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Preface

This current discussion paper in the Mountain Natural Resources' Series, "Biodiversity of the Qinghai-Tibetan Plateau and Its Conservation," is one of a number of papers delivered at the "Regional Conference on the Sustainable Development of Fragile Mountain Areas of Asia" which took place from December 13th to 16th 1994 in Kathmandu, Nepal. Support for this Conference came from the Swiss Development Cooperation, FAO, UNDP, UNEP, and the UNU.

The unanimous concern expressed at this conference was for the deteriorating conditions of both the environments and livelihoods of mountain people. Mountain development had not been geared to the people nor the environment it purported to serve.

One of the achievements of the Conference was a wider sharing of knowledge amongst the mountain countries of Asia and insight into the constraints that confronted them and the opportunities offered by the wide diversity of their special mountain environments. Another significant achievement was the formulation of a Call to Action on the Sustainable Development of Mountain Areas of Asia, or SUDEMAA recommendations.

By publishing the conference papers in its various discussion paper series, ICIMOD seeks to share the knowledge gained with a wider audience. This current paper should be of interest to all those who are working with or concerned the conservation of biodiversity and the protection of regions that are valuable source areas for rare and endangered species.

Contents

Biodiversity of Qinghai-Tibetan Plateau and its Conservation

Abstract

The Qinghai-Tibetan Plateau, as the largest and highest plateau in the world, has always enjoyed the reputation of being "the roof of the world". This unique geographic unit towers over the centre of the continent of Eurasia, linked with the Northwest Himalayas and the Pamir Plateau in the west, screened by the Hengduan Mountains in the east, bounded by the Himalayan Mountains in the south, and connected with the Kunlun Mountains and the Qilian Mountains in the north, with a total area of about 2,500,000sq.km., covering approximately a quarter of the Chinese land area. The Qinghai-Tibetan Plateau, with its vast land surface in the middle of the troposphere, has wide climatic variation caused by the unique plateau atmospheric circulation system resulting from the strong heat-island effect and the great difference in elevation of the peripheral boundary surface. Such unusual natural conditions give rise to a diverse and complex species. The marginal areas of the eastern and southern Plateau are the most active places for species' differentiation. It is an important world centre for the formation and differentiation of mountainous species. Obviously, the Qinghai-Tibetan Plateau is an extremely important area for conservation of biodiversity.

Economically, the Qinghai-Tibetan Plateau is not too well developed, and this is seriously affecting the conservation of biodiversity in the region. Based on this situation, regarding establishment of nature reserves in the Qinghai-Tibetan Plateau, the emphases should be given to those which are of significance in zonality and well represent their ecosystems.

Part 1: Physical Geographic Features of the Qinghai-Tibetan Plateau

The Uplift of the Immense Landmass and the Complex Conditions of the Peripheral Boundary Surface

The Qinghai-Tibetan Plateau, on an average is 4,500m in elevation. Topographically it is the highest terrace in China and the highest and biggest highland in the world. In the southeast, the average elevation is 4,000m and in the northwest it gradually ascends to 5,000m. The surface of the main plateau is mainly covered by low mountains and undulating and broad basins. On the edges of the plateau, high mountain ranges constitute the geomorphologic skeleton of the Plateau. These mountain ranges are composed of two groups of mountains which run in almost east-westerly and south-northerly directions. From south to north lie the east-west oriented Himalayan Mountains, the Gangdise-Nyainqentanglha Range, the Karakorum-Tangula Mountains, and the Kunlun Mountains. On the eastern edge of the plateau lie the south-north oriented Hengduan Mountains, a mountain system folded by the tips of the eastern extensions of the Tangula and Nyainqentanglha mountains, and, from west to east, the Baishula Range, the Taniantaweng Mountains, the Ningjing Mountains, the Shaluli Mountains, and the Daxue Mountains. The Qinghai-Tibetan Plateau landform covers approximately 2,500,000sq.km. in extent and towers above the centre of the Eurasian continent.

Topographically, the contrast between the Qinghai-Tibetan Plateau and its periphery is remarkable, and such a contrast is further enforced by the surrounding criss-crossed mountains. On the western edge of the Plateau, the Northwestern Himalayan Mountains are linked with the Karakorum Mountains and extend northwards to the Pamir Mountain knot. These almost south-north ranging mountains average 6,000m in height and, among them, there are many high snow-capped peaks, e.g., the Qiaogeli Peak (8,611m), the second highest peak in the world, Nanjiapaerbati Peak (8,125m) and four more peaks over 8,000m high. The western sides of these mountains suddenly descend to the Indus River Plain, which is only several hundred metres in elevation, making an absolute difference of over 5,000m in altitude. The eastern edge of the Plateau is occupied by hilly land and mainly consists of the Minshan Mountains, the Qionglai Mountains, and the Daxue Mountains. This area averages 4,000m in elevation and descends to the Sichuan Basin where the elevation is 500m; the absolute difference is still over 3,000m. The Qinghai-Tibetan Plateau is shut off on the south from the rest of the world by the Himalayan Mountains with their main ridges averaging above 7,000m. Mount Everest in the Middle Himalayan Mountains is 8,848m high, the highest peak in the world, and eight of the 14 peaks that are above 8,000m are also to be found there. South of the Himalayan Mountains lies the Ganges-Brahmaputra Delta below 500m in elevation, an absolute difference of 6,000m in altitude between the Delta and the Plateau. The northern edge of the Plateau is covered by the Kunlun, Altun, and Qilian mountains, which average 5,500-6,000m in elevation. In the north, beyond these high and magnificent mountains, the Tarim Basin and Hexi Corridor have elevations of 1,400-2,500m, making an absolute difference of 3,000-4,000m in altitude between the mountains and the rest of the area.

The southern and eastern parts of the Qinghai-Tibetan Plateau are located on the windward sides of the southwest and southeast monsoons, and they have plentiful precipitation owing to the influence of the special boundary surface effect produced by the warm-humid currents and the terraces. Moreover, the great difference in topographic conditions enhances the erosive power of the running waters. Therefore, the boundary surfaces of these two terrace series are serrated, caused by numerous deep cutting rivers. Thus, the environmental complexity between the Plateau and its peripheral zones is further increased. On the other hand, the Plateau is not completely shut off from the outside world by high terraces. Some of its mountain ranges extend to the mountain systems outside. For example, in the west of the Plateau, the Karakorum and Kunlun mountains are connected westwards, via the Pamir Mountain Knot, with the Xingdukushi Mountain Range which extends further west linking with the Caucasus and Alpas mountains in Europe via the Pamisush Mountains and the mountains on the Plateau of Iran. Northeasterly, the Pamir Mountain Knot is connected with the mountains in Siberia via the Tianshan, Altay, Tannu Ola, and Sayanling Mountains. In the northeastern parts of the Plateau, the Qilian and Minshan Mountains are linked eastwards with the mountains in east and northeast China via the Qinling Mountains and the Daba Mountains. In the southeast, the Hengduan Mountains extend directly southwards to the mountains in the Indo-Chinese Peninsula.

The landforms described above bring distinctiveness to the Qinghai-Tibetan Plateau and lead to the formation of its unique fauna and flora and to the close relationship between the Plateau and its adjacent regions. Consequently, the Qinghai-Tibetan Plateau has a drastic effect on biodiversity in other regions.

Unique Heat-island Effect and Complex and Diversified Climates

The Qinghai-Tibetan Plateau, a land mass of about 2,500,000sq.km. and towering to the middle of the atmosphere between the earth's surface and the tropopause, has a strong impact on the atmospheric circulation that originates from the exchange of heat between the continents and oceans. This effect includes the mechanical pull of the land mass in the atmosphere, the frictional force of the land boundary surface on atmospheric movement, and the heating power produced by the land mass through solar radiation

Based on repeated research on the climate of the Qinghai-Tibetan Plateau, Chinese meteorologists have confirmed that "in winter, the Qinghai-Tibetan Plateau mainly effects atmospheric movement, however, this is caused by heat rather than mechanical power." In spring and summer, the Qinghai-Tibetan Plateau is a huge heat source. In June especially, an area of one square centimetre may produce 210 Kcal. per day. A Plateau with an area of about 2,500,000sq.km. can produce $1.1x10^{18}$ Kcal. in the atmosphere per day, on the average, over the year. In June, the whole Plateau produces $5.0x10^{18}$ Kcal. Under such circumstances, in spring and summer, the Plateau boundary surface directly heats the atmosphere over the surface, thus affecting the temperature and humidity of the low-level atmosphere. Below 500mb, a strong, hot low atmospheric pressure is formed. The upward movement of hot air leads to the appearance of an upper strong and stable, warm high atmospheric pressure of above 430mb (the strongest at 150-200mb) in the Plateau's troposphere, which is quite unique. The high atmospheric pressure occupies the upper level of the troposphere over the vast subtropics of Asia and Africa, not only affecting the current field of the northern hemisphere but also that of the southern hemisphere.

Thus, along with the seasonal change of the features and intensity of the Plateau's cold and heat sources, the air pressure field undergoes remarkable seasonal change, and so does the wind field. The most distinct feature is that, in summer, the wind around the Plateau converges on to the Plateau and in winter it diverges away. Thus, a unique plateau seasonal phenomenon occurs (Ye Duzheng et al. 1979). The special heat-island effect of the Qinghai-Tibetan Plateau exerts a tremendous influence on the climate of the Plateau.

1. The Qinghai-Tibetan Plateau monsoon destroys the planetary air pressure belt and planetary circulation in the middle of the troposphere; hence, the influence of the descending continental air mass (which is controlled by subtropical high atmospheric pressure and the westerly planet wind belt, both of which are of decisive importance to the climate of the latitudinal zone of the region) is weakened. As a result, a warm and rainy region of considerable size appears in the arid and semi-arid desert near the Tropic of Cancer.

2. The Qinghai-Tibetan Plateau monsoon enforces the monsoon phenomenon between the southern and northern hemispheres and the exchanges of air, water, momentum, and energy between the two hemispheres. The most important point is that it induces and thickens the southwest monsoon at the lower layer of the troposphere. Confirmed by the simulated tests of Habn and Manabe (1925), without the plateau the centre of the continental low pressure is located at 45°N latitude and 125°E longitude. Thus, in July, the mean southwest monsoon cannot go beyond 15°N latitude on the South Asian Continent. However, enforced

by the plateau monsoon, it can travel through all the longitudinal passages composed of numerous valleys on the southern edge of the Plateau that are deeply cut by running water and move further northwards into the hinterland of the Plateau. Influenced by various landforms, the southwest monsoon regularly releases the water and heat that it brings while it moves northwards into the Plateau's hinterland. Eventually, it has a direct effect on the distribution patterns of the ecosystems of the Qinghai-Tibetan Plateau region.

3. The plateau monsoon also enforces the exchange of air currents between Eurasia and the southeastern and southern areas of the South China Sea and the southwestern Arabian Sea. In summer, the southeast monsoon is enforced by the plateau monsoon and moves northwards along the eastern and northeastern edges of the Plateau to the Qilian Mountains, affecting the climate of those regions. Influenced by the plateau-heat-island effect, the winter rainfall cloud masses of the western Arabian Sea may affect the climate of the mountainous regions in the west of the Plateau and cause rainfall there in winter.

4. The plateau hinterland, facing the centre of the plateau's low-level heat, low pressure area, is a convergence centre for the air current around and horizontally becomes the drought and cold limit of the Qinghai-Tibetan Plateau. Revolving around this limit, the gradient change of water-heat assemblage conditions in the Qinghai-Tibetan Plateau brings polar zonality to the ecosystems of the Plateau (Li Bosheng 1985a).

Controlled by the special Qinghai-Tibetan Plateau circulation system, the Plateau has complex and diversified climates, and its water-heat assemblage is of great variation.

The plateau is the focus of international attention because of its numerous climatic types. Although it falls into subtropical latitudes, its action in enforcing the southwest monsoon and in impeding the cold air masses from the north causes the tropical monsoon climatic zone in the South Asian Subcontinent to extend to the southern edge of the Plateau and form a zonal climatic type at its base. This type of climate may even extend to 29°30'N latitude along the Yarlung-Zangbo River Valley. Because of the height of the Plateau itself, a climatic type, similar to that in a cold zone, appears on its northwestern edge. The movement of the southwest monsoon northwards, the core of drought and coldness in the northwest of the Plateau, and the gradual ascendance of its topography induce gradient changes of water-heat assemblages. Thus, the Qinghai-Tibetan Plateau has developed 'a plateau climatic zone,' similar to a climatic latitude zone, and different climatic regions that are features of the Plateau itself. From southeast to northwest the following regions can be found, (a) a tropical, lower montane, monsoon humid, climatic region, (b) a subtropical montane, monsoon humid, climatic region, (c) a plateau temperate humid, climatic region, (d) a plateau temperate monsoon, semi-humid climatic region, (e) a plateau temperate monsoon, semi-arid climatic region, (f) a plateau temperate monsoon, arid climatic region, (g) a plateau sub-cold monsoon, semi-humid climatic region, (h) a plateau sub-cold monsoon, semi-arid climatic region, (i) a plateau sub-cold monsoon arid climatic region, and (j) a plateau cold monsoon, arid climatic region (Shen Zhibao 1984).

The variation in the Plateau's climate not only reflects its diversified zonal climatic types but also its numerous vertical climatic types. Owing to a vast mountainous area on the edges of the Plateau, and snow-capped mountains on the broad flat plateau surface reaching into the clouds, the mountains in the different plateau climatic zones have their own distinctly vertical climatic zonal spectra. For example, the southern slopes of the eastern Himalayan Mountains on the southeastern edge of the Plateau have the most complete vertical climatic zonal spectra (Table 1) (Li Bosheng 1984) among all the humid mountains in the world. Their basal tropics with optimum water-heat assemblage conditions, along with the gradient change in water-heat assemblage caused by a gradual rise in altitude, transits to an extremely cold, polar montane ice-snow zone, via montane subtropics, a mid-mountain warm-temperate zone, a subalpine cold-temperate zone, an alpine cold zone, and an alpine cold-freezing zone. On Mount Everest, the highest peak in the world, standing at the southern edge of the Qinghai-Tibetan Plateau, and on the Qiaogeli Peak on the western edge, the second highest peak in the world, there is a most severe, montane cold-pole climate. According to measurements carried out by Chinese mountaineers at the summit of Mount Everest at 14:30 on 27 May 1975, the temperature there then was -35°C So one can speculate that the annual temperature at the top of Mount Everest is below -20°C. Thus, it can be seen that a great change takes place in the vertical climatic zone on the southern edge of the Qinghai-Tibetan Plateau from low mountain tropics to alpine cold pole; meanwhile, the climatic water and heat conditions may have different combinations.

Tables 2-4 show the structures of the windward mountain climatic vertical zonal spectra of the mountains on the east, south, west, and northern edges of the Qinghai-Tibetan Plateau. They are different to varying degrees from the world's most simplified climatic vertical zones of plateau cold-drought cores (Table 5). This shows that successional series of mountain climatic vertical zonal spectra exist from all edges up to the plateau cold-drought core. They are regularly distributed on the slopes of all the mountains of the Plateau. The Qinghai-Tibetan Plateau has extremely diversified mountain vertical, climatic association types and no other place in the world is compatable.

Table 1. Climatic Vertical Zones of the Southern Wing of the Himalayas (South Slope of Mount Nankabawa)

No.	Climatic Vertical zones	Ecosystemic Vertical Zones	Altitudes (m)	Annual Mean Temp. (°C)	Annual Mean Rainfall (mm)
1	Humid low mountain tropical climatic zone	Low mountain evergreen, semi-evergreen monsoon rain-forest zone	<1100	>18	2500-5000
2	Humid montane subtropical climatic zone	Montane evergreen, semi-evergreen broad-leaved forest zone	1100-2400	11- 18	1500-2500
3	Humid mid-mountain warm temperate climatic zone	Mid-mountain evergreen needle-leaved forest zone	2400-2800	8 -11	2000-2500
4	Humid sub-alpine cold temperate climatic zone	Subalpine evergreen needle-leaved forest zone	2800-4000	2 - 8	1500-2000
5	Humid alpine cold climatic zone	Alpine shrub and meadow zone	4000-4400	-3 - 2	1000-1500
6	Humid alpine cold-freezing climatic zone	Alpine ice-edge zone	4400-4900	-5 - -3	< 1500
7	Humid alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4900	<-5	< 1500

Table 2. Climatic Vertical Zones of the Eastern Edge of the Qinghai-Tibetan Plateau (East Slope of Gonggar Mountain)

No.	Climatic Vertical Zones	Ecosystem Vertical Zones	Altitudes (m)	Annual Mean Temp. (°C)	Annual Mean Rainfall (mm)
1	Humid montane subtropical climatic zone	Montane evergreen broad-leaved forest zone	1000-2200	8 to 18	1000-1500
2	Humid mid-mountain warm temperate climatic zone	Mid-mountain needle-leaved and broad-leaved mixed forest zone	2200-2500	5 to 8	1300-1500
3	Humid subalpine cold temperate climatic zone	Subalpine evergreen needle-leaved forest zone	2500-3600	0.8 to 5	1600-1700
4	Humid alpine cold climatic zone	Alpine shrub and meadow zone	3600-4600	-3 to 0.8	1000-1600
5	Humid alpine cold-freezing climatic zone	Alpine ice-edge zone	4600-5000	-5 to -3	< 1500
6	Humid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>5000	<-5	< 1500

Table 3. Climatic Vertical Zones of the Western Edge of the Qinghai-Tibetan Plateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudesim
1	Arid montane subtropical climatic zone	Low mountain desert zone	800-2000
2	Arid mid-mountain warm temperate climatic zone	Mid-mountain steppe zone	2000-3000
3	Arid subalpine cold temperate climatic zone	Subalpine evergreen needle- leaved forest zone	3000-4300
4	Arid alpine cold climatic zone	Alpine shrub and meadow zone	4300-4600
5	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	4600-4800
6	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4800

Table 4. Climatic Vertical Zones of the Northern Edge of the Qinghai-Tibetan Plateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudes (m)
1	Arid montane warm temperate climatic Zone	Montane desert zone	< 1400
2	Arid mid-mountain temperate climatic zone	Mid-mountain desert zone	1400-2800
3	Arid subalpine cold temperate climatic zone	Subalpine steppe zone	2800-3400
4	Arid alpine cold climate zone	Alpine meadow zone	3400-3800
5	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	3800-4800
6	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	>4800

Table 5. Cold-arid Polar Climatic Vertical Zones of the Interior Continent of the Qinghai-Tibetan Piateau

No.	Climatic Vertical Zones	Ecosystemic Vertical Zones	Altitudes (m)
1	Arid plateau cold climatic zone	High and cold desert zone	4500-5000
2	Arid alpine cold-freezing climatic zone	Alpine ice-edge zone	5000-5400
3	Arid polar alpine ice-snow climatic zone	Polar alpine ice-snow zone	> 5400

In addition, the extremely complex landforms of the Plateau result in the formation of some unique climatic types, of which the most well-known is the dry river valley climate that occurs in the Hengduan Mountain region in the east of the Plateau. Meteorologists have different explanations for its formation. For example, because this region falls in the subsidence compensation area of the outer sphere of the plateau monsoon circulation sphere, the foehn effect caused by mountains in blocking monsoons and the influence of the local circulation of the valley wind are the reasons for the formation. Climatically dry river valleys are distinctly characterised by less rainfall, intense evaporation, plentiful heat, and a dry climate. According to the aridity formula of H.L. Punman, the aridity of such a climate is 1.5-5.0, belonging to semi-arid and arid steppe or desert-steppe climate. As to the heat, owing to the differences in physical position and in altitude, the criteria for heat are different for different dry river valleys in the Hengduan Mountain region. They are divided into three types: arid heat, arid warm, and arid temperate. This special, dry river valley climatic type has developed an unusual ecosystem and vertical zonal spectra, and it has given rise to special species.

In short, the Qinghai-Tibetan Plateau climatic variation is evident. The substantiality of this variation is that all of the climatic elements are discrepant in climatic niche at different horizontal and vertical locations on the Plateau. Although it is impossible to discuss the extremely high mountains owing to the inadequacy of first-hand data or on-the-spot investigation, speaking about changes at distances of from 500-5,000m from the Plateau edges up to its hinterland, the two extreme values of each climatic element are very impressive. For example, the annual mean temperature ranges from 20°C to -8°C, the annual rainfall ranges from 4,000mm to 25mm, and the solar total radiation ranges from 110Kcal./cm^2yr and 210Kcal/cm^2yr. The possible arrangement of the combination of all the elements will definitely form a fantastic astronomical figure. All these elements vary in different places and in different months of the year. The diversified climatic niches formed by these climatic elements have a decisive influence on biodiversity in the Qinghai-Tibetan Plateau.

Finally, it is necessary to point out that, owing to the complexity of the Plateau geomorphology, the climate is controlled by a plateau unique circulation. Hence, the plateau climate is obviously changeable according to time coordinates. If the southwest monsoon is considerably strong, the water-heat assemblage conditions along its water-vapour passages vary remarkably, and vice versa. Supposedly influenced by the monsoons, the annual mean temperature of this region ranges between 0.4°C and 7°C; thus each climatic zone boundary in the vertical zone will vary by about 100m up or down. Definitely this greatly affects the mountain ecosystems and directly influences the species' differentiation rate.

Long History of Development, Formation of Unique Modern Fauna and Flora

The Qinghai-Tibetan Plateau is not as many scientists outside China conjectured: glaciers thoroughly destroyed the previous vegetation without any trace and the plant kingdom after the Ice Age bore no relation to that of the Tertiary period; the re-establishment of this plant kingdom relied upon the flora of the areas surrounding those topographic barriers that did not suffer from glacial attacks (Li Shiying 1976 and Rau 1975). The Qinghai-Tibetan region was ancient land during the Proterozoic era. Since the Palaeozoic era, it gradually subsided into a huge sea basin and became the eastern sea waters of the Tethys Sea. Even during that period, terrestrial life occurred on numerous islands in the sea basin. The most ancient terrestrial, *Psilophyton,* was found in the stratum of the Devonian Poququn on the northern slopes of the Himalayan Mountains. At the beginning of the Carboniferous period, an ancient forest ecosystem composed of arboroid ferns, including huge arboroid *Lepidodendron* and *Archaeocalamites,* developed from the ancient continental island in Qamdo in eastern Tibet. In the Permian period, this forest ecosystem was succeeded by a palaeotropical fern forest ecosystem dominated by southern *Cathysia* flora, including *Lepidodendron, Sublepidodendron, Calamites, Cyathea spinulosa,* and *Gigantopteris* of Chinese origin (Xu Ren 1982). Some paleontologists believe that the *Cathysia* flora, composed of pteridosperms, including *Gigantopteris*, are ancestors of the modern Chinese angiosperms. If so, plentiful fossils of pteridosperms found in the Permian stratum in the Qinghai-Tibetan region can fully support the idea that the Qinghai-Tibetan region should occupy a place in the history of the development of Chinese fauna and flora.

Up to the continuous action of the Triassic period, with movement of the land west of the Tethys and Yanshan Mountain, the sea basin of the Tethys began to lift slowly from north to south and from east to west. During the Upper Triassic period, the Kunlun Mountains, Hoh Xil Range, and Qamdo-Deqen area in the Qinghai-Tibetan region emerged as land from the sea and formed the ancient lands of northern Tibet and Qamdo. In the early Cretaceous period, northern Tibet and Qamdo became one piece of land, linked to other parts of China on the east and northeast. To the south and west of this ancient land, there were strip island lands along the Gangdise-Lhasa. The terrestrial ecosystem of the Qinghai-Tibetan region started a constant successional process. In the late Cretaceous period the movement of the Yanshan Mountains came to and end, and the powerful movement of the Himalayas commenced. This was followed by the rapid uplifting of the earth's crust in the Karakorum Mountain region and along the Gangdise-Lhasa-Bowo-Zay (Isotope K-Ar Group of the Institute of Geology of the Chinese Academy of Sciences 1979). Till the Palaeocene epoch of the Cenozoic era, several east-west oriented island lands emerged successively from the sea along today's Fenshuiling in southern Tibet to the Himalayan Mountains, separating the western sea realm of the Tethys into several latitudinally extending sea basins. Later, through the continuous movement of the Himalayas, these island lands began to rise and expand and water through the long narrow sea passages between them receded in northwesterly or southeasterly directions. In the late Eocene epoch, the movement of the Himalayas entered into the second stage. The Indian continental mass moved below the Eurasian continental mass, causing the Himalayan Mountains to rise rapidly. Consequently, the left over ancient sea in the Qinghai-Tibetan region completely disappeared, and the plateau was connected with Eurasia.

The great vicissitudes of the Qinghai-Tibetan region caused a great change in the terrestrial ecosystems of the region. In the late Triassic period, a tropical elfin forest ecosystem composed of *Cycas,* gymnosperms (pines and cypresses), and pteridosperms was developing on the ancient continent of northern Tibet and Qamdo in northeastern Tibet, which belong to the Tethys littoral subregion of the southern China palaeontological geographic region (Wu Xiangwu 1982). In the Jurassic period, large-scale sea erosion shrank the area of the ancient Qinghai-Tibetan continent. By then, a tropical forest ecosystem, composed of gymnosperms and pteridosperms, similar to that of the late Triassic period was developing in this ancient continent, and *surischia* were multiplying in tropical swamps in the humid warm climate. In the early Cretaceous period, the sea erosion in the Qinghai-Tibetan region ended and the dense lush tropical forest ecosystem expanded further. It was an important period for coal formation on the Plateau. In the late Cretaceous period, the terrestrial part of the QinghaiTibetan region expanded further, and the Tethys diminished. Great changes took place in the geographic conditions of the Qinghai-Tibetan Plateau and its adjacent regions. The humid marine climate was replaced by a Mediterranean climate, which is dry in summer and humid in winter. In such a climate, up to the Eocene epoch. the tropical forest ecosystem, composed of ancient gymnosperms and pteridosperms, in the Qinghai-Tibetan region was gradually substituted by a newly developing angiosperm community, a Mediterranean sclerophyllous forest composed of Eucalyptus (Tao Junrong 1981). Meanwhile, *Tsuga* forests appeared in the mountains. Since its appearance, this forest ecosystem, dominated by newly developing angiosperms, has displayed the unique features of the region and its differences from other regions of China.

In the Oligocene epoch, after the land formation process finally ended, the Qinghai-Tibetan region began to enter into a period of rapid upliftment in the formation of the plateau. The third movement of the Himalayas occurred during the Oligocene epoch and promoted the continuous uplifting of the ancient continent of northern Tibetan and Qamdo, with an average altitude of 2,000m and a gradually ascending terrain. Southern Tibetan, shortly after developing into a continent from a sea, drastically squeezed by the Indian continental mass, formed a series of east-west oriented mountain ranges, i.e., the Gangdise Range, the Nyainqentangha Range, and the Himalayan Mountains. In the Miocene and Pliocene epochs, the fourth movement of the Himalayas caused the Qinghai-Tibetan continental stratum to reach a high tide of folding, faulting, rock mud movements and entire upliftment (Isotope K-Ar Group of the Institute of Geology of the Chinese Academy of Sciences 1979). This unprecedentedly strenuous movement laid the basic outline for the modern geomorphy of the Qinghai-Tibetan Plateau. By the late Tertiary period, the Qinghai-Tibetan region attained an average altitude of 2,000-2,500m, and the mountains standing on the Plateau averaged above 3,500m, i.e., the Kunlun Mountains, the Karakorum Mountains, the Gangdise Range, the Nsainqen-Tangulha Range, and the Himalayan Mountains. So far, the Qinghai-Tibetan region had completed the initial stage in the formation of the Plateau, and it began to enter into the final stage of its formation (Li Jijun 1979).

Owing to the above described changes in the Qinghai-Tibetan region, the Plateau gradually enforced its influence on atmospheric circulation and gradually strengthened the monsoon climate of the Asian region. With the influence of this climate, obvious discrepancies occurred in horizonal distribution of the Qinghai-Tibetan Plateau ecosystems.

Owing to the strong impact of the marine monsoon, a *Dipterocarpus* tropical monsoon rain forest ecosystem was developing on the southern slopes of the Himalayas on the southeastern edge of the Plateau and a *Quercus semecarpifolia* sclerophyllous evergreen, broadleaved forest ecosystem was widely distributed in the Yarlung-Zangbo River Valley in the south of the Plateau. Along with the weakening marine monsoon, a semi-humid and semi-arid subtropical forest-steppe ecosystem was gradually being established in the north and northwest of the Plateau. The discovery of *Hipparion* fossils from the Pliocene epoch in the Biru Basin of northern Tibet, Gyirong of western Tibet, and Nyalam and the Zanda Basin clearly confirmed the occurrence of this ecosystem (Huang Wanbo 1980). Meanwhile, because of the formation of a series of large, high mountains on the Plateau, this region became a cradle for the development of vertical zones of world tropical and subtropical montane ecosystems in the early Cenozoic era. For example, the discovery of *Spiraea alpina, S.mollifolia, Cotoneaster microphyllus, Rhododendron baileyi,* and *R.laudandum* in Mongxiang of Namling County in southern Tibet, from the Oligocene to the early Miocene, and *Rhododendron sanzugawaense* and R. *namlingense* from the Wulong flora in the Zondang Basin of Namling County from the late Miocene indicated that the world's earliest tropical and subtropical subalpine and alpine ecosystems had already been established on the Qinghai-Tibetan Plateau.

In the Quaternary period, the movement of the Himalayas was in the ascendant. Within three million years, the Qinghai-Tibetan Plateau, with an average altitude of 2,500m, became the 'roof of the world' with an average elevation of 4,500m. The mountains at its edges rose even higher. In three million years, the Himalayas and the Karakorum Mountains rose about 4,000m. This lifting speed is not comparable anywhere. With the uplifting of the Plateau, the heat-island effect on the Qinghai-Tibetan Plateau became stronger and stronger. Under the influence of the heat-island effect, the Plateau gradually developed its own special plateau monsoon climate. The aridity of the climate in the northwest of the Plateau intensified. Influenced by the fauna and flora from the arid region of Middle Asia, high-cold steppe and high-cold desert ecosystems with unique plateau features gradually became established. From southeast to northwest, the Qinghai-Tibetan Plateau gradually formed a horizonal distribution pattern of tropical rainforest, subtropical evergreen broad-leaved forest, subalpine evergreen needle-leaved forest, alpine shrub-meadow, high-cold steppe, and high-cold desert. In the mountains of each horizonal zone, ecosystemic vertical zonal spectra developed especially for that zone.

During the Quaternary period, the alternation of glacial period and interglacial period had tremendous effect on the formation of the Plateau's modern ecosystems. When a glacial period came, the climate turned cold. There were frequent contacts between the warm cloud masses from the south and southeast and the cold air masses on the Plateau. Thus, rainfall increased the snowline of the Plateau appreciatively, and its mountains descended and valley glaciers extended downwards. The boundary of each horizontal zone of the Plateau indicated in time coordinates was pushed from northwest to southeast and vertically to low altitude. The distance of this shift could be several hundred kilometres horizontally and several hundred metres vertically. During an interglacial period, the climate on the Plateau turned warm and the Plateau ecosystems shifted horizontally and vertically in the opposite direction. This alternation of cold and warm, humid and dry climatic conditions accelerated the differentiation of the species in the ecosystems, as well as the disappearance of some species. However, due to the topographic and geomorphic complexity, man/species survived in relatively stable microenvironments in valleys on the southeast of the Plateau. This made the coexistence of ancient species and new species possible, as well as the plentitude of biodiversity (Li Bosheng 1988).

The fauna and flora on the Qinghai-Tibetan Plateau were established during a long and changeable historical environment. Such a complex process greatly affected modern biodiversity.

Part 2: Biodiversity of the Qinghai-Tibetan Plateau

1. Ecosystemic Diversity

Biodiversity refers to the diversity and variation of living things and the ecological complex on which their existence depends. It includes genetic diversity, species' diversity, and ecosystemic diversity (three levels). Ecosystemic diversity refers to the diversity of habitat, fauna, and flora, and the ecological processes in the biosphere, the variation of habitats, and the change in ecological processes in an ecosystem (McNeely et al. 1990). As described above, the diversified climates resulting from the Plateau's unique geographic position, atmospheric circulation, and complex surface configuration directly add to the diversity of habitats for fauna and flora in this region. This diversity in the Plateau's life succession history has resulted in the Plateau's complex diversified ecosystemic types and the diversity of ecological processes in each ecosystem.

According to Ellenbeg's scheme (l973) for determining world ecosystems, the Qinghai-Tibetan Plateau contains all of the large ecosystems of the macro-ecosystem--terrestrial ecosystem: forest, scrub, steppe desert, and aquatic formations. Such ecosystems can be fully displayed only on a continental scale; however, they are concentrated on the Qinghai-Tibetan Plateau, a unique geographic unit, and have been transformed into four major, plateau zonal ecosystemic types with distinct regional features (Zhang Xinshi 1978): humid, semi-humid forest on the eastern and southern edges of the Plateau; plateau semi-humid scrub and meadow; plateau semi-arid, high-cold steppe; and plateau arid high-cold desert.

Owing to the reasons described above, each of these large ecosystems contains many mesoecosystems (basic units of an ecosystem) with lots of special plateau types. For example, the humid and semi-humid forest ecosystem on the eastern and southern edges of the Plateau contains low mountain, evergreen monsoon rainforests such as *Dipterocarpus turbinatus* forest; low mountain, semi-evergreen monsoon rainforests such as *Terminalia myriocarpa* forest; montane semi-evergreen, broad-leaved forests, such as *Oyclobalanopsis xizangensis* forest (Li Bosheng 1985b); mid-montane sclerophyllous, evergreen broad-leaved forests, such as *Quercus semecarpifolia* forest; subalpine sclerophyllous evergreen, broad-leaved forests, such as *Quercus aquifolioides* forest; mid-montane evergreen needle-leaved forests, such as the forest of *Tsuga yunnanensis* and *Quercus semecarpifolia;* subalpine evergreen needle-leaved forests, such as the vertical zonal ecosystemic type composed of *Abies spectabilis* forest, *Picea likiangensis* var. *balfouriana* forest, etc. In addition, in the local environment of an ecosystem there are intrazonal forest ecosystems, for example, low mountain, montane, and mid-montane river valley, broad-leaved forests., such as *Alnus nepalensis* forest; subalpine river valley deciduous broad-leaved forests such as *Hippophae salicifolia* forest; subalpine deciduous broad-leaved forests such as *Betula utilis* forest; and subalpine deciduous, needle-leaved forests such as *Larix potaninii* forest.

On the Qinghai-Tibetan Plateau, there are also various kinds of meso-ecosystems of semihumid alpine shrubs and meadows. They include alpine evergreen, leathery-leaved shrubs, such as *Rhododendron* spp shrubs; alpine evergreen needle-leaved shrubs, such as *Sabina* spp shrubs; alpine deciduous broad-leaved shrubs, such as *Potentilla fruticosa* shrubs; alpine cushion deciduous, broad-leaved shrubs, such as *Salix lindleyana* shrubs and *Caragana tibetica* shrubs. Besides these alpine shrub and meadow ecosystems of Plateau zonal significance, there is another unique shrub ecosystemic type on the Plateau, i.e., the dry river valley shrub ecosystem (Zhang Rongzu 1992), which is mainly distributed in the longititudinal valleys of the Hengduan Mountains in the east of the Plateau. This shrub ecosystem is mainly composed of open spiny shrubs, such as *Phyllanthus emblica, Diospyros mollissima;* succulent spiny shrubs, such as *Euphorbia royleana;* river valley microphyllous, deciduous broad-leaved shrubs, such as *Caryopteris mongolica* and *Ajania potaninii.* In addition, there are subalpine evergreen bamboo groves in the plateau forest ecosystems, for example, *Sinarundinaria nitida* groves. The steppe and desert ecosystemic type contains high-cold steppes of plateau zonal significance, such as *Stipa purpurea* steppe and high-cold deserts (Wang Jinting and Li Bosheng 1982), such as cushion *Ceratoides compacta.* Additionally. it also includes low mountain tropical herbosa, such as *Saccharurn arundinaceum* herbosa; montane and mid-montane herbosa, such as *Pteridium aquilinum* var. *latiusculum* herbosa type, and temperate montane desert, such as the *Ceratoides latens* desert type.

It is especially necessary to point out that the Qinghai-Tibetan Plateau alpine ecosystem types are remarkably diversified and unique. For example, alpine cushion vegetation ecosystems widely occurring in projected parts of the perfectly round summits and ridges of the plateau's interior mountains (Li Bosheng 1985c), e.g., *Androsace tapete* ecosystem, the alpine ice-edge ecosystem (Li Bosheng 1981) along the snowline, and the polar alpine, ice-snow ecosystem above the snowline. On the Qinghai-Tibetan Plateau, higher plants can grow at about 6,200m and *Musca, Collembola,* and *Acariformes* can grow at 6,750m. L.W. Swan, an American biologist, believed that these insects lived on organic dribs dispersed by wind and nutrient elements in the air. He called this highest life zone a 'wind-made zone (Swan 1981). In fact, many lower organisms can be distributed at much higher elevations. For example, *Geodermatophilus everesti* was found among the gravel on Mount Everest at 8,306m. Because the ecosystems in the polar alpine, ice-snow zone are still not fully known, they are in general incorporated into the polar alpine, ice-snow ecosystem.

2. *Diversified Species, Complex Geographic Components*

2.1 Diversified Species: On the Qinghai-Tibetan Plateau, diversified ecosystems and complex, varied boundary surface conditions between them provide a favourable setting for the preservation of ancient species, differentiation of new species,and exchange of geographic components. Under such conditions, the Qinghai-Tibetan Plateau has produced its own species' diversity.

As far as we know (Wu Sugong and Feng Zuojian 1992), on the Qinghai-Tibetan Plateau within the boundaries of China, there are over 12,000 species of 1,500 genera of vascular plants, accounting for 34.3 per cent of the total species and over half of the total genera found in China; over 5,000 species of 700 genera of fungi, accounting for 41.67 per cent of the total species and 82.4 per cent of the total genera countrywide; 210 species in 29 families of mammals, accounting for 46.67 per cent of the total species and 65.90 per cent of the total families found in China: 532 species in 57 families of birds, accounting for approximately 44.97 per cent of the total species and 70.37 per cent of the total families found in China; and 115 species of fishes, or 6.28 per cent of the total countrywide.

It is necessary to point out that the distribution of species on the Plateau is extremely uneven. Few species occur on the vast plateau's interior arid region, due to the harsh ecological environment. For example, the Qiangtang Plateau in northern Tibet occupies a quarter of the Qinghai-Tibetan Plateau, but hosts only one-tenth of the total species found on the Plateau. However, the Himalayan and Hengduan Mountains cover less than one-fifth of the Qinghai-Tibetan Plateau, but host over 80 per cent of the total species occurring on the Plateau.

2.2 Complex Geographic Components: As described above, a most important function of the Qinghai-Tibetan Plateau heat-island effect is to induce and intensify the southwest monsoon. Under its influence, the tropical monsoon climate extends northwards to the southern slopes of the Himalayas and along the Yarlung-Zangbo River Valley, finally reaching 29°30' N latitude, after moving through almost six latitudinal zones beyond the Tropic of Cancer. It is of great significance for the formation of fauna and flora on the Qinghai-Tibetan Plateau. Hence, the Plateau consists of two biogeographic regions, the pan-arctic and the paleotropical region for plants and the palaeoarctic realm and the Indo-Malayan region for animals. In some respects, species in the ancient, humid tropical biogeographic region were differentiated according to the boundary surfaces of the mountains on the northern edge of the region; this stimulated the formation of panarctic flora and palaeoarctic fauna.

According to C.Y.Wu, Chinese paleotropical flora belong to six different geographic distribution patterns: pantropical distribution, tropical American and tropical Asian distribution, Old World tropical distribution, tropical Asian to tropical Australian distribution, tropical Asian to tropical African distribution, and the tropical Asian distribution (Indo-Malayan distribution). The Qinghai-Tibetan Plateau contains all of the six distribution patterns: the pantropical distribution, e.g., *Erythrina arborescena;* the tropical Asian and tropical American distribution, such as Gibotium barometz, the Old World tropical distribution, such as *Procris laevigata;* the tropical Asia to tropical Australia distribution, for example, *Arenga pinnata;* the tropical Asia to tropical Africa distribution, e.g., *Arundo donax;* and the tropical Asian distribution (Indo-Malayan distribution), *e.g., Altingia excelsa* (Wu Zhengyi 1983). In addition, the Qinghai-Tibetan Plateau also contains the eight different geographic distribution patterns of the Chinese panarctic region and has species' differentiation sites of many geographic distribution patterns. For example, in the northern temperate distribution, the Qinghai-Tibetan Plateau is the differentiation centre for *Rhododendron, Primula. Saussurea,* and *Pedicularis;* in the East Asian distribution the Plateau is the source of origin of one of its two aberrations, i.e., the origin of the China-Himalayas aberration. Many endemic genera of this aberration are distributed throughout the Qinghai-Tibetan Plateau region as well as throughout East Asia ,e.g. as *Circaeaster*, *Hemiphragma,* and *Chionocharis.* In the other five distribution patterns, the Plateau also has many of their species, for example, the Old World temperate distribution, *Sibiraea laevigata;* the temperate Asian distribution, *Caragana jubata;* the Mediterranean region, West Asia to Middle Asia distribution, *Cicer microphyllum;* the Middle Asia distribution, *Ceratoides latens.*

The Qinghai-Tibetan Plateau contains various animal geographic components, including all of the four geographic components of the Indo-Malayan regionl (Zhang Ronzu 1979); for example, the Hengduan-Himalayan type geographic components are mainly distributed along the eastern and southern edges of the Plateau: mammals such as *Ailuropoda melanoleuca, Bodorcus taxicolor, Petaurista yunnanensis, Moschus berezovskii, Presbytis entellus,* and *Hemitragus jemlahicus;* birds, including *Aethopyga ignicauda, Psittacula himalayana, Carduelis thibetana,* etc; amphibious animals, including *Bombina* *maxima.* Besides the above major components, the Qinghai-Tibetan Plateau also contains several other geographic components of the Indo-Malayan Region: Old World tropical-subtropical types, including the mammals *Panthera pardus, Sorex caecutiens,* etc.; birds such as *Bubulcus ibis, Egretta alba, Merops philippinus, Ceryle rudis,* etc.; the southeast Asian tropical-subtropical type with mammals like *Macaca assamensis, Aonyx cinerea, Tamiops macclellandi, Muntiacu muntiak,* etc.; birds like *Pericrocotus flammeus, Ardeola bacchus, Aceros nepalensis,* etc.; amphibious animals such as the *Hyla annectans; reptiles* such as *Ophisaurus gracilis, Ophiophagus hannah.* etc., the southern China geographic components including mammals such as *Rhinoputhecus bicti, Ailurus fulgens, Crocidura attenuata, Crocidura dracula,* etc.; birds like *Babax lanceolatus,* etc.; amphibious animals like *Vibrissaphora boringii, Rhacophorus dugritei, Rana pleuradeu* and so on. In addition, the Qinghai-Tibetan Plateau also contains palaeoarctic realm geographic components of which the important one is the Qinghai-Tibetan region geographic component (highland type geographic component); a geographic component belonging to the Plateau only. The typical representative animals of this geographic component include beasts such as *Poephagus mutus, Asinus kiang, Procarpra picticaudata,* and *Pantholops hodgsoni*, birds such as *Tetraogallus tibetanus, Grus nigricollis*, and *Carpadacus rubicilla;* amphibious animals such as *Altirana parkeri* and *Bufo tibetanus;* reptiles such as *Phrynocephallus theobaldi* and *Agama himalayana.* The Qinghai-Tibetan Plateau also contains the northern type geographic component of the northeastern subregion of the palaeoarctic region, with mammals such as *Cervus elaphus, Lynx lynx,* and so on; birds such as *Remiz pendulinus* and *Phylloscopus trocuiloides;* amphibious animals such as *Rana temporaria;* and reptiles such as *Agkistrodon halys.* The Middle Asian type geographic component, another important geographic component of the northeastern subregion of the palaeoarctic region, also appears on the Qinghai-Tibetan Plateau and contains mammals such as *Felis biete, F. manul, Dipus sagitta, Allactaga sibirica,* etc; birds such as *Calandrella rufescens, C. cinerea, Oenanthe isabellina,* and 0. *deserti;* and reptiles such as *Eryx miliaris.* The northeastern type geographic component of the northeastern subregion of the palaeoarctic region is also on the Qinghai-Tibetan Plateau and hosts mammals such as *Apodemus peninsulae, Mustela sibirica, M. eversmanni,*and so on; and birds such as *Phylloscopus borealis, Luscinia cyane, Emberiza cia*, and so on.

Active Differentiation of Species and Abundance with Unique Elements

The unique geomorphological configuration, the complex boundary land conditions, the diversified and changeable climate, and the singular geological development enable the Qinghai-Tibetan Plateau to become a crucial centre for the composition and differentiation of mountain species in the world, of vital importance to the composition of high-mountain and Boreal fauna and flora.

Among the Tracheophytes, the China-Himalayan factor, affiliated to the East Asian Element, was the result of the evolution of the Southeast Asian tropical plant community of the Tertiary Period on the ancient Qinghai-Tibetan land mass (Wu Zhengyi 1987), in accordance with the rapid ecological change during the uplift of the Qinghai-Tibetan Plateau; and it was a derivation of its moist mountain soil. This geographic factor includes 135 featured genera, of which monotypes and oligotypes make up 80 per cent and many are newly differentiated, e.g., *Dysosma* of *berberidaceae. Parryodes* of *Cruciferae, Oreosolen of Scrophulariaceae. Omphalogramma* of *Primulaceae, Megacodon* and *Eriophyton* of *Labiatae, Chionocharis* and *Pedinogyne* of *Boraginceae. Xizangia* of *Scrophulariaceae, Leptocodon* of *Platycodonceae, Aucklandia* and *Sinoleontopodium* of *Compositae, Risleya, Diphylax* ,and *Diplomeris* of *Orchidaceae,* and so on. These are mostly either of the monotype or of the oligotype. In terms of species, the Qinghai-Tibetan Plateau is the origin of a variety of species and their modern differentiation centre. Take *Rhododendron* of *Ericaceae*, there are altogether 850 species throughout the world and, among the 470 species in China, 400 are distributed throughout the Qinghai-Tibetan Plateau, a percentage of 88 per cent. Taking into account those on the southern brink of the Plateau outside China, the area hosts 60 per cent of all *Rhododendron* species. In addition, some primitive or quasi-primitive species of the genus are also centred around here (Min Tianlu and Fang Ruizheng 1979). All this demonstrates the important role of the Qinghai-Tibetan Plateau in the differentiation of the *Rhododendron* plant. Similar cases can be amply found in gymnosperms like *Picea* and *Abies* of the Pine family and in angiosperms such as *Aconitum* (Li Liangqian 1988) of *Ranunculaceae, Primula* (Chen Feng-huai and Hu Qiming 1981), *Androsace* (Hu Qiming and Yang Yongchang 1986) of *Primulaceae, Arenaria* of the Pink family, *Arisaema* (Li Heng 1981) of *Arisaemaceae, Gentiana* (He Ting-nong 1981) of *Gentianaceae, Cyananthus* of the Platycodonceae, Corydalis *(Wu Zheng-yi et al. 1981)* of *Papaveraceae,* and *Saussurea* and *Cremanthodium* (Shi Zhu and Chen Yilin 1982) of *Compositae,* to list a few.

In the interior arid area of the Qinghai-Tibetan Plateau, there is another species which originates in the arid desert and among its surrounding semi-arid grassland flora in Central Asia.This species has an even younger history of composition and is far less abundant in variety than the China-Himalayan factor The representative plants are *Ceratoides compacta*, differentiated from the typical Asian desert plant, *Ceratoides latens; Salsola nepalensis,* derived from the Central Asian desert feature genus *Salsola;* and *Stipa purpurea, Stipa capillacea, Stipa roborowskyi,* derived from the characteristic genus of the Central Asian grassland.

As to the animal kingdom, the two primary factors constituting the fauna of the Qinghai-Tibetan Plateau are the Mt. Hengduan-Himalayan geographic factor located in the moist mountainous region of the eastern and southern fringes of the Plateau and the highland geographic factor located in the arid interior areas of the Plateau-- and both were differentiated during the elevation of the Plateau. The first factor has its origin in the Indo-Malayan animal community of the tropical and subtropical moist forest ecological environment of the Tertiary period on the southeastern fringe, and the second originated from the Paleoarctic Region animal community of the subtropical, temperate arid desert and grassland of the Tertiary period in the region bordering the north and northwest of the Plateau.

In the Hengduan-Himalayan geographic factor, the mammal *Cervus albirostris is* a geographic differentiation of the *Rusa* of the South and *Moschus fuscus* and *Moschus chrysogaster* are both geographic differentiations of *Moschus* in these areas. Similar species are *Hemitragus jemlahicus, Soriculus nigrescens, Nectoglac elegans, Ochotone himalayana, Dremomys lokriah, Rattus eha, Pitymys sikkimensis*, and *Microtus millicens*. The most convincing example in birds is the *Tragapon.* Its differentiation centre is situated on the eastern and southern fringes of the Qinghai-Tibetan Plateau with two endemic species, *Tragapon melanocephalus* and *Tragapon satyra. Lophophorus* is a similar case, *Lophophorus impejanus* and *Lophophorus sclateri* are native only to this area. Other examples include *Pomatorhinus ruficollis, Pomatorhinus erythogenys, Grandala coelicolor, Cettia major, Carduelis thibetana, Carpodocus rhodopelus,* and so on. With regard to amphibians, this is the current centre for the distribution and differentiation of *Megophrys, Scutiger,* and *Oreolalax*, and hosts the largest variety of them, examples being *Megophrys shapingencis, Megophrys omeimontis* ,and *Oreolalax xiangchengensis,* and so on.

The evolution and composition of the highland geographic factor were closely related to the growing frigidity and aridity of the climate after the Plateau rose as well as to the cold climate of the glacial period. For instance, *Pantholops,* the sole endemic genus of mammals on the Qinghai-Tibetan Plateau and closely related to the Central Asian Desert genus, *Saiga,* was probably differentiated from the *Caprinae* in the Miocene epoch (Feng Zuojian et al.1986); and *Poephagus* was a highland differentiation of *Bovinae* at the end of the Pleiocene epoch. *Ochotina* would serve as a good example of Plateau animal differentiation, most species of this genus are scattered throughout the Plateau, which has become a modern centre for their differentiation and distribution. Similar examples include *Lepus oiostolus, Marmota Himalayana,* and *Vulpes ferrilata, etc. Tetraogallus is* a native genus of birds on the Qinghai-Tibetan Plateau. One of its species, *Tetraogallas tibetanus* lives primarily on the Plateau. To add more to the list, *Perdix hodgsoniae, Syrrhaptes tibetanus, Emberiza koslow, Pyrrhula erythaca, Carpodacus pulcherrimus, Carpodacus rubescens, Montifringilla adamsi, Montifringilla taczanowskii, Montifringilla ruficollis,* and *Montifringilla blanfordi* are all specifically differentiated species under plateau conditions (Zheng Zuoxin 1983). As to amphibians and reptiles, the plateau environment is so severe that only a few cryotolerant endemic genera are differentiated, e.g., *Altrirana parkeri, Bufo tibetanus, Phrynocephallus theobaldi, Phrynocephallus vlangolii,* and *Thermophis baileyi* (Tian Wanshu and Jiang Yaoming 1986).

A biological species can be called endemic or native of a certain area when its distribution is restricted within this area. Endemic studies are very significant for ascertaining the differentiation of species and the floral and faunal origin of the region. Regrettably, in the past, many scholars took administrative divisions (e.g., country, Province, and county, etc), as the basic geographical unit and this can hardly represent the law of biological distribution. The unique biological distribution of the Qinghai-Tibetan Plateau is a true reflection of its species' differentiation and the composition of its biological community. Hence, study of the the peculiar distribution of the Qinghai-Tibetan Plateau as a complete geographic entity. As mentioned above, the entity consists of the two major regions; the moist eastern and southern fringe of the Qinghai-Tibetan Plateau and the Plateau proper. The endemic species of the Qinghai-Tibetan Plateau are the sum of the endemic species of the two areas put together. Another point to be made is that the endemic species of the Qinghai-Tibetan Plateau are actually composed of the residual ancient species and the young, newly differentiated species.

According to the Chinese endemic plants' study of Ying Junsheng and Zhang Zhisong (1984), in China there are three endemic centres and one ot them lies in between Eastern Sichuan and Northwestern Yunnan along the eastern and southeastern edges of the Qinghai-Tibetan Plateau. In this area, 80 Chinese endemic species falling into 39 families can be found. *Dysosma* of *Berberidaceae*, *Gymnotheca* of *Saururaceae, Eucommia* of *Eucommiaceae, Kingdonia, Anemochema* , *Metanemone* of *Ranunculaceae,* and *Sinofranchetia* of *Lardizabalaceae* are all endemic genera of ancestral nature. The study of

Wang Hesheng (n.d.) on endemic Chinese seed plants also indicates that Chinese endemic species are mainly scattered throughout the southwestern provinces, especially in Yunnan and Sichuan which claim 96 genera and are the centres of distribution and differentiation for Chinese endemic species and may also be the places of origin of some species.

It is regrettable that all the above studies draw the boundary of endemic genera according to administrative divisions. As a result, the importance of the Qinghai-Tibetan Plateau in the distribution of endemic Chinese plants is not properly reflected. For example, as part of the Himalayas lies outside China, many endemic species there are not mentioned, e.g., *Archiclematis* of *Ranunculaceae, Chionocharis, Pedinogyne, Actinocarya* and *Maharanga* of *Boraginceae, Leptocodon, Cyananthus* of *Platycodonceae, Aucklandia, Dubyaea* and *Cremamthodium* of *Compositae, Parryodes* of *Cruciferae, Oreosolen* of *Scrophulariaceae, Milula* of *Liliaceae, Tricarrelema* of *Commelinaceae, Omphalogramma* of *Primulaceae, Dactylicaphos* and *Meconoposis* of *Papaveraceae, Chamaesium* and *Physospermopsis* of *Umbelliferae, Merilliopanax* of *Araliaceae, Drimycarpus* and *Pegia* of *Arcacardiaceae, Siphonosmanthus* of *Oleaceae* and *Hymenopogon* and *Luculia* of *Rubiaceae,* etc. This even leads to the complete ignorance of the Himalayas as an important centre for the composition of world mountain species.

Since no accurate statistics have been available until now, it can only be estimated that there are altogether about 50 regional native genera of vascular plants (tracheophytes) on the Qinghai-Tibetan Plateau, 90 per cent of which are on the southern and eastern fringes of the Plateau. The number of endemic species of vascular plants is even more abundant, with an estimation of no less than 2,000 types. In view of this, the Qinghai-Tibetan Plateau, especially its eastern and southern fringes, is an important modern differentiation centre for plant species and a centre for the preservation of ancient species.

The endemic distribution of animals on the Qinghai-Tibetan Plateau is also very important. However, since animals have a wider area of activity, their endemism is far less obvious than that of plants. Even so, endemic animal species are abundant on the Plateau. It boasts 40 endemic mammals, 60 per cent of the total of their kind in China; 28 endemic birds, approximately 30 per cent of the total; two endemic reptiles; and 10 endemic amphibians.

Similar to plants, the endemic animals of the Piateau are also made up of the endemic species of both its eastern and southern fringes (Himalayan and Hengduan Mts) and the Plateau proper. The former includes mammals such as

Ailuropoda melanoleuca, Ailurus fulgens, Bodorcus taxicolor, Moschus berezovskii, Presbyeis entellus, Hemitragus jemlahicus, Petaurista yunnanensis, Soriculus nigrescens, Dremomys lokriah, Rattus eha, Tetrastes sewerzowi, Tetraophasis obscurus, Perisoreus internigrans, Lophobasileus elegans, Babax koslowi, Urocynchramus pylzowi, Emberizz koslowi ,and the aforementioned endemic birds, the various species of *Tragopan, Lophophorus*, and *Pomatorhinus.*

The Plateau proper hosts fewer endemic animal genera, but still there is a fairly large number of animals in each genus, including mammals like *Pantholops hodgsoni, Poephagus mutus, Asinus kiang, Lepus oiostolus, Marmota himalayana, Ochotona curzoniae,* and *Pitymys leucurus;* and birds like *Syrrhaptes tibetanus, Tetraogallus tibetanus, Perdix hodgsoniae,* and the above-mentioned various species of *Montifringilla*.

To sum up, the Qinghai-Tibetan Plateau is both a centre for the differentiation of young species and a centre for the preservation of ancient species. These two factors combine to provide it with rich and variegated endemic biological species.

A Multitude of Rare and Extinct Species

The billions of years' evolution of the earth has generated five million to 50 million modern biological species, and the species are still in the course of continuous birth and death, occurrence and extinction as time elapses. With the increasing influence on nature of human activities and production, biological species are extinguishing at a far faster rate than they would naturally. Consequently, many species experience unnatural extinction and many are facing threats of varying degrees. The most vulnerable are the regional endemic genera and those in special circumstances; both of which are of limited geographic distribution and number. According to the preceding passages, a feature of the diversified biological composition of the Qinghai-Tibetan Plateau is the presence of great numbers of endemic species, some of which are lingering ancient species confined to the local Plateau surroundings and others which are more recently differentiated, yet both with narrow distribution. Furthermore, the comparatively less severe human influence on the Plateau enables it to become a modern haven for certain rare genera. All of the above enables the Qinghai-Tibetan Plateau to host many rare species, that are more or less extinct elsewhere, and become an important base for the preservation of biological diversity.

Among the higher plants, primordial species can be found, e.g., *Takakia lepidozioides* among the bryophyte genus; this plant has only four chromosomes (n = 4), the least among all continental plants, and can be called a 'living fossil' of the bryophytes (Wu Pengcheng et al.1983).

Among the pteridophytes, *Archangiopteris wallichiana* produced in the Himalayan and Hengduan Mountains and various kinds of *Alsophila spinulosa, Gymnosphaera andersonii, Sphaeropteris brunoniana, Dipteris conjugata, Lomariopsis specitabilis* , and *Sinopteris grerilleoides* are all relatively ancestral rare species.

Among the gymnosperms, *Cupressus gigantea* grows only in the valley of the middle reaches of the Yarlung-Zangbo River of Tibet, *Cycas panzhihuaensis* in the valley of the Jinsha River, *Cephalotaxus mannii, Cephalotaxus lanceolata, Cupressus chengiana, Abies georgei, Larix masterisiana, Picea smithiana, Pseudotsuga forrestii, Tsuga forrestii, Podocarpus annamicusis, Amentotaxus argotaenia* var. *brevifolius* and *Taxus wallichiana;* all of these are rare tree species on the verge of dying out in China.

There are too many rare species of angiosperm on the Qinghai-Tibetan Plateau to be listed out specifically. Among them, the rarest are the star-like monotype and oligotype plants scattered only in a certain narrow area of the Plateau. Examples include *Ajaniopsis penicilliformis, Bolocephalus saussureoides, Sinoleontopodium lingianum, Diplazoptilon picridifolium, Xizangia serrata, Tsaiorchis neottianthoies, Sinochasea trigyna, Sinadoxa corydalifolia, Salweenia wardii, Parapteropyrum tibeticum, Musella lasiocarpa, Dysosma tsayuansis, Alcimandra cathcartii, Neopicrorhiza scrophulariiflora,* and *Pyrgophyllum yunnanensis*.

The Qinghai-Tibetan Plateau is famous for hosting numerous rare animals (see Annex I). The world renowned *Ailuropoda melanoleuca* mainly inhabits the valleys on the eastern fringe of the Plateau area. Besides, scattered on the eastern and southern edges of the Plateau are some animals in the forest-class protection category in China, e.g., mammals like *Budorcas taxicolor, Hemitragus jemlahicus, Capricornis sumatraensis, Naemorhedus cranbrooki, Moschus berizovskii, Moschus sifanicus, Cervus albirostris, Ailurus fulgens, Aonyx cinerea, Felis temmincki, Neoflis nebulosa, Panthera tigris, Presbytis entelus, Macaca assamensis, Rhinopithecus roxellanae;* birds like *Aceros nepalensis, Crossoptilon crossoptilon, Tragopon melanocephalus, Tragopon satyra, Tragopon temminckii, Lophura leucomelana, Lophophorus impejanus, Lophophorus sclateri,* and *Psittacula derbiana*; and reptiles like *Python molurus.*

Animals in the first-class protection category scattered throughout the Plateau proper include mammals such as *Poephagus mutus, Pantholops hodgsoni, Ovis ammon, Panthera uncia, Ursus arctos,* and *Asinus king*; and birds such as *Grus nigricollis, Aquila chrysaetos, Gypaetus barbatus, Haliaetus leucogaster, Lerwa lerwa,* and *Tetragallus himalayensis*.

Important Influence on the Biological Diversity of Neighbouring Areas

Numerous fossil data reveal that, as early as the Eocene Epoch, an ecosystem of subtropical mountain, evergreen conifer forest composed of *Tsuga* had already existed on the Qinghai-Tibetan Plateau; and in the Oligocene and Miocene Epochs, the sub-Alpine evergreen conifer forest ecosystem, consisting mainly of *Abies* and *Picea,* had been growing abundantly on the Plateau and in its bordering mountains. It is widely known that the temperate frigid, dark conifer forest (Taiga forest) encircling the North Pole is also mainly comprised of the plants of *Abies* and *Picea* and greatly resembles the sub-Alpine, evergreen conifer forests of the Himalayan and Hengduan mountains, both in community structure and in the composition of plant varieties. Based on the evidence that the latter preserves the ancestral plants of *Abies* and *Picea* and their main associated genera such as *Sorbus, Betula,* and *Pyrola,* some experts believe that the Taiga forest around the Arctic area is derived from sub-mountain, evergreen conifer forest, which again originated on the Qinghai-Tibetan Plateau and in its neighbouring mountain lands. The Plateau may also be the origin of the modern temperate, deciduous broad-leaved forests because some superior species of the northern deciduous broad-leaved forests, such as like *Betula* and *Acer,* have their ancestral types in this area and transitional quasi-evergreen broad-leaved forests between evergreen broad-leaved forests and deciduous broad-leaved forests still exist in the Himalayas. From all this, we can conclude that the biological diversity of the Qinghai-Tibetan Plateau plays an important role in the formation of the middle-level temperate forest ecosystem of the Northern Hemisphere. As to the influence of the Alpine ecosystem of the Plateau on the shaping of the Alpine and tundra ecosystem of the Northern Hemisphere, it is pretty easy to detect either in plant variety composition or by analysing plant community types and their structures.

Analysis at the species' level also indicates the intimate relationship between the Qinghai-Tibetan Plateau and the mountains of the Northern Hemisphere. Various studies have shown that the Plateau is an important centre of origin and differentiation for global mountain species. Many species originating here have exerted great influence on the diversity of mountain plant and animal life in neighbouring areas by means of radiative distribution into mountain areas in Eurasia. The climatic fluctuations during the glacial and interglacial ages of the Quaterary period helped to extend this influence to regions around the North Pole and thus have left a profound impact on arctic fauna and flora

Among the higher plants,the Qinghai-Tibetan Plateau is the centre of origin and differentiation for global Alpine plants. For example, *Rhododendron, Cassiope, Diplarche, Gaultheria* ,and *Vaccinium* of *Ericaceae; Aconitum, Delphinium* and *Trollius* of *Ranunculaceae; Meconopsis* and *Corydalis* of *Papaveraceae; Geranium* of *Geraniaceae; Salix* of *Salicaceae; Primula* of *Primulaceae; Gentiana, Lomatogonium, Comastoma, Gentianopsis, Gentianella* ,and *Swertia* of *Gentianaceae; Cremanthodium, Anaphalis, Aster, Saussurea* ,and *Ligularia* of *Compositae; Pedicularis* of *Scrophulariaceae; Diapensia* of *Diapensiaceae; Rhodiola* of *Crassulaceae; Arenaria* of *Caryophyllaceae; Ribes* and *Saxifraga* of *Saxifragaceae; Draba* of *Cruciferae; Potentilla* and *Sorbus* of *Rosaceae;* and *Pyrola* of *Pyrolaceae.* All of the above form the main genera of the flora of Eurasia, North America, and the area around the Arctic. Species' communication between the Qinghai-Tibetan Plateau and these three areas can also be identified from the migrating modes of some species.

To the west, some mountain species of the Plateau spread to Europe's Caucasus and the Alps along the western Himalayas ,the Gangids, Kala Kunlung, and Kulung Mountains joined to the Pamirs via the Xingdukushi, Pamisus, and Iranian mountains. Examples cover the following species: *Thalictrum alpinum, Caltha palustris, Stellaria uliginosa, Geranium pratense, Pyrola minor, Orthilia secunda. Monotropa uniflora, Circaea alpina, Stellaria graminea, Potentilla a fruticosa, Ribes orientale* ,and *Draba alpina*.

To the north and the northeast, some mountain species reach Siberia along the various mountains connected with the Pamirs via the Tianshan, Altai, Tangnu, and outer Xinganling mountains, or northeastwards along the Qingling ridge, the eastern part of the Loess Plateau, and the Yin, Changbai, and Lesser Xinganling mountains; some reached North America by way of the continental bridge of the Bering Straits. The former group includes *Juniperus sibirica, Betula platyphylla, Polygonum sibiricum, Corydalis pauciflora, Draba altaica, Arabidopsis mollissima, Rhodiola quadrifida, Saxifraga sibirica, Ribes orientales, Spriraea alpina, sibiraea laevigata, Potentilla sericea, Paraquilegia microphylla, Clematis tanggutica, Ranunculus laetus, Ranunculus natans, Oxygraphis glacialis Corydalis impatiens, Dimorphostemon pinnatus, Gastrodia elata, Cypripedium macranthon, Potentilla multifida* var. *nubigena, Thermopsis alpina, Thermopsis lanceolata, Saussurea gnaphaloides, Torularia grandiflora, Gentiana* *leucomelaena, Bupleurum triradiatum* ,and *Veronica campylopoda;* the latter group include *Loenigia islandica, Polygonum viviparum, Stellaria uliginosa, Silene tenuis, Caltha palustris, Thalictrum alpinum, Halerpestes cymbalaria, Draba incana, Potentilla biflora, Potentilla fruticosa, Potentilla multifida, Orthilia secunda, Monotropa uniflora, Comastoma tenellum, Lomatogonium carinthiacum, Anaphalis margaritacea* ,and *Cypripedium guttatum*.

The Alpine plant species of the Plateau, especially those in the moist mountains of the eastern Himalayas, spread northeastwards from the Hengduan and Min mountains via the Qinling Ridge, the Taihang Mountains, and eastern China and entered Japan in the ice age when Japan was connected to the eastern Asian continent. These species have deeply affected the mountain plants and flora of Japan. According to data collected by Wu Zhengyi, there are altogether 48 families and 110 genera or 114 species (Wu Zhengyi 1987) of identical plants in Tibet's Himalayas and in Japan. For example, *Sagina japonica, Cerastium* subsp. *triviale* var. *angustifolium, Cerastium furcatum, Pseudostellaria sylvatica, Melandrium apricum, Melandrium firmum, Thalictrum foetidum, Clematis brevicaudata, Caulophyllum robustum, Tiarella polyphylla, Actaea asiatica, Rubus pungens, Potentilla glabra, Circaea cordata, Helwingia himalaica, Microcarpaea minima, Trillium tschonoskii, Goodyera repens,* and *Goodyera foliosa.* Some people even classify the Himalayan flora into a Sino-Japanese flora area (Zheng Mian 1984). However, although the two have a close relationship, there are obvious differences between them. The Sino-Japanese flora developed on the basis of the moist subtropical, lowland flora originating in the Tertiary period when continental China was connected to Japan. However, the Himalayan flora were transformations of the Southeast Asian subtropical flora in the mountains during the uplift of the Himalayas in the Tertiary period, and they are related to Japanese mountain flora only as a result of the lowering and extending eastwards of the flora during the Ice Age.

Eastwards to the seaside mountains of Southeastern China from the Hengduan mountains via the Min, Qinling, Daba, and Dabie mountains, then passing the Wuling and Mufu mountains or from the Hengduan mountains, passing the Yunnan-Guizhou Plateau, eastwards to the Southern ridge and then the hilly lands of southeastern China (Wang Wencai 1992 and Wang Wencai et al.1993), one can list *Castanopsis hystrix, Castanopsis indica, Cyclobalanopsis glauca, Celtis cerasifera, Pilea bracteosa, Elatostema obtusum, Anemone tomentosa, Aconitum hemsleyanum, Clematis ganpiniana, Corylus heterophylla, Carpinus cordata, Pecaisnea fargesii, Aquilegia ecalcarata, Oreocnide frutescens, Euonymus grandiflorus* , *Cardiocrinum cathayanum*, and so on, altogether 63 families, 92 genera, or 97 species.

What is interesting is the surprising similarity between the Qinghai-Tibetan Plateau, especially the eastern part of the Himalayas, and the vertical ecosystemic spectrum of the Taiwanese mountains. However, there are not many identical species between the two; in total only 15 species, 15 genera, or 15 families in all, e.g., *Clematis montana, Trochodendron aralioides, Hemiphragma heterophyllum* var. *dentatum, Orobanche caerulescens, Lonicera acuminata, Anaphalis nepalensis,* etc. Some varieties are of the same species but have undergone great changes, for example *Juniperus squamata* var. *morrisonicola* is a variant of *Juniperus squamata, Pinus armandii* var. *masteriana is* a variant of *Pinus armandii* and *Rosa sericea* var. *morrisonensis* a variant of *Rosa sericea.* There is evidence that the mountain plants of Taiwan originated in the eastern Himalayas. However, after long separation from the Himalayas, they have formed a mountain flora of obvious Taiwanese type in the new ecological environment.

Southwestwards across Weilu mountain in the Hengduans to the mountain peninsula of the mid-south, or further southwards to Malaysia and Indonesia, the former groups such as *Castanopsis hystrix, Castanopsis echidnocarpa, Castanopsis indica, Castanopsis tribuloides, Chamabainia cuspidate, Maoutia puya, Osyris wightiana, Viscum articulatum var. liguidambaricolum, Brachystemma calycinum, Schisandra grandiflora, Alseodaphne andersonni, Tiarella polyphylla, Exbucklandia populanea, Hydrangea heteromalla. Hydrangea robusta, Photinia integrifolia, Pyus pashia, Rubus ellipticus* var. *obcordatus, Rubus pentagonus, Gevranium nepalense, Pentapanax leschanayltii, Polygala crotalarioides, Elaeocarpus braceanus, Meliosma dumicola,* and *Meliosma thomsonni;* the latter group like *Celtis cinnamonea, Laportea bultifera, Laportea sinuata, Pillea melastomides, Debregeasia longifolia, Rumex nepalensis, Polygonum molle, Polygonum runcinatum, Polygonum strigosum, Cinnamomum glanduliferum, cinnamomum iners, Cinnamomum subavenium, Altingia excelsa, Neillia thyrsiflora, Rubus ellipricus, Rubus lineatus, Rubus niveus, Zanthoxylum nitidum. Eurya acuminata, Eurya trichocarpa, Hypericum uralum, Terminalia myriocarpa, Gaultheria fragrantissima,* and *Mycetia longifolia* can be found.

Concerning the diversity of animals, the Qinghai-Tibetan Plateau's contribution to its bordering areas is not comparable to its contribution to the diversity of plants. However, it is still obvious. Collected animal fossils reveal that, in the early and mid-Pleiocene Epoch, ancient mammals had been scattered throughout the Plateau and on its fringe areas, e.g., the Swalic animal community spotted on the slopes of the Himalayas and the *Hipparion guizhongensis* and *Hipparion buzhongensis* on the Plateau proper. Those appearing in the

Hipparion group are the *Hipparion xizangensis, Chilogherium tanggulaensis, Chilotherium intermedius, Brachyrhizomys nagquensis, Rhizomyoides punjabiensis, Croduta gigantea* var. *thibetensis, Metailurus* sp. *Felis* sp., *Hipparion guizhongensis, Chilogherium xizangensis, Metacervulus capreolinus, Gazella gaudryi, Ochonatana guizhongensis, Cricetidae* gen. et *indet,* and *Heterosiminthus* sp.; all of these illustrate the Plateau's significance in the composition of the modern fauna of Asia. Animal fossils found in Tibet in the recent epoch of the Quarterary period, such as *Ovis* sp., *Equus* sp., *Alticola* sp., *Bos* sp., *Cervus* sp., *Ochotona curzoniae, Marmota himalayana, Pitymys leucurus, Cricetulus lama, Cervus albirostris. Cervus elaphus, Naemorhedus goral, Capricornis* sp., *Ca preolus capreolus, Macaea assamensis*, and *Macaca* sp., all demonstrate the gradual evolution of the modern fauna of the Qinghai-Tibetan Plateau.

The Plateau's animal community would certainly exert an influence on its bordering area, however analysis becomes difficult because animals have a strong migrating ability and it is hard for us to judge the place of origin for each animal in the absence of fossil data. However, the communicating route for Plateau animals and the bordering areas is still clear and identiable, and it is similar to the migrating route of plants, only over a much shorter distance.

Some animals of the Paleoarctic Region endemic to the Qinghai-Tibetan Plateau often migrate westwards to the Pamirs and Kashmir mountains or northwards to the Tianshan mountains and other areas of Xinjiang or northwestwards to the Hexi corridors, e.g., mammals like *Sorex buchariensis, Ochotona macrotis, Ochotona ladacensis, Lepus oiostolus, Cricetulus kamensis, Alticola stoliczkanus, Alticola stracheyi, Pitymys juldaschi, Columba leuconota, Pseudopodoces humilis, Prunella fulvescens, Luscinia suecica, Syrrhaptes tibetanus,* and *Tetraogullus tibetanus;* and reptiles like *Phrynocephalus theobalda.*

Northeastwards, the Plateau animals of the Paleoarctic often spread to the Qingling ridge and Mt. Daba via the Animaqing and Bayankela, mountains, for example mammals such as *Ochotona thibetana, Cricetulus longicaudatus, Micromys minutus, Apodenus draco, Apodemus agrarius,* etc.; birds like *Mycerobas carnipe, Carpodacus vinaceus, Prunella collaris, Prunella rubeculoids, Pyrrhocotax pyrrhocorax, Nucigraga caryocatactes,* and *Garrulus glandarius.*

Some animals of the Indo-Malayan region often travel to the Qingling ridge and Mt. Daba along Mt. Min to the eastern edge of the Qinghai-Tibetan Plateau.

They include mammals like *Ailuropoda melandoleuca, Ailurus fulgens, Bodorcus taxicolor, Moschus berezovskii, Petaurista kanthotis, Soriculus hypsibius, Raltus loxingi;* and birds like *Ithaginis cruentus, Tragopan temminckii, Dendrocopos cathpharius, Aerhopyga nepalensis, Zosterops erythoplenra, Pomatorhiuns erythrogenys, Pomalorhiuns ruficollis, Babax lanceolatus, Garrulax albogularis,* and *Garrulax sonnio;* amphibians like *Dreolalax pepei, Ooeidozyga laevis, Amolops chunganensis, Amolos mantzorum, Japalura flaviceps, Japalura splendida, Elaphe perlacea*, and *Lylodon fasciatus.*

The Plateau fauna can also spread southeastwards to the mountains of the Midsouth Peninsula via Weilu mountain in the Hengduans. These include mammals such as *Sorex vuchariensis, Soriculus caudatus, Crocidura attenuata, Crocidura dracula, Chimmarogala styani, Nectogalae elegans, Ailurus fulgens, Budorcas taxicolor, Naemorhedus goral,* etc; birds like *Psittacula derbiana;* and reptiles like *Tylototrito asperrimus, Brachytarsophrys cariensis, Megophrys lateralis, Megophrys minor, Megophrys spinatus, Bufo andrewsi, Hyla annectans, Rhacophorus cavirostris, Rhacophorus translineatus, Platyplacopus intermedius,* and Pareas macularilius.

Part 3 The Current Situation and the Preservation of Biological Diversity on the Qinghai-Tibetan Plateau

1. Significance of the Qinghai-Tibetan Plateau in the Preservation of Biological Diversity

There have already been a great many studies and scientific examinations of the direct and indirect values of and the significance of preserving biological diversity. As for the Qinghai-Tibetan Plateau, the preservation of its biological diversity is of special significance.

Firstly, the Plateau is, up to now, one of the few unprobed storehouses of mountain biological resources, containing unknown or already known but not yet fully explored resources .

The following are a few examples: the medical herb, *Picrorhiza scrophulariiflora,* the medicinal oil plant, *viburnum cylindricum*, the aromatic plant, *Zanthoxylum tibetanum* the amylum plants, *Quercus aquifolioides* and *Prunus mira* the fibre plant, *Edgeworthis gardneri,* a plant used for industrial chemicals, *Quercus semecarpicolia* ,and the decorative plant, *Magnolia* *rostrata.* In addition the following animals have useful attributes: for medicine, *Moschus berezouskii,* for fur, *Panthera uncia,* for meat,*Cervus albirostris* , and for its ornamental value, *Tragopon satyra.*

With regard to domestic animals and cultivated plants also , the Plateau is a rich source of species. For example, *Pophagus mutus,* a savage species and the ancestor of the domesticated *Bos grunniens*, is still living on the Plateau and is of great significance for improving the quality of the domestic *Bos grunniens* because the progenies born of the male *Pophagus mutus* and the female *Bos grunniens* are of greater stature and strength than purebred stock. A similar example is the *Hordeum vulgare,* a cereal crop originating in China. On the Plateau, people have discovered its ancestral species, such as *Hordeum lagunculiforme, Hordeum spontaneun, Hordeum agriocrithon,* and its near relatives--the perennial *Hordeum brevisubulatum, Hordeum violaceum, Hordeum bulbosum* ,and *Hordeum bogdanni,* all of which are of inestimable value for improving the quality of *Hordeum vulgare.*

The Plateau has become a diversified hereditary gene pool of varieties of domestic animals and cultivated plants, since livestock, pets, and crops for human cultivation have evolved in the special conditions of the Qinghai-Tibetan Plateau and generated many new species with special hereditary and ecological characteristics. To illustrate, examples of livestock include the endemic *Bos grunniens* on the Plateau, having many species like the white bossin, the endemic Plateau ox of Tibet and the *Zhong-dian* horse, sheep, and pig of Tibet. Among domesticated animals are the Tibetan *Ao* (a kind of huge and ferocious dog), the Tibetan toady, and so on and, among the cultivated plants, *Hordeum vulgare* has five sub-species and 260 variants on the Plateau; and 83 variants have been found of *Triticum aestivum* in Tibet.

The development of modern biotechnology has opened a wide vista for the exploration and use of the rich biological hereditary diversity on the Qinghai-Tibetan Plateau. Under the varied adverse conditions of the Plateau, the longstanding living beings from this area have developed particular adversity-resistant genes, especial]y those for anti-frigidity, anti-drought, and anti-short wave radiation. In addition, many living beings on the Plateau have grown special resistant genes against abrupt changes in the environment. When the sun rises on the plateau, the temperature can rise from below zero to 10-20 C, and in a short time a dark cloud may bring sudden snow and the temperature drops steeply to below 0°C again; adversity-resistant genes are of critical importance in cultivating cold-resistant crops.

From a broader perspective, as the Plateau is the source of many of the big rivers of Asia, like the Yangtze River, the Yellow River, the Lancang River, the Nujiang River, the Bulanaputela River, the Ganges, the Indus River, and the Talimu River, when these rivers flow across the edges of the Plateau, they cause serious erosion because of the steep terraces. This makes the protection of the primitive ecosystem of the Plateau extremely important, especially for the eastern and southern fringes which have abundant rainfall. If the forest ecosystem on the fringes of the Plateau were to be destroyed, the soil erosion in the upper reaches of the above rivers would inevitably increase and heavy rain would bring massive floods. The lower reaches and various water conservancy facilities on the mainstreams would be affected, reservoirs silted up, and dams destroyed because of sudden downpours. History has taught us this.

One great concern for mankind is the change in the global environment. Many of the Plateau biological communities and individuals are distributed throughout the transitional areas between the horizontal life belt of the Plateau proper and the vertical life belt on the mountain fringes. These are exceptionally sensitive to changes in the environment. Therefore, dynamic observation of the biological diversity of the Qinghai-Tibetan Plateau might serve as a good monitoring system for global environmental changes.

2. *The Current Situation of the Natural Protection Zones on the Qinghai-Tibetan Plateau*

The establishment of Natural Protection Zones to achieve effective biological protection within a zone is the primary approach for preserving biological diversity.

Since the founding of the first batch of natural protection zones in Wolong and at Qinghai Lake on the east skirst and in the heart of Qinghai-Tibetan Plateau respectively on the first of January 1975, the number of zones has risen to 58, nine of which are of national level and the rest of provincial or municipal levels (see Annex 2).

In terms of the types of ecosystem, the Qinqhai-Tibetan Plateau Natural Protection Zone(QTPNPZ) can be divided into two major categories: the arid or semi-arid prairie and desert ecosystem on the Plateau proper and the moist or the semi-moist mountain forest ecosystem on its eastern and southern fringes. Among the protection zones belonging to the first type ecosystem, Mt. Alking in Xinjiano and Qiangtang in Tibet take the lead, followed by wildlife proteclion zones such as the protection zone for *Grus nigricollis* in Shenzha, Birds' Isle at Qinghai Lake, the protection zone for *Grus nigricollis* in Longbao; the Marshland of Migrating Birds in the Big and Little Sugan Lakes, Saiba, Banggu, Longxi, Dangka, Jieji Temple, Laruo Temple and Gasan of Akesai county; Sekang, Kuanzhong, and Zhaxilawu Temple of Chengduo county; Gejia Temple, Gongya Temple, Zhangda Temple, Juela Temple, Bami Temple, and Jue Temple of Nagqian county; and Salt Bay of Subei county in Gansu province. The overall number may well be limited, yet with Qiangtang and Mt. Alking as the first and second largest national protection zones, the whole area covers 29,000,000 hectares, or 10 per cent of the Qinghai-Tibetan Plateau.

Annex Two reveals that the moist or semi-moist mountain-forest ecosystem has the largest number of protection zones, i.e., 32 all told, and 12 of them are protection zones for *Ailuropoda melanoleuca*.

In addition to the above mentioned, the site on the southern edge of the Qinghai-Tibetan Plateau bordering China and Nepal, the third largest national natural protection zone-- is the Mt Everest (Mount Qomolangma) protection zone, which covers the transitional area between the moist or semi-moist mountain forest ecosystem on the southern fringe and the arid or semi-arid arctic prairie and desert ecosystem in the interiors of the Qinghai-Tibetan Plateau, and it thus integrates the characteristics of both ecosystems.

From Annex Two we perceive that a fairly large number of natural protection zones have been established in the Qinghai-Tibetan Plateau, and the area covered by them constitutes 10 per cent of the whole Plateau, far larger than the average in East Asia. Nevertheless, it is also important for us to bear in mind that this is due to the presence of the three largest protection zones (i.e., Qiangtang, Mt. Alking, and Mt. Everest) in the hinterland of the Qinghai-Tibetan Plateau. When taking sole consideration of the eastern and western fringes of the Plateau, which abound in biological varieties, then the number of protection zones and their areas are far less than could be desired. There is still a long way to go.

The biggest problem is the background economy, the shortage of talented personnel, and lack of funds and materials, which seriously cripple the smooth running, effective functioning, and management of the already established natural protection zones. Apart from the protection zones for *Ailuropoda melanoleuca,* which can expect more investiment in the long run, the economic situation in other zones is not optimistic. In view of this position, the development strategy for the protection zones on this plateau is to concentrate on essential points and make the best use of the limited, existing human, material, and financial resources to achieve the best protection possible. Concommitantly,we should publicise, both at home and abroad, the key position this area occupies in natural protection and another strategy is to bring about international cooperation to raise more funds for the construction and upkeep of the protection zones.

The vital issue is the building up of a comprehensive natural protection zone for various types of ecosystem in order to preserve the diversity of the plateau. In line with this we suggest that a network of protection zones be established so as to promote the development of natural protection areas around the Qinghai-Tibetan Plateau (see Annex 3).

Annex 1: Endangered Animal Species in the Qinghai-Xizang (Tibet) Plateau

1. Mammals

Artiodactyla

- *Budorcas taxicolor*
- *B. t. taxicolor*
- *B. t. tibetana*
- *B. t. whitei*
- *Capra ibex*
- *Capriconis sumatraensis*
- *Cervus albirostris*
- *Cervus elaphus*
- *Hemitragus jemlahicus*
- *Moschus berizovskii*
- *Moschus sifanicus*
- *Moschus fuscus*
- *Moschus cephalophus*
- *Naemorhedus cranbrooki*
- *Naemorhedus goral*
- *Ovis ammon*
- *Pantholops hodgsoni*
- *Poephagus mutus*
- *Pseudois nayaur*

Carnivora

- *Ailuropoda melanoleuca*
- *Ailurus fulgens*
- *Aonyx cinerea*
- *Felis chaus*
- *Felis temmincki*
- *Lutra lutra*
- *Lyns Lynx*
- *Martes foina*
- *Neofelis nebulosa*
- *Panthera tigris*
- *Panthera unica*
- *Selenarctos thibetanus*
- *Viverra zibetha*
- *Ursus arctos*

Perrisodactyla

- *Asinus kiang*

Rhinopithecus roxellanae

Primates

- *Macaca assamensis*
- *Macaca mulatta*

Macaca thibetana

- *Presbytis entelus*

2. Birds

Charadriiformes

- *Capella nemoricola*
- *Limos limosa*

Ciconiiformes

- *Platelea leucorodia*

Columbiformes

- *Syrhhaptes tibetanus*

Coraciformes

- *Aceros nepalensis*

Falconiformes

- *Aquila chrysaetos*
- *Aquila rapax*
- *Buteo rufinus*
- *Falco cherring*
- *Gypaetus barbatus*
- *Haliaetus leucogaster*
- *Haliastur indus*

Galliformes

- *Arborophila mandellii*
- *Arborophila rufipectus*
- *Arborophila rufogularis*
- *Chrysolophus amberstiae*
- *Crossoptilon crossoptilon*
- *Ithaginis cruentus*
- *Lerwa lerwa*
- *Lophophorus impejanus*
- *Lophophorus sclateri*
- *Lophura leucomelana*
- *Tetraogallus himalayensis*
- *Tetraophus obscurus*
- *Tetrastes sewerzowi*

Tragopan blythii
Tragopan melanocephalus
Tragopan satyra
Tragopan temminckii
Gruiformes
Anthropoides virgo
Grus nigricollis
Porzana bicolor
Passeriformes
Calandrella acutirostris
Emberiza koslowi
Melanocorypha maxima
Psittaciformes
Psittacula derbiana
Strigiformes
Harpactes erythrocephalus

3. Reptiles
Serpentes
Python molurus

4. Amphibians
Anura
Rana tigrina
Caudata
Andrias davidianus
Tylototriton taliangensis
Tylototriton verrucosus

Annex 2: Protected Areas in the Qinghai-Tibetan (Tibet) Plateau

Part A: The Xizang (Tibet) Autonomous Region

No.	Name of Protected Areas	Location	Rank
I	Mangkang	Mangkang County	Provincial
2	Leiwuqi	Leiwuqi County	Provincial
3	Mount Qomolungma	Shigaze District	National
4	Jiangcun	Jilong Country	Provincial
S	Zhangmu	Nielamu County	Provincial
6	Qiangtang	Naqu District	Provincial
7	Shenzha	Shenzha County	Provincial
8	Dongjiu	Linzhi County	Provincial
9	Bajie	Linzhi County	Provincial
10	Motuo	Motuo County	National
11	Gangxiang	Pomi County	Provincial
12	Chayu	Chayu County	Provincial

Part B: The Qinghai Province

No.	Name of Protected Areas	Location	Rank
1	Baoku Water Resources Reserving Forest	Datong County	District
2	Dongxia Water Resources Reserving Forest	Datong County	District
3	Mengda	Xuhua County	Provincial
4	Bird Island of Qinghai Lake	Gangca County	Provincial
5	Caruo	Yushu County	District
6	Saiba	Yushu County	District
7	Bangqu	Yushu County	District
8	Longxi	Yushu County	District
9	Longbao	Yushu County	National
10	Dangka	Yushu County	District
11	Jiegu Temple	Yushu County	District
12	Laruo Temple	Yushu County	
13	Gasang	Yushu County	District
14	Gala	Yushu County	District
15	Sekang	Chengduo County	
16	Kuanzhong	Chengduo County	
17	Zhaxilawu Temple	Chengduo County	
18	Cuoyie Temple	Nangqian County	District

19	Gejia Temple	Nangqian County	District
20	Gongya Temple	Nangqian County	District
21	Zhangda Temple	Nangqian County	District
22	Juela Temple	Nangqian County	District
23	Bami Temple	Nangqian County	District
24	Jue Temple	Nangqian County	District

Part C: The Xijiang Weiwur Autonomous Region

No.	Name of Protected Areas	Location	Rank
1	Aerjin Mountain	Ruoqiang County	National

Part D. The Gansu Province

No.	Name of Protected Areas	Location	Rank
I	Yanchiwan	Subei County	Provincial
2	Dasugan Lake	Arkesai County	Provincial
3	Xiaosugan Lake	Arkesai County	Provincial
4	Ananba	Arkesai County	Provincial
5	Qilian Mountain	Zhangye District	National
6	Dongdashan	Zhangye Town	Provincial
7	Baishuijiang	Longnan District	National

Part E: The Sichuan Province

No.	Name of Protected Areas	Location	Rank
1	Panzhihua Cydas	Panzhihua City	District
2	Xiao-zhaizi-gou	Beichuan County	Provincial
3	Wanglang	Pingwu County	Provincial
4	Tangjiahe	Qingchuan County	National
5	Mabian-Dafengding	Mabian County	Provincial
6	Labahe	Tianquan County	Provincial
7	Fengtongzhai	Baoxing County	Provincial
8	Wolong	Wenchuan County	National
9	Huanglong Temple	Songpan County	County
10	Jiuzhaigou	Nanping County	Provincial
11	Baihe	Nanping County	Provincial
12	Norgai	Norgai County	District
13	Kasha Lake	Luhuo County	County
14	Quershan	Dege County	County
15	Xinluhai	Dege County	County
16	Luojishan	Liangshan County	County
17	Meigu-Dafengding	Meigu County	Provincial

Part F: The Yunnan Province

No.	Name of Protected Areas	Location	Rank
1	Bitahai	Zhongdian County	Provincial
2	Haba Xueshan	Zhongdian County	Provincial
3	Nabahai	Zhongdian County	Provincial
4	Baima Xueshan	Deqin County	National
5	Dedang Houxuyuan Lin	Yongde County	County
6	Da Xueshan	Yongde County	Provincial

Annex 3: Integrated Protected Areas' System in Qinghai-Tibetan (Tibet) Plateau

Part A. Wet and semi-wet forest ecosystems on the southern and eastern edges of the Plateau

1. Wet and semi-wet tropical forest ecosystems on the southern edges of the Plateau
   a. Mid-himalayan wet and semi-wet tropical forest ecosystems
      1) Qomolungma Nature Preserve
   b. East-himalayan wet tropical forest ecosystems
      2) **Mo-tuo Protected Area**
      3) **Cha-yu Protected Area**

2. Wet and semi-wet tropical/subtropical forest ecosystems in the Hengduan Mountain Range (on the southern edges of the Plateau)
   a. Wet tropical forest ecosystems on the western edge of the Hengduan Mountain Range
      4) **DulongJiang Protected Area**
   b. Semi-wet, subtropical forest ecosystems in the western part of the Hengduan Mountain Range
      5) **Meili Snow-Mountain Protected Area**
      6) **Yulong Snow-Mountain Protected Area**
   c. Semi-wet warm-temperate forest ecosystems in the middle part of the Hengduan Mountain Range
      7) **Mangkang Protected Area**
   d. Semi-wet, cold-temperate forest ecosystems in the northern part of the Hengduan Mountain Range
      8) **Quershan Protected Area**
   e. Shrub ecosystems in the warm and dry valleys in the southern part of the Hengduan Mountain Range
      9) **Panzhihua Cycas Protected Area**

3. Wet sub-tropical forest ecosystems in the Hengduan Mountain Range (on the eastern edge of the Plateau)
   a. Wet forest ecosystems in the southern part of the eastern edge of the Hengduan Mountain Range
      10) **Meimaping Protected Area(to be established)**
   b. Wet subtropical forest ecosystems in the middle part of the eastern edge of the Hengduan Mountain Range
      11) **Gonggashan Protected Area**

c. Wet subtropical forest ecosystems in the middle part of the eastern edge of the Hengduan Mountain Range

   12) **Wolong Protected Area**

   13) **Baishuijiang Protected Area**

Part B Semi-arid, arid, and desert ecosystems in the Qinghai-Tibetan(Tibet) Plateau and mountain on its northern edge

4. Semi-arid/arid high-cold steppe/desert ecosystems
   a. Arid high-cold steppe/desert ecosystems in the western part of the Plateau
      14) **Qiangtang Protected Area**
   b. High-cold steppe/desert ecosystems in the northwestern part of the Plateau
      15) **Arking Protected Area**
   c. Semi-arid shrub steppe ecosystems in the northern part of the Plateau
      16) **Qomolungma Nature Preserve**

5. Arid/desert ecosystems in the Chaidamu Basin (in the northern part of the Plateau)
   17) **Chaidamu Protected Area (to be established)**

6. Arid/desert ecosystems in the Kunlun and Qilian Mountains on the edge of the Plateau
   18) **Qilian Protected Area**

7. Mountainous arid/desert ecosystems in the Karakulum Mountain (on the western edge of the Plateau)
   19) **Chirgeli Protected Area (to be established)**

It should be noted that some parts of the southern and western edges of the Plateau are located outside the area of China. For this reason, international cooperative efforts should be carried out in order to complete research on the biodiversity of the Qinghai-Tibetan (Tibet) Plateau. A good model that exists is the Qomolungma project supported by the Woodlands Mountain Institute (West Virginia USA). The implementation of this project has given satisfactory protection to all types of ecosystems on both slopes of Mount Qomolungma, which is located in China and Nepal.

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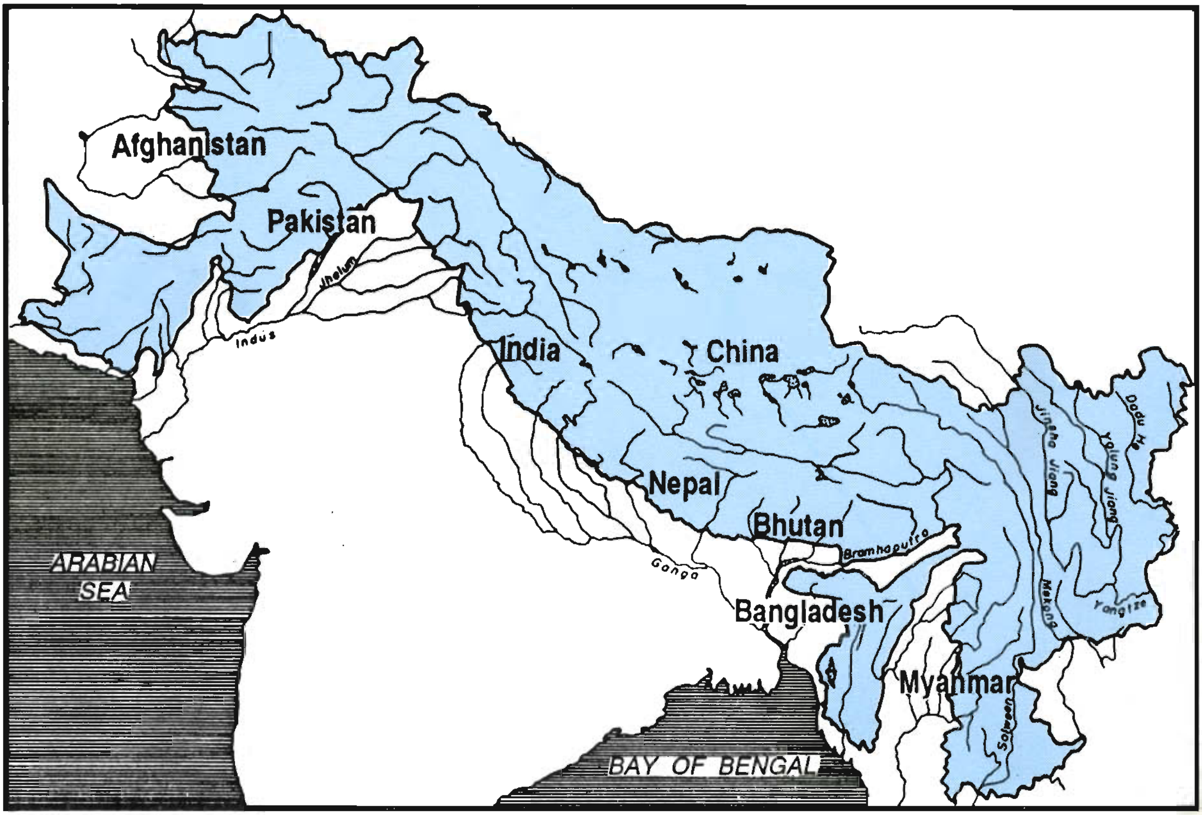
- Afghanistan
- Bhutan
- India
- Nepal
- Bangladesh
- China
- Myanmar
- Pakistan



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