DIET AND DIGESTIVE EFFICIENCY OF ZEBRAPERCH (*HERMOSILLA AZUREA*)

AN HERBIVOROUS KYPHOSID FISH OF SOUTHERN CALIFORNIA MARINE WATERS

Erick A. Sturm
California State University, Fullerton
800 N. State College Blvd.
Department of Biology, MH 282
Fullerton, Ca. 92634
(714) 449-5267: ESturm@Fullerton.edu

Michael H. Horn
California State University, Fullerton
(714) 773-3707: MHorn@Fullerton.edu

Diet

Herbivorous fishes in tropical and subtropical marine waters often eat algae containing secondary metabolites that act a chemical defenses. Included in this group are members of the family Kyphosidae, several of which in the genus *Kyphosus* appear to feed mainly on brown algae with chemical defenses (Randall,1983; Rimmer and Wiebe,1987; Steinberg,1989). In the present work we proposed first to test the hypothesis that the zebraperch (*Hermosilla azurea*), a little-studied temperate-zone kyphosid, also consumes chemically defended brown algae as a major part of its diet.

To test this hypothesis, zebraperch were captured by spear and gillnet off Santa Catalina Island between July 1993 and April 1994. Digestive tracts from the esophagus to the anus were removed and their lengths measured. Stomachs were separated from the rest of the digestive tract, and their contents fixed in 10% buffered formalin, sorted to the lowest possible taxon and then dried to a constant weight to determine the contribution of each algal species to the diet of the fish.

Results of the stomach content analysis showed that zebraperch ate 17 different species of algae (Table 1), with the red algae *Polysiphonia* spp. comprising nearly two-thirds of the diet by dry weight and occurring in more than 75% of the stomachs.

These results do not support our hypothesis that zebraperch eat chemically defended brown algae as do their tropical relatives. Zebraperch diets consisted mainly of red algae not known to contain defensive chemicals (Hay and Fenical,1988). A small proportion of the fish's diet did include the brown alga *Halidrys dioica*, which is known to contain secondary compounds that act to deter invertebrate herbivores (Steinberg,1985). Therefore, zebraperch appear to eat chemically defended algae occasionally but more often choose to eat algae with weak or no chemical defenses.

Table 1. Diet of zebraperch based on stomach content analysis of individuals (n=60) captured at Santa Catalina Island.

Dietary Item	Frequency of occurrence	% of total (dry weight)
Red algae (Rhodophyta)		
Polysiphonia spp.	78.3	63.8
Chondracanthus canaliculatus	42.4	11.6
Ceramium spp.	5.0	5.0
Pterocladia capillacea	8.3	4.6
Gelidium coulteri	8.3	1.2
Corallina officinalis	16.7	<1.0
Cryptopleura crispa	1.7	<1.0
Hypnea valentiae	1.7	<1.0
Liagora californica	11.3	<1.0
Rhodoglossum affine	3.3	<1.0
Brown algae (Phaeophyta)		
Halidrys dioica	10.0	3.7
Ectocarpaceae	5.0	2.4
Cylindrocarpus rugosus	16.7	1.7
Green algae (Chloropohyta)		
Enteromorpha spp.	6.7	2.3
Chaetomorpha linum	10.0	1.7
Codium fragile	1.7	<1.0
Ulva lobata	3.3	<1.0

Digestive Efficiency

In this part of the work, we hypothesized that zebraperch can digest nondietary brown algae that contain secondary chemicals and that occur abundantly in the fish's habitat as efficiently as they digest dietary red and green algae. We based this hypothesis on the expectation that zebraperch retain the ability to digest chemically defended brown algae even though not part of the fish's diet because their tropical relatives (*Kyphosus* spp.) consume and apparently digest such algae. Our goal was to test the hypothesis by comparing the efficiencies with which zebraperch digest three species of dietary red and green algae and three species of nondietary brown algae, each of the latter know to contain measurable concentrations of secondary metabolites (Table 2).

The digestive efficiency of zebraperch was determined by feeding individual fish (n=10) each alga and calculating the total amount of organic matter, carbon, nitrogen, and protein assimilated from the alga. Efficiencies were calculated by comparing the amounts of these constitutents in the food and feces using ash as an assumed nonabsorbed marker. Each nondietary alga was fed to the fish by first anesthetizing the fish in MS-222 and then placing the food chopped to bite size into the stomach using forceps and a glass rod. The fish revived and swam normally within a few minutes after the procedure. The effect of the procedure on digestive efficiency was assessed by comparing the digestive values obtained for a dietary alga (*Chondracanthus canaliculatus*) when fed to the fish naturally and when force-fed to the fish under anesthesia.

Table 2. Dietary and nondietary algae used (and to be used) in the digestive efficiency experiments with zebraperch.

Algal species	Order/division	Secondary metabolites
Dietary		
Chondracanthus canaliculatus	Gigartinales/Rhodophyta	Halophenolics
Mazzaella leptorhynchos	Gigartinales/Rhodophyta	Unknown
Ulva lobata	Ulotrichales/Chlorophyta	Unknown
Nondietary		
Sargassum muticum	Fucales/Phaeophyta	Terpenoids and Phlorotannins
*Macrocystis pyriferia**	Laminariales/Phaeophyta	Terpenoids and Phlorotannins
*Pachydictyon coriaceum**	Dictyotales/Phaeophyta	Terpenoids and Phlorotannins

* In progress

The food, food material used as a control for loss of nutrients in the tanks, and fecal material were ground to a fine powder and stored in screwtop vials until the constituent analyses were performed. Carbon and nitrogen contents of the food and fecal material were determined by the Marine Science Analytical Laboratory at the University of California, Santa Barbara. Protein content was assayed using the dye Coomassie Brilliant Blue G-250 following Neighbors and Horn (1991). Ash and organic content of the ground samples were determined by burning triplicate subsamples (>50mg) for six hours at 550°C in a muffle furnace following Montgomery and Gerking (1980).

Results of the experiments designed to compare the digestive efficiency of zebraperch when fed a dietary alga under normal conditions and when force-fed the same alga under anesthesia showed a significant difference ($P<0.05$) only for carbon digestion. In this case, the anesthetized fish assimillated significantly more carbon than the naturally fed fish (Table 3).

Table 3. Digestive efficiency of zebraperch (n=10) for carbon, nitrogen, and protein when fed the dietary alga *Chondracanthus canaliculatus* normally (N) and when force-fed the alga under anesthesia (A). The same superscript letter in a column indicates no significant difference ($P>0.05$) between the two treatments.

Alga	Mean digestive efficiency (%) Carbon	Nitrogen	Protein
Chondracanthus canaliculatus (N)	73.6^{a}	77.6^{a}	85.9^{a}
Chondracanthus canaliculatus (A)	89.2^{b}	86.0^{a}	88.1^{a}

Results obtained to date show that zebraperch can digest carbon, nitrogen, and protein form the nondietary alga *Sargassum muticum* with an efficiency equal or greater than that for the three species of dietary algae (Table 4).

Table 4. Digestive efficiency of zebraperch for carbon, nitrogen, and protein when fed three dietary algae (D) and one nondietary algae (ND). The same superscript letters in a column indicates no significant differences (P>0.05) in digestive values among the different algae.

	Mean digestive efficiency (%)		
Alga	Carbon	Nitrogen	Protein
Chondracanthus canaliculatus	73.7^{a}	77.7^{a}	85.9^{a}
Mazzaella leptorhynchos	74.5^{a}	73.7^{a}	88.4^{a}
Ulva lobata	$82.7^{a,b}$	79.1^{b}	83.2^{a}
Sargassum muticum	82.9^{b}	$80.7^{a,b}$	94.9^{b}

The results of the dietary component of this project do not support our hypothesis that zebraperch consume chemically defended brown algae as a major part of its diet but rather showed that zebraperch eat a wide variety of algae in their shallow subtidal habitat, mainly red algae and some green algae both with apparently weak or no chemical defenses. Brown algae made up only a small proportion of the stomach contents. The data obtained to date on digestive efficiency, however, do support our second hypothesis that zebraperch can assimilate nutritional constituents from nondietary brown algae as efficiently as from dietary red and green algae. Zebraperch digested nutrients from a brown alga just as well as they did from three dietary algae. Digestive efficiency experiments on two other nondietary brown algae are in progress.

References

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