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## A new species of *Betula* section *Betulaster* (Betulaceae) from China

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Received 18 August 2005; accepted for publication 22 October 2007

A new species of Betulaceae, *Betula fujianensis*, is described and illustrated from Luoboyan Reserve, Fujian Province, south-eastern China. *Betula fujianensis* is distributed in subtropical evergreen and deciduous broad-leaved mixed forest at elevations above 500 m, mostly as scattered individuals and occasionally as populations alone or with *B. luminifera*. *Betula fujianensis* belongs to section *Betulaster* and differs from other species in general morphology and phenology. A key to all species currently recognized in this section is presented, and the relationships between the new species and its closely related taxa are discussed. © 2008 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2008, 156, 523–528.

ADDITIONAL KEYWORDS: Luoboyan Reserve – morphology – phenology – taxonomy.

### INTRODUCTION

*Betulaster* (Spach) Regel is an eastern Asian section (or subgenus) in the genus *Betula*. There have been six species recognized in the section since 1904, i.e. *Betula alnoides* Buch.-Ham. ex D. Don, *B. baeumkeri* H. Winkl., *B. cylindrostachya* Lindl., *B. luminifera* H. Winkl., *B. rhombibracteata* P. C. Li in southern China, and *B. maximowicziana* Regel in Japan (Winkler, 1904; Li, 1979; Li & Cheng, 1979; Ito, 1989). All the species were described in the 19th or early 20th centuries, except for *B. rhombibracteata*, which was published in 1979 (Li, 1979). In the recent revision of the section *Betulaster*, Skvortsov (1997) recognized four species and clarified the distinction between them. He suggested that *B. rhombibracteata* should belong to *B. cylindrostachya*, and treated *B. baeumkeri* as the synonym of *B. luminifera*.

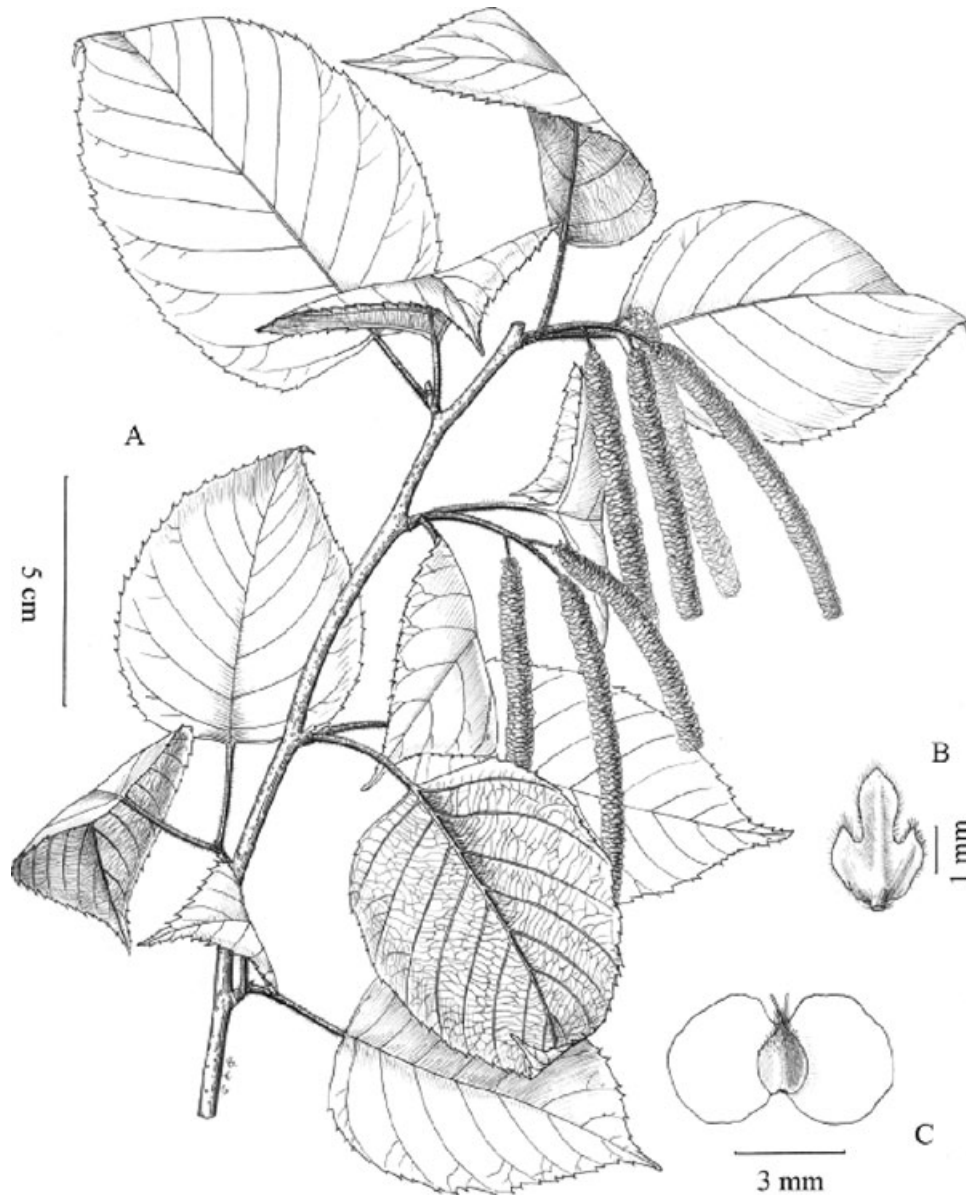
Whilst the first author was carrying out a survey of genetic resources of *B. alnoides* across southern China from Yunnan to Fujian Province in early May

2003, he discovered some birch trees in the evergreen and deciduous broad-leaved mixed forest at an altitude above 500 m in Luoboyan Reserve, Fujian Province. The trees resembled *B. alnoides* in having three to four pendulous and narrowly cylindrical female inflorescences in a raceme. In the following year, more fruiting specimens were collected. In late January 2005, flowering specimens with staminate inflorescences were collected, but pistillate inflorescences were still in bud. A detailed comparative study of species of *Betulaster* indicated that these trees in Luoboyan Reserve represented a new taxon.

### MATERIAL AND METHODS

The first author has visited Luoboyan Reserve five times since 2003. It is located at the boundary between Shaxian and Mingxi County, Shanming City, Fujian Province. More than 20 infructescence-bearing specimens and seven inflorescence-bearing specimens were collected from at least eight trees. The specimens with both leaves and infructescences or inflorescences were deposited in PE (Herbarium, Institute

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**Figure 1.** *Betula fujianensis*: A, fruiting branch; B, bract; C, nutlet.

of Botany, Chinese Academy of Sciences, Beijing, China). The bract and nutlet were observed using a stereomicroscope (SZ-CTV, Olympus, Japan), and photographed with a digital camera (CoolPix 995, Nikon Corporation, Japan).

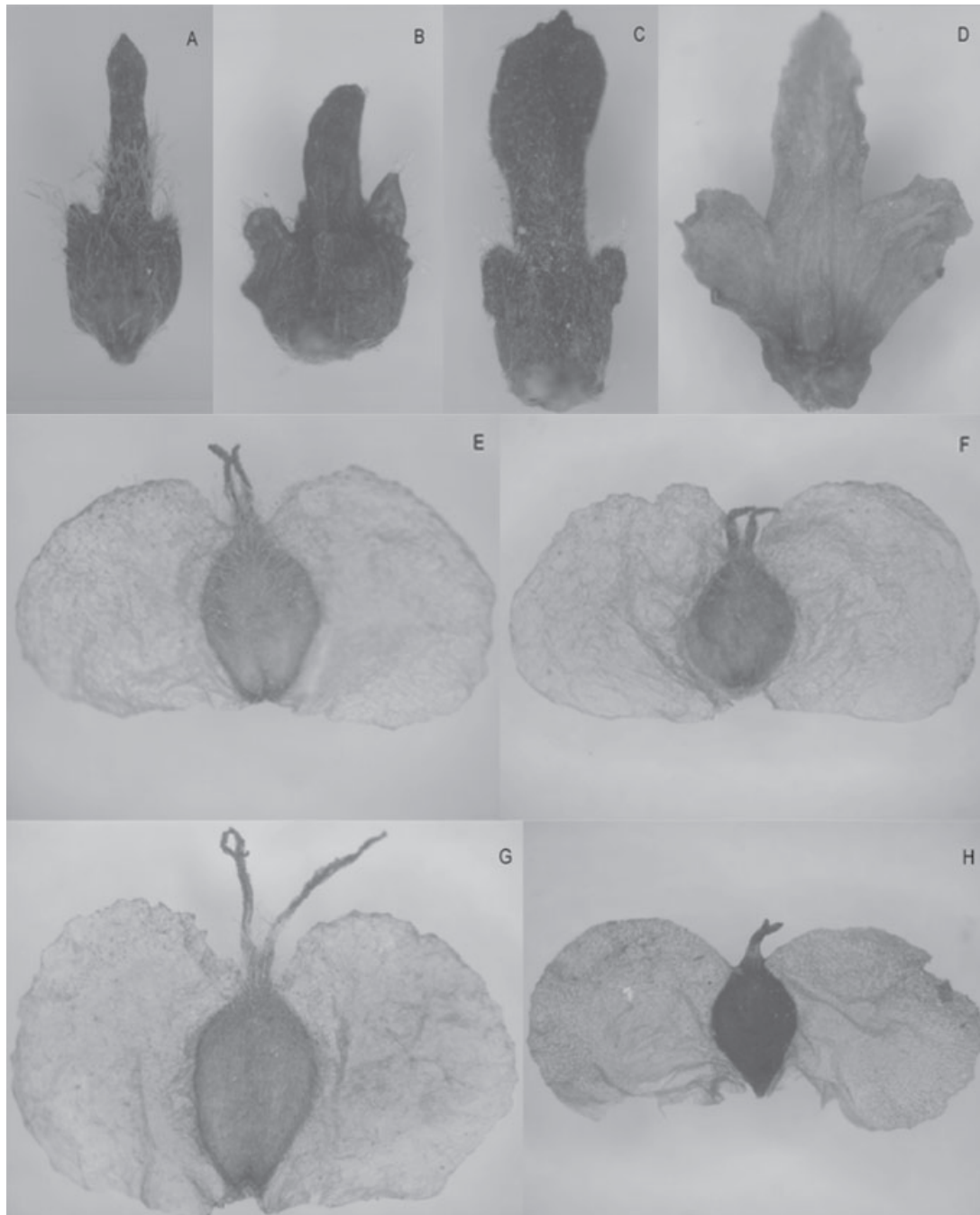
Meanwhile, an introduction trial has been conducted in Fujian Yong'an Forestry Company, Yong'an County, Shanming City, Fujian Province since July 2003, in which the adaptability of 14 provenances of *B. alnoides* from its main natural ranges has been investigated in comparison with *B. luminifera* and the new species collected from Luoboyan Reserve. The trial plantations were established in April 2004. The

young plantations underwent a severe freeze injury in early January 2005 when the air temperature was as low as  $-7^{\circ}\text{C}$ . Their phenology and resistance to freeze injury were thus observed.

#### SPECIES DESCRIPTION

***BETULA FUJIANENSIS*** J. ZENG, J. H. LI & Z. D. CHEN **SP. NOV.** [SECTION *BETULASTER* (SPACH) REGEL] (FIGS 1, 2B, F)

*Diagnosis:* Species *Betula maximowiczianae* et *B. alnoidi* affinis, sed foliis in axillis nervorum lateralium glabris, margine serratis; inflorescentiis femineis



**Figure 2.** A–D, Bract of *Betula fujianensis* and closely related species to show the length ratio of the lateral and middle lobes: A, *B. alnoides*; B, *B. fujianensis*; C, *B. luminifera*; D, *B. maximowicziana*. Magnification: A, B, C,  $\times 11.25$ ; D,  $\times 8.75$ . E–H, Nutlet of *B. fujianensis* and closely related species to show the pubescence at the apex: E, *B. alnoides*; F, *B. fujianensis*; G, *B. luminifera*; H, *B. maximowicziana*. Magnification: E,  $\times 11.25$ ; F, G,  $\times 8.75$ ; H,  $\times 7.50$ .

3–4 in pedunculis, racemosis; bracteis sparsim albo-pubescentibus, lobis lateralibus  $1/3$ – $1/2$  longioribus quam lobis mediis; nuculis apice dense pubescentibus, alis 3–4 plo latioribus quam nuculis differt.

*Type:* CHINA, Fujian, Shaxian, Luoboyan Reserve, evergreen and deciduous broad-leaved forest, 500–600 m, 5.v.2004, Zeng 2004050501 (holotype, PE); *ibid.*, Zeng 2004050502 (paratype, PE).

*Description:* Trees up to 25 m tall with diameter at breast height up to 60 cm. Bark dark grey or grey-brown, vertically furrowed and exfoliating. Branchlets red-brown or grey-brown, densely villous and resinous glandular. Leaves on dwarf shoots and on long branches. Petiole 1.5–3.0(–3.5) cm, densely villous and resinous punctate. Leaf blade oblong or ovate-elliptic, 6–12 × 4.5–6.5 cm, papery, abaxially densely glandular punctate, beardless in axils of secondary veins; apex cuspidate caudate; base rounded or subcordate; secondary veins 8–12 on each side of midvein. Margin irregularly incurved or not incurved serrate; each primary tooth with secondary vein entering has one to three secondary teeth, and the primary tooth is not conspicuously longer than the secondary teeth. Male inflorescences 2–3(4) arranged on the top of branches or 1–2 axillary on the upper part of branches. Female inflorescences 3–4 in a raceme, pendulous, narrowly cylindrical, c. 5.5–8.5 cm × 6 mm when mature, peduncle 5–10 mm, densely white villous. Bracts subcordate, sparsely white pubescent, and ciliate, three-lobed, lateral lobes rounded, c. one-third to one-half as long as middle lobe. Nutlet suborbicular or ovate, c. 2 × 1–1.5 mm, sparsely pubescent, densely pubescent at apex, with membranous wings three to four times as wide as nutlets. Stigmas 2, persistent.

*Distribution, habitat, ecology, and commercial uses:* *Betula fujianensis* is known only from Luoboyan Reserve, Fujian Province. Based on our 2-year observations, fruits ripen between late April and early May, generally 1–2 weeks earlier than those of *B. luminifera* in the same area at similar altitudes.

Luoboyan Reserve has a typical subtropical monsoon climate. According to the data from the local meteorological station, the annual mean temperature is 19.5 °C, with the mean temperatures in January and July being 8.5 °C and 28.4 °C, respectively. The absolute minimum and maximum temperatures are 7.1 °C below freezing and 40.1 °C, respectively. The annual mean frost-free period is 297 days. The mean annual precipitation is 1643.2 mm. Our introduction trial at Fujian Yong'an Forestry Company showed that the new species is as cold hardy as *B. luminifera*. Saplings of *B. alnoides* were killed at the low temperature of –7 °C, whereas both *B. fujianensis* and *B. luminifera* survived the cold temperature.

*Betula fujianensis* is a deciduous tree usually with a scattered distribution. However, occasionally, it forms a pure stand or mixed community with *B. luminifera* in the mixed evergreen and deciduous broad-leaved forest. According to the World Conservation Union (IUCN) (IUCN, 2001), this species should be categorized as a critically endangered species (CR).

The other accompanying species include *Phoebe bournei*, *Ilex formosana*, *Castanopsis lamontii*, *Eurya loquiana*, *Castanopsis tibetana*, *Cinnamomum micranthum*, and *Machilus pauhoi*. The soil substrate is granite. The soil layer is c. 80 cm thick with a pH value of 4.5–5.5. The tree is used locally for veneer production, furniture-making, building construction, and decoration, etc. Therefore, it has been introduced into cultivation for commercial usage at Fujian Yong'an Forestry Company this year, and will be introduced to other provinces in southern China in the near future.

## DISCUSSION

Within the genus *Betula*, it is fairly easy to distinguish species of section *Betulaster* from all other species by their narrowly elongate cylindrical and pendulous female inflorescences, and wings of the nutlet which are much wider than the nutlet and are partly exerted in ripe aments (Skvortsov, 1997). *Betula fujianensis* has three to four pistillate inflorescences in a raceme, and reduced lateral lobes of fruit bracts. All of these characteristics are consistent in the specimens of the new species (Fig. 1), and thus it can be confidently classified as a species of section *Betulaster*.

*Betula fujianensis*, however, differs from all other species in section *Betulaster* with regard to several features. Its leaf is beardless in the axils of lateral veins, and its primary teeth are not conspicuously longer than the secondary teeth (see Table 1). The differences in the bract and nutlet between *B. fujianensis* and its closely related species are given in Figure 2.

Although *B. fujianensis* and *B. luminifera* are deciduous species with similar phenology, and sometimes grow naturally together in Luoboyan Reserve, they are quite distinct from each other with regard to their bark and female inflorescences, in addition to the characteristics mentioned above. The old bark of *B. fujianensis* exfoliates, and the feature was even observed on trees with a diameter at breast height of approximately 30 cm, whereas the bark of *B. luminifera* is usually smooth, even on trees with a diameter at breast height above 40 cm. The remaining differences between *B. fujianensis* and *B. luminifera* are shown in Table 1.

*Betula fujianensis* differs remarkably from *B. maximowicziana* with regard to leaf shade, bract, and nutlet, as described in the above key, although both species have three to four female inflorescences in a raceme. Their phenological characteristics are also quite different: *B. maximowicziana* flowers in May to June and the fruiting catkins ripen in September to



KEY TO THE SPECIES IN SECTION *BETULASTER*

1. Female inflorescences 2–5 in a raceme
  2. Female inflorescences 3–4 in a raceme; lateral lobes of bracts distinct; wing of nutlet c. three to four times as wide as nutlet, apex of the nutlet sparsely or densely pubescent; leaves broadly ovate, ovate-elliptic or oblong
  3. Leaf blade broadly ovate, base deeply cordate; bract glabrous, base cuneate, margin sparsely ciliolate or glabrous, middle lobe one to two times as long as lateral lobe; nutlet broadly obovate, apex sparsely pubescent..... *B. maximowicziana*
  3. Leaf blade oblong or ovate-elliptic, base rounded or subcordate; bract subcordate, sparsely white pubescent, margin densely ciliolate, middle lobe two to three times as long as lateral lobe; nutlet suborbicular or ovate, apex densely pubescent..... *B. fujianensis*
2. Female inflorescences 2–5 in a raceme; lateral lobes of bracts small or much reduced; wing of nutlet two to three times as wide as nutlet, apex of the nutlet densely pubescent; leaves lanceolate or ovate-lanceolate..... *B. alnoides*
1. Female inflorescences 1 or 2
  4. Female inflorescences 1 (or 2)..... *B. luminifera*
  4. Female inflorescences always 2
    5. Scales of buds glabrous; petiole glabrous except villous in furrow; bracts rhombic, glabrous; nutlet 3–5 × 1.5–3 mm..... *B. rhombibracteata*
    5. Scales of buds villous; petiole densely yellow villous; bracts oblong-lanceolate, pubescent at base; nutlet c. 2 × 1–1.5 mm..... *B. cylindrostachya*

Note: information about *B. cylindrostachya* and *B. rhombibracteata* in the above key was abstracted from Li & Skvortsov (1999).

**Table 1.** Diagnostic morphological and phenological characters distinguishing *Betula fujianensis* from its closely related taxa in section *Betulaster*

Character	<i>B. alnoides</i>	<i>B. fujianensis</i>	<i>B. luminifera</i>	<i>B. maximowicziana</i>
Beardless in axils of secondary veins	No	Yes	No	No
Primary teeth conspicuously longer than secondary teeth	Yes	No	Yes	Yes
Number of female catkins in a raceme	2–5	3–4	1	3–4
Pubescence on bract	Densely	Sparsely	Sparsely	Glabrous with glabrous or sparsely pubescent margin
Length ratio of lateral and middle lobes of bract	< 1/3	1/3–1/2	< 1/3 or much reduced	1/2–1
Pubescence at apex of nutlet	Densely	Median level	Median level	Very few
Width ratio of wing and nutlet	2–3	3–4	2.5–3.5	3–4
Fruiting period	Generally Jan–Mar	Apr–May	May–Aug	Sept–Oct

October in Japan (Kitamura & Murata, 1986), whereas those of *B. fujianensis* ripen in April to May in Fujian, China.

When compared with *B. alnoides*, *B. fujianensis* is easily identifiable by its distribution range, phenology, and morphological characteristics. Firstly, *B. alnoides* is distributed in Yunnan, Guangxi, Ghizhou, and south-eastern Tibet, extending to Vietnam, Laos, Thailand, Myanmar, India, and Nepal, based on our investigations during recent years and relevant references (Zeng, Zheng & Weng, 1999). This is different from the description in *Flora of China* (Li &

Skvortsov, 1999), in which Fujian Province is considered as a part of the natural range, perhaps because of the confusion of *B. alnoides* with *B. fujianensis* or *B. luminifera*. This is also confirmed by the fact that *B. fujianensis* has much stronger ability to resist freeze injury than *B. alnoides*.

These species can also be identified by their phenology. Although both are deciduous species, *B. fujianensis* loses its leaves in October and grows new ones in March, whereas *B. alnoides* loses its leaves in about November and then commences to grow new ones after 7–10 days. The fruiting catkins

of *B. alnoides* generally ripen in January to March, 1–4 months earlier than those of *B. fujianensis*.

The leaves of *B. fujianensis* are oblong or ovate-elliptic with an irregularly incurved or not incurved serrate margin and mucronate caudate apex, whereas the leaves of *B. alnoides* are lanceolate, ovate-lanceolate, or ovate-elliptic, with an irregularly incurved, sometimes doubly setiform serrate margin and acuminate or caudate acuminate apex. *Betula alnoides* has clusters of hairs in the axils of lateral veins abaxially, whereas *B. fujianensis* does not. With regard to the bracts, the lateral lobes are reduced and auriculate in *B. alnoides*, but are distinct and one-third to one-half as long as the middle lobe in *B. fujianensis*.

#### ACKNOWLEDGEMENTS

We thank Professor Pei-Qiong Li (Fairy Lake Botanical Garden, Shenzhen City, Guangdong Province) for her guidance, and Dr Hui Ren and Professor An-Ming Lu for their help in preparing the diagnosis. We are also grateful to Mr Ying-Bao Sun (Institute of Botany, Chinese Academy of Science) for his drawings of the species. This work was financially supported by the National Natural Science Foundation of China (30400345 and 30370094), the Chinese Academy of

Sciences (KSCX2-YW-R-136) and State Forestry Administration, China (2002BA515B0204).

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