ANALYSIS OF PREY SELECTION IN CHAIN PICKEREL

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Abstract: Chain pickerel (*Esox niger*) in Lake Conway consumed progressively more fish with increase in size. A shift also occurred in size, species composition, and relative abundance of fish prey with chain pickerel size. An index of selection was applied to food habit data. There was an increase in number of species and an increase in size of species that were positively selected as chain pickerel size increased. Size, rather than abundance of forage fish was the dominant influence on prey selection.

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Early theories of feeding ecology by fishery biologists were based on the simplifying assumption that predation rates were proportional to the food supply (Ware 1972). Such attempts have met with little success in forecasting the outcome of predation in aquatic habitats. The importance of predator-prey relationships and their effect on natural systems has been only recently evaluated (Carver et al. 1976). Knowledge of food selectivity by predators is essential to evaluating the competition that may occur between species and in providing a scientific basis for management of the forage base.

Abundant literature has accumulated on the food and feeding habits of most sport fish predators. Unfortunately, most observations were made without accompanying evaluations of predator-prey relationships. A casual comparative analysis between chain pickerel dietary data presented in Guillory (1979) and fish population data in Lake Conway revealed that the proportion of prey varied between the two data sets. With this in mind, food habit data were further analyzed to define and identify possible factors influencing prey consumption and, if present, prey selection by chain pickerel. The purpose of this paper is to report on these findings.

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MATERIALS AND METHODS

This study was conducted from June 1976 to August 1977 in the Lake Conway system, Orange County, Florida. This complex was described earlier in a series of reports (see Guillory 1979) on the Lake Conway project.

A minimum of 20 chain pickerel was obtained monthly with seine or electorshocker. A total of 521 fish was collected for food habiat analysis. Each fish was weighed and measured (mm SL) and stomach contents immediately identified, enumerated, and, where possible, weighed to the nearest 0.01 g. Food habit data were stratified with respect to 4 major size groups: 51-100 mm; 101-200 mm; 201-300 mm; and above 300 mm. Common names of fishes follow Bailey (1970).

An index of selection, termed electivity by Ivlev (1961), was employed to determine if chain pickerel were selective in their feeding. This index compares the abundance of a food item in the environment to that in the stomachs and is calculated according to the following formula:

$$E = (R_i - P_i)/(R_i + P_i),$$

where R_i is the proportion of species i in the diet of chain pickerel and P_i is the proportion of the same species found in the environment. Values range from +1 to -1, with positive values indicating selection "for" an item, zero indicating that the prey species was taken in direct proportion to its abundance in the field, and negative values reflecting selection "against" the species.

To identify possible differential prey selection with chain pickerel size, electivity indices were calculated for the previously delineated size groups.

Several points must be clarified at this time. First, the analysis was restricted to fishes because this was the only group of organisms for which population estimates existed. Second, unidentified fish were not included in electivity determinations because it was assumed that each species was represented in the unidentified category in the same ratio and that remains could be recognized with equal facility. Third, the abundance of each prey species in the field was derived from averaging their overall percentages in rotenone-blocknet and Wegener ring (Wegener et al. 1973) samples. While other techniques (i.e. seine, electroshocker, gill net) were used to sample fish for other purposes, the methods selected were chosen because both are quantitative and the techniques complement each other with respect to habitats sampled. Three 0.41 ha blocknet-rotenone samples were taken in May 1976, in October 1976, and in May 1977. A total of 12 Wegener ring samples were taken monthly from May 1976 to August 1977.

A number of terms used in this paper which are subject to varying interpretations will be defined here. "Consumption" describes the simple ingestion of prey by chain pickerel. "Selectivity" is defined as the extent to which chain pickerel eats one size or species of prey rather than another. "Electivity," as defined earlier, is a quantitative measure of selection. "Preference" is the inherited, instinctive desire to consume a given food item. "Accessibility" is the measure of the degree of difficulty in feeding upon a specific food item. "Abundance" refers to the density of prey.

RESULTS

The general sequence of major food groups with respect to chain pickerel size is shown in Fig. 1. The general trend is a progression from zooplankton to macroinvertebrates to fish. Zooplankton dominated in 25-50 mm fish but declined thereafter and was absent in chain pickerel larger than 75 mm. Macroinvertebrates closely followed zooplankton in 25-50 mm fish, dominated in 50-125 mm chain pickerel, declined and disappeared by the 175-200 mm size group, and reappeared again in small numbers in chain pickerel large than 300 mm. The sequence of dominant macroinvertebrates was as follows: aquatic insects (Culicidae, Chironomidae, Gomphidae, Trichoptera), 25-50 mm; *Hyalella,* 50-75 mm; *Palaemonetes,* 75-175 mm; and *Procambarus*, 300 mm and up. As chain pickerel incrased in size fish were encountered more frequently until they became dominant in the 135-150 mm size class. Mature individuals were almost exclusively piscivorous.

Since consumption and selection of prey fish by chain pickerel is the primary emphasis of this report, only piscine fod items will be discussed hereafter. Size variation in percentage empty stomachs, percentage stomachs containing fish, average number of fish, average weight of fish, and number of species in chain pickerel stomachs is depicted in Fig. 2. Average weight and percentage empty stomachs displayed an increase with chain pickerel size whereas the number of prey showed a slight decrease in the largest fish. Small chain pickerel thus consume smaller, but larger numbers of fish. The decrease in total number of species in the 3 largest size groups of chain pickerel is partly attributed to the examination of fewer numbers of stomachs in those size classes. The graph of percentage stomachs containing fish is at first misleading. The initial increase is due to increased fish utilization with chain pickerel size. However, at the same time percentage empty stomachs began to increase and caused a corresponding decrease in percentage stomachs containing fish despite an increase in the percentage utilization of fish (see Fig. 1); in essence, larger chain pickerel tend to feed less often than smaller individuals but when they do, fish are usually consumed.

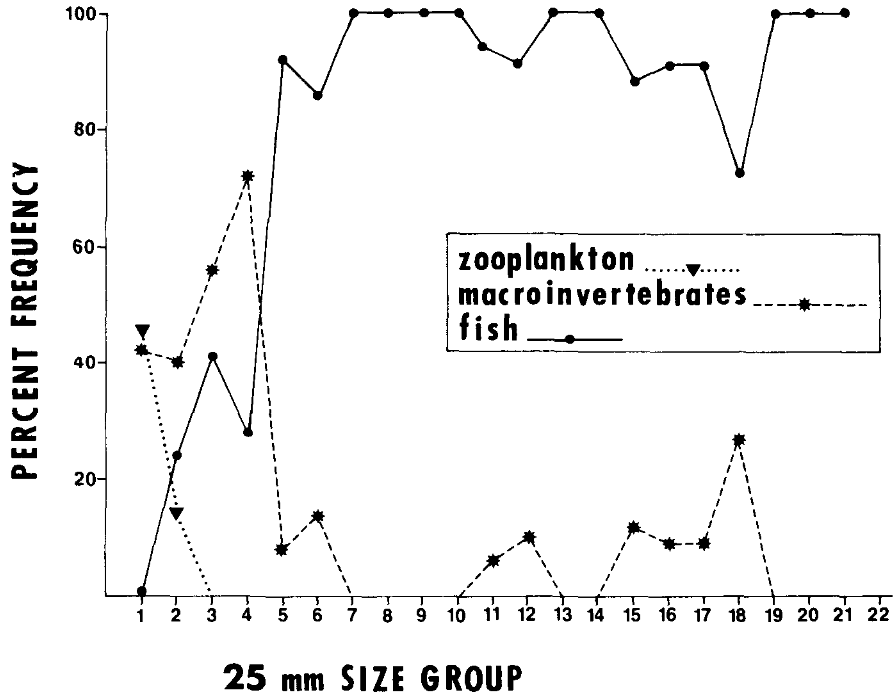

Fig. 1. Ontogenetic progression in consumptum of zooplankton, macroinvertebrates, and fish in Lake Conway chain pickerel (1 = 25-50 mm; 2 = 51-75 mm; .... 22 = 551-575 mm).

To further illustrate variations in consumption of fish food items with chain pickerel size, percentages of prey in four size groups are presented in Table 1. An obvious trend in food habitat data is the shift in both species composition and relative abundance of prey with chain pickerel size where small chain pickerel tend to consume smaller prey species than do large chain pickerel. No fish were encountered in chain pickerel smaller than 50 mm. In the next size group (51-100 mm), 6 species plus post-larval fish were found. Post-larval fish, with 69.4% of the total, and mosquitofish, bluespotted sunfish, and swamp darter with 4.8%, 3.2%, and 3.2%, respectively, were most common. Eight identified species plus a *Lepomis* were contained in 101-200 mm chain pickerel, with the most abundant species being, in order, mosquitofish, bluefin killifish, brook silverside, and bluespotted sunfish. Chain pickerel 201-300 mm in size contained 9 species; most abundant prey were *Lepomis* sp., bluefin killifish, swamp darter, and largemouth bass. The largest chain pickerel (above 300 mm) consumed 13 different speices, with the 4 most common species being brook silverside (12.8%), bluegill (8.6%), threadfin shad (7.8%), and redear sunfish (5.7%). Collectively, *Lepomis* spp. comprised 32.8% of the total. Three species (threadfin shad, brown bullhead, lake chubsucker) were found only in pickerel above 300 mm. Pooling all size groups, brook silverside, bluespotted sunfish, bluegill, bluefin killifish, threadfin shad, largemouth bass, and redear sunfish were the most frequently eccountered identified food items. However, post-larval fish and *Lepomis* sp. (probably a composite of warmouth, redear sunfish, and bluegill) were more abundant than any of the above species. A total of 16 species was identified.

The results presented thus far have been concerned with what chain pickerel utilized and have indicated nothing of the relative abundance of various prey species in the

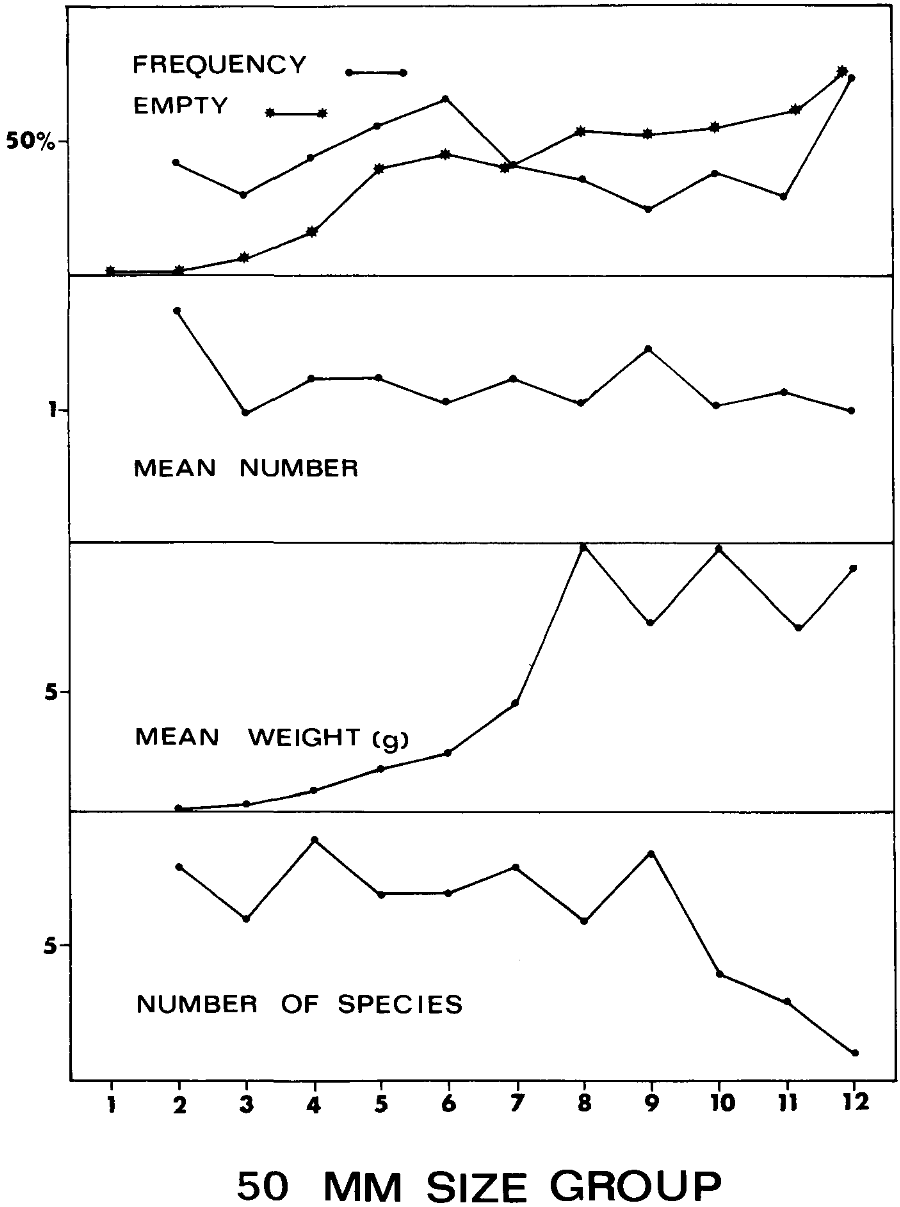

Fig. 2. Ontogenetic progression in percent empty stomachs and in percent frequency, mean number, mean weight, and total number of species of fish in Lake Conway chain pickerel (1 = 0-50 mm; 2 = 51-100 mm; .... 12 = 551-600 mm).

TABLE 1. Variation in percent number (No.) and frequency of occurrence (F) of fish with respect to chain pickerel size.

Species	50-100 mm		101-200 mm		201-300 mm		>300 mm		Total	
	No.	F	No.	F	No.	F	No.	F	No.	F
threadfin shad	----	----	----	----	----	----	7.8	----	4.0	.7
golden shiner	1.6	1.2	----	----	----	----	1.4	.6	1.1	.6
coastal shiner	----	----	17.4	8.7	----	----	----	----	1.4	.7
brown bullhead	----	----	----	----	----	----	.7	.3	.4	.2
lake chubsucker	----	----	----	----	----	----	.7	.3	.4	.2
golden topminnow	----	----	4.4	2.2	----	----	----	----	.4	.2
Seminole killifish	----	----	4.4	2.2	3.9	2.8	2.8	1.2	2.5	1.3
bluefin killifish	11,3	7.3	13.0	6.5	7.8	4.2	.7	.3	5.4	2.4
mosquitofish	4.8	3.6	17.4	4.3	----	----	----	----	2.5	.6
brook silverside	----	----	13.0	6.5	3.9	2.8	12.8	1.8	8.3	2.0
bluespotted sunfish	3.2	2.4	8.7	4.3	5.9	4.2	1.4	.6	5.4	1.7
warmouth	1.6	1.2	4.4	2.2	3.9	2.8	2.1	.9	2.2	1.1
bluegill	----	----	----	----	3.9	2.8	8.6	3.3	5.4	2.6
redear sunfish	----	----	----	----	2.0	1.4	5.7	2.4	3.3	1.7
largemouth bass	----	----	----	----	7.8	4.9	2.8	1.2	2.9	1.8
Lepomis sp.	----	----	4.4	2.2	9.8	7.0	16.4	6.9	10.5	5.4
swamp darter	3.2	2.4	----	----	7.8	4.2	.7	.3	2.5	1.1
post-larval fish	69.4	12.2	----	----	----	----	----	----	15.6	1.8
fish remains	4.8	3.6	13.0	6.5	43.1	31.0	35.0	14.0	27.9	13.9

environment. Numerical abundance of all fishes collected by blocknet and Wegener ring is summarized in Table 2. Combining both methods, 3 species dominated (bluespotted sunfish, mosquitofish, and bluefin killifish), followed by largemouth bass, Seminole killifish, coastal shiner, redear sunfish, and bluegill. A total of 26 species was collected by these 2 methods. An additional 9 more uncommon species (longnose gar, bowfin, American eel, redfin pickerel, white catfish, channel catfish, Everglades pgymy sunfish, redbreast sunfish) were collected via other methods or observed in commercial fishermen catches.

Although chain pickerel consumed certain species more often than others, this does not necessarily imply that chain pickerel were selecting these fishes from the forage base. Food selection can only be measured by comparing the abundance of a food item in stomachs and in the field. Only if the relative abundances are different can it be concluded that selective processes are operative.

Electivity values for prey species in 4 chain pickerel size groups are found in Table 3. Fish were not encountered in 25-50 mm chain pickerel; consequently, this size group was omitted from the table. An index value of -1.00 indicates that the species in question was absent in stomachs in that size group. Four species (golden shiner, bluefin killifish, warmouth, and swamp darter) were positively selected by 51-100 mm chain pickerel. In the next size group (101-200 mm), coastal shiner, golden topminnow, Seminole killifish, bluefin killifish, brook silverside, and warmouth were selected "for". Brook silverside, swamp darter, warmouth, largemouth bass, bluegill, Seminole killifish, redear sunfish,

TABLE 2. Average number per sample and percent and combined percent of fishes collected by blocknet and Wegener ring.

	blocknet		wegener ring		combined
	No.	%	No.	%	%
Florida gar	.6	.01	.1	.05	.03
gizzard shad	1.4	.01	---	---	.01
threadfin shad	156.3	.42	---	---	.21
chain pickerel	135.6	.37	.1	.05	.21
golden shiner	4.4	.01	---	---	.01
coastal shiner	55.3	.15	1.4	6.56	3.36
lake chubsucker	.6	.01	---	---	.01
yellow bullhead	.8	.01	---	---	.01
brown bullhead	223.6	.61	.1	.14	.37
tadpole madtom	1.9	.01	---	---	.01
golden topminnow	---	---	.4	1.68	.84
Seminole killifish	91.1	.25	1.8	8.53	4.39
flagfish	2.8	.01	.1	.24	.12
bluefin killifish	1,593.7	4.33	5.2	24.82	14.58
mosquitofish	---	---	9.1	43.51	21.76
least killifish	15.3	.04	.2	1.20	.57
brook silverside	50.2	.14	.1	.05	.08
bluespotted sunfish	27,247.3	74.01	.3	1.58	37.79
warmouth	602.6	1.64	.2	1.15	1.39
bluegill	1,494.8	4.06	.3	1.49	2.77
dollar sunfish	117.0	.32	.1	.05	.18
redear sunfish	1,313.8	3.57	.5	2.54	3.05
spotted sunfish	---	---	.1	.65	.02
largemouth bass	3,592.5	9.76	.3	1.20	5.48
black crappie	87.8	.24	---	---	.12
swamp darter	27.7	.08	1.1	5.22	2.65

and bluefin killifish were positively selected by 201-300 mm fish. The largest chain pickerel (above 300 mm) selected "for" 10 species.

Several trends are evident from the progression of electivity indices with chain pickerel size. First, there was a steady increase in number of species selected "for". While probably related to the overall increase in utilization of fish as chain pickerel became larger, it may also be an indication of increased selectivity with size. The diet of small chain pickerel (less than 200 mm) was more strongly correlated with prey abundance than in the largest chain pickerel (above 300 mm); the correlation coefficient was +0.50 for the former and -0.04 for the latter. Allen (1941) found that the number of individual Atlantic salmon exercising selection increases with size. Second, selection by smaller chain pickerel was biased towards smaller species such as bluefin killifish, golden topminnow, and coastal shiner. Conversely, the majority of species (e.g. warmouth, bluegill, redear sunfish, and largemouth bass) showing an increase in electivity values with chain pickerel size were large species. Third, only warmouth were positiviely selected by all size groups,

TABLE 3. Electivity values of prey species with respect to various chain pickerel size groups.

	51-100 mm	101-200 mm	201-300 mm	>300 mm
threadfin shad	-1.00	-1.00	-1.00	±.97
golden shiner	+.99	-1.00	-1.00	+.99
coastal shiner	-1.00	+.72	-1.00	-1.00
brown bullhead	-1.00	-1.00	-1.00	+.65
lake chubsucker	-1.00	-1.00	-1.00	+.99
golden topminnow	-1.00	+.72	-1.00	-1.00
Seminole killifish	-1.00	+.09	+.32	+.15
bluefin killifish	+.50	+.04	+.07	-.81
mosquitofish	-.07	-.02	-1.00	-1.00
brook sivlerside	-1.00	+.98	+.98	+.99
bluesoptted sunfish	-.50	-.56	-.50	-.85
warmouth	+.38	±.58	+.71	+.52
bluegill	-1.00	-1.00	+.50	+.73
redear sunfish	-1.00	-1.00	+.15	+.59
largemouth bass	-1.00	-1.00	+.51	+.04
swamp darter	+.65	-1.00	+.73	-.29

whereas bluespotted sunfish was the only fish to be negatively selected by all chain pickerel. Finally, although not encountered in every size group, threadfin shad, coastal shiner, brown bullhead, lake chubsucker, golden topminnow, brook silverside, and bluegill were strongly selected whenever available (when found in stomachs).

In general, the electivity values also show that selection is "for" rather than "against" most fish. Disregarding species not consumed by chain pickerel in each size group (those with an electivity value of -1.00), the number of prey species with positive selection values greatly outnumbered those with negative values. Moreover, of a total "forage pool" of 35 species in Lake Conway, only 16 were selected for consumption by chain pickerel.

DISCUSSION

Ivlev (1961), in his classic work on feeding ecology of fish, concluded that the phenomenon of selectivity is a function of characteristics of both predator and prey that operate simultaneously. Selection is based on the sum total of 2 broad interrelated factors: (1) the preference shown by the predator to consume one size or species of prey rather than another; and (2) the degree of prey accessibility. Inherent predator preference is influenced by predator size, prey density, degree of satiation, available feeding opportunities, and conditioning. Accessibility of prey is affected by population density, size, mobility, degree of utilization of shelter, protective coloration, presence of armament or spines, and character of prey distribution.

The efficiency which a predator collects its food is an important factor governing its success in competition with other species in its trophic level. Selection can normally be expected only if the energy lost due to not utilizing other resources is negligible in comparison to that gained by specializing (McArthur and Levins 1964). According to the optimal foraging theory, a predator will feed in a manner which will produce an optimum reward for the amount of energy expended.

There is some disagreement in the literature as to whether the chain pickerel feeds selectively or randomly based on relative abundance of prey. Wich and Mullan (1958) reviewed the available literature on this species and concluded that food consumption seemed to be based more on relative abundance and/or ease of capture of prey species rather than an innate preference for one species over another. For example, Raney (1942) presented data showing that large chain pickerel are lazy feeders and prefer slow moving prey, such as brown bullheads, irrespective of their abundance. In Virginia the abundance of prey was the apparent determining factor in prey consumption by chain pickerel (Lewis 1971). According to Dejean (1954), large individuals preferred harvestable bluegills in Alabama farm ponds. Among other esocids, there appears to be a broad range of predator-prey relationships from those based solely on a critical size-relationship between predator and prey to those where consumption is based on relative abundance, and to a more definite association between the 2 where selection is influenced by mechanisms other than abundance (Crossman 1962; Mauck and Coble 1971).

Unfortunately, no chain pickerel food habit studies either mentioned in the previous paragraph or reviewed employed a quantitative index of selection or experimentally investigated selection. However, in Oklahoma grass pickerel, Ming (1968) used Ivlev's index and found that prey selection varied with pickerel size. The smallest grass pickerel strongly selected darters (*Etheostoma*), mosquitofish, topminnows (*Fundulus* sp.), chubsuckers (*Erimyzon* sp.), and grass pickerel, whereas the largest individuals showed a slight positive selection only towards centrarchids, darters, and cyprinids. Three studies have investigated prey selection in northern pike under controlled laboratory conditions. Beryle and Williams (1968) found that northern pike chose soft-rayed species such as golden shiner, fathead minnow, and lake chubsucker over spiny-rayed centrarchids and yellow perch, and the latter group over bullheads. Prey were divided into 3 levels of vulnerability by Mauck and Coble (1971): high (gizzard shad, carp, bigmouth buffalo, fathead minnow, and smallmouth bass); intermediate (white sucker, green sunfish, largemouth bass, golden shiner, and yellow perch); and low (channel catfish, northern pike, bluegill, and black bullhead). Weithman and Anderson (1977) reported that vulnerability to esocid predation was highest for gizzard shad, goldfish, and golden shiners, intermediate for bluegills and largemouth bass, and lowest for channel catfish.

The use of Ivlev's index of selection under natural conditions has been questioned by several workers. Borutskii (1960) pointed out that the forage base consists of an infinite variety of combinations, proportions, and aggregations and that the constant changes in the forage base resulting from the selective consumption of certain components and the extreme liability of the interrelationships impede a clarification of forage utiliztion by predators. Obrien and Vinyard (1974) felt that the selectivity imposed by the field sampling methods may be such that an apparent positive selection by a predator for a given prey species may be in acutality due to a negative sampling bias. Further, fish are distributed in a nonrandom, clumping pattern and "average prey density" as determined by sampling methods is largely an abstraction. Recent analysis by Strauss (1979) has indicated that the index is neither unbiased nor relatively independent of sample size. Rather, the statistical reliability is dependent upon both the absolute and relative sample size (stomach and field) as well as the relative rarity or abundance of the prey in the environment. Another shortcoming of selection indices is that predator preference cannot be separated from prey accessibility (Beryle and Williams 1968). Indeed, a clear distnction between these 2 categories is impossible, as one and the same feature may influence simultaneously both the preference for, and the accessibility of, a particular food item (Ivelev 1961).

In light of the above criticisms, it would appear prudent to derive condlusions from Ivlev's index only after copious deliberation and with extreme caution. However, realizing the shortcomings inherent via his index, a quantitative approach to defining an ecological relationship such as prey selection is usually superior to a nonquantitative one, where subjectivity or bias often prevails. As pointed out by Dr. James Mitchell in the Symposium on Predator-Prey Systems in Fish Communities and their role in Fisheries Management (see SFI Bull. No. 298, Sept. 1970), the broad classification of a fish as being either selective or opportunistic is misleading and the best approach would be to quantify the degree of selectivity.

An attempt will now be made to analyze factors influencing prey consumption and/or selection by chain pickerel. A number of biological and physical attributes were listed earlier which influence prey selection by predators. Unfortunately, most are impossible to verify or quantify in nature and this discussion will largely be restricted only those those parameters for which data exists.

Perhaps the most obvious feature in chain pickerel feeding habits is the shift is species composition and abundance of prey with progression of size. Every predator is adapted to feeding on particular food items; however, these adaptions do not remain constant throughout their life span. Ontogenetic changes in the feeding and digestive organs correspons to shifts in the species composition and relative abundance of ingested prey. This may be an adaptation towards increasing the range of the food supply, enabling the species as a whole to assimilate a variety of foods. Pooling all fish species into a single category, the proportion of fish in the diet of chain pickerel increases until mature fish over 300 mm are almost exclusively pisciverous. In general, consumption and selection is biased toward species such as bluefin killifish, bluespotted sunfish, mosquitofish, and golden topminnow in smaller chain pickerel and towards centrarchids, in particular *Lepomis*, in larger individuals.

The above changes in chain pickerel diet with maturity are also related, in part, to prey size. As described previously, chain pickerel in Lake Conway ingest progressively larger fish prey. Obviously, species dominating in smaller chain pickerel are smaller than the major prey of larger chain pickerel. Indeed, it is a general rule that with increased predator size the size of the prey also increases (Borutskii 1960; Ivlev 1961). Predators prefer prey of a definite size, usually consuming species of the largest size compatible with their morphological features. In the case of the chain pickerel, Lawrence (1960) determined that the species can swallow fish whose body depth is equal to, or less than, its own body depth when the abdomen is distended. Differential prey consumption and selection based on size or weight may be explained by the reinforcement of optimal food reward and, possibly, by visual mechanism principles. Assuming equal accessibility, the ratio of effort expended to energy received in consumption of prey would be greater in larger prey, resulting in positive reinforcement for selection of large specimens. Hester (1968) demonstrated that for visual predators large conspicuous objects stand a high risk of discovery and that predator reactive distance and prey size is possibly related. Ware (1972) found a strong positive correlation between the size of individual prey offered to rainbow trout and the distance from which they were approached (reactive distance) by fish.

The relationship between prey abundance and their occurrence in chain pickerel stomachs will also be examined. A prey selection based primarily on relative abundance would result in a convergence of electivity values toward 0; however, in my study only 9 values out of a possible 48 were within the bonds +0.30 to -0.30, implying that prey selection is not strongly related to abundance of prey. As presented earlier in the results, small chain pickerel stomach contents were only weakly correlated ($r = +0.50$) with prey abundance whereas in larger specimens no relationship existed ($r = 0.04$). My data were similar to those of Mauck and Coble (1970), who found that northern pike continually selected a particular species despite the decrease in relative abundance of the preferred form as consumption decreased its numbers while the numbers of other prey remained constant. Ivlev (1961) concluded that with increased forage density increased selectivity for positively selected forms resulted, as well as a constant index of 0 for neutral components, and a drop in the selectivity of species that were initially negatively selected.

Lest it be misunderstood that abundance of prey has no influence on chain pickerel consumption, the following clarification is offered--that is, while selection of prey from the "pool of species" that were found in stomachs had no strong correlation with prey abundance, as a group the 16 species consumed by chain pickerel were the most common ones in Lake Conway. An additional 19 species were rare or uncommon in Lake Conway and were unknown from chain pickerel stomachs. My data merely imply that, of species consumed by chain pickerel, relative abundance appears to have little influence on selection.

Other influences on prey selection by predatory fish will be briefly mentioned (Bortutskii 1960; Ivlev 1961). An increase in the overall population density of the prey population or progressive satiation of the predator will lead to an increase in the selectivity of preferred forms. The probability of prey capture by a predator is proportional to the degree of shelter utilized by the prey. A uniform increase in the aggregation of certain food components results in a greater divergence of electivity values while preserving the general tendency observed in the case of uniform distribution of prey. Protective armament, such a ictalurid spines, reduces the vulnerability, and hence decreases selection pressure of prey.

The importance of predation as a force controlling the species composition of forage fish communities and its use in the development of predictive models for future species introductions or related fish management practices has been approached quantitatively only recently. Introduction of predators to achieve better balance in fish communities and to improve the quality of the fishery should proceed only after an evaluation of selectivity toward the forage pool. The use of an index of selection, while subject to some shortcomings and criticism, could be valuable in developing predator prey combinations in ponds or reservoirs, in selecting predators to control undesirable or overcrowded forage species, or in encouraging the buildup of highly vulnerable and selected forage. In the case of the chain pickerel, the species may prove beneficial in farm pond management, where suitable stocking combinations that ensure optimal balance over a sustained period has been sought for many years. The selectivity of chain pickerel towards *Lepomis* spp. in general may help alleviate the problem of overcrowding because of insufficient predation pressure with the use of the traditional largemouth bass as the sole predator. For instance, Panek (1978) reported that after chain pickerel were stocked in a New Jersey pond, there occurred a decrease in the bluegill population, an increase in the standing crop of largemouth bass, and a resultant increase in the potential harvestability of the fish population. Weithman and Anderson (1977), however, cautioned that stocking of esocids could adversely affect the balance of fish communities. The use of chain pickerel in stocking combinations and the use of selection indexes in predator-prey relationships are worthy of further investigations.

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