CHANGES IN LOCAL MOSQUITO FAUNA FOLLOWING BEAVER *(CASTOR CANADENSIS)* ACTIVITY

WILLIAM L. BUTTS
Biology Department, State University College, Oneonta, NY 13820

ABSTRACT. A marked decrease in anthropophilic temporary water mosquito populations subsequent to impoundment of extensive areas of larval development by beavers is documented. Absence to date of development of other mosquito species in the permanent water thus established is noted and discussed relative to current characteristics of the site.

INTRODUCTION

The Biological Field Station of the State University of New York, College at Oneonta was established in 1968 as a site for collection and recording of base line data concerning natural populations of plants and animals under conditions as undisturbed by human activity as possible. It is located west of Otsego Lake and just north of the village of Cooperstown, New York. Studies on the upland site of the field station from 1968 to 1972 characterized the anthropophilic mosquito fauna. Large populations of univoltine *Aedes* spp. developed in ground pools left by snow melt and spring rains. An early season peak emergence of *Aedes punctor* (Kirby) and a subsequent peak emergence of *Ae. stimulans* (Walker) accounted for the bulk of the mosquitoes attacking humans. These two *Aedes* species, along with seven other species (five of which develop in ground pools as indicated above), represented the characteristic seasonal mosquito population. Five additional species were collected in larval surveys but not in landing/biting sampling (Butts 1974).

Mosquito population levels were generally high each year and a source of considerable annoyance to research workers in wooded areas on the upper site, with numerous mosquitoes feeding through light cloth garments as well as on exposed skin. Such feeding activity was generally noted from approximately June 1 until mid-August. Repellents were used with success on exposed skin surfaces. Attempts to impregnate work clothing gave quite inconsistent results, apparently due to differences in fabric composition; so for people working in the area the choice was to be annoyed and bitten or to perspire heavily in clothing thick enough to bar entry of mosquito mouthparts.

In the summer of 1980 while studying populations of calliphorid flies, I observed a marked decline in mosquito numbers. This observation was corroborated by a student assistant who resided on the upper site during that time. The investigations undertaken due to this observation are recorded in the following text.

EVIDENCE OF BEAVER ACTIVITY

The first evidence of beaver (*Castor canadensis*) activity on the upland site was recorded on April 28, 1978 when two felled *Populus* sp. saplings were seen near the spillway of a pond (Moe Pond) in the research area. On April 21, 1979 it was noted that the water level in the area surrounding the bog mat was higher than on any prior date of recording and that a small beaver dam built across a culvert south of the bog area late in the previous autumn was now submerged, leaving about a 20 cm space between the beaver pond and the adjacent area in which the level of surface water had also risen. This area included Area IV of the original adult sampling sites (Butts 1974). On July 24, 1980 an arcuate beaver dam with curvature toward Area IV had been constructed at the causeway and the water was confluent with that in Area IV. The causeway has remained submerged since that date, and the water level has been raised in stages through the summer of 1983. An apparently stable remnant of the bog mat remains, supporting a few living trees up to about 7.5± m high. All large trees which previously surrounded the bog have died and most have fallen into the beaver pond. The Area IV sampling site is covered by more than 1 m of standing water. An area of approximately 12 ha is flooded, and the contours are such that it appears unlikely that further deepening of the pond will occur, since quite extensive addition to the dam would be required and most of the winter food supply within a reasonable distance appears to have been cut. The water level on July 26, 1984 appeared to be the same depth as at the end of the previous summer.

SURVEY OF ADULT MOSQUITO POPULATIONS

During the summer of 1981 a follow-up survey conducted in the same manner as those

made through 1972 was completed (Table 1). Although a study of landing and biting activity done in 1977 had indicated that a 10-min sampling period might be appropriate, the original 20-min sampling period was chosen to be consistent with previous studies. In the sampling time study the 20-min period was divided into successive 5-min segments. During each 5-min period two assistants counted mosquitoes landing on and departing from a 0.09 m^2 area of the author's back. Results were subjected to chi-square analysis assuming equal activity in all periods. Results listed in Table 1 give a reasonable example of typical mosquito activity prior to 1980.

Sampling was carried out in the same manner as reported by Butts (1974) using 20-min exposure per sampling site. Five of the original sampling sites were used. Area I is on a gentle, west-facing slope with a dense plantation of Norway spruce about 10–12 m high. Area II is in a stand of mixed hardwoods with sparse understory on a steep, west-facing slope. Area IV was originally a low, poorly-drained area with a dense understory beneath a sparser stand of deciduous trees. It is now totally inundated and is part of the area impounded by beavers. Sampling was done at a point near its south edge. Area V is in a stand of mature hardwood with sparse understory on a well-drained, southwest-facing slope and adjacent low area. Area VI is on a south-facing slope in a mature stand of mixed hardwoods with a well-developed understory. Dates of collection were as follows: June 4, 9, 18, 25; July 9, 16, 23, 29; August 6, 13, 20, 26; September 5, 11; October 15, 1981.

Similar sampling was conducted during the summer of 1982 beginning on July 18 with subsequent samplings on August 1, 15, and 21 and September 10 (Table 2). This concentration of sampling in late summer was designed to assure exposure to species which might be utilizing the permanent water of the impounded area and for which later population peaks would be expected. The collector also sat quietly at the east edge of the beaver pond for about 45 minutes at dusk on August 14 and 20 and September 9 and 18. No mosquitoes were collected at this site during any of these sampling periods. This contrasts sharply with collections made at this same site in 1970 by Miss Monichia Wang. In 20-min exposures she collected the following: June 9:24 *Ae. punctor,* 5 *Ae. stimulans,* 4 *Aedes provocans* (Walker); June 17:37 *Ae. punctor,* 2 *Ae. provocans;* July 25:10 *Ae. stimulans,* 1 *Ae. cinereus* Meigen.

During the summer of 1983, a sampling series was conducted in a site at the east edge of the beaver pond. Beginning in early evening the collector was exposed for 20 min of each hour through mid-morning of the following day. The intervals between sampling periods were spent in a closed vehicle about 50 m from the sampling site. This pattern of sampling was designed to insure exposure to species which tend to be nocturnal feeders. Results are recorded in Table 3.

LARVAL DEVELOPMENT

Sites of larval development which had been located in previous years were sampled using a standard hand dipper. Larval populations during 1980 and 1981 experienced late mortality because of the distribution of rainfall. The normal flooding of ground pools associated with snow melt and early rainfall occurred, but additional precipitation was not sufficient to maintain water levels and many of the pools were dry before development was completed. During 1982 and 1983 most of the ground pools retained standing water long enough that there was no apparent reduction in adult

Table 1. Mosquito Activity Index. Number of mosquitoes landing on one square foot of the clothed back of a stationary human male during each of four successive 5-min periods. Counts were made at two sites, each approximately 50 m east and north respectively of the currently impounded area. Asterisks indicate departure from equal activity per 5-min segment as determined at the 5% level by chi-square analysis.

	Area V					Area north of Moe Pond				
	Time intervals in minutes				20 min.	Time intervals in minutes				20 min.
Date (1977)	0–5	5–10	10–15	15–20	total	0–5	5–10	10–15	15–20	total
July 11	18	11	5	18	52*	10	19	24	12	65*
July 13	28	15	19	8	61*	11	22	15	17	65
July 14	45	26	28	21	120*	25	18	22	14	79
July 14	10	11	12	11	44	16	24	20	24	84
July 18	42	23	3	17	85*	10	0	5	3	18*
July 20	95	76	73	65	309*	46	15	11	8	80*
July 21	53	41	28	15	137*	40	14	8	8	70*
Totals	291	203	159	155	808*	158	122	105	86	461*

Table 2. Summary of collection of landing/biting mosquitoes taken during 1981 and 1982. Adult female mosquitoes were collected from the body of the collector during a 20-min exposure. Dates of collection are recorded by month-day with parenthetical notation of number of individuals collected. (Originally designated Area III not utilized.)

1981	Total collected	Area I	Area II	Area IV	Area V	Area VI
Anopheles punctipennis	5			Aug. 26	May 29(2); Aug. 6; Aug. 13	
An. earlei	3			Jul. 29(2) Jul. 6		
Coquillettidia perturbans	3		Jul. 9 Jul. 23		Jun. 25	
Aedes c. canadensis	4	Jul. 9	Jul. 9(2)		Jun. 25	
Ae. stimulans	10	Jul. 9 Aug. 6	Jul. 16 Aug. 6		Jul. 23(2); Aug. 13	June 25(2) Jul. 9
Ae. triseriatus	4		Jul. 9			June 25; Jul. 9 Aug. 20
Ae. cinereus	3			Jul. 16 Jul. 29	Jul. 23	
Ae. excrucians	1				Aug. 6	
Totals	33	3	7	6	11	6
1982						
Anopheles earlei	1			Jul. 18		
Coquillettidia perturbans	1		Jul. 18			
Aedes c. canadensis	2	Jul. 18	Jul. 18			
Ae. stimulans	3	Aug. 1	Aug. 1(2)			
Totals	7	2	4	1	—	—

numbers due to premature drying. Surveys taken around the edge of the beaver pond and from those sites in the pond accessible by canoe indicated that larval development in this essentially permanent water source does not appear to be a factor in the development of anthropophilic species. However, larvae of species not recorded in biting counts were collected from sites adjacent to but not continuous with the beaver pond (a flooded animal burrow and the hull of an aluminum boat). No larvae of permanent water mosquito species such as *Culex territans* Walker, *An. earlei* Vargas or *An. punctipennis* (Say) have been collected.

RESULTS AND DISCUSSION

Although previous studies had suggested that a shorter sampling might be sufficient, the 20-min exposure was chosen to be as consistent as possible with sampling procedure in the earlier studies (Butts 1974). This choice was fortunate as in several instances when *Anopheles* spp. were collected, they were taken during the last 10 min of a sampling period.

The difference in the mosquito population prior to the onset of beaver activity compared to that which now occurs is extreme. This appears to be due to the impoundment of a large area surrounding the bog mat. Prior to beaver activity, this area was a border about 20–30 m wide in which water depth varied from 0 to 1.0 m in the early spring, receding to a depth of 0–0.3 m during the summer. This provided an area of approximately 1.6–2.0 ha in which larvae of snow-melt *Aedes* spp. could develop, and it supported large populations yearly. As the water receded there was a tendency to concentrate larval and pupal populations. This area represented a consistent and dependable source of mosquitoes. Although the actual water level might vary from year to year with differing patterns of precipitation, the area was never completely dry and there was a consistent seasonal fluctuation in water level with receding levels occurring during periods when oviposition took place.

During the period in which beavers have been active, the water level in this area has been essentially stable or gradually rising to its current level. There has been no lowering of the water level which is critical for development of the *Aedes* spp. which were dominant prior to the onset of beaver activity.

A similar sequence of events has taken place in a large area surrounding the Area IV designated in the original sampling sites. This has made a somewhat smaller area unavailable in the same manner since the two bodies of water became confluent in July 1980.

The total number of beavers in the area is difficult to estimate. Adult and quite young individuals have seen on several occasions, and four adults have been seen at one time. A

Table 3. Adult female mosquitoes seen and collected during sampling series beginning at 1800 hr and ending at 0920 hr on dates indicated. Collections were made during the first 20 min of each hour.

Date (1983)	Time	No. mosquitoes Approaching	No. mosquitoes Collected	Species
May 24, 25[1]	—	—	—	—
June 1, 2[2]	—	—	—	—
June 8, 9[3]	—	—	—	—
June 15, 16	1900–1920 hr	1	—	—
	2100–2120 hr	several	3	*Anopheles earlei* (2) *Aedes c. canadensis*
	2200–2220 hr	1	1	*An. earlei*
	0500–0520 hr	1	1	*An. earlei*
	0700–0720 hr	1	1	*Ae. c. canadensis*
June 21, 22		1	1	*Ae. stimulans*
July 6, 7	2100–2120 hr	1	—	—
	0900–0920 hr	1	1	*Ae. triseriatus*
July 13, 14	2000–2020 hr	2	2	*Ae. hendersoni* *Coquillettidia perturbans*
	0200–0220 hr	1	—	—
July 20, 21	1900–1920 hr	1	1	*Ae. hendersoni*
	2100–2120 hr	several	—	—
July 27, 28	2000–2020 hr	3	2	*Cq. perturbans* *An. earlei*
Aug. 1, 2[4]	1900–1920 hr	2	1	*Ae. hendersoni*
Aug. 10, 11	1900–1920 hr	2	—	—
	2000–2020 hr	1	1	*An. punctipennis*
Aug. 17, 18[5]	—	1	—	—
Aug. 23, 24	2000–2020 hr	1	—	—
Aug. 31, Sept. 1	—	—	—	—
Sept. 7, 8	1900–1920 hr	1	—	—
	2300–2320 hr	1	—	—

[1] Sampling suspended 2220 hr—low temperature.
[2] Sampling suspended 0020–0920 hr—low temperature.
[3] Sampling suspended 2220–0800 hr—low temperature.
[4] Sampling suspended 2120–2400 hr—heavy rain (electrical storm).
[5] Sampling suspended 0120–0300 hr 0420–0800 hr—heavy rain.

family group of as many as 12 individuals of various ages is probably active in the approximately 12 ha impoundment.

The mosquito population which now exists in the area is at a much lower level in terms of absolute numbers, but the species distribution remains very much the same (see Table 4). Only one species new to the site, *Anopheles earlei,* has been collected, but the populations of *Ae. punctor* and *Ae. stimulans* do not greatly exceed those of the other species. There has also been an apparent increase in the *Anopheles* spp. segment of the population. It is possible that this may be an artifact associated with the sampling procedure. These species were often taken in the latter portion of the sampling period and may exhibit a slower approach to the host when compared to other species present. This in association with the movement of the collector required to capture specimens, may have been a deterrent to landing and biting by the two *Anopheles* spp. collected.

At present there is no evidence in the impounded area of the occurrence of any mosquito species which characteristically de-

Table 4. Estimated relative abundance of species in populations before and after onset of beaver activity. The last species listed was not known to be present before 1980. All others listed had been collected from humans on site.

Species	Relative abundance Before 1980	Relative abundance After 1980
Aedes stimulans	++	+
Ae. punctor	++	−
Ae. c. canadensis	+	+
Ae. cinereus	+	−
Ae. triseriatus	+	+
Ae. hendersoni	−	−
Ae. vexans	−	−
Ae. riparius	−	−
Coquillettidia perturbans	−	+
Anopheles punctipennis	−	+
An. earlei		+

velop in permanent standing water. Certain characteristics of the habitat may be cited in this respect. In recent years there has been a virtually continuous mat of species of Lemnaceae covering most of the pond by mid-July. The mat consists largely of densely concentrated *Wolffia* sp. and a somewhat lesser amount of *Lemna* sp.; early in the season there appears to be more of the latter in the mat with an apparent reversal of dominance later. The deterrent effect of these species to development of mosquito larvae has been reported by Hall (1972) who indicates that relative density of the mat may be a factor in the degree of development of *Anopheles* spp. Using the term "duckweeds" to include *Lemna, Wolffia* and *Spirodela,* he notes that "Duckweeds completely blanketing the water surface may exclude breeding sites but in scattered or dispersed condition may contribute to anopheline larval production." Furlow and Hays (1972) reported the deterrent effects of duckweed on anopheline larval development when studied under controlled conditions. A small area of water which is largely free of this mat is maintained in the southwest portion of the pond. The margin between open water and duckweed mat varies somewhat with wind activity, which appears to explain, in part, why the mat does not completely cover the area. The wave action involved is also a deterrent to larval development. Although there is considerable emergent woody vegetation (now dead) and floating woody vegetational remains, the interface therewith at water level is enveloped by the floating duckweed mat.

It would be instructive to follow the sequence of events which accompanies beaver activity in those regions of the United States in which they are being introduced as a natural means of stream erosion management (Johnson 1984). The nature of the mosquito fauna in such impoundments can be of considerable interest to the associated human populations. The information presented here indicates that the presence of increased areas of impounded permanent water need not necessarily mean that larger pest mosquito populations will appear.

This study may also illustrate the usefulness of the research area in which it was conducted. This site was set aside as an area in which base line data could be collected under conditions of minimal human disturbance and in which long term changes might be documented. Had our studies begun during or after 1980, there would be no record of the nature of the previous mosquito populations. Our earliest collections also contain specimens of both terrestrial invertebrates and vertebrates which were trapped in the original sampling Area IV, which is now covered by water more than 1 m deep.

References Cited

Butts, W. L. 1974. An extended survey of mosquito populations in an ecological research tract in eastern New York. Mosq. News 34:224–228.

Furlow, B. M. and K. L. Hays. 1972. Some influences of aquatic vegetation on the species and number of Culicidae (Diptera) in small pools of water. Mosq. News 32:595–99.

Hall, F. J. 1972. The influence of plants on anopheline breeding. Am. J. Trop. Med. Hyg. 21:787–794.

Johnson, P. 1984. The dam builder is at it again! National Wildlife 22(4):8–15.