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SPIDER BALLOONING: DEVELOPMENT AND EVALUATION OF FIELD TRAPPING METHODS (ARANEAE)

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ABSTRACT

Sets of two types of sticky traps, horizontal wires and vertical panel traps, the latter including clear polyester, ½″ hardware cloth, and ¼″ hardware cloth substrates, were run concurrently for eighteen weeks in a Missouri soybean field to see which gave the best taxonomic- and mass-frequency representations of the aeronaut fauna. The wire traps significantly underrepresented the largest family (Linyphiidae) and mass class ($\leq$ 0.6 mg) in the fauna. Of the three panel trap substrates, there were no differences between the two hardware cloth meshes but the polyester trap catches declined significantly during cold periods in late fall. An estimate is given of the number of hardware cloth traps needed for an effective sampling program.

INTRODUCTION

Spiders are among the most abundant and consistently present arthropod predators in crop fields and may contribute significantly to biological control of pests (Riechert and Lockley 1984). As with other natural enemies there may be a time lag between their population buildup and that of their prey, due in part to the need to recolonize fields following harvest or diapause. Spiders may recolonize either by walking or by ballooning [passive aerial dispersal, or aeronautic behavior (Richter 1967, Greenstone 1982)].

The composition of the aeronaut fauna has been assessed by mechanical suction traps (Taylor 1974), by kite-borne nets (Farrow and Dowse 1984), and by sticky traps of various designs. These have been mounted on airplanes (Glick 1939) or on ground level supports (Duffey 1956, Yeargan 1975, Van Wingerden and Vugts 1976). The purpose of the present investigation was to compare the efficacy and convenience of two simple and inexpensive sticky trap types, horizontal wires (Van Wingerden and Vugts (1976) and vertical panels (Yeargan 1975), and to see whether there were detectable differences among various substrates for the panel traps. We also wished to know whether height above the ground or compass direction affected the catches.

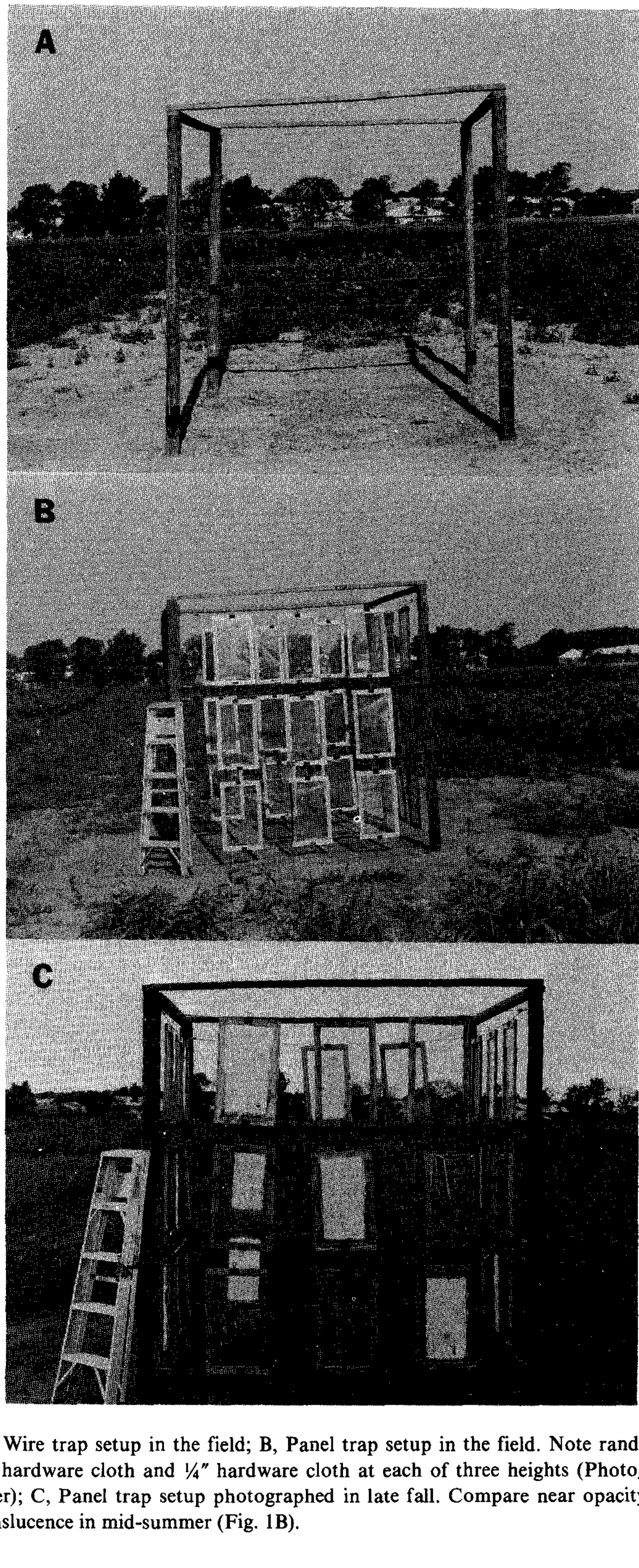

Fig. 1.—A, Wire trap setup in the field; B, Panel trap setup in the field. Note random arrangement of Mylar, ½″ hardware cloth and ¼″ hardware cloth at each of three heights (Photograph was taken in mid-summer); C, Panel trap setup photographed in late fall. Compare near opacity of Mylar traps with their translucence in mid-summer (Fig. 1B).

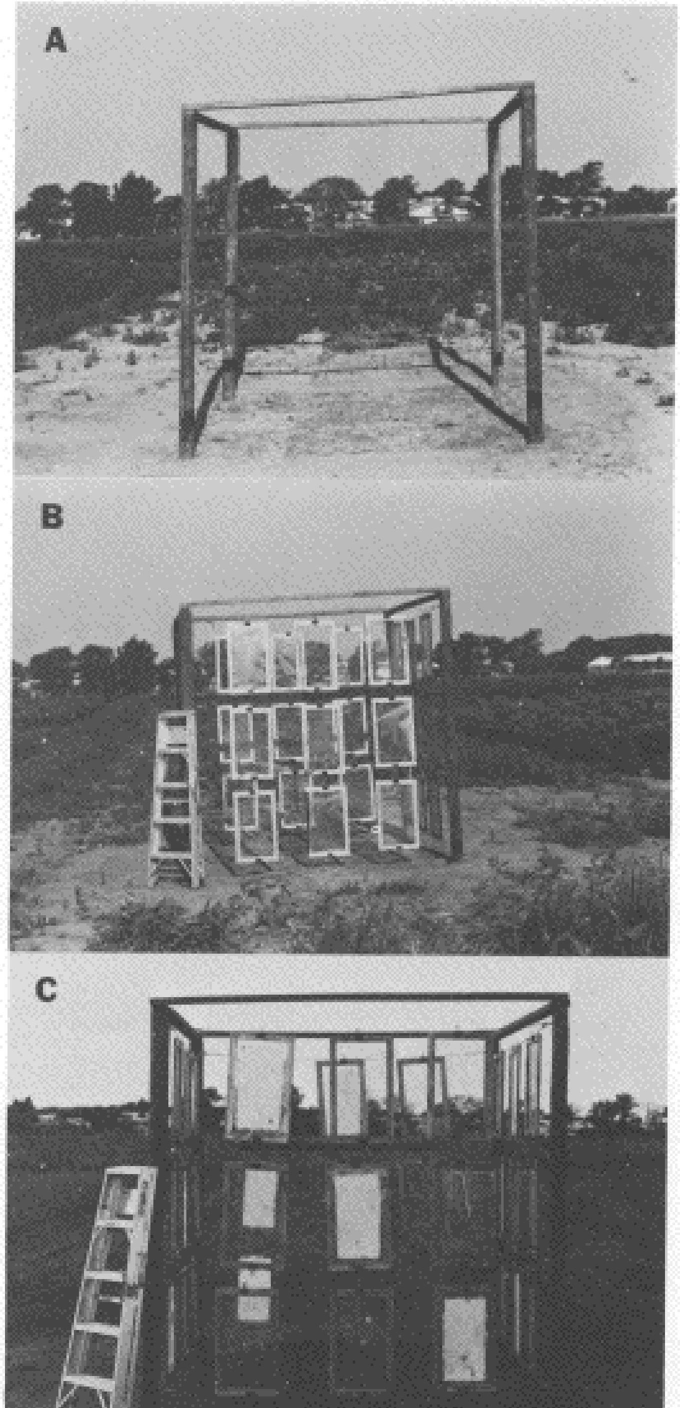

Fig. 1.—A, Wire trap setup in the field; B, Panel trap setup in the field. Note random arrangement of Mylar, ½" hardware cloth and ¼" hardware cloth at each of three heights (Photograph was taken in mid-summer); C, Panel trap setup photographed in late fall. Compare near opacity of Mylar traps with their translucence in mid-summer (Fig. 1B).

MATERIALS AND METHODS

The studies were performed in a 2.0 ha field at the University of Missouri South Farms, 9.7 km SE of Columbia in Boone County, Missouri. The field was planted in 18.3 m x 22.9 m plots of soybeans with admixtures of sunflowers ranging from 60 to 240 plants per plot. The placement of sunflower treatments among plots was determined by a randomized complete block design, as part of a study on the influence of cropping scheme on natural enemy diversity (N. L. Marston, personal communication). The treatments were set out in a three column by four row array, separated by 18.3 m wide alleyways, which produced six intersections in which the traps could be set up. Two of these were selected by use of a table of random digits (Rohlf and 1B 1969) and the wire traps set in one and the panels in the others. The two set-ups were 50-m apart.

Each set of traps was supported by a structure comprising four vertical posts set into the ground and braced with 2 x 4′s at the top, forming a cube 2.5 m on a side with its vertical faces perpendicular to the cardinal compass directions. For the wire traps, six 2 mm diameter horizontal wires were nailed to the posts at heights of 35, 75, 115, 155, 195 and 235 cm (Fig. 1A). The central 2.0 m of each stretch of wire was coated with adhesive (Tack Trap,® Animal Repellents, Inc., Griffin, GA) to form the trapping surface. For the panel traps, pulleys were placed on the inside corners of the four posts at heights of 20 and 84, 95 and 160, and 170 and 235 cm, and a plastic coated three-wire clothesline run through each set of four pulleys and secured with a turnbuckle. Wooden frames holding the traps were attached to adjacent pairs of clotheslines using standard one-inch binder clips. The frames were 38 cm x 64 cm rectangles made up by gluing and nailing together lap-jointed 1 x 2′s. They were dipped twice in varnish before use. Stapled to each frame was one of the following three panel substrates: 0.076-mm (.003 in) clear polyester (Mylar®) (Air Plastics, Inc., Mt. Vernon, NY), 12.7-mm (½″) galvanized hardware cloth, or 6.35-mm (¼″) galvanized hardware cloth. In order to facilitate coating the panels without fouling the wooden frames, an aluminum template having a 25-cm x 50 cm cutout in the center was placed over the panel, and prewarmed adhesive was painted on the unmasked area with a brush. The frames were hung from the clotheslines in three rows of three traps on each face (Fig. 1B), one of each substrate type, with position (left, right, or middle) determined by consulting the table of random digits. For transport to and from the field, the panel traps were stacked in groups of 18 on a wooden pallet with 1.8-cm diameter vertical pipes cemented into the corners to prevent shifting.

The two sets of traps were run concurrently for eighteen consecutive 1-wk periods beginning on June 15, 1983, and the panel traps for an additional five. (The wire traps were discontinued after it became clear that the panel traps were easier to handle and sampled the most important family more effectively [see below]). After each collection the panel traps were replaced with a fresh set and returned to the laboratory for microscopic examination at 6X with a Wild®M-5 stereo microscope. The wire traps were examined in the field with the aid of a 2½ X magnifying glass. Mylar traps were renewed by disposing of and replacing the Mylar. Hardware cloth traps were renewed by removing and soaking the hardware cloth panels overnight in Stoddard's solvent, cleaning them with a wire brush, and drying, restapling and recoating them with prewarmed adhesive. The wire traps were cleaned in the field with paint thinner and paper towels and recoated each week.

To ensure that animals caught by the traps were ballooning and not crawling or "rappelling" (i.e., travelling via bridge lines, J. Carico, personal communication) onto the traps, all vegetation was cleared from within 3.0-m of all trap faces (see Figs. 1A and 1B) by three applications of Roundup® (Monsanto Chemical Co., St. Louis, MO), and 10 cm barrier bands of adhesive were placed encircling the tops and bottoms of all posts and the ends of all wire (trapping and clothesline) segments. These were checked for stickiness and renewed as needed.

The spiders collected were placed for three days each in paint thinner and toluene before final preservation in 70% ethanol. They were identified to family and the individual masses estimated using volume-mass regressions from previously live-massed and measured preserved animals (Greenstone et al., 1985). Because of the tedium of these measurements, a subset of seven samples, chosen to span the season and include a range of catches from very low to very high, was selected.

The numbers of spiders caught were subjected to multi-way analysis of variance of the factors date, height, compass direction, and, for the panel traps, substrate, using the SAS general linear models procedure at the University of Missouri, Columbia, Computing Center. The date x height x direction mean square was used to provide an error term for the wire trap ANOVA's, and the sums of squares for the four- and all three-way interactions were pooled to produce an error mean square for the panel trap ANOVA's.

RESULTS

Results of the ANOVA's are given in Table 1. All factors except compass direction show significant main effects, but all are also involved in significant interactions. The results are most easily understood if the two sets of comparisons are taken separately.

Comparison of Hardware Cloth and Mylar Panel Trap Substrates.—There were no obvious trends in any of the interactions except for that of date x type.

Table. 1—Results of F Tests.

	PANEL TRAPS			WIRE TRAPS		
Source	*F*	*d.f.*	*P*	*F*	*d.f.*	*P*
Date	73.6635	22,628	***	150.1029	17,255	***
Height	6.0902	2,628		5.6602	5,255	*
Date x Height	1.2563	44,628		1.3965	85,255	*
Type	20.1498	2,628	*	—	—	
Date x Type	3.8025	44,628	***	—	—	
Height x Type	3.9545	4,628		—	—	
Direction	6.8794	3,628		1.8818	3,255	
Date x Direction	1.6339	66,628	**	1.4478	51,255	
Height x Direction	0.3480	6,628		2.7032	15,255	*
Type x Direction	1.4564	6,628		—	—	

***p<.001; **p<.01; *p<.05

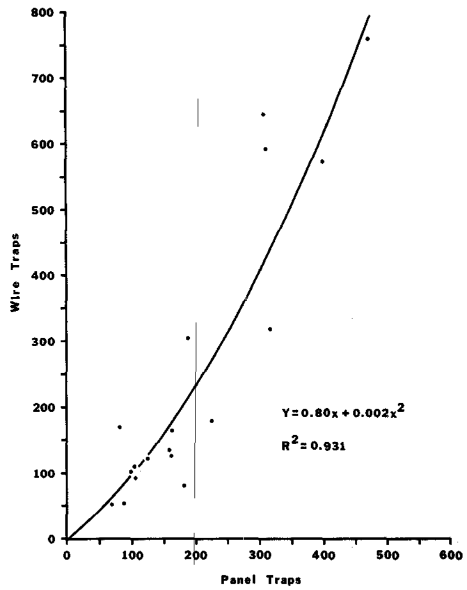

Fig. 2.—Relationship between total number of spiders caught on the hardware cloth traps and wire traps on the eighteen concurrent dates.

All six significant F's for panel trap type occurred toward the end of the season (the last week of September, the last two weeks of October, and the first and third week of November). We noticed a tendency for the Mylar traps to be more visible from a distance when we picked up the traps during this period (compare Figs. 1B and 1C). Close inspection showed that the adhesive, which is usually translucent, had become a nearly opaque white. Directions on the Tack Trap can indicate that it will not work consistently at temperatures below 35° F. There were eight weeks in which the temperature at the site fell to 35° F or below at least once. Five of these were included among the six weeks for which the F-test on trap type was significant, while the other three fell among the seventeen non-significant F-tests. This difference is highly significant by the log-likelihood ratio test (Sokal and Rohlf 1969, $G = 8.47$, $p. < 0.01$).

In order to determine where the differences among the panel substrates lay, Student-Newman-Keuls tests (Sokal and Rohlf 1969) were run on the data of the significant dates. In all six cases the ½″ and ¼″ hardware cloth means were not significantly different, while the Mylar traps were always significantly ($p < 0.05$) less than the ½″ hardware cloth and in all but one case significantly less than the ¼″ hardware cloth as well. The mean numbers on the hardware cloth panels on these dates ranged between 1.8 and 2.4 times those on the Mylar panels.

Comparison of Wire Traps and Panel Traps.—The relationship between the total numbers of spiders trapped on the wire traps and the ½″ plus ¼″ hardware cloth panel traps for the eighteen dates on which they were operated concurrently is shown in Fig. 2. These data were fitted to simple linear and polynomial regressions forced through zero. Both regressions were significant ($p < 0.0001$) but the polynomial gives a significantly better fit to the data ($F_{2, 12} = 5.27$, $p. < 0.025$). This is the curve which has been fitted to the data in Fig. 1. It describes 93.1% of the variance in wire trap catches.

The wire and panel traps were compared further in their representations of the mass-frequency and taxonomic-frequency distributions of trapped spiders. Five

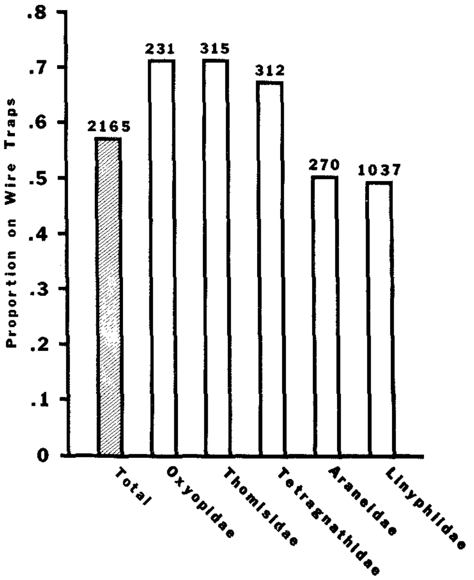

Fig. 3.—Proportions of the totals (heights of bars) and sample sizes (above the bars) for all spiders (hatched) and major families which were caught on the wire traps. See text for further explanation.

families each contributed at least five percent of all trapped individuals from the seven representative identified samples. Fig. 3 shows the proportions (heights of bars) of all spiders and of each family caught on the wire traps and the total numbers (above the bars) of all spiders and of each family caught on all traps. Of the 2165 animals in the sample, 1236, or 0.57 of the total, were caught on the wire traps. This is the expected proportion of animals on the wire traps for each family. The departures from expected are highly significant ($G = 94.398$, $p < 0.0001$). It can be seen by inspection that the family Linyphiidae, which makes up almost half of the total catch, is underrepresented on the wire traps.

Fig. 4 shows the proportions and totals for the mass classes of the same sample (the total sample size is slightly higher in Fig. 4 than in Fig. 3 because not all animals which could be measured could also be placed taxonomically). Again the departures from expected are highly significant ($G = 86.296$, $p < 0.001$). The largest mass class, animals 0.6 mg or less which make up slightly more than half the total, is underrepresented on the wire traps.

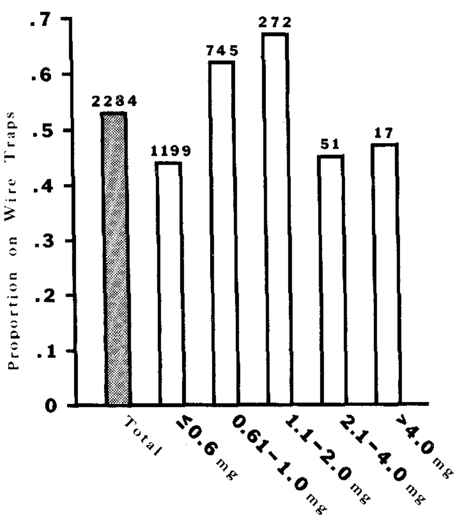

Fig. 4.—Proportions of the totals (heights of bars) and sample sizes (above the bars) for all spiders (stippled) and principal mass classes which were caught on the wire traps. See text for further explanation.

DISCUSSION

The curvilinear relationship depicted in Fig. 2 is partially explained by the data in Figs. 3 and 4. The smallest spiders tend to be linyphiids, so that Figs. 3 and 4 both reflect the tendency for the wire traps to undersample this family. There is a persistent, moderate to large number of linyphiids ballooning throughout the season. The other families are rare or absent early in the season, increase in numbers through early fall and then wane (Greenstone et al., unpublished data). This makes the wire traps appear to become more efficient as total numbers increase and the proportion of linyphiids, which they undersample, decreases (Fig. 2).

Our experience prior to data analysis led us to favor the panel traps since they can be brought into the lab and examined microscopically under uniform lighting conditions. Although all three authors seemed to get comparable counts on adjacent wires on the wire traps on any given day and compass direction, we did not feel confident about seeing the smallest spiders, particularly under changing lighting conditions in the field. The data in Fig. 4 bear this out. Whether the difference is due to actual differences in trapping efficiency or the difference in magnification and lighting used in scanning them is immaterial, because the wire traps must be checked in the field and therefore do not lend themselves to microscopic examination. At our site, where the linyphiids make up such a large proportion of the aeronaut fauna, wire traps can be expected to give a distorted picture of the taxonomic- and mass-frequency distributions of ballooners. In fact, the use of wire traps is probably not wise throughout mid to high latitudes in the Northern hemisphere, where linyphiids tend to be the largest family of ballooners.

Of the panel traps, Mylar is clearly at a disadvantage in cold weather. Furthermore, high winds destroyed two Mylar traps, so they are also less reliable. Because there were no significant differences between the ½″ and ¼″ hardware cloth, we recommend the ½″, because, with less surface area they are easier to scan and require less adhesive.

We can think of two possible explanations for the halving of the catch on the Mylar traps in six of the late season samples. First, higher winds in the fall may tend to blow spiders around these solid traps more so than around the perforated, hardware cloth traps, a difference which may disappear at lower wind speeds (R. Suter, personal communication). Unfortunately we lack an *a priori* criterion for determining what windspeed is "high." The lowest mean windspeed recorded during the six significant weeks was 8.4 kph. If we take this as the threshold for a wind effect, then six of six significant weeks exceeded this threshold and 13 of the 17 non-significant samples also exceeded it. This difference is not significant ($G = 2.70$, $p > 0.1$). If we take as our threshold for a wind effect 12.2 kph, which was the next highest mean wind speed among the six significant dates, then five of six significant dates and five of twelve non-significant dates meet or exceed it. This difference is significant ($G = 5.49$, $p < 0.02$). We can look at the windspeed hypothesis in another way. If the drop in catches on the Mylar traps is indeed due to this wind effect, then the smallest animals should be most strongly affected (R. Suter, pers. commun.). The spiders caught on one of the significant dates, October 18, have been measured. Fig. 5

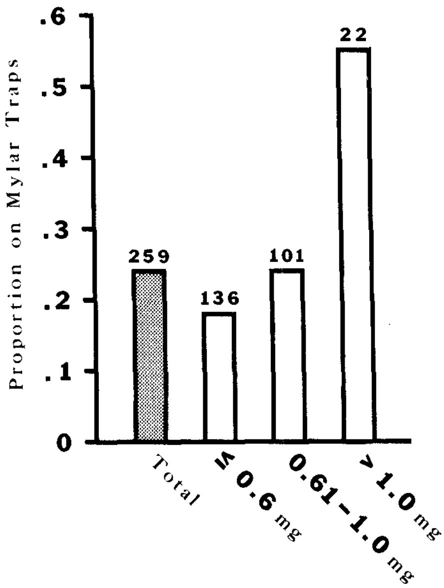

Fig. 5.—Proportions of the totals (heights of bars) and sample sizes (above the bars) for all spiders (stippled) and principal mass classes which were caught on the Mylar traps on October 18, 1983. See text for further explanation.

shows the proportions of the totals and sample sizes for all spiders (stippled) and principal mass classes which were caught on the Mylar traps. The departures from expected are highly significant ($G = 11.89$, $p < 0.01$) with the smallest spiders underrepresented and the largest overrepresented on the Mylar traps. These results are consistent with the wind-speed hypothesis.

One alternative explanation is that the spiders are better able to see the Mylar traps due to the large area of nearly opaque adhesive visible on cold days, and actively avoid them, e.g., by changing the length of the ballooning threads to rise above or drop below the traps. If correct, this would indicate that spiders may be at least partially able to guide their flight and thereby effect some degree of habitat selection before alighting (cf. Meijer 1977). This working hypothesis could be tested by setting up Mylar traps which are either clear or opaque and comparing the catches.

Our extensive trapping data can be used to estimate the number of traps required for a long-term ballooning study, using the formula presented by Sokal and Rohlf (1969, p. 247). In order to use this formula, the investigator must specify the size of difference between samples he or she wishes to detect, the probability that such a difference will be found if it exists, and the level of significance. There must also be an estimate of the variability of the data. The modal coefficient of variation for the hardware cloth trap data for this study was 44.9%. Taking 50% as a conservative expected coefficient of variation, $\alpha = 0.05$ for rejection of the null hypothesis, $P = 0.8$ as our probability of finding a certain difference between two means, and $d = 0.3$ as that difference, we get $n \simeq 16$ traps. Given the absence of main effects of height and compass direction (Table 1), a four-sided trap with two traps at each of two heights on each side would support this number conveniently.

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