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Growth and survival of European sea bass (*Dicentrarchus Labrax*) larvae fed from first feeding on compound diets containing medium-chain triacylglycerols

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Abstract

A 21-day feeding trial was carried out to investigate the ability of first feeding European sea bass larvae to utilize medium-chain triacylglycerols as an alternative source of energy. Three compound diets based on soluble fish protein concentrate and yeast were supplemented with either 3% tricaproin (TC6), tricaprylin (TC8) or tricaprin (TC10). A diet containing triolein (TOL) was used as a reference diet. Diets were tested on four replicate groups of first feeding European sea bass larvae at 20°C, i.e. 6 days after hatching. At the end of the 21-day trial, TC8 yielded significantly higher survival ($57 \pm 8\%$ vs. $28 \pm 11\%$ for the three other groups). Considered together, larvae fed TC8 and TC6 displayed better growth rates than larvae fed TOL and TC10 (final mean wet weights: 1.5 ± 0.3 mg vs. 1.2 ± 0.2 mg, respectively). The fatty acid composition of larval total lipid revealed a low deposit of medium-chain fatty acids (between 1 and 3% of total fatty acids) suggesting that medium-chain fatty acids were oxidized for energetic purposes. Tricaprylin and to a lesser extent tricaproin, appear to be potential energy sources for first feeding European sea bass larvae reared on compound diets.

Keywords: *Dicentrarchus labrax*; European sea bass; Larva; Dry diet; Medium-chain triacylglycerols

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1. Introduction

Elaboration of dry diets allowing for a reduction in the use of live food, such as rotifers and *Artemia*, for the rearing of marine fish larvae is an important objective of research for the further development of aquaculture. It has been shown recently that significant survival and growth can be obtained in European sea bass larvae fed only dry diet (Cahu et al., 1998b). The diet used yielded lower results than live food but appeared interesting as a starting point for further identification of the nutritionally limiting factors. Data about the nutritional requirements of first feeding marine larvae concerns mainly essential fatty acids (Watanabe and Kiron, 1994) since the manipulation of live prey composition is difficult for most other nutrients. Nutritional needs have been extrapolated from results obtained in both marine fish larvae, pre-fed on live prey and weaned at several milligrams, and in freshwater fish larvae, such as first feeding 2-mg common carp larvae. This approach has shown the importance of phospholipids (Kanazawa, 1993; Geurden et al., 1995) and of the form of the nitrogen supply (Carvalho et al., 1997; Zambonino Infante et al., 1997). In European sea bass larvae fed 8 days on live food and weaned at 3 mg, Zambonino Infante and Cahu (1999) have found a beneficial effect of dietary lipid supplementation, with up to 30% lipid, consisting of fish oil and soybean lecithin. Soybean lecithin contains phosphatidylcholine, which promotes the formation of very low density lipoproteins (VLDL) during the intestinal absorption of long-chain fatty acids and thus results in an increased amount of energy available for growth (Fontagné et al., 1998). However, another mechanism of intestinal absorption of neutral lipids, which does not require the synthesis of VLDL, is known in vertebrates. This mechanism concerns medium-chain triacylglycerols (MCT), composed of fatty acids (FA) with a chain length comprised between 6 and 12 carbon atoms. MCT proved to be an efficient energy source for newborn infants and lambs as they are rapidly hydrolyzed and absorbed (Jensen et al., 1986; Aurousseau et al., 1989). The present study investigated the possible utilization of MCT (tricaproin, tricaprylin and tricaprin) instead of long-chain triacylglycerols as energy sources in first feeding European sea bass larvae.

2. Materials and methods

2.1. Experimental fish and diets

European sea bass (*Dicentrarchus labrax*) larvae were obtained from the commercial hatchery Sepia International (Gravelines, France). Five days after hatching, larvae were randomly distributed into 16 tanks with 2700 larvae per 35-l tank at the experimental facilities in running seawater of the Center IFREMER (Brest, France) as described in Zambonino Infante and Cahu (1994). Water temperature was progressively increased from 16°C to 20°C during 2 days, thereafter it remained at 20°C throughout the feeding trial. First feeding (day 0 of the feeding trial) occurred 6 days after hatching. Belt feed dispensers delivered food in excess throughout the day. Remaining larvae from the

initial stock were starved and served as a negative control. Compound diets were fed to four replicate groups of first feeding European sea bass larvae during 21 days.

The origin of dietary ingredients is described in Table 1. All ingredients were finely ground below 100 μm and mixed before addition of the lipid emulsion and water. The moist blend was pelletized using a meat grinder. The pellets were dried in a ventilated oven at 36°C for 24 h, ground and sieved to obtain microparticles with graded diameter (50–100 and 100–200 μm). The basal diet contained yeast and soluble fish protein concentrate which has been shown to give promising results in first feeding European sea bass larvae (Cahu et al., 1998b). Fatty acid composition of lipid sources was checked by gas chromatographic analysis. Purified MCT were composed of one single FA amounting to 98% of total FA. Triolein was determined to be a blend of 64% oleic acid and of 13% linoleic acid with some saturates and monoenes from 12:0 to 18:0 but was used as a reference oil since it was devoid of both MCFA and essential fatty acids. Highly unsaturated fatty acids (HUFA) longer than 20 carbon atoms represented 4.8% of

Table 1
Formulation and composition of experimental diets

	Experimental diets			
	TOL	TC6	TC8	TC10
Ingredients[a] *(g 100 g^{-1} dry weight)*				
Yeast	39.5	39.5	39.5	39.5
Soluble fish protein concentrate	39.5	39.5	39.5	39.5
Soybean lecithin	5	5	5	5
Vitamin mix[b]	8	8	8	8
Mineral mix[c]	5	5	5	5
Triolein	3	–	–	–
Tricaproin	–	3	–	–
Tricaprylin	–	–	3	–
Tricaprin	–	–	–	3
Proximate composition (% dry matter)				
Dry matter (%)	93.5	94.5	93.8	94.0
Crude protein	50.0	50.4	50.2	50.1
Total lipids	17.2	17.5	17.7	17.6
Ash	10.3	9.5	10.0	10.0
Gross energy (kJ g^{-1} dry matter)	21.6	21.7	21.8	21.8

[a] Sources: yeast Protibel, Bel Fromageries (Paris, France); soluble fish protein concentrate CPSP G, Sopropêche (Boulogne-sur-Mer, France); soybean lecithin LPR, SAPA DAFA S.D.A. (Marne-la-Vallée, France); triolein, Prolabo (Fontenay-sous-Bois, France); tricaproin, tricaprylin and tricaprin, Sigma (Saint Quentin Fallavier, France).

[b] Vitamin mixture (g kg^{-1} vitamin mix): retinyl acetate, 1; cholecalciferol, 2.5; DL-α-tocopheryl acetate, 5; menadione, 1; thiamin–HCl, 0.1; riboflavin, 0.4; D-calcium panthothenate, 2; pyridoxine–HCl, 0.3; cyanocobalamin, 1; niacin, 1; choline, 200; ascorbic acid (ascorbyl polyphosphate), 5; folic acid, 0.1; D-biotin, 1; meso-inositol, 30. All ingredients were diluted with α-cellulose.

[c] Mineral mixture (g kg^{-1} mineral mix): KCl, 90; KI, 0.04; $CaHPO_4 \cdot 2H_2O$, 500; NaCl, 40; $CuSO_4 \cdot 5H_2O$, 3; $ZnSO_4 \cdot 7H_2O$, 4; $CoSO_4$, 0.02; $FeSO_4 \cdot 7H_2O$, 20; $MnSO_4 \cdot H_2O$, 3; $CaCO_3$, 215; MgOH, 124; Na_2SeO_3, 0.03; NaF, 1.

Table 2
Main fatty acid composition of experimental diets (% of total fatty acids)[a]

	Experimental diets			
	TOL	TC6	TC8	TC10
6:0	0.2	26.9	0.2	0.1
8:0	0.1	0.1	28.4	0.4
10:0	0.1	0.1	0.2	29.0
12:0	0.6	0.1	0.1	0.2
14:0	4.7	3.6	3.6	3.3
16:0	16.8	14.7	14.6	14.0
18:0	2.4	2.0	2.2	2.1
Total saturates[b]	26.5	48.9	50.5	50.1
16:1	7.3	5.8	5.7	5.2
18:1	29.4	14.0	13.7	14.1
20:1	3.9	3.2	3.1	3.4
22:1	2.6	2.2	2.1	2.3
Total monoenes[c]	44.2	25.8	25.3	25.7
18:2$n-6$	17.6	14.6	14.5	14.1
20:4$n-6$	0.3	0.3	0.3	0.3
Total $n-6$ HUFA[d]	0.7	0.4	0.5	0.6
Total $n-6$	18.3	15.1	15.1	14.8
18:3$n-3$	2.9	2.7	2.6	2.5
20:5$n-3$	2.2	2.1	1.9	1.9
22:6$n-3$	2.4	2.2	2.1	2.2
Total $n-3$ HUFA[e]	5.3	4.8	4.4	4.7
Total $n-3$[f]	9.0	8.1	7.6	7.8

[a] Values are means of three replicate analyses.
[b] Includes 15:0 and 17:0.
[c] Includes 14:1 and 17:1.
[d] Includes 20:2$n-6$.
[e] Includes 20:4$n-3$ and 22:5$n-3$.
[f] Includes 18:4$n-3$.

total FA for $n-3$ HUFA (8% for $n-3$ FA) and 0.6% for $n-6$ HUFA (15–18% for $n-6$ FA) (Table 2). Requirement of first-feeding European sea bass larvae for $n-3$ HUFA and arachidonic acid are not exactly known. The $n-3$ HUFA supply (around 0.9% of dietary dry matter) was a little higher than the requirement of 0.8% estimated by Robin et al. (1987). Since all $n-3$ FA were provided by the soluble fish protein concentrate, the HUFA levels as well as the ratios between the various HUFA were similar for the four experimental diets.

2.2. Sample collection and analysis

The final survival was calculated from daily mortality from day 4 onwards corrected with the final record of surviving larvae in each tank. Thirty larvae per tank were sampled on days 0, 5, 10, 15 and 20 for dry and wet weight determination. A sample of larvae was withdrawn on day 0 and stored at -80°C for lipid analyses of the initial

sample. At the end of the 21-day trial, the whole tank populations were starved for 24 h for mean wet weight determination and lipid analyses.

Dry matter of diets and larvae was determined after drying at 105°C for 24 h. Crude protein ($N \times 6.25$), ash and gross energy of diets were determined by the Kjeldahl method after acid hydrolysis, by incineration at 550°C for 16 h and in an adiabatic bomb calorimeter IKA C4000, respectively. Total lipids of diets and larvae were extracted and measured gravimetrically according to Folch et al. (1957) using dichloromethane instead of chloroform. Due to small quantities of larvae, 21-day larvae from two rearing tanks were pooled before lipid extraction. Fatty acid methyl esters were prepared by acid-catalyzed transmethylation of total lipids according to Shantha and Ackman (1990) and analyzed using a Varian 3400 gas chromatograph equipped with a DB Wax fused silica capillary column (30 m $\times$ 0.25 mm i.d., film thickness: 0.25 μm, J&W Scientific, Folsom, CA). Helium was used as carrier gas (1.4 ml/min). The thermal gradient was 100°C to 180°C at 8°C/min, 180°C to 220°C at 4°C/min and a constant temperature of 220°C during 30 min. Injector and flame ionization detector temperatures were 260°C and 250°C, respectively. Fatty acid methyl esters were identified by comparison with known standards and quantified using a Spectra Physics 4270 integrator.

2.3. Statistical analyses

Results are given as means $\pm$ standard error (SE). Diet-related differences were analyzed using one-way ANOVA. The Newman–Keuls multiple range test was used to compare means when a significant difference was found. Percentage data of survival and composition of larvae were arc–sin transformed and weight data were log-transformed before analysis. The theoretical biomass of each group, calculated as the product of survival by the mean wet weight of 100 larvae, was also log-transformed before analysis. A contrast test was also used to compare weight data among treatments. All the statistical analyses were performed with the computing program STAT-ITCF (ITCF, 1988) and differences were considered significant when P values were < 0.05.

3. Results and discussion

European sea bass larvae effectively ingested dry compound diets from first feeding as revealed by observation of the digestive tract under the binocular microscope. Survival of all groups of larvae was greater than 94% by day 7 (Fig. 1). Mortality of the unfed negative control group began at day 7 and was complete at day 12. Similar results were observed for unfed common carp larvae (Fontagné et al., 1999). From day 10, mortality was higher in groups fed TOL, TC6 and TC10 compared to that of larvae fed TC8, whereas from day 13 to day 21, decreases of survival were not significantly different ($-4 \pm 2\%$ per day). Survival of TC8-fed larvae reached $57 \pm 8\%$ at the end of the trial vs. an average of $28 \pm 11\%$ for the three other groups.

The survival of larvae fed TC8 was similar to the values reported for 27-day-old European sea bass larvae fed live food by Person Le Ruyet et al. (1993). In the present study, the initial beneficial effect of TC8 on survival of European sea bass larvae was

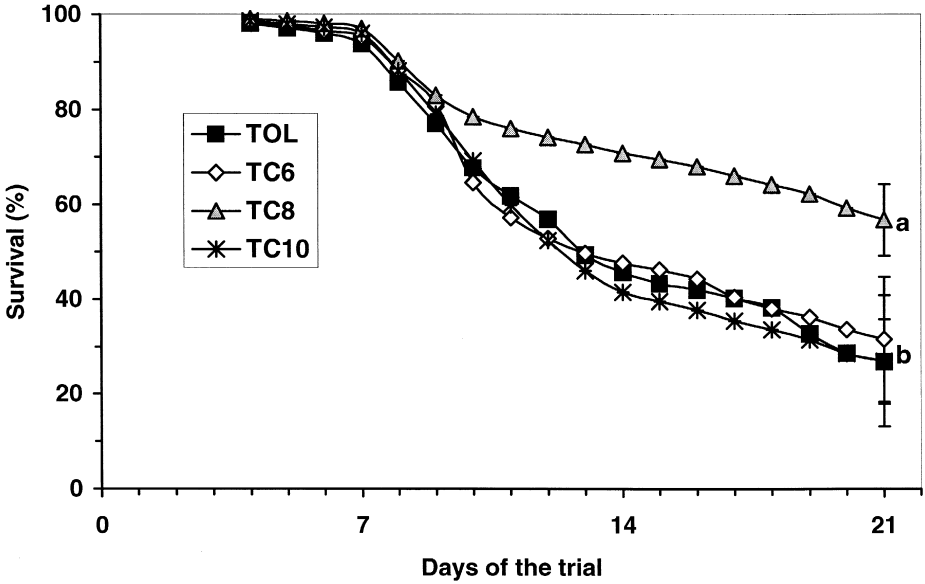

Fig. 1. Survival of European sea bass larvae fed the four compound diets supplemented with either triolein (TOL), tricaproin (TC6), tricaprylin (TC8) or tricaprin (TC10). At the end of the 21-day trial, means ± SE ($n = 4$) with different letters are significantly different ($P < 0.05$).

not seen with other MCT. In contrast to European sea bass, decreased survival has been observed for common carp larvae fed tricaprylin for 21 days (Fontagné et al., 1999). A superiority of 8:0 over other dietary lipids was found for initial survival of neonatal piglets by Jean and Chiang (1999) who compared 8:0-rich MCT oil, 12:0-rich coconut oil and soybean oil in the diet of late gestating sows. The effects of 8:0 on survival of young animals may be related to the high ketogenic properties compared to other MCFA or long-chain FA. In some cases, the ketone bodies produced by intensive β-oxidation of 8:0 are efficiently used as energy source (Odle et al., 1991; Jean and Chiang, 1999) and in other cases, ketone bodies seem to be poorly used (Craig and Gatlin, 1995).

No significant difference in growth rates could be detected at the end of the trial by ANOVA performed on final mean weights obtained for individual treatments (Table 3). However, significant differences were evidenced when TC6 and TC8 were compared together to TC10 or to TC10 and TOL by a contrast test. On days 20 and 21 of the feeding trial, larvae fed TC6 and TC8 displayed together significantly higher dry and wet weights (241 ± 69 μg and 1.5 ± 0.3 mg, respectively) than larvae fed TC10 and TOL (165 ± 28 μg and 1.2 ± 0.2 mg, respectively). Corresponding values for theoretical biomass at day 21 were 71 ± 38 mg and 34 ± 18 mg, respectively.

The growth rates obtained in the present study were similar to those reported for European sea bass larvae fed a compound diet composed of the same basal diet and supplemented with 2% fish oil by Cahu et al. (1998b). Final mean wet weights were lower than the values (10 mg) reported for European sea bass larvae fed live food for 21 days by Person Le Ruyet et al. (1993), Cahu and Zambonino Infante (1994) and Cahu

Table 3
Growth and theoretical biomass of European sea bass larvae fed experimental compound diets from first feeding (initial mean wet weight: 0.6 mg)[a]

	Dietary treatment			
	TOL	TC6	TC8	TC10
Dry weight (μg)				
Day 5	53 ± 2	55 ± 4	57 ± 6	53 ± 8
Day 10	87 ± 14 a,b	80 ± 9 a,b	110 ± 17 a	68 ± 19 b
Day 15	147 ± 25	134 ± 36	180 ± 44	119 ± 19
Day 20	168 ± 27	222 ± 77	259 ± 55	162 ± 31
Wet weight (mg)				
Day 5	0.5 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	0.5 ± 0.0
Day 10	0.6 ± 0.1	0.7 ± 0.2	0.8 ± 0.1	0.6 ± 0.1
Day 15	0.9 ± 0.2 a,b	0.8 ± 0.1 a,b	1.2 ± 0.3 a	0.8 ± 0.1 b
Day 20	1.4 ± 0.4	1.7 ± 0.5	1.8 ± 0.3	1.2 ± 0.4
Day 21	1.3 ± 0.2	1.4 ± 0.3	1.6 ± 0.4	1.1 ± 0.2
Theoretical biomass (mg)				
Day 21	36 ± 14 a,b	48 ± 30 a,b	94 ± 33 a	32 ± 24 b

[a]Values are means ± SE ($n = 4$). Within rows, means not sharing a common following letter are significantly different ($P < 0.05$). The decrease of wet weight between days 21 and 20 may be due to the 24-h starvation. The mean wet weight of larvae at day 21 was indicated as it concerned samples used for fatty acid analyses.

et al. (1998a). The diets used in the present study were mainly designed in order to compare MCT effects, but they were clearly less efficient than live prey. The difference between compound diets and live food is unlikely due to essential fatty acid deficiency. The docosahexaenoic acid/eicosaenoic acid ratio (presently 1:1) differed from the 2:1 ratio recommended by Sargent et al. (1997). However, the HUFA content and the docosahexaenoic acid/eicosaenoic acid ratio were close to values encountered in live prey used for European sea bass larvae production. Beneficial effects of dietary TC8 and TC6 supplementation have been reported for development of young mammals (Aurousseau, 1984; Aurousseau et al., 1984, 1989) and of juvenile ayu (Mustafa et al., 1991). In contrast, decreased growth rates have been observed in juvenile red drum (Craig and Gatlin, 1995) and common carp larvae (Fontagné et al., 1999) fed TC8. In another trial with first feeding common carp larvae, a beneficial effect of TC8 feeding could be seen during the first week of life, thereafter TC8 feeding yielded decreased growth performances (Fontagné et al., 2000). These latter results suggest a different utilization of TC8 according to the energetic needs of fish larvae.

The FA composition of European sea bass larvae is shown in Table 4. No significant differences in dry matter and total lipid levels were detected between dietary treatments. Compared to initial larvae sampled on day 0, amounts of saturates and $n-6$ FA of larvae fed the four diets were higher whereas the amounts of $n-3$ FA and monoenes, especially 16:1 and 18:1, were lower. Larvae fed TOL exhibited lower amounts of 18:1 than initial larvae ($20.1 \pm 3.1\%$ of total fatty acids vs. $23.6 \pm 0.7\%$, respectively). No significant differences in total saturates, monoenes, $n-6$ and $n-3$ FA were noted

Table 4
Main fatty acid composition of larval total lipids (% of total fatty acids)[a]

	Initial	Dietary treatments			
		TOL	TC6	TC8	TC10
Dry matter (%)	11.2 ± 0.4	13.9 ± 0.4	14.9 ± 0.2	13.8 ± 0.5	13.8
Total lipids (%)	3.3 ± 0.2	2.9 ± 0.2	2.9 ± 0.3	2.7 ± 0.2	2.8 ± 0.4
6:0	*t*	*t*	0.9 ± 0.5	*t*	0.2 ± 0.1
8:0	0.2 ± 0.0	0.2 ± 0.0 b	0.2 ± 0.0 b	1.3 ± 0.2 a	0.3 ± 0.2 b
10:0	*t*	*t*	0.2 ± 0.2 b	0.1 ± 0.0 b	2.9 ± 1.4 a
12:0	*t*	0.1 ± 0.0 b	*t*	*t*	0.5 ± 0.1 a
14:0	3.7 ± 0.2	1.7 ± 0.6	1.9 ± 0.1	1.7 ± 0.2	1.7 ± 0.4
16:0	18.3 ± 0.9	20.0 ± 4.3	23.4 ± 1.2	24.0 ± 0.8	21.4 ± 2.6
18:0	3.4 ± 0.0	5.2 ± 0.1 b	6.4 ± 0.5 a	6.1 ± 0.0 a,b	5.7 ± 0.3 a,b
Total saturates[b]	26.4 ± 1.2	29.1 ± 4.1	34.7 ± 2.2	34.9 ± 1.2	34.2 ± 4.3
16:1	12.2 ± 0.6	4.4 ± 1.2	5.0 ± 0.2	5.2 ± 0.2	4.4 ± 0.5
18:1	23.6 ± 0.7	20.1 ± 3.1	17.0 ± 1.0	17.0 ± 0.1	15.5 ± 1.3
20:1	1.7 ± 0.1	3.3 ± 0.8	3.7 ± 0.3	3.4 ± 0.1	2.8 ± 0.2
22:1	0.3 ± 0.0	1.1 ± 0.1	1.7 ± 0.4	1.7 ± 0.1	1.5 ± 0.2
Total monoenes[c]	38.8 ± 1.0	29.5 ± 3.6	28.0 ± 1.4	28.0 ± 0.1	24.9 ± 2.3
18:2*n* − 6	6.5 ± 0.2	14.7 ± 1.5	15.6 ± 0.6	15.8 ± 0.6	14.6 ± 1.2
20:2*n* − 6	0.2 ± 0.0	1.4 ± 0.7	1.5 ± 0.1	1.3 ± 0.1	1.4 ± 0.4
20:4*n* − 6	0.7 ± 0.0	1.0 ± 0.1	1.1 ± 0.1	1.1 ± 0.0	1.1 ± 0.0
Total *n* − 6 HUFA[d]	1.0 ± 0.0	2.8 ± 0.9	2.7 ± 0.0	2.6 ± 0.2	3.2 ± 1.4
Total *n* − 6[e]	7.6 ± 0.3	17.7 ± 0.5	18.4 ± 0.5	18.6 ± 0.8	17.8 ± 0.3
18:3*n* − 3	5.1 ± 3.0	5.0 ± 2.5	3.1 ± 0.1	2.6 ± 0.4	4.6 ± 1.8
20:5*n* − 3	5.8 ± 0.2	2.8 ± 0.1	3.5 ± 0.3	3.5 ± 0.0	3.3 ± 0.2
22:6*n* − 3	11.5 ± 0.4	6.5 ± 0.1	7.5 ± 1.5	7.7 ± 0.1	7.8 ± 0.1
Total *n* − 3 HUFA[f]	18.2 ± 0.6	10.4 ± 0.4	11.9 ± 1.8	12.1 ± 0.2	12.1 ± 0.3
Total *n* − 3[g]	24.1 ± 2.4	16.4 ± 3.8	15.5 ± 1.8	15.1 ± 0.6	17.6 ± 2.6

[a] Values are means ± SE ($n = 2$) except for dry matter determination of larvae fed TC10, only one data. Within rows, means not sharing a common following letter are significantly different ($P < 0.05$). SE < 0.05 is tabulated as 0.0; *t*, trace value < 0.1%.
[b] Includes 15:0, 17:0 and 20:0.
[c] Includes 17:1.
[d] Includes 22:5*n* − 6.
[e] Includes 18:3*n* − 6.
[f] Includes 20:4*n* − 3 and 22:5*n* − 3.
[g] Includes 18:4*n* − 3.

between larvae from dietary treatments. Deposition of MCFA was low (less than 3% of total FA) and slightly increased with the chain length of dietary FA (6:0, 8:0 and 10:0 represented 0.9, 1.3 and 2.9% of total FA after feeding with TC6, TC8 and TC10, respectively). A minor increase in the level of 12:0 in larval lipids was noted after TC10 feeding (0.5 ± 0.1% vs. 0.1 ± 0.0% of total FA for TOL fed larvae). No increase of the 2-carbon longer chain MCFA was noted after TC6 and TC8 feeding.

In the present experiment, initial larvae displayed HUFA levels (25% of total FA) lower than those reported for yolk sac European sea bass larvae (40% of total FA) by Corneillie et al. (1990). The fatty acid profile of initial larvae, with high levels of 18:1, 16:0 and 22:6*n* − 3, was close to that of first feeding common carp larvae (Fontagné et

al., 1999). These three main FA have been shown to be used as energy substrate during the embryonic and the early larval stages of European sea bass before exogenous feeding (Rønnestad et al., 1998). The low deposition of 18:1 in total lipid of larvae fed TOL suggests that this FA was degraded for energetic purposes after first feeding, in contrast to the marked 18:1 deposition reported in total lipid of common carp larvae fed TOL (Fontagné et al., 1999). In the present experiment, only minor amounts of MCFA were deposited in total larval lipids suggesting that MCFA were also degraded for energetic purposes. The low deposition of 18:1 and MCFA could explain the small difference in the FA composition between the different dietary groups. Low deposition of MCFA in body lipid stores is a common feature in fish (Nematipour et al., 1990; Davis et al., 1999) and mammals (Bach and Babayan, 1982). No elongation of dietary 8:0 into 10:0 was observed in the present study in contrast to results obtained in common carp larvae (Fontagné et al., 1999). An impairment of essential FA absorption has been noted in red drum juveniles fed TC8 (Craig and Gatlin, 1995). In the present experiment, such a negative effect could not be suspected in larvae fed the different MCT compared to larvae fed TOL.

In conclusion, MCT, especially TC8 and to a lesser extent TC6, appear to be potential dietary energy yielding nutrients for first feeding European sea bass larvae reared on compound diets. By analogy with results obtained with common carp larvae (Fontagné et al., 2000), this beneficial effect may be temporary.

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