Sagaria cilentana gen. et sp. nov.—A New Angiosperm Fructification from the Middle Albian of Southern Italy

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ABSTRACT

A single specimen of a new fossil angiosperm, Sagaria cilentana gen. et sp. nov., has been recovered from limestones of the “plattenkalk” of the Middle Albian at Monti Alburni, near Petina, Campania, Italy. Associated fossils include Pagiophyllum sp., Podozamites sp. and Zamites sp. The angiosperm has a main axis approximately 8 cm long with three attached leaves and a distal cyme bearing three fructifications. The fructifications display divided distal tips indicating three - four lobes. Four cm from the base, underneath the main axis, there is a lobed structure, presumably a leaf. An unattached leaf near the specimen is in a position that suggests that it comes from the same plant. The leaf has an elongate petiole, obtuse base and on the right side of the lamina are three lobes. Affinities are uncertain but show similarities in overall morphology to basal eudicots, especially Ranunculaceae.

1. Introduction

Few Cretaceous age angiosperms have been reported from Italy. Late Cretaceous angiosperm leaves and seeds of uncertain affinity have been described from the Venetian Alps in northeastern Italy (Gomez et al., 2002) and a leaf ascribed to Sapindopsis has been described from the Middle Albian of the southern Apennines (Bravi et al., 2004). The present study describes a newly discovered angiosperm fructification from the Albian of southern Italy. A single specimen has been recovered from fine-grained limestones of the “plattenkalk” of the Middle Albian at Monti Alburni near Petina, province of Salerno, region of Campania, Italy. This is the first discovery of a fossil angiosperm fructification from this region and represents the oldest angiosperm megafaunal as described from the Italian peninsula. This fossil also provides new information about basal eudicot angiosperms.

2. Geological setting and methods

The specimen comes from the “plattenkalk” locality of Monti Alburni that is located approximately 1.5 km SSW of the town of Petina [Fig. 1; circa 40° 31’ 18” N 15° 22 05” E; I. G. M. sheet 198, I SE–Auletta; 1:25.000], in the Provence of Salerno in Campania, Italy (Bravi and Garassino, 1998). Plant fossils are found within thinly laminated limestones and dolomite-limestones termed “plattenkalk” (Fig. 2). In addition to abundant invertebrate and vertebrate remains (mainly decapod crustaceans and fishes), frequent plant remains are also encountered, including Pagiophyllum sp. and Brachyphyllum sp. (Barone Lumaga et al., 2005; Fig. 3A), and Podozamites sp. and Zamites sp. (Bravi and Garassino, 1998). The depositional environment of the strata at this locality is interpreted as a strongly restricted, shallow lagoonal area not far from land, with upper subtidal-intertidal conditions; it evolves upward to more subtidal marine conditions into a limited carbonate platform lagoonal environment (Bravi and Garassino, 1998).

The specimen was studied by light microscopy and photographed under visible and ultraviolet (λ = 312 nm) spectra. Ultra-violet photography was done using a Transilluminator Lourmat UV TFX-20 M.

3. Systematic paleobotany

Order: aff. Ranunculales Lindley 1833
Family: aff. Ranunculaceae Jussieu 1789
Genus: Sagaria gen. nov.
Derivation of Name: Sagaria is named in honor of the collector of the specimen; Giovanni Sagaria.

Type species: Sagaria cilentana sp. nov.

Generic Diagnosis. Angiosperm, axis with leaves and fruits. Leaves lobate, petiolate. Distal tips of foliar lobes mucronate. Inflorescence cymose. Fruits borne by an elongate peduncle, on an expanded cup-shaped recepticle, up to 1.1 cm long, and 0.6 cm wide and composed of at least three follicles with a maximum width of 3 mm and partially fused in their basal three-quarters. Distal tips of the follicles mucronate.

Derivation of specific epithet. From the area, Cilento, in which the specimen was found.

Holotype. Specimen 301a housed at Museum of Paleobotany and Ethnobotany, at Orto Botanico University of Naples, (Fig. 3 A) [part] and specimen 301b housed at the Paleontology Museum of Magliano Vetere (Cilento National Park), Provence of Salerno (Fig. 3B) [counterpart].

Type locality. Monti Alburni locality located approximately 1.5 km SSW of the town of Petina [Fig. 1; circa 40° 31′ 18″ N 15° 22′ 05″ E; L. G. M. sheet 198, 1SE–Auletta; 1:25,000], in the Provence of Salerno in Campania, Italy.

Type Stratum. “Plattenkalk” at Monte Alburni (Bravi and Garas-sino, 1998).

Age. Middle Albian.

Material. The species is represented by a single specimen preserved as part and counterpart of a coalified compression.

Sagaria cilentana sp. nov.

Figs. 3–5

Specific diagnosis. Characteristics as for the genus.

Description of specimen

The specimen consists of a main axis with four attached leaves and a distal cyme bearing three fructifications. The specimen is approximately 8 cm long, with the main axis about 1.75 mm wide and remaining at a relatively uniform width. In addition, there is a detached leaf that is clearly derived from the specimen. The specimen displays five nodes (Fig. 3A,B). The disposition of the nodes indicates an alternate or helical arrangement of appendices. The two most proximal nodes show axes that are broken off but at their bases are approximately the same diameter as the main axis of the specimen (Fig. 3A).

About 4 cm from the base of the specimen and lying underneath the main axis there is a lobed structure, presumably a leaf (Fig. 3A,B, 4G). It is quite folded and details of the morphology are difficult to discern.

Two small leaves are found in an axillary position approximately 0.5 cm from the insertion of a lateral appendage (Figs. 3A,B, 4D,H). These leaves are probably in early stages of development. Both leaves are lobate and about 2 mm long. One leaf, more clearly visible, displays three distinct lobes (Fig. 4H); at the apex of each lobe is a small, pointed tip (Fig. 4H arrow). Based on their position, these leaves could represent stipules or immature leaves of a small branch, however, the lack of such structures at other nodes indicates that these are leaves on a branch just beginning to develop.

In proximity to the specimen, part of a lobed leaf is visible on the matrix (Fig. 3A,B, 4D,E). The petiole of this leaf is not in direct connection with the main axis (Figs. fig3A, 4D,H); however, from the position of the petiole (Fig. 4H), and morphology of the leaf (Fig. 4D), it is highly probable that it comes from the same plant as the axis. The leaf has a petiole that is 4 mm long and about 0.5 mm wide. The broken base of the petiole matches the broken end of the adjacent appendage from the axis of the Sagaria specimen (Fig. 4D,H). The leaf shows an obtuse base, and on the right side of the lamina three lobes with deep sinuses are visible (Fig. 4E). Lobes are about 2 mm deep and 1.5 mm wide (Fig. 4D,E). At the apex of each lobe is a small pointed tip (Fig. 4D,E arrow). Primary venation is faint but medial (Fig. 4D). It is not possible to discern secondary venation, but the position of the lobes and the mucronate tip suggest a median secondary vein at a perpendicular angle to the
primary veins. The form of the leaf and broken petiole base strongly indicate that this leaf is from the *Sagaria* specimen.

At the distal end of the axis a dichasium subtended by a 5 mm long axillary bract bears three fructifications (Figs. 3A,B). One fructification is borne singly on what appears to be a continuation of the main axis (Fig. 3A), the other two are borne on a branching lateral axis, giving a cymose appearance to the specimen (Fig. 3A,B). The lateral axis is subtended by a leaf (Fig. 4I arrow) whose attachment was visible most clearly under ultraviolet light. The leaf is folded proximally and the lamina is partially obscured by the lamina of the detached leaf (Figs. 3A, 4I).

The first fructification is 1.1 cm long, and 0.6 cm wide (Figs. 3A,B, 4A). This fructification is borne on a pedicel 1 cm long and 1 mm wide that supports one enlarged, cup-shaped receptacle (Fig. 4A). Fine striations are visible on the pedicel proximal to the receptacle (Fig. 5A, lower arrow). Three follicles are visible (Fig. 4A, 5A,B). The follicles have a maximum width of 3 mm and are fused at their basal three-quarters. The tips of the follicles are mucronate (Fig. 4A, 5A,B). On the first fructification there is a single longitudinal line visible (Fig. 5A, upper arrow) on one of the lobes, especially on the counterpart (Fig. 5B, arrow). A similar line is also visible on the part, on another lobe (Fig. 5A, arrow). These lines appear to represent dehiscence slits. Because these putative dehiscence slits are seen only on part or counterpart suggests that they occur only on one face of the fruit wall. This further suggests that the fructification is composed of fused or partially fused follicles. At a distance of approximately 1.5 mm from the receptacle two linear structures appear in the illustrations (Fig. 4A) approximately 2.5 mm long that appear to be bract-like leaves. However, these structures are actually artifacts of the matrix fracture pattern from collection (Fig. 5A) and are not bracts.

The other two fructifications are of similar size and show only the outer surfaces (Figs. 3A,B, 4B,C). The distal tips are not as distinct in the matrix as the first fructification, but clearly display three, possibly four lobes (Fig. 4B,C). They are borne on a branching axis (Fig. 3A,B) with the first of the two fructifications borne nearly sessile; the other is on a pedicel about 0.5 cm long. The fructifications are inserted on an expanded receptacle that is 2.0 mm long and expands to 2.3 mm in diameter (Fig. 4F). One of the fructifications has basal markings that are suggestive of scars of other floral parts (Fig. 4F). There is no other evidence of a calyx or corolla present on the fossil.

### 4. Discussion

Because it is incompletely preserved, taxonomic placement of this fossil is somewhat problematic. One possibility is that it is a gnetophyte. However, the reproductive structures do not appear
to be paired, as occurs in Gnetales (Foster and Gifford, 1989; Krassilov and Bugdaeva, 2000) and the leaves are unlike any known gnetophyte, living or fossil, in phyllotaxy or morphology (Foster and Gifford, 1989; Taylor et al., 2009). The fossil does not closely resemble any other group with the exception of the dicotyledonous angiosperms.

The overall form of the fruit, the fruit’s position with respect to the receptacle, and possible scars of subtending organs indicate that Sagaria possessed a superior ovary. It is impossible to ascertain if the flower was perfect or imperfect, or if sepals, petals or either were present in the living plant. The degree of fusion of the fruit of Sagaria is also difficult to interpret, especially in light of the incomplete preservation of two of the three specimens preserved. The best preserved specimen shows a degree of fusion reflecting about ¼ of the distance from the base to distal tip. This may represent the actual developmental degree of fusion or may represent a stage in which all of the follicles were fused and as dehiscence occurred, the follicles separated from each other as occurs in a number of species (e.g., Anderberg, 2001: delpsta1.htm).

In the absence of cuticle, sepals, petals, stamens, clear scars of these floral parts or associated pollen, affinities of this fossil are problematic to ascertain. The general features of Sagaria, including a capsular fruit composed of at least three follicles and fruits borne in a cyme are most consistent with those of “basal” eudicots as outlined by APG (1998, 2003). Among the basal eudicots, specific affinities of Sagaria are not entirely clear, but shape, disposition, fusion and apparent mode of dehiscence of the fruit, apparent herbaceous habit, and lobed leaves are most similar to those seen in Ranunculales, especially Ranunculaceae (Cronquist, 1981) such as Delphinium (Moraldo et al., 1981; Anderberg, 2001). Certainly, fused fruits occur in other families such as the Trochodendraceae (Cronquist, 1981) but the overall form of the fructification is most similar to Ranunculaceae (Cronquist, 1981).

A number of fossil Ranunculaceae are known (see Pigg and DeVore, 2005). Among these are forms known from the Early Cretaceous, including Teixeiraedeflata (von Balthazar et al., 2005), a fossil similar to Thalictrum (Friis et al., 1994), Hyrcantha karatscheensis (Krassilov et al., 1983), H. decussatus (Dilcher et al., 2007), Achaenocarpites capitellatus (Krassilov and Volynets, 2008) and Ternicarpites floribundus (Krassilov and Volynets, 2008). Teixeiraedeflata is unisexualy staminate, while Sagaria is bisexual or unisexualy carpellate. Additional specimens of each species may permit more direct comparison.

Early Cretaceous fruits from the Famalicão and Vale di Agua localities in Portugal similar to Thalictrum (Ranunculaceae) are reported by Friis et al. (1994). These fruits clearly differ from Sagaria. The fruits reported by Friis et al. (1994) are about one-third the size of Sagaria and have marked longitudinal ribs in contrast to the lack of ribs in Sagaria.

Hyrcantha karatscheensis is known from the Middle Albian of Kazakhstan (Krassilov et al., 1983). The gynoeicum of H. karatscheensis possesses three or five free carpels and a persistent calyx is present. Leaves are pinnately compound (Krassilov et al., 1983). Sagaria differs from H. karatscheensis in that Sagaria has fused carpels, lacks a persistent calyx, and displays simple, lobate leaves.

Hyrcantha decussatus is known from the Barremian or Aptian of the Yixian Formation of China (Leng and Friis, 2003; Dilcher et al., 2007) and shows 3–4 carpels that are basally fused for about one-half of their length, but as in Sagaria, it is difficult to ascertain if the degree of fusion is due to development or dehiscence. The size of the carpels are similar, 1.25 cm long in H. decussatus and 1.1 cm in Sagaria, but the arrangement of fruits is decussate in H. decussatus (Leng and Friis, 2003; Dilcher et al., 2007) whereas they do not appear to be so in Sagaria. Further, an ocrea is reported at the nodes and base of the fruits in H. decussatus (Dilcher et al., 2007), a characteristic not present in Sagaria.

Achaenocarpites capitellatus and Ternicarpites floribundus were described from the Middle Albian of the Primorye Region of Russian Far East by Krassilov and Volynets (2008). Both are referred to Ranunculaceae, and are both known from whole or nearly whole plants that show a rhizomatous habit. Achaenocarpites is characterized by fruiting heads composed of 16 radially spreading achenes while Sagaria differs in fruit type and number of fruits per fruiting structure. A small leaf associated with Achaenocarpites is trilobed (Krassilov and Volynets, 2008) and similar in appearance to the small leaf attached to the axis of Sagaria. Ternicarpites is known from several branching axes with terminal fruits. The fruits are ternate follicles 6–8 mm long, showing a longitudinal keel of two parallel ridges and free to the base (Krassilov and Volynets, 2008). Fruits of Sagaria are larger, about 11 mm long, partially fused, and do not show a keel. Leaves associated with Ternicarpites are more deeply lobed than those of Sagaria, with the leaves of Ternicarpites appearing nearly pinnate (Krassilov and Volynets, 2008) while the leaves of Sagaria are more laminar.

In addition to leaves discussed above, a few angiosperm leaves from the Early Cretaceous also display a deeply lobed morphology as seen in Sagaria. One of these is Vitiphyllum Fontaine, (1889: Doyle and Hickey, 1976) from the Lower Cretaceous of eastern North America. Both the leaves associated with Sagaria and Vitiphyllum
are simple, lobed leaves but Vitiphyllum shows a greater degree and complexity of lobing than seen in those associated with Sagaria; there is probably little affinity between these genera. Another is the genus Araripia Mohr and Ecklund (2003). Sagaria differs from Araripia in that Sagaria leaves are more highly lobed and the venation in Sagaria is inferred to be at a more perpendicular angle. The base of the leaf attributed to Sagaria is similar to that seen in Ranunculus. Araripia is attributed to Lauraceae (Mohr and Ecklund, 2003).

Sagaria adds to the growing number of basal eudicots known from the Early Cretaceous flora. While the exact morphology and affinities of Sagaria are uncertain, its characteristics place it most closely with the Ranunculales. The great diversity displayed by Sagaria, Teixeiraea (von Balthazar et al., 2005), Thalictrum-like fossil (Friis et al., 1994),
Hyrcantha (Krassilov et al., 1983; Leng and Friis, 2003; Dilcher et al., 2007), Achaenocarpites, and Ternicarpites (Krassilov and Volynets, 2008) suggests that early radiation of ranunculoid eudicots was well underway during Early Cretaceous time.

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References