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The Outdoor Fungal Airspora in Hualien (I) — The Agar Plate Method

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ABSTRACT : The outdoor fungal airspora in urban Hualien has been investigated based on one year's collection (from April 1993 to March 1994) by the agar plate method. Among the fungi isloated, the majority (59.84%) comprised species of *Cladosporium* (33.18%), *Aspergillus* (11.06%), yeasts (7.41%), *Penicillium* (3.94%), *Fusarium* (1.73%), *Curvularia* (1.50%) and *Alternaria* (1.02%). All these fungi occurred every month. Spore showers occurred for yeast on July 1993 and for *Aspergillus* on January 1994. The mean number of colonies forming on the agar plates in the morning exposure was higher than during noon or afternoon exposure. This phenomenon is significantly correlated with the diurnal relative humidity. Summer is the season with the highest number of colonies formed. The month with the highest number of colonies formed was July 1993.

KEY WORDS : **Fungal airspora, Hualien, Taiwan.**

INTRODUCTION

Air is the most common medium for the dispersal of pollen grains, fungal spores and hyphal fragments. Even by the beginning of the nineteenth century, this fact was widely recognized. Like pollen grains, airborne fungal propagules may cause human allergies. Unlike pollen grains which are easily traced back to their plant species, the source of fungal propagules is not easily identified (Gregory, 1973).

Investigations of fungal airspora are usually made by one or both of two sampling methods: the exposure of culture plates gives information upon the numbers and nature of spores of those moulds which are vital and can be cultivated, and the exposure of sticky tapes or slides enables counts to be made of the entire spore load, but gives an incomplete picture of the types comprising it. Although airborne fungal particles have been extensively studied in many diffferent places around the world, because of the two different sampling techniques used, the results obtained are not easily compared.

In Taiwan, several studies of fungal airspora have been carried out, but mostly in the Taipei area (Lü *et al.* 1969; Hsiung, 1976; Tseng and Chen, 1979; Han *et al.* 1981; Chang *et al.* 1983). Only Han and Chuang (1981) have investigated the Hualien airspora by means of the gravity slide method, recording 12 genera of fungi. They also reported that the fungal spore load in Hualien was larger than that from the other parts of Taiwan.

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In order to obtain more complete data of the fungal airspora in Hualien, from April 8, 1993 to March 24, 1994, the outdoor fungal airspora in urban Hualien was investigated. Data was collected by means of the agar plate method as well as the sticky tape method. The data collected in this study can be used to assist doctors treating patients with allergies. This paper summarizes the results of one year's investigation on fungal airspora in urban Hualien by the agar plate method. The results obtained from the sticky tape method will be reported later.

MATERIALS AND METHODS

This work covers almost a whole year, from April 1993 to March 1994. Sampling was carried out by means of Burkard portable air sampler for agar plates. Exposure was carried out on the third floor roof of the Bureau of Health of Hualien County located in urban Hualien and closed to the seashore on the eastern side. Standard 90 mm disposable Petri dishes containing 27 ml of medium were exposed in the sampler for 20 seconds. The rate of air flow was set at 10 litres/min. Two kinds of isolation media were used: (1) Malt Extract Agar (MEA): maltose (12.75g), dextrin (2.75g), Bacto glycerol (2.35g), Bacto peptone (0.78g), Bacto agar (15.00g), chloramphenicol (100mg), distilled water (1000ml). (2) Sabouraud Agar (SA): peptone (10g), dextrose (40g), yeast extract (5g), agar (20g), distilled water (1000ml), chloramphenicol (100mg). On the second and fourth Thursdays of every month, two plates per medium were exposed at 8:00, 12:00 and 17:00 hr. And every Thursday in the first and third weeks of each month, two plates per medium were exposed at 10:00 hr.

After exposure, the plates were taken to Taipei and incubated at 24°C for 3 days, after which time fungal colonies were counted and identified (excluding yeasts). Further inspection of the plates was made occasionally within one month for more slowly growing colonies. The number of colonies at 30 days on each sampling was recorded. Most of the fungal colonies were identified to the genus only, however, some were identified to the species level. The correlations for isolate number and some meterological conditions were preliminarily investigated. Meterological data were obtained from The Central Weather Bureau. Statistical analysis was carried out using 2-way ANOVA and Pearson correlation coefficient method. A value of $P<0.01$ was considered statistically significant.

RESULTS

I. Fungi Isolated

A total of 6289 isolates was recorded during the study, these were assigned to 45 genera or taxonomic groups (Table 1). Among these fungi, most are Deuteromycetes (56.49%), the others are yeasts (7.41%), Basidiomycetes (0.35%), Zygomycetes (0.13%) and Ascomycetes (0.08%). There were numerous isolates which did not sporulate in culture (sterile colonies), these fungi made up 30.74% of the total number of isolates. About 4.74% of the isolations

remain unidentified. The occurrence of each of the identified fungi is listed in Table 1 in descending order.

Table 1. The genera or groups of fungi isolated lited in descending order of frequency (%). (Not including sterile colonies and unknown genera).

Genera	Frequency (%)	Order	Genera	Frequency (%)	Order
Cladosporium	*33.18*	*1*	Ascomycetes	0.08	21
Aspergillus	*11.06*	*2*	*Chrysosporium*	*0.08*	*21*
Yeasts	7.41	3	*Rhizopus stolonifer*	*0.08*	*21*
Penicillium	*3.94*	*4*	*Stemphylium*	*0.08*	*21*
Fusarium	*1.73*	*5*	*Aureobasidium*	*0.06*	*22*
Curvularia	*1.50*	*6*	*Phyllosticta*	*0.06*	*22*
Alternaria	*1.02*	*7*	*Schizophyllum commune*	*0.06*	*22*
Geotrichum	*0.80*	*8*	*Sporothrix*	*0.06*	*22*
Pestalotiopsis	*0.72*	*9*	*Pyricularia*	*0.05*	*23*
Trichoderma	*0.64*	*10*	*Rhinocladiella*	*0.05*	*23*
Acremonium	*0.51*	*11*	*Syncephalastrum racemosum*	*0.05*	*23*
Sphaeropsidales	*0.51*	*11*	*Tritirachium*	*0.05*	*23*
Nigrospora	*0.37*	*12*	*Verticillium*	*0.05*	*23*
Basidiomycetes	0.29	13	*Choanephora*	*0.03*	*24*
Phoma	*0.22*	*14*	*Chalaropsis*	*0.03*	*24*
Botrytis	*0.19*	*15*	*Gonatobotrys*	*0.03*	*24*
Paecilomyces	*0.19*	*15*	*Periconia*	*0.03*	*24*
Pithomyces	*0.19*	*15*	*Ulocladium*	*0.03*	*24*
Drechslera	*0.18*	*16*	*Apiocarpella*	*0.02*	*25*
Phomopsis	*0.16*	*17*	*Endophragmia*	*0.02*	*25*
Scopulariopsis	*0.13*	*18*	*Spegazzinia*	*0.02*	*25*
Arthrinium	*0.11*	*19*	*Zygosporium*	*0.02*	*25*
Neurospora	*0.10*	*20*			

The fungi isolated fell into one of three groups according to the number of months isolated. The groups were: I. Numerically dominant genera occurring throughout the year; II. Genera isolated during 6-11 months, and III. Fungi occurring during fewer than 6 months.

Group I :Fungi occurring monthly throughout the 12-month period

This group comprised genera occurring throughout the year and provided the greatest number of isolates (59.84% of the total). It was represented by yeasts and 6 genera: *Alternaria, Aspergillus, Cladosporium, Curvularia, Fusarium* and *Penicillium.* All these fungi are in the 7 most frequently occurring genera. These fungi along with the number of colonies for each are listed in Table 2 .

Table 2. Incidence of fungi occurring during all 12 months

Group (I) genus	No. of occurring months	No. of colonies
Cladosporium	12	2087
Aspergillus	12	696
Yeasts	12	466
Penicillium	12	248
Fusarium	12	109
Curvularia	12	94
Alternaria	12	64

Group II : Fungi occurring during 6-11 months in the one year period

This group of fungi (Table 3) included 8 genera which made up 3.85 % of the total number of isolates. The occurrence of the genera in this group varied according to genus, from 6 to 11 months during the 12-month period. Some fungi of this group such as *Geotrichum, Pestalotiopsis, Acremonium*, Sphaeropsidales, *Trichoderma* and *Nigrospora* were among the most frequently occurring 13 fungi.

Table3. Incidence of fungi occurring for monthly 6-11 months.

Group (II) genus	No. of occurring months	No. of colonies
Geotrichum	11	50
Pestalotiopsis	10	45
Acremonium	9	32
Sphaeropsidales	8	32
Trichoderma	7	40
Nigrospora	6	23
Pithomyces	6	12
Arthrinium	6	7

Group III: Occasionally occurring fungi

This group comprised 30 genera of fungi made up only 4.12% of the total number of isolated colonies (Table 4). The occurrence of this group of fungi was never more than 5 months during the 12-month period and varied with the genus. Some genera appeared only for one month in the entire sampling period.

II. Effect of Culture Media and Collecting Time on the Number of Isolates

Sampling was carried out using two media: MEA and SA. Records were taken on days when plates were exposed at 8: 00, 12:00 and 17:00 hr. Variation of the monthly total colony number exposed at different time during the experimental period is given in Fig.1. It illustrates that the number of colonies formed on the 8:00 hr plates was consistently higher than those on the 12:00 hr and 17:00 hr plates during nearly the entire period. Two-way

Table 4. Incidence of fungi occurring during 5 or fewer months

Group (III) genera	No.of occurring months	No. of colonies
Basidiomycetes	5	18
Botrytis	5	12
Drechslera	5	11
Phoma	4	14
Scopulariopsis	4	8
Rhizopus stolonifer	4	5
Paecilomyces	3	12
Neurospora	3	6
Stemphylium	3	5
Ascomycetes	3	4
Aureobasidium	3	4
Sporothrix	3	4
Pyricularia	3	3
Phomopsis	2	10
Chrysosporium	2	5
Phyllosticta	2	4
Rhinocladiella	2	3
Syncephalastrum racemosum	2	3
Tritirachium	2	3
Verticillium	2	3
Chalaropsis	2	2
Periconia	2	2
Schizophyllium commune	1	4
Choanephora	1	2
Gonatobotrys	1	2
Ulocladium	1	2
Apicarpella	1	1
Endophragmia	1	1
Spegazzinia	1	1
Zygosporium	1	1

ANOVA also showed that the number of colonies formed on the agar plates at 8:00 hr, 12:00 hr and 17:00 hr was significantly different ($P<0.001$). Meanwhile, Scheffe's test showed that the number of colonies formed on the agar plates at 8:00 hr was significantly different from that at 12:00 hr ($P<0.001$) and 17:00 hr ($P<0.001$). However, there is no significant difference between noon and afternoon exposure ($P>0.01$).

The number of colonies formed on MEA and SA media each month throughout the sampling period is shown in Fig. 2. It shows that the relative monthly colony numbers forming on the two kinds of media varied from time to time. Two-way ANOVA showed that the difference between the number of colonies collected by the two kinds of media is not

significant (P>0.01). Meanwhile, 2-way ANOVA also showed that the interaction between culture meida and collecting time was not statistically significant (P>0.01).

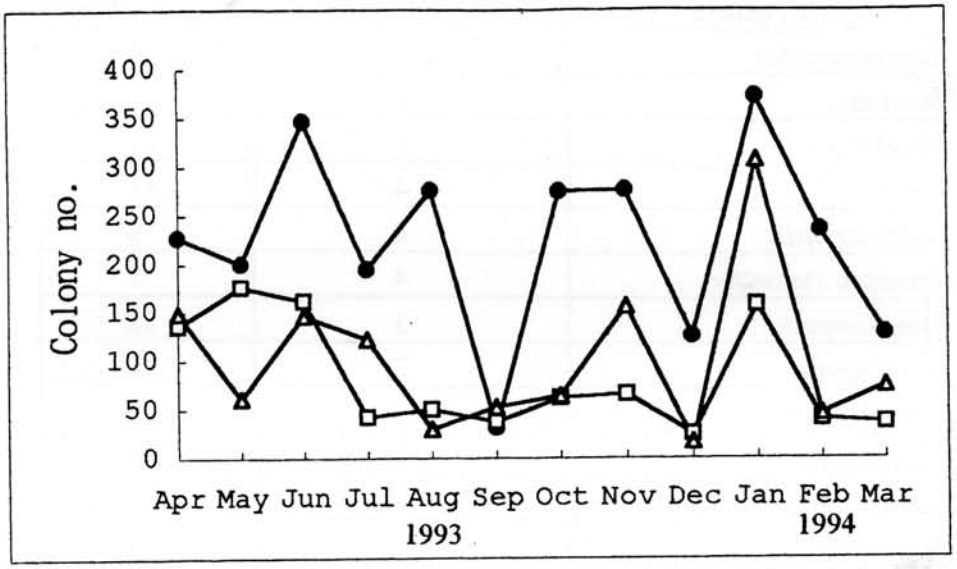

Fig. 1. Monthly total colony number on agar plates exposed at 8:00, 12:00 and 17:00 hr during the period April 1993 to March 1994. -●- 8:00 hr; -□- 12:00 hr; -△- 17:00 hr.

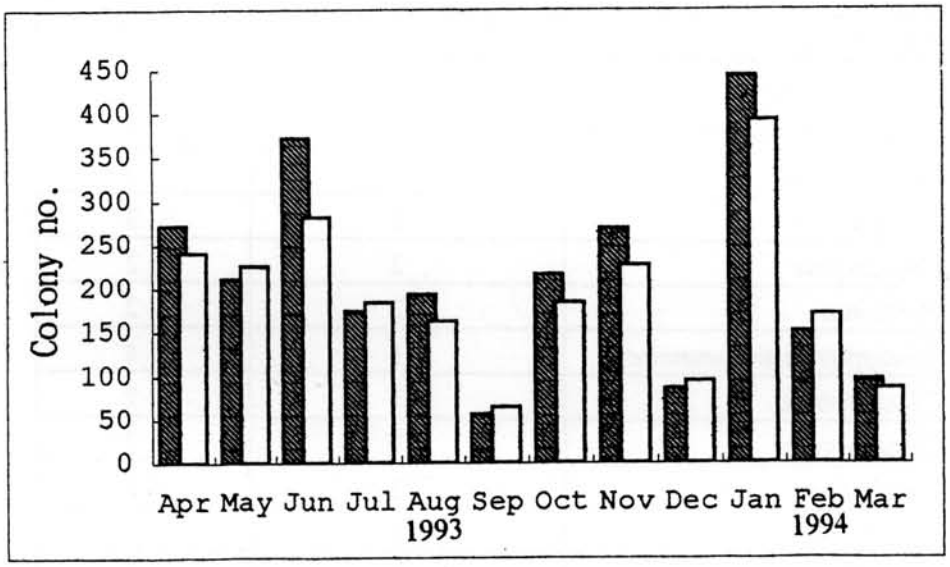

Fig. 2. Monthly total colony number on MEA and SA throughout the sampling period. ▩ MEA; □ SA.

The fluctuation of colony number collected at the three periods within a day was significantly correlated to the variation of diurnal relative humidity (P<0.001), but not correlated to the other climatic factors. Fig. 3 shows the fluctuation of mean diurnal relative humidity during the entire year.

III. Seasonal Variation of Total Colony Number

Hualien city is at the eastern side of this island, the temperature and relative humidity are high through the year. The climate can be divided into four seasons which are cool spring, hot summer, warm autumn and cold winter. Fig. 4 shows the climatic data between April 1993 and March 1994. From May to September 1993, the mean monthly temperature exceeded 25°C, after which there was a steady drop to approximately 19°C in January 1994

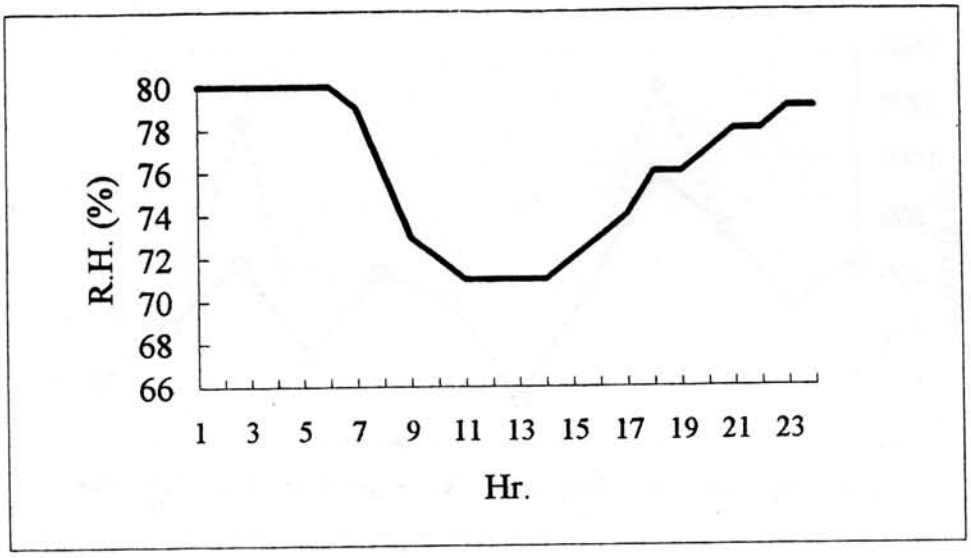

Fig. 3. Mean diurnal fluctuation of relative humidity (R. H.) during the year.

and then rose again. Relative humidity remained at 75-80 % during entire experimental period, except drops occurred in October (69%) and December 1993 (71%). Most rain fell from April to June, Septermber to November 1993 and February 1994. Wind speed remained fairly constant between 2.6-3.0 m/s except there were two peaks occurred in October (3.3m/s) and December (3.9 m/s) 1993.

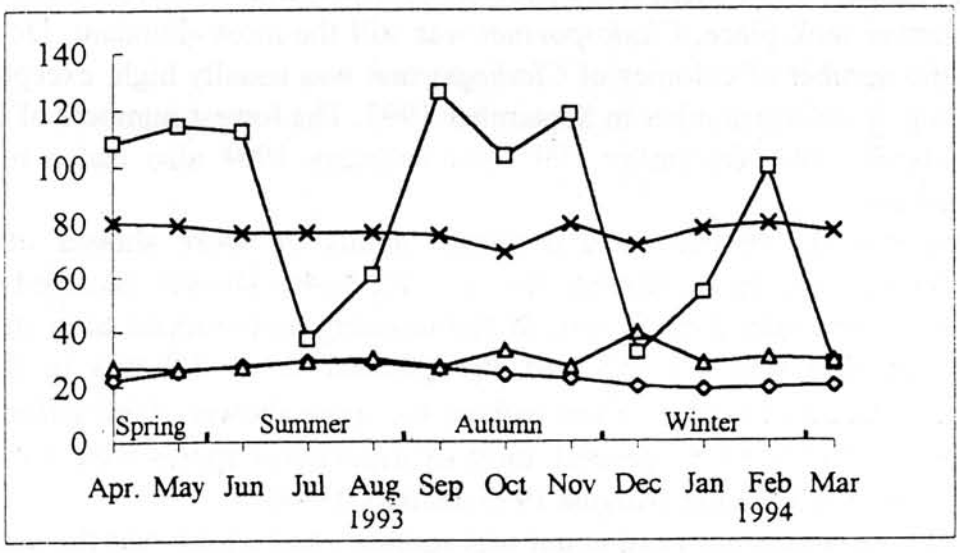

Fig. 4. Climatic diagram of monthly total of precipitation, monthly average temperature, wind speed and relative humidity during April 1993 through March 1994. -◇- Temperature (℃); -□- Precipitation (㎜); -△- Wind speed (0.1m/s); -×- R. H. (%).

Fig. 5 shows the monthly fluctuation of total colony number during the experimental period. The variations between different seasons were not large, except the summer months (June-August) had the largest number of colonies among the seasons. The largest monthly total colony number occurred in July 1993. This is the month with the highest average monthly temperature and lowest total precipitation during the year. However, correlation between monthly total colony number and climatic factors cannot be found.

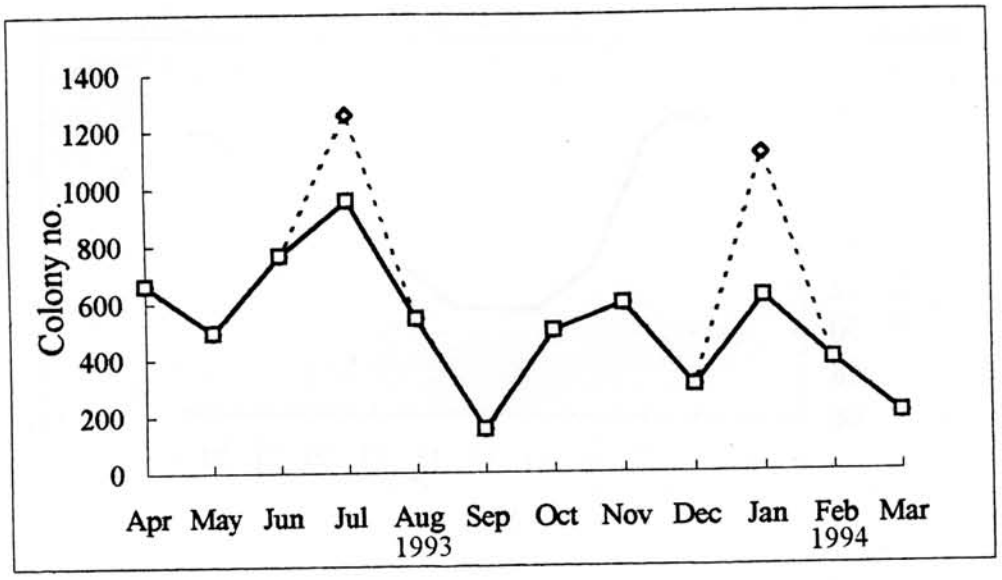

Fig. 5. Monthly fluctuation of total colony number during the experimental period. --◇-- with spore shower; –□– without spore shower.

IV. Seasonal Variation of Predominant Groups of Fungi

The Bulk portion (59.84%) of the total number of isolates was made up by yeasts and 6 genera (Group I) which occurred during all 12 months. Fig. 6 shows the seasonal fluctuation of these fungi. *Cladosporium* was the most predominant component during nearly entire period, except January 1994 when spore showers of *Aspergillus* occurred. Even in July 1993, when yeast shower took place, *Cladosporium* was still the most abundant. During summer and autumn, the number of colonies of *Cladosporium* was usually high, exception was that there was a drop of colony number in September 1993. The lowest numbers of colonies was recorded in March 1994. December 1993 and February 1994 also had a relatively low number of colonies.

Aspergillus was the second most dominant genus. A spore shower of *Aspergillus* occurred in January 13, 1994. During this day, the spore shower occurred at the three sampling times. There was a small rain in the morning and stopped after midday. Wind speed in the morning was 1.1 m/s and strengthened to as 8.8 m/s in the afternoon. Temperature was around 18-19°C. Even without the spore shower, *Aspergillus* still showed a peak in this month (Fig. 6). In general, most of *Aspergillus* spores were collected during late summer, autumn and winter (August 1993-January 1994).

The season with maximum yeast count was summer, and winter was the second. A peak occurred in July 1993. It was resulted mostly from a spore shower which took place during this month. This spore shower took place at morning collection on a hot (32°C), clear day with wind speed 7.5m/s. The lowest number of colony formed was recorded in September 1993.

More colonies of *Penicillium* were collected during the winter months (December 1993-February 1994) than during the other month and the maximum count occurred in January 1994. Seasonal periodicity of *Fusarium* was not clear. Number of colony formed remained stable, except a peak occurred in October 1993 and a drop occurred in April 1993. Most *Curvularia* colonies were collected from early summer to mid autumn (June 1993-October

1993). There was also a local peak in June 1993. The occurrence of *Alternaria* was sporadic with two peaks in mid summer (July 1993) and mid winter (December 1993).

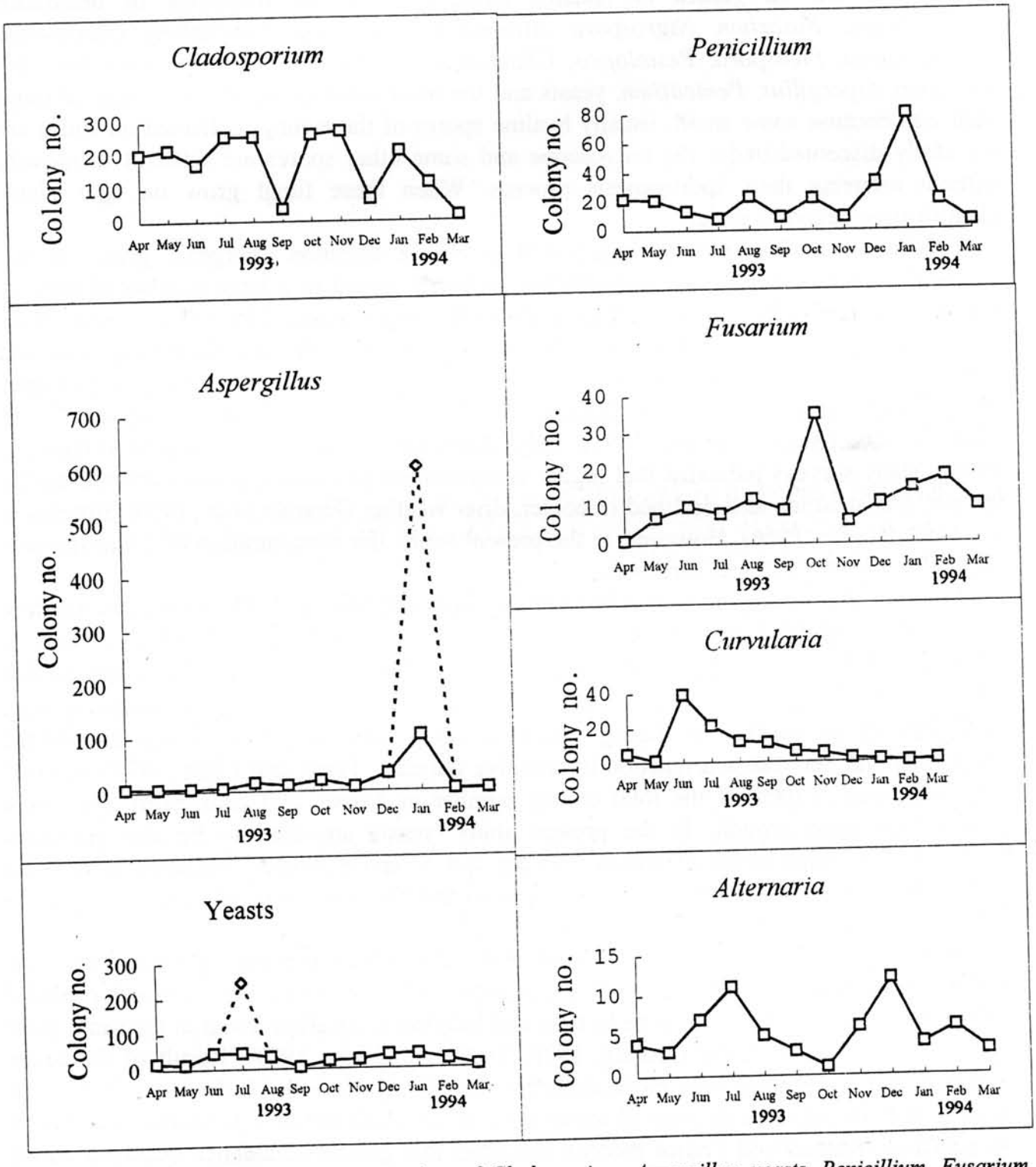

Fig. 6. Monthly fluctuation of colony number of *Cladosporium*, *Aspergillus*, *yeasts*, *Penicillium*, *Fusarium*, *Curvularia* and *Alternaria* isolated throughout the year. --◇-- with spore shower; –□– without spore shower.

DISCUSSION

The results of this study reveraled that the bulk portion of the Hualien airspora was made up by yeasts and 6 genera (Group I). These were considered to be the most stable component

of the airborne fungal flora in Hualien. Tseng and Chen (1979) also reported these 7 fungi as the most predominant isolates in Taipei. Using the gravity slide method, Han and Chuang (1981), reported 12 genera in Hualien listed in order of frequency of occurance: *Cladosporium, Fusarium, Nigrospora, Alternaria, Curvularia, Drechslera, Ganoderma Leptosphaeria, Pleospora, Pestalopsis, Chaetomium and Ulocladium.* However, they did not report *Aspergillus, Penicillium,* yeasts and the most other Group II and Group III fungi. That was because some small, usually hyaline spores of these fungi collected on slides are not easily discerned under the microscope and some other spores are difficult to identify without referring their sporogenesis process. When these fungi grow on agar plates, identification becomes easier.

Cladosporium is a phytopathogen and is also a common allergenic genus. It has consistently been reported as the dorminant air-borne mould in a large number of surveys, not only from cities in Taiwan such as Hualien (Han and Chuang, 1981); Taipei (Han et al., 1981; Hsiung, 1976 ; Tseng and Chen, 1979); Tainan (Lee, 1995) and Kaohsiung (Han and Chuang, 1981) but also from various portions of the world as well: Hong Kong (Turner, 1966); Japan (Asada, 1963); New Zealand (Di Menna, 1955); England (Pawsey and Heath, 1964); France (Simeray *et al*,, 1993); Italy (Marchisio *et al.*, 1992); Nigeria (Ogunlana, 1975). Many surveys indicated that higher concentration of *Cladosporium* occurred during the hot, wet summer, and declined in cooler, drier weather (Kramer *et al.* 1959; Simeray *et al.*, 1993; Turner, 1966). However, in the present study, the concentration of *Cladosporium* showed no clearly seasonal variation.

Most aerial fungal spore researchers ignore yeasts (Di Menna, 1955). However, Harsh & Allen (1945) reported that 4% of allergic patients in San Diego reacted to extract of "Torula" and 6% to an extract of "Yeasts". Pawsey and Heath (1964) also demonstrated that whilst the proportion of air-borne yeasts to moulds is usually low, there are occasions, such as in still, snowy weather, or during "spore showers", when they form a large part of the spore load and may cause a reaction in sensitive patients. Tseng and Chen (1979) reported that yeast was 27.08% of the total colony number in Taipei, and cool, rainy days were suitable for yeast growth. In the present study, yeasts appeared to be also prevalent. However, maximum count of colony number and a "spore shower" occurred in summer (July 1993). On the contrast, Lee (1995) reported that the occurrence of yeasts was only 0-0.5% of the total colony number in Tainan.

Aspergillus and *Penicillium* have both been recorded as prevalent air fungi in many surveys throughout the world and both are common allergens. The relative amount recorded of these two fungi varies from time to time and location to location. Even in the same place, the results may be different (Hsiung, 1976; Tseng and Chen, 1979). Result of this study revealed that *Aspergillus* was more abundant than *Penicillium* in Hualien air. In Sweden, Ripe (1962) recorded an absence of seasonal variation of air borne *Aspergillus,* whereas, in Hong-Kong, Kansas and France records indicated that greater abundance occurred during cooler periods (Kramer *et al.* 1959; Kramer *et al.*, 1960; Simeray, 1993; Turner, 1966). In the present study, more *Aspergillus* colonies also were recorded during cooler months especially in January 1994, when there was a "spore shower". Di Menna (1955) demonstrated that the sudden fluctuations in spore load, particularly during the winter months when the level of aerial antigens is usually low, are of considerable importance to the allergic subject .

Seasonal fluctuation of *Penicillium* varies in different locations. In Kansas, higher incidence was during warmer months (Kramer *et al.*, 1959; Kramer *et al.*, 1960). In France, this fungus appeared sporadically (Simeray *et al.*, 1993). The result of the present study indicated that the spore concentration of *Penicillium* was more abundant in the cooler winter (December-February) than in the other seasons in Hualien. This result is similar to those studies of Hong Kong (Turner, 1966) and Taipei (Tseng & Chen, 1979).

Fusarium is a phytopathogen and also a human allergen. In northern Nigeria, this fungus occurred at a fairly even level throughout the year, only showing a small peak at the start of the rainy season when rainfall was comparatively light (Dransfield, 1966). In Australia, however, *Fusarium* occurred irregularly throughout the year (Upsher and Griffith, 1973). In Hualien, *Fusarium* occurred irregularly through the year with lowest record of colony number in April 1993 and the maximum record in October 1993.

Curvularia mostly occurrs as a facultative or secondary parasite on monocotyledons such as grasses, sorghum, maize, millet and sugar cane and is also a human allergen. It is prevalent throughout this island (Han and Chuang, 1981; Lee, 1995; Tseng and Chen 1979). Also this fungus has been reported in Hong Kong (Turner, 1966), Singapore (Tan *et al.*, 1992) and Nigeria (Ogunlana, 1975). In Nigeria, *Curvularia* was found to be the second most frequent genus only after *Cladosporium* (Dransfield, 1966; Ogunlana, 1975). However, it's not prevalent in cooler places like England (Pawsey and Heath, 1964) and France (Simeray *et al.*, 1993). Dransfield (1966) and Upsher and Griffith (1973) mentioned that this fungus favours warmer conditions and cannot grow well during periods of low minimum temperature. In Hualien, *Curvularia* showed the maximum count in summer (June -August). Lü *et al.* (1969) reported the same result in Taipei as well.

Many species of *Alternaria* are phytopathogenic and nearly all allergenic. This fungus was not only recorded as abundant in Hualien, but also as abundant in other areas throughout Taiwan (Han and Chuang, 1981; Lee, 1995; Tseng and Chen, 1979) and around the world (Asada, 1963; Di Menna, 1955; Marchisio *et al.*, 1992; Ogunlana, 1975; Pawsey and Heath, 1964 ; Simeray *et al.*, 1993; Tan *et al.*, 1992; Turner, 1966). According to Dransfield (1966), this genus is abundant in temperate countries. However, in tropics Tan *et al.* (1992) reported that *Alternaria* was the second most frequent species trapped in Singapore only after *Nigrospora*. In the present study, *Alternaria* had high spore concentration in air both in summer and winter.

The criterion of a "spore shower" is the presence of over fifty colonies of a given mould per 100 mm plate (Di Menna, 1955). In this study, spore showers were recorded for yeasts on a hot, dry day in July 1993 and for *Aspergillus* sp. in a cold, lightly rainy day in January 1994. No correlation could be found between these showers and change of relative humidity, temperature or wind direction and velocity. Similar spore showers have been reported from around the world (Di Menna, 1955; Lee, 1995; Pawsey and Heath, 1964; Turner, 1966). However, the reason for the occurrence of spore showers for individual genera still has not been defined. In the absence of associated macroclimatic changes it must be assumed that factors of microclimate and substrate become operative. Di Menna (1955) reported that the spore shower of *Cladosporium herbarum* was caused by mowing of grass in the nearby university lawn. The reason of spore shower may be generic specific and related to the the environmental change.

In the present study, the number of colonies recorded during morning exposure was significantly different and higher than during midday and afternoon exposures. The variation of the number of colonies is significantly correlated with diurnal relative humidity. Chang *et al.* (1983) also reported the same diurnal periodicity in Taipei. They pointed out that climatic conditions in the morning may be better for fungal spore in the air to be trapped than at noon and in the afternoon. The most spores were produced during the high relative humidity night and released in the morning when the humidity began to change and air turbulance was present. As the temperature increased toward midday, air currents carried spores upward and the spores became more difficult to catch. This situation continued until sunset, when the tempeature went down, thus making the colony number during afternoon and midday exposures less than during morning exposure. It indicated that diurnal spore fluctuation was affected not only by relative humidity but also by temerature. Thus, for further understanding of the correlation between diurnal spore fluctuation and meterological factors, more studies is still needed.

Results of this study indicated that the maximum spore load in Hualien occurred during summer. The most stable components of Hualien air spora were *Cladosporium*, *Aspergillus*, yeasts, *Penicilium*, *Fusarium*, *Curvularia* and *Alternaria*. All of these fungi were reported as allergens (Hsiung, 1976). They are all prevalent during the whole year in Hualien. Among these, *Cladosporium*, yeasts, *Fusarium*, *Alternaria* show no clear seasonal change. Yet, some fungi such as *Curvularia* had higher spore concentration in the air in the hot season. Other fungi such as *Penicillium* and *Asergillus* had higher spore concentration in the air during cooler season.

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花蓮市空中真菌孢子相 (I) — 平板培養基法

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摘　　要

自82年4月至83年3月間，以平板培養基收集空中真菌孢子，形成菌落數最多，且每個月均出現的真菌為：枝孢黴屬(*Cladosporium*) (33.18%), 麴黴屬(*Aspergillus*) (11.06%), 酵母菌(yeasts) (7.41%), 青黴屬(*Penicillium*) (3.94%), 鐮刀黴屬(*Fusarium*) (1.73%)，彎孢黴屬(*Curvularia*) (1.50%) 及鏈格孢黴屬(*Alternaria*) (1.02%)。這些主要種類共佔總菌落數的 59.84%。於82年7月及83年1月分別有酵母菌及麴菌屬的孢子兩出現。以麥芽抽出物培養基(MEA)及沙氏培養基(SA)收集空中真菌孢子，分早、午、晚三個不同時段收集。得到之菌落數，以清晨八時為最多，中午及傍晚則無顯著差異。此現象與相對溼度有顯著相關，而與其他氣象因子無關。一年中以夏季菌落數最多，每月菌落數則以1993年7月為最多。

關鍵詞：空中真菌孢子相、花蓮市，臺灣。

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