Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v40i1.39766

AQUICULTURE

Performance of fat snook juveniles reared at different temperatures

Daniel Correia[1], Luiz Henrique Castro David[1,2*], Sara Mello Pinho[1,2], João Costa-Filho[3], Maurício Gustavo Coelho Emerenciano[1,4] and Giovanni Lemos de Mello[1]

*[1]Laboratório de Aquicultura, Departamento de Engenharia de Pesca, Universidade do Estado de Santa Catarina, Rua Cel. Fernandes Martins, 270, 88790-000, Progresso, Laguna, Santa Catarina, Brasil. [2]Centro de Aquicultura, Universidade Estadual Paulista "Júlio de Mesquita Filho", Jaboticabal, São Paulo, Brasil. [3]Programa de Pós-Graduação em Aquicultura, Instituto de Oceanografia, Estação Marinha de Aquacultura, Universidade Federal de Rio Grande, Rio Grande, Rio Grande do Sul, Brasil. [4]Programa de Pós-Graduação em Zootecnia, Universidade do Estado de Santa Catarina, Chapecó, Santa Catarina, Brasil. *Author for correspondence: luiz.h@outlook.com*

ABSTRACT. We aimed at evaluating the effects of different water temperatures on the zootechnical performance of fat snook. The experiment lasted for 60 days, which was conducted in water recirculation systems, and was randomly designed with three treatments and three replicates each, corresponding to three water temperatures (25, 28 and 31°C). A total of 225 fat snook juveniles with a mean weight of 6.45 ± 0.58 g were used, which were fed daily until apparent satiety. Zootechnical parameters were assessed and feeding rates were registered for each tested temperature. Survival rates varied from 96 to 100% among treatments. Higher values of standard and total length, and weight gain were found in 28 and 31°C ($p < 0.05$). With regard to final weight, final biomass, feed conversion and specific growth rate, no significant differences were observed ($p > 0.05$). Feeding rates did not differ among evaluated temperatures. The results show that the used temperatures did not negatively affect zootechnical performance of fat snook juveniles.

Keywords: marine fish farming; water recirculation; *Centropomus parallelus*.

Desempenho de juvenis de robalo-peva cultivados em diferentes temperaturas

RESUMO. O objetivo deste estudo foi avaliar os efeitos de diferentes temperaturas da água no desempenho zootécnico de robalo-peva. O experimento teve duração de 60 dias, foi conduzido em sistemas de recirculação de água e contou com três tratamentos de diferentes temperaturas: 25, 28 e 31ºC, com três repetições cada. Foram utilizados no total 225 juvenis de robalo-peva com peso médio de 6,45 ± 0,58 g e alimentados até saciedade aparente. Foi avaliado o desempenho zootécnico e reportadas as taxas de alimentação para cada temperatura testada. A sobrevivência dos juvenis variou de 96 a 100% entre os tratamentos. Foram observados maiores valores de comprimento-padrão, comprimento total e ganho de peso nos tratamentos de 28 e 31ºC ($p < 0,05$). Em relação aos parâmetros de peso final, biomassa final, conversão alimentar aparente e taxa de crescimento específico, não apresentaram diferenças significativas entre os tratamentos ($p > 0,05$). As taxas de alimentação também não diferiram entre as temperaturas avaliadas. Os resultados mostram que as temperaturas utilizadas não afetaram negativamente o desempenho zootécnico dos juvenis de robalo-peva.

Palavras-chave: piscicultura marinha; recirculação de água; *Centropomus parallelus*.

Introduction

Brazilian marine fish farming began in the XVII century in Pernambuco, and the main produced species were snooks (*Centropomus spp*.), mullets (*Mugil spp*.) and mojarras (*Eugerres diapterus*). The fish farming activity of these estuarine species was performed in ponds that were naturally filled by tides, with little constructive technology, and the aim was to develop commercial farms. However, in the following decades, marine fish farming did not turn out to be a commercial activity in the Northeast region, nor in any other region of the country. The growth of the metropolitan area of Recife (PE) lead several ponds to vanish, which became marine shrimp farms, notably from the 1990s onwards (Cavalli, Domingues, & Hamilton, 2011; Cavalli & Hamilton, 2009). Brazilian researches were performed with three main species for a long time, which received a lot of attention in the last 30 years: fat snook (*Centropomus parallelus*), mullet (*Mugil brasiliensis*) and the sole (*Paralichthyis orbignyanus*) (Cavalli et al., 2011). Fat snook is one of the main candidates for Brazilian marine fish farming (Cerqueira & Tsuzuki, 2009). This species prefers waters near the coast, estuaries, coastal lagoons and rivers in South America (Lemos, Netto, &

Germano, 2006). The wide area of fat snook occurrence allows this species to tolerate a wide range of temperature variation (15 to 31ºC) (Ferraz, Carvalho, Schafer, Narahara, & Cerqueira, 2011; Rivas, 1986). Temperature is one of the factors that mostly influences a fish's physiological processes, such as growth, body composition and energy balance. Its metabolic activities are also altered according to thermal variations, increasing in a proportional way to increased temperatures (Fang, Tian, & Dong, 2010; Kır, Sunar, & Altındağ, 2017; Person-Le Ruyet, Mahe, Le Bayon, & Le Delliou, 2004). Likewise, this pattern influences feed consumption, which also increases along with temperature, as observed by Ferraz et al. (2011), in fat snook.

As other aquatic organisms, marine fish can be reared in different types of production systems and in opened or closed environments (Liu et al., 2017). However, depending on the region in Brazil, open systems might be easily influenced by temperature variations throughout different seasons, especially in the South and Southeast. Each species has a temperature range in which it survives and growth occurs normally (Katersky & Carter, 2005; Simon et al., 2017; Xie et al., 2011). Yet, growth is maximized only in an optimal range, located within its range of thermal tolerance (Handeland, Imsland, & Stefansson, 2008; Vikeså, Nankervis, & Hevrøy, 2017).

In this sense, knowing the influence of temperature in food consumption and the importance of supplying adequate quantities of feed, seen that it may represent more the 60% of production costs (Scorvo-Filho, Frascá-Scorvo, Alves, & Souza, 2010), the aim of this study was to evaluate the effects of different water temperatures on animal performance of fat snook juveniles.

Material and methods

The study was performed in the Laboratory of Aquaculture of the Santa Catarina State University (LAQ-UDESC), Laguna – SC, Brazil. Fat snook juveniles were acquired from the Laboratory of Marine Fish Farming of the Santa Catarina Federal University (LAPMAR - UFSC), where they were produced by induced spawning, according to the protocols described by Cerqueira and Tsuzuki (2009). Two weeks prior to the experiments, fish were kept in 1000 L tanks disposed in a water recirculation system, at a temperature of 25°C, salinity of 15 g L^{-1} and a density of 500 fish m^{-3}, fed with a commercial diet for marine juvenile carnivorous fish (INVE®), containing 59% of crude protein, 13% of ether extract and a granulometry of 1.2 mm. Fish were stocked in the experimental systems at 25ºC and acclimatized up to each treatment's temperature with a 1°C increase every four hours.

The experiment lasted for 60 days, which was designed with three treatments, according to tested temperatures, and three replicates each: 24.96 ± 1.07°C (T25), 27.94 ± 1.08°C (T28) and 30.47 ± 1.06°C (T31), maintained with the aid of thermostats. Each experimental device was composed by an independent water recirculation system, with a flow of 500 L h^{-1}, formed by three tanks for fish rearing (200 L of useful volume), connected to a water treatment system, with mechanical and biological filters, and UV treatment. The mechanical filter was of bag type (Perlon®), while the biological was composed by bioballs, occupying a volume of approximately 0.1 m^3, besides the sump (150 L of useful volume), where the submerged pump (Atman®) was allocated to return the water to the experimental units. Furthermore, fish tanks were daily siphoned, with a water exchange close to 4% of the total volume of each system. In each replicate, 25 fish were stocked (125 fish m^3), totaling 225 juveniles, with initial weight, standard and total length of 6.45 ± 0.58 g, 7.47 ± 0.32 cm and 9.44 ± 0.40 cm, respectively.

Daily measures of temperature, dissolved oxygen and salinity were taken twice a day (8:30 and 16:00h), with the aid of a digital multiparameter device (YSI, 55 Dissolved Oxygen Instrument, Yellow Spring - OH, USA). Differently, total ammonia, nitrite, nitrate and orthophosphate levels were determined on a weekly basis, by means of a photocolorimeter (ALFAKIT model AT 100P, Florianópolis – SC, Brazil), while alkalinity was measured by a volumetric titration method (ALFAKIT - 2058 and 2460).

Fish were fed with a commercial diet for marine carnivorous juveniles (INVE®) containing 59% of crude protein, 13% of ether extract and a grain size of 1.2 mm, twice a day (10:00 and 15:00h) until apparent satiety. Throughout the experimental period, two biometrics were performed, at 30 and 60 days. Weight and length estimates were determined using a digital scale (accuracy of 0.01 g) and an ictiometer. Animal performance of fish was measured by means of the following variables: survival (%), final weight (g), standard and total length (cm), apparent feed conversion ($AFC = \text{consumption of feed/biomass gain}$), weight gain (g) ($\text{WG} = \text{final weight} - \text{initial weight}$), final biomass (g) ($\text{FB} = \text{final biomass x survival}$) and specific growth rate

$(SRG = 100 * [\frac{\ln \text{mean final weight} - \ln \text{mean initial weight}}{60}])$. Feeding rates were registered for each temperature, determined according to the relation between quantities of weekly supplied feed (satiety) and the biomass in each experimental unit, calculated with the data of initial weight and specific growth rate of each treatment.

After checking normality premises (Shapiro-Wilk's test) and homoscedasticity of data (Leven's test), the results were submitted to a *one-way* ANOVA, followed by a Tukey's test for comparison of means of each treatment. All analyses were performed considering a 5% significance level.

Results and discussion

In general, water quality parameters (Table 1) did not present significant statistical differences ($p > 0.05$) among treatments, and remained within the standards required for the species (Pinho, Brol, Almeida, Mello, Jerônimo, & Emerenciano, 2016). With an exception of dissolved oxygen, which was higher ($p < 0.05$) in T25 (24.96 ± 1.07°C) when compared to T28 (27.94 ± 1.08°C) and T31 (30.47 ± 1.06°C), the remaining parameters were statistically similar ($p > 0.05$) among treatments. Closed aquacultural systems, where there is no water exchange, may present increased concentrations of some compounds in the water, such as nitrogen compounds (Colt, 2006), an effect that was observed in this study, with increased levels of nitrate and orthophosphate in all evaluated treatments (Figure 1).

Table 1. Water quality parameters (mean ± standard deviation) observed throughout the experimental period of juvenile fat snook reared at different temperatures.

	Treatments		
Parameters	T25	T28	T31
DO (mg L^{-1})	7.29 ± 0.75^a	6.43 ± 0.71^b	6.08 ± 0.75^b
SL (g L^{-1})	25.08 ± 3.2^a	24.62 ± 3.34^a	25.43 ± 3.47^a
TAN (mg L^{-1})	0.02 ± 0.01^a	0.00 ± 0.01^a	0.01 ± 0.02^a
NO_2 (mg L^{-1})	0.26 ± 0.12^a	0.67 ± 0.28^a	063 ± 0.26^a
NO_3 (mg L^{-1})	0.49 ± 0.02^a	0.44 ± 0.01^a	0.48 ± 0.02^a
PO_4 (mg L^{-1})	3.97 ± 1.38^a	3.22 ± 1.21^a	3.71 ± 1.11^a

DO = Dissolved Oxygen; SL = Salinity; TAN = Total Ammonia; NO_2 = Nitrite; NO_3 = Nitrate; PO_4 = Orthophosphate. Means followed by different letters in the column indicate significant differences by the Tukey's test ($p < 0.05$).

Similarly to the results found in this study, by analyzing the effects of stocking densities (1, 2, 4 and 8 fish L^{-1}) of fat snook juveniles in opened salt water circulation systems, Corrêa and Cerqueira (2009) has also found low levels of total ammonia (0.006 ± 0.001), at 25.1 ± 0.90°C, salinity of 35 g L^{-1} and pH of 7.7 ± 0.2. However, in a study performed by Oliveira et al. (2013) with juvenile of the same species in a static system with 80% of water renewal twice a week, when evaluating different feed rates (3 and 6% per day) and temperatures (25 and 28°C), it was observed that at 25°C and 6% of the fish's biomass per day, total ammonia reached 1.29 mg L^{-1}. The authors reported that this was probably due to a lower growth performance of fish in comparison to the other tested treatments. These results indicate that even in low temperatures, one must be careful with accumulated ammonia in the system, seen that when it combines with elevated pH (> 8), it becomes toxic for fish; leading to high mortality rates (Ip & Chew, 2010).

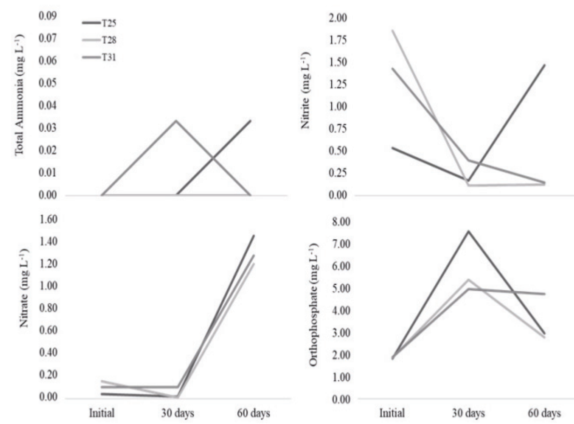

Figure 1. Fluctuation of Total Ammonia (TAN), Nitrite (NO_2), Nitrate (NO_3) and Orthophosphate (PO_4) throughout the experimental period, in cultivations of fat snook at different temperatures in recirculation systems.

Concerning the juveniles' animal performance, survival ranged from 96% (T28) to 100% (T25 and T31), which corroborated with the results reported by Cerqueira and Tsuzuki (2009); thus demonstrating that this species may adapt to different water temperatures, with excellent survival rates.

The growth parameters registered at the end of the experimental period are shown in Table 2. Higher values were obtained for standard length, total length and weight gain ($p < 0.05$) in treatments T28 and T31. With regard to final weight, final biomass, apparent feed conversion and specific growth rate, these variables did not present any significant difference ($p > 0.05$) among the evaluated temperatures.

Bendhack, Peczek, Gonçalves, and Baldan (2013), when evaluating the influence of different temperatures (20, 23, 26 and 29°C) in the growth of fat snook juveniles in a water recirculation system, reared at a density of 0.6 kg m^{-3} and salinity of 30, found a SGR varying from 0.25 to 1.43% day^{-1} and a AFC of 5.83 to 1.74, between the lowest and highest temperatures, respectively. These results demonstrate that the offered rearing conditions ensured that the juveniles presented higher animal performance in all evaluated temperatures, when compared to the aforementioned study. This greater result may be explained by the use of a feed with higher protein level (55%) in relation to the one used by Bendhack et al. (2013) (43.9%), seen that some carnivorous fish such as the fat snook, demand high protein concentrations. The same trend was found by Tsuzuki and Berestinas (2008), who tested commercial feeds (shrimp feed with 45% of CP and freshwater carnivorous fish feed with 40% of CP) and different feeding frequencies (1 or 2 daily feeding events) for fat snook juveniles. As result, the authors obtained a mean SGR of 0.9% day^{-1} in treatments where the fish feed was supplied (40% CP) and 1.25 % day^{-1} when supplying the shrimp feed (45% of CP).

Table 2. Growth parameters (mean ± standard deviation) of fat snook juveniles reared at different temperatures, observed at the end of the experimental period.

	Treatments		
Parameters	T25	T28	T31
FW (g)	23.18±3.45^{a}	25.90±4.79^{a}	25.65±3.89^{a}
TL (cm)	13.91±0.63^{b}	14.43±0.79^{a}	14.45±0.67^{a}
WG (g)	16.64±0.91^{b}	19.48±1.51^{a}	18.93±0.26^{ab}
AFC	1.16±0.04^{a}	1.17±0.03^{a}	1.18±0.03^{a}
SGR (% dia^{-1})	2.18±0.07^{a}	2.28±0.10^{a}	2.29±0.01^{a}

FW = Final Weight; TL = Total Length; WG = Weight Gain; AFC = Apparent Feed Conversion; SGR = Specific Growth Rate. Means followed by different letters in the columns indicate significant differences by the Tukey's test ($p < 0.05$).

Although weight gain of fish exposed to the lowest temperature was inferior ($p < 0.05$) (Table 2), the results indicate an optimal growth of fat snook juveniles at the three tested temperatures, with SGRs above 2% day^{-1}. This is possibly due to three conceivable facts: i) the species' tolerance to different rearing conditions; ii) the nutritional quality of supplied diets; iii) the adopted feeding protocol (frequency and feeding rate). Reported feeding rates based on the supplied feed up to satiety (Table 3), demonstrated that, regardless of temperature, all of them decreased according to the growth of juveniles throughout the experimental period, ranging from 4% of biomass to 2% in 5 weeks (fish of ~ 13g). Thus, this demonstrates that in these experimental conditions, temperature did not influence the quantity of consumed feed in relation to the cultivated biomass, but it did in the stage of fish's growth.

When cultivating fat snook juveniles performance for 40 days in net-tanks, with different feeding rates (1; 1.5; 2 and 2.5% of live weight per day) at 25°C, Barbosa, Neves, and Cerqueira (2011) observed a 100% survival rate in all treatments. The authors recommended the adoption of a feeding rate of 1.7% of the fish's biomass per day, considering fish with approximately 30 g. This rate was similar to what was found in this study, in which a 2% rate was determined regarding live weight per day for juveniles with 21 g, regardless of the adopted temperature. This reinforces that, in such conditions, feeding rate is not directly related to the chosen temperature, and 4 to 2% of the live weight can be used for the evaluated stage, with juveniles of 6 to 22 g.

Table 3. Reported feeding rates for fat snook juveniles reared at different temperatures, determined at the end of the experimental period.

	25ºC		28ºC		31ºC	
Week	Rate (%)	Mean Weight (g)	Rate (%)	Mean Weight (g)	Rate (%)	Mean Weight (g)
1	4	7.06	4	6.95	4	6.92
2	4	8.30	4	8.23	4	8.20
3	4	9.65	4	9.64	4	9.60
4	3	11.23	3	11.29	3	11.25
5	2	13.20	2	13.37	2	13.34
6	2	15.69	2	16.01	2	15.99
7	2	18.43	2	18.96	2	18.94
8	2	21.68	2	22.45	2	22.45

Conclusion

The present study demonstrated that the used temperatures did not negatively affect the zootechnical performance of fat snook juveniles, ensuring great performance rates in any temperature from 25 to 31°C.

Acknowledgements

The authors thank the National Council for Scientific and Technological Development - CNPq (Projects 559777/2009-4 and 559790/2009-0) and the Scientific and Technological Research Support Foundation of Santa Catarina State - FAPESC (Projects 2013TR3406 and 2015TR453). Thanks also to Prof. Dr. Vinícius Ronzani Cerqueira (UFSC) for the donation of juveniles, to Jéssica Brol, Wagner João Vieira and all staff of the LAQ-UDESC by the technical support.

References

Barbosa, M. C., Neves, F. F., & Cerqueira, V. R. (2011). Taxa alimentar no desempenho de juvenis de robalo-peva em tanque-rede. *Acta Scientiarum. Animal Sciences, 33*(4), 369-372. doi: 10.4025/actascianimsci.v33i4.11413

Bendhack, F., Peczek, V., Gonçalves, R., & Baldan, A. P. (2013). Desempenho do robalo□peva em diferentes temperaturas de cultivo. *Pesquisa Agropecuária Brasileira, 48*(8), 1128-1131. doi: 10.1590/S0100-204X2013000800046

Cavalli, R. O., Domingues, E. C., & Hamilton, S. (2011). Desenvolvimento da produção de peixes em mar aberto no Brasil: possibilidades e desafios. *Revista Brasileira de Zootecnia, 40*(Sup.), 155-164.

Cavalli, R. O., & Hamilton, S. (2009). Piscicultura marinha no Brasil com ênfase na produção do beijupirá. *Revista Brasileira de Reprodução Animal, 6*, 64-69.

Cerqueira, V. R., & Tsuzuki, M. Y. (2009). A review of spawning induction, larviculture, and juvenile rearing of the fat snook, *Centropomus parallelus*. *Fish Physiology and Biochemistry, 35*(1), 17-28. doi: 10.1007/s10695-008-9245-y

Colt, J. (2006). Water quality requirements for reuse systems. *Aquacultural Engineering, 34*(3), 143-156. doi: 10.1016/j.aquaeng.2005.08.011

Corrêa, C. F., & Cerqueira, V. R. (2009). Densidade de estocagem para juvenis de robalo-peva após a larvicultura. *Boletim do Instituto da Pesca, 34*(4), 571-576.

Fang, J., Tian, X., & Dong, S. (2010). The influence of water temperature and ration on the growth, body composition and energy budget of tongue sole (*Cynoglossus semilaevis*). *Aquaculture, 299*(1-4), 106-114. doi: 10.1016/j.aquaculture.2009.11.026

Ferraz, E. M., Carvalho, G. C. S., Schafer, A. L. C., Narahara, M. Y., & Cerqueira, V. R. (2011). Influência da temperatura de cultivo sobre crescimento e diferenciação sexual de robalo-peva, *Centropomus parallelus* Poey, 1860. *Revista Brasileira de Engenharia de Pesca, 6*(1), 1-16. doi: 10.1016/j.aquaculture.2009.11.026

Handeland, S. O., Imsland, A. K., & Stefansson, S. O. (2008). The effect of temperature and fish size on growth, feed intake, food conversion efficiency and stomach evacuation rate of Atlantic salmon post-smolts. *Aquaculture, 283*(1-4), 36-42. doi: 10.1016/j.aquaculture.2008.06.042

Ip, A. Y. K., & Chew, S. F. (2010). Ammonia production, excretion, toxicity, and defense in fish: a review. *Frontiers in Physiology, 1*, 134. doi: 10.3389/fphys.2010.00134

Katersky, R. S., & Carter, C. G. (2005). Growth efficiency of juvenile barramundi, *Lates calcarifer*, at high temperatures. *Aquaculture, 250*(3-4), 775-780. doi: 10.1016/j.aquaculture.2005.05.008

Kır, M., Sunar, M. C., & Altındağ, B. C. (2017). Thermal tolerance and preferred temperature range of juvenile meagre acclimated to four temperatures. *Journal of Thermal Biology, 65*, 125-129. doi: 10.1016/j.jtherbio.2017.02.018

Lemos, D., Netto, B., & Germano, A. (2006). Energy budget of juvenile fat snook *Centropomus parallelus* fed live food. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 144*(1), 33-40. doi: 10.1016/j.cbpa.2006.01.028

Liu, S., Chen, H., Xu, X.-R., Hao, Q.-W., Zhao, J.-L., & Ying, G.-G. (2017). Three classes of steroids in typical freshwater aquaculture farms: Comparison to marine aquaculture farms. *Science of the Total Environment, 609*, 942-950. doi: 10.1016/j.scitotenv.2017.07.207

Oliveira, L. A. A. G., Almeida, A. M., Pandolfo, P. S. V., Souza, R. M., Fernandes, L. F. L., & Gomes, L. C. (2013). Crescimento e produtividade de juvenis de robalo□peva a diferentes temperaturas e taxas de alimentação. *Pesquisa Agropecuária Brasileira, 48*(8), 857-862. doi: 10.1590/S0100-204X2013000800007

Person-Le Ruyet, J., Mahe, K., Le Bayon, N., & Le Delliou, H. (2004). Effects of temperature on growth and metabolism in a Mediterranean population of European sea bass, Dicentrarchus labrax. *Aquaculture, 237*(1-4), 269-280. doi: 10.1016/j.aquaculture.2004.04.021

Pinho, S. M., Brol, J., Almeida, E. J. d., Mello, G. L. d., Jerônimo, G. T., & Emerenciano, M. G. C. (2016). Effect of stocking density and vertical substrate addition on growth performance and health status of fat snook *Centropomus parallelus*. *Aquaculture, 457*, 73-78. doi.: 10.1016/j.aquaculture.2016.02.016

Rivas, L. R. (1986). Systematic review of the perciform fishes of the genus *Centropomus*. *American Society of Ichthyologists and Herpetologists, 3*, 579-611. doi: 10.2307/1444940

Scorvo-Filho, J. D., Frascá-Scorvo, C. M. D., Alves, J. M. C., & Souza, F. R. A. (2010). A tilapicultura e seus insumos, relações econômicas. *Revista Brasileira de Zootecnia, 39*(1), 112-118. doi: 10.1590/S1516-35982010001300013

Simon, Y., Levavi-Sivan, B., Cahaner, A., Hulata, G., Antler, A., Rozenfeld, L., & Halachmi, I. (2017). A behavioural sensor for fish stress. *Aquacultural Engineering, 77*, 107-111. doi: 10.1016/j.aquaeng.2017.04.001

Tsuzuki, M. Y., & Berestinas, A. C. (2008). Desempenho de juvenis de robalo-peva *Centropomus parallelus* com diferentes dietas comerciais e freqüências alimentares. *Boletim do Instituto de Pesca, 34*(4), 535-541.

Vikeså, V., Nankervis, L., & Hevrøy, E. M. (2017). Appetite, metabolism and growth regulation in Atlantic salmon (*Salmo salar* L.) exposed to hypoxia at elevated seawater temperature. *Aquaculture Research, 48*(8), 4086-4101. doi: 10.1111/are.13229

Xie, S., Zheng, K., Chen, J., Zhang, Z., Zhu, X., & Yang, Y. (2011). Effect of water temperature on energy budget of Nile tilapia, *Oreochromis niloticus*. *Aquaculture Nutrition, 17*(3), e683-e690. doi: 10.1111/j.1365-2095.2010.00827.x

Received on September 29, 2017.
Accepted on November 14, 2017.