THE WATER BEETLES OF MILLER BLUE HOLE, SANDUSKY COUNTY, OHIO (INSECTA: COLEOPTERA)[1, 2]

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ABSTRACT

Thirty-one species of aquatic beetles, representing the families Dytiscidae, Hydrophilidae, Haliplidae, and Gyrinidae, were collected in the Miller Blue Hole, a large spring, between October 21, 1967, and January 27, 1969. The numbers of each species collected are tabulated by monthly intervals. Some of the species present in this unusual habitat are rare; *Tropisternus columbianus* is apparently recorded from Ohio for the first time.

INTRODUCTION

The Ohio "blue holes" are the outlets of an extensive underground drainage system occurring in limestone bedrock. They may best be thought of as gigantic springs reaching the surface as deep, conical pools or ponds which are drained by streams flowing into Lake Erie. There are several "blue holes" located in Sandusky and Erie counties, the best known being the Castalia Blue Hole, which has been "developed" as a commercial tourist attraction, with the result that its original natural environment has been destroyed. Closely adjacent to this one is the biggest of the "blue holes," the large spring-fed lake in the center of the town of Castalia.

The Miller Blue Hole, six miles to the west of this town, is nearly two acres in size, and has been preserved by the state since 1932 in a relatively natural condition. It is located in a 13-acre wooded tract surrounded by agricultural lands.

Earlier works dealing with Miller Blue Hole have only briefly mentioned water beetles. Wolfe (1931) noted thick swarms of Gyrinidae ("as many as 40 to the square foot"), haliplids feeding on the *Spirogyra*, and hydrophilids always on the surface vegetation. He also found a specimen which he believed to be an amphizoid, though this is almost certainly an error as Amphizoidae have not been recorded east of the Rocky Mountains (Arnett, 1968). Hille (1955) found *Gyrinus*, *Hydroporus*, and *Hydrophilus triangularis*, and Brungs (1959), in a study of the stream which drains Miller Blue Hole, identified the following families: Dytiscidae (*Agabus* and *Laccophilus*), Elmidae (*Dubiraphia* and *Stenelmis*), Gyrinidae (*Gyrinus*), Haliplidae (*Haliplus* and *Peltodytes*), Hydrophilidae (*Berosus*, *Helocombus*, and *Tropisternus*) and an unidentified helodid.

The Miller Blue Hole is oval in shape, roughly 300 by 225 feet, and reaches a maximum depth of 62 feet (Wolfe, 1931; Hille, 1955). There is a narrow underwater shelf or bench, present chiefly along the southern portion of the shore, which ranges from five to 25 feet in width (fig. 1). From this shelf, there is an abrupt drop-off into deep water. It is in the dense growth of vegetation on this shelf that the water-beetle populations exist.

The water is mildly alkaline (pH 7.3) due to calcium carbonate dissolved from the limestone through which the water has passed before reaching the pool (Wolfe, 1931). Water flows rapidly at a rate of 800 to 1000 gallons per minute (Hille, 1955) from the spring at the bottom of the pool, and exits through a single outlet on the east side of the pool. This circulation maintains an annual water temperature of 8.5 to 13.5°C on the bottom and 8.5 to 17.5° at the surface (Wolfe, 1931),

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occasionally rising to 28° in August (Hille, 1955). Because of these temperatures, the Miller Blue Hole, and also the other "blue holes", unlike other small lakes and ponds in this area, remain ice-free throughout the winter.

Miller Blue Hole is highly oligotrophic. The organic material which reaches the water is rapidly drained out into the stream and does not settle to the bottom.

The vegetation has been discussed by Pinkava (1963). He divides the aquatic plants into the following ecological zones: (1) an innermost zone of open water, characterized at times by free-floating algae; (2) a zone of *Spirogyra*, *Chara*, and

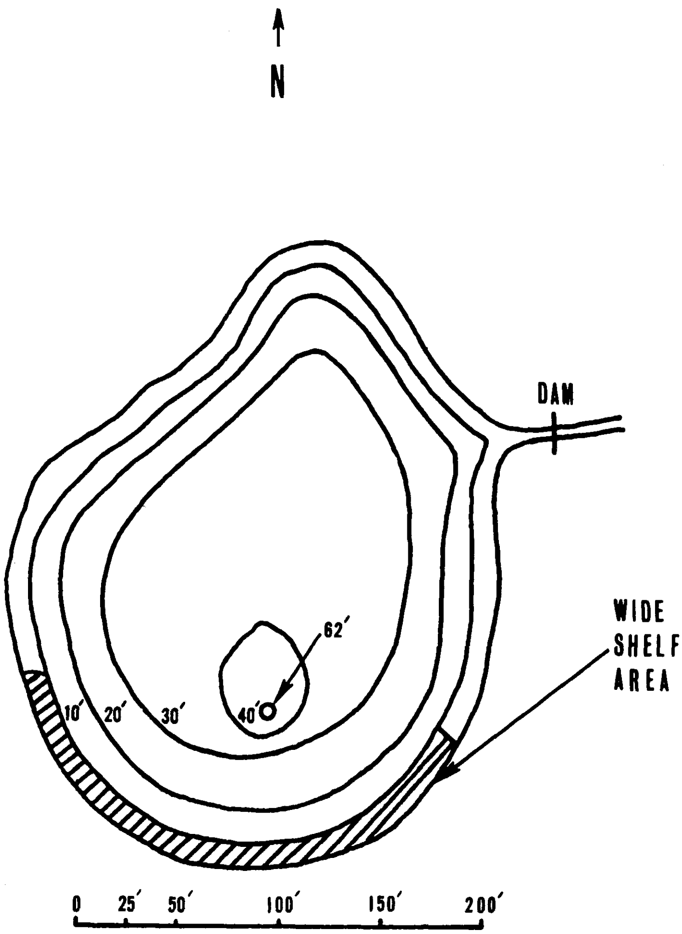

FIGURE 1. The Miller Blue Hole (modified from Wolfe, 1931).

other algae, mosses, and diatoms, which together form a thick mat covering the shelf area; (3) a shoreline zone made up of emergent sedges and grasses. Terrestrial vegetation is not dense, and the pool is largely exposed to sunlight.

The water entering the Miller Blue Hole is very low in dissolved oxygen; Hille (1955) concluded that the oxygen content was not sufficient for the support of higher forms (presumably fish). Only two species of fish are known from the pool, *Fundulus diaphanus menona* (Jordan and Copeland) and *Umbri limi* (Kirtland) (Hille, 1955). Both are small, and we found them largely restricted to the algal zone near the shore, where the oxygen content is relatively higher. Turtles and frogs are also present here.

A number of insects are present in and close to the Miller Blue Hole. This paper presents a survey of only the truly aquatic beetles, those in the families Dytiscidae, Haliplidae, Hydrophilidae, and Gyrinidae. "Semiaquatic" species belonging to other families (e.g. Carabidae, Curculionidae, Sphaeriidae, etc.) were present in mosses and vegetation along the shore, but are not truly aquatic and so were not considered in this investigation.

More than 450 specimens of water beetles, representing 31 species, were collected, mounted, and identified during this study. The ecology of several of these species is discussed in Balduf (1935), Leech and Chandler (1956), Balfour-Brown (1940), Pennak (1953), Hickman (1931), Wilson (1923), and Arnett (1968) and is not repeated here.

COLLECTING METHODS

A preliminary study indicated that the water beetles (with the exception of gyrinids which skim on the surface) were concentrated in the algal zone along the shelf indicated by cross-hatching in Figure 1. The center of the pool, sampled by boat, yielded no water beetles; collecting was therefore restricted to this shelf area. The rest of the blue hole appeared to be largely uninhabitable to aquatic insects (and most other organisms) because of the lack of oxygen, the absence of food and shelter, and the effects of the strong current of water. The shelf area is shallow, supports abundant submerged vegetation, which produces oxygen, and is protected from the current which flows from the spring into the outlet stream.

Beetles were collected by (1) sweeping with a dip net, and (2) throwing handfuls of vegetation onto a plastic sheet on the bank and capturing the beetles as they exposed themselves. No known method of sampling from such a habitat is truly quantitative. In order to keep the samples as similar as possible, each sample was collected during a one-hour period and by the same person (BEM), who covered the shelf area, using the same techniques in the same proportion, to the best of his ability. All samples were taken between 10:00 a.m. and 4:00 p.m. Collecting began October 21, 1967, and was continued, generally at monthly intervals, until January 27, 1969. Collections could not be made during June, July, and August of 1968.

Specimens collected in this study are deposited in the authors' collections and in the United States National Museum, Washington, D.C.

DISCUSSION

The results of the collections are given in Table 1 and are self explanatory for the most part. Thirty-one species of water beetles are listed here, together with the numbers collected on each date.

Aquatic Coleoptera play an important part in the blue hole community. This is especially true because of the fact that it is an oligotrophic habitat with a limited number of species. The Haliplidae, most numerous in number of individuals, feed on algae and on other vegetation, both as larvae and adults; adult Hydrophilidae feed mainly on living and dead plant material and occasionally on dead animal matter, while their larvae are generally carnivorous; Dytiscidae and Gyrinidae are active predators as both larvae and adults (Balduf, 1935; Leech and Chandler, 1956; Balfour-Browne, 1940).

Between the January 7 and the February 29 collections, a dam was built on the outlet stream by the Ohio Department of Natural Resources in order to test its flow for its possible development as the site of a trout hatchery. This caused the water level in Miller Blue Hole to rise 18 inches above the previous level. It is interesting to note that, following this, no beetles at all could be found in March and April, 1968 (Table 1), when at least some should have been present.

TABLE 1

Aquatic beetles of the Miller Blue Hole.
Vertical line identifies time of dam construction on outlet stream.

Species	Oct. 21–22	Nov. 12	Jan. 7	Feb. 29	Mar. 31	Apr. 28	May 30	Sept. 17	Nov. 1	Jan. 27
DYTISCIDAE										
Laccophilini										
Laccophilus maculosus (Germ.)	2	1	0	0	0	0	0	1	3	0
Hydroporini										
Hygrotus sayi Balfour-Browne	13	8	2	1	0	0	0	0	7	0
Hygrotus nubilis (LeC.)	6	0	5	0	0	0	0	11	3	0
Hydroporus niger Say	22	0	0	0	0	0	0	0	1	0
Hydroporus undulatus Say	1	0	0	0	0	0	0	0	5	0
Hydroporus dentellus Fall	1	0	0	0	0	0	0	0	0	0
Hydroporus dichrous Melsh.	6	0	0	0	0	0	0	0	0	0
Hydroporus striola (Gyll.)	1	0	0	0	0	0	0	0	0	0
Hydroporus signatus youngi Gordon	1	0	0	0	0	0	0	0	0	0
Agabini										
Agabus stagninus Say	0	4	0	0	0	0	0	0	1	0
Agabus disintegratus (Cr.)	5	5	1	0	0	0	0	0	4	0
Matini										
Matus ovatus ovatus Leech	1	0	0	0	0	0	0	0	0	0
Coptotomini										
Coptotomus interrogatus (Fab.)	0	1	0	0	0	0	0	0	4	0
Thermonectini										
Acilius semisulcatus Aubé	7	4	0	0	0	0	0	0	5	0
GYRINIDAE										
Enhydrinae										
Dineutus assimilis Kirby	0	0	0	0	5	0	0	0	0	0
Gyrininae										
Gyrinus minutus Fab.	1	0	0	0	0	0	0	0	0	0
Gyrinus maculiventris LeC.	6	0	0	0	0	0	0	0	0	0
HALIPLIDAE										
Haliplus triopsis Say	7	0	1	0	0	0	0	4	1	0
Haliplus immaculicollis Harr.	7	1	0	0	0	0	0	5	1	0
Peltodytes muticus (LeC.)	6	0	1	0	0	0	0	2	5	0
Peltodytes pedunculatus Blatch.	2	0	0	0	0	0	0	0	0	0
Peltodytes sexmaculatus Robts.	1	0	0	0	0	0	0	0	0	0
Peltodytes duodecimpunctatus (Say)	11	1	0	0	2	0	0	10	26	0
Peltodytes edentulus (LeC.)	16	2	2	3	10	0	0	40	84	0
HYDROPHILIDAE										
Helophorinae										
Helophorus sp.	0	0	0	0	0	0	0	0	1	0
Hydrophilinae										
Tropisternus mixtus LeC.	1	3	0	0	0	0	0	0	0	0
Tropisternus lateralis nimbatus (Say)	4	0	0	0	0	0	0	1	3	0
Tropisternus natator D'Orchymont	4	4	0	0	0	0	0	0	0	0
Tropisternus columbianus Brown	5	13	0	0	0	0	0	0	0	0
Hydrobiinae										
Enochrus nebulosus (Say)	0	1	0	0	0	0	0	0	0	0
Enochrus new species?	0	0	1	0	0	0	0	2	2	0

In the September collection, only nine out of 25 species collected in the previous October were present. By November, 17 species were present, representing a total of 156 individuals. We suggest that it was the disturbance of the habitat caused by the damming of the blue hole that produced the adverse effect upon the water-beetle populations, but that in time much re-establishment of many of the species had occurred. Unfortunately, the populations of rare environmentally sensitive, semi-aquatic *Sphaerius* (Sphaeriidae) which had previously existed in the wet shoreline mosses were apparently completely destroyed, along with their habitat.

Some very rare species were discovered during this study. *Tropisternus columbianus* seems to occur in unusual habitats such as Miller Blue Hole, rather than in normal ponds or lakes, and at present is not known from any other locality in Ohio (P. J. Spangler, personal communication, 1968); no individuals of this species were found in the blue hole after construction of the dam, and it is possible that the erection of this structure caused its final extinction in the state. Also collected was *Tropisternus lateralis nimbatus*, which is known to be a "pioneer" species in community succession and may be a sensitive indicator of polluted conditions (Wooldridge and Wooldridge, 1967). The disturbance caused by the dam construction may have restricted this species, but individuals were subsequently again collected, indicating that the disturbance had not caused its extinction in the blue hole.

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