

FEEDING HABITS OF THE KAHALA, SERIOLA DUMERILI,  
IN THE HAWAIIAN ARCHIPELAGO

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ABSTRACT

Stomach contents of kahala, Seriola dumerili, were examined for a determination of possible relationships between the feeding habit and incidence of ciguatoxicity in this species and also as part of a study on its overall life history. Preliminary results indicated a change from cephalopods to fish as the principal dietary constituent with increase in weight of kahala. Also, the diet of fish caught in the Northwestern Hawaiian Islands appeared more varied in terms of a larger combined cephalopod and crustacean volume than those caught in two other areas within the main islands. Fish dominated the diet of kahala, with Carangidae the largest contributor among forage items. High incidences of parasitic nematodes and trematodes were observed with nematodes the most predominant in occurrence. Further examination of stomach contents is needed to ascertain the dietary trends indicated thus far.

Northwestern Hawaiian Islands  
Seriola dumerili  
ciguatera  
stomach analysis

INTRODUCTION

The kahala, Seriola dumerili (Risso), is found worldwide and its Indo-Pacific distribution reaches Hawaii, Australia, Japan, China, and eastern Africa (Mather and Bartlett, 1966). Within the Hawaiian Archipelago, kahala is found primarily in 40 to 100-fathom depths within coastal waters and it appears to be primarily associated with the bottom (Gosline and Brock, 1960).

Food habit studies on members of Seriola are few. The feeding habits of pelagic larval and juvenile stages of Seriola quinqueradiata were studied in waters off Kyushu, Japan. The diet consisted primarily of planktonic crustaceans and the larvae and juvenile stages of Engraulidae, Scomberesocidae, and Mullidae (Anraku and Azeta, 1965). Studies on the yellowtail, Seriola dorsalis, in California indicated that this species was an "opportunistic feeder," its diet consisting mainly of pelagic red crabs, squid, sardines, anchovies, jack mackerel, Trachurus symmetricus, and Pacific mackerel, Scomber japonicus (Baxter, 1960). No published food habit studies are available for kahala found in Hawaiian waters or elsewhere.

The objectives of the current food habit study on kahala are two-fold: (1) to determine whether differences in forage items exist in the diets of ciguatoxic and non-ciguatoxic fish in conjunction with the current ciguatoxin study of kahala and, (2) to investigate the food habits as part of an overall life history study of this species.

#### METHODS

Stomachs are collected along with gonads and flesh samples as part of an ongoing ciguatoxin study of kahala. A cooperative program was established by which fishermen and fish dealers send all kahala to the fish auction house located at the United Fishing Agency (UFA). Sampling is conducted by National Marine Fisheries Service employees six days a week on all kahala sent to UFA. Data are collected on weight, fork length, sex, depth, and location of capture for each fish.

The samples are processed at the University of Hawaii John A. Burns School of Medicine, Pathology Department, with a practical and relatively specific radioimmunoassay (RIA) for the detection of ciguatoxin (Hokama et al., 1977). The toxicity levels of the fish tissues are determined from radioactive counts per minute per gram tissue (c/min/g) as follows: <350,000 c/min/g tissue - negative; 350,000 to 399,999 c/min/g tissue - borderline; and ≥400,000 c/min/g tissue - positive.

Because stomachs are not preserved at time of capture, there is a lag time of one to ten days before stomachs are collected and preserved. Collected stomachs are placed in a cloth bag and preserved in 10% formaldehyde until time of examination.

For detailed examination, stomach contents are emptied and sorted into identifiable groups. The volume of each food item is measured (by water displacement) and coded as to its state of digestion. Invertebrates were usually identifiable to suborder whereas most fish were identifiable to family and occasionally to species. Unidentified fish were cleaned of flesh and stained in alizarin for identification via vertebrae count and morphology.

Bait is usually identifiable by its appearance (sliced fish sections) and its minimal state of digestion. Food items suspected as bait are recorded but not considered actual food items. Additionally, all nematodes

and trematodes collected from stomachs are recorded and preserved but are considered to be parasites and not food items.

## RESULTS

The percentage of frequency of occurrence and total volume of each food item indicated that the major categories of food consumed by kahala consisted of Crustacea, Cephalopoda, and other Mollusca, fish, and unidentified remains. Diet was analyzed in relation to ciguatoxicity, sex, location of capture, and weight.

### Ciguatoxicity versus diet

No apparent differences in the major food categories appear between ciguatoxic and non-ciguatoxic kahala examined. Fish appeared frequently and predominated in volume for both groups. Among ciguatoxic individuals, fish contributing the most by volume were Carangidae, Tetraodontidae, and unidentified fish remains; whereas, for non-ciguatoxic fish Carangidae, Scombridae, and unidentified fish remains were the major contributors (Tables 1 and 2).

TABLE 1. NUMBER, FREQUENCY OF OCCURRENCE, AND VOLUME OF FORAGE ITEMS FOUND IN STOMACHS OF 29 CIGUATOXIC KAHALA

Food Items	No. of Items	Stomachs in Which Occurred		Aggregate Total Volume	
		Number	Percent	Milliliter	Percent
Crustacea					
Unidentified shrimp	2	1	3.4	--	--
Fish					
Carangidae					
<u>Decapterus</u> sp.	1	1	3.4	18	5.5
<u>Trachurops crumenophthalmus</u>	1	1	3.4	66	20.3
Mullidae	1	1	3.4	2.0	0.6
Balistidae	1	1	3.4	13	4.0
Tetraodontidae	35	3	10.3	60.0	18.4
Unidentified fish larva	1	1	3.4	--	--
Unidentified fish	5	4	13.8	10.6	3.3
Unidentified fish remains	--	6	20.7	59.5	18.3
Unidentified remains	--	22	75.9	96.2	29.6
Parasites					
Trematodes	40	11	37.9	--	--
Nematodes	152	10	34.5	--	--

TABLE 2. NUMBER, FREQUENCY OF OCCURRENCE, AND VOLUME OF FORAGE ITEMS FOUND IN STOMACHS OF 125 NON-CIGUATOXIC KAHALA

Food Items	No. of Items	Stomachs in Which Occurred		Aggregate Total Volume	
		Number	Percent	Milliliter	Percent
Annelida					
Unidentified	12	4	3.2	--	--
Crustacea					
Isopoda	2	2	1.6	0.3	--
Decapoda					
Heterocarpus ensifer	21	1	0.8	8.3	0.1
Unidentified penaeid shrimp	5	2	1.6	6.6	0.1
Unidentified caridid shrimp	1	1	0.8	0.5	--
Unidentified shrimp	148	2	1.6	59.9	0.9
Unidentified shrimp remains	--	1	0.8	52	0.8
Crab megalops	1	1	0.8	0.1	--
Unidentified Crustacea	5	3	2.4	0.3	--
Unidentified Crustacea remains	--	1	0.8	0.1	--
Mollusca					
Unidentified gastropod	2	1	0.8	--	--
Unidentified Bivalvia remains	--	2	1.6	1.8	--
Squid	17	7	5.6	51.3	0.8
Octopus	7	6	4.8	135.5	2.1
Unidentified Cephalopoda	6	4	3.2	10.7	0.2
Unidentified Cephalopoda remains	--	1	0.8	11.4	0.2
Fish					
Congridae	3	3	2.4	74.3	1.2
Antigonidae	3	2	1.6	19	0.3
Fistulariidae	2	1	0.8	6.1	0.1
Carangidae					
Decapterus <u>pinnulatus</u>	4	4	3.2	449	7.0
Decapterus <u>sp.</u>	20	14	11.2	1,107.8	17.3

TABLE 2. NUMBER, FREQUENCY OF OCCURRENCE, AND VOLUME OF FORAGE ITEMS FOUND IN STOMACHS OF  
125 NON-CIGUATOXIC KAHALA (Continued)

Food Items	No. of Items	Stomachs in Which Occurred		Aggregate Total Volume	
		Number	Percent	Milliliter	Percent
<u>Trachurops crumenophthalmus</u>	4	2	1.6	133	2.1
Unidentified	3	3	2.4	115	1.8
Unidentified remains	--	4	3.2	177	2.8
Lutjanidae	2	2	1.6	406	6.3
<u>Pristipomoides sieboldii</u>	2	2	1.6	50	0.8
Unidentified	1	1	0.8	4.0	0.1
Mullidae	2	2	1.6	22	0.3
Labridae					
Scombridae	4	3	2.4	843	13.1
Auxis sp.	1	1	0.8	547	8.5
<u>Auxis thazard</u>					
Monacanthidae	5	1	0.8	218	3.4
<u>Pseudomonacanthus garretti</u>	8	3	2.4	116.8	1.8
Unidentified	--	1	0.8	1.3	--
Unidentified remains					
Ostraciontidae	--	1	0.8	6.8	0.1
Unidentified remains	6	6	4.8	116.6	1.8
Tetraodontidae	1	1	0.8	4.7	0.1
Unidentified flatfish	46	20	16.0	83.3	1.3
Unidentified fish	--	43	34.4	799.6	12.5
Unidentified fish remains	--	1	0.8	5.6	0.1
Unidentified squid and fish remains	--	65	52.0	772.6	12.0
Unidentified remains					
Parasites	183	33	26.4	--	--
Trematodes	2,757	92	73.6	--	--
Nematodes					

Among ciguatoxic fish, nematodes and trematodes occurred in approximately 35% of the stomachs; whereas, among non-ciguatoxic fish, nematodes and trematodes occurred in approximately 75% and 25% of the stomachs, respectively.

#### Sex versus diet

Both sexes appear identical in their diet of major food categories; fish predominated followed by small amounts of cephalopods and crustaceans. Among both sexes, most of fish by volume were Carangidae and Scombridae.

The incidence of nematodes and trematodes between the sexes were very similar. Nematodes occurred in the stomachs two to three times more often than trematodes.

#### Location versus diet

Diet comparisons were made for fish from three areas: the island of Hawaii and the Molokai-Lanai-Maui-Kahoolawe area among the main islands, and Gardner Pinnacles in the Northwestern Hawaiian Islands. The frequency of occurrence of major food items among the three areas appear very similar. Kahala from both the island of Hawaii and the Molokai-Lanai-Maui-Kahoolawe area had a high content of fish and rather low content of crustaceans or cephalopods. For kahala from Gardner Pinnacles, fish were still predominant in volume although to a lesser extent than for kahala from the other two areas. The former had a larger volume of cephalopods and crustaceans and the volume of unidentified remains also was larger.

For kahala from the island of Hawaii the major fish contributors by volume were the Scombridae and Carangidae. In kahala from the Molokai-Lanai-Maui-Kahoolawe area the Carangidae and Lutjanidae predominated in volume and from those in the Gardner Pinnacles area, Monacanthidae, unidentified fish remains, and Carangidae predominated. Octopus was the only cephalopod.

Occurrence of nematodes and trematodes was very similar among fish in the three areas; nematodes occurred in approximately 75% of the stomachs and trematodes in about 25%.

#### Weight versus diet

The kahala were divided into three groups according to weight: <5.4 kg (12 lb), 5.4 to 10.0 kg (12 to 22 lb), and >10.0 kg (22 lb).

The volumetric data showed that the lighter weight group had a smaller percentage of fish compared to the two heavier groups. The lighter group showed a larger proportion of cephalopod compared to the other two groups which showed a predominance of fish. Octopus comprised practically all the cephalopods and Tetraodontidae contributed most of the fish for the first group. In the 5.4 to 10.0 kg group Carangidae and unidentified fish remains contributed the bulk of the fish whereas in

kahala >10.0 kg the fish species consisted chiefly of Scombridae and Carangidae.

In the two groups >5.4 kg, nematodes and trematodes occurred in approximately 75% and 25% of the stomachs, respectively. Among fish in the lighter weight group, nematodes and trematodes occurred in 17% and 39% of the stomachs, respectively.

#### CONCLUSION

Preliminary results show no relation between toxicity, diet, and sex among kahala examined thus far. There appears to be some relationship though between diet and location of capture; fish from Gardner Pinnacles apparently have a more varied diet (a greater proportion of combined cephalopod and crustacean volume) than those from the island of Hawaii and the Molokai-Lanai-Maui-Kahoolawe area. Dietary differences are also indicated in comparisons of weight versus diet which show a greater volume of cephalopods for fish <5.4 kg and a changeover to fish as the major dietary component in larger kahala. Hence, except for the younger kahala, fish is the principal diet of kahala. Carangidae was the most frequently occurring family in terms of percentage of occurrence and total volume. Results to date reflect only trends in the data and should be considered only preliminary because of the small sample sizes.

The incidence of parasitic nematodes and trematodes were high in the stomachs of kahala; nematodes and trematodes were present in approximately 75% and 25%, respectively, of stomachs examined, regardless of sex and location of capture. In the ciguatoxic group and the group comprising fish <5.4 kg, trematodes were more abundant than nematodes. With the exception of the two above-mentioned groups, nematodes were the predominant parasite.

#### FUTURE RESEARCH NEEDS

Further analysis of stomach contents is needed to confirm the trends in dietary composition and incidence of parasites. Because only 15% of the kahala stomachs collected have so far been examined it should be emphasized that the results are preliminary. As more stomachs are examined other relationships will be investigated such as the consistency of diet over time, prey size in relation to fish weight, and various combinations of factors such as weight and location versus diet. Also, as more samples are processed, it may be possible to identify other food items, especially fish, that presently remain unidentified.

#### SUMMARY

One hundred and fifty-four stomachs collected from kahala, Seriola dumerili, representing 15% of the stomachs collected to date, were examined to determine a possible relationship between feeding habits and incidence to ciguatoxicity and as part of an overall study of the life history aspects of commercially valuable fishes in the Hawaiian Archipelago. Preliminary results indicate a change from cephalopods to fish as the principal food item with increase in size. In general, members of the family

Carangidae were the most important contributors among forage items for kahala. The results also indicated no apparent differences in the major food categories between ciguatoxic and non-ciguatoxic fishes and between sexes. Among sampling sites, however, differences were noted in volumes of cephalopods and crustaceans consumed.

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