原　著

空中花粉の季節変動 II

重心法による分析

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Seasonal variation in the number of airborne pollen grains II

Analytical survey by the gravitational center method

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In the previous paper,[1] the authors found that the gravitational center method reported by Edwards[2)3)] could be one of the practicable indicator to grasp the seasonal variation in number of airborne pollen grains. In the present study, they tried again the analytical survey on the airborne pollen grains which were collected during three years, from 1976 to 1978 at Funabashi, Chiba Prefecture, and obtained almost the same results as shown in the previous paper.

The authors selected five kind of airborne pollen samples which are the allergens of pollen allergies (pollinosis), and collected in large quantities through the season, and carried out the analytical survey by the gravitational center method. The analytical method of the airborne pollen grains was almost the same as in the previous paper.

Methods

The airborne pollen grains were collected by the gravimetric method using standard sampling apparatus.[4)] The slide coated with vaseline was set two days per week to collect the pollen grains, and replaced

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with new slide each day, then the surface of the slides were covered with glycerine jelly containing a small portion of 0.01% gentianviolet alcohol solution.[5] After the preparation of the slide, it was observed under the light microscope, usually from 400 to 1000 magnified, and each airborne pollen grains were counted per 10 cm^2 of a slide.

The five selected airborne pollen samples used for the analytical survey in the present paper are as follows ; *Cryptomeria japonica* (including *Chamaecyparis obtusa*), *Pinus* sp. (*P. thunbergii*, *P. densiflora*), *Ambrosia* sp. (*A. elatior*, *A. trifida*), *Artemisia* sp. (*A. japonica*, *A. princeps*) and *Humulus japonicus*.

Each selected pollen sample was counted total in number per year, and the monthly percentages were also calculated, and then calculated α and θ as shown in Table 1 for each selected airborne pollen sample. The center of gravity can be obtained from α and θ.

On the other hand, a year was expressed as a circle, the circle divided equally into twelve sectors. The monthly variation in number of the airborne pollen grains (symbol, ●) was plotted into the sector, and the center of gravity (symbol, ★) which obtained from α and θ was also plotted into the circle. If the seasonal variation is not observed, the expected center of gravity will be at the center of the circle. The intensity of the seasonal variation defines the amplitude from the center of the circle, i.e. showing the distance (α), whereas θ defines the phase of the maximum incidence (number) and also the maximum peak's month.

If the number of pollen grains is large in particular sector, the center of gravity will go away from the center of circle, but if the former is small in number, the latter will get nearer.

The position of the center of gravity for each sample and the maximum peak's month coincide with each other, and it is said that the distance from the center of the circle to the center of gravity defines the relative intensity of the seasonal variation in the number of air borne pollen grains.

Results

Table 1 presents an example of result for a number of *Pinus* pollen grains collected in 1978 and gives estimated values of parameters. Fig. 1 gives the variation of the monthly number of *Pinus* pollen grains (plotted as ●) and the center of gravity (plotted as ★) which was led from α and θ as shown in Table 1.

Table 2 shows the calculated data for the five airborne pollen samples and the data of N, S, C, α and θ were obtained in each year during three years, from 1976 to 1978. The calculation was conducted by the same method as described under the Table 1. Fig. 2 gives the centers of gravities in comparison with the five airborne pollen samples in years from 1976 to 1978.

Discussion

From both Table 1 and Fig. 1, the total number of *Pinus* pollen grains in 1978 was 3871 grains, while the maximum peak's month (the largest in number in a month per year) was May, and counted 3535 grains (91.27%). The center of gravity was plotted at the middle of the sector of May, namely it is equal to 14th May in the circle from the data of θ ($-47°47'$) and α (3.76). Acoordingly, both the maximum peak and the center of gravity were recognized in May.

Every four airborne pollen samples used in this study were consisted of only two closely related species

Table 1. Caluculation of seasonal trends by the gravitational center method (3C^a 1−aperturate, *Pinus* sp., 1978)

Month	No. of pollen (n)	%	θ	$\sqrt{n}$	sin(θ−15°)	$\sqrt{n}$sin(θ−15°)	cos(θ−15°)	$\sqrt{n}$cos(θ−15°)
January	--	--	15°	--	0.000	--	1.000	--
February	--	--	45°	--	+0.500	--	+0.866	--
March	--	--	75°	--	+0.866	--	+0.500	--
April	299	7.72	105°	17.29	+1.000	17.29	0.000	--
May	3533	91.27	135°	59.44	+0.866	51.48	-0.500	-29.72
June	37	0.96	165°	6.08	+0.500	3.04	-0.866	-5.27
July	1	0.03	195°	1.00	0.000	--	-1.000	-1.00
August	--	--	225°	--	-0.500	--	-0.866	--
September	1	0.03	255°	1.00	-0.866	-0.87	-0.500	-0.50
October	--	--	285°	--	-1.000	--	0.000	--
November	--	--	315°	--	-0.866	--	+0.500	--
December	--	--	345°	--	-0.500	--	+0.866	--
	N=3871	100.00		W=84.81		S=70.94		C=-36.49

$$d = \frac{\sqrt{S^2 + C^2}}{W} = 0.9406, \qquad \mathrm{Var}\,\alpha = 2/N = 0.00512,$$

$$\alpha = 4d = 3.76, \qquad \chi^2 = \frac{1}{2} N\alpha^2 = 27363.3, (\mathrm{d.f.} = 2)$$

$$(\theta - 15^\circ) = \tan^{-1} S/C = -62^\circ 47',$$

$$\theta = -47^\circ 47' \ (\text{i. e. middle May})$$

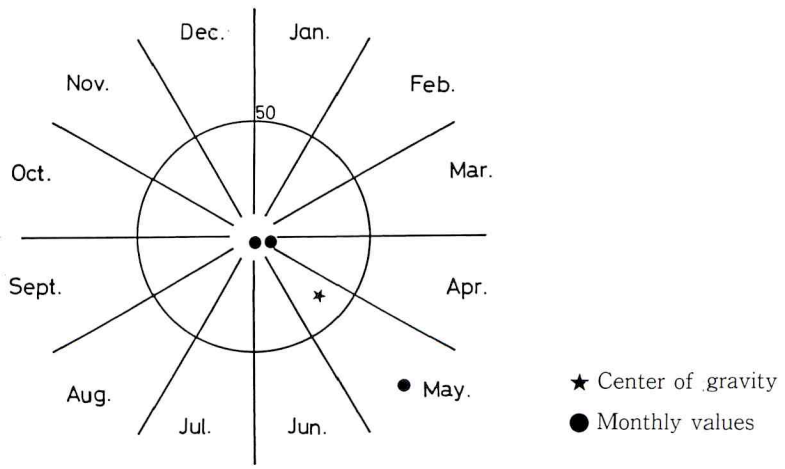
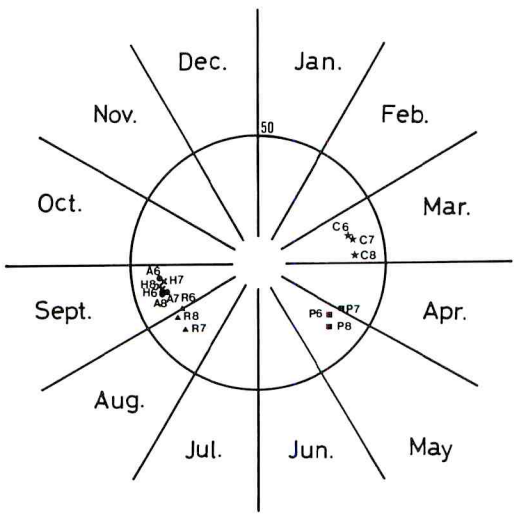


Fig. 1. Intensity and direction of seasonal variation on the pollen grains (3C^a 1-aperturate, *Pinus* sp.) in 1978.

Table 2. Estimated parameters of three years' variation in the total numbers of the pollen grains of five kind of airborne pollen samples.

species	year	No. of pollen (N)	$\sqrt{n}$ sin(θ-15°) (S)	$\sqrt{n}$ cos(θ-15°) (C)	α	θ
$3B^c$ 1-aperturate						
Cryptomeria japonica	1976	4695	74.49	45.18	3.67	73°46'
(Chamaecyparis obtusa)	1977	444	24.09	12.83	3.80	76°58'
	1978	1723	50.99	18.21	3.85	85°21'
$3C^a$ 1-aperturate						
Pinus sp.	1976	2416	65.98	-24.14	3.48	-54°54'
[P. thunbergii]	1977	3536	78.01	-18.40	3.76	-61°44'
[P. densiflora]	1978	3871	70.94	-36.49	3.76	-47°47'
$6B^b$ 3-colporate						
Artemisia sp.	1976	111	-11.75	-5.05	3.91	81°45'
[A. japonica]	1977	33	-6.45	-3.96	3.84	73°27'
[A. princeps]	1978	102	-9.20	-5.90	3.96	72°20'
$6B^b$ 3-colporate						
Ambrosia sp.	1976	432	-19.23	-19.20	3.50	60°03'
[A. elatior]	1977	183	-10.01	-13.22	3.90	49°08'
[A. trifida]	1978	295	-15.08	-17.17	3.87	56°18'
$5A^{b-c}$ 3-(4)-porate						
Humulus japonicus	1976	208	-16.44	-8.87	3.85	76°39'
	1977	106	-13.18	-6.31	3.79	79°25'
	1978	70	-8.19	-4.15	3.95	78°08'



Abbreviations.
★ Cryptomeria japonica ·····C
■ Pinus sp. ·····P
● Artemisia sp. ·····A
▲ Ambrosia sp. ·····R
× Humulus japonicus ·····H

1976·····6, 1977·····7, 1978·····8

Fig. 2. Seasonal variation in the proportion of airborne pollen grains with various types in 1976, 1977 and 1978.

and one sample was borne only one species, so that each sample showed only one peak in a year.

Among fifteen centers of gravities, only that of *Pinus* sp. in 1976 got out a little from the position, but others agreed with the months of the maximum peaks.

The centers of gravities of *Cryptomeria japonica* including *Chamaecyparis obtusa* in three years (1976—1978) were plotted in March and their α showed from 3.67 to 3.85, and variation of the amplitude was 0.18. The dispersal seasons of the pollen grains were observed from 17th February to 14th May in 1976, from 18th February to 19th April in 1977 and from 3rd March to 25th April in 1978. The estimated center of gravity in each year was corresponded to 15th March in 1976, 19th March in 1977 and 28th March in 1978, and the maximum peak was observed in the same month. The total number of the pollen grains in 1977 were extremely small. It might be derived from the weather conditions, namely, twenty rainy days and unusually low temperature in March.

On *Pinus* sp., the total numbers of the pollen grains in 1977 and in 1978 were almost equal in number, but smaller in 1976. The dispersal seasons of the pollen grains were as follows; from 16th April to 21st June in 1976, from 19th April to 22nd June in 1977 and from 25th April to 8th June in 1978. While the estimated center of gravity in each year was corresponded to 7th May in 1976, 30th April in 1977 and 14th May in 1978. The maximum peak's month in both 1976 and 1977 was April, however, May in 1978. According to these results, both of the maximum peak's month and the center of gravity were observed in same month, in April 1977 and in May 1978, but in 1976 the center of gravity got out a little from the position. The values of α in three years were from 3.48 to 3.76, and variation of the amplitude was 0.28.

On *Ambrosia* sp., the total number of the pollen grains was a few hundred in each three year, the number in 1976 was twice larger than in 1977. The dispersal seasons of the pollen grains were from 30th June to 8th October in 1976, from 5th August to 9th September in 1977 and from 1st August to 15th September in 1978. Furthermore the estimated centers of gravities were corresponded 31st August in 1976, 20th August in 1977 and 28th August in 1978. These values of α in three years were from 3.50 to 3.90, then the variation of the amplitude was 0.40. Namely the centers of gravities in three years were observed in the same months as the maximum peak's ones. In 1976 the beginning of the scattering of the pollen grains was earier than other years, and also the end of the scatterring of the pollen grains was the latest. These results brought the large number of the pollen grains in 1976. Contrary in 1977, the pollen dispersal season was short and pollen grains was small in number.

On *Artemisia* sp., the total number of the pollen grains in three years were only 111 in 1976, 33 in 1977 and 102 in 1978. Especially in 1977, it was about one-third of the others. This result might be led from the weather conditions, nemely sixteen rainy days were obeserved in September of 1977. The scattering seasons of the pollen grains were shown from 3rd September to 5th October in 1976, from 30th August to 20th September in 1977 and from 15th September to 26th September in 1978. The estimated centers of gravities were corresponded to 22nd September in 1976, 14th September in 1977 and 13th September in 1978. From these results, both the maximum peak's month and the center of gravity in each year were recognized in the same month. While α in three years were from 3.48 to 3.96, and the variation of the amplitude was shown very small value of 0.12.

On *Humulus Japonicus*, the total number of the pollen grains in each year were small in number, i.e. 208 in 1976, 106 in 1977 and 70 in 1978. The dispersal seasons of the pollen grains were from 31st August to lst October in 1976, from 19th August to 7th October in 1977 and from 12th September to 26th September in 1978. The estimated centers of gravities were corresponded to 16th September in 1976, 20th September in 1977 and 19th September in 1978, and the maximum peak was observed in the same month. The values of α in three years were from 3.79 to 3.95, and the variation of the amplitude was 0.16.

In this study, the seasonal variation had a tendency to be low, when the dispersal season was long. The center of gravity in fifteen samples was agreed with the maximum peak's month, except that of *Pinus* in '1976 got out a little from the maximum peak's month. Also, the seasonal variations (α) of the five kind of airborne pollen samples, each of which was consisted of closely related species (except on species of *Humulus japonicus*), were recognized between 3.0 amd 4.0. The variance of the intensity of seasonal variation (α), which represents the difference of the dispersal condition in every years, was larger on *Ambrosia* sp. (0.40) and on *Pinus* sp. (0.28), but smaller on *Artemisia* sp. (0.12), on *Humulus japonicus* (0.16) and *Cryptomeria japonica* (0.18). Furthermore, on the whole sample, the parameters of seasonal variations were confirmed to be statistically significant with x^2 test.

It is well Known that the dispersion of pollen grains of each plant is influenced by the situation of environment which were a period of flowering plants, the vegetation and the weather condition, etc. The statistical analysis by the gravitational center method, which shows the dispersal conditions such as sea-'sonal variation graphically, can be regarded as one of the practicable indicator to identify or to compare the annual, monthly or even daily changes in number of dispersal pollen grains.

In previous paper, the pollen grains were collected three days per week by the volumetric method, and in this study, were collected two days per week by the gravimetric method through the year, and the authors obtained a results available to the statistically analysis by the gravititional center method.

The present study will be continued for the purpose of the approach to the pollen allergy.

Summary

A statistical analysis by the gravitational center method was applied to the numbers of pollen grains of five kind of plants collected at Funabashi in 1976–1978, and the following results were observed ;

1) The variation of the intensity of the seasonal variation (α) was larger on *Ambrosia* sp. (0.40) and on *Pinus* sp. (0.28), but smaller on *Artemisia* sp. (0.12), on *Humulus japonicus* (0.16) and *Cryptomeria japonica* (0.18).
2) The seasonal variations (α) of the five airborne pollen samples, each of which was selected from closely related species (except one species of *Humulus japonicus*), were recognized between 3.0 and 4.0.
3) The center of gravity in each sample was agreed with the maximum peak's month, however only that of *Pinus* sp. in 1976 got out a little from the position.
4) The seasonal variation had a tendency to be low, when the dispersal season was long.

From those results, a conclusion was obtained that the dispersal season of the pollen grains, the total

number of the pollen grains and the intensity of the seasonal variations are very closely related to each other. Furthermore, the center of gravity can be regarded as one of the practicable indicator to identify or to compare the annual, monthly or even daily changes in the numbers of the dispersal pollen grains.

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Jpn. J. Allergol., 22, 321—325 (1973) (in Japanese)

要　　約

船橋市において、1976年から1978年の3年間に渡って、標準花粉捕集器で採取した飛散数の多かった5種類の花粉について、重心法によって統計的解析を行い、次のような結果を得た。

1) 花粉の季節変動（α）の変動幅はブタクサ属（0.40）、マツ属（0.28）と大きな値を示したが、ヨモギ属（0.12）、カナムグラ（0.16）、スギ（ヒノキ属を含む）（0.18）と比較的変動に幅がなかった。
2) 近縁種のみで構成される（カナムグラは1種のみ）5種類の夫々の空中浮遊花粉の季節変動の強さは、いずれも3.0から4.0の間に認められた。
3) 求めた15の重心のうち、1976年のマツ属では最大飛散月と重心月がわずかにずれたが、他のものでは、いずれも最大飛散月と重心月は一致した。
4) 飛散期間が長いと季節変動の強さは低めになる傾向が認められた。

これらのことから花粉の飛散において、花粉数と季節変動の強さは互に密接な関連性があるといえる。従って、重心は花粉の年・月・日の飛散状況を把握し、比較し、判断するための実際的指標の1つと思われる。

☆ パリノロジーの中国名は孢粉学

20年前、日本花粉学会の前身、花粉の会をつくる時に、パリノロジーを何と訳するかで討論したことがある。胞子の専門家からは胞子学、花粉の専門家からは花粉学という案がでて、そこで花粉胞子学としたらということになったが、出席していた文部省の百瀬静男博士（シダ研究家）が胞子も広い意味で花粉と同意義だから花粉学ということになった。

さて隣の中華人民共和国はいかがかと、先日送られて来た中国植物学会編集の植物分類学報を見るとパリノロジーを孢粉学と訳している。さすが文字の国で見事な訳だと感心した。中国ではシダの胞子を孢子とよぶ。胞子はニクヅキがついているように動物性であり、正しい使用は同胞というように動物でなければならない。そこで胞子はシダの子供になるので子がついた孢子とよぶ。孢粉学はシダの孢子と種子植物の花粉の両者を扱う学問である。その内容は別記したように形態・分類・系統が主であるらしい。また花粉分析の仕事もある。しかし生理・化学・微細構造などの研究は植物分類学報には見られなかった。（上野）

☆ 玉川大学「ミツバチ科学」Honeybee Science の創刊を祝す

玉川大学ミツバチ科学研究所は農学部教授ミツバチ先生の岡田一次（イチジ）博士を中心としたミツバチ総合研究グループである。昭和24年玉川大学発足と同時に岡田研究室ではミツバチ研究を開始し、卒業生は200名を越え、その業績は国内ばかりでなく、国際的にも高く評価されている。上野もかつてここを訪問したが全員熱心にしかも楽しく勉強している姿には深く感心した。

今回ここからミツバチに関する科学研究誌「ミツバチ科学」が発刊された。その創刊号の内容は、日本の養蜂・ハチミツα-グルコシダーゼ・ミツバチヘギイタダニの知見・ミツバチヘギイタダニの薬剤防除・スズメバチ駆除効果の一例・オオスズメバチの誘引捕殺の試み・養蜂と蜜源・第27回国際養蜂会議（1979 ギリシャ・アテネ）・ローヤルゼリーなどである。ミツバチは虫媒や花粉・蜜源などとも重要な関係があり、今後の「ミツバチ科学」の発展を祈る。B5判・年4回（季刊）・会費1年3,000円 申込先は〒194 町田市玉川学園6－1－1 玉川大学ミツバチ科学研究所 Tel. 0427—32—9111 内線474 郵便振替口座 東京6—56447（上野）