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# A SUPERIOR TRAP FOR MIGRATING BUTTERFLIES

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**ABSTRACT.** Flight traps for studying butterfly migrations should be economical, efficient, and easy to construct, erect, service, and maintain. A 3-m-wide, semi-portable trap with these features was constructed of lumber, electrical conduit, braided nylon rope, and nylon-twine netting. Intercepted butterflies are guided into removable hardware cloth cages seated in metal trays at either end of the trap. These traps, which cost about $50 each for materials and can be moved intact by two persons, caught the targeted migrants more efficiently than previous traps, including much taller and costlier immovable traps. They should foster and facilitate studies of migrating butterflies.

**Additional key words:** migration, *Phoebis sennae, Agraulis vanillae,* Florida.

Most migrating butterflies fly within a few meters of the ground and go over, rather than around, obstacles they encounter. This behavior makes migrants particularly susceptible to capture by flight traps, and such traps have been used for 17 years to study butterfly migrations in Florida and Georgia (Walker 1978, 1985a, 1991, Walker & Riordan 1981, Lenczewski 1992, Hatcher 1990). The earliest traps were made of mosquito netting and were fragile, squat, and inefficient (Walker 1978). These were superseded by permanent traps, made of hardware cloth on a steel and timber frame, that intercepted migrants flying as high as 3.3 m and were substantially more efficient (Walker 1985b). Need for inexpensive, portable traps prompted Walker and Lenczewski (1989) to develop traps of mosquito netting suspended from taut nylon ropes attached to end frames of electrical conduit. These traps had to be anchored and kept trimmed with guy ropes staked in four directions. Lenczewski (1992) used such traps to monitor migration along a 430-km north–south transect, and Whitesell successfully promoted their use by Georgia high school science students to trap migrants for marking and release (Hatcher 1990). The chief shortcomings of these traps were the large amount of sewing required to make them, difficulties in erecting, trimming, and maintaining them, their modest trapping efficiency, and the short outdoor life of the fabric. These problems, and the need for many more traps to service expanding studies of butterfly migration in Georgia schools, prompted us to design, construct, and test new traps. This article describes the trap that best combined low cost, ease of construction, efficiency, and durability and the 3 years of

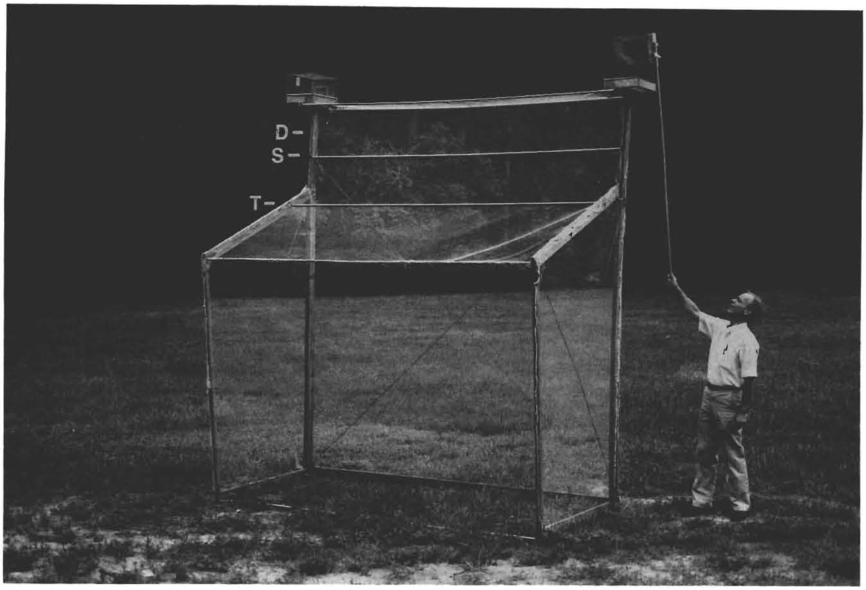



FIG. 1. Semi-portable trap, showing method of removing holding cage. Throat of trap begins at T and narrows to slot (S) through which migrants pass into triangular duct (D).

tests that led us to it. It is designated the semi-portable or s-p trap to distinguish it from the portable trap (Walker & Lenczewski 1989) and the permanent trap (Walker 1985b) developed previously.

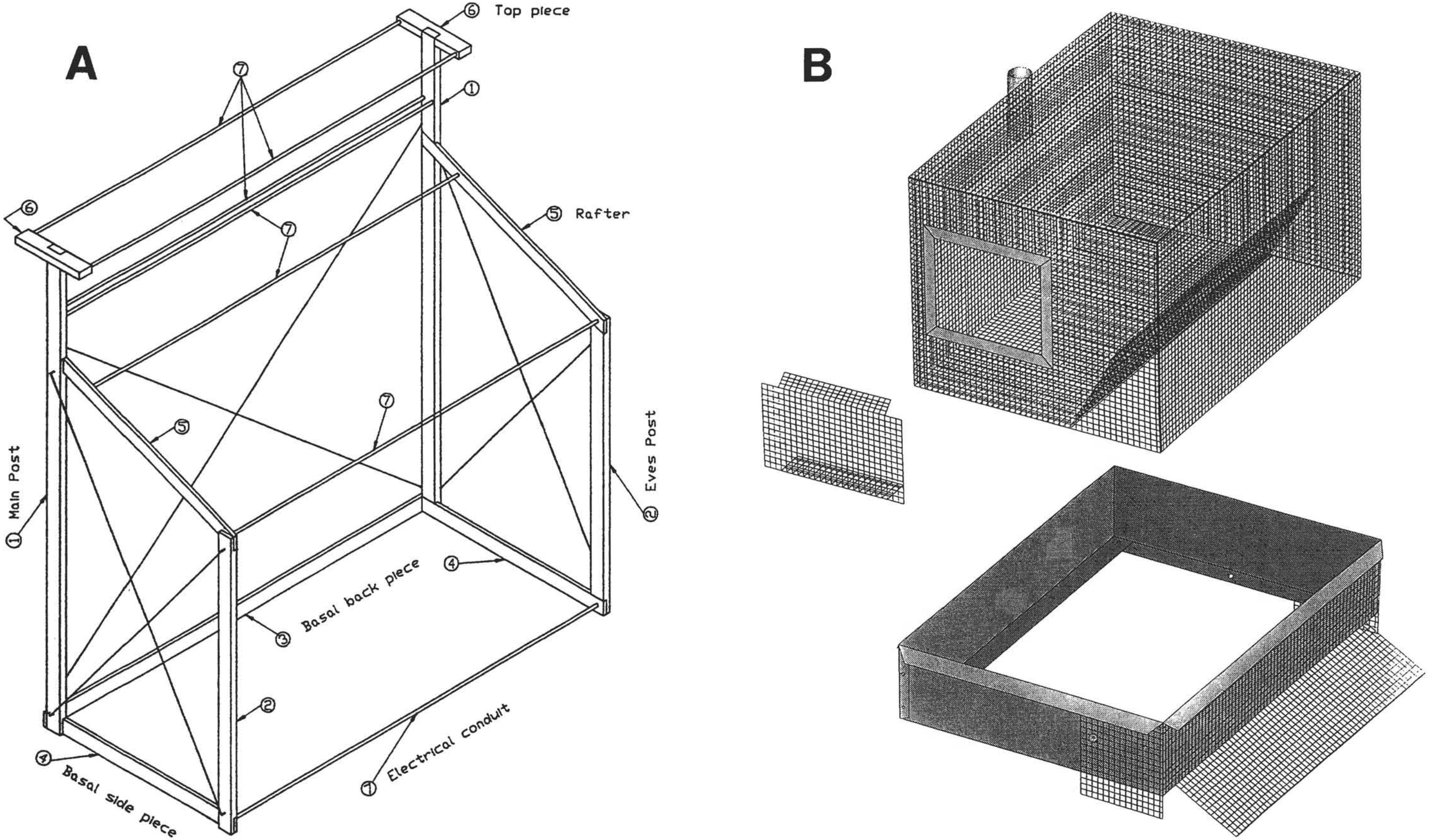
## THE SEMI-PORTABLE TRAP

The s-p trap (Fig. 1) has a rigid frame of wood and ½″ thin-walled electrical conduit (=EMT) internally braced with rope (Fig. 2A). Except for its bottom and a 3 × 2 m (w × h) opening, the trap is covered with 13-mm-mesh, nylon-twine netting. Migrants that enter the trap encounter a wall of netting and, as they attempt to fly over it, flutter into a narrowing throat, through a slot, and into a duct that leads to hardware cloth cages held by metal trays at either end of the trap. The traps are set perpendicular to the direction of migration. If net movement in the migratory direction is to be quantified, half the traps are pointed upstream and the other half downstream. A stake at each inside corner keeps traps from blowing over. An Appendix gives details of construction.

## TESTS OF TRAPS

### Materials and Methods

All tests were at the site of the two extant permanent traps (models #3 and #5; Walker 1985b). Trios of test traps were positioned to the



A
B
Top piece
Rafter
Main Post
Eves Post
Basal back piece
Electrical conduit
Basal side piece

east and west of the permanent traps on the same ENE-WSW line as the permanent traps. Traps in a trio were about 1 m apart and faced WNW in fall and ESE in spring. Traps were serviced daily by removing and recording trapped butterflies, unless otherwise noted. To control for position effects, the traps in a trio were rotated periodically in their positions along the ENE-WSW line.

**Fall 1988.** Two frame designs and three fabrics were tested 9 September to 4 November by means of a trio of traps to the east of the permanent traps. The trio consisted of a *shrimp net* trap (s-p frame covered with 10-mm-square-mesh netting made of knotted 0.28 mm nylon monofilament), a *19-mm-mesh twine* trap (s-p frame covered with 19-mm-square-mesh netting made of #147 multifilament nylon twine), and a *no-throat* trap (s-p frame with the transition between rafters and slot eliminated, making the trap about 23 cm shorter but leaving the opening the same; covered with 19-mm-mesh twine netting until 6 October; on 6 October the fabric was changed to 13-mm-square-mesh netting made of double-knotted 0.28 mm nylon monofilament). Traps were rotated on 6 October.

**Spring 1989.** Three fabrics were tested 27 March to 29 May by means of two trios of traps. Each trio consisted of s-p frames covered with three fabrics: *shrimp net* (see above), *13-mm-mesh monofilament netting* (see above), and *13-mm-mesh twine netting* (13-mm-square mesh made of double-knotted #104 multifilament nylon twine). Traps were rotated on 22 April.

**Fall 1989.** Two fabrics and two catching systems were tested 12 September to 15 October by means of two trios of traps. Each trio consisted of a *standard s-p* trap (catching cage on both ends; covered with 13-mm-mesh twine netting), a *13-mm-mesh monofilament* trap (s-p frame covered with 13-mm-mesh monofilament netting), and a *one-cage* trap (like the standard trap except no opening in the netting and no catching device on the west end). Traps were rotated on 23 September and 4 October.

**Fall 1990.** Two catching systems and two trap heights were tested 29 August to 11 November by means of two trios of traps. Each trio consisted of a *standard s-p* trap (3.35 m main posts), a *one-cage* trap (see above), and a *12-foot* trap (same as standard s-p trap except all posts and the trap opening 0.3 m taller). Traps were run 29 August to

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FIG. 2. Construction details of semi-portable trap. A. Frame of 2 × 4 and 1 × 4 lumber and ½″ EMT, braced at back and ends with diagonals of braided nylon rope. B. Holding cage (more details in Walker & Lenczewski 1989) and tray.

TABLE 1. Numbers of butterflies trapped during tests of semi-portable traps, fall 1989 and 1990. In 1989, catches of s-p traps were not significantly different for any species (ANOVA); in 1990, they were for *P. sennae* and marginally so for *A. vanillae*. S-p catches followed by same letter, in a column, are not different (least significant difference; P = 0.05).

| Type of trap | Fall 1989 | | | Fall 1990 | | |
|---|---|---|---|---|---|---|
| | *P.s.* | *A.v.* | *U.p.* | *P.s.* | *A.v.* | *U.p.* |
| Semi-portable traps (2 ea., 3-m) | | | | | | |
| Standard | 355 | 453 | 117 | 454a | 678a | 31 |
| 13-mm monofilament | 293 | 451 | 122 | — | — | — |
| 12-foot | — | — | — | 387ab | 599ab | 22 |
| One-cage | 286 | 425 | 82 | 329b | 483b | 20 |
| Permanent traps (1 ea., 6-m) | | | | | | |
| Model #3 | 372 | 245 | 196 | 327 | 357 | 63 |
| Model #5 | 351 | 321 | 276 | 282 | 320 | 59 |
| Relative efficiencies | | | | | | |
| Std. s-p/avg. perm. | 0.98 | 1.60 | 0.50 | 1.49 | 2.00 | 0.51 |

11 November and serviced every one or two days (n = 39). After service 13 and 26, traps were rotated.

**Trapping efficiency.** During 20 periods totaling 18.5 h, on 6 days between 27 September and 13 October 1989, migrants were watched as they encountered the trios of test traps. Migrants that were on a track leading to or over one of the traps were classed as "candidates," and candidates were scored as to their behavior relative to the trap: over, rise-and-over, in-and-over, through-slot-into-duct, etc.

## Results

**Fall 1988.** Only the shrimp net trap (10-mm-mesh) caught migrants at a rate similar to the permanent traps. Per meter of trap, it caught 94, 115, 34, and 77% as many *Phoebis sennae* (L.) (Pieridae), *Agraulis vanillae* (L.) (Nymphalidae), *Precis coenia* (Hübner) (Nymphalidae) and *Urbanus proteus* (L.) (Hesperiidae) as the average of the permanent traps. The 19-mm-mesh netting allowed many migrating butterflies to pass through easily. The no-throat trap, even when covered with 13-mm-mesh fabric, caught fewer of the larger migrants than did the similar throated trap with 19-mm-mesh. For *P. sennae*, the totals were 82 and 111; for *A. vanillae*, 257 and 381.

**Spring 1989.** Per meter of trap, the shrimp net, monofilament, and twine traps caught 50, 13, and 20% as many *P. coenia* as the average of the permanent traps, which was 27.3/m. As usual, other spring migrants were scarce (≤5.2/m).

**Fall 1989 and 1990.** Table 1 shows that the standard s-p trap performed better than any of its three variations, but only in 1990 were differences significant or nearly so (ANOVA, *P. sennae*, $P = 0.04$; *A. vanillae*, $P = 0.11$). Least significant difference tests for catches of these two species in 1990 indicated that the standard trap was better than the one-cage trap in both cases ($P \leq 0.05$).

**Trapping efficiency.** S-p traps were more efficient at catching the larger migrants than were the permanent traps that separated the trios of test traps (Table 1). Per meter of trap, combining the data for fall 1989 and 1990, standard s-p traps caught 1.21, 1.82, and 0.50 times as many *P. sennae*, *A. vanillae*, and *U. proteus* as the average of the permanent traps. Direct observation of butterflies encountering the fall 1989 trios of test traps gave counts of 86 of 308 candidate *P. sennae* entering the ducts and 55 of 137 *A. vanillae*. Assuming that those in ducts make their ways into holding cages (which they generally do), the trapping efficiency and 95% confidence limits (based on binomial distribution) for *P. sennae* are 28 ± 5%; for *A. vanillae*, 40 ± 8%.

## DISCUSSION

Few nonmigratory butterflies were trapped. Trapped butterflies were generally in good condition when removed from the holding cages, even when the traps were serviced at two-day intervals.

Of the four fabrics tested on the s-p frame, shrimp net (10-mm-mesh monofilament) was best for catching the smaller migrants. However, it caught *P. coenia* only 34 and 50% as efficiently as the permanent traps and *U. proteus* only 77% as efficiently. For the larger migrants, which were the ones we most wanted to catch, the 13-mm-mesh nylon-twine netting worked well. Traps with this fabric caught *P. sennae* and *A. vanillae* 121 and 182% as efficiently as the permanent traps. Traps with 13-mm-mesh monofilament and 13-mm-mesh nylon-twine netting did not differ significantly in their catches of *P. sennae* or *A. vanillae* (Table 1). An important advantage of 13-mm-mesh netting over the 10-mm-mesh netting required to catch the smaller migrants is its low wind resistance.

The importance of a throat—i.e., a gradual transition from the roof of a trap to the slot that accesses the duct—was first demonstrated in tests of permanent traps (Walker 1985b). The fall 1988 tests suggest that a throat is also important in s-p traps.

Having a tray and holding cage at each end of the trap adds to its cost and the time required to service it. However, in our tests of fall 1989 and 1990, traps with only one tray and cage caught 24 and 20% fewer *P. sennae* and *A. vanillae* than the standard s-p trap.

During direct observations of trapping efficiency, 44% of candidate *P. sennae* and 9% of candidate *A. vanillae* flew over the traps without going in. Consequently, increasing the height of the trap seemed a promising means of increasing its efficiency. However, adding 0.3 m to the trap at the bottom, thereby increasing the height of its opening from 2.0 to 2.3 m, decreased numbers of target migrant caught by >10%. Perhaps more butterflies entered the trap but the roof and throat were no longer as effective at funnelling them into the slot.

When data from fall 1989 and 1990 are combined, the standard s-p traps caught 1.21 times as many *P. sennae* and 1.82 times as many *A. vanillae* as the average of the two permanent traps. These relative efficiencies, based on more than 2000 captured butterflies of each species, point the way to another means of estimating absolute efficiencies of the s-p trap. Walker (1985b) reported that 15.4 h observation of the Model #3 permanent trap in October 1984 yielded 96 and 52 candidates and estimated efficiencies of 49–70% and 22–50% for *P. sennae* and *A. vanillae* respectively. When the data in Table 1 are used to calculate the efficiency of the standard s-p trap relative only to the #3 trap, the numbers are 1.16 for *P. sennae* and 1.88 for *A. vanillae*. When these numbers are applied to the estimates of Model #3 efficiencies, inferred efficiencies for s-p traps are 57–81% for *P. sennae* and 41–94% for *A. vanillae*. Estimates of efficiencies for s-p traps based on direct observation were 23–33% for *P. sennae* and 32–48% for *A. vanillae* (see above). The two methods of estimating s-p efficiencies yield overlapping ranges for *A. vanillae* but not for *P. sennae*. Because sample sizes for estimating absolute efficiencies by direct observation were small, those estimates for either the #3 or the s-p traps (or both) are more likely to be non-representative than the estimates of the relative efficiencies of the two.

The ratio of *P. sennae* to *A. vanillae* in the permanent traps is significantly higher than that ratio in the standard s-p traps (2 × 2 contingency table; chi square, $P < 0.001$). It seems likely that the lower roof and throat of the s-p trap are more effective for the low-flying *A. vanillae*, while the high opening of the permanent trap intercepts more of the higher flying *P. sennae* (Walker 1985a, Fig. 1).

The fabric of our standard s-p trap proved appropriate to our needs, but other materials and meshes might have yielded larger catches. Indeed our data indicate as much for species other than *P. sennae* and *A. vanillae*. For studies lasting more than one year, a material more durable than nylon twine would be desirable. A candidate material is UV-resistant polypropylene netting, used for excluding birds from crops, which is reputed to last 5 yr outdoors. Tests of one such material (Ornex SM, Tenax Corporation, Jessup, Maryland) demonstrated that it was as effective as 13-mm-mesh nylon twine netting.

Compared to previously developed traps, the semi-portable trap combines economy, efficiency, and ruggedness to a noteworthy degree. Materials cost less per meter of trap than for the portable and permanent traps. Making the trap and erecting it is easier and less time consuming than for the other two trap types. For our two target species, the s-p trap is the most efficient of the three. Routine maintenance and service is easier than for the portable trap and about the same as for the permanent traps. The chief way that the s-p trap does not equal or exceed both of the other two is in durability of fabric. In Florida weather, the polyester netting used on the portable traps lasted only a few months, but the hardware cloth of the permanent traps has lasted for more than 9 years. The nylon-twine netting of s-p traps fails in about 1 year—it is good for a fall and the following spring but will not last through the next fall. To sum up, the s-p trap has a combination of features that recommend its use in studies where butterflies migrating in the boundary layer are to be counted, marked and released, or collected for behavioral or physiological studies.

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## APPENDIX: HOW TO BUILD TRAPS

Measurements are mostly in inches and feet, because the materials used were made and sold by those units (1″ = 2.54 cm; 1 ft = 0.305 m).

**Frame.** For each end, prepare a main post, eaves post, top piece, rafter, and basal side piece (132, 81, and 20″ of treated pine 2 × 4, and 65 and 58″ of treated 1 × 4). Dado posts and top pieces as shown in Fig. 2A. The bottom of the dado for the rafter is at 100 ¾″ on the back of the main post; its angle is 67.5°. Drill a ¾″ diam hole ¾″ deep to receive each of seven 10-ft lengths of ½″ EMT (Fig. 2A). The center of the upper hole on the rafter is 1″ from the upper edge and 15¾″ from the upper end of the rafter. The lower hole on the rafter is 2 m above the bottom of the eaves post (making the trap mouth 2 m high). The EMT holes that define the slot of the trap are 18″ from the top of the main post with centers ⅝″ from either edge. Secure top piece to the main post with a ⅜ × 4″ carriage bolt, and the rafter and basal side piece to the posts with four 5/16 × 2″ stove bolts. On each end of the frame install four ¼ × 2″ eye bolts, eyes out, to secure the rope braces (see Fig. 2A). Install a 5/16 × 2″ eye bolt with ¾″ diam hole, eye in, near each end of the basal side pieces, to receive stakes. With a helper, successively put in place the seven pieces of EMT and fasten each end in its ¾″ hole with a 6d galvanized common nail inserted in a ⅛″ hole drilled through the wood and EMT. Nail the basal back piece (121½″ of 1 × 4) in place.

**Netting and braces.** Install the main net (3 m × 6 m) by stapling one end to the basal back piece and threading the other end through the slit, around the upper 2 pieces of EMT, back through the slit, under the EMT that defines the throat, and to the eaves. [We first used Stock No. 132, #104 multifilament nylon gill netting, ½″ square, 102 mesh and 7 feet deep, purchased from Memphis Net & Twine Co., Memphis, Tennessee. We subsequently avoided having to staple and silicon-caulk two lengths together for the main net by special ordering double-depth (192 mesh, 14 feet) netting of the same type.] Starting at the basal back piece and keeping the net stretched, staple both edges of the netting to main posts, top pieces, main posts, and rafters. Staple the net to itself around the eaves EMT; then use silicon caulk to glue it to the EMT. Screw four ¼ × 1″ eyes into the main posts and install the rear braces of 3/16″ braided nylon rope (Fig. 2A). Stretch and staple pieces of netting onto the ends and install the four ropes that brace the ends.

**Trays and cages.** Make each tray from a 4¾ × 56¾″ piece of 20 ga galvanized metal twice bent longitudinally in a sheet metal break: 90° inward at 1″ and maximally outward at 4″ (Fig. 2B). At 11½, 28, and 39½″ cut the 90° bend and notch the sharper bend. At 56″ cut away the remaining bent metal leaving the rest as a tab for riveting. Now bend the piece 90° inward at each cut, and pop rivet (flat side in) the ends together and the inside flanges at two corners (to keep the tray from flexing). Complete the tray by drilling a ¼″ mounting hole at the midpoint of each lateral interior flange and riveting on an apron and side pieces made from a 6 × 24″ piece of ¼″-mesh hardware cloth (Fig. 2B). Attach a tray to either end of the trap with ¼ × 2″ carriage bolts passing through holes drilled in the top piece. Carefully cut a slit in the netting and pull the netting over the apron. By bending the side pieces outward and the apron upward and by keeping the slit in the netting small, you can make a butterfly-tight seal between the tray and the netting. Repair any mishaps with silicon caulk.

Construct holding cages of ¼″-mesh hardware cloth as described by Walker and Lenczewski (1989) (11 × 16 × 10″ with a valve in the bottom) (Fig. 2B). As an aid to servicing the cages, rivet a 3″ piece of 1¼″-diam PVC vertically to the top center of the back of each cage. Make a device for installing and removing cages from a 2 m length of ½″ EMT with 4″ and 11″ crosspieces of 1¼″ PVC riveted at 3½ and 7″ from the upper end (Fig. 1).

**Securing the trap.** Make stakes by cutting 18″ lengths of ½″ EMT. Near the top of each stake, drill a hole and install a bolt to prevent the stake from passing through a ¾″ eye. With the trap in position, thread each of its four inside eyes with a stake and drive each stake until the bolt reaches the eye.