Klaipeda University
Marine Research Institute

EFFICIENCY OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) RECIRCULATING AQUACULTURE TECHNOLOGY UNDER BRACKISH WATER CONDITIONS

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Introduction

It is known that certain species show better growth performance in marine/brackish water than freshwater. Mostly this was evident for representatives of *Perciformes*.

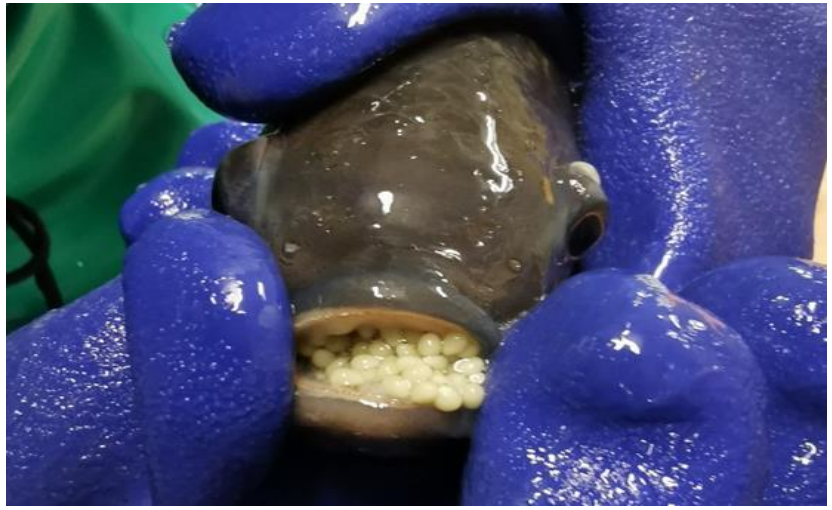
The aim of this study is to evaluate the influence of salt water on the efficiency of Nile tilapia (*O. niloticus*) aquaculture technology.

Tasks:

- Determine the influence of brackish water on the functioning of RAS;
- Determine the influence of brackish water on Nile tilapia growth, mortality, feed conversion;
- Determine the influence of gender on the efficiency of aquaculture;
- Determine the influence of brackish water on reproductive performance and early ontogenesis;
- Determine the influence of brackish water and sex on meat quality.

Nile tilapia (*O. niloticus*):

- Can grow up to 60 cm, 4,3 kg, lives up to 9 years. Males grow larger than females;
- Eurihaline species;
- Females incubate brood in their mouths;
- Optimal conditions: temperature – 25-30 °C, dissolved oxygen content – above 5 mg L^{-1}, salinity – up to 15‰, pH 6-9;
- One of most popular aquacultured species.



Photos by author

Materials and methods: structure of the experiment

- The experiment was performed at the KU MRI Fisheries and Aquaculture Laboratory, in a closed water circulation system;
- Nine tanks have been converted into three separate closed water circulating systems (3x3): freshwater (0‰), diluted seawater (3‰), seawater (6‰);
- Experiment period: 2020 August 5-December 18;
- Salinity (‰), temperature (°C), dissolved oxygen content (%) and pH were continuously measured, and water samples were taken for ammonium (NH_4), nitrite (NO_2) and nitrate (NO_3) tests.

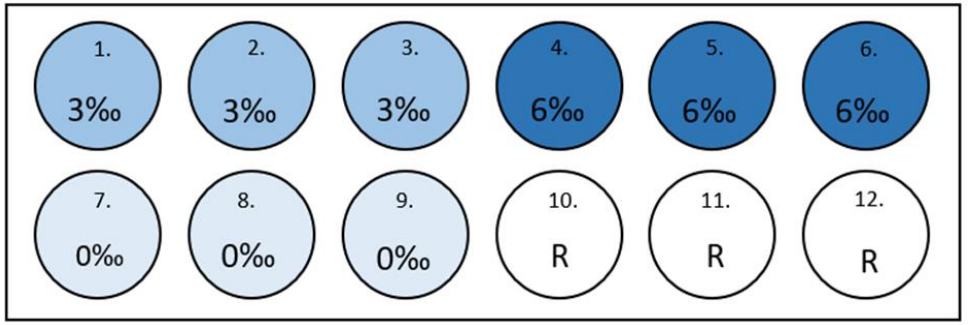


Photo and figure by author

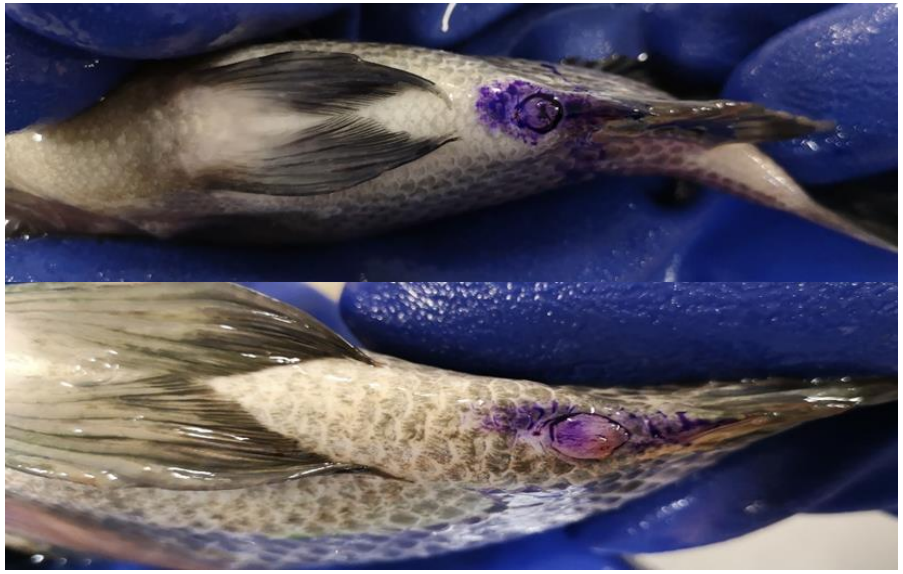
Materials and methods: measuring of fishes

- Fishes were sorted and distributed into the tanks (100 indv. each). Mean weight – 72.33 g ± 1.67 g.
- The number of dead fish were counted daily.
- Approximately every three weeks 30 tilapias were caught from each tank, measured their absolute and zoological lengths L and l (cm) and weight (g).
- At the end of the experiment, all fishes were measured and weighed, calculated biomass, weight gain (ΔW), specific growth rate (SGR), Fulton‘s condition factor (K), survival rate (SR), feed conversion ratio (FCR).

Photos by author

Materials and methods: evaluation of reproductive performance

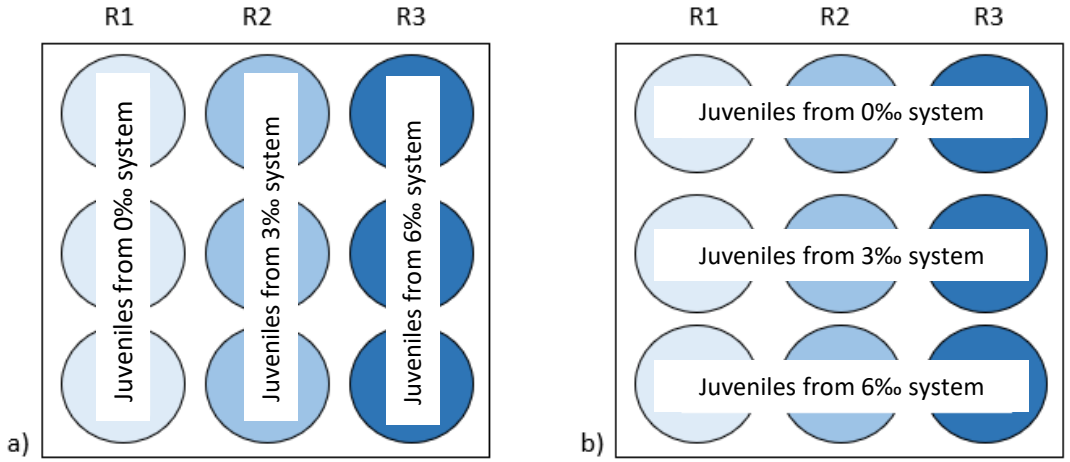
- The sex of the fish was determined by the shape and size of the papillae and the urogenital organs. A toluidine blue solution diluted with distilled water was used to highlight the papillae.
- Eggs ar larvae were collected and counted
- Counted juveniles were released into separate aquariums filled with water of appropriate salinity for further experiments.



Photos by author

Materials and methods: respiration experiment

- A PyroScience FireSting O_2 optical oxygen meter was used for the respiration test.
- Were used three meter systems – R1 (0‰), R2 (3‰) and R3 (6‰).
- The experiment was performed in two trials.
- The metabolic oxygen uptake rate (MO_2) (mg g^{-1} h^{-1}) was calculated from the data using the RStudio package.



Structure of experiment: a – first trial, b – second trial.

Photos and figures by author

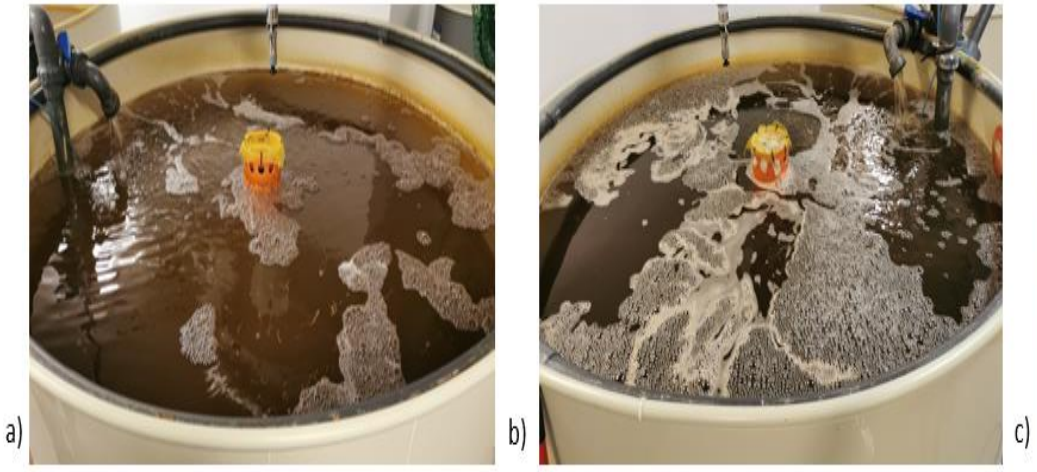
Materials and methods: evaluation of meat quality

- The evaluation of physico-chemical properties of meat was performed at LSMU VA Institute of Animal Husbandry Technologies.
- pH and the percentage of protein, fat, ash, dry matter, water binding and water content of the samples was determined.

Photo by author

Problems

In the middle of the experiment, an excessive amount of organic matter and particulate matter was encountered, which the biofilter and mechanical filter were not able to completely clean. This particularly affected the 6‰ system – the water became very cloudy and foamy. This system malfunction affected the results of this study.



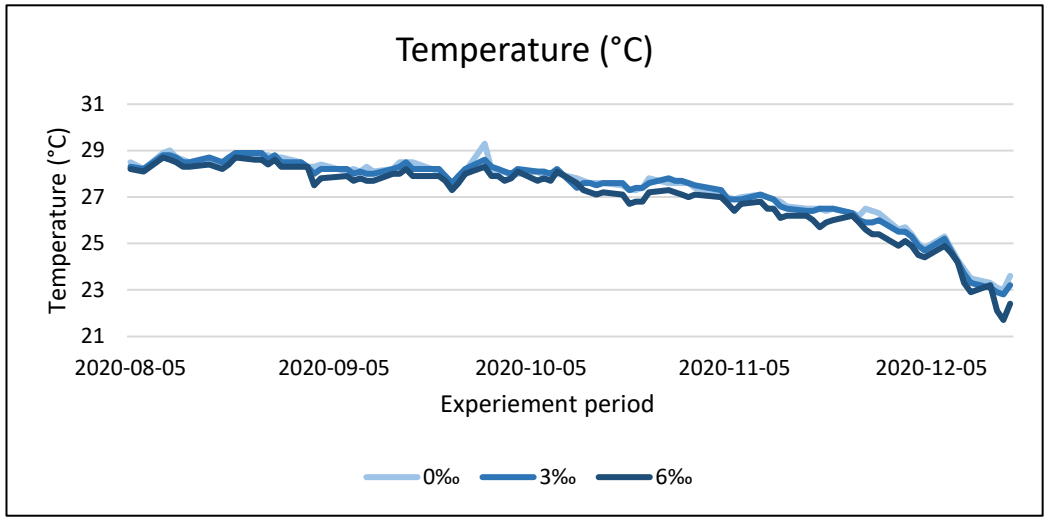
Water quality a) 0‰ system, b) 3‰ system, c) 6‰ system.

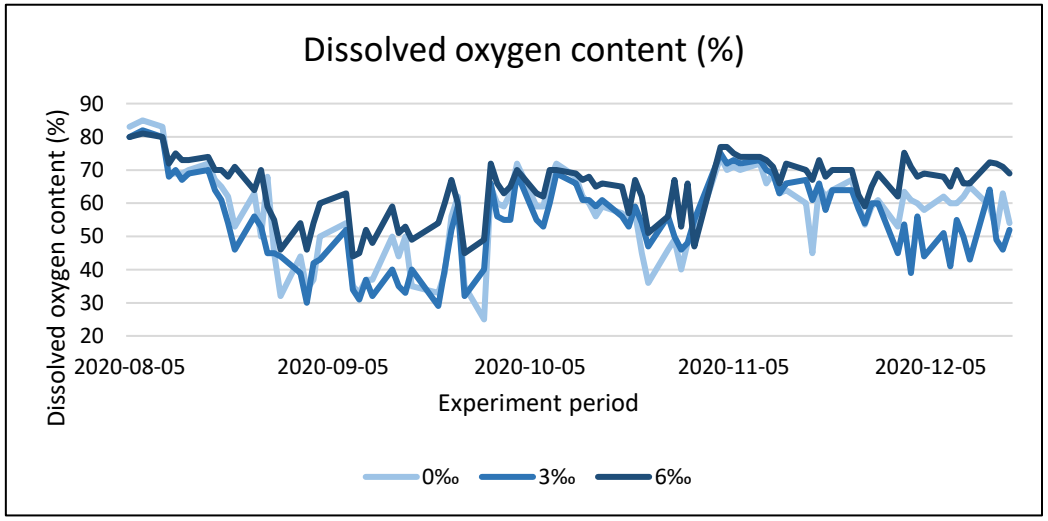
Photos by author

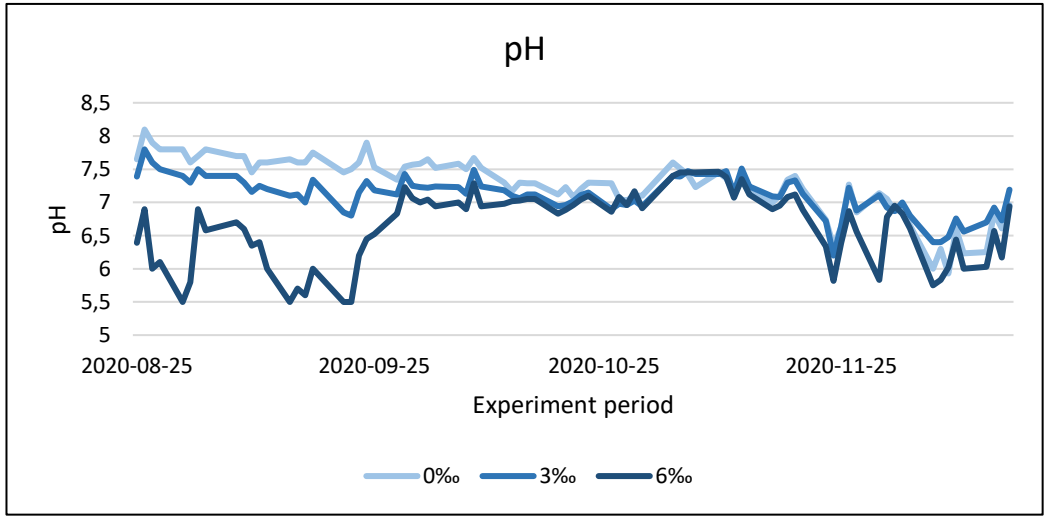
Water quality at the time of malfunction in 6‰ system.

Results: water quality (1)

The **dissolved oxygen content** (ANOVA, Welch F-test, $p = 1{,}052e^{-9} < 0{,}05$) and **pH** (ANOVA, Welch F-test, $p = 4{,}549e^{-12} < 0{,}05$) statistically significant varies between systems.

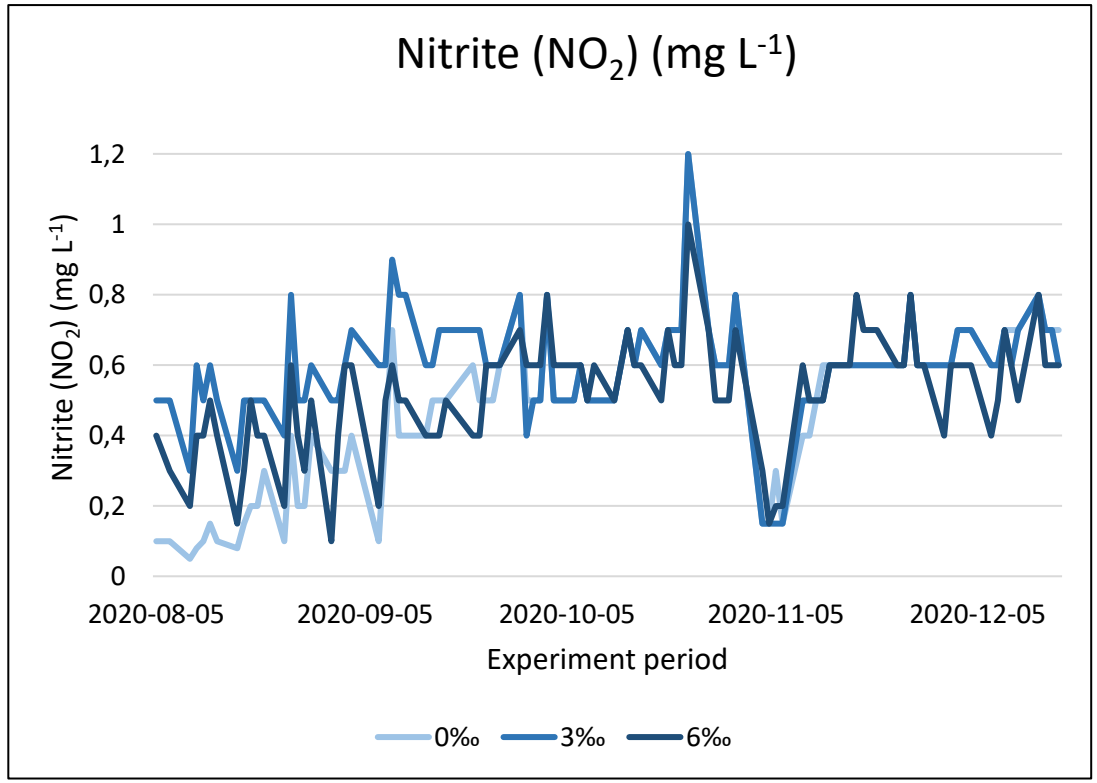


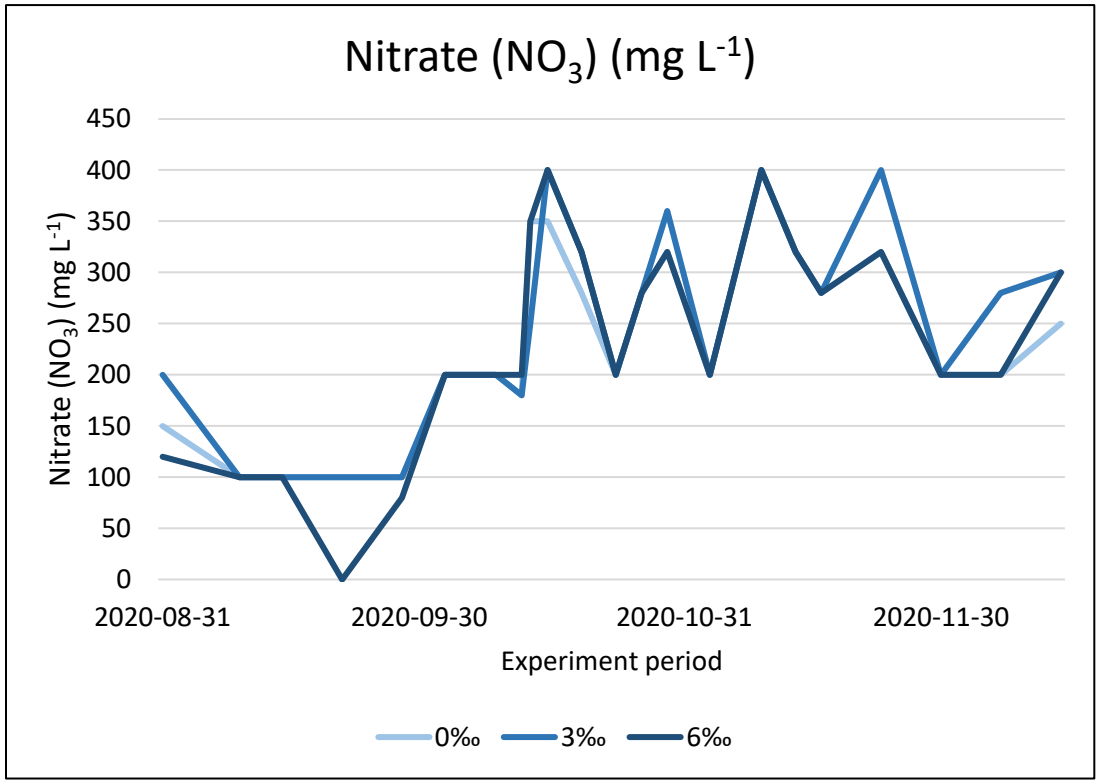




Results: water quality (2)

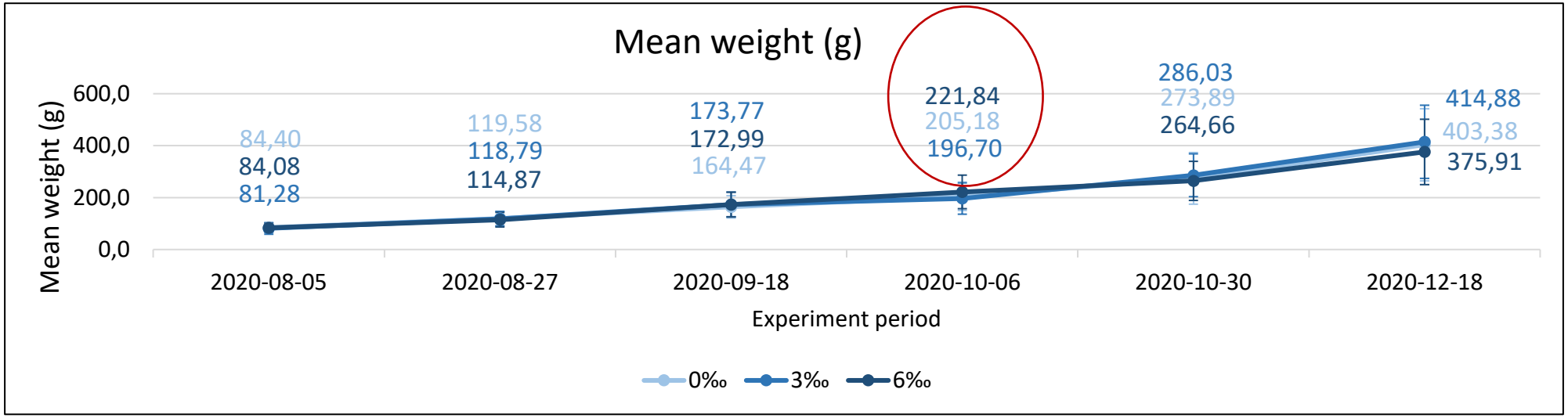
Ammonium (NH_4) content was the same throughout the experiment (< 0,05). A statistically significant difference in **nitrite (NO_2)** content was found between the systems (ANOVA, Welch F-test, p = $6{,}412e^{4}$ < 0,05).





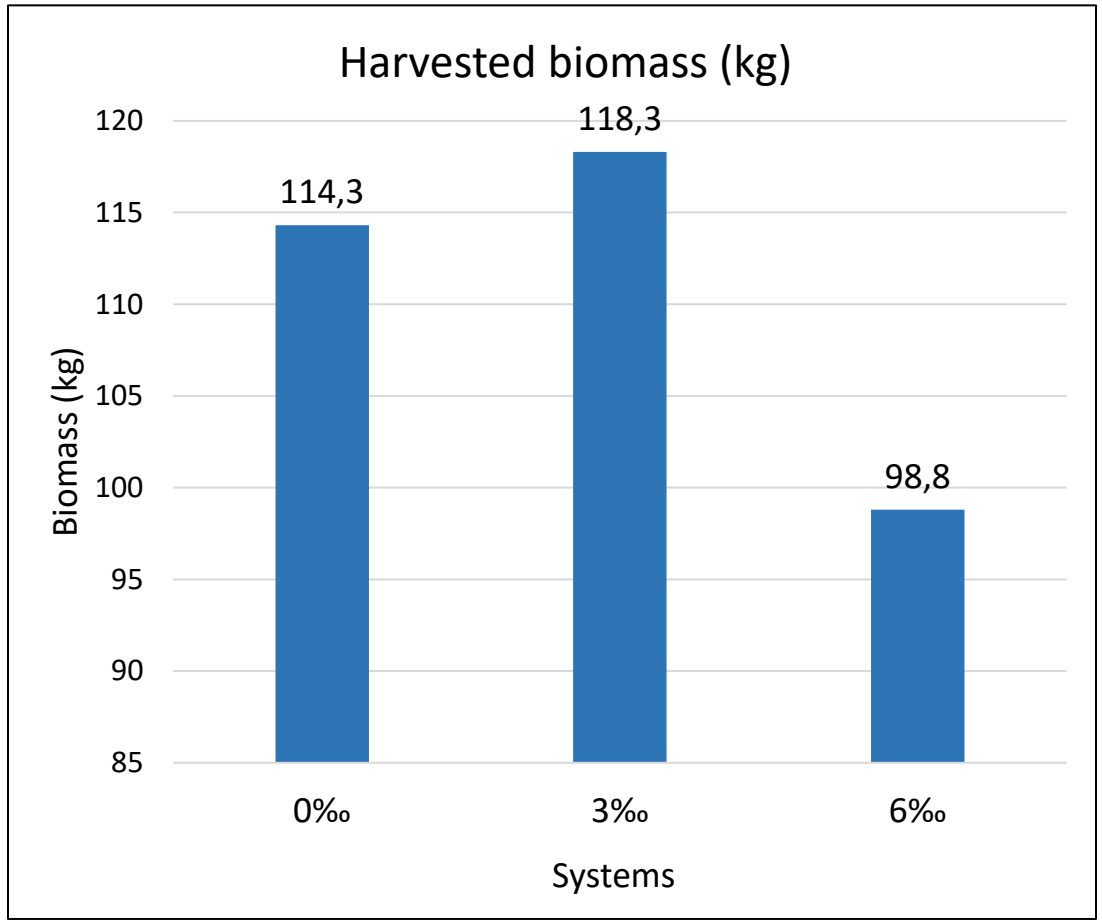
Results: growth

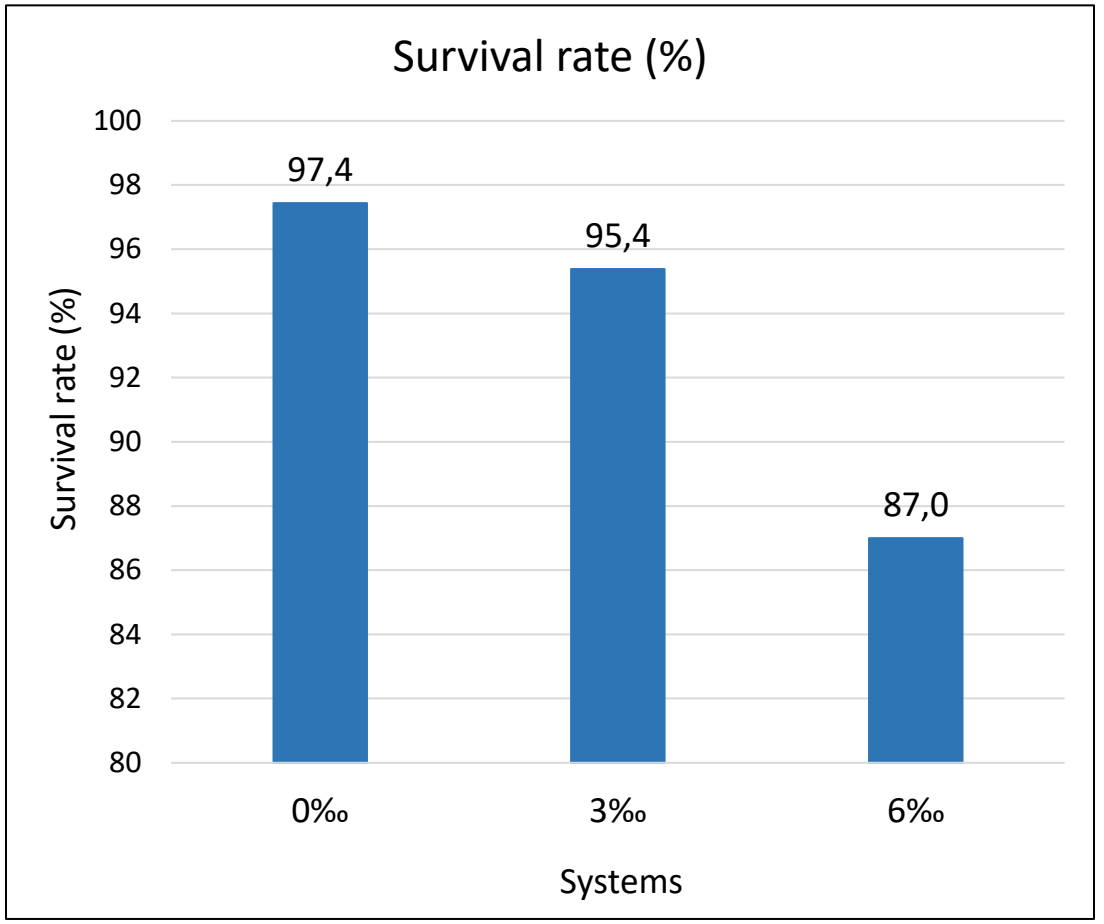
There was a statistically significant difference in the average weight of Nile tilapias between systems at the time of measurement on **2020 10 06** (ANOVA, p = 0,0179 < 0,05). The **final Fulton's condition factor (Kf)** also differed between systems (ANOVA, p = 0,0163 < 0,05).



System	Δw (g)	SGR (% d^{-1})	FCR	K_i	K_f
0‰	318,47 ± 38,17	1,16 ± 0,1	1,25 ± 0,13	1,8 ± 0,2	2,25 ± 0,16
3‰	333,42 ± 26,03	1,2 ± 0,09	1,20 ± 0,06	1,84 ± 0,3	2,21 ± 0,2
6‰	291,87 ± 6,35	1,1 ± 0,01	1,31 ± 0,04	1,84 ± 0,18	2,33 ± 0,19

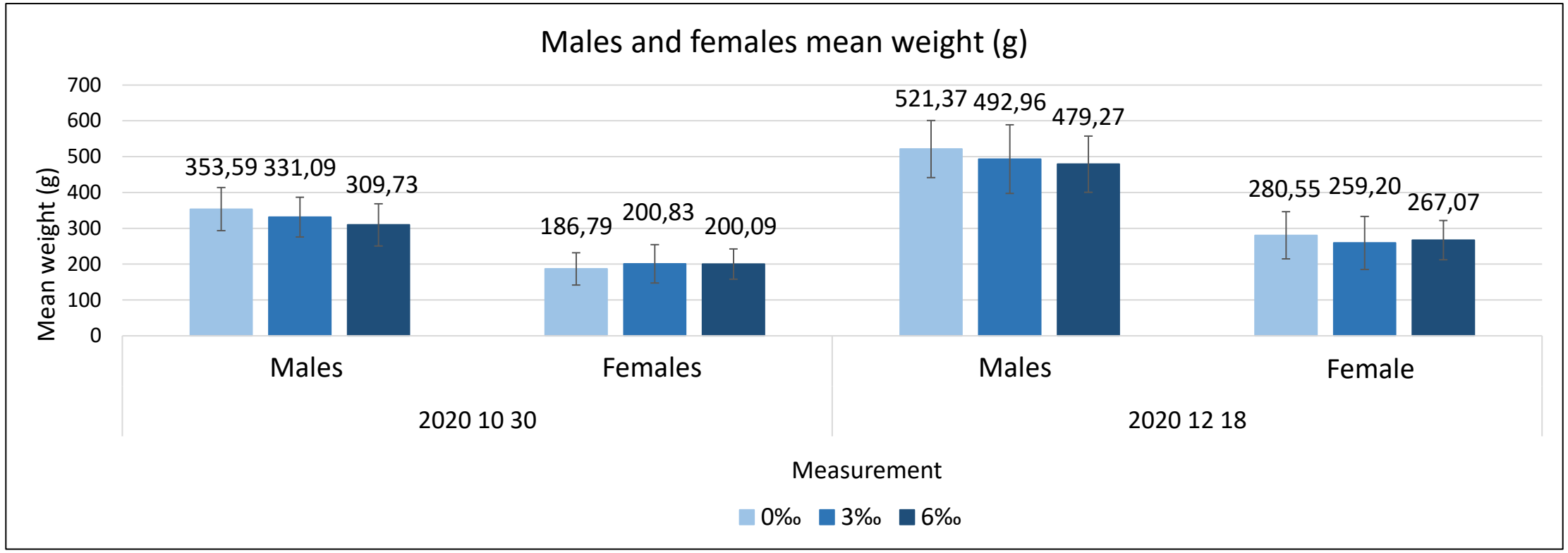
Results: harvested biomass and survival rate



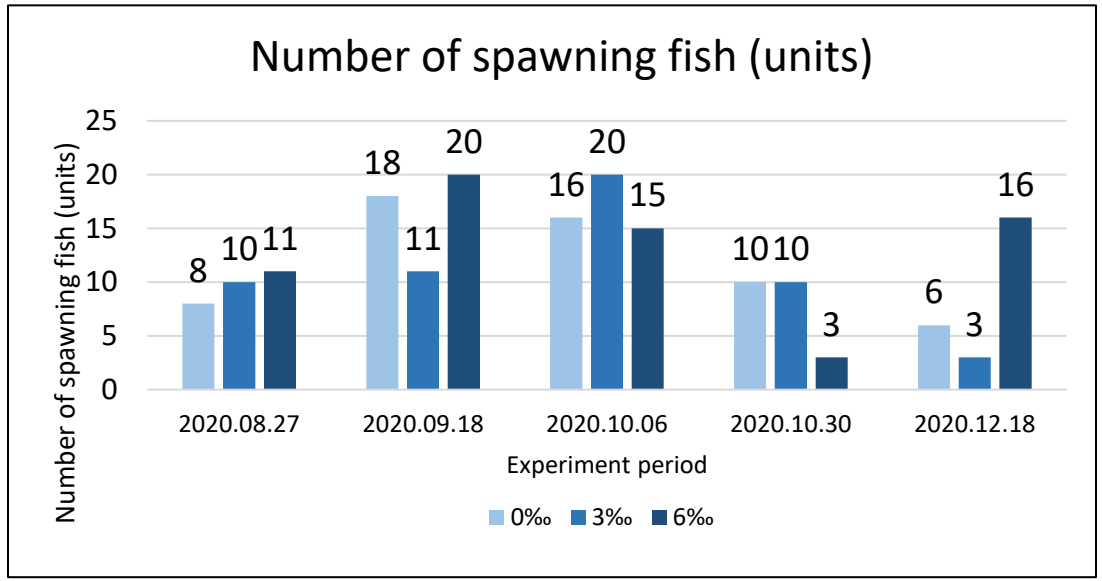


Results: growth differences between sexes

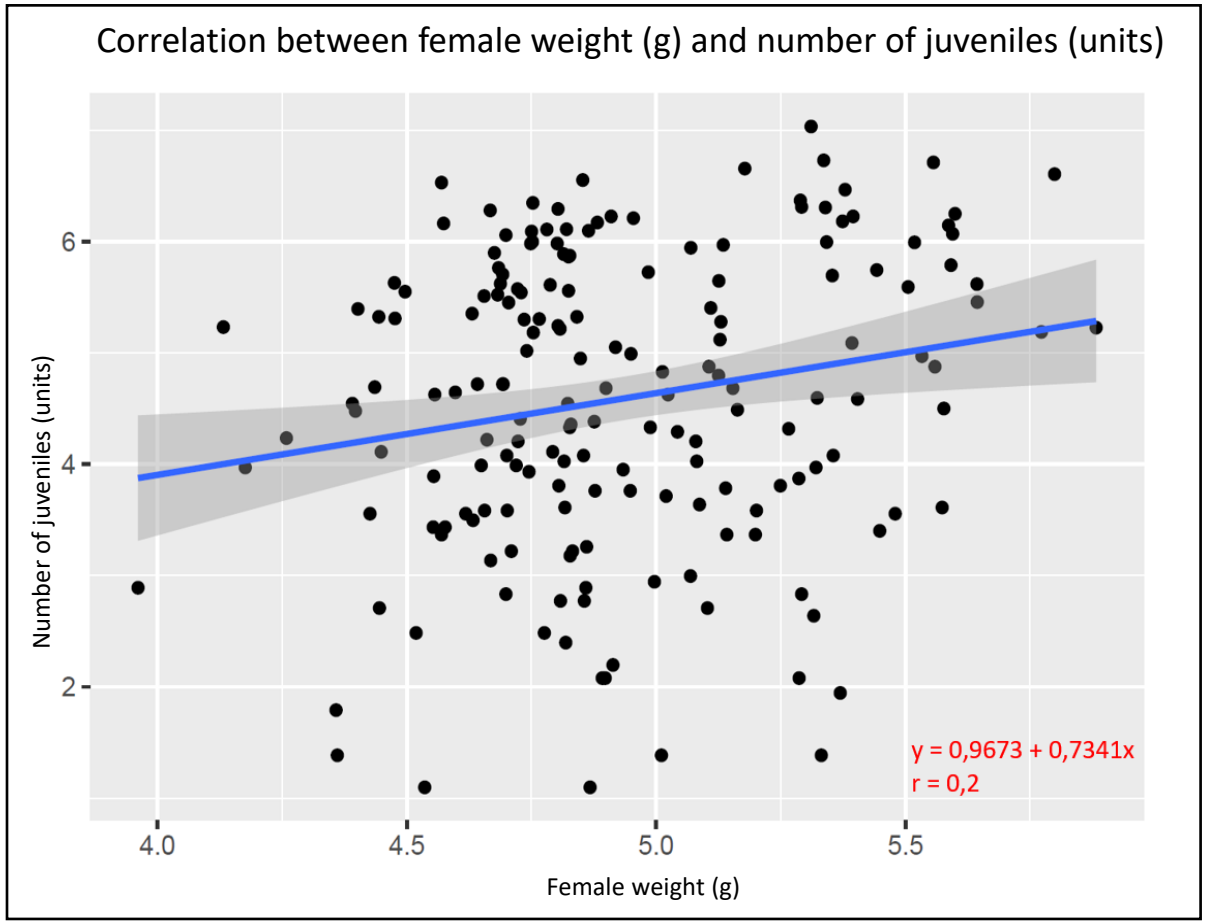
A significant difference between male and female weights was found in both measurements (ANOVA, $p = 2{,}2e^{-16} < 0{,}05$ and $p = 2{,}2e^{-16} < 0{,}05$).



Results: spawning performance

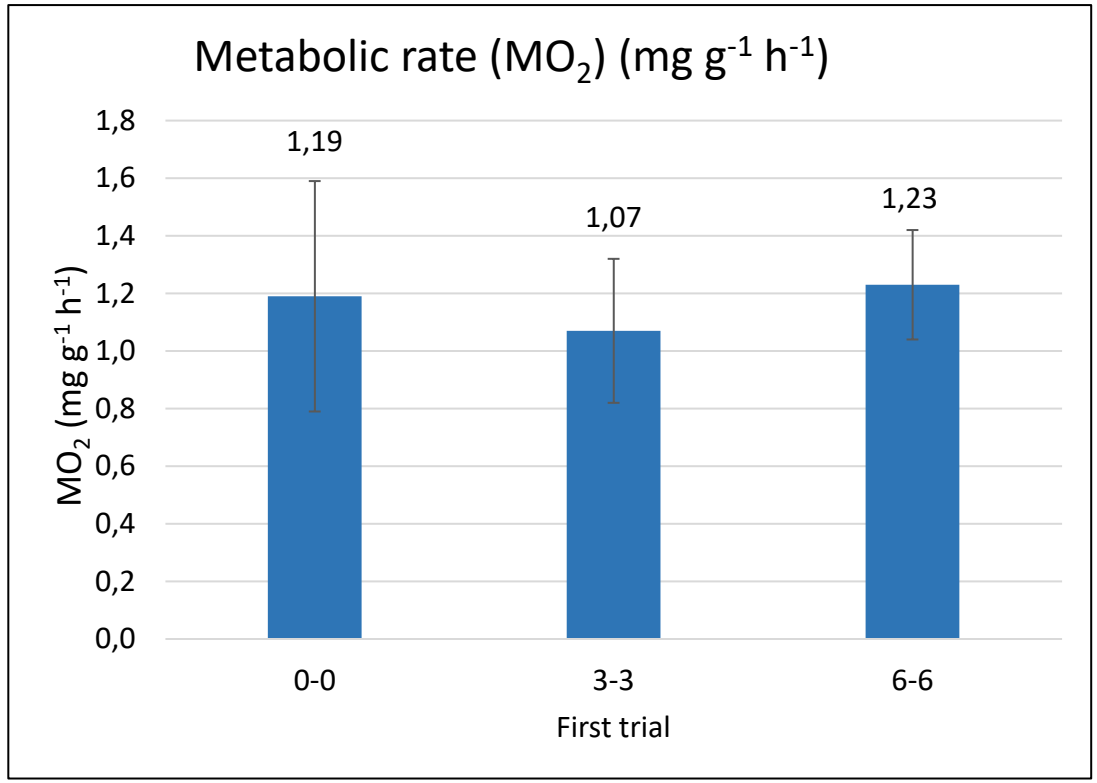


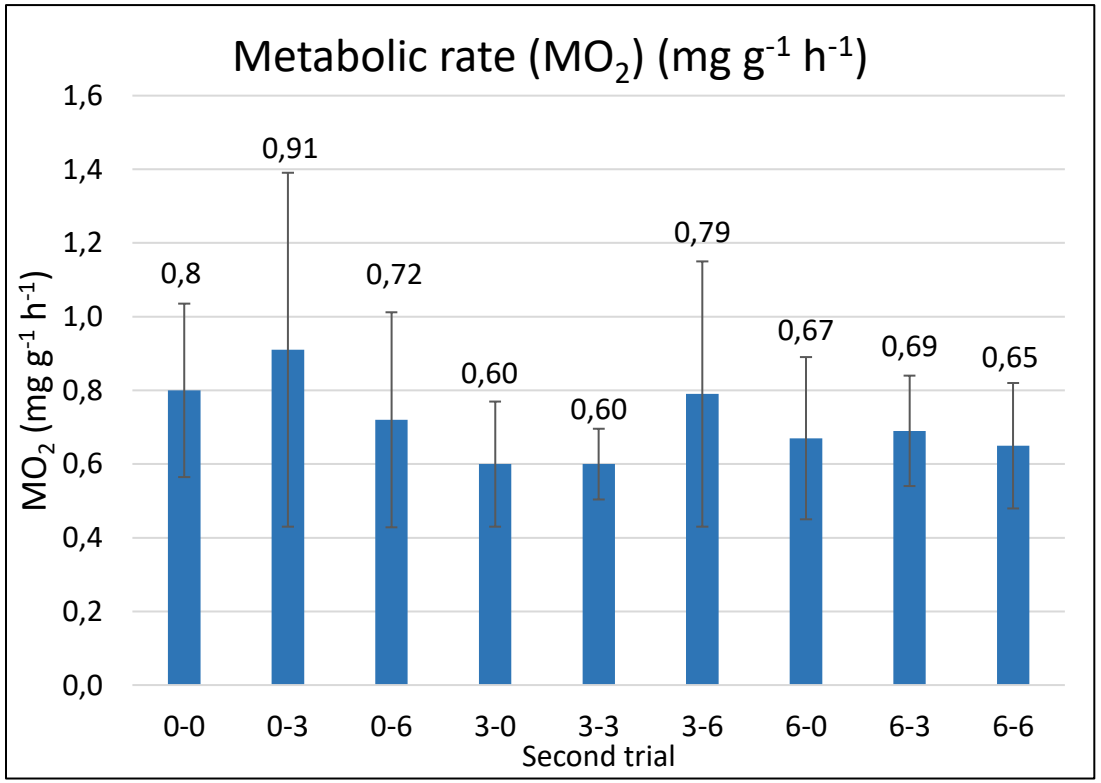
During each measurement, juveniles of all stages were found in almost all systems. There was a statistically significant difference in **eggs content** between the systems (ANOVA, p = 0,02405 < 0,05).



Results: physiological metabolism of juveniles

No statistically significant differences were found between the physiological costs of osmoregulation in either trial.





Results: physico-chemical properties of meat

There is a statistically significant difference in **water content** between males and females (ANOVA, $p = 0{,}005 < 0{,}05$) and between systems (ANOVA, $p = 0{,}019 < 0{,}05$) and **pH** between systems (ANOVA, $p = 0{,}044 < 0{,}05$) and their interactions with sexes (ANOVA, $p = 0{,}008 < 0{,}05$).

Salinity effect was determined for organoleptic parameters – smell and taste which were better in fish reared in brackish water, compared to muddy taste of compared to muddy taste of compared to muddy taste of freshwater system fish.

	Fat (%)		Ash (%)		Protein (%)		Dry matter (%)		Water content (%)		Water binding (%)		pH	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0‰	3,92 ± 0,42	3,68 ± 0,28	1,27 ± 0,14	1,35 ± 0,1	18,86 ± 1,18	19,41 ± 0,68	24,06 ± 1,19	24,44 ± 0,89	1,1 ± 0,1	1,49 ± 0,29	65,85 ± 3,81	64,89 ± 3,36	6,31 ± 0,1	6,11 ± 0,01
3‰	4,09 ± 0,5	3,18 ± 0,65	1,3 ± 0,16	1,35 ± 0,12	18,42 ± 0,95	19,31 ± 0,47	23,81 ± 1,39	23,83 ± 0,77	1,38 ± 0,15	1,73 ± 0,15	63,21 ± 2,59	64,95 ± 1,35	6,21 ± 0,1	6,28 ± 0,1
6‰	4,25 ± 1,06	3,6 ± 0,5	1,25 ± 0,15	1,48 ± 0,04	18,56 ± 0,84	19,43 ± 0,55	24,07 ± 1,72	24,51 ± 0,41	1,55 ± 0,41	1,69 ± 0,18	63,68 ± 2,84	66,59 ± 1,51	6,29 ± 0,1	6,39 ± 0,1

Recommendations

- Maintain the optimal water temperature, especially during the cold season, provide additional heat sources.
- Use a water skimmer to reduce the amount of organic matter and solids in the water.
- Avoid stressful situations for fish.
- For cultivation, choose a monoculture of Nile tilapia males due to significantly higher average weight and growth rate compared to females.
- Carry out fish sorting, in which larger fish are separated from smaller ones, thus avoiding competition for feed, allowing equal growth.

Conclusions

1. Brackish water had a statistically significant effect on the dissolved oxygen content (%), water pH, and nitrite (NO_2) (mg L^{-1}). Due to the RAS being not suitable for the use of salt water, the water quality deteriorated during the study, especially in the 6‰ system – the dissolved oxygen content was below the optimal limit (58,4 ± 7,4%), the nitrite content increased to 1,2 mg L^{-1}.

2. The highest final Fulton‘s condition factor was statistically significantly higher in the 6‰ system. Growth and feed conversion ratios did not differ statistically significantly under different salinity conditions. The worst survival was in the 6‰ system due to deteriorating water quality during the study, and the best was in the 0‰ system.

3. The sex of Nile tilapia is important for the efficiency of aquaculture. Gender had a statistically significant effect on fish weight. The final weight of males was 54% higher than that of females.

4. Brackish water conditions did not significantly affect the spawning of Nile tilapia females and amount of juveniles. There were no statistically significant differences in the metabolic rate of the juveniles. A weak correlation was found between the weight of Nile tilapia adult females and the number of juveniles.

5. Comparing the meat quality between the systems, there was a statistically significant difference in the pH of the meat: the average pH of the samples from the 6‰ system (6,33 ± 0,08) was higher than that of the 0‰ and 3‰ systems – 6,21 ± 0,11 and 6,25 ± 0,09 respectively. The water content (%) of the meat also differed statistically significantly between the systems – in the samples of the 6‰ system it was 20% higher than in the 0‰ system. The water content also differed statistically significantly between the sexes – in the female samples the average water content was 17,7% higher than in the male samples.