

# EFFECT OF VERTEBRATE SIZE AND DENSITY ON HOST-SELECTION BY CAGED *CULEX NIGRIPALPUS*<sup>1</sup>

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**ABSTRACT.** The host-blood sources of *Culex nigripalpus* Theobald caged with different numbers of rabbits/chickens and raccoons/chickens were determined by blood meal identification. Mosquito feeding patterns varied with the numerical ratio of the 2 hosts available. Though physically somewhat smaller, chickens were apparently

more attractive than rabbits on a 1:1 basis. However, 4-5 chickens were required to equal 1 raccoon both in size and as a blood source for mosquitoes. Total engorgement rates were highest when mosquitoes were exposed with hosts of the same species as opposed to mixed groups.

Numerous field studies of mosquito-feeding behavior have suggested that, in many species, host-feeding patterns are largely a reflection of the availability of suitable vertebrates within the flight environment of the mosquito. Although availability is often equated only with numerical density, other attributes such as defensive behavior, spatial distribution, periodicity, size, age, fur and feather characteristics, etc., also have been implicated as important components of host-availability.

In spite of the assumption cited above, there have been few attempts to demon-

strate experimentally the direct impact of host size and/or density on the feeding pattern of mosquitoes. Experiments reported by Downe (1960, 1962) were uncontrolled in that the number of mosquitoes attempting to feed was an unknown variable and hosts were not uniformly exposed. Still, feeding appeared to be more closely related to the aggregate surface area of the different domestic hosts available than to their aggregate number or weight.

In the present study of mosquito-host interrelationships, two controlled experiments were conducted in which varying numbers and sizes of hosts were uniformly exposed at close range with standard numbers of female *Culex nigripalpus* Theobald. Host-blood sources were then determined by precipitin tests.

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## MATERIALS AND METHODS

Experiments were conducted in 8 x 8 x 8 ft (2.4 x 2.4 x 2.4 m) screen-over-weldwire cages situated under an outdoor canopy in the forest. For a further description see Edman and Kale (1971). Unmated female *Culex nigripalpus* 6-12 days old were automatically released into the cages (200 per cage) ½-hour after sunset, and survivors were collected the following morning with an aspirator. Test mosquitoes were reared from the eggs of wild females and handled as in the past (Edman and Kale 1971), and the blood meals of recaptured individuals were identified as previously outlined by Edman (1971). All animals were weighed before and after each experiment and the mean surface area of test animals was estimated using the Mech formula and the K values given by Lusk (1928).

**EXPERIMENT 1.** Test animals were six cage-adapted adult marsh rabbits (mean weight = 1.10 kilograms; mean surface area = 0.128 square meters) and six 8-10 week old leghorn cockerels (mean weight = 0.765 kilograms; mean surface area = 0.087 square meters). Both of these hosts display a similar but limited amount of defensive behavior (Edman et al. 1974). A total of 6 animals was exposed each night but the composition by species varied from 0 to 6. During testing, hosts were confined in wire (2.5 x 5 cm mesh) holding cages 50 x 20 x 20 cm and these were arranged in a hexagonal pattern at the center of the test cage. The selection and assignment of animals to test positions was done randomly except that individuals of each species were alternated whenever possible. Each of the 7 combinations in Fig. 1 was tested 2 nights and the results for each combination were averaged.

**EXPERIMENT 2.** Two cage-adapted adult raccoons (mean weight = 3.85 kilograms; mean surface area = 0.246 square meters) and six 8-10 week old leghorn cockerels were used, and the number of hosts exposed each night varied from 1 to 7. One raccoon was always confined at the center of the test cage, and it was surrounded by

either 0, 2, 4, or 6 young cockerels. Raccoons are very non-defensive hosts but the somewhat lower recovery of mosquitoes after exposure with this host is indicative of some host-induced mortality (Edman et al. 1974). Still, most survivors fed successfully. Animals were randomly assigned, and each of the 4 test combinations in Fig. 2 was tested 2 nights and the results averaged.

## RESULTS

**EXPERIMENT 1.** There was a stepwise reduction in feeding on rabbits and a corresponding increase in feeding on chickens as the numerical ratio of rabbits: chickens was gradually reduced (Fig. 1). The total engorgement rate remained relatively constant (58-60% of mosquitoes recovered); however, somewhat higher rates were obtained in both instances when all 6 hosts were of the same species (70 and 74% of mosquitoes recovered). Also, chickens proved to be better hosts in direct competition with rabbits in that the feeding rate on 1 chicken was approximately equivalent to that on 2 rabbits in most tests. This was true in spite of the fact that rabbits were about 46% heavier and had about 1.5 x the surface area of chickens. In test combinations involving both rabbits and chickens about 2% of the engorged mosquitoes contained blood from both species.

**EXPERIMENT 2.** Increasing the number of chickens with 1 raccoon caused a corresponding reduction in feeding on the raccoon, but again the total engorgement rate was actually highest when the raccoon was exposed alone (Fig. 2). About 4% of the engorged mosquitoes contained blood from both host species.

The much larger raccoon was readily selected over the chicken on a 1:1 basis; the feeding on 4-5 chickens appeared to be the approximate equivalent of that on one raccoon. Five chickens also weighed about the same as one raccoon while 2.8 chickens provided an equivalent surface area.

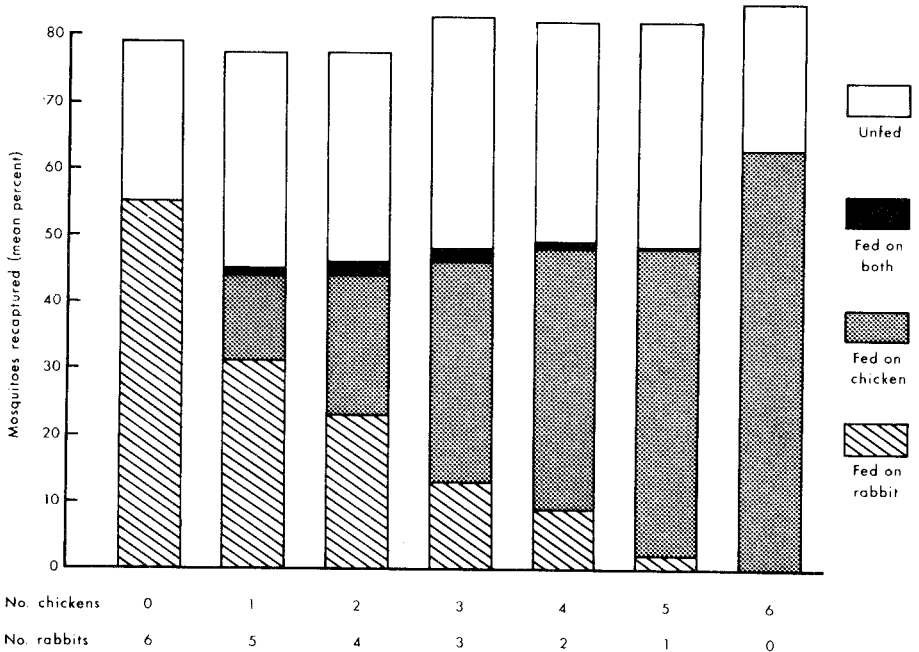


Fig. 1. Host-blood source of *C. nigripalpus* exposed overnight to various densities of rabbit and chicken.

DISCUSSION

Host density establishes the actual number of separate sources of attractive stimuli being released in the environment and thereby should directly influence the probability of a suitable host-species being encountered by most biting flies. Animals of relatively similar size, tolerance, etc. (i.e. equally available) such as the chickens and rabbits used in experiment 1 should show the closest relationship between host density and mosquito blood sources (Fig. 3). Had these two hosts been equally attractive, this relationship presumably would have been even closer. Even though the chicken consistently was more attractive than the rabbit it is clear that inequities in density can soon overshadow differences of individual attractiveness. There was no apparent difference in the attractiveness of the raccoon and chicken once these hosts were equalized on a size basis. However, the greater size difference between these hosts caused

a weaker relationship between density and feeding (Fig. 3). As stated earlier, raccoons are even less defensive than young chickens. Although this behavioral difference in availability was not great it could have masked some minor preference for chicken since we only considered the numbers feeding and not the numbers attracted.

Our observation of consistently higher feeding rates when a single species (or species group) was exposed is interesting but difficult to explain. We questioned whether the close spacing of our test birds and mammals might have resulted in interspecific agitation which did not occur with intraspecific groupings. Certainly if natural predator and prey animals were placed close to each other, one might expect such a reaction. Although the later addition of visual screens between hosts did not change this engorgement pattern, the communicative elements of sound and smell could not be eliminated. That

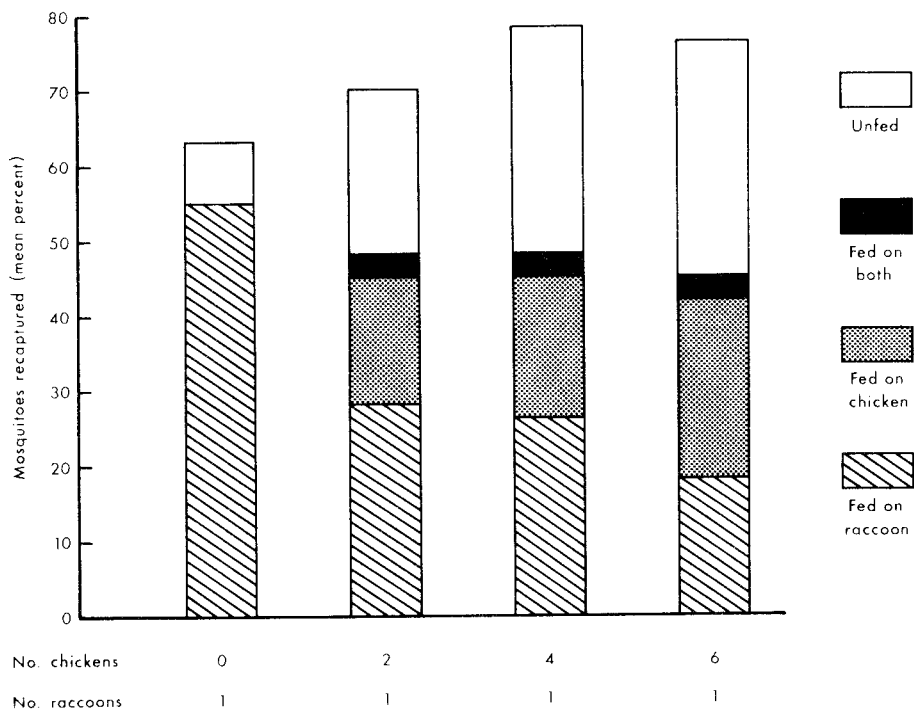


Fig. 2. Host-blood sources of *C. nigripalpus* exposed overnight to various densities of raccoon and chicken.

mixed (i.e. from contrasting physiological sources) odor plumes may introduce elements of "confusion" into the host-finding process of the mosquitoes, is another possibility.

Since a relatively small portion of the total surface area of birds and long-haired mammals is actually suitable for mosquito penetration, it may be inappropriate even to examine the direct relationship between body surface area and mosquito feeding rates on the animals used in these experiments. Moreover, we have never observed any shortage-induced competition for suitable biting sites, even among mosquitoes selecting very small hosts. Hence, surface area as an independent force would not seem to be a serious limiting factor;

though it still would be a positive factor insofar as visual and/or olfactory attraction is influenced by animal mass. Host size, be it expressed in weight, measure, or metabolic rate, is generally related to feeding in that large animals normally produce larger and more concentrated odor plumes, which are likely to be encountered by more mosquitoes (of most species) than are smaller plumes. In this same regard, however, animals which crowd together for mutual protection from biting flies are apparently partially successful in that the larger odor plume emanating from the group is not spatially equivalent to the multiple albeit smaller plumes associated with the same animals when they are dispersed individually over a

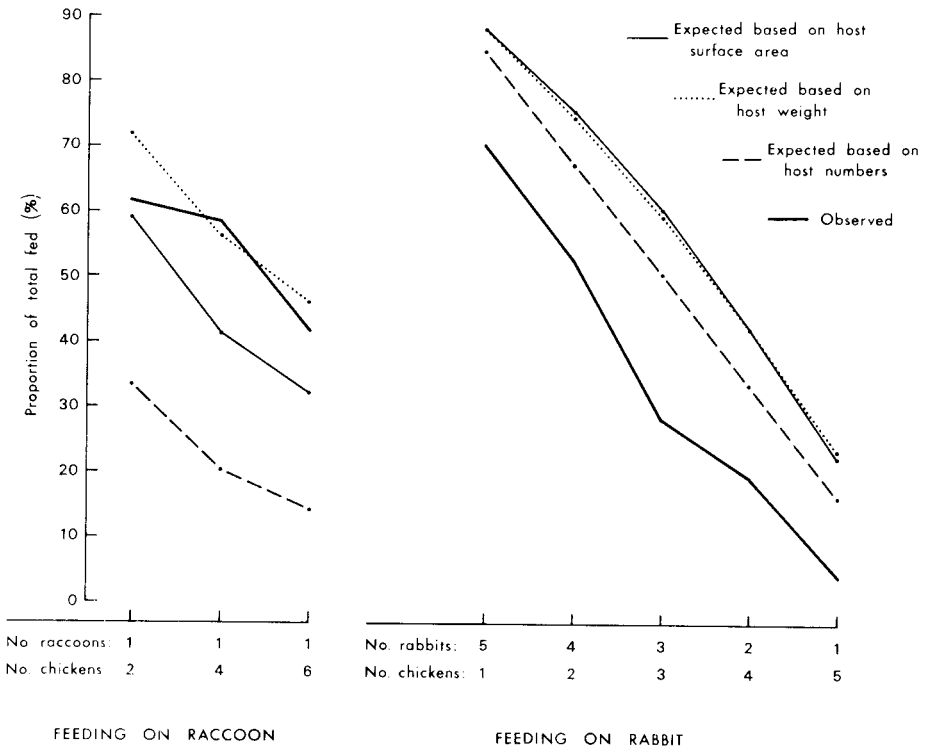


Fig. 3. Comparison of the observed host-feeding ratios of *C. nigripalpus* with those expected based on the number and size of hosts available.

wider area. Our experiment with raccoons and chickens clearly shows the relative importance of host size. As seen in Fig. 3, weight and surface area, as indicators of host size, were quite comparable for the 3 species we used.

In our experiments, the role of density and size was considered only at close range and a multiple choice of suitable hosts always accompanied the selection process. When hosts are more scattered, as they often are in nature, the importance of these two components of availability would appear to be equal or greater than that observed at close range. Host-density and host-size presumably would have an even greater effect on the probability of host detection by blood-seeking mosquitoes than on host selection once contact with a mixed group is made.

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