An Introduction to the Biodiversity of a Mountain Ecoregion

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A new animal geographical area?

"six animal geographical area divisions of the world have been recognised"

Chen Yiyu, a member of the Chinese Academy of Sciences, has proposed the Qinghai-Tibetan Plateau as the seventh animal geographical area, based on studies on the space-time distribution of fish and on biota differentiation in the Qinghai-Tibetan Plateau (Chen Yiyu 1999).

Traditionally six animal geographical area divisions of the world, as proposed by renowned British scientist Wallance, have been recognised. Eurasia was categorised as part of the Paleoarctic area and part of the east-ocean area. Since the 1930s, scholars in China and abroad have considered the Qinghai-Tibetan Plateau as part of the Paleoarctic area and part of the east-ocean area. From the point of view of demonstrating geological history, the differentiation of biota, and space-time variation, the Qinghai-Tibetan Plateau was proposed as a juxtaposed first-level area, the seventh animal geographical area.

"the inland plateau belongs to the Paleoarctic area"

The present flora and fauna of the Qinghai-Tibetan Plateau (Table 7) have originated from two systems, which have very different genetic and ecological features (Zhang Rongzu 1982). For fauna, the inland plateau belongs to the Paleoarctic area and the south-eastern part belongs to the oriental realm. For flora, the inland plateau belongs to a pan-arctic area (the Qinghai-Tibetan Plateau sub-area) and the south-eastern part belongs to the Sino-Himalayan sub-area (Wu Zhengyi 1979). The plateau consists of two biogeographic regions for plants, the pan-arctic and the paleo-tropical, and two for animals, the paleoarctic realm and the Indo-Malayan region (Li Bosheng 1995). Figure 4 presents the biogeographical divisions of China that are popularly recognised. Table 8 gives an explanation of Figure 4 on the bio-geographical distribution/ divisions of China (Zheng Zuoxing and Zhang Rongzu 1959), which can be seen as the biogeogaphical classification system and description of the mapping areas.

Table 7: Species diversity in the Qinghai-Tibetan Plateau Plateau of China

Types of species	Number of species in the Qinghai-Tibetan Plateau Plateau (QTP)	QTP/China (%)
Vascular plants	12,000	34.3
Fungi	5000	41.67
Mammals	210	46.67
Birds	532	44.97
Fish	115	6.28

Source: Li Bosheng (1995)

The Qinghai-Tibetan Plateau has had an important influence on the biodiversity of

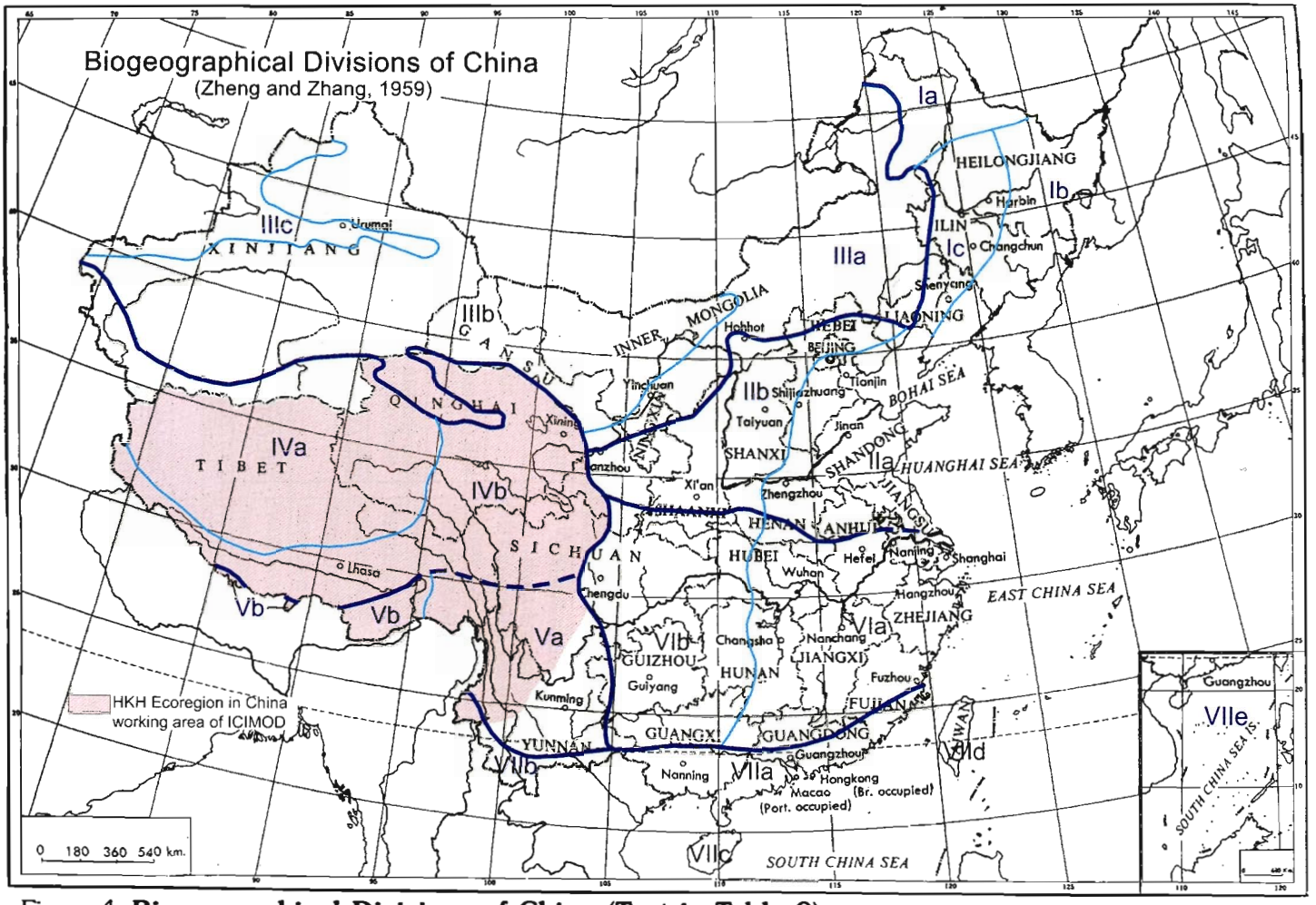

Figure 4: **Biogeographical Divisions of China (Text in Table 8)**

Source: Editorial Committee of China's Physical Geography, Chinese Academy of Sciences, Physical Geography of China Zoogeography, Science Press 1979, Beijing

Table 8: Biogeographical Divisions of China (see Figure 1)

Realm	Region group	Region	Sub-Region	Description
Paleo-arctic Realm	North of Monsoon Region	North-eastern Region (cool temperate and temperate, moist and semi-moist)	IA (Daxingan Mountains and Altay Mountain)	Coniferous forest
			IB (Changbai Mountains)	Mixed coniferous and deciduous forest
			IC (Songliao Plain)	Forest-grassland-meadow
		North China Region (warm temperate, semi-moist and semi- arid)	IIA (Huang-Huai Plain)	Deciduous and forest-grassland
			IIB (Loess Plateau)	Deciduous and forest-grassland
	West Plateau	Mongo-Xinjiang Region (temperate and warm-temperate, arid and semi-arid)	IIIA (East Grassland)	Dry grassland
			IIIB (West Desert)	Desert and semi-desert
			IIIC (Tianshan Mountains)	Mountain forest and forest-grassland
		Qinghai-Tibetan Plateau Region (semi-moist, semi-arid and arid)	IVA (Qiangtang High Plateau)	Meadows and mountain forest
			IVB (Qinghai-Zangnan)	Forest, meadows, and grassland
Oriental Realm	South of Monsoon Region	Southwest Region (Hengduan Mountains)	VA (Western Mountains)	Mountain meadows and mountain forest
			VB (Himalayan)	Mountain meadows and mountain forest
		Mid-China Region (mid and north subtropical, moist)	VIA (Eastern Hillock-Plain)	Deciduous, evergreen forest and mixed forest
			VIB (Western Mountainous)	Deciduous, evergreen forest and mixed forest
		South China Region (tropical and south subtropical, moist)	VIIA (Min-Guang Coastal)	Evergreen, subtropical, and tropical monsoon rainforest
			VIIB (Diannan Hill)	Monsoon tropical rainforest
			VIIC (Hainan Island)	Tropical monsoon rainforest
			VIID (Taiwan Island)	Tropical monsoon forest and subtropical mountain forest
			VIIE (South Sea Islands)	Ocean island tropical forest

Source: Zheng Zuoxing and Zhnag Rongzu (1979)

the Northern Hemisphere. Considering higher plants, the Qinghai-Tibetan Plateau is the centre of origin and differentiation for some of the world's alpine plants (Li Bosheng 1995).

"the Qinghai-Tibetan Plateau is the centre of origin and differentiation for some of the world's alpine plants"

If animals, in particular mammals, are to survive in the Qinghai-Tibetan Plateau (Qinghai-Tibetan) Plateau, they need to be adapted to the ecological environment (low temperatures, a long frozen period, thin air, specific food availability in the region (for example short growing season or coarse fibres of grass), and regeneration conditions. The hard conditions of

the Qinghai-Tibetan Plateau compared with other ecological zones of China are presented in Table 9.

Table 9: Environmental conditions of the Qinghai-Tibetan Plateau Plateau compared with other ecological zones in China

Ecological zone	High elevation	Rare oxygen	Low rainfall	Low temperature	Strong wind	High radiation	Vertical change
Qinghai-Tibetan Plateau Plateau	x	x	x	x	x	x	x
Hengduan Mountains	+, -	+, -		+, -			xx
Eastern Subtropical Hill of China							
North-east Mountains of China				x			+,-
Inner Mongolian Plateau of China			x	x	x	x	

X, present; XX, strongly present; +,-, variable

There are no plants above 4,000m in the Alps in Europe. But there are more than 100 species of plants in the northern part of the Tibetan Plateau, and 52 species in the belt from 5,200 to 5,400m in this area; this is due to the heat effect of the Qinghai-Tibetan Plateau. Thus there are resources to support animals as part of an ecosystem. The endemic animal species have been brought up to the Qinghai-Tibetan Plateau as the plateau has risen in geological time (Table 10).

The discoveries of two Hipparion fauna in the Tibetan Plateau were reported in the summer of 1975, in Bulong Basin, Biru County and Gyrong Basin, Girong County. The Bulong Hipparion fauna are considered to be early Pliocene in age and equivalent to the Vallecian of Europe. The Gyrong Hipparion fauna have the same characteristics as the Hipparion fauna of north China of

Table 10: Rare and special endemic fauna in the Hindu Kush-Himalayan Ecoregion of China

English name	Scientific name	Geographical region/Division no.	Protection class
Asiatic wild ass	*Equus hemionus*	Mongo-Xinjiang and Qinghai-Tibetan Plateau (QZ)/III, IV	I
Giant panda	*Ailuropoda melanoleuca*	Hengduanshan, southwest mountains/VA	I
Golden-hair monkey	*Rhinopithecus roxellanae*	Hengduanshan, southwest mountains/VA	I
Red panda	*Ailurus fulgens*	Hengduanshan, southwest mountains/VA	II
Takin	*Budorcas taxicolor*	Hengduanshan, southwest mountains/VA	I
White-lipped deer	*Cervus albirostris*	QZ/IV	I
Argali sheep	*Ovis ammon*	QZ/IV	II
Blue sheep	*Pseudois nayaur*	QZ/IV	III
Stone marten	*Martes foina*	QZ, IV	III
Tibetan antelope	*Pantholops hodgsoni*	QZ/IV	II
Wild yak	*Bos grunniens*	QZ, IV	I
Tibetan eared pheasant	*Crossoptilon harmani*	QZ/IV	II
Black-necked crane	*Grus nigricollis*	QZ/IV	I
Snow cock	*Tatraogullus* spp.	QZ/IV	III

Source: Zhang Rongzu (1979)

"there has been an on-going evolution of flora and fauna to adapt to the very-high-elevation"

the middle Pliocene and are equivalent to the Pontian fauna from Eurasia. This suggests that the Bulong area has risen about 4,000m and the Gyrong area about 3,000m since the middle Pliocene. All these data suggest great changes in elevation and physical environment in the Qinghai-Tibetan Plateau (Ji Hong-Xiang et al. 1981). Thus there has been an on-going evolution of flora and fauna to adapt to the very-high-elevation ecological environment along with geological change.

Schizothoracine fish provide an example of this evolution. Morphological, paleontological, and zoogeographical evidence demonstrates that these fish arose from primitive Barbine* fish distributed over the area of Qinghai-Tibet during the late Tertiary period. Schizothoracine fish constitute a natural group which has adapted itself to the special conditions of the plateau. According to the modification of scales, pharyngeal teeth, and barbels, the eleven genera of the subfamily Schizothoracine can be divided into three ranks with different degrees of specialisation, representing three developmental stages during the course of evolution. Based on the degree of specialisation of the oropharyngeal organs, each rank may be subdivided into a trunk genus and several branch genera. Moreover, the trunk genus of the lower rank could further evolve to form the next trunk genus of a higher rank, which in turn would give rise to certain branch genera of the corresponding rank (Cao Wen-Xuan et al. 1981).

"this town in western Tibet is located at 4,300m above sea level"

In the central part of the Qinghai-Tibetan Plateau, the Tibetan antelope (*Pantholops hodgsoni*), the yak (*Bos grunniens*), and *Montigringilla* represent the special species that have adapted to the high elevation-cold-arid environment with low oxygen content, high radiation, and strong wind. They have a high vital capacity and strong hooves to break snow and ice cover to find food. More research on their regeneration capacity should be conducted. Due to the short time that the present environment has existed and due to severe physical conditions, the number of species inhabiting this area is small. These species could not be replaced by other species from outside the area.

Ritu County Town provides an example of specialised use and habitation. This town in western Tibet is located at 4,300m above sea level and there are 6,500 people living here in an area of 75,400 sq.km. These specific physical conditions are made use of as sports training grounds, which have been sited at Xining, Qinghai (2,600m); the aim is to increase the special capacity of sportsmen and women. In the future the training grounds could be built even higher, for example, at 4,000m.

The Hindu Kush-Himalayan (HKH) Ecoregion, which extends further than the Qinghai-Tibetan Plateau, accommodates more complicated components of flora and fauna and highly differentiated ecosystems (Figures 5 and 6). In geological history the HKH was an important refuge for many species that can be traced back to the Tertiary period or even earlier (including *Cycas*, *Ginkgo biloba*, and *Cercidiphullum japonicum*). More recently the HKH Ecoregion has also become a place for the

"in the future the training grounds could be built even higher"

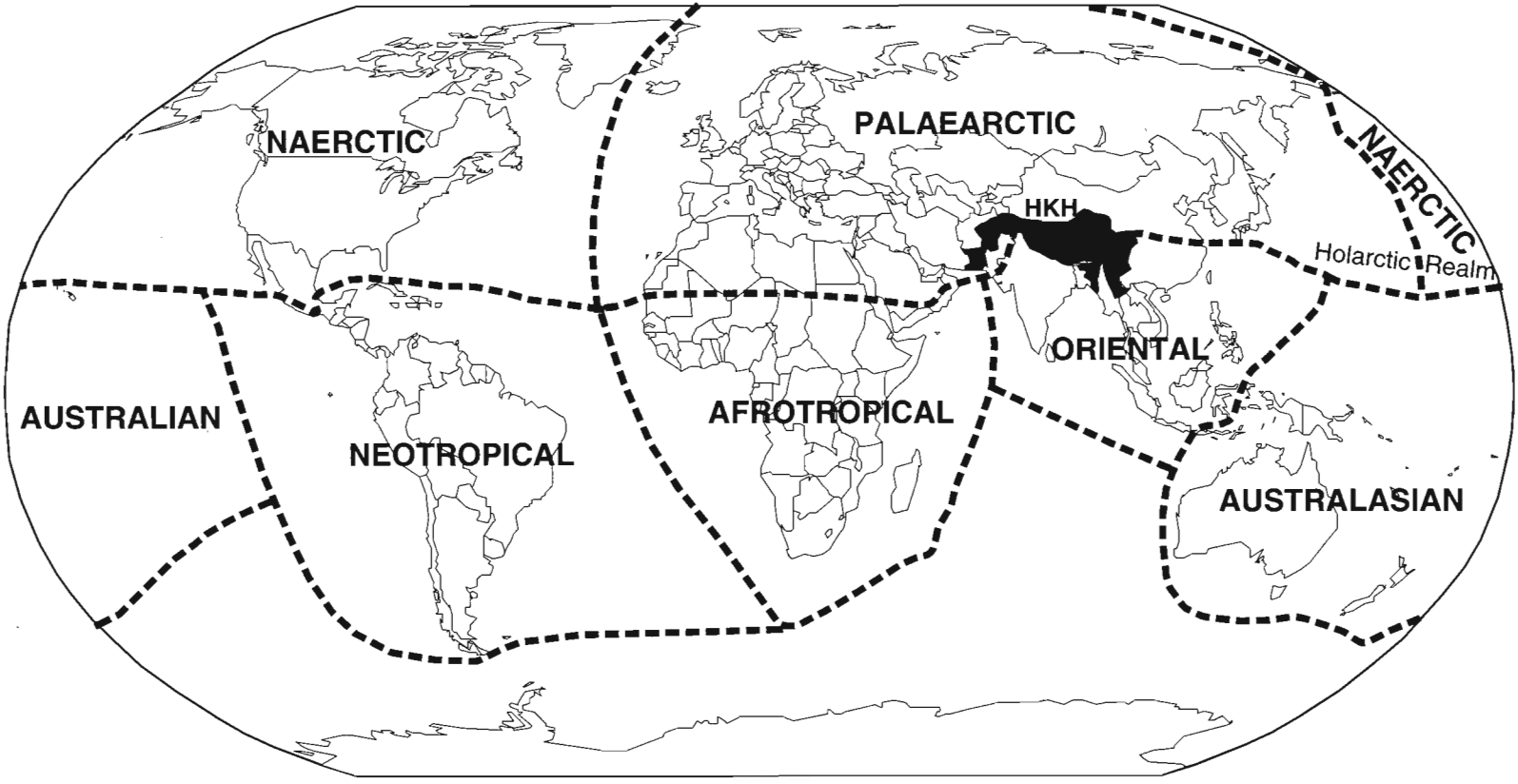

Figure 5: **World Biogeographic Regions and location of the HKH**
(Physical Geography of China - Zoogeography, 1979)

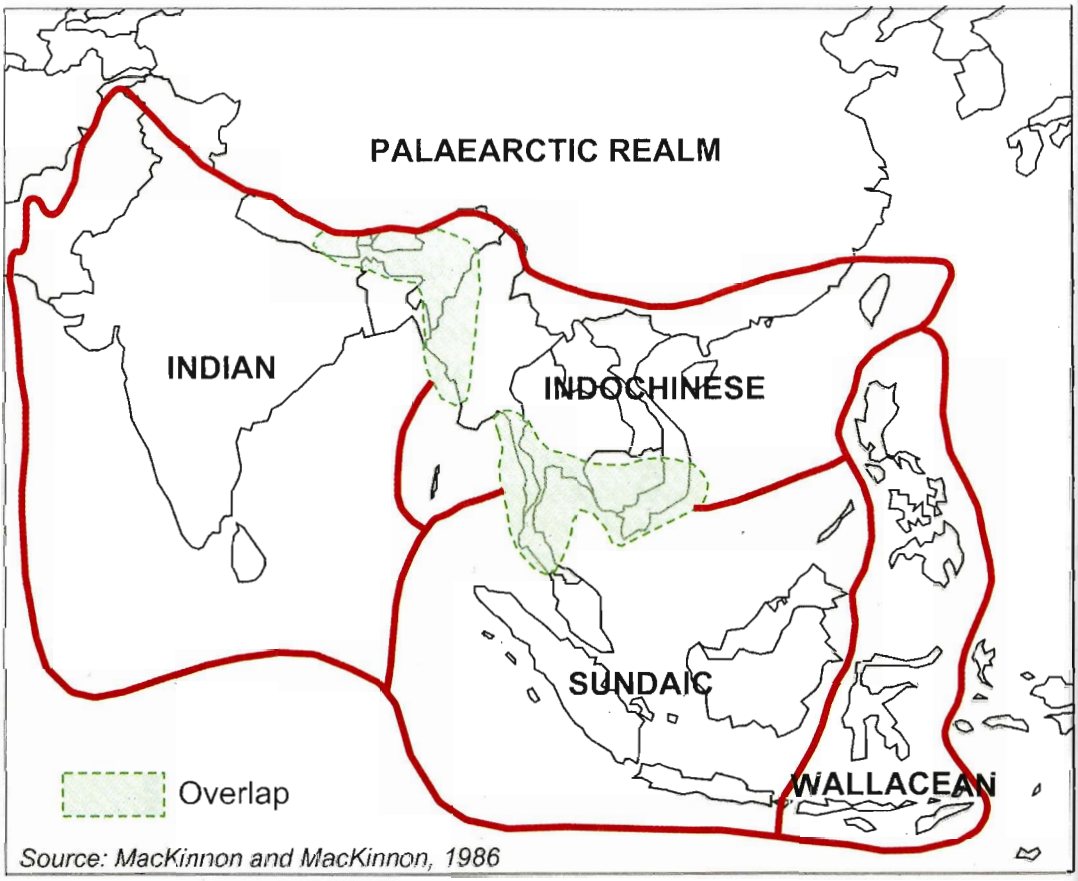

Figure 6: **A biogeographical perspective of Nepal**

"discoveries have led to assertions that this region is a unique Pleistocene refuge"

evolution of new species (for example, *Rhododendron* and *Garuiar* (bird)). Five species of large mammals have recently (1993-1998) been discovered or rediscovered in the mountain regions of Laos and Vietnam, of which three are muntjac (*Muntiacus* spp.). These discoveries have led to assertions that this region is a unique Pleistocene refuge. Another muntjac was discovered and reported using diagnostic Deoxy Ribonucleic Acid (DNA) characters in the remote area of Putao of north Myanmar (the eastern wing of the HKH Ecoregion) during a recent biological survey expedition (23 February-29 April 1997) (Amato et al. 1999). This mountainous region contains floral communities of Miocene origin isolated since the last glaciation (Ward, 1936, 1944). All this indicates rich biodiversity within the transition zone from the Indo-Malaysian to the Sino-Himalayan Region.

There is a wide diversity of ecosystems, species and genetics and a very specific vertical change of ecosystems from a few hundred to six thousand metres or more (as described by Li Bosheng) for the Grand Canyon of the Yarlung Zangbo River. Plate 1 shows the summit of Jialabailei, (7,151m) Plate 2 the Yunnan Golden-Haired Monkey that lives in the coniferous mountain forest between 3,000-4,000m, and plates 3 and 4 show the leaf deer.

Hundreds of millions of years are required to develop a new animal geographical area with its specific species and environment. Due to the short development history and unstable physical dynamics, as well as lack of supporting data, it is still too early to define a new animal geographical area of Qinghai-Tibetan Plateau.

Plate 1: **A view of Jialabailei (7,151m) in South-eastern Tibet** — Chen Guangwei

The definition of 'alpine' in the Hindu Kush-Himalayan Ecoregion

'Alpine' represents high-mountain environments, this is accepted worldwide; hills, mountains, sub-alpine, and alpine are used to describe physical environments; and sub-alpine and alpine are commonly employed by scientists to classify mountains higher than 3,000m above sea level. Unlike mountain regions in Europe, most of the HKH Ecoregion is above 3,000m (Figure 7).

Plate 2: **Yunnan Golden-Haired Monkey, a rare animal endemic to north-west Yunnan. It lives in mountain coniferous forest (3,000-4,000m)** — (Xu Zhihui 'Yunnan Wildlife' p203,Yunnan Education Press 1999)

The valley of the Lhasa River could be defined as a valley in an alpine region. The Qinghai-Tibetan Plateau is generally higher than 4,000m. The Global Observation Research Institute in Alpine Environment (GLORIA) observation should include the Qiangtang Plateau or the Zangbei Plateau (the North Tibet Plateau). This region is characterised by high elevation, low temperature, low precipitation, and fragile ecosystems. It could be described as a dry, cold desert, for example Ritu County, located in the northwest part of the Tibetan Plateau, has an area of 75,400 sq.km along with 16,000 sq.km of water surface. In this vast area there are 6,300 permanent residents. The average elevation is 4,500m and the highest is 6,800m. Annual mean precipitation is 70-80 mm. Within its ecosystems fauna include wild crane, geese, yellow duck, golden-haired yak, blue sheep, and antelope bear. There is no observation station in the vast plateau of north Tibet and there is a lack of data. Because of the diversity of alpine regions in the world, subclasses could be widely used to present a more complete picture of the alpine world. The richest alpine areas exist in the HKH Ecoregion and these deserve particular attention.

Plate 3: **Leaf dear in Yangon Zoo (U Saw Tun Khaing)**

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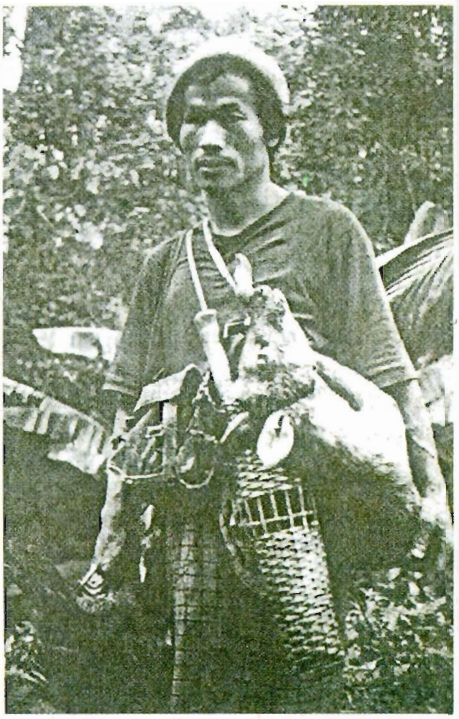

Plate 4: **A local hunter emerging from the forest with a freshly snared deer, identified as a new species, the leaf muntjac** — (Alan Rabinowitz)

Plates 3 & 4: **A new species of barking deer *Muntiacus putaoensis* (leaf deer) was discovered in this region in 1997.**

Examples of sub-alpine and alpine vertical zones are given in Table 11 to illustrate the variation in alpine environments. Thus it is important to propose indicators to identify sub-alpine and alpine zones and these should include climatic regimes, vegetation, and geological and geomorphological processes.

"there have been many studies on the principal vertical vegetation regimes but now a comparative study seems necessary"

Vertical vegetation regimes in the Hindu Kush-Himalayan Ecoregion

Vertical change is a common and important feature of vegetation distribution in alpine environments. The base vegetation belt starts with tropical-subtropical rainforest in the southeast mountains of the HKH Ecoregion. Temperate forest of broad-leaf or mixed deciduous starts in the areas north of the subtropical climate. The grass-bush belts of the base vegetation may change to coniferous forest belts in the upper areas. There have been many studies on the principal vertical vegetation regimes but now a comparative study seems necessary. Table 11 reflects the general situation, showing a variety of sites with differences in characteristics such as degree and exposure of slopes, base rock, and soil type.

A research network for alpine studies in the Hindu Kush-Himalayan Ecoregion

A lot of data have been presented in the ICIMOD publication 'Banking on Biodiversity' (Pei Shengji 1996) as part of a review of biodiversity

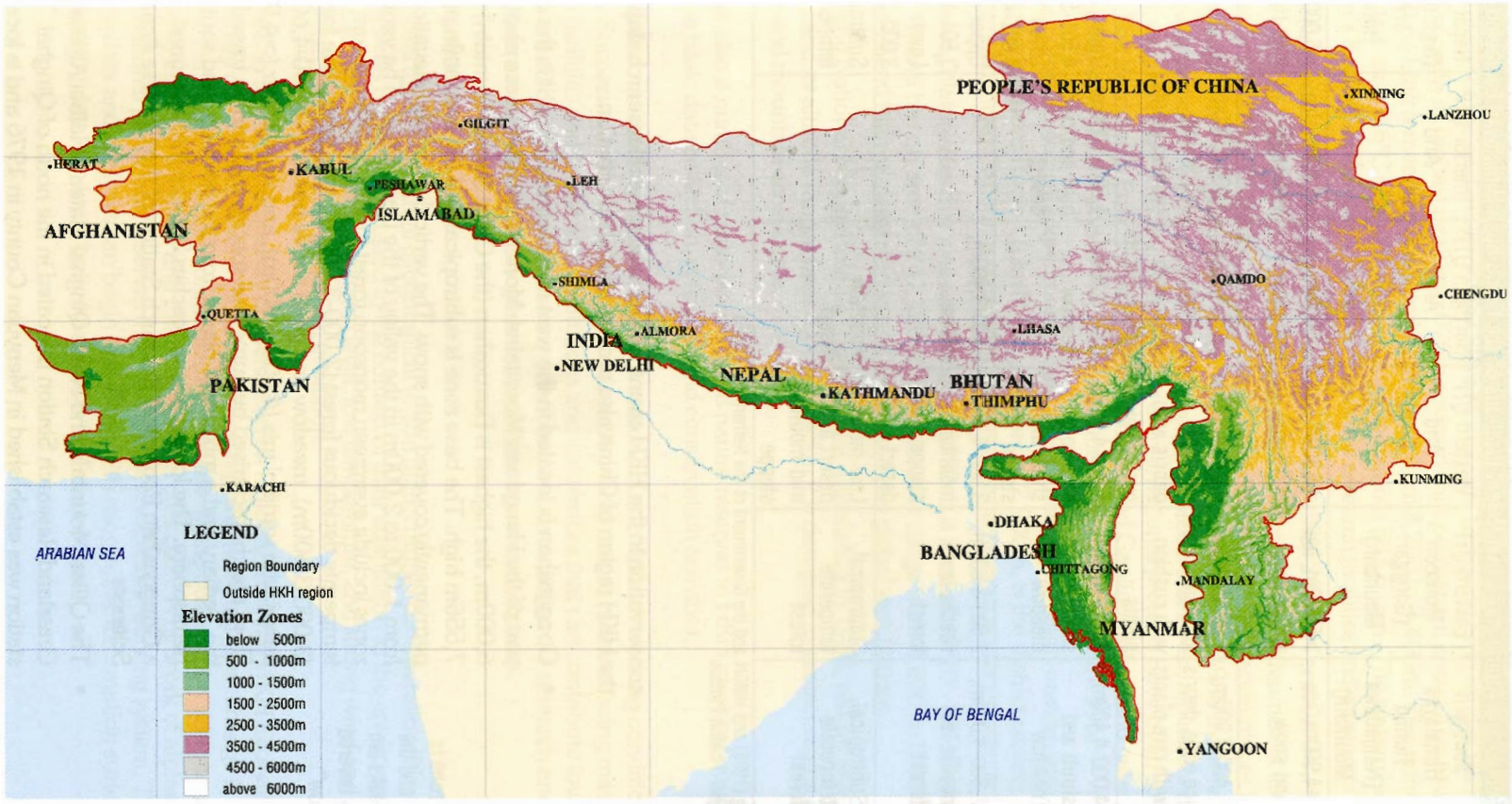

Figure 7: **Hindu Kush-Himalayas Ecoregion**

Table 11: Sub-Alpine and Alpine zones in different locations of the Hindu Kush-Himalayan Ecoregion

Climatic zone	Southern Himalayas Humid (Nanjabawa Mountain)	Eastern QTP Monsoon (Gonggar Mountain)	Western QTP Arid	Northern QTP Arid	Interior QTP Arid	Nepal Monsoon (high mountains and high Himalayas)
Polar alpine ice-snow climatic zone	>4,900m, ice and snow	>5,000m, ice and snow	>4,800m, ice and snow	>4,800m, ice and snow	>5,400m, ice and snow	>5,000m, nival, high Himalayas
Alpine cold-freezing climatic zone	4,400-4,900m, ice edge, debris with rare plants	4,600-5,000m, ice edge, debris with cushion plants	4,600-4,800m, ice edge, debris with cushion plants	3,800-4,800m, ice edge, debris with cushion plants	5,000-5,400m, debris with cushion plants	
Alpine cold climatic zone	4,000-4,400m, shrub and meadow	3,600-4,600m, shrub and meadow	4,300-4,600m, high-cold shrub and steppe	3,400-3,800m, meadow	4,500-5,000m, high and cold desert	Upper line = 4,501-5,000m Lower line = 4,001-4,500m
Sub-alpine zone	2,800-4,000m, needle-leaf forest	2,500-3,600m, needle-leaf forest	3,000-4,300m, mountain steppe and desert	2,800-3,400m, steppe		Upper line = 3,501-4,000m, Lower line = 3,000-3,500m
Base zone	Subtropical, temperate forest	Subtropical, temperate forest	Low-mountain desert and mid-mountain steppe	Mountain desert		Subtropical, temperate forest

Source: Li Bosheng (1995) and HMGN and the Government of the Netherlands (1995)
Note : QTP = Qinghai-Tibetan Plateau

conservation in the HKH countries. Some ecological research stations in the HKH region of China also provide useful information.

"the base zone is subtropical and the mountain peaks are permanently covered with snow"

- Gonggashan is located in the west of Sichuan, China; it is the central part of the Hengduan Mountains. More than 45 peaks are above 6,000m, the highest is Daxueshan (the Great Snow Mountain) which is 7,556m high. The base zone is subtropical and the mountain peaks are permanently covered with snow. The vertical change in elevation ranges from 1,000 to 2,000m in the valley of the Dadu River. The vegetation zones include evergreen monsoon forest (under 2,000m), warm temperate deciduous forest (2,000-3,000m), cool temperate forest (3,000-3,600m), meadow and grass above tree-line (3,600-4,600m), debris with some plants (4,600-4,900m), and snow cover (>4,900m). Flora are characterised by numerous species that can be traced back to the Tertiary and a mixture of plants from the northern and southern hemisphere. The lowest glacier reaches 2,850m into the forest. There is a Gonggashan Ecological Research Station of the Chinese Academy of Sciences.
- The Qilian Mountain and North Qinghai Plateau Haibei Alpine Grassland Research Station is located in the north of Qinghai. The station was established in Menyuan County in 1976 and is located at

37°29'-37°45' N and 101°12'-101°33' E. The station is situated in the Lenglong Ling (mountain) of the east range of the Qilian Mountains. Lenglong Ling ranges from 4,600 to 4,800m, with its highest peak of 5,076m covered with permanent snow. The south foot of Lenglong Ling is meadow grassland and ranges from 3,200 to 3,400m. The annual mean temperature is 0.6°C and annual mean precipitation is 531.6 mm. The station belongs to China's Ecological Research Network. There are research facilities and a research team.

- Gaoligongshan is located in the west of Yunnan at 24°56'-26°09'N and 98°34'- 98°50' E and has an area of 1,239 sq.km. The highest peak is 5,128m and the difference in elevation ranges from 1,090 to 3,900m. Three natural reserves with administration offices have been established. The Gaoligongshan Nature Reserve was established in 1983 to protect its complete vertical forest strata, subtropical evergreen broad-leaf forest, alpine coniferous forest, and rare flora and fauna. A number of international projects have been conducted here. The Worldwide Fund for Nature (WWF) reviewed Gaoligongshan and gave it a rating of 'A' (global significance and in very good condition) (Mackinnon et al. 1996).
- Linzhi Forest Ecological Experimental Station is located in the south-eastern mountains of the Tibet Autonomous Region (Linzhi City, situated at 2,900m, is the district centre). The famous Yaluzangbu Great Canyon is located in this area. Several snow peaks are above 7,000m.
- Qiangtang Nature Reserve was established in 1993. It is located 33°10'- 37°10'N and 80°10'-91°40'E and has an area of 247,120 sq.km. Altitudes range from 4,800 to 5,000m. It is a kind of inland high-plateau steppe and desert and has global significance.
- Zhu Feng National Nature Reserve (Everest) was established in 1988, has an area of 33,810 sq.km and its altitude ranges from 5,000-8,848m. It is designed to protect alpine primary forest and mountain ecosystems.

There are also a number of national parks and nature reserves in HKH member countries that undertake basic data collection, research, and conservation activities.

There are few mountain ecological research stations due to difficult working conditions and lack of funds. Successes in China have been achieved by most nature reserves being matched with research facilities and linked with institutions and universities that can contribute towards manpower and data collection. These experiences demonstrate that the research and observation network should be integrated with nature reserves and parks.

Conclusions

The proposal for a new animal geographical region merits further consideration. New species and subspecies could be discussed in the context of their adaptation to the environment (their tolerance to high elevation, low oxygen level, low temperature, and strong wind and radiation), which has occurred alongside geological evolution.

In any case, in terms of biodiversity conservation on a global level, the HKH Ecoregion is an important key node where several biogeographical regions meet and great change is taking place. Due to the harshness of the environment, there are few alpine observation stations, so it is necessary to establish a system and methods for data collection. A network of alpine research stations, national parks, and reserves may be the best choice as a working system. The gathering of existing data and analyses can begin and along with geographic information system and remote sensing data can lay a basic foundation for future action.

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