Zooplankton Population Periodicity in a Tropical Pond

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Introduction

The larvae of several tilapia species (e.g., *Sarotherodon galilaeus* and *Oreochromis niloticus*) feed on zooplankton (Drenner et al. 1982; Fernando 1983). Noakes and Balon (1982) hypothesized that environmental influences during early life history (larval period or earlier) might account for some of the observed variability in age at onset of sexual maturation in the tilapias. Recognizing that many other environmental variables play a role in regulating sexual maturation and reproduction (Brummett 1995), researchers at the National Aquaculture Center in Domasi, Malaŵi, hypothesized that the relative abundance of zooplankton in a tilapia's early life history might be part of the maturation trigger mechanism suspected by Noakes and Balon.

The production of sufficient zooplankton to test this hypothesis has proved difficult. Fishpond flora and fauna fluctuate widely (Boyd 1990; Fernando 1994). We fertilized several ponds with organic matter and produced sufficient zooplankton for a few weeks but it became increasingly obvious that, even with continual feeding and harvesting, the pond ecosystems did not seem to be reaching any sort of equilibrium.

This small study was conducted primarily to follow the periodicity of zooplankton populations in small ponds, in order to facilitate the design of a pond-based zooplankton production system.

Materials and Methods

On 8 March 1995, a 165-m² earthen pond was limed at a rate of 2 500 kg/ha with $CaCO_3$ and filled to a depth of 60 cm. On 22 March, 10 000 kg/ha of mixed dried grasses (0.4 g N/kg dm, 0.03 g P/kg dm; 76.5% organic matter, 46.5% dry matter) was chopped into 3-cm fragments and broadcast over the pond surface. An additional 5 000 kg/ha of chopped dried grass was added every three weeks for the duration of the study. Total alkalinity of incoming water was 18.5 mg/l as $CaCO_3$.

Water temperature and dissolved oxygen were measured daily at 0500 with a YSI Model 57 polarographic oxygen meter. pH was measured daily at 0500 with a Hach One portable pH meter. Electrical conductivity was measured weekly with a YSI Model 33 S-C-T meter. Total alkalinity of pond water was measured monthly according to standard methods (APHA 1989).

Zooplankton were sampled every three days, on average, sometimes at longer intervals during periods of very low abundance and at shorter intervals when the system seemed to be changing from one trophic state to another. A team of two collected 100 l of water from the middle of the water column at 10 sampling sites. Samples were collected from the relatively clear water ahead of where the sampling team was walking through the pond. A 10-l pail was placed top-down on the water surface, lowered to the middle of the water column and inverted. Each sample was then poured through a 0.16-mm mesh nylon plankton net. After sampling, the net was rinsed with tap water, concentrating the collected organisms into a 90-ml graduated plastic centrifuge tube. The tube was stirred vigorously to distribute suspended organisms evenly and three independent samples were collected by dropping in a straight-sided 10-ml bottle. The 10-ml bottle was then agitated and three random samples were collected with a 1.0-ml eye-dropper. Zooplankton were killed with 0.1 ml of formalin and counted in a Sedgwick-Rafter chamber at 40x magnification.

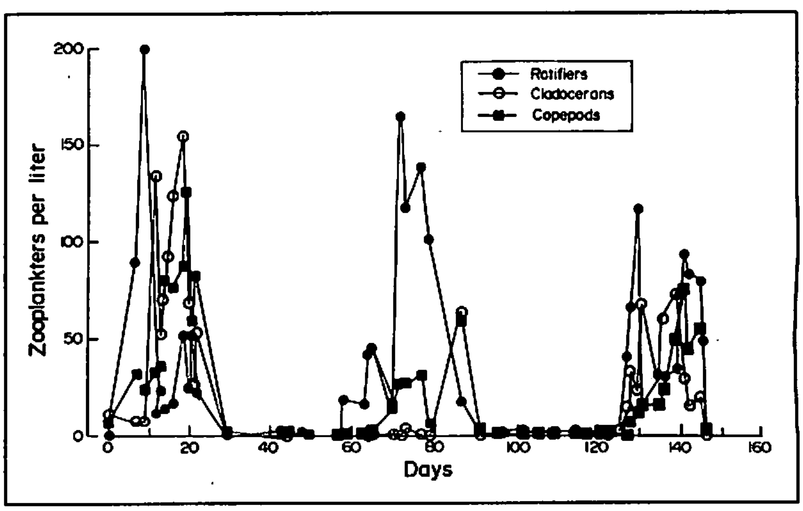

Fig. 1. Cyclical fluctuations of rotifer, cladoceran and copepod populations over 146 days in a 165-m² earthen pond fed with chopped dried grass at 21-day intervals.

Results

Counts for rotifers, cladocerans and copepods are shown in Fig. 1. Since the intention of the study was to produce zooplankton to feed to larval tilapia, these groups were considered the most important on account of their size and abundance. Rotifers were classified as either solitary or colonial. Cladocerans and copepods were grouped according to size (less than or greater than 1.2 mm).

Populations of these groups fluctuated with approximately 30-day cycles. Rotifers tended to peak earlier than other forms, followed by cladocerans and then copepods. Initially (days 0-14), solitary rotifers and nauplii predominated. Colonial rotifers were common only during the first population peak (days 9-30). During the second peak (days 60-90), cladoceran populations were elevated for only a very short period, with by far the largest part of this peak being composed of solitary rotifers. The third peak (days 125-145) was composed of all forms, except colonial rotifers.

The average zooplankton densities (no./l) were 429.0 during the first peak (days 9-30), 198.5 during the second peak (days 60-90), and 249.4 during the third peak (days 125-145). Between peaks, zooplankton numbers averaged 6.1/l and 8.6/l, respectively, for the first (days 30-60) and the second (days 90-125) periods.

Water quality remained within acceptable limits for zooplankton growth and reproduction (Ovie and Adeniji 1994). Dissolved oxygen measured at 0500 averaged 2.7 mg/l (range 1.1-4.0). pH at 0500 averaged 6.6 (range 6.5-7.1). Electrical conductivity averaged 45.8 µmho/cm (range 24.9-97.0). Total alkalinity averaged 63.2 mg/l as $CaCO_3$ (range 59.8-65.8). Water temperature (measured at 0500) declined over the course of the study from an average of 24.0°C during the first peak to 18.6°C during the second peak and 18.7°C during the third peak. No relationship between grass application time and water quality or zooplankton bloom was indicated. Grass applications, being on an independently determined schedule, occured at all phases of the zooplankton population cycles.

Besides those mentioned above, other groups of organisms noted in samples were ostracods, nematodes, insect larvae, tadpoles of the genus *Xenopus*, various aquatic bugs and large phytoplankton of the genera *Volvox* and *Closterium*. Populations of these groups tended to be always at very low densities with no discernible pattern of rise and decline.

Discussion

The results of this single pond trial must be regarded as very preliminary and interpreted cautiously. A thorough study of the dynamics of zooplankton in tropical ponds would include an analysis of population structure at the species level, and a much more detailed study of phytoplankton and conservative water quality parameters (Downing and Rigler 1984). Our aim was simply to determine how ponds treated with the low-quality inputs might fulfill a need for zooplankton of a certain size. Therefore more extensive measurements, typical of rigorous ecological studies, were not taken.

The magnitude of the zooplankton boom and bust cycles that we observed are interesting in light of the large variability between ponds commonly observed in aquaculture experiments. Were the 30-day cycles that we observed a fixed characteristic of all pond zooplankton populations? Would the zooplankton populations in other ponds in an experimental design each fluctuate with a specific rhythm? If so, unless this is known, the actual amount of natural food present at any particular time across an entire experimental treatment will be more or less unpredictable. If individual ponds follow different cycles, then the natural food profile of these ponds must also vary widely within and among ponds.

Insufficient data were collected to determine which environmental variables might regulate the fluctuations of zooplankton in the absence of fish predation. However, it seems likely that some external regulator is involved because all three groups of zooplankton fluctuated with approximately the same frequency. That frequency did not correspond to the reproductive cycles of any of the species encountered: 7-21 days for rotifers, 60-80 days for copepods and cladocerans (Moss 1988). It also appeared to be unrelated to lunar cycles, full moons occuring on days 2, 30, 58, 114 and 142. Temperature may have influenced the somewhat lower population in peaks two and three, and the slightly longer interval between them, although lack of replication makes conclusions risky.

Researchers wishing to sample zooplankton populations in aquaculture ponds should take the cyclic behavior of these populations into consideration. Trophic cascade theory predicts that the observed fluctuations in zooplankton will both affect and be affected by fluctuations in the phytoplankton (Carpenter et al. 1985) although, also according to trophic cascade theory, it is quite possible that the presence of fish will directly and/or indirectly alter the manner in which zooplankton populations fluctuate (Cerný and Bytel 1991; Machácek 1991) and may override or obscure these fluctuations completely.

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