FOOD OF ANGLER HARVESTED LARGEMOUTH, SPOTTED AND SMALLMOUTH BASS IN BULL SHOALS RESERVOIR

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ABSTRACT

Stomachs from angler-harvested specimens of 259 largemouth bass, *Micropterus salmoides*, 263 spotted bass, *M. punctulatus*, and 256 smallmouth bass, *M. dolomieui* were collected from the mid-lake region of Bull Shoals Reservoir during March 1971 - February 1972. Stomach contents were compared on the basis of frequency of occurrence, weight, and seasonal distribution of food items.

Black basses were piscivorous in feeding habits during the summer and early autumn, with young of the year shad contributing substantially to the diets. Utilization of young shad by adult basses followed shad spawning by six to eight weeks.

During late autumn and in the spring, food habits of the three species varied. Largemouth bass stomachs contained primarily crayfish and centrarchids during the late autumn and crayfish, yearling shad and unidentified fish remains during the winter and spring months. Spotted bass fed primarily on crayfish throughout the period. Smallmouth bass stomachs contained centrarchids and crayfish during the late autumn and winter, and non-burrowing mayflies *(Stenonema* sp.) and unidentified fish during the spring.

Total black bass production in Bull Shoals during the twentieth year of impoundment appeared to be primarily dependent upon clupeid and crayfish availability.

INTRODUCTION

Largemouth bass, *Micropterus salmoides*, spotted bass, *M. punctulatus*, and smallmouth bass, *M. dolomieui* contribute substantially to the total sport fish harvest in Bull Shoals Reservoir. During 1971, angler harvest of these species constituted 45 percent of the 15 kilograms per hectare harvested (unpublished creel data). The coexistence of these closely related species in a reservoir environment has prompted study of the factors which permit their survival and relative abundance. The study of food habits represents one of several logical approaches for comparing the ability of these species to coexist in a reservoir.

In Bull Shoals Reservoir, the feeding relationships of young of the year black basses have been studied extensively (Applegate, Mullan, and Morais, 1967; Applegate and Mullan, 1967; and Mullan and Applegate, 1968). Food habits of a limited number of adult specimens have been discussed by Applegate and Mullan (op. cit.). These results indicated that adults of all three black bass species are largely piscivorous. This paper describes the food of angler-harvested black bass in Bull Shoals Reservoir. Temporal variations in feeding habits are considered, and possible competitive relationships are discussed.

DESCRIPTION OF RESERVOIR

Bull Shoals Reservoir, impounding the White River for some 140 kilometers in northern Arkansas and southern Missouri, is located downstream from Table Rock and Beaver Reservoirs. It is the oldest and largest of the major White River impoundments (Figure 1). At power pool elevation its dendritic configuration

encompasses an area of approximately 18,400 hectares, with a mean depth of 20.4 meters and a shore development of 24.8. Pertinent physicochemical characteristics have been reported by Mullan and Applegate (1965) and Mullan *et al.* (1970). During the period of study, pool elevation ranged from 199.1 meters (mean sea level) in May to 194.7 meters (msl) in November. Temperature in the upper 6 meters at mid-lake ranged from 5.5°C in March to 27.5°C in September. Secchi transparencies averaged 5.2 meters (range 2.7-7.7 meters).

METHODS AND MATERIALS

Specimens of angler-harvested largemouth, spotted and smallmouth bass were collected at the Highway 125 Boat Dock during the period March 1971 - February 1972 (Figure 1). The fish came from an area extending several miles uplake or downlake from the point of collection. Approximately 25 stomachs from each species were obtained monthly from March - December 1971. Fewer fish were collected during January and February 1972, and samples for these months were combined. Length and weight measurements were obtained for each specimen from March December 1971. Stomachs, including intestines and attached viscera, were removed and placed in one gallon jars containing formalin solution. Stomachs were separated into jars by species and by total lengths of either less than or greater than 410 millimeters (about 16 inches). Whenever possible, stomachs of each species were collected at the rate of approximately six per week so that collections were spread over the entire month. During the warmer months, May through September, many anglers place fish on ice as soon as they are caught. Attempts were made to use iced fish for stomach analysis during this period.

In the laboratory, stomach samples were washed to remove excess formalin. Stomachs were excised from the remainder of the viscera and placed in jars containing 10 percent formalin for subsequent analysis. In processing, each stomach was split longitudinally, and the food contents examined. Items in the stomach were separated to the lowest identifiable taxon and enumerated. Material from each taxon was drained and blotted, then weighed to the nearest .01 gram.

Comparisons of stomachs from fish either greater than or less than 410 millimeters indicated no significant difference in percent of stomachs with food. Stomachs from larger fish did tend to contain larger food items than those from smaller fish but values varied. Therefore, all stomachs from each month's collections were combined.

For comparing food habits of the three black bass species, food items were grouped into the following categories: shad (threadfin, *Dorosoma petenense* and gizzard, *D. cepedianum*); centrarchids (primarily longear sunfish, *Lepomis megalotis*, bluegill, *L. macrochirus*, and green sunfish, *L. cyanellus*); miscellaneous fish (mostly unrecognizable fish remains); crayfish and insects (aquatic and terrestrial).

RESULTS

Food habits

Largemouth bass. Of 259 largemouth bass stomachs examined, 47 percent contained food (Table 1). The largest proportion of stomachs containing food were collected in April and the smallest in November. The average weight and length of specimens collected during the period March - December 1971 was 0.90 kilograms and 384 millimeters, respectively. Largest specimens were collected during April and the smallest during November.

Crayfish were the most abundant food items encountered in largemouth bass stomachs (57 percent) when considered on an annual weight basis. Fish were numerically (58 percent) most abundant (Table 4). Crayfish were encountered

in stomachs throughout the year, but they occurred with greatest relative frequency during the late autumn, winter and spring (Figure 2). Shad were dominant in stomachs during the summer but occurred throughout the year. Young of the year shad entered the diet abruptly in July and were utilized heavily until October when consumption rapidly declined. This pattern was characteristic of all three black bass species. Centrarchids (mostly *Lepomis*) occurred in stomachs most frequently during late summer and autumn and appeared to follow shad in the pattern of seasonal utilization. Unidentifiable fish remains were encountered throughout the year. The frequency of occurrence of these remains combined with identifiable fish in stomachs suggests a predominantly piscivorous diet by the largemouth bass during much of the year. However, seasonal comparisons based on weight of food in stomachs indicate crayfish to be a major component of the diet except during the summer (Figure 3). Most crayfish found in stomachs were relatively large (mean weight 5.3 grams). Centrarchids (mean weight 8.9 grams) also contributed disproportionate amounts when considered as a percentage of total food ingested by weight. This reflects the use of larger *Lepomis* as food by adult largemouth bass.

Spotted bass. The 263 spotted bass stomachs examined contained a greater proportion with food (53 percent) than either the largemouth or smallmouth bass. The largest percentage of stomachs with food was found in July samples and the lowest in May (Table 1). The mean weight of spotted bass examined was 0.63 kilograms and mean total length 346 millimeters. The largest specimens were collected in April and the smallest in July. Those collected during cooler months tended to be larger than those obtained during the summer.

Spotted bass utilized crayfish to a greater extent than either largemouth or smallmouth bass (Table 2). Crayfish comprised the bulk of the food on an annual basis both by weight (79 percent) and total number of food items ingested (49 percent). As with largemouth bass, crayfish found in stomachs were usually large (mean weight 4.1 grams). They were the dominant food items encountered except during the summer and early autumn when young of the year shad dominated (Figures 2 and 3). Shad were found infrequently during the remainder of the year. Aquatic insects (*Stenonema* sp.) were found in some stomachs during the spring, but contributed little to the total weight of food obtained from stomachs during this period. Centrarchid consumption was lower than that observed for either largemouth or smallmouth bass and occurred during late summer and autumn. Identifiable centrarchids were relatively small (mean weight 2.9 grams). Unidentifiable fish remains comprised a substantial portion of the total number and weight of food items from spring through autumn. Of the three black bass species studied, however, spotted bass appeared the least piscivorous and were perhaps the most selective in their feeding habits.

Smallmouth bass. Of the 256 smallmouth bass stomachs examined, only 43 percent contained food (Table 1). The frequency of stomachs with food was greatest in July and smallest during late autumn and early winter. These were also the smallest of the three species (mean weight 0.56 kilograms and mean total length 344 millimeters). The largest specimens were collected during March and the smallest during July.

Smallmouth bass consumed fewer crayfish than either largemouth or spotted bass (Table 2). Fish were the dominant food items encountered in stomachs by weight (64 percent). Insects were numerically most abundant (70 percent). Crayfish, although occurring in stomachs throughout the year, were dominant in the diet of smallmouth bass only during midwinter (Figures 2 and 3). During the spring, naiads of a non-burrowing mayfly, *Stenonema* sp., were consumed in large numbers by adult smallmouth. They were small and contributed little to the total weight of food ingested. Large adult terrestrial insects were encountered infrequently in stomachs during the summer. These included

specimens of Coleoptera, Orthoptera and Hymenoptera. Yung of the year shad were major components of the diet during summer and early autumn (July - October). Centrarchids also contributed an increasing proportion of the diet from late spring through late autumn, particularly when considered on a weight basis. The mean weight of centrarchids (5.6 grams) taken from smallmouth stomachs was smaller than those obtained from largemouth stomachs. Unidentified fish remains occurred frequently in stomachs, particularly from late spring through autumn months. Their contribution as a fraction of total numbers and weight of foods ingested implies extensive utilization of fish by smallmouth bass during much of the year.

Feeding interaction

By sampling approximately equal numbers of fish each month from March through December 1971, and measuring occurrence frequency of major food items in stomachs, it was possible to compare relative use of food items by the different black bass species. Frequency of occurrence values, expressed as percentages, were transformed using an arcsin percentage transformation (Steel and Torrie, 1960), and use of each major food group, by predator species, was compared using a Duncan's multiple range test (Table 3). Shad, centrarchids and total fish consumption did not differ significantly ($P = .05$) between adults of the three basses examined, although smaller relative quantities of centrarchids and total fish were observed in spotted bass stomachs. The occurrence of crayfish was significantly higher in spotted than in smallmouth bass stomachs. Smallmouth bass consumed a significantly higher percentage of insects than largemouth bass.

DISCUSSION

When stomach contents are enumerated over a period of one year, digestion rate must be considered. Foods ingested during the summer months may be digested at rates 5-6 times those observed during the winter (Johnson and Charlton, 1960); (Molnar and Tolg, 1962). Differential digestive rates also present problems in stomach analysis. Crayfish, for example, are identifiable even when badly fragmented, and the thick integument slows digestive processes. Some food items, particularly small fish may lose identifying marks in a relatively short time after digestion begins. This problem, coupled with seasonal variations in digestion rates, can bias the relative importance assigned to different foods for total growth of the black bass species studied.

Adults of the three black basses consumed similar foods in Bull Shoals Reservoir, but there were seasonal differences. The three basses were piscivorous during the summer, but there were variations in the late winter and spring. Similarity of food habits appeared to be directly related to forage fish abundance. The gizzard and threadfin shad represent a major forage component in Bull Shoals Reservoir. They begin spawning from late April to mid or late May (Netsch, *et al.,* 1971). Upon reaching a threshold size for acceptance during July, young of year shad were preyed upon extensively by adults of all three black basses. In the autumn, shad consumption declined rapidly and other foods were substituted in the diet. Ivlev (1961) reported that preferred foods may be selected to a certain minimum density at which time there is a rather abrupt change to less desirable foods. Shad appeared to fit this pattern in Bull Shoals. However, this may also reflect a seasonal change in shad distribution. Winter midwater trawl samples on Bull Shoals indicate that shad move to deep, open water where they may occur in huge, relatively inactive schools (Houser, personal communication). Movement of shad away from areas inhabited by black bass species may also be important in the seasonal pattern of utilization.

Species of *Lepomis* were not heavily utilized when shad were abundant, particularly by largemouth and spotted bass. Cove rotenone samples from the mid-lake area of Bull Shoals in August 1971, indicated a standing crop of 36.2 kilograms per hectare of young of year and intermediate *Lepomis*. Lepomids appeared most frequently in stomachs collected during late autumn, however. Green sunfish, bluegill and longear sunfish are the most common sunfishes with the longear being most abundant. Bennett (1962) and Lewis and Helms (1964) have reported the bluegill to be a species of low vulnerability to largemouth and smallmouth bass in ponds in the midwest. Also, Viosca (1952) has reported low utilization of bluegill in a small lake in northwest Louisiana. In Bull Shoals, lepomids appear less vulnerable than shad to predation by black basses as their seasonal utilization follows that of shad.

Unidentified fish, combined with identifiable fish, reflect a heavy reliance of all three black bass species upon fish during the summer growing season and imply that fish contribute most of the energy required for growth of black basses in Bull Shoals Reservoir.

Crayfish were utilized most extensively during the cooler portions of the year, and may serve primarily as a winter maintenance food and contribute to gamete production, but little to actual growth of the black basses in Bull Shoals Reservoir. This seasonal pattern of crayfish utilization is somewhat surprising since they are considered by some workers to be highly vulnerable to predation by bass during warmer months (Lambou, 1961; Heman, *et al.*, 1969; Snow, 1971; and Taub, 1972). Many littoral areas of Bull Shoals Reservoir are composed of large, blocky, angular chert. Benthos samples have indicated crayfish to be closely tied to these substrates (South Central Reservoir Investigations, unpublished data). During warmer months, crayfish may be more active and better able to avoid predation in the rocky substrates. Reduced motility of crayfish during cooler portions of the year, and decreases in abundance of other forage items may render them more vulnerable to predation by bass. Winter utilization of crayfish indicates that these forms remain active throughout the year in Bull Shoals.

Motile forage species such as the gizzard shad and threadfin are capable of dispersal and active movement throughout the habitat of most warmwater predators in Bull Shoals Reservoir. Consumption of these forms by the black basses offers little insight into habitat preferences of the latter. However, comparative utilization of other less motile forage sources may offer behavioral insights. Adult smallmouth bass consumed large numbers of non-burrowing mayfly naiads (*Stenonema* sp.) in the early spring while spotted bass fed to a much greater extent on crayfish. Naiads of *Stenonema* sp. are distributed along rocky, windswept shoreline areas in Bull Shoals Reservoir, mostly at depths of less than 3 meters, South Central Reservoir Investigations, unpublished data. Crayfish, although inhabiting similar substrates appear to exhibit a wider vertical distribution. Smallmouth bass also consumed more terrestrial insects and shoreline inhabiting centrarchids than spotted bass during warmer periods of the year. This implies that smallmouth may forage more in the shallower littoral areas than does the spotted bass. Dendy (1946), and Hubbs and Bailey (1938) have reported differences in distribution of black bass species in other bodies of water and Dendy suggested that variations in vertical distributions of predator species may serve to reduce interspecific competition in a given body of water.

Largemouth bass appeared to be more ubiquitous feeders than either spotted or smallmouth bass. Specimens captured throughout the study were considerably larger than the other bass species and the increased size afforded them access to forage items not available to adults of the other two species. These size differences weaken any direct attempt to compare feeding behavior of largemouth bass with the other two bass species.

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Table 1. Number of specimens, mean weights and total lengths of largemouth, spotted and smallmouth bass collected from Bull Shoals Reservoir, 1971-72; percent of stomachs containing food and ranges for weights and total length in parentheses.

	Largemouth bass			Spotted bass			Smallmouth bass		
	No. specimens (% with food)	Mean weight kg (Range)	Mean length mm (Range)	No. specimens (% with food)	Mean weight kg (Range)	Mean length mm (Range)	No. specimens (% with food)	Mean weight kg (Range)	Mean length mm (Range)
March	24 (46)	.94 (.31-2.16)	384 (275-525)	25 (52)	.73 (.43-1.42)	365 (320-435)	25 (28)	.73 (.31-1.28)	377 (295-450)
April	24 (71)	1.33 (.40-3.32)	420 (300-570)	25 (68)	.84 (.37-1.48)	380 (300-455)	25 (64)	.55 (.23-1.02)	338 (365-420)
May	24 (46)	.86 (.37-3.09)	384 (305-575)	25 (28)	.58 (.37- .99)	345 (310-390)	25 (44)	.64 (.25-1.53)	358 (280-480)
June	25 (40)	.83 (.34-1.59)	389 (305-490)	25 (56)	.54 (.23- .90)	331 (260-390)	25 (40)	.67 (.23-1.08)	372 (270-435)
July	25 (48)	.87 (.37-2.58)	383 (305-565)	25 (92)	.39 (.23- .91)	299 (255-395)	25 (72)	.33 (.17- .82)	292 (240-405)
August	25 (64)	.95 (.26-3.86)	384 (280-640)	25 (56)	.59 (.26- .97)	340 (265-405)	24 (38)	.56 (.28-1.33)	339 (280-490)
September	25 (48)	.84 (.37-1.65)	381 (290-475)	24 (63)	.67 (.31-1.28)	351 (280-460)	25 (60)	.43 (.26- .77)	316 (265-370)
October	25 (56)	.83 (.28-2.16)	380 (290-520)	25 (48)	.62 (.31-1.22)	343 (290-440)	25 (40)	.57 (.37- .85)	352 (310-410)
November	25 (40)	.70 (.23-1.48)	363 (270-515)	23 (48)	.68 (.34-1.33)	349 (280-440)	25 (20)	.65 (.43-1.19)	358 (310-440)
December	25 (24)	.84 (.26-2.95)	374 (280-570)	25 (48)	.70 (.40-1.45)	357 (310-440)	25 (32)	.51 (.26- .86)	337 (290-400)
January February	12 (33)	-	-	16 (31)	-	-	7 (14)	-	-
Total	(259) (48)	.90 (.23-3.86)	384 (270-640)	263 (54)	.63 (.23-1.48)	346 (255-460)	256 (43)	.56 (.23-1.53)	344 (240-490)

Table 2. Total number and wet weights of food items collected from stomachs of adult largemouth, spotted and smallmouth bass, Bull Shoals Reservoir, March 1971 - February 1972.

Food item	Largemouth bass		Spotted bass		Smallmouth bass	
	Number	Weight in grams	Number	Weight in grams	Number	Weight in grams
Shad	54	82.3	60	102.4	36	41.7
Centrarchids	13	115.9	3	8.8	12	67.2
Misc. Fish	35	64.2	30	41.1	41	50.9
Crayfish	73	348.4	113	464.4	24	66.5
Insects	1	t	25	11.0	266	22.1
Total	176	610.8	231	627.7	379	248.4
Mean weight of food item in gram	3.5		2.7		0.7	

Table 3. Relative utilization of major food items by three black bass species in Bull Shoals Reservoir, based on frequency of occurrence of food items in stomachs. Values represent arcsin$\sqrt{\text{percentage}}$. Values in any column not followed by the same letter differ significantly (P = .05).

	Food items				
	Shad	Centrarchids	Total fish	Crayfish	Insects
Largemouth bass	16.5 a	10.2 a	31.7 a	25.1 ab	6.3 b
Spotted bass	16.5 a	7.4 a	27.0 a	31.5 a	10.1 ab
Smallmouth bass	14.2 a	12.0 a	31.4 a	16.9 b	15.2 a

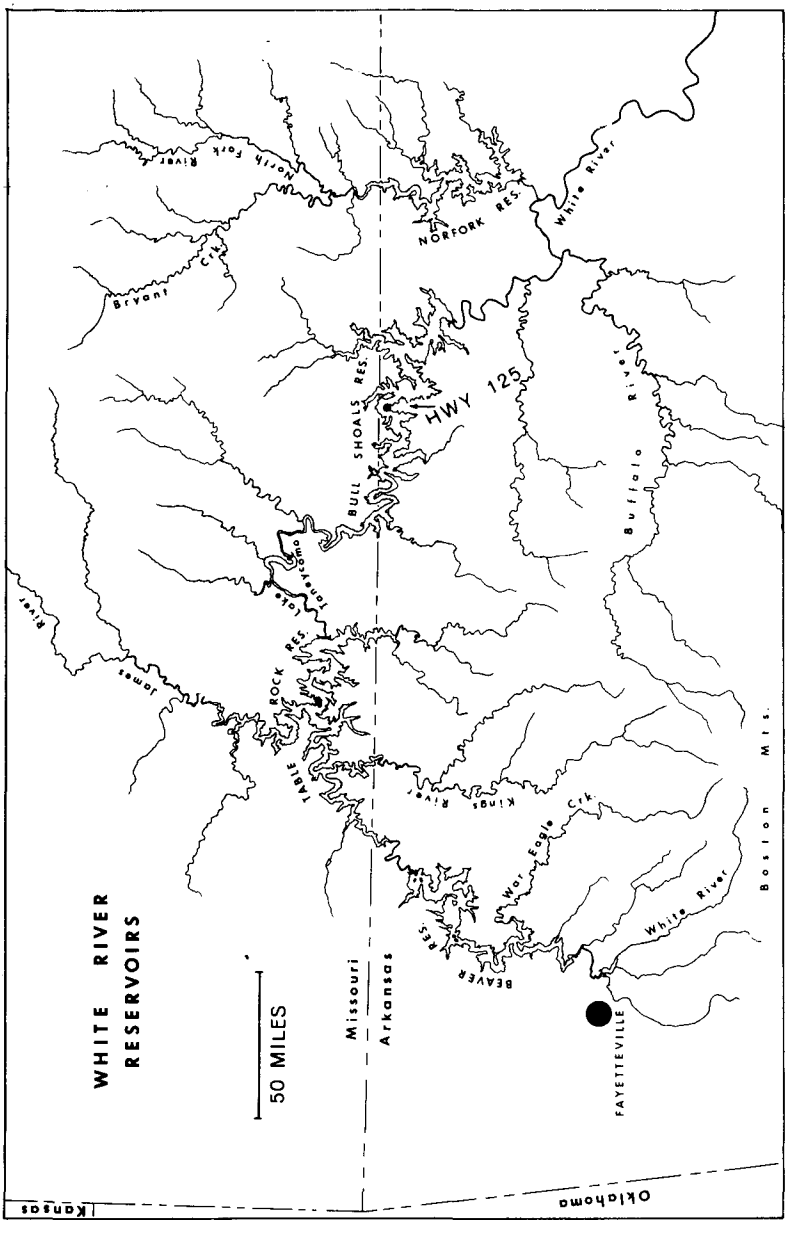

Figure 1. Major main stem White River impoundments showing Bull Shoals Reservoir and location of Highway 125 Boat Dock, the sampling area.

Figure 2. Seasonal distribution of major food items in stomachs of black bass species, Bull Shoals Reservoir, 1971-72, expressed as percent of frequency of occurrence in stomachs containing food; number of stomachs with food indicated by season and species.

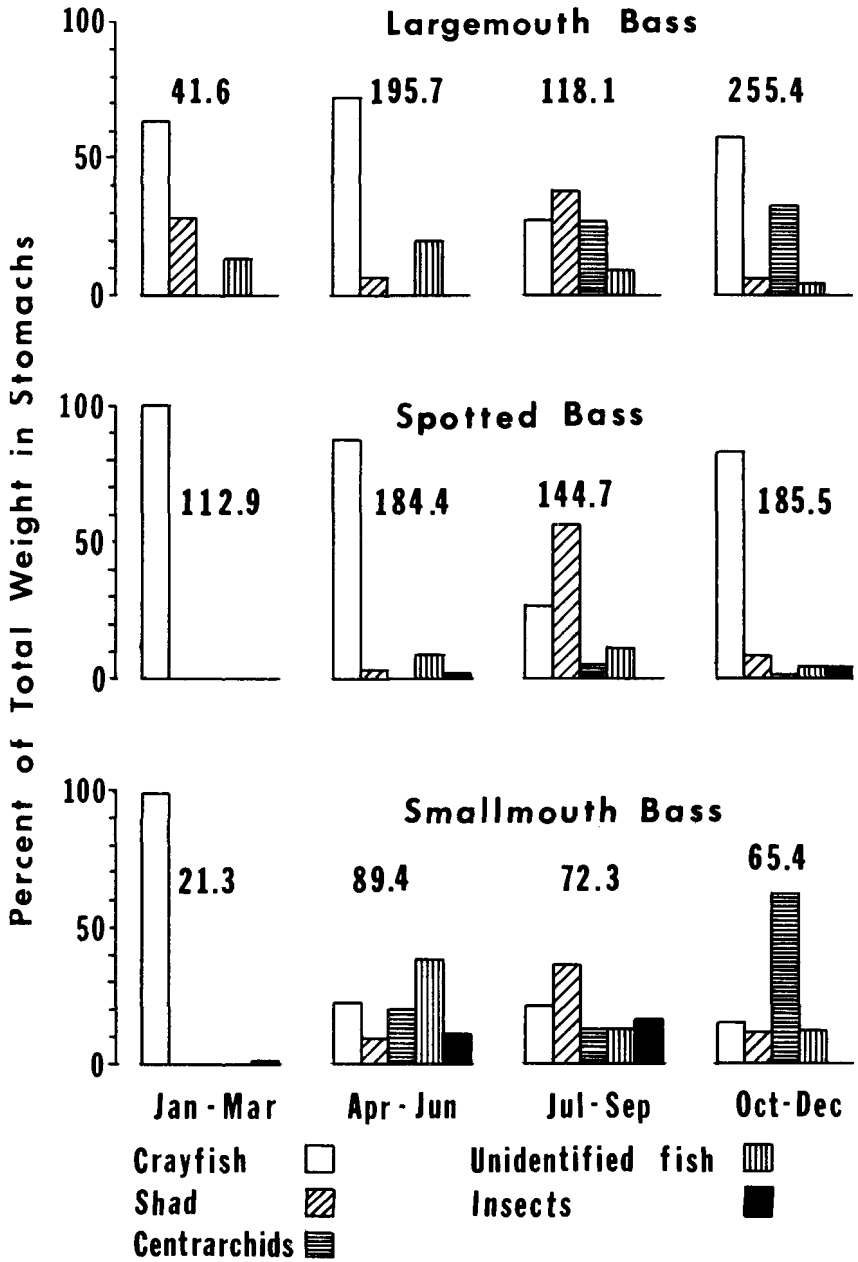

Figure 3. Seasonal distribution of major food items in stomachs of black bass species, Bull Shoals Reservoir, 1971-72, expressed as percent of total weight of food in stomachs by seasons; total weight of food in stomachs indicated by season and species.