# FOOD HABITS OF JUVENILE MARINE FISHES: EVIDENCE OF THE CLEANING HABIT IN THE LEATHERJACKET, *OLIGOPLITES SAURUS*, AND THE SPOTTAIL PINFISH, *DIPLODUS HOLBROOKI*

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## ABSTRACT

Quantitative gravimetric analyses of stomach contents of juvenile leatherjacket, *Oligoplites saurus*, and spottail pinfish, *Diplodus holbrooki*, have revealed that both species pass through a stage in which they clean ectoparasites from other fishes. This cleaning stage is most evident in juveniles between 26 and 40 mm standard length and is far less evident among juveniles of larger or smaller size. These findings represent the first report that cleaning is practiced by either species and the first quantitative data on the significance of the cleaning habit to members of the Family Carangidae and Family Sparidae. Neither *O. saurus* nor *D. holbrooki* depend exclusively on cleaning as a source of food. Juveniles of *O. saurus* feed heavily on plankton and small shrimp whereas juveniles of *D. holbrooki* feed heavily on epiphytic algae, plankton, and encrusting organisms. Juveniles of both species exhibit distinct changes in diet during growth.

The important role of the estuarine zone in providing nursery areas utilized by the juvenile stages of a large number of marine fishes is now well documented (Sykes and Finucane, 1966; Smith, Swartz, and Massmann, 1966; and others). Although much is known about the food habits of the adults and subadults of most estuarine-dependent species, only a limited literature exists on the food habits of the smaller juvenile individuals. Consequently, we have been studying the food habits of juveniles of all available species of fishes which inhabit certain nursery areas in the nearshore estuarine zone between the Crystal River and the Withlacoochee River on the northwest coast of Florida. To date our study involves 18 species which we are studying concurrently.

In the course of the investigation described above, we have discovered that juveniles of two species, the leatherjacket, *Oligoplites saurus* (Bloch and Schneider) (a carangid), and the spottail pinfish, *Diplodus holbrooki* (Bean) (a sparid), clean ectoparasites from other fishes. This phenomenon has not been reported previously for either species. The report which follows describes the diets of juveniles of both species and shows that these diets include considerable amounts of ectoparasites and other material obtained by cleaning.

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## MATERIALS AND METHODS

### DESCRIPTION OF STUDY AREA AND SAMPLING METHODS

Specimens of juvenile *Oligoplites saurus* and *Diplodus holbrooki* were collected in the vicinity of the Florida Power Corporation steam electric station located 7.5 miles northwest of the town of Crystal River, Fla. (lat 23°57'N, long 82°45'W). This station is situated approximately 3 miles northwest of the mouth of the Crystal River and 4 miles southeast of the mouth of the Withlacoochee River on the northwest coast of Florida. Sampling sites in this estuarine area were located to the north and south of the dikes delimiting the intake canal of the electric station. The sampling sites were densely vegetated with seagrasses, primarily *Ruppia maritima* and *Diplanthera wrightii*, and several

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types of algae among which two species of *Caulerpa*, *C. prolifera* and *C. paspaloides*, were most conspicuous. Collections of fishes were made near low tide at which time the depth at the sampling sites was 3 to 4 ft. Specimens analyzed for this report were collected from April 3 to August 25, 1971. Water temperatures at the sampling sites during this period ranged from 17.3° to 33.1°C whereas salinities ranged from 16.4 to 24.1 ‰. All sampling sites were greater than a mile from the zone of influence of thermal discharge from the electric station.

The majority of juvenile fishes used in this study were collected with a bag seine (50 ft × 6 ft) constructed of ⅜-inch stretched mesh netting. A few specimens were collected in a 5-ft cast net constructed of ½-inch stretched mesh netting. Specimens were preserved immediately in 20% Formalin-seawater. In the laboratory, fish were washed in tap water, sorted to species, and stored in 75% isopropyl alcohol. High concentrations of preservative were used to assure adequate preservation of stomach contents. Specimens of adult *D. holbrooki* were collected with hook and line, injected immediately with Formalin, and treated as above.

## ANALYSIS OF STOMACH CONTENTS

Juvenile fishes were measured to the nearest 1.0 mm standard length and sorted into size classes of 5-, 10-, or 20-mm increments depending on the number of fish available. All references to fish length are in terms of standard length. After removal of stomachs, food items were removed in alcohol with the aid of a dissecting microscope. Stomach contents from similar size classes were pooled and analyzed as to percent composition using a modified gravimetric procedure which employed a preliminary fractionation of food items with a series of sieves. This procedure is outlined below:

1. Large food items of similar types easily recognizable to the naked eye were removed onto preweighed filter pads (Whatman[2] No. 42, 2.5-inch diameter). This initial step was used only for certain food items (i.e., shrimp, crabs, larval fish, etc.) obtained from fish in the larger size classes.
2. The remaining stomach contents were poured into a series of 3-inch diameter sieves (U.S. Standard Nos. 10, 20, 30, 60, 120, 200) arranged and clamped together in order of decreasing mesh size. Sieves Nos. 10 and 20 were frequently not needed for fractionations of material from fish in very small size classes.
3. The series of sieves was secured to a Burrell "Wrist Action" shaker and shaken gently for 10 to 15 min while washing continuously under slowly flowing water.
4. The contents of each sieve (comprising a sieve fraction) was washed into a finger bowl for detailed analysis beneath a dissecting microscope. Analysis involved adding five large drops of the sieve fraction to a gridded petri dish (13 squares per inch) and recording the frequency of occurrence of each type of food item in each drop. The accuracy of this method is good because all food items in a particular sieve fraction are of comparable size. The portion of the contents of each sieve fraction attributable to each type of food item was recorded.
5. After analysis of all sieve fractions, each fraction was vacuum-filtered onto a sepate preweighed filter pad using a Millipore filter holder and a vacuum flask.
6. Filter pads were dried overnight in a drying oven (ca. 70°C) and dry weights of food items were calculated after weighing the pads to the nearest 0.0001 g on a microbalance.

Further comments on the efficacy of this procedure for analyzing the stomach contents of small fish are given in the following section on Results.

## RESULTS

### *OLIGOPLITES SAURUS*

Figure 1 shows the results of analyses of stomach contents of juvenile *O. saurus* belonging

[2] Reference to trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service.

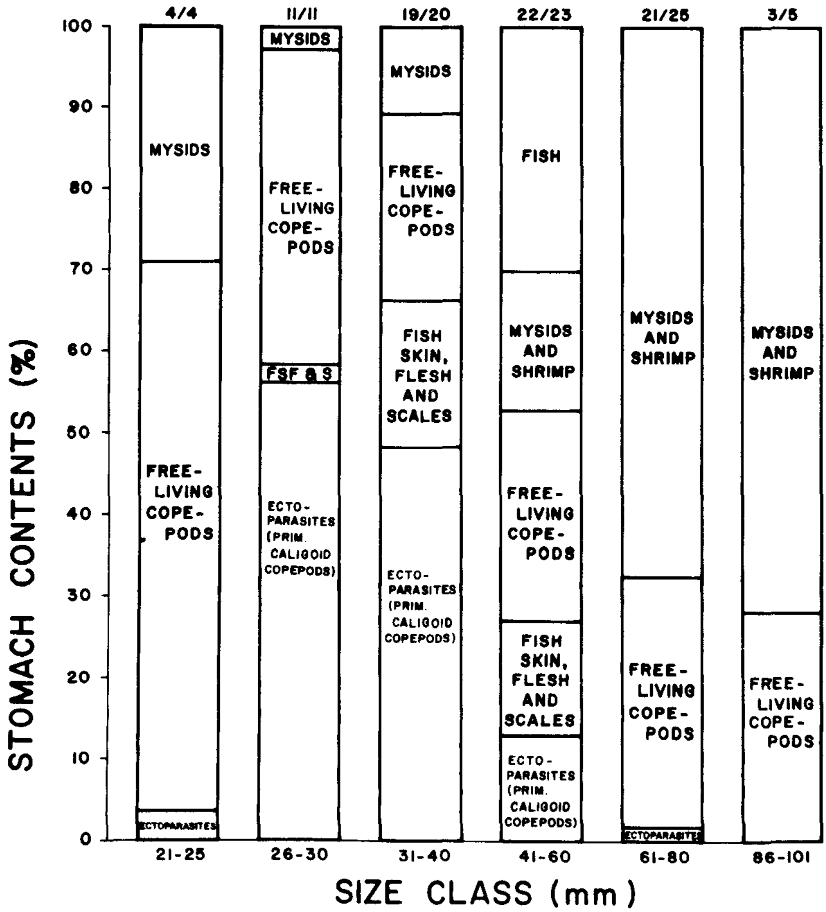


FIGURE 1.—Stomach contents of juveniles of *Oligoplites saurus*. Bar graph for each size class shows percent of total stomach contents attributable to individual food items. Designation of sample size above each bar graph shows fraction of stomachs analyzed which contained food.

to the six size classes obtained in our collections. Juveniles of this species go through a stage in which ectoparasites of fish make a major contribution to their diet. The relative contribution of ectoparasites to the diet is at a maximum in fish that are betweeen 26 and 40 mm long. Ectoparasites account for approximately 56% of the stomach contents of fish 26 to 30 mm long and approximately 48% of the contents of fish 31 to 40 mm long. The majority of the ectoparasites consumed were caligoid copepods; a few were branchiurans, *Argulus* sp. In contrast, ectoparasites constituted only 2 to 4% of the stomach contents in fish less than 26 mm long or greater than 60 mm long. Ectoparasites made up less than 1% of the stomach contents of fish 86 to 100 mm long.

The importance of food material obtained by cleaning in juveniles of this species is even greater if the contribution of bits of fish skin, flesh, and scales is combined with that of ectoparasites (see Figure 1). In leatherjackets between 26 and 60 mm in length, the total portion of the stomach contents attributable to material obtained from cleaning ranges from 27 to 67% with maximum percentages obtained in 26 to 40 mm fish (58 to 67%).

Most of the fish skin, flesh, and scales present in the stomachs are construed to have come from cleaning activities, since other than occasional fish larvae, fish per se were seldom encountered in any of the stomachs examined.

A sizable portion of the diet of juveniles of all size classes consists of free-living organisms, primarily copepods, mysids, and small shrimp (see Figure 1). Free-living organisms account for 96 to 100% of the stomach contents of juveniles outside the 26 to 60 mm size classes. Free-living copepods comprise the major food item of 21 to 25 mm individuals whereas mysids and small shrimp made up the major food items of fish in the 61 to 100 mm size classes.

Since there were no prior reports on *O. saurus* functioning as a cleaner, additional analyses were made of other specimens collected from other sites at other times. Collections of juvenile *O. saurus* were obtained from Dr. Carter R. Gilbert of the Florida State Museum for this purpose. The results of analyses of these collections are given in Table 1. Ectoparasites were present in the stomachs of fish belonging to all size classes examined. The relative contribution of ectoparasites to the diet was again maximum in fish between 26 and 40 mm in length. A maximum of 24 ectoparasites was recovered from each of two stomachs of fish 41 to 60 mm long. The relative contribution of ectoparasites to the total diet decreased dramatically in fish greater than 60 mm in length. The data from analyses of museum collections correlated remarkably well with the data presented earlier on freshly collected specimens. The lower percentages of stomach contents attributable to ectoparasites in the museum collections may have been due to the fact that these fish had been stored for 10 to 20 years and were not as well preserved as our freshly collected specimens. This was suggested by the presence of significant amounts of unidentifiable debris in the stomachs of the museum fish.

## *DIPLODUS HOLBROOKI*

Figure 2 shows the results of analyses of stomach contents of juvenile *D. holbrooki* in the 10 size classes obtained in our collections. As was the case with *O. saurus, D. holbrooki* goes through a juvenile stage in which it is a cleaner. One or more species of the ectoparasitic branchiuran, *Argulus*, is significant in the diet of juveniles between 21 and 50 mm in length. The percentage of ectoparasites in the total stomach contents is maximum in fish 31 to 35 mm long (20%) with somewhat smaller percentages recorded in fish 26 to 30 mm long and in fish 36 to 40 mm long. A maximum of 16 ectoparasites (*Argulus*) was recovered from the stomach of a single fish in the 36 to 40 mm size class. The relative contribution of ectoparasites to the total stomach contents decreases dramatically to less than 1% in fish less than 61 mm long. Only one ectoparasite was found in the stomachs of 35 fish 61 to 70 mm long. Ectoparasites were absent from the stomachs of fish less than 21 mm or greater than 70 mm in length. Likewise, ectoparasites were absent from the stomachs of 18

TABLE 1.—Analyses of stomach contents of *Oligoplites saurus* obtained from Florida State Museum.[1]

| Size class (mm) | Number of fish | Number of stomachs with food | Stomachs with food and ectoparasites | | Number of ectoparasites per stomach with food | | Ectoparasites - % of total stomach contents |
|---|---|---|---|---|---|---|---|
| | | | Number | Percent | Average | Range | |
| 21-25 | 2 | 1 | 1 | 100 | 2 | (2) | Not determined |
| 26-30 | 5 | 5 | 4 | 80 | 1.4 | (0-3) | 26 |
| 31-40 | 12 | 11 | 9 | 82 | 4.1 | (0-9) | 21 |
| 41-60 | 23 | 21 | 19 | 90 | 6.8 | (0-24) | 13 |
| 61-80 | 15 | 15 | 13 | 87 | 3.1 | (0-12) | 3 |
| 81-100 | 7 | 7 | 3 | 43 | 0.4 | (0-1) | 0.3 |

[1] Fish taken from collections indicated as follows:
Cedar Key, Fla., 10/27/47, 7/24/48, 10/24/48, 9/25/53.
Little Gasparilla Pass, Charlotte Co., Fla., 7/21/60.

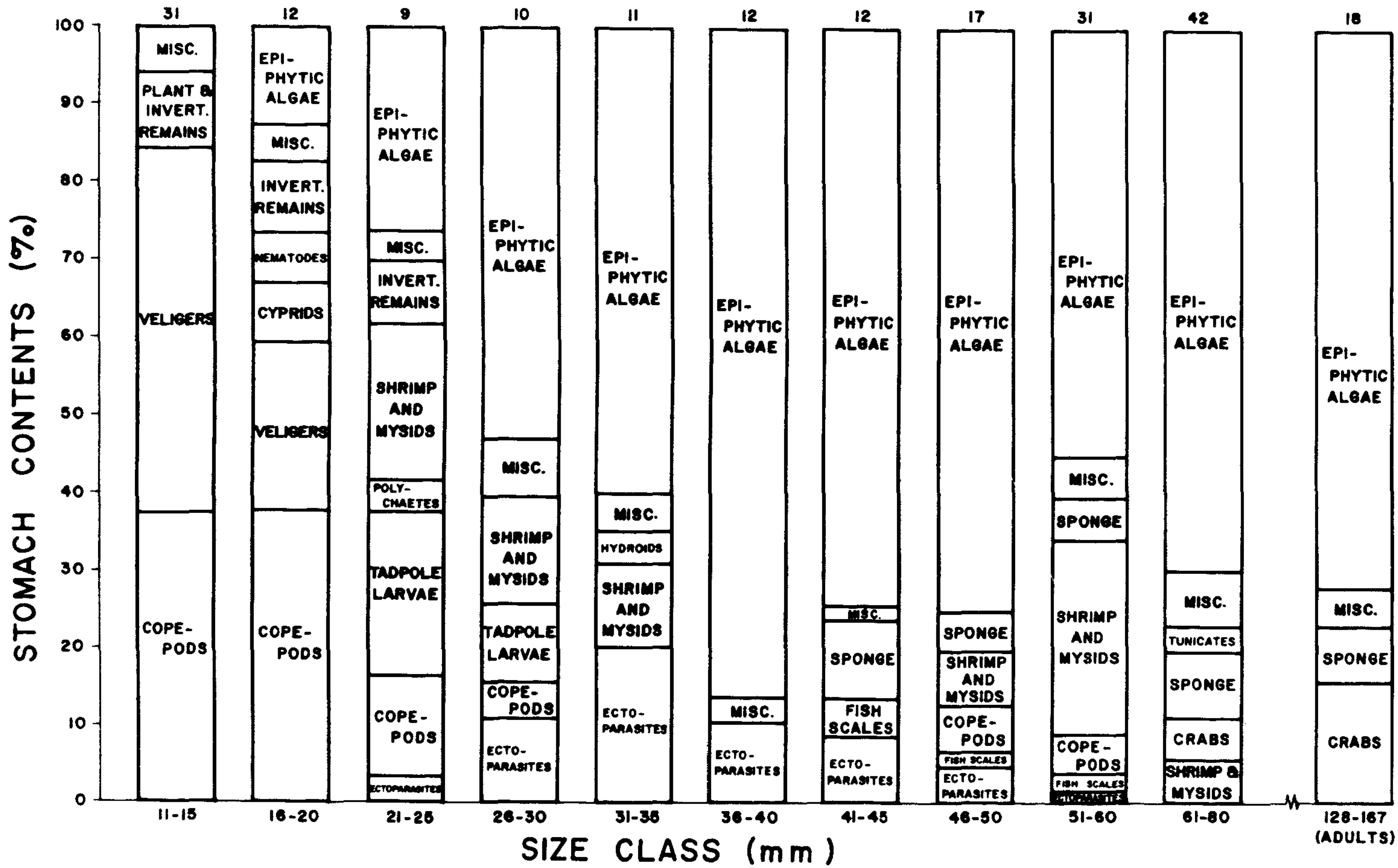


FIGURE 2.—Stomach contents of juveniles of *Diplodus holbrooki.* Presentation same as in Figure 1. Sample size above each bar graph shows number of stomachs with food which were analyzed. Misc. = combination of all items which individually account for less than 3% of total.

adult *Diplodus* which were analyzed. Fish scales were a common constituent of stomachs of fish in size classes between 21 and 70 mm in length. The contribution of fish scales to the stomach contents was at a maximum in 41 to 45 mm fish (5%). The majority of the fish scales present in stomachs are construed to have come from cleaning activities since fish per se were seldom encountered in the stomachs of any of the *Diplodus* examined.

As shown in Figure 2, the bulk of the diet of juvenile *D. holbrooki* consists of free-living animals and epiphytic algae. Cleaning activities provide only a modest portion of the total food ingested by fish in any of the size classes. Individuals in size classes between 11 and 25 mm are primarily planktivorous with veligers, copepods, tunicate tadpole larvae, mysids, and small shrimp accounting for 56 to 87% of the total stomach contents. Fish over 25 mm become very dependent on plant material in the form of epiphytic algae. This plant material accounts for 53 to 87% of the total stomach contents of all size classes above 26 mm in length, including adults. However, variable amounts of animal material, especially sponge, copepods, shrimp, and mysids, are also consumed. Stomach contents of fish greater than 25 mm in length show that *Diplodus* feeds heavily on plant and animal material which grows attached to other subjects. Even the crabs consumed by larger individuals are primarily porcellanids (*Petrolisthes* sp.) that live in association with submerged rock and shell.

Since there are no prior reports of *D. holbrooki* functioning as a cleaner, additional juvenile specimens were obtained from Dr. Carter R. Gilbert. These specimens were collected in 1951 and 1957 near Cedar Key, Fla. Unfortunately, the museum collections were short on specimens in the 21 to 60 mm size range and those that were provided did not have well-preserved stomach contents. All that can be stated with certainty from these specimens is that ectoparasites did appear in stomachs of 5 of the 13 fish available in the size range of 26-35 mm. Representatives of other juvenile size classes were either not available or inadequately preserved for analysis.

## EFFICACY OF SIEVE FRACTIONATION PROCEDURE

The sieve fractionation procedure described in Materials and Methods has contributed greatly to our capacity to analyze quantitatively the stomach contents of very small fish. This procedure provides a convenient means of separating a heterogeneous mixture of minute food items into fractions which are individually quite homogeneous with respect to particle size. Table 2 presents the format used and the results obtained following a sieve fractionation of stomach contents of *D. holbrooki* belonging to the 11 to 15 mm size class. This table and the following discussion are provided to illustrate the efficacy of this procedure. After identification of the food items in each sieve fraction (Column A), the determination of the portion of each fraction attributable to a particular food item (Column B) is eased considerably by the fact that all items in the fraction are of comparable size. After determining the dry weight of each fraction (Column C), the contribution of individual food items (Column D) is estimated by multiplying the weight of the fraction by the value defining the portion of the fraction attributable to that food item. Finally, the total amounts and percentages of the entire stomach contents which are attributable to the individual food items are determined by simple compilation (Columns E and F). This procedure has now been employed in this laboratory to analyze the stomach contents of juvenile stages of 18 species of fishes.

## DISCUSSION

Randall (1967) has described the Carangidae as a family of carnivorous fish whose food habits may be divided into three major categories: fish feeders, plankton feeders, and mollusk feeders. His classification was based primarily on feeding habits of adult fish, and it was recognized that not all of the species, including their juvenile stages, fit perfectly into these categories. Randall analyzed stomach contents of *Oligoplites saurus* (149 to 234 mm) from the West Indies and found this carangid to be primarily a fish feeder. Similar findings have been reported by

TABLE 2.—Data obtained from sieve fractionation and gravimetric analysis of stomach contents of 31 juvenile *D. holbrooki* in 11-15 mm size class.

| Sieve mesh size[1] | (Col. A) Food item | (Col. B) Portion of Sieve fraction attributable to food item | (Col. C) Dry weight of entire sieve fraction (mg) | (Col. D) Calculated weight of food item (mg) |
|---|---|---|---|---|
| No. 60-250 μ | Copepods | 0.47 | 3.5 | 1.6 |
| | Veligers | 0.38 | | 1.3 |
| | Cyprids | 0.07 | | 0.3 |
| | Nematodes | 0.07 | | 0.3 |
| No. 120-125 μ | Copepods | 0.40 | 3.2 | 1.3 |
| | Veligers | 0.60 | | 2.0 |
| | Nematodes | <0.01 | | <0.1 |
| No. 200-74 μ | Copepods (larval) | 0.17 | 2.2 | 0.4 |
| | Veligers | 0.43 | | 0.9 |
| | Animal remains | 0.22 | | 0.5 |
| | Plant remains | 0.17 | | 0.4 |

Summarization of data:

| Food item | (Col. E) Total dry weight (mg) | (Col. F) Percent of total sample |
|---|---|---|
| Copepods | 3.3 | 37 |
| Veligers | 4.2 | 47 |
| Cyprids | 0.3 | 3 |
| Nematodes | 0.3 | 3 |
| Animal remains | 0.5 | 6 |
| Plant remains | 0.4 | 4 |
| Total | 9.0 | 100 |

[1] A No. 30 sieve (595 μ) also used in sieve series employed here, but it retained none of the items consumed by 11- to 15-mm fish.

Beebe and Tee-Van (1928) on specimens from Haiti and by Springer and Woodburn (1960) on specimens from Tampa Bay, Fla. Tabb and Manning (1961) reported that this species (30 to 120 mm) in Florida Bay feeds heavily on snapping shrimp and small pink shrimp in addition to fish larvae. With the exception of the modest data presented by Randall (1967), the literature is devoid of quantitative information on the food habits of this common inshore species. No prior reports have been made on this species acting as a cleaner.

Our quantitative determinations of the stomach contents of juvenile *O. saurus* (21 to 80 mm) collected near Crystal River, Fla., show clearly that this carangid passes through a stage in the initial year of its development in which intensive cleaning behavior is implicated. Food materials obtained from cleaning activities, especially caligoid copepods, account for 58 to 67% of the stomach contents of fish 26 to 40 mm in length (see Figure 1). Lesser amounts of such material were present in fish outside of this size range. Although no observations were made of *Oligoplites* actually engaged in cleaning activities in the field, it is extremely unlikely that any other type of feeding activity can account for these results. If ectoparasites, such as caligoid copepods, were readily ingested from the plankton, then they would be expected to be common in the stomachs of the planktivorous stages of other species of fishes in the area. We have analyzed the stomachs of more than 6,000 juvenile fishes belonging to 18 species present in our study area and, aside from a single *Argulus* sp. found in the stomachs of one *Orthopristes chrysopterus* and one *Menidia beryllina*, have found no ectoparasites or other indicators of cleaning activity in species other than *O. saurus* and *D. holbrooki*. The only other reports of cleaning behavior among the carangids are brief accounts given by divers on the pilotfish (*Naucrates ductor*) and young bar jack (*Caranx ruber*) (Hass, 1953; Randall, 1962).

Although many studies have been done on various aspects of the biology of members of the Family Sparidae, the literature contains only one very brief account of an apparent cleaning episode involving a member of this family. Breder (1962) noted a single juvenile *Lagodon rhomboides* picking at the pelvic axils of three successive *Mugil cephalus* in Lemon Bay, Fla. Breder commented that this was the only time he had observed this interaction although he was thoroughly familiar with both species.

Our analyses of stomach contents of juvenile *D. holbrooki* (11 to 80 mm, see Figure 2) show clearly that this species, like *O. saurus*, goes through a stage in the initial year of its development in which cleaning behavior is implicated. Concurrent analyses of more than 3,000 stomachs of juveniles of another sparid, *Lagodon rhomboides* (10 to 130 mm), collected from the same area failed to yield a single ectoparasite or other evidence of cleaning activity in this related species. Data on food habits of *L. rhomboides* and juveniles of other species in our study area will be published at a later date.

It is noteworthy that, in juveniles of both *D. holbrooki* and *O. saurus*, fishes in the size range of 26 to 40 mm are the ones in which ectoparasites make their maximum contribution to the diet. Likewise, ectoparasites become markedly less important in the diets of slightly larger individuals thereby strongly implying that the cleaning habit is confined to only a portion of the total juvenile phase of development in both species. Although our data show that the diet of juvenile *O. saurus* includes proportionately greater amounts of material obtained from cleaning activities than the diet of juvenile *D. holbrooki*, it is clear that neither species depends exclusively on this activity. Limbaugh (1961) has previously reported that some species are cleaners only as juveniles and that few cleaners depend exclusively on this habit as a source of food.

Our analyses of stomach contents of *D. holbrooki* show that after reaching a length of 26 to 30 mm, this species becomes very dependent on plant material in the form of epiphytic algae. Reid (1954) found algae as well as other items in the stomachs of *D. holbrooki* from Cedar Key, Fla.; however, neither the size of the individuals analyzed nor any sort of quantitative information was reported. The study of Caldwell (1955) on this species from the same area included no information on stomach contents. Randall (1967) has reported that the diet of the closely related species, *D. caudimacula*, from the West Indies is approximately 80% algae, thereby making it quite similar in this regard to our findings with *D. holbrooki*.

Although our studies on fishes, collected in the field and obtained from museum collections, show clearly that juveniles of both *O. saurus* and *D. holbrooki* are cleaners, attempts to observe cleaning behavior in the field have been unsuccessful. The estuarine water in our study area is too turbid to permit underwater observations of the behavior of small fish at a distance. Aside from the excellent studies of Limbaugh (1964) and Hobson (1971) on cleaning symbiosis among inshore fishes of southern California, there have been few reports on visual observations of cleaning behavior by fishes in waters of the Temperate Zone. McCutcheon and McCutcheon (1964) alluded to the fact that water conditions in the Temperate Zone are frequently less favorable than those in the tropics where many detailed descriptions of cleaning symbiosis have been made. On two occasions, we observed groups of pinfish (*Lagodon rhomboides*) in our study area behaving in a manner suggestive of that described for groups of blacksmith (*Chromis punctipinnis*) when presenting themselves to a cleaner (Limbaugh, 1964; Feder, 1966; and Hobson, 1971). On both occasions, a group of several dozen subadult pinfish were seen milling about in a tight circle just beneath the surface in water approximately 6 ft deep. Pinfish are normally bottom dwellers, and the sight of a large group near the surface behaving as described above was extremely unusual. Although sizable numbers of juvenile *D. holbrooki* were seen swimming back and forth in the vicinity of the pinfish, poor visibility made it impossible to determine whether the pinfish were being cleaned. Juvenile *Diplodus* collected from this same area at this time were found to have ectoparasites (primarily *Argulus*) in their stomachs. In addition, it may be noteworthy that juveniles of *D. holbrooki* and of *L. rhomboides*, both sparids, are frequently seen swimming together in small mixed schools.

Although no observations have been made of suggestive interspecific associations of *O. saurus*, the notes of Breder (1942) on the unusual "leaf-mimic" behavior of juveniles of this species may well be related to its cleaning behavior. Likewise the potent sting associated with the dorsal and anal spines, and the exaggerated size of these spines in juveniles (Breder, 1942), is likely to be an adaptation providing a degree of immunity from predation in this species. *Oligoplites* has not been found in the stomachs of any of the fishes we have examined even though juveniles of this species are very common in the area. We are currently investigating a change in dentition, quite likely related to the cleaning habit, which is exhibited by this species. Juveniles have an outer row of closely fitting, distinctly flattened, incisorform teeth which are seemingly well adapted to the task of scraping or of tearing objects from surfaces. In adults these teeth are more widely separated and caniform.

Limbaugh (1961) and Feder (1966) have generalized that cleaners in the Temperate Zone tend to be more gregarious and less brightly colored or contrastingly marked than cleaners in tropical waters. These generalizations have been criticized by Hobson (1969). Field observations of juveniles of both *O. saurus* and *D. holbrooki* reveal that both species are gregarious and swim about in small schools of frequently several dozen individuals. Whereas *O. saurus* is a rather unspectacular dull olive color, *D. holbrooki* possesses a bright silver sheen with a large pronounced black spot on the caudal peduncle. Hence the characteristics of these two cleaners from temperate waters provide both support and dissent to the generalizations of Limbaugh and Feder. Since *O. saurus* is also found in tropical waters, evidence of cleaning activity there would result in this species being ranked among the most unspectacularly colored of the tropical cleaners.

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## LITERATURE CITED

BEEBE, W., AND J. TEE-VAN.
1928. The fishes of Port-au-Prince Bay, Haiti, with a summary of the known species of marine fish of the island of Haiti and Santo Domingo. Zoologica (N.Y.) 10:1-279.

BREDER, C. M., JR.
1942. On the behavior of young *Oligoplites saurus* (Bloch and Schneider). Copeia 1942:267.
1962. Interaction between the fishes *Mugil* and *Lagodon*. Copeia 1962:662-663.

CALDWELL, D. K.
1955. Notes on the distribution, spawning, and growth of the spottailed pinfish, *Diplodus holbrooki*. Q. J. Fla. Acad. Sci. 18:73-83.

FEDER, H. M.
1966. Cleaning symbiosis in the marine environment. *In* S. M. Henry, (editor), Symbiosis. Vol. I, p. 327-380. Academic Press, N.Y.

HASS, H.
1953. Manta: Under the Red Sea with spear and camera. (Translated from the German by J. Cleugh.) Rand McNally, Chic., 278 p.

HOBSON, E. S.
1969. Comments on certain recent generalizations regarding cleaning symbiosis in fishes. Pac. Sci. 23:35-39.

1971. Cleaning symbiosis among California inshore fishes. Fish. Bull. U.S. 69:491-523.

LIMBAUGH, C.

1961. Cleaning symbiosis. Sci. Am. 205:42-49.

1964. Notes on the life history of two Californian Pomacentrids: Garibaldis, *Hypsypops rubicunda* (Girard), and blacksmiths, *Chromis punctipinnis* (Cooper). Pac. Sci. 18:41-50.

MCCUTCHEON, F. H., AND A. E. MCCUTCHEON.

1964. Symbiotic behavior among fishes from temperate ocean waters. Science (Wash., D.C.) 145: 948-949.

RANDALL, J. E.

1962. Fish service stations. Sea Front. 8:40-47.

1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. (Miami) 5:665-847.

REID, G. K., JR.

1954. An ecological study of the Gulf of Mexico fishes, in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf Caribb. 4:1-94.

SMITH, R. F., A. H. SWARTZ, AND W. H. MASSMAN (editors).

1966. A symposium on Estuarine Fisheries. Am. Fish. Soc., Spec. Publ. 3, 154 p.

SPRINGER, V. G., AND K. D. WOODBURN.

1960. An ecological study of the fishes of the Tampa Bay area. Fla. State Board Conserv. Mar. Lab., Prof. Pap. Ser. 1, 104 p.

SYKES, J. E., AND J. H. FINUCANE.

1966. Occurrence in Tampa Bay, Florida, of immature species dominant in Gulf of Mexico commercial fisheries. U.S. Fish. Wildl. Serv., Fish. Bull. 65:369-379.

TABB, D. C., AND R. B. MANNING.

1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf Caribb. 11:552-649.