enable us to have a better understanding of the chemistry of the T-T adduct as it relates to photobiology (*6*).

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Mosquitoes Feeding on Insect Larvae

Abstract. *Caged* Aedes aegypti *and* Culex tarsalis *are attracted to insect larvae, engorge on their body fluids, and produce viable eggs. Attractiveness of the larvae is related to their size, shape, and color but not to their movement. The possibility that wild mosquitoes substitute insect hemolymph for vertebrate blood is discussed.*

Serological analyses of their gut content show that mosquitoes attack most groups of vertebrates, some species feeding selectively on particular hosts [for example, *Culex territans* Walk. on amphibians and reptiles (*1*)], and others on many taxa [for example, *Aedes aegypti* (L.) (*2*)]. However, the few records of mosquitoes feeding on insects have been discounted by Downes (*3*), and it is generally assumed that the nourishment needed for egg development is not supplied by the body fluids of invertebrates. Our results, by contrast, show that in the laboratory some mosquitoes feed on insect larvae and produce viable eggs as a result; they are attracted to the larvae and evidently recognize them as hosts.

Laboratory-propagated *Aedes aegypti* and *Culex tarsalis* were kept in cages, 22 by 22 by 37 cm (approximately 150 females and 50 males to a cage), at 26°C, 65 percent relative humidity, and a 14-hour photoperiod (14 hours light and 10 hours dark). Honey solution (10 percent) was available at all times. Host acceptance by *Aedes aegypti* (Table 1) was determined by placing invertebrates—either living or coddled (that is, previously immobilized in warm water)—in the cages and by watching for at least 2 hours to see if feeding occurred. The living invertebrates were placed in the cage with the mosquitoes, and the coddled insects were tied to the cage walls. The comparative attractiveness of various insect features was investigated with the use of fifth-instar *Galleria mellonella* (L.), and third-instar *Celerio euphorbiae* (L.) of similar size; living, coddled, and stuffed larvae (that is, those whose body contents had been replaced with latex) were offered in paired cages and observed for 30 minutes to determine the landing rate on each (Table 2). Mosquitoes that fed were transferred for oviposition to clear plastic tumblers inverted over wet filter paper.

Figure 1 shows *Aedes aegypti* feeding on a coddled *Celerio euphorbiae* larva. The *Aedes aegypti* also fed on larvae of Coleoptera, Hymenoptera, and other Lepidoptera but not on Neuroptera, spiders, or earthworms (Table 1). A similar test showed also that *Culex tarsalis* fed on coddled *Celerio euphorbiae*, with a landing rate of 30 per hour. However, in contrast to *Aedes aegypti*, which fed on insects within 4 days of its emergence, *Culex tarsalis* did not do so until at least 2 weeks old although they would accept red-blood meals during this period. Also, unlike that of *Aedes aegypti*, the stock of *Culex tarsalis* was partially autogenous; therefore the evidence that *Culex tarsalis* had used hemolymph for egg production was not conclusive. The *Aedes aegypti* fed less successfully on some species of larvae than on others. For example, the violent reactions of *Celerio euphorbiae* when probed usually dislodged the mosquitoes before they could feed. In contrast, *Euxoa messoria* (Har.) merely curled up and remained motionless, so that the mosquitoes could probe and feed without disturbance, although they had difficulty in penetrating the cuticle of this species. Immobilization of the larvae by coddling usually enabled more mosquitoes to feed and larger meals to be taken. However, persistent individual mos-

Table 1. Acceptance of coddled invertebrates by *Aedes aegypti* in the laboratory.

Test host	Landing rate*	Response	
		Feeding	Eggs laid†
Arthropoda			
Lepidoptera			
Celerio euphorbiae (L.)	74	X	X
Manduca quinquemaculata (Haw.)	76	X	0
Calophasia lunula (Hufn.)		X	X
Euxoa messoria (Har.)	57	X	X
Danaus plexippus (L.)	55	X	0
Galleria mellonella (L.)	10	X	X
Coleoptera			
Leptinotarsus decemlineata (Say)	42	X	0
Hymenoptera			
Neodiprion lecontei (Fitch.)		X	X
Neuroptera			
Corydalis cornutus (L.)	0	0	0
Araneida			
Argiope aurantia Lucas *Araneus trifolium* (Hentz)	6	0	0
Annelida			
Oligochaeta			
Lumbricus sp.		0	0

* Number of mosquitoes (both sexes) landing during 1 hour on five host specimens except for the spiders (Araneida) in which two specimens (one of each species) were tested together. † Laid eggs were viable.

Table 2. Attractiveness of live and stuffed insect larvae to mosquitoes. Mean number (plus of minus S.E.) of mosquitoes (both sexes) landing in 30 minutes on five larvae on the cage walls.

Species of mosquito	Age (days)	Replicates (No.)	Host	Landings (No.)
Aedes aegypti	19–20	2	Live *Galleria mellonella*	3.5 ± 2.5
			Live *Celerio euphorbiae*	37.0 ± 6.0
Culex tarsalis	27–31	8	Stuffed *Celerio euphorbiae*	6.9 ± 0.8
			Stuffed *Galleria mellonella*	2.4 ± 0.4
Culex tarsalis	27–31	8	Coddled *Celerio euphorbiae*	14.9 ± 0.8
			Stuffed *Celerio euphorbiae*	6.0 ± 0.4
Aedes aegypti	3–13	10	Live *Galleria mellonella*	40.7 ± 2.0
			Coddled *Galleria mellonella*	47.7 ± 0.9

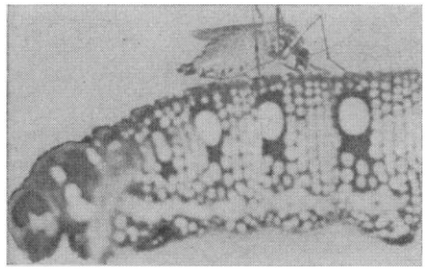

Fig. 1. *Aedes aegypti* engorging on *Celerio euphorbiae* hemolymph.

quitoes did obtain at least partial meals from even intractable living larvae. For example, when *Aedes aegypti* were caged with living *Celerio euphorbiae* that had been injected with 20 μc of P^{32}, many became radioactive, although few obtained noticeably large meals.

Whether these mosquitoes can be expected to feed on insect larvae in nature depends on the extent to which they find the larvae by being attracted to them, rather than by merely encountering them haphazardly, as in a crowded cage. Evidence of attraction for *Aedes aegypti* is (i) the aggregation around a coddled *Celerio euphorbiae* larva, and (ii) the widely different rates of landing on test invertebrates (Table 1). Although no experiments were conducted specifically to identify the attracting stimuli, values in Table 2 offer some indication of their nature. Thus its contrasting color and pattern may have made *Celerio euphorbiae* (alive or stuffed) more attractive than the off-white *Galleria mellonella* (tests 1 and 2). The fact that coddled larvae attracted more mosquitoes than did stuffed ones (test 3) and were at least as attractive as living larvae of the same species (test 4) suggests that heat or a chemical by-product of metabolism may be involved and movement is not. Size of the larva may also play a role. When coddled *Celerio euphorbiae* were exposed four at a time for 1 hour, six, three, one, and zero *Aedes aegypti* fed when the average larval weights were 0.69, 0.16, 0.04 (only 14 mm long), and 0.03 g or less, respectively.

That mosquitoes feed on insects in the laboratory does not prove that they do so in nature. The lack of records of this activity does not conflict with the possibility, because such feedings may well have been overlooked. In serological surveys the gut contents of wild-caught mosquitoes are tested only if dark or red, and then only against vertebrate antiserums. Mosquitoes with pale, swollen abdomens are assumed to have fed on carbohydrate material such as nectar or to have hypertrophy of the fat body, and are not analyzed further. This practice eliminates the possibility of detecting invertebrate meals, which are normally yellow, pale green, or colorless.

In open windswept regions, mosquitoes shelter in clumps of dense vegetation where they are close to feeding larvae; thus the mosquitoes do not necessarily have to cover distances greater than those in our experiments to find larvae. The behavior of *Culex tarsalis*, which did not feed on insects during the first 2 weeks after emergence, suggests that hemolymph may be taken as a last resort if vertebrate hosts are not available. If mosquitoes do indeed feed often on insect larvae in nature, they may be vectors of insect diseases and may even transmit microorganisms from insects to man and other vertebrates.

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Linkage of Lactate Dehydrogenase B and C Loci in Pigeons

Abstract. *Synthesis of lactate dehydrogenase in somatic and gametic tissues of certain avian and mammalian species is controlled by alleles at three loci,* A, B, *and* C. *We report breeding experiments with pigeons that conclusively demonstrate linkage between the* B *and* C *structural loci in this species. The most probable recombination fraction is zero, and contiguity is not excluded. The upper 95 percent probability limit is 4.5 percent. This tight linkage of two loci that produce closely similar polypeptides suggests that the loci acquired their separate identities through a duplication event. Furthermore, the existence of recognizable B- and C-type polypeptides in both the bird and the mammal suggests that the event and the resulting linkage preceded the separation of these fauna. If so, then the linkage has persisted for a very long time.*

Lactate dehydrogenase (LDH) in the somatic tissues of many avian and mammalian species can be resolved into five molecular forms (isozymes) by chromatography and electrophoresis. The isozymes are tetramers formed by association of monomers of two different classes (A and B) in all possible combinations (*1*). Thus, the polypeptide composition of the five isozymes may be designated as follows: LDH-1 (B_4), LDH-2 (A_1B_3), LDH-3 (A_2B_2), LDH-4 (A_3B_1), and LDH-5 (A_4). Studies of electrophoretic variants of LDH in deer mouse (*2*) and in man (*3*) have indicated that the synthesis of the A and B subunits is mediated by alleles at two loci, LDH_A and LDH_B.

Electrophoretically unusual forms of LDH (LDH-X) first appear in testes from certain mammalian and avian species during sexual maturation (*4*). Observations on the pigeon (*5*) have shown that the synthesis of the LDH-X enzyme is dependent on a third genetic locus, LDH_C. In pigeons, therefore, as well as in other species with uniquely testicular forms of LDH, the total complement of LDH isozymes is determined by the activity of alleles at three loci, LDH_A, LDH_B, and LDH_C, each being responsible for the synthesis of a corresponding polypeptide.

A survey of the LDH composition of somatic tissues and testes from approximately 1000 wild pigeons revealed the existence of polymorphisms at both the