

A COMPARISON OF GRAVIMETRIC AND VOLUMETRIC POLLEN SAMPLERS

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THE PURPOSE of this paper is to investigate the distributions of pollen clump counts obtained by two types of samplers: gravimetric and volumetric. The gravimetric sampler¹ consists of a collection slide mounted between two horizontal plates. As its name implies it depends on natural processes to capture clumps of pollen. The volumetric sampler² employs a black membrane filter in a suitable holder. A metered volume of air is drawn through the filter by a vacuum pump and a flow regulating device. Gravimetric samplers have been in common use for many years. For instance, physicians often use them to measure the prevalence of pollen. However, a volumetric sampler would appear, because of its air volume component, to be a more satisfactory sampler. Despite adverse aerodynamic factors of the device which interfere with its accuracy in the quantitation of the total particulate load of a unit volume of air, it probably is the nearest mechanical proximation of the human nose and it may, therefore, more accurately represent the quantity of particles inhaled than do devices more aerodynamically perfect.

In 1956, the Biophysics Section in the Technical Development Laboratories of the Communicable Disease Center collected pollen from pairs of samplers, one gravimetric and one volumetric, mounted within six feet of each other at varying distances from a pollen source. After two hours of exposure the gravimetric slides were removed from the samplers and stained; then the *Ambrosia elatior* grains were counted within twenty-four hours. After three cubic yards of air were drawn through the volumetric sampler membrane filters, in approximately the same time period as the exposure of the gravimetric slides, they were carefully removed from the holders and were mounted between 2 by 2 inch photographic slide cover glasses. The mounted filters were stored on edge until counting could be done during the winter season. At that time, the filters, in their glass mounts, were illuminated by oblique light by means of which counting could easily be done without staining. A total of 172 pairs of pollen clump counts were obtained during two-hour periods.

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We shall first examine the correlation between the gravimetric and volumetric counts. Then to better characterize and contrast these two types of samplers we shall investigate separately the distributions of pollen clumps collected by them.

RESULTS

In order to examine the association between counts of pollen clumps obtained by the two sampling methods, the logarithms of the pollen clump counts plus one for the gravimetric samplers are plotted against the corresponding logarithms for the volumetric samplers in Fig. 1. Logarithms are used because the distributions of the logarithms of numbers of clumps plus one are more

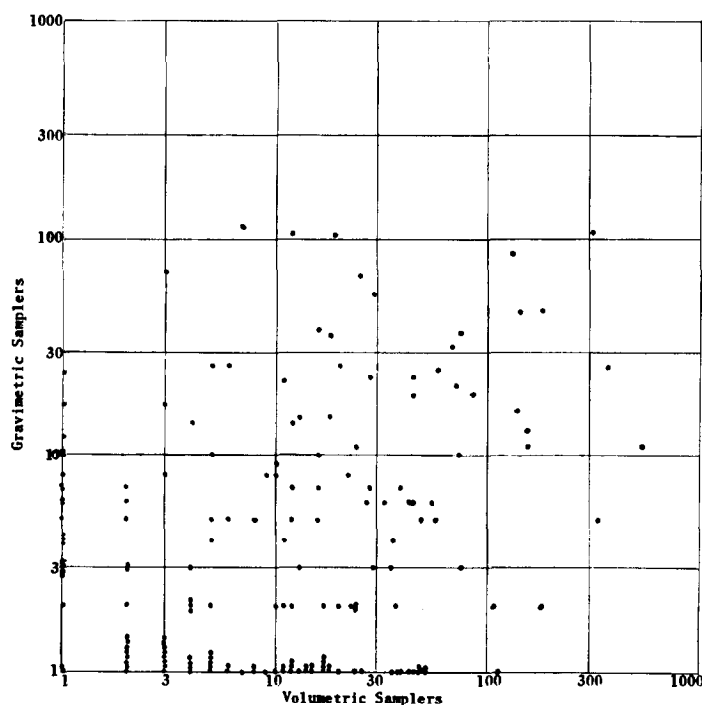


Fig. 1.—A comparison of logarithms of pollen clump counts, plus 1, per two hours for pairs of adjacent gravimetric and volumetric samplers.

nearly symmetrical than the distributions of the actual counts. The points in Fig. 1 are widely scattered and there is only a slight tendency for high gravimetric counts to be associated with high volumetric counts. The product moment correlation coefficient for these logarithms is 0.24. This is much closer to zero, which would indicate no correlation, than it is to one, which would indicate complete positive correlation. This is not a high enough level of correlation to permit precise prediction of, say, a volumetric count to correspond with an observed gravimetric count. This confirms the experience of Cocke³ who predicted volumetric counts from gravimetric counts and found that they deviated by as much as 56 per cent from concurrent volumetric observations.

Next, the logarithms compared in Fig. 1 are plotted separately as the abscissas on logarithmic normal graph paper in Figs. 2 and 3 for the gravimetric and volumetric samplers, respectively. The proportions on the ordinates at the left are the cumulative proportions with which the corresponding numbers of clumps or fewer clumps are observed. The straight lines were computed to represent the data in Figs. 2 and 3 by Bartlett's method.⁴ Expected proportions and, subsequently, frequencies of samples with each number of clumps were determined from the straight lines. These expected frequencies are compared with the observed frequencies of clumps for the gravimetric samplers in Table I and for the volumetric samplers in Table II.

TABLE I. A COMPARISON OF OBSERVED GRAVIMETRIC FREQUENCIES OF POLLEN CLUMP COUNTS PER TWO HOURS WITH EXPECTED FREQUENCIES COMPUTED FROM A LOGARITHMIC NORMAL DISTRIBUTION

NUMBER OF POLLEN CLUMPS PER TWO HOURS	OBSERVED FREQUENCY O	EXPECTED FREQUENCY E
0	64	61.06
1	17	23.22
2	10	13.76
3	7	9.46
4	10	6.88
5	8	5.16
6-7	12	8.60
8-9	6	6.02
10-12	5	6.02
13-15	5	5.16
16-20	5	5.16
21-30	9	5.16
31-45	5	5.16
46+	9	11.18
Total	172	172.00

$$\chi^2 = \Sigma(O-E)^2/E = 11.27 \text{ with 11 degrees of freedom.}$$

TABLE II. A COMPARISON OF OBSERVED VOLUMETRIC FREQUENCIES OF POLLEN CLUMP COUNTS PER TWO HOURS WITH EXPECTED FREQUENCIES COMPUTED FROM A LOGARITHMIC NORMAL DISTRIBUTION

NUMBER OF POLLEN CLUMPS PER TWO HOURS	OBSERVED FREQUENCY O	EXPECTED FREQUENCY E
0	21	18.06
1	14	16.34
2	11	12.04
3	9	10.32
4	10	8.60
5-6	6	12.04
7-8	5	10.32
9-10	9	8.60
11-12	11	5.16
13-15	8	8.60
16-18	10	6.88
19-21	4	5.16
22-25	7	5.16
26-30	5	5.16
31-40	8	8.60
41-50	10	5.16
51-75	10	8.60
76-125	3	6.88
126+	11	10.32
Total	172	172.00

$$\chi^2 = \Sigma(O-E)^2/E = 23.12 \text{ with 16 degrees of freedom.}$$

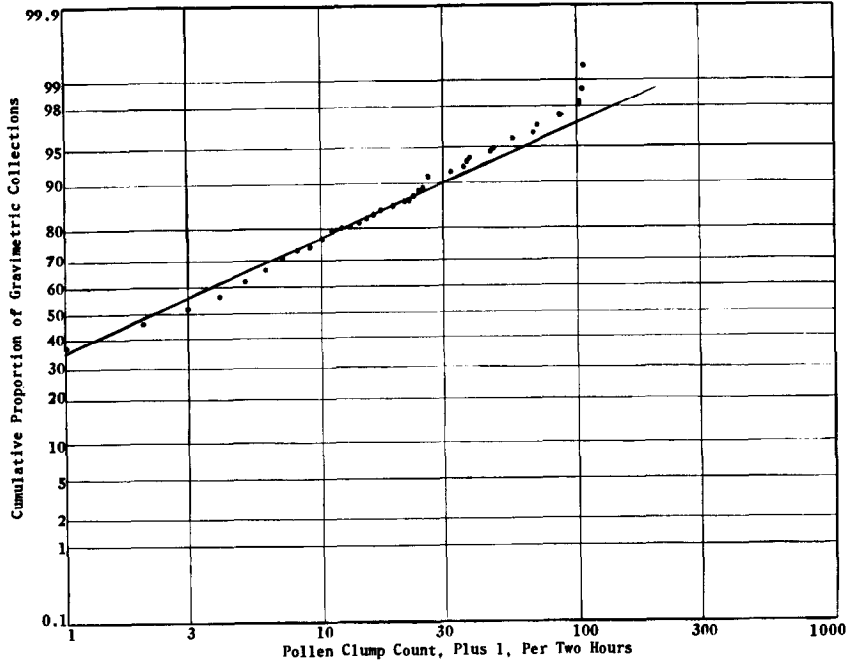


Fig. 2.—Cumulative proportions of gravimetric collections plotted on logarithmic normal graph paper versus pollen clump counts, plus 1, per two hours.

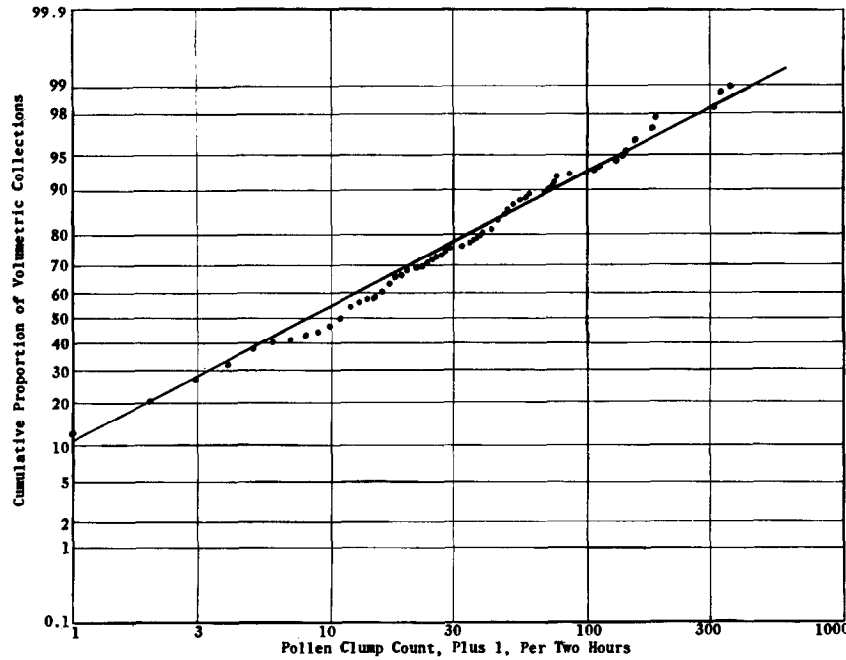


Fig. 3.—Cumulative proportions of volumetric collections plotted on logarithmic normal graph paper versus pollen clump counts, plus 1, per two hours.

The chi-square goodness-of-fit statistic for Table I is 11.27 with 11 degrees of freedom and for Table II is 23.12 with 16 degrees of freedom. The probability, P , of the first chi-square arising when the observations actually come from the fitted distribution is such that $0.25 < P < 0.50$. For the second chi-square value, $0.10 < P < 0.25$.

An attempt was also made to describe the distributions of numbers of clumps for the gravimetric and volumetric samplers by the less skewed negative binomial distribution using the estimation method of maximum likelihood.⁵ The calculated mean m and exponent k for the gravimetric counts were 9.419 and 0.2710,

TABLE III. A COMPARISON OF OBSERVED GRAVIMETRIC FREQUENCIES OF POLLEN CLUMP COUNTS PER TWO HOURS WITH EXPECTED FREQUENCIES COMPUTED FROM A NEGATIVE BINOMIAL DISTRIBUTION

NUMBER OF POLLEN CLUMPS PER TWO HOURS	OBSERVED FREQUENCY O	EXPECTED FREQUENCY E
0	64	65.249
1	17	17.187
2	10	10.617
3	7	7.812
4	10	6.210
5	8	5.156
6-7	12	8.237
8-9	6	6.412
10-12	5	7.459
13-15	5	5.749
16-20	5	7.157
21-30	9	9.090
31-45	5	7.211
46+	9	8.454
Total	172	172.00

$$\chi^2 = \Sigma(O-E)^2/E = 8.045 \text{ with 11 degrees of freedom.}$$

TABLE IV. A COMPARISON OF OBSERVED VOLUMETRIC FREQUENCIES OF POLLEN CLUMP COUNTS PER TWO HOURS WITH EXPECTED FREQUENCIES COMPUTED FROM A NEGATIVE BINOMIAL DISTRIBUTION

NUMBER OF POLLEN CLUMPS PER TWO HOURS	OBSERVED FREQUENCY O	EXPECTED FREQUENCY E
0	21	27.962
1	14	11.622
2	11	8.148
3	9	6.488
4	10	5.475
5-6	6	9.034
7-8	5	7.380
9-10	9	6.282
11-12	11	5.484
13-15	8	7.118
16-18	10	6.115
19-21	4	5.349
22-25	7	6.205
26-30	5	6.602
31-40	8	10.450
41-50	10	7.901
51-75	10	13.099
76-125	3	12.384
126+	11	8.902
Total	172	172.00

$$\chi^2 = \Sigma(O-E)^2/E = 29.319 \text{ with 16 degrees of freedom.}$$

respectively, while for the volumetric counts the corresponding estimates were 31.01 and 0.4213. Tables III and IV compare the observed frequencies with the expected negative binomial frequencies for the two types of samplers. For the gravimetric data, chi-square equals 8.045 with 11 degrees of freedom and $0.50 < P < 0.75$; for the volumetric data chi-square equals 29.319 with 16 degrees of freedom and $0.010 < P < 0.025$.

Note that both the logarithmic normal and the negative binomial distributions better describe the distribution of gravimetric clump counts than that of volumetric clump counts. However, the gravimetric count distribution is fitted more closely by the negative binomial distribution than by the logarithmic normal while the opposite is true for the volumetric count frequencies.

DISCUSSION

One way in which the negative binomial distribution may be generated mathematically is to assume that the probability of capture in different samplers or in the same sampler at different times varies in accordance with a gamma distribution, a flexible unimodal distribution, and that the distribution of clumps for a given sampler and time is Poisson. The latter assumption implies that each pollen clump is sampled randomly and independently. Since the distribution of pollen clump counts for the gravimetric samplers is described very well by the negative binomial distribution, it is reasonable to assume that each gravimetric sampler collects a random sample of the pollen clumps passing over it.

On the other hand, the volumetric samplers placed adjacent to the gravimetric samplers yielded relatively fewer samples with no pollen clumps and the range of the number of clumps captured by the volumetric samplers was much greater. This greater skewness of the pollen clump distribution for the volumetric samplers was borne out by the better fit of the logarithmic normal distribution than the negative binomial distribution to the volumetric data.

SUMMARY AND CONCLUSIONS

The correlation between pollen clump counts obtained by the two types of samplers is not sufficiently high to predict the performance of one type of sampler from results obtained with the other. The gravimetric sampler would seem to be preferable if the number of pollen clumps which would be expected to fall on a surface without special attraction were desired. However, the volumetric sampler is more appropriate for determining the number of clumps which are injected into the nose because of similarity of construction. The volumetric samplers captured at least one pollen clump more often than did the gravimetric samplers and, in general, the volumetric samplers tended to give higher pollen clump counts even though the two types of samplers were placed side by side.

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