Supporting Information

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SI Materials and Methods

Fossiliferous Localities. Samples were collected by E.B.O. in Snow Hill Island and López de Bertodano Formations on James Ross and Vega islands, Antarctica (Fig. 1) during several summer field trips. These units constitute the middle and upper parts (Campanian–Danian) of the Marambio Group, which include two major shallowing-upwards depositional sequences (1). These sequences are denominated the NG Sequence (Snow Hill Island and Haslum Crag Formations, mid–late Campanian–early Maastrichtian) and the MG Sequence (López de Bertodano Formation, early–late Maastrichtian–Danian).

In the studied section near Santa Marta Cove, James Ross Island, the outcrops of the Snow Hill Island Formation are included in the Gamma Member. This member consists of a lower sandstone-dominated package with lenticular coquinas, approximately 120 m thick, and an upper mudstone-dominated package, approximately 50 m thick (Fig. S1*A*). Both packages represent the transgressive system tract of the NG Sequence, with proximal, sandstone-dominated shore–face deposits at the base, followed by prodelta mudstones interbedded with sandy tempestites at the top (7). The lower package of the Gamma Member bears important fossil vertebrates, including a partial skeleton of the ankylosaur *Antarctopelta oliveroi* (30) and the ornithopod *Trinisauras antamartaensis* (31). Ammonites are scarce, but the basal conglomerate bears a reworked ammonite fauna, including diagnostic mid Campanian taxa, such as *Baculites subanceps*, *Metaplacenticeras subtilistriatum*, and *Hoplitoplacenticeras* sp., and several horizons, including the kossmaticeratid *Neograhamites primus*, which defines the mid–Campanian Ammonite Assemblage 8-1 (7). The studied samples in this package were recovered within the Ammonite Assemblage 8.1 *Neograhamites primus*, and include samples D8-1, D10-8, D11-1, D12-8, and D13-3b (Fig. S1*A*). The upper mudstone-dominated package of the Gamma Member is more fossiliferous and bears, in stratigraphic order, the Ammonite Assemblage 8-2 *Neogramites cf kiliani*, late Campanian, and the Ammonite Assemblage 9 *Neograhamites–Gunnarites*, latest Campanian–early Maastrichtian. The studied samples 14S-4d, Hy-20, and Hy were recovered within the Ammonite Assemblage 8-2, and the sample 14S within the Ammonite Assemblage 9 (7) (Fig. S1*A*).

The mudstone-dominated package of the Gamma Member crops out also on Hump Island and southern Cape Lamb on Vega Island (7). At Cape Lamb, it is transitionally covered by a coarsening-upward succession of silty mudstones and sandstones referred to the Cape Lamb Member of the Snow Hill Island Formation (7). The Cape Lamb Member is interpreted as a prograding deltaic wedge (7). The ammonite genus *Gunnarites* is very abundant throughout the member characterizing the Ammonite Assemblage 10 *Gunnarites* of early Maastrichtian (latest Campanian?) age (ref. 7 and references therein). The studied samples V6-10 and V8-8 were recovered from this interval (Fig. S1*B*). In Cape Lamb, Vega Island, the Snow Hill Island Formation is unconformably covered by the López de Bertodano Formation (Fig. S1*B*). The López de Bertodano Formation consists of a basal conglomerate followed by a mudstone-dominated succession with abundant ammonites, dominated by *Maorites densicostatus*, which are interpreted as offshore deposits representing a transgressive system tract. Based on sequence stratigraphy (7), these offshore mudstones are correlated with the late Maastrichtian deposits of the López de Bertodano Formation on Seymour Island, which bear the Ammonite Assemblages 12, 13, and 14 of Olivero (7). The studied samples V10-12, and V10-24 were recovered from the mudstone-dominated interval of the López de Bertodano Formation (Fig. S1*B*). The upper part of the López de Bertodano Formation at Cape Lamb consists of regressive sandstone and conglomerates included in the Sandwich Bluff Member of latest Maastrichtian age (32). Thin conglomerates at the top, possibly Paleocene, were referred to the Sobral Formation (33).

Fossil Pollen Morphotypes. The samples were treated following standard palynological techniques (34). Fossil pollen grains were examined under transmitted white light with a Leica microscope and photomicrographs were taken with a Leica camera DFC 290. SEM photographs were included to illustrate the superficial morphological features of the pollen morphotypes. Specimen coordinates are referred to the England Finder. Pollen terminology follows Punt et al. (35).

Extant Reference Samples. Pollen characters were obtained from the examination of slides of acetolyzed pollen grains from 368 species representing all families of extant Asterales. Pollen of *Ilex*, chosen as an outgroup taxon, was also included. The specimens are deposited in the herbaria ALCB, B, BAF, C, CANB, CBG, FM, G, GÖTT, HAC, HAJB, HUT, K, LP, MO, S, US, WIS (sweetgum.nybg.org/ih/). Most pollen slides were used in previous studies, mainly those of Asteraceae (36–41), but additional specimens were included. For the specimens examined specifically for the present study under scanning electron microscope, pollen grains were acetolyzed (42), suspended in 90% (vol/vol) ethanol, and mounted on stubs. The samples were sputter-coated with gold-palladium and details of the exine sculpture were examined using a JEOL JSM T-100 SEM. A list of the specimens investigated is provided in *Supporting Data*, below. Additional information was obtained from the literature (*Supporting Data*).

Estimation of Divergence Times. We selected two fossil taxa for the estimation of the divergence times for the Asteralean lineages: one pollen morphotype placed on the phylogenetic tree using characters of extant clades (*Tubulifloridites lilliei* type A), and one macrofossil (capitulum) and associated pollen (*Raiguenrayun cura* + *Mutisiapollis telleriae*) related to extant Asteraceae (3, 5). Finally, the origin of the crown eudicots with fossil records (tricolpate pollen) near the late Barremian/early Aptian was used as a maximum age constraint (ref. 43, and references therein) on the root node of the phylogenetic tree (Table S4). The geologic age of each fossil was determined with precision. All stratigraphic ages were converted into absolute ages by using the geological timescale of Gradstein et al. (44). The late Campanian-early Maastrichtian to late Maastrichtian age range of the fossil *T. lilliei* type A translated into an absolute age of 76.4–72.1/66.0 Ma. This fossil provides a safe minimum age of 72.1 Myr for node A (Fig. S6 and Table S4).

We explored a number of alternative calibration scenarios based on the position of *T. lilliei* type A in the backbone tree of Asterales (Fig. 2, Fig. S5, and Table S1). The most parsimonious reconstruction placed this fossil within the extant genus *Dasyphyllum* (Fig. 2). We also studied other possible placements of *T. lilliei* type A by randomly sampling all 26 characters from our original matrix with replacement (5,000 replicates) with the aim of simulating the variability that we would get if we could have sampled more characters. The resulted bootstrap consensus tree placed *T. lilliei* type A next to all living Asteraceae (Fig. S5*A* and calibration scenario 2 in Table S2) as an extinct stem relative. The age of the origin of the crown Asteraceae occurred during the Late Cretaceous either using *T. lilliei* type A as a crown relative (i.e., nested within *Dasyphyllum*) (Fig. 5 and calibration scenario 1 in Table S2) or as a stem relative (i.e., sister to all Asteraceae) (Fig. S5*A* and calibration scenario 2 in Table S2). We also analyzed the impact on the age of origin of Asteraceae, MGCA (Menyanthaceae, Goodeniaceae, Calyceraceae, and Asteraceae) and Asterales when calibrating the tree using the deepest placements in next-best parsimonious positions (MP+1 and MP+2) of the parsimony analysis (Fig. S5 *B–E* and calibration scenarios 3–6 in Table S2).

Supporting Data

Systematic Remarks.

Comments on* T. lilliei *(Couper) Farabee and Canright 1986.

General morphology. This species assembles tricolporate, oblate to subspheroidal pollen grains characterized by having microechinate sculpture. The exine is faintly stratified (0.8–1.5 μm thick), the colpi are long, often with rimmed margins, and the ora are irregular in outline with ragged margins. However, this species shows variation in colpi development, density of spines and clarity of the ora (ref. 9, and references therein).

Stratigraphic distribution. *T. lilliei* was widely reported in the Late Cretaceous of New Zealand, Australia, Antarctica, and southern South America [e.g., Couper (45); Raine et al. (8); Dettmann and Jarzen (9); Wilson (46); Barreda et al. (47)].

Botanical affinity. *T. lilliei* was botanically related to Ranunculaceae [*Clematis* (45, 48)], Euphorbiaceae [*Neoscortechinia* (49)], or considered as an unknown angiosperm group (9).

Specimens from Antarctica. The specimens recovered from the Campanian-Maastrichtian of Antarctica fit with the general diagnosis of *T. lilliei* and support the polymorphic features of this morphospecies. However, some of these specimens, in particular, show consistent and well defined characters that lead us to circumscribe them within a new morphotype that we retained within *T. lilliei* and informally named as *T. lilliei* type A. A formal definition should wait until a complete study of most *T. lilliei* specimens recorded in the Late Cretaceous of southern Gondwana (Australia, Patagonia, New Zealand, Antarctica) are carried out.

T. lilliei type A.

Description. Pollen grain tricolporate, isopolar, subspheroidal to subprolate; amb circular to subcircular and elliptic outline in equatorial view. Colpi long with rounded ends and rimmed margins, colpal membrane microgranulate, ora well defined, lalongate. Exine faintly stratified (1.2–2 μm thick), thickened at poles; nexine equal to or thinner than sexine. Exine surface microechinate, sometimes interspersed with microbacula and small verrucae, 0.2–0.5 μm in basal diameter, 0.3–0.8 μm in height, and spaced 2–4 μm apart. Intercolpal depressions often present but poorly defined.

Dimensions. Equatorial diameter 18–22 μm; polar diameter 20–25 μm.

Main studied material. Specimens on slide BAPal. ex CIRGEO Palin 963b: N42(4), L36(0), P57(1).

Distribution. Occurs in trace amounts in late Campanian-late Maastrichtian sequences of Snow Hill Island and Lopez de Bertodano Formations, Snow Hill and Vega Islands, Antarctica.

Remarks and comparisons. This new type fits with the broad diagnosis of *T. lilliei* but it shows variations in general shape (subspheroidal to subprolate), clarity of apertures (with well-defined lalongate ora), and exine structure (thickened at poles and with intercolpal depressions). Some specimens reported from the Late Cretaceous of Paparoa Coal Measures, Westland, New Zealand (8) bear strong similarities with *T. lilliei* type A, as they have a thick exine and poorly defined intercolpal depressions (Fig. S4).

Botanical affinity. Several angiosperm families produce triaperturate pollen grains with microechinate exine sculpture. Here we used the apomorphy-based method [in the sense of Sauquet et al. (10)] as a first attempt to estimate the closest living relatives of the fossil *T. lilliei* type A, conducting exhaustive comparisons with members of Lamiaceae, Ranunculaceae, Cleomaceae, Solanaceae, Hectorellaceae, Rhamnaceae, Euphorbiaceae, Rubiaceae, Caprifoliaceae, and families of Asterales (Stylidiaceae, Campanulaceae, Goodeniaceae, Calyceraceae and Asteraceae) by using information available in the literature (36, 50–60). Despite gross similarities, however, most of these families have significant differences in apertures, structure, or sculpture with *T. lilliei* type A: Lamiaceae (*Clerodendrum* type) are tricolpate, have short colpi, uniformly microechinate sculpture, and perforate tectum (53); Ranunculaceae (*Clematis*) are larger (approximately 40 μm), oblate to spheroidal, tricolpate, have a clearly columellate exine structure and variable sculpture (microechinate-microgranulate), with minutely perforate tectum (52, 54, 55); Cleomaceae (*Cleome*) are tricolporoidate, with thin exine (< 1 μm) and conspicuous columellae (50); Solanaceae (*Latua*) have indistinct ora and very thin exine (< 1 μm) (50); Hectorellaceae (*Hectorella*) are tricolpate, larger (approximately 40 μm), clearly columellate and with perforate tectum (54); Rhamnaceae (*Pomaderris*) have circular ora and sparingly perforate tectum (54); Euphorbiaceae (*Neoscortechinia*) differ in having shorter colpi, clearly columellate exine, and stout microspines with acute ends (57); Rubiacae, (*Bikkia*) have shorter colpi with poorly defined margins (56); Caprifoliaceae (*Symphoricarpos*, *Plectritis*) have tricolporate apertures, but with short colpi, clearly columellate exine, and conical microspines with acute ends (51). The strong morphological similarities from *T. lilliei* type A occur within the members of Asterales. In particular, the phylogenetic method we conducted to evaluate the accurate placement of the fossils from Antarctica within the order indicate the genus *Dasyphyllum* of the Barnadesioideae (Asteraceae) as the closest living relative of *T. lilliei* type A.

List of Characters and Character State Definitions Used to Compile a Matrix Used as Input in Parsimony Analyses Aimed at Placing the Fossil Taxa (Table S1). Pollen characters are as follows: 1- Pollen units: single monads (0), tetrads (1) . 2- Pollen size (average): small (< 20 μm) (0), medium (20–40 μm) (1), large (>40 μm) (2). 3- Shape (P/E index): peroblate (0), oblate-suboblate (1), spheroidal (2), subprolate (3), prolate (4). 4- Outline in equatorial view: circular-subcircular (0), elliptic (1), rhomboid-subrhomboid (2), rectangular-subrectangular (3). 5- Outline in polar view (Amb): circular-subcircular (0), subangular (1), angular (2). 6- Aperture number: three (triaperturate) (0), many (polyaperturate) (1). 7- Aperture type: porate (0), colpate (1), colporate (2). 8- Aperture fusion: syncolpate (0), nonsyncolpate (1). 9- Endoaperture shape: circular to subcircular (0), lalongate (1). 10- Apocolpia size: small (equatorial diameter/apocolpium ratio > 5) (0), medium (equatorial diameter/apocolpium ratio between 3–5) (1), large (equatorial diameter/apocolpium ratio <3) (2). 11- Colpi ends: rounded (0) yes, acute (1). 12- Sculpture of the apertural membrane: psilate (0), microgranulate (1), scabrate (2), verrucate (3), microechinate (4). 13- Exine sculpture: microechinate (0), echinate (spines longer than 1 μm) (1), striate-rugulate (2), striate (3), clavate (4), punctate (with sparse puncta) (5), rugulate (6), verrucate (7), microgranulate (8), baculate (9). 14- Sculpture size (observations under light microscopy): sculpture visible in optical section (approximately >0.8 μm) (0), sculpture faintly visible in optical section (approximately 0.8–0.4 μm) (1), sculpture not visible in optical section (approximately < 0.4 μm) (2). 15- Tip of spine: acute (0), rounded (1). 16- Tectal surface among major sculptural elements (observations under SEM): psilate (0), scabrate (1), striate (2), microperforate (3), rugulate (4). 17- Intercolpal depressions: absent (0), present (1). 18- Intercolpal depressions development: well defined (1), poorly defined (0). 19- Columellate layer (observations under light microscopy): columellae clearly distinguishable (0), columellae poorly distinguishable (1), columellae not distinguishable (2). 20- Internal tectum: present (1) yes, absent (0). 21- Ectexine layers (observations under light microscopy): one layer (0), two layers (1), three layers (2). 22- Exine thickness at the mid–mesocolpium: ≤1 μm (0), between 1 and 3 μm (1), >3 μm (2). 23- Exine thickened at the poles: thickened (1), nonthickened (0). 24- Exine thickened at the equator: thickened (1), nonthickened (0). 25- Nexine/sexine ratio: >2 (0), between 1 and 2 (1), <1 (2). 26- Exine thickened at apertures level: thickened (1), nonthickened (0).

Details of the Extant Material Examined for Morphological Characters Provided in Data Matrix and References for Scoring. Specimens examined specifically for the present study are identified with an asterisk (*).

Extant specimens investigated. ALSEUOSMIACEAE: *Alseuosmia*. *A. macrophylla* A. Cunn.: *Chapman 258560 (K); *A. quercifolia* A. Cunn.: *Melville 1665 (K). *Crispiloba*. *C. disperma* (S. Moore) Steenis: *Arboretum 1501 (K), *Gray 1904 (K). ARGOPHYLLACEAE: *Argophyllum*. *A. lejourdanii* F. Muell.: *Forster 9487 (K). *Corokia*. *C. buddleioides* A. Cunn.: *S. Andreos s/n° (K). ASTERACEAE: *Brachylaena*. *B. discolor* DC.: Mogg 16165 (US). *Chaetanthera*. *C. acerosa* (Remy) Benth. & Hook. f.: Ruiz Leal 24661 (LP), Cabrera 3525 (LP); *C. apiculata* (Remy) F. Meigen: Werdermann 627 (LP), Philippi, s/n° (LP 66472); *C. australis* Cabrera: Böcher et al., 1658 (LP); *C. brachylepis* Phil.: 9842 (LP), Barros 7443 (LP); *C. chilensis* DC.: Barros 7441 (LP), Riera s/n° (LP 66820); *C. chiquianensis* Ferreyra: Cerrate 1323 (LP); *C. ciliata* Ruiz & Pav.: Brochers 1071c (LP), Landbeck s.n. (LP 66975); *C. cochlearifolia* (A. Gray) B. L. Robinson: Macbride & Featherstone 845 (LP); *C. dioica* (Remy) B. L. Robinson: Kurtz 13717 (LP), Jörgensen 1325 (LP); *C. elegans* Phil.: without leg. (ex LPS 1592 in LP), Barros 2410 (LP); *C. euphrasioides* (DC.) F. Meigen: Spegazzini (ex LPS 2542 in LP), Looser 5751 (LP); *C. flabellata* D. Don: Pisano et al., 1641 (LP), Zöllner 660 (LP); *C. flabellifolia* Cabrera: Werdermann 189 (LP), Rossow & Rizzo 5642 (LP); *C. glabrata* (DC.) F. Meigen: Looser 4389 (LP), Jiles 2363 (LP); *C. glandulosa* Remy: Jiles 1237 (LP); *C. gnaphalioides* (Remy) I.M. Johnst.: Wagenknecht 4388 (LP), Jiles 1237a (LP); *C. incana* Poepp. ex Less.: Jiles 2326 (LP), without leg. (LP 66959). *C. lanata* I. M. Johnst.: Cabrera 3550 (LP), Gijoux s.n. (LP 66804); *C. leptocephala* Cabrera: Muñoz & Johnson 2192 (LP); *C. limbata* (D. Don) Less.: Germain s/n° (LP 66884), Barros 2402 (LP); *C. linearis* Poepp. Ex Less.: Montero O. 293 (LP), Looser 5214 (LP); *C. lycopodioides* (Remy) Cabrera: Boelcke 2468 (LP), Looser 2150 (LP); *C. microphylla* (Cass.) Hook. & Arn.: Cabrera 11120 (LP), Mahu 1040 (LP); *C. minuta* (Phil.) Cabrera: Cabrera 3568 (LP), Krapovickas & Hunziker 5700 (LP); *C. moenchioides* Less.: without leg. (LP 67034), without leg. (LP 67033); *C. pentacaenoides* (Phil.) Hauman: King 336 (LP), Ruiz Leal & Roig 23617 (LP); *C. peruviana* A. Gray: Cerrate et al., 6490 (LP), Weberbauer 6876 (LP); *C. planiseta* Cabrera: without leg. (LP 66498), Barros 9849 (LP); *C. pulvinata* (Phil.) Hauman: Pérez Moreau 158 (LP), Ruiz Leal 3182 (LP); *C. pusilla* (D. Don) Hook. et Arn.: Germain s/n° (LP 66621), without leg. (LP 6371); *C. renifolia* (Remy) Cabrera: Philippi s/n° (LP 66746), Philippi s/n° (LP 6370); *C. revoluta* (Phil.) Cabrera: Cabrera 8372 (LP), Cabrera 8874 (LP); *C. serrata* Ruiz & Pav.: Junge 1282 (LP), Gunckel 432 (LP); *C. spathulifolia* Cabrera: Pérez Moreau s/n° (LP 66809), Spegazzini s/n° (ex LPS 1600 in LP); *C. sphaeroidalis* (Reiche) Hicken: Werdermann 253 (LP), *C. splendens* (Remy) B. L. Robinson: Jiles 1567 (LP), Reiche s/n° (LP 66742); *C. stuebelii* Hieron.: Rohmeder T–18 (LP), Krapovickas & Hunziker 5332 (LP); C. *valdiviana* Phil.: Philippi 1068 (LP); Barros 178 (LP). *Chuquiraga*. *C. acanthophylla* Weddell: Cabrera 7721 (LP), Cabrera 9468, 7721 (LP); *C. arcuata* Harling: Asplund 17679 (S); *C. atacamensis* Kuntze: Budins 5 (LP), Cabrera 8288 (LP); *C. aurea* Skottsberg: Castellanos 7927 (LP), Birabén & Birabén 1 (LP); *C. avellanedae* Lorentz: Boelcke 1687 (LP), Morello 34 (LP); *C. calchaquina* Cabrera: Novara 1123 (MCNS), 1283 (LP); *C. echegarayi* Hieronymus: Roig 13026 (LP), Zardini & Volponi 100 (LP); *C. erinaceae* D. Don.: Cabrera 9036 (LP); *C. jussieui* J.F. Gmelin: Cañigueral 280 (LP), Herzog 2477 (LP); *G. kuschelii* Acevedo: Ricardi et al., 110 (LP), Ricardi and Silva 3362 (LP); *C. longiflora* (Grisebach) Hieronymus: Fabris 1361, 1385 (LP), Rodríguez 1411 (LP); *C. morenonis* (Kuntze) Ezcurra: Ruiz Leal 26876 (LP), Ameghino s/n; *C. oblongifolia* Sagástegui: Sánchez et al., 6076 (HAO), Sánchez & Briones 3761 (HAO); *C. oppositifolia* D. Don.: Ruiz Leal 153, 27159 (LP); *C. parviflora* (Grisebach) Hieronymus: Schikendantz 152, 278 (LP); *C. rosulata* Gaspar: Cabrera 19533 (LP), Pérez Moreau 3018 (LP), Ruiz et Leal 16057 (LP), *C. ruscifolia* D. Don.: Ruiz Leal 1838 (LP), Botino 85 (LP); *C. spinosa* subs. *huamapinta* Ezcurra: López et al., 8327 (HUT); *C. straminea* Sandwith: Cabrera 20574 (LP); *C. ulicina* (Hook. et Arn.) Hook & Arn.: Barros 2075 (LP), Cabrera 12674 (LP); *C. weberbaueri* Tovar: López et Sagástegui 3229 (HUT), Sánchez Vega 1146 (LP). *Cnicothamnus lorentzii* Griseb.: Maldonado 408 (LP), Cabrera et al., 14497 (LP). *Cyclolepis genistoides* D. Don, Zardini & Kiesling 114 (LP); Ruiz Leal 4055 (LP). *Dasyphyllum. D. argenteum* Kunth: Rose 23055 (US), *D. armatum* (Koster) Cabrera: Cárdenas 4805 (US); *D. brasiliense* Cabrera: Glaziou 14948 (LP), Rojas 4645 (LP); *D. brevispinum* Sagástegui & M.O. Dillon: Sagástegui et al., 14277, 14454 (HAO); *D. cabrerae* Sagástegui: Díaz et al., 1105 (HUT); *D. candolleanum* (Gardner) Cabrera: Lima 49163 (LP); *D. colombianum* (Cuatrecasas) Cabrera: Killip & Smith 19690 (US); *D. cryptocephalum* (Baker) Cabrera: Santos Lima & Brade 14194 (LP); *D. diacanthoides* (Lessing) Cabrera: Cabrera 11495 (LP), Boelcke 1798 (LP); *D. donianum* (Gardner) Cabrera: Gardner 4946 (LP), Duarte 8169 (LP); *D. excelsum* (Don) Cabrera: Garavente 4146 (LP); *D. ferox* (Weddell) Cabrera: López 1121 (LP), Isern 475 (LP); *D. flagellare* (Cassaretto) Cabrera: Duarte 2633 (LP), Hatschbach 38797 (LP); *D. floribundum* (Gardner) Cabrera: Hassler 11251 (LP); *D. horridum* (Muschler) Cabrera: Weberbauer 5847 (LP); *D. hystrix* Weddell: López & Sagástegui 8065 (HUT), Smith et al., 12019 (HUT); *D. inerme* (Rusby) Cabrera: Tolaba et al., 1844 (LP), Cabrera 3100 (LP), Ragonese 268 (LP); *D. infundibulare* (Baker) Cabrera: Pohl 344 (K); *D. lanceolatum* (Lessing) Cabrera: Hoehne 2348 (BAF); *D. lanosum* Cabrera: Glaziou 19571 (LP); *D. latifolium* Rojas 10533 (LP), 10484 (LP); *D. leiocephalum* (Weddell) Cabrera: Samaloa 56, 68 (LP), Marín 2053 (LP); *D. leptacanthum* (Gardner) Cabrera: Occhioni 1023 (LP), Cabrera 12256 (LP); *D. marialianae* Zardini et Soria: Guerrero 13263 (MO), Soria 7047 (LP); *D. orthacanthum* (De Candolle) Cabrera: Glaziou 5912 (US); *D. popayanense* (Hieronymus) Cabrera: Lehmann 6231 (US); *D. reticulatum* (De Candolle) Cabrera: Pereira Duarte 2400 (LP), Hatschbach 29840 (LP); *D. retinens* (S. Moore) Cabrera: Malme 2117 (LP); *D. spinescens* (Lessing) Cabrera: Sehnen 2514 (LP), Kuhlman s/n° (LP), *D. sprengelianum* (Gardner) Cabrera: Duarte 2660 (LP), Hatschbach 32099 (LP); *D. synacanthum* (Baker) Cabrera: Rambo 45445 (LP), Reitz 1528 (LP); *D. tomentosum* (Sprengel) Cabrera: Hunziker 926 (LP), Rambo 47174 (LP); *D. trichophyllum* (Baker) Cabrera: Damazio s/n° (LP); *D. vagans* (Gardner) Cabrera: Glaziou 11059 (LP), Melo Barreto 3766 (LP); *D. velutinum* (Baker) Cabrera: Duarte 2906 (LP), Mello Barreto 10884 (LP); *D. vepreculatum* (D. Don) Cabrera: Williams & Alston 243 (LP), Steyermark 61092 (F); *D. weberbaueri* (Tovar) Cabrera: López et al., 7805 (HUT). *Dicoma. D. anomala* Chisumpa 26 (LP). *Doniophyton. D. anomalum* (D. Don) Kurtz: Buenanueva s/n° (LP); King 648 (LP); Maldonado 1448 (LP), Bonifacino et al., 96 (LP); *D. weddelli* Katinas et Stuessy: Ruiz Leal 2093 (LP). *Gochnatia*. *G. arborescens* T. S. Brandegee: Keid Moran 9538 (US), Spjut & Edson 6085 (US); *G. argyrea* (Dusén) Cabrera, Smith, Klein & Hatschbach 14460 (LP); *G. attenuata* (Britton) R. N. Jervis & Alain: Bisse et al. s/n° 50424 (HAJB); *G. arequipensis* Sandw.: Eyerden & Beetle 22120 (LP); *G. barrosoae* Cabrera: Macedo 5574 (US), Cabrera 12313 (LP), Mantovani 503 (LP); Mathes 3 (LP); *G. boliviana* S. F. Blake: Beck 6264 (LP), Herzog 1757 (LP), *G. buchii* (Urb.) J. Jiménez Alm.: Jiménez & Holdridge 2039 (US), Jiménez 3613 (LP), Leonard & Leonard 11858 (US); *G. calcicola* (Britton) R. N. Jervis & Alain: del Risco et al. s/n° (HAC 27561); *G. crassifolia* (Britton)

R. N. Jervis & Alain: Arias et al. s/n° (HAJB 58526); *G. cordata* Less.: Burkart & Crespo 23169 (LP), 19951 (US); *G. cowellii* (Britton) R. N. Jervis & Alain: Howard 5098 (US), Ventosa s/n° (HAJB); *G. cubensis* (Carabia) R. N. Jervis & Alain: López Figueiras 1692 (HAC); *G. curviflora* (Griseb.) O. Hoffm.: Jerez et al., 4912 (LP), Fiebrig s/n° (C); *G. densicephala* Sancho: Assis & Williams 7393 (LP), Glaziou 11072 (K); *G. discolor* Baker: Clausen 1301 (NY); *G. ekmanii* (Urb.) R. N. Jervis & Alain: Ekman 13865 (S), Ekman 16865 (S); *G. elliptica* (León) Alain: Valentín Montero 21269 (HAC); *G. floribunda* Cabrera: Roque et al., 281 (LP); *G. foliolosa* (D. Don) Hook. & Arn.: Boelcke 3887 (LP), Marticorena et al., 25217 (LP), Jiles 1693 (S); *G. gardneri* (Baker) Cabrera: 4183 (K, G), *G. glutinosa* (D. Don) Hook. & Arn.: Simon & Bonifacino 509 (LP), Navarro & Bruno 9228 (S); *G. gomezii* (León) R. N. Jervis & Alain: León 20876 (HAC); *G. hatschbachii* Cabrera: Maguire et al., 49149 (US); *G. haumaniana* Cabrera: Maguire et al., 49194 (US), Rojas 10391 (K); *G. ilicifolia* Less.: Eggers 4473 (C), Small & Carter 8526 (US), Ventosa, Oviedo & Fuentes 42615 (HAC); *G. intertexa* (Griseb.) R. N. Jervis & Alain: Bisse et al. s/n° (HAJB 41557). *G. magna* Cabrera: Cronquist 11277 (NY); *G. mantuensis* (Griseb.) R. N. Jervis & Alain: Shafer 11208 (LP), Wright 2876 (HAC); *G. microcephala* (Griseb.) R. N. Jervis & Alain: Ekman H– 9280 (S); *G. maisiana* (León) R. N. Jervis & Alain: La Salle 17576 (HAC), *G. montana* (Britton) R. N. Jervis & Alain: Ekman 18725 (S); *G. obovata* (Urb. & Ekman) J.Jiménez Alm.: Ekman 5366 (S); *G. obtusifolia* (Britton) R. N. Jervis & Alain: Acuña & Díaz Barreto 17456 (HAC); *G. oligocephala* (Gardner) Cabrera: Menezes s/n° (59198 LP); *G. orbiculata* (Malme) Cabrera: Handro 156 (US); *G. palosanto* Cabrera, Ventura 9793 (LP), Wood 12696 (US); *G. parvifolia* (Britton) R. N. Jervis & Alain: Bisse et al. s/n° (HAJB 38075); *G. patazina* Cabrera: Velande Nuñez 3178 (LP); *G. pauciflosculosa* (Wight) R. N. Jervis: Eggers 3866 (C), Brace 4019 (US); *G. picardae* (Urb.) J. Jiménez Alm.: Ekman 5385 (US); *G. polymorpha* (Less.) Cabrera: Harley et al., 26 497 (US), Woolston 808 (S), Blanchet 3251 (LP), Glaziou 3039 (LP); *G. ramboi* Cabrera: Rambo 51161 (LP); *G. recurva* (Britton) R. N. Jervis & Alain: Bisse et al. s/n° (HAJB 21657), Alvarez et al. s/n° (HAJB 56472), Acuña 12788 (US); *G. rotundifolia* Less.: Hoehne 3411273 (US), Brade 5346 (S); *G. sagreana* R. N. Jervis & Alain:, Britton et al., 13981 (US), Bisse et al. s/n° (HAJB 42105); *G. shaferi* (Britton) R. N. Jervis & Alain:, Bisse et al. s/n° (HAJB 35368); *G. tortuensis* (Urb.) J. Jiménez Alm.: Ekman H–4313 (S); *G. vernonioides* Kunth.: López et al., 3354 (LP), Becker & Torrones 1391 (US), López Sagástegui 3354 (LP): *Hecastocleis shockleyi* A. Gray: Train 3973 (LP), A. Kellog 5301 (US). *Hyalis argentea* D. Don: Daciuk (LP), *Pertusi 259 (LP). *Mutisia*. *M. acerosa* Poepp.: Cabrera 3463 (LP); *M. acuminata* var. *paucijuga*: Cabrera et al., 13894 (LP); *M. alata* Hieron.: A. López et al., 6719 (LP); *M. andersonii* Sodiro: Scolniek 1532 (LP); *M. arequipensis* Cabrera: Treacy 840, 829 (WIS); *M. brachyantha* Phil.: Wederman 541 (LP); *M. campanulata* Less.: G. Hatschbach 4058 (LP); *M. cana* Poepp. Et Endl.: Jiles 2710; *M. clematis* L.: F. Fosberg 22294 (LP); *M. coccinea* St. Hil.: Krapovickas et al., 22993 (LP); *M. cochabambensis* Hieron.: Cañigueral 11 (LP); Zamaloa 2033 (LP); *M. comptoniafolia* Rusby: Krach 7178 (SI); *M. decurrens* Cav.: Grüner 132 (LP), Soriano 4294 (LP); *M. friesiana* Cabrera: Cabrera et al., 22501 (LP); *M. hamata* Reiche: Cabrera et al., 22495 (LP); *M. homoeantha* Wedd.: Meyer 17565 (LP); *M. ilicifolia* Phil: Jiles 1871 (LP); *M. involucrata* Phil.: Barros 3804 (LP); *M. latifolia* D. Don.: Jiles 3139 (LP); *M. ledifolia* Decaisne: Cabrera 9438 (LP); *M. kurtzii*: Fabris et al., 4082 (LP); var. *anomala*: Cabrera 9001 (LP), Rodríguez 320 (LP); *M. linearifolia* Cav.: Marticorena & Matthei 947 (LP); *M. linifolia* Hook.: Dawson & Pujals 1611 (LP);); *M. macrophylla* Phil.: Barros 7552, 1772 (LP); *M. mandoniana* Wedd.: Beck & Seidel 14549 (SI); G. & D. Schmitt 123 (FM); Cárdenas 4869 (FM); *M. manigera Wedd.*: Riccardi & Marticorena 25468 (LP); *M. mathewsii* var. *anomala* Cabrera: Macbride & Featherstone 907 (LP); *M. retrorsa* M. A. Vignati 420 (LP), *M. saltensis* Cabrera: Cabrera et al., 25519 (LP). *M. sinuata* Cav.: Fabris & Marchionni 2344 (LP), King 334 (LP), Ruiz Leal 2146 (LP); *M. spectabilis* Phil.: C. Jiles P. 1834 (LP); *M. subspinosa* Cav.: Ruiz Leal 1051 (LP); Villavicencio, O'Donell 1331(LP); *M. subulata* R. & P.: Jiles 4189, 2586 (LP); *M. orbignyana* Wedd.: Meyer, Cuezzo & Legname 20888 (LP), Isern 394 (LP); *M. grandiflora* Humb. & Bonpl.: Cuatrecasas 20917 (FM), Acosta Solís 5442 (FM); *M. hamata* Reiche: Cabrera et al., 22495 (LP); *M. intermedia* Hieron.: Sodiro (BAF); *M. lanata* Weddell 2314 (LP); Scolnik & Luti 519 (LP); *M. lehmannii* Hieron.: Jaramillo 5415 (FM), Dorr & Valdespino 6382 (FM); *M. microphylla* Willd ex C.D.: Sodiro (BAF); Zak 715 (FM), Romoleroux 297 (FM), Firmin 524 (FM); *M. oligodon* Popp. Et Endl.: Cabrera 6090 (LP), Ledezma 650 (LP); *M. pulcherrima* Muschl.: Sagástegui 7469 (LP); *M. retrorsa* Cav.: M. A. Vignati 420 (LP); *M. rimbachii* Sodiro ex Harris: Villacrés 234 (FM); *M. sodiroi* Hieron.: Sodiro (BAF), Fosberg 21188 (FM); *M. speciosa* Ait.: Grüner 1077 (LP), Rodríguez 1265 (LP), T. Rojas 4042 (LP); *M. spectabilis* Phil.: Carlos Jiles 1834 (LP), Zorrilla & Jiles 1816 (LP); *M. spinosa* R. & P.: Hollermayer 725 (LP); *M. stuebelii* Hieron.: Cuatrecasas 19156 (FM). *M. venusta* Blake: Vargas 4420 (LP); *M. vicia* Koster: 2256 (LP); *M. wurdackii* Cabrera: López, Sagástegui & Kollantes 4303 (LP). *Onoseris*. *O. alata* Rusby: Cabrera 15862 (LP); Cabrera et al., 14525 (LP); *O. odorata* Hook. & Arn.: Scolnick 1013 (LP); Cabrera & Fabris 13427 (LP). *Perezia*. *P. atacamensis* (Phil.) Reiche: *Cabrera et al., 22482 (LP); *P. bellidifolia* (Phil.) Reiche: *Eskuche 599–20 (LP); *P. recurvata* Less.: *1493 (LP). ***Pertya.*** *P. scandens* (Thunb. Ex Thunb) Sch. Bip.: Steward & Cheo 972 (NY); *P. discolor* Rheder: Smith 5786 (MO). *Proustia*. *P. cuneifolia* D. Don: Burkart & Troncoso 11974 (LP), *Fabris & Zuloaga 8466 (LP). *Stenopadus*. *S. huachamacari* Maguire: Maguire et al., 30116 (MO); *S. affinis* Maguire et al.: Liesner 18346 (MO); *S. connellii* (N.E.Br.) S. Blake: Liesner 23109 (MO); *Schlechtendalia*. *S. luzulaefolia* Less.: Rosengurtt B–4507 (LP); *Pereira 8490 (LP). *Senecio*.* *S. pampeanus* Boffa 1087 (LP). *Stifftia*. *S. chrysantha* J.C. Mikan: Cabrera 12242 (LP). *S. parviflora* (Leandro) D. Don: Hering 7680 (LP); *S. uniflora* Ducke: Ducke s/n° (LP). *Tarchonanthus*. *T. camphoratus* Regmen 501 (US). *Wunderlichia*. *W. azulensis* Maguire & G.M. Barroso: Harleg et al., 25209 (MO); *W. crulsiana* Taubert: Ratter et al., 2615 (MO); *W. mirabilis* Riedel ex Baker: Ratter et al., 2621 (MO). CAMPANULACEAE: *Canarina*. *C. campanula* (L.) Vatke: *s/n° (GÖTT). ***Campanula***. *C. barbata* L.: *Pedersen 6779 (LP).

CALYCERACEAE: *Boopis*. *B. anthemoides* Juss.: *Bottino 437 (LP). ***b****M. fuensis*: *Neumeyen n° 20 (LP). ESCALLONIACEAE: *Carpodetus*. *C. arboreus* (Lauterb. & K. Schum.) Schltr.: *30638 (K); *C. major* Schltr.: *Regdado 1145 (K). *Pentaphragma*. *P. decurrens* Airy Shaw: *Christensen 1055 (K). GOODENIACEAE: *Coopernookia*. *C. polygalaceae* (de Vriese) Carolin: *Jackson 1432 (CANB). *Dampiera*. *D. lanceolata* A. Cunn.: *Wheeler 454 (GÖTT). *Goodenia*. *G. ovata* Sm.: *Wolls (GÖTT); *G. incana* R. Br.: *Von Müeller (GÖTT). ICACINACEAE: *Ilex*. *I. paraguarienses* A. St.–Hil.: *Zardini et al., 727 (LP). MENYANTHACEAE: *Menyanthes*. *M. trifoliata* L.: *2263, Vöhrnm (Gött). *Nymphoides*. *N. aquatica* (J.F. Gmel.) Kuntze: *Nelson 23881 B); *N. brevipedicelata* (Vatke) A. Raynal: *4576 (B); *N. peltata* (s.G. Gmel.) Kuntze: *Fratiles (B). *Liparophyllum*. *L. capitatum* (Ness) Tippery & Les.: *Pritzel 108 (B). RANUNCULACEAE: *Clematis*. *C. montevidensis* Spreng.: *Torres Robles 1613 (LP). ROUSSEACEAE: *Abrophyllum*. *A. ornans* var. *microcarpum* F.M. Bailey: *Wannana (K), Arboretum (K). *Cuttsia*. *C. viburnea* F. Muell.: *Telford 2623 (CBG). *Roussea*. *R. simplex* Sm.: *Botana 1483 (K). STYLIDIACEAE: *Levenhookia*. *L. preisii* (Sond) F. Muell.: *Wrigley s/n° (CBG); *L. stipitata* F. Muell. *Phyllachne*. *P. uliginosa* J.R. Forst & G. Forst: *Reed s/n° (K). *Stylidium*. *S. inundatum* R. Br.: *Kenneally 11435 (CANB); *S. preissii* (Sond) F. Muell.: *Carquist 4013 (CANB).

Specific literature used. Karehed, 1965 (61); Karehed et al., 1999 (62); Rowley and Nilsson, 1972 (63); Bronckers and Stainier, 1972 (64); Nilsson, 1973 (65); Martin, 1977 (66); Lobreau-Callen, 1977 (67); Skavarla et al., 1977 (51); Ferguson and Hideux, 1978 (68);

Dunbar 1978 (69); Praglowsky and Grafström, 1985 (70); Cilliers, 1991 (71); Hansen, 1991 (72); Moar, 1993 (54); Gustafsson et al., 1997 (59); Urtubey and Tellería, 1998 (36); Lundberg, 2001 (73); Tellería et al., 2003 (74), Tellería et al., 2013 (41); Tellería, 2008 (37); Polevova, 2006 (75); Wortley et al., 2007 (76); DeVore et al., 2007 (60); Blackmore et al., 2010 (77); Pereira Coutinho et al., 2012 (78); Hong and Pan, 2012 (58); Freire et al., 2014 (79).

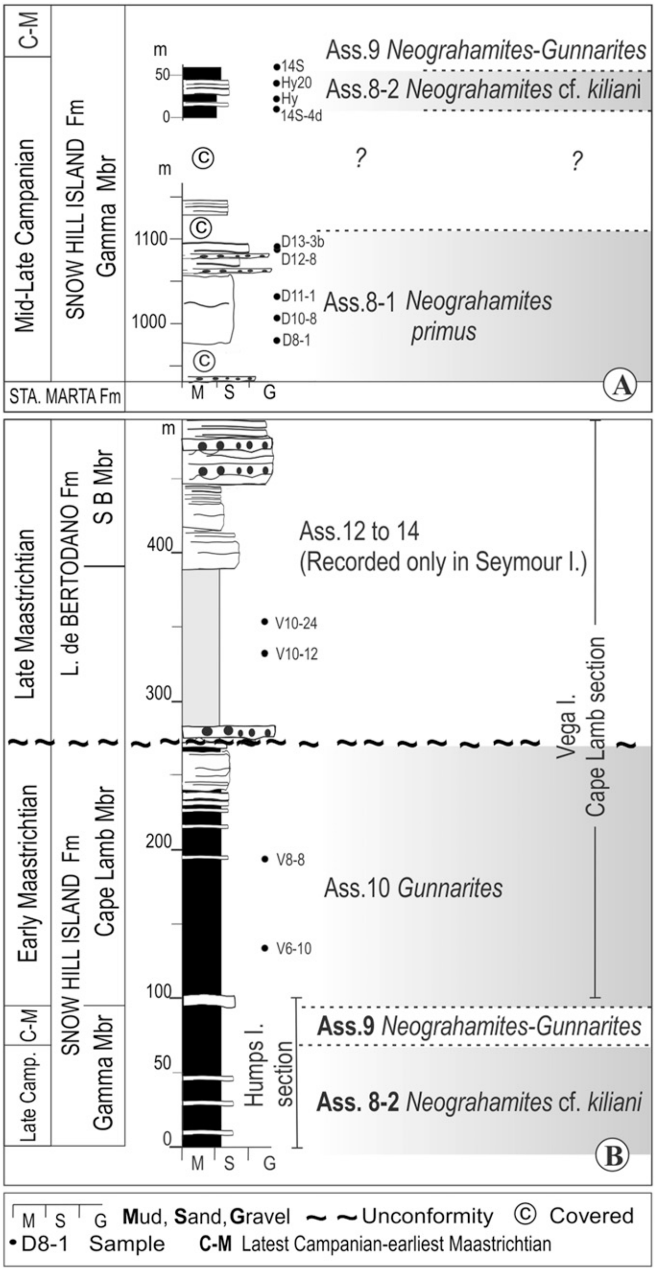

Fig. S1. Stratigraphic sections of the Upper Cretaceous Snow Hill Island and López de Bertodano Formations. (*A*) Stratigraphic section of the Snow Hill Island Formation at Santa Marta Cove, James Ross Island with the situation of the studied samples and Ammonite Assemblages [Assemblages 8–9, adapted from Olivero (7)]. (*B*) Stratigraphic section of the Snow Hill Island and López de Bertodano Formations at Cape Lamb, Vega Island with the situation of the studied samples. To highlight the stratigraphic continuity of the samples, the lower 100 m of the section includes the Gamma Member of the Snow Hill Island Formation exposed on Humps Island, which bear the same Ammonite Assemblages 8-2 and 9 (Assemblages 8-2 and 9) recorded in Santa Marta Cove area (see *A*).

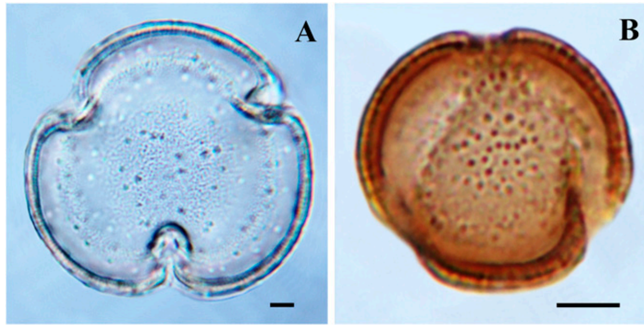

Fig. S2. Extant species of Campanulaceae and Ranunculaceae that bear superficial similarities with the fossil *T. lilliei* type A. (*A*) *Canarina canariensis* (L.) Vatke shows a general resemblance to *T. lilliei*. (*B*) *Clematis montevidensis* Spreng., family Ranunculaceae, has been previously considered related to *T. lilliei*. Both *Canarina* and *Clematis*, show marked differences in exine structure and sculpture. Note the clearly columellate exine structure (see *Supporting Data*, *Systematic Remarks*). (Scale bars, 5 μm.)

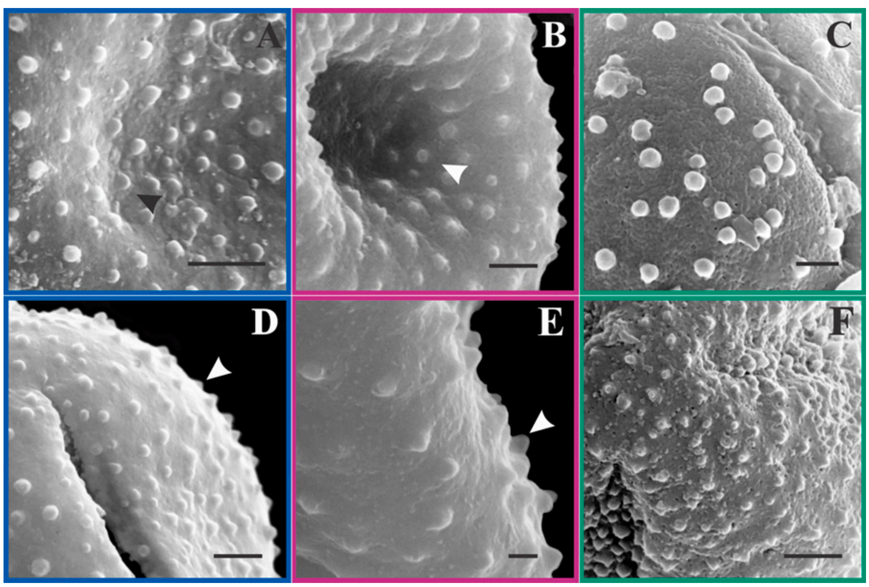

Fig. S3. Details (SEM) of the fossil *T. lilliei* type A from the Late Cretaceous of Antarctica and extant representatives of Asteraceae, Campanulaceae, and Ranunculaceae. (*A* and *D*) Specimens of *Tubuliflorides lilliei* type A (blue frames). (*A*) Poorly defined intercolpal depression (arrowhead); (*D*) detail of sculpture, note microspine (arrowhead) and bacula. (*B* and *E*) Extant *Dasyphyllum inerme* (Barnadesioideae subfamily, Asteraceae, pink frames). (*B*) Well-defined intercolpal depression (arrowhead); (*E*) microspines and baculum (arrowhead). (*C*) *Canarina canariensis* (L.) Vatke (Campanulaceae, green square), verrucate-perforate sculpture. (*F*) *Clematis montevidensis* (Ranunculaceae, green square) details of the microechinate- microgranulate-punctate sculpture. (Scale bars, 2 μm.)

Fig. S4. Specimens of *Tubulifloridites lilliei* (Couper) Farabee & Canright from the Late Cretaceous of New Zealand that bear strong similarities with *T. lilliei* type A. (*Supporting Data*, *Systematic Remarks*). Specimens on slide L5664/3 (Paparoa Coal Measures, Westland Plate VI, figures 17–18 in ref. 8). (*A*) Specimens in equatorial view with a poorly defined intercolpal depression (arrowhead), L40(1). (*B*) Specimen in subpolar view, Q40(0). (Scale bars, 5 μm.)

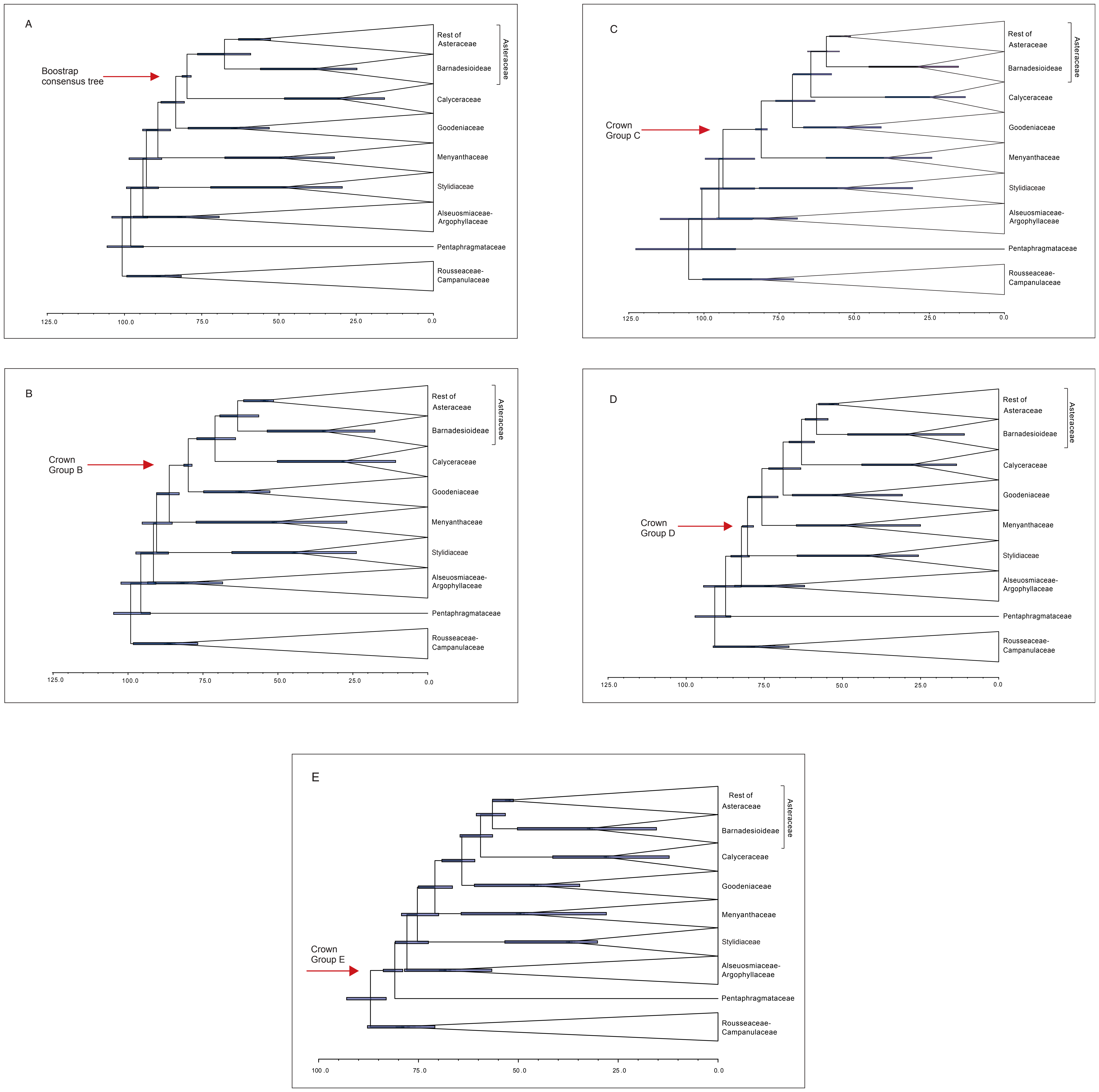

Fig. S5. Timing of diversification of Asterales using different calibration scenarios. Chronograms (*A–E*, scale at the bottom in Mya) estimated using a Bayesian relaxed clock calibrated with a previously described fossil inflorescence and pollen from the Eocene (crown Asteraceae, except Barnadesioideae and Famatinanthoideae) and the oldest eudicot records (ref. 43, and references therein) from the Cretaceous (see Table S4). Our newly discovered specimens from the Cretaceous of Antarctica (red arrow) were used to calibrate alternative nodes according to the results of our sensitivity analysis (see *SI Materials and Methods*, *Estimation of Divergence Times*, and Table S2).

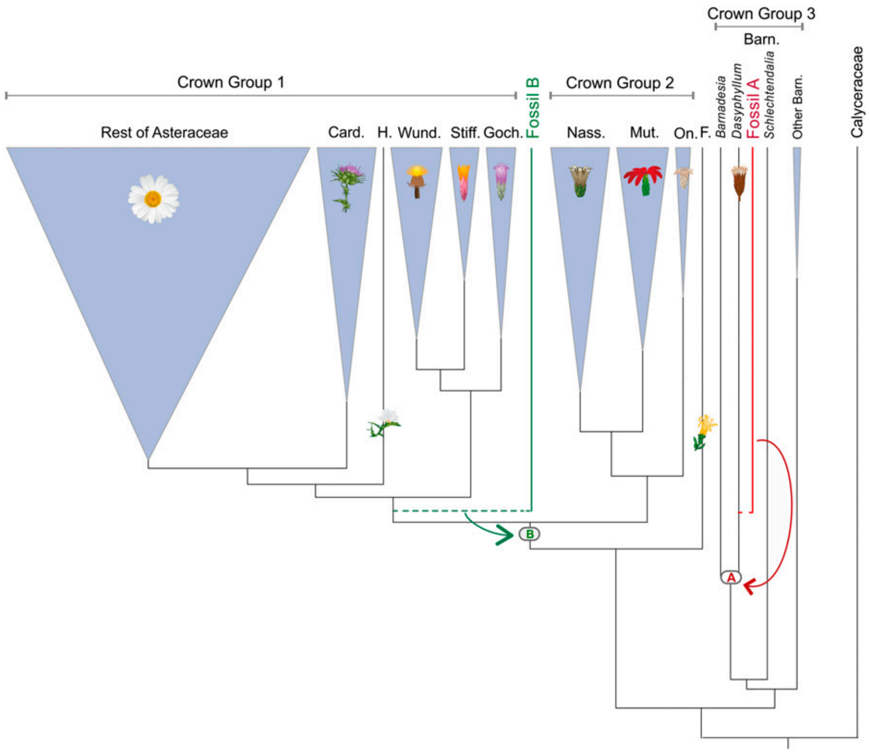

Fig. S6. Placement of the fossils used in the calibration scenario 1. Fossils A (*T. lilliei* type A) is an extinct species of *Dasyphyllum* in the Crown Group 3 and hence we used the age of this Fossil A to calibrate the split between *Dasyphyllum* and its sister genus *Barnadesia*. Fossils B (*Raiguenrayun cura* + *Mutisiapollis telleriae*) are extinct taxa that we identified as stem relatives of Crown Group 1. We used its age to calibrate the split between Crown Group 1 (Stifftioideae; Wunderlichioideae; Gochnatioideae; Hecastocleidoideae; Carduoideae subfamilies and rest of Asteraceae) and Crown Group 2 (Onoserideae; Mutisioideae; Nassauvieae subfamilies). Barn., Barnadesioideae; Card., Carduoideae; F., Famatinanthoideae; Goch., Gochnatioideae; H., Hecastocleidoideae; Mut., Mutisieae; Nass., Nassauvieae; On., Onoserideae; Stiff., Stifftioideae; Wund., Wunderlichioideae.

Table S1. Pollen morphological data matrix of extant and fossil taxa

Table S1

Table S2. Calibration scenarios

Table S2

Table S3. GenBank accession numbers

Table S3

Table S4. Fossil data

Table S4