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 (1973) 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 Ṭaiwanese 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.