Boletín Micológico Vol. I 187 – 199 1983

AIRBORNE FUNGUS AT PAVIA (ITALY)

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SUMMARY

From March 1st, 1979 through February 28th, 1980 three plates of 16 cm Ø containing PDA were exposed three times a week in Pavia. A total of 12,734 isolates (belonging to 46 genera and 88 species) were recorded.

Most of isolates (54,6 o/o) were species of the genera **Cladosporium** *(13,4 o/o),* **Epicoccum** *(11,7 o/o),* **Aureobasidium** *(9,3o/o),* **Alternaria** *(7,9 o/o),* **Penicillium** *(6,4 o/o) and* **Botrytis** *(5,9o/o)* **Alternaria, Cladosporium** *and* **Epicoccum** *increased in late Summer and at the beginning of Autumm.* **Aureobasidium, Aspergillus** *and* **Penicillium** *were frequent in Winter;* **Botrytis** *occurred abundantly in Spring. The dominant species isolated were:* **A. alternata** *and* **A. longipes, Aspergillus fumigatus, A. niger** *and* **A. flavus, Aureobasidium pullulans** *var.* **pullulans, B. cinerea, C. cladosporioides, E. purpurascens, P. janthienellum.** *Also a numerous species were* **Fusarium roseum** *var.* **gibbosum (= F. equiseti), Phoma destructiva, Rhodotorula glutinis** *and* **Sporobolomyces roseus.**

The results show a similarity with other research; the frequency of some species has been discussed.

RESUMEN

Entre el 1º de Febrero de 1979 al 28 de Febrero de 1980, fueron expuestas en Pavia, 3 veces por semana, tres placas de petri de 16 cm Ø conteniendo PDA. Se aislaron un total de 12.734 colonias (pertenecientes a 46 géneros y 88 especies).

Muchos de los aislamientos (54,6 o/o), fueron especies de los géneros **Cladosporium** *(13,4 o/o),* **Epicoccum** *(11,7 o/o),* **Aureobasidium** *(9,3 o/o),* **Alternaria** *(7,9 o/o),* **Penicillium** *(6,4 o/o) y* **Botrytis** *(5,9 o/o).*

Alternaria, Cladosporium *y* **Epicoccum,** *aumentan en el Verano avanzado y en los inicios de Otoño.* **Aureobasidium, Aspergillus** *y* **Penicillium** *son frecuentes en Invierno;* **Botrytis,** *es abundante en Primavera. Las especies dominantes aisladas fueron:* **Alternaria alternata, A. longipes, Aspergillus fumigatus, A.niger** *y* **A. flavus, Aureobasidium pullulans** *var.* **pullulans, Botrytis cinerea, Cladosporium cladosporioides, Epicoccum purpurascens, Penicillium janthinellum.** *Las especies de* **Fusarium roseum** *var.* **gibbosum (= F. equiseti), Phoma destructiva, Rhodotorula glutinis** *y* **Sporobolomyces roseus** *fueron también numerosas.*

The atmosphere itself does not constitute a biotype but a medium of dissemination of a mycota fully ubiquitarian. Qualitative and quantitatively variable in function of numerous atmospheric and environmental factors, of which the most important are the wind, temperature, humidity and type of local vegetation. The airborne fungal spores, as Gregory defined them in 1952, are found in all types of areas in the world, from the Arctic (Pady & Kapica, 1953) to temperate, tropical and desert areas as well (Davies 1969). Knowledge of the fungus load in the air and of its local variability, both daily and seasonal, provides certain useful information for the interpretation of several problems of vegetal, medical and veterinary pathology, and in the field of food and preserve industries as well. Along with the fungus spores of phytopathogenic species, we find species responsible for respiratory allergies in man, superficial or deep mycosis or contamination of stored food. Studies of an anemophila mycota can be undertaken with quantitative value using Hirst's automatic volumetric spore traps or qualitatively by freely exposing dishes containing a medium of culture. Both methods do not always offer a real picture of the biotic potential present in the sampled air, Therefore the methodology must be correlated with objectives of the research.

The air spores concentration is very variable, rarely it exceed 10^6 spores/m^3 in the rural area. The average concentration is 10^4 spores/m^3 (Gregory 1961). In the air of a closed place we registered a concentration of over 10^6 spores/m^3 up to 10^9 spores/m^3 specially in environments where leaves and moldy hay is moved, or in food industries (Barkai-Golan, 1961; Stallybrass, 1961; Gregory, 1963; Kotimaa, 1977; Lacey, 1962, 1971, 1973; Sreeramulu, 1958; Darke et al., 1976, Gregory et al., 1963).

Ubiquity is not yet a general rule for all fungi. Spores of some phytopathogenic groups as **Uredinales** and **Ustilaginales** with manifestations of immediate parasitarian attacks, can be airborne at considerable distances from its site of origin by ascending air currents. Besides, as specialized parasites they can be limited in their dispersion by lack of receptive plants. Up to aproximately 1.600 m., above ground level, atmosphere can contain a discreet number of fungal spores. At 45 m. above ground level, these are continuosly present in the air with peaks of maximum concentration in the Summer months of July and

August.

Aeromycology has been surveyed in several localities all over the world. Of these studies, most of them have been performed in Europe, North America and South East Asia, producing a model of fluctuations of the fungal constituents of the air and annual or seasonal variations of genera with phytopathological interest.

In this survey a report is given on the results of a year of study on air-borne fungus spores in Pavia, obtained by the agar plate method of exposing Petri dishes containing a culture media.

Materials and methodology.

Three Petri sterile dishes of 16 cm of diameter containing potato-dextrose-agar (PDA) were exposed three days a week at 12 A.M., during 10 minutes, from March 1st. 1979 through Frebruary 28, 1980.

The survey was made from the balcony of a house in downtown Pavia, 15 meters above ground level. The area is surrounded by houses and streets without high trees and 300 meters away from the green areas.

After the exposure, the plates were incubated at 25° C for four days. After counting the colonies, they were maintained for 15 days at room temperature. Most of the colonies were resown in optimal cultures and identified at species level. The weather conditions consider the average decades of temperature, relative humidity and rainfall. On rainy days the samples were taken under a roof 2 meters away from the plates. Presence of bacterias and actinomycetes, were not considered. The unidentified strains due to abscence of fructitication were clustered under the name "Micelia withauth fructification".

Results.

A total of 12,734 colonies were isolated during a year of sampling of the air of Pavia, and identified in 46 genus and 99 species. 156 samples were made by exposure of 468 plates with an average isolation of 27 colonies per plate.

The monthly results and the total of the genus registered ar summarized in Table I. More than half of the colonies isolated belong to the genus **Alternaria**, **Aspergillus**, **Aureobasidium**, **Botrytis**, **Cladosporium**, **Epicoccum** and **Penicillium**. Of these the dominant genus was **Cladosporium** (13,4o/o); **Epicoccum** present rather a high frequency (11,7o/o), **Aureobasidium** (9,3o/o) and **Alternaria** (7,9o/o). **Penicillium** and **Botrytis** has almost the same frequency 6,4o/o and 5,9o/o respectively. It follows with a lower value **Aspergillus** with an incidente of 5,1o/o. It seems that the group of yeast-like colonies is also present with a high incidence, specially **Basidiomycetes** (11,8o/o) and the genus **Sporobolomyces** (5o/o) and **Rhodotorula** (2,4o/o).

The mentioned genus were more or less isolated during a whole year of sampling. Its seasonal incidence is distributed in the following way: **Alternaria**, **Cladosporium** and **Epicoccum** were more frequent at the end of Summer and the beginning of Autumn with a peak of maximum isolation in October for **Alternaria** and September for **Cladosporium** and **Epicoccum**. **Aureobasidium** is frequent in Winter and the beginning of Spring with a high incidence in January and April. **Aspergillus** and **Penicillium** were frequent also in Winter and the beginning of Spring with a high incidence in December - March and Frebruary - April. **Botrytis** is more frequent in Summer with a maximum incidence in April. In the group of yeasts a high incidence in the genus **Sporobolomyces** and **Rhodotorula** was observed in Winter, with a peak of maximum isolation in February: the yeast-like Basidiomycetics (**Teliomycetes**) has a high incidence in Winter, that is December, January and March. The 50o/o left is represented by 37 genera some of which are frequent in different months of the year, others intermittently. We can include in the first group: the genus **Phoma** isolated during 8 months with a high incidence in May and November; **Fusarium** absent in February. but present in the rest of the year with the highest incidence in October, November and December; **Chaetomium** present specially in January, March and December; **Trichoderma**, **Trichothecium**, **Sclerotium**, **Phialophora** and **Oidiodendron** must be included also in this group in spite of the fact that their incidence is variable but significant in certain months by its high incidence of isolation. The fungal genera which can be described as rare due to its irregular presence and limited number of their isolated colonies, represent the majority of the genera. Among these, some deserve being mentioned as they belong to a very few isolated species wich are rare such as the genera **Coremiella** and **Mycotypha**.

Considerations of the main isolated species.

The identification of the isolated fungal strains at species level has allowed us to consider the dominance, frequency and variability of numerous species within the genus scope in a period of 12 months. (Table 2).

The genus **Alternaria** includes five species: **Alternaria alternata** dominant, and **A. longipes** which is very frequent and has been isolated every month around the year; **A. alternata** with a high frequency in August (119 colonies) and September (114 colonies); **A. longipes** is also frequent in August and October. Both species present a high incidence of isolation in Summer and Autumn seasons, while they are ocassional or scarce in Winter and Spring.

The genus **Aspergillus** is represented by 13 species, ocassionals some of them (**A. ornatus**, **A. wentii**, **A. terreus**, **A. sydowi**, **A. amstelodami**, **A. clavatus**) others with a sporadic frequency (**A. nidulans**, **A. candidus**, **A. versicolor**, **A. glaucus**) and other dominants in number, in spite of theyare not present during the whole year (**A. fumigatus** 384 colonies, **A. Niger** 76, and **A. flavus** 62). **Aspergillus fumigatus** presents a high incidence in Autumn and Winter with peaks in December and March, while it decreases in Spring-Summer. By the contrary, **Aspergillus niger** and **A. flavus** are rare in Winter and are

TABLE 1 MONTHLY INCIDENCE OF ISOLATED GENERA FROM AIR

	3	4	5	6	7	8	9	10	11	12	1	2	TOT	o/o
Acremonium		2									3		5	
Alternaria	28	21	21	68	149	188	208	234	45	25	7	5	999	7,9
Aspergillus	141	13	30	13	19	63	15	28	88	132	88	24	654	5,1
Aureobasidium	151	328	136	9	15	58	10	8	7	5	349	110	1186	9,3
Beauveria	1					1							2	
Botrytis	94	371	107	6		3		1	2	56	43	67	750	5,9
Chaetomium	50		1	5		1		1	4	50	50		162	1,3
Cladosporium	176	56	69	274	220	271	381	72	44	24	35	87	1709	13,4
Coremiella	1									1			2	
Curvularia						1							1	
Diheterospora				2									2	
Drechslera	6			3	2	1	2	1	2				17	0,1
Epicoccum	78	12	21	142	185	245	403	218	95	27	7	57	1490	11,7
Fusarium	6	7	14	9	11	22	36	66	68	52	3		294	2,3
Geotrichum				1			1				1		3	
Gilmaniella									50				50	0,4
Gliocladium				1		2	3	4	4	2			16	0,1
Gliomastix												1	1	
Graphium											1		1	
Humicola						1			4				5	
Monascus											1		1	
Mucor			1			1	20	6	3	2	2	1	36	0,3
Mycotypha							5						5	
Nigrospora			2			7		15	3		1		28	0,2
Oidiodendron	50	153				1			1			1	206	1,6
Paecilomyces		1	1					3	1	1			7	
Penicillium	108	164	98	7	39	26	57	56	60	34	35	134	818	6,4
Periconia							1	1					2	
Pestalotia				1	1								2	
Phialophora	2	1									3	1	7	
Phoma	6	4	99		3			2	209	1	4		328	2,6
Ramichloridium				1									1	
Ramularia									1				1	
Rhizopus		1				2	23	5	1	1	2		35	0,3
Rhodotorula	23	15	11	17	1	3	28	3	2	21	38	138	300	2,4
Scopulariopsis			2										2	
Sporobolomyces	31	31	22	32	1	8	75	6	5	40	95	286	632	5,0
Stemphylium	1		2	12	7	7							29	0,2
Stilbum	50	1	3						1				55	0,4
Syncephalastrum					3	1							4	
Torula			2			1			1	15	1		20	0,2
Trichoderma	1		2		9	1	1	3	2	2	4		25	0,2
Trichothecium		1				2	101	5	2		1	1	113	0,9
Tritirachium			48										48	0,4
Ulocladium						1					2		3	
Verticillium			1							1		1	3	
Micelia without fructification	133	69	10	58	52	37	90	136	251	187	76	73	1172	9,2
Basidiomycetes (yeast form)	309	54	60	58	53	52	62	40	83	279	161	291	1502	11,8
TOTAL	**1446**	**1305**	**763**	**719**	**770**	**1007**	**1522**	**914**	**1039**	**958**	**1013**	**1278**	**12734**	
Percentage	11,4	10,2	6,0	5,6	6,0	7,9	12,0	7,2	8,2	7,5	8,0	10,0		

TABLE 2 MONTHLY INCIDENCE OF ISOLATED SPECIES FROM AIR

	3	4	5	6	7	8	9	10	11	12	1	2	TOT
Acremonium kiliense Grütz		2									3		5
Alternaria alternata (Fn) Keissler		3	11	29	51	119	114	71	14	4	5		421
A. citri Ellis & Pierce							10		1				11
A. longipes (Ellis & Everch.) Mason	5	17	7	28	35	51	14	57	18	14	1	1	248
A. radicina Meier, Drechsler & Eddy								40					40
A. tenuissima (Kunze ex Pers.)Wiltshire									2				2
Alternaria sp.	23	1	3	11	63	18	70	66	10	7	1	4	277
Aspergillus amstelodami (Mangin) Thom & Church						1							1
A. candidus Link	3			3		1			2		1	2	12
A. clavatus group						1	2						3
A. flavus Link	3	6	23	2	7	3	2	7	9				62
A. fumigatus Fresenius	106	5		4	5	2		18	59	119	56	10	384
A. glaucus group	3				3		4	3	3	4	4	5	29
A. nidulans (Eidam) Wint.	6			1			1				6		14
A. niger Van Tieghem	12		1	1	1	54	1		5		1		76
A. ornatus Raper, Fennel & Tresner					1	1						3	5
A. sydowi (Bain & Sart.) Thom & Church				2			2						4
A. terreus Thom	3								1				4
A. versicolor (Vuill.) Tiraboschi	2	1	1						1	1	8		14
A. wentii Wehmer												2	2
Aspergillus sp	3	1	5		2		3		8	8	12	2	44
Aureobasidium pullulans (De Bary) Arn. var. **melanigenum** Herman.-Nijhof		5	58	4	4	13	5		5	1	102	6	203
Aureobasidium pullulans (De Bary) Arn. var. **pullulans**	151	323	78	5	11	45	5	8	2	4	247	104	983
Beauveria bassiana (Bals.) Vuill.	1					1							2
Botrytis cinerea Pers. ex Nocca e Balb.	94	371	107	6		3		1	2	56	43	67	750
Chaetomium elatum Kunze ex Fr.	50		1						4				55
C. globosum Kunze ex Fr.				1		1		1		50	50		103
Chaetomium sp. Kunze ex Fr.				4									4
Cladosporium cladosporioides (Fresen.) de Vries	154	16	34	55	139	211	120	21	8		18	25	801
C. herbarum (Pers.) Link ex Gray	1	1	8				50				4	14	78
C. resinae (Lindau) de Vries *			11	44			50		4			9	118
Cladosporium sp.	21	39	16	175	81	60	161	51	32	24	13	39	712
Coremiella cubispora (Berk & Curt) Ellis	1									1			2
Curvularia lunata (Wakker) Boed.						1							1

* (= **Hormoconis resinae**)

Pestalotia pezizoides de Not.				1	1								2
Phialophora hofmannii (Beyma) Schol-Schwartz	2	1									3	1	7
Phoma destructiva Plowr.									208				208
Ph. exigua Desm.		4	1										5
Ph. fimeti Brun.									1				1
Ph. glomerata (Corda) Wollenw. & Hochapf.	1												1
Ph. herbarum Westend.	1				2					1	4		8
Ph. medicaginis Malbr. & Roum var. **pinodella** (Jones) Boer., Dor. & Leff.			98										98
Ph. pomorum Thüm.	4				1			2					17
Ramichloridium subulatum de Hoog				1									1
Ramularia beticola Fautr. & Lamb.									1				1
Rhizopus nigricans Ehrenb.		1				2	23	5	1	1	2		35
Rhodotorula glutinis (Fres.) Harrison	10	5	6	7		1	15	1		10	14	101	170
Rh. rubra (Demnie) Lodder	13	10	5	10	1	2	13	2	2	11	24	37	130
Scopulariopsis brevicaulis (Sacc.) Bain.			2										2
Sporobolomyces roseus Kluyver & Niel	31	31	22	32	1	8	50	6	4	40	95	266	586
Sporobolomyces sp.							25		1			20	46
Stemphylium sarciniforme (Cav.) Wiltsh.	1		2	7	5	4							19
Stemphylium state of **Pleospora herbarum** (Pers. ex. Fr.) Rabenh.				5	2	3							10
Stilbum sp.	50	1	3						1				55
Syncephalastrum racemosum Cohn ex Schröter					3	1							4
Torula graminis Desm.			2			1					1		4
Torula sp.									1	15			16
Trichoderma viride Pers. ex Gray	1		2		9	1	1	3	2	2	4		25
Trichothecium roseum (Pers.) Link ex Gray		1				2	101	5	2		1	1	113
Tritirachium oryzae (Vincens) de Hoog			48										48
Ulocladium botrytis Preuss						1					2		3
Verticillium lateritium Berk			1							1		1	3
Micelia withauth fructification	133	69	10	58	52	37	90	136	251	187	76	73	1172
Basidiomycetes (yeast form)	309	54	60	58	53	52	62	40	83	279	161	291	1502
TOTAL	**1446**	**1305**	**763**	**719**	**770**	**1007**	**1522**	**914**	**1039**	**958**	**1013**	**1278**	**12734**

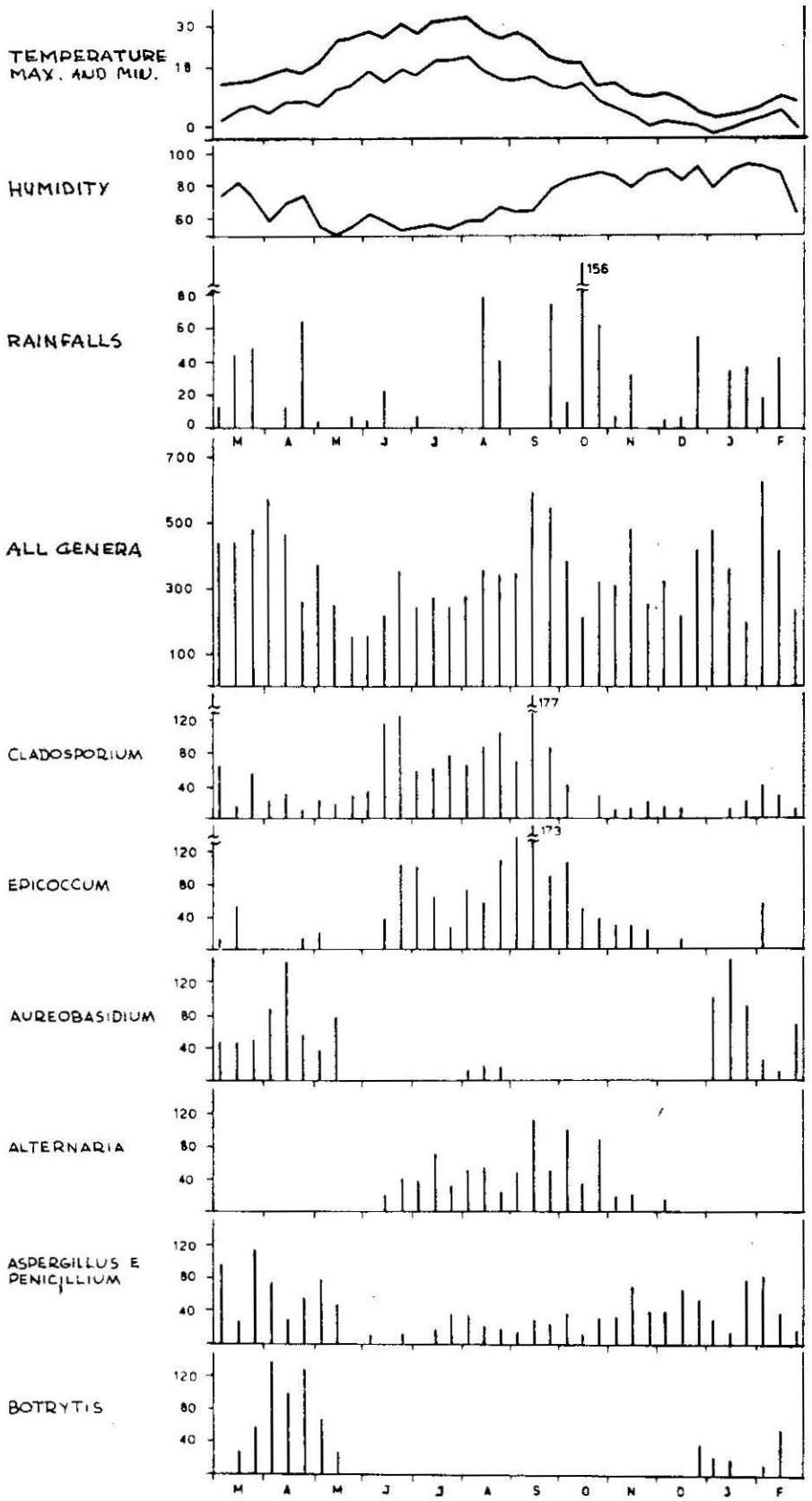

FIGURE 1. Weather data and incidence variations of the main isolated genera from Pavia atmosphere during a year.

found ocassionally in the other months with peaks of maximum frequency in August for **Aspergillus niger** and in May for **A. flavus.**

The genus **Aureobasidium** is present with the specie **A. pullulans** var. **melanigenum** and **A. pullulans** var. **pullulans.** The last is dominant in number with a high incidence in Winter and Spring, specially in January and April.

Botrytis is present only with the specie **B. cinerea,** specially dominant in Winter and Spring with a high incidence in April (371) and May (107).

Cladosporium is represented by the species **Cladosporium cladosporioides, C. herbarum** and **C. resinae (Hormoconis resinae).** The specie **C. cladosporioides,** dominant in number is specially frequent in Summer with a high incidence in August (211), ocassional or absent in Winter time.

In this research **Epicoccum** is the genus dominant in number and is present throughout the year along with the specie **E. purpurascens.** August. September and October are the months of high incidence of isolation during which colonies of this specie were isolated almost everyday.

Penicillium is the genus with the greatest number of not identified fungical strains (almost 50o/o) at species level. Of the six identified species, **P. janthinellum** is regularly present and dominant in number with a maximum incidence in March and April. **P. spinulosum** and **P. funiculosum** have the same frequency in April.

Rhodotorula glutinis, R. rubra and **Sporobolomyces roseus** are the species identified within the family **Sporobolomycetaceae.** The highest incidence for these species were found in Winter with a maximum isolation in February. This seasonal behaviour was also observed in the yeast-like state of **Phragmobasidiomycetes (Uredinales)** and **Ustilaginales).**

Among the other genera, **Fusarium** has in **F. roseum** var. **gibbosum** and in **F. moniliforme** the most frequently found species. **Phoma** was irregularly isolated with several species among which **P. destructive** has the highest incidence in November and **Ph. medicaginis** var. **pinodella** in May.

Seasonal Variations

Average for decades of temperature, relative humidity and rainfall registered in the course of one year in Pavia, are shown in Figure 1. Average of temperature range between the values of +1 to +18° C as maximum, and −4 to +7° C as minimum from January through April; from May, through September the temperature increase constantly with values ranging from +18 +32° C as maximum and +5 to +20° C as minimum! July has the higher maximum and minimum temperature values. Temperature tends to decrease in Autumn reaching the minimum values in January.

The daily values between maximum and minimum increases range from +4 to +10° C in Winter and from + 10 to + 13° C in Summer season. Relative humidity in the course of the year, ranges between a minimum value of 48,7o/o in May and a maximum of 91,4o/o in December. The year average was 71,5o/o. The maximum rainfalls was in October with 236,4 mm and August with 123,0 mm. The mimimum rainfalls occurs in July and May with 7,8 and 10,0 mm repectively. The annual average rainfall was 76,21 mm.

Padana plains and specially the air of Pavia is affected by fog during most of the year with maximum frequency in the months of December, January, February and March. During the research when the sampling was made the misty days, were not more than a dozen and were concentrated in November through February.

Correlation between relative humidity and number of colonies isolated in the course of the month is observed in Figure 1. Subdivision of the monthly isolation in three decades allows us a better valoration of the variability of the fungal airspores.

The highest peaks of the total colonies isolated are correlative to a high percentage of relative humidity in the air found from September through April. In Summer we find an inverse correlation with a minimum of isolation in June–July with low values of relative humidity. A similar behaviour is observed in the analysis of the temperatures: the highest number of colonies were isolated in the cold months, whereas the lowest number were isolated in the hot summer months. Very few correlations between the number of colonies isolated and rainfall were detected.

Discussion

The genus **Alternaria, Aspergillus, Aureobasidium, Botrytis, Cladosporium, Epicoccum** and **Penicillium** represent in this survey the dominant fungical component of the air of Pavia, being more than 50o/o of the total colonies isolated.

The most frequent genus is **Cladosporium** with an incidence of 13,4o/o. This data is considerably minor in relation to those found in other countries. **Cladosporium** has been described as a dominant genus in Japan (Hara & Durha, 1939), Australia (Frey & Durie, 1962), New Zealand (Di Menna, 1955; Dye & Vernon, 1952), in Israel (Barkai-Golan, 1961), in England (Ainsworth, 1952), in Hong-Kong (Turner, 1966), in Nottingham (Pawsey & Heath, 1964), in Gales (Hyde & Williams, 1949(, in Sweden (Nilsby, 1949), in Denmark (Samsøe–Jensen & Flensborg, 1950; Larsen, 1981), in Canada (Pady & Kapica, 1956), in Mexico (Blackaller, 1950), in Panama (Taylor & McFadden, 1962), in USA (Harsh & Allen, 1945; Vinje & Vinje, 1955), in Colombia (Grose et al., 1967), in Nigeria (Dransfield, 1966), in Spain (Calvo et al., 1980a). Still the frequency can be quite different with value variation such as 78,8o/o in Cambridge (Hudson, 1969) to 44,5o/o in Kansas (Kramer et al., 1960) to 68,9o/o in Copenhagen (Larsen, 1981), to 34,6o/o in Barcelona (Calvo et al., 1980a), to 72,6o/o in Nottingham (Pawsey & Heath, 1964) and 21,2o/o in Hong Kong (Turner, 1966). Spores are specially abundant when the weather is humid and peaks are detected in mid

Summer when temperature, humidity, and vegetation increase favourable conditions for the production and dispersion of conidia.

C. cladosporioides and **C. herbarum** both isolated by us, are the most common of this genus, being very frequent on vegetables and soil, as saprophites of philoplane or other vegetables in discomposure on the ground (Jensen, 1931; Park, 1956). The conidia on the air are specially abundant in June - July - September and October (Harbey, 1967). Both species are frequently found on cereals, mainly wheat (Flannigan, 1970; Hyde & Galleymore, 1951; Noble & Richardson, 1968), oats and soybeans (Hanlin, 1969). The frequency of these two species in Pavia, specially in August, most probably correlates with the high temperature and humidity detected during this month. Both represent the most important factors for the production of conidia of **Cladosporium**. During this month the agriculture of this area are principally rice and corn. Wheat has been harvested in July, all being graminaceas on which many species of **Cladosporium** can also develop as simple saprophites.

We have also isolated **Amorphotheca resinae (Hormoconis resinae)**, which is more important as petroleum fungus than as phytopatogen. It is a contaminant capable of developing on kerosene and creasote and it is responsible of gas filters obstruction of airplanes (Marsden, 1954; Hendey, 1964; Parbery, 1967; Parbery, 1969).

Aspergillus and **Penicillium** were found in Pavia with a frequency of 5,1o/o and 6,4o/o respectively. Among mould they are the most frequently mentioned by several authors in aeromycologics studies but with a wide incidence from country to country related to weather conditions. While **Aspergillus** is more frequent in warm humid regions, **Penicillium** predominates in temperate areas. This last one represents 16,3o/o of all the colonies isolated in Barcelona, while **Aspergillus** does not represent more than 2,8o/o (Calvo et al., 1980b). Both genera do not present a clear seasonal periodicity to evaluate, no matter in temperated weather **Penicillium** shows the highest frequency in Winter and Spring (Di Menna, 1955; Pawsey & Heath, 1964). Both genera reach the highest concentrations in the air of the open country during the reaping of the grass (Dransfield, 1966) or during the seasonal rice cultivation (Sreeramulu & Seshavataram, 1962) as well as in the urban centers (Ambles & Vernon, 1951). The isolated species are several; the most common are: **A. fumigatus** (Calvo et al., 1980b, Hudson, 1969, Lacey, 1975, Mallea et al., 1972), **A. flavus** (Calvo et al., 1980b, Kramer et al., 1960), **A. niger** (Kramer et al., 1960, Calvo et al., 1980b, Rippel, 1940) and **A. nidulans** (Rati & Ramalingam, 1965). In Barcelona (Calvo et al., 1980b) the dominant specie was **A. flavus**, followed by **A. niger**, **A. fumigatus**, and **A. clavatus** with a maximum incidence between April and December. In Cambridge (Hudson, 1969) the four most common species are **A. fumigatus**, **A. amstelodami**, **A. repens**, and **A. versicolor**. A comparative study of the distribution of the species of **Aspergillus** found in Paris, London, Marsella and Lyon (Mallea et al., 1972) reveals that **A. glaucus** is the dominant specie in Lyon (40,1o/o) and in Marsella (20.5o/o); while in London and Paris the dominant specie is **A. fumigatus** with an incidence of 39,1o/o and 35,7o/o respectively.

In Pavia the most frequent species in decreasing orden are: **A. fumigatus**, **A. niger**, and **A. flavus**. The first, cosmopolitan, that includes several strains which are thermotolerant and termophilic, The second, which is widely known, is most frequent in tropical and subtropical areas, in a similar way to **A. flavus**, whose importance is correlated to the toxigenic property of certain strains that can produce mycotoxins (aflatoxins).

Epicoccum is a common genus as a component of airmycota. In spite of there are several sinonyms of the monotype specie **E. nigrum** Link, according to Schol-Schwarz (1959), who made a critical study of 70 strains and considered that all of them are sinonyms of **E. nigrum**, in literature the fungus is still described as **E. purpurascens** Ehrenb. ex Schlecht This specie that we have isolated with a frequency of 11,7o/o is one of the most representative and constant organisms of airmycota in several areas: In Brisbane, Australia, with an incidence of 13,7o/o (Rees, 1964; Frey & Durie, 1962 and Upsher & Griffiths, 1973), in England (Richards, 1956 and Pawsey & Heath, 1964), in Samaru, Nigeria (Dransfield, 1966). It is a common colonizer of vegetables detritus parasites of gramineous and specially wheat where it is present during the first months after flowering. In Nigeria it is specially dominant in July through September during the development of mijo in Samaru (Dransfield, 1966), and in Nottingham where it is also dominant in the Summer months of August through September similarly to our finding in Pavia. Our high incidence is in relation to the period of the cultivation of cereals. It is a parasite of rice (Baldacci & Picco, 1948), and its cultivation is widely spread in Pavia, and also is a parasite of trees, specially banana tree (Locci et al., 1975).

Aureobasidium occupies the third place among fungi of the air in Pavia, with an incidence slightly higher to that found in a former research work in the same towns but in Winter (Caretta et al., 1975). This observation is not contradictory to actual results, because **Aureobasidium** presents a high incidence during the months of recolection of the smears in the foregoing research. The identification of **Aureobasidium pullulans** var. **pullulans** and **A. pullulans** var. **melanigenum** was made based on morphologic and ontogenic criterias of conidia proposed by Hermanides Nijhof (1977). The genus **Aureobasidium** includes 15 species present as saprophites in different substrates or as parasites in several phanerogams (Rogers - Locci & Locci, 1975). In the air of Hong Kong **Aureobasidium** is dominant (Turner, 1966), among the first four fungi in Australia (Frey & Durie, 1962), Denmark (Samsø e-Jensen & Flensborg, 1950), Sweden (Rennerfelt, 1947),

Gales (Hyde & Williams, 1953), and as a common genus in India (Rajan et al., 1952), USA (Kramer et al., 1959) and Panama (Taylor & McFadden, 1962)

The incidence of **Aureobasidium** in the air, varies in the different countries with a prevalence in Summer. This fungus which is frequent in our samplings, is specially important for some enzimatic activities as the production of 1–4, 1–6 and 1–3 α glucan pullulan in cultures with a low pH, and in the presence of NH_4^+ ion (Catley, 1971a; 1971b). This ecological aspect is treated in detail by Cooke (1959).

Alternaria is a genus (44 species according to Ellis 1976), which includes several parasites species of plants over specific hosts and saprophites species present in soil over organic material. It is an ubiquitarian genus amply difuse in the world, rare in the arctic or alpine regions (Bassett et al., 1978) with a particular capacity to degrade cellulose, sugars, pectine and lignine. This relatively big poroconidia can be dispersed in a radio of nearly 4800 Km., and at an altitude of 1,6 Km. (Christensen, 1965). Some clinical pictures of asthma in man are related with the inhalation of **Alternaria** conidia (**Collins-Williams** et al., 1973). High concentrations of **Alternaria** conidia, have been found in sampling in grain fields in India (Mishra & Srivastava, 1972) in the Kansas prairies, (Long and Kramer, 1972) in Manitoba (Walton and Dudley, 1945) and in Toronto, Canada (Collins-Willimas et al., 1973). It was described as a frequent genus in Australia (Frey and Durie, 1962), in Hong Kong (Turner, 1966) and in Copenhagen with an incidence of 9,4o/o and second after **Cladosporium** (Larsen, 1981); while in Nigeria it is a genus with great variations, even though **A. macrospora** is a common parasite in cotton, cultivated at 800 m. distance from the sampling (Fransfield, 1966). In Pavia it occuppied the fourth place in order of frequency, with an incidence of 7,9o/o. The dominant species **A. alternata** and **A. longipes**, are more frequent in Summer–Autumn. **A. alternata** is the most common and cosmopolitan species. It is present in many types of plants and other substrates as soil, food, textile fibres, etc. (Ellis, 1976). **A. longipes** is particularly frequent on tabacco leaves where it produces the dark stain. The incidence of this specie in Pavia can be justified because in the province tabacco is cultivated.

Brotytis is a genus among the most ubiquitarians, it includes a number of saprophite and pathogenic species of plants, specially aireal parts of vine. In a more limited way in certain fruits and ornamental plants (Liliaceae, Iridiaceae) tomato, lima, beens, peas and pickled cucumber. Taxonomy, certain morfologic and epidemiologic aspects are summarized by Coley-Smith, Verhoeff and Jarvis (1980). Of the 22 species retained as valid by Hennebert (1973). **B. cinerea** is the most known and present mainly in temperature, humid and subtropical regions. In Pavia this species is dominant with an incidence which is prevalent in Spring, with a peak in april. This incidence in the air (5,9o/o) of Pavia is similar to that found in Nottingham by Pawsey and Heath (1964), in Spring(5o/o). The incidence of this species is related to extensive vine culture in the hills surrounding the city.

Among to so called pink-yeast, the species **Rhodotorula glutinis** and **Sporobolomyces roseus**, are specially interesting as they were regularly isolated during the year, with peaks of maximum frecuency in February. These yeasts not very numerous in the ground, are very abundant in fruit trees and vineyards (epifitic mycota) and frecuent in the air. specially in cold-humid weather coinditions. **Sporobolomyces** is common in the air (Pady, 1974; Gregory and Sreeramulu, 1958; Gregory, 1954; Hirst, 1953; Pady and Kramer, 1960), with a prevailing incidence in Winter and Spring, with peaks in rainy days, but specially at night and in humid weather conditions (Pady and Clary, 1967). **Rhodotorula** is isolated from the air with high frecuency in Amristar (India) in October (Sandhu and Waraich, 1981) in Barcelona (Spain), (Calvo et al., 1980c), and in citric processing industries in Italy (Todaro, 1978). The species **Rh. rubra** and **Rh. glutinis** are extremely common and distributed over the whole world, either in the ground, sea or in the gastrointestinal tract in man and animals.

The genus **Phoma**, includes a great number of species that have a morphologic affinity with other genera of the **Sphaeropsidales**, as **Phyllosticta, Diplodina, Discella** and **Macrophoma**. Its morphologic and physiologic characteristics were studied again by Dennis (1946) and by Boerema and Dorenbosch (1973). It is widely spread in the nature, and it is potencially pathogenic in its saprophytic phase because of the physiological damage it can cause on host plant. The nutritional specialization is a characteristic in some species because it presents a parasite behaviour of monofagus or polifagus type.

Of the 7 species isolated in the air of Pavia, **P. destructiva** is responsible of a prevailing tomatoes pathology and **P. medicaginis** of a widely spread pathology in plants, shrubs and flowers.

Our high number of isolated species allow us to think of a great diffusion of this genus, which probably find environmental conditions and vegetable hostess in degrees that assure its continuous presence.

Among the seldom isolated fungi from the air, we can mention the genus **Chaetomium**, which has more than 180 species, mostly saprophytes (specially over plants debris and important for its cellulolytic activity. This genus is mentioned for the following curiosity which we have observed: the plates where a **Chaetomium** was isolated, were all contaminated in an aproximate period of two months by **Tyrophagus putrescentiae**, an acarus which is very common over plants debris, cereals, animal hair, cheese, etc. (Lodha, 1964; Millner, 1975); **Chaetomium** has been frequently isolated from feathers, birds nests or from the fur of animals (Hubalek, 1974a; 1974b; 1975; 1976; Hubalek et al., 1973; Caretta et al., 1976). For this reason, the relation between **Chaetomium** and **Tyrophagus** seems to be justified, assuming the fungus the function of vector of the acarus eggs,

which under favorable conditions of humidity and temperature, begins its short life cycle.

Conclusion

In spite of the limitations of our methodology of air sampling, our research has allowed us to obtain useful information, not only on the distribution and influence of metereologic factors of fungi at generic level, but about the incidence of species within each genus. This circumstance can allow us to correlate problems of physiopathology and allergology in man, with seasonal variations of the fungal airspores of some species. The isolation of several strains of the same species, allows us to study these fungi from differents points of view and to valorize the eventual correlation between toxigenicity, pathogenicity or the usefulness of strain for eventual enzimatic activity necessary to man. As an example we can mention that among the isolated species of **Cladosporium cladosporioides, Epicoccum purpurascens, Penicillium expansum**, we have isolated specimen that produce secondary metabolites with antibacterial activity.

The relation between toxigenicity, pathogenicity was observed by us in fungal strains isolated from pathological pictures produced by this over vegetables.

This is a huge problem, which could be studied from several points of view, as each of these strains, even in the same species, can perform saprophyte, pathogenic or toxigenic.

Acknowledgement

This research was supported by a contribution of the Ministery of Public Instruction. We wish to thank Mrs. Gloria Della Volpe Sorrentini, and Mr. Luigi Morandi for their technical assistance.

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