Yolk sac conversion efficiency of brown trout (*Salmo trutta m. fario*) and rainbow trout (*Oncorhynchus mykiss*) during endogenous nutrition

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INTRODUCTION

Brown trout (*Salmo trutta* m. *fario)* and rainbow trout (*Oncorhynchus mykiss)* represent important salmonid fish species in aquaculture and sport fishing. Desirable water temperatures for spawning and incubation fertilized eggs range from 8 to 10°C (Savić et al. 2018). Salmonid fish species have bigger eggs in comparison to many other fish species, and big embryos, that contain a large yolk sac. Bonislawska et al. (2001) releases data that the duration of embryonic development measured in thermal units points to a significant level of interconnectedness between egg size and embryogenesis duration. Many researches about eggs size and properties were conducted without relation to other characteristics (area and volume, yolk sphere and perivitelline space) and because of that, they lack a common denominator, that is, a unifying theory of phylogenetic correlation between species that would properly describe the rate of change during embryogenesis (Imanpoor et al., 2009). The goal of the paper was to determine the efficiency of yolk sac conversion in brown and rainbow trout during endogenous nutrition.

MATERIAL AND METHODS

The experiment on the yolk sac conversion efficiency for brown trout (*Salmo trutta m. fario)* and rainbow trout (*Oncorhynchus mykiss*) was conducted in Aquaculture Laboratory of the Faculty of Agriculture, University of Banja Luka. The eggs was placed in three repetition trays for brown and rainbow trout. Water analysis included water temperature (°C) and dissolved oxygen content in water (mg/l). The diameter (d) of brown trout eggs (n = 20), and rainbow trout eggs (n = 20) was measured at the embryonic stage of eyes, after which the average diameter of the eggs was determined. Standard body length, yolk sac length and height were measured after the hatching, on the 27th day of incubation (357 dd) of rainbow trout (n = 20) and the 30th day of incubation (404 dd) of brown trout (n = 20) and just before the swimming, 36th day of incubation (492 dd) of rainbow trout (n = 20) and 43rd day of incubation (571 dd) of brown trout (n = 20). Yolk sac conversion efficiency (CE_y) was calculated according to Fraser et al. (2010). Digital images inserted into a computer and analyzed using ImageJ 1.49v were used to measure the diameter of eggs, standard body length, length and height of the yolk sac. The SPSS 7 program was used for statistical analysis.

RESULTS AND DISCUSSION

The incubation duration in this study for rainbow trout and brown trout is shorter considering higher water temperatures during incubation.

Table 1. Water temperature (°C) and dissolved oxygen (mg/l) (average±SD) during the observation period

Parameter		Brown trout (*Salmo trutta* m. *fario*)		Rainbow trout (*Oncorhynchus mykiss*)	
		The number of days		The number of days	
		from fertilization to hatching	from fertilization to swimming	from fertilization to hatching	from fertilization to swimming
		30	43	27	36
Water temperature	°C±SD / CV	13.45±0.69 / 5.11	13.28±0.87 / 6.55	13.23±1.43 / 10.78	13.67±1.00 / 7.31
Dissolved oxygen	mg/l±SD / CV	8.48±0.81 / 9.60	8.81±0.84 / 9.56	8.68±0.13 / 1.52	8.54±0.22 / 2.62

The dissolved oxygen content of water was within the allowed limits. Kocaman et al. (2009) state that incubation of fertilized rainbow trout eggs at a water temperature of 9.5°C takes 28-30 days, and brown trout 37-43 days, and the yolk sac phase lasts 19-20 days for rainbow trout and 34-38 days for brown trout. The incubation duration in this study for rainbow trout and brown trout is shorter considering higher water temperatures during incubation.

Table 2. The diameter of the eggs (average±SD) brown and rainbow trout in the eyes stage

	Diameter of eggs (mm)			
	average±SD	Min	Max	CV (%)
Brown trout (*Salmo trutta* m. *fario*)	5,82±0,53	4,92	6,84	9,07
Rainbow trout (*Oncorhynchus mykiss*)	4,99±0,35	4,10	5,45	7,09

Table 3. Standard body length (SL), length and height of yolk sac (average ±SD) of brown trout 30th and 43rd days after fertilization and rainbow trout 27th and 36th days after fertilization, the efficiency of the conversion yolk sac and the cumulative degree days (dd)

Parameter		Brown trout (*Salmo trutta* m. *fario*)		Rainbow trout (*Oncorhynchus mykiss*)	
		The number of days		The number of days	
		from fertilization to hatching	from fertilization to swimming	from fertilization to hatching	from fertilization to swimming
		30	43	27	36
Standard body length	mm±SD / CV	15.99±1.03 /6.46	22.94±1.89 / 8.25	14.38±1.36 / 9.44	21.23±1.88 / 8.84
Yolk sac length	mm±SD / CV	7.16±0.90 / 12.51	5.84±0.95 / 16.28	5.42±0.54 / 9.93	5.15±0.33 / 6.35
Yolk sac height	mm±SD /CV	3.86±0.46 / 11.94	2.56±1.02 / 39.74	3.59±0.69 / 19.07	2.43±0.45 / 18.71
Yolk sac conversion efficiency		0,121		0.178	
Cumulative degree days from fertilization	dd	404	571	357	492

The standard brown trout body length after hatching was not correlated to the volume of the yolk sac (Pearson's r = 0.25; P = 0.141), while the standard body length for rainbow trout was correlated with the volume of the yolk sac after hatching (Pearson's r = 0.47; P = 0.019; α = 0.05). The conversion efficiency of the brown trout yolk sac from hatching to swimming was 0.121, while for rainbow trout it was 0.178. Although the volume of the brown trout yolk sac was higher after hatching, compared to rainbow trout, the yolk sac conversion efficiency was determined to be poorer.

CONCLUSIONS

Standard body length, length and height of brown trout yolk sac from hatching to swimming were higher in comparison to rainbow trout, but the yolk sac conversion efficiency of the brown trout was poorer.