

The Oaks of China

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China has a flora very rich in oaks with more than 125 species recognized so far, nearly 25 percent of the world total. Apart from the number of species, the biodiversity of oaks is very important in China. Chinese oaks have a very wide distribution, and the genus is spread over the whole country except Xinjiang, (northwest China). They occupy various habitats and can be found from tropical, and subtropical to temperate zones, and from sea level to very high in the mountains. They have various habits, and can be evergreen, semi-evergreen, or deciduous trees, shrubs and stoloniferous shrubs. Oaks have become a large and important genus in Chinese broadleaf forests since the Tertiary and remain some of the most important trees in Chinese forests.

Chinese oaks are classified into two subgenera: *Quercus* subg. *Quercus*, and *Quercus* subg. *Cyclobalanopsis*. Circumscription of the subgenera, and relationships and phylogeny in the genus, have always been debated issues in China, and have been researched for many years. Different authors using different materials have expressed different opinions (Hsu & Jen, 1976, 1985; Hsu, 1990; Huang and Zhang, 1992; Zhou, 1992, 1993, 1995, 1996). However, most of these papers were published in Chinese, making it difficult for those who cannot read Chinese to understand their opinions. In the present paper, we have attempted to approach these problems and we present a very brief review of Chinese oaks. The common synonyms in Chinese literature are given, and we have attempted taxonomic clarification of Chinese oaks. Their relationships and distributions also are discussed in this paper.

contd. on pg. 14

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Oaks of China . . .

contd. from pg. 13

Quercus subg. *Cyclobalanopsis* (Oerst.) Schneid.

Quercus subg. *Cyclobalanopsis* contains about 150 species mainly distributed in tropical and subtropical areas of east and southeast Asia. China includes 77 of these species (Table 1). Oaks in this subgenus provide one of the main Chinese subtropical forests. All of them are small to large evergreen trees 10 to 40 m tall, with smooth, occasionally fissured bark. The leaves are leathery, lanceolate or elliptic, deep bronze-red or red when young becoming blue-green with a glabrate adaxial surface and toothed or entire margins. Acorn cup scales are lamellate and most mature in one year. These oaks are easy to distinguish from those of *Quercus* subg. *Quercus* by their leaf and acorn morphology. Therefore it is not surprising that *Cyclobalanopsis* was considered as a genus by Ørsted and is still recognized as such by some Chinese oak experts (Hsu & Ren, 1975, 1985, 1990; J. C. Liao, 1991). However, *Cyclobalanopsis* appears as a subgenus of *Quercus* in nearly half of the Chinese taxonomic literature (Huang, 1992; Wang and Zhang, 1986; Liu & Fang, 1986; Zhou, 1992, 1993, 1995, 1996). Pollen morphology, leaf and wood anatomy, molecular biology and cladistic analysis all suggest that the true phylogenetic position of *Cyclobalanopsis* is as a subgenus of *Quercus* (Menitsky, 1984; Nixon, 1989; Soepadmo, 1972; Zhou, 1992, 1995, 1996). Taxonomic confusion arises for this reason. Botanists and horticulturists and even taxonomists who are not experts in Fagaceae have long suffered from using the scientific name of this subgenus. For example, *Quercus schottkyana* can be called *Cyclobalanopsis glaucoides* or *Quercus glaucoides* Koidz.¹ and

a new name, *Q. yongchuniana* Z. K. Zhou has to be given to *Cyclobalanopsis longifolia* Y. C. Hsu & Q. Z. Dong because the name *Q. longifolia* has existed for a long time. The correct scientific name and common synonyms found in Chinese botanical literature are given in table 1. We have tried to clear up the taxonomic confusion.

Many attempts have been made to establish a systematic division of subg. *Cyclobalanopsis*. However, there is no universally accepted system. Camus (1936-1954) founded a classification of *Quercus* in her monograph. She divided *Quercus* into subg. *Quercus* and subg. *Cyclobalanopsis*. Six sections of subg. *Quercus* were founded in this work but no further division for *Cyclobalanopsis* was made. Menitsky established the classification of *Quercus* subg. *Cyclobalanopsis* (1976, 1977) mainly based on hair type, length of style and shape of acorn. He treated *Quercus* subg. *Cyclobalanopsis* as containing nine sections. Menitsky later modified his system (1984). In his new system, subg. *Cyclobalanopsis* is divided into eight sections but because it was published in Russian, it was not understood by Chinese taxonomists. Also, many species of subg. *Cyclobalanopsis* from China were not included in Menitsky's classification. In addition, characters employed to define sections by Menitsky are difficult to find on herbarium sheets and to deal with. Therefore Menitsky's system is not the best for the treatment of Chinese *Cyclobalanopsis* oaks. Several attempts on this subject have also been made by Chinese taxonomists. For example, Sheng Chung-Fu who tried to divide Chinese *Cyclobalanopsis* oaks into two groups and four subgroups. However, his work was not published officially and the details of his divisions were

not made available. We treat *Cyclobalanopsis* as a subgenus of *Quercus* and try to classify species of subg. *Cyclobalanopsis* from China as three groups based on the shape of the nuts (Table 2). Group 1, the long acorn group, has elliptic acorns with the ratio of width to length of nuts less than 1 and includes 40 species. Group 2, the round acorn group has spherical acorns with the ratio of width to length close to 1 and includes 15 species. Group 3, the oblate acorn group has oblate acorns with the ratio of width to length more than 1 and includes 18 species. This is a temporary treat-

ment, and more work is needed to establish a universally acceptable classification of *Quercus* subg. *Cyclobalanopsis*.

Oaks of this subgenus play a very important role in the ecosystem of tropic, tropic mountains and subtropical areas. They occur in several subtropical forest types, called subtropical evergreen broad-leaf forests, where many of them are the dominant elements. *Quercus glauca* forms pure blue Japanese oak forest in

text contd. on pg. 22

Key to subgenera, sections and groups of *Quercus* from China

1. Evergreen trees, leaves coriaceous, scales lamellate, forming distinctive ringed acorn cups (go to 2)

Subgenus *Cyclobalanopsis*

2. Nut cylindrical, diameter/height < 1 -- **long acorn group**
2. Nut spherical or oblate, diameter/height = 1 (go to 3)
 3. Nut spherical, diameter/height = 1 -- **round acorn group**
 3. Nut oblate, diameter/height > 1 -- **oblate acorn group**

1. Evergreen tree or shrubs or deciduous trees, leaves chartaceous or coriaceous, scales not lamellate, not forming ringed acorn cups (go to 4)

Subgenus *Quercus*

4. Evergreen trees or shrubs, leaves coriaceous (go to 5)
 5. Leaves with adaxial hypodermis, leaf apex rounded or obtuse, with fasciculate hairs, primary vein \pm zigzag, branched at the top -- sect. *Brachylepides*
 5. Leaves without adaxial hypodermis, leaf apex acute, attenuate, primary vein straight, not branched (go to 6)
 6. Leaves with stalked fasciculate hairs -- sect. *Engleriana*
 6. Leaves with stalked stellate hairs -- sect. *Acrodonta*
4. Semi-evergreen or deciduous trees, leaves chartaceous (go to 7)
 7. Semi-evergreen trees, leaves 6 cm long with spiral stellate hairs -- sect. *Echinolepides*
 7. Deciduous trees, leaves at least 7 cm long with stellate hairs (go to 8)
 8. Leaves narrow ovate to lanceolate with long-spined teeth -- sect. *Aegilops*
 8. Leaves obovate, occasionally elliptic, with rounded teeth, or lobed -- sect. *Quercus*

#	Scientific Name	Common synonym in Chinese botanical literature (<i>C.</i> = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
1.	<i>Q. albicaulis</i> Chun & Ko	<i>C. albicaulis</i> Hsu & Jen	Hainan, China	250-600	20-30/40	2
2.	<i>Q. annulata</i> Smith	<i>C. annulata</i> Oerst.	Yunnan & Sichuan,		11-14/12-15	1
3.	<i>Q. argyrotricha</i> A. Camus	<i>C. argyrotricha</i> Chun & Chang	Guizhou	1600	8-15/8-15	1
4.	<i>Q. augustinii</i> Skan	<i>C. augustinii</i> Schott.	SW China, Vietnam	1200-1700	8-12/10-17	2
5.	<i>Q. austrocochinchinensis</i> Hickel & A. Camus	<i>C. austrocochinchinensis</i> Hjelmq.	Xishuangbanna, Yunnan, Vietnam	760-930	13-18/11-14	?
6.	<i>Q. austroglauca</i> Chang	<i>C. austroglauca</i> Hsu & Jen	Xichou, Yunnan	850-1500	20-22/20-22	?
7.	<i>Q. bambusifolia</i> Hance	<i>C. bambusifolia</i> Hsu & Jen	S China, Vietnam	500	10-16/15-25	1
8.	<i>Q. bella</i> Chun & Tsiang	<i>C. bella</i> Chun	S. China	200-700	22-30/15-15-20	1
9.	<i>Q. blakei</i> Skan	<i>C. blakei</i> (Skan) Schott.	S & SW China, Laos	100-2500	15-3/2.5-3.5	1
10.	<i>Q. breviradiata</i> Huang	<i>C. breviradiata</i> Cheng	C & SW China	1100-1850	12/15	1
11.	<i>Q. camusiae</i> Trel. ex Hickel & A. Camus	<i>C. camusiae</i> Hsu & Jen, <i>C. faadoouensis</i> Hu	Xichou, Yunnan	1400-2000	17/17	?
12.	<i>Q. championii</i> Benth.	<i>C. championii</i> Oerst.	S & SE, China, Yunnan	800-1400	10-15/15-20	1
13.	<i>Q. chapensis</i> Hickel & A. Camus	<i>C. chapensis</i> Hsu & Jen; <i>C. koumeii</i> Hu; <i>C. shianpyngensis</i> Hu	S & SE Yunnan; Vietnam	1300-2000	15-27/10-22	?
14.	<i>Q. chevalieri</i> Hickel & A. Camus	<i>C. chevalieri</i> Hsu & Jen; <i>C. nigrinux</i> Hu	Guangxi, Guangdong, Yunnan, Vietnam	650-1500	6-8/10-15	?
15.	<i>Q. chrysocalyx</i> Hickel & A. Camus	<i>C. chrysocalyx</i> Hjelmq.	Luchun, Yunnan, Indochina	1200	25-35/15-25	1

Table 1. contd.

#	Scientific Name	Common synonym in Chinese botanical literature (C. = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
16.	<i>Q. chungii</i> Metc.	<i>C. chungii</i> Hsu & Jen	S & SE, China	200-800	14-17/15	?
17.	<i>Q. ciliaris</i> Huang & Chang	<i>C. gracilis</i> Cheng & T. Hong; <i>Q. glauca</i> var. <i>gracilis</i> Rehd. & Wils.	south of Yangtze river	500-2600	10/15-20	1
18.	<i>Q. daimingshanensis</i> Huang	<i>C. daimingshanensis</i> S. Lee	Wumin, Guangxi	1400	13/20-22	1
19.	<i>Q. delavayi</i> Franch.	<i>C. delavayi</i> Schott.	SW China	1000-2000	10-15/18	2
20.	<i>Q. delicatula</i> Chun & Tsiang	<i>C. delicatula</i> Hsu & Jen	Guangxi, Guangdong	300-700	15/20-25	1
21.	<i>Q. dinghuensis</i> Huang	<i>C. dinghuensis</i> Hsu & Jen	Gaoyao, Guangdong	950	17-22/30-35	?
22.	<i>Q. disciformis</i> Chun & Tsiang	<i>C. disciformis</i> Hsu & Jen; <i>Q. shingjenensis</i> Cheng	Guangxi, Guangdong, Guizhou	200-1500	20/15-20	1
23.	<i>Q. dongfangensis</i> Huang		Hainan	1500	11/13	?
24.	<i>Q. edithiae</i> Skan	<i>C. edithiae</i> Schott.;; <i>Q. tephrosia</i> Chun & Ko	S China, Vietnam	400-1800	20-30/30-45	1
25.	<i>Q. elevaticostata</i> Huang	<i>C. elevaticostata</i> Hsu & Jen	Ningjiang Hujiang	600-1000	10-21/15-22	1
26.	<i>Q. fleuryi</i> Hickel & A. Camus	<i>C. fleuryi</i> Hsu & Jen; <i>C. austro-yunnanensis</i> Hu, <i>Q. tsoi</i> Chun	C & S China, Tibet, Vietnam	500-1500	20-30/30-45	1
27.	<i>Q. fulvisericea</i> Z. K. Zhou	<i>C. fulvisericea</i> Hsu & D. M. Wang	SE Yunnan	1200	12/12	?
28.	<i>Q. gambleana</i> A. Camus	<i>C. gambleana</i> Hsu & Jen	C & SW China India	1100-3000	15/20	1
29.	<i>Q. gilva</i> Bl.	<i>C. gilva</i> Oerst.; <i>Q. hunanensis</i> H.-M.	E, S & C China	300-1500	10-13/15-20	1
30.	<i>Q. glauca</i> Thunb.	<i>C. glauca</i> Oerst.; <i>Q. sasakii</i> Kanehira; <i>Q. longipes</i> Hu	China, Japan, Korea & India	60-2600	9-14/10-16	1

Table 1. contd.

#	Scientific Name	Common synonym in Chinese botanical literature (C. = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
31.	<i>Q. helferiana</i> A. DC.	<i>C. helferiana</i> Oerst	S & SW China, India, Thailand, Indochina	900-2400	15-22/10-16	1
32.	<i>Q. hui</i> Chun	<i>C. hui</i> Hsu & Jen	C & S, China	250-1250	15-25/15-20	1
33.	<i>Q. hypophaea</i> Hayata	<i>C. hypophaea</i> Hayata	Taiwan	50-800	12-18/17-21	1
34.	<i>Q. hypargyrea</i> Huang & Cheng	<i>C. multinervis</i> Cheng & T. Hong, <i>C. hypargyrea</i> Hsu & Jen, <i>Q. hypargyrea</i> (Seem.) Huang & Cheng, <i>Q. glauca</i> var. <i>hypargyrea</i> Seem.	C China	1000-2000	10/18	2
35.	<i>Q. jenseniana</i> Hand.-Mazz.	<i>C. jenseniana</i> Cheng & T. Hong	C & S China	300-1700	13-15/17-22	2
36.	<i>Q. jinpinensis</i> Huang	<i>C. jinpinensis</i> Hsu & Jen	Jinpin, Yunnan		15/18	
37.	<i>Q. kerrii</i> Craib	<i>C. kerrii</i> Hu	S & SW China Vietnam, Thailand	160-1800	20-28/7-12	1
38.	<i>Q. kiukiangensis</i> Cheng	<i>C. kiukiangensis</i> Hsu & Jen; <i>Q. xizangensis</i>	Yunnan, Tibet	1800-2700	14-17/15-17	1
39.	<i>Q. kontumensis</i> A. Camus	<i>C. kontumensis</i> Hsu & Jen	Guannan, Yunnan	1700	15/20	?
40.	<i>Q. kouangsiensis</i> A. Camus	<i>C. kouangsiensis</i> Hsu & Jen; <i>Q. fengii</i> Hu & Cheng, <i>Q. nemoralis</i> Chun	C S & SW China	200-2000	25/50	1
41.	<i>Q. lamellosa</i> Smith	<i>C. lamellosa</i> Oerst.	Guangxi, Yunnan, India, Burma, Nepal	1300-2600	30-40/20-30	1

Table 1. contd.

#	Scientific Name	Common synonym in Chinese botanical literature (C. = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
42.	<i>Q. liboensis</i> Z. K. Zhou	<i>C. pseudoglauca</i> Y. K. Li & X. M. Wang	Guizhou	530	?	?
43.	<i>Q. litseoides</i> Dunn	<i>C. litseoides</i> Schott.	Guangdong, Guangxi	700-1000	10-15/18	?
44.	<i>Q. lobbii</i> Etting.	<i>C. lobbii</i> Hsu & Jen	Yunnan & Burma	2800-3300	12/15	?
45.	<i>Q. longinux</i> Hayata	<i>C. longinux</i> Schott.; <i>Q. pseudomyrsinifolia</i> Hayata	Taiwan	500-2500	10-12/8-9	1
46.	<i>Q. lungmaiensis</i> Huang & Cheng	<i>C. lungmaiensis</i> Hu	Huning, Yunnan	1100-1300	15-20/15-20	1
47.	<i>Q. meihuashanensis</i> Huang	<i>C. meihuashanensis</i> Q. F. Zheng	Shanhang, Fujian	1600	12-15/13-18	1
48.	<i>Q. morii</i> Hayata	<i>C. morii</i> Schott.	Taiwan	600-2600	10-18/15-25	1
49.	<i>Q. motuoensis</i> Huang	<i>C. motuoensis</i> Hsu & Jen	Motuo, Tibet	1700	10-13/14-18	1
50.	<i>Q. myrsinifolia</i> Bl.	<i>C. myrsinifolia</i> Oerst.	South of Yangze river	200-2500	10-15/14-25	1
51.	<i>Q. nanchuanica</i> Huang	<i>Q. lineata</i> var. <i>macrophylla</i> Seem.	Nanchuan, Sichuang		12/25	?
52.	<i>Q. ningangensis</i> Huang	<i>C. ningangensis</i> Cheng & Hsu	C. China		8-12/15-20	1
53.	<i>Q. obconica</i> Z.K. Zhou	<i>Q. hainanica</i> Huang & Y. T. Chang; <i>C. litoralis</i> Hsu & Jen	Hainan	900-1000	25-28/45	2
54.	<i>Q. obovatifolia</i> Huang	<i>C. obovatifolia</i> Hsu & Jen	C & SE, China	1500-1800	10-16/8-20	1
55.	<i>Q. oxyodon</i> Miq.	<i>C. oxyodon</i> Oerst., <i>Q. fargesii</i> Franch., <i>Q. lineata</i> var. <i>grandifolia</i> Skan	C, S, CW China Tibet, India, Burma	700-2800	14-17/16-22	1

Table 1. contd.

#	Scientific Name	Common synonym in Chinese botanical literature (C. = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
56.	<i>Q. pachyloma</i> Seem.	<i>C. pachyloma</i> Schott.; <i>Q. conduplicans</i> Chun; <i>Q. gracilenta</i> Chun	C & E China	150-850	15-30/20-30	1
57.	<i>Q. pentacycla</i> Chang	<i>C. pentacycla</i> Chang	Guizhou	1600	8-15/8-15	1
58.	<i>Q. petelliformis</i> Chun	<i>C. petelliformis</i> Hsu & Jen	Jiangxi, Guandong	400-1000	25-28/20-25	1
59.	<i>Q. phanera</i> Chun	<i>C. phanera</i> Hsu & Jen; <i>Q. basellata</i> Chun & Ko; <i>Q. insularis</i> Chun & Tam	Hainan & Guangxi	900-2400	20-2.5/3-4	1
60.	<i>Q. pinbianensis</i> Huang & Y. T. Chang	<i>C. pinbianensis</i> Hsu & Jen	Pingbian, Yunnan	1300-1700	8/20	?
61.	<i>Q. poilanei</i> Hickel & A. Camus	<i>C. poilanei</i> Hjelmq.	Guangxi, China; Vietnam	1300	13-15/18-15	?
62.	<i>Q. rex</i> Hemsl.	<i>C. rex</i> Schott.	SW Yunnan, Vietnam, Burma, India	1100-1800	35-5/25-35	1
63.	<i>Q. salicina</i> Blume	<i>C. salicina</i> Oerst.	Taiwan, Japan	200-700	10-13/15-18	1
64.	<i>Q. schottkyana</i> Rehd. & Wils.	<i>C. glaucoides</i> Schott.; <i>Q. glaucoides</i> Koidz.	SW China	1500-2500	7-10/10-14	1
65.	<i>Q. semiserrata</i> Roxb.	<i>Q. semiserratoides</i> Huang & Y. T. Chang; <i>C. semiserratoides</i> Hsu & Jen	Yunnan & Tibet, China; Indochina, India, Burma	650	12-20/40	1
66.	<i>Q. sessilifolia</i> Bl.	<i>C. sessilifolia</i> Schott.	South of Yangze, China	250-600	8-15/17-24	1

Table 1. contd.

#	Scientific Name	Common synonym in Chinese botanical literature (C. = <i>Cyclobalanopsis</i>)	Natural range	Altitude range (m)	Fruit size (d/h) mm	M*
67.	<i>Q. shennongii</i> Huang & Fu	<i>C. shennongii</i> Hsu & Jen	Hubei	700	10/6	?
68.	<i>Q. sichouensis</i> Huang & Chang	<i>C. sichouensis</i> Hsu & Jen	Xichou, ling, Yunnan	850-1500	30-40/20	?
69.	<i>Q. stewardiana</i> A. Camus	<i>C. stewardiana</i> Hsu & Jen	E & C China	100-2400	8-15/8-15	2
70.	<i>Q. subhinoidea</i> Chun & Ko	<i>C. subhinoidea</i> Hsu & Jen	Hainan	380-500	25-3/10-15	1
71.	<i>Q. tenuicupula</i> Huang	<i>C. tenuicupula</i> Hsu & Jen	Jinping, Yunnan	122	25-30/20-25	1
72.	<i>Q. thorelii</i> Hickel & A. Camus	<i>C. thorelii</i> Hsu & Jen; <i>Q. hsiensiui</i> Chun & Ko; <i>Q. chingsiensis</i> Chang <i>C. chingsiensis</i> Chang	S Yunnan & Guangxi	1000	25-30/10-15	1
73.	<i>Q. tiaoloshanensis</i> Chun & Ko	<i>C. tiaoloshanensis</i> Hsu & Jen	Hainan, China	900-1400	14-16/20-22	1
74.	<i>Q. tomentosinervis</i> Huang	<i>C. tomentosinervis</i> Hsu & Jen	Jinping, Yunnan	2300	13-15/15-17	1
75.	<i>Q. xanthotricha</i> A. Camus	<i>C. xanthotricha</i> H. & J.; <i>C. fuhsingensis</i> Chang; <i>Q. fuhsingensis</i> Chang	SW Yunnan	800-1300	7-10/9-13	1
76.	<i>Q. yingjiangensis</i> Govaerts	<i>C. yingjiangensis</i> Hsu & Q. Z. Dong	Yingjiang, Yunnan	2000	30/20	?
77.	<i>Q. yonganensis</i> L. Lin & Huang	<i>C. yonganensis</i> H. & H	Yongan, Hujian	100-1370	12-15/14-18	?
78.	<i>Q. yongchuniana</i> Z. K. Zhou	<i>C. longifolia</i> Hsu & Dong	Yingjiang, Yunnan		15/7	?

*M: acorn maturation - 1 or 2 years

Oaks of China . . .

text contd. from pg. 15

south to central China, or can be associated with other subtropical trees such as: *Lithocarpus*, *Castanopsis*, *Lindera*, *Litsea*, etc. *Q. schottkyana* (*Q. glaucoides*) is endemic to central Yunnan, where it comprises pure or mixed Schottky oak forest. This is a typical forest in central Yunnan, China. *Q. oxyodon*, *Q. kiukiangensis*, and *Q. lamellosa* are the main oak trees in eastern Himalayan areas. They grow at altitudes of 1,500 to 3,000 m and comprise pure- or mixed-oak forests. These oaks are totally deciduous in the season April to May, before the new leaves develop. These forests are called semi-evergreen forests by some authors (Li, 1985). *Q. myrsinifolia* forms the oak forest mainly in central west China. *Q. nubium*, *Q. fleuryi*, *Q. bambusifolia*, *Q. rex* and *Q. edithiae* form the oak forest in subtropical regions of southern China.

Quercus subg. *Quercus*

Quercus subg. *Quercus* has about 47 native oak species distributed in China. They are classified into six sections: *Brachylepides*, *Engleriana*, *Echinolepides*, *Acrodonta*, *Quercus* and *Aegilops* (Table 3). This subgenus has the widest ecological range and the most diverse morphology and habits. Oaks of subg. *Quercus* are found growing in four different forest types in China: evergreen oak forest, evergreen sclerophyllous oak forest, semi-evergreen oak forest and deciduous oak forest.

I. Sect. *Brachylepides*

Section *Brachylepides* has 11 or 12 species and forms evergreen sclerophyllous oak forest. They are distinguished easily from other Chinese oaks by their obovate, occasionally elliptic leaves with round or occasionally ob-

tuse apices and variable margins, mainly entire or revolute, or with few to many spinose teeth in some species. Leaf blades are very thick and leathery, with yellow or gray fasciculated hairs (Jones, 1986) and adaxial hypodermis; the primary vein is more or less zigzag and branched at the top. Acorns mature in one year for most species, two years for three species. Oaks of this section range from Chiang Mai in Thailand to southwest China, Burma, India, Bhutan, and Nepal to Afghanistan. However, these oaks are mainly concentrated in eastern Himalayan areas, particularly northwest Yunnan and southwest Sichuan, China in the Hengduan Mountains. All species of this section can be found in these regions. Seven oaks, *Q. fimbriata*, *Q. gilliana*, *Q. guyavifolia*, *Q. longispica*, *Q. pannosa*, *Q. pseudosemecarpifolia* and *Q. rehderiana* are endemic to the Hengduan mountain areas. Their altitude range is from 1,700 to 4,800 m, but they occur mainly from 2,400 to 3,600 m. They have various growth habits. *Q. monimotricha* is a stoloniferous shrub only 0.2 to 1 m tall, mostly in open areas or at the tops of mountains, usually occupying a large area. Other species are small or large trees, 7 to 30 m tall in undisturbed forests, but they become shrubs, even stoloniferous, under excessive human activity when they are frequently cut for their wood and foliage. The tree oaks in this section form pure evergreen sclerophyllous oak forests or occur mixed with pines. This is a dominant forest type in the Hengduan Mountain areas of northwest Yunnan and west southwest Sichuan, and is very important in the high mountain ecosystem. These areas have a high altitude, cold and dry weather and poor soils and it is very difficult for most angiosperm

Table 2. A proposed systematic treatment of Chinese *Cyclobalanopsis*

Round Acorn Group

- Q. annulata*
- Q. argyrotricha*
- Q. austroglauca*
- Q. camusiae*
- Q. chungii*
- Q. elevaticostata*
- Q. fulvisericea*
- Q. glauca*
- Q. kiukiangensis*
- Q. lungmaiensis*
- Q. meihuashanensis*
- Q. pachyloma*
- Q. schottkyana*
- Q. stewardiana*

Oblate Acorn Group

- Q. austrocochinchinensis*
- Q. bella*
- Q. chapensis*
- Q. chrysocalyx*
- Q. disciformis*
- Q. helferiana*
- Q. hui*
- Q. kerrii*
- Q. lamellosa*
- Q. longinux*
- Q. petelliformis*
- Q. rex*
- Q. shennongii*
- Q. subhinoidea*
- Q. tenuicupula*
- Q. thorelii*

Long Acorn Group

- Q. albicaulis*
- Q. augustinii*
- Q. bambusifolia*
- Q. blakei*
- Q. breviradiata*
- Q. championii*
- Q. chevalieri*
- Q. daimingshanensis*
- Q. delavayi*
- Q. delicatula*
- Q. dinghuensis*
- Q. dongfangensis*
- Q. edithiae*

- Q. fleuryi*
- Q. gilva*
- Q. hyophaea*
- Q. hypargyrea*
- Q. jenseniana*
- Q. kontumensis*
- Q. kouangsiensis*
- Q. litseoides*
- Q. lobbii*
- Q. morii*
- Q. motuoensis*
- Q. nanchuanica*

- Q. ningangensis*
- Q. obconica*
- Q. obovatifolia*
- Q. oxyodon*
- Q. phanera*
- Q. pinbianensis*
- Q. salicina*
- Q. semiserrata*
- Q. tiaoloshanensis*
- Q. tomentosinervis*
- Q. xanthotricha*
- Q. yonganensis*

trees to grow there. However, oaks in this section have obvious xerophytic characters such as dense hairs, thick cuticles, lignified epidermal cell walls and cuticles, and low stomatal density (Zhou et al, 1995), and are adapted to such an environment. Therefore, they become dominant trees and form one of the most attractive landscapes of the high mountains.

Oaks of this section are very similar to some of the Mediterranean oaks such as *Q. ilex* and *Q. suber* and some more distantly related American evergreen oaks such as *Q. myrtifolia* and *Q. wislizeni* etc. It would be very interesting to research their relationships and distribution patterns.

II. Sect. Engleriana

The original section *Engleriana* was founded by Prof. Hsu Yongchun (1985), a taxonomist and expert on Chinese oaks who died in 1993. It included about 20 species. This is a confusing section. The characters used by Hsu to establish sect. *Engleriana* are: mature leaf toothed or sometimes entire; leaf apex acute or acuminate; primary vein straight (Hsu, 1985). However, these characters are shared by other sections of *Quercus*. For example, the leaves of most species are toothed, and the primary vein is straight in all sections of *Quercus* except

text contd. on pg. 28

Table 3. List of *Quercus* subg. *Quercus* from China

#	Scientific Name	Common synonym in Chinese botanical literature	Natural range	Altitude range (m)	E*	M*
	Sect. <i>Brachylepides</i>				E	
1.	<i>Q. aquifolioides</i> Rehd. & Wils.		Tibet, SW China	2700-4800	E	1
2	<i>Q. fimbriata</i> Chun & Huang		Sichuan, Yunnan	2800-3100	E	1
3	<i>Q. gilliana</i> Rehd. & Wils.		Tibet, Shangxi, SW China	1900-3100	E	1
4	<i>Q. guyavifolia</i> Levl.	<i>Q. pileata</i> Hu & Cheng	Yunnan, Sichuan,	2500-4000	E	1
5	<i>Q. longispica</i> A. Camus	<i>Q. semecarpifolia</i> Sm. var. <i>longispica</i> H.-M.	Yunnan, Sichuan,	2260-3800	E	1
6	<i>Q. monimotricha</i> H.-M.	<i>Q. spinosa</i> David var. <i>monimotricha</i> H.-M.	Yunnan, Sichuan,	2600-3500	E	2
7	<i>Q. pannosa</i> H.-M.	<i>Q. ilex</i> L. var. <i>rufescens</i> Fr.	Yunnan, Sichuan	2000-3900	E	2
8	<i>Q. pseudo-semecarpifolia</i> A. Camus	<i>Q. semecarpifolia</i> Sm. var. <i>glabra</i> Fr.	Yunnan, Sichuan	1500-4000	E	1
9	<i>Q. rehderiana</i> H.-M.		Yunnan, Sichuan,	1500-3800	E	1
10	<i>Q. semecarpifolia</i> Sm.	<i>Q. obtusifolia</i> D. Don	Thailand, Burma, Northern India, Tibet, China, Nepal, Bhutan, Pakistan, Afghanistan	2100-3600	E	1
11	<i>Q. sensecens</i> H.-M.		SW China, Tibet	2200-3500	E	1
12	<i>Q. spinosa</i> Fr.	<i>Q. semecarpifolia</i> Sm. var. <i>spinosa</i> Schott. <i>Q. taiyunensis</i> Ling	South of Yangtze river China	1700-2900	E	2
	Sect. <i>Engleriana</i>					
13	<i>Q. bawanglingensis</i> Huang et al.		Hainan, China	900	E	?
14	<i>Q. cocciferoides</i> H.-M.		Yunnan, Sichuan,	1000-2500	E	1

Table 3. contd.

#	Scientific Name	Common synonym in Chinese botanical literature	Natural range	Altitude range (m)	E*	M*
15	<i>Q. dolicholepis</i> A. Camus	<i>Q. spathulata</i> Seem.	South of Yangtze river China	500-2800	E	2
16	<i>Q. engleriana</i> Seem.		South of Yangtze river China	700-2700	E	2
17	<i>Q. franchetii</i> Skan		Yunnan, Sichuan	800-2600	E	1
18	<i>Q. kingiana</i> Craib		Yunnan, China, Burma, Thailand		E	
19	<i>Q. lanata</i> Sm.	<i>Q. tungmaiensis</i> Y. T. Chang, <i>Q. kongshanensis</i> Hsu & Jen.	Vietnam, Thailand Burma, Northern India, Nepal, Bhutan, Tibet, Yunnan, China	1600-2800	E/S	2
20	<i>Q. lodicosa</i> O.E. Warb.		India, Burma Tibet, China	1800-2400	E/S	1
21	<i>Q. marlipoensis</i> Hu & Cheng		SE Yunnan, China	1100	E	?
22	<i>Q. oxyphylla</i> H.-M.		South of Yangtze river China	200-2900	E	2
23	<i>Q. setulosa</i> Hickel & A. Camus	<i>Q. sinii</i> Chun	Thailand, Vietnam, Yunnan, China	130-1300	E	1
24	<i>Q. shangxiensis</i> Z. K. Zhou	<i>Q. lanceolata</i> S. Z. Qu & W.H. Zhang	Shangxi, China	1130	E	?
25	<i>Q. tarokoensis</i> Hayata		Taiwan	350-1250	E	1
26	<i>Q. utilis</i> Hu & Cheng		Kuangxi, Guizhou, Yunnan, China	1000-1500	E	1
27	<i>Q. yiwuensis</i> Huang		Yunnan, China	1000	E	?
	Sect. <i>Acrodonta</i>					
28	<i>Q. acrodonta</i> Seem.	<i>Q. parvifolia</i> H.-M. <i>Q. handeliana</i> A. Camus	Shangxi, Gansu, Henan, Fubei, Sichuan, Guizhou Yunnan China	300-2300	E	1

Table 3. contd.

#	Scientific Name	Common synonym in Chinese botanical literature	Natural range	Altitude range (m)	E*	M*
29	<i>Q. phillyreoides</i> A. Gray	<i>Q. ilex</i> L. var. <i>phillyreoides</i> Fr. <i>Q. fokienensis</i> Nakai <i>Q. singuliflora</i> A. Camus <i>Q. lichuanensis</i> Cheng <i>Q. fooningensis</i> Hu & Cheng, <i>Q. myricifolia</i> Hu	South of Yangtze river China	300-1200	E	1
	Sect. <i>Echinolepides</i>					
30	<i>Q. baronii</i> Skan	<i>Q. pseudoserrata</i> Liou	Shanxi, Shaanxi, Gansu, Henan, Fubei, Sichuan, Yunnan	500-2700	S	2
	Sect. <i>Aegilops</i>					
31	<i>Q. acutissima</i> Carruth	<i>Q. lunglingensis</i> Hu	Whole of China except Xinjiang, Vietnam, Burma, India, Bhutan, Nepal, Japan	60-2300	D	2
32	<i>Q. chenii</i> Nakai	<i>Q. acutissima</i> Carr. var. <i>brevipetiolata</i> Hoo, <i>Q. acutissima</i> Carr. var. <i>chenii</i> Menits.	C & E China	0-600	D	2
33	<i>Q. variabilis</i> Bl.	<i>Q. chinensis</i> Bunge	Whole of China except Xinjiang, Vietnam, Korea, Japan	500-3000	D	2
	Sect. <i>Quercus</i>					
34	<i>Q. aliena</i> Bl.	<i>Q. hirsutula</i> Bl.	South of Yellow river China, Thailand, Japan, Korea	100-2000	D	1
35	<i>Q. dentata</i> Thunb.	<i>Q. obovata</i> Bunge, <i>Q. dentata</i> subsp. <i>eudentata</i> A. Camus	Whole of China except Xinjiang, Guangdong, Guansi, China, Korea, Japan	50-2700	D	1
36	<i>Q. fabri</i> Hance		South of Yangtze river China	50-1900	D	1

Table 3. contd.

#	Scientific Name	Common synonym in Chinese botanical literature	Natural range	Altitude range (m)	E*	M*
37	<i>Q. x fenchengensis</i> H. W. Jen & L. M. Wang		Liaonin Shangxi, China	200-2000	D	1
38	<i>Q. griffithii</i> Miq.	<i>Q. aliena</i> Bl. var. <i>griffithii</i> Schott.	Yunnan, Sichuan, Guizhou, China Burma and India	700-2800	D	1
39	<i>Q. x hopeiensis</i> Liou		North China	50-900	D	?
40	<i>Q. malacotricha</i> A. Camus	<i>Q. griffithii</i> var. <i>urticifolia</i> A. Camus, <i>Q. aliena</i> Bl. var. <i>urticifolia</i> Skan	Yunnan, Sichuan, Guizhou	1500-2800	D	1
41	<i>Q. mongolica</i> Ledeb.	<i>Q. sessilifora</i> var. <i>mongolica</i> Fr.	N & NE China, Korea Japan,	350-1400	D	1
42	<i>Q. x mongolico-dentata</i> Nakai		Northeast China, Korea	100-200	D	?
43	<i>Q. monnula</i> Hsu & Jen		Sichuan	99-103	D	
44	<i>Q. serrata</i> Thunb.	<i>Q. glandulifera</i> Bl.	Whole of China except Xinjiang, Japan, Korea	200-2000	D	1
45	<i>Q. stewardii</i> Rehd.		C & E China	1000-1750	D	1
46	<i>Q. wutaishanica</i> Mayr	<i>Q. liaotungensis</i> Koidz., <i>Q. mongolica</i> Ledeb. var. <i>liaotungensis</i> Nakai	N NW & NE China, Korea	600-2500	D	1
47	<i>Q. yunnanensis</i> Fr.	<i>Q. dentatoides</i> Liou, <i>Q. yui</i> Liou, <i>Q. dentata</i> subsp. <i>yunnanensis</i> Menits. <i>Q. dentata</i> Thunb. var. <i>oxyloba</i> Fr.	C S & SW China	1000-2600	D	1

E: evergreen, S: semi-evergreen, D: deciduous, M: year the acorns mature

Oaks of China . . .

text contd. from pg. 23

those in the section *Brachylepides*. On the other hand, oaks of sect. *Engleriana* have different anatomical and morphological characters, particularly in hair types. *Q. baronii*, has spirally stellate hairs, *Q.*

acrodonta and *Q. phillyreoides* have stalked stellate hairs and other oaks of this section have columnar fasciculate hairs. According to Hardin (1976,1979), columnar fasciculate, spirally stellate and stalked stellate hairs are not only anatomically different but also represent different evolutionary stages. Therefore, sect. *Engleriana* (sensu Hsu and Jen) can be divided into three sections based on hair types (Zhou et al., 1995).

Now, sect. *Engleriana* includes 15 species (Table 3). All of them are medium to large evergreen trees 15 to 35 m tall. Their leaves are leathery, ovate to narrowly oblong, and toothed. They fall into of the modified urticoid type (Hickey and Wolfe, 1975; Zhou et al., 1995), with apex acute, occasionally mucronate, and base acute to obtuse and with columnar fasciculate hairs, the primary vein



Photo by Zhekun Zhou

Mixed oaks at 2,700 m elevation on Jizu Mountain above the temple at Bichuan, Peoples Republic of China.

straight, and acorn maturing in one year or two years. Oaks in this section are distributed from Chiang Mai, Thailand in the south, north to the Qingling mountains, central west China, and from the east

Himalayas to Taiwan. They can grow from sea level to 2,800 m. The best growth, however, can be found at around 2,000 m. They occupy different ecological sites to the oaks of sect. *Brachylepides*. Oak trees in this section form evergreen oak forests in subtropical areas of China.

III. Section *Echinolepides*

Section *Echinolepides* has only one species, *Q. baronii*. This is a semi-evergreen tree or shrub oak up to 15 m tall. Its leaves are dry in winter but do not drop off until the next year when the new leaves develop. They are narrow lance-ovate in shape, 3-6 cm long and 1.3-2 cm wide with yellow spirally stellate hairs, toothed in the distal two thirds, the apex is acute and the base acute to obtuse. The acorns mature in two years. One variation is recog-

nized which has more dense, white, spirally stellate hairs. It is distributed in Henan, Shaangxi, Shangxi, and Sichuan, west central China. *Q. baronii* is found at the boundary of evergreen and deciduous oak forests, usually on limestone hillsides. It forms pure semi-evergreen oak forest in Henan, mixed with *Pinus armandii*. Its altitude distribution is from 500 to 2,700 m but it is most common below 2,000 m in the mountains.

IV. Sect. *Acrodonta*

Two oak species, *Q. acrodonta*, and *Q. phillyreoides* are included in this section. Sect. *Acrodonta* is very similar to Sect. *Engleriana* except that sect. *Acrodonta* has stalked stellate hairs and sect. *Engleriana* has columnar fasciculate hairs. Both oaks in this section are small evergreen trees, 10 to 15 m tall, sometimes shrub-like. The leaves have a few teeth on the distal portion of the blade, with more or less yellow hairs on the abaxial surface. The acorns mature in one year. *Q. acrodonta* is distributed in Shangxi, Gansu, Henan, Hubei, Sichuan, Guizhou and Yunnan, China. *Q. phillyreoides* ranges from Shangxi east to Japan and south from Guandong to Anhui. Both species grow in limestone mountains, from 300 to 2,300 m altitude. *Q. acrodonta* forms pure oak forest in southeast Yunnan. *Q. phillyreoides* is a tree in forests but becomes shrubby in areas of severe human impact.

V. Sect. *Aegilops*

This is a deciduous oak section. Only three oak species are recognized in China. They can be distinguished from the other deciduous oaks by their leaf outline and tooth type. All of them are large trees 30 m tall with a well developed crown. The bark is gray and gray-brown, deeply fissured in *Q. acutissima* and *Q. chenii*, thick and corky in *Q. variabilis*; leaves are narrow ovate to lanceolate, narrow-oblong to narrow-ovate, densely but thinly gray-hairy beneath in *Q. variabilis*, smooth on both side

in *Q. acutissima* and *Q. chenii*. The toothed leaves have long spine-tipped teeth, and the acorns mature in two years. *Q. chenii* can be distinguished from *Q. variabilis* by the leaves being smooth beneath and from *Q. acutissima* by the linear, straight cupule scales slender at the top and the small nuts and leaves. The nuts of *Q. chenii* are usually less than 15 mm in diameter while the leaves are 7-12 cm long. *Q. acutissima* has long slender scales. The nuts of *Q. acutissima* are usually 15 to 20 mm in diameter, and its leaves are 9 to 18 cm long.

These oaks have very wide distribution ranges and can be found in all of China except Xinjiang province, northwestern China. They also can be found in Vietnam, Burma, India, Nepal, Bhutan, Korea and Japan. They grow well in temperate areas and form pure oak forests there. No hybrids are recognized in this section. It is interesting that chemical and DNA evidence has shown that section *Aegilops* is most closely related to section *Brachylepides*.

VI. Sect. *Quercus*

This is the other deciduous oak section with 14 species recorded in China. All of them are small to large trees 12 to 30 m tall, with dark brown or gray bark, fissured or split into deep vertical cracks. They have obovate, occasionally elliptic leaves with round teeth or numerous untoothed lobes, more or less stellate-hairy on the abaxial surface and with irregularly arranged wax flakes on the adaxial surface, a unique character of this section. The acorns mature in one year. These characters make the sect. *Quercus* a natural group easily distinguished from the other deciduous oak section in China, sect. *Aegilops*.

Oaks in this section can grow on sunny hillsides, open mountains or in forests. They can grow in different soils and grow well in poor or rocky soils. They are widespread throughout China, and also in Japan, Korea and Russia .

contd. on pg. 30

Oaks of China . . .

contd. from pg. 29

One species, *Q. griffithii* can be found in Thailand, Laos, Burma, India and Nepal. Most species of this section are concentrated in forest regions where they reach their greatest development. Here they occur in several forest types. *Q. mongolica* and *Q. wutaishanica* (*Q. liaotungensis*) are dominant species in temperate forests and usually occur in pure oak forests or associated with other trees such as *Populus Butal*, *Pinus* and other oaks. *Q. malacotricha*, *Q. fabri* and *Q. aliena* are usually found in upland subtropical areas and occur in pure forests or associated with *Liquidambar*, *Schima*, *Acer*, *Pinus* and other oaks.

Several hybrids oaks are recognized in this section. They are *Q. x mongolico-dentata* (*Q. dentata* x *Q. mongolica*), *Q. x fenchengensis* (*Q. aliena* x *Q. dentata*), *Q. x fangshanensis* (*Q. dentata* x *Q. mongolica* subsp. *crispula*), and *Q. x hopeiensis* (*Q. dentata* x *Q. wutaishanica*)

In all, 125 oaks species are recognized in China. They are treated as two subgenera, *Quercus* subg. *Cyclobalanopsis* and *Quercus* subg. *Quercus*. The former can be temporarily divided into three groups based on the shape of their acorns, and the latter into six sections based on hair types, leaf shape and morphology. The main differences between subgenera and sections are given in the key to subgenera and sections of *Quercus*, which is found on page 15 of this publication.

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2. The name *Q. glaucoides* Martens & Galeotti applies to a Mexican species