Taiwania, 44(1): 22-31, 1999

Airborne Pollen Concentration in Tainan, Taiwan, 1993-1995

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(Manuscript received 27 November, 1998; accepted 22 February, 1999)

ABSTRACT: An investigation of airborne pollen concentration was conducted in two consecutive years in Tainan, Taiwan, by using a Burkard seven-day volumetric recording trap. A total of 14,232 pollen grains of seed plants were counted. The mean of pollen concentration was 1.35 grains/m^3. In the course of a year, airborne pollen was most abundant in spring (late March to May) and least in autumn (from September to November). Most of the pollen grains collected were contributed by urban vegetation and garden trees. The important pollen taxa were *Broussonetia* (39.10%), Gramineae (10.15%), *Casuarina equisetifolia* (6.68%), *Artrocarpus* (5.50%), Chenopodiaceae (5.19%), *Macaranga tanarius* (4.70%), *Alnus formosana* (4.40%), *Typha angustifolia* (3.91%), *Humulus scandens* (2.66%) and Compositae (2.46%). In the above taxa, the main contributors of tree pollen are members of subclass Hamamelidae. *Broussonetia* is increasingly important in aeropalynological studies in Taiwan for its high pollen concentration reported in this study as well as many other recent investigations.

KEY WORDS: Aeropalynology, Airborne pollens, *Broussonetia*, Tainan city, Taiwan.

INTRODUCTION

Chao *et al.* (1962) conducted the pioneer work on studies of aeroallergens in Taiwan. A series of similar works were proceeded by medical researchers and then succeeded by botanists. Huang *et al.* (1997), Huang (1982) and Tsou (1982) reviewed the aeropalynological studies published from 1962 to 1997. Most of those investigations were proceeded on northern Taiwan. An integrated project, covered the whole island on aeropalynology, was supported by the National Science Council, Republic of China from November 1991 to October 1995 and six collection sites were established in Taiwan. The collaborators and the collection sites of this team were Su-Hwa, Chen (Taipei Station, northern Taiwan), Tze-Hwa, Tsou (Taichung Station, central western Taiwan), Chang-Sheng Kuoh (Tainan Station, southwestern Taiwan), Tseng-Chieng, Huang (Pingtung Station, southern Taiwan), Su-Hui, Chen (Hualien Station, northeastern Taiwan) and Hui-Chu, Chang (Taitung Station, southeastern Taiwan) respectively. Four papers and a book on this project have been published recently (Peng and Chen, 1997; Huang *et al.*, 1997; Tsou *et al.*, 1997; Huang, 1988; Huang *et al.*, 1998). This paper presents the results of a daily two year (1993-1995) airborne pollen investigation in the Tainan area, the southern collection site of the integrated project.

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MATERIALS AND METHODS

Pollen count

Atmospheric pollen grains were collected in Tainan city from 1 May 1993 to 30 April 1995, using a Burkard seven-day volumetric recording trap. The trap was placed on the roof of the Department of Biology (23°00'01.8" N, 120°13'125" E) in National Cheng-Kung University, 18 m above the ground. The adhesive layer on the cellophane tape was a mixture of gelvatol (35 g), glycerol (50 ml), phenol (2 g), and distilled water (80 ml). The pollen grains were sucked at an airflow rate of 10 l/min (liters per minute) and the moving rate of the tape was 2 mm/hr. Finally, a segment of the tape (48 mm long) was obtained for daily collection and was mounted as a permanent slide after being stained with methyl blue.

Collected pollen grains of angiosperms and gymnosperms were identified and counted with an aid of a software, TAPIRA (Kuoh *et al.*, 1998), on an hourly basis at 400X magnification. Besides referring to the Pollen Flora of Taiwan (Huang, 1972) and Pollen Flora of China (Wang *et al.*, 1995) for identification, pollen grains were collected fresh from more than 330 species of plants to make reference slides.

The meteorological data of the Tainan city used in the present report were obtained from the Central Weather Bureau, R.O.C. The Tainan meteorological station is about 2km away from the pollen collection site.

Location and vegetation of sampler

Tainan City is located in southern Taiwan, at altitude around 50 m above the sea level. Besides sandy plants and mangrove at western coast region, many species in the waste areas, parks, gardens, and roadsides constitute the urban vegetation. In these areas, many cosmopolitan weeds are rather common, such as *Chenopodium*, *Amaranthus*, *Bidens*, *Erigeron*, *Ipomoea*, *Chloris barbata*, *Panicum maximum*, *Pennisetum setosum*, and *Saccarum spontaneum*. The vast majority of the trees growing in the vicinity of the collection site were cultivated plants such as *Juniperus chinensis*, *Alstonia scholaris*, *Bischofia javanica*, *Mangifera indica*, *Casuarina equisetifolia*, *Terminalia* spp., *Macaranga tanarius*, *Cinnamomm camphora*, *Cassia surattensis*, *Artocarpus*, *Ficus*, *Delonix regia*, *Roystonea regya*, and *Ixora*. A few wild trees such as *Broussonetia papyrifera* or shrubs such as *Ricinus communis* were along roadside or occurred in small patches in the wasteland of the Tainan City. The closest natural vegetation was more than 12 km away.

RESULTS AND DISCUSSION

Pollen concentrations

From 1 May 1993 to 30 April 1995, a total of 14,232 pollen grains were collected. Of them, 8,851 pollen grains appeared in the first year, with an average pollen concentration of 1.68 grains/m^3, and 5,381 pollen grains were counted in the second year, averaging 1.02 grains/m^3. Compared with other collection sites, the average pollen concentration of the two years in Tainan is conspicuously lower than that in Taipei, Taichung and Pingtung areas

(Peng and Chen, 1997; Tsou *et al.*, 1997; Huang, 1998). This is probably due to the height of the recording pollen trap in difference site, since it will influence the concentration of pollen (Rantio-Lehtimaki *et al.*, 1991), and it is, 18 m above the ground in Tainan, higher than any site.

The pollen spectra of the two years are rather similar in pollen concentrations. In each year, there were two distinct pollen seasons: from March to May and from late July to October (Fig. 1). Such annual airborne pollen pattern is the same as that in other subtropical and temperate zones (Banik and Chanda, 1992; Majas, 1992; Peng and Chen, 1997). The pollen concentration was the lowest in the late autumn and winter averaging only about 0.61 grains/m^3, and the highest daily peak in the two years was recorded on 8 March 1994, with 42.5 grains/m^3 (Fig. 1).

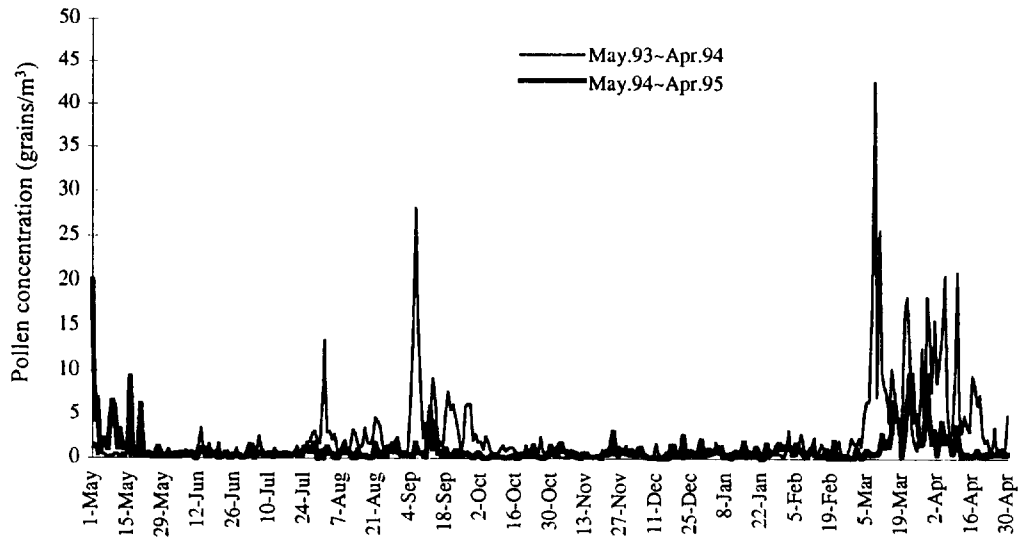

Fig. 1. Daily pollen concentration in the atmosphere in Tainan City, Taiwan, from 1 May 1993 to 30 April 1995.

Pollen contributors

In terms of plant habits, tree pollen grains were dominant in the Tainan atmosphere that they comprised about 68% of the total grains. Grass pollen grains amounted to 10.5% and herbs to 16.7%. The percentage of pollen from grasses and other herbs was higher in south-western plain than that in Taichung area (Tsou *et al.*, 1997), and similar to the percentage in Pingtung area (Huang *et al*, 1997).

The collected pollen included 95 gymnosperm pollen grains (0.67%) and 1,4137 angiosperm pollen grains (99.33%) (Table 1). The percentage representations of the ten most frequently important taxa were as follows: *Broussonetia papyrifera* (39.10%), Gramineae (10.15%), *Casuarina equisetifolia* (6.68%), *Artrocarpus lanceolata* (5.50%), Chenopodiaceae (5.19%), *Macaranga tanarius* (4.70%), *Alnus formosana* (4.40%), *Typha angustifolia* (3.91%), *Humulus scandens* (2.66%) and Compositae (2.46%) (Fig. 2). The gymnosperm pollen mainly belonged to Cupressaceae and Pinaceae. Of all the angiosperm pollen, Moraceae was decisively dominant. Gramineae and Casuarinaceae took the second and the third rank respectively.

Table 1. Annual totals and percentages of daily pollen counts in Tainan city, Taiwan, from 1 May 1993 to 30 April 1995.

Item	1st year	%	2nd year	%	Sum	%	Rank
Gymnosperms	69	0.7795	26	0.4831	95	0.6675	
Cupressaceae	7	0.0790	1	0.0185	8	0.0562	
Cycas	0	0	1	0.0185	1	0.0070	
Pseudotsuga wilsoniana	1	0.0112	0	0	1	0.0070	
Pinaceae	30	0.3389	5	0.0929	35	0.2459	
Calocedrus	31	0.3502	19	0.3530	50	0.3513	
Angiosperms	8782	99.220	5355	99.516	14137	99.332	
Artocarpus lanceolata	373	4.2142	410	7.6194	783	5.5016	4
Amaranthaceae	113	1.2766	123	2.2858	236	1.6582	
Alnus formosana	498	5.6264	128	2.3787	626	4.3985	7
Artemisia	50	0.5649	13	0.2415	63	0.4426	
Ardisia	42	0.4745	21	0.3902	63	0.4426	
Betulaceae	3	0.0338	0	0	3	0.0210	
Begonia	15	0.1694	15	0.2787	30	0.2107	
Boerhavia	8	0.0903	1	0.0185	9	0.0632	
Broussonetia papyrifera	3379	38.176	2186	40.624	5565	39.102	1
Bischofia javanica	91	1.0281	173	3.2150	264	1.8549	
Casuarina equisetifolia	668	7.5471	283	5.2592	951	6.6821	3
Cassia	3	0.0338	1	0.0185	4	0.0281	
Caryophyllaceae	10	0.1129	1	0.0185	11	0.0772	
Cestrum nocturum	2	0.0225	2	0.0371	4	0.0281	
Chenopodiaceae	500	5.6490	238	4.4229	738	5.1854	5
Compositae	287	3.2425	63	1.1707	350	2.4592	10
Cruciferae	12	0.1355	0	0	12	0.0843	
Cucurbitaceae	5	0.0564	0	0	5	0.0351	
Cyperaceae	12	0.1355	0	0	12	0.0843	
Dehaasia triandra	2	0.0225	0	0	2	0.0140	
Ehretia microphylla	5	0.0564	3	0.0557	8	0.0562	
Engelhardtia roxburghiana	1	0.0112	4	0.0743	5	0.0351	
other Euphorbiaceae	48	0.5423	8	0.1486	56	0.3934	
Eucalyptus maculata	3	0.0338	0	0	3	0.0210	
Gramineae	798	9.0159	647	12.023	1445	10.153	2
Humulus scandens	202	2.2822	176	3.2707	378	2.6559	9
Helwingia	1	0.0112	6	0.1115	7	0.0491	
Ixora	7	0.0790	0	0	7	0.0491	
Koelreuteria henryi	35	0.3954	8	0.1486	43	0.3021	
other Leguminosae	29	0.3276	14	0.2601	43	0.3021	
Lysimachia	3	0.0338	0	0	3	0.0210	
Mallotus	98	1.1072	0	0	98	0.6885	
Macaranga tanarius	147	1.6608	522	9.7007	669	4.7006	6
Menispermaceae	43	0.4858	0	0	43	0.3021	
Michelia alba	2	0.0225	0	0	2	0.0140	
Mimosa pudica	15	0.1694	1	0.0185	16	0.1124	
other Moraceae	15	0.1694	0	0	15	0.1053	
Muntingia calabura	3	0.0338	10	0.1858	13	0.0913	
Myrsinaceae	3	0.0338	1	0.0185	4	0.0281	
Myrtaceae	0	0	4	0.0743	4	0.0281	
Oleaceae	3	0.0338	0	0	3	0.0210	
Radermachia sincia	6	0.0677	10	0.1858	16	0.1124	

Table 1. Continued.

Item	1st year	%	2nd year	%	Sum	%	Rank
Rehmannia glutinosa	0	0	16	0.2973	16	0.1124	
Ricinus communis	74	0.8360	48	0.8920	122	0.8572	
Rubiaceae	41	0.4632	9	0.1672	50	0.3513	
Rutaceae	2	0.0225	1	0.0185	3	0.0210	
Saurauia oldhamii	5	0.0564	1	0.0185	6	0.0421	
Solanaceae	187	2.1127	106	1.9698	293	2.0587	
Sterculia nobilis	6	0.0677	21	0.3902	27	0.1897	
Syzygium samarangense	17	0.1920	15	0.2787	32	0.2248	
Trema orientalis	66	0.7456	11	0.2044	77	0.5410	
Typha angustifolia	539	6.0897	17	0.3159	556	3.9066	8
Umbelliferae	5	0.0564	2	0.0371	7	0.0491	
Miscellaneous	300	3.3894	36	0.6690	336	2.3608	
Sum	8851	100	5381	100	14232	100	

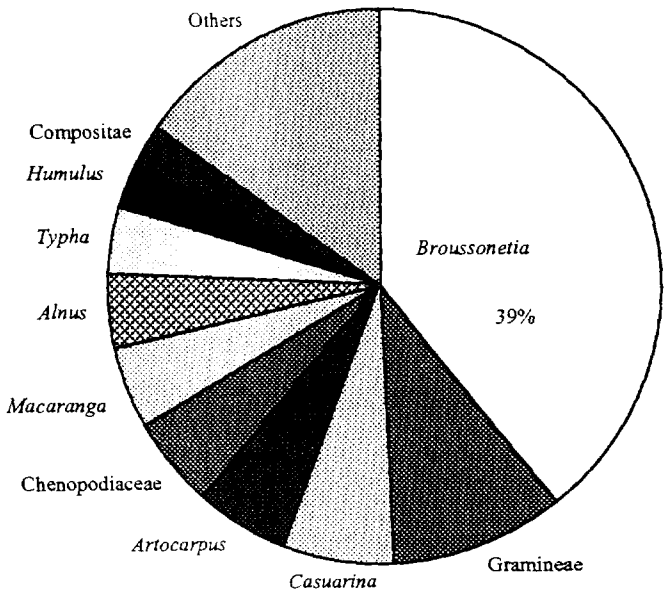

Fig. 2. Composition of pollen species in Tainan city, Taiwan, from 1 May 1993 to 30 April 1995.

Among these ten important taxa, *Broussonetia*, *Casuarina equisetifolia*, *Artocarpus*, *Macaranga*, *Humulus scandens* and *Alnus* are the members of Hamamelidae. Those pollen grains are porate or tricolporate. The porate pollen produced by these taxa are small or medium in size, each ranging from 10-50 μm. Among them, the genus *Broussonetia*, represented by *B. kazinokiis* and *B. papyrifera* in Taiwan, was the most important pollen contributor in Tainan as well as in Taipei, Taichung and Pingtung (Peng and Chen, 1997; Tsou, 1997; Huang, 1998). In addition, there was a tendency that the percentage of pollen concentration of *Broussonetia* gradually decreased from north to south in Taiwan.

The present investigation also showed that the airborne pollen spectrum did not reflect the floristic composition. There were many individuals from more than 110 families growing naturally or cultivated in the area within 5-km distance from the collection site during the investigation period. But some quantitatively significant plants such as Euphorbiaceae and Leguminosae were not the main pollen contributors because most species of them are basically zoophilous.

Pollen calendar

Two patterns of pollen calendar were illustrated. The first pattern shows one or two short-sustaining but strong concentrations in a year such as those of *Artocarpus*, *Broussonetia*, and *Casuarina* (Fig. 3). The second pattern has many peaks throughout a year such as those of Gramineae and Chenopodiaceae (Fig. 3).

In one year course, pollen concentration was the heaviest in spring (from March to May). At that time, *Broussonetia*, *Casuarina*, and *Artocarpus* were major pollen contributors. In summer (from June to August), the important contributors were Gramineae and *Humulus*. In autumn (from September to November), pollen concentration of Gramineae and *Alnus* increased moderately. In winter (from December to February), the total amount dropped down and *Casuarina*, Utricaceae, and *Humulus* became important contributors.

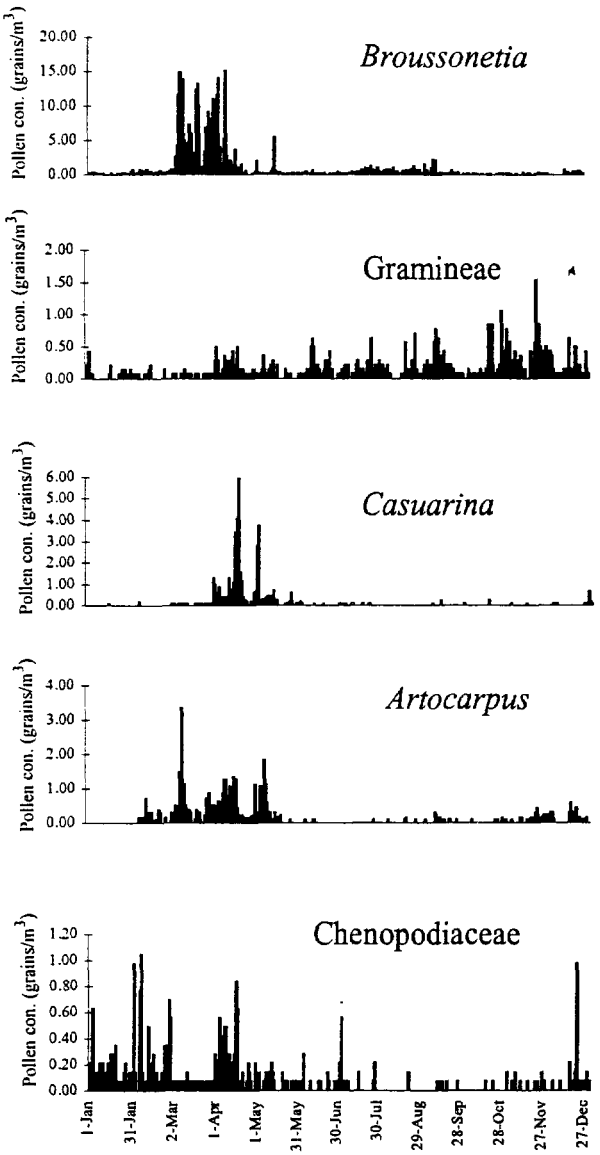

Fig. 3. Pollen calendars of *Broussonetia*, Gramineae, *Casuarina*, *Artocarpus* and Chenopodiaceae in Tainan during 1994.

Climate and pollen concentration

A rain shower always decreased the pollen concentration drastically, and a sharp pollen peak normally appeared following a rain shower (Hart *et al.*, 1994; Tsou *et al.*, 1997). In general, rainfall was linked with a decrease in the pollen concentration of *Broussonetia*. It was high on days without rainfall and low on days of high rainfall (Fig. 4). This is because the release of pollen is low during and after rain, and the rain wash airborne particles from the air. The pollen concentration of *Broussonetia* detected was associated with the temperature, and showed a positive correlation (Fig. 4). According to Hart *et al.* (1994), high temperature was linked with an increase in the recorded pollen concentration at Leicester.

Allergy and pollen concentration

Grass pollen has been reported as a major component in some earlier aeropalynological investigations (Huang and Chung, 1973; Chen and Huang, 1980; Tsou and Huang, 1982; Chen and Chien, 1986). In recent aeropalynological studies in Taiwan, *Broussonetia* was found to be predominant, in the period from 1993 to 1995, while grasses and Compositae were of minor importance (Peng, 1994; Tsou *et al.*, 1997).

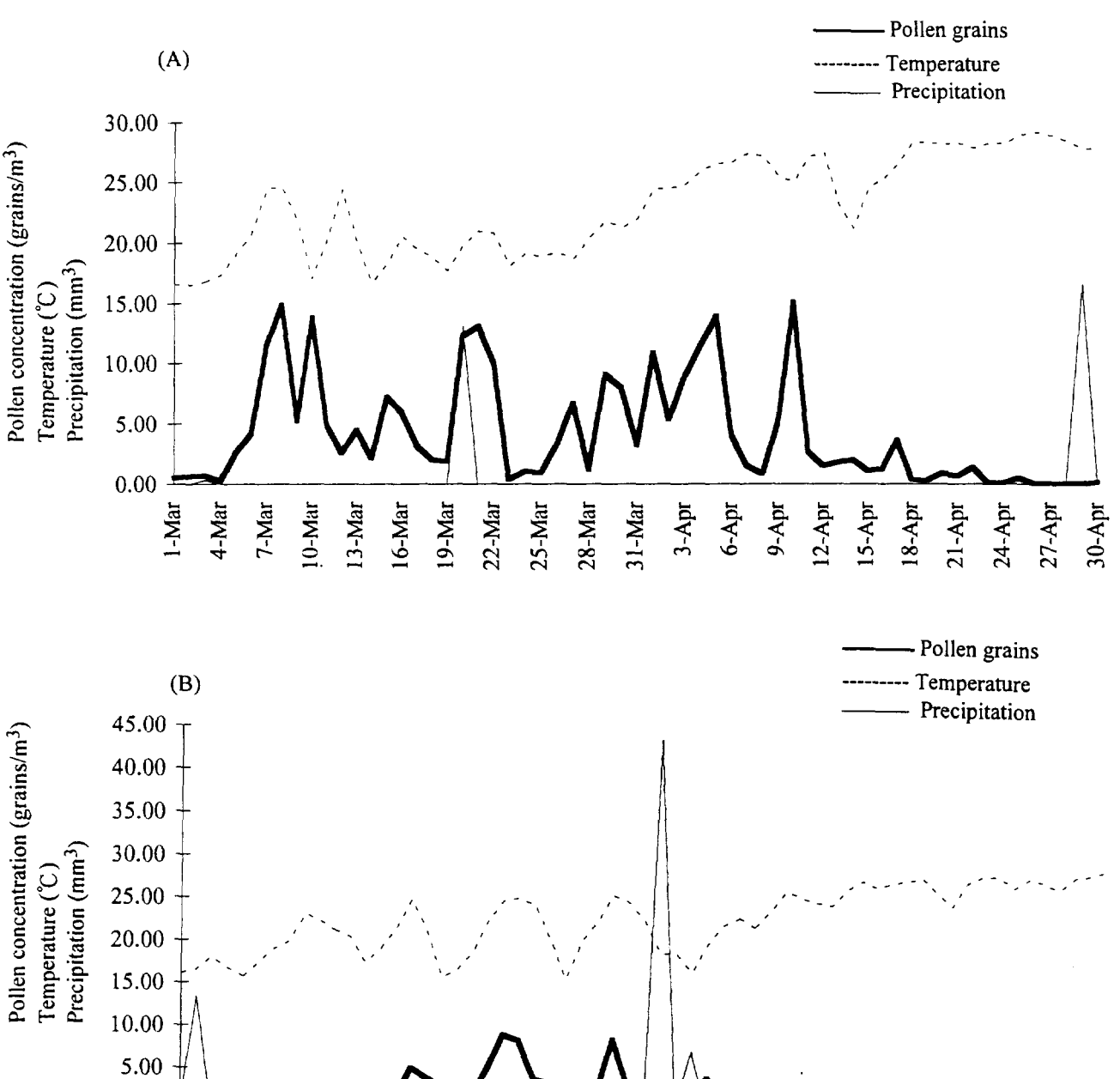

Fig. 4. Correlation between pollen concentration of *Broussonetia* and meteorological factors (temperature and precipitation). (A) from 1 March 1994 to 30 April 1994, (B) from 1 March 1995 to 30 April 1995.

According to the skin tests of pollen allergy (Ye *et al.*, 1988), most of the significant pollen taxa (frequency > 2.46%) revealed in the present study are allergic. Of them, one finds the ten quantitatively most important taxa in Tainan site: *Broussonetia*, Gramineae, *Casuarina equisetifolia*, *Artocarpus lanceolata*, Chenopodiaceae, *Macaranga tanarius*,

Alnus formosana, *Typha angustifolia*, *Humulus scandens* and Compositae constituting 84.75% of the total. In conclusion, further study of these ten taxa on the correlation between their individual pollen concentration and the allergenicity, especially in *Broussonetia papyrifera* , appears crucial.

ACKNOWLEDGMENTS

This research was supported by the National Science Council of the Republic of China, under grants NSC 83-0409-B001, NSC 84-0409-B001 and NSC 85-0409-B001. We are also very grateful to Dr. C.-H. Tsou and Ms. L.-F. Hung for valuable comment.

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民國八十二年至八十四年間台南市空中花粉調查

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（收稿日期：1998 年 11 月 27 日；接受日期：1999 年 2 月 22 日）

摘　　要

利用七日式花粉定量捕捉器在台南市進行兩年空中孢粉調查。總共收集到 14,232 顆種子植物的花粉粒，平均花粉濃度為每立方米 1.35 粒。在一年之中，空中花粉數量以春季最高，冬季最低；在台南地區，空中花粉的主要供應者為都市及公園中的植物種類。調查結果指出最重要的花粉種類分別屬於 *Broussonetia* (39.10%)、Gramineae (10.15%)、*Casuarina equisetifolia* (6.68%)、*Artrocarpus* (5.50%)、Chenopodiaceae (5.19%)、*Macaranga* (4.70%)、*Alnus* (4.40%)、*Typha* (3.91%)、*Humulus scandens* (2.66%) 和 Compositae (2.46)；其中構成木本的花粉大部分來自於金縷梅亞綱的植物。在台南市重要的花粉種類中，構樹為最主要的組成分子，和全省其他花粉站的研究報告相似。且其花粉具致過敏性，當為台灣臨床過敏學者所注意。

關鍵詞：空中孢粉學、空中花粉、構樹屬、台南市、台灣。

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