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Diet Composition and Daily Ration Estimates of Selected Trawl-Caught Fishes in San Miguel Bay, Philippines*

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Abstract

The diet composition of fish caught in San Miguel Bay, Philippines, in April and May 1993 was studied. The diets of *Otolithes ruber*, *Stolephorus commersonii* and *S. indicus* consisted mainly of zooplankton, primarily crustaceans. The stomach contents of *Leiognathus bindus* was found to consist mostly of detritus and unidentified materials. Daily rations estimated were: 1.90 g·day^{-1} for *O. ruber* of 17.3 g mean body weight (BW), 0.078 g·day^{-1} for *S. commersonii* of 3.8 g mean BW, 0.062 g·day^{-1} for *S. indicus* of 3.9 g mean BW and 0.56 g·day^{-1} for *L. bindus* of 7.7 g mean BW.

Introduction

Information on the daily ration and diet composition of fish are important for the construction of trophic models of aquatic ecosystems (Christensen and Pauly 1993). It is still difficult to obtain this information even though much research has been done on the topic. Most of the models proposed in the past involved laboratory experiments, requiring special equipment, and the results of such experiments were often biased and/or inaccurate because experimental fish were under stress. There are, however, straightforward models of stomach contents dynamics requiring a minimum of data (e.g., a single 24-hour cycle of stomach contents) which are easily obtained from field studies. Moreover, the results are not affected by stress.

This paper presents the results of a study of the diet composition and food consumption of four species of trawl-caught fishes sampled in San Miguel

Bay, Philippines, namely the tiger-toothed croaker, known as *alakaak* in the local language (*Otolithes ruber*); the orangefin ponyfish, *sapsap* (*Leiognathus bindus*); Commerson's anchovy, *dilis (Stolephorus commersonii)*; and the Indian anchovy, *dilis (Stolephorus indicus)*. The daily rations (R_d) of these species were estimated using a computer software program, MAXIMS, which based its estimate on analysis of a 24-hour cycle of stomach contents.

Methodology

Daily ration

Fish were sampled every two hours over a 24-hour cycle using a "baby" trawl with a headrope length of 12 m and a mesh size of 0.9 cm. The trawling speed at each fishing track was about 3 knots. The sampling area was located between latitudes 13°51' and 13°46' north and longitudes 123°05' and 123°07' east at 4.5 to 5.5 m depth (Fig. 1). The data were obtained over two sampling days, 27 April 1993 (1000 to 1700 hours) and 24 May 1993 (1800 to 0900 hours). Each haul lasted 30 minutes. Five individual similar sized samples for each species were collected from each haul. A 5% seawater-formalin solution was injected in the digestive tract through the anus and the fish were then stored in an ice-cold container.

After the last haul of the day, each specimen was measured and weighed in a wet laboratory at the field station in Naga City. Their stomachs were removed and preserved in labelled bottles with 5% seawater-formalin solution.

Further analysis was performed at the laboratory of the University of the Philippines Marine Science Institute (UPMSI), Manila. The stomachs were weighed and then emptied and the stomach contents (SC) weighed using an analytical balance. For very small individuals with minute stomachs, the stomach contents were weighed by subtraction, i.e., as the difference of the weight of the stomach before and after emptying. Thus, SC = full - empty stomach. Empty stomachs were recorded as SC = 0. It must be noted that empty stomachs are equally important in the analysis of daily ration and should not be ignored nor left unrecorded.

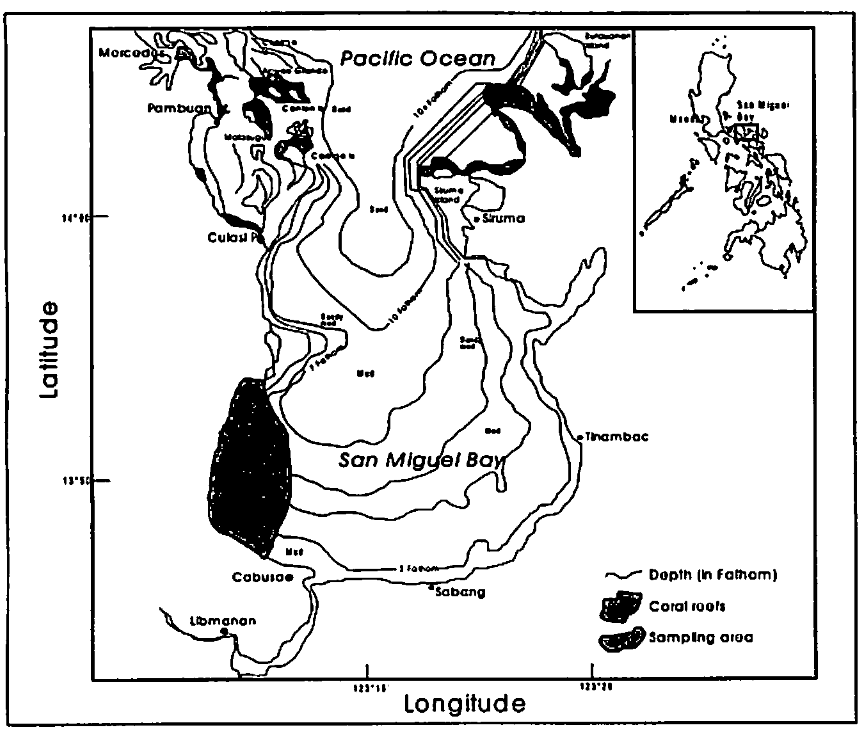

Fig. 1. Map of San Miguel Bay, Philippines showing the sampling area (shaded).

The fish sampled were not always of similar length. In order to account for the variability which might be caused by size differences, all stomach contents were re-expressed in percent of the body weight of the fish:

$$\%SC = \frac{SC}{W} \cdot 100 \qquad ...1)$$

where W is the total wet weight of the fish.

The MAXIMS software

Size-specific daily rations (R_d) were estimated through the method of Jarre et al. (1991), using the data presented in Table 1. MAXIMS computes R_d from estimates of ingestion and evacuation rates and the feeding times with a choice of two approaches. Both assume a simple exponential evacuation rate: one model is based on a constant ingestion rate (Model I) and the other on an ingestion rate linearly dependent on stomach fullness (Model II). A nonlinear algorithm is used to vary the parameter values in question in order to minimize the sum of squared residuals.

MAXIMS can accommodate either one or two feeding periods per 24-hour cycle. Our data suggested that the fish sampled had only one feeding period per 24-hour cycle. The main component of MAXIMS is an exponential evacuation model, viz:

$$S = S_0 \exp(-E(t-t_0)) \qquad ...2)$$

where

S = the stomach contents at time t;

E = the instantaneous evacuation rate (in hour $^{-1}$);

S_0 = the stomach contents at the beginning of a given period; and

t_0 = the time at the beginning of the period in question.

As stomach contents are continously evacuated, the amount of food evacuated must be subtracted from the amount of food actually ingested. Thus, this change in stomach contents is given for Model I by:

$$dS/dt = J_1 - E\,S \qquad ...3)$$

where

$S = S_r \exp(-E(t-t_0)) + J_1/E(1 - \exp(-E(t-t_0))$ ... 4)

and where

J_1 = the ingestion rate (g·hour^{-1});

S_r = the weight of the stomach contents at the beginning of the feeding period.

The first addend represents the evacuation of the stomach contents present before a given feeding period and the second addend incorporates ingestion and evacuation of the newly ingested food.

The change in stomach contents during the feeding period for Model II is given by :

$dS/dt = J_2 (S_m - S) - ES$ ... 5)

where

$S = S_r \exp((-E + J_2)(t-t_0)) + S_\infty(1 - \exp(-(E+J_2)(t-t_0)))$ ... 6)

and where

J_2 = an instantaneous ingestion rate (hour^{-1});

S_m = the maximum possible weight of the stomach contents (g);

S_∞ = the asymptotic weight of stomach contents which is related to S_m by:

$S_\infty = J_2 (S_m / (J_2 + E))$. ... 7)

During the feeding period, the stomach contents for both models increased from S_r towards the asymptote J_1 / E in Model I or S_∞ for Model II. Note that daily ration is computed as the integral of the ascending part of the trajectory of stomach contents, representing the feeding period. Further details on MAXIMS may be found in Jarre et al. (1990, 1991).

Diet composition

Using a stereomicroscope, stomach contents were sorted into major food groups/taxa (e.g., crustacean, fish, plankton). These were weighed to the nearest 0.0001 g using an analytical balance. The percentage frequency of occurrence (a measure of regularity of inclusion of major food groups in the diet of the fish samples) and percentage volume (bulk of the major food items in the stomach) were obtained. The overall relative importance of each major food group in the diet was assessed using the index of relative importance (IRI) with respect to both measures (Gomez et al. (unpublished); Garces 1988):

IRI = (% frequency of occurrence) · (mean % volume) .. 8)

Results

Fish sampled

Four out of 13 species caught from San Miguel Bay were represented in over 50% of the sampling hauls. These are *Otolithes ruber*, *Leiognathus bindus*, *Stolephorus commersonii* and *Stolephorus indicus*. Their characteristics are summarized in Table 1.

Diet composition

The food items identified from the stomachs of the four species sampled in San Miguel Bay included crustaceans (isopods, amphipods, malacostracan larvae, caprellids, penaeid shrimp larvae, mysid larvae), soft-bottom organisms (annelid worms, polychaete worms, sponges) teleosts (anchovies, fish eggs and larvae), and plants (cladophoran algae) and fine sand. The diet of *O. ruber* was dominated by crustaceans with a mean volume of 45.6% and occurrence of 57.8%. Similarly, the diet of *S. commersonii* was also dominated by crustaceans with a mean volume of 41.5% and occurrence of 55.6%.

S. indicus was found to ingest plankton and crustaceans with mean volume of 21.3% and 22.2%, and frequency of occurrence of 38.5% and 12.8%, respectively. Plankton was found to be more important in its diet than crustaceans. *L. bindus* stomachs generally contained partly digested items which were difficult to classify. Table 2 summarizes the results of the stomach contents analysis.

Daily ration estimates

Table 3 presents the statistics estimated using MAXIMS from the data given in Table 4. Model II in MAXIMS was found to fit the trajectories of the stomach contents of all four species (Fig. 2).

Discussion

All of the four trawl-caught species from San Miguel Bay fed on zooplankton and fish, which matched the results reported by other authors. *O. ruber*, a demersal species, is known to be highly carnivorous (Pillai 1983). Its postlarval and juvenile stages are surface zooplankton feeders (Vaidya 1960), with diets consisting mainly of *Acetes* and mysid shrimps (Bal and Bapat 1949; Venkataraman 1960; Basheeruddin and Nayar 1961; Nair 1980). The adults fed near the substrate, mainly on teleosts, shrimps and cephalopods (Vaidya 1960; Nair 1980). *L. bindus* feeds mainly on zooplankton, fish larvae and nematodes throughout its life (Guarin 1991). Both

Table 1. Statistics of the samples of four trawl-caught fish species from San Miguel Bay, Philippines.

Statistic		*O. ruber*	*L. bindus*	*S. commersonii*	*S. indicus*
Size range	High	23.6	6.8	9.3	8.6
(TL, cm)	Mean	11.2	5.7	7.8	7.3
	Low	8.2	4.1	5.6	5.1
Weight range	High	148.0	4.5	6.4	5.8
(g wet weight)	Mean	17.3	2.8	3.8	3.9
	Low	4.4	1.2	1.3	1.2
Number		45.0	35.0	54.0	39.0

Table 2. Mean percentage volume, frequency of occurrence and index of relative importance of the major food items for four trawl-caught fish species in San Miguel Bay, Philippines.

Major food items	Mean volume (%)	Frequency of occurrence	Index of relative importance	Rank
O. ruber				
Fish	21.6	11.1	240	3
Crustaceans	45.6	57.8	2 633	1
Others	20.4	15.6	318	2
L. bindus				
Crustaceans	7.2	5.7	41	2
Others	46.1	40.0	1 844	1
S. commersonii				
Fish	12.7	1.9	24	3
Crustaceans	41.5	55.6	2 304	1
Others	23.1	11.1	256	2
S. indicus				
Crustaceans	22.2	12.8	284	2
Plankton	21.3	38.5	820	1

Table 3. Daily ration estimates and parameters of stomach contents dynamics obtained for four trawl-caught fish species in San Miguel Bay, Philippines using the MAXIMS software.

Parameter	Model I	Model II			
	L. bindus SMB	*L. bindus* *	*O. ruber*	*S. commersonii*	*S. indicus*
Ingestion rate ($hour^{-1}$)	0.307	0.016	0.057	0.005	0.079
Evacuation rate ($g \cdot hour^{-1}$)	0.204	0.322	0.054	0.270	0.072
Asymp. stom. cont. (% weight)	-	0.198	1.54	1.34	0.537
Feed began (hour)	16:30	17:30	15:87	15:01	15:70
Feed ended (hour)	4:58	2:00	08:11	11:90	2:05
R_d ($g \cdot day^{-1}$)	0.105	0.565	1.86	0.078	0.062
SSR	0.0369	0.010	0.042	0.161	0.026

* Results from combined data sets of Guarin (1991) and this study.

species of *Stolephorus* are pelagic zooplankton feeders, feeding mainly on crustaceans, such as copepods and shrimps (Whitehead et al. 1988).

The estimates of rations for the four species appear reasonable, although considerable portions of the 24-hour cycles for *O. ruber* (between 1000 and 1500 hours), *L. bindus* (between 1800 and 2400 hours) and *S. indicus* (between 1000 and 1500 hours) were missing. In the case of *O. ruber*, the available data points used for fitting the trajectory represent the ascending phase (feeding period); the missing stomach contents data were presumed to represent the downward phase, i.e., the nonfeeding period. Thus, a nocturnal feeding activity and a daytime resting phase could be inferred. It is possible that *O. ruber* was not represented in any of the daytime samples because being demersal (Navaluna 1982), it may have followed the marked tidal movements in the bay, migrating daily into the deeper waters at the center of the bay to a depth of 9 m (Mines et al. 1982). Sampling hauls were consistently done on the shallower coast down to 5 m along the southwestern portion of the bay (see Fig. 1).

The *L. bindus* samples (Table 4) represented the nonfeeding period, since the fish were not caught during the feeding period. Murty (1986) reported that at nighttime, *L. bindus* usually stays 6-15 m above the sea bottom in waters of 21-35 m depth. As zooplankton feeders generally follow the nighttime upward migration of zooplankton (Longhurst and Pauly 1987), it is likely that *L. bindus* stays near the water surface at night. Since the bottom trawl used in this study had a vertical opening of about 2 m, it would have been difficult to catch any fish swimming above 2 m in waters 5-6 m deep.

A previous study by Guarin (1991), which confirmed the nocturnal feeding activity hypothesis for this species, reported a daily ration of 15% of BW for *L. bindus* of 12.6 g. A diurnal cycle with two feeding phases was assumed which probably overestimated R_d. On the other hand, this study's value of 3.71% of BW for fish of 2.83 g based on an incomplete data set would have been an underestimate. Combining the two sets of data, a daily ration of 7.2% of BW for a mean weight of 7.71 g could be obtained (see Fig. 2) which is probably a more accurate estimate than either of the two previous estimates.

The data for *S. indicus* are incomplete and the daily ration may be underestimated although this is not much lower than that for *S. commersonii* for which the cycle was complete.

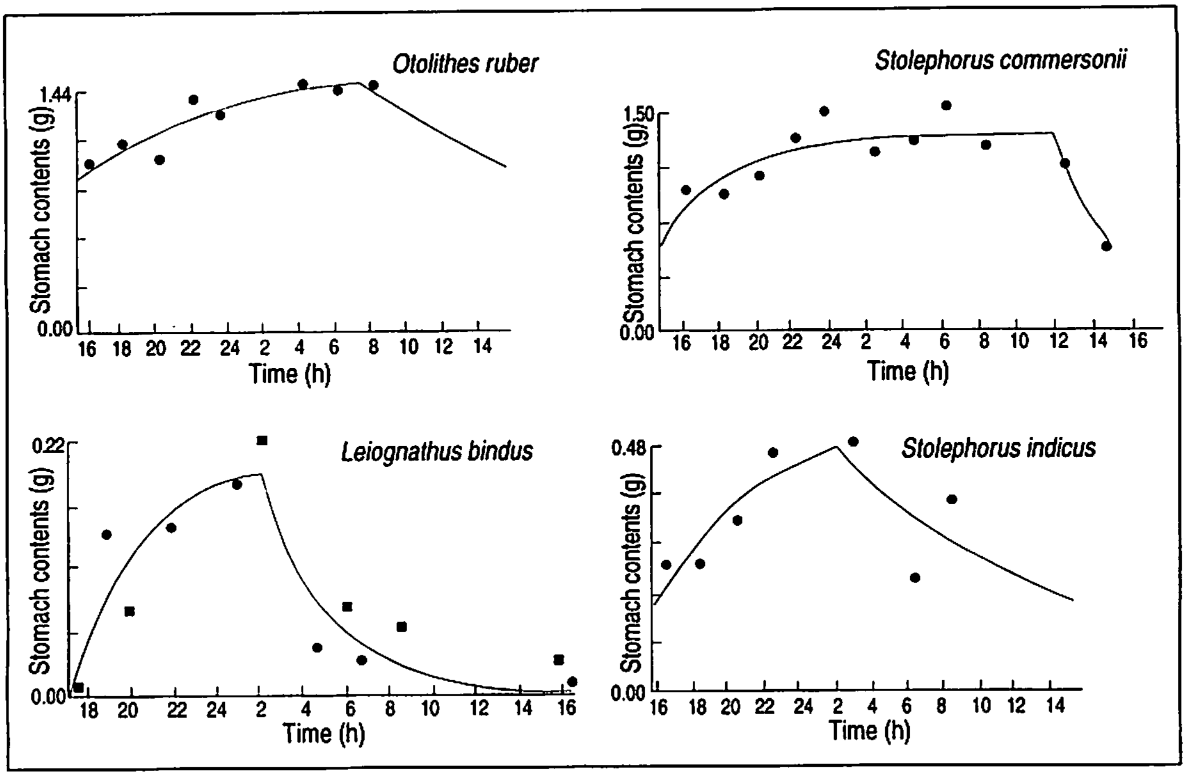

Fig. 2. Daily ration estimates for the four species of fish caught over a 24-hour cycle in San Miguel Bay, Philippines. Note that the data used for L. bindus *are a composite of Guarin (1991, in squares) and this study (in circles).*

Table 4. Mean stomach contents (g) per sampling hour of four trawl-caught fish species in San Miguel Bay, Philippines.

Time of sampling	*O. ruber*	*L. bindus**	*L. bindus*	*S. commersonii*	*S. indicus*
01:00		0.1830			
02:00	0.2220				
02:35	0.2380			0.0436	0.0186
04:35	0.2490		0.0390	0.0468	
06:00		0.0739			
06:30	0.2420		0.0285	0.0541	0.0086
08:30	0.2450		0.0542	0.0461	0.0143
10:00		(0.164)			
10:30			0.0119		
12:40			0.0086	0.0407	
13:00		(0.132)			
14:50			0.0036	0.0195	
16:00		0.0282			
16:30	0.1760		0.0086	0.0339	0.0097
17:30		0.0123			
18:35	0.1920			0.0327	0.0097
19:00		0.1370			
20:00		0.0739			
20:35	0.1790			0.0367	0.0129
22:00		0.1430			
22:30	0.2380			0.0471	0.0176
24:00	0.2210			0.0537	0.0098

* Data from Fig. 6 in Guarin (1991). Values in parentheses were based on only two fishes and were thus not used in this analysis.

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Samples for each species are sorted.