METABOLIC REARRANGEMENTS OF *Synbranchus marmoratus* SUBMITTED TO ENVIRONMENTAL DEHYDRATION

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Seasonal changes in the environment, like those occurring in the tropical regions, might lead species to rearrange their metabolic profile to reach proper adjustments, which help to avoid a sort of injuries. Amongst different classes of response to environmental changes, aestivation, which occurs during the dry season, probably causes the major number of transitory modifications in the metabolism.

For some fish, dry season means little water availability or even its total absence. For instance, lungfish like *Lepdosiren paradoxa* may experience confination in a moist mud burrow and survive several months during the dry season (Dunn, 1983).

There are four problems that emerge when fish is exposed to the air: 1) Their gas exchange apparatus is not able to perform O_2 uptake and CO_2 releasing, unless they have (like Lepidosirenidae and Synbranchidae) air breathing organs. Such an inability causes anoxia and blood pH decrease. 2) Ammonia, the main nitrogen metabolism waste, cannot be released to the environment via gills during air exposure and, as it’s well known, this molecule is toxic to the nervous system even in relatively low levels. 3) Air exposition causes strong dehydration, whose consequences are changes in plasma electrolytic composition and acid-basic equilibrium and 4) Air exposed fish are not able to get food, so they suffer starvation during such exposition (Johansen, 1970; DeLaney, *et al.*, 1974).

To face the problems above, fish adopt physiological, biochemical and behavioural strategies which include decrease in metabolic rate and increase in anaerobic metabolism; changes in nitrogen metabolism, and burrowing in the mud (Long, 1995).

Synbranchus marmoratus, called swamp eel, can be found in many different habitats. It has a single ventral opercular opening and its branchial chambers have a well-developed vascular epithelium able to perform gas exchange (Liem, 1987). All individuals are hermaphrodites, which explains their ability in thrive in environments recently emerged. During severe dry season they aestivate and, in laboratory facilities, they were kept for 9-month aestivating (Bicudo and Johansen, 1979).

Eighteen specimens of *S. marmoratus* were kept in well-aerated 250 litre containers at 25^{O}C for one week. Thereafter, six individuals (the control group) were killed by punching their spinal cord and then blood, liver, kidney, white muscle, heart and brain were taken. The other twelve individuals were divided into two groups of six, and each group was placed within containers with water and mud. Afterwards, water was gradually removed from the containers creating a muddy environment that induced fish to aestivate. Both groups were kept aestivating, one for 15 and the other for 45 days. After each period, the fish were killed and their tissues and blood were taken as described for control group.

Analysis of variance (ANOVA) and Tukey-Kramer Multiple Comparisons test was applied for all data, with $p>0,05$.

Table1. Measures made in each tissue.

	Liver	*Kidney*	*Heart*	*Brain*
Glucose	§	§	§	§
Glycogen	§	§		
Lactate	§	§	§	§
Pyruvate	§	§		
f.a.a.[1]	§	§		
Arginase	§	§		
GS[2]	§	§		
GDH[3]	§		§	§
LDH[4]	§		§	§
MDH[5]	§		§	§

1= free amino acids; 2= glutamine synthetase; 3= glutamate dehydrogenasse; 4= lactate dehydrogenase; 5= malate dehydrogenase.

The results showed that metabolic adjustments occurred in *S. marmoratus* in the way to attend its energetic demands. The increase of free amino acids in the kidney suggests the occurrence of proteolysis followed by gluconeogenesis and the exportation of glucose to the plasma. The enzyme activity of MDH, LDH and GDH suggest the preference for oxidative metabolism in brain and heart during aestivation.

The kidney seems to assume an important role in ammonia detoxification at the beginning of aestivation due to its glutamine synthetase activity. The activity of hepatic arginase suggests the role of the liver in the protein catabolism under the aestivation of swamp eel, which might provide free amino acids to gluconeogenesis pathway.

Table 2. Results. Values are mean ± SD

		Liver	Kidney	Heart	Brain
Glucose	Control	275,9±51,3	25,1±1,9	88,4±15,1	19,3±3,8
µmols/g	15 days	280,4±31,9	21,2±3,4	67,7±7,3	19,9±1,7
	45 days	190,0±56,0	24,4±4,0	95,6±20,9	25,2±1,7
Glycogen	Control	308,3±63,2	62,7±3,1	-	-
µmols/g	15 days	365,6±35,8	32,0±5,7	-	-
	45 days	135,3±40,3	33,9±4,1	-	-
Lactate	Control	20,4±10,1	18,7±3,5	28,4±8,6	30,4±5,6
µmols/g	15 days	22,2±6,8	11,0±3,8	22,85±2,5	28,5±2,6
	45 days	15,7±5,6	8,1±1,5	18,0±2,7	15,1±2,7
Pyruvate	Control	0,63±,033	0,27±0,16	-	-
µmols/g	15 days	0,83±0,32	0,47±0,33	-	-
	45 days	0,97±0,12	1,18±0,16	-	-
f.a.a.	Control	1,52±0,21	2,0±0,46	-	-
µmols/g	15 days	1,61±0,9	1,35±0,29	-	-
	45 days	19,7±0,04	16,2±3,5	-	-
Arginase	Control	13,1±3,0	10,9±3,0	-	-
nmols/mg	15 days	17,1±1,8	5,1±0,4	-	-
min	45 days	21,5±2,6	17,9±1,6	-	-
GS	Control	0,09±0,02	0,04±0,001	-	-
nmols/mg	15 days	0,0	0,1±0,013	-	-
min	45 days	0,0	0,0	-	-
GDH	Control	12,4±3,4	-	5,0±1,8	4,18±0,63
µmols/g/	15 days	13,8±3,3	-	9,9±1,2	5,8±1,3
min	45 days	22,3±4,9	-	8,5±1,6	4,9±0,6
LDH	Control	3,4±0,5	-	115,5±40,0	81,1±21,4
µmols/g/	15 days	3,3±0,4	-	232,0±74,0	118,5±214
min	45 days	,2±0,9	-	267,0±18,4	104,2±9,5
MDH	Control	18,8±4,1	-	23,4±4,0	6,1±0,9
µmols/g/	15 days	18,4±4,1	-	47,3±7,6	-
min	45 days	17,9±1,2	-	43,3±2,0	8,3±1,5

References

Bicudo, J. E. P. W. and Johansen, K. Respiratory gas exchange in the air-breathing fish, *Synbranchus marmoratus*. Environ. Biol. Fishes 4:55-64, 1979.

Delaney, R. G., Lahiri, S, & Fishman, A. P. Aestivation of the African lungfish Protopterus *aethiopicus*. Cardiovascular and respiratory functions. J. Exp. Biol. 61:111-128, 1974.

Dunn, J. F., Hochachka, P. W., Guppy, M. & Davidson, W. Metabolic adjustments to diving and recovery in the African lungfish. Am. J. Physiol. 245:R651-R657, 1983.

Johansen, K. Air breathing fishes. In: Hoar, W. S. and Randall, D. J. (eds.). Fish Physiology Vol. IV. Academic Press, New York, pp 361-411, 1970.

Liem, K. F. Functional design of the air ventilation apparatus and overland excursions by teleosts. Fieldiana: Zool. 37:1-29, 1987.

Long, J. A. The rise of fishes: 500 million years of evolution. Johns Hopkins Univ. Press, Baltimore, 233 pp, 1995