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A versatile wind-resistant insect cage

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ABSTRACT

Ecological field studies often require cages that can withstand adverse weather conditions such as high winds, without greatly altering environmental conditions within them. A large field cage was designed, fabricated and tested for predator-prey studies on raspberry plantings. It consisted of a wood base and screening suspended with loops of canvas from a framework of PVC pipe. The cage withstood gusts above 70 km/h, did not appreciably alter temperature or RH, but did reduce light by 40% and rainfall by 25%. The cage design is simple and can be adapted to many experimental situations.

INTRODUCTION

Field cages have traditionally been designed with vertical walls and right-angled corners (e.g. Fay and Meats 1987; Grant and Shepard 1985; and Savinelli *et al.* 1988). This shape provides ample standing room. However, rectangular cages have stability problems, particularly in the 40 km/h winds frequently experienced in the Lower Fraser Valley of British Columbia. A cage, 4.3 m long x 2.6 m wide x 2.1 m high and semi-elliptical, was designed and tested through three field seasons during predator-prey studies in raspberry field plots.

MATERIALS AND METHODS

The cage (Fig. 1A) was made from a rectangular piece of fabric (Fig. 2) suspended from a frame of PVC pipe (Table 1). The frame consisted of four poles arched between two sides of a rectangular wooden base and made rigid at the top by one ridge-and two lateral-poles (Fig. 1:A,C). The fabric was sewn so that the seams lay along the length of the ridge- and lateral-poles (Figs. 1A, 2). Cages constructed in 1990 were made entirely of grey noseeum screening while those constructed in 1991 and 1992 were made of white noseeum screening, (Table 1) except for the woven synthetic Lumite® roof panels [(Table 1; Fig. 2 (grey area)]. Fabric width was determined as:

$$\text{width} = 2.22 \times \sqrt{(\text{cage height})2 + (\text{cage width}/2)^2}$$

Canvas reinforcing strips 8 cm wide were sewn onto the screen along the lines where the PVC poles would lie (Fig. 2). Sleeves for the poles were made from a folded piece of canvas 13 cm wide, that was sewn along the centre of the reinforcing strip. The sleeves extended to within

Table 1
Materials used in field cage.

Item	Specifications
Lumite® Saran screening (light gold color)	20.5 x 20.5 threads/cm Chicopee P.O. Box 2537 Gainesville, Georgia 30503-2537
Noseeum screening (100% polyester)	11.0 x 59.0 threads/cm Seattle Textile Co. 16 South Idaho, Seattle, WA 98134
Canvas	waterproof, 283.5 gm weight (10oz.)
Nylon	waterproof, medium weight
Velcro	2.54 cm width
Poles	PR 200 solvent-weld PVC pipe, O.D. 2.67 cm, 4 x 5.7m (arch-poles), 3 x 4.3m (ridge- and lateral-poles)
Wood	rough cedar, 10 x 10 cm (4″x4″), 2 x 2.6m and 2 x 4.3 m
Poly-fastener®	PR 800 plastic track Curry Industries Ltd. Unit 5, 1031 Springfield Road Winnipeg, Manitoba R2G 3T2
Aluminium	flat bar, 0.48 x 7.6 cm (3/16″x3.0″) 30.5 cm per corner
Hardware – pole assembly	hex head bolts, 0.64 x 6.4 cm (1/4″x 2½″) National coarse threaded nyloc nuts 0.64 cm (1/4″) fender washers 0.64 (1/4″)
– base assembly	wood screws, # 12 x 5.1cm (2″) Robertson round head, cadmium plated drywall screws – flat head, length 2.54-3.18 cm (1″-1¼″)

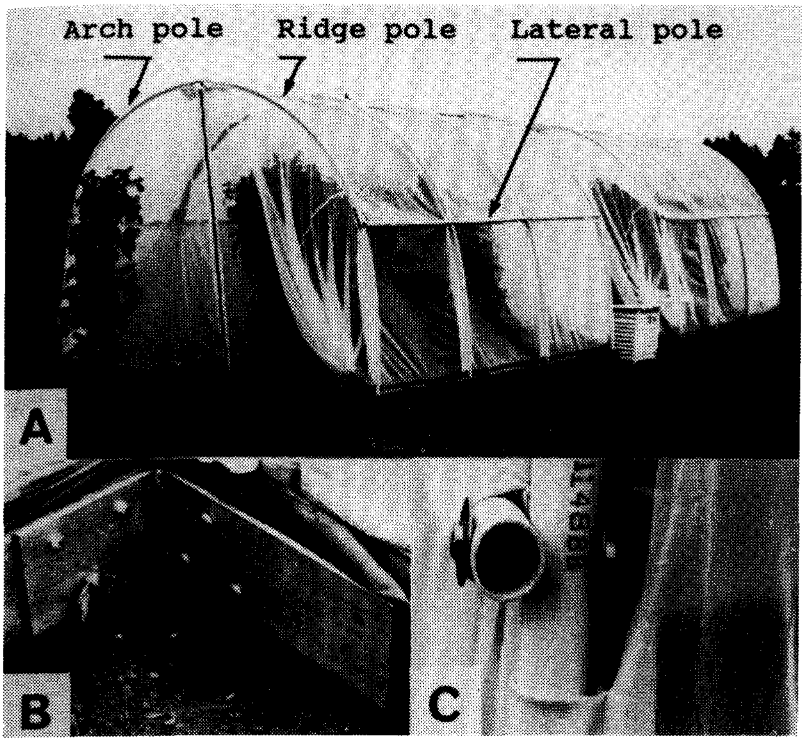

Figure 1. Field cage overview (A); aluminium corner bracket on wood base (B); assembled lateral-pole and arch-pole (C).

8 cm of the pole intersections to allow room to bolt the ridge- and lateral-poles to the arch-poles. A 12 cm strip of medium-weight, waterproof nylon was sewn around the edge of the fabric, serving as the point of attachment between the fabric and the Poly-fastener® plastic track (Table 1) that was screwed to the wooden base. All seams were lock stitched on industrial machines with Koban (cotton wrapped polyester) thread.

Cage assembly proceeded as follows: four 2.7 cm holes were drilled through each of the two longest pieces of 10 x 10 cm wood in correct alignment to receive the arch-poles. The wood base was bolted together with aluminium corner brackets (Fig. 1B). The channel portion of the Poly-fastener® plastic track was attached near the top inside face of the wooden base with dry-wall screws. With the netting laid flat on the ground (Fig. 2), the four PVC arch-poles were pushed through their respective sleeves. Next the ridge-pole and two lateral-poles were inserted through their sleeves so that they lay on top of the arch-poles. The ridge-pole was bolted in the middle of the intersecting arch-poles (Fig. 1A). The arch-poles were bent and installed into their respective holes in the 10 x 10 cm base. The nylon edge of the fabric (Fig. 2) was attached to the base by snapping the insert strip into the channel of the Poly-fastener® track. The lateral-poles were bolted to the arch-poles (Fig. 1C). The large piece of excess fabric remaining at each corner was sealed off by looping the fabric in a knot and fastening the velcro strips (Fig. 2). Soil was packed around the outer edge of the base to position the cage and limit insect movement. Guy ropes and stakes were not used to stabilize the cage.

The cages were tested from Dec. 1989 - Oct. 1990, May - Nov. 1991 and Jun. - Sep. 1992 at Abbotsford, British Columbia. Wind speed was measured with an RM Young anemometer placed 2 m above the ground, 10 Jan. - 22 May 1990, and temperature and RH were measured with HMP-112A Vaisala probes, 25 May - 3 Sep. 1990, and 12 Jun. - 11 Sep. 1992. All instruments were linked to an Easylogger® 824-GP field unit which recorded hourly, averages of readings taken at 5 min intervals for wind and 10 min intervals for temperature and RH. The

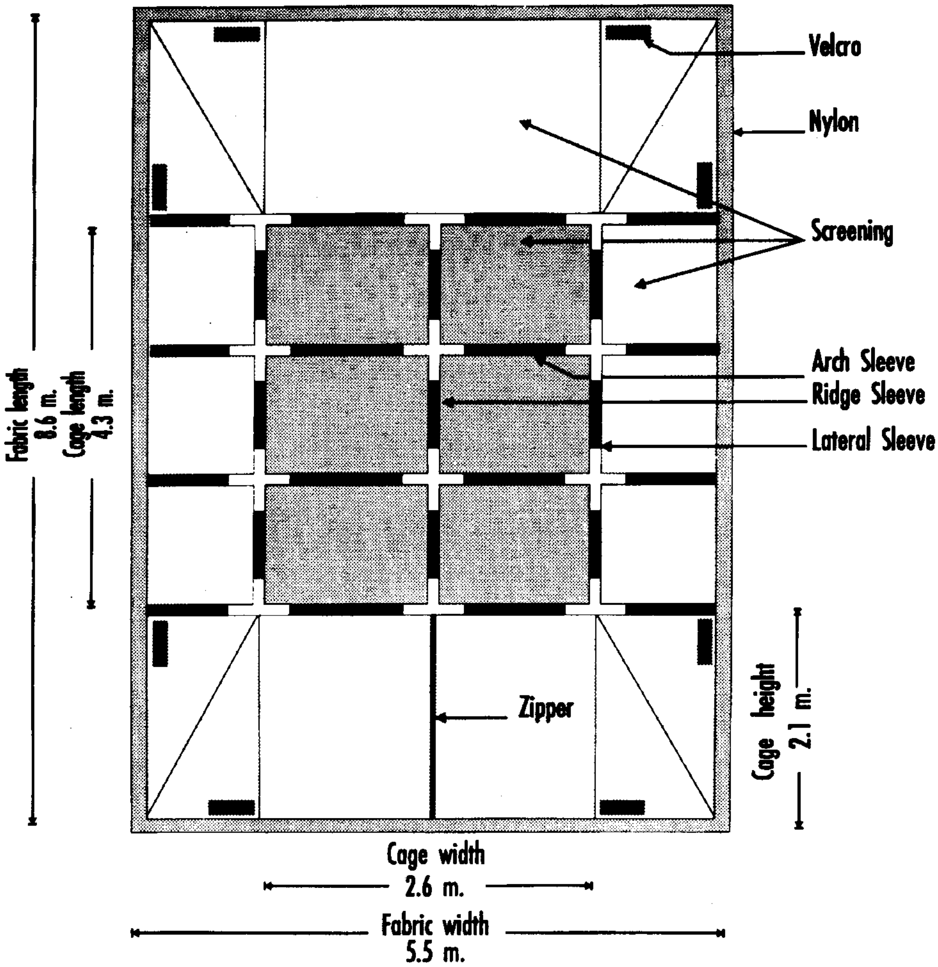

Figure 2. Pattern for cage screening.

temperature and humidity probes were shielded by a 15 X 15 X 30 cm open-ended white box located 1 m above the ground both inside and outside the cages. The wind data were augmented with Environment Canada readings of daily maximum wind speed above 30 km/h, recorded 10 m above the ground, 1 km from the field site. Photosynthetically active radiation was measured with a Li-Cor® 188-B photometer placed on the ground and 1.2 m above the ground inside and outside of a cage on clear sunny days, 21 Jun. 1990 and 17 Jun. 1992. Rainfall was measured with funnel rain gauges placed on the ground inside and outside of a cage, 7 and 13 Jun. 1990.

RESULTS AND DISCUSSION

Wind speeds recorded at 5 min intervals from 10 Jan. - 22 May 1990 were often greater than 30 - 40 km/h (Fig. 3). Maximum daily gusts recorded by Environment Canada during 3 yr that the cages were field tested were: 30-40 (km/h), 29 times; 40-50, 23 times; 50-60, 10 times; 60-70, 9 times; and 70-80, twice. Throughout, the PVC pipe simply flexed, allowing the wind to spill off the top of the cage. One leeward arch-pole cracked near the base during winds of 40 km/h, but this was replaced and the event did not recur. Temperatures, measured inside a cage constructed entirely of grey noseeum screening, were higher than outside; the opposite trend was observed for RH, (Fig. 4). The difference between average daily temperature inside and

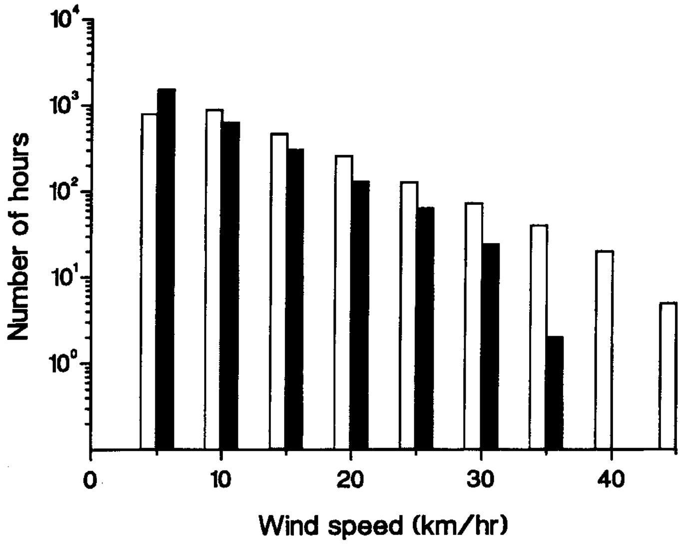

Figure 3. Field cage exposure to winds from Jan. - May 1990. From readings taken at 5 min intervals, the light bars indicate the number of hours in which the given maximum wind speed occurred and the dark bars indicate the number of hours of a given average wind speed. The bars are plotted at the top of the wind-speed interval (e.g. 0-5 km/h).

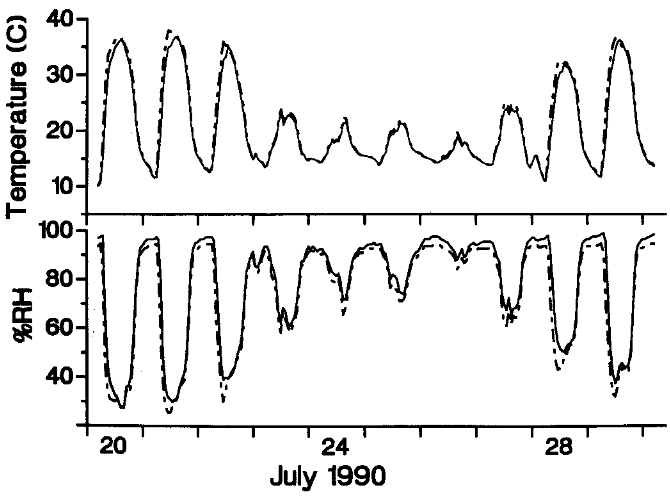

Figure 4. Temperature and RH inside (dotted line) and outside (solid line) a field cage made entirely of grey noseeum screening (1990).

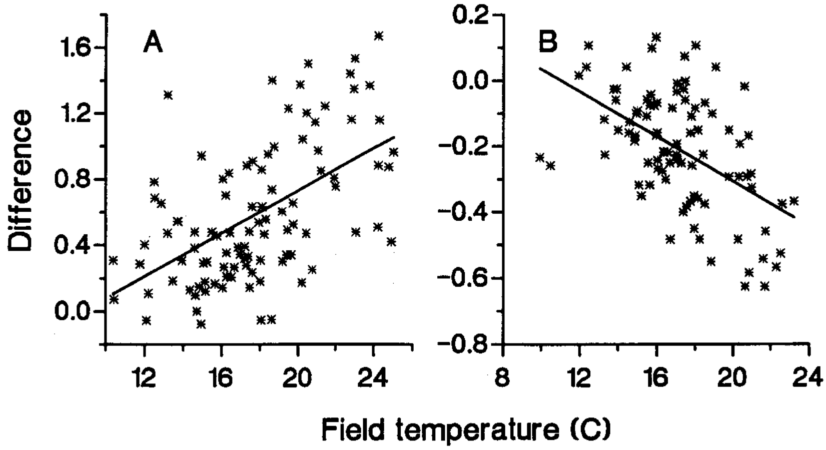

Figure 5. The difference between average daily temperature inside and outside a cage plotted as a function of temperatures outside: A, cage constructed with grey noseeum screening (1990) ($y = -0.569 + 0.0650\,x$; $p < 0.01$; $r = 0.54$; $n = 99$); and B, cage constructed with white noseeum screen and a Lumite® roof (1992) ($y = 0.376 - 0.0341\,x$; $p < 0.01$; $r = 0.52$; $n = 90$).

outside a cage increased during hotter weather, (Fig. 5A). This pattern was reversed in 1992 in cages constructed with white noseeum screening and a Lumite® roof, (Fig. 5B). The difference between the two cage types was probably due to differences in screen reflectance, grey screen (1990) *vs* white and light gold (1992). Radiation was reduced by 40% in the grey noseeum cage and by 45% in the white noseeum, Lumite® cage. Rainfall was reduced by 25% inside the cage constructed entirely of noseeum screening.

The cage cost $750.00: 1/3 for screening, 1/3 for all additional materials and 1/3 for sewing. It can be constructed on site, or lifted over a field plot. It is easily dismantled by reversing the order of assembly and all the parts can be stored in a linear bundle. The design and the nature of the component parts make modifications for other plot sizes or other field crops exceedingly simple. The component parts could also be modified for other experimental situations. For example, in a wet environment, 10 cm black PVC pipe and corners could be substituted for the 10X10 cm rough cedar base. Given the strength of the cage, the ease of assembly, the similarity of temperature and RH in and outside the cage, and the small storage requirements, it will be very useful for ecological field studies.

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