ON BIOLOGY OF THE MARKET SQUID, *LOLIGO OPALESCENS*, A CONTRIBUTION TOWARD THE KNOWLEDGE OF ITS FOOD HABITS AND FEEDING BEHAVIOR

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ABSTRACT

Out of 1,000 stomachs of the market squid, *Loligo opalescens*, from the waters of southern and central California collected in different months and different years, only 33.1% contained food in various quantities, while 66.9% were empty. The amount of food in the stomachs varied from full stomach capacity to less than ⅛ capacity. Dominating food items were found to be crustaceans (42.0%), indeterminate fleshy material and fluid matter (24.8%), fish (19.6%) and polychaete worms and miscellaneous material (13.6%).

INTRODUCTION

Between November 1970 and June 1974, twenty-three collections of stomachs of market squid, *Loligo opalescens* Berry, totaling 1,000, were made in the waters of central and southern California. Of this number four winter collections were made in central California in November and December 1970, January 1971, and March 1972, yielding 221 stomachs. Ten summer collections from the same area were made in July 1971, June and July 1972, May 1973, and June 1974, yielding 511 stomachs. In southern California eight winter collections composed of 180 specimens were made in January 1971, October, November, and December 1973, and only one summer collection of 88 squid stomachs was made in June 1974.

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RESULTS

Unfortunately, the 1,000 specimens collected contained over 66% empty stomachs (Table 1). Therefore the limited quantitative data presented here are considered by me only as a preliminary study to serve as a guideline toward further investigations and more conclusive results.

Of the stomachs containing food or food remains from either collecting area, most were filled to no more than ¼ capacity and often far below that (Table 2). Only 57 out of 331 stomachs were completely filled, including 29 "gorged" (when upon cutting the abdomen, the stomach would burst). As to the empty stomachs in the collections, most represented material from central California (Monterey Bay to Point Conception), both summer and winter collections. The ratio between filled and empty stomachs collected in southern California is just about equal, regardless of collecting season.

Crustaceans constitute a major item in the squid's diet, with shrimp (such as *Sergestis* sp.) and shrimp-like euphausiids as dominant forms (Table 3). Fishes are next on the menu of squid, and the third place is taken by pelagic worms. Cannibalistic tendencies of squid (preying upon very young specimens of their own kind) were noted three times in collections from central California, and three times in collections from southern California.

DISCUSSION

During my participation in research cruises of the M/V ALASKA in California and Mexican territorial waters between 1958 and 1974, there were numerous occasions to observe schools of squids entering the illuminated zone at nightlight stations in the open sea. Sometimes these schools were engaged in very active pursuit of the organisms, such as young fish, euphausiids, or nereid worms concentrated under the light of the 1,000 watt incandescent electric lamp.

TABLE 1

Stomachs of Market Squid, *Loligo opalescens*, Collected during 1970, 1971, 1972, 1973, and 1974, by Region and Season.

Season	Central California			Southern California			Both regions		
	Cont. food	Empty	Total	Cont. food	Empty	Total	Cont. food	Empty	Total
Summer	149	362	511	46	42	88	195	404	599
Winter	46	175	221	90	90	180	136	265	401
Total	195	537	732	136	132	268	331	669	1,000
Percentages	26.6	73.4	100.0	50.8	49.2	100.0	33.1	66.9	100.0

TABLE 2

Stomachs of the Market Squid, *Loligo opalescens*, Collected during 1970, 1971, 1972, 1973, and 1974, by Region, Season, and Food Contents as Related to Stomach Capacity.

Region	Season	Contents in relation to stomach capacity*								
		Full	¾	½	¼	⅛	<⅛	Total	Empty	All
Central California	Summer	23[a]	2	15	50	32	27	149	362	511
	Winter	5	8	5	3	8	17	46	175	221
Total		28[a]	10	20	53	40	44	195	537	732
Percentages		14.4	5.1	10.2	27.2	20.5	22.6	100.0	--	--
Southern California	Summer	12[b]	3	6	6	8	11	46	42	88
	Winter	17[c]	13	8	10	18	24	90	90	180
Total		29[d]	16	14	16	26	33	136	132	268
Percentages		21.3	11.8	10.3	11.8	19.1	25.7	100.0	--	--
Grand total		57[e]	26	34	69	66	79	331	669	1,000
Percentages		17.2	7.8	10.3	20.9	20.0	23.8	100.0	--	--

* Explanation of symbols: [a] including 19 "gorged" or extreme capacity.
[b] including 6 "gorged" or extreme capacity.
[c] including 4 "gorged" or extreme capacity.
[d] including 10 "gorged" or extreme capacity.
[e] including 29 "gorged" or extreme capacity.

On several occasions, when the blanket net was used for getting a sample from the fish school under the light, the catch included a number of adult squids of large sizes, and some of them were found holding in their arms a fish 8 to 10 inches long (sardine or jack macherel). It looked like a head-on collision: The squid's arms were found entangling the head of the fish so tightly that mouth and gill covers were unable to open, thus causing the fish to die from asphyxiation.

TABLE 3

Frequency of Occurrence of Dominating Food Items in 331 Filled Stomachs of the Market Squid, *Loligo opalescens*, Collected in Central and Southern California during 1970, 1971, 1972, and 1974.

Description	Central California (numbers)	Southern California (numbers)	Both	
			(numbers)	(percent)
1. Crustacean remains, indeterminate	88	19	107	32.3
2. Crustacean remains (larvae)	0	8	8	2.4
3. Crustacean remains (Euphausiids)	10	11	21	6.4
4. Crustacean remains (Sergestid shrimp)	3	0	3	0.9
Subtotal	101	38	139	42.0
5. Fish parts and fish remains	30	35	65	19.6
6. Fleshy material, indeterminate	35	36	71	21.5
7. Fluid matter, indeterminate	11	0	11	3.3
8. Polychaete worms remains	8	24	32	9.7
9. Pelgic worms remains(?)	1	0	1	0.3
10. Young squid remains	3	3	6	1.8
11. Young octopus remains	5	0	5	1.5
12. Part of unidentified animal	1	0	1	0.3
Subtotal	94	98	192	58.0
Total	195	136	331	100.0
Percentages	58.9	41.1	100.0	--

I did not have an opportunity to observe feeding behavior of squid kept in captivity; however, a few comments on this subject by earlier contributors are given below.

Hardy (1956) refers to observations made by Anna M. Bidder (1950) on feeding behavior of the European *Loligo* in an aquarium. According to her, the fish is always "seized behind the head and held obliquely with the tail uppermost and is so carried until the head is bitten off and dropped . . . The trunk of the fish is then held horizontally in the arms, in line with the body . . . (and then) . . . the squid bites through the fish from head to tail by a series of transverse bites . . . " The consumption of a meal may last from 15 to 20 minutes, or even longer, and by this time the stomach may expand to ⅓ of the length of the mantle and ½ its width. W. Gordon Fields (1965) described his observations of feeding behavior of the market quid, *L. opalescens,* in a holding tank, using brokenback shrimp, *Spirontocaris* sp., as its prey. After a shrimp was caught, it was immediately held to the mouth and eaten in several bites, dropping rejected parts to the bottom. While eating the squid would continue to catch more shrimps with its tentacles. Fields also mentions that squids in captivity often attack one another; "in cases where an animal has unaccountably disappeared, its entire consumption by other members of the school has been considered likely."

As stomach contents attest, the squid feeds mainly upon free and actively swimming animals, such as fish and crustaceans. Food in the stomach was usually found to be of one type: it was either crustacenas, or fish, or polychaetes. However, this rule was not

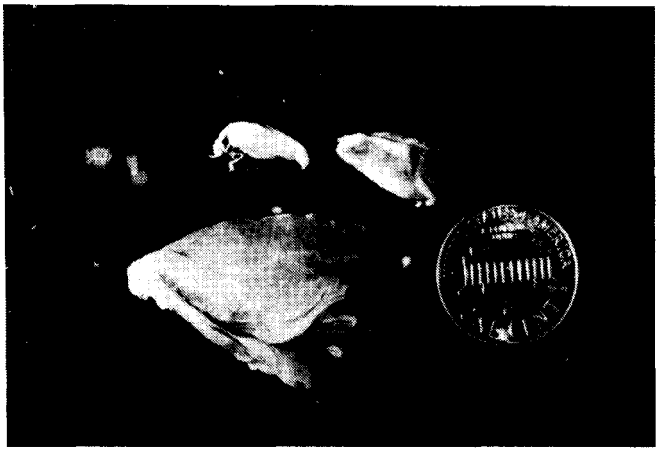

FIGURE 1. Squid stomachs, natural size. Upper photos (left to right): two empty stomachs (no. 1552, 1553), a stomach about ¼ filled (no. 1568), and a stomach about ½ filled (no. 1561).

Lower photo, "gorged" stomach of squid no. 1554, collected by James Hardwick near Fisherman's Breakwater, Monterey Bay, February 15, 1971. Male specimen, body length 300 mm.

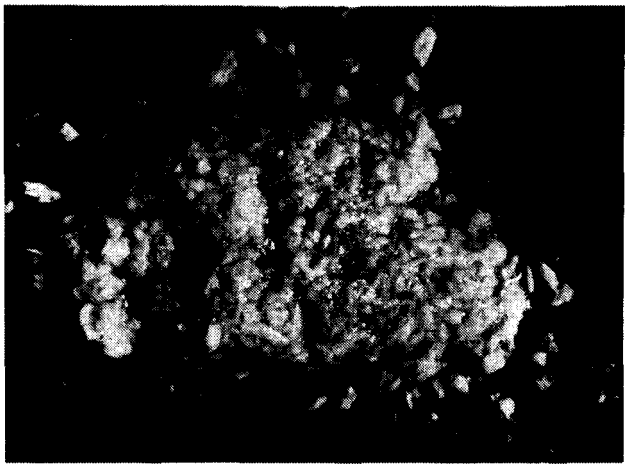

FIGURE 2. Contents of "gorged" stomach shown above, consisting almost entirely of fragmented euphausiids. All five specimens of squid were of the same body length within a few mm.

infrequently broken; two or even three kinds of food in various proportions sometimes were found. During the spawning season almost all female stomachs were found empty. Most of the male stomachs at this period also indicate a tendency to feed only sparingly. Well filled stomachs were rare. Phillips (1960) states, "Numbers of squid have been noted dead or in dying condition following spawning"—an observation that may be relevant in this connection.

The identification of food items found in the squid's stomach contents presents a difficult task even for the experienced microscopist, because this animal does not swallow its prey intact, as do most of the fishes. Instead, it thoroughly dismembers it; heads are removed, appendages are almost never found intact. What the investigator finds under the microscope are very tiny bites of flesh, vertebrae, scales, parts of carapace or fish bones, crustacean eyes, along with digestive fluid, oil, and small lumps of grease.

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