THE EFFECTS OF THE QUALITY OF BLOOD AND TEMPERATURE ON THE PRODUCTION AND VIABILITY OF EGGS IN *CULEX QUINQUEFASCIATUS*

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In maintaining a colony of *Culex quinquefasciatus,* various animals on hand in the laboratory at the time furnished blood for the females. Since there were noticeable variations in the size of egg rafts, depending on the blood source, some simple feeding experiments were designed and carried out (1) to measure the effects of the quality of various bloods on the production and viability of eggs, and (2) to measure the effect of temperature on the number of eggs laid. Certain host preferences indicated in this paper may add to the scant information concerning the natural feeding habits of *C. quinquefasciatus.*

The following animals were used as a source of blood: the Eastern fence lizard (*Sceloporus undulatus* (Latreille), the anole (*Anolis carolinensis* Voigt), the hognosed snake (*Heterodon platyrhinos* Latreille), the common kingsnake (*Lampropeltis getulus* Linnaeus), a boa (*Constrictor constrictor*), Tennessee brown bats (*Myotis grisescens* Howell), the opossum (*Didelphis marsupialis* Linnaeus), and the domestic chicken (*Gallus domesticus*).

METHODS. Because of the nature of the animals employed in these experiments, it was impossible to keep methods of exposure to mosquitoes uniform. The natural habits and habitat of certain animals make it impractical to apply standard methods of procedure in exposing them to mosquitoes for a blood meal. The simple practice of immobilizing chickens and feeding mosquitoes on them from lantern globes was used for this host. However, this method was impractical for small, infrequently handled animals such as bats and lizards. Although lizards and bats will hang perfectly still on the wall of cloth cages for hours, they resist being immobilized artifically; therefore they were turned loose in the colony cage (capacity: about 8 cubic feet). On the other hand, larger animals such as the opossum and snakes were confined to hardware-cloth cages placed inside the colony cage permitting the free movement of mosquitoes in and out of the cage containing the animals furnishing the blood meal.

After feeding on various animals, fully engorged femlaes were removed singly by suction tube, placed at the desired temperature and allowed to oviposit. Egg rafts were floated onto a piece of filter paper and the eggs counted under a dissecting microscope. To ascertain viability of the eggs, individual rafts were placed in separate dishes and the resulting larvae counted. In experiments designed to measure the effect of temperature, two comparable batches were made up by random selection as the engorged females were separated from the feeding cage and one batch placed at 28° C., the other at 16° C. No consideration was given to the amount of blood ingested, since much of it is habitually extruded a few hours after the blood meal is taken. All females fed to repletion. After the blood meal, all mosquitoes were fed on preserved raisins.

EXPERIMENTAL RESULTS AND DISCUSSION. Although autogeny is known to exist among mosquitoes, the vast majority of them require some sort of blood for the development of viable eggs, and the number of eggs laid seems to vary according to the blood source. Production of eggs seems to be dependent upon the nature and concentration of blood proteins. Greenberg (1951) found that *Aëdes aegypti* laid 16 times as many eggs when fed de-fibrinated sheep blood as when fed

* Study aided by National Science Foundation Research Grant G2486.

washed sheep red blood cells. Several proteins and protein products increased oviposition in mosquitoes fed on sheep red blood cells. Detailed quantitative studies on the effect of blood and blood fraction on the production of eggs by *A. aegypti* have been made by Woke (1937a; 1937). Following ingestion of blood from man and rhesus monkeys, *A. aegypti* produced significantly fewer eggs than after feeding on canaries, rabbits, guinea pigs, turtles, or frogs. Roy (1931) reported that *Anopheles stephensi* produced considerably fewer eggs when fed on man than when fed on rats, rabbits and guinea pigs. Similar differences have been noted by Roubaud and Mezger (1934) and by Tate and Vincent (1936) for *Culex pipiens*.

Figure 1, Section A, shows the average number of eggs produced by *C. quinque-*

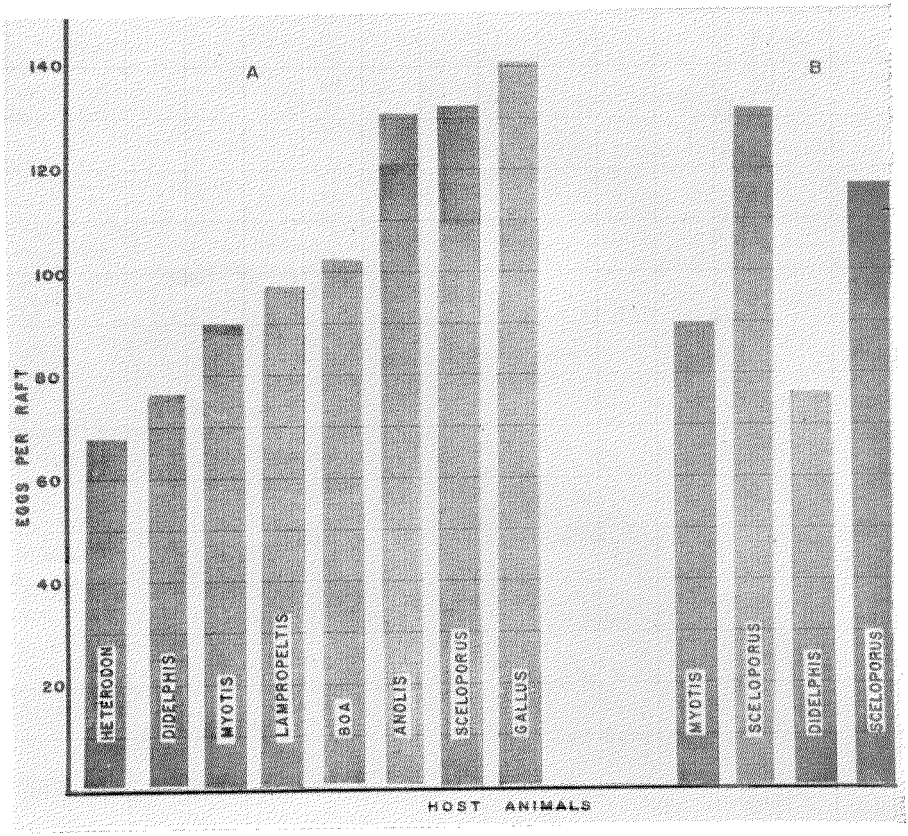

FIG. 1.—A—Effects of various vertebrate bloods on the production of eggs in *Culex quinquefasciatus*. The number of egg-rafts counted to obtain averages: *Heterodon*—25; *Didelphis*—65; *Myotis*—86; *Lampropeltis*—150; boa (*C. constrictor*)—90; *Anolis*—51; *Sceloporus*—174; Gallus—66.

B—Batches of mosquitoes initially fed on bats (*Myotis*) and opossum (*Didelphis*) were allowed to re-feed on lizards (*Sceloporus*). Egg-nutrient blood variable is indicated by the number of eggs resulting from lizard blood. All mosquitoes were stored at 28° C.

fasciatus when fed on various animals, and kept at 28° C.; Section B of the same figure shows the difference in the number of eggs laid by the same lot of mosquitoes when they re-fed on a different animal. Mosquitoes previously fed on bats and kept at 28° C., re-fed on a lizard about three weeks later and kept at the same temperature, produced an average of 132 eggs per raft (40 rafts used in computing average) as compared to an average of 90 resulting from the initial blood meal on bats, or a difference of 42 eggs per raft (86 rafts used in computing the average). Similarly, mosquitoes previously fed on an opossum were re-fed on a lizard, and produced 117 eggs per raft (30 rafts used in computing average) as compared to 79 resulting from the opossum blood meal, or an increase of 38 eggs per raft (65 rafts used in computing average). Mosquitoes previously fed on a kingsnake and kept at 28° C. were re-fed on a lizard. An average of 116 eggs per raft (50 rafts used in computing average) was obtained from lizard blood as compared to 98 from the kingsnake (150 rafts used in computing average). Although the effect of aging was not designed to be a part of this experiment, it seems that it has little or no effect on oviposition of this mosquito. In all three re-feeding experiments, mosquitoes feeding on *Sceloporus* (from two to three weeks after the initial blood meals from other animals) produced significantly larger numbers of eggs than when they took the first blood meal from another animal.

Culex quinquefasciatus fed on both cold and warm-blooded animals, but some host preference was indicated in both groups of vertebrates. They fed more freely on the boa and the kingsnake than on the hognose snake. A snapping turtle, frogs (*Rana pipiens*) and white rats were exposed to them under the same conditions under which they fed very well on the other animals. Only six mosquitoes fed on the turtle, and none at all fed on the frogs and white rats, although these animals were exposed to them several times.

Regardless of the source of blood ingested, eggs were laid during the third day after feeding if kept at 28° C., and during the sixth day if kept at 16° C. Although there is an apparent decrease of about five eggs per raft when mosquitoes were kept at the lower temperature, as Table 1 shows, the mean differences are insignificant according to t-test analysis. Fewer females laid eggs at the lower temperature. All of the eggs resulting from chicken blood hatched, while those produced from reptile and mammal blood were only 96 percent viable.

TABLE 1.—The effect of temperature on the number of eggs produced by *Culex quinquefasciatus*

Host animal	Temperature	Average no. of eggs per raft	Range
Bats (*Myotis grisescens*)	28° C.	90(86)*	25–182
	16° C.	84(50)	30–184
Boa (*Constrictor constrictor*)	28° C.	103(90)	30–192
	16° C.	98(81)	56–181
Opossum (*Didelphis marsupialis*)	28° C.	79(65)	38–122
	16° C.	74(58)	40–154

* Figures in parentheses indicate the number of egg-rafts used to make up averages.

References

GREENBERG, J. Some nutritional requirements of adult mosquitoes (*A. aegypti*) for oviposition. J. Nutrition, 1951, 43(1):27–35.

ROUBAUD, E. and MEZGER, J. L'influence du sang d'oiseau sur la fecondité du moustique commun *Culex pipiens*. Bull. Soc. Path. Exot., 1934, 27:666–668 (85).

ROY, D. N. On the ovulation of *Anopheles stephensi*. Ind. J. Med. Res., 1931, 19:629–634 (86).

TATE, P. and VINCENT, M. The biology of autogenous and anautogenous races of *Culex pipiens*. Parasitology, 1936, 28:115–145.

WOKE, P. A. Effects of various blood fractions on egg production of *Aëdes aegypti*. Amer. J. Hyg., 1937a, 25:372–380 (84, 85).

———. Comparative effects of the blood of different species of vertebrates on egg production of *Aëdes aegypti*. Amer. J. Trop. Med., 1937b, 17:729–745 (84, 87).