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TERTIARY OCCURRENCE OF THE FERN *LYGODIUM (SCHIZAEACEAE)* IN AUSTRALIA AND NEW ZEALAND

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Tertiary occurrence of the fern *Lygodium* (Schizaeaceae) in Australia and New Zealand

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Sterile and fertile leaves of the climbing fern *Lygodium* are found in Eocene deposits from Anglesea (Victoria), Maslin Bay and Golden Grove (South Australia) and in the early Tertiary from Dinmore in Queensland (*L. dinmorphyllum* Churchill, 1969). Sterile material is known from Late Eocene/Early Oligocene sediments at Cethana (Tasmania) and the Middle Eocene at Temuka, in New Zealand.

Lygodium is ubiquitous in early Tertiary floras of Australia. The Australian species are very similar to the Eocene Chilean species *L. skottsbergii* Halle, 1940. *Lygodium aureonemorosum* sp. nov. from the Golden Grove, Maslin Bay and Anglesea localities is based on sterile and fertile pinnules, spores, and cuticular information. The fertile pinnae contain spores of *Cyathidites splendens* Harris, 1965. This palynomorph has a Paleocene to Pliocene range in southern Australia. *Lygodium dinmorphyllum* Churchill, 1969 is considered a *nomen dubium*; its leaf morphology overlapping that of *L. skottsbergii* and *L. aureonemorosum*. It is referred to *L. aureonemorosum* primarily on geographic evidence. Heterophylly, possibly exacerbated by climatic/environmental factors, present problems in interpreting variation in fossil *Lygodium*.

Lygodium, Schizaeaceae, *Cyathidites splendens*, Tertiary, palynology, palaeobotany, biogeography, Australia, New Zealand.

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Extant *Lygodium* is a pantropical climbing fern with temperate outliers occurring in New Zealand (*L. articulatum* Rich), Eastern United States (*L. palmatum* (Bernh.) and Japan [*L. japonicum* (Thunb.) Sw.]. About 40 species are known world wide with four occurring in Australia (Holttum, 1959). The Australian species *L. japonicum* (Thunb.) Sw., *L. flexuosum* (L.) Sw., *L. microphyllum* (Cav.) R. Br. and *L. reticulatum* Schkuhr are tropical occurring in northern and eastern Australia. In this paper fossil *Lygodium* leaves including sterile and fertile pinnules are described from Dinmore (Queensland), Maslin Bay and Golden Grove (South Australia) and Anglesea (Victoria) and a number of other localities in southern Australia and New Zealand (Fig. 1). Previous records of *Lygodium* or *Lygodium*-like ferns are reviewed. Problems inherent in classifying and describing variable taxa are discussed.

PREVIOUS RECORDS OF FOSSIL *LYGODIUM* IN AUSTRALIA AND NEW ZEALAND

Lygodium or *Lygodium*-like fossils have been reported by Johnston (1894), Ettingshausen (1888), Shirley (1898), Churchill (1969), Hill *et al.*, (1970), Douglas (1978) and Christophel and Greenwood (1987). Churchill's material was the first unequivocal fossil evidence of the genus in Australia. The taxa described in the 19th century was based on fragmentary sterile pinnules but none can be confidently assigned to *Lygodium* (Churchill, 1969). Of these taxa the type of *Osmunda tasmanica* Johnston 1893 could not be located in collections in Tasmania (R.S. Hill, N. Kemp; pers. comm.). The holo type of *L. strzeleckii* Ettingshausen, 1886 collected from the Vegetable Creek locality was restudied and prepared further (Fig 3A) but referral to *Lygodium* is dubious because it is based upon small pinnule fragments with abraded margins. The Late Triassic *Lygodium antiquorum* Shirley, 1898 from the Ipswich Coal Measures is based upon a trilobate seed fern or fern pinnule (Fig. 3F) with no evidence of sporangia, and is not referrable to *Lygodium* as Walkom (1917) indicated.

Churchill (1969) described *L. dinmorphyllum* based upon two fertile pinnules from the early Tertiary Redbank Plains Formation at Dinmore in south eastern Queensland. However, the pinnules are indistinguishable from the Eocene *L. skottsbergii* Halle, 1940 from Chile. Hill *et al.* (1970) recorded sterile *Lygodium* pinnules from Dinmore, which they referred to *L. skottsbergii.* Douglas (1978) figured a fertile pinna from Anglesea in Victoria. Christophel and Greenwood (1987) recorded *Lygodium* from the Golden Grove locality.

Additional material was collected from Dinmore and Anglesea by ACR and DCC respectively over a number of years. *Lygodium* has also been recently collected from the Middle Eocene Maslin Bay and Golden Grove floras (South Australia) and the Late Eocene/Early Oligocene Cethana flora of Tasmania. *Lygodium* pinnae have also been recognised from Temuka in New Zealand (D. Mildenhall pers. comm. 1986).

LOCATION OF SITES AND AGES OF FLORAS

The Dinmore site in the Redbank Plains Formation, south eastern Queensland is of Paleocene/Eocene age (Day *et al.*, 1983). This largely undocumented flora includes ferns, Podocarpaceae and dicotyledonous leaves a(Selling, 1950, Hill *et al.*, 1970.

The diverse Anglesea flora occurs in the Middle Eocene Eastern View Coal Measures, and while *Lygodium* occurs in most lenses the majority come from the *Gymnostoma* lens (Christophel *et al.*, 1987). Elements of the Maslin Bay flora were described by Blackburn (1981) from a carbonaceous clay lens in the Middle Eocene North Maslin Sands (McGowran *et al.*, 1970, Alley, 1987). A well preserved flora from the North Maslin Sands at Golden Grove north of Adelaide is also Middle Eocene in age. A recent overview of the flora has been provided by Christophel and Greenwood (1987).

The Late Eocene/Early Oligocene Cethana flora has yielded *Nothofagus* leaves (Hill, 1984), and the remaining flora, which includes 'tropical' rainforest elements, is presently being studied (R. Carpenter pers. comm., 1987). The geology and stratigraphic information on the Temuka potteries clay pits in New Zealand is discussed in Wellman (1953) and Gair (1967) and indicates an Eocene age for this flora. Specimens from these two localities were not available for study.

METHODS AND PRESERVATION OF FOSSILS

The Dinmore, Cethana and Vegetable Creek materials are preserved as impressions in fine grained mudstones lacking cuticle. Latex peels of the surface of sterile *Lygodium* pinnules from Dinmore examined with a SEM yielded no cellular information (D. Dilcher pers. comm.). However, SEM examination of fragments of the original specimen do show some cellular information (Fig. 11). The Maslin Bay and Anglesea specimens are preserved as compressions or impressions while *Lygodium* leaves and sorophores from Golden Grove are 'mummified'. The method for preparing 'mummified' leaves follows that of Christophel (1984). The Golden Grove *Lygodium* are usually opaque and could not be studied using the fluorescence technique of Friedrich and Schaarschmidt (1977). Small areas of venation in these specimens were illuminated using narrow beams of light from cold light sources.

The mummified sorophores from Golden Grove were cleaned with concentrated HF acid for a few days and the sporangia were gently macerated to release spores. Spores were studies and photographed with a Zeiss Photomicroscope 111. Attempts to obtain fragments of cuticle from these leaves, however, have been largely unsuccessful.

Lygodium examined in this paper (Appendix A) includes material from the Queensland Museum (QMF), Geological Survey of Queensland (GSQF), University of Queensland (UQF), Museum of Victoria (NMVP), University of Tasmania (UTC), University of Adelaide (Maslin Bay, UAS; Golden Grove, UAG), and Geological Survey of New Zealand (GSNZ). Modern *Lygodium* material referred to is in ACR's collection unless otherwise stated.

Systematic Palaeobotany

Lygodium aureonemorosum sp. nov. (Figs 4-10)

Holotype UAS3040

Type locality. Golden Grove Locality, North of Adelaide, South Australia.

Etymology. Named after the latin derivation of the type locality Golden Grove, aureo: gold and nemorosum: forest or grove.

Diagnosis. Sterile asymmetrical pinnules unilobate, bilobate, trilobate, quadrilobate, base cuneate to truncate, apex rounded to acute, venation dichotomous branching from central vein two to three times before reaching leaf margin. Margin variable, undulose, smooth to rarely lobed. Fertile pinnules usually lacking lamina, sorophores variable in size, often united in tetards. Spores referrable to *Cyathidites splendens* Harris, 1965. Cell walls of cuticle sinuous, stomata anomocytic.

Remarks. The presence of well preserved spores, cuticle and sterile and fertile pinnules warrants recognition of a new taxon for this material. The type locality is Golden Grove but material from Anglesea and Maslin Bay is also referred to this taxon. *Lygodium aureonemorosum* is closely comparable with *L. skottsbergii* but is referred to a new taxon based upon spores and limited cuticular information. Halle (1940, p. 259) noted that the spores of *L. skottsbergii* are finely punctate or almost smooth and hence differ from *Cyathidites splendens.* The status of *L. dinmorphyllum* Churchill, 1969 from Dinmore, is equivocal because of the lack of spores and it overlaps the foliar morphology of *L. skottsbergii* and *L. aureonemorosum.* The only indication that the Dinmore material may represent a distinct species is the acute angle (75-85°) of lower order branching in the fertile pinnae (Fig. 4, A, G, H). The only relatively complete specimen from Anglesea (Fig. 8D) has obtuse angled lower order branching (130-150°), which is similar to modern *L. articulatum* (Fig. 2). Complete fertile axes have not been collected from Golden Grove or Maslin Bay. The systematic implications are, however, difficult to assess because insufficient material has been collected from enough localities to assess variation.

Churchill's (1969) description of *L. dinmorphyllum* does not differ significantly from *L. skottsbergii* and it is best treated as a *nomen dubium.* As the material from Dinmore lacks spores it cannot be referred confidently to either taxon on morphological criteria. Based upon geographical evidence and the widespread distribution of the spore *Cyathidites splendens* in the early Tertiary in Australia it would seem likely that the Dinmore specimens are also referrable to *L. aureonemorosum.*

FOLIAR HETEROMORPHISM IN EXTANT *LYGODIUM*

Foliar heteromorphism is the production of morphologically variable leaf types on the same individual (Eckenwalder, 1980). Changes in the size and shape of successive leaves can be due to heteroblastic development (Wareing and Phillips, 1982). This may occur in the transition from juvenile to adult leaves or may result from environmental factors. In *Lygodium,* transition from sterile to fertile pinnae results in morphologically distinct pinnae. Pinnae intermediate in character between sterile and fertile pinnules occur in *L. articulatum* and *L. palmatum.* The lamina in the fertile pinnae of the extant species *L. articulatum* and *L. palmatum* is very reduced and the pinnules are strongly dimorphic (Fig. 2; Manchester and Zavada, 1987, figs. 6, 7). The degree of lamina reduction varies in fertile leaflets of *L. articulatum* (Fig. 2).

In *Lygodium,* there is great plasticity of form in sterile and fertile pinnae, and fusion of pinnules occurs. Sterile leaflets in extant *L. articulatum* are characteristically unilobate although fused bilobate pinnules also occur. Fused pinnules may explain some variation in fossil material from Australia.

Aberrant pinnules with accessory lobing were collected from Dinmore, Maslin Bay and Golden Grove and were figured by Manchester and Zavada (1987, figs. 9A, F, H) for *L. kaulfussi*. In modern *L. reticulatum* from north eastern Queensland similarly deformed leaves occur and may be due to climatic or environmental factors (disease, insect herbivory) or may be teratologic in origin.

FOSSIL *LYGODIUM* MORPHOLOGY

Taxonomic treatments of extant *Lygodium* are based upon the form of sterile and fertile pinnules, spores, venation and mode of branching. Holttum (1959, p. 39), commented that "there is so much variation in leaflet form due to the age of the plant, height above ground and perhaps polploidy and hybridisation that even with ample material it is not easy to give specific limits". Fossil *Lygodium* presents further problems due to the incomplete and fragmentary nature of material available for study. Morphological variation in sterile *Lygodium* pinnules from sites in Australia and New Zealand is presented in Table 1. As Dinmore and Golden Grove have yielded the largest amount of vegetative and fertile material, discussion will centre on these two localities. The strongly dimorphic sterile and fertile pinnules occur in association at Dinmore, Golden Grove, Anglesea and Maslin Bay. *Lygodium* pinnules can be referred to the same plant (Fig.s 4E-F).

Sterile pinnule morphology

Fossil *Lygodium* pinnules from the various sites are asymmetrical and palmately lobed. The number of lobes in sterile *Lygodium* was used by Berry (1930) to define new fossil taxa, although it is an extremely variable feature. *Lygodium* pinnules at most sites, but particularly at Dinmore and Golden Grove, exhibit considerable variation in the number and degree of lobation (Table 1). At Dinmore, unilobate and trilobate and bilobate and trilobate pinnules have been found in organic connection (Figs. 5E, H; 6C). In the extant New Zealand species *L. articulatum*, unilobate pinnules predominate but fused bilobate pinnules occur. Similarly, in fossil *Lygodium* from Dinmore, bilobate and trilobate pinnules are the most common, although rare quadrilobate and pentalobate pinnules occur (Figs. 5B, I). These are interpreted as resulting from the fusion of trilobate with unilobate and bilobate pinnules. Bilobate and trilobate pinnules also predominate in the Golden Grove, and Maslin Bay localities (Table 1). The Australian fossil *Lygodium* pinnules resemble extant *L. palmatum* in having lobate pinnules but like *L. kaulfussi* Heer they differ in their larger, more elongate pinnules.

All the major localities in Australia have yielded sterile pinnules with petiolules. In most specimens the petiolules are short (<3.0 mm long), except a few specimens from Dinmore which have a preserved petiolule length of up to 15.0 mm (Fig. 6B). The end of the petiolule in the Golden Grove material is frequently enlarged indicating a point of attachment (Figs. 9B-E, H). In extant *L. articulatum* pinnules (sterile and fertile) have an abcission node and at senescence dehisce at their base (Fig. 2). This feature also occurs in the fossil *L. kaulfussi* and was used by Manchester and Zavada (1987) to differentiate between *L. kaulfussi* and *L. skottsbergii*. Sterile pinnules from Dinmore, Anglesea and Golden Grove also lack an abscission node. *Lygodium skottsbergii* and the fossil Australian material resemble extant *L. palmatum* in that their leaflets are firmly affixed to petiolules and lack abscission nodes (Manchester and Zavada, 1987).

The pinnule margins in *L. aureonemorosum* are entire to undulose with some specimens showing irregular lobation (Figs. 9F, H). These irregularly lobate pinnules are probably due to environmental factors or may represent teratologic forms. One of the Cethana specimens (Fig. 3B) is irregularly serrate and is only tentatively referred to *Lygodium* but the other specimen is asymmetrical and bilobate (Fig. 3C) and comparable to other *Lygodium* material. The convexly curved basal margin of the pinnule is similar in both specimens. This feature occurs consistently in most of the Tertiary *Lygodium* material in Australia. The base of the pinnule is typically cuneate or truncate while in *L. kaulfussi* it is rounded to obtuse or cordate (Manchester and Zavada, 1987).

The venation in the fossil Australian and New Zealand material is dichotomous (Table 1), branching two-three times before reaching the margin. The venation of the Australian *Lygodium* material appears indistinguishable from *L. kaulfussi* from the Eocene Bridger Formation material from Wyoming figured by Manchester and Zavada (1987). Venation is relatively uniform in *Lygodium*, except those with anastomosing venation e.g. *L. reticulatum*.

Preservation of the mode of branching and evidence of the climbing habit which is characteristic of modern species in this genus is rare in the fossil record and is unlikely to occur in those species where the pinnules dehisce at senescence. The only evidence of the mode of branching in fossil *Lygodium* comes from impressions at Dinmore.

Fertile pinnule morphology

The sorophores of *L. aureonemorosum* like that of *L. kaulfussi* and the extant species *L. palmatum* and *L. articulatum* are produced terminally on branched axes. The sorophores vary in size, reflecting their position on the plant and stage of development. *Lygodium skottsbergii*, *L. articulatum* and the *L. aureonemorosum* all show variation in reduction of lamina in fertile pinnae. The fertile pinnae of *L. articulatum* vary in the free lamina between sorophores (Fig. 2) and *L. skottsbergii* shows similar variation in the amount of leaf lamina between sorophores (Halle, 1940, pl. 1, figs 4-8). *Lygodium aureonemorosum* pinnae from Dinmore exhibit similar ranges of variation (Fig. 4) with some fertile pinnae 'free' of lamina, others bear extensive lamina between the sorophores (Churchill, 1969, fig. 4). In most of the Golden Grove, Maslin Bay and Anglesea material the fertile pinnae are nonlaminar. Fertile pinnae of *L. kaulfussi* are also nonlaminar although pinnules intermediate in character between sterile and fertile pinnules are preserved (Manchester and Zavada, 1987, figs. 8). The sorophores attached to the sterile pinnule from Dinmore can similarly be explained as an 'leaflet' intermediate in character between sterile and fertile pinnules (Figs. 4E-F). The annulus on the sporangia is not preserved in material from any site. Halle (1940) and Manchester and Zavada (1987) noted that the annuli could not be discerned in *L. skottsbergii* and *L. kaulfussi* respectively.

Spore morphology

Spores from complete sorophores of *L. aureonemorosum* are known from Anglesea (Douglas, 1978) and have been extracted from Golden Grove material. The spores broadly resemble those from fossil *Lygodium* (excluding *L. poolensis* Chandler, 1955) described from the Northern Hemisphere (Buzek and Konzalova, 1983; Chandler, 1955; Manchester and Zavada, 1987). Although spores were recovered from *L. aureonemorosum* from a number of sites the best preservation is in the Golden Grove material and descriptions are based on this material. In general, the spores possess a subtriangular amb with convex to straight (occasionally concave) interradials and rounded radials. The laesura are slightly sinuous, often open and gaping, and extend two thirds of spore radius towards the amb. The laesura are bordered by labra 5-7 µm wide and raised 6-8 µm. Spore exine is approximately 2 µm thick and thickened in the radial areas to 5 µm. Ornamentation is best developed on the distal surface and comprises low verruca, short rugula and low sinuous to bifurcating ridges enclosing short irregular lumina; ornamentation is reduced on the proximal surface, particularly in the proximal polar area (Fig. 10). In optical section the amb is gently undulating. Some specimens appear to bear remnants of an irregular perisporum. Based upon measurements from 15 specimens the equatorial diameter of the spores is 67 (82) 95 µm and polar diameter is 59 (75) 90 µm.

The spores from *L. aureonemorosum* sorophores are identical to the form species *Cyathidites splendens* Harris 1965. The holotype of *C. splendens* was examined but the mounting medium and spore are too dehydrated to provide useful morphological information and comparisons were limited to photographs and published descriptions. However, free spores of *C. splendens* occur consistently in the Golden Grove and Maslin Bay carbonaceous lenses as well as other Australian early Tertiary sediments (Fig. 10). Spores of the form species *Cyathidites gigantis* (Cookson) Harris 1965 also bear some similarity to the spores extracted from the *L. aureonemorosum* sorophores. However, the holotype of *C. gigantis* and other free spores from early Tertiary sediments were examined and found to be smaller, possess a much thickened exine with prominently thickened radials, and coarse ornamentation in the proximal polar area, diminishing greatly in the equatorial interradial areas. The *L. aureonemorosum* spores therefore correlate with the form species *C. splendens* Harris 1965.

Cuticle Morphology

Attempts to prepare cuticle from the mummified Golden Grove leaves have been largely unsuccessful although further work is continuing. Small fragments of cuticle from Golden Grove suggest the stomata are anomocytic which is the condition in extant *Lygodium* (Clifford and Constantine, 1980) and cell walls are sinuous. SEM micrographs of impressions of Dinmore material also demonstrate sinuous cell walls but stomata are not evident. *Lygodium* *kaulfussi* also has sinuous cell walls and anomocytic stomata (Krausel and Weyland, 1950).

CONCLUSION

Even with ample material as provided by the Golden Grove and Dinmore localities, species assessment is difficult, as the material is extremely variable. The limited material from Cethana or Temuka is therefore difficult to interpret particularly with only photographic evidence available. Similarly the early records of *Lygodium* (such as Ettingshausen, 1888), which are based solely on sterile foliage are also not easily resolvable, unless better preserved material can be obtained. Northern Hemisphere species based on limited material present similar problems as Manchester and Zavada (1987) have shown.

Palaeobiogeographical speculation on the radiation and evolution of *Lygodium* is difficult because of the cosmopolitan distribution and extensive Tertiary fossil record (Krausel and Weyland, 1950; Reed, 1947). The extensive fossil record of *Lygodium* in Australia would suggest that the extant Australian species may be derived from these early Tertiary forms. However, as fossil *Lygodium* is also known from the Miocene Notonakijima flora of Japan and Oligocene floras of Manchuria (Matsuo, 1963; Florin, 1922) it is equally possible that the modern northern Australian species *L. japonicum, L. flexuosum, L. microphyllum* and *L. reticulatum* are recent arrivals from Asia as Page and Clifford (1981) speculated. These species are all widely distributed within the Malesian region (Holttum, 1959). The weakly dimorphic fertile foliage of most of the Malesian species, i.e. the fertile pinnules resemble the sterile pinnules suggests a closer affinity to *L. mioscandens* Matsuo from Japan than with the fossil material from the early Tertiary of Australia. Manchester and Zavada (1987) suggested that species with lamina surrounding the sorophores e.g. *L. japonicum* and *L. flexuosum* are relatively recent in origin. The high diversity of *Lygodium* species in the Malesian area may be due to a relatively recent speciation and radiation in this region. This may explain, in part, Holttum's (1959, p. 39) difficulties in defining modern species within the genus.

Cyathidites splendens ranges from the Late Paleocene through to the Pliocene in southern Australia. In the early Tertiary Eyre Formation of the Lake Eyre Basin *C. splendens* is common and can be locally more frequent in parts of the Paleocene section. The frequency of the spore in palynomorph assemblages, however, decreases through the Tertiary and *C. splendens* is rare in Pliocene assemblages. *Cyathidites splendens* is commonly associated with palynofloral assemblages that are indicative of rainforest communities. The gradual decrease in the frequency of *C. splendens* through the Tertiary in southern Australia may be related to the overall decline in temperature and precipitation during this interval.

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APPENDIX A

A. Lygodium material examined

(F = fertile; S = sterile)

<u>Dinmore, Redbank Plains Formation, south eastern Queensland</u>

QMF2857-8 (S); QMF12544 (F); QMF13464 (S); QMF14096 (S); QMF14360 (S); QMF14361 (S/F); QMF14362-3 (S); QMF14365-7 (S); QMF14464-7 (F); QMF14530 (F): QMF15809 (S); QMF14924 (F); QMF14974 (S); QMF15314 (S); QMF15317 (F); QMF15318-9 (S); QMF15320-1 (S); QMF18035 (S); QMF18904 (S).

UQF10620 (F); UQF10720 (F); UQF10726 (S); UQF12450-1 (F); UQF32006 (S).

GSQF12973 (F); GSQ12974 (S).

NMVP26688 (F) Holotype, *L. dinmorphyllum*; NMVP26689 (F) Paratype, *L. dinmorphyllum* (F).

<u>Cethana, Tasmania</u>

UTC232 (S); UTC235 (S).

<u>Vegetable Creek, New South Wales</u>

GNSWF8820 (S), Holotype, *L. strzeleckii.*

<u>Maslin Bay, North Maslin Sands, South Australia.</u>

UAS715-6 (S); UAS1211 (S); UAS1868 (S); UAS2274 (S); UAS2513-4 (S); UAS2691-2 (S); UAS3502 (S); UAS3524 (F); UAS3537-8 (S); UAS3546-7 (S).

Golden Grove, North Maslin Sands, South Australia.

UAG1379 (S); UAG1398 (S); UAG1400 (S); UAG2604-5 (S); UAG2607-8 (S); UAG2718 (S); UAG2720 (S); UAG3001-26 (S); UAG3036-42 (F).

<u>Anglesea, Eastern View Coal Measures, Victoria.</u>

NMVP165681 (F); NMVP178144-9 (S); NMVP178150 (F).

<u>Temuka, New Zealand.</u>

NZGSB25/90-92.

LOCALITY	PINNULE SHAPE	VENATION	APEX OF PINNULES	BASE OF PINNULES	REFERENCES
L. aureonemorosum					
Dinmore, Queensland	asymmetrical/palmate; bi., tri., quad., pentalobate	dichotomous	Acute, obtuse, retuse	cuneate, truncate	Churchill, 1969; Hill *et al.*, 1970
Anglesea, Victoria	asymmetrical/palmate; bilobate, quadrilobate	dichotomous	acute, obtuse, retuse	cuneate	Douglas, 1978
Maslin Bay, S. Aust	asymmetrical/palmate; uni., bi., trilobate	dichotomous	acute, obtuse	cuneate, truncate	–
Golden Grove, S. Aust	asymmetrical/palmate; uni., bi., trilobate	dichotomous	acute, obtuse, retuse	cuneate, truncate	Christophel and Greenwood, 1987
Lygodium sp.					
Cethana, Tasmania	asymmetrical/palmate?; uni., trilobate	dichotomous	acute?, obtuse	cuneate	–
Temuka, New Zealand	asymmetrical/palmate?; uni.,trilobate	dichotomous	obtuse, acute	truncate	
Vegetable Creek, N. S. W.	unilobate	dichotomous	obtuse	-	Ettingshausen, 1888
L. skottsbergii, Chile (fossil)	asymmetrical/palmate; bi., trilobate	dichotomous	acute, obtuse	truncate, broadly cuneate	Halle, 1940
L. articulatum, New Zealand (extant)	usually unilobate, occassionally bilobate	dichotomous	acute	cuneate	–

Table 1.

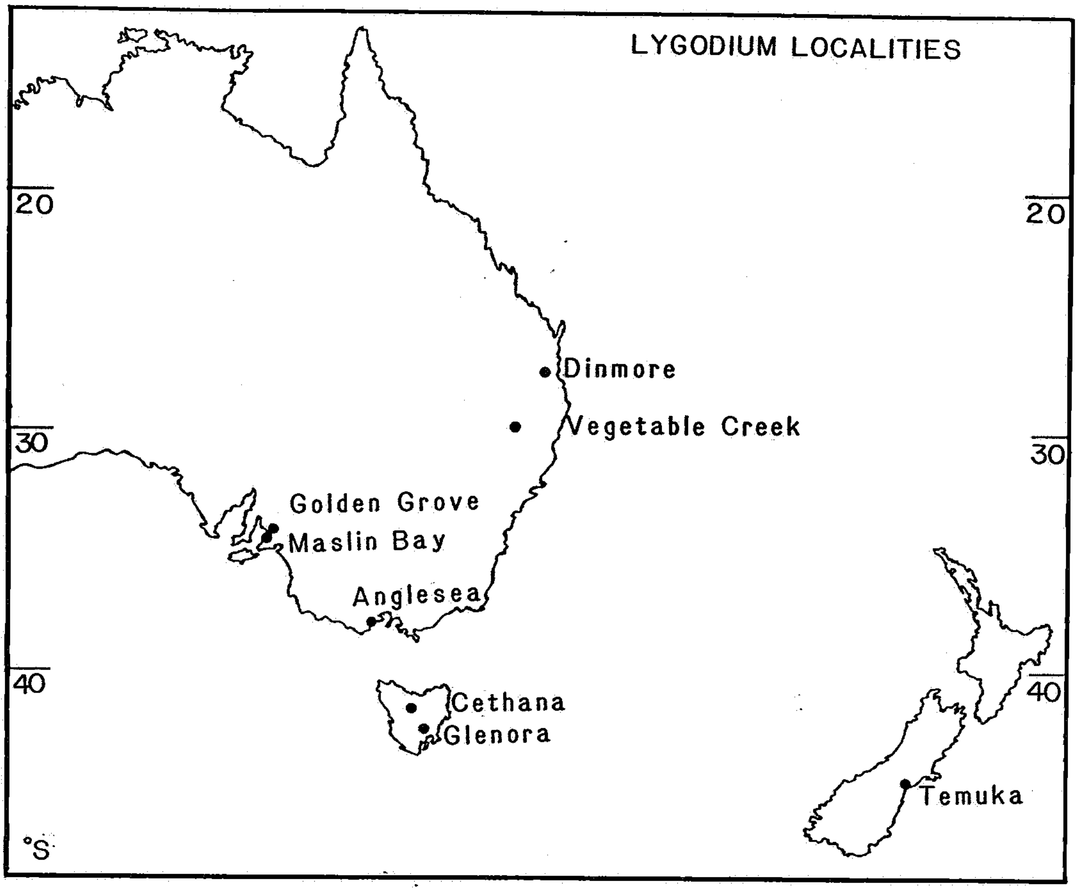

LYGODIUM LOCALITIES
20
20
Dinmore
Vegetable Creek
30
30
Golden Grove
Maslin Bay
Anglesea
40
40
Cethana
Glenora
Temuka
°S

Figure 1.

No 153015 BOTANY DIVISION, D.S.I.R., CHRISTCHURCH, NEW ZEALAND

LYGODIUM ARTICULATUM. H. RICH.

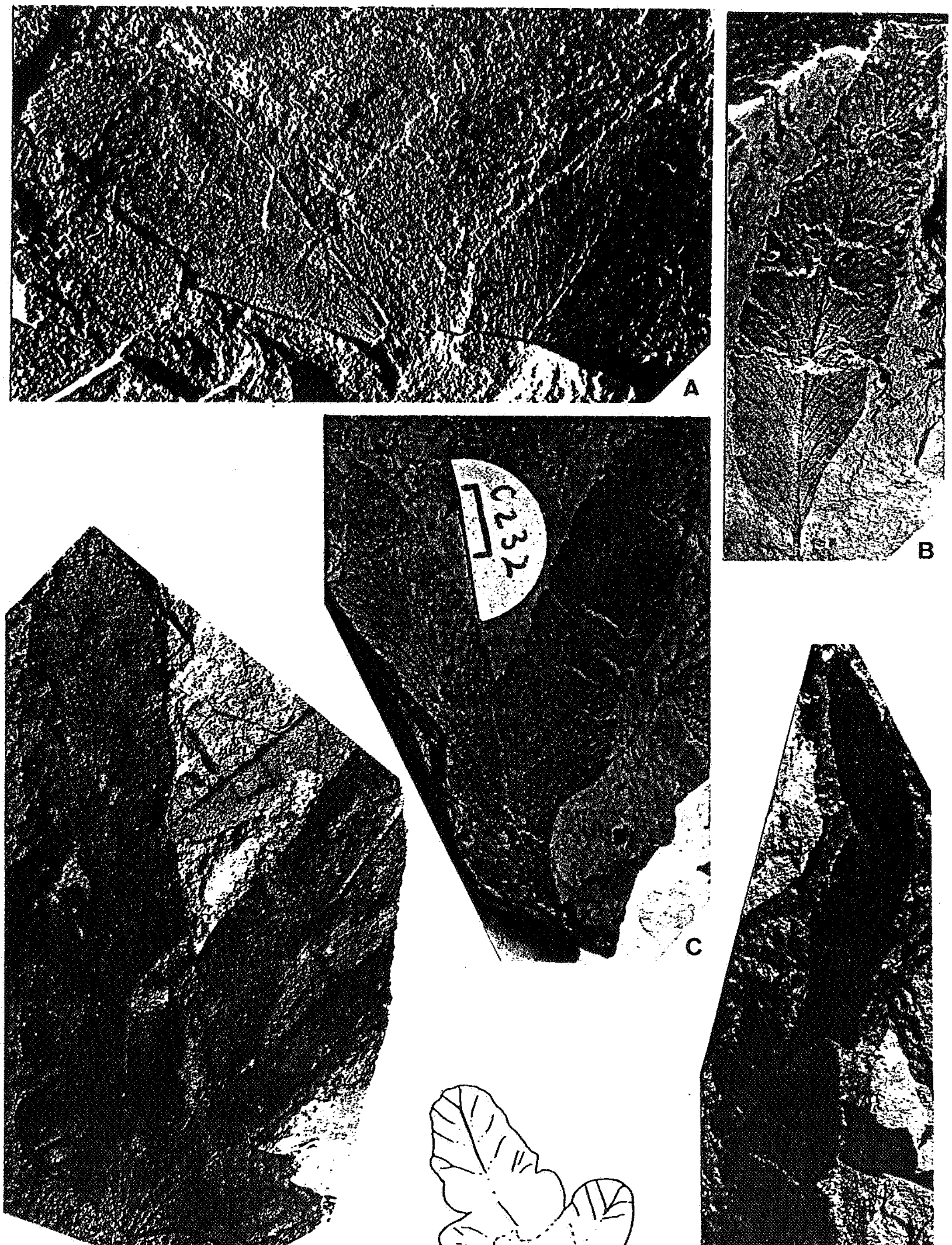
Loc. FAIRY FALLS TRACK, WAITAKERE RANGES, AUCKLAND.

Hab. [illegible] OVER FALLEN TREE.

Col. I.K. FRIER. Date: 26-12-1963

I.K. FRIER. 26-12-1963

Figure 2.



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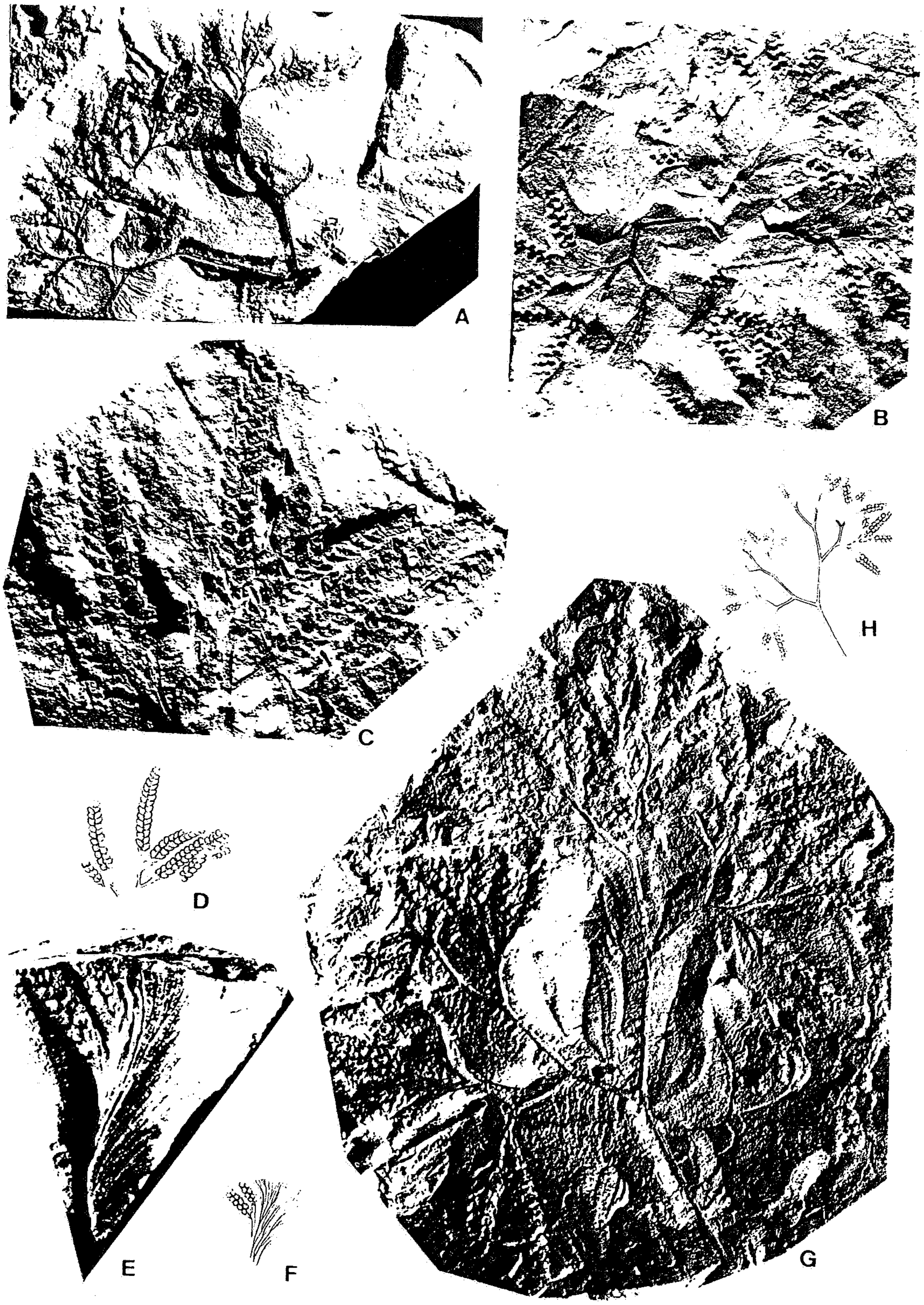

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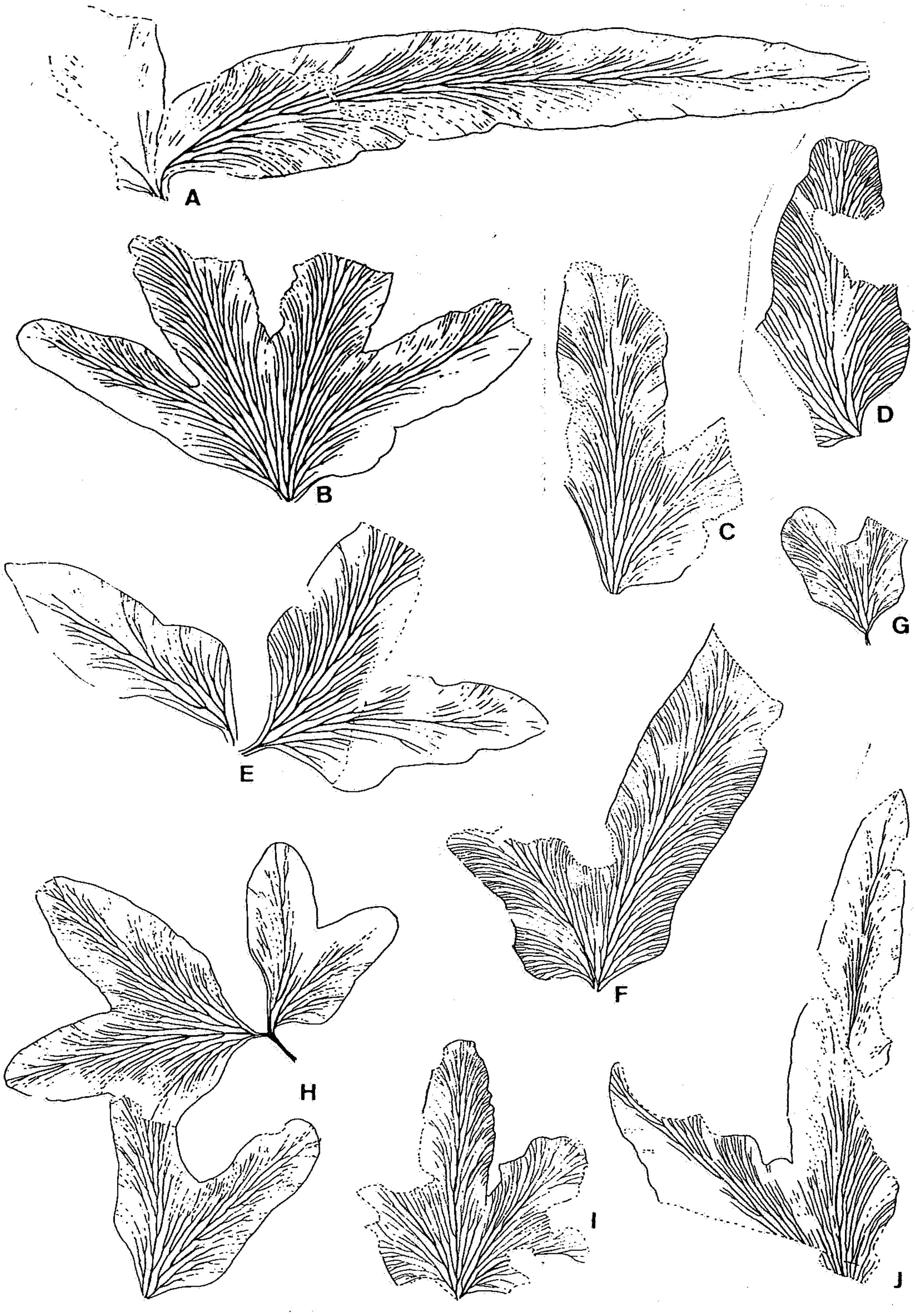

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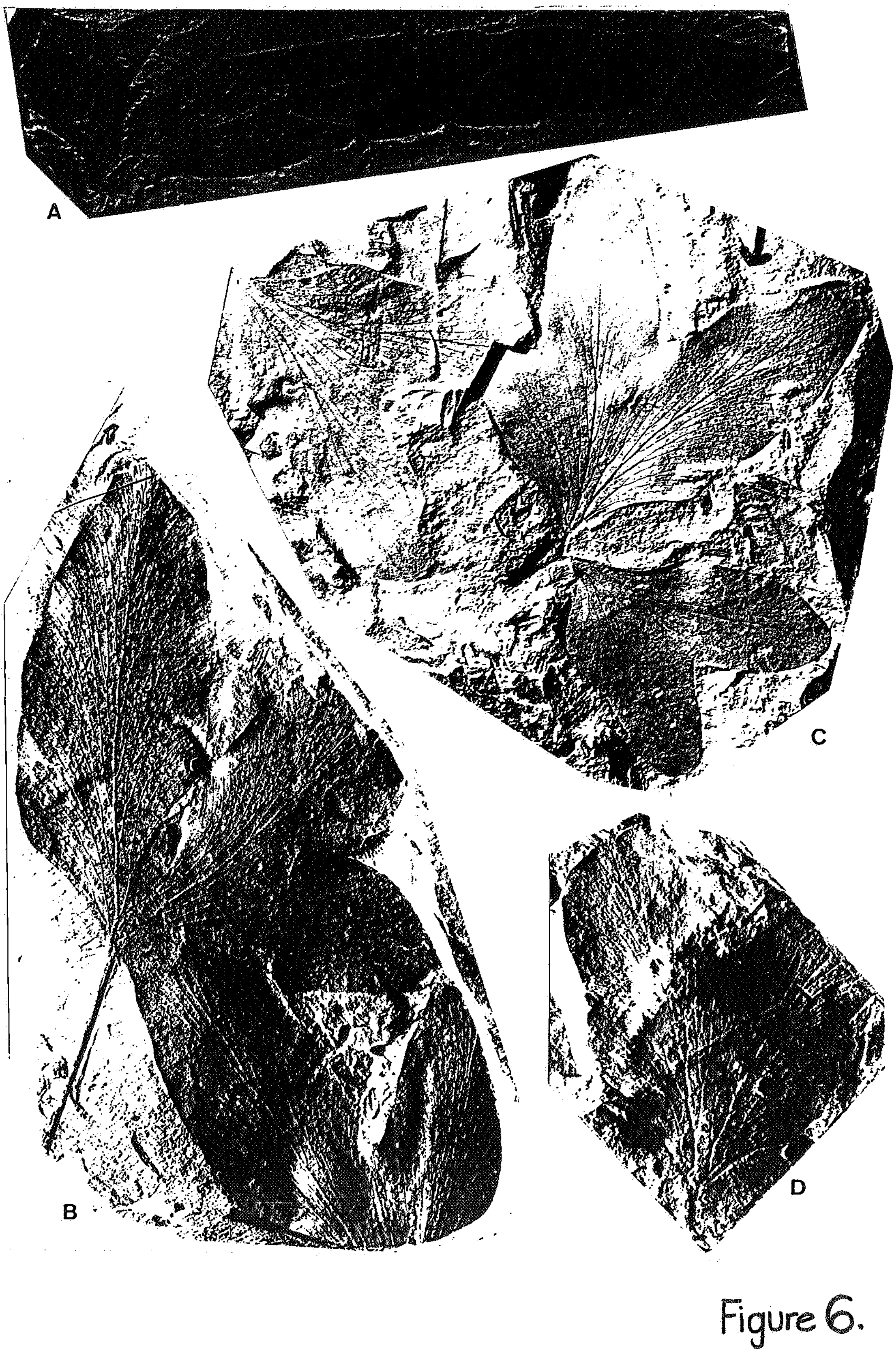

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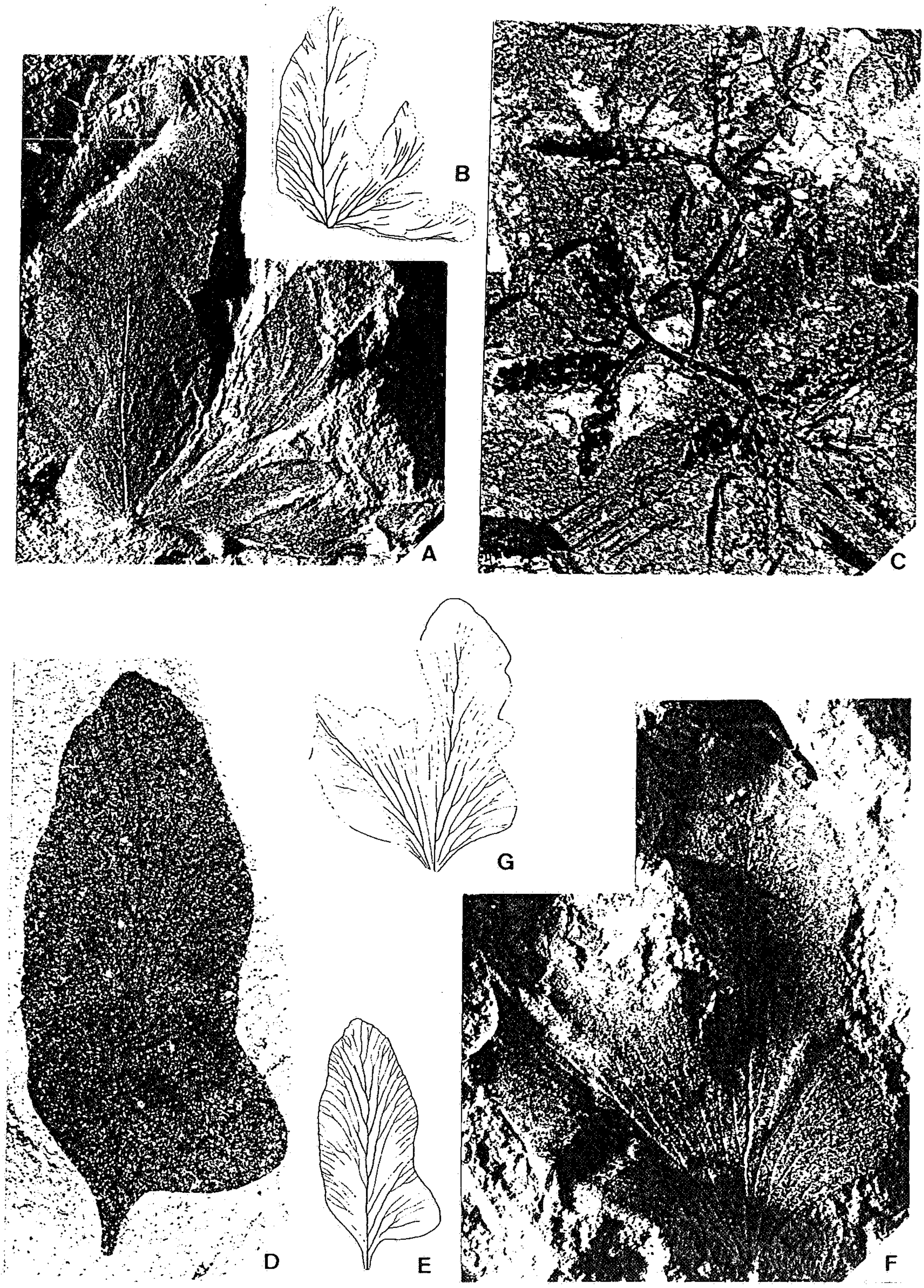

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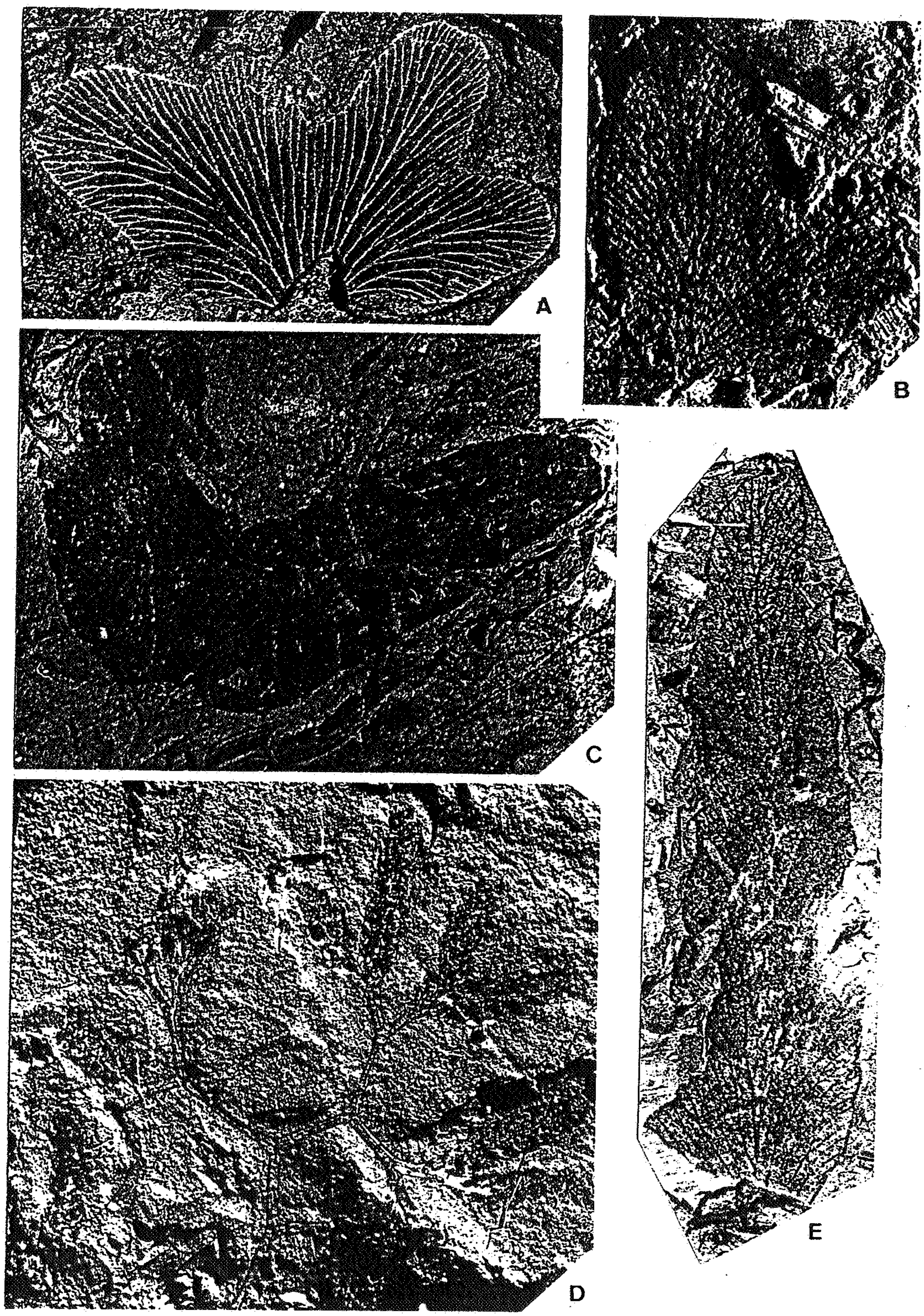

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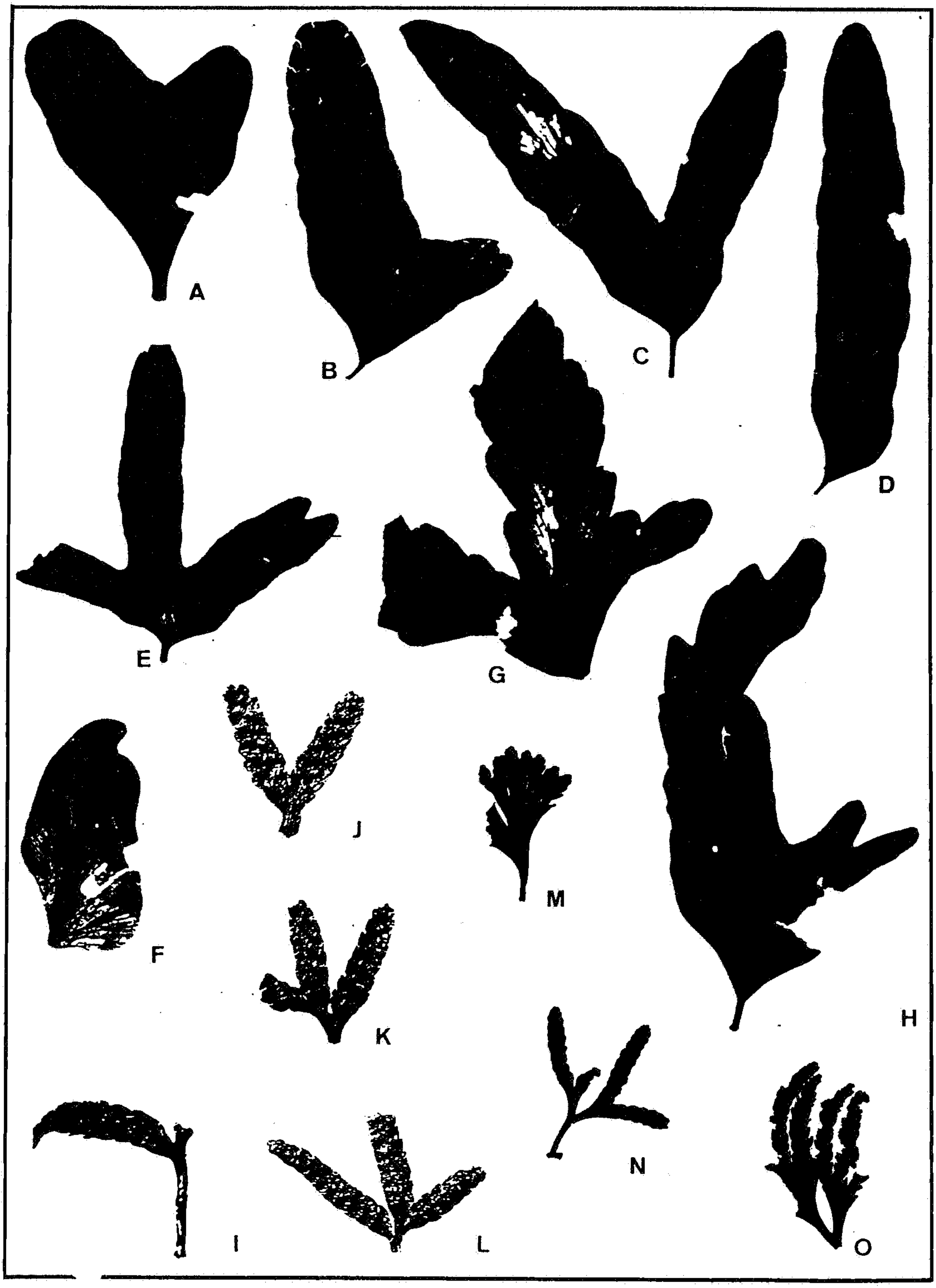

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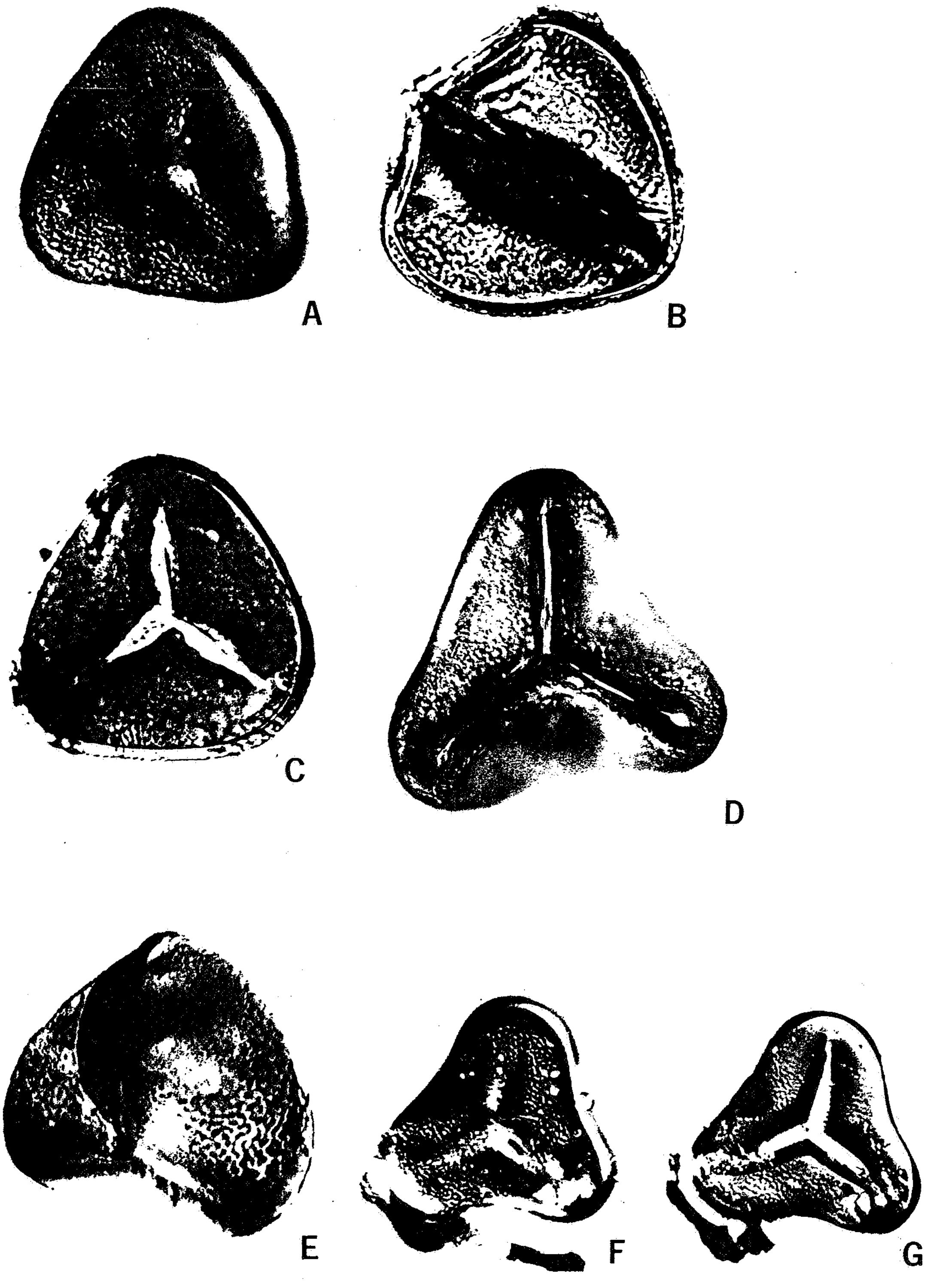

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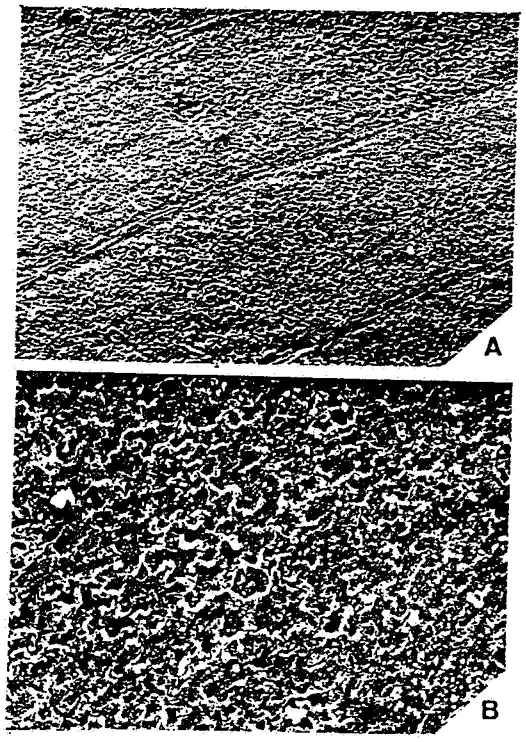

Figure 11.