AEROPALYNOLOGICAL STUDY OF TAIWAN (1)–CHU-SHAN STATION[1]

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Abstract: The total number of 4760 palynomorphs distributed in 6 families of pteridophytes, 3 familes of gymnosperms and 29 families of angiosperms were observed and indentified. About 34.2% or 13 families of these airborne palynomorphs belong to autopatric plants, 50% or 19 families to allopatric Plants, and 15.8% or 6 families to both autopatric and allopatric vegetation. Based on the data of seasonal variation of air borne grains the flowering periods of these palynomorphs is largely divided into fall and spring groups: Betulaceae, Compositae, Magnoliaceae and Gramineae belong in the former group, and Pinaceae, Taxodiaceae, Cupressaceae, Chenopodiaceae, Euphorbiaceae, Fagaceae, Lauraceae, Moraceae, Myrtaceae, and Cyperaceae are found to be in the latter.

INTRODUCTION

There only have been two papers dealing with aeropalynological study in the past ten years, these were by the two medical doctors, Dr. Chao *et al* (1962) and Dr. Chen (1970). Their objective was to study the pollen responsible for hay fever. Pollen dispersal and the relationship between the airborne palynomorphs and the surrounding floristic compositions was not discused. In order to obtain basic information on the relation between the airborne palynomorphs and the surrounding vegetations, the flowering periodicity, and the dispersal distance of the pollen of important economic trees is carried, the senior author set up four stations in the Experimental Forest of National Taiwan University, Nan-tou District (Fig. 1) to obtain the airborne palynomorphs during 15 August 1968 to 26 June 1969. These were located at Chu-shan, Che-kuan-liao, You-shui-keng and Chi-tou. This paper will report the results obtained from the first station, i.e. the Chu-shan collection, other reports will follow.

MATERIALS AND METHODS

Matunami slides which were coated with adhesive medium were used for catching airborne pollen grains and spores. The adhesive medium for the slides was prepared as follows according to the modified Wodehouse's method (1959, 1971)*. The slides coated with this adhesive medium were placed horizontally in a special designated holder called trap (Fig. 2). The pollen traps which were made of two

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* By dissolving 50 gm of gelatin powder in 400 cc of tap water, this was placed in a water bath and heated to melt completely the gelatin solution. Then adding 600 cc of glycerine and agitating until this was homogenized then adding 10–20 gm of phenol to the mixture, to this was added a saturated solution of methyl green in 50% alcohol until the mixture become green ink color.

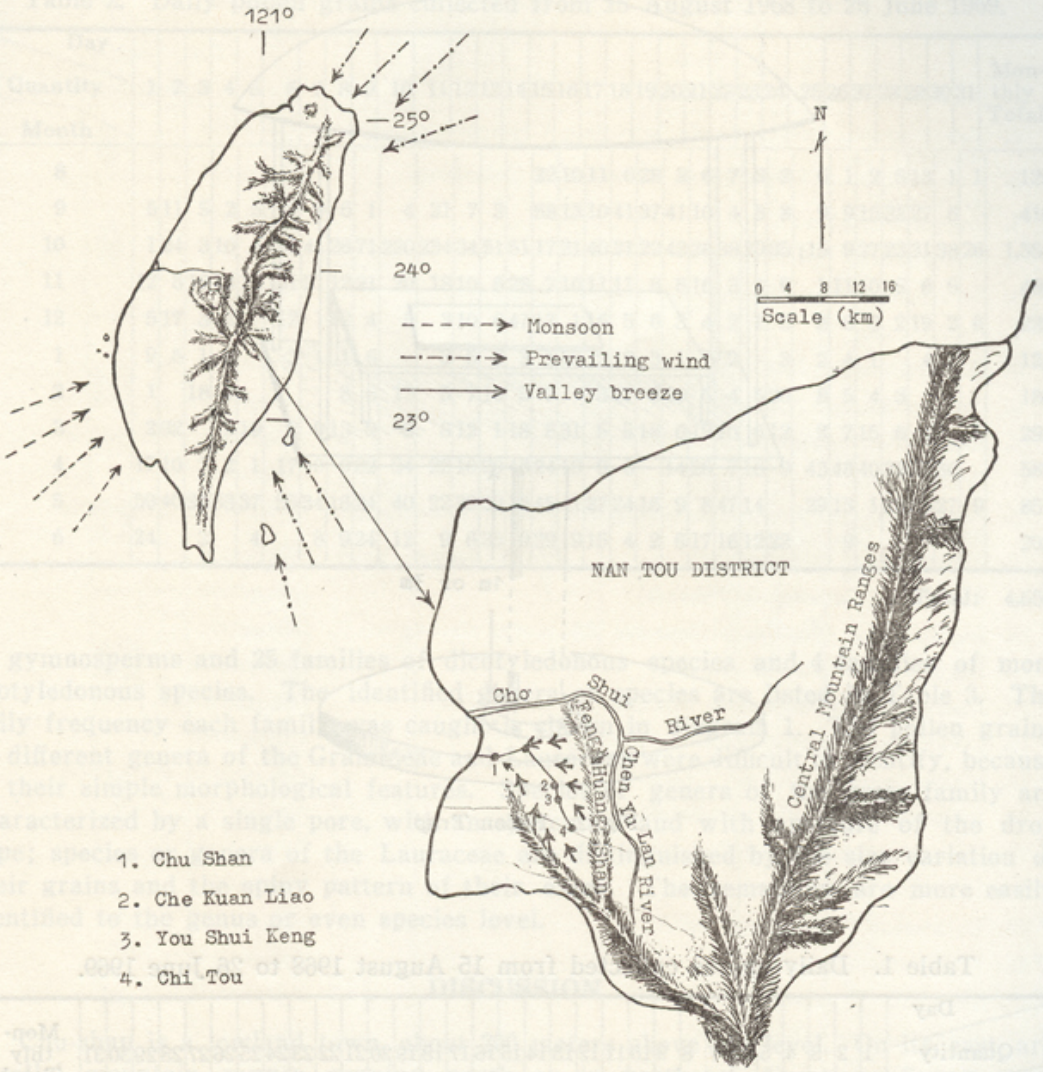

Fig. 1. Map for showing palynomorphs collecting station and wind direction

different heights, one was 1 m and the other built to stand 3 m above the ground, these were placed in an open field near the Experimental Forest Station office. The slides were collected once daily from 15 August 1968 to 26 June 1969. The palynomorphs appearing under a standard No. 1, 18 mm cover glass were examined, counted and identified. The area under each cover glass is 1.91 sq. cm. The aids used in identification were the standard palynological books of Erdtman (1952, 1954, 1957), Huang (1972), and Ikuse (1956).

RESULTS

A total of 4760 pollen grains and spores were counted and identified after ten months' collection (see Tables 1–2). About 2% were fern spores and 98% were pollen grains. The ferns were distributed in about 6 families. There were 3 families

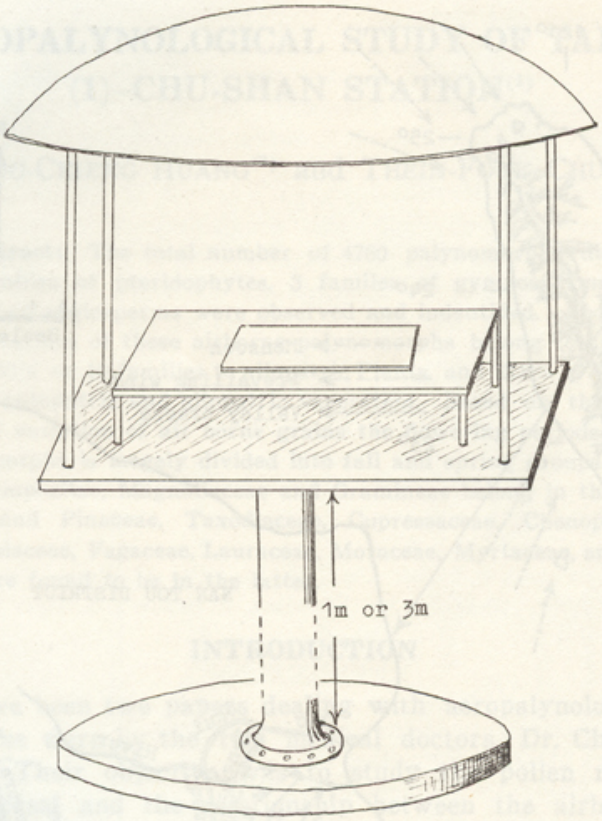

Fig. 2. Pollen Trap

Table 1. Daily spores collected from 15 August 1968 to 26 June 1969.

Month \ Day / Quantity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Monthly Total
8															2	2		1		1	2			1		2	1		3	1		16
9	1	4	2	3	6	1	1	2			1						1						1		1		1					25
10			1			1	4	2		1	1	2	1	1	1		2	1		1	1	1			2	1						24
11							1	4	2	1	1	1	1	1		2	3								1							18
12						1	1						1						1	1												5
1						1															1					1			2	1		6
2										1	1						1			1											4
3																																
4																																
5															1	1	1															3
6																										1						1
																															Total:	102

Table 2. Daily pollen grains collected from 15 August 1968 to 26 June 1969.

Month \ Day / Quantity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Monthly Total
8															22	10	11	6	28	2	6	7	3	2	6	1	2	5	13	1	1	125
9	5	11	5	2	5	9	9	6	1	4	21	7	3		58	13	10	41	37	41	10	4	8	8	9	9	15	32	27	6		416
10	1	24	3	10	4	21	41	26	71	220	234	34	51	51	17	21	40	21	22	42	28	39	29	35	115	9	27	23	31	38	26	1,351
11	12	5	19	14	12	151	21	12	21	20	18	10	6	28	7	10	11	11	8	8	16	3	4	9	1	11	10	6	6	9		489
12	5	17	3	2		12	1	12	4	5	3	10	6	47	17	1	16	5	6	3	4	2	1	6	8	6	6	2	19	2	6	237
1	9	8	1	6		3	1	1	6		3	5	2	3	1	12	19	12	3	1	1	2		3	2	4	1		4	1		124
2	1		18	1				8	6	13	5	7	10	5	7		3	17	8	19	6	4	5	20	8	5	4	3				183
3	2	32		3	19	2	9	13	9	6	8	12	1	18	8	31	5	5	18	6	19	10	6	12	2	7	15	6	4		5	293
4	17	10	7	2	1	17	10	9	22	24	22	10	20	48	24	19	9	6		14	26	7	18	9	43	48	40	38	37	30		587
5	50	40	31	53	37	55	34	16	24	40	22	39	30	16	45	41	27	24	16	9	8	47	14		29	13	1	22	33	27	9	851
6	24		2		4		8	9	24	12	9	6	35	9	39	19	15	4	2	6	17	16	12	22		9						202

Total: 4,658

of gymnosperms and 25 families of dicotyledonous species and 4 families of monocotyledonous species. The identified genera or species are listed in Table 3. The daily frequency each family was caught is shown in diagram 1. The pollen grains of different genera of the Gramineae and Lauraceae were difficult to identify, because of their simple morphological features. Species or genera of the grass family are characterized by a single pore, with an operculum and with aperture of the drop type; species or genera of the Lauraceae are distinguished by the size variation of their grains and the spiny pattern of their exine. The remaining are more easily identified to the genus or even species level.

DISCUSSION

Chu-shan is a lowland town, about 200 meters above sea level. On its east are parallel mountain ranges running north or in northeast direction. Sugar cane, cereals, fruit trees, such as *Syzygium* and some economic bomboos together with such trees as *Acacia confusa, Lagerstroemia subcostata* are commonly cultivated in this area. The annual temperature is 18–22°C. There are three major wind directions blowing across the island of Formosa, i.e. in the summer the monsoons blow from the southwest but the prevailing winds are from the southeast. In the winter, the prevailing winds are from the northeast. Since the Central Mountain Range lies east of Chu-shan and runs from north to south, the prevailing winds do not effect this area, but the monsoon and valley breeze do effect the distribution of palynomorphs of Chu-shan. In the Nan-tou area the breezes in the valleys come from the neighbouring mountains and blow in various directions (Fig. 1).

There were 38 families of palynomorphs counted and identified, about 34.2% or 13 families of the airborne grains belonged to autopatric vegetation, 50.0% or 19 families belonged to allopatric vegetation and 6 families or 15.8% belonged to both autopatric and allopatric vegetation (see Table 3 and Diagram 1). The pollen grains of gymnosperms and fern spores were mostly of allopatric vegetation. Regarding,

Table 3. Taxa identified and their distribution.

Taxa	Distribution
1. Pinaceae (*Pinus cf. luchuensis*)	Autopatric, Allopatric
2. Taxodiaceae (*Cunninghamia lanceolata, Cryptomeria japonica*)	Allopatric
3. Cupressaceae (*Chamaecyparis formosensis, Calocedrus formosana*)	Allopatric
4. Rosaceae (*Rubus*)	Allopatric
5. Apocynaceae (*cf. Formosia*)	Allopatric
6. Betulaceae (*Alnus formosana, Carpinus rankanensis*)	Allopatric
7. Orchidaceae	Autopatric
8. Caprifoliaceae (*Lonicera*)	Allopatric
9. Chenopodiaceae (*Chenopodium*)	Autopatric
10. Compositae (*Artemisia* and other genera)	Allopatric, Autopatric
11. Cruciferae	Autopatric
12. Euphorbiaceae (*Jatropha panduraefolia, Mallotus tanarius, Bischoffia, Claoxylon*)	Autopatric, Allopatric
13. Gentianaceae (*Crawfurdia*)	Allopatric
14. Fagaceae (*Castanopsis, Pasania*)	Allopatric
15. Juglandaceae (*Juglans cathayensis, Platycarya strobilacea*)	Allopatric
16. Leguminosae (*Acacia confusa*)	Autopatric
17. Lauraceae (*Cinnamomum, Machilus, Actinodaphne*)	Allopatric
18. Lythraceae (*Lagerstroemia subcostata*)	Autopatric
19. Magnoliaceae (*Michelia formosana*)	Autopatric, Allopatric
20. Malpighiaceae (*cf. Tristellateia austrlasiae*)	Allopatric
21. Casuarinaceae (*Casuarina equisetifolia*)	Allopatric
22. Moraceae (*Morus australis*)	Autopatric
23. Urticaceae (*Debregeasia edulis*)	Allopatric
24. Myrtaceae (*Syzygium*)	Autopatric
25. Oleaceae (*Faxinus formosana*)	Autopatric
26. Polygonaceae (*Polygonum*)	Autopatric
27. Sterculiaceae (*Kleinhovia hospitata*)	Allopatric
28. Symplocaceae (*Symplocos chinensis*)	Autopatric
29. Ulmaceae (*Trema orientalis, Celtis nervosa, Zelkova formosana*)	Autopatric
30. Cyperaceae (*Cyperus, Carex*)	Autopatric
31. Typhaceae (*Typha latifolia*)	Allopatric
32. Gramineae (*Zea mays* and other genera)	Autopatric
Trilete spores	
33. Gymnogrammaceae (*Pityrogramma*)	Allopatric
34. Monachosoraceae (*Monachosorum*)	Allopatric
35. Lycopodiaceae (*Lycopodium*)	Allopatric
36. Cyatheaceae (*Cyathea*)	Allopatric
Monolete fern spores	
37. Polypodiaceae (*Polypodium, Drynaria, Microsorium*)	Autopatric, Allopatric
38. Aspidiaceae (*Dictyocline, Polystichum.*)	Allopatric, Autopatric

Polypodium, *Polystichum*, and *Pinus cf. luchuensis*, it was difficult to tell whether they belonged to the allopatric or autopatric, because they are so widely distributed in the surrounding areas. The allopatric palynomorphs are grains which are small in size, and simple in sculpture; large numbers of these were collected. They all seem to be from wind pollinated vegetation. Most of the allopatric vegetation identified were growing on hillsides about 15 km east of Chu-shan and carried down to this area by the valley breezes.

The flowering period of this local vegetation is shown in Diagram 1 and is distinctly divided into two major groups, that is its fall and spring groups. The families of Betulaceae (*Alnus japonica*, *Carpinus rankanensis*), Compositae (*Artemisia*), Magnoliaceae (*Michelia formosana*) and Gramineae belong in the fall group; Pinaceae (*Pinus cf. luchuensis*), Taxodiaceae (*Cunninghamia lanceolata*, *Cryptomeria japonica*), Cupressaceae (*Calocedrus formosana*) of gymnosperms and Casuarinaceae (*Casuarina equisetifolia*), Chenopodiaceae (*Chenopodium*), Euphorbiaceae (*Jatropha panduraefolia*, *Macaranga tanarius*, *Mallotus paniculatus*), Fagaceae (*Castanopsis*, *Pasania*), Lauraceae (*Actinodaphne*, *Machilus*), Moraceae (*Morus australis*), Urticaceae (*Debregeasia edulis*), Myrtaceae (*Syzygium*) and Cyperaceae (*Cyperus*, *Carex*) are commonly found in the spring season. Besides, Euphorbiaceae (*Mallotus paniculatus*, *Macaranga tanarius*), Chenopodiaceae (*Chenopodium*), Magnoliaceae (*Michelia formosana*), Betulaceae (*Alnus japonica*) and Gramineae have been continuously found but in smaller numbers in every month throughout the year, since these families are the commonest ones in this and neighbouring areas.

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REFERENCES

Chao, I. T., L. F., Chen, & J. T. Shich, 1962. Study and survey of Aeroallergen of Taiwan. Chinese Medical Jour., **9**(4): 233-243.

Chen, C. Y., 1970. Seasonal variations of fungi in the Sputa and Throat of asthmatic patients. Jour. of the Formosan Medical Assoc., **69**(4): 190-200.

Erdtman, G., 1952. Pollen morphology and plant taxonomy. Waltham, Chronica Botanica Co. 239 pp.

———, 1954. An introduction of pollen analysis. Waltham Mass., 228 pp.

———, 1957. Pollen morphology and plant taxonomy. The Ronald Press Co. 150 pp.

Hibino, K., 1969. Relation between airborne pollen and the living vegetation in Mt. Hakkoda. Ecological Rev., **17**(3): 189-195.

Huang, T. C., 1972. Pollen Flora of Taiwan. Botany Department Press, NTU, pp. 275, pls 177, 10 text-figs, Taiwan, ROC.

Hyde, H. A., 1950. Study in atmospheric pollen IV. Pollen deposition in Britain. New Phytol., **49**: 398-406.

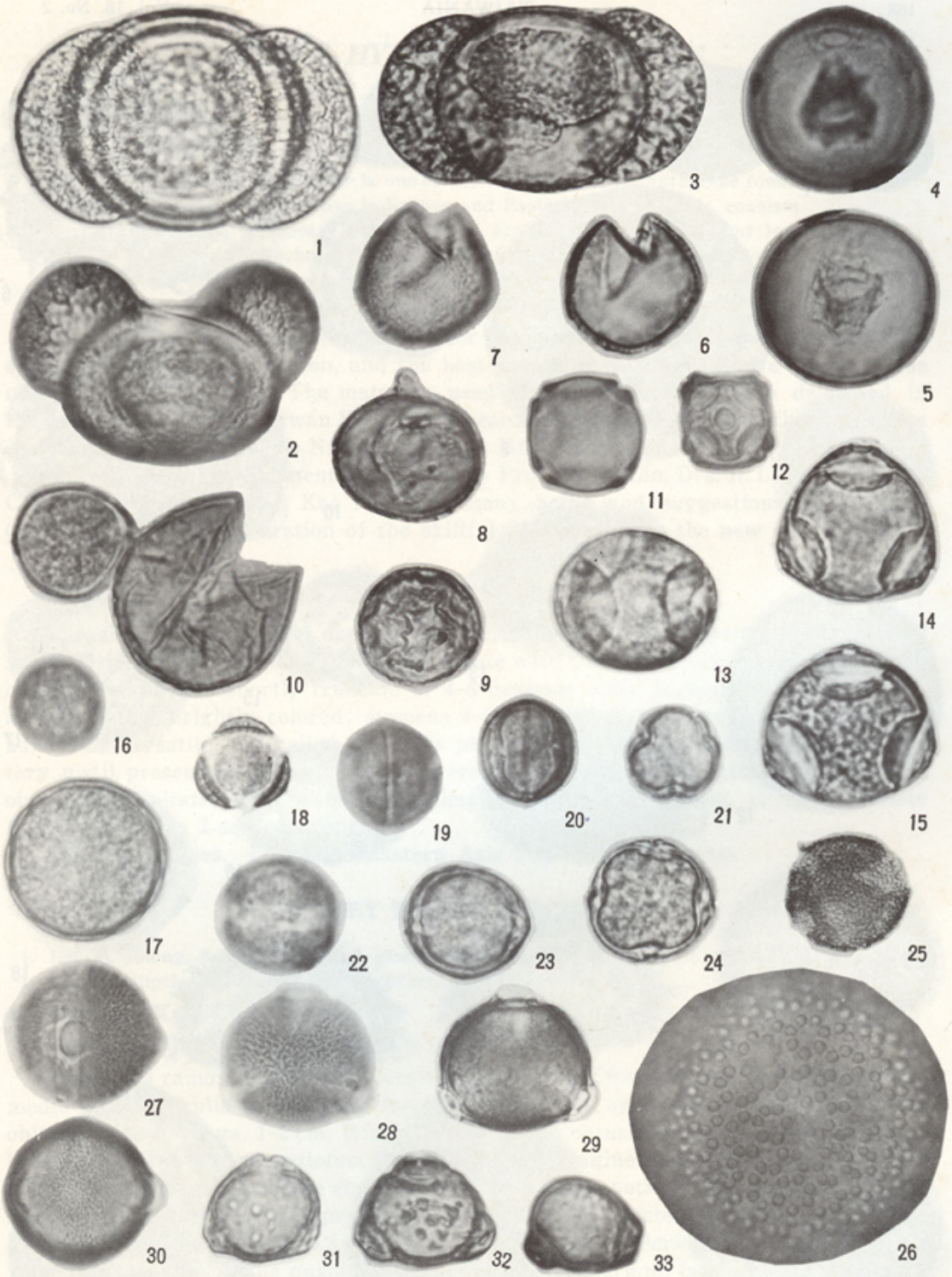
———, 1969. Aeropalynology in Britain—an outline. New Phytol., **68**: 579-590.

Ikuse, M., 1956. Pollen grains of J apan. Hirokawa Pub. Co. Japan, 303 pp.

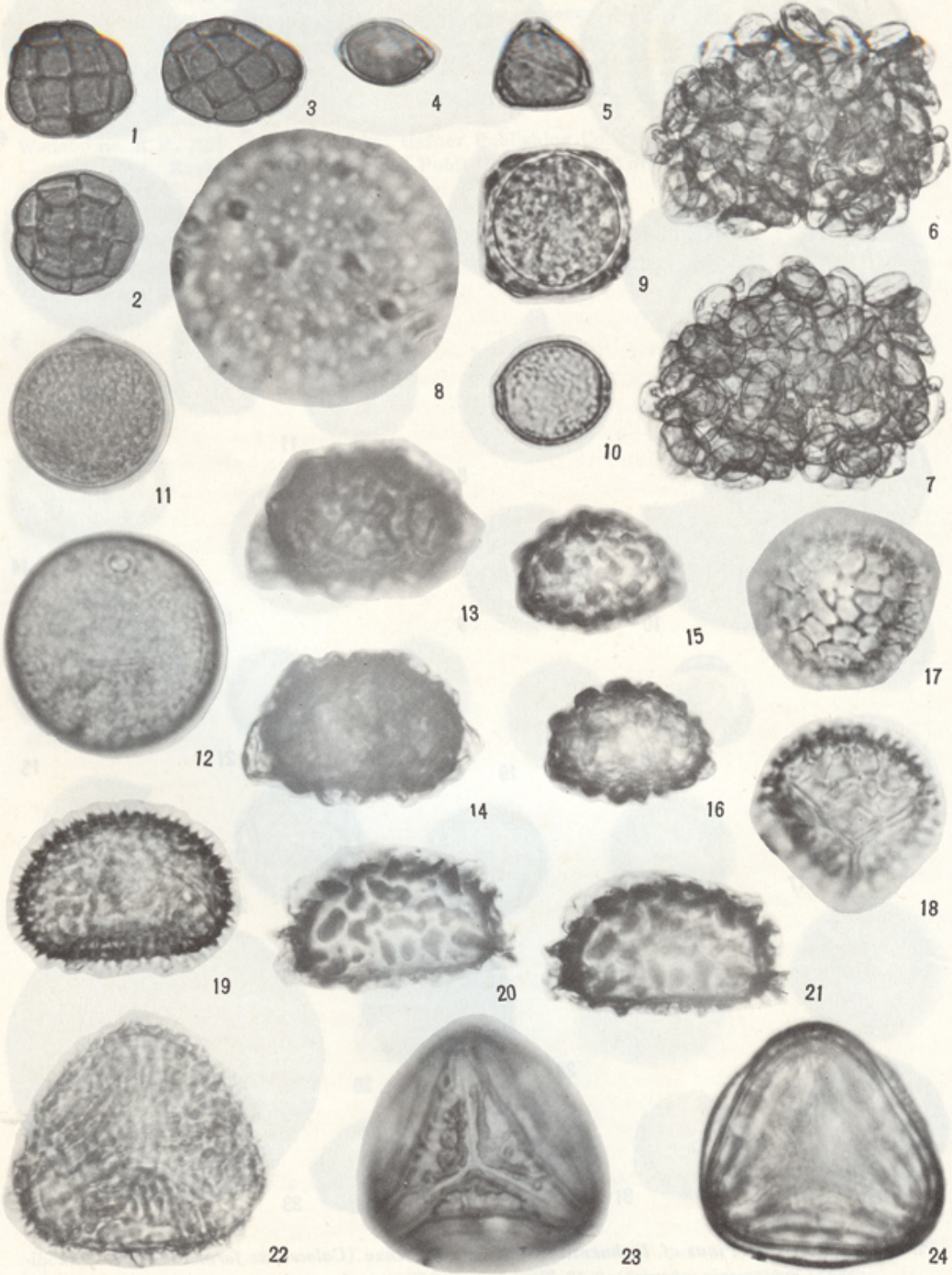
Moss, J. E., 1965. Air borne pollen in Brisbane, Austr. J. Bot., **13**: 23-37.

Potter, L. D., & J. Rowley, 1960. Pollen rain and vegetation in San Augustin Plains, New

Mexico. Bot. Gaz., **122**(1): 1-24.
Ramirez, B. W., 1969. Mechanism of pollen transfer. Science, **163**: 580-581.
Tauber, H. E., 1967. Investigation of the mode of pollen transfer in forest area. Rev. Palaeobot. Palynol., **3**: 277-286.
Whitehead, D. R., & K. W. Tan, 1969. Modern vegetation and pollen rain in Bladen County, North Carolina. Ecology, **50**(2): 235-248.
Wodehouse, R. P., 1959. Pollen grains. Hafner Publishing Co. New York, 574 pp.
———, 1971. Hayfever plants. Hafner Publishing Co. New York, 280 pp.



Pl. 1, 1-3, Pinaceae (*Pinus cf. luchuensis*); 4-7, Cupressaceae (*Calocedrus formosana*); 8, Taxodiaceae (*Cryptomeria japonica*); 9-10, Taxodiaceae (*Cunninghamia lanceolata*); 11-13, Betulaceae (*Alnus japonica*); 14-15, Betulaceae (*Carpinus rankanensis*); 16-17, Chenopodiaceae (*Chenopodium*); 18, Compositae (*Artemisia*); 19-21, Euphorbiaceae (*Bischoffia javanica*); 22-23, Euphorbiaceae (*Mallotus tanarius*); 24, Euphorbiaceae (*Claoxylon brachyandrum*); 25-26, Euphorbiaceae (*Jatropha panduraefolia*); 27-30, Gentianaceae (*Crawfurdia japonica*); 31-33, Casuarinaceae (*Casuarina equisetifolia*). 11-12, 16, 18, 25, 27-30, X400; 1-10, 13-15, 17, 19-24, 26, 31-33, X1000.



Pl. 2, 1-3, Leguminosae (*Acacia confusa*); 4-5, Myrtaceae (*Syzygium*); 6-7, Orchidaceae; 9, Ulmaceae (*Zelkova formosana*); 10, Ulmaceae (*Trema orientalis*); 11-12, Gramineae; 13-14, Aspidiaceae (*Polystichum*); 15-16, Polypodiaceae (*Polypodium*); 17-18, Lycopodiaceae (*Lycopodium*); 19, Aspidiaceae (*Dictyocline*); 20-21, Polypodiaceae (*Drynaria*); 22, Cyatheaceae (*Cyathea*); 23-24, Gymnogrammaceae (*Pityrogramma*). 1-3, 6-7, X400; 4-5, 8-24, X1000.