SUGAR-DEPRIVATION FOLLOWING A BLOOD MEAL DOES NOT REDUCE YOLK FORMATION AND FERTILITY IN *CULEX QUINQUEFASCIATUS*[1]

EMILE VAN HANDEL

IFAS—University of Florida, Florida Medical Entomology Laboratory, 200 9th Street S.E., Vero Beach, FL 32962

ABSTRACT. Adult *Culex quinquefasciatus*, maintained from emergence on sugar, were fed blood and then fed either sugar (control) or water (starving) for 7 days. Analysis of ovaries and egg rafts for protein, lipids and glycogen showed that only glycogen levels were diminished by starvation. Eggs from both control and starving females, however, were equally viable. Nonbloodfed starving females lived longer than bloodfed starving females. These results suggest that the blood meal maximizes fertility, not longevity.

INTRODUCTION

In many insects, including mosquitoes, oogenesis is curtailed in response to inadequate food and sometimes nutrients already invested in yolk can be resorbed as the follicle degenerates (Bell and Bohm 1975). Oosorption is common among blood-sucking Diptera (Detinova 1962). In *Aedes aegypti* (Linn.) arrest, resorption or maturation of oocytes depends on the quantity of blood and the interval between blood meals. After a 1-μl bloodmeal, females either reenter oogenic arrest within 24 h or complete maturation of a limited amount of oocytes (Lea et al. 1978). Once oocytes are committed to maturation and the chorion is formed, they are ready to be oviposited. Many mosquitoes are able to postpone egg laying until an appropriate oviposition site becomes available.

The present experiments were designed to test whether sugar deprivation after a blood meal will lead to diminished yolk production by diverting blood nutrients to maternal nutrition and whether resorption of nutrients from mature oocytes are used for maternal maintenance. Because ovaries may still contain follicle cell components, a comparison was made between the composition of ovaries and that of deposited eggs. *Culex quinquefasciatus* Say were used because females retain eggs until provided with an appropriate aqueous attractant and then deposit eggs in an intact raft.

MATERIALS AND METHODS

Culex quinquefasciatus (Vero Beach strain) were reared on brewer's yeast under a 12-h light 12-h dark photoperiod. Adults were maintained on 5% sucrose solution for 6 or 7 days, then given access to a chicken for at least 6 h. One group of bloodfed females was fed on water alone and the other group was fed on 5% sucrose. Seven days after bloodfeeding, 48 females of each group were ovariectomized, and the remainder oviposited on a clear supernatant of oak leaf infusion. Newly laid egg rafts were immediately collected with a fine brush. Twenty-four ovaries and egg rafts were analyzed individually for protein using techniques described in Van Handel and Day (1989). Twenty-four other ovaries and egg rafts were analyzed for glycogen and total lipids as described in Van Handel and Day (1988). Eggs in ovaries were counted and compared with the number of larvae hatching from individual egg rafts.

To determine the extra-ovarian maternal fuel reserves, 24 carcasses of each group from which the ovaries were removed were also analyzed for protein, lipids and glycogen. All experiments were carried out at 25°C.

RESULTS

Females, after the blood meal fed on water, started to die after 7 days, and for that reason all experiments were concluded at that time. Starvation did not reduce protein content of ovaries and egg rafts below that of controls. However, egg rafts of starved and sugar-fed females contained significantly less protein than did the ovaries (Fig. 1). This suggests that after oviposition, some follicular protein was retained that was not available for maternal nutrition. Indeed, the abdomen of mosquitoes that had oviposited contained significantly more protein than that of females that had been ovariectomized (70 ± 10 μg and 20 ± 4 μg, respectively). Lipid content of the ovaries and egg rafts of starved mosquitoes was the same as in sugar-fed controls (Fig. 1), suggesting that during starvation, the female did not use ovarian lipids as a

[1] IFAS—University of Florida Experiment Stations Journal Series No. R-01022.

nutritional reserve. Furthermore, it demonstrated that after oviposition, no lipid component remained in the ovary and no lipids were lost from the egg rafts. The proteins and lipids of the egg rafts are moieties of the lipoprotein vitellin that constitutes the bulk of the mosquito egg content.

Glycogen is a minor component of mosquito eggs, and was the only component that was significantly reduced by starvation, both in ovaries and in egg rafts (Fig. 1). However, loss of glycogen did not reduce fertility, as was demonstrated by the following experiment. Twelve egg rafts of each group were individually placed in test tubes containing 5-ml water. Each egg raft from the sugar-deprived group produced 210 ± 12 live larvae versus 200 ± 10 larvae from sugar-fed controls. Ovaries from both groups contained between 200 and 220 eggs. This suggests that each egg raft represented the entire egg content of a pair of ovaries.

The composition of the carcass from which the ovaries were removed is listed in Table 1. Expressed in cal per female (9 cal/mg of lipid, 4 cal/mg of glycogen), in starved females 0.585 cal of fuel was derived from lipids (9 cal/mg × 0.065 mg) and 0.3 cal from glycogen (4 cal/mg × 0.075 mg), while protein was not used. Glycogen had almost disappeared, but in starved females the lipid level was still rather high because the assay included structural lipids that had not been metabolized.

Blood feeding shortened survival of starving females. When *Cx. quinquefasciatus* were maintained on sugar for 6 days, then starved, at least 50% lived for an additional 10–11 days. However, when these sugar-fed females were fed blood after 6 days and then starved, 50% died within 7–8 days. Apparently the commitment to mature eggs prevails over the survivability of the female.

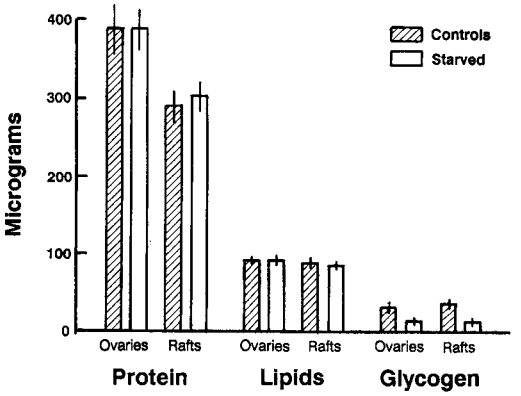

Fig. 1. Composition of ovaries and egg rafts of *Culex quinquefasciatus*, 7 days after a blood meal, maintained on sucrose (controls) or on water (starved). Each bar represents the mean of 24 ovaries or egg rafts ± SE (vertical line).

Table 1. Composition of carcass of *Culex quinquefasciatus* after removal of ovaries.*

	Lipids	Glycogen	Protein
Controls	105 ± 5	80 ± 3	190 ± 4
Starving	40 ± 2	5 ± 1	180 ± 5

* Seven days after blood feeding; μg per female ± SE; $n = 24$.

DISCUSSION

The data show that following a bloodmeal the amount of lipid and protein (the lipoprotein vitellin) present in the eggs of starving females was equal to that found in females that were maintained on sugar. Both groups produced the same number of fertile eggs, even though starving females died with a full complement of mature eggs. Thus, nutrients apparently were not resorbed from maternal oocytes for maternal maintenance. The only measurable difference in egg composition from starved females was a 15-μg lower glycogen content. This difference was less than 3% of the total caloric content of the ovary; it did not affect fertility, and was too small to have a significant effect on female survival. Survival of starving females depended on glycogen and lipid reserves, that were accumulated before the bloodmeal. Protein was not used as a maternal fuel (Table 1). This was also concluded from an earlier experiment in which newly emerged female *Ae. aegypti* were maintained on 10% sucrose for 1 wk. During this time, the protein content diminished about 6%. These same females were then starved for 1 wk during which time there was no further decrease of protein in the survivors (Van Handel and Day 1989).

In *Ae. aegypti* provided a suboptimal bloodmeal, all oocytes initiated development, and although some continued to mature eggs, other oocytes resorbed the yolk already deposited and degenerated in 14–24 h (Lea et al. 1978). Presumably these resorbed yolk constituents were used for maternal nutrition.

ACKNOWLEDGMENT

Technical assistance by Hilda C. Lynn is gratefully acknowledged.

REFERENCES CITED

Bell, W. J. and M. K. Bohm. 1975. Oösorption in insects. Biol. Rev. 50:373–396.

Detinova, T. S. 1962. Age grouping methods in Diptera of medical importance, with special reference to some vectors of malaria. W. H. O. Monogr. Ser. 47.

Lea, A. O., H. Briegel and H. M. Lea. 1978. Arrest, resorption, or maturation of oöcytes in *Aedes aegypti*: dependence on the quantity of blood and the interval between blood meals. Physiol. Entomol. 3:309–316.

Van Handel, E. and J. F. Day. 1988. Assay of lipids, glycogen and sugars in individual mosquitoes: correlations with wing length in field-collected *Aedes vexans*. J. Am. Mosq. Control Assoc. 4:549–550.

Van Handel, E. and J. F. Day. 1989. Correlation between wing length and protein content of mosquitoes. J. Am. Mosq. Control Assoc. 5:180–182.