Increasing productivity of snakehead fish (*Channa striata*) juvenile in ponds with different bottom substrates

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**Abstract.** Low production of striped snakehead juvenile in ponds is due to the difference between pond and their natural habitat. Bottom substrate might probably a factor influencing the growth performance of striped snakehead juvenile. The purpose of this research was to determine the best bottom substrate to increase growth performance of striped snakehead juvenile reared in ponds. A randomized design consisted of three treatments of bottom substrates, sand, mud, no substrate as control, with three replications were used in the present study. Striped snakehead juvenile sized 6.1±0.05 cm and 2.11±0.07 g were in a 3 × 2 × 1 m plastic line pond, with 30 cm depth water. The density of fish were 20 fish per m³ and juveniles reared for 60 days. The result showed that juvenile reared with sand substrate had better survival rate and blood glucose (P<0.05) than other treatments. The substrate treatments, sand and mud, were also better in absolute length, absolute weight, specific growth rate, than no substrate one (control). In contrast, control was better than substrates treatments (sand and mud) in feed efficiency. Overall data indicated that sand substrate is a supporting environment for growing out juvenile of snakehead fish.

**Key words:** *Channa striata*, substrate, juvenile, productivity, growth

**1. Introduction**
Striped snakehead fish (*Channa striata*) is one of the specific local fishes of Indonesian waters [1]. Their habitat is in swamps, rice fields, and watersheds with slow currents and mud emulsions spread throughout Indonesia, especially in Sumatra, Java, and Kalimantan, has high economic value. Striped snakehead has a high protein content that is equal to 25.2% and contains albumin that does not appear in other fish [2]. Striped snakehead has an albumin content of 62.24 g per kg or 6.22% [3]. Albumin is an essential for the human body, especially in the formation of new tissues, post operation healing, and helping the growth of children [4]. The discovery of striped snakehead fish albumin extract is then used as an alternative to get cheaper albumin [5]. Thus, striped snakehead fish has a high demand increasing year by year [1].
Culture of snakehead technology is still not complete yet. One of crucial stage is the juvenile phase. In the natural habitat, striped snakehead fish are generally found in shallow waters with muddy, rocky or sandy waters and lot of plant or tree roots. The substrate is much used to protect young snakehead fish from predators or cannibalism among them. Under research condition on mud crab seed, different substrates influenced growth and survival rate due to the substrate enabled to reduce cannibalism [6]. Similar case could also exist in snakehead fish. In the present study, effect of sand and mud as bottom substrates in the rearing of juvenile were observed to improve the productivity of the fish studied.

2. Material and methods
A randomized design consisted of three treatments of bottom substrates, sand, mud, and no substrate as control with three replications were used in the present study.

2.1. Pond and substrate preparation
Nine earthen ponds \((3 \times 2 \times 1 \text{ m})\) were used. The inside part of ponds was covered with plastic line-in, and dried for one day. The pond was filled up to 30 cm water depth. PVC pipe equipped with net was used at the outlet in pond to control the water level. Bottom substrate with a height of 5 cm arranged at pond base in method by Djunaidah et al. [7] for each treatment.

2.2. Fish preparation and rearing
Fish juvenile was obtained from spawning activities. Juvenile with a length of \(6.1 \pm 0.05\) cm and a weight of \(2.1 \pm 0.07\) grams were used in this study. Stocking density 20 fish per \(m^3\) were acclimatized for 10 days before use, in order to had suitable media. The juveniles were then reared during 60 days. Commercial fish feed with a protein content of 35% was given. Restricted feeding method was used with a feeding rate of 5% of fish biomass in each pond. Feeding time carried out four times a day: in the morning (08:00), afternoon (12:00), evening (16:00), and night (20:00).

2.3. Estimation of survival, growth rate, feed efficiency, and blood glucose
Fish sampling was conducted every 10 days during the test period. The number of samples was five fish for each pond. Parameters observed during the test period were total length, total weight, and survival rate. The total length of fish was measured using plotting paper with a level of accuracy of 0.1 cm while the weight of the fish was measured using a digital scale with a level of accuracy of 0.1 g. Blood glucose tested at the end of study and measured using the glucose digital kit.

The growth performance in length and weight, specific growth rate (SGR) and feed efficiency was estimated. Absolute length and absolute weight growth were calculated simply by deducting the mean initial length and weight values from that of the final. SGR calculated as the percentage increase in body weight each day over any given time interval [8]. Survival rate calculated as the percentage of number fish at the end of experiment divided with the initial stock. Calculation of feed efficiency is based on the ratio between the weight gain of fish obtained by the amount of feed consumed. Feed efficiency (\(\%\)) = ((biomass fish at the end + biomass dead fish) -biomass fish at the beginning) \(\text{in g/ Feed consumed x 100}\)).

2.4. Water quality
Water quality was monitored every 10 days during the study. Parameters observed were dissolved oxygen (DO) and temperature using a DO meter, pH, and nitrate using a digital kit.

2.5. Data analysis
Data obtained for parameters of absolute length, absolute weight, specific growth rate, survival rate, feed efficiency, and blood glucose were statistically analysed using the variance method (ANOVA) with 95% confidential differences. Water quality parameters data were analysed descriptively to explore its correlation with the biological data.
3. Results
Calculation of absolute length, absolute weight, specific growth rate, survival rate, feed efficiency, and blood glucose during the test are presented in Table 1.

Table 1. Growth of absolute length and weight, specific growth, survival rate, feed efficiency, and blood glucose of striped snakehead juvenile reared with different bottom substrate

| Parameters                       | Sand     | Mud      | Non (control) |
|----------------------------------|----------|----------|---------------|
| Absolute length (cm)             | 5.14±0.50b | 5.05±0.36b | 4.28±0.16a    |
| Absolute weight (g)              | 6.17±0.27b | 6.01±0.42b | 5.14±0.07a    |
| Specific growth rate (%)         | 2.30±0.06b | 2.27±0.09b | 2.08±0.02a    |
| Survival rate (%)                | 81.33±5.77b | 70.33±2.52a | 68.00±5.00a   |
| Feed efficiency (%)              | 42.23±2.08b | 40.94±0.78b | 38.12±1.68a   |
| Blood glucose (mg dL⁻¹)          | 33.88±1.41a | 41.00±2.83b | 40.67±3.05b   |

Remark: Different superscript letters on the same line show significantly different statistic results at 95% confidence intervals.

The ANOVA showed that the growth of absolute length, absolute weight, and specific growth rate were significantly different (P < 0.05) than no substrate one (control). The absolute length of the sand substrate (5.14 ± 0.50 cm) and mud (5.05 ± 0.36 cm) significantly different from the control (4.28 ± 0.16 cm). Figure 1 showed the growth on total length.

![Figure 1. Growth of the total length of striped snakehead fish juvenile kept in pond with different bottom substrates reared for 60 days](image-url)
The absolute weight of the sand substrate (6.17 ± 0.27 g) and mud (6.01 ± 0.42 g) were significantly different than control (5.14 ± 0.07 g). The growth of body weight on Figure 2.

![Figure 2](image)

**Figure 2.** Growth of the body weight of striped snakehead fish juvenile kept in pond with different bottom substrates reared for 60 days.

Specific growth rates between sand (2.30 ± 0.06%) and mud (2.27 ± 0.09%) substrate are significantly different (P <0.05) than control (2.08 ± 0.02%).

The juvenile reared with sand substrate had better survival rate and significantly different results (P <0.05) than no substrate. Striped snakehead fish juvenile in sand substrate has the best survival rate (81.33 ± 5.77%) then mud substrate (70.33 ± 2.52%) and no substrate (68.00 ± 5.00%).

Juvenile in control was better on feed efficiency than other substrates (sand and mud). Feed efficiency of no substrate (38.12 ± 1.68%) is significantly different than sand substrate (42.23 ± 2.08%) and mud substrate (40.94 ± 0.78%).

The juvenile reared with sand substrate had better blood glucose (P<0.05) than other treatments. Blood glucose on the sand substrate (33.88 ± 1.41 mg dL⁻¹) were significantly different with mud treatment (41.00 ± 2.83 mg dL⁻¹) and control (40.67 ± 3.05 mg dL⁻¹)

The measured water quality parameters consisting of dissolved oxygen (DO), temperature, pH, and nitrate are presented in Table 2. Based on these data, the range values for all water quality parameters are optimum or tolerant for physiological striped snakehead fish.

**Table 2.** Dissolved oxygen (DO), temperature, pH, and nitrate of striped snakehead fish pond with different bottom substrates

| Parameters     | Sand          | Mud           | Non (control) | Optimum values |
|----------------|---------------|---------------|---------------|----------------|
| DO (mg L⁻¹)    | 4.9-7.7       | 2.5-6.8       | 6.3-9.1       | >0.2 (a)       |
| Temperature (°C)| 28.5-30.7    | 28.1-29.6     | 29.1-30.3     | 27.8 – 32.5 (a)|
| pH             | 7.7-8.1       | 7.5-8.4       | 7.6-8.8       | 4.25–9.4 (b)   |
| Nitrate (mg L⁻¹)| 0.4-1.6      | 0.3-1.1       | 0.4-1.5       | 0.2–10 (c)     |

*Remark: a: Astria [9]; b: Courtenay and Williams [10]; c: Boyd [11].*
4. Discussion
The substrate material at the bottom of the water usually depends on the sedimentation process and formed by materials exist surrounding the area studied. The texture of bottom substrate made from various materials such as the clay, mud, and sand expressed in percentage. Texture plays an important role in determining the physical properties of the soil due to the organic material and minerals sizes exist of clay, mud, and sand.

Striped snakehead fish in nature are generally found in waters with muddy bottoms at the river sides, lakes, dams, swamps, and even rice fields. High survival rate means that the treatment could imitate the natural habitat of fish studied [12]. Survival rate achieved by a population is a picture of the interaction of the carrying capacity of the environment with the physiological response of the existing population [13]. In the present study, sand bottom substrate was able to support the juvenile of snakehead survive.

In general, growth has tight correlation with environment. The existence of a bottom substrate provided better environment in present study. Previous study [14] described that on optimal environmental conditions, the allocation of energy used in standard metabolic processes (osmoregulation) will become minimum as big portion of energy will be allocated for growth e.g. absolute and specific growth [15].

Feed efficiency will run optimally if the environmental conditions are in normal conditions so that the digestion process in fish will be more efficient [16]. The result of the present study is congruent with statement mentioned above as represented by the sand bottom substrate. High feed efficiency values indicate the feed given is able to be optimally converted for growth [17] and reducing cannibalism [18].

Water quality such as dissolved oxygen, temperature, pH, and nitrate in all treatments are in the optimum range and tolerance range [9]. In other word, the result obtained in the present study is mainly due to the treatments given. Three different bottom substrates clearly indicate the positive effect.

5. Conclusion
The results showed that sand substrate had better survival rate and blood glucose on snakehead (Channa striata) juvenile fish reared. The substrate treatments, sand and mud, were also better in growth performance such as absolute length, absolute weight, specific growth rate, than no substrate one (control). In contrast, control was better in feed efficiency than sand and mud substrates. Overall data indicated that sand substrate provided better environment and supporting for growing out the juvenile of snakehead fish. It is recommended to use bottom substrate in increasing productivity of juvenile of snakehead fish.

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