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THE RAMP-TRAP, AN UNBAITED DEVICE FOR FLIGHT STUDIES OF MOSQUITOES

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The study of the flight paths of mosquitoes has been hampered in the past by lack of suitable traps. The most commonly used method for actively sampling flying populations is the truck trap of Chamberlin and Lawson (1945). This has been modified in various ways, e.g., Sommerman and Simmet (1965), Loy *et al.* (1968), and has been profitably used by Bidlingmayer (1964, 1966) to study the flight activity of *Aedes taeniorhynchus* (Wiedemann) in relation to the lunar cycle. It takes a linear sample of a very large volume of air and hence provides large catches, but its use is strictly limited to motorable terrain and it can give only marginal information on vertical distribution. Moreover, in common with other active sampling methods, including suction traps and the rotating net traps of Chamberlin and Lawson (1945), it is impossible to obtain any directional information from its use.

The alternative approach is to adopt passive sampling methods in which the mosquitoes enter the trapping area whilst in flight and are trapped or not according to their reactions. Examples of these are sticky traps, as used by Gordon and Gerburg (1945) and Provost (1960), the stationary traps of Nielsen (1960), and the open net-traps tested by Colless (1959) in

Singapore. The latter, which had one end open, might well be described as "fly-in, fly-out" traps since the design incorporated no trapping device and relied on periodic closing of the net by the collector. Nielsen's trap had the disadvantage that it appeared to catch only mosquitoes showing directed flight, as in the case of migrating *Aedes*. The Malaise trap (Breeland and Pickard, 1965), should also be regarded as a flight trap, although its action undoubtedly relies in part on the visual attraction of the dark interior.

The problem, therefore, is to devise a trap that allows the free entry of mosquitoes from one direction only, yet prevents their escape afterwards. A number of designs employing Colless's principle were tried out in the field with limited success, Gillies and Snow (1968). Attempts to improve on this by guiding the mosquitoes into a narrower trapping section were at first unsuccessful. Observations at night with open types of trap showed that this was because, in the absence of bait, mosquitoes that encountered a vertical partition of netting tended to turn around and fly out rather than track along it into an inner compartment where they could be trapped. The same was probably happening with Nielsen's trap. However, when the mosquitoes were presented with a long ramp of netting, inclined at an angle of 135° with the horizontal, it was found that they would fly on up and over the inclined surface and so could be guided into a cage fitted over the top of the ramp. This simple method of trapping was found to be highly effective and large catches of night-flying species have been made with it in a variety of situations.

DESCRIPTION OF THE TRAP. The trap stands 4 feet 6 inches high and 3 feet wide. Construction is of plastic or fibre glass netting stretched across wooden frames. The trap is made in two parts, the ramp unit and a detachable cage. Its design is shown in Figs. 1–3. The ramp unit is made up of two triangular side pieces, a frame for the ramp 6 feet long by 3 feet wide, and a roof 4 feet 2 inches long by 3 feet wide. The side frames are right-angled triangles with equal short sides of 4 feet 6 inches, the upper and inner corner subsequently being cut off to give an approximate length of 4 feet 2 inches for the upper side. Supports for the ramp unit are also provided, as shown in the photographs. When the frames are fitted together a gap of 4 inches remains between the roof and the top of the ramp which acts as an entry slit.

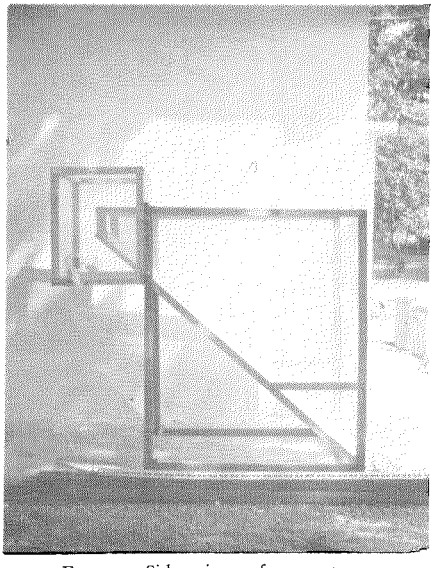

FIG. 1.—Side view of ramp-trap.

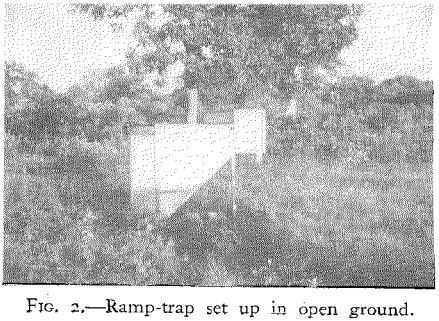

FIG. 2.—Ramp-trap set up in open ground.

The cage is 3 feet 5 inches wide by 2 feet high by 17 inches deep and is made to fit snugly against the vertical supports of the ramp. It is held in position by spring clips. A horizontal strut is fitted across the front of the cage, the base of the strut being approximately 7 inches below the top of the cage, so that the cage rests securely on the roof of the ramp unit. Another strut nailed across the roof of the ramp unit serves to buttress it in this position. Apart from the portion of the front wall of the cage that fits over the top of the ramp the remaining walls are covered with netting. Two cotton netting sleeves are fitted into the side walls of the cages.

It was found necessary to taper off the wooden frame of those parts of the ramp unit that project into the cage so that, when fitted together, a clearance was left between the sides of the cage and the netting on either side of the entry slit. Without this there was a tendency for mosquitoes to rest in inaccessible corners in the front of the cage. It was also necessary to check the fitting of the cage onto the ramp unit and to plug any gaps with sponge rubber. A useful modification would be to line the points of contact of the cage with the ramp unit permanently with sponge rubber.

FIG. 3.—Ramp-traps in two tiers showing method of closure of traps when not in operation. A collector is removing the catch from the upper cage.

When not in operation the entrance to the trap is closed with a loosely fitting panel of netting kept in place with curtain wire. This is essential during the hours of daylight, since without it the cages soon become filled with a variety of flies, Lepidoptera and Hymenoptera and even occasionally lizards which are liable to damage the netting. Tree frogs are also frequently trapped in them at night. The traps are put into operation by removing the entrance panel. This is replaced at the end of the catching period and the trap left until the morning. On occasions when they are operated all night the panel is replaced a half to one hour before dawn so as to preclude the entry of mosquitoes seeking daytime resting sites. The mosquitoes are caught in the morning with a sucking tube mounted on a short rod and with a long rubber connecting tube. This enables the collector to reach all corners of the cage. If often happens that one or two mosquitoes conceal themselves in the narrow part between the side of the cage and the projecting part of the ramp, and patience may be required to dislodge them. Improvements in the design of the cage should obviate this difficulty.

Under field conditions the traps need regular maintenance. The netting and the sleeves of the cage may get torn, and the wooden frames of the cage may warp so that they fail to fit sufficiently close to the ramp unit. Termites may attack the bases of the traps if they are left in position for long periods. The vegetation in the trapping area must also be kept down to a uniform level, although excessive growth of grass underneath the ramp is

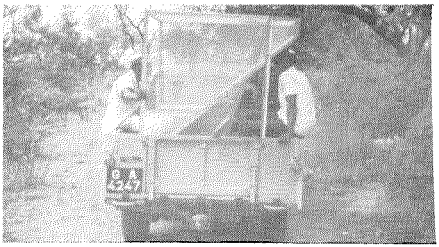

FIG. 4.—Transporting a ramp-trap by Landrover.

probably not important provided the entrance is clear.

The most important feature of the design seems to be the principle of the ramp. There is consequently nothing critical in the dimensions given above. They were primarily adopted to suit the materials that were available locally and with the portability of the traps in mind (fig. 4). The size of the slit was also arbitrarily determined. My concern was to avoid any hindrance to the entry of mosquitoes in free flight, if necessary at the cost of losing some of the catch. Clearly a more systematic study of this feature would be desirable. It would also be of advantage to modify the cage so as to make possible the changing of cages at night without losing the catch.

USES OF RAMP-TRAPS. The traps are currently being used on a moderately large scale in a program of research into the flight pattern of West African mosquitoes. They have been found to be of considerable value in determining aerial density and the direction of flight in relation to wind direction and nocturnal periodicity. They are also being used to study the vertical distribution of mosquitoes flying at low levels. With suitable scaffolding it is possible to stack three traps one above the other so as to reach a height of 14 feet above the ground. They are particularly productive when used in association with animal baits to study the relationship of density to distance from the host, in an attempt to determine the range over which natural or simulated baits are affecting the flight paths of hungry mosquitoes. To obtain directional information the traps are set up in groups facing out in four or more different directions.

As with all passive sampling methods some bias in the catch is to be expected. For instance, on dark nights visual effects are likely to be negligible, but in bright moonlight it is probable that the presence of the traps may influence flying mosquitoes to approach or avoid them. Critical evaluation of this effect has yet to be made. A more tangible influence comes from the drag effect on air flow on the down-wind side of the trap. At the very low wind speeds which are common in the wet season in the tropics and may be less than 1 ft./sec. for substantial periods of the night, this factor is likely to be small. But at measurable speeds the effect is considerable. Wind speed was recorded with two sensitive cup-anemometers reading down to 0.8 ft./sec. and with the trap entrance facing down-wind. One anemometer was placed 5 feet to one side of the trap, the other 6 inches in front of the entrance. Simultaneous readings were taken over periods of 20–90 seconds. The results showed that at wind speeds of 2–5.5 ft./sec. the air flow in the lee of the trap was reduced by a factor of 0.54 ± 0.05. At wind speeds of 5.5–9 ft./sec. the reduction was 0.42 ± 0.05. Thus it is possible that the flight pattern of mosquitoes is altered when they fly into the lee side of the traps, and this should be borne in mind when the traps are being used in studies of natural flight paths.

Although the trap as described here has a number of imperfections, it seems that the principle of the ramp is an effective one. It is suggested that it may be found to be a useful tool for the study of the flight pattern of mosquitoes in nature, especially at low vertical levels.

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THE EGG OF *WYEOMYIA SMITHII* (COQUILLETT) AND A REVIEW OF KNOWLEDGE OF THE EGGS OF THE SABETHINI

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The egg of *Wyeomyia smithii* was first described by Smith (1902): "The eggs are chestnut brown in color, somewhat chunky, bean-shaped, the ends somewhat pointed, the inner margin nearly straight. There is no evident sculpture; yet when first mounted and examined under the microscope, there seems to be a somewhat irregular tesselated reticulation that disappears later, when the shells become more transparent."

Price (1958a) extended this description: "The individual chestnut-brown egg is provided with a longitudinal hydrophobic area along the slightly concave surface, which represents the ventral side of the developing embryo. This enables the majority of the eggs to float ventral side up at the water surface and often to gather together in loose aggregations. Once an egg is pressed below the water surface, it sinks to the bottom, a thin film of air being revealed as a silvery region on the ventral surface. A definite chorionic sculpturing, present along this ventral region and inconspicuous on the other more dorsal portions of the egg, may well contribute to the ability of the egg to float."

An opportunity to observe the eggs of this species was presented when Dr. T. J. Zavortink collected larvae from *Sarracenia* in Ohio and Michigan and brought them to Los Angeles for rearing. Adult females were given a water bowl lined with paper towelling for egg deposition. When the bowl was later examined, most of the eggs were on the water surface while a few were on the moist paper, as was true with Price (1958a) and Wallis and Frempong-Boadu (1967). The eggs (Fig. 1a, c), as noted by Price, appeared to have an upper, hydrophobic face and a lower, more or less hydrophilic surface. The egg thus floats with the upper, non-wettable face exposed to the air. As Price noted, if the egg is submerged in water the upper face is not wetted but is enclosed in a film of air, owing to the hydrophobic