Fish Physiology and Biochemistry vol. 10 no. 2 pp 91-98 (1992)
Kugler Publications, Amsterdam/Berkeley

A quantitative comparison between diet and body fatty acid composition in wild northern pike (*Esox lucius* L.)

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Accepted: February 11, 1992

Keywords: lipids, freshwater fish, piscivore, diet composition, essential fatty acids, omega 3, omega 6, polyunsaturated fatty acids

Abstract

The fatty acid compositions of wild female northern pike (*Esox lucius* L.) and their principle prey species were compared to assess the extent to which pike modify the relative abundance of dietary fatty acids during assimilation and to indicate the optimum dietary content of essential fatty acids (EFAs) for pike. Only minor differences existed between the estimated whole body fatty acid composition of pike and diet fatty acid composition as calculated from the contribution of each prey species to the pike's diet. Saturated fatty acids comprised a slightly higher percentage of diet lipids (25% wt) than of pike lipids (21% wt) whereas monounsaturated fatty acids were less abundant in diet lipids (26% wt) than in pike (29% wt). Percentages of total polyunsaturated fatty acids (PUFAs), n – 3 fatty acids, and n – 6 fatty acids were approximately 43, 30, and 13% wt respectively and differed by less than 1% wt between pike and diet lipids. Among individual PUFAs, the largest differences occurred in 20:5(n – 3) and 22:6(n – 3) which comprised, on average, 9.6 and 14.7% wt respectively of diet lipids and 5.9 and 18.3% wt respectively of pike lipids. The close similarity in fatty acid composition between pike and their diet suggests that pike may have limited abilities to elongate and desaturate 18 carbon PUFAs and may require specific long chain PUFAs in the diet. The n – 3 PUFA content of the pike's natural diet may exceed the minimum EFA requirements of better studied species such as rainbow trout and turbot.

Introduction

Fatty acid analysis of prey species provides a useful guide to the optimum essential fatty acid (EFA) intake of large piscivorous fish such as adult northern pike (*Esox lucius* L.) which are difficult to feed and maintain in captivity. Furthermore, comparison of fatty acid composition between wild fish and their prey may indicate the degree to which dietary fatty acids are structurally modified or selectively catabolized during the incorporation of dietary lipids into fish tissues. To date, however, the fatty acid compositions of the natural diets of fish have not been well characterized (Henderson and Tocher 1987; Sargent *et al.* 1989).

Available evidence suggests that the ability to modify dietary fatty acids varies greatly between fish species and is related to diet fatty acid composi-

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tion. Rainbow trout (*Oncorhynchus mykiss*) have a relatively good ability to elongate and desaturate 18 carbon n – 3 and n – 6 fatty acids (Owen *et al.* 1975; Sellner and Hazel 1982; Watanabe 1982; Christiansen 1984; Bell *et al.* 1986; Hagve *et al.* 1986) and this ability may be an adaptation to their high consumption of insects. Aquatic insects do not appear to contain significant amounts of 22:6(n – 3) (Hanson *et al.* 1985), the predominant polyunsaturated fatty acid (PUFA) in fish tissues. In contrast, piscivorous marine fish such as plaice and turbot have a poor ability to chain elongate and desaturate 18 carbon n – 3 and n – 6 PUFAs, presumably because they normally obtain adequate amounts of long chain PUFAs such as 20:4(n – 6), 20:5(n – 3), and 22:6(n – 3) in their diet (Owen *et al.* 1972, 1975; Linares and Henderson 1991).

The poor ability of piscivorous fish to elongate and desaturate 18 carbon EFAs suggests that the relative quantities of individual long chain PUFAs in the body as a whole may be largely determined by diet fatty acid composition. However, this hypothesis has not been tested and it is possible that piscivorous fish have considerable ability to synthesize saturated and n – 7 and n – 9 unsaturated fatty acids and to selectively catabolize or retain individual EFAs and thus maintain a whole body fatty acid composition different from that of the diet.

In this study, the fatty acid compositions of female northern pike and their principle prey species were compared to determine the extent to which pike modify the relative abundance of different dietary fatty acids during their incorporation into body tissues and to aid in defining the optimum dietary EFA content for pike. Female pike were analyzed, rather than males, because this study is part of a larger one which examines the role of environmental and physiological factors in the seasonal cycles of fatty acid composition in female pike (Schwalme 1991).

Materials and methods

Adult female pike and their principle prey species were collected from Lac Ste. Anne, Alberta (53°, 44′ N, 114°, 22′ W) in June and August 1989. The diet of adult pike in Lac Ste. Anne consists predominantly of yellow perch (*Perca flavescens*), white sucker (*Catostomus commersoni*), burbot (*Lota lota*), and spottail shiner (*Notropis hudsonius*), which together comprise 94% of total dietary caloric content (Diana 1979). Whitefish (*Coregonus clupeaformis*), walleye (*Stizostedion vitreum*), and other pike comprise the remainder of the diet (Diana 1979). Pike, white sucker, and whitefish were collected using gill nets whereas juvenile perch, spottail shiner and burbot were collected by seining or dip netting in shallow water along shore. A description of the pike and prey species collected and the tissues analyzed for fatty acid content is given in Table 1.

In the case of small prey items such as juvenile perch, spottail shiner, and burbot, lipids were extracted from the whole fish. For each pike, and prey items too large to homogenize whole, the major organs and tissues were sampled and whole body fatty acid composition was calculated after summing the content of each fatty acid in all organs and tissues analyzed.

Fish collected using gill nets were kept in a freezer (– 20°C) prior to lipid extraction from tissues which was completed within 4 to 5 hours after removal of fish from the nets. Smaller prey species were kept alive in lake water until lipid extraction. Lipid extraction was done by homogenizing whole fish or tissue samples (2 to 4 g) with 40 volumes of a 2:1 mixture of chloroform-methanol (Folch *et al.* 1957) containing butylated hydroxytoluene (BHT) at levels of approximately 0.1% of the lipid content of the extract. Lipid extracts were cleared of particulate matter by filtering through Whatman # 1 filter paper, bubbled with nitrogen, and stored in completely filled glass vials (at – 30°C) prior to further processing. The washing procedure of Folch *et al.* (1957) (using 0.58% NaCl) was used to remove nonlipids from the chloroform-methanol extracts.

Fatty acid analyses were performed separately on the neutral and polar lipid fractions of muscle from pike collected in August. Procedures used to separate neutral and polar lipids and the use of internal standards to quantify fatty acids in these fractions are described in Schwalme and Mackay (1992). In all other tissues, fatty acid analyses were

Table 1. Characteristics of pike and prey items sampled for fatty acid analysis

Month	Species sampled	n	Body weight (g) (mean ± SD or range)	Standard length (cm) (mean ± SD or range)	Tissues analyzed
June	female pike	6	1,290 ± 456	52.3 ± 6.0	liver, white muscle, adipopancreatic tissue
	white sucker	3	88 to 368	17.1 to 26.3	white muscle, viscera (includes gonads, liver, adipose tissue, and digestive tract)
	burbot	3	12 to 72	–	white muscle, viscera (includes gonads, liver, adipose tissue, and digestive tract)
	spottail shiner	6	2.6 ± 0.5	–	whole fish
	juvenile perch	8	2.7 ± 0.5	–	whole fish
August	pike	6	789 ± 209	43.9 ± 4.1	liver, white muscle, adipopancreatic tissue
	whitefish	4	214 ± 21	24.3 ± 0.8	liver, white muscle, viscera (includes gonads, adipose tissue, digestive tract)
	burbot	9[a]	1.7 ± 0.4	–	whole fish
	spottail shiner	8	2.8 ± 1.1	–	whole fish
	juvenile perch	8	4.4 ± 0.6	–	whole fish

[a] To obtain enough tissue for analysis, the six smallest burbot were homogenized in pairs, giving a total of six replicates.

Table 2. Contribution of various prey species to the wet weight and fatty acid content of the northern pike diet in Lac Ste. Anne

Prey species	Sampling date					
	June			August		
	FA concentration[a] % wet wt (mean ± SEM)	% of Diet[b] wet wt	% of Dietary[c] FA content	FA concentration[a] % wet wt (mean ± SEM)	% of Diet[b] wet wt	% of Dietary[c] FA content
Yellow perch	1.09 ± 0.13	51.1	51.1	1.42 ± 0.12	57.7	71.0
White sucker	0.66 ± 0.04	22.1	13.4	–	23.9	13.8[d]
Spottail shiner	1.45 ± 0.16	12.7	16.9	2.49 ± 0.34	0	0
Burbot	1.54 ± 0.61	11.9	16.8	0.98 ± 0.01	11.8	10.1
Whitefish	–	2.2	1.8[d]	0.89 ± 0.08	6.6	5.1
Total		100.0	100.0		100.0	100.0

[a] total fatty acid concentration of each prey species; [b] the contribution of each prey species to the pike's diet, expressed as a percentage of diet wet weight and calculated from data given by Diana (1979). In August, walleye and juvenile pike together comprised about 6% of the pike's diet (Diana 1979), but were not included in the analysis; [c] the contribution of each prey species to the pike's total dietary intake of fatty acids was calculated from the fatty acid concentration of each prey species and that species' percentage contribution to diet wet weight; [d] calculated using the fatty acid concentration of sucker in June and that of whitefish in August because these were the only dates on which sucker and whitefish were caught.

performed on total lipids. A known weight of tri-O-tridecanoylglycerol was added to the washed extract of total lipids to serve as an internal standard for quantifying fatty acids. Saponification of lipids, methylation of fatty acids and gas chromatographic determination of tissue fatty acid content and percent composition were performed as described in Schwalme and Mackay (1992). Quantities of 14:0 could not be accurately measured because that fatty acid co-eluted with BHT during gas chromatography.

The prey species compositions of the diet of female pike in Lac Ste. Anne during June and August as given by Diana (1979) were used to estimate diet

fatty acid composition. Diana (1979) presented data on the percentage of the pike's caloric intake contributed by different prey species and each prey species' caloric equivalent (cal/g dry wt) and dry wt:wet wt ratio. Those data were used to calculate the percentage contribution of each prey species to the pike's diet on a wet wt basis (Table 2). The total fatty acid concentration (% wet wt) of each prey species and its contribution to diet wet wt were used to calculate each prey species' contribution to diet fatty acid content (Table 2). Finally, diet fatty acid composition was calculated by weighting each prey species' fatty acid composition according to that species' contribution to diet fatty acid content.

Results

The various prey species eaten by pike differed considerably in fatty acid content (Table 2). Therefore, the contribution of each prey species to the fatty acid content of the pike's diet differed somewhat from its contribution to the diet calculated on the basis of weight. This was most evident for white sucker, which contributed relatively less to diet fatty acid content than to diet weight, and for yellow perch, which in August contributed relatively more to diet fatty acid content than to diet weight (Table 2).

The prey species collected also differed considerably in fatty acid composition (Tables 3 and 4). For example, 18:1(n – 9) varied from 10.1% wt in sucker to 22.6% wt in burbot (Table 3) and 22:6(n – 3) varied from 7.8% wt in spottail shiner (Table 4) to 24.1% wt in sucker (Table 3).

Calculation of diet fatty acid composition from the average fatty acid composition of each prey species (weighted according to each species' contribution to diet fatty acid content) gave only a single estimate for diet fatty acid composition at each collection period. This meant that statistical tests based on the variability in diet fatty acid composition could not be performed. However, the reliability of comparisons between the fatty acid compositions of pike and their diet can be assessed by comparing the data obtained in June and August (Tables 3 and 4).

In both June and August, pike contained percentages of saturated fatty acids (SFAs) which were lower (by 3.2 to 4.3% wt) and percentages of monounsaturated fatty acids (MUFAs) which were higher (by 2.1 to 3.8% wt) than those in diet lipids (Tables 3 and 4). Percentages of n – 3, n – 6, and total PUFAs in pike lipids were nearly identical to those in diet lipids (Tables 3 and 4).

Individual fatty acids whose percentages in pike and diet lipids differed by more than 2% wt were, 16:0 (August only), 18:0 (both months), 16:1(n – 7) (June only), 20:5(n – 3) (both months), and 22:6(n – 3) (both months) (Tables 3 and 4). Comparison of Tables 3 and 4 shows that differences in the percent composition of individual fatty acids between pike and diet lipids in June were qualitatively and quantitatively similar to the differences which existed in August. In both months, pike lipids contained lower proportions of 16:0 and 18:0 and higher percentages of 16:1(n – 7) and 18:1 (n – 9) compared to diet lipids (Tables 3 and 4). Percentages of 18:2(n – 6) were greater in pike than in their diet and were offset by similarly large but opposite differences in the percentage of 20:4(n – 6) (Tables 3 and 4). Compared to diet lipids, pike contained higher percentages of 18:3(n – 3) and 22:6(n – 3) which were offset by reductions in the percentage of 20:5(n – 3) (Tables 3 and 4).

Between June and August, the pike's principle food, yellow perch, underwent significant changes (t-test, $p < 0.05$) in fatty acid composition of which the most notable were increases in the percentages of 16:1(n – 7) and total MUFAs, and decreases in 22:6(n – 3) and total n – 3 PUFAs (Tables 3 and 4). The percentage of 22:6(n – 3) in pike lipids also declined between June and August (Tables 3 and 4), but this change was not statistically significant (t-test, $p < 0.05$).

Discussion

The similarity in fatty acid composition between pike and their diet suggests that pike do not need to, and may not have the ability to, significantly modify the fatty acid composition of dietary lipids during their assimilation. Certainly, percentages of

Table 3. Fatty acid compositions of pike, the pike's diet, and prey species in June

Fatty acid	Pike[a] (n = 6)	Pike diet[b]	Yellow perch (n = 8)	Burbot (n = 3)	Shiner (n = 6)	Sucker (n = 3)
16:0	15.3 ± 0.15[c]	16.4	16.1 ± 0.21	15.5 ± 0.35	16.7 ± 0.46	18.6 ± 0.21
18:0	5.9 ± 0.15	8.0	7.9 ± 0.32	8.4 ± 1.35	8.2 ± 0.28	7.5 ± 0.40
16:1(n − 7)	11.4 ± 0.46	9.4	9.5 ± 0.66	9.6 ± 1.88	9.9 ± 0.60	8.4 ± 0.22
18:1(n − 9)	17.6 ± 1.26	15.7	14.9 ± 1.09	22.6 ± 3.15	16.1 ± 0.70	10.1 ± 0.22
18:2(n − 6)	5.4 ± 0.28	3.7	3.6 ± 0.27	3.9 ± 0.41	4.7 ± 0.50	2.8 ± 0.13
20:4(n − 6)	5.9 ± 0.22	7.2	6.9 ± 0.25	8.9 ± 1.76	6.6 ± 0.39	7.4 ± 0.33
22:5(n − 6)	1.7 ± 0.09	1.9	2.4 ± 0.17	1.0 ± 0.14	0.9 ± 0.05	2.1 ± 0.20
18:3(n − 3)	3.7 ± 0.17	2.7	2.1 ± 0.22	3.6 ± 0.44	4.0 ± 0.53	2.1 ± 0.06
20:5(n − 3)	5.6 ± 0.12	9.7	9.5 ± 0.30	11.0 ± 1.24	9.7 ± 0.45	9.0 ± 0.50
22:5(n − 3)	2.0 ± 0.08	2.6	2.2 ± 0.06	2.9 ± 0.20	2.8 ± 0.18	3.8 ± 0.11
22:6(n − 3)	19.8 ± 1.20	15.7	16.4 ± 1.13	8.0 ± 1.47	14.0 ± 1.24	24.1 ± 0.66
others	5.7 ± 0.14	6.9	8.5 ± 0.37	4.7 ± 0.15	6.4 ± 0.38	4.0 ± 0.25
SFA	21.2 ± 0.14	24.4	24.0 ± 0.48	23.8 ± 1.02	24.9 ± 0.67	26.1 ± 0.19
MUFA	29.0 ± 1.51	25.2	24.5 ± 1.66	32.2 ± 5.02	25.9 ± 1.29	18.6 ± 0.43
PUFA	44.1 ± 1.45	43.5	43.0 ± 1.31	39.3 ± 4.15	42.7 ± 1.04	51.3 ± 0.34
all n − 6	13.0 ± 0.42	12.8	12.9 ± 0.28	13.7 ± 1.66	12.2 ± 0.22	12.3 ± 0.11
all n − 3	31.1 ± 1.09	30.7	30.1 ± 1.16	25.5 ± 2.49	30.5 ± 1.10	38.9 ± 0.34
FA conc. % wet wt	0.93 ± 0.084	1.09	1.09 ± 0.125	1.54 ± 0.607	1.45 ± 0.164	0.66 ± 0.037

Data shown as mean ± SEM; [a] fatty acid compositions of pike and prey species were estimated from weighted averages of the compositions of the individual organs and tissues identified in Table 1; [b] the fatty acid composition of the pike's diet was calculated from the contribution of each prey species to the pike's dietary fatty acid intake as indicated in Table 2; [c] fatty acid compositions are the mean weight % of the indicated fatty acids in total lipids of pike, the pike's diet, and prey species; Abbreviations: SFA – total saturated fatty acids, MUFA – total monounsaturated fatty acids, PUFA – total polyunsaturated fatty acids, n − 3 – ω 3 fatty acids, n − 6 – ω 6 fatty acids, FA conc. – total fatty acid concentration.

Table 4. Fatty acid compositions of pike, the pike's diet, and prey species in August

Fatty acid	Pike[a] (n = 6)	Pike diet[b]	Yellow perch (n = 8)	Burbot (n = 6)	Shiner (n = 8)	Whitefish (n = 4)
16:0	14.9 ± 0.23[c]	17.0	16.8 ± 0.29	16.4 ± 0.23	17.6 ± 0.32	16.3 ± 0.46
18:0	6.4 ± 0.14	8.6	8.7 ± 0.27	10.6 ± 0.13	8.1 ± 0.32	6.1 ± 0.10
16:1(n − 7)	11.3 ± 0.28	10.9	11.9 ± 0.67	7.8 ± 0.13	12.8 ± 0.47	8.6 ± 0.74
18:1(n − 9)	17.6 ± 0.38	15.9	17.0 ± 0.43	17.4 ± 0.18	21.3 ± 0.66	13.5 ± 0.82
18:2(n − 6)	5.7 ± 0.11	4.4	4.9 ± 0.27	3.5 ± 0.10	6.5 ± 0.37	4.3 ± 0.36
20:4(n − 6)	5.8 ± 0.16	7.0	6.7 ± 0.37	9.6 ± 0.15	5.2 ± 0.39	4.9 ± 0.23
22:5(n − 6)	1.8 ± 0.05	1.6	1.6 ± 0.10	1.1 ± 0.03	0.9 ± 0.07	1.8 ± 0.14
18:3(n − 3)	4.3 ± 0.23	3.7	3.9 ± 0.28	3.2 ± 0.06	5.0 ± 0.29	5.4 ± 0.51
20:5(n − 3)	6.2 ± 0.15	9.5	9.4 ± 0.29	11.2 ± 0.26	6.9 ± 0.34	8.6 ± 0.38
22:5(n − 3)	2.6 ± 0.05	2.3	1.8 ± 0.09	3.2 ± 0.07	2.1 ± 0.10	3.6 ± 0.10
22:6(n − 3)	16.7 ± 0.78	13.7	11.8 ± 0.79	10.1 ± 0.21	7.8 ± 0.62	18.2 ± 1.95
others	6.8 ± 0.43	5.4	5.4 ± 0.22	5.7 ± 0.10	5.8 ± 0.16	8.6 ± 0.62
SFA	21.3 ± 0.36	25.6	25.5 ± 0.43	27.0 ± 0.22	25.8 ± 0.39	22.4 ± 0.46
MUFA	28.9 ± 0.64	26.8	29.0 ± 1.03	25.3 ± 0.28	34.1 ± 0.99	22.2 ± 1.51
PUFA	43.1 ± 0.68	42.2	40.2 ± 0.95	42.0 ± 0.18	34.3 ± 0.87	46.8 ± 1.64
all n − 6	13.3 ± 0.16	13.1	13.2 ± 0.39	14.3 ± 0.24	12.6 ± 0.21	11.0 ± 0.25
all n − 3	29.8 ± 0.69	29.1	26.9 ± 0.71	27.7 ± 0.35	21.8 ± 0.81	35.8 ± 1.70
FA conc. % wet wt	1.39 ± 0.100	1.15	1.42 ± 0.120	0.98 ± 0.013	2.49 ± 0.342	0.89 ± 0.083

Data shown as mean ± SEM; Footnotes and abbreviations are given in Table 3.

20:4(n – 6) and 20:5(n – 3) which are 1.2 to 4.1% wt lower in pike than in diet lipids (Tables 3 and 4) provide no evidence of significant elongation and desaturation of 18:2(n – 6) or 18:3(n – 3) by pike. Although amounts of 22:6(n – 3) were 3.0 to 4.1% wt higher in pike than in their diet (Tables 3 and 4), this is not sufficient to indicate that pike are actively elongating and desaturating 20:5(n – 3) to 22:6 (n – 3). Because the gross dietary conversion efficiency of pike is about 30% (Diana 1982), pike probably consume considerably more 22:6(n – 3) (and other nutrients) than they accumulate in their tissues. Therefore, higher percentages of 22:6 (n – 3) in pike compared to their diet can be due to selective retention of this fatty acid and does not necessarily imply that pike are synthesizing 22:6 (n – 3) from 20:5(n – 3).

Quantities of n – 3 PUFAs present in the pike's diet equal or exceed the minimum dietary requirements for these essential fatty acids which have been established experimentally in better studied species such as rainbow trout and turbot. Assuming the water content of the pike's diet to be similar to that of yellow perch (78% of wet wt; Tanasichuk and Mackay 1989), the total n – 3 PUFA content of the pike's diet is about 1.5% of dry weight. This corresponds well with the dietary n – 3 PUFA requirements established experimentally in rainbow trout (0.5 to 1.7% of diet dry wt) (Castell *et al.* 1972; Watanabe *et al.* 1974; Takeuchi and Watanabe 1977) and turbot (0.57 to 1.3% of diet dry wt) (Gatesoup *et al.* 1977; Leger *et al.* 1979; Le Milinaire *et al.* 1983). However, the EFA requirements of fish vary according to the quantity of lipid and the type of fatty acid (*i.e.*, 18 carbon vs long chain PUFA) supplied in the diet. Accordingly, the n – 3 PUFA requirements of rainbow trout have also been expressed as 20% of diet fatty acids if supplied as 18:3(n – 3) and as 10% of diet fatty acids if supplied as 20:5(n – 3) plus 22:6(n – 3) (Takeuchi and Watanabe 1977). Percentages of total n – 3 PUFAs (29.1 to 30.7; Tables 3 and 4) in the pike's diet thus exceed the requirements of rainbow trout expressed as 18:3(n – 3) and percentages of 20 and 22 carbon n – 3 PUFAs in the pike's diet (25.5 to 28.0; Tables 3 and 4) are double to triple the requirements established for trout. Although quantities of n – 3 PUFAs four times in excess of dietary requirements suppress growth in trout (Takeuchi and Watanabe 1979), the high percentage of n – 3 PUFAs in the diet of pike does not appear to be detrimental because pike in Lac Ste. Anne exhibit normal growth rates (Mackay 1989) and otherwise appear healthy. This suggests that the optimum dietary intake of long chain n – 3 PUFAs for pike may be higher than the minimum n – 3 PUFA requirements established experimentally for rainbow trout. On the whole, the good agreement between the n – 3 PUFA content of the pike's natural diet and experimentally derived n – 3 requirements of fish suggests that natural foods can be useful indicators of the optimal fatty acid composition of fish diets.

Total fatty acid content and percent composition exhibited considerable variation between different prey species and temporal variation within a single species (Tables 3 and 4). The potential exists for pike to experience similarly large temporal variations in diet composition if they feed exclusively on a single prey species or if they switch from eating predominantly juvenile yellow perch to eating one of the other prey species. However, the strategy of feeding on several prey species may allow pike to reduce the amount of temporal variation in diet fatty acid composition they have to deal with.

One would expect that pike, and other north-temperate fish, might be able to increase their dietary lipid intake in winter, and thus help satisfy the requirements of fatty acids for ovary growth, by feeding on adult females of prey species such as burbot and yellow perch which also undergo ovarian maturation over winter. However, lipids of mature ovaries of yellow perch and burbot consist predominantly of wax esters which are considerably less digestible than triacylglycerols and polar lipids (Henderson and Tocher 1987). The low digestibility of wax esters, together with the low fatty acid content (0.56% wet wt) of the combined somatic tissues of yellow perch from Lac Ste. Anne in January (Schwalme 1991), suggests that female perch with mature ovaries may not provide greatly increased quantities of fatty acids to pike over winter.

In summary, it appears that pike in Lac Ste. Anne have acquired a fatty acid composition which

closely resembles that of dietary lipids. This suggests that pike may resemble piscivorous marine fish and terrestrial carnivores such as the cat (Davidson *et al.* 1990) in having relatively poor abilities to elongate and desaturate 18 carbon EFAs and in requiring specific long chain n – 3 and n – 6 PUFAs in the diet. Furthermore, seasonal or age related changes in diet fatty acid composition can be expected to significantly influence the fatty acid composition of pike. Interestingly, adult pike in a few Alberta lakes consume considerable quantities of insects such as dragonfly nymphs (Chapman and Mackay 1990). In those waters, pike may need to convert dietary 20:5(n – 3) to 22:6(n – 3) and, if unable to do so, may experience a deficiency of 22:6(n – 3).

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