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THE OCCURRENCE AND ALLERGISING POTENTIAL OF AIRBORNE POLLEN IN WEST BENGAL, INDIA

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Abstract: A continuous 2-year volumetric aerobiological survey was conducted in Berhampore town, a centrally located and representative part of West Bengal, India. The aim of the study was to assess the allergising potential of airborne pollen grains of West Bengal. A total of 31 pollen types were identified of which Poaceae (grasses) pollen showed maximum frequency, followed by Cyperaceae, *Cassia* sp., *Acacia auriculiformis*, etc. The seasonal periodicities of the pollen types and their relationship to meteorological conditions were investigated. It was found that the pollen concentration is positively correlated with temperature and negatively correlated with rainfall and relative humidity. Clinical investigations by skin prick test were carried out to detect allergenicity of pollen types. Eighteen common airborne pollen types induced positive responses of which pollen extracts of *Saccharum officinarum* (grass), *Azadirachta indica*, *Cocos nucifera*, *Phoenix sylvestris*, *Cyperus rotundus* and *Eucalyptus citriodora* showed strongest sensitising potential. This result is consistent with previous investigations in different parts of West Bengal.

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INTRODUCTION

The importance of pollens causing pollinosis is well established and documented in India [1, 5, 9, 10, 20, 29, 31, 32, 33, 34, 35]. Reports on allergenic pollen concentration in the air of West Bengal are not adequate, although the plants producing pollen with strong allergising potential are fairly common. Aerobiological surveys in relation to pollen allergy have been confined to only a few places of West Bengal [3, 4, 5, 6, 8, 9, 11, 16, 17, 21], but most of them, including the present biozone, have remained unexplored. The aim of the present study was to examine seasonal changes in pollen concentration in Berhampore - a centrally located and representative part of West Bengal. More specifically, the study was aimed at assessing the distribution pattern of pollen grains in different seasons of the year, and in relation to meteorological factors. Moreover, the allergising potential was assessed of pollens suspected as major causes of health problems among residents of Berhampore. The present results have been correlated with previous observations in different parts of West Bengal to highlight the occurrence and allergising potential of airborne pollen in West Bengal.

MATERIALS AND METHODS

Pollen counts. A 1-day Astir volumetric slide sampler (Astir India Co. Ltd., New Delhi) was used for aero-biological survey for 2 consecutive years (May 1995–April 1997). The sampler was placed on the roof of a domestic

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Table 1. Airborne pollen types recorded at Berhampore town in 1995–1997.

Taxa with Family	Pollen concentration in grains/m^3 of air			
	1995–1996		1996–1997	
	Number	Percent	Number	Percent
Acacia auriculiformis (Fabaceae)	36.00	5.62	33.0	5.81
Areca catechu (Arecaceae)	24.0	3.75	24.0	4.22
Azadirachta indica (Meliaceae)	18.00	2.81	17.0	3.0
Barringtonia racemosa (Barringtoniaceae)	7.00	1.09	-	-
Bombax ceiba (Bombacaceae)	11.00	1.72	11.0	1.93
Borassus flabellifer (Arecaceae)	14.00	2.19	15.0	2.64
Carica papaya (Caricaceae)	17.00	2.66	16.0	2.81
Cassia sp. (Fabaceae)	52.00	8.12	32.0	5.63
Casuarina equisetifolia (Casuarinaceae)	13.00	2.03	13.0	2.28
Cheno-Amaranthaceae	34.00	5.31	34.0	5.98
Cocos nucifera (Arecaceae)	23.0	3.59	20.0	3.52
Croton bonplandianum (Euphorbiaceae)	23.00	3.59	19.0	3.43
Cyperaceae	57.66	9.01	50.33	8.85
Dillenia indica (Dilleniaceae)	5.00	0.78	6.0	1.05
Eucalyptus sp. (Myrtaceae)	14.00	2.19	14.0	2.46
Hyptis suaveolens (Lamiaceae)	7.00	1.09	-	-
Litchi chinensis (Sapindaceae)	16.00	2.5	16.0	2.81
Madhuca indica (Sapotaceae)	32.00	5.0	20.0	3.52
Malvaceae	25.00	3.91	21.0	3.69
Mangifera indica (Anacardiaceae)	11.00	1.72	15.0	2.64
Mimosa pudica (Fabaceae)	18.00	2.81	17.0	3.0
Morus indica (Moraceae)	16.0	2.5	14.0	2.46
Oldenlandia sp. ((Rubiaceae)	7.00	1.09	9.0	1.58
Phoenix sylvestris (Arecaceae)	14.0	2.19	11.0	1.93
Phyllanthus emblica (Euphorbiaceae)	11.00	1.72	11.0	1.93
Poaceae (Grasses)	70.00	11.0	71.0	12.50
Psidium guajava (Myrtaceae)	9.00	1.41	8.0	1.41
Ricinus communis (Euphorbiaceae)	16.00	2.5	13.0	2.28
Tinospora cordifolia (Menispermaceae)	4.00	0.625	6.0	1.05
Trema orientalis (Urticaceae)	28.00	4.37	25.0	4.40
Xanthium strumarium (Asteraceae)	7.00	1.09	7.0	1.23

house of Berhampore town (about 200 km north-east of Calcutta), about 4 m above ground level. The sampler (suction rate of 10 litres of air per minute) was run for 10 minutes twice in a day between 07:00–08:00 and 18:00–19:00 at 4-day interval. The grains were identified in the usual way by comparing with reference slides from the Sporotheca of the Environmental Botany Laboratory, Visva-Bharati, with the help of Erdtman [14]. The counts were converted to concentration m^{-3} of air by multiplying with an appropriate conversion factor [30], as suggested in the guidebook of The British Aerobiology Federation [39].

Influence of weather on pollination. The meteorological data [6] was collected from the Pulses and Oil-seeds Research Station, Berhampore which is about 1 km from the sampling site. The main type of vegetation around the trap covers tropical plants, coming from open land vegetation, avenue trees, gardens and city parks.

With the help of MINITAB computer programme, non-parametric statistical analysis by Spearman's rank test was applied to determine whether monthly pollen concentration and meteorological parameters were positively or negatively correlated [22]. The statistical significance of correlation

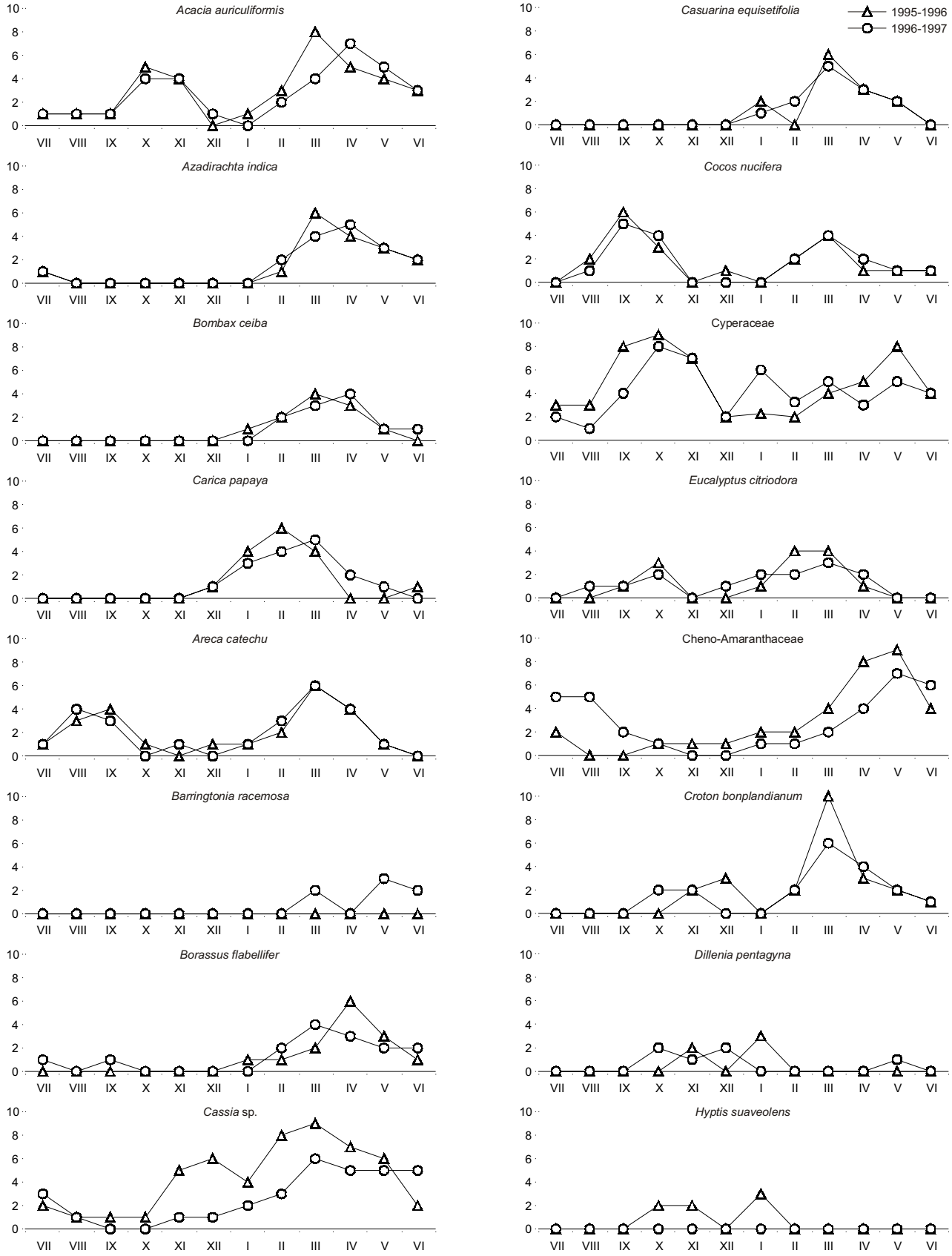

Figure 1. Seasonal variation of the monthly mean pollen concentration (pollen grains/m^3) recorded in the air of Berhampore, 1995-1997.

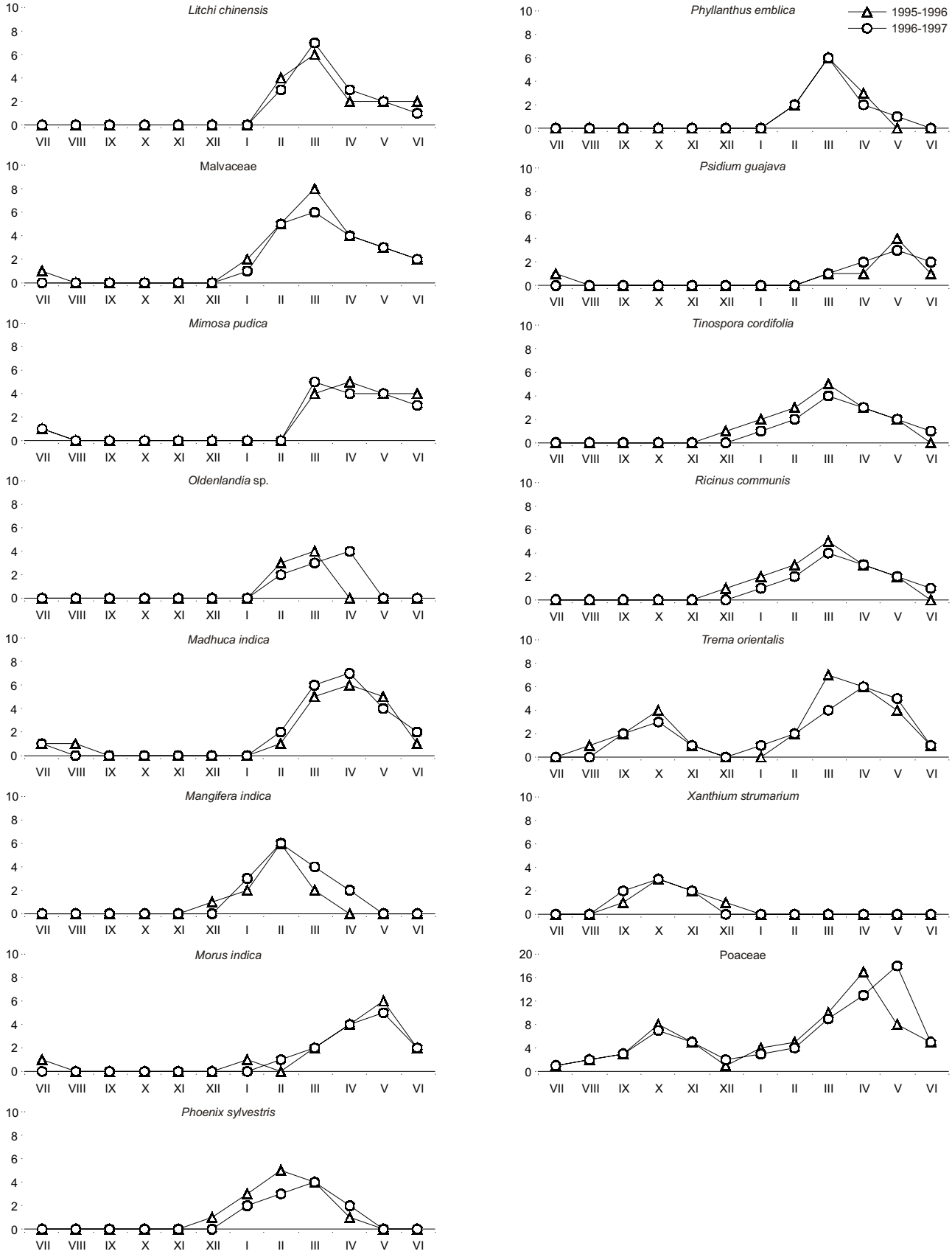

Figure 1 (continuation)**.** Seasonal variation of the monthly mean pollen concentration (pollen grains/m^3) recorded in the air of Berhampore, 1995-1997.

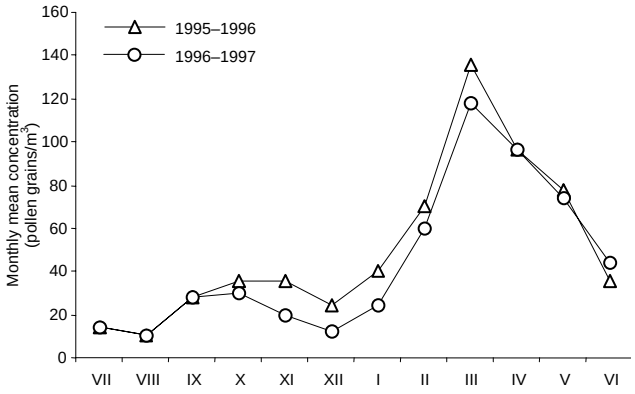

Figure 2. Variations in the total pollen count of Berhampore (1995-1997).

was studied by students *t*-test for paired samples following the methods of Subiza *et al.* [38] and Vega-Maray [40].

Allergising potential of pollen. The clinical investigations in terms of skin prick tests were carried out with the crude pollen extract (1:50 wt/vol) at the Allergy Unit of the Institute of Child Health, Calcutta. For skin prick tests, a variable number of patients with respiratory disorders, ranging within 18–65 years of age, were selected. The male and female ratios are indicated in Table 4. Ninety percent pure pollen was defatted with diethyl ether and extracted in sodium phosphate buffer (pH 7.4) by continuous stirring at 4ºC for 24 h following the methods of Sheldon *et al.* [30], modified considering the total conditions by Shivpuri [28] and Gupta and Chanda [16]. Extracts were used in skin prick tests on adult respiratory allergic patients with histamine diphosphate (1 mg/ml) as positive control, and 0.1 M PBS (Phosphate buffered saline) as negative control. Tests were performed with 20 ml of aliquots of allergen solution placed on the ventral side of the forearm and each side was pricked with a disposable hypodermic (No. 26) needle. The wheal responses were measured after 20 minutes and graded 1+ to 3+ according to Stytis *et al.* [37].

RESULTS

Pollen counts. A total of 31 pollen types were identified (Tab. 1). The results of pollen count for both years are shown in Table 1. The most abundant type originated from Poaceae, followed by Cyperaceae, *Cassia* sp., *Acacia auriculiformis* etc. (Tab. 1).

The seasonal periodicities were studied for all the pollen types (Fig. 1). The total pollen count varied throughout the year with the peak period in March for both years. By months, on average, March was recorded for the highest incidence of total pollen (Fig. 2). Some pollen grains such as Poaceae, Cheno-Amaranthaceae, *Acacia auriculiformis*, etc., were found all year round with maximum concentration during March–May, while Cyperaceae showed its peak in October (Fig. 1). Other pollen types, such as *Eucalyptus* sp., *Borassus flabellifer*, *Madhuca indica*, *Mimosa pudica*, etc., were found

Table 2. Volumetric monthly distribution of total airborne pollen grains.

Months	1995–1996		1996–1997	
	No. of pollen m^{-3}	%	No. of pollen m^{-3}	%
May	83	13.02	77.0	13.79
June	41.66	6.53	46.0	8.24
July	15	2.35	15.0	2.69
August	12	1.90	11.0	1.97
September	29	4.55	29.33	5.25
October	38.33	6.01	33.0	5.91
November	38.00	5.96	21.0	3.76
December	27.33	4.29	14.0	2.51
January	42.33	6.64	27.0	4.83
February	73.00	11.45	63.0	11.28
March	136	21.32	121.0	21.67
April	102	16.0	101.0	18.10

Table 3. Correlation between meteorological parameters and monthly total pollen count (coefficient of correlation (r) values).

	Temperature	Rainfall	Relative humidity	Wind speed
1995–1996				
Rainfall	0.587			
Relative humidity	0.453	0.828		
Wind speed	0.429	0.247	0.382	
Total pollen	0.086	-0.534	-0.802	-0.120
1996–1997				
Rainfall	0.525			
Relative humidity	0.697	0.888		
Wind speed	0.684	0.284	0.400	
Total pollen	0.239	-0.439	-0.421	0.353

Degrees of Freedom (DF) → 12 - 2 = 10

frequently with moderate concentration. Pollen grains of *Mangifera indica*, *Bombax ceiba*, *Psidium guajava*, etc. showed distinct seasonality confining to a restricted period of the year. Poaceae, *Acacia auriculiformis*, *Trema*, *Cocos*, etc., showed 2 peak periods, one in March-May and the other between September–November (Fig. 1).

Influence of weather on pollination. Magnitude and quality of annual pollen load in the atmosphere varies significantly. Meteorological parameters like temperature, rainfall, relative humidity, wind direction and velocity are responsible for fluctuations in pollen concentration [2, 7, 18]. Maximum concentration of pollen grains were found mostly between March–May (Fig. 2), probably due to moderately high temperature, low relative humidity,

Table 4. Results of skin-prick test using different pollen extracts on adult respiratory allergic patients of West Bengal.

Pollen allergen extract	Present investigation				Reports of previous investigations			
	Total No. of tested patients (male:female)	No. of positive responses (% of patients)	Intensity of reaction (% of patients)		Total No. of tested patients	No. of positive responses (% of patients)	Intensity of reaction (% of patients)	
			+1	+2 or more			+1	+2 or more
Acacia auriculiformis	147 (104:43)	30 (20.41)	17.68	2.72	–	–	–	–
Amaranthus viridis	150 (102:48)	20 (13.33)	13.33	–	120[C]	12 (10.00)	10.00	–
Areca catechu	555 (418:137)	222 (40.0)	34.60	5.40	638[B]	87 (13.63)	9.03	4.60
Azadirachta indica	950 (782:168)	485 (51.05)	45.05	6.00	1058[C] 1502[B]	560 (52.93) 736 (40.00)	45.63 45.74	7.30 3.26
Bombax ceiba	450 (369:81)	95 (21.11)	20.00	1.11	492[C]	106 (21.53)	20.33	1.20
Borassus flabellifer	455 (363:92)	144 (31.65)	24.45	7.20	94[B]	14 (14.89)	14.89	–
Carica papaya	550 (409:141)	140 (25.45)	21.95	3.50	560[C] 503[B]	154 (27.57) 90 (17.89)	23.67 17.89	3.90–
Cassia siamea	175 (108:67)	54 (30.85)	25.71	5.14	–	–	–	–
Chenopodium album	150 (105:45)	33 (22.00)	20.00	2.00	250[C]	42 (16.80)	16.00	0.80
Cocos nucifera	945 (778:167)	415 (43.91)	39.41	4.50	1102[C] 1626[B]	481 (43.64) 510 (31.36)	38.74 26.66	4.90 4.70
Croton bonplandianum	200 (122:78)	27 (13.50)	13.50	–	–	–	–	–
Cyperus rotundus	135 (97:38)	52 (38.51)	33.01	5.50	138[C]	52 (37.68)	31.98	5.70
Eucalyptus citriodora	260 (183:77)	89 (34.23)	27.69	6.53	492[C] 289[B]	106 (21.53) 89 (30.79)	20.33 25.18	1.20 5.61
Madhuca indica	135 (91:44)	33 (23.70)	20.74	2.96	–	–	–	–
Mangifera indica	180 (114:66)	18 (10.00)	10.00	–	170[C]	18 (10.52)	10.52	–
Phoenix sylvestris	475 (379:96)	205 (43.16)	35.66	7.50	542[C] 22[B]	239 (44.09) 3 (13.63)	36.89 13.63	7.20 –
Poaceae (*Saccharum officinarum*)	350 (276:74)	190 (54.28)	39.28	15.00	370[C] 156[B]	203 (54.86) 104 (66.66)	37.86 66.02	17.00 0.64
Trema orientalis	135 (89:46)	12 (8.88)	8.88	–	120[C] 43[B]	11 (9.16) 15 (13.95)	9.16 13.95	– –

[C]Report of Chakraborty *et al.* 1998 (male:female ratios not mentioned) [8]; [B]Report of Banik and Chanda 1992 (male:female ratios not mentioned) [3].

moderately low wind speed and low rainfall. The count became very low during June–August due to heavy rainfall, high relative humidity and high wind speed. Thus, the pollen concentration depends upon the climatic factors and this has been statistically supplemented. A correlation was made between the monthly total pollen count (Tab. 2) and meteorological factors through statistical analysis. From the value of the correlation coefficient (r), it was found that pollen concentration was positively correlated with temperature and negatively correlated with rainfall, relative humidity and wind speed during 1995-1996 (Tab. 3). In 1996-1997, it showed a similar result, except for wind speed, which showed positive correlation. The level of significance was also determined from the statistical table. In the case of temperature, the level of significance was below 0.1, while it was in between 0.1–0.05 for rainfall, and between 0.01–0.001 for relative humidity, and below 0.1 for wind speed.

Allergising potential of pollen. Skin prick tests were performed (Tab. 4) with the whole pollen extracts of 18 common airborne pollen types of the present investigation on patients having relevant case history. All 18 taxa induced at least 1+ reaction in allergenic patients. The highly potent allergenic pollen showing 2+ to 3+ positivity reactions were *Saccharum officinarum* (grass), *Azadirachta indica*, *Cocos nucifera*, *Phoenix sylvestris*, *Areca catechu*, etc. Our results regarding allergising potential of pollen are consistent with previous investigations [3, 8] in other parts of West Bengal (Tab. 4).

DISCUSSION

Pollen counts. In India, the importance of pollen allergy in triggering respiratory allergy has been successfully documented [1, 5, 9, 10, 17, 20, 29, 31, 32, 33, 34, 35]. Our results regarding the incidence of airborne pollen in Berhampore are consistent with the previous observations

in different parts of West Bengal [3, 4, 8, 21]. From previous investigations it is observed that Poaceae (grass) pollens are the most dominant types in all the biozones of West Bengal, showing maximum concentration in Digha, followed by Durgapur, Madhyamgram, Berhampore, Cooch Behar and Central Calcutta. Pollens of *Acacia auriculiformis*, *Eucalyptus* sp., *Borassus flabellifer*, *Cassia* sp., *Azadirachta indica*, etc., are also found in moderate concentration in most places. The frequency of pollen differs from place to place due to the difference in geographical position, local vegetation and other environmental conditions [15, 27, 38, 40]. For example, the abundance of *Trema orientalis* in Central Calcutta was due to their planting along the road side as avenues of trees [3]. Similarly, the high concentration of *Acacia auriculiformis* pollen in Digha was because of the mass cultivation of *Acacia* along the sea shore [4]. Frenz [15] demonstrated that airborne pollen concentrations exhibit spatial variability, as pollens from nearby vegetation exert a profound local influence. Moreover, the size of the source area represented by a pollen sampler depends on the distance between the sampler and the nearest vegetation. Our results support the view of Frenz [15], because of high incidence of *Acacia*, *Cassia* and Poaceae (grasses) pollens was probably due to the presence of a large area of such vegetation and grass lawn, in and around the sampling site.

Influence of weather on pollination. Apart from the individual rhythm of plant pollination, meteorological conditions are considered the most important factors determining the dispersion and content of pollen in the air [9, 12, 26, 38, 40].

Analysis of vertical profile of airborne pollen in West Bengal, India, has shown that the source height is the general determining factor for the abundance of pollen [9]. Subiza *et al.* [38] have shown that humidity and rainfall appear to be the predominant factors in determining the grass pollen potential for the season in Madrid, Spain. It is evidenced that temperature is the factor that exerts the greatest influence on the release of pollen grains in the atmosphere [25, 40]. Rainfall and relative humidity yielded negative correlations since water droplets wash away pollen particles [40]. Puc and Wolski [26] showed a positive and statistically significant correlation between the air temperature and the *Betula* pollen concentration, while a similar but negative correlation was found for *Populus* pollen. A relationship was established between the airborne ragweed pollen concentration and the macro-synoptic weather situation in Budapest, Hungary [13].

In the present investigation, the influence of meteorological factors on the pollen concentration was studied. Here, a positive and statistically significant correlation was found between the air temperature and the pollen concentration. Conversely, a negative correlation was observed between rainfall, relative humidity, wind speed and pollen concentration. Our results are consistent with previous observations in different countries [26, 40]. Therefore, the aerobiological survey in relation to meteorological parameters has proved that weather factors have great influence on the occurrence and distribution of pollen grains in the atmosphere.

Allergising potential of pollen. The symptoms of pollen allergy confirm a good correlation with the airborne pollen count [9, 27]. However, the most important factors conducive to pollen allergy are genetic and environmental (air pollution, exposure to allergens, infection of respiratory tract, diet) and microflora of pollen grains [25]. The analysis of hereditary relationship to Japanese cedar pollinosis suggests that at least 3 years may be necessary for establishment of sensitization in children [19]. Moreover, it was established that the onset of symptoms is not only influenced by hereditary factors, but also by pollution from automobile exhausts [19]. The analysis of the airborne pollen concentration, skin prick test, allergy symptoms and serum immunoglobulins in allergic people in Cracow, Poland, suggested a high correlation between these factors [24]. It has also been established that increasing air pollution in industrialized areas and big cities with O_3, HCHO, SO_2, NO_x and industrial dust increases the risk of allergies [23, 25]. As a result, many more pollinosis sufferers live in the cities than in the country. In India, Singh and Dahiya [31] have shown that the protein content in allergic pollen did not exhibit statistically significant variability. However, pollen samples collected during the peak flowering season showed a higher protein content [31]. Śpiewak *et al.* [36] have demonstrated that pollen grains are contaminated with bacterial endotoxin in amounts sufficient to influence clinical course of pollinosis. Moreover, such endotoxin is capable of acting as an adjuvant facilitating the initial sensitization to pollen allergens [36]. Results of our study confirm that pollen grains of the grasses (*Saccharam officinarum*), *Azadirachta indica*, *Cocos nucifera*, *Cyperus rotundus* and *Eucalyptus citriodora* are the common aeroallergens in the cities of West Bengal causing significant allergic symptoms in susceptible patients. Although the present investigation to some extent differed in respect to *Areca catechu* and *Borassus flabellifer* pollen which were reported to cause much low allergic response in other parts of West Bengal [3, 8, 9]. These variations are probably due to the difference in the environmental conditions.

CONCLUSION

Thirty-one common airborne pollen types have been identified from the Berhampore town of West Bengal, India. *Saccharam officinarum* (grass), *Azadirachta indica*, *Cocos nucifera*, *Cyperus rotundus* and *Eucalyptus citriodora* are the common aeroallergens causing respiratory allergy among susceptible individuals. A positive correlation was found between pollen concentration and air temperature, while a negative correlation of pollen concentration was observed with rainfall, relative humidity and wind speed.

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