

# AN ADDITIONAL RECORD OF *CRAIGIA*-FRUITS (MALVACEAE S.L.) FROM THE EOCENE OF HAINAN ISLAND, SOUTH CHINA

WeiQiu LIU<sup>1)</sup>, XiaoYan LIU<sup>1)</sup>, DaFang CUI<sup>2)</sup> & JianHua JIN<sup>1\*)</sup>

<sup>1)</sup> Guangdong Key Laboratory of Plant Resources, and School of Life Sciences, Sun Yat-sen University, Guangzhou, 510275, China;

<sup>2)</sup> College of Forestry, South China Agriculture University, Guangzhou 510642, China;

<sup>\*)</sup> Corresponding authors, Issijh@mail.sysu.edu.cn, cuidf@scau.edu.cn

## KEYWORDS

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## ABSTRACT

A fossil species, *Craigia hainanensis*, has recently been reported from the Eocene coal-bearing series of the Changchang Basin of Hainan Island, South China. Here, we report an additional record of the genus *Craigia* from the same stratigraphic level in open nomenclature. The new record appears different from *C. hainanensis* and may indicate a second *Craigia* species for the Eocene of Hainan Island. Although *Craigia* fossils are common in the Northern Hemisphere, those from Hainan are the only records from South China where the genus is still living today.

## 1. INTRODUCTION

*Craigia* W.W. Smith et W.E. Evans is a genus with only two extant species (*C. yunnanensis* W.W. Smith et W.E. Evans and *C. kuangsiensis* Hsue) and is mainly distributed in the southwestern part of China and the northernmost part of Vietnam (Chang and Miao, 1989). The two extant members of the genus *Craigia* are deciduous trees and shrubs about 6-20 m in height and mainly live at altitudes between 1000 and 1500 m above sea level (Chang and Miao, 1989), although shrubby individuals have been found at an elevation of 2200 m in the Yunnan Province of China (Kvaček et al., 2005). Both species are endangered, and *C. kuangsiensis* Hsue may even have become extinct due to deforestation already.

The research history on the systematic position of *Craigia* has been summarized in detail by several authors (Kvaček et al., 2002; Kvaček, 2008; Jin et al., 2009). Here we adopt the most recent opinion and put *Craigia* in the Tilioideae (Malvaceae s.l.) (Judd and Manchester, 1997; Bayer et al., 1999; Bayer and Kubitzki, 2003).

The systematic position of fossil *Craigia* fruits has long been debated, having been variously assigned to extant genera of *Ulmus* (Bronn, 1837; 1838), *Zygophyllum* (Saporta, 1873), *Abronia* (Laurent, 1904), *Ptelea* (Brown, 1937), and *Koelreuteria* (Arnold, 1952). It was also assigned to extinct morpho-genera such as *Pteleaecarpum* (Weyland, 1948) and *Rutaceites* (Iljinskaja, 1963). Bužek et al. (1989) studied the fossil material of this genus, and identified two species of *Pteleaecarpum*: *P. bronnii* (Unger) Weyland and *P. oregonense* (Arnold) Manchester. In still another reassessment, Kvaček et al. (1991) re-examined the fossil material of the genus, assigned it to the extant genus *Craigia* based on the fruit morphology and characters of the indumenta and renamed the two fossil species accordingly: *Craigia bronnii* (Unger) Kvaček, Bužek et Manchester and *C. oregonensis* (Arnold) Kvaček, Bužek et Manchester. Further studies of the genus confirmed the assignment of the two fossil species to *Craigia*, and assured that the fossils were different from the extant species (Uzunova et al. 2001; Kvaček et al., 2002; Kvaček, 2004; Kvaček et al., 2005).

So far, a total of three fossil species of *Craigia*, *C. bronnii*, *C. oregonensis*, and *C. hainanensis* has been recognized.

The discovery of *C. hainanensis* Jin et Kodrul in the Eocene Changchang Formation of Hainan Island expanded the distribution area of this genus to tropical Asia for the Eocene (Jin et al., 2009). Here we report an additional record of *Craigia* from the same location in open nomenclature. It provides new evidence to spur an investigation of the phytogeographic history of the genus *Craigia*.

## 2. MATERIALS AND METHODS

The studied specimens were collected from the coal-bearing series of the Changchang Formation in the Changchang Basin which is located in the northeastern part of Hainan Island, China (19°38'03" N, 110°27'04" E). Part and counterpart of *Craigia* capsule valves were recovered from the upper part of the coal-bearing series in approximately the same strata from which *Craigia hainanensis* fossils were collected previously (Jin et al., 2009). The associated plant assemblage is a mix of temperate and tropical-subtropical components (Jin, 2009; Jin et al., 2009). The Changchang Formation has been palynologically dated as early Eocene-early late Eocene (Lei et al., 1992). The specimens are deposited in the Museum of Biology, Sun Yat-sen University, Guangzhou, China. The fossil cuticles from the locular area were prepared by removing residual mineral matrix with HF and subsequent oxidation with Schulze's solution (1 part KClO<sub>3</sub> with 3 parts HNO<sub>3</sub>) followed by a treatment with 5% KOH (Ye, 1981). Cuticles were mounted on glass slides using neutral balsam and were then observed and photographed with a Zeiss Axioscope A1 microscope using transmitted light.

## 3. SYSTEMATICS

Family: Malvaceae Jussieu s.l.

Subfamily: Tilioideae Arnott

Genus: *Craigia* W. W. Smith et W. E. Evans

Species: *Craigia* sp. (Fig.1)

**Type stratum:** Changchang Formation, early Eocene-early late Eocene.

**Locality:** Changchang Basin, Hainan Island, China.

**Repository:** Museum of Biology, Sun Yat-sen University, Guangzhou, China.

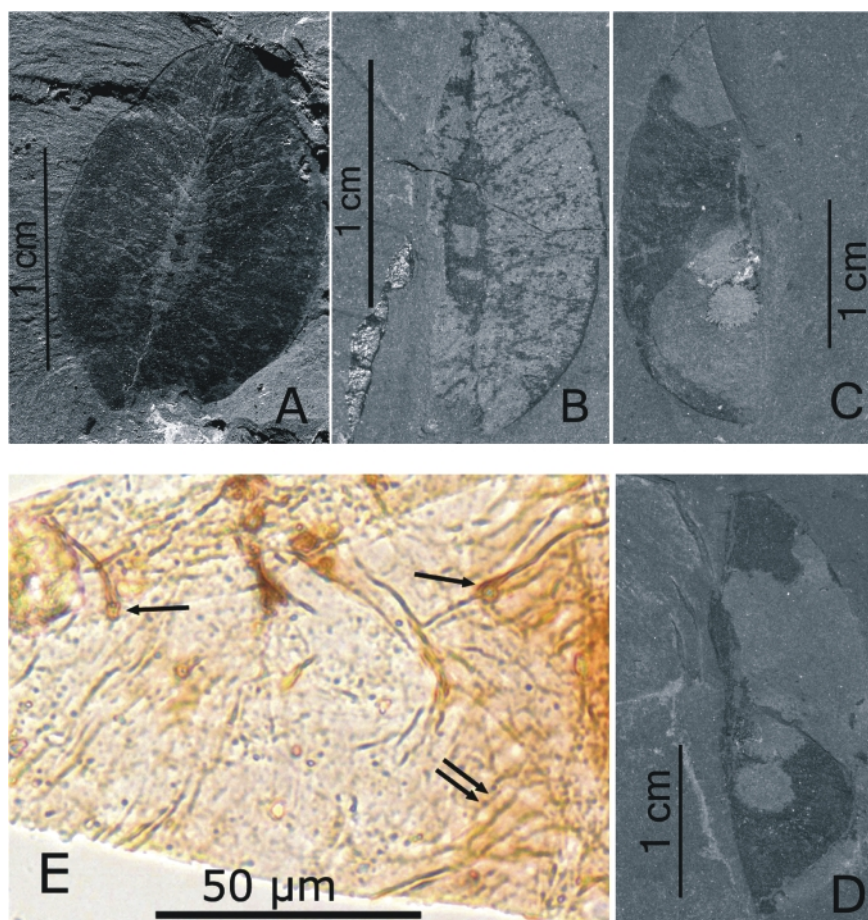
**Description:** Detached fruit capsule valve oval, 18–30 mm long, 11–22 mm wide, with subobtuse apex and blunt base. No terminal projection is found. The valve possesses a distinct median suture line and a well defined fusiform central locular area (about 8–14 mm long and 2–4 mm wide). The venation of the valve radiates outward, with dichotomizing veins extending to the margin, forming a reticulum. As to the quality of preservation, only several epidermal cells can be discerned from the cuticles. The cells of the locular area are prosenchymatous, about 10  $\mu\text{m}$  in length and 3–4  $\mu\text{m}$  in width. Locule walls are covered with solitary trichomes which have a length of about 40–50  $\mu\text{m}$ .

**Comparisons:** The fruits of the specimens are obviously different from *Craigia hainanensis*, with their wings 2 to almost 3 times larger than *C. hainanensis* (which is 11 mm in width, and 10 mm in length) and their shape much narrower than *C. hainanensis*. The fruit size of the specimens is similar to *C. bronnii*, *C. oregonensis*, *C. yunnanensis* and *C. kwangsiensis*, and they also bear a certain resemblance to the latter in shape although some differences exist between them (Table 1). As the differences are not distinctive enough and more detailed characters are needed to identify them to a species, we presently favor the use of open nomenclature, *Craigia* sp. Table 1

compares the fruit characters of the extant and fossil species of *Craigia*.

#### 4. DISCUSSION

According to the published record, the earliest occurrences of *Craigia* are known from Paleocene strata of Sakhalin Island and the Kamchatka Peninsula (Gladenkov et al., 1997; Kodrul, 1999; Kvaček et al., 2005; Budantsev, 2006). Fossils of *C. ore-*



**FIGURE 1:** Detached capsule valves and anatomy of *Craigia* sp. from the Eocene of Hainan Island, South China. A. Part (CC993a). B. Counterpart (CC993b). C. Part (CC994a). D. Counterpart (CC994b). E. Cuticle from the locule wall (CC993b), showing prosenchymatous cells of the epidermis (indicated by double arrow) and solitary trichomes (indicated by arrows). The specimens are currently deposited in the Museum of Biology, Sun Yat-sen University, Guangzhou, China.

<i>Craigia</i> species	shape	width (mm)	length (mm)	base	tip
<i>C. sp.</i>	oval	11–22	18–30	blunt	subobtuse apex without terminal projection
<i>C. bronnii</i>	elliptical	7–18	9–24	round or subcordate	emarginated apex without or less commonly with terminal projection
<i>C. oregonensis</i>	elliptical	12–33	15–30	round or subcordate	emarginate apex with terminal projection
<i>C. hainanensis</i>	round	11	10	cordate	emarginate apex without projection
<i>C. yunnanensis</i>	elliptical	25–30	35	round	round apex with terminal projection
<i>C. kwangsiensis</i>	elliptical	20–24	25–30	truncate	truncate or round apex with terminal projection

**TABLE 1:** A comparison among fruits of fossil and extant *Craigia* species

*gonensis* were widespread in the Eocene of North Korzokia, the Penzhinskaya estuary, Japan, south and west Primorye, North Korea, China, Kazakhstan, and North America. In Europe, however, fossils of *Craigia brononii* were mainly found in Miocene and Oligocene strata (Bužek et al., 1989; Kvaček et al., 2005). Based on the fossil evidence, Kvaček et al. (2005) concluded that *Craigia* originated in high latitude areas of northeast Asia in the Paleocene, and then spread westward to Siberia and Spitsbergen, eastward via Beringia to North America, and southward along the coast to East Asia during the Eocene greenhouse period.

*Craigia hainanensis* from the Eocene of Hainan Island further expanded the known distribution of the genus and suggested that it had reached its center of modern distribution in South China not later than in the early late Eocene (Jin et al., 2009). The specimens reported here appear different from *C. hainanensis* (although they cannot be identified to species level), indicate that at least 2 *Craigia* species may have lived in the area of Hainan Island during the Eocene and provides further evidence supporting the view of Jin et al. (2009).

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WeiQiu LIU<sup>1)</sup>, XiaoYan LIU<sup>1)</sup>, DaFang CUI<sup>2)</sup> & JianHua JIN<sup>1)</sup>

<sup>1)</sup> Guangdong Key Laboratory of Plant Resources, and School of Life Sciences, Sun Yat-sen University, Guangzhou, 510275, China;

<sup>2)</sup> College of Forestry, South China Agriculture University, Guangzhou 510642, China;

<sup>\*)</sup> Corresponding authors, lssjhh@mail.sysu.edu.cn, cuidf@scau.edu.cn

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