OBSERVATIONS ON THREE SPECIES OF *CHAOBORUS* LICHT. (DIPTERA: CULICIDAE) AT CHURCHILL, MANITOBA [1]

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Mosquitoes of the genus *Aedes* Mg. breed in enormous numbers in the subarctic regions of Canada, and their control in establishments of the far north has been the subject of considerable research. Though much is known about the biology of the pest species, comparatively little is known about their natural enemies, including culicid predators of the genus *Chaoborus* Licht.

Contributions to the biology of nearctic species of *Chaoborus* by various workers were summarized by Johannsen (1934) and Matheson (1944). More recently, Jenkins and Knight (1950), Haufe (1952), and Sailer and Lienk (1954) reported on the behavior and ecology of some of the northern species.

The present paper contains information obtained at Churchill, Manitoba from 1949 to 1952 on the habits and seasonal histories of *Chaoborus nyblaei* (Zett.), *Chaoborus americanus* (Joh.), and *Chaoborus borealis* Cook (Cook, 1956).

METHODS: AREA. Larvae of *Chaoborus* spp. were collected from Churchill southeast to Farnworth Lake and south on both sides of the C.N.R. line to Goose River (Figure 1). According to Haliday (1937), this area is on the border between the northern Boreal forest and the arctic barrens, and includes both types of terrain. The severe climate stunts tree growth, and the low elevation and the presence of permafrost permit only superficial drainage. On the tundra and in the forest, melting snow and ice during May and June form additional pools, in which culicids breed.

Larval development of the three species was determined from spring and summer collections. In addition, *C. nyblaei* larvae were studied in a selected forest pool near Goose River in 1950. Larvae and associated arthropods were collected with a suction-type sampler that consisted essentially of a watertight steel cylinder attached to a length of brass pipe. To operate the sampler, the cylinder was submerged and its bottom opened by a lever on the handle. Water containing aquatic organisms replaced the air in the cylinder, and was trapped when pressure on the lever was released. A sample was taken from four representative parts of the pool at 10 a.m. at intervals of three days from June 17 to August 16.

In 1951, a tent trap somewhat resembling the pyramidal cage of Lindquist and Deonier (1942) was used to catch adults of *C. nyblaei* emerging from a deep pool (Figure 2). The base of this trap was provided with sharpened stakes at the corners so that it could be partly submerged and securely anchored to the bottom of the pool. The sides were of translucent plastic, and the top section was ventilated by screened windows at each side. The cage, which covered an area of one square yard, was set up in a pool on July 6, when 31 percent of the larvae had pupated, and was examined daily until July 20 and subsequently every second day. *C. nyblaei* adults were directed toward the trap jar by placing a cover of black denim over the top section and gently tapping the latter. Pool temperatures were recorded with a maximum-

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minimum thermometer three inches below the surface outside the cage.

Emerging adults of *C. borealis* were trapped by means of a plastic screen cage with a removable top (James, 1957). In 1951, this cage was placed over part of a shallow pool in open forest near Farnworth Lake on June 28, when approximately 35 percent of the larvae had pupated (Figure 3). Emerged adults were reared in deep Melrose boxes in a laboratory at Fort Churchill, and fed split raisins and a 10 percent solution of sucrose on cotton wads.

The feeding habits of *C. borealis* were studied in an insectary. In the first test, mature larvae were reared individually in eight-ounce glass jars containing strained pond water, and each was supplied daily with 10 *Aedes* larvae or with 10 adult *Daphnia* spp. In the second test, the predators were each given 10 or 20 *Aedes* larvae and then reared for five days. In the third, the predators were kept without food for one day and then each was confined with 10 *Aedes* larvae for 24 hours.

LARVAL HABITATS. *Chaoborus borealis.* This species, which appears to be closely related to the European species *Chaoborus crystallinus* (De G.), has so far been found only in Canada, at points along the northern fringe of the Boreal forest (Cook, 1956). At Churchill the mature larvae, previously mis-identified as of *Chaoborus flavicans* (Mg.) (James, 1953), were first collected from shallow, open forest pools in association with *Aedes communis* (De G.) and *Aedes punctor* (Kby.). These pools were 6 to 14 inches deep and were situated in a depression among scattered black spruces, tamaracks, and dwarf willows near Farnworth Lake. They were margined with sedges and reindeer moss, and had an average pH of 5.0. Larvae were also present in the shallow water of deeper, permanent pools. In general, this species was the most common chaoborine of the open forest.

Larvae were found also in steep-banked pools in the vicinity of Warkworth Creek and Goose River. In the latter area they were exceptionally numerous in a narrow,

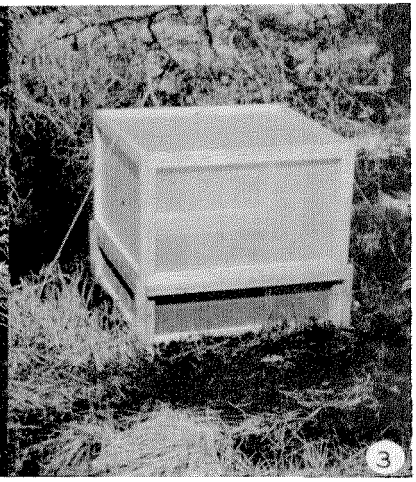

FIG. 2.—Pyramidal tent trap in a forest pool near Goose River, in which adults of *Chaoborus nyblaei* emerged.

FIG. 3.—Plastic screen cage used in a pool near Farnworth Lake to trap adults of *Chaoborus borealis.*

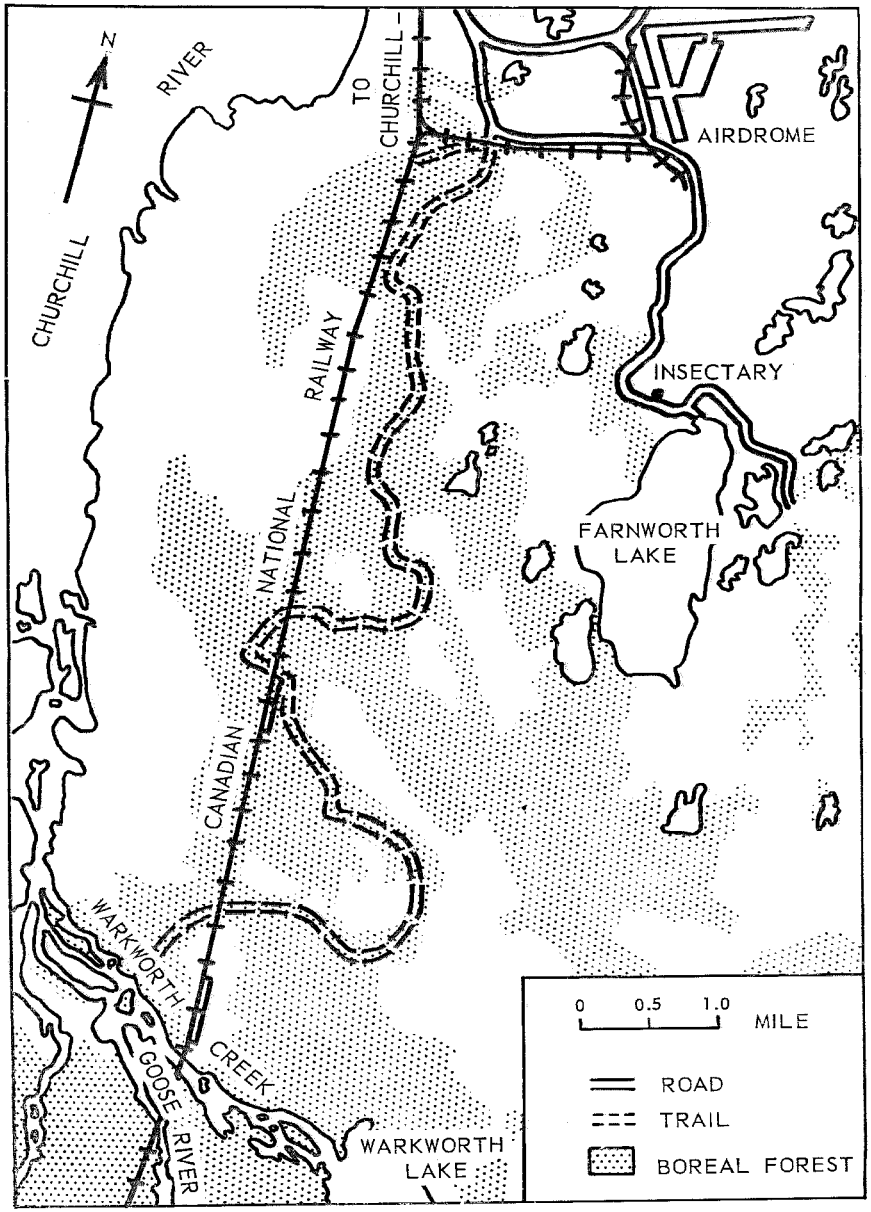

FIG. 1.—Principal sites investigated near Churchill, Manitoba.

sinuous pool containing larvae of *A. communis* and *A. punctor*. This pool, approximately 25 feet long, 3 feet wide, and 18 inches deep, had a muck bottom and was bordered mainly by scrub willow and emergent sedges. No larvae of *C. borealis* were found in tundra-meadow pools.

Chaoborus nyblaci. Both Matheson (1944) and Cook (1956) reported that this species is widely distributed in North America, particularly in arctic and subarctic regions. Larvae from Churchill were collected from rather deep forest pools near Goose River. The pool chosen for studying the larvae was approximately 16 feet long by 6 feet wide, and its greatest depth on June 16 was 3¼ feet. The bottom consisted of a three-inch layer of black muck, rich in hydrogen sulphide, which overlay compact clay and some gravel. Though the pool was shallow at each end, much of it was shaded by the south bank that rose abruptly above the deeper water to a height of four feet. The pool was also shaded by dwarf birches and willows.

Emerging adults were trapped from a somewhat smaller forest pool of an average depth in July of only 10 inches. This pool was well shaded, however, and temperatures three inches below the surface ranged from 12.4° to 17.0° C. from July 10 to August 23. Associated with the predator in this pool were *Aedes cinereus* Mg., *Aedes excrucians* (Walk.), *Aedes implicatus* Vock. (*A. impiger* of American authors), and *Aedes pionips* Dyar.

Chaoborus americanus. Of the three species of *Chaoborus* found at Churchill, *C. americanus* was encountered least frequently. Larvae were abundant, however, in one open forest pool near the C.N.R. tracks at Mile 503. This was a long, narrow pool, five to seven feet wide and up to two feet deep, with a five-inch layer of black muck overlying the frozen soil beneath. Few mosquito larvae were present. Additional larvae of the predator were collected near Goose River from forest pools that also contained *C. borealis*.

SEASONAL HISTORY. *Chaoborus borealis*. One generation was produced annually. The mature, overwintering larvae usually resumed development early in June, after the variable arrival of the spring thaw, but as a rule the larvae were not found until after the eggs of *Aedes* spp. had hatched. In 1950, the predators were not found on June 1 in pools containing first-instar *Aedes* larvae and none were obtained from samples of soil and moss dredged from these pools. This suggests that the larvae remained in the frozen mud until the level of the permafrost receded. Mature larvae were abundant in pools near Farnworth Lake on June 6, and on June 11 they aggregated in some forest pools to the extent of three to four per litre. In general, larvae appeared later in the forest pools than in those of the open forest.

Pupation occurred in June or July, depending on the weather and on the site and type of pool. Pupae were found in transitional forest pools from June 3 to July 8 and in forest pools during early July. In 1951, pupae observed in an open forest pool on June 28 remained in this stage as long as 10 days.

Emergence probably occurs during late June and July. Of 16 adults trapped in the plastic, screen cage near Farnworth Lake, males emerged from June 30 to July 6 and females from July 1 to July 16, when the last adults of *A. communis* and *A. punctor* emerged in the same cage. In addition to 215 *Aedes* spp. adults, 298 other adult Nematocera were taken in the trap, including the craneflies *Limnophila poetica* O.S., *Prionocera proxima* Lack, and *P. turcica* (F.), and a midge, *Pentaneura* sp.

Presumably eggs are deposited in the pools during July. Though oviposition was not observed, several fertile egg rafts were obtained in the laboratory during July 21 to 25 from caged females. The rafts, each consisting of 80 to 160 eggs, were laid in a gelatinous support on the surface of water in watch glasses. In one raft observed, the eggs darkened after two days and on the third day most of them hatched. Variations in the lengths of

young larvae in different pools during July indicated that some eggs are deposited much earlier than others. Mature larvae were found in late August.

Chaoborus nyblaei. There was one generation a year. The presence of late-instar as well as newly-hatched larvae in the earliest spring collections indicated that the winter was passed either as a larva or in the egg stage. Regular sampling of a selected pool at Goose River in 1950 showed that though mature and early-instar larvae were present in the first samples on June 17, the number per sample later increased and reached a peak on June 26 apparently as more larvae were released from the thawing pool bottom (Figure 4). Later, as they began to pupate, fewer larvae were taken, though this did not account fully for the reduction. Toward the end of July, however, the numbers increased again as young larvae of the new generation appeared in the samples. These small larvae were distinct from those of *C. americanus* and *C. borealis;* larvae of *C. nyblaei* were collected also from an adjacent pool. The pH of the selected pool, from June 17 to August 4, ranged from 7.0 to 8.3 with a mean of 7.6. During this period the higher levels of pH were observed when the larvae of *C. nyblaei* and *Aedes* spp. pupated and also when *Daphnia* spp. became abundant.

Adults emerged from early July until mid-August, depending on the season and the site and depth of the breeding pool. Twinn *et al.* (1948) reported *C. nyblaei* from a male swarm at Churchill on July

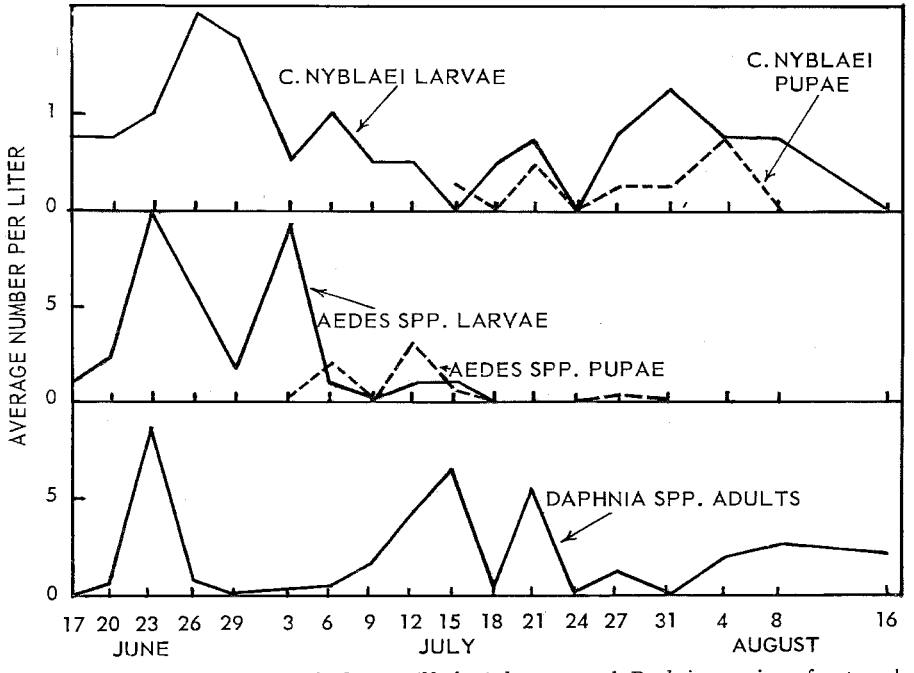

FIG. 4.—Relative abundance of *Chaoborus nyblaei, Aedes* spp., and *Daphnia* spp. in a forest pool near Goose River, June 17 to August 16, 1950.

24, and in 1950 the junior author observed adults emerge in an insectary from July 31 to August 8. A total of 43 males and 46 females were taken in a tent trap in 1951. Emergence was marked by two peaks, the first on July 11, consisting of males only, and the second on July 30, consisting of males and females (Figure 5). In a deeper, and more shaded forest pool, *C. nyblaei* emerged in a plastic screen cage from August 3 to August 17. It is evident that larvae that mature late in such pools greatly extend the emergence period of this species.

Eggs laid by the early-emerging females hatched into larvae that completed their growth by the end of the summer; presumably the later eggs either produced young, overwintering larvae, or went into diapause. In 1951, caged females deposited several egg rafts in beakers of pond water during August 14 to 17, but none of these eggs hatched in late summer.

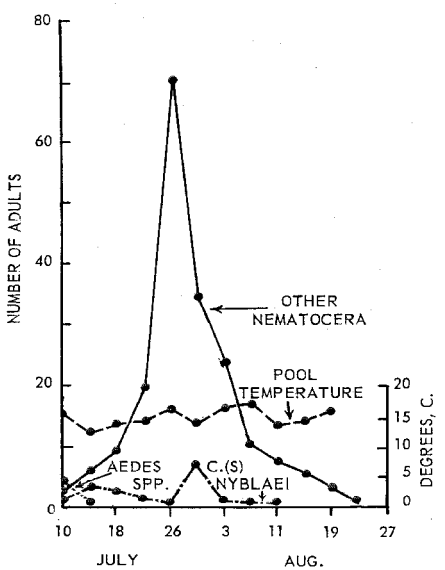

FIG. 5.—Average numbers of *Chaoborus nyblaei* and other Nematocera emerging during four days in a pyramidal tent trap near Goose River, 1951.

Chaoborus americanus (Joh.). This species had one generation a year and usually overwintered as a mature larva. Fourth-instar larvae and some pupae were found in forest pools near Warkworth Creek soon after the spring break-up in 1949. Similar larvae were collected in the forest pools at the end of August. At Great Whale River, Quebec, Jenkins and Knight (1950) found pupae on June 24 and observed male swarms from June 28 to July 3. In the Churchill area, pupae were taken on June 18 and July 2 from forest pools, all near Warkworth Creek.

FEEDING TESTS. During preliminary feeding tests in 1949, fourth-instar larvae of *C. borealis* destroyed an average of 0.7 (range, 0–1.2) *Aedes* spp. larvae in 24 hours. Further tests in 1950 confirmed that *C. borealis* is a predator of *Aedes* spp. larvae and of *Daphnia* spp., though the latter diet delayed pupation. In the first test, each of eight predators destroyed an average of 0.3 (range, 0.2–0.5) *Aedes* larvae and 0.1 *Daphnia* in 24 hours. In the second, each of eight predators that were confined with 20 *Aedes* larvae killed an average of 0.6 *Aedes* daily; those confined with 10 *Aedes,* 0.3 daily. In the final test, 10 predators each destroyed an average of 0.4 *Aedes* in 24 hours. Approximately eight percent of the *Aedes* larvae in the test lots and controls of the first two experiments died from undetermined causes, but no such losses occurred in the final test. Admittedly, in the pools the rate of predation may be greater or less than that in the experiments, depending on the relative size of the mosquito larvae, their population density, and the presence of other prey. In the pools at Goose River mature larvae of *Chaoborus nyblaei* were observed to capture pupae as well as fourth-instar mosquito larvae. After the mosquitoes had emerged, however, dissections indicated that the predators were feeding on *Daphnia* spp., ostracods, and other crustaceans.

SUMMARY. During a survey of predators of *Aedes* spp. near Churchill, Manitoba, *Chaoborus americanus* (Joh.) and

C. borealis Cook were collected from forest and open forest pools, the latter species in association with *Aedes communis* (De G.) and *A. punctor* (Kby.). *Chaoborus nyblaei* (Zett.), however, was found principally in deep forest pools, some of which contained late-emerging *Aedes* spp.

Each species produces one generation annually and overwinters as a larva, though presumably some of *C. nyblaei* overwinter as eggs. The number of overwintered larvae of *C. nyblaei* taken from a selected pool increased from 0.7 per litre on June 17 to 1.9 on June 26, but then decreased until mid-July as they pupated; as the new generation appeared, the number again increased, reaching a peak toward the end of July. Adults of *C. nyblaei* emerged from early July to mid-August. The development of *C. borealis* and *C. americanus* varied with the weather and the type of pool. In 1951, adults of *C. borealis* emerged from an open-forest pool mainly in July and some laid eggs that hatched in three days. Young larvae also present in the pools in early July matured in late August. *C. americanus* pupated from mid-June to early July and larvae of the new generation matured at the end of the summer.

C. borealis and *C. nyblaei* preyed on *Aedes* spp. Larvae of the former destroyed an average of 0.3 to 0.6 prey daily in insectary tests.

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A.M.C.A. members in the North Atlantic and Southeast Central Regions are invited to an informal meeting in Baltimore at the time of the Eastern Branch meetings of the Entomological Society of America, November 24 and 25, 1958. Full information will be furnished later. Make your plans now for a visit to Baltimore.