AN EARLY PERMIAN FLORA WITH LATE PERMIAN AND MESOZOIC AFFINITIES FROM NORTH-CENTRAL TEXAS

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ABSTRACT—Early Permian (late Leonardian Series) plant assemblages from King, Knox, and Stonewall Counties of North-Central Texas are dominated by seed plants, some apparently congeneric with taxa heretofore known only from the Late Permian or the Mesozoic. Conifers are the dominant elements, including one or more species of *Ullmannia, Pseudovolzia liebeana*, both known from the Late Permian Zechstein flora of Germany and England, *Podozamites* sp., characteristic of the Mesozoic, and *Walchia* sp., abundant in Early Permian floras. Locally common are *Tuaenipteris cf. eckardii*, a Zechstein species, an unidentified plant represented by pinnule-like laminae with fine parallel veins, similar to pinnules of some Mesozoic cycads, and calamite stems. Rarely encountered are leaf fragments of the Paleozoic ginkgophyte *Dictranophyllum*, flabellate ginkgophyte leaves, leaves with a broad midvein and narrow, filibrata lamina, and *Wattia*, typical of the Early Permian. Associated with these foliar remains are ovulate reproductive structures including the presumed cycad megasporophyll *Dioonocarpidium*, known only from the Mesozoic, a volitant cone scale similar to *Swedenborgia*, and a variety of seeds, some remarkably similar to *Agathis*, of Cretaceous age. The assemblage includes only rare scraps of foliage and seeds possibly attributable to the pteridophyllous elements (gigantopterids, callipterids, and ferns) that dominate the Permian. The fossil plants occur in multistorey, fining-upwards, tidal-channel deposits that also include pelecypods and fragmentary palaeoniscoid fish. The occurrence of derived lineages in xeric habitats during the Early Permian indicates that some supposed Mesozoic groups actually preceded and survived the end-Permian extinction, reappearing in basinal lowlands during the mid-Mesozoic.

INTRODUCTION

RECENT FIELD work in the Early Permian of North-Central Texas has produced plant assemblages that differ significantly from any Paleozoic floras known from Euramerica. Continental sediments of this area have long been recognized as a source of gymnosperm groups that would come to dominate most Mesozoic landscapes (Read and Mamay, 1964). However, previously reported Early Permian representatives of seasonally dry, gymnosperm-dominated floras appear to be primitive, and the emergence of the tropical seasonally dry flora is poorly understood. The new Early Permian material, which includes taxa heretofore known only from Late Permian and Mesozoic rocks, provides an enhanced understanding of late Paleozoic vegetational change and challenges existing hypotheses of plant evolution and paleoecology during the Permian and early Mesozoic.

The newly discovered flora was found at seven localities in the lower portion of the Pease River Group in King, Knox, and Stonewall counties, Texas (Fig. 1). Plants occur in association with locally abundant pelecypods and poorly preserved palaeoniscoid fish in copper-bearing, multistorey, fining-upward, tidal-channel deposits at or near the contact between the San Angelo Formation and the overlying Blaine Formation; the sedimentology and stratigraphy of these deposits have been described by Stroud et al. (1970) and Smith (1974). Although amphibian and reptile remains from the San Angelo Formation of this region have been attributed to the Guadalupian Series ( Olson, 1962), biostratigraphic correlations based upon marine invertebrates (fusulinids and ammonoids) between our study area and the Delaware and Midland Basins indicate that the San Angelo Formation and lower part of the Blaine Formation are late Leonardian in age (Böse, 1917; Plummer and Scott, 1937; Clifton, 1945, 1946; Skinner, 1946; Mear, 1984).

GEOLOGIC SETTING

The fossiliferous deposits reported here occur at or near the contact between the San Angelo Formation and the overlying Blaine Formation, both within the Pease River Group in King, Knox, and Stonewall Counties, Texas (Fig. 2). The San Angelo Formation, 20–40 m thick, is divisible into two members of roughly equal thickness. The lower is the Duncan Sandstone Member, which consists of light-colored crossbedded and ripple-laminated sandstone, and the upper is the Flowerpot Shale Member, which is largely red mudstone, containing thin bodies of channel-form sandstone and nodules and stringers of gypsum. The Blaine Formation is over 200 m thick, composed of interbedded mudstone, gypsum in beds up to 10 m thick, and has regionally traceable members of limestone and dolomite. The San Angelo-Blaine contact is gradational, but customarily is mapped at the base of the lowest bed of gypsum thicker than 30 cm. The lithostratigraphic interval of the fossiliferous deposits spans approximately 12 m in the transitional interval between the two formations. The Clear Fork Group lies immediately below the Pease River Group in the study area. The upper part of the Clear Fork Group on outcrop is dominantly red mudstone, which contains nodules, stringers, veins, and thin (a few centimeters thick) beds of gypsum, along with thin (a few centimeters thick) but laterally continuous beds of micritic dolomite.

All plant-bearing deposits occur in channel facies that originated as tidal channels within a coastal plain setting on the Eastern Shelf of the Midland Basin. In overall aspect, the upper San Angelo is dominated by gypsum-bearing red mudstones that have been attributed to tidal-flat depositional settings (Smith, 1974, 1976). The occurrence of numerous thick (>3 m) bedded gypsum deposits in the Blaine Formation has been interpreted to indicate origin in sabkha-dominated coastal plain environments (Jones, 1971; Jones and Henz, 1988). Paleosols in this interval range from immature protosols to well-developed vertisols that lack pedogenic carbonates, contain finely disseminated pedogenic sulfates within their matrix and along vertisol slickensides, and have poorly developed root structures. Preliminary analysis indicates that these paleosols developed under strongly seasonal climates (Neil Tabor, personal commun., 1998).

AGE OF THE PLANT-BEARING ROCKS

Skinner (1946) dated the San Angelo Formation as latest Leonardian on the basis of the fusulinid *Schubertella melonico* in limestone interbedded with San Angelo sandstones in drill holes; this fusulinid is known only from the upper half of the Leonardian. Skinner (1946) did not specify a location, but it is probably along...
the margin of the Midland Basin, given that the San Angelo Formation does not extend into the deep Midland Basin or the Delaware Basin. A limestone above the San Angelo in Ector County—what is now known as the Road Canyon Formation (Guadalupian)—served jointly, overlap only within the Guadalupian Series. Based on these various lines of evidence, it appears that the Blaine Formation is largely Guadalupian in age, but may include the latest Leonardian at its base (this cannot be ruled out; all fossiliferous carbonates lie above the plant-bearing interval). Therefore, the flora can be no older than Leonardian and no younger than Guadalupian and most likely is late Leonardian.

LOCALITY AND REPOSITORY INFORMATION

All specimens examined in this study are housed in the Paleobotanical Collections of the United States National Museum of Natural History, Smithsonian Institution. All illustrated specimens are housed in the Paleobotanical Type and Illustrated Collections under the USNM catalogue numbers cited in the figure captions. At the request of property owners, locality information is to the general collecting areas rather than exact sites. Collections were made at seven sites. These sites are listed below according to their occurrence from north to south in the outcrop belt of the lower Pease River Group. (Longitude and Latitude are for the middle of the indicated 7.5' USGS map quadrangle.)

1. Pyron Prospect (USNM 41399) Cedar Mountain 7.5' quad. Knox Co. TX; 33 33 45N 99 56 15W
2. Snake Den Tank
   A. Shooting Range (USNM 41386) Buzzard Peak 7.5' quad. King Co. TX; 33 33 45N 100 03 45W
   B. Log Jam (USNM 41426, 41644, 41645, 41646, 41648, 41658, 41659, 41660) Buzzard Peak 7.5' quad. King Co. TX; 33 33 45N 100 03 45W
3. Buzzard Peak (USNM 41384, 41391, 41392, 41394, 41395, 41396, 41397, 41398) Cedar Mountain 7.5' quad. Knox Co. TX; 33 33 45N 99 56 15W
4. East Taylor Pasture

FIGURE 2—Generalized stratigraphic column for the San Angelo and Blaine Formations and the lower Pease River floras, north central Texas. Chronostratigraphic sequence is shown on the left; lithostratigraphic sequence is shown on the right. Ranges of fusilinids (A and B) ammonoids (C through K) used in bracketing the age of the lower Pease River flora are shown in the center: A = Schubertiella melonica, B = Parafusulina fontanui, C = Perrinites hilli, D = Waagenoceras, E = Eumedlocottia burckhardti, F = Propinacoceras knighti, G = Medlicottia whitneyi, H = Pseudogastroceras texanum, J = Adriinites newelli, K = Agathiceras girtyi. Ammonoids C and F–K occur in the Blaine Formation, according to Clifton (1942). Their ranges are taken from Zhou et al. (1996), except for H, which has been identified in Roadian and Wordian rocks of West Texas by Clifton (1946, p. 558). *Date of Perno-Triassic boundary event, 251+/-0.3 ma at Meishan, China (Bowring et al., 1998). *Date at base of Capitanian, 265.3+/-0.2 ma in West Texas (Bowring et al., 1998). *Leaders Formation is part of the marine Albany Group, which is the upper unit in the southern lateral equivalent of the Wichita Group. *Date at Tri/β boundary 199.6+/-0.3 mybp, Kungur Island, Canada (Pálfi et al., 2000).
The Flora

Plant fossils of the lower Pease River flora are preserved mainly as compressions and coalescences. Included are partial remains of large trunks up to 33 cm wide and over 8 m long, variously disarticulated foliage, cones, and seeds. Cuticles are present on a few specimens; many without cuticles yield carbonaceous films that contain anatomical detail, such as placement of stomata. Despite incomplete preservation, we have recognized several taxa on the basis of gross morphology. Our taxonomic appraisal of the flora is detailed in Table 1.

Ribbons-like foliar organs.—The most prominent element in the lower Pease River flora is strap- or ribbon-like foliar organs. In several instances, these remains occur in abundance on single bedding planes and show distinct current-lineation patterns. Dimensions vary, but two forms can be identified based on gross morphology. We interpret these two forms to be taxonomically distinct.

One form may reach lengths of about 6.0 cm and widths of 0.5 cm. Some specimens are considerably wider, approaching 1 cm in width; others are much narrower and shorter. All have parallel sides with acute, tapered distal ends, and basal ends that terminate squarely, with no diminution of width. When visible, veins are fine, parallel and closely spaced. Many of the specimens are strongly falcate and appear to be pinnules rather than leaves (Fig. 3.1); they often have longitudinal wrinkles that appear to result from compression of a thick lamina. These falcate ribbon-like organs may be pinnules of a pinnately compound cycad-like frond. If pinnules, the square base suggests that the pinnules were inserted perpendicularly, rather than obliquely, and broke away by abscission, as seen in some modern cycads. Among the known fossil cycad-like foliar forms, is the genus Pseudovoltzia, reported from the Zechstein flora of the Late Permian and commonly from the Upper Permian and the dominant element of the Late Permian Zechstein flora (Schweitzer, 1986).

Voltzialean conifers also are represented by numerous cone-scale complexes (Fig. 5.8). These are bilaterally symmetrical fan-like structures characterized by a group of five to seven pointed scale-like units reaching 5.0 mm in length and attached to the end of a naked stalk up to 1.2 cm in length. The stalk is sharply truncated at the base, as though abscissed. Many examples also bear a single, somewhat rounded central lobe. Similar lobate cone scales from the Zechstein flora of England have been attributed to Pseudovoltzia (Stoneley, 1958; Clement-Westerhof, 1988). The overall aspects of the specimens also strongly resemble the form-genus Swedenborgia, originally described from the Lower Jurassic of Sweden (Nathorst, 1876), with occurrences elsewhere in Europe, Greenland, and Asia all of Early Mesozoic age. Swedenborgia consists of a loosely constructed ovulate cone that bears long stalks terminated in a deeply dentate, five-lobed cone-scale aggregate, each lobe of which bore one seed.

Possible araucarian conifers.—Winged seeds are a conspicuous element of some of the collections (Fig. 4.1–4.3). The specimens are flattened, ovoid to pyriform or narrowly triangular bodies measuring about 1.2 cm in length and 0.2 cm wide. The bottom (presumably micropylar) end may be pointed but more often
is bluntly rounded. The opposite (chalazal) end bears a pair of thin, wing-like appendages, positioned oppositely on the seed "shoulders" in the plane of the seed, which creates a V-shaped configuration. The wings are irregularly ovoid or orbiculoid in outline, usually with a slightly constricted base and outward flare, with a slightly curved upper edge and a more deeply rounded lower edge. The largest wing has dimensions of 1.2 by 1.0 cm. Beyond the basal, slightly thickened area of attachment, the wing tissue is thin with a faint indication of a venation pattern, approximately parallel to the long axis of the wing. The two wings of a given seed may be essentially equal in size, but more often are unequal. Several stages in size differential are present, with the most reduced individual wing represented only by a short, stubby outgrowth about 2.0 mm long.

Many modern conifers have winged seeds, but aside from the living araucarian genus Agathis, none produce paired, unequal wings similar to those of the material from the lower Pease River flora. The smaller wing of Agathis seeds (Fig. 4.4) varies among species from a slight hump in the seed outline to a well-defined outgrowth of the integument in most specimens (A. labillardieri); sometimes it forms a rigid point. The large wings on Agathis seeds are extremely thin and delicate and are proportionately nearly twice as large as those of the Permian fossils. Nonetheless, the similarities between Agathis seeds and lower Pease River fossils set them apart from all other conifers. In a recent review of the Araucariaceae, Stockey (1994), noted that Agathis is not known from strata older than Cretaceous. Thus, if further study of the lower Pease River seeds and associated remains prove to have an affinity with Agathis, the age of Agathis would be extended by roughly 100 m.y. to about 260 m.y.

At present, however, the affinities of the lower Pease River fossils are unclear. A single specimen was found in which a bunched winged seed was superimposed, perhaps accidentally, on a lobed cone scale similar to those typical of the Majonicaceae, a family in which she also placed Pseudovoltzia on the basis of distinct organization of cone-scale complexes and ovules. The cones of the Majonicaceae are usually single-seeded, solitary, uniovulate strobili, closely invested by a reduced ovuliferous scale with its five adnate component scales; the whole then rests on the adaxial face of its subtending bract. Nearly all lower Pease River flora seeds in this size class show a carbon-filled seam or crevice along their length suggestive of the junction between the inverted ovule and its stalk.

Walchia conifers.—Conifers attributable to Walchia or possibly Culmitzschia (Clement-Westhof, 1984) occur at several sites in abundance, although they are generally rare. Typically, these plants consist of axes clothed in short, sinuoidally curved, decurrent leaves up to 1 cm in length and 0.5 cm wide (Fig. 5.1). Stripped of leaves, stems are covered with elongate, diamond-shaped leaf scars. It is probable that some of the unattached winged seeds were produced by these plants.

Dicranophyllum and possible ginkgophyte foliage.—Several specimens consist of an elongate, narrow lamina that is forked, the lobes terminating either bluntly or in tapered acute ends (Fig. 3.5). All specimens are incomplete, although fragments vary from stems with attached leaves (Fig. 3.6) to terminal portions of forked leaves. Affinities of these specimens lie clearly with Dicranophyllum (Grand Eury, 1877), which is known from the Late Carboniferous of Euramerica, generally in association with xeromorphic vegetation. Leaves fork at least once and have sparse, strong veins that diminish in number with each dichotomy. It seems possible that some of the narrow, ribbon-like organs may be fragments of Dicranophyllum leaves, although they lack the prominent veins.

Rare fragments of foliage possibly attributable to ginkgophytes, also were found. These have broad, but terminally lobate laminae and open, dichotomous venation (Fig. 3.7).

Cycads.—Prior to this report, the cycadaceous megasporophyll Dioonotocarpidium was known only from the upper Triassic of Bavaria. It is characterized as a simple megasporophyll with a pinnate apex and a broad, undissected basal portion to which paired ovules are attached. It was first reported in 1928 by Lillie (1928) and Krässel (1949, 1953) subsequently described two additional species from the same area. The lower Pease River collection contains dozens of detached sporophyll fragments (Fig. 6.6–6.8), two of which have a single seed attached near their bases. They have a dense covering of short, stiff hairs, reminiscent of the megasporophylls of modern cycads (Fig. 6.8). The Texas specimens present no major morphological differences from the European material.

The present material does not permit certain identification of the sterile foliage of Dioonotocarpidium. However, laminae with parallel veins and a dense covering of short hairs (possibly linking

FIGURE 4—Plant fossils from the Early Permian lower Pease River Group, Texas. Scale bar in 4 applies to all elements and represents 1 cm. 1–3. Seeds of Araucarian aspect, similar to modern Agathis; 3 is a reversed image to allow easier comparison with 4, both at the same magnification. Seed body bears unequally developed wings. In 2, the seed is superimposed on a cone scale of Pseudovoltzia (see Fig. 5.8), USNM 508146, 508147, 508148. 4. Seed of modern Agathis for comparison. 5. Ullmannia sp., possibly U. frumentaria. Axis with broad leaves attached helically. Leaf surfaces have stomata arranged conspicuously in rows paralleling the long axis of the leaf, USNM 508149. 6. Ullmannia sp., bases of attached leaves on stem surface showing stomatal bands, USNM 508150.
them to *Dioonitocarpidium* also occur rarely. These vary in width and length and cannot be assigned unambiguously to any taxon; they resemble most closely fragments of wide *Taeniopteris*, but this seems unlikely given the lack of any specimens with a recognizable midrib.

Also occurring rarely are foliar fragments similar to cycad foliage. These leaves have wide midribs and narrow laminae that have parallel veins perpendicular to the midvein; the margins of these leaves are very difficult to uncover from the matrix and appear to be dissected into narrow lobes, each containing a single vein, again similar to the toothed margins of *Dioonitocarpidium* megasporophylls (Fig. 5.6, 5.9).

Other elements.—The remaining identifiable elements in the flora include *Taeniopteris* cf. *eckardtii*, a form known from the Late Permian Zechstein flora, characterized by a narrow lamina, 1.0 to 1.5 cm wide, bluntly rounded apices, strong midvein, lateral veins that branch close to the midrib or are unbranched, and form an angle of about 60 degrees with the midrib (Stoneley, 1958; Schweitzer, 1986) (Fig. 6.1–6.3). Calamites are rare at all but one site; they have weakly developed nodes and no foliage has been positively identified (Fig. 6.4). Also in the flora is *Watia* sp. (Fig. 6.9), a plant of uncertain affinities characteristic of the Early Permian (Mamay, 1967). Small fragments of strap-like foliage with parallel veins suggest the presence of cordaites, but this identification is tentative. Pteridophyllous elements in the flora are represented only by small scraps of foliage: a single pinnule was found reminiscent of fern foliage and several small fragments were recovered of laminar foliage with parallel, open dichotomous venation, not assignable to any taxa. A variety of unattributable seeds were recovered (Figs. 5.2, 5.3, 6.5, 6.10, 6.11). Strombili of likely conifer affinity also were found (Fig. 5.5), as were some organs similar to cone scales (Fig. 5.4). Rare, fragmentary specimens similar to *Taeniopteris* sp. also were encountered at several sites (Fig. 5.7); these often occur in association with the fragmentary frimbriate laminae associated with *Dioonitocarpidium*, and, thus, we reserve our taxonomic assessment.

**DISCUSSION**

Continental sediments of the Permian tropics record the change from ever-wet, pteridophyte-rich, coal-age rainforests to vegetation from seasonally dry environments, rich in the more advanced groups of gymnosperms that would dominate most Mesozoic landscapes (Read and Mamay, 1964; Frederiksen, 1972). The replacement of everwet lowland-wetland forests by gymnosperm dominated xeromorphic vegetation was globally synchronous, proceeding eastward from its first appearance in western North America (Knoll, 1984). Although Early Permian representatives of the seasonally dry flora include members of derived gymnospermous groups such as conifers, cycads, and peltasperms, these were still quite primitive when compared with their Mesozoic descendants. The evolutionary modernization of the tropical, seasonally dry flora, however, is poorly understood for several reasons. Late Permian fossil floras from the Eurasian tropics are few and paleogeographic coverage is limited (none are known from South America, for example); in China and eastern Russia, Late Permian floras share many genera with those from the Early Permian of North America, or, if preserved in coal beds, are similar to middle Carboniferous floras of Europe and North America (Guo, 1990). Similarly, Early Triassic tropical floras are few and are notably distinct from those of both the Permian and those of the later Triassic. The end-Permian extinction appears to have had a major, devastating effect on the ecological organization of lowland vegetation, leaving Early Triassic floras species-poor and dominated largely by opportunists (Retallack, 1995, 1997). More complex floras began to reappear in the Middle Triassic (Ash, 1994; Looy et al., 1999).

The lower Pease River flora is one of the youngest Permian floras yet discovered in North America. Still younger floras occur in the upper Pease River Group (Chaney et al., 1997) and the Del Norte Mountains of west Texas (Mamay et al., 1988). Compared to these younger floras, the Lower Pease River flora is quite diverse, including at least six orders, predominantly gymnosperms. The as-yet-undescribed Upper Pease River flora is quite limited in composition, with cordaitem material most conspicuous and minor representatives of calamites, gigantopterids, and pteridophyllous elements. The flora of the Del Norte mountains is species poor and dominated by the gigantopterid genus *Dehnoreia*, a flora possibly characteristic of coastal regions (DiMichele et al., 2000). The lower Pease River flora indicates that the radiation of major Mesozoic seed-plant-lineages was well advanced by the Early Permian. The transition from earlier Paleozoic vegetation, composed of lower vascular and primitive seed plants, to a seed-plant and fern flora typical of the Mesozoic was a multistage process that involved successive replacement of lowland forms by groups of species from progressively more remote, physically drier regions. In the tropics, this transition involved at least three distinct species pools. The first was the incumbent wetland flora with origins in the early Carboniferous. The second was an extrabasinal flora, the earliest evidence of which comes from reports of scrappy conifers in the Middle Pennsylvanian (Scott, 1974; Lyons and Darrah, 1989). The replacement of flora 1 by flora 2 began during the Late Pennsylvanian, when a few strikingly anomalous "Permian"-like assemblages appeared in lowland depositional environments, apparently during pulses of seasonal dryness (Cridland and Morris, 1963; Rothwell and Mapes, 1988; Winston, 1983; Broun et al., 1990; DiMichele and Aronson, 1992; Mamay, 1992). Such floras became increasingly common in the depositional lowlands during the Permian and eventually replaced the wetland vegetation, except in parts of China (Ziegler, 1990).

The lower Pease River flora is evidence of yet a third, more typical Late Permian and "Mesozoic" flora in low latitudes during the Early Permian. The occurrence of highly derived cycads and conifers is an indication that major centers of plant evolution, favoring the survival of the most novel morphologies, existed significantly earlier than previously known, likely in the more environmentally peripheral, stressful environments. Extreme drying of the basinal lowlands caused the constriction and possible migration of the incumbent lowland vegetation of flora 2 and permitted plants of flora 3, from environmentally peripheral areas, to move in. Rare Mesozoic elements have been described elsewhere in the Paleozoic, as part of the Late Permian Zechstein flora (Schweitzer, 1986) and from palynomorph records of...
Oklahoma (Wilson, 1962). Scraps of such plants have also been seen in still older floras in the mid-Leonidian of Texas (Mamay, unpublished data). However, the lower Pease River flora includes more such forms and earlier than described previously. The marine invertebrate record across the Permo-Triassic boundary is one of rapid, <1 m.y., extinction during which over 85 percent of known species did not survive (Bowring et al., 1998). This was followed by radiation of surviving forms into available ecospace. Even though terrestrial sequences thus far lack the temporal control and resolution found in the marine strata across the Permo-Triassic boundary, the lower Pease River flora makes it clear that the mechanics of the end-Permian event for terrestrial plants were very different from those of the marine invertebrates. If, as proposed by Retallack (1995, 1997), the Early Triassic lowlands were an ecological wasteland, elements of the Permian “Mesozoic” flora must have survived in peripheral areas until basinial conditions began to ameliorate in the Middle Triassic (Ash, 1994; Looy et al., 1999). This emphasizes the elusiveness of major evolutionary transitions in continental biotas, due to the poor representation of extrabasinal areas prior to the late Neogene (Pfefferkorn, 1980). It should discourage a direct, stratigraphic reading of evolutionary and biogeographic patterns from the continental stratigraphic record without strong consideration of palaeoecology.

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REFERENCES


FIGURE 6—Plant fossils from the Early Lower Pease River Group, Texas. Scale bar in 11 applies to all elements of this figure except 8. Scale bars in both 8 and 11 equal 1 cm. 1–3, Tenuipteris eckardtii, base, mid-section, and tip of leaf, USNM 508160, 508165, 508170. 4, Calamite stem, USNM 508162. 5, Phylaspermic seed with wide wing, USNM 508163. 6–8, Dioonocarpodium sp. megasporophyll. Area of seed attachment at base proximal to fimbriate, tapering terminal segment. Hairs covering surface are visible on 8, USNM 508164, 508165, 508166. 9, Wattia texana, organ of indentaneous affinity, USNM 508167. 10, Small, unwinged seeds possibly attributable to Ullmannia. Seeds have a small groove running their length, USNM 508168. 11, Small, corolate seeds, USNM 508169.


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