

A side-by-side comparison of Rotorod and Burkard pollen and spore collections

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ABSTRACT

Background: The Rotorod sampler and Burkard spore trap are 2 devices commonly used to quantify airborne particles.

Objective: To evaluate the differences in collections between the 2 devices for a wide range of plant pollens and fungal spores.

Methods: Pollens and spores were collected simultaneously with each device on 167 days during a 1-year period.

Results: The Burkard yielded significantly higher total and individual mold spore counts. It yielded statistically higher total grass, total weed, and Urticaceae daily pollen counts, although the absolute differences were small. Daily counts were positively correlated between the 2 devices for the most abundant pollens and mold spores.

Conclusion: The Burkard spore trap collects many more mold spores than the Rotorod over a wide variety of species. The Burkard also yielded higher total grass, total weed, and Urticaceae daily pollen counts. Despite these differences, however, either device can be used to follow trends in the most abundant pollen and mold spores.

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Introduction

The practice of allergy requires careful attention to patients' exposures to suspect allergens. In the evaluation and treatment of allergic rhinitis and allergic asthma, locally obtained pollen and mold spore counts often serve as a surrogate for patient exposure to these agents. Understanding differences between collection techniques for local aeroallergen counts is therefore critical to the proper practice of allergy. We briefly discuss 2 common sampling devices, the Rotorod sampler and Burkard spore trap, and compare the results obtained using both devices during a 1-year period.

The Rotorod sampler is a rotating arm impactor that collects airborne particles on 2 rapidly spinning polystyrene rods. The leading surface of each rod is coated with an adhesive to retain any impacted particles. After the collection period, the rods are removed and examined under light microscopy. The volume of sampled air is then calculated, allowing results to be expressed as particles per meter cubed. A 10% duty cycle (1 minute on, 9 minutes idle) is generally recommended.¹ The Rotorod has traditionally been considered to be insensitive to wind, although it may be most efficient at moderate wind speeds.^{2,3} The Rotorod collects particles

down to 10 μm efficiently, becoming progressively less efficient as particle size decreases further.^{3,4}

The Burkard 7-day recording spore trap is a Hirst-type (suction-slit) sampler. A pump pulls air through a slit at 10 L/min, causing particles to affect the collection surface below. The 7-day collector uses an adhesive tape rotating at a 2 mm/h. An attached wind vane rotates the device to keep the slit aligned in the direction of the wind. This device is generally effective at collecting particles larger than 3.7 μm .³ The Burkard's collection efficiency is more affected by wind speed than the Rotorod.^{2–5}

Previous parallel pollen and mold spore trapping studies have tended to favor the Burkard but have generally been limited to one or a few aeroallergen species during a single season.^{6–12} We compare pollen and spore collections from multiple plant and fungal species during a 1-year period.

Methods

A Rotorod sampler model 40 and a Burkard 7-day recording volumetric spore trap were operated on the corner of a roof of a second story building in San Antonio, Texas. The rooftop was 4.5 m above ground level, with the sampling areas of the Burkard and Rotorod located an additional 1.4 and 1.3 m above the rooftop, respectively. There were no obstructions within 270°. The nearest obstruction was a 4.6-m wall located 16.1 m from the devices. There was no unusual vegetation in the immediately surrounding area.

The 24-hour pollen and mold spore collections were obtained simultaneously using both devices on 167 days from June 23, 2011, through June 29, 2012. The collection periods started at 6:30 AM

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Table 1
Mold spore device comparison data

Mold spores	Spore size, μm	Device	Days ^a	Sum of counts	Median count, particles/ m^3	Interquartile range	Peak, particles/ m^3	Wilcoxon <i>P</i> value ^b	Device correlation	
									Spearman coefficient	Spearman <i>P</i> value ^b
<i>Cladosporium</i>	5–7 ^c	Burkard	167	599,872	1,360	346.5–4059	44,205	<.001	0.941	<.001
		Rotorod		175,236	366	157–1,122	11,814			
<i>Ascospores</i>	5–10 ^c	Burkard	167	218,880	381	206.5–835.5	24,631	<.001	0.854	<.001
		Rotorod		62,939	162	89.5–402.5	5,123			
<i>Alternaria</i>	20–63	Burkard	167	41,530	132	67–328.5	2,642	<.001	0.947	<.001
		Rotorod		19,968	74	35.5–161.5	1,190			
Basidiospores	5–10	Burkard	162	32,805	37	17–102	3,760	<.001	0.853	<.001
		Rotorod		4,803	9	3–17	794			
<i>Myxomycetes</i> or smut	10–13	Burkard	167	30,520	149	86–249	747	<.001	0.744	<.001
		Rotorod		12,745	64	37–101	300			
<i>Fusarium</i>	12–15	Burkard	136	4,852	12	5–35	453	<.001	0.723	<.001
		Rotorod		1,517	5	2–13	122			
<i>Bipolaris</i>	55–75	Burkard	157	4,592	17	7–35	408	<.001	0.745	<.001
		Rotorod		2,116	8	3–17	162			
<i>Nigrospora</i>	15–20	Burkard	164	3,909	17	7–30	164	<.001	0.722	<.001
		Rotorod		2,061	9	5–17	81			
<i>Curvularia</i>	30–40	Burkard	150	1,759	7	2–17	62	<.001	0.472	<.001
		Rotorod		796	3	1–7	61			
<i>Periconia</i>	16–18	Burkard	146	1,080	5	2–10	35	<.001	0.407	<.001
		Rotorod		572	2	1–6	49			
<i>Epicoccum</i>	25–40	Burkard	142	862	5	2–7	37	.047	0.356	<.001
		Rotorod		712	3	2–7	68			
<i>Puccinia</i> (rust)	25–35	Burkard	65	486	5	2–7	62	.002	0.28	.02
		Rotorod		270	2	0–7	19			
<i>Pithomyces</i>	16–23	Burkard	86	221	2	2–2	15	<.001	–0.252	.02
		Rotorod		93	1	0–1	6			
<i>Stemphylium</i>	40–55	Burkard	51	182	2	2–5	17	<.001	0.174	NS
		Rotorod		105	0	0–2	24			
Total molds	5–75	Burkard	167	941,550	2,581	1,048–5,863	67,568	<.001	0.916	<.001
		Rotorod		283,933	951	446.5–1,826.5	15,086			

Abbreviation: NS, nonsignificant.

^aThe number of days a spore was detected on either device (of 167 possible collection days).

^bIndividual test *P* values. Correcting for multiple comparisons, study wide $\alpha < .05$ corresponds to *P* < .001.

^cAlthough these spores can vary greatly in size, most were in this range.

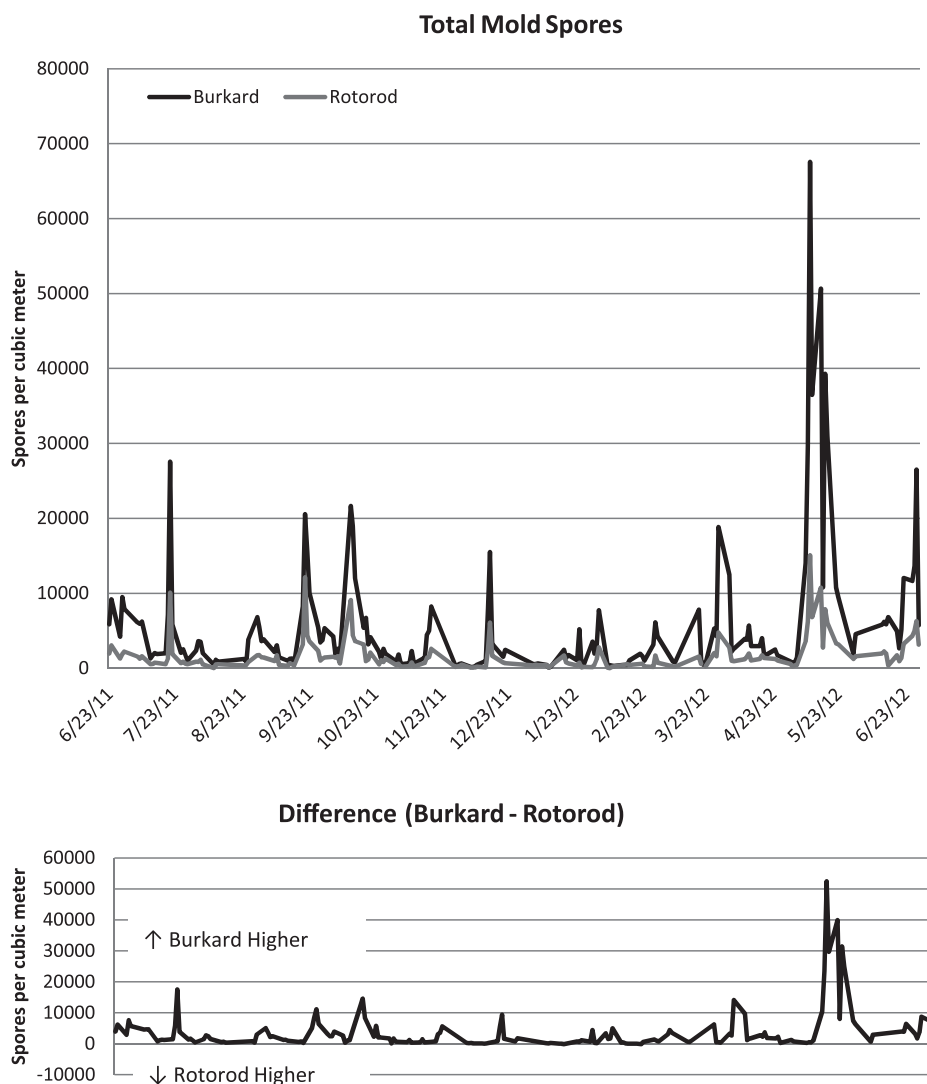


Figure 1. Daily total mold spore counts.

Mondays through Thursdays, ending at 6:30 AM Tuesday through Friday. The devices were harvested daily, and the collection day was defined as the day the collection ended. Because of holidays and absences, the number of simultaneous collections per month ranged from a minimum of 10 in March to a maximum of 17 in September. The devices were operated as recommended by their manufacturers, including a 10% duty cycle for the Rotorod.

After collection, samples were stained with Calberla's solution and examined under light microscopy at $\times 400$ magnification. Pollens and spores were identified by an individual (R.A.G.) certified by the National Allergy Bureau as a pollen and mold counter, and particles per cubic meter were calculated. The paired particle counts were analyzed using the 2-tailed Wilcoxon signed ranks test, and correlation between devices was assessed using Spearman ρ . Days when neither device collected a relevant particle were excluded from analysis to avoid systematically biasing the correlation toward equivalence and to facilitate interpretation of median counts.

Results

Mold spores were detected every day. There were significant differences in median total mold count between the Burkard and Rotorod (2,581 particles/m³ vs 951 particles/m³; $P < .001$), but there

was a high correlation between devices ($\rho = 0.916$, $P < .001$) (Table 1 and Fig 1). Most individual molds had spore counts that were positively correlated between the 2 devices but with significantly different medians (Table 1). One or more tree pollens were detected on 149 of the 167 days. Differences in the median total tree pollen count were observed between the Burkard and Rotorod (16 particles/m³ vs 13 particles/m³; $P = .009$) (Table 2 and Fig 2). Results for individual tree pollens are summarized in Table 2. One or more weed pollens were detected on 151 days, and a difference in median pollen count was observed between the 2 devices (9 particles/m³ vs 7 particles/m³; $P < .001$) (Table 3 and Fig 3). One or more grass pollens were detected on 128 days, and a difference was noted between the 2 devices in median grass pollen count (4.5 particles/m³ vs 2 particles/m³; $P < .001$) (Table 3 and Fig 4). The Burkard and Rotorod daily pollen counts were positively correlated for total trees, total weeds, and grass ($P < .001$). Significance values listed are for individual tests. With adjustment for multiple tests, an experiment-wide significance level of $\alpha < .05$ corresponds to individual significance levels of $P < .001$.

Discussion

Previous parallel aeroallergen trapping investigations have focused on a limited number of fungal and plant species and/or

Table 2
Tree pollen device comparison data

Pollen	Pollen size, μm	Device	Days ^a	Sum of counts	Median count, particles/m ³	Interquartile range	Peak, particles/m ³	Wilcoxon <i>P</i> value ^b	Device correlation	
									Spearman coefficient	Spearman <i>P</i> value ^b
<i>Quercus</i> (oak)	30–45	Burkard	25	3,055	5	0–115	1,312	NS	0.88	<.001
		Rotorod		4,302	3	1–111	1,440			
<i>Juniperus</i> (mountain cedar)	25–35	Burkard	57	2,075	3	1–17	538	NS	0.698	<.001
		Rotorod		7,308	3	1–9	2,700			
<i>Celtis</i> (hackberry)	28–30	Burkard	96	1,893	7	1.5–24	162	.004	0.893	<.001
		Rotorod		1,550	5.5	1–20.5	133			
<i>Fraxinus</i> (ash)	20–30	Burkard	26	1,455	13.5	2–84	356	.008	0.903	<.001
		Rotorod		1,332	4	1–52	345			
<i>Ulmus</i> (cedar elm)	28–33	Burkard	26	666	8	2–22	248	NS	0.881	<.001
		Rotorod		713	7	3–21	303			
<i>Salix</i> (willow)	18–20	Burkard	33	261	2	0–7	52	.003	0.547	.001
		Rotorod		148	1	1–5	39			
<i>Carya</i> (pecan)	50–55	Burkard	16	157	7	2–16	30	NS	0.884	<.001
		Rotorod		116	6	4–11.5	17			
<i>Acer</i> (maple)	35–40	Burkard	34	138	2	2–5	32	.003	0.145	NS
		Rotorod		59	1	1–2	10			
<i>Prosopis</i> (mesquite)	32–36	Burkard	48	93	1	0–2	20	NS	0.285	.0499
		Rotorod		100	1	1–2	18			
<i>Morus</i> (mulberry)	20–22	Burkard	27	52	1	0.5–2	7	NS	0.24	NS
		Rotorod		51	1	0.5–3	7			
<i>Ulmus</i> (American elm)	28–33	Burkard	18	47	1	0–5	15	NS	0.336	NS
		Rotorod		31	1	1–2	9			
<i>Pinus</i> (pine)	100–130	Burkard	29	39	1	0–2	5	NS	0.028	NS
		Rotorod		34	1	0–1	7			
<i>Ligustrum</i> (privet)	30–40	Burkard	27	27	1	0–2	5	NS	–0.13	NS
		Rotorod		29	1	0.5–1	4			
<i>Populus</i> (cottonwood)	30–35	Burkard	8	25	2	2–3.5	10	.03	0.12	NS
		Rotorod		6	1	0–1	2			
<i>Broussonetia</i> (paper mulberry)	10–12	Burkard	3	6	2	1.5–2.5	3	NS	0.866	NS
		Rotorod		8	0	0–4	8			
<i>Juglans</i> (walnut)	35–45	Burkard	5	4	0	0–2	2	NS	0.612	NS
		Rotorod		6	1	1–1	2			
<i>Alnus</i> (alder)	22–25	Burkard	3	3	1	0.5–1.5	2	NS	–0.866	NS
		Rotorod		1	0	0–0.5	1			
Other trees ^c	23–60	Burkard	22	40	0.5	0–2	12	NS	0.398	NS
		Rotorod		53	2	1–4	7			
Total trees	10–130	Burkard	149	10,036	16	3–52	1,482	.009	0.922	<.001
		Rotorod		15,847	13	3–46	2,700			

Abbreviation: NS, nonsignificant.

^aThe number of days a pollen was detected on either device (of 167 possible collection days).

^bIndividual test *P* values. Correcting for multiple comparisons, study wide $\alpha < .05$ corresponds to *P* < .001.

^cPredominantly *Acacia* and *Betula*.

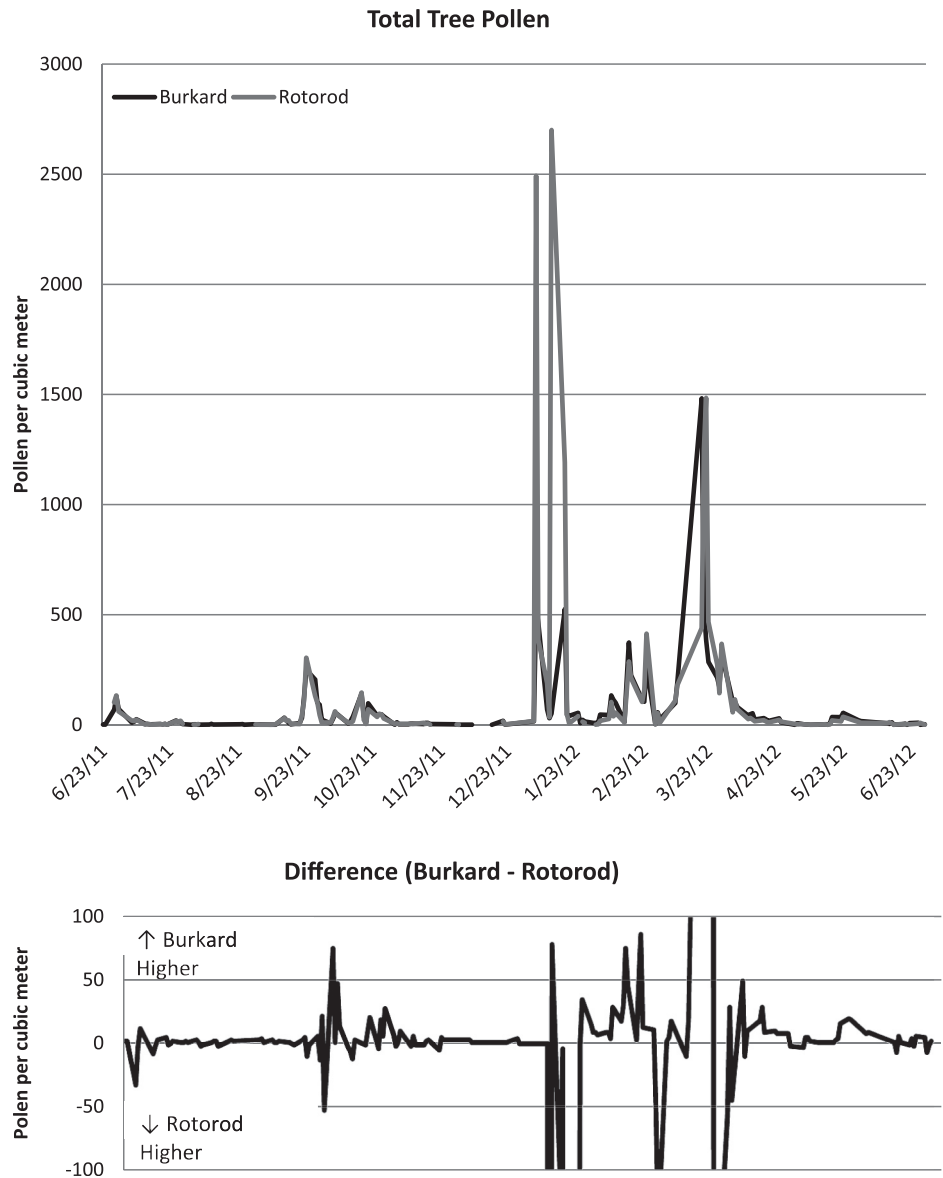


Figure 2. Daily total tree pollen count.

Table 3
Weed and grass pollen device comparison data

Pollen	Pollen size, μm	Device	Days ^a	Sum of counts	Median count, particles/ m^3	Interquartile range	Peak, particles/ m^3	Wilcoxon P value ^b	Device correlation	
									Spearman coefficient	Spearman P value ^b
Urticaceae (nettle/pellitory)	14–17	Burkard	109	1,999	4	2–12	214	<.001	0.694	<.001
		Rotorod		1,008	2	1–6	104			
<i>Ambrosia</i> (ragweed)	16–23	Burkard	84	723	2	1–11	53	NS	0.747	<.001
		Rotorod		596	2	1–9.5	50			
<i>Chenopodium</i> (goosefoot)	20–32	Burkard	114	429	2	2–5	30	NS	0.558	<.001
		Rotorod		362	2	1–4	21			
<i>Rumex</i> (dock/sorrel)	20–30	Burkard	65	318	2	1–7	32	.01	0.465	<.001
		Rotorod		212	1	1–3	22			
<i>Artemisia</i> (mugwort)	20–29	Burkard	42	271	1	1–4	100	NS	0.388	.01
		Rotorod		160	1	1–3	29			
Asteraceae	17–22	Burkard	52	62	1	0–2	10	NS	–0.244	NS
		Rotorod		76	1	0–2	7			
Total weeds	14–32	Burkard	151	3,802	9	3.5–27.5	316	<.001	0.853	<.001
		Rotorod		2,415	7	3–22.5	112			
Grass	28–55	Burkard	128	827	4.5	1–10	52	<.001	0.812	<.001
		Rotorod		484	2	1–6	21			

Abbreviation: NS, nonsignificant.
^aThe number of days a pollen was detected on either device (of 167 possible collection days).
^bIndividual test P values. Correcting for multiple comparisons, study wide $\alpha < .05$ corresponds to $P < .001$.

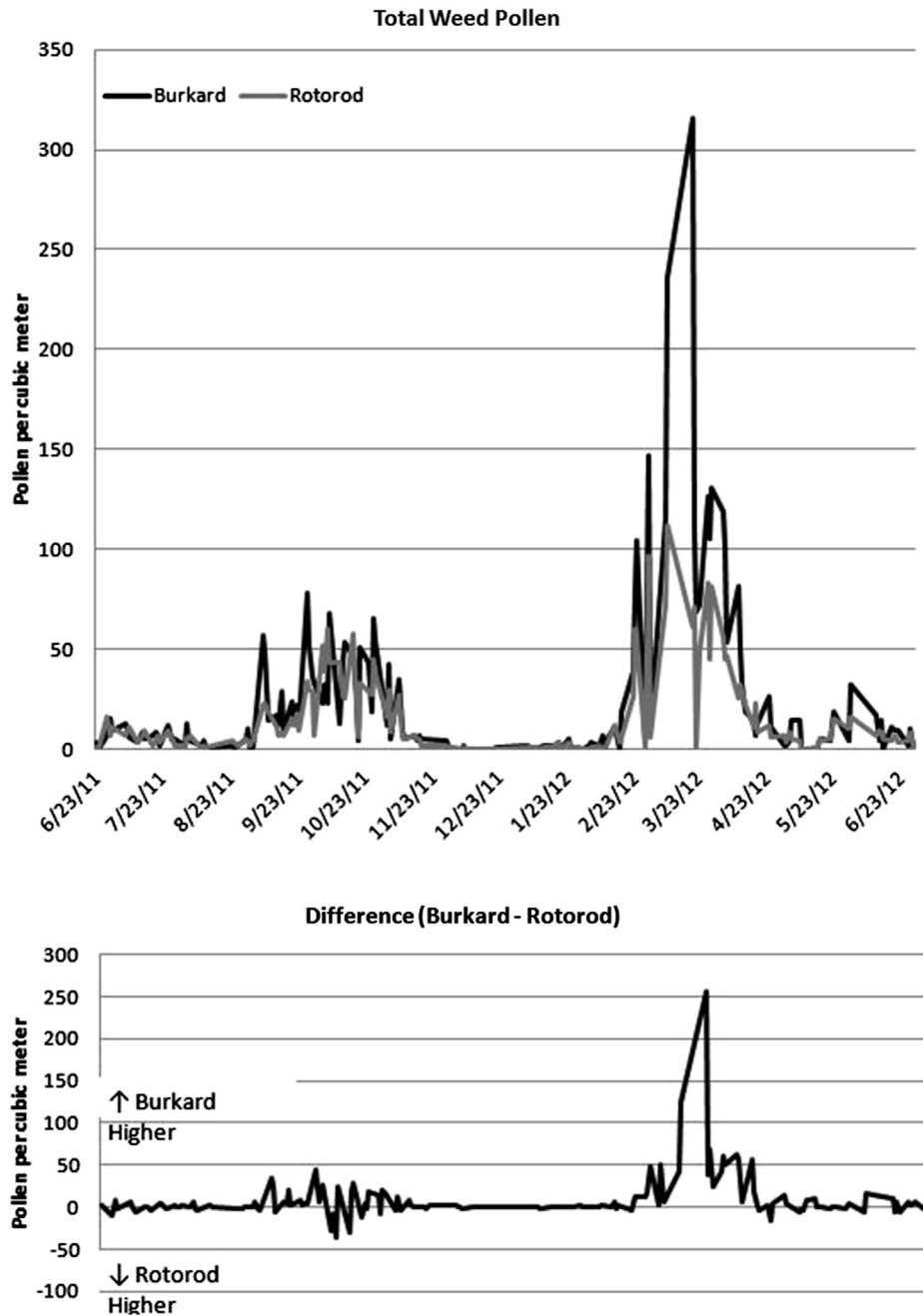


Figure 3. Daily total weed pollen counts.

were performed for limited amounts of time.^{6–12} To our knowledge, this is the longest parallel trapping investigation to date that involves multiple potential allergens. We confirmed that the Burkard consistently collects total and individual mold spores in significantly higher numbers than the Rotorod. Of note, *Aspergillus* and *Penicillium* spores were not included in our daily collections because of the difficulty in accurately identifying these molds without culture. Because their small size ($<5\ \mu\text{m}$), however, we would also expect the Burkard to significantly outperform the Rotorod in their collection.

Although the Burkard provided higher total grass, total weed, and total tree daily pollen counts, the absolute difference was small and may not meaningfully affect a clinician's interpretation. Our data also suggest that the Burkard is more efficient than the

Rotorod for some individual plant species pollens, particularly Urticaceae (nettle/pellitory), which produce a small pollen on the order of $14\ \mu\text{m}$ in diameter.

We found positive correlations between devices for total tree pollen, weed pollen, grass pollen, and mold spore daily counts for the most abundant individual genera. Similarly, Latorre et al⁶ also found total pollen counts between the Burkard and Rotorod were positively and significantly correlated. This finding implies that although daily counts may not always be equal between devices, either device can be used to follow trends for the most abundant particles.

There are limitations to our study worth noting. Some pollens were detected at only low levels and/or on a limited number of days, limiting the ability to find a true difference that may exist between devices in areas with higher airborne pollen levels and/or

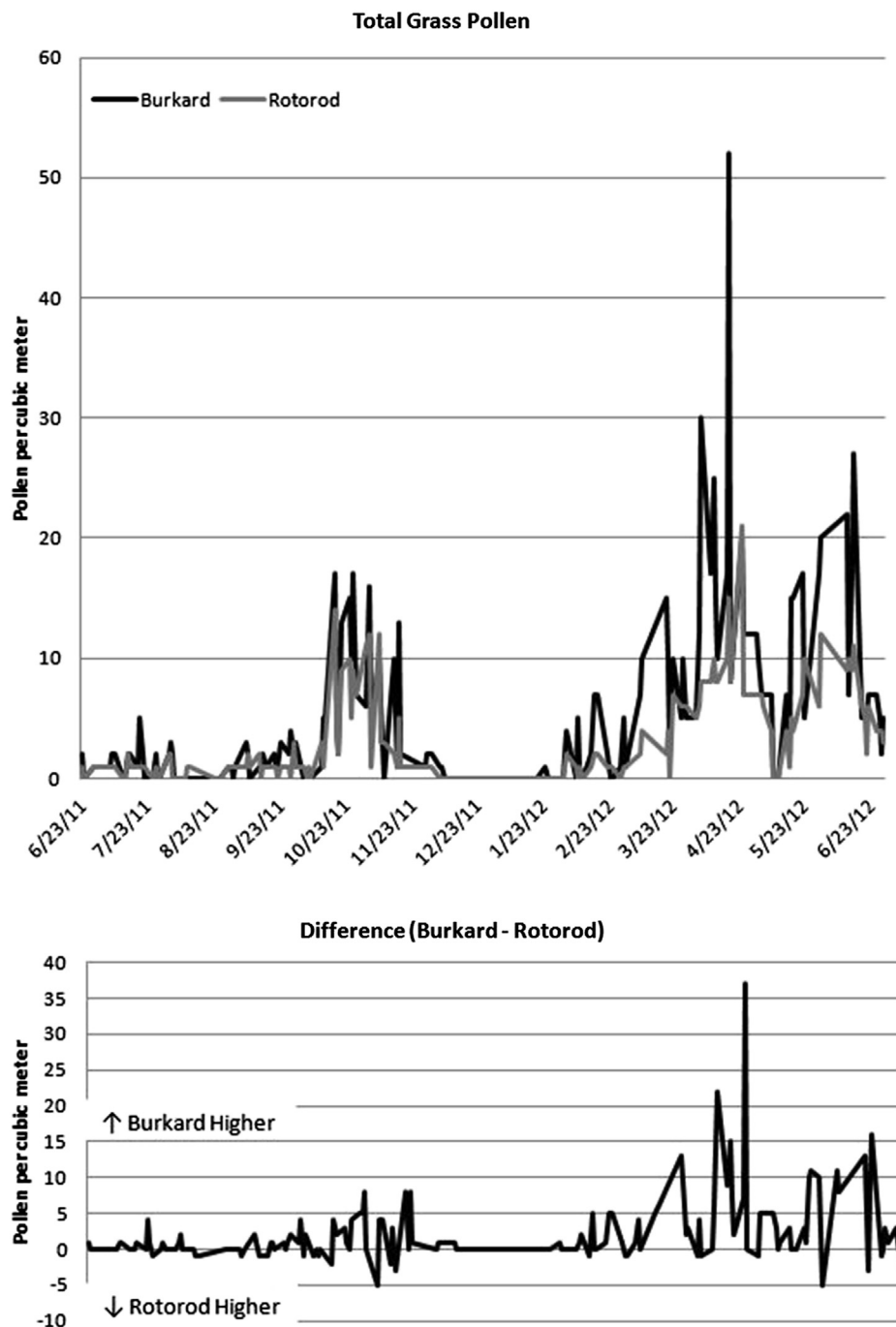


Figure 4. Daily total grass pollen counts.

longer pollination seasons. The fewer collections in March may have reduced the ability to detect small collection differences for some spring pollinators, such as *Quercus* (oak). Because we had only one of each type of device, intradevice variability could not be assessed. Our devices were located 1.4 m from each other. Although we expect little of the variation between devices to be due to location, this could not be definitively assessed. Lastly, our analysis did not evaluate the possible effect of wind or rain.^{8,9}

Two outlying days of collection were noted for *Juniper asheii* (mountain cedar) that were also reflected in the total tree pollen count. These days occurred at the peak of the pollen season, when the Rotorod yielded counts of 2,492 particles/m³ and 2,700 particles/m³, whereas the Burkard yielded 538 particles/m³ and 52

particles/m³. The reason for this difference is unclear. The latter day had wind gusts above 61 km/h, which may have affected device performance. Alternatively, device malfunction is possible because the Rotorod also had higher mold spore counts on that day. Our use of nonparametric tests minimizes the effects of such outliers.

Our findings are in line with and expand on previous mold spore parallel trapping investigations that used *Venturia inaequalis*, *Epicoecum*, *Alternaria*, *Ganoderma*, *Pithomyces*, and the club moss *Lycopodium* and found consistently higher median spore counts with the Burkard.^{8–12} Previous studies found that the Burkard provided higher median pollen counts for *Ambrosia* (Ragweed) and *Urticaceae*, although our study only confirmed a difference for *Urticaceae*.^{7–9} We had comparatively lower ragweed pollen counts

than these studies, which may account for the lack of statistical difference between devices in our study.

This study confirms the Burkard has a higher collection efficiency when compared with the Rotorod for daily total mold spore counts and for spores from most of the individual fungal genera evaluated. The Burkard also produced statistically significantly higher daily pollen counts for total grass, total weed, and Urticaceae, although the absolute difference was small. Daily particle counts between devices were positively correlated for the most abundant pollens and spores, allowing either device to be used to follow overall trends.

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