CALF-BAITED TRAPS AS A METHOD FOR SELECTIVE SAMPLING OF ADULT POPULATIONS OF *ANOPHELES ALBIMANUS* WIEDEMANN

RONALD E. LOWE[1] AND DONALD L. BAILEY

Insects Affecting Man and Animals Research Laboratory, Agricultural Research Service, USDA, Gainesville, Florida 32604.

ABSTRACT. A calf-baited trap was designed and used to capture *Anopheles albimanus* adults in El Salvador. Daily collections during a 1-yr study showed that this type of trap was useful in sampling mosquitoes for estimating population densities and providing live, healthy adults for biological assays from areas where other methods of collection were not possible. Capturing mosquitoes with traps generally proved to be a more efficient method than the standard method of capturing adults from stables.

The use of animals or humans as baits for capturing adult mosquitoes was one of the earliest methods of procuring live, healthy specimens for biological studies. Zetek (1915) compared various methods of trapping anopheline mosquitoes to study malaria transmission in the Panama Canal Zone. By constructing large net cages and baiting them with humans, dogs, or chickens, he captured large numbers of *Anopheles albimanus* Wiedemann females for use in marked-release/recapture experiments. Also, Magoon (1935) reported good results with a portable stable trap that had horses as bait.

The use of portable light traps is an effective and economical method of monitoring populations of mosquitoes, and numerous modifications of this method have been used. However, light traps have the following disadvantages: (1) they attract a wide variety of insects and thus require many man-hours to sort and identify the different species; (2) they usually provide only dead or immobilized specimens suitable for use only in taxonomy or in estimates of population density; (3) they require an electrical power supply; and (4) they may attract only a segment of the population, which may not be the same as that attracted to animal baits.

Researchers have also used combinations of trapping methods to obtain more accurate information about anopheline mosquitoes. Breeland and Glasgow (1967) designed a portable box for assaying and collecting adult anopheline mosquitoes during diurnal resting periods. Breeland (1972) used collections from box traps, natural sites, stables, human bait, and light traps to study anopheline densities in El Salvador. Hobbs (1973a, 1973b) used similar methods to trap *An. albimanus* in a coastal zone of El Salvador. During an experiment to release sterile male *An. albimanus* for control of this species, Lofgren et al. (1974) determined that the best collections of healthy, viable adults came from evening captures in stables, or from human bait. Their attempt to use calf-baited traps was unproductive and was discontinued after a few weeks. Lowe and Bailey (1979) showed that for *An. albimanus* morning captures from stables were more productive than evening collections, because female mosquitoes that entered the stable during the night in search of a blood meal could be collected in greater numbers from sheltered resting sites early in the morning. However, the number of stables in a large area may be limited and may not be uniformly located near potential breeding areas; thus they may attract different segments of the population. These problems led to a renewed effort to devise an efficient, porta-

[1] Present address: USDA-APHIS, Comision Mexico Americana, Apartado Postal 544, Tuxtla Gutierrez, Chiapas, Mexico.

ble, animal-baited trap. This paper describes a calf-baited trap for anopheline mosquitoes that is economical and efficient in many situations.

METHODS AND MATERIALS

Before we began using the calf-baited traps, *An. albimanus* adults had been collected from 18 stables located throughout a 150-km^2 area along the Pacific coast of El Salvador. Part of this area was being used in a sterile-male release program. Females captured from stables within the release zone were used to assay the level of induced sterility; those captured from stables outside of the release zone were used as controls. Mosquitoes were collected from each stable for 1 man-hr/wk, and additional collections were made from selected sites as needed. In comparison, mosquitoes from calf-baited traps were collected every morning, and data were recorded as the number captured per trap-night.

We constructed traps with a wooden frame 1.2 × 2.4 × 1.8 m high. The lower 0.9 m of the trap was covered with 6-mm plywood, and the upper section was covered with 6 × 6 mesh/cm fiberglass screen. On each side these 2 sections were divided by an opening 15 cm high that ran the length of the trap. These openings were fitted with supports that gradually narrowed the entrance. The final opening for mosquito entry was 2.5 cm high along the length of each side of the trap. Figure 1 shows a trap placed in the field, with a hinged door at one end for access and plastic sheeting over the plywood top for protection from rain. A wooden support inside the trap at the end opposite the door was used to tether the animal.

For ease of handling and mobility we constructed the traps so that 2 people could load one of them into a pickup

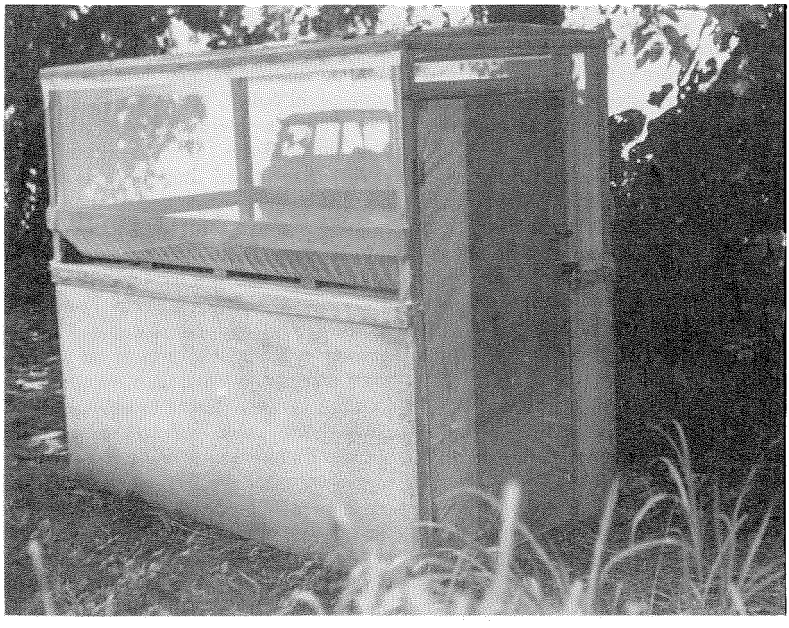

Fig. 1. Calf-baited mosquito trap showing locked entry door and horizontal opening for attracted *Anopheles albimanus* adults.

truck and unload it in the field. A trap could be built in 1 day from readily available and inexpensive materials, and the minimal maintenance that was necessary throughout the year of this study was performed at the trap location. For bait we used yearling calves that were rented on a nightly basis from local inhabitants. The owner put the calf with a food supply in the trap each evening and removed it the next morning. The field team collected mosquitoes and did necessary maintenance.

The first calf-baited trap was placed near a known mosquito breeding site on the Tihuapa River about 3 km from the Pacific Ocean on February 14, 1978. This location was ca. 0.6 km from a stable, from which routine collections were made. We chose this site to enable us to determine the effectiveness of the trap in relation to collections made in the stable and to compare the sex ratio and viability of mosquitoes from the trap with those from the stable.

Within a few days, we had determined that the trap attracted adult females, so we constructed 2 more traps and put them into operation the next week. We placed 1 trap near a second river 10 km west of the first, in an environmentally different area, and placed the other in a pasture near an estuarine canal where ground depressions contained water. Collections from these traps appeared to be greater than those from nearby stables, so standardized trap collections were begun each morning during wk 9 (February 26-March 4). During wk 10, a fourth trap was placed near a coastal salt marsh at the interface of a wooded area and cultivated fields.

The location of the first calf-baited trap was outside the sterile male release zone, but the locations of the other 3 were within the release zone. All 4 traps remained in their original locations throughout the study. Two more traps were added in wk 12 and 21 for studies of populations in specific locations. These traps were moved periodically to provide data for special tests.

RESULTS AND DISCUSSION

Table 1 shows average daily numbers of adult *An. albimanus* males and females captured throughout the study with the 4 original traps. From the beginning, the traps captured large numbers of female mosquitoes and allowed the sterility levels to be assayed from within and outside the sterile-male release area; these data were used to indicate population trends. With the beginning of the dry season (wk 13), captures from river sites (traps 1 and 2) dropped sharply, but captures from the estuarine areas remained high. As rains began in wk 21, the low areas flooded, and the numbers of adults captured in these areas increased. By wk 26, pools had formed along the rivers. These pools provided more locations for mosquito breeding, and the numbers of captured mosquitoes again increased. As the rainy season continued and the number of potential breeding sites increased throughout the area, the numbers of mosquitoes captured per trap diminished. This probably was because emerging adults were diffused over such a large area that a single calf became less attractive than cattle stables or concentrations of human dwellings. Bailey et al. (1979), measured larval populations in numerous locations through the year and reported a similar shift in population densities.

High numbers of adult males were captured in traps located in the sterile-male release zone but not in the trap outside the zone. Because we were releasing as many as 1.3 million sterile males per day in the area, we expected the number of captured males to be higher inside the area than outside, but not as high as the numbers we actually captured. Males were seldom attracted to trap 1, outside the release zone (avg < 1 captured/night), even when numbers of females captured were high. However, inside the release area males sometimes constituted more than one-third of the number collected, though the number of males captured was only 0.01–0.02% of those released.

Table 1. Average daily numbers of adult *Anopheles albimanus* males and females captured in calf-baited traps during a 52-week period in El Salvador. Trap 1 was outside the sterile-male release zone; traps 2–4 were within the zone.

	Trap number								Average within release zone	
	← 1		← 2		← 3		← 4			
Weeks	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
					1978					
9–12	1.2	211	11	64	3	84	8	60	7	69
13–16	0.2	14	23	42	10	90	19	75	17	69
17–20	1.3	40	32	45	12	32	25	63	23	47
21–24	0.4	19	30	36	29	159	78	153	45	116
25–28	1.4	93	60	101	34	291	102	142	66	180
29–32	0.8	91	73	67	48	186	58	113	60	125
33–36	0.6	62	81	17	60	48	21	22	54	29
37–40	0.1	11	29	3	40	14	3	20	24	13
41–44	0.0	1	32	12	27	47	0.5	10	20	23
45–48	0.1	3	55	51	47	126	0.8	6	34	86
49–52	0.2	7	86	129	59	353	13	29	52	170
					1979					
1–4	0.2	51	52	52	63	106	50	77	55	79
5–8	2.1	180	57	7	22	16	93	144	58	56

Although males would not have been attracted to the calf for food, they might have been attracted for mating by the increased activity of females in the trap. The male:female ratio increased in wk 31 and 32. In wk 33 we began collecting more males than females, and this trend continued for 8 wk. Numbers of males captured in traps 2 and 3 remained high even when the number of females decreased.

To determine whether the calf-baited traps were competitive when they were placed near other sites that attracted adult females, we used traps 5 and 6 to compare population densities in various locations. During wk 13, we placed trap 5 near a row of small houses near the Tihuapa River, about 3 km north of trap 1. Each house sheltered one or more families and their assorted animals, and the open construction of the houses provided easy access for mosquitoes. We observed adult *An. albimanus* females resting in sheltered areas inside the houses in the morning. Although trap 1 captured ca.1–18 females/day, trap 5 captured only 1 female/day and was therefore not competitive. During wk 14, we moved trap 5 midway between the river and the houses, but only a few more adults per day were captured. During wk 15, we moved the trap to another river with no houses nearby and numbers of mosquitoes captured rose to a level comparable with those of other traps.

Average numbers of females captured per night in the 4 calf-baited traps compared to average numbers collected in 1 man-hr from stables are shown in Table 2. Numbers of females captured were higher from calf-baited traps than from stables until wk 32, when the adult population began to diffuse. These data coincided with those shown previously and appeared to support our contention that a single calf was not as competitive as a stable when mosquito breeding was diffused. Therefore, trap location was the most important factor in capturing large numbers of mosquitoes.

One benefit of using calf-baited traps

Table 2. Comparison of numbers of adult *Anopheles albimanus* females captured in 4 calf-baited traps with those in 18 stables.

Weeks	Calf-baited trap avg. no./ trap night	Stables avg. no./ man-hr
	1978	
9–12	108	43
13–16	55	14
17–20	45	16
21–24	92	33
25–28	157	42
29–32	114	81
33–36	37	108
37–40	12	42
41–44	18	12
45–48	47	14
49–52	130	34
	1979	
1–4	72	74
5–8	81	45
Mean	74.5	42.9

was that we did not have to follow a standard time of collection as we did in collections from stables. Collectors had to search for 1 hr in each stable, though in some instances almost every adult could be found in much less time. In contrast, all mosquitoes could usually be collected from a calf-baited trap in less than an hour, even when it held large numbers of mosquitoes, because the area in the trap was small.

Vandalism of field equipment, which had been a problem in previous phases of the program, was not a problem with the calf-baited traps. Local inhabitants were paid to use their own animals in the traps; therefore, they maintained a high degree of security. Their involvement also improved public relations, and education of the local population helped the program.

In this study, we concluded that calf-baited traps for anopheline mosquitoes were more effective and also more logistically beneficial than collections from stables.

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