GROWTH AND PRODUCTION OF GOLDEN SHINER *NOTEMIGONUS CRYSOLEUCAS* (MITCHILL), UNDER DIFFERENT STOCKING DENSITIES AND PROTEIN LEVELS

by

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ABSTRACT

Golden shiner fry (0.18-0.21 g) were raised in 60-gallon tanks for a period of six months under constant temperature and photoperiod but varying stocking densities and protein levels in food. The stocking densities and protein levels were 20, 28, and 36 fish per tank, and 28, 33, and 38% protein. All the fish were fed at 5% of body weight. Growth in weight and production were evaluated in relation to stocking densities and protein levels. It was found that a density of 20 fish/60 gallons (100,000 fry per acre) and feed containing 33% protein were desirable for raising golden shiner.

INTRODUCTION

The production of bait fish for use in fishing is an important and continuously growing enterprise. In 1969 Arkansas led the nation in production of bait fish, devoting 21,550 acres to minnow production. Of these, 93.7% or 20,200 acres produced golden shiner (*Notemigonus crysoleucas*) amounting to a retail value of $6,595,300 or 91% of the total income derived from bait fish in Arkansas during 1969 (Meyer et al., 1970). In 1972 the acreage devoted to golden shiner increased to 26,527 representing 91.2% of the total bait fish acreage and the retail value increased to $8,812,800 (Bailey et al., 1973).

Golden shiner are the most preferred bait minnow on a nationwide basis (Prather, 1957; Forney and Lawrence, 1962). They are the most suitable minnow for bait fish production as they are hardy, reach a usable size in one season, spawn readily in ponds and do not die after spawning during a first season (Forney, 1957). These characters also make the golden shiner an excellent forage fish (Cooper, 1937; Regier, 1963).

Production of bait fishes, as well as other fishes, is partially a function of feeding and stocking densities among a group of environmental factors. Prather (1957) noted that one of the principal problems of golden shiner culture is heavy stocking resulting in the production of small fish as a consequence of inadequate amounts of food for many individuals. Hickman and Kilambi (1974) described several feeding and stocking density conditions in relation to growth and production of golden shiner fed on 33% protein food. There is a great deal of information on quality of food (protein content) and its relationship to production of food and game fish but there is lack of knowledge of optimum protein levels for bait fishes. Therefore, this study was undertaken to evaluate the effects of quality of food (i.e. protein content) and stocking densities on growth and production of golden shiner.

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MATERIALS AND METHODS

The golden shiner fry used in this study were obtained from Anderson Minnow Farm, Lonoke, Arkansas. Of the estimated 4,000 golden shiner fry transported for possible use in the study only 53 died during the holding period, prior to the initiation when the tanks were prepared for use.

Plywood tanks, 76 cm long, 66 cm wide, and 33 cm deep, coated with fiberglass and resin were used in this study. Although these tanks had a volume of 226.8 liters (63

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gallons) they were maintained at 216 liters (60 gallons). The water temperature in the tanks was maintained at 22.8 C by two 100-watt submersible heating elements which were controlled by a mercury column thermoregulator while a 12-hour photoperiod (8 AM to 8 PM) was maintained in each tank by two 20-watt Gro-Lux fluorescent lamps that turned on and off by automatic timers. The tanks were stocked with golden shiner fry (30-32 mm; 0.18-0.21 g) with population densities of 20 fish per tank (100,000 fish/acre), 28 fish per tank (150,000 fish/acre) and 36 fish per tank (200,000 fish/acre). Each density group was fed a 28% protein feed (donated by Darragh Feed Co.) or a 38% protein feed (donated by Thibault Feed Co.) with each density X protein level condition being replicated. All fish were fed at a rate of 5% of body weight. The 28% protein feed contained 5% crude fat and 7% crude fiber while the 38% protein feed contained 4% crude fat and 3% crude fiber. The fish were fed daily, as soon after the lights came on as possible. Both feeds were mill ground so that food particle size was the same.

The experimental feeding period ran six months (June 22, 1973-December 23, 1972). On the 23rd day of each month individual fish from a random sample of five fish from each tank was weighed and measured before the fish were fed. The fish were weighed (to the nearest 0.01 g) on a Torbal balance by using a previously weighed small jar filled with water and subtracting the weight of the jar from the weight of the jar plus the fish to obtain the weight of the fish. At the final weighing all the fish were used instead of a subsample of five.

Production is expressed in units of pounds per acre-foot since individual pond depth is variable but these values may be viewed as per acre since it is assumed that even in the pond it is the acre foot that is in production.

After compiling the data, analyses were undertaken with the aid of the Monroe desk calculator and the IBM 360 Computer and significance was expressed at the 0.05 level.

RESULTS

Growth in Weight

The initial average weights (0.19+0.02 g) of the fish in all of the experimental tanks were not significantly different from tank to tank ($F_{11, 324}=0.33$). Hence, the growth in weight data for the replicates were combined for other analyses.

The growth in weight was adequately expressed as:

$\ln W_T = \ln W_o + bT$

W_T = mean weight in grams at a time period (T).

W_o = mean initial weight in grams.

b = regression coefficient or instantaneous relative growth rate.

T = a sampling period (1 month increments).

All the instantaneous relative growth rates were significantly different from each other with the exception of the 28 fish at 38% protein condition and the 20 fish at 28% protein condition (Table 1). The instantaneous relative growth rates for the 33% protein level fish (Hickman and Kilambi, 1974) were much higher than any of the other conditions (Table 1), but the fish were distinctly younger and smaller.

Table 1. Instantaneous relative growth rates for weight in relation to protein level and stocking density.

Experimental Condition	Instantenous relative growth rate
20 fish at 38% protein	0.30617
20 fish at 28% protein	0.24693
28 fish at 38% protein	0.25331
28 fish at 28% protein	0.23896
36 fish at 38% protein	0.25871
36 fish at 28% protein	0.19211
20 fish at 33% protein*	0.45078
28 fish at 33% protein*	0.40226
36 fish at 33% protein*	0.37570

The two values joined by the same line are not significantly different.

*From Hickman and Kilambi (1974).

The details of initial weight, final mean weight, absolute weight gain and percentage of weight gained are given in Table 2 as well as mortalities, sruvival rates and standing crops. The average final weights showed significant differences, $F_{8, 419}=17.85$, dependent upon the variables of protein level and stocking density with the exception of 36 fish at 38% protein and 20 fish at 28% protein. The fish used by Hickman and Kilambi (1974) were younger and showed a much larger percentage gain in weight even though the absolute weight gain is not much different reflecting a lower total weight in the younger fish.

Since the fish of the present study and those of Hickman and Kilambi (1974) were not of the same ages they are not directly comparable. At the start of the third time period their experimental fish were approximately of the same weight and length as the fish of the present study at the inception of the experiments. Therefore the instantaneous growth rates for the last four months of their study and the first four months of the present study were compared (Table 3), and it was evident that the 33% and the 38% protein levels yielded similar instantaneous relative growth rates for each of the density conditions.

Table 2. Details of gain in weight, mortality rates, and standing crop estimates for fish raised under different experimental conditions.

Condition	Initial Average Weight in Grams	Final Average Weight in Grams	Absolute Weight Gain	Percent Gain	Mortalities	Survival Percentage	Standing Crop lb/acre
20 fish at 38%	0.18	1.13	0.95	528	1 out of 40	39 40=97.5%	263.5
28 fish at 38%	0.21	0.96	0.75	357	2 / 56	54 56=96.4%	310.1
36 fish at 38%	0.18	0.85	0.67	372	4 / 72	68 72=94.4%	345.8
		N.S.					
20 fish at 28%	0.20	0.88	0.68	340	3 / 40	37 40=94.4%	194.8
28 fish at 28%	0.18	0.76	0.58	319	3 / 56	53 56= 94.6%	239.4
36 fish at 28%	0.18	0.57	0.39	217	9 / 72	63 72=87.5%	214.8
*20 fish at 33%	0.06	0.82	0.76	1267	4 / 40	36 40=90.1%	176.6
		N.S.					
*28 fish at 33%	0.06	0.71	0.64	1067	30/56	26 56=46.4%	108.9
*36 fish at 33%	0.06	0.52	0.46	767	20/72	52 72=72.2%	161.8

*(Hickman and Kilambi, 1974).

Production

The equations used to obtain production values are those of Chapman (1968) for net production which includes the weight gained by those fish which died before the termination of the experiment. The basic production equation is P=GB where G is the instantaneous growth coefficient during each time period and B is the average biomass during that time period. Since the growth was exponential G is defined by the relationship:

$$G = \frac{\log_e W2 - \log_e W1}{T}$$

Where: W1 = mean weight at time T1.
W2 = mean weight at time T2.
T = change in time or T2-T1.

Average biomass (where G Z) is estimated by:

$$B = \frac{B1(e^{G-Z}-1)}{G-Z}$$

Where: B1 = biomass at beginning of time period.
Z = instantaneous coefficient of mortality.

The instantaneous mortality coefficients were obtained by:

$$Z = \frac{\log_e N2 - \log_e N1}{T}$$

Where: N2 = the number of fish at T2.
N1 = the number of fish at T1.

Table 3. Instantaneous relative growth rates for four month overlap period between fish at 33% protein (Hickman and Kilambi, 1974) and those of the present study at 28% protein and 38% protein.

	Density		
Protein Level	20 fish	28 fish	36 fish
28%	.28	.26	.16
33%	.37	.33	.24
	NS.	NS.	NS.
38%	.33	.31	.23

Production estimates for the experimental conditions are given in Table 4. Highest production was obtained in stocking densities of 36, 28, and 20 fish in that order, all fed on 38% protein feed. Analysis showed that there were no significant differences either in the interaction term or among the stocking densities, however, differences in production among protein levels were significant ($F_{2,49}$=12.11).

Table 4. Production estimates in relation to stocking densities and protein levels.

Condition	Production g/60 gal	Production lb/acre
20 fish at 38% protein	19.0	227.5
28 fish at 38% protein	20.7	247.3
36 fish at 38% protein	24.0	286.2
20 fish at 28% protein	13.4	160.1
28 fish at 28% protein	15.9	189.8
36 fish at 28% protein	13.0	155.0
*20 fish at 33% protein	14.3	171.6
*28 fish at 33% protein	10.8	129.1
*36 fish at 33% protein	13.5	161.2

*(Hickman and Kilambi, 1974).

DISCUSSION

Among the many factors affecting growth, production and survival of fish are light, temperature, space or volume of water occupied (density), chemicals, amount of food and nutrient level of food (Brown, 1957). The commercial fish culturist is concerned with those factors which he can most easily control to increase growth and production, namely stocking density and protein level of food.

During the duration of this study, temperature and photoperiod were constant while factors such as dissolved oxygen (6.2-7.1 ppm) and water chemistry were not allowed to vary from within the ranges recommended for warm water fish (FWPCA, 1968). The pH varied from 7.4-7.8 while the total nitrogen never surpassed 0.15 ppm or the total phosphates 1.2 ppm. All the fish were fed at the same rate of five percent of their total weight. The only intentionally manipulated variables were stocking density and protein level of food.

Growth: The best results for absolute growth in weight were obtained from stocking density of 20 fish per tank at 38% protein level (Table 2) followed by 28 fish at 38% protein, 20 fish at 28% protein, 36 fish at 38% protein, 28 fish at 28% protein and 36 fish at 28% protein. From the data it is evident that there is an inverse relationship between stocking density and growth, and a direct relationship between protein level of food and growth within the limits of the present study. However, the differences in growth rates between fish of the same age fed 38% protein and 33% protein feed were not significantly different (Table 3). It may be that the optimum level of protein has already been reached at 33% and that no significant gain in feed efficiency will occur with increase in protein level thereafter. Dupree and Sneed (1966) showed linear increase in growth of young catfish up to the 35% protein level and hypothesized that protein utilization past that point was limited by caloric content of the food. Nail (1962) similarly found young-of-the-year catfish show no significant increase in growth rate past the 25% protein level ration for yearling catfish. Tiemeier and Deyoe (1969) recommend protein levels of 32-35% for young-of-the-year catfish as the most efficient ration. Comparison with the study of Hickman and Kilambi (1974) is difficult since the younger fish of that study did not attain as great an absolute growth as the fish of this study. However, by using the period where the ages overlap, the instantaneous growth rates were calculated showing no gain in growth rate by increasing the protein level from 33% to 38% (Table 3). The information from the literature and the results of this study and that of Hickman and Kilambi lead to the conclusion that cost of extra protein as well as no significant increase in growth between 33% and 38% protein levels should discourage the use of feeds with more than the adequate level of protein.

Production: Production is the total biomass produced during period T by all fish in experiment including those which died. Fish farmers are interested in production when it applies to maximizing the number of uniformly marketable-sized fish he can raise in a given culture pond.

Fish fed 38% protein food had significantly higher production values than those fed 28% protein food. Production of the fish that were fed 33% protein food (Hickman and Kilambi, 1974) was lower but the fish had higher mortality values than in the present study. The higher mortalities reported by them were not related to the quality of feed but attributable to various randomly occurring phenomena. This is supported by the fact that, in the present study, fish under 28% protein diet did not show a high mortality rate such as those of the previous study. The instantaneous growth rates of the fish fed on 33% protein diet and those of the present study fed a 38% protein diet showed no significant differences, and were significantly different from those fed a 28% protein diet. This would indicate that under identical experimental conditions, the production obtained on a 33% protein diet would equal the production obtained on a 38% protein diet.

Within the 38% protein condition, production increased with density but this does not hold for the 28% protein condition fish (Table 4). There were no significant differences in production values within a protein condition; however, the variation in length also increased with density (Roseberg, 1974), indicating that a few larger — more aggressive fish were accounting for part of the increased production at higher densities. This would not be desirable in a commercial situation as the fish farmer needs uniform-sized marketable fish. Higher population densities also cause fish to be more susceptible to diseases, parasites, dissolved oxygen depletions, predators, thermal stress, and chemical stress (Brown, 1957).

Even though the higher densities showed somewhat higher production, the present study indicates that the most favorable densities for producing a maximum of uniformly market-size fish, and thus a maximum profit, with a minimum of food and environmental hazards are the lower stocking densities. The recommended condition based upon the combined information of Hickman and Kilambi (1974) and that of the present study would be 20 fish per 60 gallons (100,000 per acre) fed at five percent of body weight with a food of 33% protein content.

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SHEEPSHEAD MINNOW (*CYPRINODON VARIEGATUS*): AN ESTUARINE FISH SUITABLE FOR CHRONIC (ENTIRE LIFE-CYCLE) BIOASSAYS[1]

by

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ABSTRACT

The sheepshead minnow (*Cyprinodon variegatus*), an estuarine fish of the Atlantic and Gulf Coasts, is suitable for both partial chronic and chronic (egg-to-egg) bioassays. The fish is easily held at high population densities in the laboratory and, at about 30 C, produces numerous eggs. The average 30-day survival of the fish from fertile egg to fry is 75%. Generation time for this species is short (3-4 months) and its small adult size (male average standard length=48mm) provides for relatively inexpensive bioassays. This killifish's susceptibility to organochlorine toxicants is similar to that of other estuarine fishes tested and thus should produce significant information on the effects of these toxicants on the estuarine community.

INTRODUCTION

Acute, partial-chronic and chronic bioassays are necessary for setting water quality standards, according to Mount and Stephans' (1967) definition of maximum acceptable toxicant concentration and experimental definition of application factor. Partial-chronic bioassays have been accomplished on several fresh-water species such as the bluegill (Eaton, 1970) and brook trout (McKim and Benoit, 1971) in which effects of toxicants were observed on each life stage. In chronic bioassays, the test organisms are exposed to a toxicant during their entire life cycle to measure effects on survival, growth and reproduction. In this manner, the most susceptible life stage can be ascertained and the survival potential of future generations of the organism estimated. Fresh-water chronic bioassays have been completed by several investigators such as Brungs (1971), using the fathead minnow (*Pimephales promelas*). To our knowledge, no marine or estuarine fish has been used in chronic or partial-chronic bioassays.

There are several criteria to be considered when choosing a fish for a chronic bioassay:

1. The fish should be able to reproduce readily in close confinement, producing large numbers of eggs.
2. Fertility as well as survival to adulthood should be high.

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