Nanjinganthus: An Unexpected Flower from the Jurassic of China

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Geological background

Initially, what is now known as the Xiangshan Group was called the "Nanking Sandstein" by Richthofen in 1868. Liu and Zhao [1] thought that the Nanking Sandstein belonged to the Jurassic and renamed it the "Chung Shan Formation". Hsieh [2] subdivided the Chung Shan Formation into six units, namely, in ascending order, Huang Ma Ching Shale, Quartzitic Conglomerate, Tzu Hsia Tung Series, Lingkusssu Shale, Light Yellow Sandstone, Variegated Sandstone and Shale. Li et al. [3] found fossil plants including *Equisetites, Neocalamites, Cladophlebis, Otozamites, Pterophyllum, Dictyophyllum, Pagiophyllum, Baiera guilhaumatii*, and *Podozamites lanceolatus*. They also changed the "Chung Shan Formation" to "Xiangshan Layers", and regarded its age as being Early Jurassic. Sze and Chow [4] used the term "Xiangshan Group" for the previous "Xiangshan Layers", and this has been the convention followed ever since. The age of the Xiangshan Group has been thought by various authors to range from the Late Triassic to the Middle Jurassic. Ju [5] divided the Xiangshan Group into a lower South Xiangshan Formation and an upper North Xiangshan Formation, respectively. The standard section of the lower part of the Xiangshan Group (the South Xiangshan Formation, the Lower Jurassic) is 394 metres thick in South Xiangshan in Nanjing, and has yielded abundant fossil plants. The standard section of the upper part of the Xiangshan Group (the North Xiangshan Formation, the Middle Jurassic) is in North Xiangshan in Nanjing. It is 1005 metres thick, and has only yielded a few stem fossils [5]. Based on fossil plants, Cao [6] thought that the age of the South Xiangshan Formation could not be later than the Early Jurassic, and considering that the early Early Jurassic flora (in the middle and lower parts of the Guanyintan Formation in southwest Hunan) [7] is biostratigraphically below the South Xiangshan Formation, Cao [6] regarded the age of the Xiangshan Group as middle-late Early Jurassic.

The South Xiangshan Formation (lower part of the Xiangshan Group) has yielded abundant bivalve and plant fossils. Its outcrops are scattered in Jiangning, Longtan, and Zhenjiang (all in the suburbs of Nanjing). In these areas, the outcrops are well exposed and especially fossiliferous near the South Xiangshan and Cangbomen regions. The formation includes sandstones, siltstones, shales, carbonaceous shales, and coal seams. There are abundant plant fossils in the South Xiangshan Formation, and almost all of the plants in the Xiangshan Group are from this formation. Various authors have collected fossil plants of the Xiangshan Flora [5, 6, 8-12]. According to Cao [6, 11, 12], Wang et al. [8], and Ju [5], the Xiangshan Group includes at least 46 genera of plants and is very similar to the flora of the Hsiangchi Group in western Hubei. Cycadophytes (34%) dominate the flora, and ferns are the second most dominant group (20%), among which Dipteridaceae play an important role. Ginkgoales are also abundant (19%)[5]. The important and frequently observed taxa include *Hysterites, Selaginellites, Equisetites* cf. *lateralis, E.* aff. *multidentatus* Oishi, *E. sarrani* (Zeiller) Halle, *Neocalamites hoerensis* (Schimper) Halle, *N. dangyangensis* Chen, *Marattiopsis asiatica* Kawasaki, *M. hoerensis* (Schimper) Schimper, *Todites goeppertianus* (Münster) Krasser, *T. princeps* (Presl) Gothan, *Osmundopsis* Harris, *Cladophlebis denticulata* (Brongniart) Fontaine, *C. goeppertianus* (Münster) Krasser, *C. raciborskii* Zeiller, *Spiropteris* Schimper, *Phlebopteris polypodioides* Brongniart, *Danaeopsis* Heer ex Schimper, *Thaumatopteris pusilla* (Nathorst) Oishi et Yamasita, *Dictyophyllum nathorstii* Zeiller, *D. nilssonii* (Brongniart) Goeppert, *Clathropteris meniscioides* Brongniart, *Cl. platyphylla* Goeppert, *Cl. obovata* Oishi, *Coniopteris hymenophylloides* (Brongniart) Seward, *Thinnfeldia* Ettingshausen, *Augustiphyllum yaobuensis* Huang, *Scoresbya dentata* Harris, *Pterophyllum firmifolium* Ye, *Pt. propinquum* Goeppert, *Pt. subaequale* Hartz, *Nilssonia complicatis* Li, *N. orientalis* Heer, *N. minor* Harris, *N.* cf. *compta* (Schenk) Ye, *N.* cf.

polymorpha Schenk, *N. pterophylloides* Nathorst, *N.* cf. *saighanensis* Seward, *N. taeniopterioides* Halle, *N. parabrevis* Huang, *N. moshanensis* Huang, *Nilssoniopteris vittata* (Brongn.) Florin, *Ctenis* Lindley et Hutton, *Ctenozamites* cf. *ptilozamioides* Zhou, *C.* cf. *cycadea* (Berger) Schenk, *Cycadolepis corrugata* Zeiller, *Anomozamites* cf. *minor* Nathorst, *A.* cf. *major* (Brong) Huang, *A.* cf. *inconstans* (Goeppert) Schimper, *A. quadratus* Cao, *Tyrmia nathorstii* (Schenk) Yeh, *T. latior* Ye, *T. lepida* Huang, *T. susongensis* Cao, *Otozamites minor* Tsao, *Ot. hsiangchiensis* Sze, *Ot. mixomorphus* Ye, *Ot. tangyanensis* Sze, *Ptilophyllum hsingshanense* (Wu) Cao, *Pt. contiguum* Sze, *Pt. pecten* (Philips) Morris, *Hsiangchiphyllum trinervis* Sze, *Ginkgoites* cf. *tasiakouensis* Wu et Li, *G.* cf. *sibiricus* (Heer) Seward, *G.* cf. *magnifolius* Du Tiot, *Baiera* cf. *furcata* (L. et H.) Braun, *B. asadai* Yabe et Oishi, *B. guilhaumatii* Zeiller, *B. multipartita* Sze et Lee, *B.* cf. *gracilis* Bunbury, *Sphenobaiera huangii* (Sze) Hsu ex Li, *S. spectabilis* (Nath) Florin, *Czekanowskia rigida* Heer, *C. hartzii* Harris, *Phoenicopsis* Heer, *Ginkgodium* Yokoyama, *Desmiophyllum* Lesquereux, *Stenorachis* (Nathorst) Saporta, *Vittifoliolum multinerve* Zhou, *Pityophyllum longifolium* (Nathorst) Möller, *Podozamites lanceolatus* (L. et H.) Braun, *Ferganiella* Prynada, *Elatocladus* Halle, *Swedenborgia cryptomerioides* Nathorst, *Taeniopteris* cf. *richthofenii* (Schenk) Sze, *T. inouyei* Tateiwa, *Conites* and *Carpolithus*.

Materials and methods

The fossils studied here were collected from an outcrop of the South Xiangshan Formation at a quarry owned by the Xiaoyetian Cement Company Ltd. in the northeastern suburb of Nanjing, Jiangsu, China (N32°08′19″, E118°58′20″) (Fig. S1). Plant fossils from the formation have been extensively studied by various scholars [4-6, 8-12], and our collection from the local outcrop indicates that the fossil plants closely associated with *Nanjinganthus* constitute a flora dominated by Dipteridaceae (*Clathropteris*) and various cycadophytes (mainly *Nilssonia*, *Ptilophyllum*, and *Pterophyllum*), which is consistent with previous works. Some of these associated plant fossils are shown in Figs. S3-S4.

The specimens were initially photographed using a Sony ILCE-7 digital camera. The sediment covering the specimens was dégaged using a JUN-AIR pneumatic drill, and the details of the fossils were observed and photographed using a Nikon SMZ1500 stereomicroscope equipped with a Digital Sight DS-Fi1 camera. Organically preserved sepals and petals were processed with 40% peroxide for cuticle analysis according to routine methods, and the processed cuticles and organic materials of the sepals and petals were observed and photographed using the Rhod fluorescent light in a Zeiss Z2 Imager with an AxioCam HRc camera. Extended-focus images were generated using the Z-stack function in AxioVs40x64 V4.9.1.0. The removed cuticles were coated with gold and observed using a Leo 1530 VP scanning electron microscope (SEM), and serial pictures were obtained after the internal details of the flower were exposed through grinding with the pneumatic drill. One of the organically-preserved petals was embedded in resin and sectioned for light microscopy and transmission electron microscopy (TEM). One fragment of the distal portion of a flower embedded in sediments was observed by Micro Computed Laminography (Micro-CL) to show the dendroid style embedded in the sediments. All photographs were saved in TIFF format and assembled for publication using Photoshop 7.0.

Palynological assemblage

Preliminary analysis of the strata yielding *Nanjinganthus* has recognized abundant palynomorphs. The palynoflora includes *Alisporites robustus* Nilsson, *A.* sp., *Araucariacites* spp., *Cerebropollenites macroverrucatus* (Thiergart) Schulz, *Chamatosporites hians* Nilsson, *C.* spp., *Circulisporites parvus* (de Jersey) Norris, *Classopollis annulatus* (Verbitskaya) Li, *C. classoides* (Reissinger) Cornet & Traverse, *C. torosus* (Reissinger) Couper, *C.* spp., *Combaculatisporites* spp., *Contignisporites* sp., *Cyathidites australis* Couper, *C. minor* Couper, *C.* spp., *Cycadopites follicularis* Wilson & Webster, *C.* spp., *Deltoidospora toralis*, *Densoisporites* spp., *Dictyophyllidites mortonii* (de Jersey) Playford & Dettmann, *Gleicheniidites senonicus* Ross, *G. spp.*, *Inaperturopollenites* sp., *Klukisporites variegatus* Couper, *Manumia delcourtii* (Pocock) Dybkjær, *Osmundacites* sp., *Perinopollenites elatoides* Couper, 1958, *Podocarpidites* sp., *Polycingulatisporites triangularis* (Bolchovitina) Playford & Dettmann, *Quadracirculina* sp., *Quadraeculina anellaeformis* Maljavkina, *Retitriletes clavatoides* (Couper) Doering, Krutzsch, *Sestrosporites pseudoalveolatus* (Couper) Dettmann, *Sterisporites* sp., *Striatella seebergensis* Mädler, *Todisporites* spp., and *Vitreisporites pallidus* (Fig. S2)[13]. This palynological assemblage suggests a latest Early Jurassic age for *Nanjinganthus*.

Isotopic Dating

There was no previous isotopic age for the Xiangshang Group. We sampled the layers above the fossiliferous layers (Fig. S1b) and picked zircon grains for U/Pb dating. The zircon grains appeared to be reworked (Table S2), with ages ranging from 2738 Ma to 207 Ma(67 zircon grains with the concordance > 90% from 168 zircon grains) , and 207 Ma (2 zircon grains) is the youngest age（Figs. S1f-g）. Most of the zircon grains were of magmatic origin with oscillation internal belts and high Th/U values, implying a provenance of granitic rocks. So the upper limit age of *Nanjinganthus* is 207 Ma (the Late Triassic). Taking all dating information into consideration, we think that the age of *Nanjinganthus* falls in the scope ranging from 174 to 207 Ma and is close to the lower limit of the scope, namely, about 174 Ma (the latest Early Jurassic).

Eliminating alternative interpretations

The Mesozoic was an age of gymnosperms, so the Jurassic age of *Nanjinganthus* necessitates a comparison with common fossil gymnosperms. The potential candidates for *Nanjinganthus* include Caytoniales, Corystospermales, Ginkgoales, Czekanowskiales, Coniferales, Iraniales, Pentoxyales, Bennettitales, and Gnetales.

Caytonia is a very intriguing fossil plant that has been frequently compared with angiosperms [14, 15]. Regardless of its ultimate position, *Caytonia* can be easily distinguished from *Nanjinganthus* by its cupule with an adaxial basal opening, bilateral reproductive organs, and lack of both a dendroid style and foliar appendages in its reproductive organs.

Corystospermales is usually considered as a Mesozoic seed fern group, unlike *Caytonia*, the cupules in most Corystospermales open on the abaxial and are rarely compared with angiosperms [16]. Corystospermales can be easily distinguished from *Nanjinganthus* by their cupule which has an abaxial basal opening, bilateral reproductive organs, and by the lack of both a dendroid style and foliar appendages in the reproductive organs.

Ginkgoales diversified greatly during the Mesozoic, and unlike extant *Ginkgo*, the Mesozoic relatives of *Ginkgo* are well represented by their reproductive organs, which are composed of ovules in clusters [17]. Mesozoic Ginkgoalean leaves are lobately segmented and inserted on the short shoot borne on woody branches. Ginkgoales can be easily distinguished from *Nanjinganthus* by their clustered naked ovules, lobate leaves, woody growth habit, and lack of a dendroid style in the reproductive organs.

Cones in the Coniferales are usually penetrated by a central axis while the pedicel of *Nanjinganthus* terminates at the bottom of the reproductive organ. This difference alone is sufficient to distinguish Coniferales and *Nanjinganthus*.

Czekanowskiales are unique fossil plants restricted to the Mesozoic, but unlike the Ginkgoales, they have conspicuously narrow leaves arranged on a short shoot. Their reproductive organs are bivalvate cupules containing two rows of seeds. Czekanowskiales can be easily distinguished from *Nanjinganthus* by their bivalvate cupules, narrow leaves, woody growth habit, bilateral reproductive organs, and lack of both a dendroid style and foliar appendages in the reproductive organs.

Irania is the only genus of the Iraniales, which is assumed to have borne clusters of pollen sacs and fruits, from the Triassic-Jurassic [18]. Although no seeds have been observed in *Irania*, it is suspected to be an angiosperm. The female and male parts are not concentrated on the same axis, and do not constitute a flower-like structure, and it is unknown whether the ovules are enclosed. These features distinguish *Irania* from *Nanjinganthus*.

Pentoxylales are Mesozoic woody fossil plants characterized by a stem with five steles [16]. Their leaves are of the *Taeniopteris*-type, and the reproductive organs are cones with numerous naked orthotropous ovules/seeds helically arranged along the axes of their cones. Pentoxylales can be easily distinguished from *Nanjinganthus* by their cones without any foliar appendages, *Taeniopteris*-type leaves, woody growth habit, cones, and lack of a dendroid style.

Bennettitales are important Mesozoic gymnosperms that are frequently argued to be related to angiosperms [19, 20]. Their leaves are pinnate compound, and the reproductive organs are characterized by orthotropous ovules with micropylar tubes surrounded by interseminal scales, and these parts are helically arranged along the cone axis. Bennettitales can be distinguished from *Nanjinganthus* by their cones with ovules bearing micropylar tubes, compound leaves, woody growth habit, and lack of a dendroid style [16].

Gnetales are important gymnosperms that diversified once in the Mesozoic, among which *Gnetum* has leaves that are difficult to distinguish from eudicots [21, 22]. The most diagnostic feature of Gnetales is their decussate arrangement of leaves and cone parts, and their leaves are either eudicot-like or with parallel veins. Like Bennettitales, the reproductive organs of Gnetales are characterized by orthotropous ovules with micropylar tubes surrounded by scales. Gnetales can be distinguished from *Nanjinganthus* by their cones with ovules with micropylar tubes, leaves with pinnate reticulate or parallel venation, woody/lianaous/shrubby growth habit, and lack of a dendroid style.

There are several reports of Jurassic angiosperms, including *Schmeissneria*[23], *Xingxueanthus*[24], *Juraherba*[25], and *Euanthus*[26]. These genera are from the Middle-Late Jurassic of northeastern China. The presence of hypanthium, inferior ovary, and dendroid style distinguish *Nanjinganthus* from all these Jurassic peers, justifying *Nanjinganthus* as a new genus.

In short, *Nanjinganthus* has little relationship with any known extant and extinct gymnosperms. This conclusion, the identification of angiospermous structures, and its Jurassic age justify *Nanjinganthus* as a new angiosperm from the Jurassic.

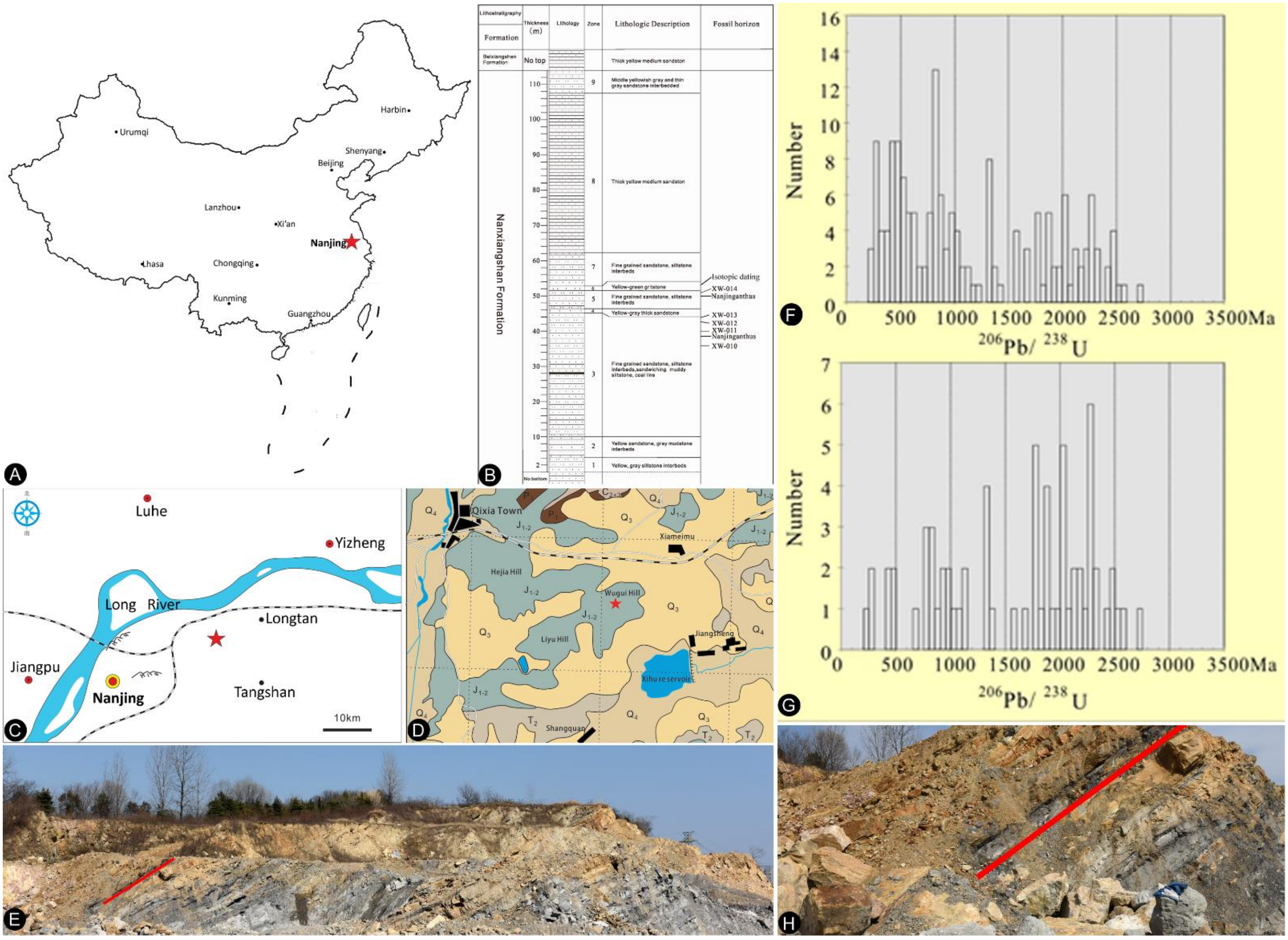

Figure S1 The type fossil locality of *Nanjinganthus*, Nanjing in China and isotopic dating.
A. Fossil locality (asterisk) in the suburb of Nanjing in eastern China. **B** Stratigraphic column showing the fossiliferous strata, strata for isotopic dating, and layers (XW010 to XW014) sampled for palynological dating**. C**. Type locality (red asterisk, N32°08′19″, E118°58′20″) of *Nanjinganthus* in the suburbs of Nanjing, China. **D**. Geological map of the region near the type locality, dark green represents the outcrop of the Xiangshan Group. **E**. Fossiliferous strata (red line) of the South Xiangshan Formation exposed in the quarry of Xiaoyetian Cement Company Ltd. Note one of the strata (red line) yielding many flowers of *Nanjinganthus*. **F-G**. Comparison of relative probability plot of zircon data (F: all data; G: concordance> 90%). **H**. Close-up of one of the *Nanjinganthus*-yielding layers (red line).

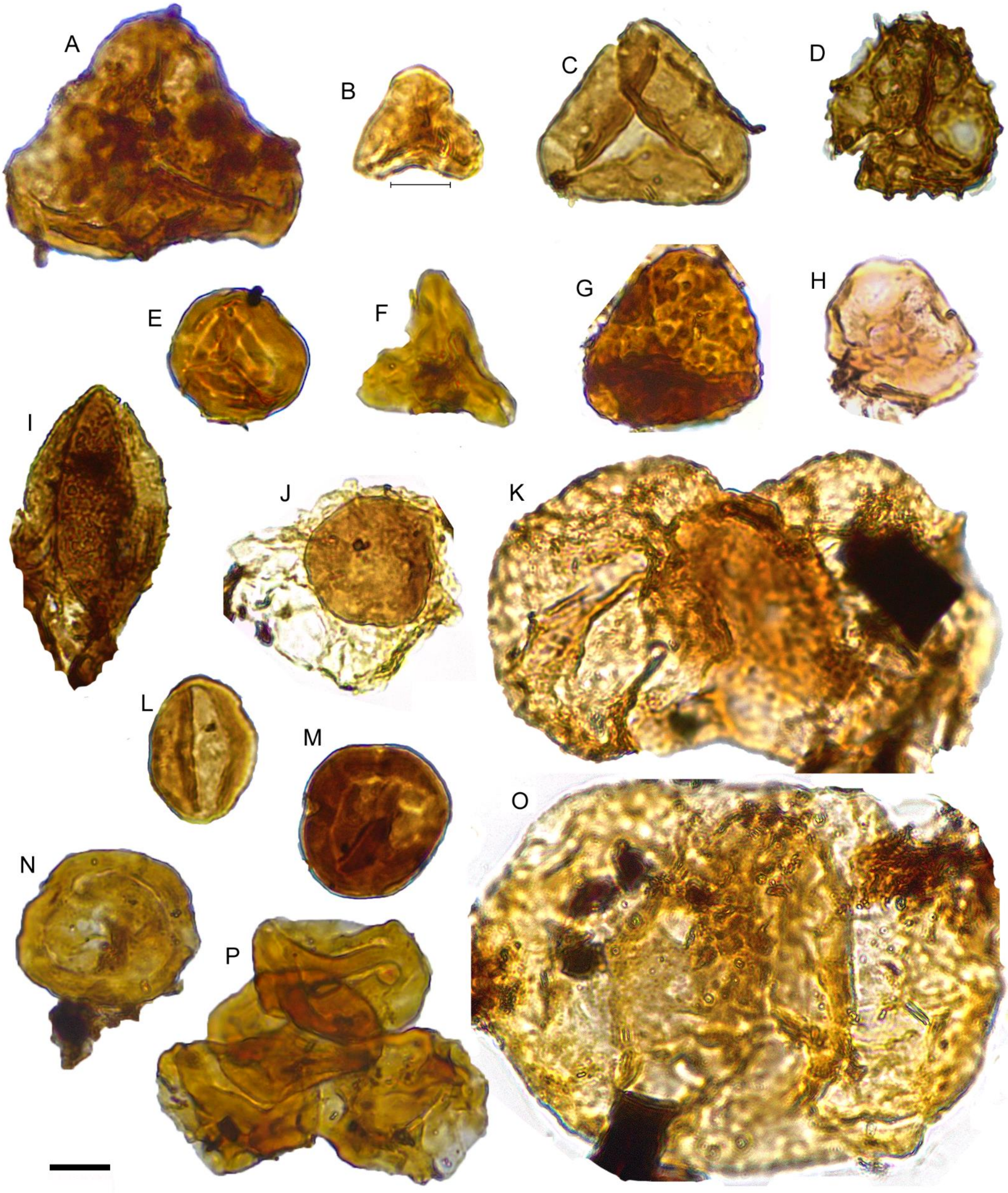

Figure S2 Frequently observed palynomorphs associated with *Nanjinganthus*. Bar = 10 μm.
A. *Cyathidites australis* Couper. **B**. *C. minor* Couper. **C**. *Deltoidospora* sp. **D**. *Retitriletes clavatoides* Döring. **E.** *Striatella seebergensis* Madler. **F.** *Gleicheniidites senonicus* Ross. **G.** *Manumia delcourtii* (Pocock) Dybkjær. **H.** *Anulispora* sp. **I.** *Cycadopites follicularis* Wilson & Webster. **J.** *Perinopollenites elatoides* Couper. **K.** *Platysaccus* sp. **L.** *Monosulcites* sp. **M, N.** *Classopollis* spp. **O.** *Alisporites robustus* Nilsson. **P.** Tetrad *Classopollis* sp.

Figure S3 Fossil plants associated with *Nanjinganthus*. Bar = 1 mm except otherwise annotated.
A. *Neocalamites horridus*. PB22234. Bar = 1 cm. **B**. Detailed view of the prickles on the stem surface of *Neocalamites horridus*. **C**. *Neocalamites*. PB22235. Bar = 1 cm. **D**. *Clathropteris meniscioides*. PB22245. Bar = 1 cm. **E**. Detailed view of the 4-order reticulate venation of *Clathropteris meniscioides*, enlarged from Fig. S3d. PB22245. **F**. Reticulate venation of *Clathropteris platyphylla*. PB22232. **G**. Two leaves of *Clathropteris meniscioides*. PB22233. Bar = 1 cm. **H**. Detailed view of the 4-order reticulate venation, enlarged from Fig. S3g. **I**. *Cladophlebis*. PB22214. Bar = 1 cm. **J**. *Coniopteris*. PB22244. **K**. *Nilssoniopteris vittata* with a robust midrib. PB22238. Bar = 1 cm. **L**. Detailed view of the smooth margin and lateral veins branching off from the midrib, enlarged from Fig. S3k. PB22238. **M**. *Cladophlebis*. PB22251. Bar = 1 cm. **N**. ?Hymenophyllaceae. PB22213. Bar = 5 mm. **O**. *Spiropteris*. PB22239. **P**. *Cladophlebis*. PB22219. Bar = 1 cm. **Q**. *Cladophlebis*. PB22217. Bar = 1 cm. **R**. *Raphaelia*. PB22233. **S**. *Otozamites*. PB22248B. **T**. *Otozamites*. PB22248B.

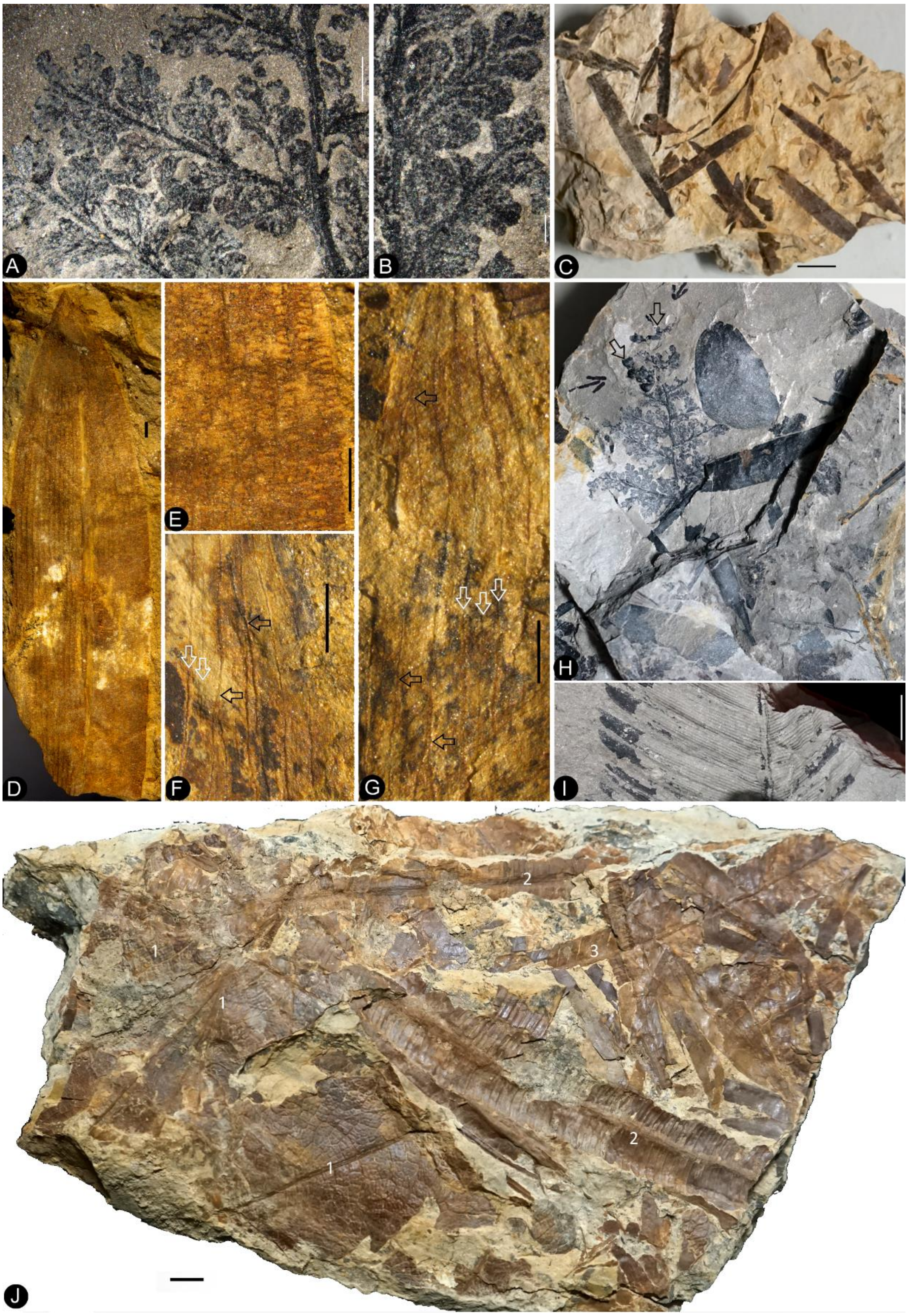

Figure S4 Fossil plants associated with *Nanjinganthus*. Bar = 1 mm except otherwise annotated.
A. Pinnae of *Coniopteris szeiana*, enlarged from Fig. S4h. PB22243. Bar = 2 mm. **B**. Detailed view of the pinnae of *Coniopteris szeiana*, enlarged from Fig. S4a. **C**. Leaves of *Desmiophyllum* on a slab. PB22231. Bar = 1 cm. **D**. A leaf of *Ferganiella* with midrib and parallel veins. PB22245. **E**. Detailed view of the parallel veins of the leaf in Fig. S4d. **F**. One of the leaves with at least two orders of longitudinal veins (white arrows) and occasional branching (black arrows), enlarged from Fig. S4g. **G**. A leaf closely associated with *Nanjinganthus* with parallel veins (white arrows) and occasional branching (black arrows). PB22241. **H**. Frond of *Coniopteris szeiana* associated with two *Nanjinganthus* (arrows). PB22243. Bar = 1 cm. **I**. *Ptilophyllum* showing pinnae with parallel venation. Bar = 1 cm. **J**. A slab loaded with fossils of *Clathropteris meniscioides* (1), *Nilssonia parabrevis* (2), and *Ptilophyllum contiguum* (3). PB22237. Bar = 1 cm.

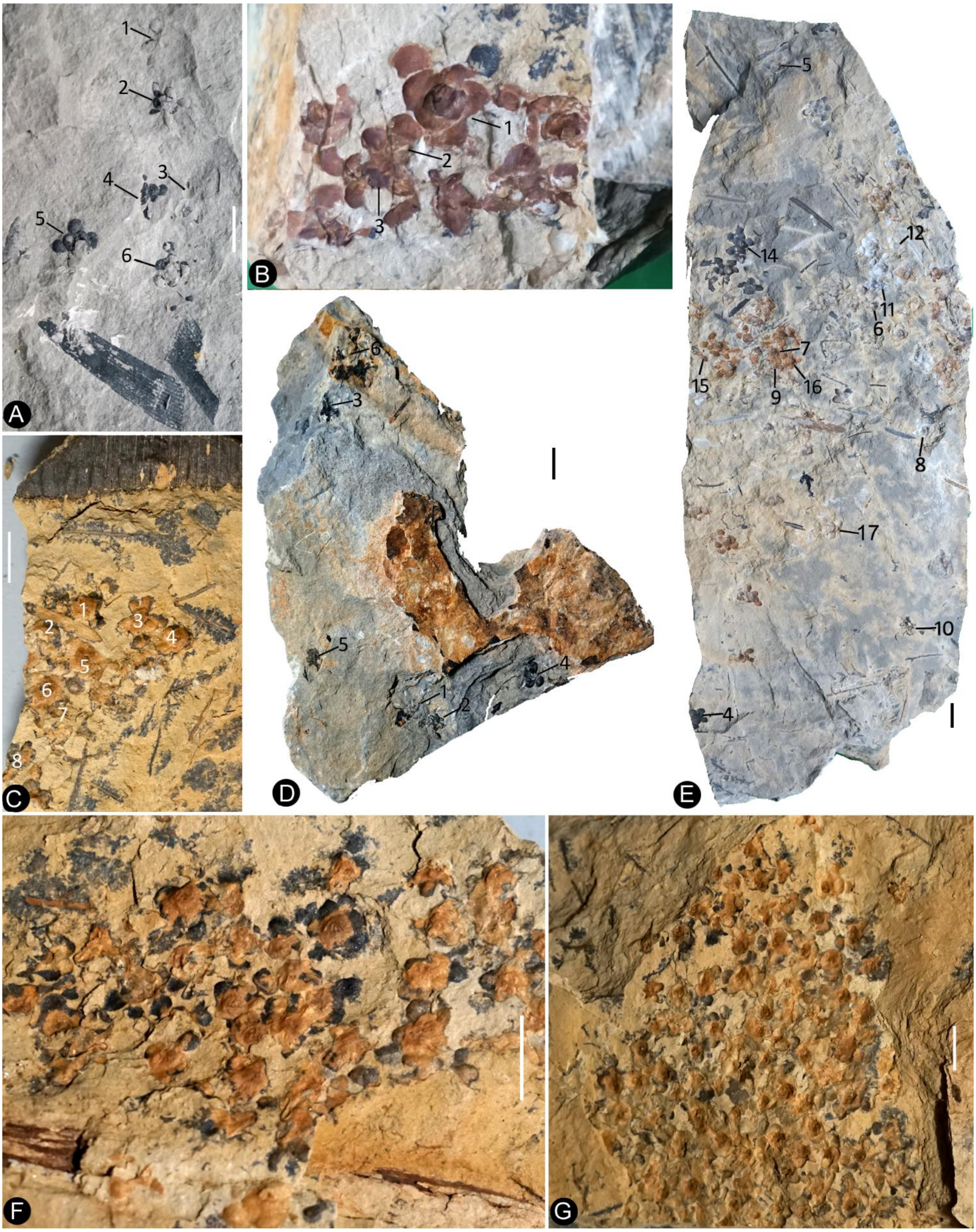

Figure S5 Siltstone slabs bearing *Nanjinganthus*. All bars are 1 cm long.
A. Six *Nanjinganthus* (1-6) on the same slab, and their associated triangular leaflet with parallel venation. PB22227. **B**. Several *Nanjinganthus* (1-3) on the same slab. 1-3 are shown in detail in Figs. 1f and 3d, e. PB22226. **C**. Several *Nanjinganthus* (1-8) on the same slab and the associated *Nilssonia parabrevis* (top). PB22220. **D**. Several *Nanjinganthus* (1-6) on the same slab. 1-3 are shown in detail in other figures. PB22224. **E**. Many *Nanjinganthus* on the same slab. The numbered flowers are shown in detail in other figures. PB22222a. **F**. A slab with numerous *Nanjinganthus*. PB22221. **G**. A slab almost completely covered with *Nanjinganthus*. PB22228.

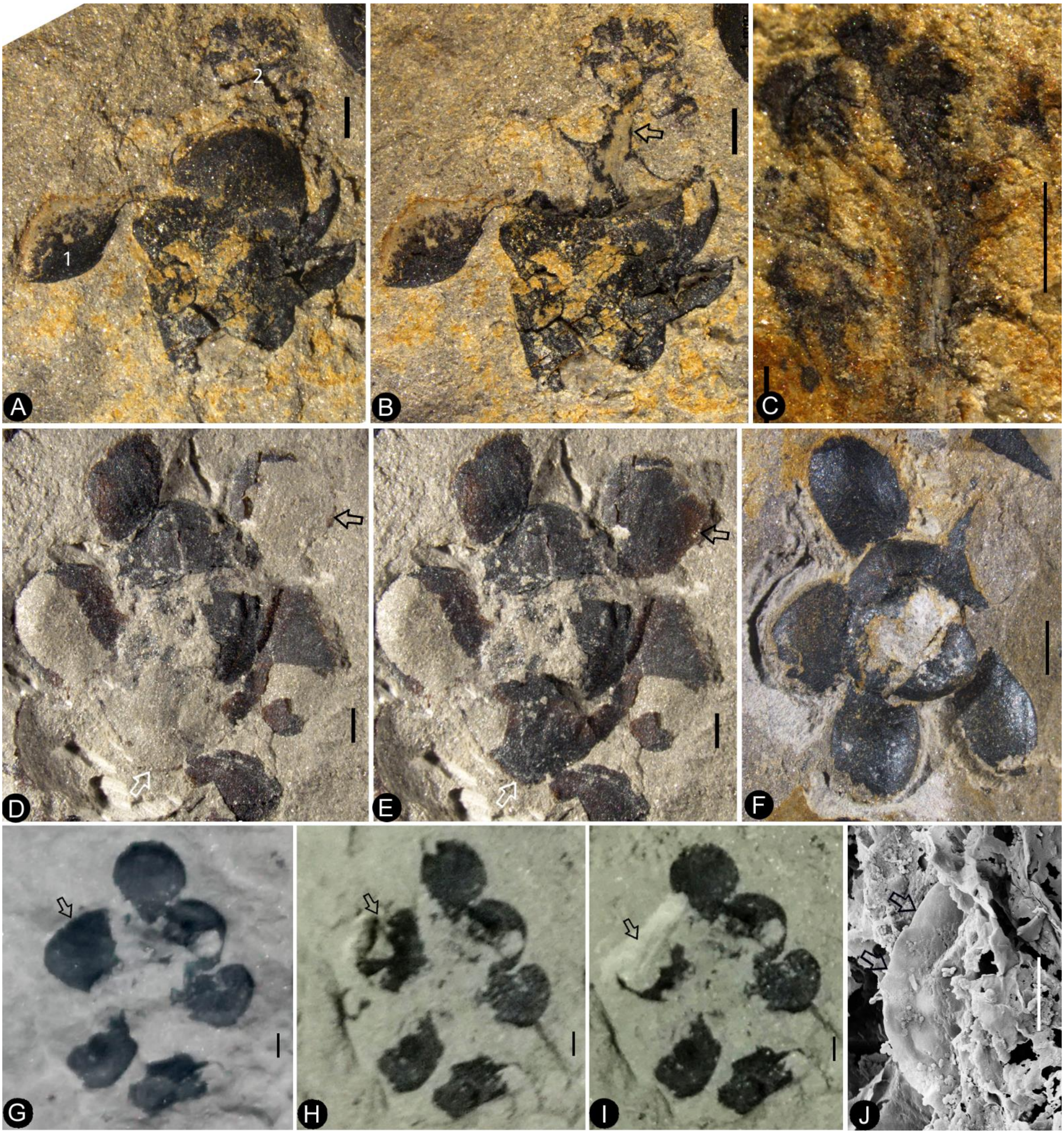

Figure S6 Individuals of ***Nanjinganthus*****. Bar = 1 mm except otherwise annotated.**
A. Flower 2 in Fig. S5d, showing the petal (1) and style (2) still embedded in the sediments. **B**. The same flower as in Fig. S6a, after dégagement, showing the exposed dendroid style (arrow). **C**. A style with lateral branches. PB22222a. **D-E**. The same flower after and before the organic material of the sepals (white arrows) and petals (black arrows) were removed for cuticle analysis. **F**. Bottom view of a flower before processing. Internal details are shown in Figs. 1e, j. PB22278. **G-I**. Serial images showing the position (arrows) of the possible stamen shown in Fig. 4i. This is Flower 4 in Fig. 1b. PB22223. **J.** A possible pollen grain half-embedded in the stamen shown in Fig. 4i. PB22223. Bar = 10 μm.

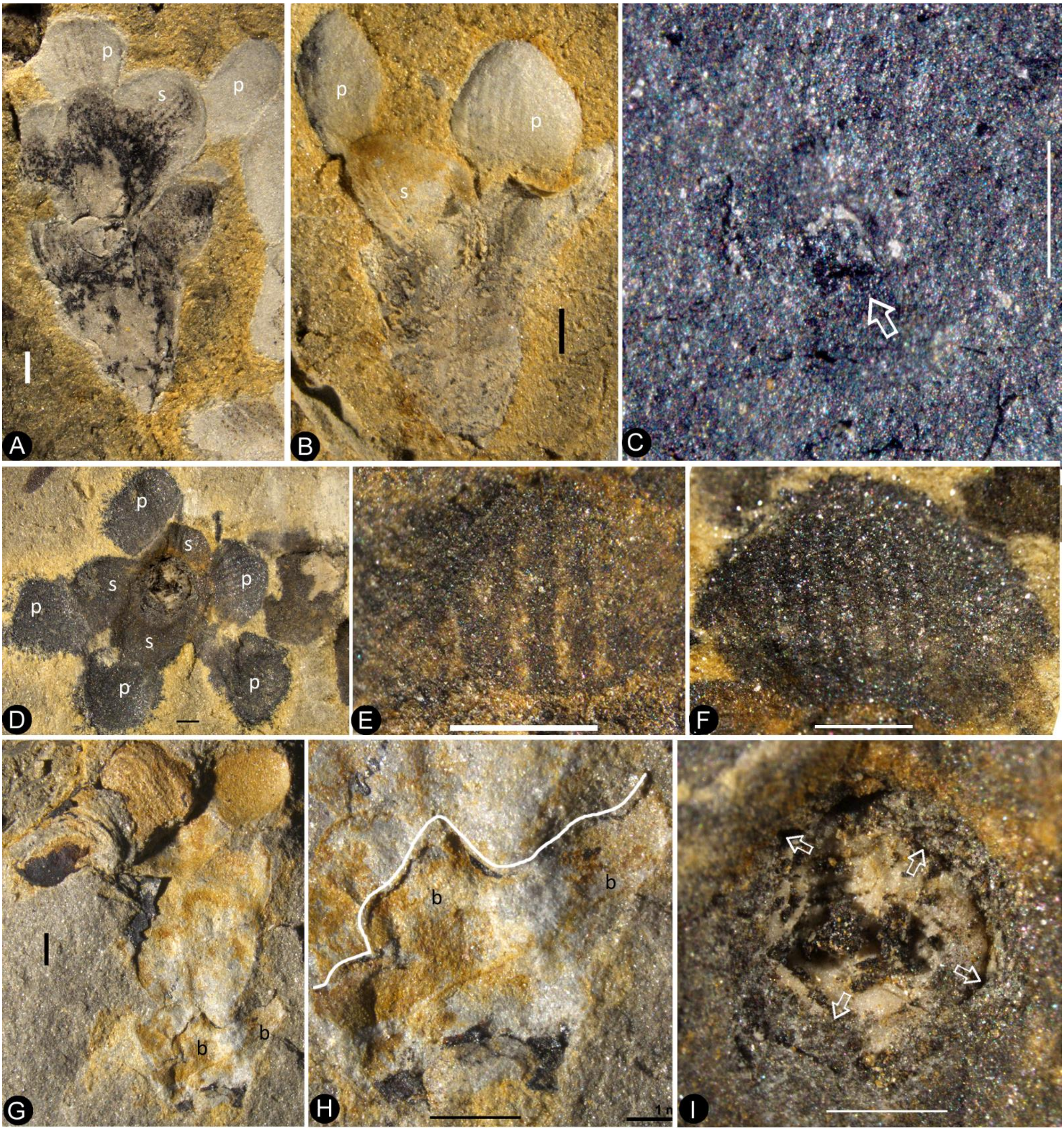

Figure S7 ***Nanjinganthus*** **preserved in various orientations and states. Bar = 1 mm except otherwise annotated.**
A. An oblique longitudinally split flower (No. 11 in Fig. S5e) with sepals (s) and petals (p). **B**. A longitudinally split flower (No. 12 in Fig. S5e) with sepals (s) and petals (p). **C**. Integral surface of an ovarian roof with a stub (arrow) left by a fallen-off style, from the flower in Fig. S8h. Bar = 0.5 mm. **D**. Bottom view of a flower (No. 14 in Fig. S5e) with three sepals (s) and five petals (p). **E**. One of the sepals in Fig. S7d, showing longitudinal ribs. **F**. One of the petals in Fig. S7d, showing longitudinal ribs. **G**. Side view of a flower, showing connate bracts (b) at the bottom. PB22229. **H**. Detailed view of the connate bracts (b) in Fig. S7g. Note the outline (white line) of the fused bracts. **I**. The locule surrounded by the ovary/receptacle wall (arrows) of the flower shown in Fig. S7d.

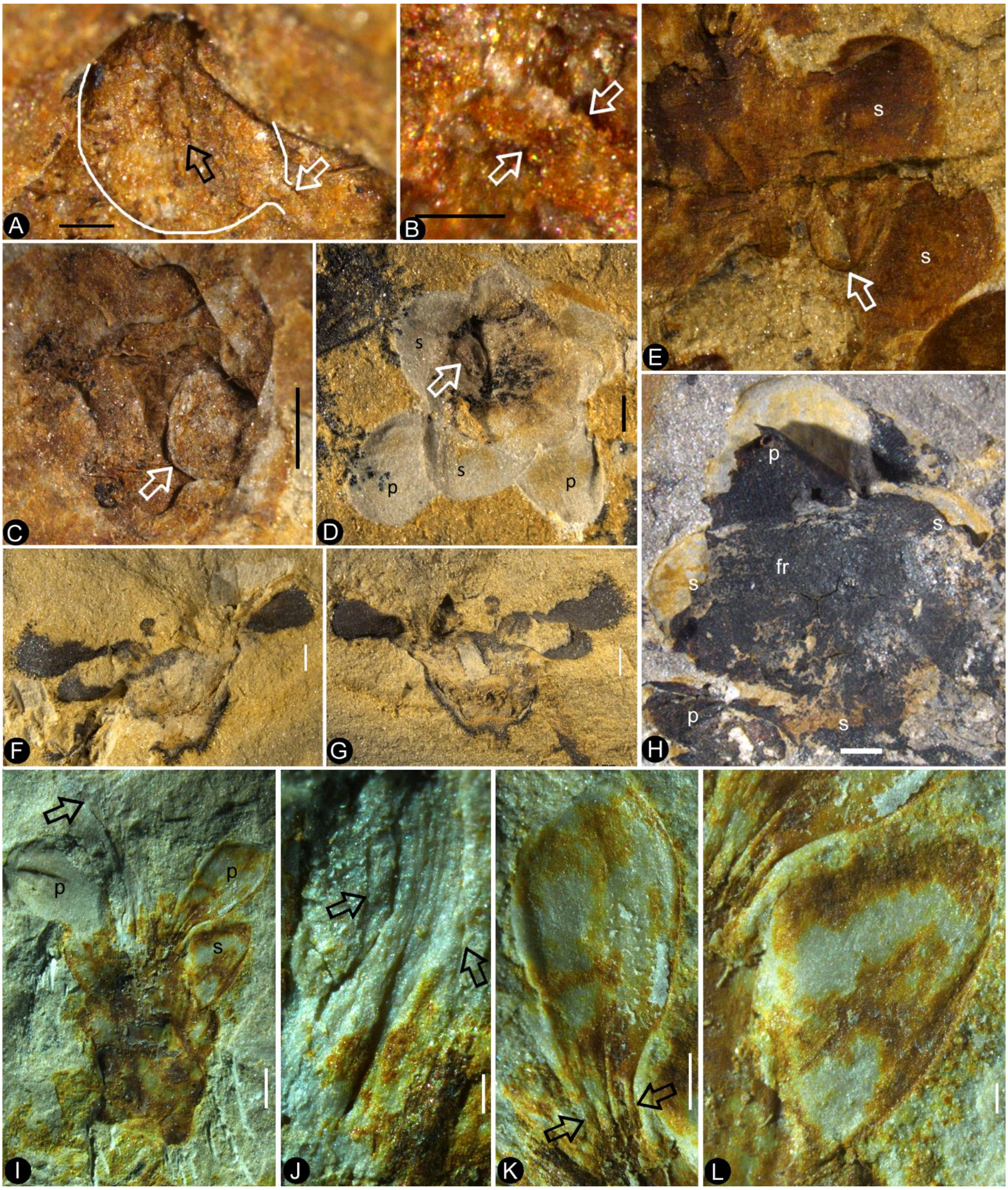

Figure S8 ***In situ*** **seeds and flowers. Bar = 1 mm except otherwise annotated.**
A. An ovule (outlined) inside the ovary of Flower 16 in Fig. S5e. Note the obovalmicropyle (black arrow) and funiculus (white arrow). Bar = 0.2 mm. **B**. Detailed view of the funiculus (between the arrows) of the ovule in Fig. S8a. Bar = 0.1 mm. **C**. An ovule/seed (detailed in Fig. 3i) inside the ovary of Flower 7 in Fig. S5e. **D**. An ovule (arrow) inside the ovary of Flower 8 in Fig. S5e. **E**. An ovule (arrow, detailed in Fig. 3d-e) inside the receptacle in Flower 2 in Fig. S5b. **F, G**. Two facing parts of the same flower (No. 10 in Fig. S5e). Note that the dendroid style is not visible in Fig. S8g but is visible in Fig. 3a after dégagement. **H**. Top view of a flower with organic-preserved sepals (s), petals (p) and ovarian roof (fr), which is detailed in Fig. S7c. PB22279. **I**. Side view of a longitudinally split flower with sepals (s), petals (p) and partially preserved style (arrow). PB22489. Bar = 1 mm. **J.** Detailed view of basal portion of the style (between arrows) arrowed in Fig. S8i. Bar = 0.2 mm. **K.** Detailed view of the right petal with narrowing base (between arrows) in Fig. S8i. Bar = 0.5 mm. **L.** Detailed view of a sepal in Fig. S8i. Bar = 0.2 mm.

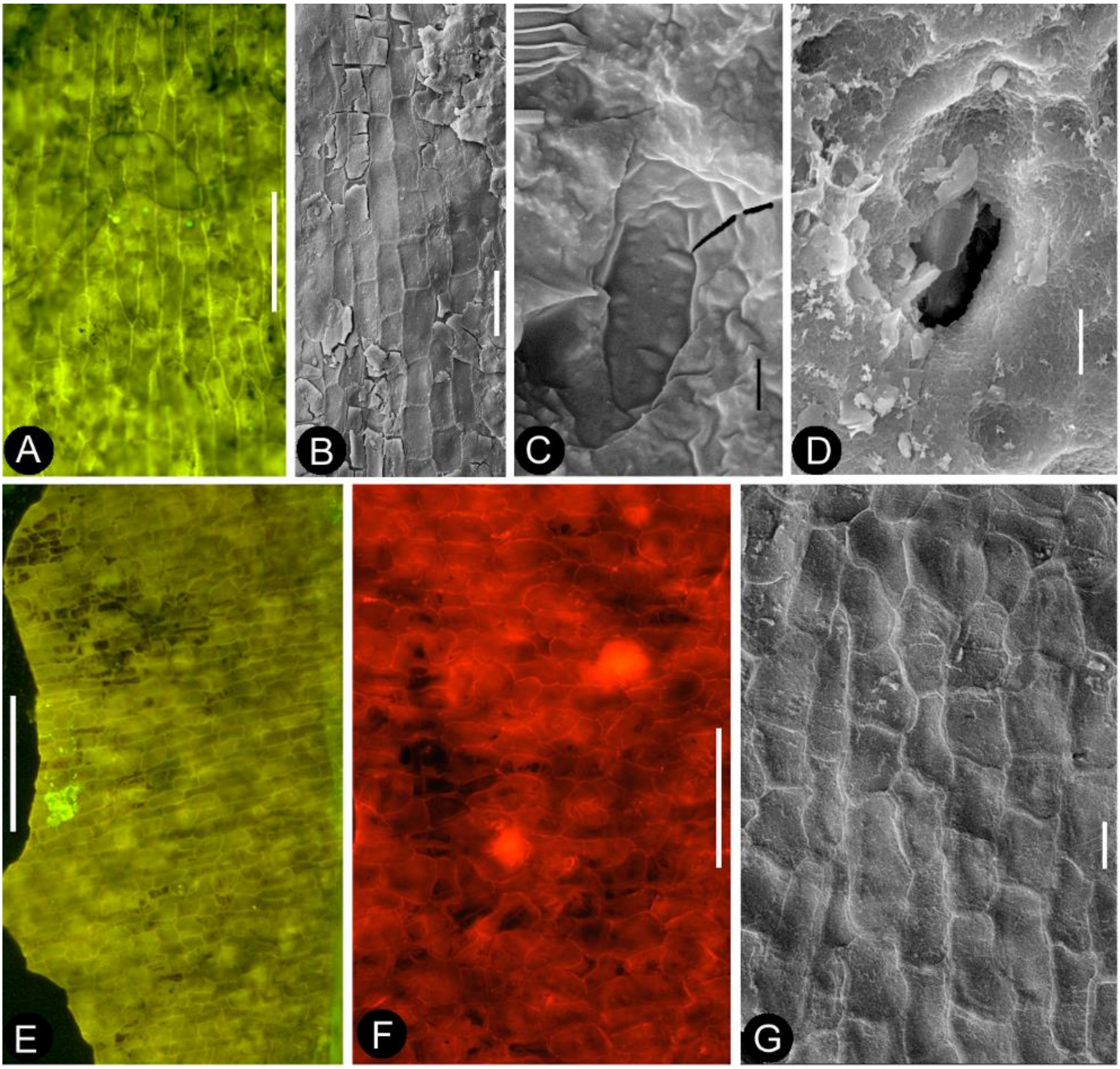

Figure S9 Cuticular details of *Nanjinganthus*. Fluorescence light microscopy except otherwise annotated.
A. Elongated epidermal cells in longitudinal files in the middle portion of the petal in Fig. 4b. Bar = 0.1 mm. **B**. Elongated epidermal cells on the rib of the petal in Fig. 4b. SEM. Bar = 50 μm. **C**. A possible stoma on the petal shown in Fig. 4b. SEM. Bar = 2 μm. **D**. Stoma on the bract of the flower in Fig. 1h. SEM. Bar = 5 μm. **E**. Elongated epidermal cells in files on the sepal of Flower 2 in Fig. 1b. Bar = 0.2 mm. **F**. Isodiametric epidermal cells on the sepal of Flower 2 in Fig. 1b. Bar = 0.1 mm. **G**. Isodiametric epidermal cells on the sepal of Flower 2 in Fig. 1b. SEM. Bar = 20 μm.

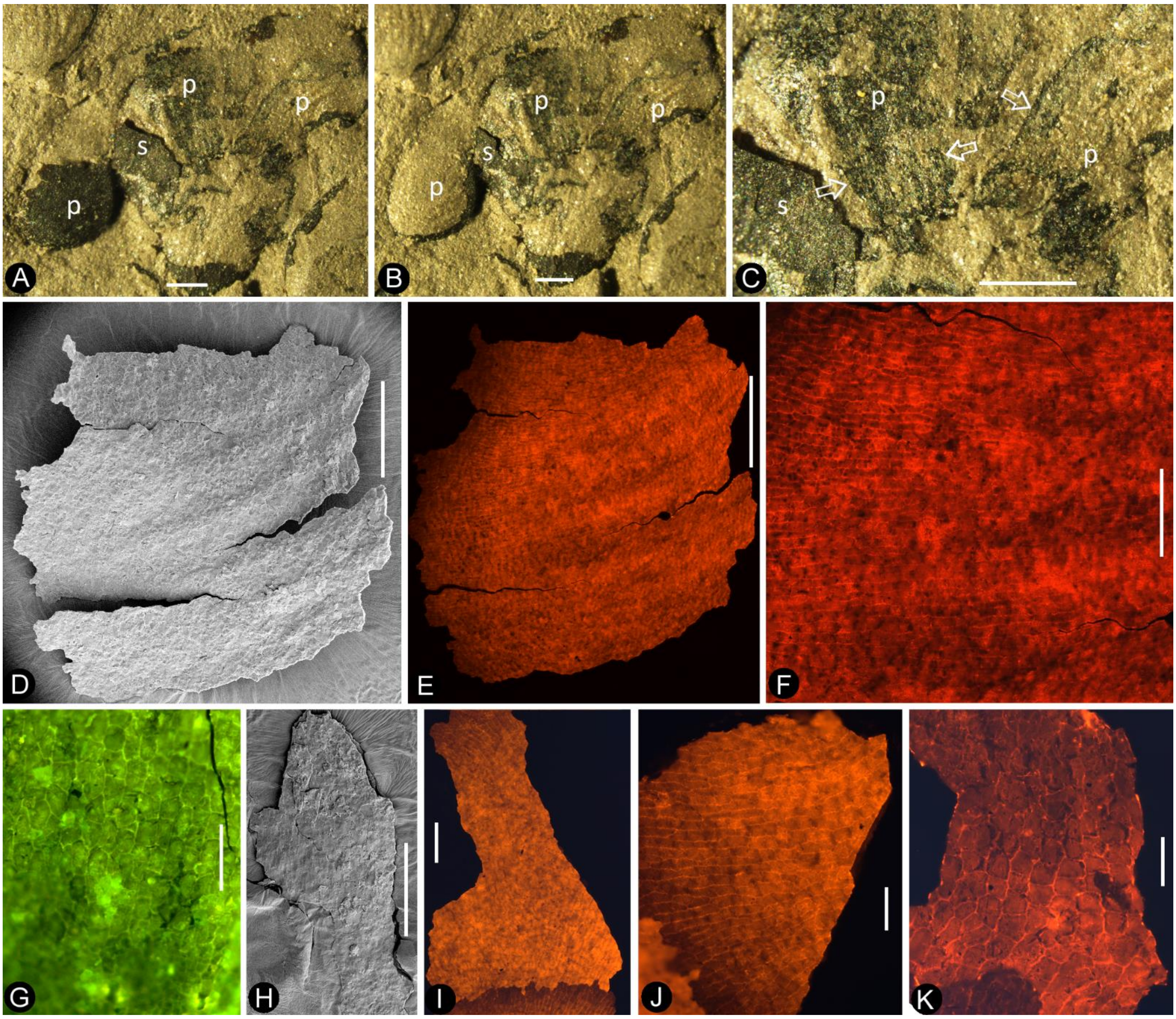

Figure S10 ***Nanjinganthus*****, petal and details.**
A. Side view of Flower 3 in Fig. 1b, showing the arrangement of the petals (p) and sepal (s). Bar = 1 mm. **B**. The same flower as in Fig. S10a. Note that some of the organic material of the petal has been removed for detailed observation. Bar = 1 mm. **C**. Margins (arrows) of the petal (p) with cuneate pedicel and their relationship to the sepal (s). Bar = 1 mm. **D**. The petal removed from Fig. S10a. SEM. Bar = 0.5 mm. **E**. Cellular details of the petal in Fig. S10d. Fluorescence light microscopy. Bar = 0.5 mm. **F**. Elongated epidermal cells arranged in files, enlarged from Fig. S10e. Fluorescence light microscopy. Bar = 0.2 mm. **G**. Isodiametric epidermal cells in the wing portion of the petal in Fig. S10e. Fluorescence light microscopy. Bar = 0.1 mm. **H**. A fragment of the sepal seen in Fig. S10a. SEM. Bar = 0.5 mm. **I**. Cellular details of the sepal in Fig. S10h. Fluorescence light microscopy. Bar = 0.2 mm. **J**. Elongated epidermal cells arranged in files on the sepal in Fig. S10i. Fluorescence light microscopy. Bar = 0.1 mm. **K**. Isodiametric epidermal cells on the wing of the sepal in Fig. S10a. Fluorescence light microscopy. Bar = 0.1 mm.

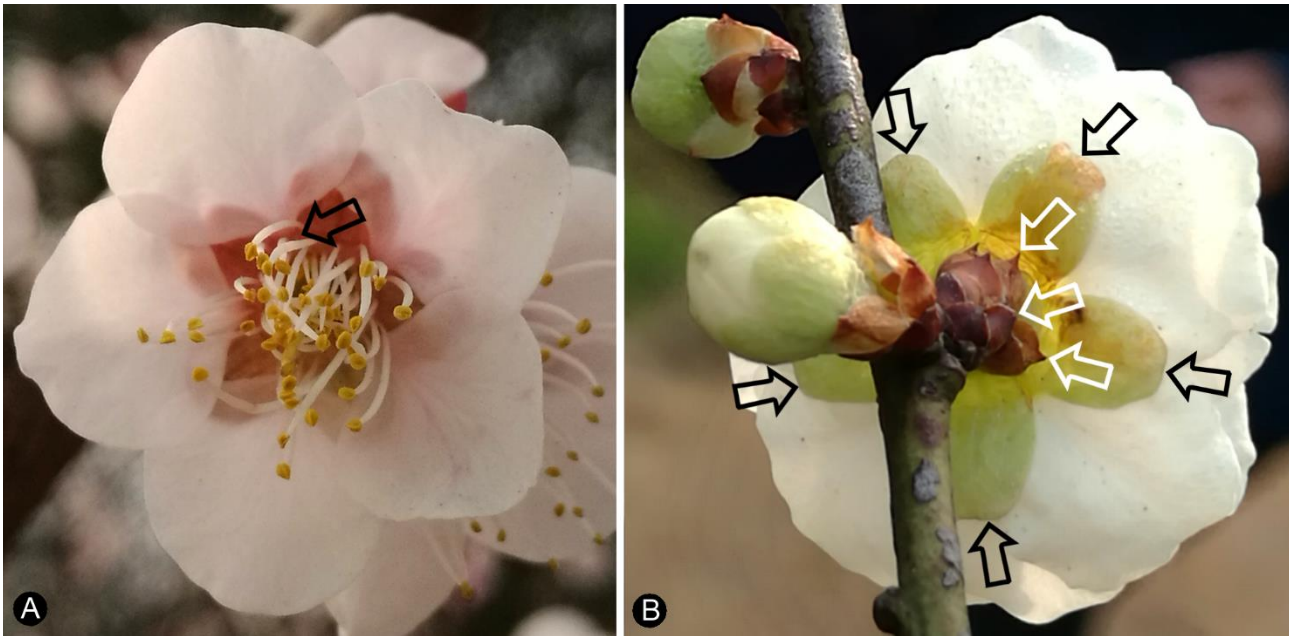

Figure S11 Flowers of a living angiosperm and its details.
A. Top view showing the white petals with narrowing bases (arrow) and green sepals in the background. **B**. Scales (white arrows), sepals (black arrows), and white petals.

Table S1 Number of flowers on each *Nanjinganthus* specimen.

Number of flowers	Specimen number
39	PB22221
82	PB22222
27	PB22223
5	PB22224
3	PB22225
10	PB22226
6	PB22227
80	PB22228
1	PB22229
1	PB22236
4	PB22238
1	PB22241
1	PB22242
2	PB22243
1	PB22245
2	PB22246
1	PB22247
1	PB22256
1	PB22257
1	PB22258
1	PB22259
1	PB22260
1	PB22278
4	PB22279
4	PB22280
1	PB22281
1	PB22282
2	PB22489

Table S2 Summary of zircon LA–ICP–MS U–Pb data for fossiliferous layers samples of the South Xiangshang Formation.

Spot	Pb	U	Th/U	Isotopic rations						Ages(Ma)						
	(ppm)			$^{207}Pb/^{206}Pb$	err%	$^{207}Pb/^{235}U$	err%	$^{206}Pb/^{238}U$	err%	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{206}Pb/^{238}U$	1σ	Concordance
16NJ09.1	42	519	0.866	0.0982	1.54	1.0345	1.63	0.0764	1.04	721	12	475	5	1591	29	48.02%
16NJ09.2	2	22	0.86	0.0961	7.80	1.3940	7.68	0.1052	1.39	886	68	645	9	1550	146	62.51%
16NJ09.4	3	37	0.905	0.1255	7.13	1.1696	7.21	0.0676	1.75	786	57	422	7	2035	126	13.54%
16NJ09.5	58	233	0.827	0.1241	1.51	3.9634	1.61	0.2316	0.99	1627	26	1343	13	2016	27	78.85%
16NJ09.6	5	88	2.32	0.0529	6.68	0.3087	6.82	0.0423	1.15	273	19	267	3	324	152	97.79%
16NJ09.7	6	122	1.099	0.0930	3.61	0.5546	3.64	0.0433	1.14	448	16	273	3	1487	68	35.95%
16NJ09.8	137	312	0.493	0.1543	1.54	8.2808	1.65	0.3891	0.99	2262	37	2119	21	2395	26	93.23%
16NJ09.10	12	234	1.14	0.0769	3.17	0.4537	3.29	0.0428	1.04	380	12	270	3	1119	63	59.34%
16NJ09.11	16	198	0.662	0.0786	2.20	0.7851	2.21	0.0724	1.00	588	13	451	4	1163	44	69.46%
16NJ09.12	166	305	0.348	0.2010	1.51	13.7308	1.65	0.4955	1.02	2731	45	2594	27	2834	25	94.72%
16NJ09.13	57	874	0.647	0.1002	1.55	0.8013	1.63	0.0580	0.99	598	10	363	4	1628	29	35.55%
16NJ09.14	107	1038	0.892	0.1103	1.56	1.4457	1.62	0.0951	1.05	908	15	585	6	1804	28	44.90%
16NJ09.16	62	748	0.672	0.0575	1.61	0.6097	1.71	0.0770	0.99	483	8	478	5	509	35	98.88%
16NJ09.19	7	155	0.651	0.0531	3.81	0.3120	3.84	0.0426	1.03	276	11	269	3	334	86	97.45%
16NJ09.20	58	804	0.458	0.0749	1.61	0.7146	1.67	0.0692	0.99	547	9	431	4	1066	32	73.03%
16NJ09.21	20	136	1.223	0.0658	2.01	1.1598	2.12	0.1279	1.06	782	17	776	8	799	42	99.24%
16NJ09.22	73	232	1.297	0.1110	1.53	4.2758	1.63	0.2794	0.99	1689	27	1588	16	1816	28	93.67%
16NJ09.24	24	194	0.828	0.0825	1.76	1.2947	1.93	0.1139	1.12	843	16	695	8	1257	34	78.67%
16NJ09.25	28	345	0.528	0.0583	1.85	0.6360	1.96	0.0791	1.01	500	10	491	5	542	40	98.14%
16NJ09.26	50	631	0.998	0.0561	1.66	0.5357	1.77	0.0693	0.99	436	8	432	4	455	37	99.15%
16NJ09.27	59	249	1.02	0.1352	1.51	3.7920	1.62	0.2034	0.99	1591	26	1194	12	2167	26	66.69%
16NJ09.28	36	163	0.761	0.0773	1.61	2.0782	1.72	0.1950	1.01	1142	20	1148	12	1129	32	99.43%
16NJ09.29	50	799	0.455	0.1016	1.55	0.8086	1.65	0.0577	1.02	602	10	362	4	1654	29	33.61%

16NJ09.30	15	290	0.988	0.0738	2.67	0.4387	2.93	0.0431	1.04	369	11	272	3	1036	54	64.28%
16NJ09.32	101	719	0.297	0.0789	1.56	1.5277	1.64	0.1404	1.10	942	15	847	9	1169	31	88.85%
16NJ17.1	0	2	8.658	0.0712	2.16	1.7990	2.44	0.1832	1.03	1045	25	1084	11	964	21	96.37%
16NJ17.2	0	2	2.388	0.0803	2.97	1.0193	3.42	0.0917	1.17	714	24	565	7	1205	36	73.78%
16NJ17.3	0	1	2.03	0.0730	3.49	1.3998	3.62	0.1392	0.86	889	32	840	7	1014	35	94.17%
16NJ17.4	1	5	1.006	0.1122	2.52	1.5091	3.17	0.0967	1.20	934	30	595	7	1835	46	42.96%
16NJ17.5	3	12	0.221	0.1323	2.18	5.0590	2.67	0.2773	1.42	1829	49	1578	22	2129	46	84.06%
16NJ17.6	1	6	0.072	0.1057	2.62	1.7656	2.99	0.1207	0.73	1033	31	735	5	1726	45	59.43%
16NJ17.7	452	233	0.4	0.1629	2.30	9.6964	2.43	0.4321	0.54	2406	59	2315	12	2486	57	96.07%
16NJ17.8	196	102	0.848	0.1628	3.04	3.7322	3.95	0.1636	1.44	1578	62	977	14	2485	76	38.40%
16NJ17.9	6	13	3.71	0.1662	2.39	9.8653	2.57	0.4309	0.72	2422	62	2310	17	2520	60	95.13%
16NJ17.10	1	6	1.237	0.0828	2.61	1.6445	3.03	0.1434	0.90	987	30	864	8	1265	33	85.73%
16NJ17.11	0	3	4.197	0.0673	2.60	0.4644	3.18	0.0497	1.03	387	12	313	3	847	22	76.10%
16NJ17.12	0	3	1.215	0.0907	3.26	1.8033	4.23	0.1417	1.46	1047	44	854	12	1439	47	77.49%
16NJ17.14	0	2	1.571	0.0672	3.50	0.4204	3.68	0.0453	0.59	356	13	286	2	844	30	75.24%
16NJ17.15	4	9	3.65	0.1881	2.73	12.1051	3.12	0.4661	1.29	2613	82	2466	32	2725	75	94.07%
16NJ17.16	0	3	1.471	0.0897	3.20	1.7950	3.44	0.1447	0.73	1044	36	871	6	1419	45	80.21%
16NJ17.17	1	5	2.129	0.1019	2.97	3.2330	3.12	0.2300	0.54	1465	46	1334	7	1658	49	90.19%
16NJ17.18	5	15	4.975	0.1168	2.75	5.1458	2.98	0.3191	0.87	1844	55	1786	16	1908	52	96.74%
16NJ17.19	2	5	5.775	0.1118	2.60	4.9003	2.76	0.3179	0.64	1802	50	1780	11	1828	48	98.72%
16NJ17.20	2	7	10.43	0.1221	2.48	4.9544	2.68	0.2942	0.72	1812	49	1662	12	1987	49	91.03%
16NJ17.21	3	9	2.782	0.1117	2.40	5.3689	2.58	0.3487	0.65	1880	48	1928	13	1827	44	97.49%
16NJ17.22	0	3	1.563	0.0767	3.00	1.3475	3.47	0.1267	0.89	866	30	769	7	1112	33	87.35%
16NJ17.23	1	7	2.336	0.0764	2.40	1.6207	2.59	0.1538	0.58	978	25	922	5	1106	27	93.94%
16NJ17.24	1	5	6.116	0.0768	2.39	1.2516	2.90	0.1182	1.39	824	24	720	10	1115	27	85.57%
16NJ17.25	7	24	2.457	0.1407	2.36	5.7386	2.55	0.2961	0.68	1937	49	1672	11	2236	53	84.12%
16NJ17.26	3	10	3.035	0.1130	2.28	4.9338	2.55	0.3169	0.96	1808	46	1774	17	1849	42	98.10%
16NJ17.27	2	9	2.316	0.0956	2.24	2.9837	2.52	0.2261	0.79	1403	35	1314	10	1540	35	93.19%
16NJ17.28	0	1	2.878	0.1004	3.05	1.9117	5.82	0.1338	3.85	1085	63	809	31	1631	50	65.94%
16NJ17.29	0	2	1.794	0.0835	2.79	1.9537	3.76	0.1680	1.65	1100	41	1001	17	1280	36	90.14%
16NJ17.31	7	20	1.833	0.1378	2.11	6.3608	2.33	0.3346	0.77	2027	47	1861	14	2200	46	91.08%
16NJ17.32	4	8	4.552	0.1685	2.10	11.0648	2.24	0.4763	0.55	2529	57	2511	14	2543	53	99.31%
16NJ17.34	2	7	2.996	0.0884	2.16	2.8030	2.30	0.2299	0.52	1356	31	1334	7	1392	30	98.34%
16NJ17.35	4	10	1.65	0.1123	2.15	5.7354	2.40	0.3705	0.91	1937	46	2032	18	1837	39	95.33%
16NJ17.36	2	7	3.382	0.1370	2.19	6.4169	2.32	0.3399	0.53	2035	47	1886	10	2190	48	92.12%
16NJ17.37	0	2	1.564	0.0908	2.83	2.2141	3.43	0.1759	1.26	1186	41	1044	13	1443	41	86.48%
16NJ17.38	0	4	2.009	0.0766	2.70	0.8340	3.09	0.0787	0.76	616	19	488	4	1110	30	73.89%
16NJ17.39	7	13	1.709	0.1702	2.48	11.0912	2.65	0.4728	0.57	2531	67	2496	14	2560	63	98.60%
16NJ17.40	2	10	9.706	0.1131	2.63	3.7761	2.87	0.2423	0.82	1588	46	1399	12	1849	49	86.48%
16NJ17.41	2	6	5.233	0.1108	2.60	5.1871	2.75	0.3398	0.56	1851	51	1886	11	1813	47	98.13%
16NJ17.42	0	2	45.9	0.0724	2.55	0.8759	2.72	0.0879	0.83	639	17	543	5	998	25	82.40%
16NJ17.43	0	4	3.102	0.0820	2.90	0.5287	3.45	0.0464	1.04	431	15	293	3	1245	36	52.67%
16NJ17.44	0	2	1.336	0.1360	2.92	1.9353	4.03	0.1017	1.93	1093	44	624	12	2177	63	24.80%
16NJ17.45	11	23	1.064	0.1512	2.20	8.8030	2.35	0.4224	0.56	2318	54	2272	13	2360	52	97.96%
16NJ17.46	1	3	4.937	0.1303	2.16	6.7052	2.37	0.3734	0.81	2073	49	2045	17	2102	45	98.64%
16NJ17.48	0	2	0.299	0.0774	3.28	0.7370	3.40	0.0696	1.49	561	19	434	6	1131	37	70.69%
16NJ17.49	2	8	0.231	0.0945	2.13	2.9850	2.29	0.2291	0.59	1404	32	1330	8	1517	32	94.44%
16NJ17.50	1	4	0.737	0.0761	2.76	1.4112	3.45	0.1332	1.13	894	31	806	9	1099	30	89.13%
16NJ17.51	1	10	0.848	0.0698	2.16	1.2866	2.35	0.1336	0.65	840	20	809	5	922	20	96.14%
16NJ17.52	3	9	0.578	0.1185	2.07	5.8582	2.21	0.3586	0.56	1955	43	1976	11	1933	40	98.96%
16NJ17.53	6	14	0.174	0.1607	2.05	9.0089	2.19	0.4065	0.55	2339	51	2199	12	2463	51	93.64%

16NJ17.54	0	4	0.409	0.1019	2.35	0.9858	4.49	0.0687	2.87	697	31	428	12	1660	39	37.44%
16NJ17.55	0	3	0.959	0.1180	3.19	1.4087	3.48	0.0878	2.34	893	31	542	13	1926	61	35.46%
16NJ17.56	3	17	1.261	0.1123	2.14	2.1656	2.31	0.1398	0.63	1170	27	843	5	1837	39	61.25%
16NJ17.57	2	4	0.316	0.1599	2.10	9.3955	2.27	0.4258	0.66	2377	54	2287	15	2455	52	96.04%
16NJ17.58	2	8	1.575	0.1210	2.86	2.2623	3.51	0.1341	0.95	1201	42	811	8	1971	56	52.02%
16NJ17.59	2	12	1.175	0.0717	2.22	1.2799	2.38	0.1293	0.54	837	20	784	4	978	22	93.25%
16NJ17.60	1	5	0.896	0.0896	2.47	1.6763	2.93	0.1350	0.81	1000	29	816	7	1416	35	77.57%
16NJ17.61	4	14	1.977	0.0967	2.46	1.8485	2.64	0.1387	0.87	1063	28	837	7	1562	38	73.03%
16NJ17.62	1	4	0.402	0.0959	2.39	3.0935	2.57	0.2336	0.59	1431	37	1354	8	1546	37	94.27%
16NJ17.63	0	4	0.176	0.0942	2.92	0.9776	3.11	0.0751	0.57	692	22	467	3	1512	44	51.71%
16NJ17.64	1	6	1.001	0.0843	2.75	0.9164	3.41	0.0780	0.92	660	22	484	4	1299	36	63.59%
16NJ17.65	5	10	0.46	0.2165	2.21	13.0890	2.57	0.4368	0.89	2686	69	2336	21	2955	65	85.03%
16NJ17.66	0	5	0.273	0.1216	2.20	1.7304	2.52	0.1031	1.05	1020	26	633	7	1980	44	38.81%
16NJ17.68	0	1	0.621	0.0854	4.30	0.6830	6.04	0.0560	1.89	529	32	351	7	1325	57	49.61%
16NJ17.69	3	9	0.198	0.1157	2.06	5.1219	2.24	0.3211	0.76	1840	41	1795	14	1892	39	97.52%
16NJ17.70	551	307	0.469	0.1287	2.06	6.6390	2.19	0.3741	0.52	2065	45	2049	11	2081	43	99.22%
16NJ17.71	734	386	1.81	0.0777	2.12	1.4160	2.25	0.1322	0.50	896	20	801	4	1139	24	88.12%
16NJ17.72	69	115	0.465	0.1185	3.16	1.5471	6.49	0.0899	3.71	949	62	555	21	1933	61	28.94%
16NJ17.73	517	192	0.734	0.1600	2.09	8.8007	2.23	0.3991	0.51	2318	52	2165	11	2456	51	92.95%
16NJ17.74	488	111	1.183	0.1991	2.21	10.8231	2.36	0.3950	0.70	2508	59	2146	15	2819	62	83.14%
16NJ17.75	135	47	0.514	0.1699	2.54	8.5726	3.40	0.3617	1.21	2294	78	1990	24	2556	65	84.74%
16NJ17.76	925	242	1.13	0.1605	2.10	9.2399	2.26	0.4183	0.51	2362	53	2253	11	2461	52	95.14%
16NJ17.77	438	270	0.501	0.1218	2.15	5.5418	2.33	0.3307	0.54	1907	44	1842	10	1983	43	96.45%
16NJ17.78	213	297	0.096	0.1223	2.18	5.2938	2.37	0.3149	0.67	1868	44	1765	12	1991	43	94.17%
16NJ17.79	434	395	0.254	0.1399	2.23	5.7558	2.47	0.2994	0.68	1940	48	1688	11	2226	50	85.10%
16NJ17.80	62	92	0.258	0.1148	2.87	2.3435	5.28	0.1435	3.10	1226	65	864	27	1877	54	58.18%
16NJ17.81	125	267	0.261	0.0708	2.28	1.6249	2.45	0.1670	0.57	980	24	996	6	951	22	98.42%
16NJ17.82	357	238	0.309	0.1632	2.16	10.1674	2.29	0.4524	0.56	2450	56	2406	14	2489	54	98.17%
16NJ18.1	6	12	1.264	0.1483	2.38	8.7178	2.49	0.4253	0.72	2309	57	2285	17	2327	55	98.94%
16NJ18.2	6	8	1.684	0.2359	2.14	15.0514	2.47	0.4611	0.84	2818	70	2444	20	3093	66	84.69%
16NJ18.3	95	43	0.843	0.1409	1.96	7.3142	1.98	0.3764	0.56	2151	43	2060	12	2239	44	95.58%
16NJ18.4	122	260	0.352	0.0771	1.77	1.6941	1.82	0.1592	0.56	1006	18	953	5	1125	20	94.36%
16NJ18.5	182	495	0.72	0.0819	2.16	0.9290	2.16	0.0823	0.54	667	14	510	3	1244	27	69.11%
16NJ18.6	430	421	0.309	0.1227	1.65	6.1997	1.74	0.3661	0.58	2004	35	2011	12	1996	33	99.68%
16NJ18.7	270	219	0.511	0.1784	1.72	5.6482	1.81	0.2302	0.96	1923	35	1335	13	2638	45	55.96%
16NJ18.9	32	50	1.027	0.1626	1.65	11.8633	1.76	0.5293	0.76	2594	46	2738	21	2483	41	94.72%
16NJ18.10	4	12	0.49	0.2186	1.66	8.3691	2.36	0.2778	1.77	2272	54	1580	28	2970	49	56.24%
16NJ18.11	1	5	0.243	0.1053	1.69	2.6474	1.77	0.1823	0.68	1314	23	1080	7	1720	29	78.30%
16NJ18.12	5	18	0.757	0.1431	1.82	4.8941	1.92	0.2479	0.54	1801	35	1427	8	2265	41	73.81%
16NJ18.13	0	1	0.597	0.0897	3.20	2.3957	3.35	0.1930	0.88	1241	42	1138	10	1420	45	90.88%
16NJ18.14	1	5	0.461	0.0792	1.92	1.6867	1.99	0.1543	0.49	1004	20	925	5	1178	23	91.52%
16NJ18.15	4	11	0.305	0.1565	2.18	7.3800	2.54	0.3403	0.67	2159	55	1888	13	2418	53	85.68%
16NJ18.16	7	19	0.326	0.1568	1.81	7.5374	2.07	0.3478	0.66	2177	45	1924	13	2421	44	86.84%
16NJ18.17	16	34	1.776	0.2739	1.77	10.5334	1.90	0.2788	0.64	2483	47	1585	10	3328	59	43.39%
16NJ18.18	7	14	3.36	0.1247	2.01	2.8524	2.86	0.1642	1.35	1369	39	980	13	2025	41	60.26%
16NJ18.19	6	14	0.712	0.1568	1.73	8.4745	2.19	0.3903	0.96	2283	50	2124	20	2422	42	92.52%
16NJ18.20	1	6	0.573	0.1214	2.60	1.4984	2.92	0.0889	0.67	930	27	549	4	1978	51	30.70%
16NJ18.21	4	12	0.346	0.1239	1.70	5.7849	1.87	0.3388	0.90	1944	36	1881	17	2014	34	96.62%
16NJ18.22	6	13	0.37	0.1604	1.74	9.4081	1.80	0.4256	0.56	2379	43	2286	13	2459	43	95.94%
16NJ18.23	0	3	0.063	0.0890	1.87	2.1665	2.03	0.1763	0.63	1170	24	1047	7	1404	26	88.20%
16NJ18.24	90	158	0.185	0.3274	2.48	21.5134	3.20	0.4693	1.06	3162	101	2480	26	3605	89	72.51%

16NJ18.27	12	18	2.626	0.3071	2.41	9.3380	4.55	0.2138	2.39	2372	108	1249	30	3506	84	10.11%
16NJ18.28	1	8	1.191	0.0757	2.21	1.3632	2.20	0.1307	0.53	873	19	792	4	1087	24	89.76%
16NJ18.30	2	6	0.33	0.1610	1.69	9.4860	1.85	0.4278	0.90	2386	44	2296	21	2466	42	96.07%
16NJ18.31	8	15	1.087	0.1883	1.70	10.6356	2.07	0.4088	1.03	2492	52	2209	23	2728	46	87.22%
16NJ18.32	568	448	0.363	0.1532	1.66	8.6438	1.85	0.4093	0.87	2301	43	2212	19	2383	40	95.95%
16NJ18.33	118	57	0.469	0.1796	2.21	9.1142	2.56	0.3666	1.04	2350	60	2014	21	2649	59	83.32%
16NJ18.34	223	75	1.416	0.1891	1.71	10.6518	1.82	0.4084	0.57	2493	45	2208	13	2735	47	87.06%
16NJ18.35	32	40	0.726	0.1061	3.73	2.1355	3.79	0.1459	0.65	1160	44	878	6	1733	65	67.82%
16NJ18.36	57	50	1.291	0.1320	3.23	2.5332	3.37	0.1388	0.60	1282	43	838	5	2125	69	47.05%
16NJ18.37	208	21	0.878	0.6272	1.77	40.7307	2.80	0.4665	1.64	3789	106	2468	41	4572	81	46.50%
16NJ18.39	163	619	0.385	0.1012	1.74	0.9685	1.81	0.0694	0.46	688	12	433	2	1646	29	41.01%
16NJ19.1	65	72	0.874	0.1151	2.17	5.9161	2.18	0.3737	0.76	1964	43	2047	16	1882	41	95.94%
16NJ19.2	11	57	0.438	0.0645	7.07	0.9697	7.44	0.1090	1.93	688	51	667	13	759	54	96.83%
16NJ19.3	78	208	0.882	0.0721	3.29	1.3771	4.19	0.1372	1.04	879	37	829	9	987	33	93.92%
16NJ19.4	168	242	2.262	0.0834	1.54	1.8194	1.67	0.1587	1.09	1052	18	950	10	1278	20	89.18%
16NJ19.6	26	259	0.416	0.0629	2.65	0.4243	2.75	0.0489	0.66	359	10	308	2	705	19	83.29%
16NJ19.7	18	207	0.678	0.0528	5.53	0.2374	5.60	0.0327	0.71	216	12	207	1	321	18	95.71%
16NJ19.8	17	223	0.513	0.0562	4.87	0.2544	5.25	0.0328	0.75	230	12	208	2	460	22	89.23%
16NJ19.9	0	3	0.958	0.0632	2.87	0.4375	3.27	0.0499	0.78	369	12	314	2	714	21	82.71%
16NJ19.10	41	98	0.913	0.0660	3.86	1.1693	4.21	0.1278	0.59	786	33	775	5	807	31	98.55%
16NJ19.11	57	69	1.296	0.1707	1.60	4.0567	1.76	0.1726	0.88	1646	29	1026	9	2564	41	39.64%
16NJ19.12	29	238	0.253	0.0589	2.47	0.5702	2.51	0.0703	0.53	458	11	438	2	562	14	95.43%
16NJ19.13	87	226	0.876	0.0733	1.61	1.4827	1.74	0.1467	0.67	923	16	882	6	1023	16	95.35%
16NJ19.14	212	239	2.109	0.1110	2.02	2.0695	2.06	0.1354	0.66	1139	23	818	5	1816	37	60.86%
16NJ19.15	83	577	0.366	0.0937	1.56	0.9200	1.85	0.0712	1.01	662	12	443	4	1503	24	50.59%
16NJ19.16	26	166	0.185	0.0734	2.18	0.9790	2.43	0.0966	0.79	693	17	595	5	1024	22	83.46%

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