EUCOMMIA (EUCOMMIAEAE), A POTENTIAL BIOETHERMOMETER FOR THE RECONSTRUCTION OF PALEOENVIRONMENTS¹

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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 uncellular 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 Eucommioides 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 Eucommidites Erdman 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 Erdmanitcales (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-