Zooplankton Abundances in Vegetated and Non-vegetated Areas: Implications for Fisheries Management

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Abstract: A 5-month series of biweekly metazoan zooplankton samples from vegetated and unvegetated littoral areas and their respective adjacent limnetic areas was collected from Lake Fayetteville, Arkansas. No significant differences ($P \leq 0.05$) in densities of Rotatoria and Cladocera were detected among any of the sample areas. However, densities of Copepoda in the vegetated littoral area were significantly less than those associated with the unvegetated littoral area. Predation by littoral-dwelling planktivorous fishes on copepods is suggested. This study further suggests that the trophic foundation of the fishery provided by euplanktonic zooplankton is not functionally inhibited by the presence of macrophytes in this system.

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Littoral areas of southern impoundments are utilized by early life history stages of many fishes. Because zooplankters are initial prey for most fish species (Siefert 1972, O'Brien et al. 1984, Keast and Eadie 1985, Noble 1986) and because growth potential and subsequent recruitment are related to the availability of appropriate forage (Shelton et al. 1979, Timmons et al. 1980, Keast and Eadie 1985), the abundance of zooplankton in littoral areas can be an important consideration for fisheries managers.

It has been suggested that zooplankton abundances associated with littoral areas may be less than those associated with adjacent limnetic zones because of horizontal migration patterns (Wetzel 1975). Also, aquatic vegetation commonly found in littoral zones has been reported to exert a negative influence on zooplankton abundance (Hasler and Jones 1949; Pennak 1966, 1973). More recently, how-

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ever, Wiley et al. (1984) found no evidence to suggest that pelagic invertebrate production was negatively correlated with macrophyte concentrations. Campbell et al. (1983) reported zooplankton densities in weed beds to average at least 1 order of magnitude greater than densities measured at corresponding limnetic stations.

Each year fisheries managers expend considerable time, effort and money enhancing plankton production and controlling aquatic vegetation in southern impoundments. Recognizing these investments, as well as noting inconsistencies in the literature, we sought to obtain data on relative abundances of zooplankton in littoral and adjacent limnetic areas of a northwest Arkansas impoundment. Further, we wanted to determine if significant differences existed with respect to abundances of euplanktonic zooplankton in littoral areas with or without emergent aquatic macrophytes.

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Methods

A 5-month series of biweekly metazoan zooplankton samples from vegetated and unvegetated littoral areas and their respective adjacent limnetic zones was collected from Lake Fayetteville, a 420-ha impoundment in northwest Arkansas. The mean depth of the impoundment was approximately 4.3 m; the maximum depth was 10.0 m. In the vegetated littoral sample area, *Nelumbo* spp. almost completely covered the water surface. Emergent aquatic macrophytes were absent from the unvegetated littoral area during the entire sampling period.

All zooplankton samples were taken within 1 hour of solar noon from water <2.0 m deep using procedures modified after Pennak (1962). A wire-spiral-reinforced rubber tube with 80-μm nitex cloth secured over 1 open end with tape was used to collect 2 separate and complete top-to-bottom zooplankton samples from each location. Zooplankters were preserved in the field with 70% ethanol, returned to the laboratory, and concentrated to 10.0 ml. Two 1.0 ml subsamples were enumerated from each 10.0 ml concentrate using a Sedgewick-Rafter counting chamber. Cladocera and rotifera were identified to species using Brooks (1959) and Edmondson (1959). Copepoda were identified to the suborder level or as nauplii or copepodids (Pennak 1953). Counts were converted to organisms per liter.

Organisms were grouped by higher taxa (Cladocera, Copepoda, Rotatoria) for comparative purposes. Paired t-tests ($P \leq 0.05$) were used to test for significant differences between sampling locations using months as replications. This procedure allows the detection of differences which may be masked by temporal variation in zooplankton densities.

Results

The sampling tube was highly selective for euplanktonic organisms because it rarely touched stems or bottom substrates associated with littoral and limnetic areas of Lake Fayetteville (Table 1). Collection of facultative zooplankters was minimal.

No significant differences were detected between the vegetated littoral area and its adjacent limnetic zone with respect to densities of Cladocera, Copepoda and Rotatoria (Table 2). Likewise, no significant differences in densities for the three groups were evident between the unvegetated littoral area and its adjacent limnetic zone. Looking collectively across all areas, no significant differences in rotifer densities were detected. Within the microcrustacea functional group, cladocerans did not deviate from this pattern. However, densities of copepods in the vegetated littoral area were significantly less than those associated with the unvegetated littoral area.

Discussion

The carrying capacity and productivity of the fisheries in most southern impoundments depend upon the trophic foundation of plankton (Dillon et al. 1971, Crance 1972, Boyd 1982). Additionally, Noble (1986) states that with regard to the fisheries of these impoundments, the littoral areas are known to be ". . . where the action is."

Table 1. Zooplankton collected from littoral and adjacent limnetic areas of Lake Fayetteville, Arkansas.

Rotatoria	Cladocera	Copepoda
Brachionus angularis	*Diaphanosoma leuchtenbergianum*[c]	Calanoida
B. calyciflorus[a,b,c]	*Ceriodaphnia lacustris*	Cyclopoida
B. havanaensis	*Daphnia galeata*	Copepodid
Euchlanis dilatata	*Bosmina longirostris*	Nauplii
Kellicottia bostonienisis	*Chydorus sphaericus*	
Keratella cochlearis		
Platyias patulus		
Lecane luna		
Monostyla quadridentata		
Trichocerca longiseta		
T. similis		
Ascomorpha saltans		
Asplanchna priodonta		
Polyarthra euryptera		
P. vulgaris		
Synchaeta pectinata[d]		
Filinia terminalis		
Conochiloides coenobasis		
Conochilus unicornis[a]		

[a]Not collected from the vegetated littoral area.
[b]Not collected from the limnetic area adjacent to vegetated littoral area.
[c]Not collected from the unvegetated littoral area.
[d]Not collected from the limnetic area adjacent to the unvegetated littoral area.

Table 2. Mean littoral and limnetic zooplankton densities (organisms/liter) of Lake Fayetteville, Arkansas.

Month	(*N*)	Cladocera		Copepoda		Rotatoria	
		Littoral	Limnetic	Littoral	Limnetic	Littoral	Limnetic
Vegetated Area							
Jun	(6)	104.50	96.17	28.83	87.17	661.17	231.17
Jul	(4)	8.00	1.50	5.75	2.50	38.00	145.00
Aug	(4)	3.50	1.50	10.50	42.25	222.25	415.00
Sep	(4)	15.25	52.00	23.75	84.25	174.00	137.00
Oct	(4)	18.50	25.00	19.25	18.50	56.00	56.25
Unvegetated Area							
Jun	(6)	135.33	615.00	72.17	135.67	1650.83	651.17
Jul	(4)	3.00	3.00	13.50	12.25	135.25	191.75
Aug	(4)	3.00	0	30.75	13.25	433.50	207.75
Sep	(4)	8.25	27.25	50.00	64.00	332.25	228.25
Oct	(4)	15.75	43.00	36.75	65.75	104.50	118.75

Among the metazoan zooplankton groups in littoral and adjacent limnetic areas of Lake Fayetteville (Copepoda, Cladocera, Rotatoria) only copepods exhibited significant differences in densities among sample areas. Copepods are generally more agile than cladocerans and through avoidance behavior are better able to escape predation by planktivorous fishes (O'Brien 1979). However, when cladoceran densities are low, planktivores tend to concentrate their attack on prey organisms like copepods which, in a relative sense, may appear to be more abundant to these fishes (Kohler and Ney 1982).

Cladocera densities in most systems tend to decline during the summer (Pennak 1953, Wetzel 1975). Threlkeld (1986) found resource-mediated changes in demographic parameters associated with summer cladocera population declines and community composition shifts in Lake Texoma. He found cladocera to exhibit reduced growth rates, size-related delays in reproduction, and lowered population growth rates during the summer compared to other seasons. Production potentials for cladocerans would therefore be low and in conjunction with low densities, as were noted in Lake Fayetteville, would be unlikely to support the assemblages of planktivorous fishes inhabiting littoral areas during the summer.

Copepods, however, may be able to maintain their production potentials during spring and summer (Pennak 1953), thereby providing appropriately sized forage items to planktivorous fishes. Greater planktivory in the vegetated area may be responsible for reduced densities of copepods in the vegetated littoral area of Lake Fayetteville relative to those of the unvegetated littoral area. Planktivory may in fact stimulate copepod productivity. This could compensate for low densities observed in the vegetated littoral area. The continuous presence of early life history stages of copepods during this study suggests such production.

According to Pace and Orcutt (1981), densities of rotifers may, in part, be related to food resource availability. In Lake Fayetteville we suspect this to be the case because rotifer densities increased with declines in microcrustacea densities. The generally small size of rotifers may preclude to some extent energetically efficient foraging by early life history stages of fishes. However, these zooplankters are considered an acceptable starting diet for some species (Snow et al. 1980). This could be especially important to bluegills (*Lepomis macrochirus*) which spawn continuously in southern impoundments when surface waters exceed 26° C (Davies et al. 1982).

Ryder (1982) and Hoyer et al. (1985) stress that fish yields and standing crops, respectively, are a function of overall lake trophic status. In this regard, individual characteristics of an impoundment and its associated fishery should be addressed prior to any generalized management orientation regarding aquatic vegetation control. In systems where alternative nutrient inputs are not or cannot be incorporated into management strategy, aquatic macrophytes may play a vital role in bringing nutrients trapped in bottom sediments back up into the aquatic environment (Boyd 1979). The detritus generated in conjunction with stands of aquatic macrophytes in these instances may boost localized production of invertebrates. Campbell et al. (1983) and Wiley et al. (1984) found evidence to suggest that zooplankton numbers and biomass, respectively, may have been augmented by the presence of aquatic vegetation. In more productive systems, large zooplankton are reported to be able to withstand high predation pressure by planktivorous fish (Gannon 1972).

The extent to which such vegetated littoral areas contribute to recruitment within the Lake Fayetteville fishery is unknown. We suspect, however, that it is substantial. Lake Fayetteville receives very little runoff from the surrounding watershed, is dependent on groundwater sources, and does not receive supplementary fertilization. Meyer (1971) found normal summer phytoplankton biomass in Lake Fayetteville to be in the range of 10 to 30 mg/l. Secchi transparencies in this reservoir normally approach and can exceed 1.0 m during the summer (Jackson 1977). Such evidence suggests that Lake Fayetteville is a low to moderately productive system relative to phytoplankton. The relatively clear water reported by Jackson (1977) probably contributes to predatory success of visually oriented piscivores (Zaret 1979). Since early life history stages of fishes seeking "safe havens" (Swingle 1950) in vegetated littoral areas must have sufficient forage if they are to grow and recruit into the fishery, it was encouraging to find little evidence to indicate that the trophic foundation of the Lake Fayetteville fishery provided by zooplankton was functionally inhibited by the presence of aquatic macrophytes.

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