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SEASONAL ACTIVITY OF MOSQUITO PREDATORS IN WOODLAND POOLS IN ONTARIO

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INTRODUCTION. The present paper reports further on the insect predators of univoltine *Aedes* mosquitoes that breed in vernal, woodland pools near Belleville in Southern Ontario. The principal aim of this research was to obtain data on behavior and species succession of predaceous water beetles in both temporary and permanent waters. This information is basic to the development of effective biological and integrated control methods (Beirne, 1962).

METHODS. Three vernal (semi-permanent) pools were selected for study in 1964 in the Marsh Hill swamp at Chatterton. Pools 1 and 2 were situated 100 yards within the south side of the swamp; each was about 75 sq. yards in area in early April, soon after the spring thaw. The area of Pool 3, some 80 yds. to the west, was about 350 sq. yards. Water depths averaged 15 inches, with a maximum depth of 27 inches in Pool 3. Aquatic traps (James and Redner, 1965) were used to record the activity and numbers of the various predators; three traps were placed in each of Pools 1 and 2, and six in Pool 3. The traps were set in the pool in one of three positions: on the bottom (B), at the top, just below the surface (T), and in shallow water at the margin (M). All were examined and reset twice daily, 1 hour after sunrise and 1 hour before sunset, from April 13 to June 18 in the smaller pools, and until June 26 in Pool 3, and catches preserved in 80 percent alcohol. Water temperatures were taken with Taylor maximum-minimum thermometers at the margin and water depths checked at each visit to the trap site. Trap collections were also obtained from a permanent pond near Belleville from March 31 to August 25.

RESULTS AND DISCUSSION. The traps

were effective for catching predaceous beetles as well as other fauna. Thirty species were trapped of which 16 were of Dytiscidae, including 4 in the larval stage, and 2 were of predaceous Hydrophilidae; other mosquito predators included a stickleback, *Eucalia inconstans* (Kirt.), a mud minnow, *Umbra limi* (Kirt.), and larvae of a caddis fly, *Limnephilus* sp. Annual spring flooding brought in fish from sections of the swamp connected with the Moira River and also distributed other fauna to the pools before they became separated. Thus the predator complex of most pools was similar.

These traps caught more predators than did other methods, particularly for such species as *Dytiscus fasciventris* Say and *Hydaticus modestus* Shp. On the other hand, the traps could not be used satisfactorily in early spring (March) until the pools were free of ice, nor in late summer when the water became too shallow. Larvae of several predators were also collected though the trap appeared to be inefficient in retaining the early stages of *Agabus* and *Colymbetes*.

The principal predators were five water beetles that completed their life-cycles in the pools (Table 1). These were collected in sufficient numbers to compare their activity in relation to each trap position during a 24-hour period. For example, approximately three times as many adults of *Agabus* and almost twice as many *Colymbetes sculptilis* Harr. were taken in the night than in the day catches. The exceptions were larvae and adults of *Acilius semisulcatus* Aubé, which appeared to be less tolerant of night temperatures at the margin and hence were more abundant in day catches.

Additional predators were as follows: *Agabus anthracinus* Mann. 1; *A. bifarius* (Kby.) 2; *A. sharpi* Fall. 4; *A.* sp. 4; *Dytiscus fasciventris* 7; *D. fasciventris* (larvae) 10; *H. modestus* 5; *Hydroporus* sp. 3; *Hygrotus impressopunctatus* (Schal.) 1; *Laccophilus biguttulus* (Germ.) 1; and *Tropisternus natator* d'Orch. 1.

More beetles were trapped at pool margins than at either the top or bottom in deep water. This applied especially to *Agabus erichsoni* G. & H., *A. phaeopterus* (Kby.), *Hydrochara obtusata* (Say), and the larvae of *C. sculptilis*. Field observations showed that these species tend to frequent the vegetation and leaf debris in shallow water where temperatures are higher and oviposition sites and food are available. Here also dark-coloured *Agabus* spp. and *H. obtusata* would appear to be less exposed to attack by vertebrate predators than the pale and more conspicuous adults of *A. semisulcatus* and *C. sculptilis* that inhabit deeper water.

The average daily catch of predators from each pool was not comparable for the whole period as traps in the smaller pools could be operated only in marginal sites

TABLE 1.—Numbers of predaceous Coleoptera collected in semi-permanent pools, Chatterton, Ontario, 1964.

Species	By Period		By Trap Position		
	Night	Day	Top	Bottom	Margin
Agabus erichsoni	466	149	159	166	290
" " (larva)	2	3	0	1	4
A. phaeopterus	28	10	7	14	17
Acilius semisulcatus	87	98	47	78	60
" " (larva)	20	61	24	33	24
Colymbetes sculptilis	63	35	23	46	29
" " (larva)	9	6	1	3	11
Hydrochara obtusata	231	187	81	97	240
" " (larva)	112	83	49	94	52
Totals	1018	632	391	532	727
Percent	61.7	38.3	23.7	31.6	44.7

after June 12 because of low water levels. Up to that time, however, the daily average per trap was 1.9 and 2.2 in Pools 1 and 2, and 1.3 in Pool 3 where the beetle population was lower. After June 12, however, high catches were obtained in Pool 3 as the predators became concentrated within the shrinking margins. As a result the average number per trap increased to 2.4. The total number of predators, including immatures, in terms of pool area, was estimated at 4.7, 5.6 and 2.7 per sq. yard in Pools 1 to 3. These values, though comparable, are higher than those obtained by area sampling in April when some dytiscids were immobile at low temperatures or in a state of cataleptic shock and perhaps were overlooked in census counts. It is evident, however, that the increase partly reflects the addition of beetles from the current generation, since a few teneral adults were found in the traps in late June.

TREND OF CAPTURES. The trap catches varied at each setting and according to fluctuations in the water temperature (Fig. 1). Higher catches at the margins are attributed to the greater activity of predators at the periphery than in deeper parts of the pool which were cooler. Peaks oc-

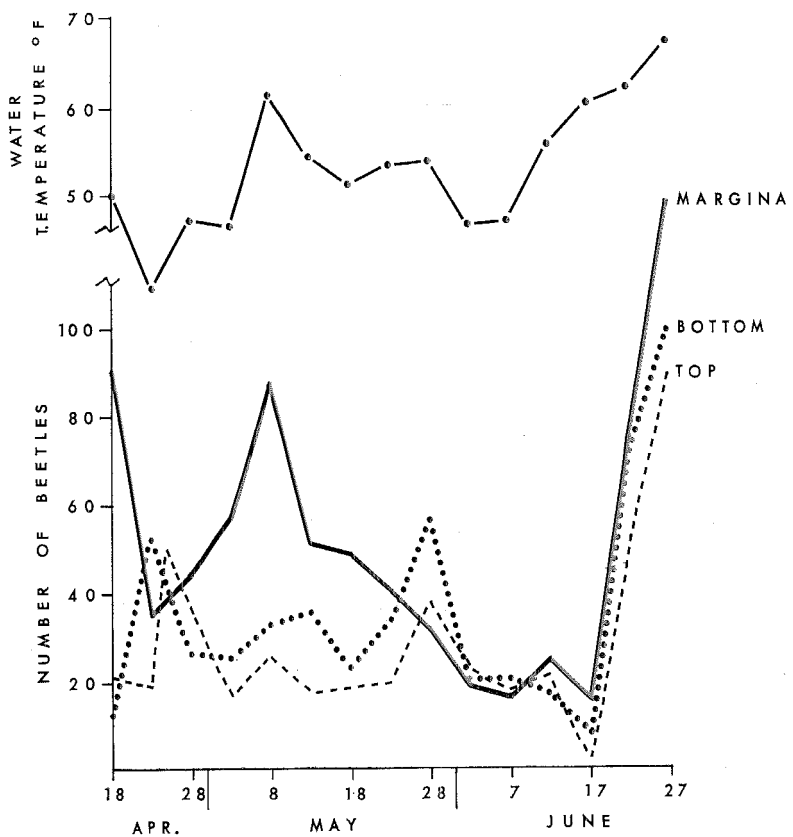

FIG. 1.—Five-day catches of aquatic Coleoptera, Apr. 18–June 27, 1964 at three trap positions in vernal pools, Chatterton, Ontario in relation to daily maximum water temperature at pool margins.

curred at the onset of trapping and also near May 8, but after this, with the exception of *Agabus,* fewer beetles were collected because of continuous trapping and lower temperatures. Parallel trends with delayed peaks at lower levels are indicated in catches from the other traps. During May, 18–30 bottom catches exceeded marginal ones because of an increase in the number of adults and larvae of *A. semisulcatus* and also larvae of *C. sculptilis* and *H. obtusata.* Catches of *D. fasciventris* were also similar although smaller.

Because of the higher temperatures more resident predators were collected overnight at the margins than at any other times or trap positions. In the less-shaded Pool 3, for example, catches were greater than in the smaller, more shaded pools during the period Apr. 17–May 12. After this, however, proportionally higher catches were made in Pool 2 where average temperatures were from 7 to 8 degrees higher. The percentages of the total seasonal catch of selected species collected in Pools 1 and 2 up to June 19, were as follows: *A. semisulcatus* 59.3; *A. erichsoni* 60.4; *H. obtusata* 67.7; and *C. sculptilis* 80.8. Predator larvae were represented mainly by *H. obtusata* (91.5 percent). These values suggest that the small pools contained larger numbers of the breeding population than did the large pool.

PREDATOR SUCCESSION. The initial appearance and length of occurrence of aquatic beetles in vernal pools varies from year to year and depends on water temperatures after the spring thaw and mainly on how long water levels are maintained. During the past 10 years predator occurrence and development in relation to that of the mosquitoes appeared to follow a consistent pattern. In 1964, (Fig. 2), for example, adult predators, with two excep-

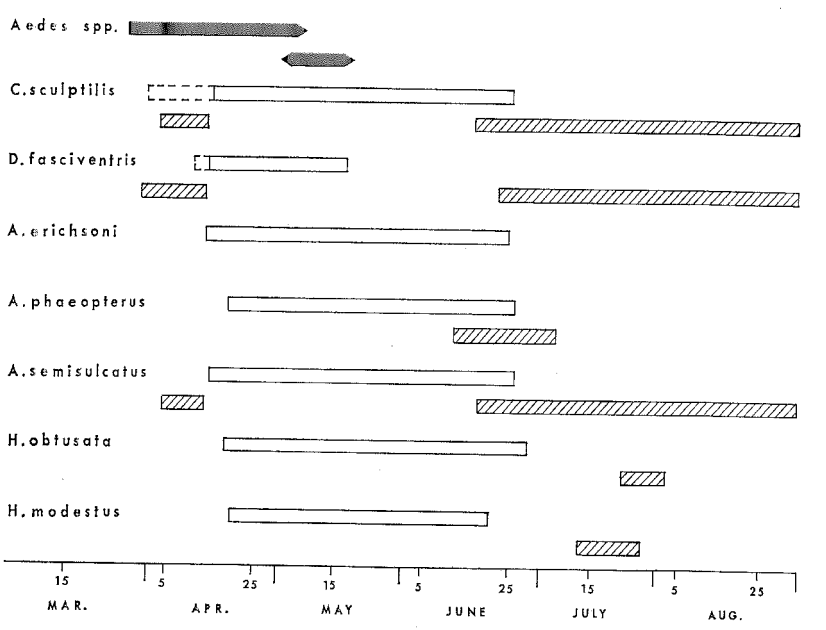

FIG. 2.—Occurrence of principal predaceous water beetles (light bars) in relation to that of *Aedes* larvae and pupae (first and second black bars respectively) in vernal pools, Apr. 18–June 27, 1964, Chatterton, Ontario. Bars with broken lines refer to occurrence previous to regular trapping. Hatched bars illustrate the presence of the same species in a permanent pond at Belleville, from Apr. 2 to Sept. 3 of the same year.

tions, were not found in the traps until mid-April, i.e., they had not come out of hiberation or entered the pools until then. At this time approximately 65 percent of the *Aedes* larvae were still in the first stage because of low seasonal temperatures. Later, however, various predators appeared and were followed by their immatures during the remainder of mosquito development. Some adults were still present on June 26, when the pools contained very little water and were about to dry up, but others perhaps had emigrated. In Europe, Wesenburg-Lund (Balduf, 1935) reported mass flights of water beetles from drying pools in both spring and summer.

The sequence of species in the permanent pond at Belleville was entirely different. The three species *A. semisulcatus, C. sculptilis,* and *D. fasciventris* were present in small numbers during early April but were not collected again in the traps until mid-June and then in increasing numbers until the end of July. After that date and until August 26, when trapping was discontinued, the numbers steadily dropped. Three other species were not collected until June (*A. phaeopterus*) and July. All of these records suggest that certain predators from the vernal pools overwinter in permanent ponds but leave them in early spring and return to their breeding pools. Later, these and other species emigrate from drying pools to ponds or other permanent waters, either as year-old individuals or as newly-emerged adults.

The earliest predator pupae at Chatterton were collected in the soil near pool margins from June 5 (*C. sculptilis*) to June 18 (*A. semisulcatus* and *D. fasciventris*). Apparently, none of these species breeds in the Belleville pond, which to date has yielded no immatures. Wilson (1923) stated that adult dytiscids are often common in fishponds from which their larvae are absent during the entire summer. He also noted several species, including *A. semisulcatus* and *Dytiscus hydridus* Aubé, in newly-constructed ponds 24 hours after flooding.

The Belleville pond also contained 11 other species of Dytiscidae (listed below) that partly characterize it as a permanent body of water. With such an extensive predator fauna, including 2 species of small fish, the pond not surprisingly has yielded only a few aedine larvae in past years. This and similar ponds thus appear to serve as permanent reservoirs for the adults of many predaceous water beetles after the breeding pools are no longer available.

Other Dytiscidae from the Belleville pond

Acilius mediatus (Say)
Agabus ambiguus (Say)
Coptotomus interrogatus (Fab.)
Dytiscus circumcinctus Ahr.
D. harrisii Kby.
D. verticalis Say
Graphoderus fasciatocollis (Harr.)
Ilybius denikei Wallis
Rantus binotatus (Harr.)
R. tostus (Lec.)
Tropisternus lateralis nimbatus (Say)

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