
The effect of windspeed on pollen and spore counts collected with the Rotorod Sampler and Burkard spore trap

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Background: A recent review article presented conflicting evidence concerning the relationship between the Rotorod Sampler's particle collection efficiency and windspeed. Conventional wisdom holds that its collection efficiency is not affected by windspeed; experimental data paint a mixed picture.

Objectives: This brief addendum will present additional data concerning the relationship between the Rotorod's collection efficiency and windspeed. This information will be contrasted with similar data for the Burkard spore trap.

Data source: Data obtained from an obscure technical report published by Ogden et al. in 1969 will be assessed.

Results: The Rotorod's collection efficiency appeared to be greatest at moderate windspeeds; lower efficiencies occurred at both lower and higher windspeeds. Maximum changes in collection efficiency ranged from 29% to 39% over the six windspeeds employed.

The Burkard exhibited the opposite relationship between collection efficiency and windspeed. Collection efficiency was lowest at moderate windspeeds and higher at both lower and higher windspeeds. Maximum changes in collection efficiency ranged from 38% to 142%.

Conclusions: Four principal conclusions emerged. First, these newly rediscovered data demonstrate that the Rotorod's collection efficiency is affected by windspeed. These results appear to overturn the conventional wisdom which holds that this device is insensitive to wind.

Second, the Rotorod is less affected by windspeed than the Burkard. The maximum change in collection efficiency uncovered for the former device was 39%; this represented the minimum maximum change for the latter device.

Third, the Rotorod and Burkard are affected by windspeed in fundamentally different ways. The former device's collection efficiency is greatest at moderate windspeeds and lower at both lower and higher windspeeds. The opposite effect occurs with the latter device.

Last, the previous two findings may partially explain some of the differences in particle recovery by the two devices noted in the parent publication. Figures and equations presented in this addendum indicate which circumstances are likely to produce these differences.

Ann Allergy Asthma Immunol 2000;85:392–394.

INTRODUCTION

A recent review article presented conflicting evidence concerning the relationship between the Rotorod Sampler's

particle collection efficiency and windspeed.¹ Conventional wisdom holds that its collection efficiency is not affected by windspeed; experimental data paint a mixed picture. Additional investigations to resolve this matter appeared warranted.

An obscure technical report that examined the relationship between the Rotorod's particle collection efficiency and windspeed recently came to the

author's attention.² The purpose of this brief addendum is to present data from that report and to comment on its significance.

EXPERIMENTAL DATA

Ogden et al studied the Rotorod's particle collection efficiency over a range of six windspeeds.² Plastic collector rods—a relatively new development at that time—were used presumably per the design of Brown et al.³

The Rotorod was placed in a wind tunnel; *Ustilago* spores (6 μm) and *Ambrosia* (20 μm) and *Phleum* (32–35 μm) pollen were then introduced. The Rotorod's particle recovery was compared to recovery by an isokinetic sampler placed nearby. Several trials ($n = 2$ to 4) of 5 to 8 minutes were conducted for each wind speed.

Figure 1 demonstrates the relationship between particle collection efficiency and windspeed for each particle type. For the smallest and largest particles employed, collection efficiency increased to a maximum at moderate windspeeds and then decreased. This effect was not apparent for *Ambrosia* where collection efficiency generally increased with windspeed (Figure 1b). The "Appendix" presents mathematical equations for the depicted curves.

The difference between the minimum and maximum collection efficiencies was nearly equivalent for *Ustilago* and *Ambrosia* (30% and 29%, respectively) but was a bit wider for *Phleum* (39%).

Similar experiments were conducted with the Hirst spore trap (= Burkard spore trap) for the same particle types; these data were presented in the parent publication.¹ Particle collection efficiency changed by 38%, 66% and

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The author is an employee of Multidata LLC. Sampling Technologies, the manufacturer of the Rotorod Sampler, is a wholly-owned subsidiary of Multidata LLC.

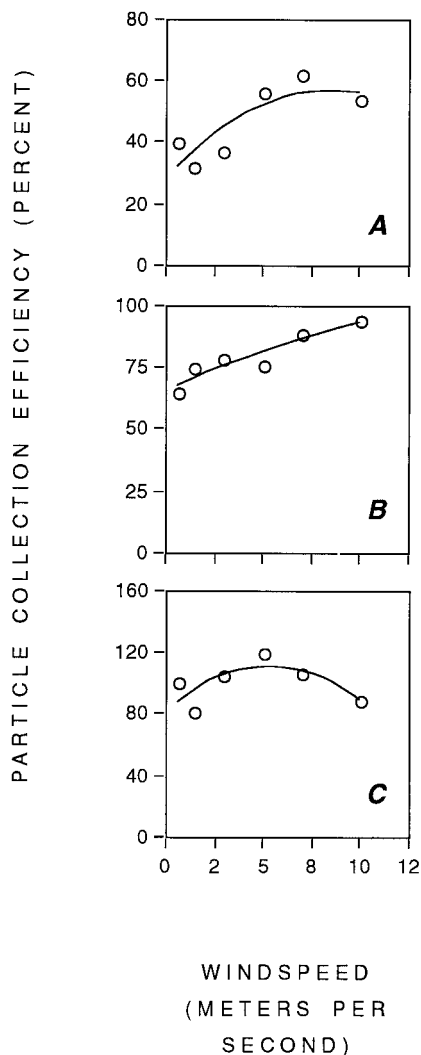


Figure 1. Rotorod Sampler empirical particle collection efficiency as a function of wind speed. (A) *Ustilago* spores ($6\ \mu\text{m}$), (B) *Ambrosia* pollen grains ($20\ \mu\text{m}$), and (C) *Phleum* pollen grains (32 to $35\ \mu\text{m}$). Data adapted from Reference 2.

142% for *Ustilago*, *Ambrosia*, and *Phleum*, respectively (Fig 2, parent).

The relationship between the Rotorod and Burkard's collection efficiency as a function of windspeed for each particle type is presented in Figure 2 (see "Appendix").

DISCUSSION

These newly rediscovered data yield four principal conclusions concerning the relationship between the Rotorod's

particle collection efficiency and wind-speed.

First, the Rotorod's collection efficiency is affected by windspeed. These results appear to overturn the conventional wisdom which holds that this device is insensitive to wind.

These findings generally agree with Carter's work with *Mycosphaerella pinodes* spores (6 to 8×12 to $15\ \mu\text{m}$).⁴ He reported that the Rotorod was 50% and 90% efficient at 1 to 2 m/s and 4 to 5 m/s, respectively. Ogden et al. reported a similar phenomenon with somewhat smaller *Ustilago* spores at 1.5 and 5 m/s (32% and 56% efficient, respectively).

In contrast, Carter's work with *Lycopodium clavatum* spores ($30\ \mu\text{m}$) is more difficult to harmonize with data from Ogden et al. In the former experiment the Rotorod was 80% to 85% and 60% to 65% efficient at 1.5 and 9 m/s, respectively. At similar windspeeds, Ogden et al. demonstrated greater recovery of *Phleum* pollen at the higher windspeed (81% and 98%, respectively, with the latter value derived from Equation 2). The reasons for these experimental differences are not clear.

Second, the Rotorod is less affected by windspeed than the Burkard. The maximum change in collection efficiency uncovered for the former device was 39%; this represented the minimum maximum change for the latter device. Figure 1 of this addendum and Figure 2 of the parent publication illustrate these contrasts.

Third, the Rotorod and Burkard are affected by windspeed in fundamentally different ways. The former device's collection efficiency is greatest at moderate windspeeds and lower at both lower and higher windspeeds (Fig 1). The opposite effect occurs with the latter device (Fig 2, parent).

Last, the previous two findings may partially explain some of the differences in particle recovery by the two devices noted in the parent publication. The Burkard yielded a higher estimate of the atmospheric particle concentration in five parallel trapping investigations (Fig 3, parent). Figure 2 indicates

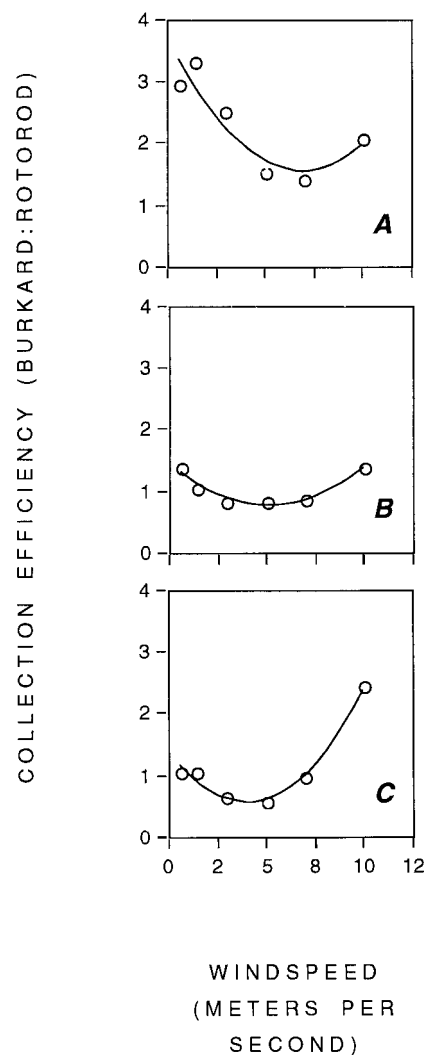


Figure 2. Empirical differences in particle collection efficiency between the Rotorod Sampler and Burkard spore trap as a function of windspeed. (A) *Ustilago* spores ($6\ \mu\text{m}$), (B) *Ambrosia* pollen grains ($20\ \mu\text{m}$), and (C) *Phleum* pollen grains (32 to $35\ \mu\text{m}$). Data adapted from Reference 2.

which circumstances are likely to produce these differences. Additional explanations for recovery differences are supplied in the parent publication.

APPENDIX

This appendix furnishes mathematical equations for the curves that appear in Figures 1 and 2.

Figure 1 depicts the relationship between windspeed (ω , m/s) and the Ro-

torod Sampler's particle collection efficiency (E , percent). The curves that appear in panes A–C, respectively, are described by the following equations:

$$E = -0.053\omega^2 + 3.281\omega + 66.480 \quad R = 0.932 \quad (1)$$

$$E = -1.032\omega^2 + 11.038\omega + 82.396 \quad R = 0.730 \quad (2)$$

$$E = -0.398\omega^2 + 6.808\omega + 28.383 \quad R = 0.845 \quad (3)$$

where R represents each equation's correlation coefficient. These expression can be directly compared to Equations 10–12 of the parent publication.¹

Figure 2 depicts differences in particle collection efficiency between the Rotorod Sampler and Burkard spore trap as a function of windspeed. The curves that appear in panes A–C, respectively, are described by the following equations:

$$B = 0.045\omega^2 - 0.631\omega + 3.746 \quad R = 0.911 \quad (4)$$

$$B = 0.027\omega^2 - 0.273\omega + 1.461 \quad R = 0.974 \quad (5)$$

$$B = 0.052\omega^2 - 0.420\omega + 1.396 \quad R = 0.991 \quad (6)$$

where B is a ratio (Burkard:Rotorod, the Rotorod component representing unity).

ERRATA

This section furnishes three pieces of errata for the parent publication.¹

First, a sentence in the passage concerning Aylor's work (page 344, reference 47) makes apparently contradic-

tory claims. Results *were* statistically significant (as indicated by $P < .01$); the word *not* appears in the sentence in error.

The data from Aylor's indoor experiment ($n = 8$) were reanalyzed for this addendum. Regression analysis demonstrated that spore counts were highly correlated ($R = 0.986$), however, data from the sixth trial appeared to exert undue influence on the model. These data were then excluded. The remaining spore counts were correlated ($R = 0.982$); a paired comparisons t test demonstrated that differences in recovery were statistically significant ($P = .005$).

Similarly, the data from the outdoor experiment ($n = 21$) were reanalyzed. A weighted regression analysis was performed to control for increasing variance as spore counts increased. Spore counts were correlated ($R = 0.768$), however, data from two trials (105.2 and 105.3) were found to exert undue influence on the model. These data were then excluded. The remaining spore counts were correlated ($R = 0.876$); a paired comparisons t test demonstrated that differences in recovery were statistically significant ($P = .001$).

Second, the passage concerning work by Solomon et al. (page 344, reference 49) presents a statement concerning statistical significance. This conclusion was based on a reanalysis of data presented in Table 2 of their original paper. Although the median recoveries by the two devices were correlated ($R = 0.829$) it was not appropriate to perform a test of statistical significance on those data. That claim is therefore withdrawn.

Last, the author here takes the opportunity to supplement the historical literature concerning the Burkard spore trap. Hirst's original device collected samples over 24 hours on standard 1 ×

3 inch glass microscope slides.⁵ A modified version of Hirst's trap was presented by Brown and Jackson two decades later.⁶ Figure 4 of their publication depicts a device that readers will recognize as the seven-day spore trap now manufactured by Burkard.

ACKNOWLEDGEMENT

The author gratefully acknowledges Brandon L Guthrie, Macalester College, St. Paul, Minnesota for statistical assistance with the issues addressed in Errata.

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