Lagler, K. F. 1956. Freshwater Fishery Biology. Wm. C. Brown, Co., Dubuque, Iowa. 421p.
Lake and Stream Survey Team No. 2, 1964. The Suwannee watershed. Fla. Game and Fresh Water Fish Comm. 105p.
McLane, W. M. 1955. The fishes of the St. Johns River system. Ph.D. Thesis, University of Florida, Gainesville.
O'Rear, R. S. 1970. A growth study of redbreast, *Lepomis auritus* (Gunther), and bluegill, *Lepomis macrochirus* (Rafinesque), populations in a thermally influenced lake. Proc. S. E. Assoc. Game and Fish Comm. 23:545-552.
Phillips, H. A. 1968. Fisheries investigations in lakes and streams. Progr. Rept., S. C. Wildlife Res. Dept. 19p.
Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish Res. Bd. Canada. Bull. 19. 300p.
Richmond, N. D. 1940. Nesting of the sunfish, *Lepomis auritus* (Linnaeus), in tidal waters. Zoologica, N.Y., 25(3):329-330.
Shannon, E. E. 1967. Geographical distribution and habitat requirements of the redbreast sunfish, *Lepomis auritus*, in North Carolina. Proc. S. E. Assoc. Game and Fish Comm. 20:319-323.
Tsai, Chu-Fa. 1970. Changes in fish populations and migration in relation to increased sewage pollution in Little Patuxent River, Maryland. Chesapeake Science, 11:34-41.
Wyatt, H. N., C. B. O'Neal, Jr., M. Norton and P. M. Loska. 1967. Life history studies. D.-J. Proj. F-19-R-2, Work Plan II, Job No. 5. Ann. Progr. Rept. July 1, 1966 to June 30, 1967. Georgia. 81p.

SOME RELATIONSHIPS BETWEEN FOOD HABITS AND GROWTH OF LARGEMOUTH BASS IN LAKE BLACKSHEAR, GEORGIA[1]

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ABSTRACT

The food habits and growth of 1,062 largemouth bass, *Micropterus salmoides* (Lacepede), collected from Lake Blackshear during the period 31 March 1970-19 December 1972 were examined. Mean lengths of bass at Age I, II, III, IV, and V were 106, 253, 350, 418, and 473 mm total length, respectively. Young-of-year and yearling bass showed great variation in growth rates. Threadfin shad, *Dorosoma petenense* (Gunther), and gizzard shad, *Dorosoma cepedianum* (LeSueur), were identified as the most important forage species to bass beginning their piscivorous feeding habits. The great variation in growth of young-of-year bass resulted from the timing of bass reproduction with respect to shad spawning activity. A specific goal and methods for managing largemouth bass are recommended for Lake Blackshear.

INTRODUCTION

Fish population estimates for Lake Blackshear based on cove sampling with rotenone have been made yearly for more than 15 years. This sampling showed that largemouth bass, *Micropterus salmoides* (Lacepede), reproduction was quite successful. However, length-frequency distributions indicated that growth of bass for the first three years was exceptionally slow. It was felt that recruitment to the catchable largemouth bass stock was significantly reduced because slow growing bass were subject to predation for a longer time than were faster growing bass.

A study of certain aspects of the life histories of largemouth bass and the principal species preyed on by bass was begun in 1968. It was hoped the study would delineate the extent and expose the causes of the bass growth problem.

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MATERIALS AND METHODS

Lake Blackshear is an 8,515 acre impoundment at River Mile 140 on the Flint River. The lake was filled in 1930 and is located on the Dougherty Solution Plain of the Georgia Coastal Plain. Lake Blackshear has a storage ratio of 0.04 and shore development is 10.0. The mean depth of the lake is 9 feet and the maximum depth is 50 feet. The growing season averages 240 days (Jenkins, 1967).

Cove sampling with rotenone was done yearly throughout the study. During this time the average total standing crop was 91 pounds per acre. Spotted sucker, *Minytrema melanops* (Rafinesque), and gizzard shad, *Dorosoma cepedianum* (LeSueur), dominated the samples. These two species accounted for 54.6 percent of the standing crop by weight. At the same time, largemouth bass made up 6.7 percent of the standing crop by weight. Although threadfin shad, *Dorosoma petenense* (Gunther), were not significant in terms of weight in the cove samples, they were numerous. Over 5,000 young-of-year threadfin shad per acre were recovered in one cove sample.

Largemouth bass were collected monthly from Lake Blackshear by electrofishing. Samples were taken from 31 March 1970 to 19 December 1972. Samples were not collected during May and December, 1971. A total of 1,062 bass were captured and examined.

All bass were put on ice immediately after capture, except during cold weather, to reduce the incidence of regurgitation. Bass under 300 mm total length were preserved in 10 percent formalin for later examination. Bass over 300 mm long were processed in the field.

Total length of all bass was measured to the nearest millimeter. Bass examined in the field were weighed to the nearest tenth pound, and those examined in the laboratory were weighed to the nearest gram. A scale sample was taken from all fish for use in age and growth studies. The sex and condition of the gonads of mature individuals were recorded along with stomach contents.

Stomach contents were identified to the lowest taxonomic levels possible. Frequency of occurrence was used to compare the percentage of stomachs containing various food items.

Impressions of scales were made on cellulose acetate slides, and the impressions were examined at 43X on an Eberbach Scale Projector.

Ages of the bass were determined by counting annuli. Measurements from the center of the focus to the annuli and anterior margin of the scale were made along the mid-line of the anterior field.

The Lee model was fitted to body-length/scale-length data using the least squares method. Back calculations of total length of bass at annulus formation were done arithmetically (Lagler, 1956).

The Dahl-Lea direct proportion method of determining length at annulus formation resulted in an underestimation of Age I total length (Carlander, 1972).

To determine the peak and duration of gizzard shad and threadfin shad spawning activity in Lake Blackshear, meter net sampling was done from 12 May 1972 to 8 June 1972 at weekly intervals. An additional meter net sample was collected 21 June 1972. Loss of equipment prevented such sampling in 1973.

All meter net samples were collected at the surface during 10 minute tows. All tows were made between 2100 and 2400 hours when shad schools were dispersed. During each sampling trip, one tow was taken at each of four stations. A mid-lake and a shoreline station were located just above Lake Blackshear dam. The other mid-lake and shoreline stations were located approximately one mile above the dam on the main body of the lake.

Meter net samples from all stations were pooled for each sampling date. Estimates or actual counts were made of the total number of shad in each 10 mm length class represented in the pooled samples. Since it was rarely possible to identify the species of young-of-year shad in bass stomachs, no attempt was made to differentiate between threadfin shad and gizzard shad in the samples.

Length-frequency histograms were constructed for young-of-year gizzard shad, threadfin shad, and bluegill, *Lepomis macrochirius* Rafinesque, taken by electrofishing and cove sampling with rotenone. Those young-of-year collected by electrofishing were measured to the nearest millimeter and those taken in cove sampling were measured to the nearest inch. The estimated maximum length of bluegill and shad that 64 mm, 89 mm, and 114 mm long largemouth bass could swallow (Lawrence, 1957) was superimposed on the length-frequency histograms. Using this procedure, I made estimates of the proportion of young-of-year shad and bluegill that were available on the basis of size to largemouth bass of various lengths.

RESULTS

Age and Growth of Largemouth Bass

The body-length/scale-length relationship was determined using the 152 largemouth bass successfully aged. The relationship, linear over the range examined, was expressed by the equation Y=37.24+1.30X with r=.977 and S.E.xy=26.45 (Figure 1).

Calculated lengths of bass in age groups I and II of the 1968 and 1969 year classes were compared to emperical lengths of bass captured between 1 January and 1 May 1970 and 1971 by length-frequency histograms (Figure 2). The general agreement between the histograms indicated that the scale method could be used successfully to

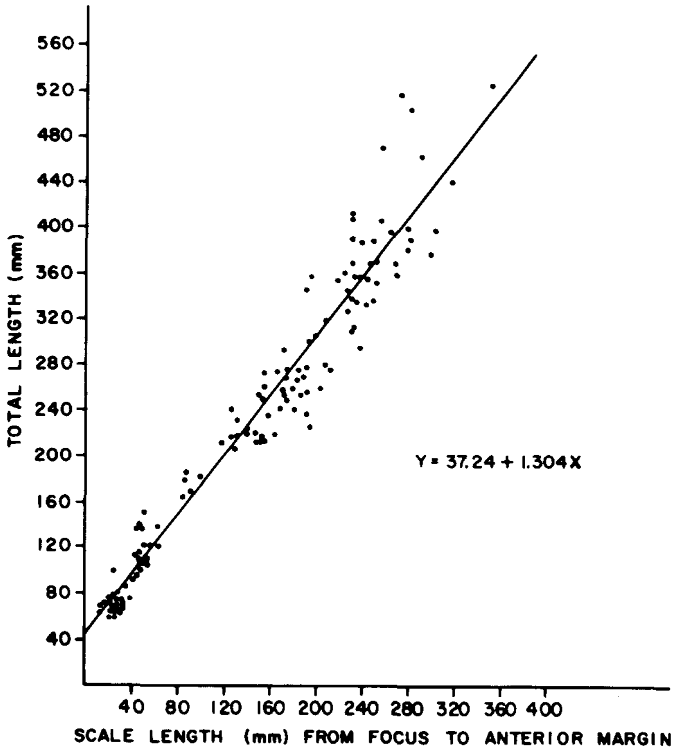

Figure 1. Body-length/scale-length relationship for Lake Blackshear largemouth bass.

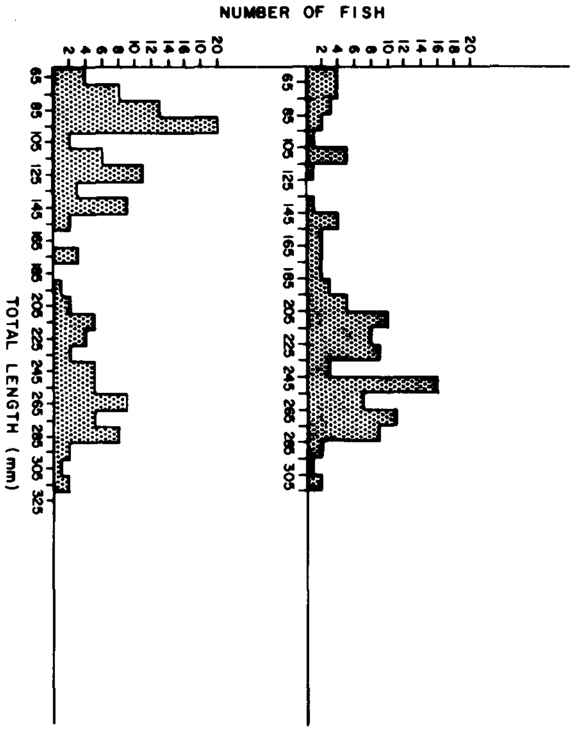

Figure 2. Length-frequency for largemouth bass captured from 1 January to 1 May 1970 and 1971 (upper) and calculated length-frequency for age groups 0 and I largemouth bass of the 1968 and 1969 year classes (lower).

Table 1. Calculated total lengths of Lake Blackshear largemouth bass collected from 31 March 1970 to 19 December 1972.

Age Group	Number of Fish	Mean Calculated Total Length in mm at End of Year of Life				
		1	2	3	4	5
I	34	114				
II	40	101	254			
III	15	104	250	349		
IV	2	92	217	357	413	
V	2	82	245	372	423	473
Mean Calculated Length		106	253	352	418	473
Mean Annual Increment		106	147	99	66	55
Numbers of Fish		93	5'	19	4	2

age largemouth bass from Lake Blackshear.

The growth rates of age groups 0, I, and II Lake Blackshear bass were highly variable. Yearling bass ranged in length from 66 mm to 161 mm and the mean length was 106 mm (Table 1). Age group II bass ranged from 170 mm to 316 mm and the mean length was 253 mm. Age group III bass ranged from 302 mm to 400 mm and averaged 352 mm in length.

A weak correlation was found between lengths of bass at Annulus I and lengths at Annulus II using regression analysis. The regression equation $Y=23.382X^{.513}$, where Y=length at Annulus II, X=length at Annulus I, and 23,382 and 0.513 are constants, provided the best fit of the data (Figure 3). The low correlation coefficient, r=.665 reflects the great variability in growth of yearling bass. For example, yearling bass which began their second year of growth in the 95 mm length class ranged from 208 mm to 288 mm in length at the beginning of their third year. The negative trend in the slope of the regression line suggests that there was some compensatory growth by the smaller yearling bass.

Table 2 presents the calculated lengths for a number of age groups of largemouth bass from various waters in the United States. Of t ose bass taken from bodies of water located in the southern tier of states, Lake Blackshear bass were the smallest at the end of their first year. By age groups II and III, however, Lake Blackshear bass were intermediate in length compared to those from the other bodies of water listed.

Within the size and age range examined, no significant difference between the growth rates of the two sexes was observed.

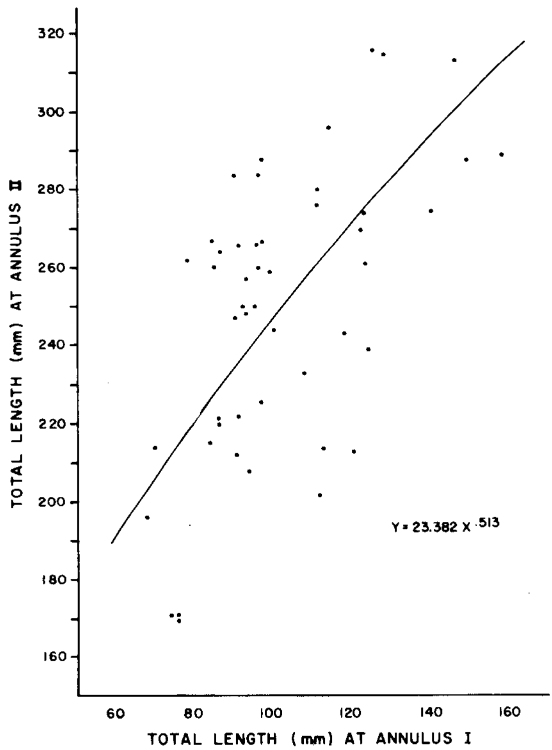

Figure 3. Relationship between calculated lengths of Lake Blackshear largemouth bass at annulus I and annulus II.

Table 2. Calculated total lengths of largemouth bass from various waters, ranked by length at the first annulus.

Body of Water	Age Group I	II	III	IV	V	VI	VII
Louisiana (Bennett, 1937)	193	287	368	478	531	597	630
Norris Lake, Tenn. (Stroud, 1948)	175	310	371	412	445	490	528
Clear Lake, Calif. (Tharratt, 1966)	170	310	376	424	503	544	
Unweighted mean: Al., Ga., La., Texas (Carlander, 1972)	166	256	315	391	437	518	557
Sutherland Res., Calif. (Tharratt, 1966)	165	290	363	414	460		
Silver Lake, Ga. (Padfield, 1951)	157	281	355	417	500	559	599
Folsom Lake, Calif. (Tharratt, 1966)	142	264	325	368	401	432	
Oklahoma Res. Avg. (Houser and Bross, 1963)	140	246	318	378	434	472	505
Lake Wapiapello, Mo. (Carlander, 1972)	137	277	338	409	460	498	
Lake Havasu, Calif. (Tharratt, 1966)	117	246	343	412			
Lake Blackshear, Ga. (present study)	106	253	352	418	473		
Wisconsin Lakes, Avg. (Bennett, 1937)	84	188	267	316	356	384	

Food Habits of Largemouth Bass in Lake Blackshear

The food habits of largemouth bass in Lake Blackshear shifted from predominantly microcrustaceans and insects to fish with increasing total length of bass (Table 3). This change in diet associated with increasing size has been noted in largemouth bass by many investigators (McGammon, LaFaunce, and Seeley, 1964; Hodson and Strawn, 1968; Applegate and Mullan, 1967; Carlander, 1972).

Table 3. Percentage occurrence of major food categories in Lake Blackshear largemouth bass collected from 31 March 1970 to 19 December 1972.

Total length in millimeters	No. containing food	Percentage occurrence Microcrustaceans	Insects	Fish
191-200	13	0	0	100
181-190	13	0	8	92
171-180	14	0	14	100
161-170	12	0	8	92
151-160	8	0	13	100
141-150	8	0	0	100
131-140	8	0	25	75
121-130	10	0	30	70
111-120	13	8	8	92
101-110	23	13	26	70
91-100	22	27	32	64
81-90	31	52	32	32
71-80	50	60	28	22
61-70	62	82	44	8
51-60	33	79	45	9
41-50	40	99	55	3
31-40	28	93	71	0
21-30	14	86	43	0

The smallest bass collected, in the 25 mm length class, fed primarily on microcrustaceans and small insect larvae. Microcrustaceans were consumed by bass up to 120 mm long. Cyclopoids were consumed more frequently than cladocerans and amphipods by bass in the 21 mm - 90 mm length range (Table 4). Cladocerans, however, were consumed by bass of greater length than were cyclopoids.

Various species of Ephemeroptera and Tendipedidae were utilized to approximately the same degree by small bass. Insect utilization by bass over 40 mm decreased with increasing length of bass and insects were insignificant in the diet of bass over 140 mm long.

The smallest largemouth bass found to have fish in its stomach measured 43 mm in length. With increasing length, bass consumed proportionately more fish and became primarily piscivorous at the 95 mm length class.

Table 4. Percentage occurrence of major invertebrate food groups in Lake Blackshear largemouth bass less than 120 mm total length collected from 5 January 1972 to 19 December 1972.

Total length in millimeters	No. in sample	Cyclopoida	Cladocera	Amphipoda	Tendipedidae	Ephemeroptera
111-120	4	0	50	0	0	0
101-110	10	0	10	0	0	20
91-110	3	0	33	0	0	0
81-90	8	63	50	13	0	0
71-80	13	23	46	0	23	46
61-70	12	67	33	42	17	17
51-60	10	70	70	30	0	20
41-50	10	86	70	20	50	40
31-40	6	67	0	17	67	33
21-30	11	82	82	45	9	9
Percentage occurrence in total sample		51	47	17	17	22

Food habits of largemouth bass were not only related to the length of bass but also to time of year. In figure 4, the food habits of three length groups of bass under 121 mm in length are related to the months during which collections were made. Bass in the 101 mm - 120 mm length range were primarily piscivorous through most of the year. This size group of bass consumed invertebrates more frequently than fish only during September and February.

Fish did not occur in the stomachs of bass in the 81 mm - 100 mm length range until May but remained the dominant food category until the following December. Insects and microcrustaceans were important food items to bass of this size from September through May.

Only during June did bass in the 61 mm - 80 mm length range utilize fish as much as microcrustaceans and insects. Fish consumption by these bass after July was infrequent.

Table 5. Percentage occurrence of major forage fish categories in Lake Blackshear largemouth bass collected from 31 March 1970 to 19 December 1972.

Total length in millimeters	No. containing fish	Percentage occurrence Sunfish	Shad	Fish Remains
541-580	3	67	0	67
501-540	7	28	14	57
461-500	8	14	0	28
421-460	14	64	7	21
381-420	33	27	6	51
341-380	50	24	18	54
301-340	46	22	15	46
281-300	17	6	53	41
261-280	28	21	7	61
241-260	20	20	5	60
221-240	17	6	41	29
201-220	38	13	26	53
181-200	25	4	44	44
161-180	19	11	26	53
141-160	12	8	17	58
121-140	10		100	80
101-120	25		16	68
81-100	20		20	60
61-80	16			88
41-60	6			100

Seventy-three percent of all bass less than 121 mm which had consumed fish contained unidentified fish remains. Twelve percent had consumed shad, and 15 percent contained other species, the most numerous having been largemouth bass, brook silversides, *Labidesthes sicculus* (Cope), and *Notropis* spp. It appears that the latter two groups were most important to the smaller piscivorous bass and that sunfish were not significant in the diet of bass less than 141 mm in length (Table 5). The high percentage of unidentified fish remains in the stomachs of small bass, however, made these findings tenuous.

Positive identification of food items to at least genus was possible in bass over 140 mm in length due to the greater size of fish consumed. With increasing length, bass consumed relatively fewer shad and more sunfish, primarily bluegill. Time of year, however, had a great affect on the frequency of occurrence of these two forage groups in the stomachs of the larger bass (Figure 5). From January through July, bass over 300 mm in length consumed sunfish more frequently than shad. Shad consumption increased dramatically from July to August and for the remainder of the year, shad and sunfish consumption was about equal.

Since smaller bass relied more on shad than sunfish, a different pattern of seasonal consumption of these two forage groups is evident for bass between 120 mm and 300 mm in length. Sunfish were never found in more than 20 percent of the stomachs of these bass. Shad were utilized more frequently than sunfish during all months except April, May, and June. These smaller bass also showed a dramatic increase in shad consumption from July to August. Shad were found in the stomachs of these bass much more frequently than sunfish during the late summer and fall months.

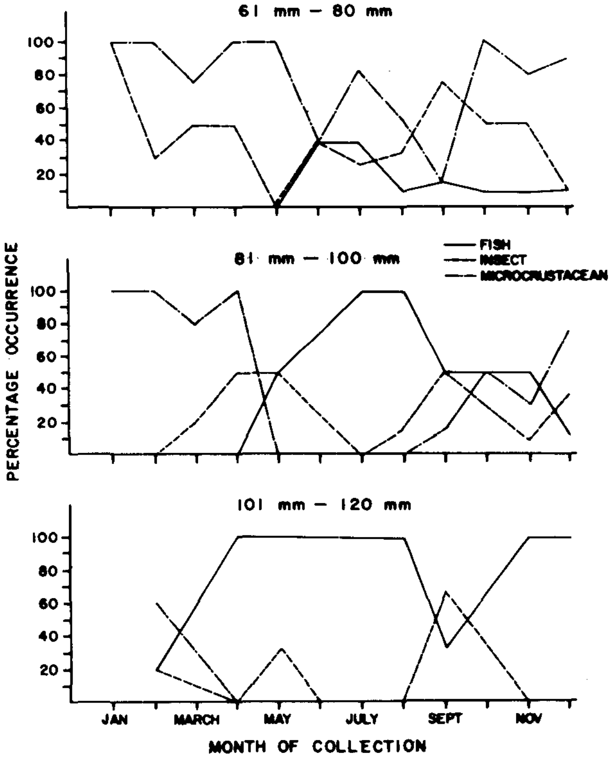

Figure 4. Relationship between time of year and percentage occurrence of micro-crustaceans, insects and fish in the stomachs of bass 61 mm-80 mm (upper), 81 mm-100 mm (middle), and 101 mm-120 mm (lower), total length collected from 31 March 1970 to 19 December 1972.

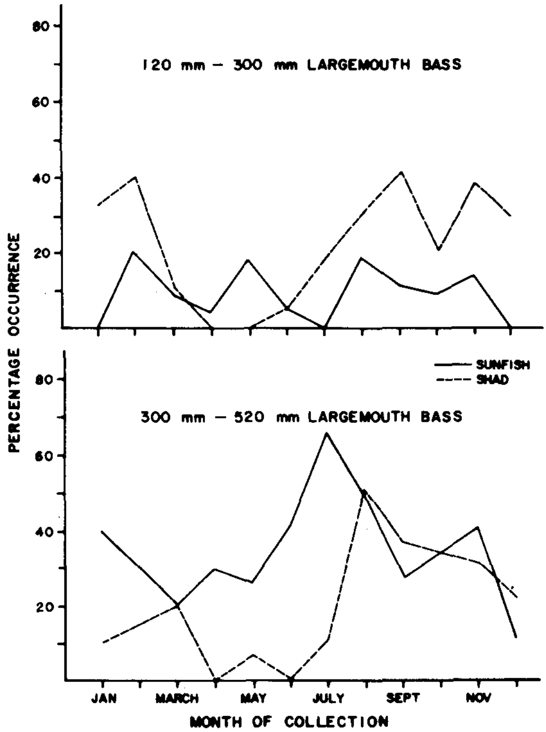

Figure 5. Relationship between time of year and percentage occurrence of shad and sunfish in the stomachs of bass 120 mm-300 mm (upper) and 300 mm -520 mm (lower) in length collected from 31 March 1970 to 19 December 1972.

Availability of forage fish to small bass

The results of meter netting for shad fry and fingerlings are presented in Table 6. There was a steady decline in the number of shad taken on each date from 12 May 1972 onward. The peak of combined threadfin shad and gizzard shad reproduction had occurred before the date that the first sample was taken. The small number of shad larvae taken during sampling on 21 May showed that spawning activity had nearly stopped by that date.

Table 6. Average number of shad, *Dorosoma* spp. taken in 10 minute meter net tows in Lake Blackshear from 12 May 1972 to 21 June 1972.

	Length Class in Millimeters			
Sampling Date	0-10	11-20	21-30	31-40
12 May	113	353		
18 May	37	34	6	
25 May	31	3		
8 June	3	17	4	17
21 June		3	4	2

Length-frequency histograms for young-of-year gizzard shad, threadfin shad, and bluegill collected during May, July, and August 1972 are presented in Figure 6. The lengths of these three forage species that largemouth bass 64 mm, 89 mm, and 114 mm long can swallow are indicated on the histograms.

A significant percentage of young-of-year bluegill were small enough for young-of-year and small yearling bass to swallow in July and August. Cove sampling in July 1972 yielded large numbers of these small bluegill. Six hours of electrofishing and shoreline applications of rotenone during November 1972, however, produced only four bluegill small enough to be consumed by 114 mm largemouth bass.

A large proportion of threadfin and gizzard shad-of-the-year was available to bass 64 mm in length during May. By July, few gizzard shad were still small enough to be consumed by bass under 89 mm in length. A higher proportion of threadfin shad, however, was still available to the smallest bass in July.

By August, most gizzard shad-of-the-year had outgrown their vulnerability to largemouth bass under 115 mm in length. A much higher percentage of threadfin shad-of-the-year was available to 114 mm bass than to either 89 mm or 64 mm bass.

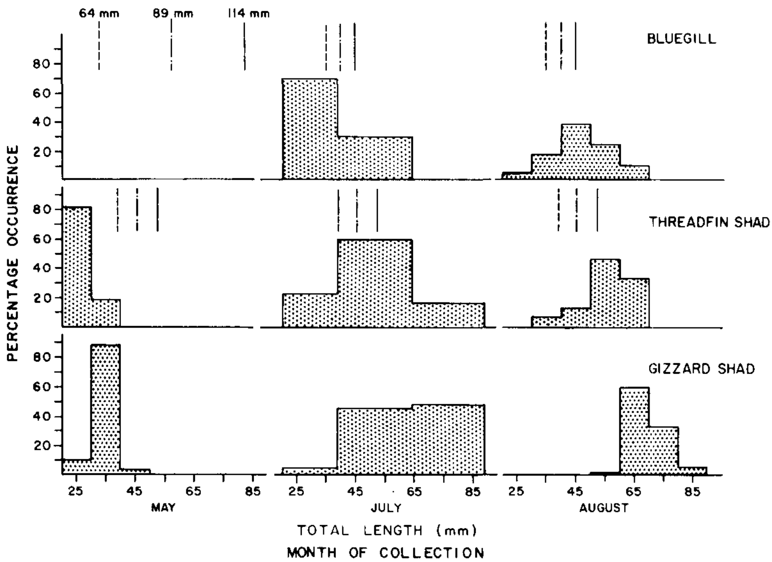

Figure 6. Length-frequency distributions of bluegill (upper), threadfin shad (middle), and gizzard shad (lower) young-of-year during May, July and August, 1972. The estimated maximum lengths of shad and bluegill that largemouth bass 68 mm, 89 mm, and 114 mm long can swallow are indicated.

DISCUSSION

The growth of age groups 0 to I largemouth bass in Lake Blackshear was highly variable. Some bass had reached a total length of 160 mm by the end of their first growing season while others had not attained a length of 70 mm in one year. It is evident that some young-of-year bass had gained a competitive advantage allowing them to grow relatively quickly through their first year of life. This advantage was lost somehwat during the second growing season as evidenced by the weak correlation between total length of bass at first and second annulus formation.

The advantage in growth during the first year, however, may have led to an enhanced probability of survival. Largemouth bass fingerlings were regularly found in the stomachs of other bass during the spring and early summer. Those young-of-year which grew most quickly would have been vulnerable to predation by a smaller portion of the predator population.

Swingle and Swingle (1967) found that largemouth bass in ponds would grow to a maximum size of 0.3 pounds (approximately 220 mm) on a diet of plankton and insects. For rapid growth, however, it was found that larger animals such as fish and crayfish had to be consumed. The availability of forage fish or other larger animals was more critically related to rapid growth of bass in Lake Blackshear than in Swingle's ponds.

The great variation in length of Lake Blackshear yearling bass could be explained in part by the inability of some young-of-year bass to make the transition from an invertebrate to fish diet. Individual variations in physiology, behavior, and morphology would be expected to affect the feeding habits of young bass. However, the relationship between length of bass under 120 mm and their food habits suggests that the size of the bass in relation to that of the forage fish was critical in determining if bass switched from an invertebrate to a consistent fish diet during their first or during their second year.

In Lake Blackshear, largemouth bass spawned from late March to mid-May. Shad spawning peaked in early May and bluegill spawning activity was greatest during June.

The later spawns of largemouth bass hatched after the peak of shad spawning and only slightly before the peak of bluegill reproduction. The bass went through an invertebrate consumption stage before becoming piscivorous. However, the forage species because of normal growth were not available for long to these small bass which subsequently had to rely on an invertebrate diet for the remainder of the year. The result of this invertebrate diet was bass ranging in length from 66 mm to 100 mm at the formation of annulus I.

The earlier spawns of bass were large enough to switch from an invertebrate to a fish diet before or during the appearance of shad and bluegill fry in the lake. These bass were large enough to take advantage of the abundant young-of-year forage for a greater portion of the year than those hatched later in the spring and attained lengths up to 160 mm at the formation of annulus I.

The relationships between time of year and food habits for various length groups of bass presented in Figure 4 can be interpreted in light of the foregoing discussion. All bass in the 61 mm - 120 mm length range from January through March were yearlings, the larger of which increased their consumption of fish during the early spring months. From April through June young-of-year bass, and the smallest yearlings, were primarily invertebrate consumers until they reached a sufficiently large size to begin preying on other fish. The earlier hatched young-of-year bass which became primarily piscivorous by May and early June grew sufficiently to remain piscivorous throughout the year. The most numerous forage in Lake Blackshear, shad and sunfish, did not outgrow their vulnerability to the early hatches of bass or the smallest yearlings.

The later hatches of bass were not large enough to begin consuming fish until late June and July. The smallest of these bass remained in the 61 mm - 80 mm length class throughout the rest of the year and fed primarily on invertebrates. Some bass which became piscivorous during June and July probably progressed into the 81 mm - 100 mm and 101 mm - 120 mm length groups depending on individual variations in feeding habits and growth rates.

Small shad were the most abundant forage in Lake Blackshear at the time largemouth bass made the transition from a primarily invertebrate to a fish diet. McCammon et al. (1964) stated that while preference may have played a role in determining the food habits of young bass, size and availability of forage were more important factors. In work carried out in May and June, 1965, comparing the food habits of young-of-year largemouth bass in Beaver and Bull Shoals Reservoirs, Applegate and Mullan (1967) found that bass grew considerably faster in Beaver

Reservoir. An adequate supply of shad fry had developed in Beaver Reservoir by early summer, and largemouth bass 40 mm and more in length fed primarily on these. The slower growth of young bass in Bull Shoals during early summer was associated with a limited supply of forage fish of suitable size.

McConnel and Gerdes (1964) studied the food habits of age 0 and I largemouth bass in a 50 acre Arizona impoundment, Pena Blanca Lake. Threadfin shad in this lake had a short spawning season and the resulting shad-of-the-year grew quite rapidly. Rapid growth of shad-of-the-year resulted in low utilization of this forage species by young largemouth bass. Consequently, age 0 and I bass in Pena Blanca Lake consumed significantly less food than bass of the same age living in Clear Lake, California which had a more heterogeneous size distribution of shad-of-the-year.

Shad were important in the diet of bass of all sizes, but especially to bass under 200 mm long. Shad, however, were consumed infrequently by bass over 120 mm during April, May, and June. Cove rotenone sampling showed poor over-winter survival of threadfin shad and gizzard shad small enough to be consumed by bass under 360 mm in length (Pasch 1973; McSwain 1972; and Gennings 1971). The increased consumption of shad by bass longer than 120 mm during August and the fall months was the result of young-of-year shad growing to a desirable forage size by that time.

Young bass in Lake Blackshear depended for food on microcrustaceans and insect larvae for part or all of their first year. A certain overlap in the food habits of largemouth bass and bluegill, redear sunfish, *Lepomis microlophus* (Gunther), and redbreast sunfish, *Lepomis auritus* (Linnaeus), in Lake Blackshear was noted by Pasch (1974). This overlap, however, was based on identification of food items to taxonomic levels no lower than family. Classification of food items to lower taxonomic levels, difficult because of digestion of the food, might reveal less overlap in food habits between the centrarchids.

If the overlap of food habits between centrarchids, however, was a manifestation of competition for food by small largemouth bass and sunfish, competition would have been severe during June and July when these small centrarchids were quite abundant. During June and July young-of-year gizzard and threadfin shad were most abundant at sizes that heavily utilize crustacean zooplankton. Severe competition for food between small bass, clupeids, and other centrarchids would have resulted in a reduced growth rate of young-of-year bass not yet large enough to consume the numerous forage fish. Such a reduced growth rate might have precluded these small bass from becoming primarily piscivorous for the remainder of their first year.

If it is deemed desirable to augment the production of a particular year class of largemouth bass in Lake Blackshear at least through Age 0, the findings of this study suggest a specific management goal. That goal should be the production of a numerically strong year class of bass in which the majority of individuals would be large enough to become piscivorous before the onset of shad spawning activity. This goal could be achieved through the stocking of fingerling bass, manipulation of water level, or genetic manipulation of the largemouth bass stock.

LITERATURE CITED

Applegate, R. L., and J. W. Mullan. 1967. Food of young largemouth bass, *Micropterus salmoides*, in a new and old reservoir. Trans. Amer. Fish. Soc. 96:74-77.

Bennett, G. W. 1937. The growth of the large mouthed black bass, *Huro salmoides* (Lacepede), in the waters of Wisconsin. Copeia. 2:104-118.

Carlander, K. D. 1972. Manuscript material from Handbook of freshwater fisheries. Dept. of Zoology and Entomology, Iowa State University. Ames, Iowa. Vol. 2:321-431.

Gennings, R. M. 1971. Population studies, reservoirs (Lake Blackshear). Ga. Dept. Natur. Resources, Game and Fish Div. Fed. Aid in Fish Restoration, Project F-21-2, Progress Report. 11 p.

Hodson, R. G., and K. Strawn. 1968. Food of young-of-year largemouth and spotted bass during the filling of Beaver Reservoir, Arkansas. Proc. Annual Conf., S.E. Ass. of Game and Fish Comm. 22:510-516.

Houser, A., and M. G. Bross. 1963. Average growth rates and length-weight relationships for fifteen species of fish in Oklahoma waters. Okla. Fish Res. Lab., Norman. Report No. 85:75 p.

Jenkins, R. M. 1967. The influence of some environmental factors on standing crop and harvest of fishes in U. S. reservoirs, p. 298 to 321. in Reservoir fishery resources symposium. Amer. Fish. Soc. Washington, D.C.

Lagler, K. F. 1956. Freshwater fishery biology. Wm. C. Brown Co., Dubuque, Iowa. 421 p.

Lawrence, J. M. 1957. Estimated sizes of various forage fishes largemouth bass can swallow. Proc. Annual Conf., S. E. Assoc. of Game and Fish Comm. 11:220-225.

McConnel, W. J., and J. H. Gerdes. 1964. Threadfin shad, *Dorosoma petenense*, as food of yearling centrarchids. Calif. Fish and Game. 50(3):170-175.

McGammon, G. W., D. LaFaunce, and C. M. Seeley. 1964. Observations on the food of fingerling largemouth bass in Clear Lake, Lake County, California. Calif. Fish and Game. 50(3):158-169.

McSwain, L. E. 1972. Population studies, reservoirs (Lake Blackshear). Ga. Dept. Natur. Resources, Game and Fish Div. Fed. Aid in Fish Restoration. Project F-21-3, Progress Report. 15 p.

Padfield, J. H. 1951. Age and growth differentiation between the sexes of the largemouth black bass, *Micropterus salmoides* (Lacepede). J. Tenn. Acad. Sci. 26 (1):42-54.

Pasch, R. W. 1973. Population studies, reservoirs (Lake Blackshear). Ga. Dept. Natur. Resources, Game and Fish Div. Fed. Aid in Fish Restoration, Project F-21-4, Progress Report. 14 p.

_____. 1974. Investigations of aspects of the life history of largemouth bass in Lake Blackshear. Ga. Dept. Natur. Resources, Game and Fish Div. Fed. Aid in Fish Restoration, Project F-21-5 Compl. Rept.

Stroud, R. H. 1948. Growth of the basses and black crappie in Norris Reservoir, Tennessee. J. Tenn. Acad. Sci. 23(1):31-99.

Swingle, H. S., and W. E. Swingle. 1967. Problems in dynamics of fish populations in reservoirs, P. 229 to 243. in Reservoir fishery resources symposium. Amer. Fish. Soc. Washington, D.C.

Tharrat, R. C. 1966. The age and growth of centrarchid fishes in Folsom Lake, California. Calif. Fish and Game. 52(1):4-16.