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SHORELINE AGGREGATION BEHAVIOR OF ADULTS OF A MIDGE, *CHIRONOMUS* SP. (DIPTERA: CHIRONOMIDAE) AT SOLBERG LAKE, WISCONSIN

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INTRODUCTION

Adult chironomid midges are well known to visitors at northern Wisconsin lakes during the spring and summer. Although the larval stages of chironomids supplement the diet of fish, the adults are often a nuisance because they aggregate in huge aerial swarms near beaches, collect at lights, alight on various objects including people, and deposit green specks wherever they rest. The most familiar midge in Wisconsin is *Chironomus plumosus* (L.) which has been studied at Lake Pepin (Johnson and Munger, 1930) and at Lake Winnebago (Burrill, 1913; Hilsenhoff, 1959, 1966, 1967).

In the summers of 1964 and 1965, adult midges were very abundant at Solberg Lake in Wisconsin. There they caused bathers and property owners considerable concern because of their habit of aggregating on the beaches at the water's edge in the evening. Aerial swarming habits of midges are well documented (*e. g.* Burrill, 1913; Johnson and Munger, 1930), but their aggregating habits on beaches are not. This paper reports the behavior and abundance of this midge on a beach at Solberg Lake.

The midge studied was not positively identified. Several taxonomists[1] placed this midge near *C. plumosus* or *C. staegeri.* According to Sublette (personal communication) it differs from typical *staegeri* in having a higher wing length, a lower leg ratio, a generally paler color, and a shorter tarsal beard; and the genitalia differ in that the dististyles are more clavate and the superior appendage has the apex slightly recurved. Hilsenhoff (personal communication) suggested the midges were not typical *plumosus* either, because *plumosus* is not known to emerge in great numbers in July, the time of the study.

LOCATION AND METHODS

Solberg Lake is a large flowage located 4 miles northwest of Phillips, Wisconsin. Hazel brush, aquatic emergents, and other plants line the shore of most of the lake. About 5 per cent of the shoreline, however, is interrupted by narrow sandy beaches. The study area, which was one of these beaches on the east side of the lake, measured 120 ft. long and varied from 1.5-2.5 ft. wide. Large logs occupied both extremities of the beach.

Ten quadrats (each 1 square foot) placed at regular intervals along the shore were used to count midges when populations were low. Water glasses (10 oz.) placed over midges at various intervals along the length and width of the shore

[1] Correspondents and examiners of midges: W. W. Wirth, U.S. National Museum, Washington D.C.; J. E. Sublette, Eastern New Mexico University, Portales, N.M.; H. K. Townes, American Entomological Institute Ann Arbor, Mich.; and W. L. Hilsenhoff, University of Wisconsin, Madison, Wisc.

were used to count high population levels. The insects trapped in the glasses were usually placed in alcohol and counted later. Counts or collections were made at intervals of a few minutes to an hour. Time is reported in central daylight time.

Most observations and records were taken between 14-18 July 1964. Residents of the lake area that year reported they had noticed midge activity at least one week earlier. Additional notes were taken between 11-16 July 1965 and 8-11 July 1968.

Two shallow V-shaped trenches (2 in. x 12 in.) and 4 conical pits (3-4 in. dia.) were dug in the sandy beach to see if the distribution of midges could be modified. The trenches which were dug to water level were perpendicular to and extended from the water's edge; pits were dug to water level about 8 in. back from the water's edge.

MIDGE BEHAVIOR AND ABUNDANCE

Adult midge behavior was similar each day of the study, but population buildup along the beach was curtailed by strong wind, cool weather, and/or rain on three occasions. Typical behavior for 15-16 July 1964 follows.

In the morning after 1030 hrs. (CDT) and throughout the rest of the day nearly all midges were resting on the undersurface of foliage in the woods near the lake. The highest numbers were on hazel brush and other low-growing plants adjacent to the beach. The number diminished away from the lake, and except for an occasional specimen in a spider web, few were beyond 70 yards from the water's edge.

Midges were rarely seen in the air until 1800 hrs. when a few were noticed over the water More appeared after that and a few alighted on the moist sand close to the water's edge at 1830 hrs. Midges slowly streamed out of the woods until the sun passed behind the horizon across the lake at 2040 hrs.--then the air became "full" of midges. Burrill (1913) and Johnson and Munger (1930) reported that aerial swarming of the closely related *C. plumosus* also occurred at dusk in Wisconsin. A few midges alighted on the shore during this swarming period, but then at 2115 hrs. hoards of them suddenly descended and settled on the sand (Fig. 1) and the logs at the ends of the beach (Fig. 2). Midges continued to settle until 2350 hrs. when the population on the shore reached maximum (Fig. 3). Numbers decreased after that but mostly from mortality of those at the water's edge.

The number of midges began to diminish about 0500 hrs. (Fig. 3) when the morning sun brightened the sky. A few midges left the beach at first, then many flew just before 0600 hrs. when the sun shone directly on the beach. Those in the shade under a pier at this time remained on the sand 10-15 minutes longer. By 1030 hrs. midges were difficult to find on the beach. Except for an occasional straggler the only ones on the shore were dead and piled up in the littoral drift line.

Behavior on the beach varied by time and location. The first midges arriving in the evening landed close to the water's edge. They moved slowly when walking and frequently stopped and put their heads down close to the moist sand. When the population increased, however, those nearest the water became crowded--up to 7 deep at times. They were continually agitated and moved rapidly over each other apparently competing for moist locations. Waves lapping the shore intensified their movements and carried some of them onto the water which caused short flights or drowning. Midges toward the rear of the beach were less crowded, and also less agitated.

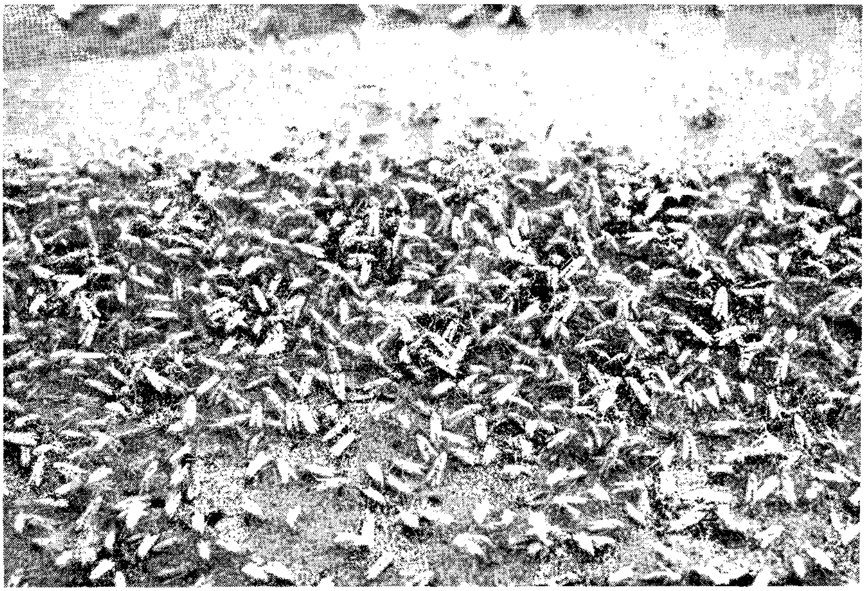

Fig. 1. Aggregation of adult midges on a sandy beach at Solberg Lake. Note the higher density along water's edge.

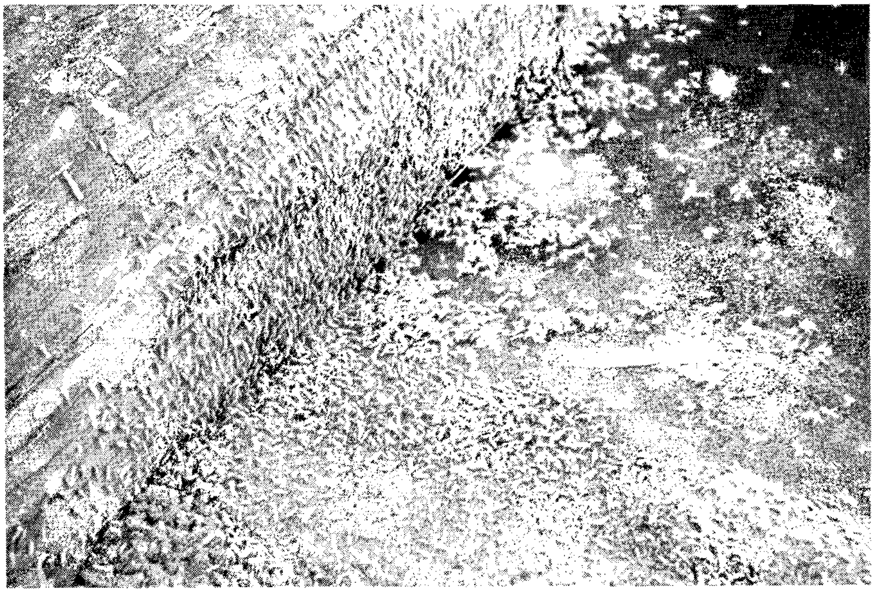

Fig. 2. Aggregation of adult midges at south end of beach. Note midges on water and regularly arranged ones on log.

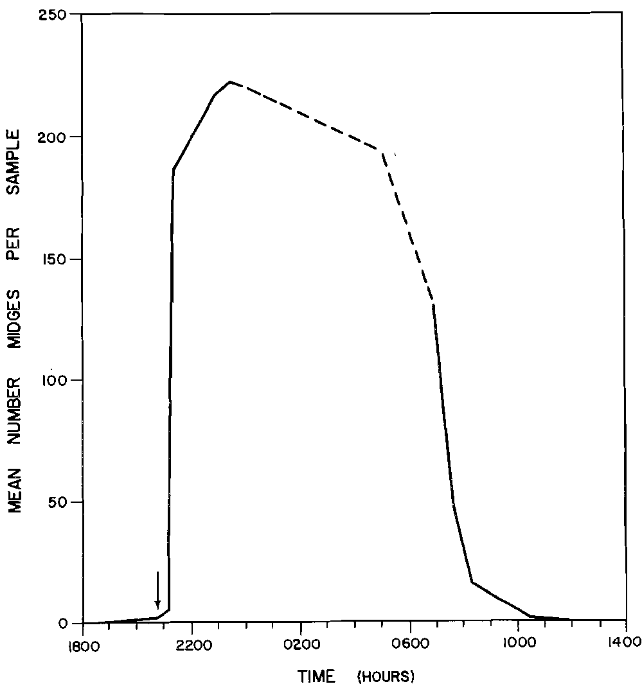

Fig. 3. Mean number of adult midges per sample on the beach. Time is CDT. Arrow indicates sunset. Population drop after midnight (dashed line) is due mainly to midge mortality from drowning and and other causes.

Apparently the 2-3 inch wide zone along the water's edge was optimum because the numbers were always highest there and diminished directly with the distance behind this zone. For example, the mean distribution of adults at 1000 hrs. (17 July 1964) from the water's edge to dry sand was as follows:

Distance from water (in.)	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30
Mean no. midges/9 in.^{2}	119	60	24	17	9	6	3	2	1	0

This diminishing density pattern is also evident in Fig. 1.

On warm windless nights midges were abundant all along the beach but particularly abundant at the south end. There they piled up in the corner between the sand and a large log (Fig. 2). On the best-flight night (15 June 1964) near the south end, there averaged over 2,100 midges/square foot in the optimal 0-3 in. zone at the peak of aggregating. Inactive insects took advantage of vertical surfaces, like the log in Fig. 2, and positioned themselves geonegatively and at regular intervals from each other.

Trenches and pits dug in the sand caused the insects to modify their distribution. Within minutes after digging, midges began to congregate in the moist trenches and pits as if they were the regular part of the shoreline at the water's edge. Three pits averaged 147 insects at 1130 hrs. on 15 June 1964 and contained up to 6 deep in the center. Similar numbers lined comparable areas of the trenches.

About one-fourth of the midges remained airborne each warm night but there was a continual exchange of places between those on the ground and those in the air. Their buzzing sound was heard all night but reached maximum loudness around 2130 hrs. On the heavy-flight nights the sound could be heard 40-45 feet back from the shore. Johnson and Munger (1930) and Burrill (1913) reported a buzzing (humming) sound for *C. plumosus* and noted it decreased after midnight.

NOTES ON ADULT PREDATION

Crayfish (*Cambarus* spp.) were the commonest predators of this midge along the shoreline. Midges on the water were grasped and pulled under. Occasionally a crayfish would crawl half way out of the water, grab a midge, and retreat again. One evening there were 102 crayfish along the 120 ft. long beach at 2215 hrs., and 165 or more than 1 per foot of shoreline at 2300 hrs.

In addition, frogs (*Rana* sp.) and toads (*Bufo* sp.) fed on the midges nightly between 2200 and 2400 hrs. Small fish occasionally broke the surface and consumed the midges. At least one species of ground beetle (Carabidae) also fed upon the midges at night.

During the day, robber flies (Asilidae), ground beetles (Carabidae), ants (Formicidae), and a few other species of insects fed on the dead and dying insects littering the beach. Midges were common in spider webs, especially in those spun near lights.

DISCUSSION

Adults of *Chironomus* sp. exhibit diel periodicity behavior (regular day to day recurrence of activities) which is extrinsic (dependent on external environmental stimuli; Odum, 1953). Apparently initial flight activities are set off by a drop in light intensity following sunset. Then the midges are attracted to the moist sand of the beach. High populations of midges on the small beach used in this study resulted in highly allelomimetic (contagious) behavior in a narrow band along the water's edge. In the morning with the increase of light intensity the adults reverse the response by first vacating the beach, then shelter seeking, and finally inactivity. This cycle is repeated daily during the adult flight period, but the evening phase of the cycle is curtailed or eliminated during cool, windy, and/or rainy weather.

The midges' morning and evening reactions to sunlight probably is a simple negative photokinesis whereby activity ceases above a light intensity threshold and begins again below the same or different threshold. Their distribution pattern and activities on the sand at night appears to be a response to a moisture gradient. Syrjamaki (1960, 1963) reported that water content of chironomid adults is high at emergence but decreases with age. Studying *Allochironomus crassiforceps* Kieff., he found that fresh-trapped specimens showed dry reactions, while netted specimens which were older than 1 day showed moist reactions in an alternate-humidity chamber. He also found an inverse correlation between water content of the insect's body and the intensity of the humidity reaction. His studies on *Cricotopus silvestris* Fabr. revealed that males showed dry reactions at the beginning of the swarming period but gave increasingly stronger moist reactions as the swarming period progressed and the males aged.

Perhaps the adults (both sexes and intersexes too) of *Chironomus* sp. aggregate on the beach at night to stablize or decrease water loss. Most of the insects were older than 1 day and probably lost considerable amounts of moisture while resting in the woods during the day.

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AN EMERGENCE TRAP FOR AQUATIC INSECTS

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The identification of organisms is a prerequisite to developing water quality criteria for aquatic life. Identification is necessary because differences in water quality requirements are specific and may be different for closely allied species. The taxonomy of various species, particularly those associated with the aquatic environment, is much more detailed and better known for adults than for immature instars. To facilitate correlation of adult and larval forms, a trap was needed to collect the emerging adults from the various streams.

Traps and collecting devices reported in the literature usually lacked one of the following factors and in some cases were deficient in several of them. Corbet (1965) describes a trap which he used in a pond. He states that the trap was affected by wave action and therefore was not suitable. Mundie (1956) describes three types of traps used in sampling three types of collection sites. His stream trap is a small gauze-covered frame which would not withstand