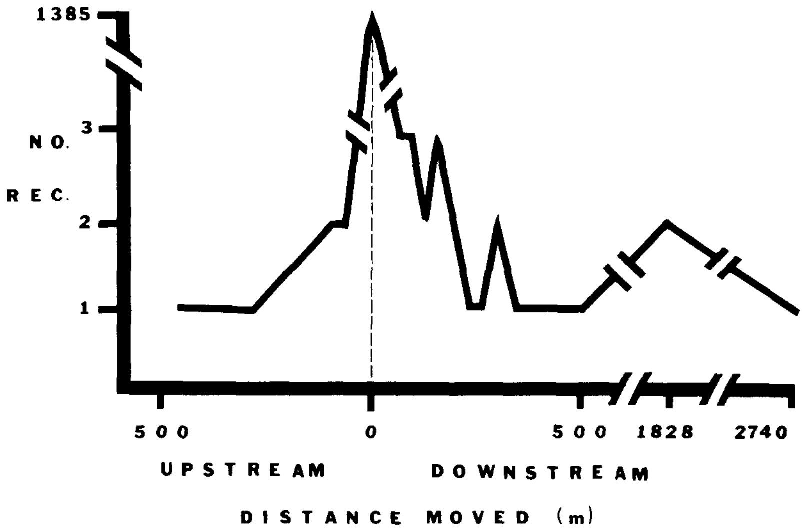

Figure 2. Diagramatic representation of distances and numbers of trout moved from point of introduction. No. Ret. = number recaptured by electrofishing.

SEASONAL VARIATION IN FOOD AND DIEL PERIODICITY IN FEEDING OF NORTHERN LARGEMOUTH BASS, *MICROPTERUS S. SALMOIDES* (LACEPEDE), IN AN OKLAHOMA RESERVOIR[1]

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ABSTRACT

Food habits of 810 northern largemouth bass, 91-2724 g total weight (age groups 0-7) were determined from collections made June 1968 through November 1969 in an 808-hectare, Oklahoma reservoir. Bass were collected by traversing the shoreline with an electrofishing apparatus and bass stomach contents observed with a gastroscope. Fifty-five percent of all bass stomachs were empty. Similar observations over a wide geographic area were reviewed and the suggestion was made that 56% occurrence of empty stomachs may be

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used as a guide to evaluate availability of forage for largemouth bass. Bass stomachs contained mostly crayfish and gizzard shad. Gizzard shad and partially digested fish were found in 31.1% of 810 fish, whole and partially digested crayfish were found in 13.9% of the bass. Bass swallowed crayfish and gizzard shad tail-first 96.8% and 33.5% of the time, respectively. Orientation of the prey in bass stomachs did not vary with size of the bass. In 1969, largemouth bass in Lake Powell, Lake Carl Blackwell and Bull Shoals spawned in the last week of April, the coincidence appears to be related to similar photoperiod at the same latitude. Variation in percentage of empty stomachs preceding, during and after the spawning season suggested that bass, probably the males, may reduce feeding during the two week interval when they are guarding the eggs and prelarval fish. Judging from occurrences of empty stomachs, bass in this lake generally fed from midmorning through afternoon rather than between evening and morning.

INTRODUCTION

A food habits analysis of northern largemouth bass of a size greater than 176 mm total length was undertaken to ascertain the type of forage, seasonal variation in forage, orientation of the prey and feeding periodicity. Observations were made on stomach contents of 810 largemouth bass collected by electrofishing in Lake Carl Blackwell, located in north central Oklahoma. Because the quantity and quality of forage consumed is important to production, and because production is also related to availability and vulnerability of the forage (Lewis 1967), the occurrence of low lake levels due to persistence of a drought offered opportunity to evaluate the effects of drought on selection of forage. Moreover, as the net production and growth of this bass population has been described for the same years (Zweiacker and Brown 1971; Zweiacker, Summerfelt and Johnson 1973), the observation allowed an opportunity to relate food habits to growth and reproduction. Use of a gastroscope (Dubets 1954) to make the observations permitted examination of nearly 45% of the estimated population number of bass (Zweiacker and Brown 1971); a sample this large is unattainable when fish are sacrificed to obtain their stomachs.

STUDY AREA

Lake Carl Blackwell is a turbid reservoir in the Permian redbeds of north central Oklahoma, approximately 12.8 km west of Stillwater, Payne County, Oklahoma. At spillway elevation, 287.7 m, m.s.l. (mean sea level), the surface area of the reservoir is 1355 ha and the volume is 68 million cubic meters. Turbidity ranges from about 20 Jackson turbidity units in the deeper portion to 180 units in the shallower western portion during periods of high winds.

Below average rainfall in Payne County, with the exception of three spring rises in the summers of 1967, 1968 and 1969, resulted in a continuous decline of lake level of Carl Blackwell 1962 to 1971. A record low of 282.9 m, m.s.l. (4.9 m below spillway level) was reached on 17 September 1971 when lake surface area was 60% of the area at spillway level and total volume only 29% of maximum volume. The littoral areas were essentially void of submergent and emergent vegetation. The average water level during the period of this study was 284.1 m (m.s.l.) in 1968 and 284.0 m (m.s.l.) in 1969.

PROCEDURES

Largemouth bass $>$ 176 mm were collected by electrofishing from June 1, 1968 through November 1, 1969, except during December, January and

February 1969 when electrofishing was ineffective. Electrical output was from a 180 cycle 230-volt, 3,000 watt AC generator mounted in a 4.9 m flat-bottom boat powered by an outboard motor. Electrofishing was done by traversing the shoreline in water approximately 1 m deep.

A gastroscope (Dubets 1954) was used to determine largemouth bass stomach contents. This technique (electrofishing and gastroscope) eliminated the problems of digestion which would have occurred in the use of a net or trap and the problem of bass gorging themselves on small fishes during sampling by poisoning (McLane 1949). Time of feeding was effectively assessed because the degree of freshness of the forage could be ascertained. In some cases, the forage was still alive in the mouth or esophagus of the bass at time of collection.

Forage species, method of swallowing (head or tail-first and horizontally), time of capture and average surface water temperature were recorded. Three different size gastroscopes (19, 25 and 38 mm for the small end) were used to accommodate the size variation of bass which varied from 91 to 2724 g total weight.

Samples were stratified to determine if bass in Lake Carl Blackwell fed more intensively during the morning or during the afternoon. Morning was from 0600 to 1200 hours and afternoon was from 1201 to 2300 hours. Percentage of stomachs examined in 1968-69 that were classified as empty, or containing fresh crayfish or gizzard shad were tabulated for fish collected in the morning and compared with percentages of the same categories for fish collected in the afternoon. Stomachs that contained digested fish or digested crayfish were not included because time of ingestion could not be determined for partially digested food.

RESULTS AND DISCUSSION

Occurrence of Empty Stomachs and Concepts of Vulnerability

Fifty-five percent of 810 bass stomachs examined June 1968 through November 1969 were empty. This compares to a range of 49.3 to 68.0% empty stomachs observed by others (Table 1). The data available from the literature on largemouth bass was tested to evaluate the hypotheses that the expected frequency (fe) of empty stomachs in the several studies on largemouth bass food habits did not deviate significantly from the observed frequency (fo) of 56.5% derived from the combined totals. A chi-square analysis to determine the similarity of the frequencies observed in the studies shown in Table 1, indicates no difference (P=0.45) and that the discrepancy in observed frequencies by various investigators on reservoirs and ponds (Oklahoma, southern Illinois and Louisiana) can be attributable to sampling error.

McLane (1949) observed only 8% of 110 largemouth bass stomachs were empty when captured after poisoning with rotenone. Also, most bass observed by McLane had a larger number of forage fishes per fish, whereas typically bass examined by gastroscope contain only a single item. Moehn (1959) evaluated the hypothesis that the high frequency of empty stomachs observed by Dubets (1954) and Schneidermeyer and Lewis (1956) was attributable to low vulnerability of the forage. Moehn's evaluation was done by comparison of percentage of empty stomachs in largemouth bass before and after rotenone treatment. In the before samples 68% of 22 bass were empty, compared to 28.1% of 32 bass with empty stomachs when collected after poisoning. Several other ponds treated by Moehn also showed a low incidence of empty stomachs in bass when collected after poisoning (7.4%, 28.6%, and 1.9%). Lewis and his students (Tarrant 1960; Lewis et al. 1961; Lewis and Helms 1964) demonstrated, by an intricate series of paired laboratory and pond studies, that vulnerability of the forage was similar regardless of the predator species used and that susceptibility

Table 1. Observed frequency (fo) of largemouth bass with empty stomachs and a chi-square test for heterogeneity against an expected frequency (fe) of 56.5%.

Source	Total No.	No. Empty (fo)	$(fo\text{-}fe)^2/fe$ fe = 56.5
Dubets (1954)*	552	337 (61.0%)	2.00
Schneidermeyer and Lewis (1956)*	211	104 (49.3%)	1.96
Moehn (1959)*	22	15 (68.0%)	0.53
Lambou (1961)	280	158 (56.4%)	0.00
Present study*	810	446 (55.1%)	0.31
Total	1875	1060 56.5%	4.80 P=0.45

*Observations made with gastroscope.

to capture was a characteristic of the forage (Lewis 1967).

Observation on the uniformity in percentage empty stomachs in largemouth bass (Table 1) suggests that under typical conditions where forage fish were not made highly vulnerable inspection of the percentage of empty stomachs can be used as a measure of effectiveness of various management techniques such as drawdown (Bennett et al. 1969), weed control (Lawrence 1954) or antimycin applications (Burress 1971). The 56% frequency observed from combined studies (Table 1) may be used as an average to evaluate forage conditions for age group I+ largemouth bass. Thus, where fo of empty stomachs is not significantly different from 56% (fe), conditions are average, when fo is significantly larger, feeding is above average, when fo is significantly less than 56%, feeding conditions are below average. Seaburg and Moyle (1964) made a similar generalization regarding the variation in percentage of empty stomachs in northern pike (*Esox lucius*) between two Minnesota lakes. They said the discrepancy in percentage empty stomachs between two lakes, 33 and 54%, respectively, was due to difference in available forage fishes on which the pike were feeding. Too little information of similar nature was reviewed to establish whether the same percentage is applicable to other predatory fishes, however, observations in Oklahoma reservoirs showed 49.2% of 1329 flathead catfish (*Pylodictis olivaris*) had empty stomachs (Turner and Summerfelt 1971), 66.0% of 180 longnose gar (*Lepisosteus osseus*) and 70.0% of 86 shortnose gar (*L. platostomus*) had empty stomachs (Summerfelt 1970). Lambou (1961) observed 37.0% of 54 alligator gar (*L. spatula*) stomachs were empty and a 50% frequency of empty stomachs in 44 spotted gar (*L. oculatus*).

A 56% frequency of empty stomachs in largemouth bass may represent the natural outcome of a normal circadian feeding periodicity-gastric evacuation rhythm as suggested by Nobel (1972) for observations on yellow perch (*Perca flavescens*) in Oneida Lake, New York, and by Lewis et al. (1974) for largemouth bass. Obviously, biological rhythms may be altered if a feeding frenzy in the predator is triggered by the appearance of distressed forage fish such as occurs during application of a fish toxicant.

Relationship Between Frequency of Empty Stomachs and Growth

Lewis (1967) stated that the typical situation in most reservoirs is for growth of piscivorous fishes to be much less than their growth potential because of a lack of available forage. According to Lewis, rapid growth in new reservoirs is related to large populations of vulnerable forage. An important but previously untested inference is that there exists an inverse relationship between percentage empty stomachs in piscivorous fishes and their growth. As scales had been taken from most bass examined by gastroscope, data was available to test the relationship between growth and percentage empty stomachs in largemouth bass. Our analysis shows a non-significant correlation, r_{xy}=-0.41, t=1.28, and with 8 df P was >.10 (Figure 1). Although the correlation was non-significant the negative slope still suggests that the inference is correct, i.e., that there is a negative relationship between growth and the percentage occurrence of empty stomachs. This analysis was done using six age groups (1-6) and only two conditions of food supply (1968-1969). We believe it would be better to calculate the correlation with percentage of empty stomachs in fish of the same age under different levels of forage density and vulnerability. Zweiacker et al. (1973) showed a faster second than first year growth of largemouth bass in 1967. In 1967 drought conditions favored piscivorous habits of the bass in their second summer compared to first year growth of bass. The latter are dependent upon a littoral zone production of macroinvertebrates which was impoverished by the declining water levels.

Zweiacker et al. (1973) observed an increase in second year growth of bass in Lake Carl Balckwell 1962-1967 when lake levels were declining markedly each year. After 1967 the lake levels stabilized (283.9 m in 1967; 284.1 m in 1968; 284.0 m in 1969), no association between growth and lake level was observed. Unfortunately, we have no observations on frequency of empty stomachs 1962-1967, however, observations were made on frequency of empty stomachs June-November of 1968 and 1969 when lake levels were similar. Thus, frequency of empty stomachs should have been similar in both years: 49.8% of 261 bass collected June-November of 1968 were empty compared to 58.4% for the same months of 1969 (Table 2). The discrepancy between these two years was non-significant (X^2=1.78, P=0.18). Even when analyzed by age group, the only significant difference was for age group 1 (Table 2). Age group 7 was not analyzed because of the small collection, and age group 0 was only analyzed from collections in 1969. The difference in percentage frequency of empty stomachs in the summer of 1968 and 1969 was too small to detect differences in vulnerability of forage fishes due to the drought, however, the evidence suggests that age-specific growth of largemouth bass in 1968 and 1969 would be similar as no new food would be available. Obviously, to obtain maximum growth, management must endeavor to decrease the frequency of empty stomachs.

Relationships Between Frequency of Empty Stomachs and Spawning

Eddy and Surber (1934) state that the male largemouth bass does not feed when guarding a nest, and a decrease in feeding activity during courtship, mating and nest guarding has been suggested by Lewis et al. (1961) and Dendy (1946). It is reasonable to assume that at least male bass would go without feeding during the interval of nest construction, the two weeks of guarding activity when eggs and prelarvae are in the nest, and even for the 3-4 week interval when the male guards the school of postlarval bass. Because this inference had not been substantiated by actual food stomach analysis, seasonal variation in frequency of occurrence of empty stomachs was analyzed (Figure 2) by age group to determine if occurrence of empty stomachs would be more frequent during the spawning season. Age group 1 bass averaged only 128 mm at the beginning of the 1969 spawning season (Zweiacker et al. 1973) and were not sexually mature. Also, the number of age group 1 bass collected during the 1969 spawning season was inadequate to evaluate their feeding habits at that time (Figure 2). It is questionable whether many age group 2 bass spawned in 1969 as they averaged only 218 mm during that spawning season (Zweiacker et al. 1973). The frequency of empty stomachs of age group 2 fish declined during the midpoint of what we infer to have been the spawning season.

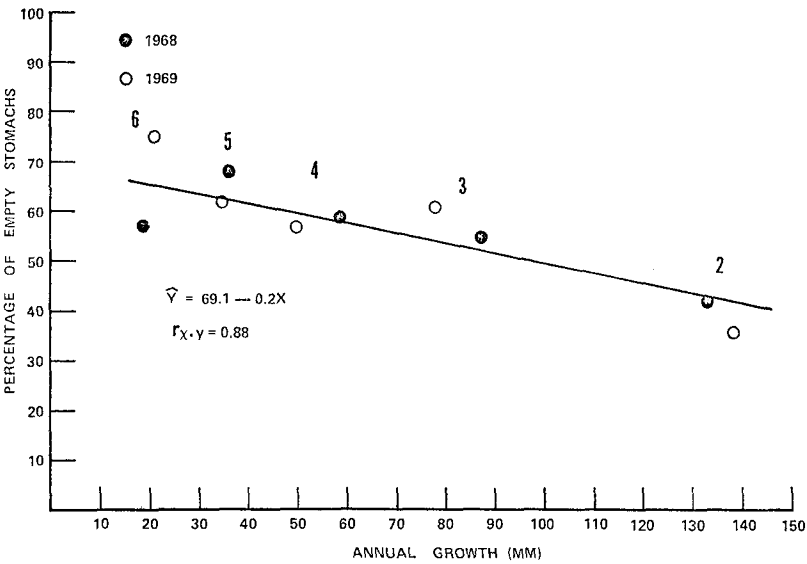

Figure 1. Relationship between mean growth increments of age groups 2-6 largemouth bass, 1968-1969, and the average percentage occurrence of empty stomachs by age group.

Table 2. Chi-square analysis of difference in frequency of occurrence of empty stomachs in largemouth bass in 1968 and 1969.

Age group	1968 (No.=261) No.	1968 % Empty	1969 (No.=262) No.	1969 % Empty	Chi-square X^2	P
0	-	-	23	69.6	-	-
1	37	24.3	88	69.3	9.420	$<0.005>0.001$
2	64	42.2	65	44.6	0.045	$<0.90>0.80$
3	62	54.8	18	50.0	0.065	$<0.80>0.75$
4	51	58.8	30	66.7	3.290	$<0.10>0.05$
5	31	80.6	24	45.8	2.495	$<0.20>0.10$
6	14	57.1	12	41.7	0.308	$<0.70>0.50$
7	2	50.0	2	100.0	-	-
	261	49.8	262	58.4	1.786	$<0.20>0.10$

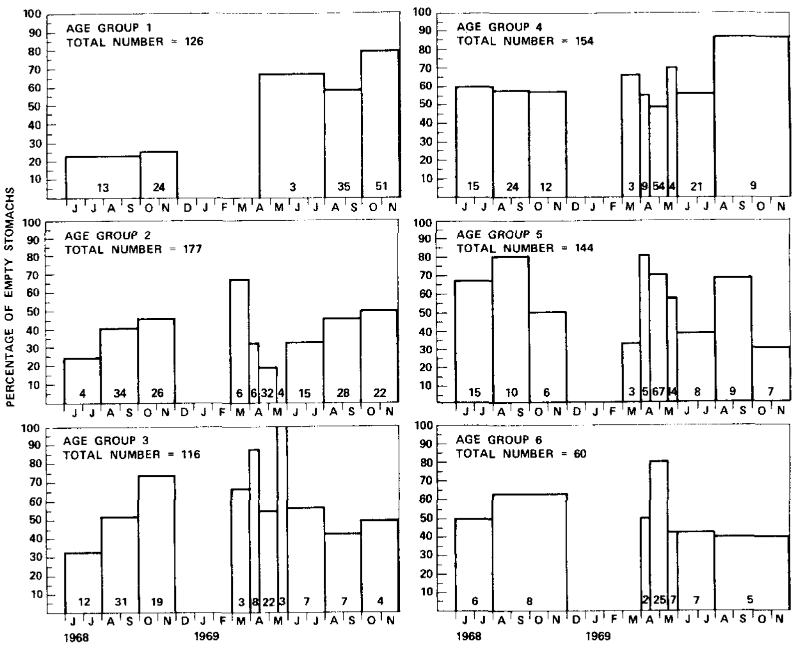

Figure 2. Seasonal variation in percentage frequency of occurrence of empty stomachs in largemouth bass by age group for observations in Lake Carl Blackwell 1968 and 1969. Numbers along the abscissa are the number examined in the interval.

The spawning dates of largemouth bass in Lake Carl Blackwell could not be ascertained by direct observation as has been done with SCUBA or a water scope (Miller and Kramer 1971) because turbidity during the spawning season reduced light penetration to a secchi disc measurement of less than 0.5 meters. Zweiacker (1972: 36) defined the spawning season as 15 April to 7 May by inference derived from observations of occurrence of frayed fins, presence of milt, and a sharp decline in condition factor following spawning. At nearly the same latitude, however, largemouth bass in Wahweap Bay of Lake Powell (Utah) in 1969 (the same year as the present study) commenced spawning April 11 when water temperatures at the depth of the nests were 11.7 to 13.9 C (Miller and Kramer 1971). In their 1969 study, water temperature at nest depths rose from 15 to 23.4 C whereas in Lake Carl Blackwell, water temperatures during the spawning season averaged 21 C. In Bull Shoals Reservoir in Arkansas, also about the same latitude, largemouth bass regularly commence nest construction by the 18th of April when water temperatures at nest depth reach 14-15 C (personal communication, 11 October 1973 with Louis E. Vogele, South Central Reservoir Investigations, BSFW, Fayetteville, Arkansas).

Therefore, it is reasonable to assume that in 1969 male largemouth bass were guarding eggs or larvae from mid-April to May 1 and would show a greater frequency of empty stomachs at this time. Unfortunately, sex could not be determined with accuracy from external morphology so the data is for both males and females with the expectation of a higher frequency of males as they would be more susceptable to the electrofishing gear while on the nest. The frequency of empty stomachs in age groups 5 and 6 during the 15 April - 1 May interval was higher than before or after this interval, but for age groups 3 and 4, the frequency of empty stomachs was somewhat lower in this interval (Figure 2). Thus, some indication for fasting by spawning fish is evident but the observations are not conclusive.

Qualitative Composition

Crayfish and gizzard shad were the most abundant and most frequently observed food items in bass stomachs. Of the total 810 bass, gizzard shad appeared in 16.7% of the stomachs, digested fish in another 14.4%, and combined fish or digested fish appeared in 31.1% of the 810 total. Fresh crayfish appeared in 10.9%, partially digested crayfish in 3.0%, and combined, 13.9% of the 810 bass contained fresh or partially digested crayfish.

Crayfish and gizzard shad were the major items occurring in largemouth bass stomachs in a 2,631 ha lake in southern Illinois (Schneidermeyer and Lewis 1956). Dubets (1954) also observed that bass fed largely on gizzard shad. Tadpoles and crayfish were used by bass in a pond where gizzard shad were not present (Lewis and Helms 1964). Shad were utilized by bass in Norris Reservoir, Tennessee where crayfish were scarce (Dendy 1946). Applegate and Mullan (1967) reported bass as small as 40 mm length would feed on sac fry and fry of shad (*Dorosoma* spp.). Thus, the two forage species most utilized by largemouth bass in Lake Carl Blackwell, gizzard shad and crayfish, are the same forage species utilized by largemouth bass in many other waters. Availability and vulnerability of the gizzard shad and crayfish are probably the reasons for their high incidence in bass stomachs.

Although gizzard shad and crayfish were the major food items, one bass contained a water beetle, two bass had bluegills, two contained frogs, one contained a crappie, one contained a largemouth bass and four contained other sunfishes. The remaining were either empty, contained gizzard shad, crayfish, different degrees of digested crayfish and gizzard shad or unknown digested fish.

One largemouth bass was found in a stomach of another bass, but bass 453 g were basically noncannibalistic. However, scarcity of small bass due to weak year-classes in 1968 and 1969 may have been the reason for the low incidence of cannibalism. Stranahan (1906) observed cannibalism in smaller but not in larger bass. Lack of cannibalism in bass 453 g in Lake Carl Blackwell seemed to be related to a greater availability of other forage species, e.g., gizzard shad and crayfish. Few bass stomachs contained more than one food item which supports a previous observation by Markus (1932) that bass do not take food readily unless their stomachs are empty. Of bass stomachs examined with two or more items, the contents frequently consisted of a crayfish exoskeleton and a more recently swallowed prey.

Channel catfish were not found in bass stomachs examined with gastroscopes. Six of ten bass ranging from 1,021 to 2,837 g, sacrificed to determine their sex, contained pectoral spines of channel catfish in their viscera. As judged by size of their spines, age II to age VI bass occasionally consume channel catfish in the 0.2 to 0.4 kg size range.

Changing food habits of fry and fingerling bass have been previously reported. Henshall (1883 and 1885) stated that bass 25 mm feed on minute crustaceans, 25 to 102 mm feed on insects and bass larger than 102 mm preferred crayfish. Murphy (1949) found largemouth bass in Clear Lake, California smaller than 46 mm (1.8 in) fed on plankton, from 46 to 71 mm (2.8 in) fed on insects, and over 71 mm they fed chiefly on fishes. Changing of food habits by fingerling bass was observed in Arkansas (Applegate and Mullan 1967; Hodson and Strawn 1969) and in Alabama (Rogers 1968). Hathaway (1927) observed small size bass eating more per body weight than large individuals.

Observations have not been made regarding changes with size occurring in the food habits of bass 453 g. Food items or percentage of different items utilized by different size groups of bass in Lake Carl Blackwell were similar. No trend was observed in frequency of occurrence of gizzard shad by bass size groups although there was generally a higher frequency of occurrence of gizzard shad in the intermediate size bass (499-905 g) than all other groups.

Feeding Periodicity

In 1968, 75.0% of the fish collected in the morning had empty stomachs compared with 56.0% of the fish collected in the afternoon (Table 3). This difference was significant ($P<.05, X^2 1df=9.2$). In 1969, 73.7% of largemouth bass collected in the morning had empty stomachs compared with 68.4% in the afternoon. This difference was not significant ($P>.05, X^2 1d.f.=1.03$), but the direction of the difference corroborates the findings of the previous year. These bass apparently fed from midmorning through the afternoon which resulted in a lower percentage of empty stomachs in the afternoon than in the morning. Thus, they are diurnal, not crepuscular or noctural feeders. The high percentage of empty stomachs in the morning indicates a lack of feeding at night, especially between 12 midnight and 6 A.M. Dubets (1954), however, in studying feeding activity through the 24-hour cycle, could not establish a specific feeding period for largemouth bass.

Orientation of Prey

Method of swallowing (capturing) prey, based on position of prey species in mouth, esophagus, or stomach was recorded for 230 bass stomachs containing freshly captured crayfish or gizzard shad. Crayfish were swallowed tail first in 96.8% of 93 bass stomachs containing fresh crayfish (Table 4). The small percentage of crayfish which seemed to have been swallowed head first may have rotated during digestion, as has been previously observed in largemouth bass (Molnar and Tolg 1962). Large bass utilizing small crayfish could swallow them head or tail first, but large bass usually utilized larger forage.[3] Orientation of the

[3]By inspection, there seemed to be a direct relationship between size of bass and size of forage species utilized. This has been reported for bass feeding on green sunfish (Tarrant 1960).

Table 3. Percentage of largemouth bass stomachs that contained gizzard shad, crayfish, or were empty in the morning and evening in Lake Carl Blackwell, 1968-69.

Month	Sample Size	Percentage Empty	Percentage Gizzard Shad	Percentage Crayfish	Sample Size	Percentage Empty	Percentage Gizzard Shad	Percentage Crayfish
1968								
	Morning				Afternoon			
June + July	15	73.3	13.3	13.3	30	63.3	13.3	23.3
Aug. + Sept.	38	78.9	5.2	15.7	50	54.0	8.0	38.0
Oct. + Nov.	11	63.6	0.0	36.3	68	54.4	22.0	23.5
Weighted Mean		75.0	6.2	18.7		56.0	15.6	28.3
Total	64				148			
1969								
	Morning				Afternoon			
Mar., Apr. + May	9	55.5	33.3	11.1	220	72.2	25.0	2.7
June + July	4	50.0	0.0	50.0	48	58.3	22.9	18.7
Aug. + Sept.	36	72.2	11.1	16.6	47	55.3	36.1	8.5
Oct. + Nov.	31	83.8	3.2	12.9	65	72.3	23.0	4.6
Weighted Mean		73.7	10.0	16.2		68.4	25.7	5.7
Total	80				380			

crayfish in swallowing was apparently to induce folding of the large chelipeds, whereas a head first orientation would cause a spreading of the chelipeds that inhibits swallowing.

Gizzard shad were swallowed head first by 66.4% of 137 bass stomachs containing fresh shad. Orientation of shad did not vary greatly in bass of different sizes, except in the 1,407-1,816 g group which usually swallowed gizzard shad tail first. The higher percentage of forage fish swallowed head first probably facilitated swallowing because this prey orientation compresses the median fins, which if spiny, would injure the predator. All gizzard shad were apparently in a horizontal position in the esophagus and/or stomach in reference to orientation of the largemouth bass. This horizontal position of the forage was probably due to the turning of the prey by the largemouth bass before swallowing, as reported by Lawrence (1958).

Table 4. Orientation of prey (crayfish and gizzard shad) swallowed by largemouth bass in Lake Carl Blackwell, 1968-69.

Weight (g) Group	Crayfish No. of Stomachs	Crayfish % Head-first	Crayfish % Tail-first	Gizzard Shad No. of Stomachs	Gizzard Shad % Head-first	Gizzard Shad % Tail-first
91- 454	25	0.0	100.0	63	69.8	30.2
499- 908	33	9.0	91.0	32	68.7	31.3
953-1362	15	0.0	100.0	18	61.1	38.9
1407-1816	11	0.0	100.0	9	33.3	66.7
1861-2270	8	0.0	100.0	13	69.2	30.8
2315-2724	1	0.0	100.0	2	100.0	0.0
Weighted Mean		3.2	96.8		66.4	33.6
Total	93			137		

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STUDIES ON SCALE STRUCTURE OF FLATFISHES I. THE GENUS *TRINECTES*, WITH NOTES ON RELATED FORMS

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ABSTRACT

A detailed comparison of the scales of *Trinectes maculatus* (Bloch and Schneider) and *T. inscriptus* (Gosse) has demonstrated species specific differences valid for taxonomic purposes. A complex hinged joint attaching very large cteni to the scale plate characterizes both species. The large cteni are associated with a marked increase in skin surface which, in turn, is combined with an apparent increase in the cutaneous vascular bed suggesting a secondary respiratory and excretory function. The rigid skin flaps produced by the cteni may also be associated with a hydrodynamic "spoiler" mechanism. The lateral-line canal in both species is uniquely composed of tubes lying end to end with no ancillary scale appendages.

INTRODUCTION

To date surprisingly few studies or series of studies contribute significantly to the general subject of scale morphology in relation to taxonomy of teleostean fishes. A brief statement of significant general contributions follows.

Cockerell in a long series of papers (1909a, 1909b, 1910a, 1910b, 1910c, 1910d, 1911a, 1911b, 1912, 1913a, 1913b, 1915, 1921), Cockerell and Calloway (1909a), Cockerell and Allison (1909b), and Cockerell and Moore (1910) published keys and diagnoses of the scales of several families, genera and species. Many of these