AEROPALYNOLOGICAL STUDY OF TAIPEI SUBURBAN (NEW FLOWER GARDEN CITY)[1]

CHIH-HUA TSOU[2] and TSENG-CHIENG HUANG[3]

Abstract: Airborne palynomorphs had been investigated in the New Flower Garden City, Taipei suburban one year during 1980 to 1981. A total of 14,044 pollen grains and fern spores were obtained, including 18.54% fern spores, 4.15% gymnospermous pollen grains, and 77.31% angiospermous pollen grains. 95.75% of palynomorphs were identified. They belong to 56 families and more than 100 taxa.

The dominant pollen taxa varied seasonally. Pollen grains of *Trema orientalis* appeared most abundantly in spring; Cyatheaceae spores in summer; *Humulus scandens* and *Miscanthus* pollen grains in autumn; and *Morus australis* and *Villebrunea pedunculata* in late winter.

The local common species and complicate vegetation in this valley were reflected in the assemblage of airborne palynomorphs. Airbone palynomorphs were mostly of short distance dispersion, and their spectra were strongly localized.

The effects of meteorological factors on airbone palynomorphs were varied with different taxa. However, in general, the rainfall could decisively decrease the pollen content in the air, but other factors impacted on them as a whole.

INTRODUCTION

Aeropalynological studies in Taiwan were reviewed by the the second auothor recently (Huang, 1982). In the past, several investigations on airborne pollen and fern spores were done. All of them, except one (Huang & Chung, 1973), were preceded in urbanized area. The present work was initiated in order to study the composition of the airborne pollen grains and spores in relation to their suburbanized environment.

METHOD

I. Place:

The sampling station situated in New Flower Garden City (latitude 24°56′N, longitude 121°32′30″–33′00″E), at altitudes of 125 meters high above sea level (Fig. 1). This big community is located on a wide slope going down north concilitorily. And the sampling station was at its northeast point, i. e. the lowest point. In other words, the back side of the station is a large community with buildings and cultivated plants; the front side is composed of a brook, a valley and steep mountainous slope covered by heavily disturbed secondary vegetation and plantation forests.

The trap was set up the north facing terrace at the second floor of the sampling station.

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(2) 鄒稚華, Research assistant, Department of Botany, National Taiwan University.

(3) 黃增泉, Professor, Department of Botany, National Taiwan University.

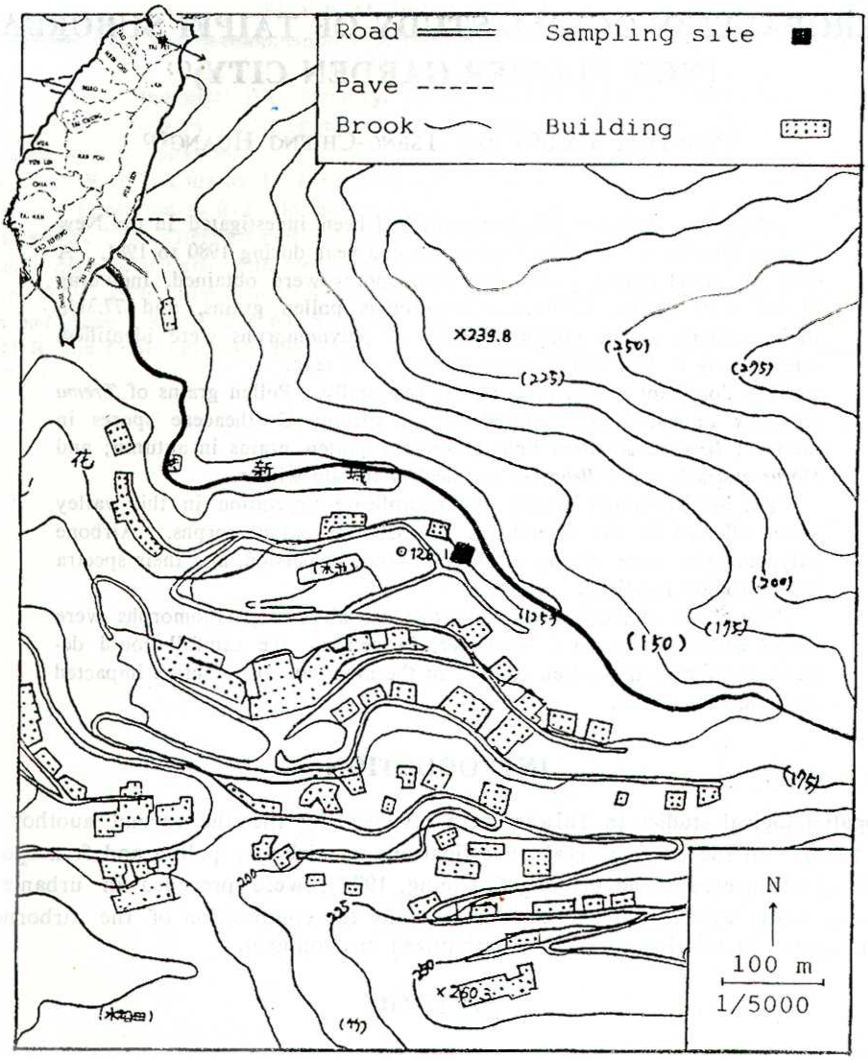

Fig. 1. Sampling site.

II. Collection of pollen slides:

Gravity-Impaction slide method was used (Wodehouse, 1972). One 76 mm×26 mm slide covered with a film of glycerin jelly was place horizontally in the atmosphere at 7:00 a. m., and was collected at 7:00 p. m. daily from November 24th, 1980 to November 23th, 1981.

III. Identification:

The main references used were Pollen Flora of Taiwan (Huang, 1972), and Spore Flora of Taiwan (Huang, 1981). Others included available to Cyatheaceae (Wang, *et al.*, 1977; Liew & Wang, 1976), Moraceae (Hsieh, 1964; Wang, 1973), Plagiogyriaceae (Liew, 1976) and others (Chen & Huang, 1980; Ikuse, 1956; Nilsson, *et al.*, 1977). Those informations about local floristic composition, flowering period, and altitudinal distribution (Hsieh, 1981) were also considered.

RESULT

Collection of palynomorphs for the 14 heavy raining days were excluded, therefore, we examined 351 slides. Total 14044 pollen grains and fern spores were recorded, and 95.75% could be identified. They were then classified into pollen grains of gymnosperms and angiosperms, and spores of pteridophytes as Table I.

Table I. Total numbers of pollen grains and fern spores (counted area as 3.24 cm^2/slide) from Nov. 24, 1980 to Nov. 23, 1981

Item. / No. & Per. / Taxa	Identifiable		Uncertain		Unknown		Total	
	No.	%	No.	%	No.	%	No.	%
Pteridophytes	2561	18.24	21	0.15	21	0.15	2603	18.54
Gymnospermae	583	4.15	0	0.00	0	0.00	583	4.15
Angiospermae	10304	73.36	498	3.55	56	0.40	10858	77.31
Total	13448	95.75	519	3.70	77	0.55	14044	100.00

Of 95.75% identified palynomorphic taxa, angiopermous pollen taxa occupies 73.36% and includes 42 families and more than 68 species; gymnospermous pollen taxa occupies 4.15% and are composed of Pinaceae and Taxodiaceae only; and fern spores taxa occupies 18.42% and includes 12 families, 24 genera and more than 36 species. Uncertain palynomorphic taxa are 3.7% and unknown taxa are 0.55%.

All palynomorphic taxa identified and classified are listed at Table II.

Table II. Palynomorphic taxa indentified (1)

I. Identified:

Family name	Taxon	Total No.
Gymnosperm		
1 Pinaceae	*Pinus luchuensis*	23
	Pinus massoniana	5
	Pinus mixed	74
	c.f. *Keteleeria davidiana*	2
2 Taxodiaceae	*Cryptomeria japonica*	258
	Cunninghamia lanceolata	22
	Crypto.-Cunning.	199
Total		583
Dicotyledons		
1 Amaranthaceae	*Amaranthus* sp.	3
2 Aquifoliaceae	*Ilex* c.f. *asprella*	18
3 Araliaceae	*Schefflera octophylla*	4
4 Berberidaceae	*Mahonia fortunei*	5
5 Betulaceae	*Alnus japonica*	50

Table II. Continued (2)

Family name	Taxon	Total No.
6 Boraginaceae	*Cordia dichotoma*	5
7 Casuarinaceae	*Casuarina huegeliana*	19
8 Chenopodiaceae	*Chenopodium* spp.	36
9 Compositae	c.f. *Artemisia*	13
	c.f. *Bidens, Blumea*	3
	unknown	22
10 Cruciferae	c.f. *Nasturtium*	1
11 Elaeagnaceae	*Elaeagnus* c.f. *oldhamii*	11
12 Elaeocarpaceae	*Elaeocarpus* sp.	5
	Sloanea formosana	61
13 Ericaceae	*Rhododendron* sp.	2
14 Euphorbiaceae	*Aleurites montana*	43
	Macaranga tanarius	18
	Mallotus spp.	33
15 Fagaceae	*Cyclobalanopsis glauca*	6
	Limlia uraiana	6
16 Hamamelidaceae	*Liquidambar formosana*	1
17 Lauraceae	Mixed	7
18 Leguminosae	*Acacia confusa*	74
	Bauhinia purpurea	1
	Phaseolus c.f. *lunatus*	1
19 Melastomataceae	*Melastoma* sp.	3
20 Moraceae	*Humulus scandens*	1062
	Morus australis	1112
21 Myricaceae	*Myrica rubra acuminata*	10
22 Myrsinaceae	*Ardisia* sp.	1
23 Myrtaceae	*Melaleuca leucadendra*	6
	Syzygium javanicum	68
	unknown 1	1
24 Oleaceae	*Ligustrum* c.f. *formosana*	1
25 Oxalidaceae	*Oxalis corniculata*	3
26 Plantagiaceae	*Plantago asiatica*	4
27 Polygalaceae	*Polygala* sp.	1
28 Polygonaceae	*Polygonum* sp.	5
29 Portulacaceae	c.f. *Portulaca*	1
	c.f. *Talinum*	1
30 Rosaceae	c.f. *Duchesnea* sp.	1
31 Rubiaceae	*Randia* c.f. *cochinchinensis*	10
	Wendlandia c.f. *formosana*	16
32 Salicaceae	*Salix warburgii*	75

Table II. Continued (3)

Family name	Taxon	Total No.
33 Saxifragaceae	*Hydrangea* c. f. *integra*	c. 800
34 Staphyleaceae	*Turpinia formosana*	30
35 Symplocaceae	*Symplocos* sp.	160
36 Theaceae	*Gordonia axillaris*	2
37 Ulmaceae	*Celtis sinensis*	5
	Trema orientalis	2077
	Zelkova formosana	1
38 Urticaceae	*Debregeasia edulis*	131
	Villebrunea pedunculata	1807
39 Verbenaceae	*Callicarpa* sp.	1
	Clerodendron cyrtophyllum	2
Monocotyledons		
1 Cyperaceae	c. f. *Kyllinga*	4
	unknown 1	2
	unknown 2	1
2 Gramineae	*Miscanthus* sp.	2291
	Mixed	159
3 Palmae	unknown 1	1
	unknown 2	1
Total		10304
Pteridophyte		
1 Lycopodiaceae	*Lycopodium clavatum*	1
2 Schizaeaceae	*Lygodium japonicum*	2
3 Gleicheniaceae	*Dicranopteris linearis*	80
	Diplopterygium chinensis	14
	Dicranopteris-Diplopterygium mixed	28
4 Osmundaceae	*Osmunda banksiaefolia*	1
5 Cyatheaceae	A1: *Alsophila metteniana*	19
	A2: *A. podophylla*	8
	A3: *Sphaeropteris lepifera*	132
	A mixed: echinate spores	170
	B mixed: striate spores	62
	C: A+B mixed	1803
6 Plagiogyriaceae	*Plagiogyria* sp.	9
7 Polypodiaceae	*Colysis* c. f. *wrightii*	4
	Crypsinus c. f. *hastatus*	4
	Lepisorus sp.	4
8 Dennstaedtiaceae	*Histiopteris incisa*	4
	Microlepia obtusiloba	2

Table II. Continued (4)

Family name	Taxon	Total No.
9 Pteridaceae	*Pteris bella*	1
	Pteris ensiformis	1
	Pteris semipinnata	2
	c.f. *Pteris*	1
10 Oleandraceae	*Nephrolepis* sp.	44
11 Aspidiaceae	*Ctenitis* sp.	14
	Hypodermatium crenatum	1
	Tectaria sp.	5
12 Dryopteridaceae	*Dryopteris formosana*	3
	Dryopteris sp.	8
13 Thelypteridaceae	*Christella dentata*	2
	Christella subarida	15
	Christella-Pronephrium	52
	Dictyocline griffithii	48
	Pseudocyclosorus esquilolii	1
14 Athyriaceae	*Athyriopsis japonica*	8
	Athyrium tozanense	2
	Athyrium sp.	5
	c.f. *Athyrium*	1
Total		2561

II. Uncertain:

Taxon	Total No.
Angiosperm	
1 c.f. Actinidiaceae (*Saurauia oldhamii*)	408
2 c.f. Ebenaceae *Diospyros* 1	13
3 c.f. Ebenaceae *Diospyros* 2	2
4 c.f. Euphobiaceae (*Mallotus* sp.)	3
5 c.f. Lauraceae	2
6 c.f. Gramineae	1
7 c.f. Palmae	2
8 c.f. Piperaceae (*Piper nigrum*)	2
9 c.f. Ranunculaceae (*Ranunculus* sp.)	4
10 c.f. Rubiaceae (*Rubia* sp.)	6
11 c.f. Polygonaceae (*Polygonum* sp.)	3
12 c.f. Solanaceae (*Solanum biflorum*)	9
13 c.f. Solanaceae (*Solanum* sp.)	43
Total	498

Table II. Continued (5)

Taxon	Total No.
Pteridophyte	
1 c.f. Athyriaceae (*Athyrium* sp.)	1
2 c.f. Athyriaceae (*Woodsia* sp.)	1
3 c.f. Athyriaceae	5
4 c.f. Cyatheaceae	7
5 c.f. Dennstaedtiaceae (*Dennstaedtia smithii*)	1
6 c.f. Dryopteridaceae	1
7 c.f. Marsileaceae (*Marsilea minuta*)	3
8 c.f. *Asplenium-Diplazium*	2
Total	21

The seasonal palynomorphic amount was shown on the Table III. Percentages range from 19.44% to 36.23%. Autumn is the highest, and summer is the lowest.

Table III. Seasonal amount of atmospheric pollen and spores

Season	Total (No.)	Percentage (%)
Spring (March-May)	3212	22.87
Summer (June-Aug.)	2730	19.44
Autumn (Sept.-Nov.)	5088	36.23
Winter (Dec.-Feb.)	3014	21.46

The pollen grains and spores were also counted monthly as Table IV. The quantitative order from the highest to the lowest is February, September, November, April, August, July, June, May, March, October, January, and December.

Table IV. Monthly total numbers of atmospheric pollen and spores

Amount / Month	Total No.	No./cm²	Amount / Month	Total No.	No./cm²
Dec. 1980	75	23.2	June 1981	838	259.0
Jan. 1981	110	34.0	July 1981	860	256.4
Feb. 1981	2829	873.1	Aug. 1981	1032	318.5
Mar. 1981	775	239.2	Sep. 1981	2318	715.4
Apr. 1981	1601	494.1	Oct. 1981	732	225.9
May 1981	836	258.0	Nov. '80+'81	2038	629.1
Total				14044	4334.9

The monthly variation of total number was shown as Fig. 2.

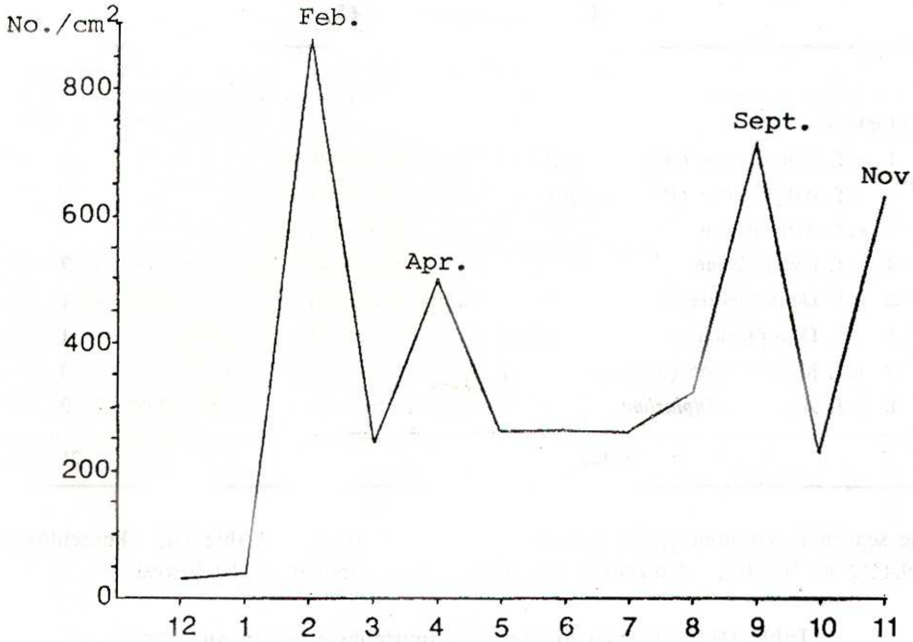

Fig. 2. Monthly variation of atmospheric pollen grains and spores.

In Fig. 2 there are four distinct peaks on February, September, November and April separately. It is clear that monthly peaks were resulted from high obtaining in one or two weeks (Fig. 3). It is also obvious that these four peaks were all due to abruptly increasing the contents of one or two taxa (Table V). The peak on February was due to increasing amount of *Morus australis* at 9th to 13th and *Villebrunea pedunculata* at 16th to 23th. The peak on late September was due to increasing amount of *Hydrangea* c. f. *integrifolia* at 19th

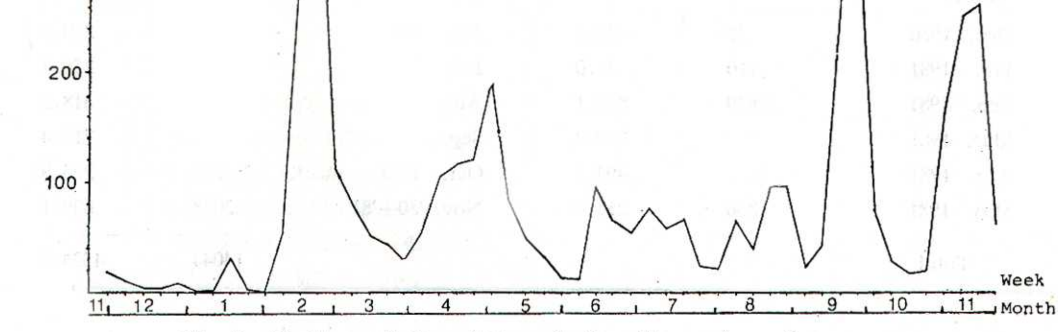

Fig. 3. Weekly variation of atmospheric pollen grains and spores.

and *Humulus scandens* at 26th. The peak on November was totally contributed by *Miscanthus* pollen. And the peak between April and May was due to *Trema orientalis* pollen grains.

The total percentage of the seven dominant taxa is 80.77% (Table V). *Miscanthus* pollen with only 16.31% is the highest one, but not evidently dominant. These seven taxa appear at different four seasons. And except Cyatheaceae spores, others are comparable with the four important months (Table IV, Figs. 2, 3).

Table V. The most important taxa, their annual total number, and their main pollen season

Priority	Taxon	Annual total number	Percentage (%)	Dominated month
1	*Miscanthus* sp.	2291	16.31	11
2	Cyatheaceae (mixed)	2194	15.62	8
3	*Trema orientalis*	2077	14.79	4
4	*Villbruna pedunculata*	1807	12.87	2
5	*Morus australis*	1112	7.92	2
6	*Humulus scandens*	1062	7.56	9
7	*Hydrangea* c. f. *integrifolia*	c. 800	5.70	9

DISCUSSION

I. Pollen spectra:

According to the amount and duration of pollen representations, four main pollen types were obtained (Fig. 4):

First type: High frequency and low quantity (Fig. 4, Type I). The pollen spectra of *Acacia* and *Aleurites* belong to this type. High frequencies are due to their dense cultivation. Their dispersion were heavily limited by their large size of grains.

Second type: High frequency and high quantity (Fig. 4, Type II). *Trema orientalis*, *Miscanthus floridulus Morus australis* and *Villbrunea pedunculata* are representative taxa. Those plants are also common ones in sampling area, and their pollen grains are small size which contributed high quantity.

Third type: Low frequency but with quantitative peak (Fig. 4, Type III). Plants of *Hydrangea* c. f. *integrifolia*, *Humulus scandens* and c. f. *Saurauia oldhamii* can be assigned to this type. The low frequency should attribute to few plants, and quantitative peaks may attribute to short distance between sampling station and appropriate plant.

Fourth type: Low frequency and low quantity. In this experiment 43 out of 62 pollen taxa are less than 20 counts in their total numbers, and have short or scattered spectra. So this type is the most important type of all. And in fact, this coincided with the the complicate and scattered plants' taxa around the sampling site.

II. Fern spores:

More than 34 kinds of fern spores appeared. At least for our present knowledge, this has not been seen in other similar investigations. But 22 out of them (about 64.7%) are low amount, with less than 10 counts.

Of all, only Cyatheaceae spores were quite abundant, which appeared 2194 grains, equivalent to 85.67% of total fern spores. The special abundance of their sporagia in one tree

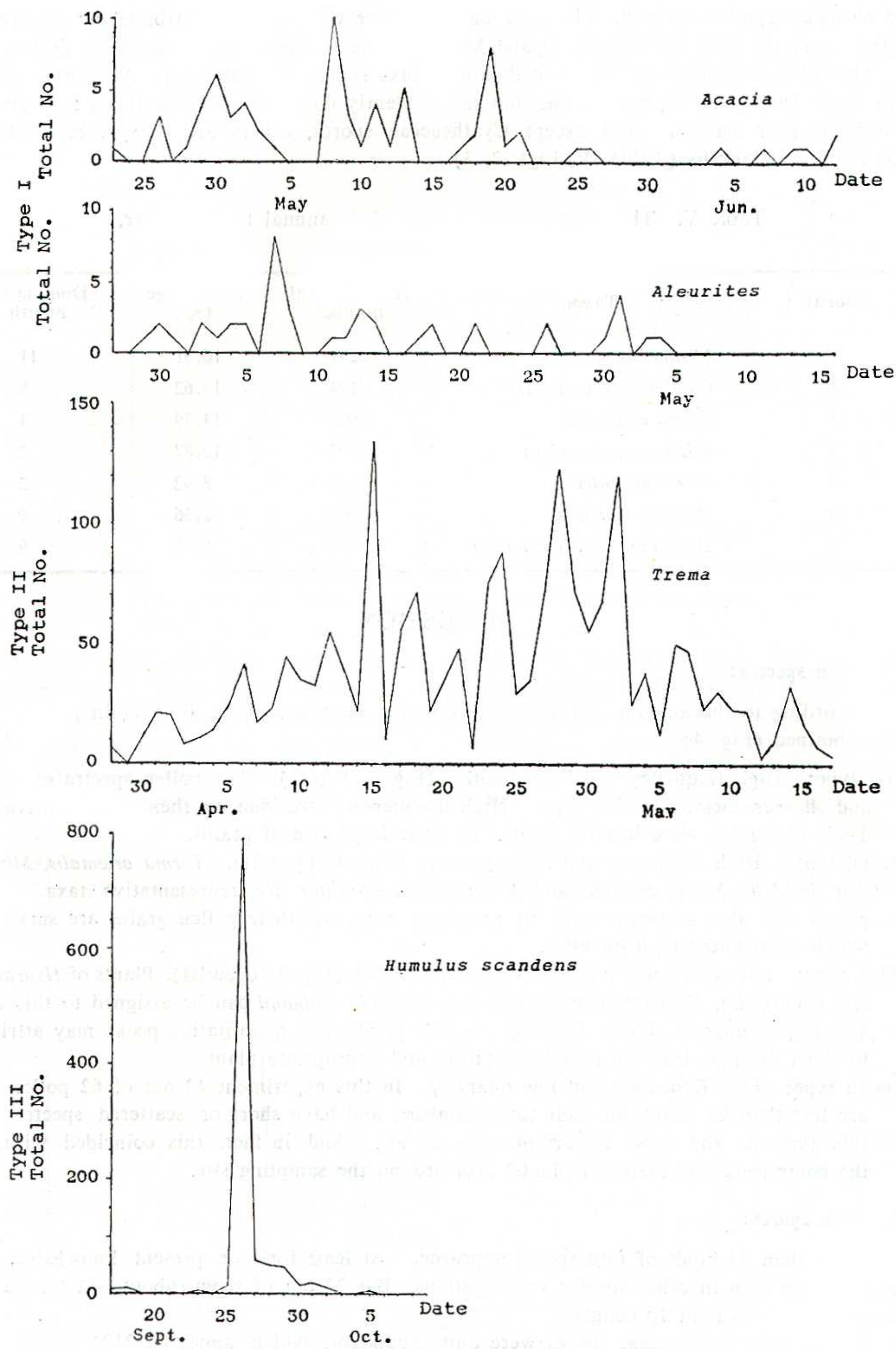

Fig. 4. Three types of pollen spectra.

fern should be one of the most important factors. And plants height seems to be another important influencing factor in fern spora, too.

III. The meteorological factors:

In Fig. 5–7, daily amount of dominant taxa were selected to compare with four meteorological factors: air temperature (Temp.), relative humidity (R. H.), duration of sunshines (S. H.), and precipitation (Precip.).

1. In Fig. 5, the first peak caused by *Morus* pollen was accompanied with high temperature, low relative humidity, short sunlight hours and no precipitation. At 20th, the lowest point was obviously due to the heaviest rain. But the peak caused by ***Villebrunea*** pollen on 21st was accompanied with low temperature.

2. In Fig. 6, from 25th of October the *Miscanthus* pollen began to increase stepwise, and which coincided with stepwise increasing of temperature and sunlight hours, and stepwise decreasing of relative humidity. According to their variation it is obvious that pollen discharging and dispersion of *Miscanthus* are greatly effected by those meteorological factors.

3. In Fig. 7, at 28th of April and 1st of May, two peaks coincided with increasing of

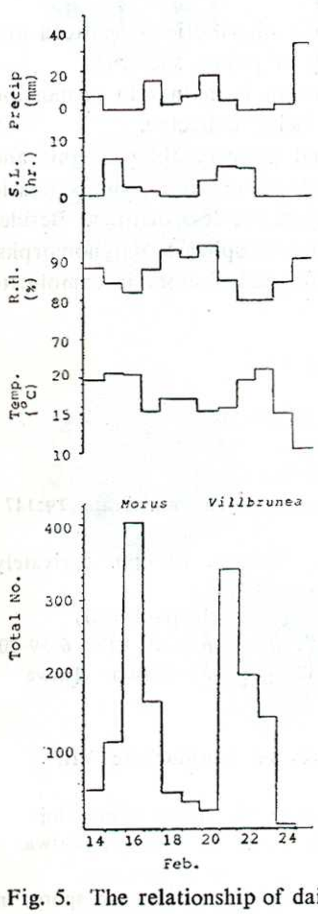

Fig. 5. The relationship of daily total number of *Morus* & *Villbrunea,* and meteorological factors.

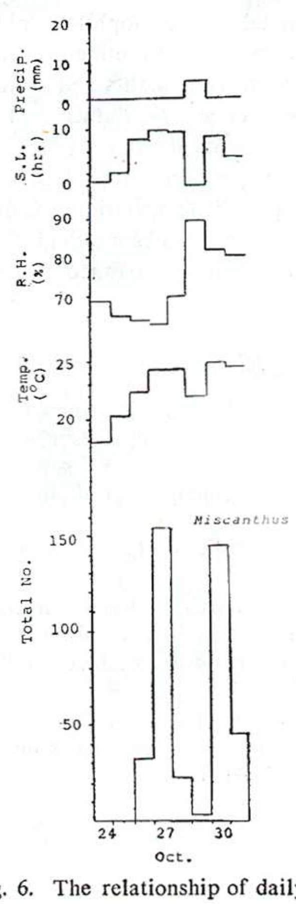

Fig. 6. The relationship of daily total numbers of *Miscanthus* spp. and meteorological factors.

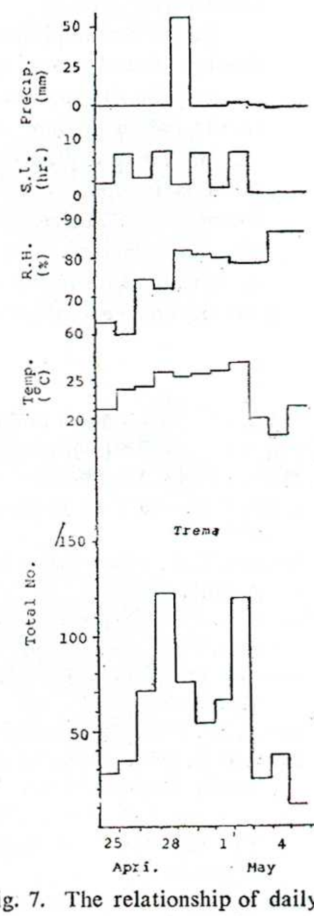

Fig. 7. The relationship of daily total numbers of ***Trema orientalis*** and meteorological factors.

temperature and sunlight hours. According to the correlation in Fig. 7, it seems that temperature-effect is stronger than effects of sunlight hour and relative humidity on *Trema orientalis*.

The low quantity of fern spores makes the comparative study without significant mean; however, in Cyatheaceae spora, heavy rains decreased their amounts strongly; but the positive effects of increasing temperature, sunlight hour, and decreasing relative humidity were weak.

CONCLUSION

1. The composition of air-borne pollen grains and spores in this area is complicate, and may reflect the local valley vegetation.

2. The parent stocks of most pollen taxa grow within 500 meters. Distance effect is strongly mainfest.

3. The amount of airborne palynomorphs did not coincide with the density of growing vegetation. Some effective factors and their impactions were analyzed as follows:

a. The amount of anemophilous pollen in the air is influenced by relative humidity, and sunlight hour, yet the precipitation decreases the palynomorphic amount most effectively.

b. To anemophilous and taller entomophilous plants, their distributional pattern and density around sampling station may determine the frequency of pollen spectrum.

c. The distance between growing plants and sampling station is mainly in proportion to the pollen amount, and also effects on duration of pollen being collected.

d. To fern plants, except plants density and distributional pattern, their heights and habitats in open or shade are also very important. In Cyatheaceae spora, the climatic factors are effective, but except the precipitation, the other factors are less distinct. Besides tree fern spores, most fern spores are less significant in all atmospheric palynomorphs.

4. The relationship between pollen occurrence and meteorological factors is complicate and far beyond generalization.

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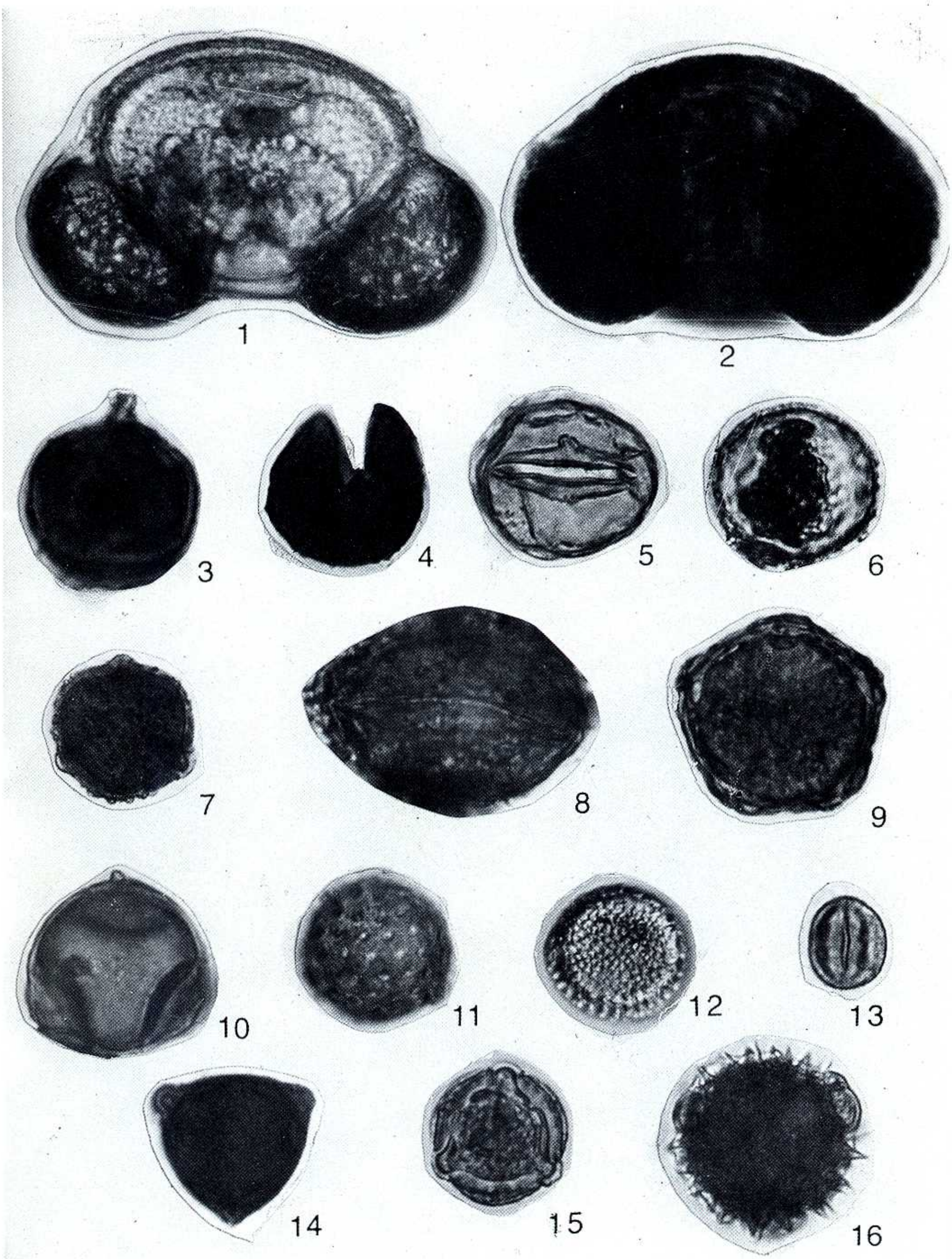
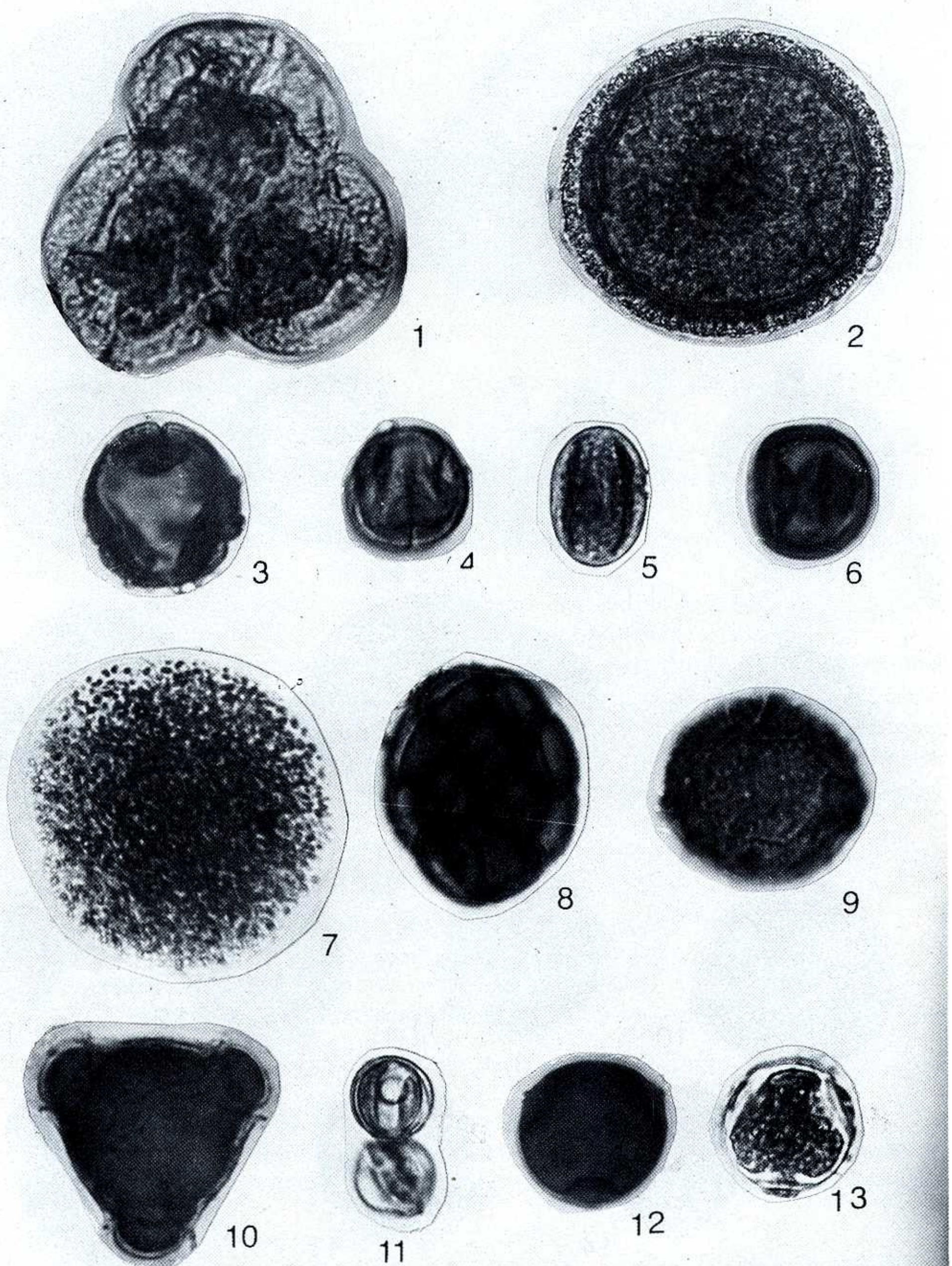
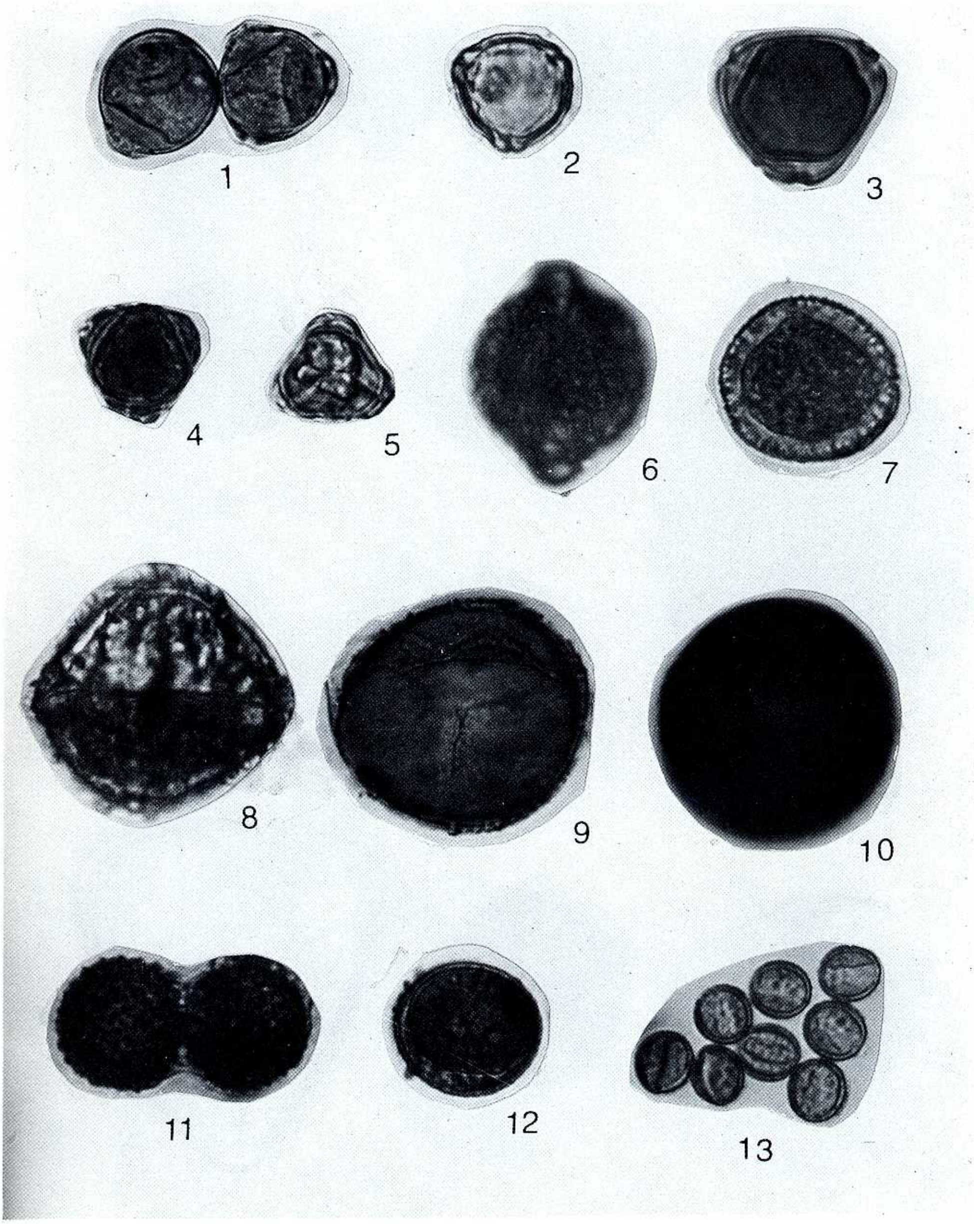


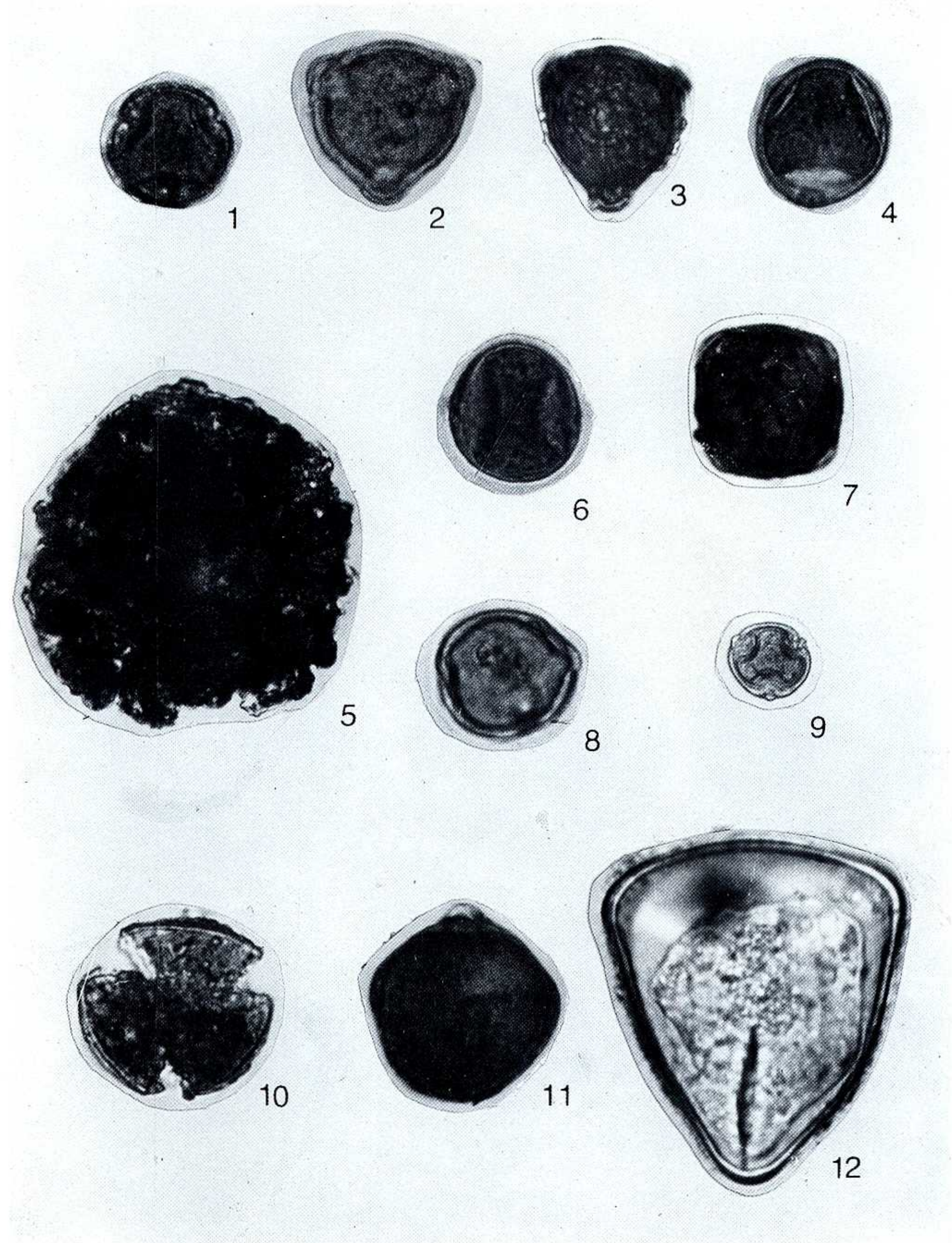
Pl. 1. Pollen grains: 1. Pinaceae (*Pinus luchuensis*); 2. Pinaceae (*Pinus massoniana*); 3-5. Taxodiaceae (*Cryptomeria japonica*); 6. Taxodiaceae (*Cunninghamia lanceolata*); 7. Aquifoliaceae (*Ilex* c. f. *asprella*); 8. Berberidaceae (*Mahonia fortunei*); 9. Betulaceae (*Alnus japonica*); 10. Casuarinaceae (*Casuarina huegeliana*); 11. Chenopodiaceae (*Chenopodium* spp.); 12. Cruciferae (c. f. *Nasturtium*); 13. Elaeocarpaceae (*Elaeocarpus* sp.); 14. Elaeagnaceae (*Elaeagnus* c. f. *oldhamii*); 15. Compositae (c. f. *Artemisia*); 16. Compositae (c. f. *Bidens*, *Blumea*). 1-16, ×900



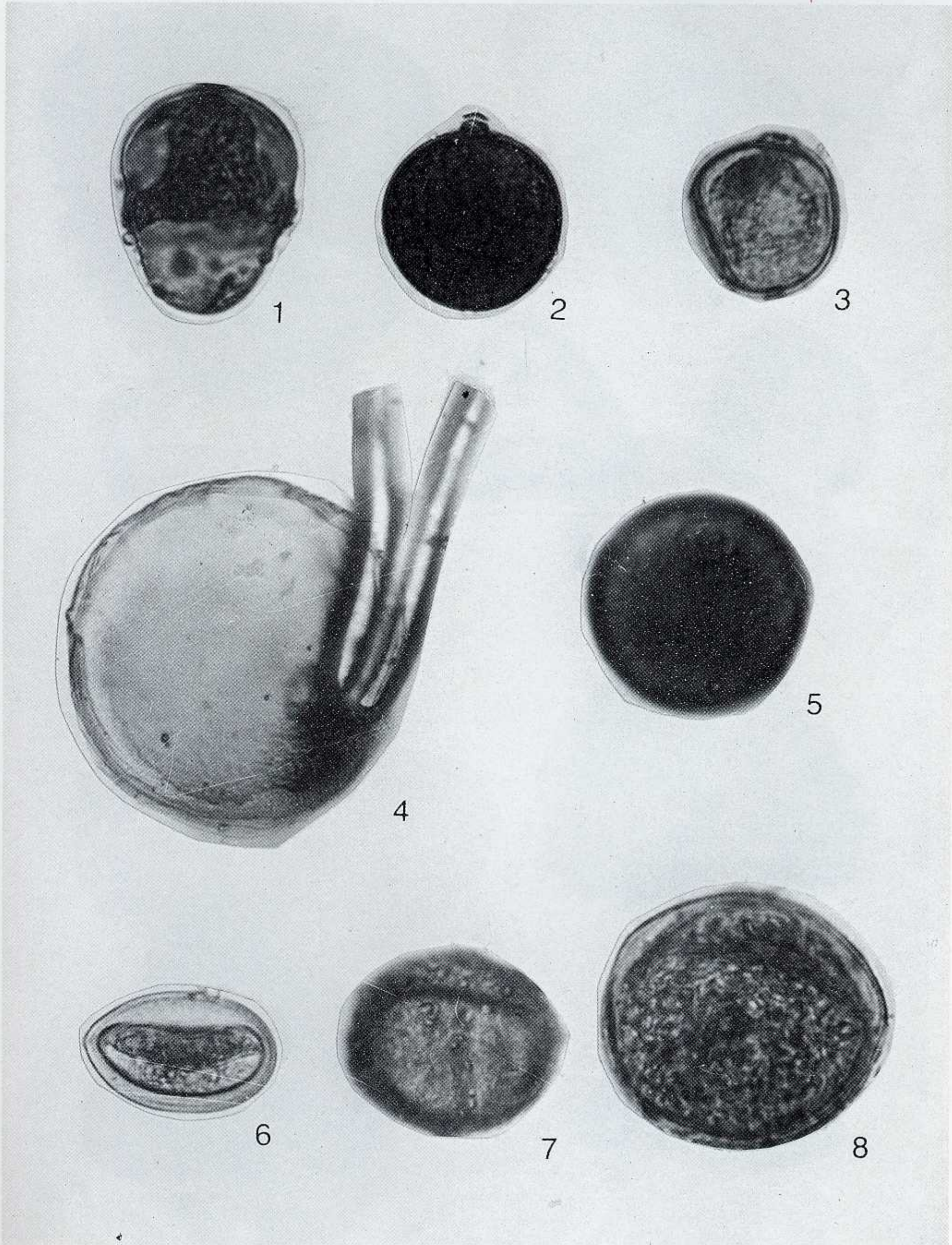
Pl. 2. Pollen grains: 1. Ericaceae (*Rhododendron* sp.); 2. Euphorbiaceae (*Aleurites montana*); 3. Euphorbiaceae (*Mallotus* spp.); 4. Euphorbiaceae (*Macaranga tanarius*); 5. Fagaceae (*Cyclobalanopsis glauca*); 6. Fagaceae (*Limlia uraiana*); 7. Lauraceae; 8. Leguminosae (*Acacia confusa*); 9. Leguminosae (*Phaseolus* c.f. *lunatus*); 10. Leguminosae (*Bauhinia purpurea*); 11. Melastomataceae (*Melastoma* sp.); 12. Moraceae (*Humulus scandens*); 13. Moraceae (*Morus australis*). 2, ×500; 1, 3-13, ×900.



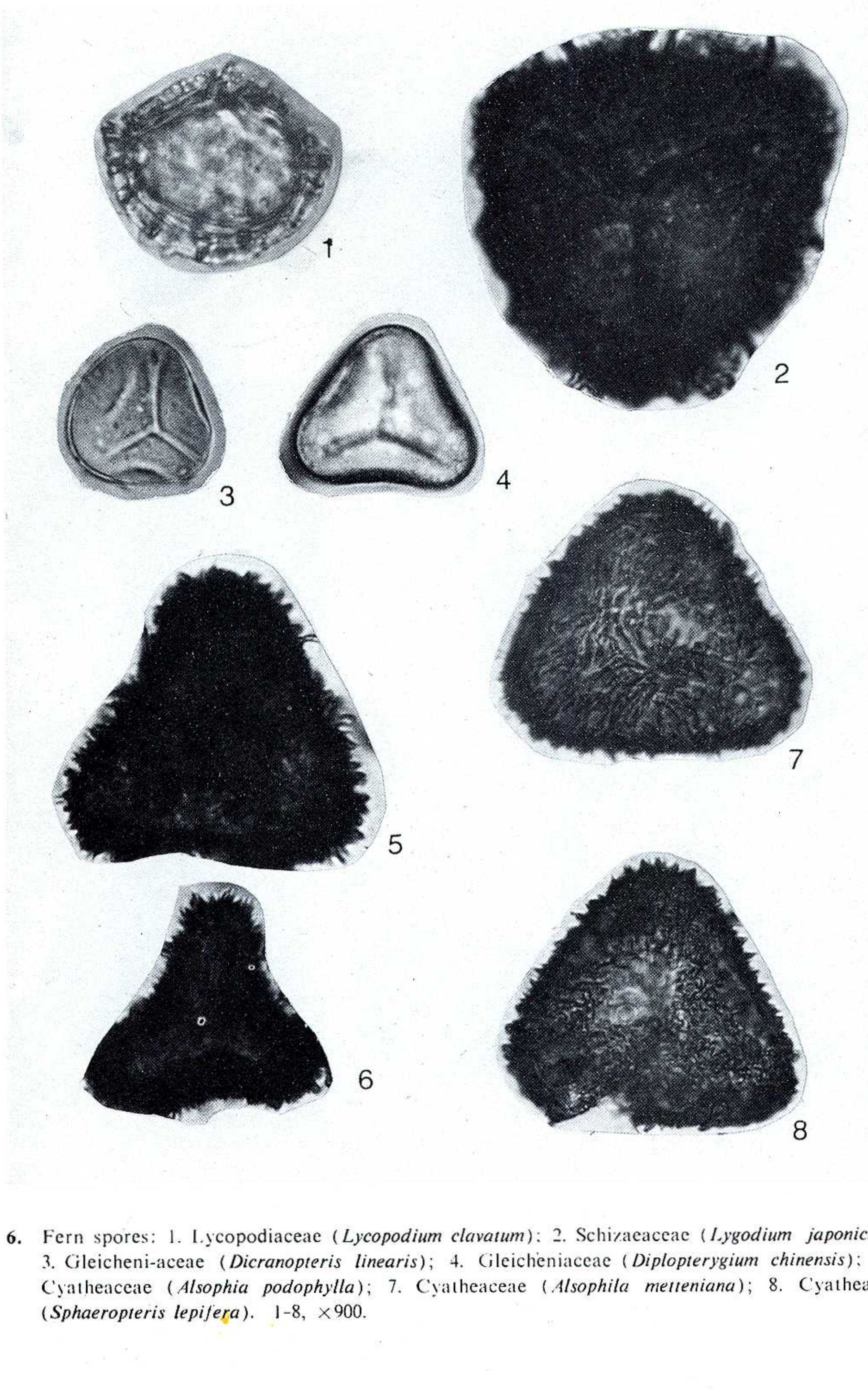
Pl. 3. Pollen grains: 1. Myricaceae (*Myrica rubra acuminata*); 2. Myrsinaceae (*Ardisia* sp.); 3. Myrtaceae (*Melaleuca leucadendra*); 4-5. Myrtaceae (*Syzygium javanicum*); 6. Oleaceae (*Ligustrum* c.f. *formosana*); 7. Oxalidaceae (*Oxalis corniculata*): 8. Polygalaceae (*Polygala* sp.); 9. Portulacaceae (c.f. *Portulaca*); 10. Portulacaceae (c.f. *Talinum*); 11. Polygonaceae (*Polygonum* sp.); 12. Rubiaceae (*Randia* c.f. *cochinchinensis*); 13. Rubiaceae (*Wendlandia* c.f. *formosana*). 1-13, ×900.



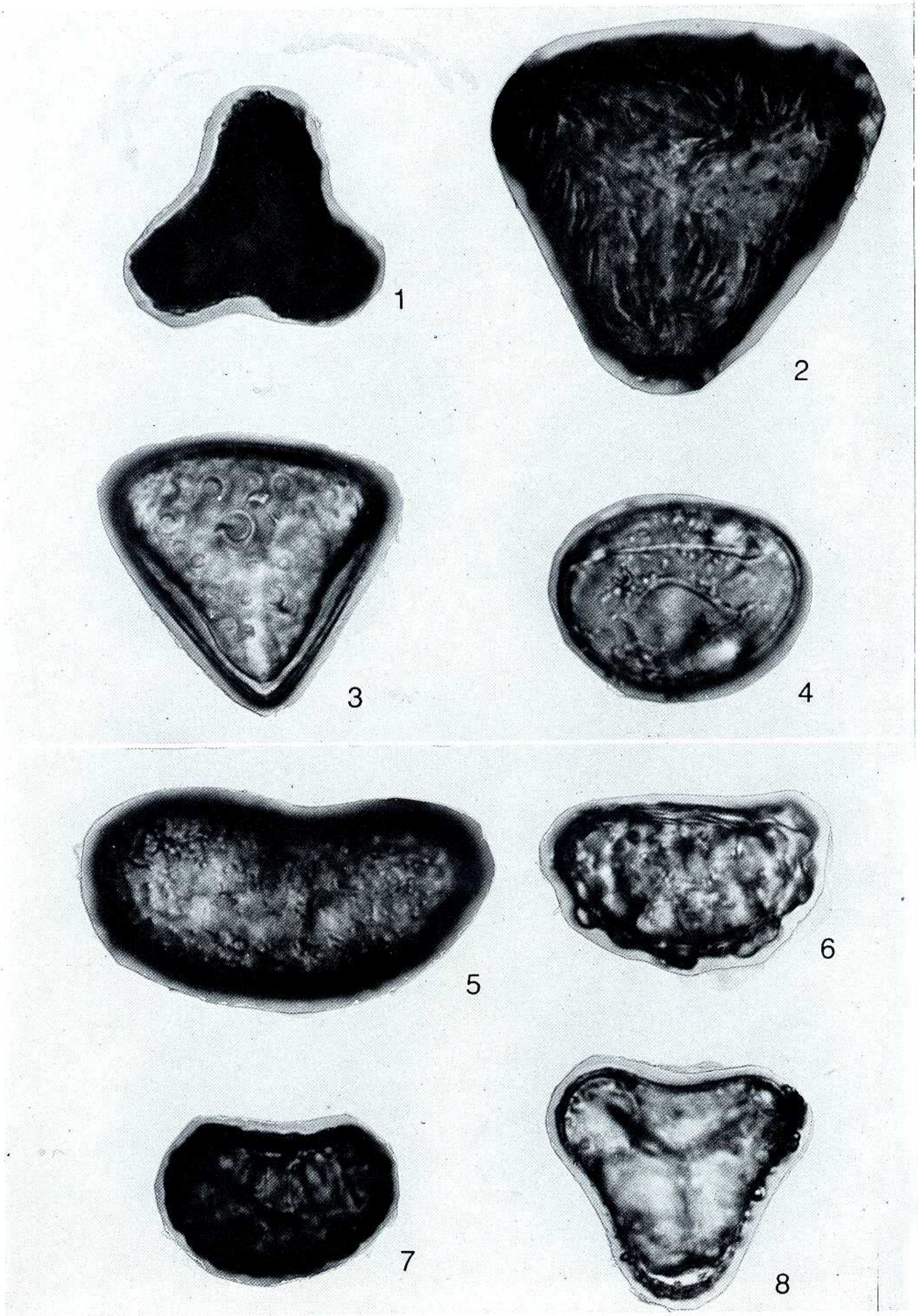
Pl. 4. Pollen grains: 1. Salicaceae (*Salix warburgii*); 2. Staphyleaceae (*Turpinia formosana*); 3. Symplocaceae (*Symplocos* sp.); 4. Ulmaceae (*Celtis sinensis*); 5. Theaceae (*Gordonia axillaris*; 6. Ulmaceae (*Trema orientalis*); 7. Ulmaceae (*Zelkova formosana*); 8. Urticaceae (*Debregeasia edulis*); 9. Urticaceae (*Villebrunea pedunculata*); 10. Verbenaceae (*Callicarpa* sp.); 11. Cyperaceae (c.f. *Kyllinga*); 12. Cyperaceae. 1-12, ×900.



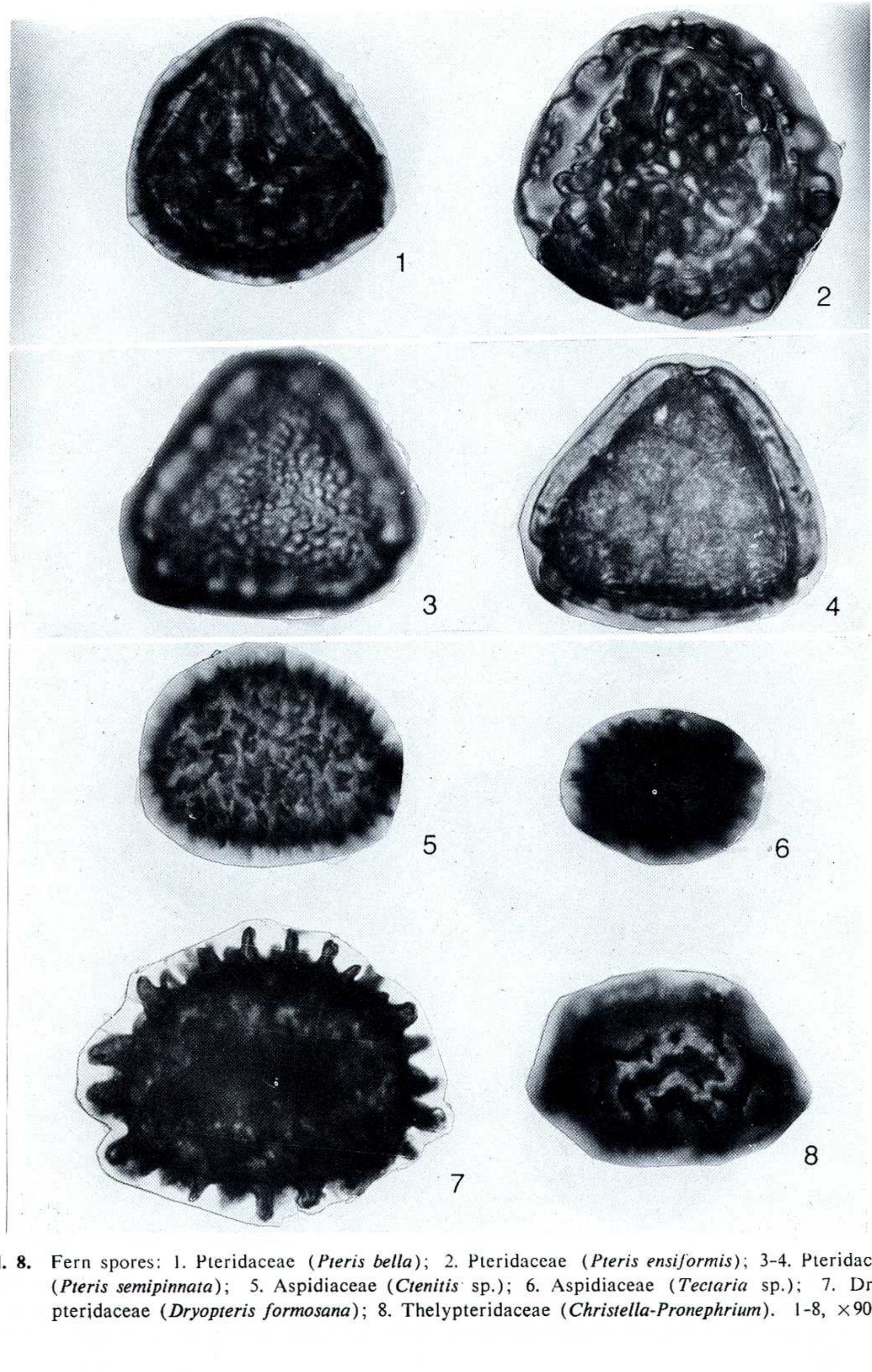
Pl. 5. Pollen grains: 1. Cyperaceae; 2. Gramineae (*Miscanthus* sp.); 3-5. Gramineae; 6-8. Palmae. 4, ×450. 1-3. 5-8, ×900.



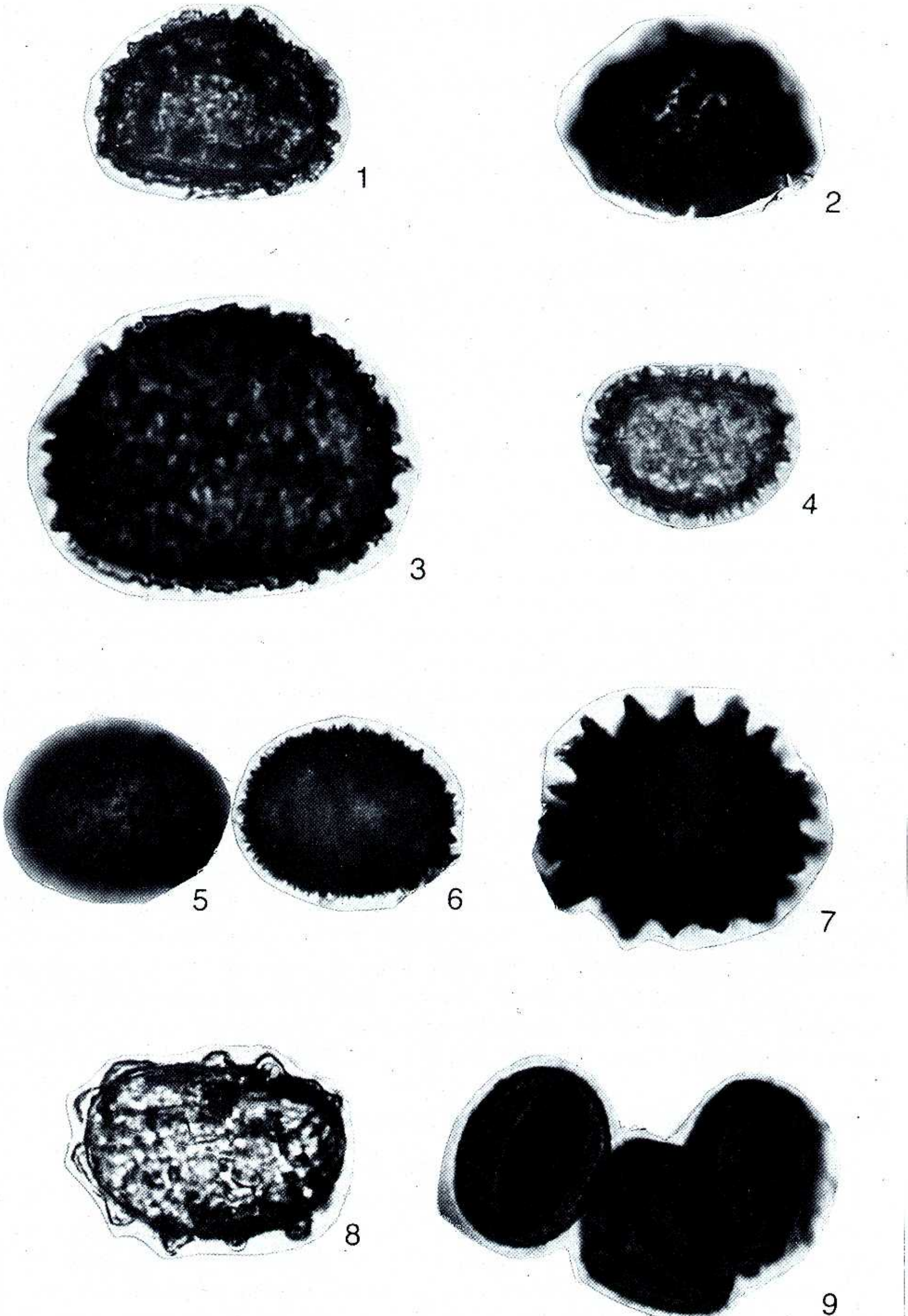
Pl. 6. Fern spores: 1. Lycopodiaceae (*Lycopodium clavatum*); 2. Schizaeaceae (*Lygodium japonicum*): 3. Gleicheni-aceae (*Dicranopteris linearis*); 4. Gleicheniaceae (*Diplopterygium chinensis*); 5-6. Cyatheaceae (*Alsophia podophylla*); 7. Cyatheaceae (*Alsophila metteniana*); 8. Cyatheaceae (*Sphaeropteris lepifera*). 1-8, ×900.



Pl. 7. Fern spores: 1-2. Cyatheaceae (*Alsophila* c.f. *spinulosa*); 3. Cyatheaceae; 4. Polypodiaceae (*Colysis* c.f. *wrightii*); 5. Polypodiaceae (*Crypsinus* c.f. *hastatus*); 6. Polypodiaceae (*Lepisorus* sp.); 7. Dennstaedtiaceae (*Histiopteris incisa*); 8. Dennstaedtiaceae (*Microlepia obtusioba*). 1-8, ×900.



Pl. 8. Fern spores: 1. Pteridaceae (*Pteris bella*); 2. Pteridaceae (*Pteris ensiformis*); 3-4. Pteridaceae (*Pteris semipinnata*); 5. Aspidiaceae (*Ctenitis* sp.); 6. Aspidiaceae (*Tectaria* sp.); 7. Dryopteridaceae (*Dryopteris formosana*); 8. Thelypteridaceae (*Christella-Pronephrium*). 1-8, ×900.



Pl. 9. Fern spores: 1-2. Thelypteridaceae (*Christella-Pronephrium*); 3. Thelypteridaceae (***Christella dentata***); 4. Thelypteridaceae (***Pseudocyclosorus esquilolii***); 5-6. Thelypteridaceae (***Dictyocline griffithii***); 7. Athyriaceae (*Athyriopsis japonica*); 8. c.f. Dryopteridaceae; 9. c.f. Marsileaceae (*Marsilea minuta*). 1-9, ×1000.