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# *EUCOMMIA* (EUCOMMIACEAE), A POTENTIAL BIOTHERMOMETER FOR THE RECONSTRUCTION OF PALEOENVIRONMENTS[1]

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The living trees of *Eucommia ulmoides*, an endemic species in China, grow from 200 to 1700 m above sea level, within the geographic range from 102° E to 118° E and from 25° N to 35° N. Spring temperatures in these regions vary from 12.3°C to 20.1°C. A physiological study (using germination tests) of *E. ulmoides* has been undertaken to test the role of spring temperature as a factor controlling the distribution of *Eucommia*. Results show that the spring temperature is a limiting factor for *Eucommia* seed germination and hence for the distribution pattern of the genus. The suitable range of temperature for seed germination, established experimentally, is from 13°C to 22°C, with an optimum of 18°C. Specimens of fossil *Eucommia* cf. *ulmoides*, preserved as a branch segment and leaves, showing the distinctive latex, were found in Middle Miocene sediments of Shanwang Formation, Shandong Province, East China. If the climatic tolerances documented here for *E. ulmoides* are extrapolated to Shanwang, they are in fact consistent with other predictions of the paleoclimate at this site, indicative of the potential value of *Eucommia* as a biothermometer. These Miocene fossils, and one previously described Eocene fruit specimen, prove the former existence of *Eucommia* in China in addition to North America and Europe. This confirms that the genus is not a recent arrival in China and extends our understanding of the past biogeography of the genus.

**Key words:** biogeography; China; East Asia; *Eucommia*; Eucommiaceae; Miocene; paleoenvironments.

In order to understand global climate change today, we need to understand the pattern and process of climate change in the past. The evolution of plants was strongly influenced by, and therefore reflects, environmental changes in the geological past. Plants have to tolerate the full climate range in their habitat and are rightly regarded as good biothermometers for the environment. Studies of fossil plants, and their closest relatives involving their systematic status, biogeography, ecology, and physiology may provide a valuable key to reconstruct past terrestrial environments.

*Eucommia ulmoides* Oliv. is the single extant species of the genus *Eucommia* (Eucommiaceae) (Cronquist, 1981). The living trees of *E. ulmoides* occur only in the hilly area of South China (Fig. 1; Ying, Zhang, and Boufford, 1993). The unicellular latex ducts and the structure of the samaras are unique features of *Eucommia* (Tippo, 1940; Tian and Hu, 1983) and have been used, as a distinctive combination of features, in tracing the history of *Eucommia* in the Northern Hemisphere (Call and Dilcher, 1997).

The earliest macrofossils that can unequivocally be placed in genus *Eucommia* are fruits found in Eocene sediments of Hokkaido, Japan (Huzioka, 1961); Fushun, Northeast China (Geng, Manchester, and Lu, 1999); and the western and southeastern United States (Call and Dilcher, 1997; Manchester, 1999). *Eucommia* macrofossils also occur in western European floras from Oligocene to Upper Pliocene (Mai, 1995; Zhilin, 1989), in North America from Eocene to Oligocene (Call and Dilcher, 1997), and extending into the Miocene of southern Mexico (Magallon-Puebla and Cevallos-Ferriz, 1994). Fossil fruits of *Eucommiodes orientalis* Tao and Zhang (1992) reported from the early Cretaceous of Jilin Province and *Eucommia brevirostria* Guo (1979) found from the early Eocene of Guangdong Province have been rejected due to their lacking key features of the *Eucommia* samara, especially the reticulate pattern of veins and latex filaments over the seed and the medial vascular strand separating the fertile and vestigial infertile carpels (Call and Dilcher, 1997). Mesozoic pollen of *Eucommiidites* Erdtman were considered at one time as early representatives of *Eucommia* but have been more recently proved to be clearly gymnospermous and have been assigned to the new order Erdtmanithecales (Friis and Pederson, 1996).

Our aim in this paper is to explore the potential role of *Eucommia* as a biothermometer in paleoenvironmental reconstruction. The concept of the nearest living relative (NLR) based on recognition of modern genus or even species (Collinson, 1986; Mosbrugger, 1999) and the climate analysis of endemic species (Li, Wang, and Sun, 2001) are adopted and applied in this paper by using the assumption that the fossil species and its NLR species have similar ecological requirements.

## MATERIALS AND METHODS

***Germination experiments***—An experiment was conducted to determine seed vigor in *E. ulmoides* as measured by the number of germinating seeds produced under different temperature conditions. Seed vigor is defined as "that condition of active good health and natural robustness in seeds which, upon planting, permits germination to proceed rapidly and to completion un-

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