Grass Carp Movement in Two Morphologically Diverse Reservoirs

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ABSTRACT

Triploid grass carp movement was monitored for 54 weeks by means of radiotelemetry in two morphologically diverse reservoirs in which grass carp were previously stocked at relatively low rates. Grass carp swimming speed, as an index of activity was relatively high for 12 weeks after release and decreased thereafter. Average monthly grass carp speed was 179.3 m/h ± 113 SD between 0900 and 1500 hours. Water temperature in the range of 22.2 to 30.3 C and daylength (photoperiod) did not significantly affect average grass carp speed. All nine individuals tracked established a home range for at least three months during the first year after release. Relatively shallow and narrow segments of one reservoir were avoided by radio-tagged individuals and vegetation density in these areas showed typical seasonal fluctuations in contrast to vegetation density in areas grass carp preferred which steadily declined for the duration of the study. Integration of additional weed control strategies are sugested when grass carp are stocked at relatively low rates, especially in morphologically diverse impoundments or lakes having confining areas that grass carp may avoid.

Key words: Chara, home range, *Najas,* stocking rate, swimming speed, *Utricularia.*

INTRODUCTION

The utilization of grass carp (*Ctenopharyngodon idella* Val.) in the United States has increased markedly since the development of triploid grass carp in 1983. By 1987, 27 states allowed either triploid and or diploid grass carp for aquatic weed management (Allen and Wattendorf 1987). Increased use has led resource managers to examine more closely the impact of grass carp on non-target macrophyte communities and recent studies have better defined the relationships of fish populations and submersed macrophytes (Durocher et al. 1984; Wiley et al. 1984; Colle et al. 1987). Greater emphasis is now put on maintaining an ecologically acceptable balance in multi-use resources between submersed macrophytes and other associated components such as the fishery, epiphytic macroinvertebrates and plankton.

Preliminary data from on-going long-term research at our laboratory, examining the effects of stocking triploid grass carp at relatively low densities, indicates that some submersed macrophytes can be conserved with this approach. However, from our experience, stocking small impoundments (<100 ha) with grass carp at relatively low rates (<25/ha) has not consistently provided a desirable level of weed control.

Reservoirs A and B, located in coastal, southwest Florida (26° N latitude) in the city of Cape Coral are represented by an artificially created network of finger canals and intermittent lakes of 1 to 4 ha at canal intersections (Figure 1). This diverse configuration provides an ideal study site for assessing the potential effects of confinement and water depth and other factors on grass carp movement and behavior. The objectives of this study was to demonstrate a relationship between grass carp movement (i.e. territoriality) and the physical dimensions of the reservoir and how it may relate to variations in submersed macrophyte density as affected by grass carp feeding.

METHODS AND MATERIALS

Radio transmitters were surgically implanted into nine grass carp ranging from 627 mm to 720 mm total length (2.8 to 3.8 kg), approximately the same size as grass carp previously stocked in each reservoir as determined by electrofishing collections. The transmitters were supplied by L. and L. Electronics (Mahomet, Illinois) and were the large external loop design: 8.5 cm long, 1.8 cm in diameter and weighed 20 grams (neutral buoyancy). Transmitter transmissions were at a relatively low frequency of 49 mHz.

Individual grass carp were heavily sedated (Stage III) and transmitters were inserted through a 5 cm incision along the ventral midline between the vent and pelvic fins. After insertion, the transmitter was nudged into the anterior portion of the body cavity so the battery or widest part was just anterior to the pelvic girdle and could not easily slip posteriorly towards the vent. The incisions were closed with nylon suture in an interrupted pattern. All nine individuals were held in concrete raceways for approximately four weeks until the incisions had healed.

Reservoir A was originally stocked in July 1986 at 3 grass carp/metric ton fresh weight of submersed macrophytes (23.6/ha). Five radio-tagged individuals were released into Reservoir A on November 18, 1986 when submersed macrophyte density was still relatively high. Reservoir B was originally stocked in October 1985 at 4 grass carp/metric ton fresh weight (18/ha). Four radio-tagged individuals were released into Reservoir B on December 17, 1986 after macrophyte density had declined to below 0.1 kg/m^2 fresh weight. Grass carp containment was achieved by means of a single barrier (horizontal bar design) attached to a drainage weir at each site.

Tagged grass carp were located with a three element Yagi antenna and 10 channel receiver (Model FL-10, L&L

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Electronics), operated from a boat. The location of a radio-tagged grass carp was marked on a scaled outline map of the reservoir in reference to shoreline configuration and landmarks. A rangefinder was used to accurately estimate the individuals location in reference to landmarks and distance from shore. Location accuracy was determined by test locations using a transmitter suspended about 45 cm above the bottom. The boat operator would estimate the location of the hidden transmitter by dropping a weighted marker at the suspected location determined by opposing approaches to an increasingly intense signal. The distance from the estimated and actual location was measured with a steel tape. This procedure was repeated 25 times, and the mean distance or error was found to be 5.7 m ± 3.9 SD and represents an average potential error of 2.2% based on average distances for computing speed.

Grass carp movement was characterized two ways, 1) as speed or degree of activity in Reservoir A only and 2) location frequency related to territoriality or home range behavior at both sites. For speed measurements, individuals in Reservoir A were located an average of 4.06 ± 0.05 SD times per date tracked based on 31 sampling dates between November 1986 and December 1987 (54 weeks). The average time spent per day determining multiple locations per individual averaged 3.8 h ± 1.1 SD between 0900 and 1500 hours. Speed was then determined from the total distance traveled for each individual from the first location through the last location for a known period of time on the day in question and was expressed as m/h.

Location frequency was based on the total number of times individual x was located per designated Area for the time interval in question (i.e. first three months). In Reservoir A each individual was located an average of 141 times (range 135 to 143) during 54 sampling dates over the 54 week period (November 1986 to December 1987). In Reservoir B individuals were located an average of 148 times (range 145 to 151) during 46 sampling dates over a 54 week period (December 1986 to January 1988).

Location frequency data were analyzed for home range behavior by dividing each reservoir into designated contiguous sections (Figure 1). The number of locations within specific Areas were compared for possible preference by the individual grass carp in question. Since the designated Areas were unequal in surface area, it was necessary to weight the number of locations within a specific Area with respect to the surface area of that section.

Submersed vegetation was sampled at seven transects (A to G) on Reservoir A (Figure 1. Samples were collected bi-monthly at four meter intervals along each transect with a 0.1m² drop and cut style biomass sampler. Samples were spun at approximately 500 rpm for five minutes in a garment washer and weighed to the nearest gram for fresh weight determination.

Regression and chi-square analyses were performed utilizing SPSS computer software (Norusis 1986).

RESULTS AND DISCUSSION

Reservoirs A and B had surface areas of 45.3 and 20.2 ha respectively, with maximum depths of 1.8 to 2.9 m, however the second order canals of Reservoir A (Areas D

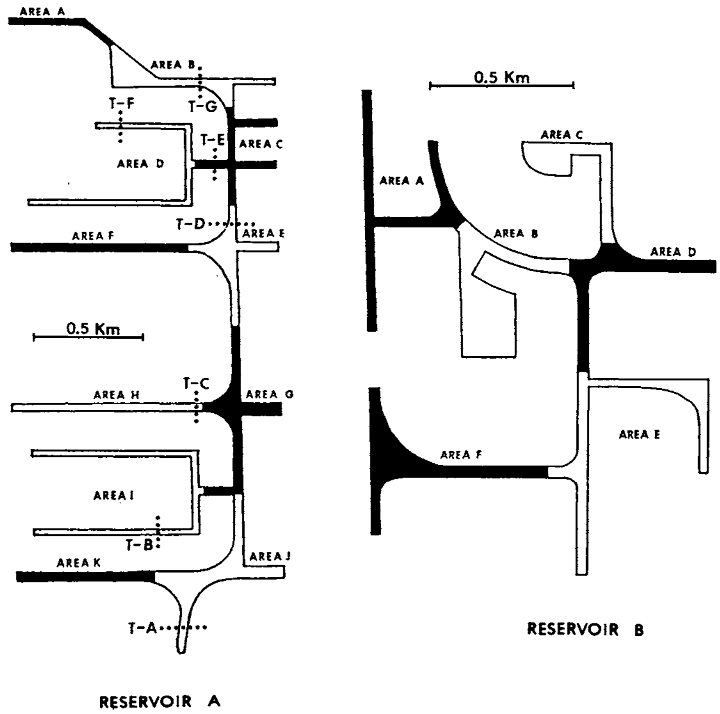

Figure 1. Configuration of Reservoirs A and B in Cape Coral, Florida. T-A refers to vegetation Transect A etc. Specific Area boundaries designated by alternate light and dark shading.

and I, Figure 1) were shallower and narrower than other areas of the system. In Areas D and I, average width and depth were 24.7 m and 2.1 m respectively. Average width and depth in the unexpanded north-south arm of Reservoir A averaged 39.7 m and 2.5 m respectively. Both reservoirs had moderate to heavy (0.3 - 0.8 kg/m² fresh weight) densities of submersed macrophytes dominated by *Najas guadalupensis* (Spreng.) Magnus, *Chara* sp., and *Utricularia* spp. at the time grass carp were originally stocked. Both sites could be classified as mesotrophic according to the definitions of trophic state by Forsberg and Ryding (1980). Dissolved oxygen concentrations, averaged from 0.5 m profile measurements were never below 5.3 ppm in either reservoir.

Grass carp speed was relatively high during the first 12 weeks after release, subsiding thereafter (Figure 2). In Lake Conway, Florida, this initial high activity period for radio-tagged grass carp was only 7 to 10 days (Schardt et al. 1982). The high initial activity was probably acclimation behavior, since food in the form of submersed macrophytes was present in all arms of the reservoir during the study. The high degree of movement just after release emphasizes the importance when necessary of installing fish barriers prior to introduction and careful maintenance during the first month or two after release.

Average grass carp speed for all dates tracked was 179.3 m/h ± 113 SD and indicates that these fish were relatively active throughout the study period, at least during the day (0900 to 1500 hours). Radio-tagged grass carp were also more active during the day in Deer Point Lake, Florida (Nixon and Miller 1978). However, Mitzner (1978) reported that nocturnal activity was not greatly different

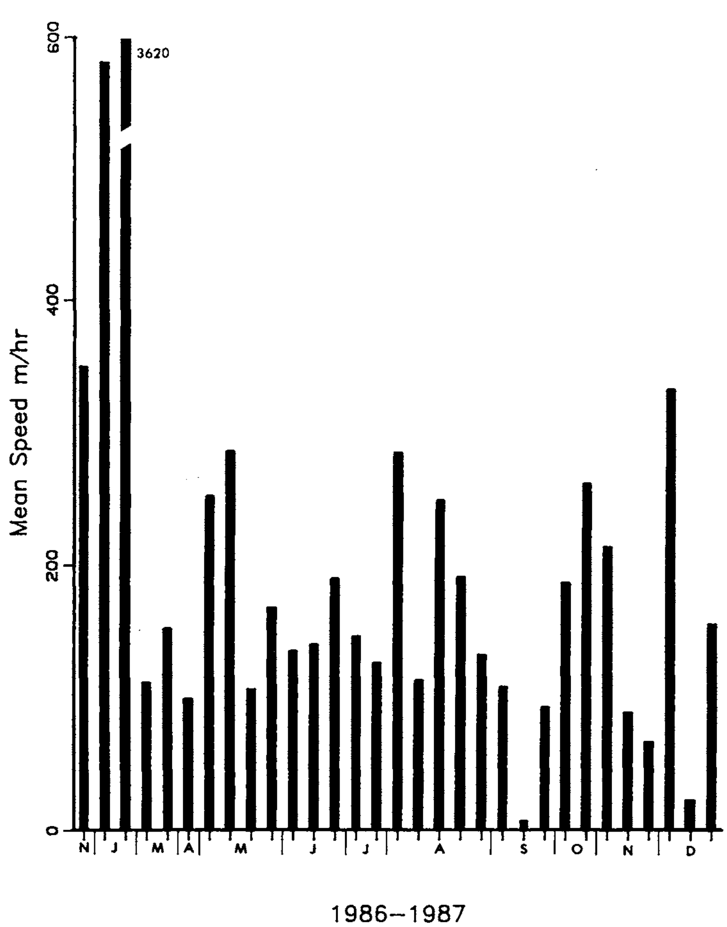

Figure 2. Mean grass carp speed in Reservoir A determined from multiple location points per individual per date tracked.

from diurnal movement at Red Haw Lake, Iowa. In a slow flowing canal, Hockin et al. (1989) found that grass carp movement was greatest before and around dawn and least in late evening. Our data for grass carp speed was considered conservative since the determinations were based on straight line measurements between multiple location points.

Mean speed and water temperature were not significantly correlated (r^2=-0.037, p≤0.05). Hockin et al. (1989) reported no correlation between grass carp movement in a slow flowing canal with water temperatures in the range of 15.6 to 22.4 C. Also, we found no significant correlation between mean monthly speed and average monthly daylength (photoperiod) (r^2= 0.198, p≤0.05). Nixon and Miller (1978) found grass carp movement decreased as water temperature decreased, however their winter water temperatures were considerably lower (6.6 to 15.7 C) than ours (22 to 25 C).

Analysis of location frequency data for both reservoirs resulted in several movement behavior patterns. All individuals established a home range (at least 50% of the time in one or two adjacent Areas) for at least a three month period but a broader temporal analysis of home range behavior indicated a variable pattern.

In Reservoir A (Figure 3), two temporal home range patterns were observed. Individuals 0, 6 and 8 didn't establish a home range until the third quarter and represent the predominant movement behavior pattern at this site. Individuals 2 and 4 (Figure 3) established a home range pattern less distinctly and, in general, for briefer periods than the others in Reservoir A and were considered free ranging for most of the study.

The most preferred Areas in Reservoir A, from more to less favored were J, F, E and G. All of these favored Areas represent deeper and wider or more open Areas within the system (Figure 1). The least preferred Areas were H, A, D and I. These represent either the shallowest or most confined Areas (narrower secondary canals). The "weighted" number of occurrences in the preferred Areas (J, F, E and G) and unpreferred Areas (H, A, D and I) were subjected to chi-square analysis assuming all Areas were equally attractive to grass carp and resulted in a significant difference (p≤ 0.01) in the distribution of observed values from the expected (χ^2= 12.86, df = 1). Similar comparisons were not made in Reservoir B because of its more uniform morphology with respect to depth and dichotomy.

Vegetation density in Reservoir A at Transects A, C, D, E and G, in or near the primary north-south arm (more preferred Areas J, G and E), demonstrated little or no seasonal bimodality and showed a decreasing trend through the study period (Figure 5). However, vegetation density at Transects B and F located in Areas that were less preferred by radio-tagged grass carp (Areas I and D), demonstrated typical seasonal fluctuations and remained at higher levels at the end of the study than all other Transects except C (Figure 5). Most of Areas D and I (least preferred Areas) developed weed infestations severe enough to warrant some type of control strategy during the summer months of the study.

In Reservoir B (Figure 4), three temporal home range patterns were evident. Individual 5 was unique because it established a home range early and maintained it throughout the study. Individuals 7 and 9 established a home range early but became free ranging during the final two quarters. The change may be a response to the near elimination of submersed macrophytes during this time. However, Individual 1 established a home range from the second through the fourth quarter. The near absence of submersed macrophytes in Reservoir B for most of the study was probably an influencing factor but we were unable to associate grass carp preference for certain Areas as related to the occurrence of submersed macrophytes due to their extremely low density and uneven distribution.

Relatively shallow and narrow basins appear to be a significant deterrent to grass carp access and may affect their ability to control vegetation in morphologically diverse systems, especially when stocked at relatively low rates. A similar observation was made by Schardt et al. (1982) where radio-tagged rass carp in Lake Conway, Florida never crossed from one basin to another when connected by a shallow, narrow canal. Schramm et al. (1986) found that confining structures or any structure that blocks free movement was a strong aversive stimulus.

Radio-tagged grass carp demonstrated a high degree of activity for 12 weeks after release. There was no apparent seasonal influence from water temperature or day

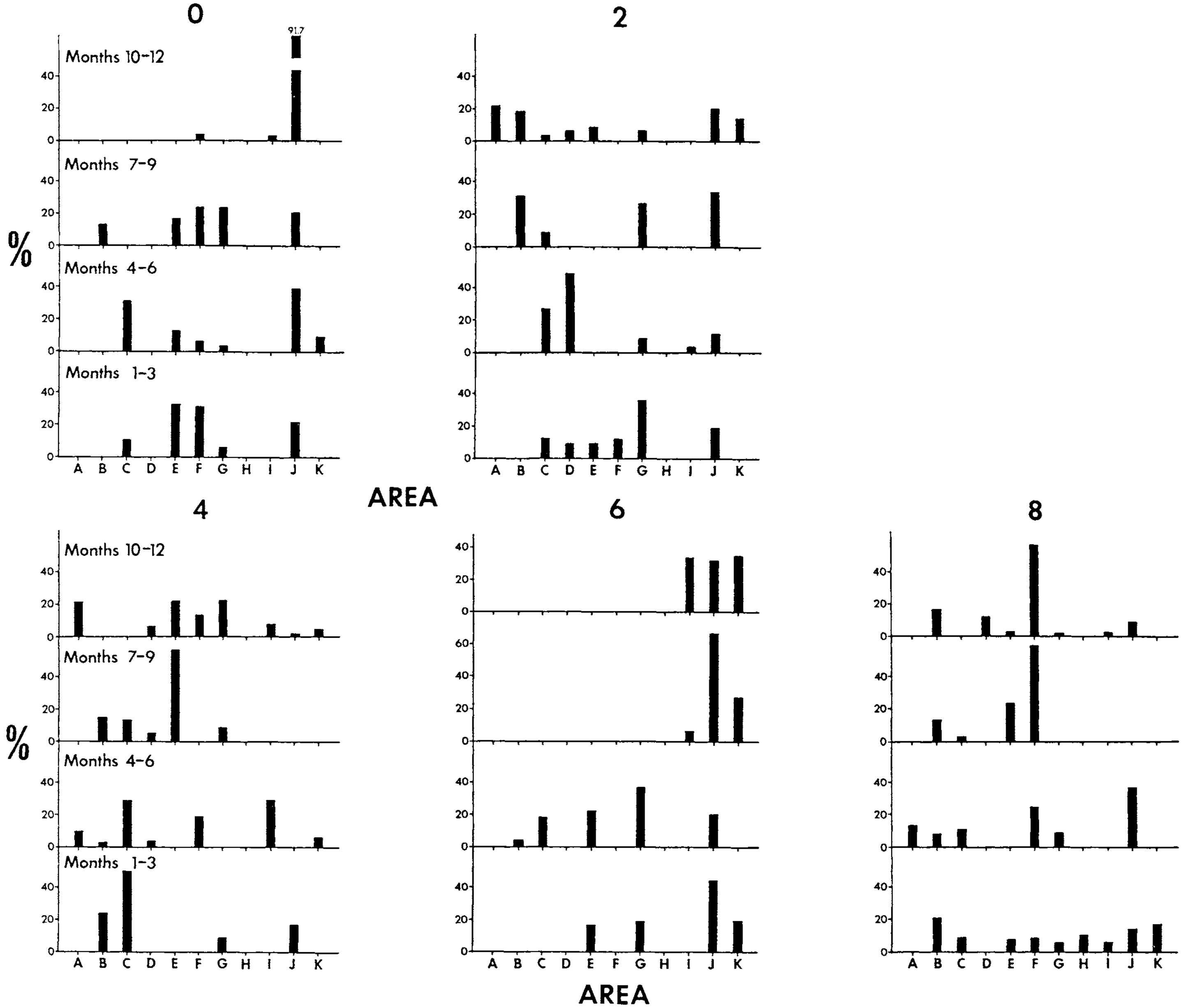

Figure 3. Weighted percent of the time individuals 0, 2, 4, 6 and 8 were located in designated Areas A-K of Reservoir A on a quarterly basis.

length on grass carp speed after this initial period of rapid movement. Water temperatures ranging from 22.2 to 30.3 C did not have a significant effect on grass carp speed. Grass carp territoriality was variable on a temporal basis but all nine radio-tagged individuals tracked clearly demonstrated a home range at some time durin the first year after release. Occupation of home range territories ranged from three months to one year. Grass carp preference for less confining areas would suggest a need for a multiple weed control strategy incorporating an alternate method in areas that become weed infested as a result of grass carp avoidance. This concept is particularly pertinent when grass carp are stocked at relatively low rates in systems with confining areas or where rapid and uniform vegetation decline is desirable.

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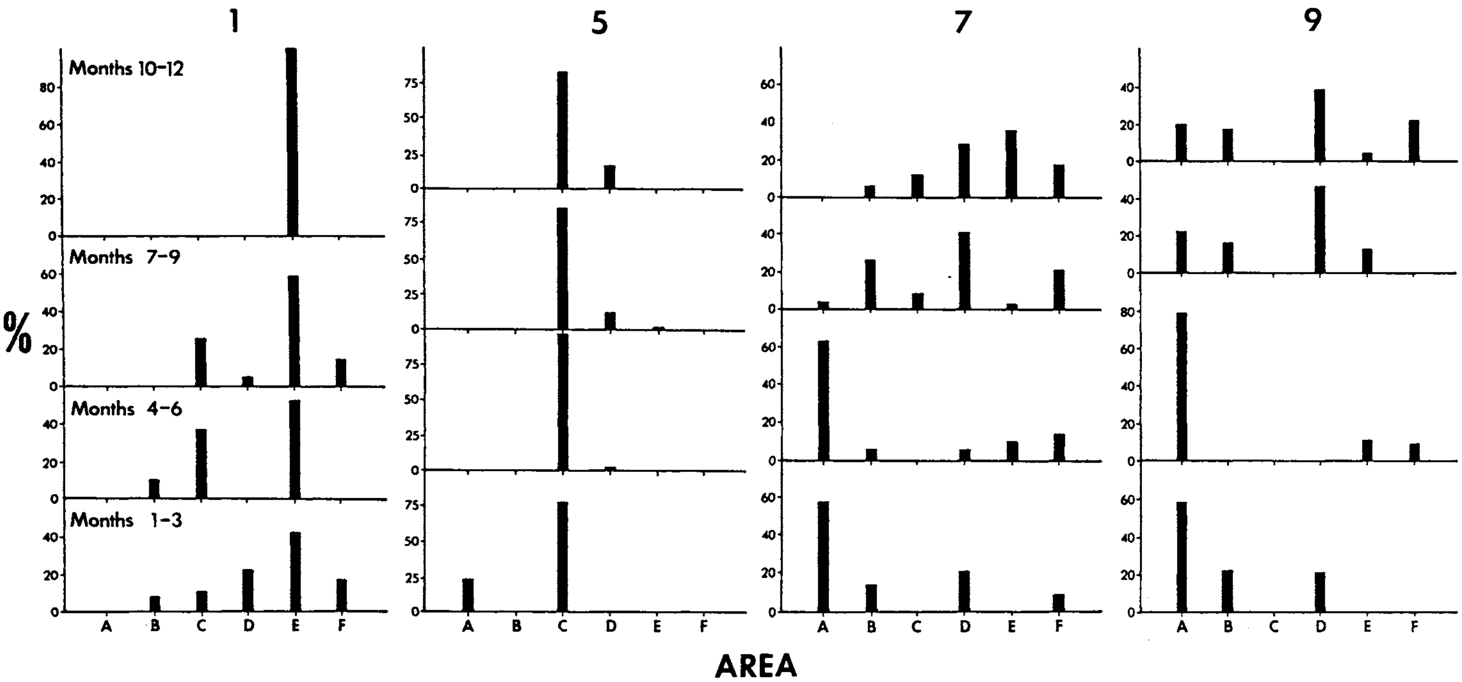

Figure 4. Weighted percent of the time individuals 1, 5, 7 and 9 were located in designated Areas A-F of Reservoir B on a quarterly basis.

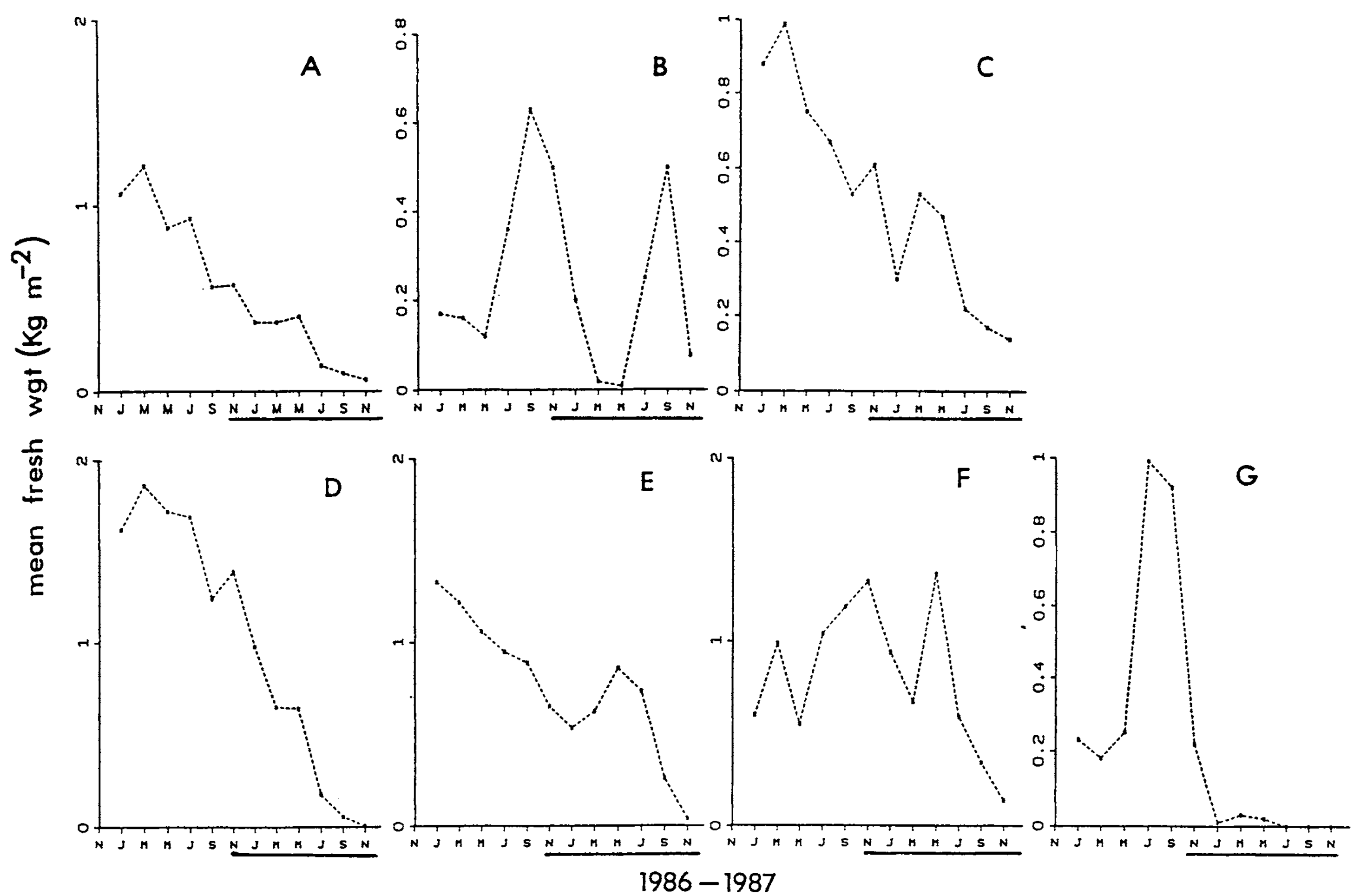

Figure 5. Mean macrophyte density along Transects A-G in Reservoir A. Underlined months refer to actual period during which grass carp were tracked.

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