THE EFFECT OF RESERVOIR FLUCTUATIONS ON POPULATIONS OF *CORBICULA MANILENSIS* (PELECYPODA: CORBICULIDAE)

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Since the early 1970's, the Asiatic clam, *Corbicula manilensis*, has become well established in Lake Texoma. Naturally occurring fluctuations of water levels in 1975 and early 1976, however, greatly reduced population densities by the following fall. Laboratory experiments showed that most clams cannot survive out of water for more than a few days even in wet sand. This nuisance organism, therefore, may be controlled by drawdowns of reservoirs at certain times of the year.

INTRODUCTION

When exotic species are released, serious problems may be created not only for the naturally occurring communities but also for man. An outstanding example is *Corbicula manilensis* (Philippi), the Asiatic clam, which is becoming one of the most troublesome introductions into North America (1). Brought to Washington State about 1938, the clam since has dispersed to nearly every major drainage within the United States (2, 3). *Corbicula* occurs in all types of lakes, ponds, streams, and rivers but is most abundant where there is a sand to gravel bottom (2). Few parasites or predators are known; thus, there appear to be no natural checks on a population once it is established.

A planktotrophic, nonswimming larva or veliger is produced which is capable of being carried long distances by water currents where it becomes demersal. Young clams secrete mucilaginous threads as holdfasts which enable them to attach to nearly any surface despite strong currents. Sexual maturity is attained within a period of months (McMahon, University of Texas at Arlington, per. comm.) to years. More complete life histories may be found in Sinclair and Isom (2), Sinclair (3), Heinsohn (4), and Bickel (5).

Perhaps because of its secure method of attachment and great reproductive rate, *Corbicula* is becoming an expensive nuisance in many water installations. Larvae may enter and attach to raw water intakes where there is sufficient flow to provide oxygen (2, 6). They have clogged irrigation canals, ditches, pumps, cooling systems, and even impeded water flow in some reservoirs (1, 2, 3, 5, 6, 7). Within an industrial or public water system, *Corbicula* may be controlled by applications of heat, chlorine, or various molluscicides (8, 9). None of the control methods, however, are readily applicable to natural systems.

Since the early 1970's, *Corbicula* has been present in Lake Texoma and other Texas and Oklahoma waters (10, 11). Reservoirs, such as Lake Texoma, have both natural and man-made water-level fluctuations; therefore, it is important to know what effect changes in waterlevels have on populations of *Corbicula.* In 1975-1976 a survey was conducted to determine the extent of *Corbicula* populations within the lake. Observations were made on habitats and densities and the effect of fluctuations of water level on density. These data were supplemented by laboratory experiments to determine survival under dewatered conditions.

MATERIALS AND METHODS

In 1975-1976 the distribution of *Corbicula* in Lake Texoma was mapped as part of a pelecypod survey (12). One large concentration of clams was found in a cove adjacent to the University of Oklahoma Biological Station (Fig. 1). Most field and laboratory observations were made on specimens from this cove. Populations were sampled using a 0.3 × 0.3 m clam rake with a mesh opening of 1.5 mm. Densities were estimated in October 1975 by removing all clams from five random transects 0.3 m wide and 10 m long taken perpendicular to the shoreline. By locating their shallow depressions in the sand, additional live specimens were collected near the water's edge. Shell lengths were measured with dial calipers to the nearest millimeter along the posterior-anterior axis.

Longevity of *Corbicula* under various conditions of desiccation was determined from populations maintained in 150-liter aquaria equipped with air, lake water, and 4-5 cm of sand. All clams were collected in October 1975 and held a minimum of 96 hr prior to experimentation. Specimens were sorted into the following groups by size in mm: 2-3, 4-5, 6-7, 8-9, 10-12, 13-15, 16-20, 21-25, and 26 or greater. Thirty of each group were placed in each of four bowls, 6 cm deep with a diameter of 15 cm. One group of 30 of each size was left dry; one was covered with 4 cm of dry sand (approximately the average depth of the sand along the beach near the Biological Station); one group was covered with 4 cm of wet sand (saturated only to the point that no water remained standing on top with some additional moisture being added daily); and one group was used as a control with 4 cm sand covered by at least 1 cm water. Dead clams were counted and removed daily. During the experiment, room

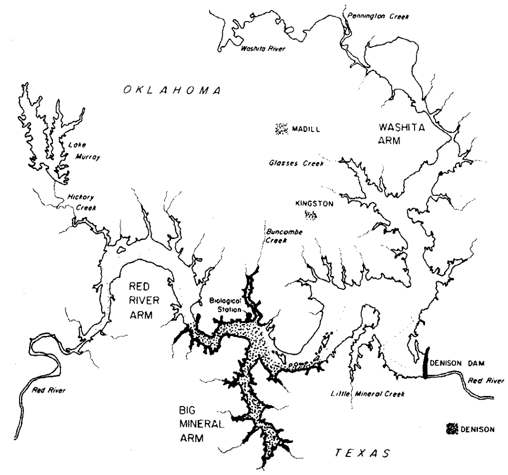

FIGURE 1. Lake Texoma, Texas and Oklahoma. Shaded area represents known distribution of *Corbicula manilensis* within the lake.

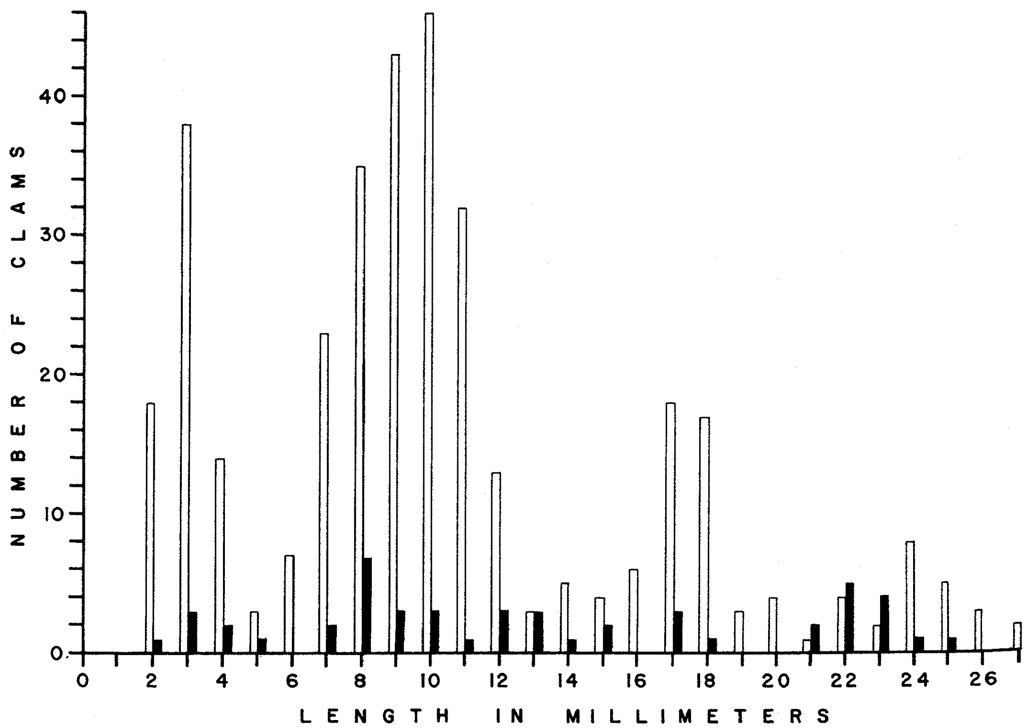

FIGURE 2. Population structure of *Corbicula manilensis* in Lake Texoma near the University of Oklahoma Biological Station. White bars represent average number of clams/m^2 in each millimeter class for five transects, October 1975. Black bars represent all clams collected from August through October 1976.

temperatures ranged from 20-24 C and relative humidity varied from 65-75%. The experiment was repeated with a second group of 1080 clams.

RESULTS AND DISCUSSION

Surveys of the molluscan fauna of Lake Texoma and surrounding areas (13, 14, 15) suggest that *Corbicula* was absent as recently as July 1971. Our first observation of *Corbicula* was in September 1974 (10). Since an established population was present in 1974, we can speculate that some clams were in the lake by 1972 or 1973. This would correspond to other first records from Oklahoma and Texas (10, 11).

Corbicula has a rather limited distribution in Lake Texoma (Figure 1). The habitat is almost exclusively rocky-sandy shorelines exposed to some wave action. It is surprising that *Corbicula* has not become more widely distributed, particularly in the Washita Arm and around Denison Dam, since seemingly suitable habitats exist in those areas of the lake.

An average density of 361 clams/m^2 (range 119-642/m^2) was present in the transects in the cove west of the Biological Station. These densities are low compared with many reports listing several thousand/ m^2 (1, 7). Clams were most numerous near the shoreline in 2-30 cm of water and decreased in abundance in deeper waters or where sand was replaced by mud or silt. No specimens were found in water deeper than 1.5 m. Although these findings are somewhat typical (2, 5), the habitat in Lake Texoma seems more restricted than elsewhere.

Four distinct size classes of clams were present in October 1975 (Figure 2); however, it is uncertain whether four distinct year classes or cohorts within a single year are presented (McMahon, University of Texas at Arlington, per. comm.). Unfortunately, lake fluctuations were so great in 1975 and 1976 that we were unable to follow growth patterns for any extended period of time.

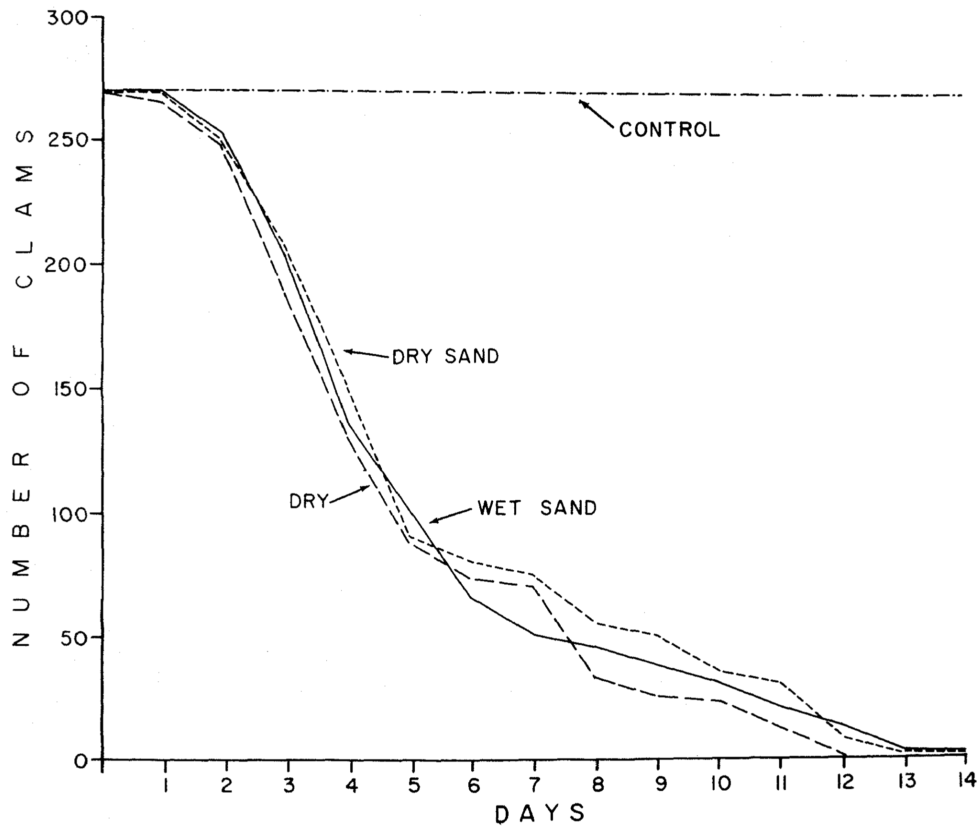

FIGURE 3. Longevity of *Corbicula manilensis* under experimental conditions.

From 1 August 1975 to 29 February 1976, a drop in the water level of Lake Texoma from 188.8 m to 186.6 m above M.S.L. stranded so many *Corbicula* on the beach that their empty shells formed wind and wave rows. By 7 May 1976 a rise of water to 188.2 m above M.S.L. had covered most of the exposed beaches. Beginning 25 July 1976, the water fell again and exposed the beaches where *Corbicula* had been most abundant the previous year. From mid-August through October 1976, we collected all clams along 200 m of the beach. Forty-nine living specimens were found, slightly more than 13% of the average which would have been expected in a square meter the previous season. Measurements of these clams also are shown in Figure 2.

Although Matteson (16) had reported that some unionids were able to withstand several weeks of desiccation without serious harm, our laboratory tests indicated that *Corbicula* were fragile in this regard. Surprisingly, there were neither differences in mortality rates of those left dry or placed in dry and wet sand (Figure 3) nor differences by size. Fifty percent of all clams died by the 4th day, 75% by the 6th day, 80% by the 8th day, 90% by the 10th day, and 98% by the 12th day. Three *Corbicula* survived to the end of 14 days (4, 14, and 25 mm long), two of which were in wet sand and one in dry sand. These clams were placed in a 150-liter aquarium where they have lived for nearly a year. After 14 days, only six of the 270 control specimens had died.

Mortality rates for the second group of 1080 clams (not figured) were virtually the same; i.e., 50% mortality by 4 days, 75% by 6 days, 90% by 8 days, 98% by 10 days, and 100% on the 11th day. Twelve or 8% of the 270 controls also had died by the llth day.

CONCLUSIONS

Although, at present, some problems associated with *Corbicula* exist on Lake Texoma, the number of public and industrial demands for water are limited. On several occasions clams have prevented valves from closing at the University of Oklahoma Biological Station filtration plant. To date *Corbicula* has not affected the hydroelectric plant at Denison Dam.

Controlled lake drawdowns could be used to check or reduce *Corbicula* populations in reservoirs such as Lake Texoma. To be most effective, drawdowns should be to a level greater than maximum depth distribution and should occur for a minimum of 14 days in late fall or winter when larvae or veligers are not present.

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