Taiwania, **42**(2): 117-134, 1997

Aeropalynological Study in Taipei County (Tan-Shui), 1993

Mei Peng[1] and Su-Hwa Chen[1, 2]

(Manuscript received 25 March 1997; accepted 12 May 1997)

ABSTRACT: An aeropalynological study was performed in the Tan-Shui area of Taipei County during 1993. A total of 128 taxa belonging to 77 families were identified. The dominant pollen were of genera *Broussonetia* (73.7%), *Trema* (7.4%), *Boehmeria* (2.8%), and *Ardisia* (2.4%). There were two major pollen seasons: March to May and August to October. The major pollen types changed with seasons: tree pollen in spring, fern spores with some weed pollen in summer and weed pollen in autumn. The majority of collected pollen were of anemophilous species. There existed a diurnal variation in the amount of airborne pollen within a day: with the highest peak occurring in the morning. On the basis of the present study, a pollen calendar was provided for the Tan-Shui area.

KEY WORDS: Airborne pollen, Diurnal variation, Meteorological factor, Pollen calendar.

INTRODUCTION

The study of aeropalynology has become more and more important in the last few decades including the study of pollen dispersal in the air (Giostra *et al.*, 1991; Hjelmroos, 1991; Mandrioli *et al.*, 1980; Romano *et al.* 1991) and the relationship between the vegetation and pollen deposits in the soil and in biological traps (Caramiello *et al.*, 1991; Yazvenko, 1991; Bradshaw, 1981). Aeropalynology provides basic information for the study of paleopalynology, including the types and changes of vegetation due to climate variations or human influence in the past (Tilak, 1989; Caramiello *et al.*, 1991). Aeropalynology is also essential for establishing the correlation between airborne pollen and the symptoms of hay fever and asthma sufferers (Banik and Chanda, 1992; Lewis *et al.*, 1991a; Malik *et al.*, 1991; D'Amato and Lobefalo, 1989).

In Taiwan, some aeropalynological studies have been done over the last thirty years. However, most of these were conducted in Taipei City and its surroundings (Chao *et al.*, 1962; Chen *et al.*, 1972; Huang and Chung, 1973; Wang, 1973; Chen and Huang, 1980; Tsou and Huang, 1982; Chen, 1984; Chen and Chien, 1986; Tsou *et al.*, 1997). In the present paper, a study of aeropalynology was done in Tan-Shui, about 17 km northwest of Taipei City, in order to compare the occurrence of airborne pollen species in Taipei City (Yang and Chen, in preparation) and to provide a pollen calendar for the studied area.

MATERIALS AND METHODS

A Burkard seven-day volumetric recording trap was placed on the 5th floor of Tan-Shui Junior High School at a height of about 60 m. The locality is situated at 25° 10' N, 121° 25' E

1. Department of Botany, National Taiwan University, Taipei 106, Taiwan, Republic of China.
2. Corresponding author.

in Tan-Shui which is 17 km northwest of Taipei City, 300 m north of Tan-Shui River and 3.5 km east of Taiwan Strait (Fig. 1).

The meteorological data of the sampling site in 1993 from the Central Weather Bureau, Republic of China (Fig. 2) are as follows: yearly mean temperature 22.2 ℃, the coldest month in January with mean temperature 14 ℃, the hottest month in July with mean temperature 29 ℃; yearly average percipitation 1,862 mm, the dryest month in December with average percipitation 24.5 mm, the wettest month in July with average percipitation 454.4 mm.

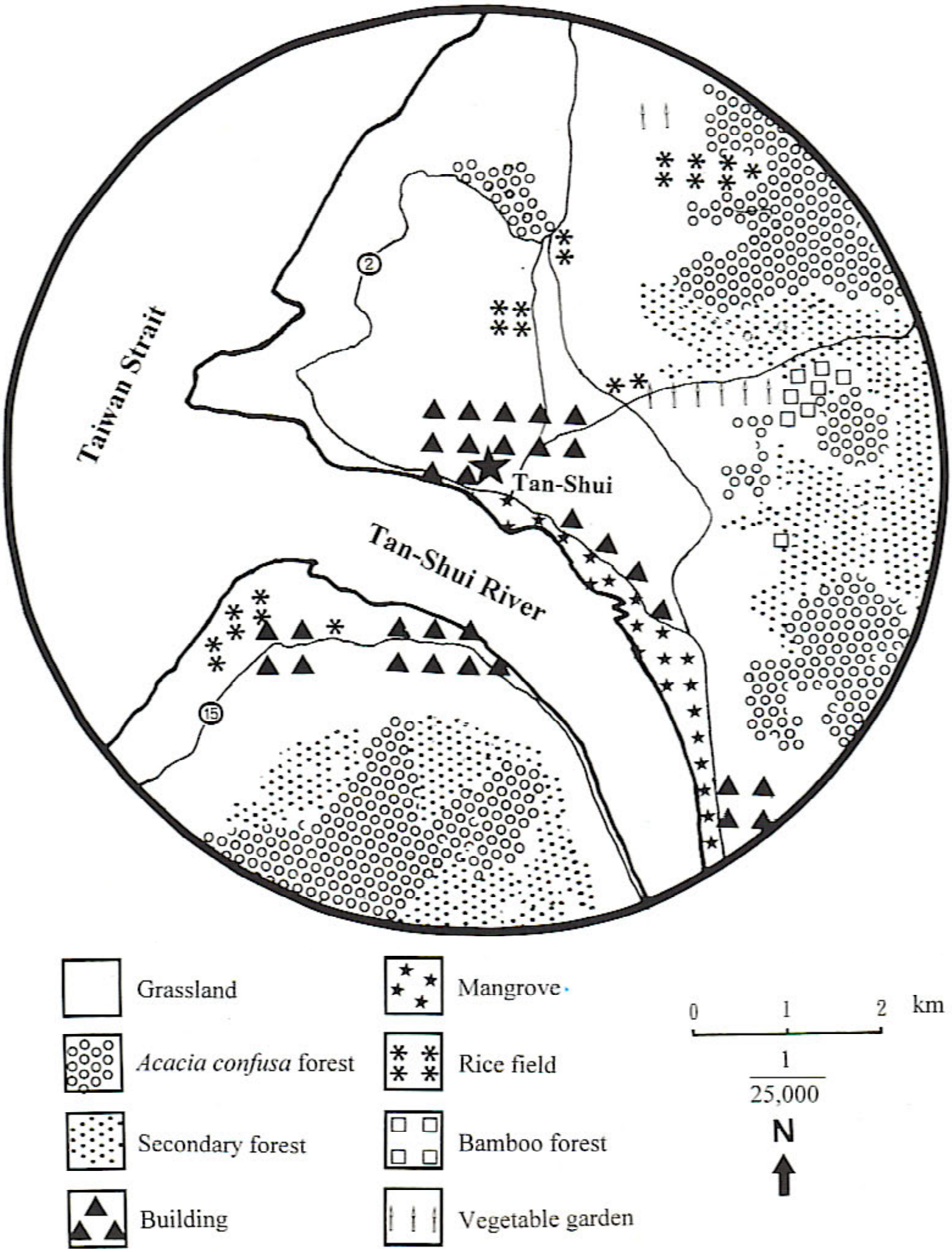

Fig. 1. The vegetation composition around the sampling site in Tan-Shui.

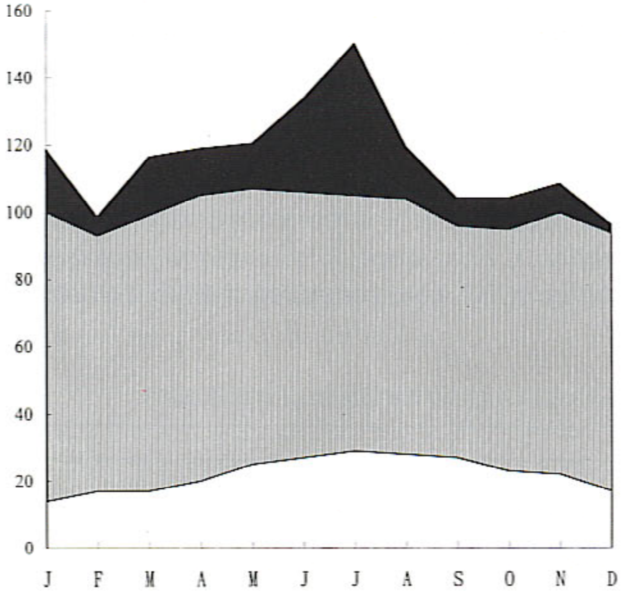

Fig. 2. Meteorological data from the Tan-Shui area during 1993 (The data used are from the Central Weather Bureau, Republic of China). ■: Rain (cm), ▥: Humidity (%), □: Temperature (˚C).

Pollen was collected on Melinex tape coated with Gelvotal solution (a mixture of 35 g Gelvotal, 100 ml distilled water, 50 ml glycerol, and 2 g phenol). The tape was rotated through a 2 mm x 14 mm orifice to expose it to the air by a rotating drum at a rate of 48 mm every 24 hours. After exposure, the tape was cut into 48 mm sections that were subsequently embedded in Entellan (Merck, Germany) for light microscopic (LM) observation. The pollen grains and fern spores were observed and identified under a Leitz Diaplan microscope. They were counted by transverse traverses for every hour (Peng and Chen, 1996).

For observation under a scanning electron microscope (SEM), the pollen grains collected on the Melinex tapes were scraped and treated by acetolysis methods (Erdtman, 1952). They were then fixed in 2.5% glutaraldehyde and 1% osmium tetraoxide. After a series of alcohol dehydration, critical point drying, and coating with gold, the samples were observed and photographed under a Hitachi S-2400 SEM (Chen, 1988). The structure of airborne-collected pollen grains observed under the SEM was compared with that of fresh pollen grains. In addition, the identification of these pollen and spore taxa were based on the examination under the LM and SEM. The works of Huang (1972, 1981) were also referred.

All the botanical names used in the present study are followed the Flora of Taiwan (Li, *et al*. 1979).

RESULTS

The vegetation composition around the sampling site is shown in Figure 1. The dominant plants in the campus of Tan-Shui Junior High School where the pollen trap was located consist of *Juniperus chinensis* var. *kaizuka*, *Pinus luchuensis*, *Cycas revoluta*, *Casuarina equisetifolia*, *Bischofia javanica*, *Liquidambar formosana*, *Cinnamomum camphora*, *Eucalyptus robusta*, *Melaleuca leucadendra*, *Fraxinus insularis*, *Murraya paniculata*, *Prunus campanulata*, and *Euphoria longana*. The plants in the vicinity of the mountain area near the campus are of secondary forest, dominated by trees such as *Trema orientalis*, *Acacia* *confusa*, *Macaranga tanarius*, *Morus australis*, and grasses such as *Miscanthus floridulus*. In addition, there are numerous *Broussonetia papyrifera* in the surrouding area.

Pollen taxa

The taxa of pollen occurring in collected samples are listed in Table 1. There are 128 taxa belonging to 77 families in total. The five airborne-collected pollen taxa, i. e., *Broussonetia papyrifera*, *Trema orientalis*, *Celtis sinensis*, *Casuarina equisetifolia*, and *Liquidambar formosana* observed under the SEM were compared with that of fresh pollen grains (Figs. 3 and 4).

Table 1. List of pollen and spore taxa caught at the Tan-Shui area in 1993.

Angiospermous plants			
Actinidiaceae		Fagaceae	*Castanopsis*
Amaranthaceae	*Achyranthes*		*Cyclobalanopsis*
	Amaranthus		*Pasania*
	Deeringia	Flacourtiaceae	*Flacourtia*
Anacardiaceae	*Rhus*		*Scolopia*
Aquifoliaceae		Gesneriaceae	
Araceae		Gramineae	
Aspidistraceae		Hamamelidaceae	*Liquidambar*
Betulaceae	*Alnus*	Juglandaceae	*Engelhardtia*
	Carpinus		*Juglans*
Bombacaceae	*Pachira*	Lauraceae	*Cinnamomum*
Caprifoliaceae	*Sambucus*		*Persia*
	Viburnum	Leguminosae	*Acacia*
Casuarinaceae	*Casuarina*	Loranthaceae	*Taxillus*
Chenopodiaceae	*Atriplex*		*Scurrula*
	Chenopodium	Lythraceae	
	Suaeda	Melastomataceae	*Melastoma*
Combretaceae	*Terminalia*		*Pachycentria*
Compositae	*Ageratum*	Meliaceae	*Melia*
	Ambrosia	Moraceae	*Broussonetia*
	Artemisia		*Humulus*
	Bidens		*Morus*
	Blumea	Myricaceae	*Myrica*
	Chrysanthemum	Myrsinaceae	*Ardisia*
	Erechtites		*Myrsine*
	Eupatorium	Myrtaceae	*Eucalyptus*
Crassulaceae	*Sedum*		*Melaleuca*
Cruciferae		Oleaceae	*Fraxinus*
Cyperaceae			*Ligustrum*
Dioscoreaceae			*Osmanthus*
Ebenaceae		Palmae	*Hyophorbe*
Elaeocarpaceae	*Elaeocarpus*		*Livistona*
Euphorbiaceae	*Acalypha*		*Phoenix*
	Antidesma		*Sobal*
	Bischofia	Piperaceae	*Peperomia*
	Euphorbia		*Piper*
	Macaranga	Plantagaceae	*Plantago*
	Mallotus	Pontederiaceae	*Monochoria*
	Ricinus	Primulaceae	*Androsace*
	Sapium		*Lysimachia*
	Melanolepis		

Table 1. continued

Rosaceae	*Eriobotrya*	Smilacaceae	*Smilax*
	Prunus	Solanaceae	*Datura*
	Rhaphiolepis		*Solanum*
	Rubus	Scrophulariaceae	
Rubiaceae	*Mussaenda*	Tropaeolaceae	
Rutaceae	*Citrus*	Ulmaceae	*Celtis*
	Evodia		*Trema*
Salicaceae	*Salix*	Umbelliferae	
Sapindaceae	*Euphoria*	Urticaceae	*Boehmeria*
Sauraceae		Verbenaceae	*Vitex*
Saxifragaceae	*Deutzia*		
	Hydrangea		

Gymnospermous plants			
Cupressaceae	*Juniperus*	Pinaceae	*Pinus*
Cycadaceae	*Cycas*		*Tsuga*
		Taxodiaceae	*Cunninghamia*

Ferns			
Adiantaceae	*Pityrogramma*	Lycopodiaceae	*Lycopodium*
Aspleniaceae	*Asplenium*	Marattiaceae	*Angiopteris*
Athyriaceae	*Diplazium*	Oleandraceae	*Nephrolepis*
Cyatheaceae	*Cyathera*	Ophioglossaceae	*Ophioderma*
Davalliaceae	*Davallia*	Polypodiaceae	*Lepisorus*
Dennstaedtiaceae	*Microlepia*	Pteridaceae	*Pteris*
	Monachosorum	Selaginellaceae	*Selaginella*
	Pteridium	Thelypteridaceae	*Christella*
Dryopteridaceae	*Dryopteris*		*Sphaerostephanos*
Gleicheniaceae	*Dicranopteris*		
	Diplopterygium		

Pollen seasons

During the study there were two distinct pollen seasons: the first in spring, from March to May; the second in autumn, from late August to early October (Fig. 5). The amount of total counts per month (Fig. 6) indicates that spring was the main pollen season. The highest pollen count (109,632 pollen grains (pg)) occurred in March, in which, counts as high as 55.8% of the yearly total were recorded. This was followed by April (22.3%), May (8.6%), and September (6.2%). The lowest pollen density was found in July (0.3%). During 1993, the dominant pollen taxa were of genera *Broussonetia* (73.3%), followed by *Trema* (7.4%), *Boehmeria* (2.8%), and *Ardisia* (2.4%) (Fig. 7).

The composition of airborne pollen and fern spores exhibited a seasonal succession during the studied year (Fig. 8). The tree pollen, *i.e.* arboreal pollen (AP) (97.5 ~ 99.6%), dominated in spring (from March to May), but declined drastically in summer (from June to August), when the fern spores (FS) and some non-arboreal pollen (NAP) became dominant species (16.9 ~ 41.1% and 34.6 ~ 45.6%, respectively). The dominance of NAP (48.7%) lasted untill autumn (from September to November). In winter (from December to February), the densities of pollen and fern spores were quite low (Figs. 5 and 6). There was no significantly dominant pollen taxa.

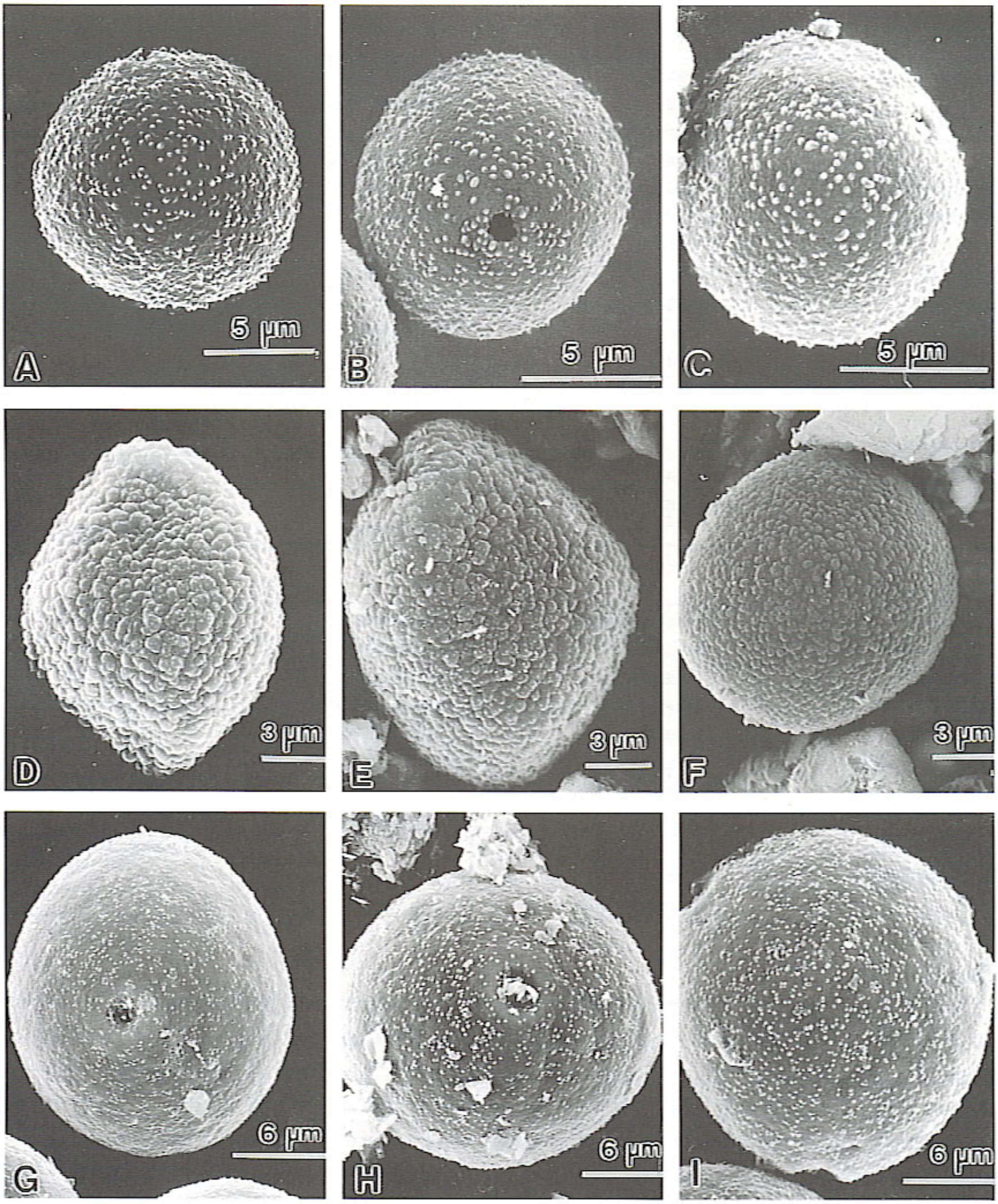

Fig. 3. Pollen morphology. A-C: *Broussonetia papyrifera*; A & B: fresh pollen grains; C: airborne-collected pollen grain. D-F: *Trema orientalis*; D & E: fresh pollen grains; F: airborne-collected pollen grain. G-I: *Celtis sinensis*; G & H: fresh pollen grains; I: airborne-collected pollen grain.

There are more than 40 airborne pollen and fern spore taxa in spring (Fig. 9) due to a lot of species of AP. At the beginning of autumn, many weed pollen and fern spores are dispersed in the air in September, and it is therefore the season with the most abundant pollen and fern taxa.

Characteristics of pollen calendar

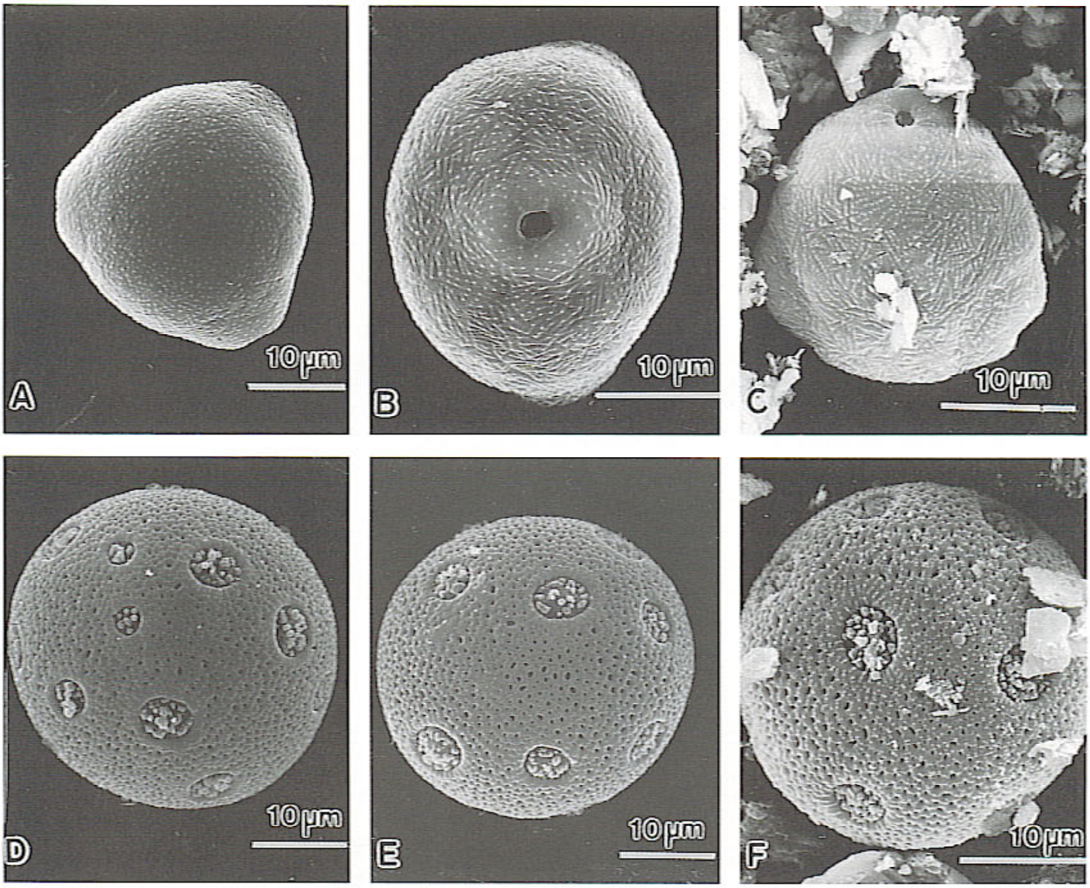

Fig.4. Pollen morphology. A-C: *Casuarina equisetifolia*; A & B: fresh pollen grains; C: airborne-collected pollen grain. D-F: *Liquidambar formosana*; D & E: fresh pollen grains; F: airborne-collected pollen grain.

The counts of 23 dominant airborne pollen and fern spore taxa during 1993 in Tan-Shui were presented in a calendar (Fig. 10). In January and February of 1993, the airborne pollen count was low. At this time the main airborne pollen grains were *Juniperus/Cunninghamia*, *Humulus*, *Morus*, *Pinus*, *Broussonetia,* and Gramineae. The pollen count increased gradually from late February to March, due mainly to the increase in *Broussonetia* pollen. The highest daily count had been as high as 44,212 pollen grains, recorded on March 26. A small amount of *Celtis* and *Bischofia* pollen were found to occur in the middle of March.

The dominance of *Broussonetia* pollen was replaced by *Trema* pollen after late March. It lasted untill the beginning of May with the peak occurring on April 28 (2,706 pg/day). During this time, *Juniperus/Cunninghamia* pollen declined rapidly, while *Pinus* pollen showed a small peak. In addition, pollen of *Euphoria*, *Casuarina*, and *Macaranga* increased gradually. *Bischofia* and *Celtis* appeared only in March and April.

In May, the dominance of *Trema* was associated with the subdominance of *Macaranga*, *Fraxinus*, and *Ardisia* pollen. Pollen of NAP species, except Gramineae, was present at low counts. Fern spores also appeared in very small quantities.

The counts of both AP and NAP were low in June, indicating the end of the first pollen period. In July, the pollen count reached its minimum, with total count as low as 0.3% of whole year count (Fig. 6). At this time, the main pollen species are of Gramineae, in association with some fern spores such as *Cyathea* and *Dicranopteris.*

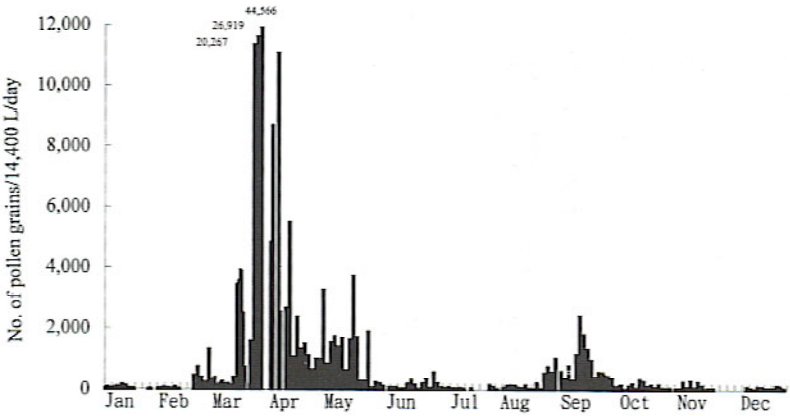

Fig. 5. Variation in pollen density in the Tan-Shui area during 1993.

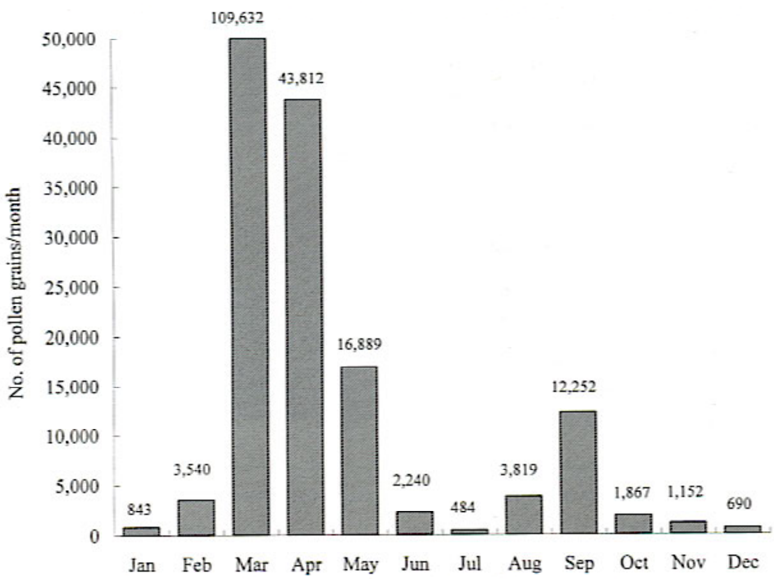

Fig. 6. Variation in total pollen counts per month in the Tan-Shui area during 1993.

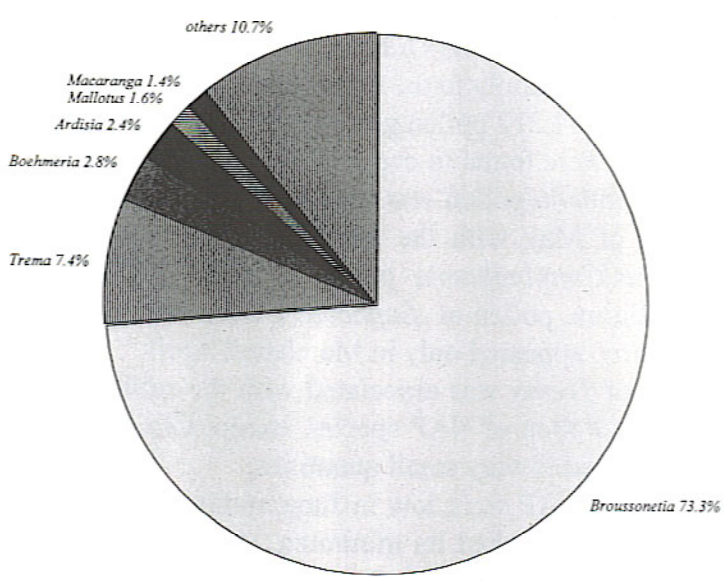

Fig. 7. Composition of pollen species in the Tan-Sui area during 1993.

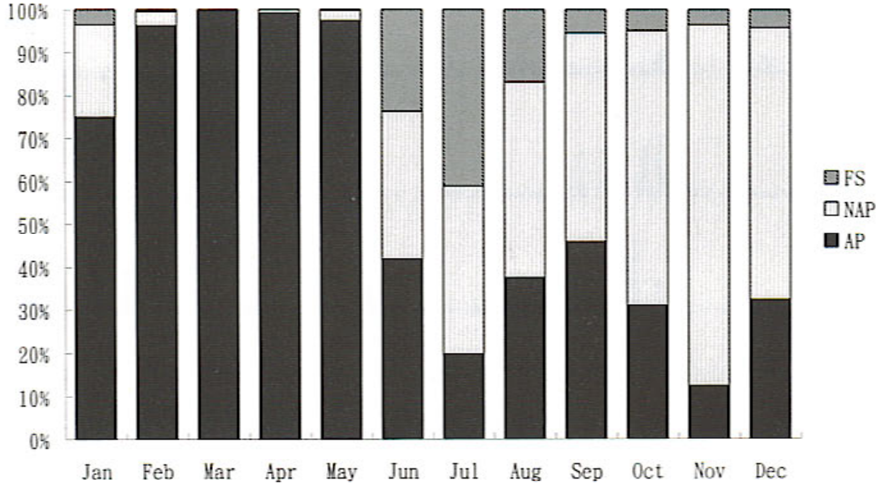

Fig. 8. Amount ratios of arboreal pollen (AP), non-arboreal pollen (NAP) and fern spores (FS) at the Tan-Shui area during 1993.

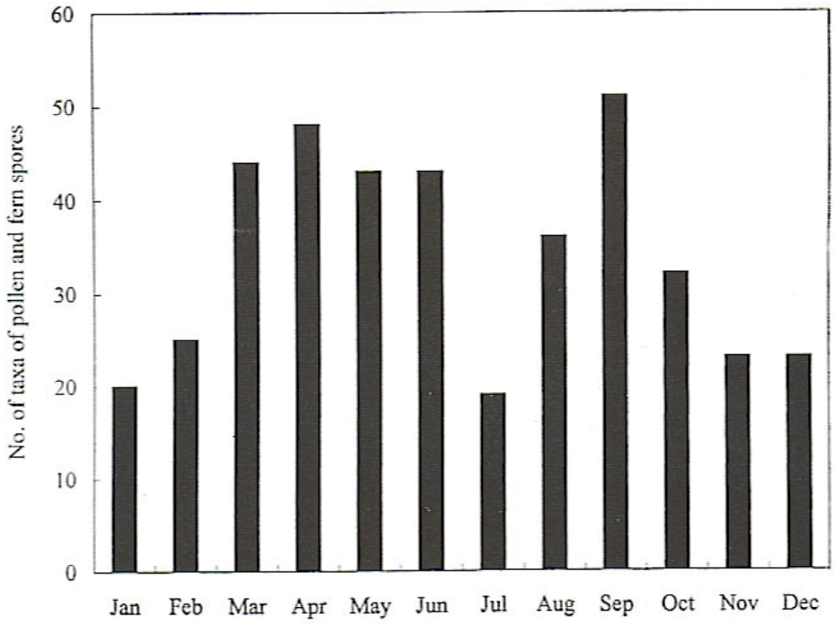

Fig. 9. Variation in total pollen and fern taxa per month in the Tan-Shui area during 1993.

The second pollen season was from late August on. As in the first pollen season, *Broussonetia* was the main pollen contributor in this time. However, its count was much lower than in spring (Fig. 10). A monthly total count of 651 pollen grains was recorded in August. This is about 0.6% of that found in March. August was the only incident time of *Eucalyptus* pollen. From August 20th on, *Juniperus/Cunninghamia* reappeared and lasted until the end of the year. The total counts of NAP were higher than AP in this month (Fig. 8), the same as found until December. Moreover, pollen of *Boehmeria*, *Ambrosia*, *Artemisia* and *Chenopodium* appeared in considerable density (Fig. 10).

In September there were 51 pollen taxa, showing the highest diversity in this year (Fig. 9). Pollen of *Boehmeria* and *Mallotus* were prevalent in this month (Fig. 10). Other species like *Broussonetia*, *Casuarina*, *Ambrosia*, *Artemisia*, *Humulus*, and *Cyathea* also appeared in relatively higher density.

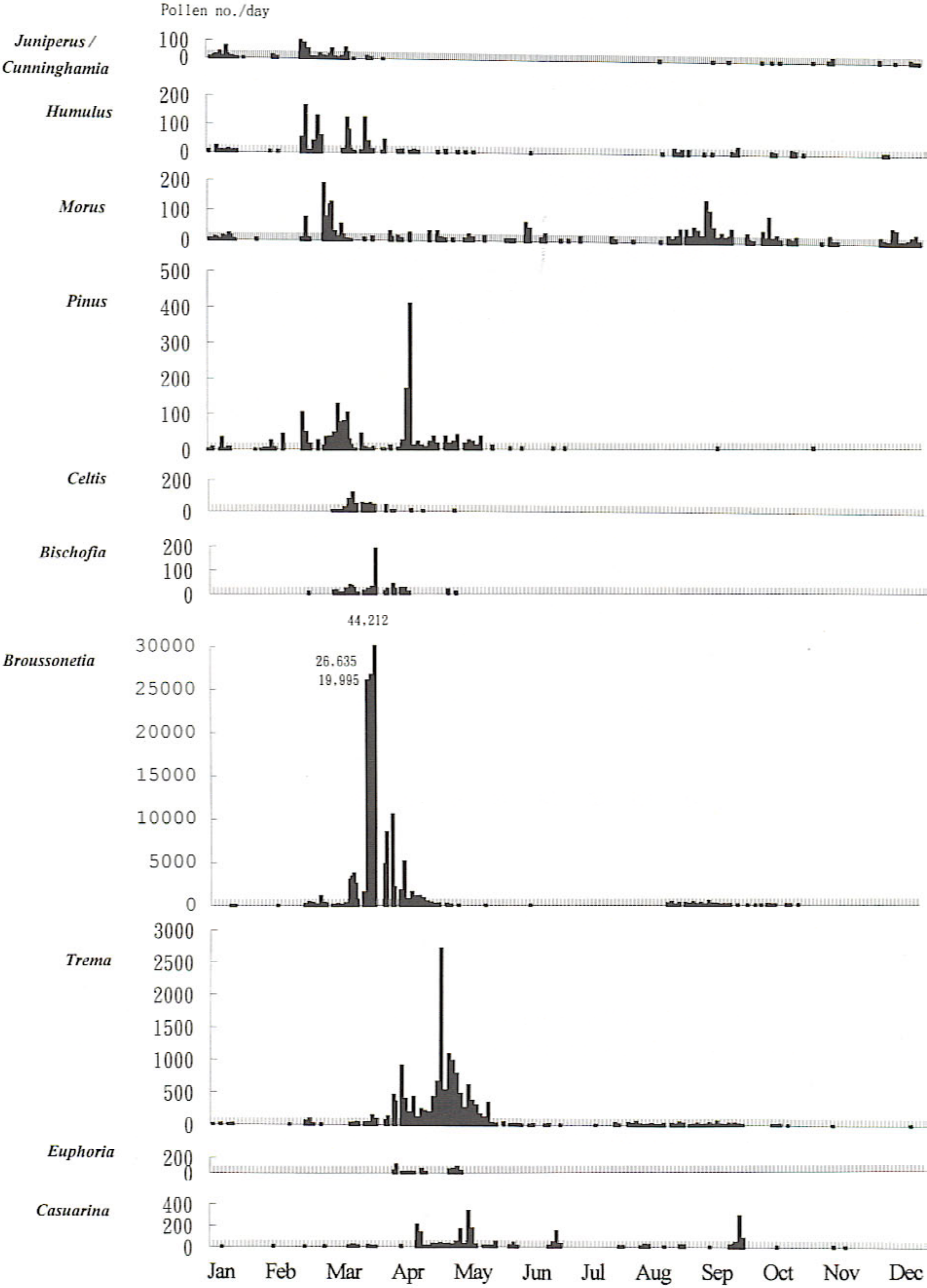

Fig. 10. Pollen calendar in the Tan-Shui area during 1993.

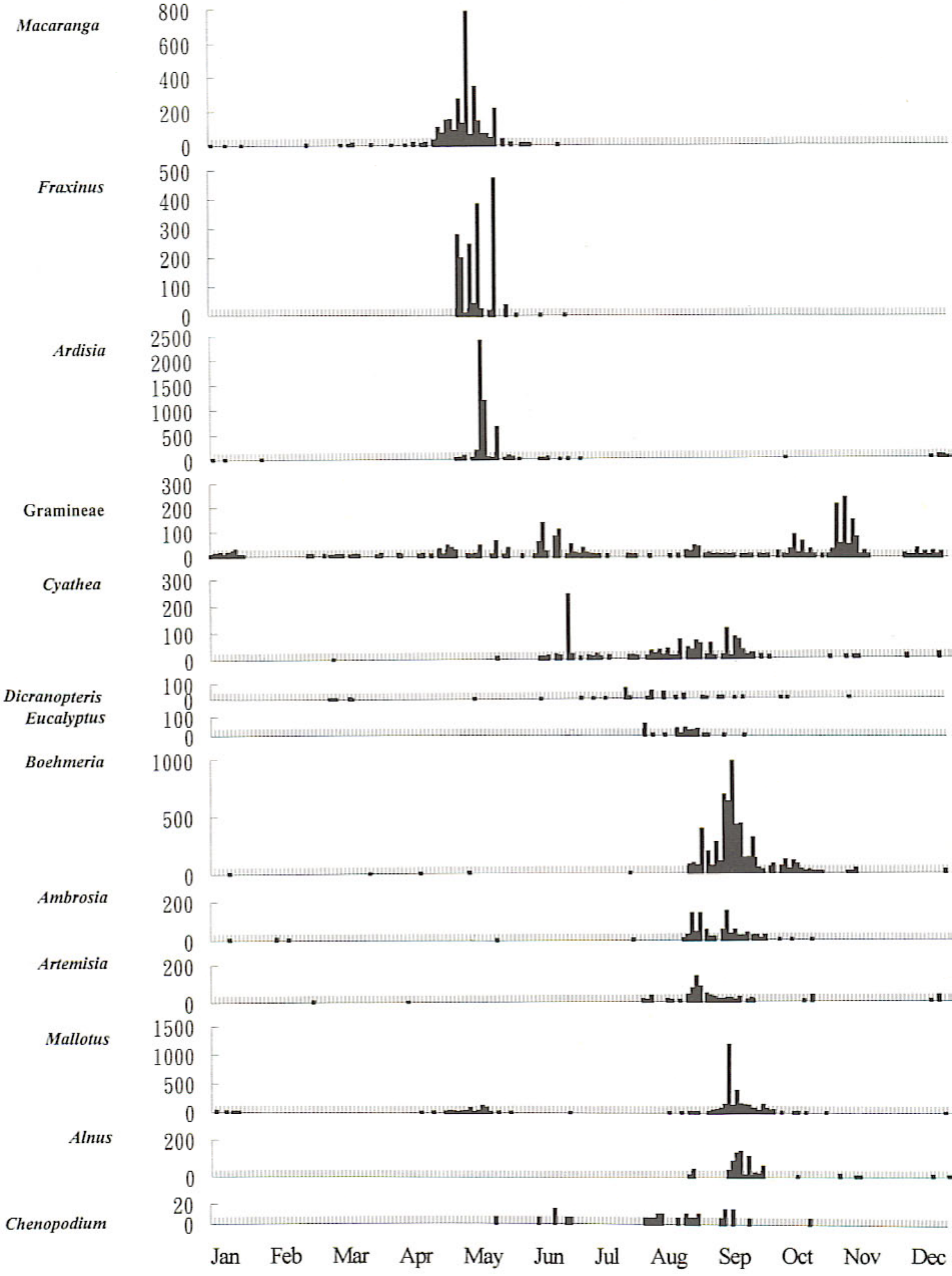

Fig. 10. Continued.

From October to December both the pollen quantities and taxa numbers decreased gradually (Fig. 6 and Fig. 9). The majority of the airborne pollen in this time were NAP type dominated by *Boehmeria*, Gramineae, *Humulus*, and *Ardisia*. Fern spores appeared only in trace (Fig. 10).

Diurnal variation

The diurnal fluctuation of airborne pollen was studied. Two diurnal patterns were observed. In the first case, maximum concentrations were recorded regularly at the same period day after day. More than one third (38%) of total airborne pollen, such as *Trema Ardisia*, and *Mallotus*, showed their peaks between 4 and 8 AM (Fig. 11). Of 23% of total airborne pollen, such as *Pinus*, *Ambrosia*, *Fraxinus*, and *Boehmeria*, appeared between 9 and 12 AM (data not shown).

In other cases, pollen of *Macaranga*, Gramineae (Fig. 12), *Humulus*, *Casuarina*, *Bischofia*, *Alnus*, *Morus*, *Juniperus/Cunningams* and *Dicranopteris* appeared irregularly within a day.

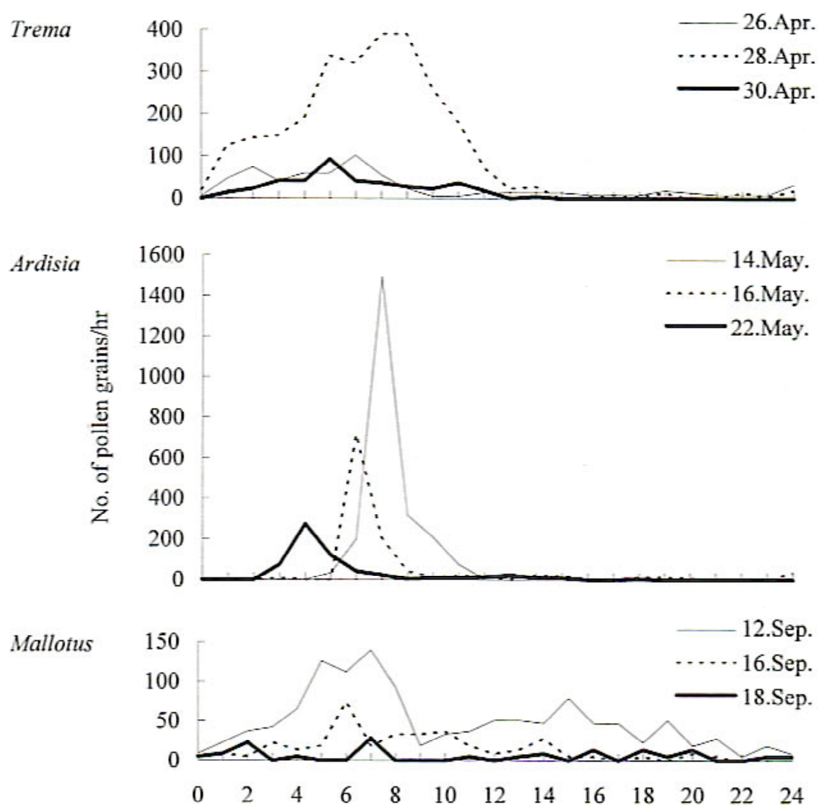

Fig. 11. Regular case of diurnal periodicities of common pollen taxa at Tan-Shui area in 1993, based on the three highest diurnal means on rainless days in each season.

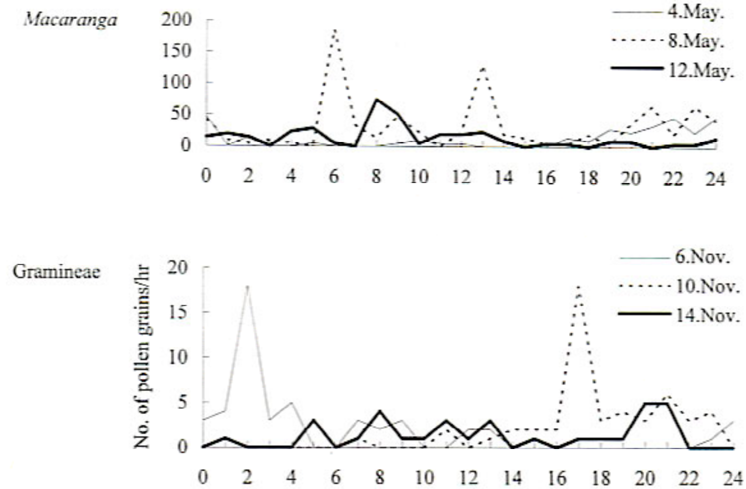

Fig. 12. Irregular case of diurnal variation of pollen taxa of *Macaranga* and Gramineae at the Tan-Shui area in 1993.

Meteorological factors

The counts of *Broussonetia* pollen obtained from March 11th to 17th were analyzed with meteorological variables (Fig. 13), because which was the most important airborne pollen species in the Tan-Shui area. The process of pollen release and dispersal influenced by meteorological parameters is discussed.

DISCUSSION

The present study shows that, in the Tan-Shui area, there are two distinct pollen seasons: March ~ May and August ~ October. The pattern is similar to that found in other subtropical zones and some temperate zones of both hemispheres (Banik and Chanda, 1992; Majas and Romero, 1992), but not to that in northern temperate zones (Stix, 1980), in which there is only one pollen season.

The three most abundant airborne pollen in the present study site are *Broussonetia* (73.7%), *Trema* (7.4%), and *Boehmeria* (2.8%). Their quantities are related to the coverage and the distance of plants to the sampling site. The extraordinarily high density of *Broussonetia* pollen is due to its high pollen productivity per plant. Moreover, a number of *Broussonetia papyrifera* plants grow close to the sampling site.

The majority of airborne pollen grains in the present study are of anemophilous species, such as *Broussonetia*, *Trema*, and *Pinus*. But some entomophilous pollen such as *Ambrosia* and *Artemisia* (both are of Asteraceae) appeared in our samples, as in the case mentioned by Lewis *et al.* (1991b). These plants produce plenty of pollen in an anther. In morphology, the pollen grains of these species are short-spineded and contain less pollenkitt on their pollen walls. Such characters are helpful for pollen transportation. In addition to asteraceous pollen,

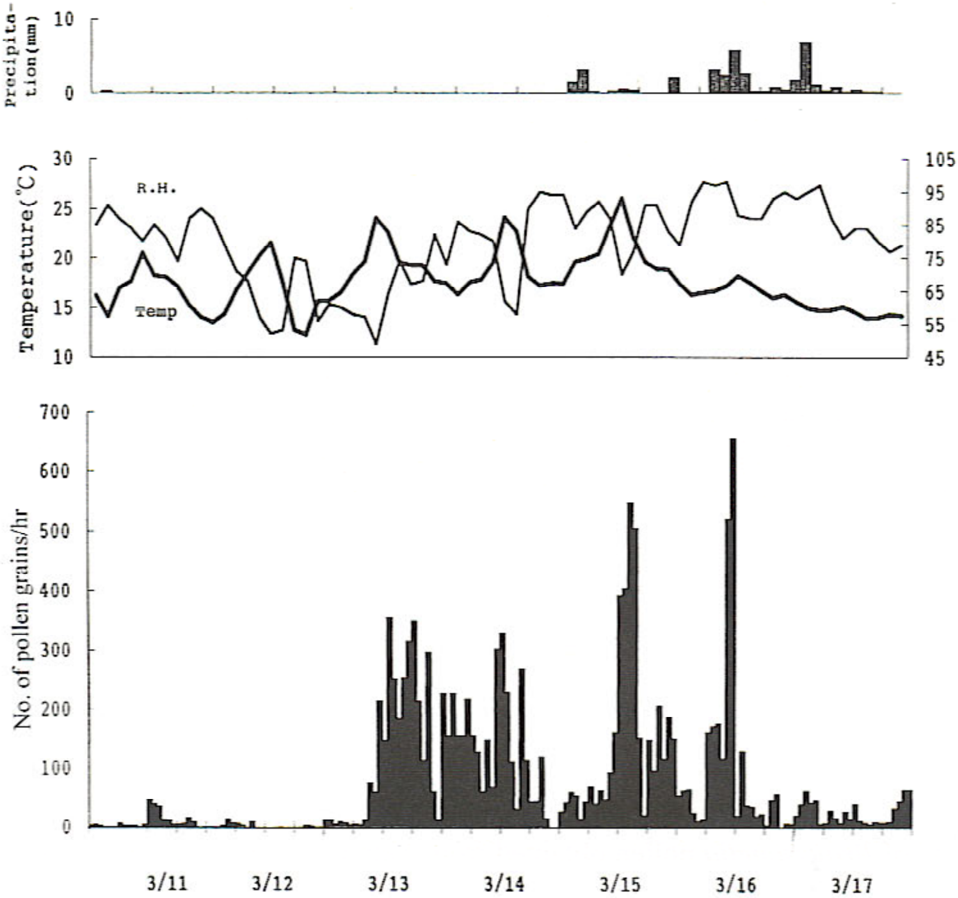

Fig. 13. Hourly variation of *Broussonetia* pollen count with respect to precipitation, temperature, and relative humidity from March 11 to 17, 1993.

there are other entomophilous pollen species, such as *Euphoria*, *Celtis*, *Acacia*, *Phoenix*, *Eucalyptus*, and *Salix*, in collected samples. They are less important, because they appeared only in trace (less than 1% of yearly count).

Various pinaceous pollen grains with airbladder present long-distance transport. Others such as Chenopodiaceae (Fraegri and Iversen, 1975), *Ambrosia* (Raynor *et al*., 1974), *Alnus* (Banik and Chanda, 1992; Johansen, 1992; Käpylä, 1981), *Betula* (Hjelmroos, 1991), *Corylus* (Mandrioli *et al*., 1980), and *Castanea* (Tampieri *et al*., 1977) were also reported. In this study, the *Ambrosia* pollen grains were also captured in the trap. There were wide dispersions of *Ambrosia* plants exclusively in Pa-Li, which is about 8 km away from the collecting station. It appears that *Ambrosia* pollen grains were transported over the Tan-Shui River, and captured in the trap consequently. Neverthless in the Tan-Shui area, the dominant taxa were almost transported from short distances by source plants in the vicinity of the station.

The registration of several *Tsuga* pollen, in late February, suggests they were long-distance transported from high altitude mountains (2,000 - 3,500 m).

In the course of a day, the majority of pollen regularly showed peaks in the morning. This suggests that the dehiscence of stomium is strongly affected by increasing temperature and decreasing relative humidity (Knox, 1979; Solomon, 1984; Bush, 1989). Otherwise, the airborne pollen of Gramineae exhibit an irregularly diurnal variation, perhaps due to the anthesis at different times of different species. For example, *Digitaria* and *Paspalidium* anthesis from 2 to 4 AM, and *Eleusine indica* from 5 to 6 AM (Bhattacharya and Datta, 1992). *Agrostis* and *Festuca* are reported to flower during the noon hours (Norris-Hill and Emberlin, 1991). *Saccharum* flowered at about 8 PM and *Cynodon dactylon* anthesised two times in a day: from 6 to 8 AM and from 4 to 5 PM (Bhattacharya and Datta, 1992).

The process of pollen release and dispersal is strongly influenced by meteorological parameters (Fairley and Batchelder, 1986). The counts of *Broussonetia* pollen obtained from March 11th to 17th were analyzed with meteorological variables (Fig. 13), because which was the most important airborne pollen species in the Tan-Shui area. In March, temperature increased and relative humidity (RH) decreased due to long daylight hours. It helped anthers to dehiscence. Pollen grains became dehydrated under 24-27°C, and this benefited pollen dispersal (Tilak, 1989). Temperature and radiation reached their maximum from 11 AM to 3 PM and 1 PM to 3 PM respectively. RH decreased to a minimum during the noon hours (49-79%). These conditions accounted for a phenomenon: during these seven days, pollen concentration increased gradually from about 10 AM, and reached the maximum from 1 to 3 PM. In addition, there were numerous flowerlets and hairs crowded on each catkin inflorescence of *Broussonetia*. The anthers needed more time and more heat to dehiscence. Besides, the peaks from 5 to 10 PM were due to inversions typically present in warmer climates. Hourly pollen counts of *Broussonetia* decreased greatly when precipitation occurred.

In Taiwan, pollen of *Salix warburgii* and *Amaranthus spinosus* have been proved to be allergenic (Chang *et al*., 1984). Pollen of *Cynodon dactylon* (Han *et al*., 1993) and *Orysa sativa* (Tsai *et al*.,1990) have also exhibited positive reactions in allergenic tests including the paper-radio-immunosorbent test (PRIST) and the radioallergo-sorbent test (RAST). The allergenic effect of airborne pollen in other species is still little known.

In nordic countries, the density of airborne pollen is considered high, when grass pollen grain exceeds $30/m^3$ (Johansen, 1992) or when the critical daily mean value of birch pollen exceeds $80/m^3$. In the Tan-Shui area, *Boehmeria* pollen concentration was often over $30/m^3$ during September. In spring, the pollen such as *Broussonetia*, *Trema*, and *Ardisia* often exceeded $80/m^3$. These readings indicate that in the Tan-Shui area pollen density during spring or September is rather high. Such information is important for further study of pollinosis in this area.

ACKNOWLEDGMENT

This research was supported by the National Science Council of Taiwan, Republic of China, under grant NSC 82-0211-B-002-368-B08. We are also very grateful to Mrs. Li-Wei Lu in Tan-Shui Junior High School for arrangement of collection site.

LITERATURE CITED

Banik, S. and S. Chanda. 1992. Airborne pollen survey of Central Calcutta, India, in relation to allergy. Grana **31**: 72-75.

Bhattacharya, K. and B. K. Datta. 1992. Anthesis and pollen release of some plants of West Bengal, India. Grana **31**: 67-71.

Bradshaw, R. H. W. 1981. Modern pollen-representation factors for woods in southeast England. J. Ecology **69**: 45-70.

Bush, R. K. 1989. Aerobiology of pollen and fungal allergens. J. Allergy Clin. Immunol. **84**: 1120-1124.

Caramiello, R., C. Siniscalco and R. Piervittori. 1991. The relationship between vegetation and pollen deposition in soil and in biological traps. Grana **30**: 291-300.

Chang, H.-N., F.-M. Lin and Y.-F. Chang. 1984. Correlation of skin test to RAST, and PRIST in asthma patients. Clin. Med. J. **34**: 376-383.

Chao, I.-T., L.-F. Chen and J.-T. Chieh. 1962. Study and survey of aeroallergens of Taiwan. Chinese Med. J. **9**: 233-243.

Chen, C.-Y., C.-Y. Chung, K.-M. Lin, K.-Y. Ou, T.-C. Huang and M.-T. Kao. 1972. Studies of pollen allergy I. A field study of the respiratory allergy plants in the Taipei area. Jour. For. Med. Asso. **71**: 196-202.

Chen, S.-H. 1984. Aeropalynological study of Nankang, Taipei (Taiwan). Taiwania **29**: 113-120.

Chen, S.-H. 1988. A scanning electron microscope survey of common airborne pollen grains in Taipai, Taiwan. Taiwania **33**: 75-108.

Chen, S.-H. and M.-C. Chien. 1986. Two-year investigation of the airborne pollen at Nankang, Taipei (Taiwan). Taiwania **31**: 33-40.

Chen, S.-H. and T.-C. Huang. 1980. Aeropalynological study of Taipei Basin, Taiwan. Grana **19**: 147-155.

D'Amato, G. and G. Lobefalo. 1989. Allergenic pollens in the southern Mediterranean area. J. Allergy Clin. Immunol. **83**: 116-122.

Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy-Angiosperm. (An Introduction to Palynology I). Almqvist and Wiksell, Stockholm.

Faegri, K. and J. Iversen. 1975. Textbook of pollen analysis. 3rd edition, Munksgaard, Copenhagen.

Fairley, D. and G. L. Batchelder. 1986. A study of oak-pollen production and phenology in northern California: Prediction of annual variation in pollen counts based on geographic and meterologic factors. J. Allergy Clin. Immunol. **78**: 300-307.

Giostra, U., P. Mandrioli, F. Tampieri and F. Trombetti. 1991. Model for pollen immission and transport in the evolving convective boundary layer. Grana **30**: 210-214.

Han, S.-H., Z.-N. Chang, H.-H. Chang, C.-W. Chi, J.-Y. Wang and C.-Y. Lin. 1993. Identification and characterization of epitopes on *Cyn d* I, the major allergen of Bermuda grass pollen. J. Allergy Clin. Immunol. **91**: 1035-1041.

Hjelmroos, M. 1991. Evidence of long-distance transport of*Betula* pollen. Grana **30**: 215-228.

Huang, T.-C. 1972. Pollen Flora of Taiwan. Natl. Taiwan Univ. Bot. Depart. Press, Taipei.

Huang, T.-C. 1981. Spore Flora of Taiwan. Natl. Taiwan Univ. Bot. Depart. Press, Taipei.

Huang, T.-C. and T.-F. Chung. 1973. Aeropalynological study of Taiwan(1)-Chushan Station. Taiwania **18**: 160-168.

Johansen, S. 1992. Aerobiological studies in subalpine birch forest at Doverefjell, Central Norway, 1982-1984. Grana **31**: 131-142.

Käpylä, M. 1981. Diurnal variation of non-arboreal pollen in the air in Finland. Grana **20**: 55-59.

Knox, R. B. 1979. Pollen and allergy. Study in biology, No.100, Edward Arnold. London.

Lewis, W. H., A. B. Dixit and H. J. Wedner. 1991a. Aeropollen of weeds of the western United States Gulf Coast. Annals of Allergy **67**: 47-52.

Lewis, W. H., A. B. Dixit and H. J. Wedner, 1991b. Asteraceae aeropollen of the western United Stated gulf coast. Annals of Allergy **67**: 37-46.

Li, H.-L., T.-S. Liu, T.-C. Huang, T. Koyama and C. E. DeVol (eds.) 1979. Flora of Taiwan, Vol. VI. Epoch Publishing Co., Ltd. Taipei, Taiwan, Rupublic of China.

Majas, F. D. and E. J. Romero. 1992. Aeropalynological research in the Northeast of Buenos Aires Province, Argentina. Grana **31**: 143-156.

Malik, P., A. B. Singh, C. R. Babu and S. V. Gangal. 1991. Atmospheric concentration of pollen grains at human height. Grana **30**: 129-135.

Mandrioli, P., M. G. Negrini, C. Scarani, F. Tampieri and F. Trombetti. 1980. Mesoscale transport of *Corylus* pollen grains in winter atmosphere. Grana **19**: 227-233.

Norris-Hill, J. and J. Emberlin. 1991. Diurnal variation of pollen concentration in the air of north-central London. Grana **30**: 229-234.

Peng, M. and S.-H. Chen. 1996. Comparison of Counting Methods for the Study of Airborne Pollen with special reference to *Broussonetia* pollen. Taiwania **41**: 35-42.

Raynor, G. S., J. V. Hayes and E. C. Ogden. 1974. Mesoscale transport and dispersion of airborne pollens. Journal of Applied Meteorology **13**: 87-95.

Romano, B., E. Bricchi, M. Fornaciari, G. Frenguelli and G. Mincigrucci, 1991. One year of pollen monitoring in an urban network, Perugia, Central Italy. Grana **30**: 242-247.

Solomon, W. R. 1984. Aerobiology of pollinosis. J. Allergy Clin. Immun. **74**: 449-461.

Stix, E. 1980. Japreszeitliche Veränderungen des Pollengehalts der Luft in Westerland/Sylt 1967-1973. Verh. naturwiss. Ver. Hamburg (NF) **23**: 127-145.

Tampieri, F., P. Mandrioli and G. L. Puppi. 1977. Medium range transport of airborne pollen. Agricultural Meteorology **18**: 9-20.

Tilak, S. T., 1989. Airborne Pollen And Fungal Spores. Vaijayanti Prakashan, Aurangabad India.

Tsai, Y.-T., S.-H. Chen, K.-L. Lin and K.-H. Hsieh. 1990. Rice pollen allergy in Taiwan. Annals of Allergy **65**: 459-462.

Tsou, C.-H. and T.-C. Huang. 1982. Aeropalynological study of Taipei suburban (New Flower Garden City). Taiwania **27**: 9-29.

Tsou, C.-H., I.-J. Tseng, R.-F. Lin and H.-Y. Hong. 1997. Aeropalynological investigation in Taichung, Taiwan, 1993-1995. Botanical Bulletin of Academia Sinica **38**: 57-62.

Yazvenko, S. B. 1991. Modern pollen-vegetation relationships on the Southeast Caucasus. Grana **30**: 350-356.

Wang, J.-L. 1973. Pollen-disease (Pollenosis) and pollen. Quart. J. Chinese For. **6**: 33-41.

淡水地區空中孢粉之研究

彭玫[1]、陳淑華[1,2]

(收稿日期：1997年3月25日；接受日期：1997年5月12日)

摘　　要

本實驗以英製孢粉收集器 (Burkard seven-day volumetric recording trap)收集淡水地區 1993 年全年的空中孢粉，經由光學顯微鏡下鑑定和計數的結果發現，本地空中孢粉主要來源以風媒種類為主，只有少數來自蟲媒花。全年所有出現的孢粉種類中，裸子植物佔 4 科 5 屬，被子植物有 57 科 88 屬，而蕨類植物佔 16 科 20 屬。就數量而言，構樹屬 (*Broussonetia*)花粉出現量佔全年總量的 73.7 %，為第一優勢花粉種類；次為山黃麻屬 (*Trema*)，佔 7.4 %；再次為苧麻屬 (*Boehmeria*)和紫金牛屬 (*Ardisia*)，分別佔 2.8 %和 2.4 %。

由逐日孢粉量分析反應出全年有二個明顯的主要花季：一為三月至五月（春季)，為最重要的開花季節，豐富的孢粉量由各樹種花粉構成；另一為八月下旬至十月初（約在秋季)，為時較短，主要由各草本花粉和蕨類孢子組成，其孢粉種類和孢粉數量，均無法與春季之孢粉量相提並論。

由一日 24小時孢粉量逐時變化趨勢 (Diurnal variation) 分析發現，有 63 % 以上的種類，在上午達到當日出現量的高峰，顯示多數種類之花藥是受到白日溫度升高、相對濕度降低的氣象因子影響而開裂，並釋出花粉。構樹屬花粉在三月出現量高的數天內，在夜間另有高峰之出現量，根據氣象資料研判，此可能與夜間逆溫層之出現有關。

由孢粉曆之建立，配合一日間孢粉最高量之出現時段，可提供淡水地區花粉過敏症研究之基本資料，以期發現可能導致過敏之孢粉種類。

關鍵詞：空中花粉，逐時變化，氣象因子，孢粉曆。

1. 國立台灣大學植物學系，台北市106，台灣，中華民國。
2. 通信聯絡員。