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A NESTABLE FIBER POT FOR SAMPLING RESTING MOSQUITOES

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ABSTRACT. To enhance the effectiveness of an arbovirus monitoring program, we evaluated a commercially available device for sampling resting vector mosquitoes. Diverse *Anopheles, Culiseta,* and *Culex* mosquitoes were taken in these nestable fiber pots. The pots sample about as many *Culiseta melanura* mosquitoes per device as do conventional resting boxes, but fewer than do boxes fitted with expanded frames. More *Cs. melanura,* and more bloodfed mosquitoes, but fewer species of mosquitoes are harvested with fiber pots than with CDC light traps. Fiber pots are more readily used, transported, and stored and are less expensive than conventional resting box devices or CDC light traps. A monitoring program based on the use of fiber pots, therefore, expends fewer resources than one using conventional resting boxes and collects about as many vector mosquitoes.

INTRODUCTION

Various kinds of devices have been used to capture resting vector mosquitoes (Service 1976). Pit traps (Muirhead-Thomson 1958), by their nature, are placed permanently in a site and generally require elaborate construction. Wooden kegs, once used for shipping nails, were adapted for sampling anopheline mosquitoes during World War II (Smith 1942), and other modifications on this theme have been used since. These resting box devices are open on one side and generally are dark colored (Goodwin 1942, Burbutis and Jobbins 1958, Gusciora 1961, Moussa et al. 1966). Efficacy is enhanced when the apparent area of the opening is enlarged by means of a funnel-like extension (Edman et al. 1968). These devices continue to be used in numerous malaria and arbovirus surveillance programs.

Although the efficacy and simplicity of the standard rectangular resting box devices render them attractive for routine monitoring, their cost and bulk impede their operational use. Because nails no longer are packed in kegs, wooden resting devices must be specially fabricated. Their parallel-sided design, however, prevents them from nesting and renders contained mosquitoes difficult to harvest. A less expensive resting box device that is more convenient to transport and easier to use may facilitate efforts to monitor mosquitoes.

To improve the efficiency of an ongoing arbovirus monitoring program, we evaluated the effectiveness of commercially available, nestable fiber pots for sampling natural populations of *Culiseta melanura* (Coq.), a diurnally resting mosquito that is the enzootic vector of eastern encephalitis (EE) and Highlands J viruses (Morris 1988). Efficacy was compared among fiber pots, conventional plywood resting boxes, and CDC light traps.

MATERIALS AND METHODS

Sampling devices: Commercially available fiber pots (Western Pulp Products Co., Corvallis, OR), are molded from recycled wood pulp in the form of hollow, truncated pyramids (Fig. 1) with a height of 28 cm. The base (open end) is 28 × 28 cm, and the top (closed end) is 15 × 15 cm. The thickness of the fiber walls is 1 cm. All surfaces of the pot are dark brown.

For comparison, we used conventional plywood boxes (20 × 38 × 30 cm) fashioned from plywood and with their interiors painted matte black. Funnel-shaped entrance frames were placed on these boxes during part of the study (Fig. 2), effectively expanding the opening to 60 × 120 cm. Resting boxes and frames were provided by John D. Edman, University of Massachusetts. Portable CDC miniature light traps (John W. Hock, Inc., Gainesville, FL) also were used for comparison (Sudia and Chamberlain 1962).

Study sites: Mosquitoes were sampled at 12 sites in southeastern Massachusetts (Bristol, Plymouth, and Norfolk counties). Seven of these sites were located in the Hockomock Swamp Wildlife Management Area, a location known for arbovirus activity, in the towns of Taunton and Easton (Bristol County) and Bridgewater (Plymouth County). Three additional sites were located in Kingston (Plymouth County) and one each in Hingham (Plymouth County) and Stoughton (Norfolk County). All sites appeared suitable for capturing resting mosquitoes and were near avian roosting sites.

Procedures: Fiber pots and resting boxes were placed on the ground with their openings oriented at random. Light traps were suspended 1–2 m above the ground at intervals of about 10 m and operated overnight using 6-V motorcycle batteries. Mosquitoes in light traps generally were harvested during morning hours; resting

Fig. 1. A fiber pot alongside a stack of 9 pots, shown to demonstrate portability and storability.

mosquitoes generally were harvested in the afternoon with a battery-operated aspirator. Mosquitoes were transported on wet ice to the laboratory, where they were killed by freezing, identified, and tested for the presence of virus by plaque assay in chick embryo tissue culture.

RESULTS

We recorded the number and diversity of mosquitoes present in fiber pots. More than 2,000 specimens of 10 different species of mosquitoes were harvested from 295 fiber pots from July 18

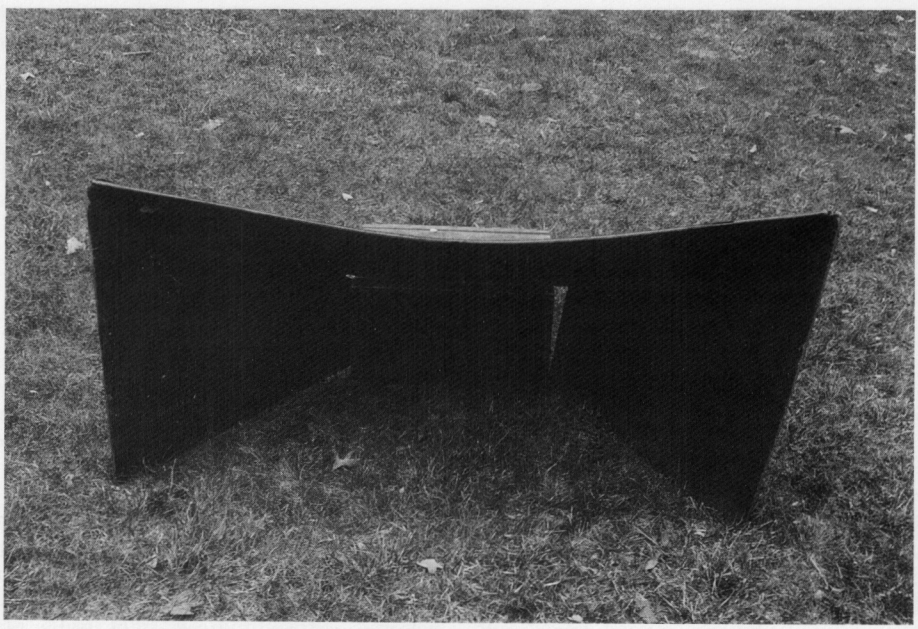

Fig. 2. A plywood resting box with its extended frame attached.

Table 1. Number of mosquitoes harvested in 2,500 collections from nestable fiber pots set in 12 southeastern Massachusetts sites.

Species	Mosquitoes per 1,000 collections: Females: No.	Females: % blood-fed	Females: No. males
Culiseta melanura	486	60	206
Culiseta morsitans	67	31	0
Anopheles quadrimaculatus	26	3	24
Culex territans	24	3	21
Aedes cinereus	6	19	0
Culex restuans	5	69	<1
Culex pipiens	3	62	1
Anopheles punctipennis	2	0	<1
Uranotaenia sapphirina	1	0	0
Culex salinarius	<1	0	0
Unidentified	4	0	41
Total	625	51	294

Table 2. Comparison of number of female mosquitoes harvested from nestable fiber pots with that from conventional resting boxes or resting boxes augmented by an expanded frame.

Test	Collection device	No. collections	Mosquitoes per 100 collections: Total no.	*Culiseta melanura*: No.	*Culiseta melanura*: % blood-fed
I	Fiber pot	95	28	24	13
	Resting box	90	30	21	21
II	Fiber pot	111	16	13	29
	Box and frame	96	107	82	18

to October 3, 1994 (Table 1). *Culiseta melanura* predominated, comprising 75% of the harvest. Some *Anopheles quadrimaculatus* Say also were harvested from these devices. More than half of the females harvested contained readily detectable vertebrate blood. On average, about one mosquito was taken from each pot per day. Highlands J virus was detected in 2 of 95 pools of pot-harvested *Cs. melanura.* Nestable fiber pots, therefore, sampled numerous vector mosquitoes.

The harvest of mosquitoes taken in fiber pots was compared to that taken with conventional plywood resting boxes and with resting boxes enhanced by an expanded frame. In Test I, 16 fiber pots and 15 resting boxes were randomly placed within a 0.5-ha wooded space from September 1 to September 17, 1994. A similar array of devices was monitored from July 18 to August 23, 1994, in Test II, except that expanded frames were placed on all resting boxes. Similar harvests of mosquitoes were recorded in the fiber pots and the frameless resting boxes (Table 2). Boxes with expanded frames, however, harvested far more mosquitoes than did the fiber pots. We conclude that fiber pots sample as many mosquitoes as do resting boxes, but fewer than do boxes fitted with expanded frames.

We then compared the diversity of mosquitoes taken with fiber pots to that taken with CDC light traps in Kingston, MA, from August 30 to September 19, 1994. Twenty fiber pots were placed in a 1-ha site near 6 light traps. This site supported the roosting of more than 1,000 American robins (*Turdus migratorius* Linn), but contained no habitat suitable for larval *Cs. melanura.* More than twice as many female *Cs. melanura* were taken per fiber pot than per light trap (Table 3). Our light trap collections included many more human-biting mosquitoes than did the fiber pot collections; no *Aedes* mosquitoes, *Coquillettidia perturbans* (Walker), nor *Culex salinarius* Coq. were taken in fiber pots. Although anopheline mosquitoes were taken with both kinds of devices, light traps collected 3-fold more than did fiber pots. Overall, more than 6 times as many bloodfed mosquitoes were taken in fiber pots than in light traps. More *Cs. melanura,* and more bloodfed mosquitoes, but a lesser diversity of mosquitoes, are harvested with fiber pots than with light traps.

DISCUSSION

Monitoring systems for vector mosquitoes must be adapted to the peculiar features of the target mosquito and to the prevailing physical and political environment. The nocturnal flight behavior of *Cs. melanura* renders them vulnerable to capture in light traps, and their attraction to dark cavities results in their entry into artificial diurnal resting devices. For various reasons the Encephalitis Surveillance Program of the Commonwealth of Massachusetts has been based on light trap collections (Edman et al. 1993) and that of New Jersey on resting boxes (Crans 1994). A 3rd option, adopted by the state of Florida, employs serological monitoring of

Table 3. Comparison of number and feeding status of female mosquitoes harvested from nestable fiber pots with that from CDC light traps.

	Mosquitoes per 1,000 collections in			
	Fiber pots (260 collections)		Light traps (33 collections)	
Species	Mean	% bloodfed	Mean	% bloodfed
Culiseta melanura	179	96	81	26
Culiseta morsitans	9	83	6	50
Anopheles quadrimaculatus	5	0	18	0
Culex territans	4	0	0	—
Culex restuans	2	80	15	20
Culex pipiens	1	100	3	0
Uranotaenia sapphirina	<1	0	3	0
Culex salinarius	0	—	36	0
Aedes cantator	0	—	9	0
Aedes vexans	0	—	3	0
Unidentified	0	—	3	0
Total	200	91	179	15

sentinel chicken flocks (Morris 1988). Each sampling strategy produces data requiring unique modes of interpretation.

The fiber pots that we evaluated for monitoring *Cs. melanura* in Massachusetts may benefit encephalitis surveillance programs. As many *Cs. melanura* were harvested by means of these convenient and inexpensive devices as with the plywood resting boxes that have conventionally been used for this purpose. Although CDC light traps are said to collect about 10 times as many female *Cs. melanura* as do resting boxes (Nasci 1980[1]), we found that nestable fiber pots collected more mosquitoes than did unbaited CDC light traps. Larger collections of *Cs. melanura* from resting boxes than from CDC light traps at an upland farm site, but not in forested wetland sites, have been reported (Joseph and Bickley 1969). This finding may be explained by the abundance of vertebrate hosts at upland sites. Perhaps the attraction of a dense nidus of birds outcompetes the attraction of a light trap. Mosquitoes seem to enter our pots most abundantly early in the afternoon, perhaps because they initially rested postprandially in the canopy near their roosting avian hosts. Harsh daytime environmental conditions may drive these mosquitoes toward the ground near our fiber pots. The relative frequency of blood-engorged *Cs. melanura* distinguishes resting collections from light trap collections. A diversified monitoring program may be particularly useful because resting devices sample a different segment of the vector population than do light traps.

The nearly total absence of *Aedes* mosquitoes in our fiber pot collections confirms observations with other resting devices (Burbutis and Jobbins 1958). The harvesting potential of fiber pots for *Cq. perturbans,* an important pest and potential EE epidemic vector (Howitt et al. 1949), has yet to be determined because this species' adult population was exceedingly low during the period of study at our sites. Although fiber pots sample many more nocturnally active *Culiseta* and *Culex* mosquitoes, light traps in Massachusetts have the advantage of sampling diverse *Aedes,* as well as *Cq. perturbans* mosquitoes. Information on the density and virus infection rate in these "bridge-vector" mosquitoes is useful in formulating an intervention decision, and this information will be lacking in a monitoring program that does not include light traps.

Nestable fiber pots sample as many *Cs. melanura,* including virus-infected females, as do conventional resting boxes. Because diverse kinds of mosquitoes, including anophelines, rest in these pots, they may be useful for monitoring the intensity of transmission of other mosquito-borne pathogens, such as human malaria.

We confirm that resting boxes fitted with funnel-like collapsible frames, which increase the apparent area of the entrance 9.6-fold, collect about 6 times more mosquitoes than otherwise would be collected (Edman et al. 1968). One person, however, can service many more pots

[1] Nasci, R. S. 1980. Vector biology of *Culiseta melanura* (Coquillett) in southeastern Massachusetts. Ph.D. dissertation. University of Massachusetts, Amherst, MA. 100 pp.

than frame-mounted boxes in a given period of time, and at far less cost. The disadvantages of mounting frames, therefore, appear to outweigh benefits gained in collection efficacy.

Economic factors may influence the choice of fiber pots over conventional resting boxes. We estimate that a resting box can be procured for about $15 and that a frame costs an additional $15. A fiber pot, in contrast, costs only $1.30 (delivered). A 0.5-kg (1-lb) fiber pot weighs significantly less than a resting box (about 3 kg) and a plywood box with its frame (about 7 kg). The nestable feature of the fiber pots combined with their light weight promotes portability and storage. Indeed, we believe that one person can comfortably carry either 20 fiber pots, 2 resting boxes, or one resting box with its accompanying collapsed frame. None of the 295 fiber pots that we have installed appears to have lost structural integrity during 1 year of exposure to an accumulated 100 cm of precipitation. In practice, we found that mosquitoes can be harvested in half the time from a trapezoidal fiber pot than from a cuboidal resting box. Furthermore, we found that artificial illumination of the interior of the resting device was essential for mosquito collection from plywood boxes, but not from fiber pots. Thus, monitoring programs that use fiber pots expend fewer resources than those using conventional resting boxes.

Our experience with nestable fiber pots for sampling arbovirus vector mosquitoes encourages us to recommend their further evaluation for use as sampling devices for mosquitoes that transmit the agents of malaria, filariasis, Rift Valley fever, and various other encephalitides. Use of these pots may facilitate routine monitoring of vector mosquitoes.

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