
Rana gerbillus Annandale																1	
Rana grahami Boulenger									1			1					
Rana guentheri Boulenger									1	1	1						
Rana japonica Günther	1						1			1	1						
Rana kuangwuensis Liu and Hu										1							
Rana liebigii Günther																1	
Rana limnocharis Boie	1						1		1	1	1					1	
Rana livida (Blyth)	1																
Rana maculosa (Liu, Hu, and Yang)															1	1	
Rana margaretae Liu							1		1	1							
Rana nigromaculata Hallowell	1	1	1	1	1	1	1		1	1	1						
Rana pleuraden Boulenger												1					
Rana quadranus Liu, Hu, and Yang	1	1				1	1		1	1							
Rana rugulosa Wiegmann										1	1						
Rana schmackeri Botettger	1						1			1							
Rana shuchinae Liu												1	1				
Rana weiningensis Liu, Hu, and Yang												1					
Rana yadongensis Wu																1	
Rana yuannanensis Anderson												1	1				
Chrixalus vittatus (Boulenger)																1	
Philautus albopunctatus Liu and Hu																1	
Philautus argus (Annandale)																1	
Philautus asper (Boulenger)																1	
Philautus cavirostris (Günther)																1	
Philautus medogensis Ye and Hu																1	
Philautus tuberculatus (Anderson)																1	
Polypedates chenfui (Liu)									1	1							
Polypedates dugritei David									1			1					
Polypedates hungfuensis (Liu and Hu)									1								
Polypedates megacephalus Hallowell	1						1		1	1	1					1	
Polypedates omeimontis Stejneger									1								

Table 1 (*continued*)

Species	A	B	C	G	K	F	E	L	M	N	O	Q	R	W	X	Y	Z
Polypedates zhaojuensis Wu and Zeng												1					
Rhacophorus bipunctatus Ahl																1	
Rhacophorus maximus Günther																1	
Rhacophorus naso Annandale																1	
Rhacophorus rhodopus Liu and Hu																1	
Rhacophorus translineatus Wu																1	
Rhacophorus tuberculatus (Anderson)																1	
Rhacophorus verrucopus Huang																1	
Theloderma moloch Annandale																1	
Total	24	10	3	7	9	10	28	16	48	29	11	27	26	8	9	38	3

Table 2
The similarity coefficient of amphibians between zoogeographical provinces of west China

	A	B	C	G	K	F	E	L	M	N	O	Q	R	W	X	Y	Z
A	1.00	0.53	0.15	0.32	0.30	0.47	0.65	0.20	0.42	0.72	0.46	0.12	0.12	0.13	0.00	0.10	0.00
B		1.00	0.31	0.59	0.53	0.70	0.37	0.15	0.24	0.46	0.36	0.00	0.00	0.22	0.00	0.00	0.00
C			1.00	0.40	0.33	0.31	0.13	0.00	0.08	0.13	0.29	0.00	0.00	0.00	0.00	0.00	0.00
G				1.00	0.75	0.71	0.34	0.26	0.22	0.28	0.33	0.00	0.00	0.40	0.13	0.04	0.20
K					1.00	0.74	0.27	0.40	0.21	0.26	0.20	0.00	0.00	0.35	0.11	0.04	0.17
F						1.00	0.37	0.31	0.29	0.41	0.29	0.05	0.06	0.22	0.00	0.00	0.00
E							1.00	0.18	0.61	0.63	0.46	0.01	0.11	0.17	0.05	0.12	0.06
L								1.00	0.19	0.13	0.00	0.09	0.24	0.58	0.24	0.04	0.11
M									1.00	0.47	0.31	0.35	0.16	0.11	0.04	0.12	0.04
N										1.00	0.50	0.07	0.11	0.11	0.00	0.09	0.00
O											1.00	0.00	0.00	0.00	0.00	0.08	0.00
Q												1.00	0.38	0.00	0.00	0.03	0.00
R													1.00	0.12	0.11	0.03	0.00
W														1.00	0.47	0.09	0.36
X															1.00	0.30	0.55
Y																1.00	0.15
Z																	1.00

warm-temperate zone or the north border of subtropical zone of China. In the zoogeographic division, it is taken as the division of the oriental and the palaearctic realms. The border is approximately located from the Lushi region of the Funiu Mt. (Henan) to the east, and extends in the westward direction to Luonan–Shang Xian–Wufeng Mountain–Zhongnan Mountain–Shouyang Mt.–Taibai Mt.–Yuhuang Mt., and reaches Gansu westward.

Totally 29 amphibians have been recorded in Shaanxi [15]. Species components of the oriental and palaearctic realm mixed up in both southern and northern Qinling Mountains provinces (Tables 1 and 3). This phenomenon indicates that the region along both sides of Qinling Mountains ridge is the transition section of the realms. Species of reptiles, birds, and mammals recorded in either oriental or palaearctic realms also simultaneously occur in this region [7,20]. The circumscription of the north and south Qinling hilly province from Luonan to Yuhuangshan is acceptable in practice. However, Qinling Mountains are not a circumscription that blocks the dispersion of animals.

Table 3
Distribution and patterns of amphibians in Shaanxi

Pattern	Southern Qinling slope (A)	Northern Qinling slope (B)	Loess plateau (C)	Northern desert (D)
Palaearctic	2	2	1	2
Oriental	14	4	0	0
Hengduan Mt.	4	1	0	0
Widespread	3	3	2	1
Endemic	1	0	0	0
Total	24	10	3	3

No species which only occurred in oriental realm is found, neither in loess plateau province (C) nor in desert province of northern Shaanxi (D). The two provinces are obviously included in palaearctic realm.

3.2. Gansu

Gansu includes seven zoogeographical provinces (E, F, G, H, I, J, and K). The south Longnan region, including south Longnan hilly province (E) and north Longnan hilly province (F), is the westward extension of Qinling Mountains. Species of oriental and palaearctic realms can be found in the two regions although more oriental species than palaearctic species occur in the south hilly province than

Table 4
Distribution and patterns of amphibians in Gansu

Pattern	Southern Longnan (E)	Northern Longnan (F)	Central loess plateau (G)	Longdong loess plateau (H)	Gannan plateau grassland (K)	Qilian mountainous region (J)	Gansu corridor (I)
Palaearctic	1	3	2	2	3	2	2
Oriental	15	3	0	0	0	0	0
Hengduan Mt.	8	1	2	2	2	0	0
Widespread	3	3	3	3	2	0	0
Endemic	1	0	0	0	2	0	0
Total	28	10	7	7	9	2	2

that in the north hilly province (Table 4). The distribution pattern of amphibians in the two provinces manifests that the species are penetrated in both geographic provinces. The similarity coefficient between E and F is 0.37. The similarity coefficient for southern Qinling hilly province with E and F are 0.65 and 0.47, and for northern Qinling hilly province with E and F are 0.37 and 0.70, respectively. The fauna of E is closer to southern Qinling hilly province, and F is closer to northern Qinling hilly province. Moreover, the coefficient of southern Longnan with west basin province nearby (M in Sichuan) is relatively high.

The fauna of amphibians in central loess plateau province (G), loess plateau province of Longdong (H), Gannan plateau and grassland province (K) obviously belong to palaearctic realm since no typical oriental species occur there.

Overall, the Longnan region (including E and F) can be considered to be the transitional belt of the palaearctic and the oriental realms in Gansu [12,24]. The north boundary can be taken as the line of Tianshui–Gangu–Wushan–Min Xian–Diebu in the north Longnan hilly province and the south boundary as the administrative borderline between Gansu and Sichuan in the south Longnan hilly province or north slightly.

3.3. Sichuan

Sichuan province has been divided into six zoogeographical provinces (Fig. 1), among which no typical palaearctic species occurred in the central basin province (O) and southwestern Sichuan plateau province (Q) [15]. Only one widespread palaearctic species has been recorded (*Rana chensinensis*) in Daba province northeast of Sichuan basin (N) and in southeastern basin province (P).

Fauna in the northwestern Sichuan plateau province (L) and western basin province (M) are quite complicated. The two provinces contain not only palaearctic and oriental species, but also species widespread and endemic to Hengduan Mt. The northwestern Sichuan plateau province (L), including Min Mt., Qionglai Mt., and west of Daxue Mt. districts harbors 16 amphibian species. Besides one typical oriental species and two typical palaearctic species, the remainder of the 13 species are either the Hengduan Mt. type or endemic type (Table 5).

Comparing the species recorded in western basin province (M) with its neighbors, the similarity coefficient between M and N (Daba province northeast of Sichuan basin) is higher (0.47) than that between M and L (0.19). This implies that the fauna in M and N have been closely related originally. Moreover, fauna in M is also close to that in E (southern Longnan hilly province).

Consequently, amphibians distributed in oriental and palaearctic realms have obviously showed a penetration pattern in the northwestern Sichuan plateau province (L) and the western basin province (M). The northern border of the transition belt starts from Diebu (Gansu), then goes to Aba–Daofu, extends into the southwest, and enters into the Hengduan Mt. near Batang; the southern border is located near the west line of western basin province of Sichuan Basin from the border of Sichuan to Songpan–Kangding, and southward from Jiulong–Daocheng to Yunnan.

Table 5
The patterns and distribution of amphibians in Sichuan

Pattern	Northwest plateau (L)	Western basin (M)	Northeast daba (N)	Central basin (O)	Southwest plateau (Q)	Southeast of the basin (P)
Palaearctic	2	2	1	0	0	1
Oriental	1	16	20	6	8	24
Hengduan Mt.	10	27	3	2	14	5
Widespread	0	3	3	3	0	3
Endemic	3	[a]	2	0	5	1
Total	16	48	29	11	27	34

[a] Species uncertain.

Table 6
Similarity coefficient of northwest gorge province (R) with its neighboring regions

District	V	T	S	U	V1	Q
R	0.29	0.30	0.39	0.34	0.18	0.4

3.4. Yunnan

Six zoogeographic provinces have been claimed in Yunnan province (Fig. 1). Among the 102 amphibians recorded there, only two species of palaearctic realm (*Bufo tibetanus* and *Scutiger mammatus*) exist in Hengduan high mountain gorge province (R). The rest of the species belong to oriental realm although some of them are endemic to this region [15].

Besides the oriental and palaearctic species, there are nine species endemic to the district R (Table 1). Due to the high ratio of endemic species, the similarity coefficients of R with its neighboring regions are lower than 0.4, which indicates that this region is very special in Yunan province. However, there is a weak relation of R with north and northeast gorge province (S), as well as with southwest plateau province (Q) (Tables 2 and 6). The fauna of both Q and S belong to oriental realm. Therefore, it is reasonable to regard R as an oriental province.

The special feature of amphibian fauna in R district indicates that the southern border of the transition belt will not exceed the southern distribution boundary of *Bufo tibetanus* and *Scutiger mammatus*. The border is along with the region from Deqin to Zhongdian in Yunnan, in other words, the central part of Hengduan Mt. can be taken as the transition belt [17,25,26].

3.5. Tibet

In Zoogeography, Tibet belongs to Qingzang region, central Asia subrelam, and palaearctic realm. It is divided into five zoogeographical provinces, i.e. Sanjiang Hengduan province (W), Cha-yu province southeast of Tibet (X), Himalayas province (Y), valley province of southern Tibet (Z) and Fioeld-mark province of Qiang-Tang (Z1). In Tibet, 44 amphibians have been recorded [18,21], and most of them belong to Hengduan Mt. species (Tables 1 and 7). In general, there is an agreement in the boundary in Himalayas province (Y), i.e. the up line of dark coniferous forest in southern slope of the Himalayas. But in the east of Tibet, the faunas of oriental and palaearctic are mixed up

Table 7
The patterns and distribution of amphibians in Tibet

Pattern	Sangjiang Hengduan (W)	Southeast Cha-yu (X)	Himalayas (Y)	Valley south Tibet (Z)	Fioeld-mark Qiang-Tang (Z1)
Palaearctic	2	1	2	1	[a]
Oriental	0	3	11	0	0
Widespread	0	0	0	0	0
Endemic	0	0	[a]	0	0
Hengduan Mt.	6	5	25	2	0
Total	8	9	38	3	[a]

[a] Species uncertain.

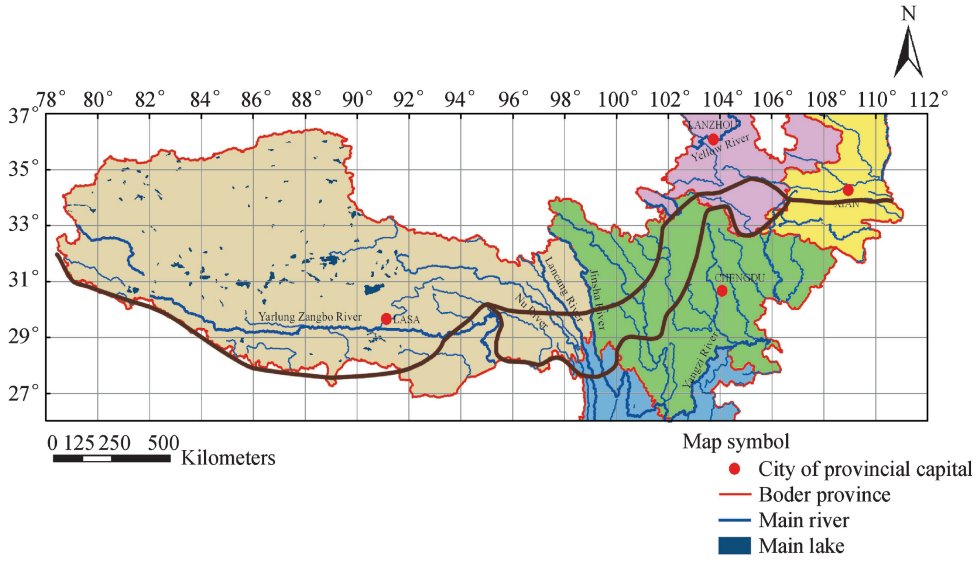

Fig. 2. The boundary of palaearctic and oriental realms in west China.

in Sangjiang Hengduan province (W) and southeast Cha-yu province (X). In the former province (W), among the eight amphibians recorded, two are typical palaearctic species (*Nanorana parkeri* and *Rana chensinensis*) and six are Hengduan Mt. pattern species. Reptile species occurring there demonstrates that a large proportion of reptile is oriental species [18,27].

In the southeast Cha-yu province (X), nine amphibians are recorded, of which one is a typical palaearctic species (*Nanorana parkeri*), three are oriental species and five endemics to Hengduan Mt. The number of oriental species also increases from north to south in X district, two species in Bomi (*Amolops monticola*, *Platymantis xizangensis*), and three species in the south Cha-yu (*Bufo cyphosus*, *Paa maculosa*, *Amolops monticola*) [18].

By reviewing the amphibian fauna in Tibet, we can find out that the central part of Hengduan Mt. is the transition belt of the palaearctic and oriental realms. The northern boundary of this belt is from Batang–Mangkang–Bomi districts; the southern boundary starts from Gongshan, then along with the national boundary, to Motuo–Bomi, and follows the western border of southeast Cha-yu province, finally both the northern and southern borders meet at Tongmai district, and then, goes along westward with Linzhi–Yadong–southern Himalayas to the Nepal and India. The exact positions are labeled in Fig. 2.

4. Discussion

4.1. The division between oriental and palaearctic realms

The distribution range of amphibian in west China is greatly influenced by the altitude. The event of uplift of Qingzang plateau has created numerous high mountains and gorges which greatly influences the local climate and vegetation, resulting in a mixed fauna in the east and southeast edge of Qinzang plateau. Therefore, some people made an effort to use the contour as the boundary of the two realms [13]. However, their results were obviously different from the traditional understanding on this issue. Zhang deliberated that the distribution patterns of modern Chinese mammals are the long-term adaptation to geology and palaeogeography. Zoogeographic division cannot complete without the history of the phylogenesis and evolution of the faunas concerned [14]. In addition, the north–south direction of Henduan Mt. also produces different influences on the distribution of water and heat than those mountains in east–west direction. Therefore, it is not suitable to simply use the altitude as the boundary of the zoogeographical division [28]. In Hengduan Mt. region, the upper part of the huge mountains harbors palaearctic species, the valley of low elevation includes the oriental species, and the middle range of the mountains contains species component of both palaearctic and oriental fauna [29], i.e. species occurring in palaearctic realm penetrate further south in the upper part, and the species occurring in Oriental realm disperses further north in the lower part of the huge mountains.

The penetration of palaearctic and oriental species near the boundary is closely related with the geographical factors, such as altitude, temperature, waterfall, soil, and vegetation. These elements, especially the temperature and precipitation, will gradually form a stable line on a comparatively long time scale. For instance, in China, the average 0 °C isotherm of January, which decides the border of subtropical zone, is believed to be the division of palaearctic and oriental realms in China. But in the western part of China, the uplift of Qingzang plateau has created a complicated landform in Hengduan Mt. region. Therefore, the penetration and intermix of various species will occur inevitability at the edge of subtropical zone. Although amphibian is more sensitive to the environmental changes than mammals and bird, the faunas of amphibian in palaearctic and oriental realms are also mixed up in the ridge of Qinling Mountains, Longnan district of Gansu, northwest of Sichuan, northwest gorge and high mountain in Yunnan, Sanjiang Hengduan and the Cha-yu districts in Tibet. This phenomenon indicates that the boundary of palaearctic and oriental realms in the west of China is a transition belt rather than a line.

4.2. The boundary of Hengduan Mt.

The landscape of Hengduan Mt. is unique and supplies passage in the north–south direction for species of palaearctic and oriental to penetrate the border. Therefore, the position of Hengduan Mt. is very important for the zoogeographical Division. Hengduan Mt., in a broad sense, is regarded as a series of mountains and valleys from Min Mt. of west Qinling Mountains along the eastern borderline of Qingzang plateau [30]. However, in a narrow sense, Hengduan Mt. is limited to the region of "concurrent flow of three parallel" rivers traditionally [26]. However, by looking into the perspective of geological process, particular landscape and climate, as well as the unique fauna of this region, Zhang proposed to separate the region, the "concurrent flow of three parallel", located in the administrative border between Sichuan, Yunnan, and Tibet as independent zoogeographical district – Sanjiang Hengduan province [7].

This study demonstrates that the amphibian fauna of Sanjiang Henduan province is formed by both palaearctic and oriental species. Penetration of reptile has also been documented in this province [18,27]. These indicate that the south and north boundaries in the middle range of Hengduan Mt. can be taken as the border of the transition belt between palaearctic and oriental realms. Based on the amphibian fauna, the northern line of the border is located near 30°N (the administrative border of Sichuan and Tibet); the southern line is near 27°N (the administrative border of Sichuan, Yunnan, and Tibet) (Fig. 2).

4.3. The position of south Tibet valley

There is a debate on the border issue of palaearctic realms in Himalayan region. Northern slope, southern slope, and even the main ridge have been claimed as the border [31]. However, the southern slope issue has been accepted by the majority of experts. From the distribution of amphibians in the south Tibet valley, only three amphibian species (*Scutiger boulengeri*, *Scutiger nyingchiensis*, and *Nanorana parkeri*) have been recorded and none of them belongs to the oriental realm [18]. This fact supports the southern slope issue. The Yarlung Zangbu Grand Canyon of Namjiagbarwa, which is located in the northern slope of Himalayas, is an important channel of hydrosphere, but it is a barrier to block the further north dispersion for tropical species [21]. All the species of reptile found in the north of Himalayas belong to palaearctic realms [27]. Therefore, both amphibian and reptile distribution data support the viewpoint that the south Tibet valley belongs to palaearctic realm.

5. Conclusion

From the above discussion based on the consequence of this study, we conclude that the boundary of palaearctic and oriental realms in west China is not a line with a clear circumscription, but a transitional belt based on the distribution data of amphibian. The northern border goes from Qinling Mountains–Feng Xian (Shaanxi)–Debu (Gansu)–Aba (Sichuan)–Batang–Bomi (Tibet), to Linzhi districts, and the southern border is from Taibai–Feng Xian in Shaanxi–Wen Xian (Gansu)–Songpan (Sichuan)–Kangding–Daocheng, to Zhongdian–Gongshan in Yunnan, and westward to Motuo and Bomi district in Tibet.

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