Physiological performance of osmotic work, survival, and growth rate of hybridized brackish Nile tilapia (*Oreochromis niloticus*) juveniles at various salinities

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Abstract. Hybridized Nile tilapia (*Oreochromis niloticus*) in brackish water is the result of a cross hybridization between GIFT (Genetic Improvement of Formed Tilapias) and *O. mossambicus*. The study aimed to assess the physiological performance of hybridized Nile tilapia in brackish water. Various salinities tested in this study were 0, 10, 16, 22, 28, and 34 ppt. The results showed that salinity had a significant effect ($p<0.01$) on osmotic work rate, survival, and growth rate of fish seeds. The minimum osmotic work rate, best survival and growth rate were obtained at a salinity of 16 ppt, whereas the maximum osmotic work rate and the lowest growth rate were obtained at a salinity of 34 ppt.
Key Words: adaptable, brackish Nile, cultivation, environmental factor, fish energy funding.

Introduction. Hybridized Nile tilapia is one type of fish that has more advantages compared with other fish. This fish is the result of a cross hybridization between GIFT male tilapia and female mujair. This fish is able to live with a wide salinity tolerance from brackish water to seawater, adaptable to the low oxygen, fast growth rate, and much in demand by consumers.

Development of Nile tilapia seed in brackish water has a main problem, namely the low survival of the fish sized 1-2 cm, in which it is still lower than the result of Nile tilapia seeding in freshwater. The salinity is an environmental factor that influences the survival of the fish (Cnaani et al 2011; Basuki & Rejeki 2014). Several studies of the salinity influence on *Oreochromis niloticus* have been conducted. Suresh & Kwei (1992), Pongthana et al (2010), El-Dahhar et al (2011), Iqbal et al (2012), Küçük et al (2013) and Moorman et al (2014) reported that salinity affects the survival and growth of several types of Nile tilapia (e.g. *Oreochromis aureus* and *O. mossambicus*).

The maintenance environment is an important external factor that affects stress and mortality of fish (Tahya 2016; Tahya et al 2016; Nursidi et al 2017). One of the environmental factors associated with cultivation of *O. niloticus* in brackish water is the optimum salinity. In this study, physiological performance of osmotic work rate, survival, and growth rate were evaluated from brackish *O. niloticus* maintained at various salinities.

Material and Method. This research was conducted at the Hall of Brackish Water Aquaculture of Takalar, South Sulawesi Province, Indonesia. The experimental animal was brackish *O. niloticus* aged 3 days with an average weight of 0.020 g, a hybridization result between GIFT (Genetic Improvement of Formed Tilapias) and *O. mossambicus*. The fish was maintained for 22 days with a density of 75 individuals/container.

The media used were seawater with a salinity of 34 ppt and freshwater that obtained around the study site. Dilution was carried out to obtain the salinity accorded to the treatment. Replacement of water was performed once a week as much as 35% of total water volume.

The feed used was natural feed in the form of S-type rotifer sized 140-200 μm and artificial feed. The artificial feed was in the form of Hi-provit powder with protein content of 30-32%. The rotifer was administered from day 1-5 with a density of 25 individuals/mL, furthermore, day 5-10 was given combination between rotifer and artificial feed, and for day 11 until the end of the study was given 100% artificial feed. The frequency of feeding was performed 3 times/day that was at 08:00, 12:00, and 15:00.

The study was designed using a complete randomized design consisting of 6 salinity treatments (0, 10, 16, 22, 28, and 34) with 3 replications for each treatment.

Parameters observed were osmotic work rate (TKO), survival rate, and daily growth rate of fish seed. The osmotic work rate is measured by the difference between the media and the plasma osmolarity. Media and plasma osmolarity was measured using an osmometer. The osmotic work rate of fish seed was calculated using the formula:

$$TKO = (O_m - O_p)$$

Where:
TKO = Osmotic work rate (mOsm/L H_2O),
O_m = Media osmolarity (mOsm/L H_2O),
O_p = Seed osmolarity (mOsm/L H_2O).

Survival rate (SR) is calculated using the formula: $SR = (N_t/N_o) \times 100$

Where:
SR = Survival of fish seed tested (%),
N_o = Number of live seeds at the beginning of the experiment (tail),
N_t = Number of live seeds at the end of the experiment (tail).

Specific growth rate of fish weight per day is calculated using the formula:

$$SGR = (\ln W_t - \ln W_o)^{-t} \times 100$$

Where:
SGR = Specific growth rate of fish weight per day (%/day),
W_o = average weight of fish seed at the beginning of experiment (g),
W_t = average weight of fish seed at the end of experiment (g),
t = duration of maintenance (day).

Result and Discussion

Osmotic work rate. Variance analysis showed that salinity had a significant ($p<0.01$) effect on osmotic work rate of hybrid fish seeds. The highest osmotic work rate was obtained at a salinity of 34 ppt, while the lowest was at 16 ppt. The osmotic work rate describes the activity of the concentration of dissolved ions such as Sodium (Na+), Potassium (K+), Calcium (Ca2+), Chloride (Cl-), Sulfate (SO42- and bicarbonate (HCO3-) (Effendy 2003). Thus, the greater is the number of ions concentrated in the water, the higher is the salinity and concentration of the solution osmolarity, so that the osmotic pressure of the media will increase. If the salinity condition is not optimal, this will lead to stress resulting in the use of large energy (Romano & Zeng 2006).

The ability of fish seed to adapt through physiological arrangements was indicated by low osmotic work rate at a salinity of 16 ppt. This is in line with the result obtained by Pamungkas (2012). While at salinity of 34 ppt, it produced a high osmotic work rate as an effort of fish to reach homeostasis in the body to the limit of salinity tolerance. Differences in osmotic pressure correlate with energy requirements, which affect the growth of fish and can be seen primarily from the feed consumption during the experiment.

There are still many species that are potential to be marketed and cultivated, however, the knowledge of ecobiology on those species is still limited (Mylonas et al 2010), so that the way of maintenance that produces maximum result is difficult to achieve, such us the influence of the external environment on energy for adaptation, growth, and reproduction. Energy funding is also lacking for growth as a result of insufficient energy funding which results in inhibition of growth process. According to Lantu (2010), at salinity of 0 ppt, fish seeds are in hyper-osmotic condition so that fish attempt to adapt by maintaining themselves so that salt does not dissolve and pass into the water. The salts from the environment will be absorbed by the fish using its metabolic energy. The fish maintains its osmosis by regulating water content between its organism and the environment, covering its skin with mucus, performing osmosis through the gills, secreting urine, and pumping salt through special cells in the gills. Meanwhile, at the salinity of 35 ppt, fish is in hypo-osmotic condition so that the fish tries to adapt by using the kidney and its ion pump to remove the excess salt.

The relationship between the salinity and the osmotic work rate of hybrid *O. niloticus* shows a quadratic pattern with the equation $Y = 383.86 – 37.616x + 1.1764x^2$ and $R^2 = 0.97$ as presented in Figure 1. Based on the equation, it can be predicted that the optimum salinity yields minimum osmotic work rate of 15.98 ppt.

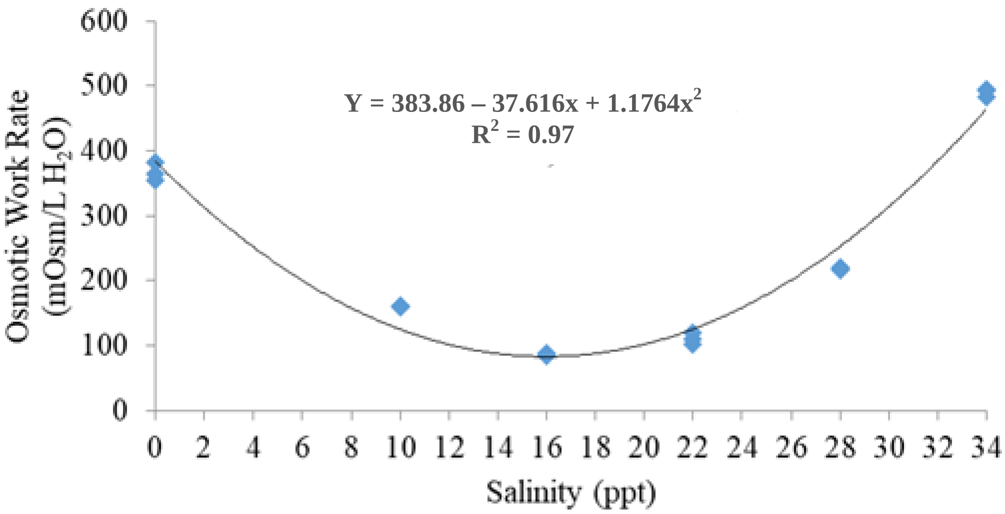

Figure 1. Relationship between salinity and osmotic work rate of *Oreochromis niloticus* juvenile.

Survival rate. Variance analysis showed that salinity had a significant effect ($p<0.01$) on the survival of hybridized fish juvenile. The highest survival was obtained at salinities of 16 and 22 ppt, while the lowest survival was at salinities of 0, 28, and 34 ppt. The high survival at salinities of 16 and 22 ppt was due to appropriate maintenance conditions (salinity) and feed adequacy which support the survival optimally. Salinity is one of the environmental factors that affect the survival rate (Ntabo 2012; Iqbal et al 2012; Kucuk et al 2013).

Salinities of 16 and 22 ppt resulted in high survival because the fish seed was able to adapt to the environmental condition. The perfect adaptability causes the energy reserve can be maintained and lead to the higher survival of the fish. Meanwhile, the low survival at salinity of 0 ppt due to the seed maintained in brackish water at salinity of 10 ppt allowed the seed facing stress when it adapted back to the salinity of 0 ppt. Furthermore, low survival at salinities of 28 and 34 ppt due to high osmotic work, in which it could increase stress and led to death. The survival rate obtained in this study ranged from 48.00 to 88.90%. Nugon (2003) examined four varieties of *O. niloticus* juveniles (*O. aureus*, *Oreochromis* sp., and *O. niloticus*), the results showed that the best survival of the fish at salinity of 20 ppt ranged from 70-100%. El-Zaeem et al (2010) obtained survival of *O. aureus* at salinity of 20 ppt of 96.24% and 54.99% at salinity of

32 ppt, while Basuki & Rejeki (2014) obtained survival of *O. niloticus* F5 at salinity of 15 ppt of 81.67%.

The relationship between the salinity and the survival of hybrid fish seed shows a quadratic pattern with the equation $Y = 45.295 + 3.9392x - 0.1148x^2$ and $R^2 = 0.76$ as presented in Figure 2. Based on the equation, it can be predicted the optimum salinity of hybrid fish seed was approximately 17.16 ppt.

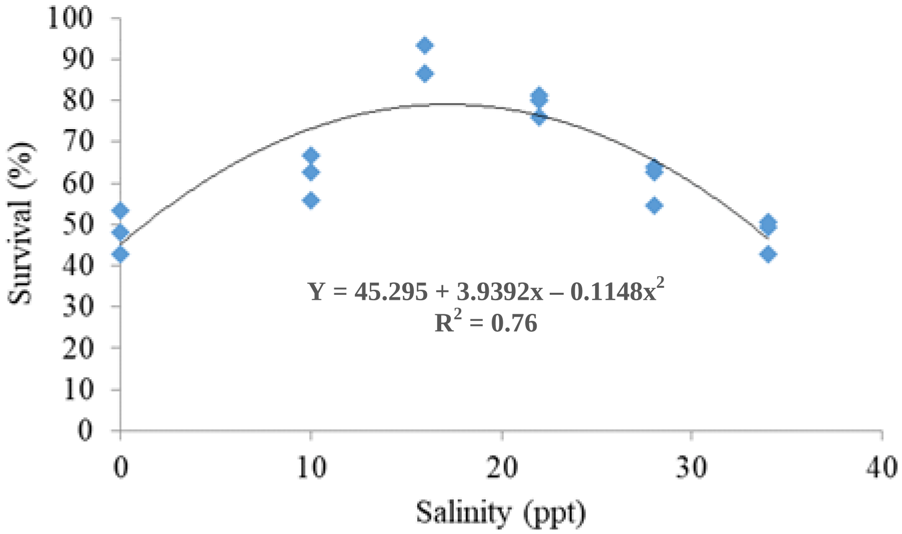

Figure 2. The relationship curve between salinity and survival hybridized *Oreochromis niloticus* juvenile.

Growth rate. The best growth rate was generated at salinities of 16 and 22 ppt and the lowest growth was at salinities of 0 and 34 ppt. This may be caused by the osmolarity load of *O. niloticus* at salinity of 16 and 22 ppt approaching an isoosmotic state which results in a minimum osmotic work rate. Thus at those salinity levels, the use of energy for osmoregulation is low so that the energy portion for growth is higher. The growth of hybridized *O. niloticus* juveniles is basically dependent on the energy availability, how the energy is used in the body and theoretically growth can only occur when the minimum needs are met. The brackish tilapia seeds obtain energy through feed consumption and the energy is used for a variety of activities including osmoregulation process. A low osmotic load reduces the workload of Na+-K+ ATPase as well as the active transport of Na+-K+ and Cl-, consequently, the Adenosine Triphosphat (ATP) used for osmoregulation decrease so that energy is available for growth. Energy availability for metabolism and growth is also influenced by environmental factors such as salinity (Karim et al 2016; Karim 2008).

The low specific growth rate of hybridized *O. niloticus* seeds at salinities of 0 and 34 ppt may be caused by the high osmotic work rate of the fish seed, thus energy use for osmoregulation is also high and reduces the energy reserves for growth. The high specific growth rate of seed weight was obtained at salinity of 16 ppt. This result is different compared to the results obtained by El-Dahhar (2011), which found that the best growth rate was at salinity of 5 ppt. In juveniles of red tilapia, it was found the best growth rate at salinity of 52 ppt and temperature of 24°C (Hassanen et al 2014).

The relationship between salinity and growth of hybridized *O. niloticus* seed in brackish water shows a quadratic pattern with the equation $Y = 17.903 + 0.1096x - 0.0032x^2$ and $R^2 = 0.73$ as presented in Figure 3. Based on the equation, it can be predicted that the optimum salinity for the survival of the fish is 17.12 ppt.

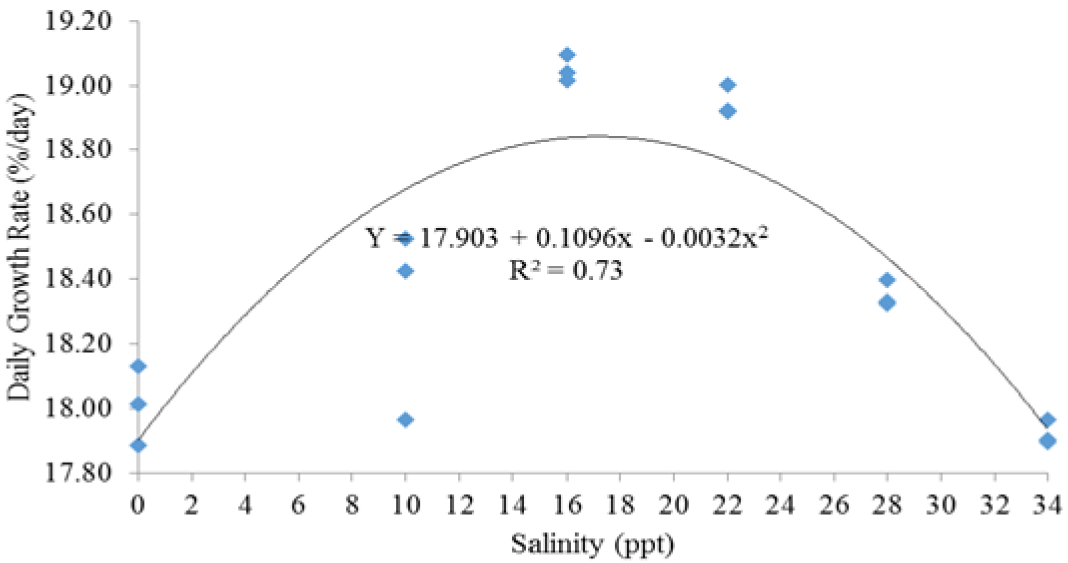

Figure 3. The relationship curve between salinity and daily growth rate of hybridized *Oreochromis niloticus* juvenile.

Conclusions. The minimum osmotic work rate, the best survival, and daily growth rate are obtained at a salinity of 16 ppt, whereas the maximum osmotic work rate, the lowest survival and daily growth rate are obtained at a salinity of 34 ppt.

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