ETIOLOGICAL AGENTS OF RESPIRATORY ALLERGY IN TROPICAL COUNTRIES OF CENTRAL AND SOUTH AMERICA

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CONTRARY to what has happened in the United States, where Durham,[1-4] Shapiro and Rooks,[5] Spain,[6] and many others[7-9] have extensively studied the incidence of air-borne pollens and its relation to hay fever, in the countries of the tropical zone a comparative study of the incidence of allergens in the air has not been carried out as yet. It is only in the last few years that investigations on atmospheric pollens, fungi, and other etiological agents of the respiratory allergies in Central and South America have begun.

These studies now make possible a conjoint review of the allergenic flora of the different countries in the tropical zone, from Mexico in the north, with Central America and the Caribbean islands, to Peru, Bolivia, and Brazil in the south.

The present study deals with the distribution and incidence of air-borne pollens and fungi and also presents some new figures on the frequency of asthma, allergic rhinitis, and "skin allergy" in the hospital population. The study is based partly upon data published by previous workers and chiefly upon counts of pollens and molds made, under my direction, in the air over certain areas in South America and upon the results of skin tests made with extracts of these pollens and molds on my patients.

AIR-BORNE POLLENS AND FUNGI

The Most Important Plants and Pollens.—In the countries of the temperate zone, with the four seasons in the year, the time of pollination of each botanical species is clearly defined and the postulates of Thommen[10] are fulfilled, but in the countries of the tropical zone there are only two seasons, which in some regions are hardly distinguishable—a rainy one and a dry one. They occur at different times in the various geographical areas. In places where the flowering of plants depends exclusively on the rains, the pollination periods of the different species are quite well differentiated. The pollen concentration is never as high, however, as it is in the countries of the temperate zone. In the places where there is soil irrigation and the temperature is appropriate, the weeds, grasses, and shrubs flower and pollinate during the whole year.

In countries of low altitude the atmospheric humidity is quite high, but in the mountain regions the humidity is lower. In both, however, flowering and pollination occur mostly with rains.

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For regions which are located between sea level and 1,000 feet (except the coasts that are influenced by the Humbolt stream), the median annual temperature is approximately 76° F., with a maximum of 82° F. The median atmospherical humidity is 92 per cent to 95 per cent. The average annual rainfall reaches 2,000 to 3,000 mm. The temperature decreases with the increasing altitude, approximately 1° F. for each 500 feet. The rain and atmospheric humidity decreases also, but there are large differences between one place and another.

In the countries of the temperate zone of both North[1, 2, 6] and South[11-13] America, the plants of the *Compositae* family, of which the genus *Ambrosia* (ragweed) is the most important, produce a high number of allergic reactions. The genus *Artemisia* (wormwood) and the genus *Xanthium* (cocklebur) are less important than *Ambrosia*. These composite plants are followed by plants of the *Chenopodiaceae* (goosefoot, pigweed) family, which embraces several genera, the different species of which may be dominant in different localities. Thus, *Chenopodium album* (lambs'-quarters), *Salsola tenuifolia* (Russian thistle), *Atriplex* (Orach), and *Kochia* (Roth) all belong to the *Chenopodiaceae* family, and in North America one or another may be important locally.

Similarly, the *Amaranthaceae* family includes several genera, of which *Amaranthus* (careless weed) and *Acnida* (water hemp) are noted most often.*

Grasses and certain trees which produce pollen in abundance at an earlier season than the weeds cause almost as much trouble in the form of allergic reactions in North America as do the weeds.

In the countries of the equatorial zone most of these plants are scarce. Table I shows the species important in distribution or in allergenic power that grow in the equatorial zone.

In the middle and north of Mexico during the high pollination days, 100 or more pollen grains can be found per square centimeter per day. Descending toward the equatorial line, however, the number of pollens considerably diminishes. In Quito, for example, it rarely reaches 10 or more. It is interesting to notice that, descending from the equator toward the south, the amount of pollen grains increases again. In Brazil,[32, 33] between Rio de Janeiro and São Paulo, 50 to 60 and even 100 pollen grains were found, according to the place and the days of highest pollination. The low concentration of pollens in the air is not due entirely to the scarceness of plants. Almost the entire tropical zone is very rich in grasses, but, nevertheless, there are very few grass pollens in the air. Temperature and humidity play an important role.

In the low regions, as mentioned before, the atmospheric humidity is such that it probably interferes with diffusion of pollens, and in the mountainous regions over 12,000 feet where the grasses are abundant, probably because of the cold, the plants flower very little.

*The classification of families and genera is taken from Gray's *New Manual of Botany*, ed. 7, New York, Cincinnati and Chicago, 1908, American Book Company.

TABLE I. FAMILIES AND GENERA OF THE MAIN ALLERGENIC PLANTS OF THE COUNTRIES OF THE TROPICAL ZONE

PLANT	MEXICO[14-19]	CENTRAL AMERICA[20]	CUBA, PUERTO RICO[21-23]	COLOMBIA[24, 29]	ECUADOR[25-29]	PERU[30]	BOLIVIA[31]	BRAZIL[32-37]	VENEZUELA[29]
Gymnosperms									
Pinaceae									
Pinus	+++		+	+	+	+			
Cupressus	+++			+	+	+		++	
Angiosperms									
DICOTYLEDONES									
Fagaceae									
Quercus	+++								
Polygonaceae									
Rumex	+	+	+	+	+	+	+	+	+
Chenopodiaceae									
Chenopodium	+++	+	+	++	+++	++	++	++	++
Salsola	+								
Kochia	+								
Atriplex								+	
Amaranthaceae									
Amaranthus	+++	++	+	+++	+++	++	+	+	++
Platanaceae									
Platanus	++			+	+			+	
Leguminosae									
Acacia					+	+			
Mimosa				+	+	+			
Anacardiaceae									
Mangifera	+	++	++	++	++			++	
Plantaginaceae									
Plantago	+		+	+	+	+		+	+

Euphorbiaceae									
Ricinus	++	+	+	+	+			+	
Oleaceae									
Fraxinus	++								
Compositae									
Franseria	+			+	++	+			
Artemisia	++		+	+	+				+
Ambrosia	++		++	+				++	+
Viguieria			++						
Helianthus	++								
MONOCOTYLEDONES									
Gramineae									
Holcus				++	++	+			+
Dactylis	++			+	++		++		
Poa	+			++	++	+	+	++	+
Lolium				+	+	+		+	+
Agrostis				++	++				
Cynodon	+	+	++	++	++	++	+	+	+
Melinis			+	+	+			++	
Phleum							+		
Cyperaceae									
Carex	+			+	+	+			
Palmaceae									
Phoenix			+				+	+	
Cocos		+	+	+	++		+	+	

Number of plus signs (+) refers to the relative abundance of plants and/or the incidence of pollens in the air.

Trees are important in Mexico and to a lesser extent in the south of Brazil. Weeds, such as *Ambrosia,* although abundant in Cuba and Brazil, are of secondary importance. In the other countries *Ambrosia* is rarely found.

Plants of the *Amaranthaceae* and *Chenopodiaceae* families are certainly the most important species in many tropical countries, followed by the *Compositae* family, of which *Helianthus* is of interest in Mexico, *Viguiera* in Cuba, and *Franseria* in Ecuador. Grasses are even less important than weeds, but *Melinis* would be of interest in Brazil and *Cynodon, Poa, Holcus,* and *Lolium* in the other countries.

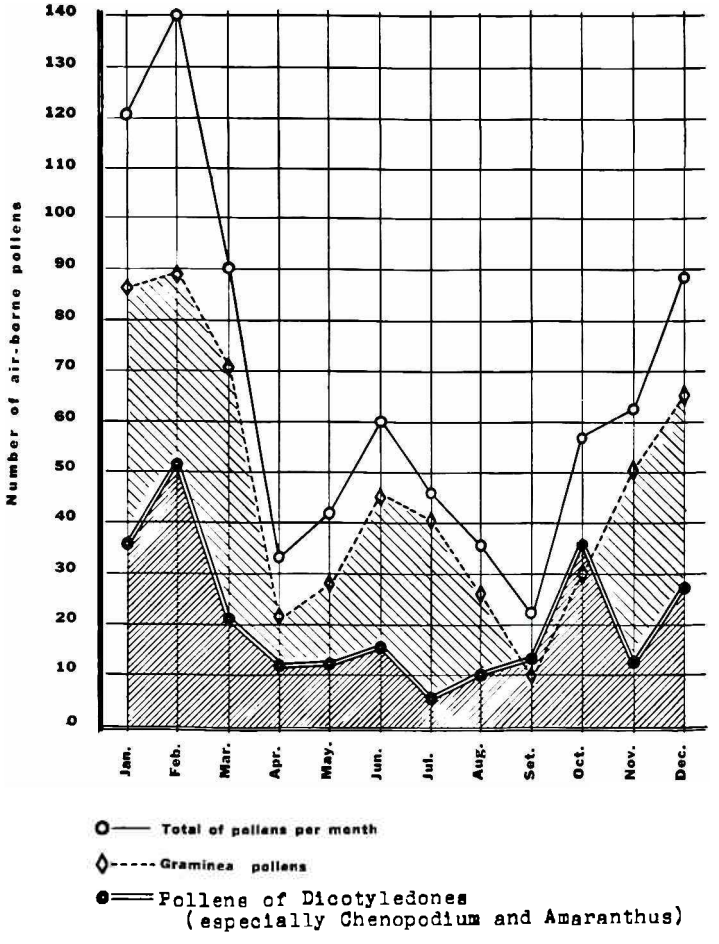

Fig. 1.—Monthly frequency of pollens in the atmosphere of Quito. In the ordinate are the number of pollens per month and per square centimeter.

Pollination Calendar.—The pollination calendar varies with the rains. From one to two months after the rainy season has started, the number of pollens in the air gradually begins to increase.[20, 21, 25] If it stops raining for a few days or weeks and the sun shines and the winds blow, the concentration

of pollens in the air can reach its maximum; inversely, when there are rainy days with clouded sky and plenty of atmospheric humidity, the air is cleansed of pollens.

In Cuba the rainy season is from May to November, on the coast of Ecuador it is from December to April, and in other places the rain starts in October and continues until May or June.

I have made special studies of two places: My own city, Quito, which is the capital of Ecuador, is in a high mountainous region 9,242 feet above sea level and 10 miles south from the equator. The other one is Cali, in Colombia, about 350 miles north of Quito. Cali lies in a subtropical valley at an altitude of only 3,000 feet between the Occidental and the Central Cordillera mountain ranges. Comparative studies of these two places are interesting.

Both Quito and Cali have rains from October to May, but in Cali the rains are more abundant. The month with the greatest precipitation varies from one year to another. It may be October, but it is more frequently April.

Counts of pollens were carried out in accordance with the method described by Durham,[3] using the standard air-sampling device, recommended as "standard" by The American Academy of Allergy,[38] which permits the calculation of the concentration of pollens per cubic yard of air.[39]

Data from Quito are based upon daily counts during 1948 and 1949 and those from Cali are based upon counts during the second part of 1954 and the first part of 1955. The pollination calendar of Quito[29] is shown in Fig. 1. When the rains begin in September, pollens, especially those from grasses, increase to reach a maximum in January, when the number of rainy days decreases. Beginning in March, the number of pollens falls off until the end of April and then it increases slightly again until June. In July the number of pollens decreases, and during August and the first part of September it remains at a low level. The pollination calendar for Cali is similar, but the number of pollens per square centimeter is three to five times greater than that from Quito. There are some differences with regard to the prevailing botanical species. In Cali there are more tree pollens (*Leguminosae, Bignoniaceae,* etc.). In Quito the pollens of *Amaranthus quitensis* predominate, and in Cali those of *A. spinosus* are numerous. Cali has an appreciable number of grass pollens.

Mold Spores.—Mold spores are especially important in the tropics. As demonstrated by Cadrecha-Alvarez[46] and others,[47, 48] the climatic conditions, being very favorable to the growth of fungi, may result in a high concentration of spores in the air which, in turn, cause an increased incidence of allergic diseases.[42]

In an attempt to study the air-borne fungi quantitatively in comparison with pollens, the spores were counted in Quito and Cali by the same method as used to count the pollens. (For their identification, the method described by Harris[40] was used, but the Petri dishes were left within the standard air-sampling device only twelve minutes.) In Quito,[29] the annual curve of incidence of fungus spores in the air was similar to that of pollens. The highest

TABLE II. THE MOST IMPORTANT AIR-BORNE FUNGI IN SOME TROPICAL COUNTRIES

(ARRANGED ALPHABETICALLY)

	MEXICO		CUBA		COLOMBIA	ECUADOR	PERU	BRAZIL	
FUNGI	MEXICO CITY[41, 42]	WESTERN MEXICO[43]	HAVANA[44-46]	CUBA[21]	CALI	QUITO[29]	LIMA[47]	RIO DE JANEIRO[48, 49]	SÃO PAULO[50]
Alternaria	+++	+++	++	+++	+++	+	++	+++	
Aerothecium		±		+			+		
Aspergillus	++	++	++++	+++	++++	+++	++++	++++	++
Candida	+				+		+	++	+
Cephalosporium	+							+	
Chaetomium		+		++					
Cheothonium		+							
Fusarium	++		+	+		+	++		
Helminthosporium		++		+	+		++	+	
Hormodendron	++++	++++	+++	+++	++++	+	+++	++++	++++
Monilia	+			+		+	+	+	
Mucor	++	+		+	++	+++	++	++	++
Penicillium	++++	+++	++++	+++	++++	+++	++++	++++	++++
Phoma		+		+			+		
Puccinia					+	+			
Pullularia									+
Rhizopus	+	+		+	+++	+++	+++	+	+
Rhodotorula					+	+		++	+++
Torulopsis							+	+	++

Number of plus signs (+) refers to the relative abundance of air-borne spores.

incidence occurred in January and the least in August. The amount of spores that settled on a square centimeter was at least ten times larger than the total amount of pollens. This ratio prevailed throughout the whole year. Since the "conversion factor"[39] is relatively great for spores, if the concentration per cubic yard is considered, then the concentration of spores was actually 10 to 100 times higher than that of pollens. Cali, at low altitude and with more atmospheric humidity, had even more molds than Quito.

In other places where quantitative studies were carried out, as in Cuba[44, 45] and Brazil,[48] a relative abundance of air-borne fungi has been found. Unfortunately, different methods were used by the various authors, and a direct comparison of their data is meaningless. However, for the purpose of summarizing in a single table major findings of these workers, Table II was elaborated under a pattern similar to Table I, but the plus signs used in Table II have a more relative value, rather than an arbitrary one.

Among the most important fungi, as determined by relative abundance or allergenic power, in all the countries studied are *Penicillium* and *Aspergillus*. *Hormodendron* is found very frequently in low and humid places (Havana, Rio de Janeiro, etc.), while in high places (Quito), *Rhizopus* and *Mucor* are much more abundant than *Hormodendron*.

ETIOLOGY AND FREQUENCY

Hay Fever.—In 1946, Oliveiro-Lima and associates[35] asserted that no hay fever exists in Brazil, and the existence or nonexistence of this allergic condition was argued in other countries of the tropical zone. The use of the word *pollinosis* brought a still greater confusion on this particular problem. If we understand *pollinosis* to mean any allergic condition produced by pollens, then pollinosis exists. But hay fever, with that dramatic and intense symptomatology in well-defined periodic form and with epidemic character, practically does not exist in the tropical zone.

Rhinitis due only to pollen is very rare[21, 24, 29, 31, 51, 52] and shows up in a mild form and without strict seasonal character, probably because of the low concentration of pollens in the air and because of the previously mentioned fact that where adequate soil humidity is available the plants pollinate indiscriminately during the whole year.

Asthma and Allergic Rhinitis.—The frequency of asthma and allergic or vasomotor rhinitis varies from one place to another. In a survey among medical students, for example, it was found that in Cali 4 per cent of the students were actually asthmatic, while in Quito there were no asthmatic students. Table III provides other comparative data from the two cities. In Quito the cases of asthma are mild; status asthmaticus is very rare. Skin allergies, however, are relatively frequent. In Cali, on the other hand, the respiratory allergies, and particularly asthma, have a rather high incidence. Of the asthmatic patients in Quito more than two-thirds had the initial onset of asthma while living in an asthmogenic region such as the coast.

It is well known by the physicians practicing in Ecuador that allergic rhinitis and asthma are uncommon diseases in the mountains, whereas in the coastal and southern parts of the country asthma is frequent.

TABLE III. RELATIVE FREQUENCY OF THE ALLERGIC DISEASES

DISEASE	QUITO (ECUADOR) (PER CENT)	CALI (COLOMBIA) (PER CENT)
Asthma	18*	51†
Allergic rhinitis	14	18
Skin allergy (urticaria, eczema, prurigo, etc.)	55	18
Others	13	11

*From a statistical sample of 200 allergic patients.
†From a statistical sample of 100 allergic patients.

In order to present some figures, statistical data from four hospitals—two from Ecuador and two from Colombia, in each country one in a high and the other in a low altitude—were reviewed. The four institutions are general hospitals, each being the largest one in its respective city. In these countries it is customary for those who can pay to go to private clinics. The choice depends on the specialists affiliated with each clinic. The poor people, who cannot pay for private medical assistance, go to these hospitals. In each hospital can be found a cross section of all the pathology in the area with no important discrepancies between the actual incidence of illness inside and outside the hospital; therefore, it is reasonable to assume that data from the individual hospitals can be validly compared.

TABLE IV. RELATIVE FREQUENCY OF HOSPITALIZED ASTHMATIC PATIENTS

PLACE AND HOSPITAL	AVERAGE TOTAL PATIENTS PER YEAR*	PER CENT ASTHMATIC PATIENTS
Bogotá (8,573 feet)†		
San Juan de Dios Hospital	11,000	6.3
Cali (3,000 feet)		
San Juan de Dios Hospital	5,500	6.7
Guayaquil (19 feet)		
Luis Vernaza Hospital	20,000	6.5
Quito (9,242 feet)		
Eugenio Espejo Hospital	6,000	1.85

*Data from the years 1955 and 1956.
†Altitude over sea level.

Table IV presents the relative frequency of asthma in the four hospitals, and the striking difference between the hospital in Quito and the others could be taken as an indication of the different incidence of asthma in the various localities. Altitude does not seem to be the determining factor in such difference. Quito and Bogotá are in the mountains and there is not a great difference in altitude; however, there is much less asthma in the first city than in the second. Evidently other conditions besides altitude determine the frequency of this allergic disease.

The etiology of allergic asthma and rhinitis was studied in patients of Quito and Cali. Most of the patients were referred by internists for their

treatment. Each had a careful history and complete physical examination. Intradermal tests were carried out in each patient. In the preparation of Table V, only those patients in whom the intradermal tests coincided with the findings of clinical history were considered. In some patients clinical exposure by intranasal application of raw materials or extracts was made. The favorable response to the specific treatment with the respective antigens was taken as a confirmation of the intradermal findings.

TABLE V. RELATIVE FREQUENCY OF THE ETIOLOGICAL AGENTS OF THE RESPIRATORY ALLERGIES

ETIOLOGICAL AGENT	ASTHMA		RHINITIS	
	QUITO (PER CENT)	CALI (PER CENT)	QUITO (PER CENT)	CALI (PER CENT)
1. House dust + fungi	16	22	12	35
2. House dust + pollens	7	6	10	15
3. House dust + inhalants	19	16	16	5
4. House dust + fungi + inhalants	38	33	39	25
5. Other combinations	14	13	15	10
6. Only house dust	6	10	5	10
7. Only fungi	–	–	3	–
8. Only pollens	–	–	–	–

The most important etiological agent was house dust; in some cases it was the only etiological agent. In a relatively high percentage of patients, there were two or more etiological agents, such as house dust, fungus spores, and one or more "inhalants" (kapok, sheep wool, cotton, epidermals, etc.). The most frequent combinations of etiological agents were about the same in Quito as in Cali. Pollens had a secondary role. In the statistical sample studied, there were no cases of asthma or rhinitis produced exclusively by pollens.

Although the grass pollens in the air are more abundant than those of other plants, the allergies in which these pollens are involved are uncommonly found. In Quito the pollens of chenopod plants have more importance, followed by those of amaranth plants, while in Cali the pollens of the amaranth plants are the most important.

Allergic Rhinitis and Deflection of the Nasal Septum.—The existence of a deviated nasal septum brought the suspicion that this may cause the rhinitis, but since surgical treatment did not produce any improvement, the deviation of the nasal septum was regarded as only a casual finding. Allergic causes must be considered carefully before surgery is advised.

SUMMARY

In the tropical countries of Central and South America there grow only a few species of plants that produce allergenic pollen, and these are not widely distributed, with the exception of the grasses which otherwise have a feeble sensitizing power. The output of pollens from grasses is very limited in the high mountains because of the lack of flowering of such plants. The most important species correspond to the families *Amaranthaceae*, *Chenopodiaceae*, and *Compositae*.

The atmospheric conditions, especially the atmospheric humidity and the hard rains, prevent the dissemination of pollen grains in the air. Pollen concentration increases after the rainy season starts. In some regions it reaches the highest level between November and February. The lowest concentration is found during the dry season.

Fungus spores are very abundant in the air. They are found from 10 to 100 times more frequently than the pollens. The spores of *Penicillium* and *Aspergillus* are present in great quantity in almost all the countries of the tropical zone. In the mountains, molds of genera *Mucor* and *Rhizopus* are also important, while in the lowlands *Hormodendron* is dominant. *Fusarium* and *Rhodotorula* are also of some interest.

In the countries of the tropical zone, hay fever practically does not exist, a fact due, at least in part, to the low concentration of pollens in the air. However, cases of nonseasonal vasomotor rhinitis, and especially asthma, are common.

The frequency of asthma varies from one region to another. There are asthmogenic regions, such as the coast of Ecuador and the greater part of Colombia. In these regions incidence of asthma is relatively high. In others, especially that of Quito, asthma is infrequent.

The most important etiological agent of asthma and allergic rhinitis is house dust. Alone or in association with other allergenic substances, this is the etiological agent of almost all the cases. The fungus spores and the group of "inhalants" (kapok, sheep wool, epidermals, etc.) are next in importance. The pollen grains are of secondary importance.

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