

HOSTS OF MOSQUITOES (DIPTERA:CULICIDAE) FROM THE IRRIGATED AREAS OF ALBERTA¹

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INTRODUCTION. Sixteen species of mosquitoes have been identified from the irrigated areas of Alberta (Shemanchuk, 1959). The majority of them are blood feeders and are therefore pests of man and livestock. A knowledge of their feeding habits is essential in determining their roles as vectors and carriers of human and animal diseases. Similarly, a knowledge of the host range and preference is also essential in implementing control measures against mosquitoes and against diseases transmitted by them.

METHODS AND MATERIALS. *Mosquitoes Collected with Sweepnets in Farmyards.* In 1955 and 1956, blood-engorged female mosquitoes were collected weekly, from July 1 to September 10, with sweepnets from farmyards near Brooks, Alberta. They were killed, pinned, identified, and shipped to the laboratory for precipitin tests. The mosquitoes were collected under rather special conditions in that each farmyard sampled had a full range of domestic livestock within a very restricted area.

Mosquitoes Collected with Visual-Attraction Traps in Open and Sheltered Sites. In 1956, in addition to the sweepnet collections in farmyards, two visual-attraction traps (Haufe, 1960) were operated 24 hours daily from June 22 to September 20 in a semi-urban location. One trap was located in a site sheltered by trees and shrubs in the town of Brooks and the other was located in an open pasture 1.5 miles east of the first trap. The traps sampled flying mosquitoes, which

infiltrated the trap sites from all directions.

Mosquitoes Collected with Visual-Attraction Traps in Farmyards. In 1957, single visual-attraction traps were located in newly established farmyards in irrigation districts at Rolling Hills, Hays, and Taber. Mosquito population densities in the three localities was highest at Rolling Hills and lowest at Taber (Shemanchuk, 1959). The traps were operated 24 hours daily from May 11 to September 20.

Precipitin Test. All of the blood-engorged mosquitoes collected were extracted for 3 to 4 hours at room temperature in 1 ml. of buffered physiological saline (pH7). The resulting extracts were placed in small serological tubes (2.5 mm inside diameter). Antisera suitable for the detection of various host bloods were layered beneath the extracts. A "ring" of precipitate at the interface between extract and antiserum indicated a positive precipitin reaction. Tests were read at 20-minute intervals for 1 hour. All antisera, except for the antichickens serum, were rendered specific by absorption techniques. The antichickens serum was capable of reacting with a wide variety of avian serum antigens but showed no cross-reactions with mammalian sera. Safranin "O" dye was added to the antisera to facilitate reading the tests.

RESULTS AND DISCUSSION. *Mosquitoes Collected with Sweepnets in Farmyards.* Precipitin tests on blood-engorged females collected with sweepnets in farmyards indicated that all of the domestic animals as well as humans were subject to attack by mosquitoes (Table 1).

A predominance of positive reactions for bovine blood was indicated for all species except *Culex tarsalis* Coq. and *Aedes riparius* Dyar and Knab. The high inci-

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TABLE 1.—Identification of the blood meals of mosquitoes collected with sweepnets in farmyards in the irrigated areas of Alberta near Brooks, in 1955 and 1956.

Species	Host
<i>Culiseta inornata</i> (Williston)	1C, 1P, 1S
<i>Aedes campestris</i> Dyar and Knab	6C, 3P, 4S, 1D, 4N
<i>Aedes cataphylla</i> Dyar	2C, 1S
<i>Aedes cinereus</i> Meigen	83C, 14P, 21F, 1Hu, 24S, 2D, 3FC, 1PHu, 11N
<i>Aedes dorsalis</i> (Meigen)	1C, 2P, 1S
<i>Aedes flavescens</i> (Muller)	3C, 1P, 1F, 1FC
<i>Aedes intrudens</i> Dyar	2C, 1S
<i>Aedes nigromaculus</i> (Ludlow)	3P
<i>Aedes riparius</i> Dyar and Knab	43C, 1P, 1F, 26S, 3D, 1CS, 16N
<i>Aedes spencerii</i> (Theobald)	89C, 21P, 13F, 1Hu, 1H, 13S, 5D, 1CH, 1PF, 1HP, 12N
<i>Aedes vexans</i> (Meigen)	2P, 14F, 1Hu, 1HuF, 6N
<i>Culex tarsalis</i> Coquillett	9C, 2P, 2Hu, 1S, 4N

C—cattle; D—dog; F—fowl; H—horse; Hu—human; N—negative; P—pig; R—rodent; S—sheep.

dence of bovine blood meals was attributed to the abundance of cattle present on the farms sampled and to the relatively larger size of the animals as compared with the size of the other domestic animals present. The results suggested that, although mosquitoes may have certain host preferences, availability of hosts was an important factor influencing the sources of blood meals. This has been reported for other species in eastern Canada (Downe 1960, 1962). Even though collections in farmyards were taken in a restricted area, the feeding patterns varied with each farmyard in accordance with the abundance of various hosts.

Approximately 2 percent of the specimens tested contained the blood of more than one host. The low incidence of multiple feeding in our study was attributed to the rarity of interrupted feedings. It was observed in this study that, once the feeding process began, the mosquitoes, particularly *Aedes* spp., were not too easily disturbed. Moreover, on the larger animals, such as cattle and horses, there were areas on the body surface where mosquitoes could not be removed by switching of the tail, licking, and stamping of the feet. Even though the percentage of multiple feedings was low under farmyard conditions, the situation exists where disease transmission by mosquitoes could occur.

Approximately 11 percent of the specimens tested and thought to be blood-engorged gave negative precipitin reactions. This may have been caused by either the destruction of the blood meal by digestive processes, or the blood meal of the mosquito was from a host not within the reaction ranges of the antisera employed. Since a considerable number of antisera capable of identifying a variety of host serum antigens were used, most negative results were probably due to destruction of the blood meals by digestion (Downe, 1960).

Mosquitoes Collected with Visual-Attraction Traps in Open and Sheltered Sites. Blood-engorged females collected with visual-attraction traps located either in an open or a sheltered site were also found to contain blood of a fairly wide range of hosts (Table 2). A greater number of blood-engorged specimens was caught at the open than at the sheltered site. The trap at the open site sampled a more transient population, i.e., females flying to seek food and oviposition sites, whereas the trap in the sheltered site sampled a more static population, i.e., females resting. Blood-engorged females of *A. vexans* (Meigen) and *C. tarsalis* were more numerous at the sheltered site. The hosts (Table 2) were not equally represented at the trapping sites. Cattle were more abundant at the open site, whereas humans were more abundant at

TABLE 2.—Identification of blood meals of mosquitoes collected with visual attraction traps at open and sheltered sites in the irrigated areas of Alberta near Brooks in 1956.

Species	Open sites	Sheltered
<i>A. dorsalis</i>	22C, 2F, 3H, 2CR	13C, 1Hu, 1HR
<i>A. flavescens</i>	1C	1C
<i>A. intrudens</i>	1C	..
<i>A. nigromaculis</i>	4C	..
<i>A. spencerii</i>	15C, 1CF	2C
<i>A. vexans</i>	21C, 1H	19C, 5H, 1S, 2R, 1HR, 1CR, 1HF
<i>C. tarsalis</i>	1C, 1F	3C, 3F, 1Hu, 1CF, 1CR
<i>C. inornata</i>	35C, 1F, 1Hu, 1H, 1R, 1HR	10C, 2H, 2CF, 1CR

C—cattle; F—fowl; H—horse; Hu—human; R—rodent; S—sheep.

the sheltered site. Horses were rare at both sites. Pigs and dogs were rarely found near either trapping site which accounts for the absence of mosquitoes with pig and dog blood. Positive reactions for avian blood indicated feeding on either poultry or wild birds.

Approximately 6 percent of the 196 blood-engorged mosquitoes tested in this study contained blood of more than one host. The blood of rodents was involved in more than 50 percent of the multiple feedings. Interrupted feeding could be more common among rodents because the rodents can scratch almost any part of their bodies as well as brush mosquitoes off their bodies while inhabiting, entering, or leaving their burrows. Also, mosquitoes seek cool moist areas such as rodent burrows or dense vegetation dur-

ing the heat of the day, and thus, the mosquito could be in contact with the rodent for a greater part of the day than with other hosts. Although the tests did not show any multiple feedings involving humans and rodents, the possibility of such a relationship and the attendant possibility of disease transmission is not ruled out.

Mosquitoes Collected with Visual-Attraction Traps in Farmyards. Blood-engorged females collected in visual-attraction traps in farmyards in three different irrigation districts contained the blood of all species of animals present in the farmyards (Table 3). All farmyards contained approximately the same range of domestic animals. Again a predominance of bovine feedings was indicated. The number of blood-engorged females caught

TABLE 3.—Identification of blood meals of mosquitoes collected with visual attraction traps in farmyards in three irrigated districts in Alberta in 1957.

Species	Rolling hills	Location of Trap	
		Hays	Taber
<i>A. campestris</i>	1C, 1N
<i>A. cataphylla</i>	1P, 1N
<i>A. dorsalis</i>	12C, 3Hu, 1H 1FH, 1CR, 1CF	3C, 2H	3C, 1Hu, 2N
<i>A. flavescens</i>	3C, 1P	1C, 1P	..
<i>A. nigromaculis</i>	1C, 1H	1C	..
<i>A. spencerii</i>	4C, 1P, 1Hu, 1H, 1CH
<i>A. vexans</i>	10C, 1P, 1F, 2Hu, 2H, 4N, 1CD	1P	..
<i>C. tarsalis</i>	2F, 1Hu, 1N, 1CF	1F, 2Hu	1H
<i>C. inornata</i>	59C, 2P, 6Hu, 10H, 2S, 1R, 17N, 1HP, 1CH, 2CHu	13C, 4P, 2Hu, 1H, 1D, 4N	17C, 1P, 1Hu, 1N

C—cattle; D—dog; F—fowl; H—horse; Hu—human; N—negative; P—pig; R—rodent; S—sheep.

in the traps was proportional to the mosquito densities (Shemanchuk, 1959).

Approximately 5 percent of the blood-engorged mosquitoes tested in this study contained blood of more than one host. No distinct pattern of multiple blood-feedings was exhibited. It was apparent that the search for a blood meal does not follow a pattern. Once a mosquito entered the feeding arena it apparently fed on the most available host. Fourteen percent of the mosquitoes thought to be blood-engorged gave negative precipitin reactions.

Factors Affecting Blood Feeding. *A. dorsalis*, *A. vexans*, *C. inornata*, and *C. tarsalis* were the most abundant of the 16 species present in the irrigated areas of southern Alberta, and were regarded as the most serious pests. From visual-attraction trap collections taken at Brooks, Alberta, in 1956, and at Rolling Hills, Alberta, in 1957, it was found that the proportion of females with blood was very low (Figs. 1 and 2). From this it was apparent that a high proportion of the female mosquito population went without a blood meal, even when there were relatively high concentrations of warm-blooded animals in the area.

The differences in the age and in gonotrophic cycle in a continuously breeding population as occurs in the irrigated areas of Alberta might produce variations in blood requirements. The crepuscular and nocturnal habits of the mosquitoes in this area limit the contacts between the mosquitoes and certain hosts to some extent. Microclimatic conditions, which differ from location to location and day to day within the irrigated areas, also affect the behavior and the attack-rate of mosquitoes.

The peaks of activity of the females with blood coincide with the peaks of activity of females without blood (Figs. 1 and 2). Initial nightly activity of the females without blood precedes the activity of the blood-engorged ones. This indicates that some search is made for a blood meal.

It was observed that when female mosquitoes fed to their capacity and detached they flew only short distances and settled to rest on vegetation near the

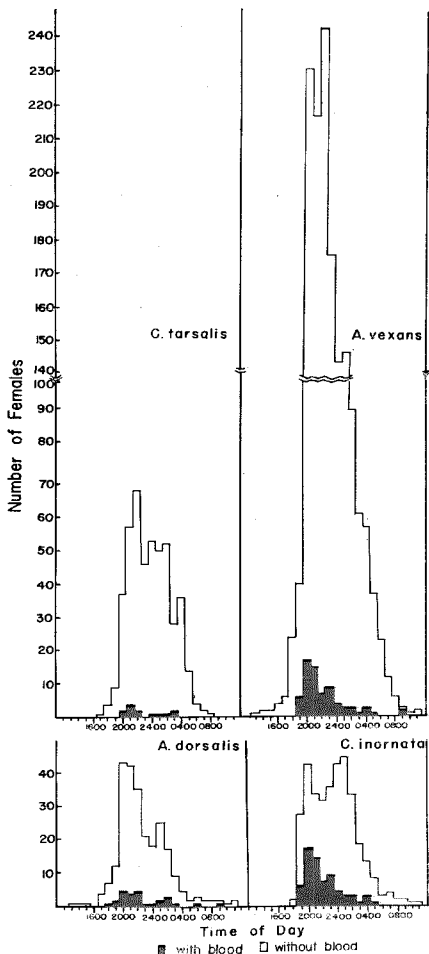


FIG. 1.—Daily periodicity in activity of females of *C. tarsalis*, *A. vexans*, *A. dorsalis*, and *C. inornata* with and without blood at Brooks, Alberta in 1956.

ground. Since the visual-attraction traps sampled only flying mosquitoes the freshly fed ones would be missed and this could also account for the low incidence of blood-engorged ones in the samples taken.

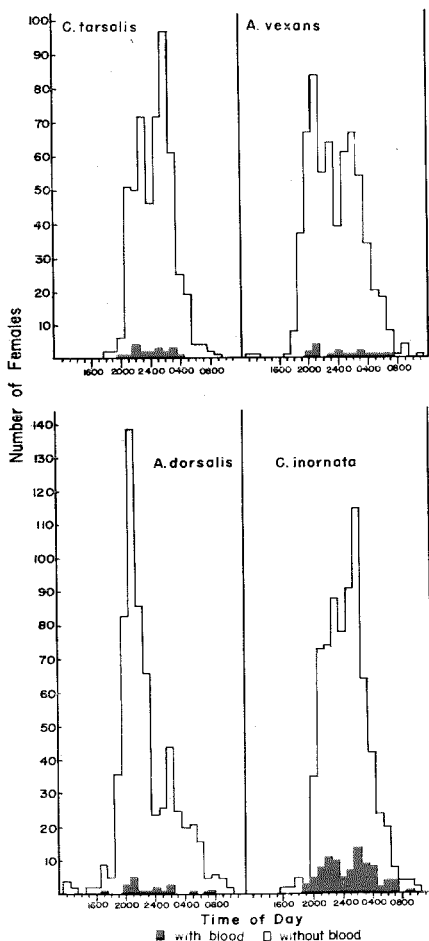


FIG. 2.—Daily periodicity in activity of females of *C. tarsalis*, *A. vexans*, *A. dorsalis*, and *C. inornata*, with and without blood at Rolling Hills, Alberta in 1957.

The percentage of multiple feedings was low. A much higher percentage of multiple feedings was expected in the irrigated areas because of the concentration of the many different types of warm-blooded animals in the area. This does not agree with the work of Rempel *et al.* (1946), who worked in an area with almost the same species composition, and who found that approximately 33 percent of the specimens collected had fed on more than one host. The limitations of the precipitin test are that it cannot detect multiple feedings separated by too great a time interval or feedings from the same kind of hosts.

Although the percentage of multiple feedings was low, the host sources were varied enough to be of importance in disease transmission among livestock and humans in this area. Irrigation has created an environment suitable for mosquito propagation and indirectly, it also created environments and habitats for animal and bird communities that were absent in the area before the introduction of irrigation. Bringing closer together of humans, domestic and wild animals, and mosquitoes under irrigation practices increases the potential of the incidence of future epidemics among livestock and man.

SUMMARY. Blood meals of mosquitoes collected under agricultural conditions in the irrigated areas of Alberta have been identified by precipitin test. It was found that all animals present in the area were attacked. Host preference was related to the availability of the host.

Multiple feedings were varied enough to be considered a factor in future epidemics among humans and livestock. Multiple feedings were encountered in all of the major species of mosquitoes in the study area.

The proportion of females with blood was low compared with females without blood, which indicated that the blood requirements vary within the population. The activity of the females with blood coincides with the activity of the females without blood.

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ORGANOPHOSPHORUS RESISTANCE IN *AEDES NIGROMACULIS* IN CALIFORNIA

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Organophosphorus insecticides, including EPN, parathion, and malathion, were first introduced in California between 1952 and 1954 to control larvae of *Aedes nigromaculis* (Ludlow), a pest of irrigated pastures, which by 1951 had already shown resistance to chlorinated hydrocarbon insecticides (Gjullin and Peters, 1952). Control failures with parathion became evident by 1958 in Kings County (Lewallen and Brawley, 1958), and that this was due to acquired tolerance was proved for material from Kings and Tulare counties (Lewallen and Nicholson, 1959). By 1960 it was evident that a very high degree of resistance to parathion was present in Tulare County (Lewallen, 1961). It was in the Delta Mosquito Abatement District of northwestern Tulare County and in Kings County that methyl parathion was substituted to control these resistant larvae, but its initial success was followed by control failures in the Delta district in 1962. The purpose of this investigation was therefore to examine cross-resistance data in order to

ascertain whether this was a case of general organophosphorus resistance to all OP compounds employed, i.e., parathion, methyl parathion, fenitrothion (Baytex) and malathion.

METHODS. Larvae were collected in the field and transported in the field water to the laboratory for test in the late third and early fourth instars. The required amount of insecticide was dissolved in acetone, and 1 ml. of this solution was added to 100 ml. of distilled water in 4-oz. waxed Dixie cups. Lots of 20 larvae were examined for 24 hours at 70° F., and the percentage mortality was scored from the sum of the moribund and the dead. A succession of concentrations was employed (e.g., 0.01, 0.02, 0.05, 0.08, 0.1 p.p.m.) so that a dosage-mortality line could be obtained and the LC₅₀ level established.

RESULTS. The LC₅₀ level of parathion (Table 1) ranged from 0.0006 p.p.m. for an untreated locality at Porterville in Tulare County to 0.170 p.p.m. on the Webb property in Tulare County. These compare with 0.00004 p.p.m. as being the LC₅₀ levels obtained in 1958 at Pinedale and Kerman in

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