

New Advances in Plant Biology Research on *Reevesia* Lindley

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Abstract *Reevesia* spp. are rare and precious trees full of characteristics. China is the geographical distribution center of *Reevesia* Lindley in the world, but all the plants of *Reevesia* Lindley are wild with very small number, which is worth developing and utilizing. This study reviews the recent advances in the study of *Reevesia* Lindley, including morphological characteristics and taxonomic status, plant species and geographical distribution, biology and humanistic sociological values, as well as population ecology and reproductive biology.

Key words *Reevesia* Lindley, Taxonomic system, Humanistic value, Population ecology, Reproductive physiology

1 Introduction

Reevesia spp., belonging to Malvaceae, are rare and precious trees full of characteristics, mainly distributed in China (Guangdong, Guangxi, Yunnan, Guizhou, Sichuan, *etc.*), Thailand, India, Myanmar, Laos, Vietnam, Sikkim, Bhutan, *etc.* China is the geographical distribution center of *Reevesia* Lindley in the world, but at present, all the plants of *Reevesia* Lindley are wild, with very small number, which is worth developing and utilizing. This study reviews the recent advances in the study of *Reevesia* Lindley at home and abroad.

2 Morphological characteristics and taxonomic status

Plants woody, bark gray, with markings on the surface, lenticels dense. Leaves alternate, leathery, margin entire, apex acuminate, base rounded, (5–7) cm × (2.5–3.0) cm. Petiole 1–3 cm long, swollen at both ends. Inflorescences cymose, corymbose, with 2 stipules in stalk of each floret, inflorescence terminal. Calyx campaniform, 5-lobed; petals 5, white, ca. 2 cm long; apical stamens 15, stamens wrapped into balls; ovary spheroidal, 5-locular. Capsule pyriform, 5-angled, ca. 3 cm long, dehiscent at maturity. Seeds winged, ca. 2 cm including wing, light and easily floating. Fl. Mar–Apr, Fr. Oct–Nov.

For a long time, *Reevesia* Lindley was taxonomically a part of the Sterculiaceae family, being juxtaposed with 17 genera such as *Firmiana* Marsili, *Sterculia* Linn., and *Theobroma* Linn.^[1] In APG IV, *Reevesia* Lindley is classified into Malvaceae^[2], which has been widely adopted. However, the relationship of Malvaceae, Sterculiaceae, Tiliaceae and Bombacaceae is quite complex, and Malvaceae contains the most species of more than 4 225, so it is still controversial to attribute *Reevesia* Lindley into Malvaceae in

the academic community^[3].

3 Plant species and geographical distribution

Reevesia spp. are basically in the wild state, and the research at home and abroad focuses on the field of plant taxonomy. At present, a total of 22 species and 3 variants of *Reevesia* Lindley have been found and confirmed in the world, distributed in the east of the Himalayas and the west of Taiwan, China, with China as the geographical distribution center. Most of them are distributed in tropical and subtropical areas, with many species in Yunnan, Guangdong and Guangxi, and a small number in Sichuan, Guizhou, Hunan, Jiangxi, Fujian and Taiwan, and a few species are distributed in temperate areas. There are about 7 species of plants in this genus distributed southward to the South Asian subcontinent, the Malay Peninsula and the Indo-China Peninsula.

At present, there are 14 species and 3 variants of *Reevesia* Lindley found and confirmed in China, accounting for nearly 70% of the total species (including variants) of the genus, 12 of which are endemic species^[4–6]. The specific species are as follows: *R. botingensis* H. H. Hsue, *R. formosana* Sprague, *R. glaucophylla* H. H. Hsue, *R. lancifolia* Li, *R. lofouensis* Chun & H. H. Hsue, *R. longipetiolata* Merr. & Chun, *R. orbicularifolia* H. H. Hsue, *R. pubescens* Mast., *R. pubescens* var. *kwangsiensis* H. H. Hsue, *R. pubescens* var. *xuefungensis* Qi, *R. pubescens* var. *pubescens*, *R. pubescens* var. *siamensis*, *R. pycnantha* Ling, *R. rotundifolia* Chun, *R. rubronervia* H. H. Hsue, *R. shangszeensis* H. H. Hsue, *R. thyrsoides* Lindl., and *R. tomentosa* Li.

4 Biological and humanistic sociological values

R. pubescens is tall, straight, with straight and rounded trunk, medium hardness and strength wood, flexible branches that are not easy to deform but easy to cut, and smooth sections that can be made into plywood, furniture, *etc.*, so it is a good wood species. The fibers from *R. pubescens* branches are also used for paper making and rope braiding^[7].

R. pubescens is a beautiful tree with few leaves, and the

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crown is covered with snow and has a pleasant smell when the flowers are in full bloom. Meantime, it is a precious garden ornamental tree species with good anti-pollution ability, and is very popular with people. Especially when it blooms in May – June, the tree is full of white flowers with rich and overflowing aroma. If decorated around the house or by poolside bridge, it is rich in poetic and pictorial splendor due to verdant trees, blue light and lush shadows^[8]. Because of straight trunk, luxuriant foliage, rich multicolored decorations, and very eye-catching flowering period, it can be used as an excellent afforestation tree or garden ornamental tree. Meantime, it also has a strong cultural heritage.

R. pubescens has certain medicinal value, and can be used for antibiosis, palliation, detoxification, diuresis, antianaphylaxis and so on. Its bark extract can relieve pollen allergy symptoms, enhance human immunity and improve skin problems, and have certain cosmetic effects as well. The leaves of *R. pubescens* can be dried and soaked in water for drinking, which has the effect of clearing heat and detoxifying, inducing diuresis to alleviate edema. Hainan herbalist doctors use the bark of *R. pubescens* for the treatment of cancer. Zhu Hui *et al.*^[8] isolated five compounds from the ethyl acetate part of *R. pubescens* bark for the first time, which were identified as β -sitosterol, daucosterol, betulinic acid, lupeol and (+)-catechin. Hsiao *et al.*^[9] extracted cardenolides and sesquiterpenoids from *R. formosana* fruits, and demonstrated that it had selective cytotoxicity. However, the medicinal value of *R. pubescens* has been rarely studied, which deserves more textual research.

R. pubescens has outstanding cultural and humanistic significance. It is said that "*R. pubescens* should be in the sky and can not be found on the earth", describing the fact that *R. pubescens* is very rare and precious. *R. pubescens* is a mythical tree in South Asia and the Taiwan Strait, and is known as the "fairy tree"^[10]. According to legend, Mahamaya gave birth to Buddha Sakyamuni by holding the tree, and it was also said that the tree in the Moon Palace was *R. pubescens*. Henry D. Thoreau, an American writer with the same name as *R. pubescens*, is world-renowned, and a large number of literatures have studied his ecological and nature conservation ideas^[11–12]. Nanjing Zhongshan Botanical Garden guest house is named "Thoreau Hotel" because there is a tall *R. pubescens* on the side of the building.

5 Population ecology

Zhu Baozhu *et al.*^[13] reported the ornamental characteristics, resource distribution and cultivation key points of *R. tomentosa*. Longhua *et al.*^[14] studied the pollen morphology and classification of *Reevesia* Lindley and supported that *R. pubescens* var. *siamensis* should be a species rather than a variant of *Reevesia* Lindley. *R. pubescens* discovered by Yang Zeyong in Xuefeng Mountain in Hunan Province was named *R. pubescens* var. *xuefengensis* after identification and classification research^[15]. Wang Chunhui *et al.*^[6] also studied the local population structure and dynamic characteristics of *R. pubescens*. Liang Jianping described the con-

servation value of *Reevesia* Lindley in his works^[16]. Zhang *et al.*^[17] analyzed the complete plastid genome sequence of *R. py-cnantha*, and complemented the phylogenetic studies of Malvaceae.

Many years ago, *R. pubescens* were planted sporadically in some places such as Nanjing Zhongshan Botanical Garden and Shanghai Botanical Garden, but the number of *R. pubescens* planted was in the single digits. The one planted by Nanjing Zhongshan Botanical Garden is the northernmost one in *R. pubescens* relocation protection and conservation areas. It is tall and luxuriant, very beautiful, heliophilous, with mild shade tolerance and obvious cold tolerance. Adult trees can remain evergreen in southern Jiangsu and Shanghai, and young trees can recover in the next spring if their leaves are frozen in winter, which indicates that it is a promising garden planting tree for moving north. Recently, Wang Chunhui^[18] conducted a systematic study on the leaf characteristics of *Reevesia* Lindley, including leaf phenotype characteristics, leaf venation characteristics, leaf epidermal micromorphology and stomatal organ characteristics, and found that the leaf length-width ratio, leaf hair condition, stomata features, primary vein thickness, final leaf margin venation, cuticle membrane features and venation morphological characteristics were the main traits to identify and distinguish *Reevesia* Lindley, which were of positive significance for scientific understanding of *Reevesia* Lindley and its resource protection, ecological adaptability and development and utilization.

6 Reproductive biology

The research on reproduction biology of *R. pubescens* is of great significance, but there are few literatures. We carried out 30 treatments in a greenhouse with small plastic arch cover, including cutting season, lignification degree of cuttings and cut site, cuttings age and diameter, growth material type (2,4-D, NAA, IAA, IBA, CTK) and concentration (0, 100, 200, 300, 400, 500 mg/L), and there were a total of 2 280 cuttings. The results showed that the survival rate of cutting in mid-March was higher than that in mid-June; the survival rate of hard branch cuttings was higher than that of tender branch cuttings; the survival rate of 1-year-old cuttings was higher than that of 2-year-old cuttings; the survival rate of spring shoot cuttings was higher than that of autumn shoot cuttings; the survival rate of cuttings with a diameter of 0.5 – 1.0 cm was higher than that of cuttings with a diameter of 0.3 – 0.5 cm or 1.0 – 1.5 cm; among the five growth substances, the survival rate of cuttings treated with 100 mg/L indole butyric acid was the highest, but there was no significant difference among all the treatments; the germination rate reached up to 22.5%, with an average of 9.5%, and the survival rate of rooting was even lower. There is no doubt that *R. pubescens* is a tree species difficult to take root.

It is feasible to sow and breed *R. pubescens*. Capsules mature from late October to early November, and are collected promptly to avoid the seeds flying with the wind after dehiscence. The basic parameters of the fruit are as follows: longitudinal diameter 2.87

cm, transverse diameter 2.05 cm, single fruit weight 3.49 g, seed number 6.0 seed/fruit, average bearing seeds per placenta 1.2. The basic parameters of the seed are: length 7.39 mm, width 4.31 mm, thickness 1.88 mm, wing length 7.23 mm, wing width 7.94 mm, 1 000-grain weight (including wings) 31.11 g, 1 000-grain weight (excluding wings) 30.97 g. According to the research of Yu Zhijun *et al.* [7] and Liu Meixiang *et al.* [19], seeds should be stored in a low temperature (4 °C) ventilated seed bank until sowing in March of the next spring. The optimum substrate for seedling cultivation was yellow soil + burnt soil + river sand (2 : 1 : 1), which was covered with 0.5 cm thick clean river sand after seeding. The seedling emergence begins at 20 d after sowing, and reaches the peak at 30 d, and the seedling emergence rate reaches 60%; the first true leaf can grow at 40 d, and the second true leaf emerges at 50 d; when there are 2–3 true leaves, seedling should be transplanted timely to cultivate bag seedlings. Seedlings grow slowly in the early stage, with an average seedling height of 30 cm and ground diameter of 0.70 cm in early October of the same year [20]. There is no obvious damage of diseases and insects in the seedling stage.

Aseptic seeding, proliferation and propagation is a valuable technique for *R. pubescens* seedling cultivation, but it needs further development. At present, the suitable medium for sowing is MS medium + 0.3% naphthylacetic acid + 0.1% activated carbon. The operational steps are as follows: the seeds are soaked in tap water for 3 h and dishwashing liquid solution for 10 min, and then rinsed with tap water for 10 min; after soaked in 70% ethanol solution for 30 s on a super-clean workbench, the seeds are rinsed with sterile water twice, soaked in 0.1% HgCl solution for 8 min, and then rinsed with sterile water for 5 times; after dried, the seeds are inoculated on the medium and cultured in a culture chamber at room temperature 26 °C and relative humidity 80%; the germination takes longer time, usually more than 20 d later than that of the seeds collected and sown at the same time, but the germination rate is slightly higher, up to 63.5%; at 30 d post emergence, the first true leaf emerge, and the taproot can gradually grow, with good growth of leaves and stems [10]. The germination rate can be higher by improving the operation technology and reducing pollution. However, such medium still needs to be further optimized for lateral root development, and the best medium suitable for proliferation and propagation still needs to be explored.

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