Does the Quality of Fish Muscle Tissue with Respect to Lipids Change During and Post Spawning Season?

ILEANA E. CLAVIJO, CAROLYN S. DUNN, PAMELA J. SEATON and JOHANNA J. VOLLENWEIDER
University of North Carolina Wilmington
Wilmington, NC USA

ABSTRACT

The spottail pinfish, a common protandrous fish in offshore reefs of North Carolina, was selected as a model to test the hypothesis that muscle tissue changes in percent lipid content, especially the n-3 fatty acids, during its spawning period. The spottail pinfish has increased in popularity as a recreational fish primarily due to the disappearance of more desirable species. We examined the percent fat and the ratio of n-6 to n-3 fatty acids in spottail pinfish to determine if there is a seasonal shift that may be related to reproduction. Fish collected during the spawning peak in April (N=11) were compared to fish from the months of May, June, July, September and October (N=38) in 1998. Our results indicated that the percent lipid in muscle tissue was not significantly different during these time periods and the ratio of n-6:n-3 did not vary much seasonally with the exception of one female collected in May possessing the highest ratio and possibly representing a recent sex change.

KEY WORDS: *Diplodus holbrooki*, fatty acids, lipid

INTRODUCTION

Diplodus holbrooki, the spottail pinfish, is present on both soft and hard substrates throughout the southeast USA (Darcy, 1985). It is one of the more abundant reef-associated fish in Onslow Bay, North Carolina (Clavijo et al. 1989; Lindquist et al. 1989). Spottail pinfish may be an ecologically important forage food for large carnivores because of their abundance. At present, the spottail pinfish is not commercially targetted, but it is a recreationally important fish and catches are expected to increase as more desirable target species decline in numbers (Chester et al. 1984; Huntsman and Willis 1989). Manooch and Potts (1996) reported an increase in headboat landings of the spottail pinfish in North Carolina making it an important component of the snapper-grouper fishery. These authors sampled the headboat fishery and considered it of sufficient importance to complete biological studies on age, growth and mortality.

The diet of spottail pinfish and changes in the dentition indicate an ontogenetic shift from carnivorous juvenile to a more herbivorous adult (Reid 1954; Carr and Adams 1972, 1973; Livingston 1982; Stoner and Livingston 1984). Pike and Lindquist (1994) studied populations of spottail pinfish from

offshore reefs in North Carolina and found and overall omnivorous diet consisting of 50% benthic algae and 50% benthic and planktonic animals, but there was a seasonal shift in diet from zooplankton, such as crustaceans to benthic foods, such as algae, bryozoans and hydroids.

The flesh of the spottail pinfish is of excellent quality (Darcy 1985). The nutritional quality of fish tissue is, in part, a function of the fatty acid composition. Lipids and fatty acids are important components of fish diets that contribute to many adaptive biological traits such as membrane function, energy storage, and buoyancy. Certain polyunsaturated fatty acids (n-6) also play a role as precursors of hormones. According to Zaidins (1989) and Seo et al. (1994), n-3 (omega-3) fatty acids are abundant in fish and can lead to drops in blood triglycerides and blood cholesterol levels when consumed by humans. These authors reported that n-3s may also produce an effect on arterial walls which reduces the risk of arteries becoming blocked. The major n-3 fatty acids found in marine fish are eicosapentenoic (C20:5) and docosahexenoic (C22:6) acids. Our primary research objective was to quantify the percent fat and relative amounts of n-3:n-6 fatty acids in muscle tissue of adult spottail pinfish to examine potential differences during and post spawning.

MATERIALS AND METHODS

Adult fish (n=49) were obtained from hook and line commercial and recreational fishermen operating in Onslow Bay, North Carolina from April 1998 through October 1998. Sampled fish could not be analyzed for August due to damage caused by hurricane Bonnie=s power outages. Fish were measured (standard length, SL, and total length, TL, in mm), weighed in g and microscopically sexed. Gonads were removed and weighed and the Gonadosomatic Index (GSI) was calculated as: GSI = gonad weight divided by body weight times 100. Age groups were determined from a study by Manooch and Potts (1996) in which fish in group 1 have a total length of 125 to 150 mm and are 1 year old, group 2 are 150 to 175 mm and 1 to 2 years, group 3 are 175 to 200 mm and 2 to 3 years, group 4 are 200 to 225 mm and 3 to 4 years, group 5 are 225 to 250 mm and 4 to 6 years, group 6 are 250 to 275 mm and 4 to 7 years, group 7 are 275 to 300 mm and 5 to 7 years, group 8 are 300 to 325 mm and 6 to 9 years, group 9 are 325 mm to 350 mm and 9 to 10 years, and group 10 are greater than 350 mm and 9 to 10 years. Muscle tissue samples consistently obtained from the dorsal region (2g) were frozen and saved for later analysis. The percent lipid composition was determined by a revised Folch et al. method (1957). A known mass of fish was homogenized and exhaustively extracted with chloroform-methanol (2:1, v:v). After concentration, the mass of the lipid extracts was determined. Lipids were saponified in a 0.5 M KOH-methanol solution and the resulting fatty acids were converted to their fatty acid

methyl esters (FAMES) by refluxing in BF_3 (Wijngaaden, 1967). FAMES were extracted in hexane, passed through a short plug of silica to remove impurities and concentrated for GC-MS analysis (HP5971 GC-Mass Spectrophotometer) using a 30 m DB-1 fused silica capillary column and a temperature gradient program. Fatty acid identification and quantification were confirmed by comparing mass spectra and retention times with commercial standards. The n-6:n-3 was calculated as a ratio. Data were arcsine transformed and analyzed using ANOVA at a probability of 0.05.

RESULTS

A range of 1.30 to 4.46 percent lipid was found in individual spottail pinfish throughout the sampling period. Figure 1 shows the mean percent lipid by month and one standard deviation above the mean.

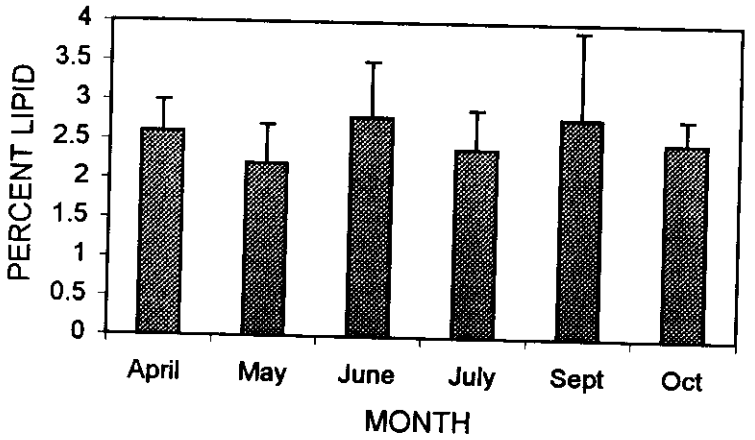

Figure 1. Mean percent lipid by month showing one standard deviation.

The mean percent lipid for adult fish was 2.51 ± 0.59 (N=49). Mean percent lipid of adult spottail pinfish varied slightly by month during the sampling period, with the highest mean value of 2.8±0.7 and 2.8±1.1found in

June and September fish, respectively, and the lowest values of 2.2±0.5 in May (Table 1). However, ANOVA showed that the mean percent lipids were not significantly different (P=0.14, Table 2). Mean size of fish collected was 176.9 SL (±23.9). Table 1 shows the mean lengths and weights of the sampled fish by month. The calculated age groups show that fish collected were between 3 and 6 years old.

All fish examined possessed gonads and were assumed to be mature. The GSI peaked in April and remained relatively constant throughout the rest of the sampling period (Figure 2).

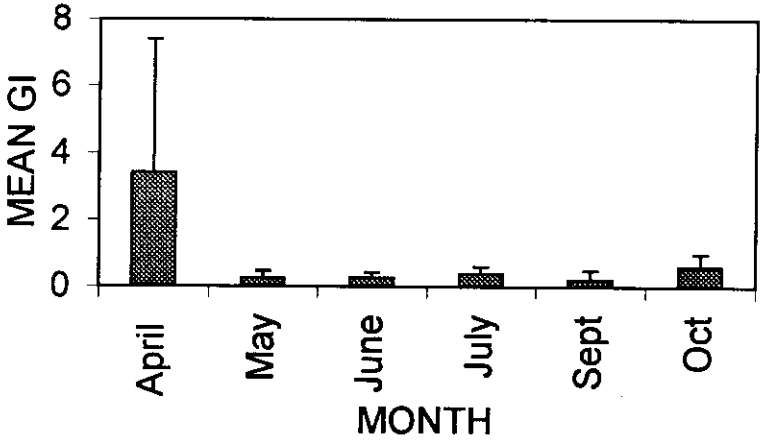

Figure 2. Mean gonadosomatic index (GSI) by month showing one standard deviation.

The n-3 fatty acid found in spottail pinfish was docosahexenoic (C22:6) or DHA, while the n-6's included linoleic (C18:2), arachidonic (C20:4) and eicosadienic (C20:2). The ratio of n-6 to n-3 lipids for spottail pinfish ranged from 0.26 in October to 1.74 in May (Table 3) with a mean of 0.74.

Table 1. Seasonal descriptive data for the spottail pinfish.

	April	May	June	July	Sept	Oct
N	11	11	10	9	4	4
Gonadal Index	3.4 (4.00)	0.25 (.22)	0.26 (0.17)	0.39 (.22)	0.20 (.29)	0.60 (.37)
Mean SL in mm(SD)	176.9 (29.4)	179 (23.3)	177.4 (23.2)	166.7 (21.2)	194.4 (22.4)	175 (19.2)
Mean TL in mm(SD)	234.1 (34.5)	239.2 (30.8)	232 (27.7)	220.2 (27.4)	255.3 (29.3)	216.8 (44.4)
Age group	4.9 (1.4)	5 (1.2)	4.7 (1.3)	4.1 (1.2)	5.8 (1.3)	4.3 (1.7)
Weight in g	235.7 (114.3)	249.5 (87.5)	223.2 (89.1)	182.9 (71.5)	301.0 (89.6)	216.7 (69.6)
Mean % lipid(SD)	2.6 (.4)	2.2 (0.5)	2.8 (0.7)	2.4 (0.5)	2.8 (1.1)	2.5 (0.3)

Table 2. ANOVA of mean % lipid by month.

SUMMARY

Groups	*Count*	*Sum*	*Avg*	*Variance*
April	11	101.05	9.19	0.56
May	11	92.31	8.39	0.92
June	10	95.72	9.57	1.35
July	7	62.42	8.92	0.44
September	4	38.04	9.51	3.27
October	4	35.95	8.99	0.41

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.68	5	1.74	1.75	0.14	2.44
Within Groups	40.66	41	0.99			
Total	49.34	46				

Table 3. Mean % lipids, % n-6 and n-3 and their ratios by month.

	April	May	June	July	Sept	Oct	Totals
N	9	8	9	8	4	3	41
% Lipid	2.58 (0.42)	2.18 (0.48)	2.81 (0.68)	2.36 (0.47)	2.82 (1.12)	2.48 (0.31)	2.53 (0.59)
n-6	6.55 (2.48)	6.97 (3.61)	10.55 (2.68)	8.28 (2.04)	5.49 (3.88)	7.01 (1.14)	7.94 (3.02)
n-3	23.26 (13.33)	24.52 (13.74)	27.10 (6.55)	31.51 (4.86)	16.55 (5.90)	26.37 (5.18)	25.53 (9.63)
n-6/n-3	0.423 (0.299)	1.735 (4.835)	0.406 (0.135)	0.276 (0.121)	0.399 (0.289)	0.267 (0.010)	0.737 (2.404)

DISCUSSION

The mean percent lipid found in the present study compared with percent lipids for other marine fish (Gooch et al., 1989) and is higher than the percent lipid reported by Clavijo et al. (In press), but within their reported range of 1.5 to 4.0. There may be interannual differences in percent lipid that may be related to variable environmental factors. Our data show a slight decrease in n-6/n-3 ratio during the sampling period that could be related to the essential role of n-3's as components of biomembrane phospholipids influencing the homeoviscosity of membranes in response to changes in environmental temperatures (Sargent et al. 1989). Fish adapt to cold temperatures by increasing the amount of long-chain fatty acids, especially docosahexenoic acid (Behar et al. 1989), and this may represent an adaptation that allows spottail pinfish to survive during the winter.

N-6 fatty acids are the preferred precursors of prostaglandins which play a role in reproduction (Sargent et al. 1989). Spawning in the spottail pinfish occurs from December to April in North Carolina (Klesath 1996). Our data show the highest n-6/n-3 ratio in May shortly after the spawning period. However, this increase was due to a single female. Since the spottail pinfish is a protandrous hermaphrodite that may change sex within 3 months after spawning (Klesath 1996), this female most likely was a recently sex reversed individual. In mullet the highest lipid content occurs prior to spawning (Deng et al., 1976).

According to Sargent et al. (1989), all n-3 and n-6 fatty acids in fish lipids ultimately originate from plant foods directly or by synthesis from essential fatty acid precursors obtained from their food. Spottail pinfish are reported to be herbivorous (Reid 1954, Carr and Adams 1972, 1973; Livingston 1982, Stoner and Livingston 1984), thereby transferring essential fatty acids up the food chain. These essential fatty acids also offer important potential health benefits to humans, such as reducing blood lipid levels particularly the serum tricylglycerols thus apparently retarding the atherosclerortic process and thrombus formation (Sargent et al. 1989).

Future studies should include analyses of fatty acids in the foods of spottail pinfish to determine if sources of fatty acids come from predominantly animal or plant material and can explain the ontogenetic and seasonal shifts to a more herbivorous diet in this fish.

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