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Food Habits, Daily Ration and Relative Food Consumption in Some Fish Populations in Ubolratana Reservoir, Thailand

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Abstract

The diet composition and feeding habits have been investigated for several economically important indigenous species based on diel surveys collected from the Ubolratana reservoir (Thailand). For some of these populations the daily food ration, feeding periods, ingestion and evacuation rates were determined using MAXIMS, an iterative computer software utilizing 24-hour series of stomach content data obtained in natural populations. The results obtained provide useful information for studies of the trophic relationship in the reservoir

Introduction

Understanding trophic relationships in reservoir ecosystems is important to defining fisheries management strategies due to the fact that they support profitable fisheries mainly in tropical regions. Diet composition, diel feeding patterns and relative food consumption of constituent species in the fish community of an aquatic ecosystem are some of the essential pieces of information needed to quantify trophic relationships (Christensen and Pauly

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1992, 1993, 1996, Christensen et al. 2000). Diet composition is a useful aspect to be investigated in fisheries sciences to understand trophic interactions (Helawell and Abel 1971; Hyslop 1980; Lauzanne 1988). Based on the methodology developed by Sainsbury (1986), to estimated daily ration in fish through studying the dynamics of stomach contents, Jarre et al. (1991) have presented a practical and analytical method, MAXIMS, to quantify daily ration. The method is applied to a 24 hours cycle of stomach content weights in natural populations of fish in order to estimate diel feeding periodicity, daily ration and relative food consumption in fish populations.

In the present study an attempt is made to analyze food and feeding habits, daily ration and relative food consumption of some fish populations in the well documented Ubolratana reservoir, in the North East of Thailand.

The Ubolratana reservoir

The Ubolratana reservoir (latitude 0°45' S, longitude 36°20' E, altitude 182 m above msl, maximum surface area approximately 410 km^2) is a large shallow and eutrophic reservoir created by damming the confluence of the Pong and Chern Rivers in North-East Province, Thailand, about 500 km from Bangkok (Chookajorn et al. 1994). It is located in a broad valley and is the largest reservoir in Thailand (Fig. 1). It is drawn down yearly to 176 m above msl and the area shrinks to about 160 km^2. At 182 m. above msl the mean depth is 12 m. Ubolratana is an "open water" reservoir with a large pelagic zone. The commercial fisheries are quite active and are exploiting several indigenous and even some introduced fish species, mostly Asian Cyprinids stocked on a yearly basis

Materials and Methods

Only littoral species will be considered here. Between brackets are range of sizes and weights. They are:

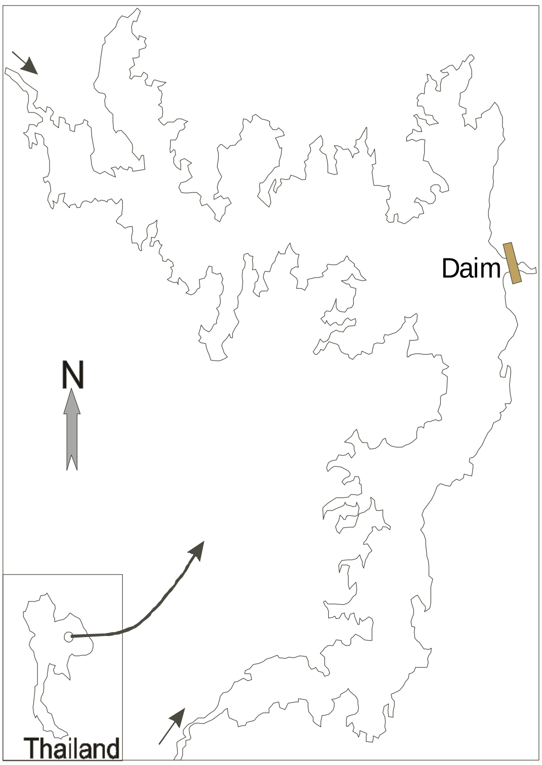

Fig. 1. General map of Lake Ubolratana

Ambassis notatus. (4.0-7.0 cm; 0.5-3.5 g)
Channa (Ophiocephalus) striata (12.7-35.0 cm; 17.0-417.0 g)
Cyclocheilichthys repasson (5.5 – 14.0 cm; 2.0-33.0 g)
Hampala dispar (7.5-30.0 cm; 4.0-344.0 g)
Henicorhyncus siamensis (9.0-13.5 cm; 7.0-26.0 g)
Mystacoleucus marginatus (4.0-8.0 cm; 1.0-5.5 g)
Osteochilus hasseltii (8.0-25.0 cm; 7.0-287.0 g)
Puntioplites proctozysron (5.0-30.0 cm; 1.5- 367.0 g)
Puntius (Systomus) orphoides (4.0-15.5 cm; 1.0-45.0 g)

Two diel surveys were carried out in February and October 2000. During these diel surveys fish were caught in two or three hourly intervals with bottom and surface gill nets of various mesh sizes, beach seines and through electric fishing. Caught fish samples were sorted according to species type. Fish samples were measured individually for their total length to the nearest millimeter, as well as their respective weights, in the nearest dg.

In order to prevent deterioration of the gut contents, gillnets were set for less than half an hour depending on the abundance of the species. Fish, which were caught in gillnets and beach seines at each time interval were preserved separately in 10% buffered formaline. Before preservation, each fish was laterally dissected near the body cavity to facilitate penetration of the preservative. Fish samples were taken to the laboratory for further analysis.

In the laboratory, the gut of each fish was then isolated. As several species (especially Cyprinids) have no well-developed stomachs, the anterior one-third of the gut was separated and contents of this portion were considered to be the recently consumed food.

The diet composition of each individual fish was determined microscopically and contents were quantified as a percentage of the total stomach content per sample. An average diet composition has been obtained by pooling the data of every individual fish belonging to the same population.

An iterative method for estimating daily food consumption rate, developed as the computer software package 'MAXIMS' (Jarre et al. 1991) was used to estimate the daily ration of fish.

For that purpose, The wet weight of the stomachs was determined to the nearest 0.001 g and stomach contents were extracted. The difference in weight between the full stomach and the empty stomach from which contents were extracted gave the wet weight of the stomach contents. It must be noted however, that in the present study, stomach/gut content weights pooled for several specimens were determined, especially for those whose stomachs/guts were small and mean values were calculated.

In order to minimize the possible effect of the variations of individual sizes of the fish under investigation, it is referred to as the percentage of the gut weight/total fresh weight.

Depending on the chronological patterns of varying weights of the stomach contents obtained from the field, one or two distinct feeding periods per 24-hour cycle which were separated by clear non-feeding time, were recognized. For a proper operation of MAXIMS in accordance with the user's instruction manual for the utilization of available field data sets, we had to assume a constant ingestion rate. The residual sum of squares (SSR) was used as a measure of goodness of fit. We considered the duration of feeding periods that minimizes the SSR values we obtained at every run. From these values of the daily food consumption, we computed Q/B equivalent to the relative food consumption per biomass (Pauly 1986). Q/B values obtained were compared to the values generated by using the predictive model of Palomares and Pauly (1998). Raw field data are available from any of the authors.

Results

The diet composition

The diet composition of the species under investigation is summarised on table 1.

The fish species considered here have a large variety of diet compositions. For this study, however, we have considered mainly the small size fish for some species that can grow into large-sized adults (e.g. *C. striata*).

C. striata is known to be a littoral zoophagous insectivorous fish and even a predatory fish, (Wongtirawatana 1981). The diet observed is quite diversified due to the generally small sizes of the fish considered.

A group of insectivorous fish has been clearly identified. *C. striata, H. dispar, M. marginatus and C. repasson* (R. Hoofer, pers. data) also identified a large amount of Chironomid larvae in the gut of *Cyclocheilichthys spp*.

Table 1. Diet composition (expressed as percentage in volume) of the main species in Ubolratana reservoir

Species		Average diet composition												
		N	F	AI	TI	ZP	G	S	IL	MB	MP	EA	PP	D
A. notatus	F	18		22		31			17	5	2		2	21
A. notatus	O	23	4	17	8	36			15	4		5	10	1
C. striata		42	28	36	8	4		4		7				13
C. repasson	F	80		4		5			23	9	2		1	56
C. repasson	O	14		6		28			22	34		2	5	3
H. dispar		35	14	34	1	8	1	6	17	7	2		3	7
H. siamensis	F	45							1	1	6		10	82
H. siamensis	O	24				1					49	5	31	14
M. marginatus	F	17		35	20	6			2	1	1	10	19	6
M. marginatus	O	51		15	4	21			18	20	8	6	6	2
O. hasseltii	F	26							1	1	26	2	25	46
O.hasseltii	O	10				11			4	5	25		27	28
P. proctozysron	F	89		2		31	1		13	6	15		1	31
P. proctozysron	O	14				47	1		28	14	2	1	1	6
S. orphoides		25		4		43			5	5	14		14	15

N (Number of fish), F (Fish) AI (Aquatic Insects), TI (Terrestrial Insects), ZP (Zooplankton), G (Gastropods), S (Shrimps), IL (Insects larvae), MB (Microbenthos), MP (Macrophytes), AE (Epiphytic algae), PP (Phytoplankton) and D (Detritus). F (February) and O (October)

For the first time, apparently, an important community of littoral zooplanktophagous fish has been categorized consisting of: *Ambassis notatus. P. proctozysron* and *S. orphoides*. These fish are quite abundant as demonstrated during the field surveys (B. Sricharoendham, pers. com). Gut analysis revealed that they consume a significant amount of zooplankton, aquatic insects and larvae (confirmed by J. Macachek pers. com). These fish can impose possible competition for food along the slightly profound littoral bentho-pelagic zone against the relatively pelagic *Clupeichthys aesarnensis.*

Finally, small plant and detrital materials are consumed significantly by *H. siamensis, O. hasseltii*

No size related trends of the diet composition could be identified except for *C. striata*, which starts to consume fish only after reaching more than 17 cm TL.

Daily food consumption and relative annual food consumption

The MAXIMS software could be used for data collected from the field and the results in terms of feeding pattern (Table 2 and Fig. 2) and daily food consumption for fish of a particular size weight, a required parameter for a proper Q/B computation of the software (Table 3). Computation of Q/B also needs information on demographic structure, which for the species considered in this paper is provided in table 4. It should be noted that several Q/B values obtained here are quite close to the one resulting from the predictive model of Palomares and Pauly (1998). Differences with this model help to interpret the computed Q/B values

In general, the results of the analysis runs show that lower daily ration (in percent of fresh body weight) and ingestion rates can be observed with species belonging to the carnivorous group or even those fish species being able to consume varying types of food but have more preference for those of animal origin since these are of higher energetic value.

From this study, *H. siamensis* appears to have high ingestion rates and to be consuming a large quantity of food. This is clearly in relation to the

Table 2. Ingestion and evacuation rates, daily ration (as percentage of body fresh weight), residual sum of square and number of feeding periods observed for the fish populations considered here (ssr = residual sum of squares)

Species	Ingestion % fw•h^{-1}	Evacuation % fw•h^{-1}	Ratio % fw d^{-1}	ssr	Number of feeding periods per day (beginning and end of each
A. notatus (Feb)	0.450	0.290	6.52	0.4400	2 (9.50-15.00/20.00-5.00)
A. notatus (Oct)	0.300	0.357	4.50	0.1600	2 (10.00-18.00/21.50-4.50)
C. striata (small)	0.549	0.157	6.18	0.3990	2 (6.50-13.50/15.75-20.00)
C. striata (large)	0.400	0.116	4.18	0.0960	2 (6.50-13.00/15.80-19.80)
C. repasson (Feb)	0.250	0.392	3.25	0.0211	2 (3.00-11.00/17.00-22.00)
C. repasson (Oct)	0.250	0.219	3.05	0.0640	2 (5.00-11.70/15.50-21.00)
H. dispar	0.350	0.482	4.15	0.0320	2 (6.50-12.35/15.00-21.00)
H. siamensis	1.150	0.177	17.6	1.4300	1 (2.50-17.80)
M. marginatus	0.450	0.090	5.41	0.1420	1 (3.50-15.50)
O. hasseltii	0.900	0.201	7.47	0.0248	2 (7.15-12.00/15.60-19.10)
P. (S.) orphoides	0.800	0.250	10.8	5.5491	2 (4.50-11.50/14.50-21.00)
P. proctozisron (Feb)	0.500	0.164	3.75	0.8740	2 (6.50-12.00/15.00-17.00)
P.protozizsron (Oct)	1.100	0.264	7.15	2.1000	2 (8.50-11.00/16.50-21.00)

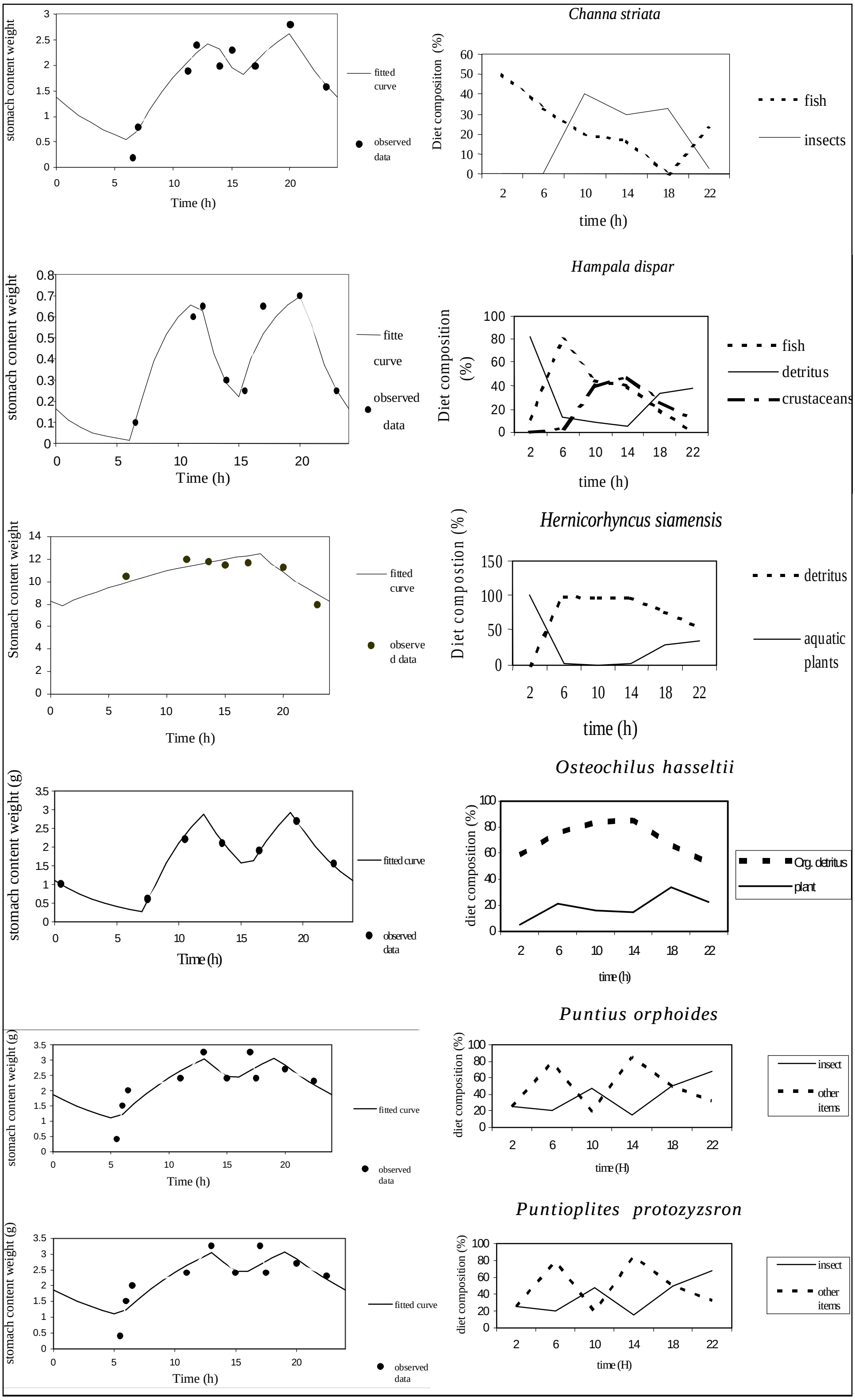

Fig. 2. Diel feeding period and diet composition (Wongtirawatana, 1981) in a 24-hour cycle of the ssme littoral fish populations in Ubolratana reservoir

nature of preferred food of this species. Microscopic studies identified mostly dead plant materials which have been at least partly digested by bacteria before ingestion by this fish. These dead materials are of very low energetic value and probably account for the long feeding period that leads to high food consumption both in terms of daily ration and relative food consumption per biomass.

The comparatively high Q/B value of *S. orphoides* might have come from the substantial quantity of plant material (even macrophytes) which appears in the diet of this species. On the opposite, *O. hasseltii* seems to eat less food than expected for a mostly detritivorous fish.

Table 3. Daily food consumption, beta and related Q/B values for fish populations in Ubolratana reservoir

Species	Mean weight (g)	Daily ration (% fw)	Daily ration (g)	Beta (+)	Q/B $year^{-1}$	Aspect ratio (1)	Q/B (2) $year^{-1}$
A.notatus(Feb)	2.0	6.52	0.130	0.0630	23.90	2.00	26.4
A. notatus(Oct)	1.5	4.50	0.068	0.1010	15.60	2.00	26.4
C. striata	35.0	6.18	2.170	0.0375	14.90	1.20	7.8
	150.0	4.18	6.270	0.0407	13.80	1.20	7.8
C. repasson (Feb)	10.0	3.25	0.325	0.1447	8.70	1.80	14.5
C. repasson(Oct)	5.0	3.05	0.152	0.2050	6.52	1.80	14.5
H. dispar	35.0	4.15	1.450	0.0584	14.30	2.50	13.8
H. siamensis	15.0	17.60	2.640	0.0208	54.10	2.20	48.9
M. marginatus	4.0	5.41	0.220	0.0564	15.80	2.20	16.5
O. hasseltii	15.0	7.47	1.130	0.0432	20.30	2.15	41.1
P. (S.) orphoides	8.0	10.80	0.860	0.0443	30.00	2.30	18.1
P. proctozisron (Feb)	35.0	3.75	1.310	0.0504	13.70	2.90	14.1
P. proctozisron (Oct)	8.0	7.15	0.500	0.0367	18.40	2.90	14.1

(+) A parameter referring to the assimilation of the food by the fish population and is required to compute Q/B using Maxims (Jarre et al, 1990; Pauly, 1986).
(1) The aspect ratio of the caudal fin, an index of activity incorporated in the model of Pauly and Palomares (see below).
(2) The Q/B value as estimated when using the predictive model of Palomares and Pauly (1998). The average temperature of the lake is 26.5 °C.

Table 4. Demographic parameters of fish populations considered in Ubolratana reservoir: The asymptotic length (Loo) and asymptotic weight (Woo), as well as the growth coefficient (K) refer to the von Bertallanffy growth curve. Z is the instantaneous total mortality rate.

Species	Loo(cm.)	Woo (g)	K (yr^{-1})	Z (yr^{-1})	Source
A. notatus	11.0	14	1.00	3.34	FD
C. striata	67.0	2645	0.35	1.35	FD
C. repasson	25.0	211	0.80	2.13	FD
H. dispar	30.0	320	0.56	1.64	FD
H. siamensis	26.0	224	0.80	2.17	FD
M. marginatus	26.0	175	0.50	2.58	FD
O. hasselti	33.0	505	0.58	1.86	FD
P(S). orphoides	21.0	125	1.50	1.50	M*
P. proctozysron	39.5	502	0.4	1.84	FD

**Puntius* or *Systomus orphoides*
Source: FD field data originating from the surveys and analyzes with the FISAT Software (Gayanilo et al,1997); M. Moreau personal data in Nam Ngum reservoir (Laos)

To some extent, a high Q/B value is also observed for *C. striata*. This might be due to the nature of the food and also from the range of sizes of the fish considered here. They have to be regarded as “small fish” when referring to the maximum size of the species.

Discussion

A possible explanation of diel habits can be based on the food preference per fish species. In certain cases, some species tend to shift their daily food preferences influenced by some ecological parameters such as niche preference and space availability.

The amount of energy derived by each species from the preferred food items being consumed contributes also to explain the duration and number of intensive feeding period per day.

Most predatory, insectivorous and zooplanktophagous fish were observed to search actively for preys during early mornings and late afternoons. This is related to their physiologic behaviour of hunting their preys by eye as suggested by De Silva et al. 1996).

Most visual feeders are known to feed during twilight so that usually two peak feeding periods are evident among them (Jarre et al. 1990). It was reported that a maximum feeding activity in some zooplanktivorous Cyprinids occurred before midnight due to protective behaviour against predators and as a result of diel pattern of zooplankton distribution (Bohl 1980). The peak feeding periods of zooplanktivorous fishes studied in this analysis, which do not coincide with the twilight periods is not therefore surprising.

A. notatus is feeding on zooplankton, aquatic insects, and insect larvae twice a day. Among these food items, however, zooplankton is usually more preferred and was observed to be consumed significantly during the afternoon (A. Duncan, pers. com. and Vijverberg et al. 2002).

C. striata, showing two periods of intensive feeding per day, is known to feed on aquatic insects and fish. Wongtiwaratana (1981) showed that aquatic insects are consumed more during the day and shifts only to fish diets when insect resources becomes depleted. A. Duncan (pers. data) has confirmed this. Even with practically overlapping feeding periods, shifting of food preferences as an adaptive mechanism may account for lesser competition with other insectivorous fish such as *A. notatus* which shifts into a zooplanktophagous diet during afternoons

H. siamensis, showing one period of intensive feeding per day, was observed to shift food item preferences as a consequence of its daily migration pattern. During day time it feeds mainly on organic detritus then starts to feed on macrophytes as it migrates towards aquatic weed dominated areas at night (Wongtiwaratana 1981). *O. hasseltii*, on the other hand, having two meals per day also feeds largely on “ organic ” detritus but may impose a limited competition with *H. siamensis due* to difference in spatial distribution and its ability to shift its diet, consuming macrophytes and phytoplankton

As these two species do not rely on visibility for feeding, digestive rhythm and appetite of fish may determine the diel feeding periodicity, which result in a single feeding period within a 24-hour cycle.

P. proctozysron and *S. orphoides* were both observed to consume a wide range of food items, commonly dominated by zooplankton, twice a day. Intense competition between these two species for food may exist since they permanently feed on the same items all throughout the day with nearly overlapping feeding periods as observed by Wongtiwaratana (1981)

High competition for food may not always occur among species such as *C. repasson* and *M. marginatus*, due to their ability to change their diets and feed on insect larvae, macrophytes and phytoplankton and aquatic insect, respectively. Less competition against other moderately organic material feeding fish species probably occurs due to their different spatial distributions (Bohl 1980, De Silva et al. 1996, Piet and Guruge 1997).

The significantly high daily ration (%fw of body weight) and ingestion rate of *H. siamensis* may be due to the lesser energetic value of organic detritus being consumed on most part of the day and ingests macrophytes only during its nocturnal migration. The relatively low evacuation rate which does not seem to agree with its relatively high ingestion rates and daily ration is due to the low utilization rate of the ingested food materials like algae due to the lack of the strong hydrochloric acid in the stomach which aids in the faster digestion of food

O. hasseltii being an omnivore, although having higher preference to food of plant origin and unicellular algae, can readily shift its diet and ingest crustaceans and macrophytes. This may explain a slightly lower daily ration as compared to *H. siamensis* and *P. orphoides*.

Following Politou et al. (1993), we tried to compare the daily ration per unit body weight of the different species considered here with temperate species having similar diets by referring to the database of Palomares (1991). It appears that the food consumption is lower in temperate zones. For instance an individual temperate zoophagous fish of 45 g (average weight) consumes about 0.7 g•day, a lower value compared to 1.3 to 1.4 g as recorded in the present study (Table 3). Similarly, temperate ichtyophagous individual fish of 150 g experience a daily food consumption of 2.3 to 3 g instead of 6.3 g as computed here for C. *striata*. The higher metabolic rates in tropical fish may require higher food consumption.

Conclusion

The literature on fish feeding ecology devotes little attention to investigating diel feeding periodicity, digestion rhythms, and seasonal variation in feeding patterns. The present study indicates that such research is important, if not essential, in order to understand the trophic dynamics of co-occurring fish species. This is especially due to the fact that fish species with similar food habits can co-exist as they relax inter-specific competition for food resources through the differences in seasonal and diel feeding patterns among fish species. Most importantly, estimation of Q/B ratios of constituent fish species in the aquatic ecosystems is useful for quantifying trophic relationships. This has led fisheries science to a new era for the management of multi-species fisheries (Christensen and Pauly 1992; Walters et al. 1997 and 1999).

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