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REVIEW

Origin and differentiation of endemism in the flora of China

WU Zhengyi, SUN Hang (✉), ZHOU Zhekun, PENG Hua, LI Dezhu

Key Laboratory of Biodiversity and Biogeography, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650204, China

Abstract The present paper analyzed 239 endemic genera in 67 families in the flora of seed plants in China. The results showed that there are five families containing more than ten endemic genera, namely, Gesneriaceae (27), which hereafter refers to the number of endemic genera in China, Composite (20), Labiatae (12), Cruciferae (11), and Umbelliferae (10), 15 families with two endemic genera, and another 30 families with only one endemic genus. Four monotypic families (Ginkgoaceae, Davidiaceae, Eucommiaceae and Acanthochlamydaceae) are the most ancient, relict and characteristic in the flora of seed plants in China. Based on integrative data of systematics, fossil history, and morphological and molecular evidence of these genera, their origin, evolution and relationships were discussed. In gymnosperms, all endemic genera are relicts of the Arctic-Tertiary flora, having earlier evolutionary history, and can be traced back to the Cretaceous or to the Jurassic and even earlier. In angiosperms, the endemic genera are mostly relicts, and are represented in all lineages in the "Eight-Class System of Classification of Angiosperms", and endemism can be found in almost every evolutionary stage of extant angiosperms. The relict genera once occupied huge areas in the northern hemisphere in the Tertiary or the late Cretaceous, while neo-endemism mostly originated in the late Tertiary. They came from Arctic-Tertiary, Paleo-tropical-Tertiary and Tethys-Tertiary florisitic elements, and the blend of the three elements with many genera of autochthonous origin. The endemism was formed when some dispersal routes such as the North Atlantic Land Bridge, and the Bering Bridge became discontinuous during the Tertiary, as well as the climate change and glaciations in the late Tertiary and the Quaternary. Therefore, the late Tertiary is the starting point of extant endemism of the flora in China.

Keywords Chinese flora, endemism, origin, evolution

1 Introduction

Endemism in China is of the type 15, which contains 239 genera in 67 families (Table 1), in the system of genera areal-types that we have established (Wu, 1991; Wu et al., 2003) (Table 2). Most of them are distributed within China's borders, but a few are found across the border and enter the neighboring countries. This is inevitable because the natural vegetation zones do not correspond to the districts of different countries. The majority of the genera across the border have been found to be of the types of 13-1, 13-2, 14SJ, 7-1, 7-2, 7-3, and 7-4, which are also regarded as the semi-endemic genera. Therefore, the endemic and semi-endemic types are more than 400 genera in total. In this paper, we strictly use endemic genera and exclude the semi-endemic ones. However, certain semi-endemic genera may sometimes be involved in the discussion.

2 Characteristics and evolution of the endemic genera of gymnosperms

In the Chinese seed plants flora, China is the core area of extant gymnosperms. Among the four subkingdoms, five classes and 17 families of extant gymnosperms, 11 families are found in China. Thus, the gymnosperms should be analyzed first, and we believe that the modern gymnosperm is a sister group of angiosperms, and that the latter does not originate from the former. Although the origin of angiosperms is later, the earliest fossils, at present, were found in the late Jurassic period (Sun et al., 1998, 2002). Besides many types of fossils that have been extinct, we divided the modern gymnosperms into 17 families, of which Ginkgoopsida in the *Ginkgo* subdivision can only be found in China.

Although Ginkgoopsida has been in existence for many years from the Permian period till the present, no other order can be differentiated and the family level only has two branches (families), namely the extinct Trichopityaceae (early Permian) and the extant Ginkgoaceae (only has one

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E-mail: hsun@mail. kib.ac.cn

Table 1 The areal-types of endemic genera of the Chinese seed plants

Scientific name of family	Number of genera	Scientific name of genera	Chinese/World species	Distribution site of China (Plants region or sub region)
Acanthochlamdac.	1	*Acanthochlamys*	1/1	Middle of Hengduan Mountains
Acanthac.	3	*Kudoacanthus*	1/1	Taiwan
		Parachampionella	(2-)3/(2-)3	Taiwan to Liuqiu
		Paragutzlaffia	2/2	Central China to Yunnan Plateau, Hengduan Mountains
Acerac.	1	*Dipteronia*	2/2	Central China, southeast of Yunnan
Actinidiac.	1	*Clematoclethra*	1(4 ssp.)/1	Central China
Adoxac.	2	*Sinadoxa*	1/1	Qinghai-Tibet Plateau
		Tetradoxa	1/1	Central China
Annonac.	1	*Chieaiodendron*	1/1	Hainan
Anthericac.	1	*Diuranthera*	1-4/1-4	Yunnan Plateau
Apocynac.	1	*Parepigynum*	1/1	Yunnan, Guizhou, Guangxi
Araliac.	4	*Hunaniopanax*	1/1	Central China
		Metapanax	2/2 (or 17)	Middle of Central China to Yunnan Plateau
		Sinopanax	1/1	Taiwan
		Tetrapanax	1/1	East China, Central China
Aristolochiac.	1	*Sarumn*	1/1	Central China
Asclepiadac.	5	*Biondia*	13/13	Qinling Mountains to Central China, Yunnan, Guizhou, Guangxi
		Dolichopetalum	1/1	Yunnan, Guizhou, Guangxi
		Pentaslelma	1/1	Hainan
		Sichuania	1/1	Central China
		Sinomarsdenia	1/1	Yunnan Plateau
Betulac.	1	*Ostryopsis*	2/2	North China, Yunnan Plateau
Boraginac.	4	*Antiotrema*	1/1	Yunnan Plateau
		Metaeritrichium	1/1	Qinghai-Tibet Plateau
		Ornphalotrigonotis	2/2	East China to south of Central China
		Sinojohnstonia	3/3	North China to Central China, East China
Calycanthac.	2	*Chimonanthus*	6/6	East China, Central China, North China to Vietnam and Laos
		Sinocalycanthus	1/1	East China
Campanulac.	2	*Echinocodon*	1/1	North of Central China
		Homocodon	1 + 1 var./ 1 + 1 var.	Yunnan Plateau
Caprifoliac.	3	*Dipelta*	3-4/3-4	Central China to Hengduan Mountains
		Heptacodium	1/1	East China, Central China
		Kolkwitzia	1/1	North China to East China
Caryophyllac.	2	*Psammosilene*	1/1	Yunnan Plateau and south of Hengduan Mountains
		Pseudocerastium	1/1	East China
Celastrac.	1	*Monimopetalum*	1/1	East China
Chenopodiac.	2	*Archiatriplex*	1/1	North of Hengduan Mountains
		Baolia	1/1	North of Hengduan Mountains
Compositae	20	*Ajaniopsis*	1/1	Qinghai-Tibet Plateau
		Dicercoclados	1/1	Central China
		Diplazoptilon	2/2	South of Hengduan Mountains
		Faberia	(4-5)7/(4-5)7	Central China to Hengduan Mountains
		Faberiopsis	1/1	Central China
		Formania	1/1	Qinghai-Tibet Plateau
		Heteroplexis	2/2	South China
		Ligulariopsis	1/1	Northern Boundary of Central China
		Myripnois	1/1	North China
		Nannoglottis	8-9/8-9	Hengduan Mountains
		Notoseris	12/12	Taiwan, East China, Central China to Yunnan Plateau
		Nouelia	1/1	Yunnan Plateau
		Opisthopappus	2/2	North China
		Phaeostigma	3/3	South of Hengduan Mountains
		Sheareria	1/1	East China, Central China
		Sinacalia	4/4	Central China to east of Hengduan Mountains
		Sinoleontopodium	2/2	South of Hengduan Mountains
		Stilpnolepis	1/1	Inner Mongolia to Gansu, Qinghai
		Syncalathium	7/7	Hengduan Mountains to Qinghai-Tibet Plateau
		Xanthopappus	1/1	Inner Mongolia to north of Hengduan Mountains

(*Continued*)

Scientific name of family	Number of genera	Scientific name of genera	Chinese/World species	Distribution site of China (Plants region or sub region)
Convallariae	2	*Heteropolygonatum*	4/4	West of Central China to Hengduan Mountains
		Speirantha	1/1	East China
Corsiaceae.	1	*Corsiopsis*	1/1	South China
Crassulac.	2	*Kungia*	2/2	North China to north of Hengduan Mountains
		Ohbaea	1/1	South of Hengduan Mountains
Cruciferae	11	*Baimashania*	2/2	Hengduan Mountains
		Coelonema	1/1	Tangut
		Dipoma	1/1	South of Hengduan Mountains
		Eurycarpus	2/2	Qinghai-Tibet Plateau
		Hemilophia	4/4	South of Hengduan Mountains
		Neomartinella	3/3	Central China to Yunnan, Guizhou, Guangxi
		Platycraspedum	2/2	Middle of Hengduan Mountains
		Shangrilaia	1/1	South of Hengduan Mountains
		Sinosophiopsis	2/2	North of Hengduan Mountains
		Synstemon	2/2	Inner Mongolia to Gansu
		Yinshania s.l.	13(12 end.)/13	Inner Mongolia, Northern China, East China, Central China, Hengduan Mountains to north of Vietnam
Cucurbitac.	1	*Bolbostemma*	2/2	North China, Central China and Yunnan Plateau
*Davidiac.	1	*Davidia*	1/1	Central China to Hengduan Mountains
Diapensiac.	1	*Berneuxia*	1/1	Southwest of Central China
*Eucommiac.	1	*Eucommia*	1/1	Central China
Euphorbiac.	2	*Archileptopus*	1/1	Yunnan, Guizhou, Guangxi
		Speranskia	3/3	Northeast China, North China, East China, Central China and Yunnan Plateau
Flacourtiac.	1	*Poliothyrsis*	1/1	East China, Central China
Gentianac.	2	*Latouchea*	1/1	Central China, South China
		Lomatogoniopsis	3/3	Qinghai-Tibet Plateau
Gesneriac.	27	*Allocheilos*	1/1	Central China to Yunnan, Guizhou, Guangxi
		Allostigma	1/1	Yunnan, Guizhou, Guangxi
		Ancylostemon	11-12/11-12	Central China
		Bournea	2/2	East of Nanling
		Briggsiopsis	1/1	West of Central China to south of Yunnan Plateau
		Cathayanthe	1/1	Hainan
		Chiritopsis	9/9	South China
		Dayaoshania	1/1	South of Central China
		Deinocheilos	2/2	East China, Central China
		Didymostigma	2/2	East of South China
		Dolicholoma	1/1	Yunnan, Guizhou, Guangxi
		Gyrocheilos	4/4	Weat of Nanling
		Gyrogyne	1/1	Yunnan, Guizhou, Guangxi
		Isometrum	13-14/13-14	Central China to middle of Hengduan Mountains
		Lagarosolen	2/2	Yunnan, Guizhou, Guangxi
		Metabriggsia	2/2	South China
		Metapetrocosmea	1/1	Hainan
		Paraisometrum	1/1	Yunnan, Guizhou, Guangxi
		Paralagarosolen	1/1	Yunnan, Guizhou, Guangxi
		Petrocodon	1 with 1 var./1	Central China of north to East China
		Primulina	1/1	Middle of Nanling
		Rhabdothamnopsis	1/1	Yunnan Plateau
		Tengia	1/1	Central China
		Thamnocharis	1/1	Central China and Yunnan Plateau
		Tremacron	7/7	Yunnan Plateau
		Wentsaiboca	1/1	Yunnan, Guizhou, Guangxi
		Whytockia	6/6	Taiwan, Central China to Yunnan, Guizhou, Guangxi
*Ginkgoac.	1	*Ginkgo*	1/1	Northeast China, North China, East China, Central China, South China, Yunnan, Guizhou, Guangxi, Yunnan Plateau
Gramineae	10	*Anisachne*	1/1	Yunnan Plateau
		Ferrocalamus	2/2	South of Yunnan Plateau

(*Continued*)

Scientific name of family	Number of genera	Scientific name of genera	Chinese/World species	Distribution site of China (Plants region or sub region)
		Gaoligongshania	1/1	South of Hengduan Mountains
		Gelidocalamus	9/9	Taiwan, East China, Central China
		Indocalamus	15/15	Taiwan, East China, Central China
		Kengyilia	3/3	Inner Mongolia, Gansu, Qinghai
		Leptocanna	1/1	Middle, south of Yunnan Plateau
		Oligostachyum	13/13	Nanling
		Qiongzhuea	12/12	Central China
		Setiacia	1/1	Hainan
Hamamelidac.	4	*Chunia*	1/1	Hainan
		Fortunearia	1/1	North of East China, Central China
		Semiliquidambar	3/3	Nanling
		Sinowilsonia	1/1	North China, Central China
Hydrocotylac.	1	*Dickinsia*	1/1	Central China
Juglandac.	1	*Cyclocarya*	1/1	Taiwan, East China, Central China
Labiatae	12	*Bostrychanthera*	2/2	Taiwan, East China, south of Central China
		Cardioteucris	1/1	Yunnan Plateau
		Hanceola	6-8/6-8	Central China to Hengduan Mountains
		Heterolamium *(Changruihuaia)*	1 + 1 var./ 1 + 1 var.	Central China
		Holocheila	1/1	Yunnan Plateau
		Kinostemon	2-3/2-3	Central China
		Loxocalyx	2/2	North China, Central China
		Ombrocharis	1/1	Central China
		Rostrinucula	2/2	Central China to Hengduan Mountains
		Sinopogonanthera	2/2	East China
		Skapanthus	1/1	South of Hengduan Mountains
		Wenchengia	1/1	Hainan
Lardizabalac.	2	*Archakebia*	1/1	Northwest of Central China
		Sinofranchetia	1/1	Central China
Laurac.	1	*Sinosassafras*	1/1	South of Hengduan Mountains
Magnoliac.	5	*Manglietiastru*	1/1	Yunnan, Guizhou, Guangxi
		Parakmeria	5/5 or 1/1	Taiwan, East China, Central China, South China, south of Hengduan Mountains
		Sinomanglietia	1/1	East of Central China
		Tsoongiodendron	1/1	Nanling to Yunnan, Guizhou, Guangxi, north of Vietnam
		Woonyoungia	1/1	Yunnan, Guizhou, Guangxi
Melastomatac.	5	*Barthea*	1/1	East China, south of Central China to South China, Taiwan
		Cyphotheca	1/1	South of Yunnan Plateau
		Stapfiophyton	3/3	South China
		Styrophyton	1/1	Yunnan, Guizhou, Guangxi
		Tigridiopalma	1/1	South China
Monotropac.	1	*Eremotropa*	1(-2)/1(-2)	Yunnan Plateau
Musac.	1	*Musella*	1/1	Yunnan Plateau
Nyssac.	1	*Camptotheca*	1/1?	Central China
Olacac.	1	*Malania*	1/1	Yunnan, Guizhou, Guangxi
Opiliac.	1	*Yunnanopilia*	1/1	South of Yunnan Plateau
Orchidac.	11	*Aceratorchis*	1/1	North China, Yunnan Plateau, Hengduan Mountains
		Changnienia	1/1	East China, Central China
		Diplandrorchis	1/1	Northeast China
		Haraella	1/1	Taiwan
		Hemipiliopsis	1/1	South of Hengduan Mountains
		Ischnogyne	1/1	West of Central China, north to Qinling Mountains
		Nothodoritis	1/1	East China
		Porolabium	1/1	North China to Tangut
		Smithorchis	1/1	Yunnan Plateau
		Tangtsinia	1/1	Central China
		Tsaiorchis	1/1	Yunnan Plateau

(*Continued*)

Scientific name of family	Number of genera	Scientific name of genera	Chinese/World species	Distribution site of China (Plants region or sub region)
Papaverac.	1	*Eomecon*	1/1	East China, Central China
Papilionac.	2	*Craspedolobium*	1/1	Yunnan Plateau
		Salweenia	1/1	Middle of Hengduan Mountains
Pinac.	3	*Cathaya*	1/1	Central China
		Nothotsuga	1/1	Nanling
		Pseudolarix	1/1	East China, Central China
Podostemac.	1	*Terniopsis*	1/1	South China
Polygonac.	2	*Parapteropyrum*	1/1	Qinghai-Tibet Plateau
		Pteroxygonum	1/1	North China
Primulac.	1	*Pomatosace*	1/1	Qinghai-Tibet Plateau
Ranunculac.	4	*Anemoclema*	1/1	South of Hengduan Mountains, Yunnan Plateau
		Kingdonia	1/1	Hengduan Mountains to Qinling Mountains
		Metanemone	1/1	South of Hengduan Mountains
		Urophysa	2/2	Central China to Hengduan Mountains
Rosac.	7	*Dichotomanthes*	1/1	Yunnan Plateau
		Pleiosorbus	1/1	South of Hengduan Mountains
		Potaninia	1/1	Inner Mongolia
		Pseudocydonia	1/1	East China
		Sinoplagiospermum	2/2	Northeast China, North China
		Spenceria	1/1	Hengduan Mountains, Qinghai-Tibet Plateau to Bhutan
		Taihangia	1/1	Northern China
Rubiac.	3	*Guihaiothamnus*	1/1	Southwest of Central China
		Trailliaedoxa	1/1	Yunnan Plateau
		Tsiangia	1/1	South China
Rutac.	2	*Poncirus*	2/2	North China, East China, Central China, South China, Yunnan Plateau
		Psilopeganum	1/1	Central China
Sapindac.	4	*Eurycorymbus*	1/1	South of Hengduan Mountains, Yunnan, Guizhou, Guangxi, Central China, East China, Taiwan
		Handeliodendron	1/1	Southwest of Central China
		Koelreuteria	3/4	North China to South China, Yunnan Plateau
		Xanthocerax	1/1	North China
Saururac.	1	*Gymnotheca*	2/2	Central China to Yunnan, Guizhou, Guangxi
Sauvagesiac.	1	*Sinia*	1/1	South China
Saxifragac.	4	*Astilboides*	1/1	Northeast China
		Mukdenia	1/1(-2)	North China, Northeast China
		Oresitrophe	1/1	North China
		Saniculiphyllum	1/1	Yunnan, Guizhou, Guangxi
Scrophulariac.	6	*Mimulicalyx*	2/2	Yunnan Plateau
		Neopicrorhiza	1/1	South of Hengduan Mountains
		Pterygiella	3/3	Yunnan Plateau to Hengduan Mountains, Yunnan, Guizhou, Guangxi
		Scrofella	1/1	North of Hengduan Mountains
		Trianophora	2/2	Central China
		Xizangia	1/1	West of Yunnan to east of Himalaya
Solanac.	2	*Atropanthe*	1/1	Central China
		Przewalskia	1/1	Qinghai-Tibet Plateau
Styracac.	3	*Changiostyrax*	1/1	Central China
		Melliodendron	1/1	East China, Central China to Yunnan, Guizhou, Guangxi
		Sinojachia	2(-4)/2(-4)	East China, Central China
Tapisciac.	1	*Tapiscia*	2/2	East China, Central China, Yunnan, Guizhou, Guangxi
Taxac.	1	*Pseudotaxus*	1/1	East China, Central China
Taxodiac.	3	*Glyptostrobus*	1/1	Central China to South China
		Metasequoia	1/1	Central China
		Taiuxania	1(-2)/1(-2)	Taiwan, Central China, Hengduan Mountains
Theac.	3	*Apterosperma*	1/1	South China
		Euryodendron	1/1	South China
		Tutcheria	6(-20)/6(-20)	South China

(*Continued*)

Scientific name of family	Number of genera	Scientific name of genera	Chinese/World species	Distribution site of China (Plants region or sub region)
Ulmac.	1	*Pteroceltis*	1/1	North China to South China, Yunnan, Guizhou, Guangxi
Umbelliferae	11	*Arcuatopterus*	3/3	South of Hengduan Mountains to Qinghai-Tibet Plateau
		Carlesia	1/1	North China
		Chaerophyllopsis	1/1	Yunnan Plateau, south of Hengduan Moutains
		Changium	1/1	East China
		Chuanminshen	1/1	East China, Central China
		Cyclorhiza	2/2	South of Hengduan Mountains
		Dactylaea	2/2	Northwest of Yunnan Plateau
		Harrysmithia	1-2/1-2	Yunnan Plateau
		Melanosciadium	1/1	Central China
		Notopterygium	3/3	Qinling Mountains to Hengduan Mountains, Qinghai-Tibet Plateau
		Sinolimprichtia	1/1	Middle of Hengduan Mountains to Qinghai-Tibet Plateau
Viticac.	1	*Schnabelia*	2/2	East China Central China
Zingiberac.	2	*Paramomum*	1/1	South of Yunnan Plateau
		Pyrgophyllum	1/1	Yunnan Plateau
Zygophyllac.	1	*Tetraena*	1/1	Inner Mongolia

species). The earliest fossils of this family were in the early Jurassic period (Zhou, 2003; Zhou and Sheng, 2003). Therefore, it is a bitypic class.

Compared with Cycadopsida, although they have the same age and both have a spermatozoid, on the general appearance and anatomical features, *Ginkgo* is closer to other gymnosperms and angiosperms than *Cycas*. Therefore, we believe that it is a blind branch in the trunk evolution of seed plants. However, *Cycas* is also differentiated from the trunk, and it obviously was a blind branch as well, so it should be placed before Cycadopsida. Despite that *Ginkgo biloba* is a Linnaeus genus and species, during the discussion on the origin and differentiation of seed plants flora in China, we have found that we have much to boast about. This is because the oldest *Ginkgo* in Shandong Province was found recently, whose diameter is four meters and the age is over three thousand years. It is also the evidence that (Zhou et al., 2003), based on fossil researches, derived from the *Ginkgo* and the other six lineages and suggested that the extant *Ginkgo* might have originated in China. Therefore, the oldest *Ginkgo* tree found in Shangdong Province might be the living proof. The wild *Ginkgo* was found in a valley that is 300–1100 meters in the Tianmu Mountains located in East China. It can still be seen in the wild populations or at least half wild populations together with *Cryptomeria* (14SJ type), *Cunninghamia* (7-4 type), *Pseudolarix* (monotypic specific in Eastern and Central China), *Torreya* (9 type disjunction), *Nyssa* (9 type disjunction), *Liquidambar* (8 (9) type disjunction), and *Litsea* (3 (5) type disjunction), which derived from the Cretaceous-Tertiary. Recently, more wild populations were found in Northeast Guizhou as well.

Cycadopsida only includes Cycadaceae in China. But Boweniaceae, Stangeriaceae and Zamiaceae are not found in China. Cycadaceae only includes one genus—*Cycas*. It is mainly distributed in the old world's tropical and subtropical regions. The *Cycas* is currently divided into two subgenera: subgen. *Panzhihuaenses* and subgen. *Cycas* (Wang, 1996). There are 86 species in the world and 22–25 species (or at least 16 species) in China, including the more primitive forest type "*Epicycas*" (Wang, 1996, 2001; Delaubenfels and Adema, 1998). As to the original time of *Cycas*, Zhu and Du (1981) reported that fossil species of *Primocycas chinensis* was found in Taiyuan in Shanxi Province. Its palmate parted microsporophylls are quite similar to the modern *Cycas*. Therefore, its original time can be traced back to the Permian. Later, Zhu et al (1994) discovered the microsporophyll of *Cycadostrobilus paleozoicus*, proving that *Cycas* was distributed in Northern China in the Permian. Recently, Hu (1999) inferred that the *Cycas* was likely to have originated in the northwest of China based on his collection of *Cycas* megaspore fossils from Gansu Province. Guan (1996) suggested that North China was the distributive center of *Cycas* in the Paleozoic, but this shifted to the southwest region in the Mesozoic. The geological environment and climatic conditions in the southwest region had been relatively stable since the Paleozoic, which could provide good conditions for the further development of *Cycas*. This was supported by fossil records of *Cycas* and seed fern as well (Xu et al., 1979). From the analysis of the modern geographical distribution of *Cycas*, Wang (2001) inferred that although the two largest distributive centers of modern *Cycas* are in the southwest of China and Australia (including neighboring islands), the area from the Indo-China Peninsula to the southwest of China gathered most of the primitive species of *Cycas*, also containing different levels of evolution of all subgenera. Therefore, the southwest of China may be the birthplace of the modern *Cycas*.

Table 2 The areal types and subtypes of Chinese genera of seed plants

1 Cosmopolitan
2 Pan-tropic
  2-1 Trop. Asia, Australasia (to N. Zeal.) and C to S. Amer. (or Mexico) disjuncted
  2-2 Trop. Asia, Africa and C. to S. Amer. disjuncted
3 Trop. Asia and Trop. Amer. disjuncted
4 Old World Tropics
  4-1 Trop. Asia, Africa (or E. Afr., Madagascar) and Australasia disjuncted
5 Tropical Asia and Trop. Australasia
  5-1 Chinese (SW.) Subtropics and New Zealand disjuncted
6 Trop. Asia to Trop. Africa
  6-1 S., SW. China to India and Trop. Africa disjuncted
  6-2 Trop. Asia and E. Afr. or Madagascar disjuncted
7 Trop. Asia (Indo-Malaysia)
  7-1 Java (or Sumatra), Himalaya to S., SW. China disjuncted or diffused
  7-2 Trop. India to S. China (esp. S. Yunnan)
  7-3 Burma, Thailand to SW. China
  7-4 Vietnam (or Indo-Chinese Peninsula) to S. China (or SW. China)
8 North Temperate
  8-l Circumpolar (Circumarctic)
  8-2 Arctic-alpine
  8-3 Arctic to Altai and N. Amer. disjuncted
  8-4 N. Temp. and S. Temp. disjuncted (“Pan-temperate”)
  8-5 Eurasia and Temp S. Amer. disjuncted
  8-6 Mediterranea, E. Asia, New Zealand and Mexico-Chile disjuncted
9 E. Asia and N. Amer. disjuncted
  9-l E. Asia and N. Amer. disjuncted
10 Old World Temperate
  10-1 Mediterranea, W. Asia (or C. Asia) and E. Asia disjuncted
  10-2 Mediterranea and Himalaya disjuncted
  10-3 Eurasia and S. Africa (Sometimes also Australasia) disjuncted
11 Temperate Asia
12 Mediterranea, W. Asia to C. Asia
  12-1 Mediterranea to C. Asia and S. Africa, Australasia disjuncted
  12-2 Mediterranea to C, Asia and Mexico to S. USA disjuncted
  12-3 Mediterranea to Temp.-Trop. Asia, Australasia and S. Amer. disjuncted
  12-4 Mediterranea to Trop. Africa and Himalaya disjuncted
  12-5 Mediterranea to N. Africa, C Asia. SW. N. Amer., S. Africa, Chile and Australasia disjuncted (“Pan-Mediterranean”)
13 C. Asia
  13-1 East C. Asia (or Asia Media), in Xinjiang (especially Kaschgaria), Gansu, Qinghai to Mongolia
  13-2 C. Asia to Himalaya and S. W. China
  13-3 W. Asia to W. Himalaya and Tibet
  13-4 C. Asia to Himalaya-Altai and Pacific N. Amer. disjuncted
14 E Asia
  14-1 Sino-Himalaya (SH)
  14-2 Sino-Japan (SJ)
15 Endemic to China

The subdivision conifers have two classes, of which Coniferopsida includes six families, i.e. Pinaceae, Cupressaceae, Taxodiaceae, Araucariaceae, Agathidaceae and Sciadopityaceae. The first three families can be found in China.

Cupressaceae is a big family that contains 18–20 genera and originated and evolved in the northern and southern temperate zones from the Triassic to early Jurassic. There are 13 genera distributed in the northern temperate zone, of which 11 genera are found in China containing two East Asian and North American areal-types, three northern temperate areal-types and four East Asian areal-types. Therefore, the areal-types of the family is presented by compound, that is, widespread distribution in the northern and southern temperate zones (i.e. 8-4(9, 14) areal-types). The origin should be considered from the East Laurasia gradually spreading to East Gondwanaland. Although not a genus endemic to China, there are two genera that can be regarded as sub-endemic. One is *Calocedrus*, which distributes from Burma and Vietnam to the Yunnan Plateau, Hainan Province and Taiwan, China. Because its morphologic characteristics and discontinuous distribution can be considered very old, it belongs to the 7-3 areal-type. Recent molecular evidence showed that the genus clustered to the *Heyderia decurrens* (Li, 1953; Gadek et al., 2000), which is endemic to Northwest America, was thus merged into *Calocedrus*. Therefore, the genus is also regarded as the disjunct distribution in East Asia and North America. The other is *Fokienia*, which is a 7-4 areal-type. It presents a small disjunct distribution in Fujian, Zhejiang, and Yunnan Provinces and is distributed abroad only in North Vietnam, Laos and Thailand. But the fossil records were in Xinjiang Autonomous Region and Jilin Provinces during the late Cretaceous to Oligocene (Zhou and Arata, 2005), and also in Canada Paleocene (Mclver et al., 1990; Mclver, 1992). These limited fossil records show that the genus was once widely distributed in the northern hemisphere from the late Cretaceous Tomiocene (Zhou and Arata, 2005).

Taxoidiaceae is a small family with 12(-16) species and nine genera in the world. All of them occupied very small areas, which are regarded as relic areas. Except for one that occurs in the southern hemisphere, all genera are in the northern hemisphere. There are four monotypic or bitypic genera including five or six species—*Metasequoia*, *Glyptostrobus*, *Cunninghamia*, *Taiwania*. Although the latter two can be considered as sub-endemic, *Taiwania* is distributed in North Myanmar and *Cunninghamia* in North Vietnam. Undoubtedly, in the four genera, *Metasequoia* and *Glyptostrobus* are paleo-endemics. According to the Cytological data, *Cunninghamia* and *Taiwania* may be the new endemics (Li, 1989).

Glyptostrobus is a relict of the Tertiary widely distributed in East Asia (Florin, 1963). It is usually regarded as an interim group between *Taxodium* of North America and *Cryptomeria* of East Asia (Liu and Su, 1983; Yu, 1999). However, Gadek et al (2000) suggested putting *Glyptostrobus* into Cupressaceae and merging Taxocdiaceae into Cupressaceae based on the studies of morphological and molecular phylogenetics. The recent molecular studies also support such a merger (Kusumi et al., 2000). All these show that there is a very close relationship among *Metasequoia*, *Glyptostrobus* and *Taxodium*.

Metasequoia had an extensive distribution in the past (Chaney, 1951). Undoubtedly, the residue left in East Asia was attributed to the late Tertiary and Quaternary glacial role in the cold climate. *Metasequoia* has the closest relationship with *Sequoia* and *Sequoiadendorn.* They may be the ancestral groups of *Glyptostrobus* and *Taxodium*. In addition, from the duration of origin, the earliest fossils of the Taxodiaceae were found in the Jurassic and Cretaceous, and all groups of Taxodiaceae had appeared and were widely distributed in the northern hemisphere. Since the Eocene, however, especially in the late Tertiary and Pleistocene, they died out one after another. Many out-groups of the Taxodiaceae such as Voltziaceae appeared in the late Permian to the early Jurassic. Therefore, the origin of the Taxodiaceae can be traced back from the late Triassic to the early Jurassic (Yu, 1999).

From the fossil records (Florin, 1963), the fossil history of the *Glyptostrobus* is very similar to that of *Taxodium* and *Metasequoia*, but the fossils of *Tawania* have less in common. *Cunninghamia* has a variety in the valley of Anning in the southwest of Sichuan. However, *Taiwania* has one variety or two species. One is a disjunct distribution from Central China and south of the Hengduan Mountains to the north of Myanmar. The other only occurs in Taiwan of China, where the ancient tree was considered as the “god tree” by local people. The distribution patterns clearly suggest that Taiwan of China might have been separated from the mainland in the latter part of the Himalayan uplift. Apart from the four genera endemic to China, East Asia also has *Cryptomeria*, which contains two species—one is in China and the other is in Japan. If they were together with *Sequoia* (*Sequoiadendron*) in the west of North America, *Taxodium* in North America and *Athrotaxis* in Tasmania, then the family might have originated in the ancient northeastern mainland and then spread to the eastern part of the ancient land. It is extinct in native eastern Australia because of the block drift and drought.

Pinaceae is a big family of Coniferopsida rising up from the late Jurassic to the Cretaceous. It is a younger family than Cupressaceae and Taxodiaceae and is mainly distributed in the northern temperate zone. Therefore, it can be certain that Pinaceae originated in Laurasia (Li, 1999). However, Florin (1963) deduced that Pinaceae must have originated in East Asia. It includes 200 to 220 species of 12 to 13 genera, among which 95 species and 10 genera are found in China, of which there are three monotypic genera endemic to China, namely, *Pseudolarix*, *Cathaya* and *Nothotsuga*. Although Pinaceae was once a very large group before the Mesozoic, a majority of it became extinct in the late Mesozoic. Then, the modern Pinaceae, which is originated and differentiated from the Cretaceous to the Tertiary, began to prosper.

Similar to *Glyptostrobusoides Cathaya* is another famous living fossil and was distributed in East Asia and North America in the late Cretaceous. Fossils were found in Germany (Eschweiler) and east Siberia (Ardant Valley) indicating that *Cathaya* spread to Europe via the North Atlantic Land Bridge in the early Tertiary (Ferguson, 1967; Florin, 1963). Later, in the Cenozoic, *Cathaya* was already widely distributed in East Asia, Europe and North America (Liu and Basinger, 2000). However, it died out from the late Tertiary to the Quaternary, mainly due to cooling climate and the fatal effects of glaciations. The latest fossil records of *Cathaya* were found in North America and Europe during the late Miocene and Pliocene. Therefore, *Cathaya*, which is now endemic to China, was regarded as a residue of a population that was once widely distributed in Asia (Liu and Basinger, 2000). *Cathaya* was likely to have a close relationship with an extinct group of *Pseudotsuga* (9 areal-type) in Laricoideae, which was considered as an endangered species distributed sporadically in primary evergreen broad-leaved forests in Sichuan, Guizhou, Hunan and Guangxi Provinces.

Nothotsuga was classified first by Prof. Hu Xiansu. It was considered as having a close relationship with *Tsuga*, and distributed sporadically in evergreen broad-leaved forests in the west of Nanling. *Hesperopeuce* is probably the counterpart of *Nothotsuga* in North America.

Pseudolarix, another monotypic genus endemic to China, is distributed sporadically in the warm areas along the middle and lower reaches of the Yangtze River, westward to Lichuan County and Wan County, eastward to East Zhejiang Province, southward to Hengyang City and northward to the south of Jiangsu Province (Ying, 1989). Furthermore, *Pseudolarix* formed many small communities in the mountainous areas in Central and East China. The fossils of *Pseudolarix* were found in Central and West America, Europe, Central Asia, Northeast China and Japan (Farjon, 1990; Florin, 1963), which indicated that *Pseudolarix* was once widely distributed in the northern hemisphere. Based on fossil records, Li (1999) inferred that *Pseudolarix* derived from the late Cretaceous, then became a big genus that occurred widely in the mid-and-high-latitude zones of the northern hemisphere during the Tertiary. However, *Pseudolarix* died out soon in North America and Central Asia. In Europe and Japan, *Pseudolarix* lived until the first glacial period of the Pleistocene (Farjon, 1990). Similar to *Cathaya*, *Pseudolarix* was regarded as a residue of Tertiary-East Asia floristic elements as well (Lepage and Basinger, 1995). *Cathaya*, *Pseudolarix* and *Nothotsuga* are three genera paleo-endemic to China. In addition, *Keteleeria*, which includes three to five species in the 7-4 areal type, can be regarded as a sub-endemic genus. Fossil records of *Keteleeria* indicated that it was once widely distributed in the northern hemisphere from the Oligocene to Miocene. In the late Miocene, it died out in North America. However, in Europe, it lived until the early Pleistocene (Axelrod, 1976, 1986; Miller, 1975; Florin, 1963).

Taxopside includes two extant orders, namely, Podocarpales and Cephalotaxales. Cephalotaxales contains Cephalotaxaceae, which has only one genus, *Cephalotaxus*, with nine species and belongs to East Asian type (14 areal-type); its distributive center is in China indeed. Fossil records of Cephalotaxaceae once found in North America, East Asia and Europe indicated that the original time of Cephalotaxaceae can be traced to the middle Jurassic. Based on the molecular evidences, Cheng et al (2000) stated that Cephalotaxaceae and Taxaceae are monophyletic and sister groups. The divergent time of the genera of the two families was estimated to be about six to eight million years. Thus, the short divergent time was considered as a major factor that resulted in the confused situations in the taxonomy of these two families among all families in Podocarpales; Phyllochdaceae is the only one that did not grow in China. A majority of the Phyllochdaceae originated in East Malaysia, distributed northward to Northern Luzon of the Philippines (excluding Taiwan of China), westward to Kalimantan and Malaysia, and eastward to Guinea. In the southern hemisphere, it is disjunct in Australia and New Zealand.

Taxales includes only one family, namely, Taxaceae. The family contains five genera (including *Amentotaxus*), among which four occur in China. However, there is only one genus, *Austrotaxus*, with one species in Taxaceae found in the southern hemisphere (New Caledonia). The earliest fossils of *Torreya* (9-1 areal-type) were found in southwestern Europe and North America during the Jurassic and Cretaceous (Florin, 1963). In East Asia, the fossils of *Torreya* indicated that this genus had been already distributed in this region in the Oligocene. During the period from the late Tertiary to the Quaternary, *Torreya*, as well as other numerous plant groups, died out in Europe due to the cooling climate and the fatal effects of glaciations (Tiffney, 1985). Furthermore, molecular evidences indicated that the divergent level of the ITS sequence in some species of *Torreya* were low (Li et al., 2001a), which suggested that modern species of *Torreya* distributed in East Asia and North America are young. Therefore, the modern *Torreya* is likely to be a young descendant originating from East Asia and North America.

Amentotaxus is a 7-4 areal-type. *Pseudotaxus*, however, is a monotypic genus. According to the results of molecular phylogeny, *Pseudotaxus* and *Taxus* are sister groups or the basic group of the modern *Taxus* (Wang and Shu, 2000; Cheng et al., 2000). Similarly, *Amentotaxus* and *Torreya* are sister groups as well. *Pseudotaxus* is a relict that is distributed sporadically in the evergreen broad-leaved forests in Eastern and Central China (Li and Fan, 1997). However, limited fossil records hardly support the idea that *Pseudotaxus* is a living fossil. *Amentotaxus* in the 7-4 areal type is a sub-endemic species distributed in Central China. Based on the analysis above, *Amentotaxus*, as well as modern *Torreya*, is a new descendant that probably originated from the ancestor of *Torreya* along with the climate change in the late Tertiary and Quaternary. Based on molecular evidences, Li et al (2001b) stated that all the modern groups of *Taxus* distributed in the north temperate zone may have originated from a common ancestor. Therefore, *Pseudotaxus* may be a residue left in Central China. It was likely to have originated from the ancestor of *Taxus*. Based on the molecular evidences, *Austrotaxus* distributed in Northern Caledonia should be placed in Taxaceae. Furthermore, it was the basic group of *Pseudotaxus* and *Taxus* (Cheng et al., 2000) as well. However, based on the morphological and anatomic characteristics of the seeds of *Austrotaxus*, Bobrov et al (2004) stated that the relationships among *Austrotaxus*, *Pseudotaxus* and *Taxus* were distant. Furthermore, he suggested regarding *Austrotaxus* as a family that is an interim group between Taxaceae and Podocarpaceae. Whereas, we need more evidences to demonstrate the phylogenic position of *Austrotaxus*.

Gnetopsida includes only one class, namely, Gnetopsida. Among three monotypic orders of Gnetopsida, two were found in China. Welwitschiaceae does not grow in China. Ephedraceae is a monotypic genus in the 8-5 areal-type. This distributive pattern was considered to have resulted from the 3 areal-type in East Asia and the western part of South America. Fourteen species of Ephedraceae are found in China, among which only two species are endemic. The modern distributive center of Ephedraceae was in the northern temperate zone and the west of South America. Although Gnetaceae is widely distributed in the pan-tropic district, its distributive center is Southeast Asia and the western part of South America. There is no genus endemic to China in Gnetaceae. Whereas, at the level of species, differentiations of Gnetaceae are found in the India-Malaya subdistrict (about 23 species). In China, there are nine species with six endemic.

3 Characteristic and differentiation of the endemic genera of angiosperms

3.1 Distribution of endemic genera in the Eight-Class System of angiosperms

All endemic genera, namely the 15 areal-type, can be found in all lineages in our Eight-Class System of classification of angiosperms (Wu et al., 2002). Details are as follows:

The first class: Magnoliosida includes two subclasses, namely, Magnoliidae and Annonidae. Magnoliaceae contains five endemic genera, i.e. *Manglietiastrum, Sinomanglietia, Parakmeria, Woonyoungia* and *Tsoongiodendron*. In spite of limited fossil records, most of these five endemic species were considered as palaeoendemic. *Chieniodendron* in Annoaceae of Annonidae is an endemic genus distributed in the tropical forests of Hainan Province.

The second class: Lauropsida. There are two subclasses, i.e. Lauridae and Calycanthidae. Lauraceae in Lauridae has one endemic genus, *Sinosassafras*. And Calycanthaceae in Calycanthidae includes two endemic genera, i.e. *Sinocalycanthus* and *Chimonanthus*. The former is a residue in East China. The latter was distributed in East to Central China.

The third class: Piperopsida. Piperopsida includes two subclasses, i.e. Aristolochiidae and Piperidae; both contain genera endemic to China. *Saruma* in Aristolochiaceae is a relict in the region from Qinling Mountains to the west of Central China. *Saururaceae* includes one endemic genus, *Gymnotheca*, with two species merely found in the region from Central China to the southeast of Yunnan Province. Liang (1995) deduced that *Gymnotheca*, which is close to *Anemopsis*, probably originated from the diageic ancestor. However, molecular evidences indicate that *Gymnotheca* is a sister group with *Saurus*, which is a disjunction of

East Asia and North America (Meng et al., 2003). Therefore, *Gymnotheca* is likely to be an endemic group that formed in Central China after the Tertiary.

The fourth class: Caryophyllopsida. Caryophyllopsida includes three subclasses, among which two contain endemics. *Archiatripex* and *Badia*, two primitive genera in Chenopodiaceae, are endemic to China. In Caryophyllaceae, *Pseudocerastium* and *Psammosilene* are endemic to China as well. The former is distributed in East China while the latter is a disjunction of the Yunnan Plateau and Southeast Tibet of China. Polygonaceae in Polygonidae includes two endemic genera, *Pteroxygonum* distributed in North China and *Parapteropyrum* found in the valleys of Brahmaputra Tibet of China.

The fifth class: Liliopsida. Liliopsida includes ten subclasses, among which four subclasses have endemic genera. *Heteropolygonatum* and *Speirantha* in Convallariaceae, which is so-called monocotyledon, are two endemic genera. In addition, *Heteropolygonatum* is likely to be a new endemic genus. *Speirantha* is palaeo-endemic that is distributed in East China. *Diuranthera* in Anthericaceae is an endemic genus limited to the Yunnan Plateau and the Hengduan Mountains areas. *Carsiopsis* (Corsiaceae) with only one species growing in saprogenic environment is an endemic genus to China. It is distributed in the primary forests in the west of Nanling, composing a Pacific Ocean disjunction with another two genera of this family (Wu and Chen, 2004). Orchidaceae includes 11 endemic genera. Therefore, the developments of endemic genera in Liliopsida were along with the evolution of the subclass. Acanthochlamydaceae (Gao, 1998; Kao and Kubitzki, 1998; Wu and Chen, 2004) or Acanthochlamyoideae (Wu, 1988; Antonio, 2001) with only one species is a relict in the Hengduan Mountains areas. Acanthochlamydaceae was placed in Bromeliidae, which is mainly distributed in the new tropics. Acanthochlamydaceae is close to Velloziaceae or as a subfamily of Velloziaceae, which is a palaeo-endemic family distributed widely in South America, Africa and Arabia. Based on molecular evidences, Velloziaceae and Acanthochlamydaceae are sister groups. Additionally, Acanthochlamydaceae was considered as a basic group of Velloziaceae (Behnke et al., 2000). As the only representative of Acanthochlamydaceae, *Acanthochlamys bracteata* is a proof which demonstrated that Acanthochlamydaceae or Velloziaceae may have originated in Tethys, and migrated via Laurasia (Davis, 2002; Sun and Li, 2003). Importantly, *A. bracteata* is evidence, which demonstrates that there exist many refuges for the residues of Tethys floristic elements in the Hengduan Mountains and its surrounding areas.

Musaceae in Zingiberidae includes one endemic genus, *Musella*, which may have originated from Gondwanaland. Zingiberaceae has one to two genera endemic to China. Gramineae is the most outstanding, which contains ten genera endemic to China. However, among these ten endemic genera, seven belong to Bambusoideae, which indicates that the differentiated time of Bambusoideae was the earliest among all of the subfamilies in Poidae. Furthermore, it demonstrates that Liliopsida, as well as other classes, originated in Pangaea from the Triassic to the Jurassic.

In eudicots, the first class is the sixth class: Ranunculopsida. Lardizabalaceae, characterized by the unclosed carpel, is the most primitive subclass in Ranunculopsida. Lardizabalaceae contains two monotypic genera endemic to China. One is *Sinofranchetia*, a blind branch having certain relationships with Illiciidae and Sargentodoxaceae, a nearly endemic family in the 7-4 areal type. The other is *Archakebia*, which can be regarded as a transitional form in Lardizabalaceae. *Archakebia* was differentiated after South America was separated from Pangaea and then Lardizabaleae appeared. Ranunculaceae includes four genera, which are *Kingdonia*, a primitive blind branch with dichotomous vein, *Anernoclema*, *Metanemone*, two interim groups, and *Urophysa*, a highly developed group. *Ranunculidae* includes a semi-endemic family with only one species, namely, Circaeasteraceae mainly distributed around the Qinghai-Tibet Plateau, Southeast Asia and East Himalayan Mountains areas. Based on molecular evidences, Oxelman and Lidén (1995) indicated that Circaeasteraceae and *Kingdonia* are sister groups. Although Circaeasteraceae and *Kingdonia* are modern groups with some primitive appearance such as those in venations, we cannot deny that the uplifting of the Qinghai-Tibet Plateau played an important role in the formations of Circaeasteraceae and *Kingdonia* (Wu and Chen, 2004).

Papaveraceae (Papaveridae) includes one endemic genus, *Eomecon*, which is a primitive group in the family. *Eomecon* has a close relationship with *Sanguinara* found in North America and Canada.

The seventh class: Hamamelidopsida. Hamamelidaceae, a basic group of Dicotyledoneae, is the main branch of Hamamelidae. Hamamelidaceae, as well as other families in this subclass, was dominant in the Cretaceous or late Tertiary. All its five subfamilies are found in China, among which four monotypic genera are endemic to China, which are distributed sporadically in the forests from the Taihang Mountains to the islands of Hainan Province. Fossils of *Fortunearia* and *Sinowilsonia*, which were found in North America, were very similar. A phylogeny study indicated that these two genera are closely related (Endress, 1989). Based on molecular evidences, Li et al (1999a, b) demonstrated that *Fortunearia* and *Eustigma* are sister groups, with the latter distributed in East Asia (from southern China to Vietnam). *Sinowilsonia* and *Molinadendron* are sister groups; the latter is distributed in Central America and Mexico. Furthermore, they indicated that *Fortunearia* and *Sinowilsonnia* are likely to be a progeny of the residue of floristic elements of the Arctic-Tertiary left in East Asia. The fossils of capsules and seeds of *Fortunearia* were found in Zwishenmitteln in Europe (Gregor, 1978) and Japan (Zheng, 1984), which proved that *Fortunearia* was once distributed in Europe, then retreated due to the effects of glaciations (Zhang and Lu, 1999). Another monotypic genus, Shaniodendron, is only found in the east of Dabie Mountain and north of the Tianmu Mountain (Wu and Chen, 2004). The fossil records were in

Shandong Province (Deng et al., 1992), and the genus was regarded to be closely related to *Fothergilla*, which is endemic to North America. Based on DNA analysis, Li et al (1997) stated that *Shaniodendron* is closely related to *Parrotiopsis*, which is distributed in western Asia. These two genera diverged until the Miocene. Besides, *Shaniodendron* was also close to *Pamotiopsis*, a monotypic genus of Mediterranean floristic elements. Furthermore, molecular evidences demonstrated that *Shaniodendron*, *Parrotiopsis* and *Pamotiopsis* are closely related (Li et al., 1999 a, b). *Exbucklandia* is a semi-endemic genus belonging to the 7-1 areal type. The fossils of *Exbucklandia* were found in Oregon and Idaho in the US, and Altai of Xinjiang Province as well as Yunnan Province. Fossils of *Altingia*, another genus of the 7-1 areal type, were found in North America during the Cretaceous (Zhou et al., 2001). Fossil records of Hamamelidaceae indicated that this family has already existed in the late Cretaceous and been distributed widely and continuously in Europe, North America and Asia. East Asia, especially China, is the diversity center of Hamamelidaceae. Additionally, Betulaceae and Juglandaceae, two small families of amentiflorae, each has one genus endemic to China. *Ostryopsis* includes two species distributing in southwestern Sichuan, northwestern Guizhou, northern Sichuan, western Liaoning and Inner Mongolia (Chen, 1999). Molecular evidences indicate that *Ostryopsis* is a sister group to *Ostrya* and *Carpinus* clade (Chen et al., 1999). Although there has been no fossil records of *Ostryopsis* so far, evidences from *Granea*, a fossil genus having a close relationship with *Ostryopsis* (Manchester and Chen, 1998), demonstrated that *Ostryopsis*, which originated in the north bank of Tethys during the Tertiary, was likely to be a residue of Tertiary floristic elements (Wu and Chen, 2004). *Cyclocarya* of Juglandaceae is a monotypic living fossil endemic to China; the phylogenic study confirmed that *Cyclocarya* and *Platycarya* are sister groups (Manos and Stone, 2001). The fossils of *Cyclocarya* were found in North America and Europe during the Pliocene (Machenster, 1999). *Cyclocarya* as well as other relicts of Tertiary floristic elements such as *Ostryopsis* probably had the same original background.

Davidiaceae includes *Davidia* with one species, *Davidia involucrate*, and one variety, *D. involucrate* var. *vilmoriniana*. Morphologically, *Davidia* is highly isolated. Fossils of another genus that was similar to *Davidia* were found in North America and north of South Asia (Steven et al., 1999), which indicated that the Bering Land Bridge might have played an important role in the course of origin and dispersal of this family.

Eucommiaceae, a monotypic endemic family, includes only one species, *Eucommia ulmoides*, which is one of the important Chinese traditional medicines. However, according to fossil records, there were once at least 22 species in the family (Guo, 2000). The structure of flowers and fruits of *Eucommia ulmoides* are simple but highly unique. Fossil records indicate that this plant species already existed in the Paleocene, and then it was widely distributed in the northern hemisphere during the Miocene. A palaeobotany study (Guo, 2000) supported that *Eucommiaceae* originated in eastern China, then extended to the northern hemisphere in the latter part of the Eocene, and migrated to North America via the Bering Land Bridge. Nowadays, Davidiaceae and Eucommiaceae are both placed in Cornidae, which were mainly distributed in East Asia, especially in China. Of the monotypic families of Cornidae, 80% are found in China, some of which are relicts of the Cretaceous-Tertiary floristic elements.

3.2 Distribution and evolution of endemic genera

Among 239 endemic genera, Gesneriaceae contains the most with 27 endemic genera (Li and Wang, 2004). Although some endemic genera in Gesneriaceae were considered to be satellite genera of *Chirita*, it is still one of the representatives of seed plants in China. This can be attributed to three factors. First, Gesneriaceae was divided into two big groups in the old and new world. The interim between these two groups is Klugieae. Gesnerioideae, a subfamily of Gesneriaceae, was mainly distributed and diversified in Indo-Malaysia (Li, 1999). In these two groups, as the basic branch of Scrophulariales, the first one should be more ancient. Both had primitive characteristics such as parietal placenta. Therefore, Scrophulariaceae should be regarded as a group derived from such groups, which is the result of the development of Cretaceous-old Tertiary floristic elements. The second factor is the distributive patterns of forests in China, which lies from the northeast to the southwest, and the appearance of large areas of limestone in sub-tropical forests especially in Yunnan, Guizhou and Guangxi Provinces. Third, anthropogenically, the fragmentation of forests due to deforestation by local people accelerated the process of endemism. As one of the distributive centers of Gesneriaceae, East Asia and Southeast Asia were linked with Central and South America, which are considered as another two distributive centers of this family. Also, a limestone forest, which is an abiotic factor, played an important role in the course of differentiation and evolution of this family. In addition, many primitive groups such as *Bournea*, *Thamnochris*, and *Tongia* prove that the mixed mesophytic forest growing from China to Japan and the evergreen forest growing in Malaysia were a representative of floristic elements of the early Tertiary (Tiffney, 1985). Therefore, these groups probably were progenies of a forest once growing in Tethys during the Tertiary (Takhtejan, 1969) or Northern Tropic (Wolfe, 1975) or Northern Tethys (Kubitzk and Krutzsch, 1996). Thus, it is reasonable to regard East Asia, especially China, as the original center of this family.

Compositae contains the second most endemic genera, which is the most advanced family in Asteridae. Although 20 endemic genera were included in many advanced tribes of this family (Especially Cynarieae, Cichorieae and Senecioneae), Mutisieae, which is regarded as the most primitive tribe in Compositae, has two monotypic genera endemic to China, namely, *Myripnois* and *Nouelia*. *Myripnois* is endemic to

North China. *Nouelia* is a primitive group characterized by a woody structure and distributed in the Yunnan Plateau and the valleys of Jinsha River and Red River. According to Peng (2002), *Nouelia*, having a hexaploid chromosome, is probably a progeny of some residues of Tethys floristic elements. Actually, Mutisieae is mainly distributed in South America (Lin, 1993, Wu et al., 2003). *Nouelia* is probably a relict in the Yunnan Plateau, and in the valleys of Jinsha River and Red River, which indicates that Mutisieae has a close relationship with counterparts distributed in South America. Therefore, the origin of Mutisieae is similar to that of Acanthochlamydaceae. Then it migrated via Tethys and Laurasia, and dispersed via the Laurasia path (Davis et al., 2002).

The third family is Labiatae. There are 12 genera in this family endemic to China. Morphologically, *Cardioteucris* and *Caryopteris* are similar to each other. Based on molecular evidences, Wagstaff (1998) placed *Caryopteris* in Teucrioideae, which is in one later branch of the family. However, differences in the structures of corolla, calyx, and fruit between *Cardioteucris* and *Caryopteris* demonstrated these two genera were completely different. Actually, Lamiales and Verbenales were derived from the same branch very early. Verbenales highly developed with some characteristics that were parallel with Teucrioideae. It is probably not appropriate to place *Cardioteucris* in *Caryopteris* just as what W. W. Smith and Cantino (1992) did. Labiatae includes many monotypic genera, such as *Kinostemon* (in Teucrioideae), *Holocheila* (in Ajugoideae), *Heterolamium* (which may be the ancestor of Plectranthoidea), *Bostrychanthera* (in Prasioideae) and *Wenchengia*, which is only a representative of Wenchengiodeae. The above analyses indicate that Labiatae originated and developed in the coastal area of Tethys (Wu and Li, 1982), then were quickly differentiated in East Asia especially in China along with the change in aridity of Central Asia and the uplifting of the Himalayas.

Cruciferae (Brassicaceae) includes 11 genera endemic to China. There are numerous representatives of Cruciferae found in the northern hemisphere, especially in the region around Tethys, Southwest Asia and Central Asia. In addition, many endemic genera of this family were found in the mountainous areas of the Sino-Himalaya (Hegde, 1976). Cruciferae is regarded as another large family differentiated in Tethys. Many monotypic genera of this family were found in the Qinghai-Tibet Plateau and the Hengduan Mountains areas, for instance *Shangrilaia*, which was described in 2004 (Al-Shehbaz et al., 2004). Therefore, the uplifting of the Sino-Himalayas from Tethys can be regarded as the second diversity center of this family.

Umbelliferae includes 11 genera, all of which are monotypic or small-type genera. The diversity centers of Umbelliferae are now Tethys and Central Asia. Although there are no primitive genera in Umbelliferae, all these genera in this family were differentiated independently. Combining the analyses above with information about genera in the 9 or 14 areal-type in Umbelliferae, it is clear that Umbelliferae originated and was differentiated in Laurasia. Besides Umbelliferae, Orchidaceae and Poaceae include 11 genera and ten genera endemic to China, respectively, as well.

Rosaceae, one of the main branches of Rosida, is a representative of the northern temperate zone. Rosaceae includes sevenendemic genera in the three subfamilies. Additionally, many monotypic (or bitypic) genera and representative of these seven endemic genera are found in the Northeast China, Inner Mongolia, North China, East China, Yunnan Plateau and the Hengduan Mountains, which demonstrates that Rosaceae originated in East Asia. The monotypic genera of Spiraeoideae and Rosoideae are in the 14 areal-type (distributing in East Asia). All the statements and analyses above do prove the fact that Laurasia was the birthplace of Rosaceae.

Scrophulariaceae, the main branch of Scrophulariales, includes six genera endemic to China. These six endemic genera are all monotypic or bitypic. *Triaenophora*, found in the cliff of the Three Gorges in the Yangtze River, has a close relationship with *Rehmannia*. Both of these genera were considered to have a close relationship with Gesneriaceae. *Xizangia*, a representative of the flora of the western Dulong River, upper Burma and southeast of Tibet of China, can be regarded as a semi-endemic genus.

Asclepiadaceae includes five genera endemic to China. Among them, *Biondia chinensis* Schltr. is distributed widely in the subtropical area of southern Qinling Mountains. The others are all monotypic, one growing in Hainan Province.

Magnoliaceae and Melastomataceae have five genera endemic to China. Magnoliaceae was analyzed above. Melastomataceae, an important floristic element in China, contains 180 species. In addition, it is considered as one of the representatives of the subtropic. It has a close relationship with counterparts distributed in South America. *Styrophyton* is a primitive monotypic genus of Melastomataceae distributed in the southeast of Yunnan. *Barthea*, however, is widely distributed in the south of East and Central China. Therefore, although Melastomataceae is advanced in Myrtales, it was derived from a period when East Asia was still linked with South America.

Boraginaceae includes four genera endemic to China. This family probably originated in the east of Laurasia and Gondwana, and differentiated in Tethys (Wu et al., 2003). Among these four endemic genera, *Sinojohnstonia* and *Omphalotrigonotis* are more primitive than the others. Meanwhile, *Thyrocarpus*, a semi-endemic genus, may have originated from the 7-4 areal type, found in the margin of the tropics.

Saxifragaceae, the basic branch of Rosidae, includes four monotypic genera. These four genera are floristic elements of forests from Northeast to Southwest China, which are regarded as the birthplace of the family. *Astilboides* is a primitive group of Astilbeae, which is a primitive tribe of Saxifragaceae. In addition, Astilbeae probably has closer relationship with Spiraeoideae of Rosaceae, especially on *Arancus*, while *Mukdenia* and *Oresitrophe* are sister groups distributed in different places. The former was found in Shengyang (up to the border of North Korea). The latter, however, is distributed from Beijing to the Taihang Mountains. *Saniculophyllum* is limited to the southeast of Yunnan Province and southwest of Guangxi Province.

Besides Hamamelidaceae, Ranuculaceae contains four endemic genera mentioned above; Sapindaceae also has four endemic genera. Among these four endemic genera, three are monotypic. *Koelreuteria* with four species was considered as a representative of forests growing in the low elevation areas. *Koelreuteria* is distributed in North China, East China and Central China, eastward to Taiwan of China, and westward to the Yunnan Plateau. Noticeably, a variety and a species of *Koelreuteria* found in Taiwan of China were found in Fiji as well. In addition, Degeneriaceae, a relative of Magnoliaceae, also was found in Fiji. These two discontinuous distributions indicate that, Fiji, as well as New Caledonia, were linked with Laurasia. *Xanthoceras* is the northern border of Sapindaceae, which is distributed in Inner Mongolia, Gansu, Qinghai Provinces and North China. *Eurycorymbus* is common in subtropical forests in Taiwan of China and south of the Yangtze River. *Handeliodendron*, however, is limited to the limestone forest in Guizhou or Guangxi Province. These distributive patterns indicate that both genera are the residues of tropical and subtropical forests in the Cretaceous-Tertiary.

Six families, namely, Theacae, Araliaceae, Styraceae, Caprifoliaceae, Rubiaceae, and Acanthaceae, contain three genera endemic to China.

Theaceae, a main branch of Dillenidae, is an important element of subtropical forests in East Asia especially in South China. Besides *Camellia*, Theaceae includes other clades that were differentiated independently. One is *Tutcheria* with 6(-20) species. The other is *Pyrenaria* (Yang and Min, 1995) endemic to South China. In addition, *Euryodendron* and *Apterosperma*, two monotypic genera, are regarded as being endangered. The former was placed in Ternstroemioideae or Ternstroemiaceae. The latter having a close relationship with *Schima* is a residue in South China (Prince and Parks, 2001).

Araliaceae is an advanced family in Cornidae. Based on molecular evidences, Wen (2001) deduced the tropics or subtropics, especially the Old Tropics (from South China, Southeast Asia to the islands in the Pacific Ocean), were likely to be the birthplace of Araliaceae. It includes three monotypic endemic genera. One is *Sinopanax*, which is probably a relict of Tethys-Tertiary floristic elements merely distributed in the mountainous areas of Taiwan of China. In addition, *Sinopanax* and *Oreopanax*, which are mainly distributed in the New Tropics, are sister groups (Wen et al., 2001). Another is *Hunaniopanax*, which has the primitive morphological characteristic of a simple leaf, is a genus endemic to Hunan Province. The last is *Tetrapanax*, which is widely distributed in the south of the Yangtze River. Recently, based on morphological and molecular evidences, Wen set up a new genus, *Metapanax*, which may be a semi-endemic genus (Wen and Frodin, 2001). It includes two species, namely, *Metapanax delavayi* (=*Nothopanax delavayi* or *Pseudopanax delavayi*) and *M. davidii*. *Macropanax* found from South and Southwest China to tropical Asia is probably a basal group of *Metapanax* (Wen et al., 2001). Thus, *Metapanax* can be regarded as a new semi-endemic group that was differentiated from the ancestor of *Macropanax* distributed in the southwest of China or nearby regions.

Styraceae is mainly distributed in East Asia. Styraceae includes 12 genera, among which 11 genera with three endemic genera and two monotypic genera are found in China. *Sinojackia* has two or four species distributed sporadically in the south of the Yangtze River. *Changiostyrax*, however, is distributed in the northwest of Hunan Province. *Melliodendron*, one of the representatives of subtropical evergreen forests, is distributed in the eastern regions of Southeast Yunnan. In addition, all genera of Styraceae belong to 7-2, 7-3, 7-4, 9 and 14SJ areal-types, except one that is endemic to South America. Fossil records indicate that the development of *Sinojackia* has a close relationship with the flora of Tethys. Some genera, such as *Rehderodendron* and *Halesia* found in North America, China and East Asia nowadays, had already occurred in Tethys during the Tertiary (Tralau, 1965; Mai, 1983; Manchester, 1999). Based on molecular evidences, Fritch (1996, 2001) stated that the *Halesia* growing in Asia and North America were not monophyletic. Groups of *Halesia* in Asia and *Rehderodendron*, which are widely distributed in East Asia, were in the same branch. This indicates that the evolutionary history of these two genera was different. Meanwhile, *Halesia* and *Rehderodendron* were regarded as floristic elements of forests in Tethys-Tertiary. The distributive region of *Styrax* is the largest in Styraceae. Huang (1999) suggests that the distributive pattern of *Styrax* plays an important role in the evolution of Styraceae. Furthermore, based on the evidences from allozyme and molecular phylogeny, Fritsch (2001) suggested that *Styrax* and Styraceae originated in Eurasia and Tethys, respectively. Therefore, these three genera in Styraceae endemic to China are likely to be the progenies of Tertiary-Tethys forest elements.

Caprifoliaceae includes two monotypic genera, *Heptacodium* and *Kolkwitzia*. The former is distributed sporadically in Eeast China (Zhejiang Province) and Central China (Hubei Province). The latter is a disjunction of North China and East China. The molecular evidences indicated that *Heptacodium* is the sister group of the clade of *Lycesteria, Lonicera, Symphoricarpos* and *Triosteum* (Pyck and Smets, 2000). Also, the cytological characteristics of ($2n = 28$) *Heptacodium* was regarded as very special in Caprifoliaceae, which supported the treatment of Heptacodieae as a tribe, namely Heptacodieae (Zhang et al., 2002). *Dipelta*, which had similar fossil characteristics to *Heptacodium*, is distributed and differentiated in the coniferous forest of the Hengduan Mountains. Caprifoliaceae, an old family, includes 9, 9-1 and 8 (9), 14, 14SJ and 14SH areal-types. *Linnaea*, a monotypic genus, was found in Caprifoliaceae in the later part of the glacial period.

Rubiaceae is widely distributed in tropical areas with three monotypic genera, namely, *Guihaiothamnus, Trailliaedoxa* and *Tsiangia*, which are endemic to China. *Guihaiothamnus* is mainly distributed in the limestone forest in Guangxi Province. *Trailliaedoxa* grows in the warm-dry valleys along Jinsha River. And *Tsiangia* is mainly distributed in the coast of Hong Kong and Guangdong Province. The distributive patterns of these three genera indicate that China is a core area in the course of development and differentiation of Rubiaceae.

Acanthaceae, especially the genera of *Stroliantheae* and *Justicieae*, are more specialized and complicated than Scrophulariaceae. *Kudoacanthus* is a monotypic genus endemic to Taiwan of China. *Parachampionella*, *Paragutzlaffia* are bitypic and tritypic genera distributing from central China to the Yunnan Plateau.

Fifteen families include two genera endemic to China: Adoxaceae, Calycanthaceae, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Convallariaceae, Crassulaceae, Euphorbiaceae, Gentianacea, Lardizabalaceae, Papilionaceae, Polygonaceae, Rutaceae, Solanaceae, and Zingiberaceae (1-(2) genera). Some of them have been discussed above, besides, eight families will be discussed as follows:

Archileptopus of Euphorbiaceae, an endemic genus growing in the limestone forest in Guangxi Province, is more primitive than *Leptopus* in Phyllanthoideae. *Speranshia*, however, is discontinuously distributed in North China, Central China, and North Yunnan Province. Both of these two genera are likely to be palaeo-endemic genera.

Crassulaceae in Rosidae, has a close relationship with Saxifragaceae. The systematic position of Crassulaceae is after Penthoraceae, which is a basic branch of Rosidae. Two genera, *Kungia* and *Ohbaea*, originated from the Hengduan Mountains and Qinling Mountains separately. The former is bitypic and the latter is monotypic genus.

Papilionaceae in Rutidae is a big family. However, Papilionaceae includes only two genera endemic to China, which was attributed to two major reasons. First, species of the family have well adaptable capacities or potentials, which enlarge the distributive regions of this family. The other is that Papilionaceae includes many sub-endemic genera in 7-2, 7-3, 7-4, 13-1, 13-2, 14SH, 14SJ areal-types. *Salweenia* in Sophoeae endemic to valleys of the upper reaches of the Salween River and the Mekong River is likely to be a relict of Tethys elements. In addition, *Salweenia* probably has a close relationship with *Calpurnia*, which is a disjunction of the Cape of South Africa and South India. Furthermore, it probably has similar original background to *Acanthochlamys. Salweenia* was found to form a predominant community along the valley of Mekong River near Changdu County.

There are two genera endemic to China in Rutaceae. *Psiloeganum* distributed in Central China, northward to the Three Gorges, derived from the basic branch of Rutaceae. *Poncirus*, another primitive group in Citroideae, includes one species distributed from Hainan Provinceto the north of Qinling Mountains. Recently, another species of *Poncirus* has been found in Fumin County of Yunnan Province.

Compared with Viburnales in Cornidae, Adoxaceae is more advanced. Based on molecular evidences, Eriksson and Donoghue (1997) and Liu et al (2000) indicated that Adoxaceae and *Sambucus*, which belongs to Caprifoliaceae, are sister groups. Adoxaceae was previously regarded as a monotypic family and the representative of the northern temperate zone. In the middle period of the 20th century, one species of *Adoxa* and two monotypic genera (*Tetradoxa* and *Sinadoxa*) of Adoxaceae were found in the Far East and China, which confirmed that Adoxaceae originated in the conifer forest of southwest China in East Asia. *Adoxa moschatellina*, however, extended to the northern temperate zone after the glacial period along with the expansion of the Taiga forest (Liang and Wu, 1999).

Campanulaceae is a primitive family in Campanulales of Asteridae. It includes two endemic genera. One is *Platycodon*, a monotypic genus in 14SJ areal-type. The other is *Leptocodon* in 14SH areal-type (Hong, 1999). Besides, Campanulaceae includes two genera, namely, *Echinocodon* and *Homocodon*, which are endemic to China. The former is monotypic restricted to the Qinba Mountain in the south side of Qinling Moutains. The latter has only one species and its varieties are only found in the Yunnan Plateau (including west of Guizhou Province and southwest of Sichuan Province in a broad sense). In addition, *Homocodon* was found to have a close relationship with one monotypic genus distributed in California in the US.

Oleales includes Gentianaceae, which is an advanced family in the subclass of Lamiidae. There are two genera in Gentianaceae endemic to China, namely, *Latouchea* and *Lomatogoniopsis*. The former is more primitive, found in the mountainous areas of southeast of Yunnan Province to the south of Fujian Province. The latter, however, is a new endemic genus that originated along with the uplifting of the Tibet-Qinghai Plateau.

As a main branch of Solanales, which is characterized by a bilaterally symmetrical flower, Solanaceae includes two genera endemic to China (Lu and Zhang, 1986). *Atropanthe*, a monotypic genus, is a descendant of *Anisodus*, which is endemic to the Himalayas, and *Scopolia*, which is a disjunction of East Asia and Tethys. *Atropanthe* is restricted to Central China. The other is *Przewalskia*, which is the basic group of *Atroanthe, Anisodus, Scopolia, Atropa*, and *Mandragora* (Hoare and Knapp, 1997; Tu et al., 2005). Therefore, *Przewalskia*, a highly specialized group in the Qinghai-Tibet Plateau, was regarded as a residue of Tethys floristic elements.

In angiosperms, 30 families include only one genus endemic to China, namely, Acanthochlamydaceae, Aceraceae, Actinidiaceae, Annonaceae, Anthericaceae, Apocynaceae, Aristolochiaceae, Betulaceae, Celastraceae, Corsiaceae, Cucurbitaceae, Davidiaceae, Diapensiaceae, Eucommiaceae, Flacourtiaceae, Hydrocotylaceae, Juglandaceae, Lauraceae, Monotropaceae, Musaceae, Nyssaceae, Olacaceae, Opiliaceae, Papaveraceae, Podostemaceae, Primulaceae, Saururaceae, Sauvagesiaceae, Tapisciaceae, Ulmaceae, Viticaceae, and Zygophyllaceae. Eleven families have been discussed above, namely, Acanthochlamydaceae, Annonaceae, Anthericaceae, Aristolochiaceae, Betulaceae, Corsiaceae, Juglandaceae, Lauraceae, Musaceae, Papaveraceae, and Saururaceae. Besides, there are still 19 remaining families in Rofopsida that will be analyzed as follows:

Sinia in Sauvagesiaceae of Dillenidae is a monotypic genus endemic to South China. This genus was classified by Xin and described by Didls. *Sinia* is mainly distributed in the middle and eastern part of the south slope of Qinling Mountains. It is differentiated from the 3 areal-type together with some monotypic genera of South America. *Poliothyrsis* in Flacourtiaceae of Flacourtiales is a primitive monotypic genus. It is distributed in East to Central China and is a common species in the subtropical mixed mesophytic forest. *Poliothyrses* as well as *Carrierea* (bitypic, 7-4 areal-type) and *Itoa* (bitypic, one in Central China up to the Yunnan Plateau, the other one disjunct in New Guinea) composed the most primitive tribe of Flacourtiaceae.

Similarly, *Bolbostemma* is a bitypic genus in Zanonioideae, which was regarded as the most primitive family in Cucurbitales. *Bolbostemma* includes two species. One species is distributed in North China. The other one is disjunct in the valley of the Yunnan Plateau, which was regarded as a proof of Captures of the Jinsha River by the Red River. Ulmaceae of Urticales of Malvidae contains a monotypic endemic genus, *Pteroceltis*, which is probably a relic genus of Cretaceous-Tertiary floristic elements distributed widely in the limestone forest in North China as well as Yunnan, Guizhou, and Gaungxi Province.

As the start point of Ericidae, Actinidiaceae is endemic to East Asia. *Clematoclethra* with only one species and four varieties in Actinidiaceae is restricted to the mountainous areas of Sichuan (Tang and Xiang, 1989), which indicates that this genus is still in differentiation. Monotropaceae is another family in the subclass of Ericidae including *Eremotropa*, which is a small genus distributed in the Yunnan Plateau still under differentiation as well. *Berneuxia*, a monotypic genus of Diapensiaceae, grows in the mountainous areas from west of Central China to south of the Hengduan. *Berneuxia*, as well as *Diplarche*, are palaeo-endemic genera distributed in China-Himalayas. *Pomatsace* is a new endemic that was derived from one branch of *Androsace* in Primulaceae. It is mainly distributed from northeast of Qinghai-Tibet Plateau to the boundary of Qinghai Province and Xinjiang Autonomous Region.

Podostemaceae, which has a close relationship with *Sedum* and Saxifragales, is a highly specialized family in the sub-class of Rosidae. Podostemaceae includes only one endemic genus, *Terniopsis*, distributed in Fujian Province. Recently, *Terniopsis* was placed in *Dalzellia*, which is discontinuously distributed in India, Thailand and Vietnam. According to these classification treatments, the tropical area of South China was connected with the Indo-China Peninsula in geological history.

As a basic group of Sapindales, Tapisciaceae, which is associated with Staphyleaceae, includes only two genera. One is distributed in the subtropical regions of China. The other is distributed in the Central to South America. *Tapiscia* includes one or two species widely distributed in the subtropics from south of the Yangtze River, to north of Nanling and north of Vietnam. In addition, *Tapiscia* was regarded as an element of mixed mesophytic forest. The fossils of seeds of *Tapiscia*, which were found in Germany and London Clay, Canada, North America and Shandong Province of China, indicate that this family once included five species (Tao, 2000). Based on these fossil evidences, the evolutionary history of *Tapiscia* can be traced to (Cretraceous-) Tertiary.

Aceraceae, another family in Rutidae, includes two to three genera. *Dipteronia*, with two species, is endemic to China. One species of *Dipteronia* is widely distributed from Qinling Mountains to the west of Central China, while another one is only found in the southeast of Yunnan Province. Similar to *Cyclocarya* in Juglandaceae, *Dipteronia* is a relict of Tertiary floristic elements. Based on paleobotanical records, the earliest fossils were found in the Paleocene from North America. *Dipteronia* was regarded as a palaeo-endemic genus whose early evolution should occur in North America (McClain and Manchester, 2001; Manchester and Tiffney, 2001). However, the accuracy of these statements is uncertain so far, due to the limited fossils of *Dipteronia* found in China.

Bretchneideraceae (7-2 (15) areal type), is a monotypic family of this subclass, distributed eastward to Taiwan of China and southward to the border of Laos and Thailand. Therefore, in terms of distributive region, Bretchneideraceae can be regarded as semi-endemic.

As an old original family with differentiation history, Zygophyllaceae in Geraniidae includes a subfamily with only one genus, *Tetraena*, which is endemic to China. The monotype of *Tetraena* is a shrub plant found in the south of Inner Mongolia, the Ordos Plateau, and the south bank of the Yellow River. It often appears in one community together with *Potaninia*, another monotypic genus of Rosaceae. The latter is a semi-endemic genus whose distributive range extended to Mongolia. *Monimopetalum* in Celastraceae of Celasteales is a monotypic genus endemic to China found in East China (Anhui Province). Additionally, it was considered to be a basal group of the *Euonymus* and *Celastrus*, which are main branches of Celastraceae. Another representative of the subclass of Geraniidae is Olacaceae, which is commonly distributed in tropical forests with one monotypic genus *Malania*, which might be a primitive group distributed in limestone forests of Guangxi and Yunnan Provinces. *Yunnanopilia*, another monotypic and endemic genus, is an element of tropical forests growing in a region near the southern boundary of Yunnan Plateau. It is also probably a basal group of three monotypic genera, *Lepionurus, Champereia* and *Melientha* (commonly distributed in North Vietnam) (Wu and Li, 2000).

Cornidae includes many relicts, isolated families and genera, among which Davidiaceae and Eucommiaceae, two monotypic families endemic to China, are the most famous. Davidiaceae is the representative of mixed mesophytic forests growing from the west of Central China to the

Hengduan Mountains areas. The other one, Eucommiaceae, is limited to Central China, and has almost disappeared in the wild field, mainly due to the unsustainable exploitation by local people. Therefore, what we see nowadays is a cultivated variety of Eucommiaceae. Actually, Eucommiaceae was an element of mixed mesophytic forests in Central China. In addition, *Camptotheca* of Nyssaceae is another monotypic genus distributed from Central China to Yunnan Province. Among all of the advanced families in Cornidae, Hydrocotylaceae, a basal group of Umbelliferae, includes a small number of representatives of flora of East Asia, despite that the origin and differentiation of this family was in 3 arealtype. The latest cytological study (Peng and She, 1991) indicated that *Dickinsia*, which was previously placed in Umbelliferae, is a representative of the monotypic species of Mulineae in Central China. Therefore, *Dickinsia* should be regarded as a palaeoendemic genus indeed, and that China is the original and early differentiation center of Cornidae.

Apocynaceae in Apocynales of Laniidae are differentiated in the tropical and subtropical. It includes two monotypic genera endemic to China. One is *Epigynurm* in the 7a areal type distributed from East Asia to the Malaya Peninsula (Western Malaya). Another is *Parepigynum*, which is probably a relict in the southeast of Yunnan Province. Another monotypic genus endemic to China in Viticaceae of Verbenales is *Schnabelia*, which was derived from *Caryopteris*, but its reproductive system of *Schnabelia* is a cleistogamous flower, which is a completely different evolutionary line from Cardioteucris.

4 Origin and development of endemic genera of the Chinese seed plants

Based on the above analysis of seed plants in China, the endemic genera, either old or young, especially those residues, exist in every stage of the evolution of seed plants. Therefore, we can draw the following conclusions:

There are numerous families and genera, especially many palaeoendemic residues of gymnosperms in China. Therefore, China should be considered as a core area of the extant gymnosperms. The distributive and original history of these endemic genera can be traced to the Paleozoic. In geological history, especially in the Tertiary, those residues were once widely distributed in the northern hemisphere. Therefore, most of them are considered as Arctic-Tertiary floristic elements. Meanwhile, many groups died out in most places (e.g., Europe) of the northern hemisphere after the Neogene Period, due to climate changes and the effects of glaciations during the Quaternary. A few survived in some refuges in North America and East Asia. Additionally, Central and East China, in particular, became a core area of those palaeo-endemic species. Then, those residues of Tertiary floristic elements developed in East Asia and North America, respectively, which resulted in numerous endemic residues distributed in these two continents.

Both the oldest and the newest endemic genera can be found in China. Meanwhile, in terms of distributive region, the differences among these endemic genera were relatively clear. These distributive regions can be divided into four districts: east of Central China, South China, West and North China (Hao, 1997). In terms of characteristics of districts, they can be classified into five types, namely, neighboring distribution, overlapping distribution, isolated and discontinuous distribution (Ying, 1996). In terms of the degree of the endemism, these districts can be arranged as the Three Gorges, Yunnan, Guizhou and Guangxi Province, middle and south of Hengduan Mountains, Qinling Mountains, Yellow Mountain-Tianmu Mountains, Zhongtiao-south Taihang Mountains and south of Inner Mongolia (Wang and Zhang, 1994). In terms of characteristics of endemic genera, these districts can be classified into Sino-Japan subdistrict, which has more palaeo-endemic residues, and Sino-Himalayan forest subdistrict, which has more young endemic genera (Wu and Wu, 1996). In terms of phylogenic positions, endemic genera are represented in all lineages in the Eight-Class system of classification of angiosperms. In addition, endemic relicts were represented in almost every evolutionary stage of the seed plants. Meanwhile, many young endemics can be found in advanced families, for instance, Gesneriaceae, Chrysomthemums, Lamiaceae, and so on. Genera endemic to China in some basal groups of gymnosperms and angiosperms have a higher level of diversity compared with their counterparts in North America. A similar phenomena can also be found in common genera between East Asia and North America (Qian, 2001, 2002), which also show the floristic characters of not only antiquity but also integrity in the flora of China and East Asia. Therefore, the differentiation and development of endemic families and genera in China reflect all the evolutionary processes of angiosperms. For the angiosperm and gymnosperm, China is not only a refuge, but also an original and differentiated center.

Chinese endemic genera are of polymorphic origin, mainly from Arctic-Tertiary, Paleo-tropical-Tertiary and Tethys-Tertiary floristic elements. In addition, many of these genera are autochthonous. The origin of endemic genera of gymnosperms can be traced back to the Cretaceous or even earlier, which is earlier than those of angiosperms (from the Tertiary or the late Cretaceous). Meanwhile, most of the new endemics originated in the late Tertiary (Wang, 1989), or in a period from the later part of the Pliocene to the early Quaternary (Zhou, 2005). In geological history, most of the palaeoendemic genera were once widely distributed in the northern hemisphere. However, some geological changes such as the blocking of the North Atlantic Bridge, the Turgai Strait, and the Bering Bridge, resulted in the discontinuity between East Asia and North America (Tiffney and Manchest, 2001). Furthermore, numerous plants in the northern hemisphere became extinct during the late Tertiary and Quaternary due to the lethal effect of glaciations. Only a few genera or species survived in some refuges of China and North

America. Compared with North America, there are more relict genera in China. The evidences from molecular phylogeny, palaeobotany and fossils showed that these relic genera were once widespread in the northern hemisphere, and mostly became extinct and endemic after the late Tertiary. Also, the disjunction between East Asia and North America formed in this period (Wen, 1999, 2001). Therefore, the late Tertiary is an important period for the formation and development of endemic genera in China.

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