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Sexual variation in biochemical indicators in adults of sea lamprey (*Petromyzon marinus* Linnaeus, 1758)

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Condition indices are generally interpreted as indicators of tissue energy reserves, which characterize components of the environmental in which organisms live (Lloret & Planes, 2003). Energy reserves have been proposed as a very sensitive indicator of the condition in fishes (Beckman *et al.*, 2000). During the reproduction period of lampreys, the supply of oxygen to the muscle tissue and other organs slows down and growth decrease or interruption occurs, especially in females due to gonads development.

The RNA/DNA ratio has been suggested as a sensitive measure of growth rate in fishes. An increase in the RNA/DNA ratio reflects a recent growth and it provides information on the nutritional condition of the specimens (Chícharo & Chícharo, 2008). Glycogen is the main source of energy to meet the metabolic demands of fishes (Bidinotto *et al.*, 1997). The amount of total protein gives a measure of long-term growth as well as for energy storage (McLaughlin

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et al., 1995). Lipid storage plays critical roles in the health of fishes by influencing energy allocation strategies, responses to environmental stressors, overwintering survival and reproductive fitness. The aim of present study, is show the results of the variation in the RNA/DNA ratio, glycogen, proteins and lipids in different organs (muscle, liver, heart and integument), in males and females of sea lamprey during the spawning migration.

We caught 65 adults of sea lamprey [24 males (748 - 891 mm) and 41 females (700 - 974 mm)] in the Miño River during the spawning migration. Samples of muscle, liver, heart and integument were taken and preserved at -80 ºC up to his later analysis.

Extraction of the nucleic acids was conducted by means of the use of TRIzol (Invitrogen). The quantification of the DNA was realized by a microspectrophotometer, whereas the RNA was done with a fluorimeter (methods described in Barca, 2016). Glycogen was quantified via the colorimetric method of the Antrona (Van Handel, 1965). Proteins quantification was carried out with the colorimetric method of the BCA, and lipids were determined by the gravimetric method of Bligh & Dyer (1985).

No significant differences were observed in RNA/DNA ratio and protein concentration between sexes in the muscle, heart and integument during the spawning migration. Nevertheless, significant differences between sexes were observed in RNA/DNA ratio (Kruskal Wallis, χ^2= 9.521; p <0.05) and protein concentration (Kruskal Wallis, χ^2= 7.465; p <0.05) in the liver, being significantly higher in females than males (Table 1). No significant differences were observed in glycogen and lipids between sexes in all analyzed organs.

The data reveal that protein synthesis in the liver is significantly higher in females than males of sea lamprey during spawning migration, probably related with the synthesis of hepatic enzymes. In this regard, Emmersen *et al*. (1979) have shown that in the liver there is an intense synthesis of protein precursors, in females, such as vitellogenin, necessary for gonad maturation. As a result, hepatic RNA and RNA/DNA ratio increased in females.

The highest concentrations of proteins found in the liver could be attributed to the reduction of glycogen and lipid deposits during spawning migration, indicating an increased gluconeogenic activity in liver, where aminoacids are used as a substrate for the synthesis of glucose.

It has often been noted that during the breeding season there are differences, both in metabolic activity and in energetic dynamics of substances of reserve, between males and females (Chícharo *et al*., 2007). We assume that the RNA/DNA ratio will be higher in females than in males due to the protein synthesis necessary for oogenesis; while the increase quantity of DNA due to spermatogenesis results in a low ratio in males. In parallel, it has been repeatedly observed an increment in the protein level prior to reproduction, more noticeable in females because the content of these substances in the egg is higher, in a wide variety of taxa (Meyer, 1990; Rosa & Nunes, 2003; Dutra *et al*., 2007; Choe *et al*., 2008).

In conclusion, the present study shows that during the anadromous migration of sea lamprey exists intersexual differences in liver, probably related to reproductive activity, but more studies are needed to corroborate these preliminary results in this species.

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TABLE 1. Descriptive statistics of RNA/DNA ratio, proteins, glycogen and lipids concentration in muscle, liver, heart and integument from males and females of sea lamprey during the spawning migration. Est. Dev.: Standard deviation, P_{25}: 25th percentile, P_{75}: 75th percentile.

		Muscle		Liver		Heart		Integument	
		♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
RNA/DNA	N	24	41	24	41	24	41	24	41
	Mean	1.28	0.94	4.04	5.90	1.43	1.36	0.87	0.87
	Median	0.99	0.83	4.12	5.32	1.29	1.20	0.65	0.76
	Variance	0.54	0.15	2.27	7.31	0.45	0.34	0.20	0.15
	Est. Dev.	0.73	0.39	1.51	2.70	0.67	0.58	0.45	0.38
	Minimum	0.51	0.21	1.72	1.61	0.43	0.43	0.41	0.32
	Maximum	3.57	1.84	7.23	13.99	3.04	2.86	1.93	1.91
	Range	3.06	1.63	5.51	12.38	2.61	2.44	1.52	1.59
	P_{25}	0.78	0.65	2.80	4.29	1.01	0.88	0.52	0.54
	P_{75}	1.65	1.21	4.83	7.06	1.67	1.80	1.29	1.15
Proteins (mg/g)	Mean	33.06	31.11	82.80	96.37	48.55	49.39	9.75	9.34
	Median	32.07	29.90	77.27	92.38	42.06	47.70	9.38	8.94
	Variance	22.50	30.15	315.87	402.21	161.80	151.82	23.66	9.24
	Est. Dev.	4.74	5.49	17.77	20.06	12.72	12.32	4.86	3.04
	Minimum	26.04	22.98	55.83	52.12	32.14	27.79	4.62	4.74
	Maximum	41.87	45.16	131.82	144.53	76.11	70.01	29.78	19.77
	Range	15.83	22.19	75.99	92.41	43.97	42.22	25.16	15.03
	P_{25}	29.42	27.28	68.12	81.03	38.26	37.54	7.59	7.75
	P_{75}	37.01	34.24	96.08	111.84	59.18	61.27	11.08	10.77
Glycogen (mg/g)	Mean	1.54	1.57	0.33	0.32	4.39	3.73	0.31	0.30
	Median	1.71	1.53	0.32	0.32	4.65	3.80	0.34	0.32
	Variance	0.48	0.41	0.00	0.01	6.17	5.31	0.01	0.01
	Est. Dev.	0.69	0.64	0.06	0.08	2.48	2.31	0.10	0.09
	Minimum	0.28	0.42	0.20	0.13	0.08	0.14	0.14	0.12
	Maximum	3.11	3.11	0.45	0.53	9.28	9.80	0.51	0.53
	Range	2.83	2.69	0.25	0.39	9.19	9.66	0.37	0.42
	P_{25}	0.99	1.13	0.28	0.29	2.47	2.18	0.21	0.22
	P_{75}	2.01	2.04	0.35	0.38	6.04	5.24	0.37	0.36
Lipids (%)	Mean	11.4	12.5	12.1	10.2	3.6	3.7		
	Median	9.8	12.6	10.5	8.9	3.3	3.6		
	Variance	19.0	13.5	24.4	14.5	0.7	0.8		
	Est. Dev.	4.4	3.7	4.9	3.8	0.8	0.9		
	Minimum	4.0	5.3	6.0	5.2	2.4	2.6		
	Maximum	19.6	21.8	20.8	19.7	5.7	5.7		
	Range	15.6	16.5	14.8	14.5	3.3	3.1		
	P_{25}	8.1	9.7	7.3	6.9	2.9	2.9		
	P_{75}	15.4	14.7	16.5	13.9	4.2	4.3		

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