# Albumin level, growth and survival rate of snakehead fish (*Channa striata*) from three islands of Indonesia

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**Abstract**. Albumin is a functional protein that is highly beneficial for human health, especially for healing. It accelerates post-surgery recovery. The purpose of this study was to evaluate the albumin content and productivity of three Indonesian snakehead fish (SHF) populations, namely Sumatera (SM), East Java (JV) and South Kalimantan (KL) populations. The SHF of SM, JV and KL populations (28.9±5.7 mm total length; 0.27±0.09 g body weight) were reared in 25 $m^2$ concrete cement ponds for 75 days. The fish were randomly plotted in 12 ponds (3 populations, 4 replications). The albumin content was analyzed from the meat and blood of the SHF. The SHF albumin content from the three populations was not significantly different (P>0.05). The values were 2.6±0.4 g $dL^{-1}$, 2.4±0.3 g $dL^{-1}$ and 2.2±0.4 g $dL^{-1}$ for KL, SM and JV, respectively. The correlation level of blood albumin to meat albumin was low (r=0.10). The survival rate of SHF from SM (0.84±0.04%) was higher (P<0.05) than the one from JV (0.42±0.27%) and KL (0.31±0.11%). The total biomass of fish from SM (398.7±84.5 g) was not different from the one from JV (293.8±262.5 g) and KL (164.5±51.2 g). The results suggest that albumin content was not affected by the SHF population source. The biomass production of the three SHF populations was not different. Blood albumin content was not an appropriate detector to predict meat albumin of SFH regarding the selection of parent candidates related to the breeding program.
**Key Words**: albumin, Indonesia, productivity, protein, snakehead.

**Introduction**. Fish from fisheries or aquaculture are healthy food for people, considering their protein and fat contents and some important nutrients, such as omega 3 fatty acids (Gjedrem 2017). The snakehead fish (SHF) (*Channa striata*), with the Indonesian names "ikan gabus" and "haruan", is an important protein source in the inland aquaculture sector of many tropical and subtropical countries, including Indonesia. The SHF is a useful source of proteins (78.32±0.23%), lipids (2.08±0.08%) and vitamin A (0.265±0.013 mg). It presents a high content of arachidonic acid (AA) 20:4ω6, docosahexaenoic acid (DHA) 22:6ω3 and albumin (Rahman et al 2018). SHF is a reputed medicinal freshwater fish among the South Asian region and used to treat wounds, alleviate pain and boost energy. It is endowed with remarkable anti-inflammatory, anti-nociceptive, platelet aggregation, as well as mild antimicrobial and antifungal properties. Its nutraceutical value is outstanding and contributes, at least in part, with its bioactive compounds, to clinical trials, therapeutics and nutritional supplements (Siswanto et al 2016; Rahman et al 2018). Therefore, SHF has a high potential to be used as a source of nutrients for the treatment of serious diseases, as well as for the improvement of general body tonus of humans (Courtenay & Williams 2004). Related to the medical function, albumin is a major functional protein of the SHF.

Albumin serum in fish plays an important role in the metabolic transportation of fatty acids, hormones, bilirubin and others (Baker 2002; Andreeva 2011; Kovyrshina & Rudneva 2012). It plays a role in osmoregulation (Zhang et al 2005). Today, albumin based nutraceutical products from the SHF have been developed in Indonesia and Malaysia due to its properties that improve the health status of hospitalized patients suffering from hypoalbuminemia and post-surgical tissue damage. Therefore, the demands for *C. striatus* in Indonesia and in the Asian market have been increasing day by day. It is also commonly used by caesarean mothers (Mustafa et al 2012; Rahman et al 2018).

The high economic value of the SHF albumin encouraged a number of Indonesian researchers to study several aquaculture aspects of the fish, including biology (Asikin & Kusumaningrum 2018), nutrition (Kusumaningrum et al 2014; Permadi et al 2017), and environment (Fuadi et al 2017; Purnamawati et al 2018). Furthermore, the albumin contents of the SHF from several populations were reported by Chasanah et al (2015) and Susilowati et al (2015). They observed the variation of the SHF albumin content from different populations (West Java and East Java) and between wild and domestic (pond) populations. Based on this information, it is possible to improve the production of the SHF albumin by selection, using a SHF strain that contains higher albumin levels. Indonesia has native SHF populations, consisting of Sumatera, Java and Kalimantan populations (Courtenay & Williams 2004). These populations show high potency for the development of superior SHF strains for albumin levels.

Quality traits and carcass composition in fish and shellfish are important characters that intensively improved through selection programs (Gjedrem et al 2012; Gjedrem 2017). The improvement is possible because the traits are heritable and individuals carrying the desirable traits can be selected as the parents of the next generation (Gjedrem 1983). However, some difficulties are present in measuring the quality traits in the potential breeders without killing the selected fish. For this purpose, a predictor for meat quality had been developed (Gjerde & Martens 1987; Sang et al 2009).

Based on this information, this study was conducted to evaluate the albumin content and productivity of three Indonesian SHF populations, and to determine the possibility of using blood albumin as a predictor to determine the albumin of SHF meat. The study aims to evaluate the albumin level of the SHF from the different populations reared in similar culture conditions, being one of the first studies on this matter in Indonesia.

## Material and Method

***Experimental location and fish***. The present study was conducted from May to December 2018, at the Research Institute for Fish Breeding, Subang, West Java, Indonesia. The albumin levels of SHF were analyzed in the Laboratory of Preservation and Processing of Aquatic Products, Bogor Agriculture University, West Java. The SHF breeders were collected from South Lampung, Sumatera, Lumajang, East Java and Mandiangin, South Kalimantan (Figure 1). The SHF from JV and KL were selected from a domesticated strain, while the SHF from SM resulted from culture pond using wild juveniles.

***Juvenile production***. The mating of SHF was conducted in concrete tanks (2x2x1 m). The sex ratio was 1:1. The mature females and healthy aggressive males of SHF from SM, JV and KL populations were chosen and mated to produce SHF larvae. The SHF eggs were observed every morning. The eggs from each mating tank were collected using a scoop net and released in incubation tanks containing 30 L of aerated freshwater. The thermostat heater was set on 29$^{o}$C in the egg incubation tank. The SHF larvae were reared for 30 days in the plastic container with an initial density of 30 larvae/L. The 2-day-old larvae were fed tubifex worms for 7 days, continuing with artificial feed with 38% crude protein, until 30 days of age.

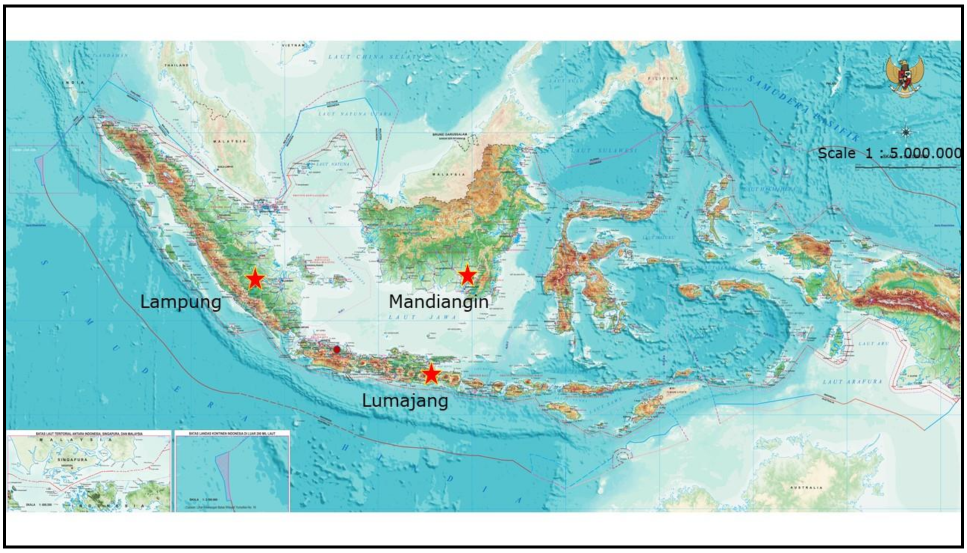


Figure 1. The origin of the three SHF populations in Indonesia (source: http://www.big.go.id).

***SHF outgrowing***. Further rearing of the SHF was conducted to prepare SHF adults for the albumin content test and the evaluation of production potency of the three populations. The SHF (28.9±5.7 mm total length; 0.27±0.09 g of body weight) from 12 pairs, 4 pairs for each population were used in this study. The juveniles were distributed in 4 concrete ponds per population (5x5x0.5 m), at a stocking density of 1 fish/m$^2$ (25 fishes/pond) and reared for 75 days. The ponds were assigned randomly for each population. The edge of the pond was covered by a net to prevent the fish from jumping out. The fish were fed three times a day at 08.00, 12.00 and 16.00, using commercial floating fish feed (38% crude protein), at a daily level of 5% of the biomass. At the end of the experiment, the survivors in each experimental pond were weighed and counted to evaluate their specific growth rate (SGR), survival rate, feed conversion ratio (FCR) and the final production (total weight of harvested fish). These parameters were determined according to the formulas described by Ponce-Palafoxa et al (2015).

$$\mathbf{SGR} = \frac{\ln \mathbf{Wt} - \ln \mathbf{W0}}{\mathbf{t}}\ x\ \mathbf{100}$$

Where:
SGR = specific growth rate (% day$^{-1}$);
Wt = the mean body weight of the fish at the end of the study;
W0 = the mean body weight of the fish at the beginning of the study.

$$\mathbf{SR} = \frac{\mathbf{Nt}}{\mathbf{N0}}\ \mathbf{x}\ \mathbf{100}$$

Where:
SR = survival rate (%);
Nt = the number of the fish at the end of the study;
N0 = the number of the fish at the beginning of the study.

$$\mathbf{FCR} = \frac{\mathbf{F}}{\mathbf{Wt} - \mathbf{W0}}\ \mathbf{x}\ \mathbf{100}$$

Where:
FCR = feed convertion ratio (%);
F = feed intake;
Wt = the biomass of the fish at the end of the study;
W0 = the biomass of the fish at the beginning of the study.

***Albumin content analysis***. The albumin content was analyzed according to the method described by Doumas et al (1971). Albumin content was measured from the flesh and blood serum of the SHF. The albumin content test of the SHF flesh (FA) was conducted to determine the variance coefficient and to compare the albumin level among the three SHF populations. Meanwhile, the albumin content test of SHF blood (BA) was conducted to determine the correlation level between the FA and BA of SHF. For the FA test, the harvested SHF were killed by direct storing into an icebox (±4°C) for 60 minutes. Boneless meat of SHF was taken from 20 fish for each SHF population. Each sample was separately stored in a small plastic bag at -20°C. The correlation test between FA and BA used 20 SHF from the JV population, which had a body weight of 40.45±13.6 g and a total length of 156.4±63.2 mm. For the BA test, 0.3 mL of blood was collected from the SHF using a 26-G needle and a 1 mL syringe, placed into a microtube and centrifuged in 6000 rpm, for 15 minutes. After the SHF blood sampling, the 20 fish were killed for flesh sampling. The serum (top layer) was collected, placed into a clean microtube and stored in -20°C. Bromocresol Green (BCG) and albumin standard solution (prepared from Bovine Serum Albumin, BSA) were used as a reagent for albumin analysis. The tests for albumin content were performed by measuring the absorbance in the sample at 578 nm wave length. A total of 2.5 mL of BCG reagent 0.01% was added to 0.5 mL albumin extract and left for 10-15 minutes. The absorption level of the mixture was measured at 578 nm wave length.

***Water quality***. Water quality parameters, including temperature, pH and dissolved oxygen (DO) concentration, were measured using a water quality checker (WQC 22A TOA OK), whereas total ammonium nitrogen (TAN) and nitrite were measured using the standard procedures described in APHA (1998).

***Statistical analysis***. Data were presented as the mean standard deviation of replicate measurements. All survival data were arcsine transformed. The normality and homogeneity of the variance were determined using Sapiro Wilk and Levene tests, respectively. Statistical analyses were carried out using the statistical software SPSS 16.0. The differences between treatments were determined using one-way ANOVA, followed by Duncan's multiple test. The correlation of albumin in the blood (BA) and albumin in the flesh (FA) was analyzed using the Spearman Correlation test. All statistical analyses were considered significant at 95% (P<0.05).

**Results and Discussion**. The main information presented in this study are the albumin content and the productivity potency of the SHF from Sumatra, Java and Kalimantan, Indonesia.

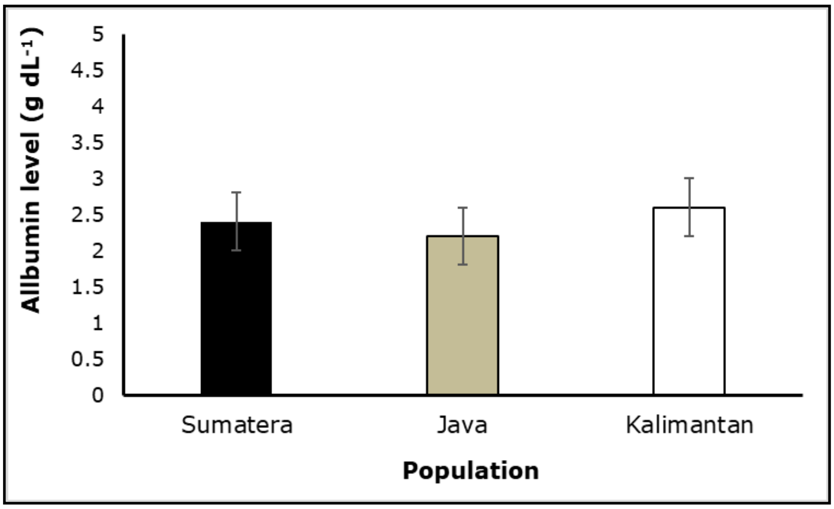


Figure 2. Albumin content of snake head fish (*Channa striata*) from Sumatera, Java and Kalimantan populations.

***Albumin content of SHF meat and blood***. The albumin contents of the SHF from Sumatera (2.6±0.4 g $dL^{-1}$), Java (2.4±0.3 g $dL^{-1}$) and Kalimantan (2.2±0.4 g $dL^{-1}$) populations were not significantly different ($P>0.05$) (Figure 2).

Albumin is a compound of the SHF with a high economic value, because it has several benefits for human health. Result from this study indicated that the albumin content of the three populations of SHF were not significantly different. Previous studies showed the differences in the albumin content of *C. striata* from different regions. The albumin content of *C. striata* from West Java was higher (107.28±3.19 mg/g) than the albumin level of the SHF from East Java (91.10±24.08 mg/g) and from Central Java (75.79±9.33 mg/g) (Susilowati et al 2015; Chasanah et al 2015). Furthermore, Fuadi et al (2017) reported that the albumin content of the SHF (4.1±0.96 mg/g) from Lamongan district (brackish water area) was significantly higher than the albumin content of the SHF (2.9±0.87 mg/g) from Lumajang district (freshwater area). The different results may be caused by the different research design used. In the current study, the albumin concentration was analyzed from SHF reared in similar conditions, both environmental and nutritional aspects being similar during the grow-out phase. Meanwhile, the previous study used SHF from different locations, with different nutrition and environment. It is probable that the variance of the albumin content in the SHF is mainly affected by the environment, rather than by genetic sources. The variation of the albumin concentration depends on several factors, including fish species, size, diet consumption rate, dietary availability and digestibility rate (Asikin & Kusumaningrum 2018; Hariati et al 2019).

The test of albumin content was also conducted on fish blood to determine the correlation value between albumin in the blood and albumin in the meat of the SHF. The correlation level (r) of these parameters was low, r=0.10 (Figure 3).

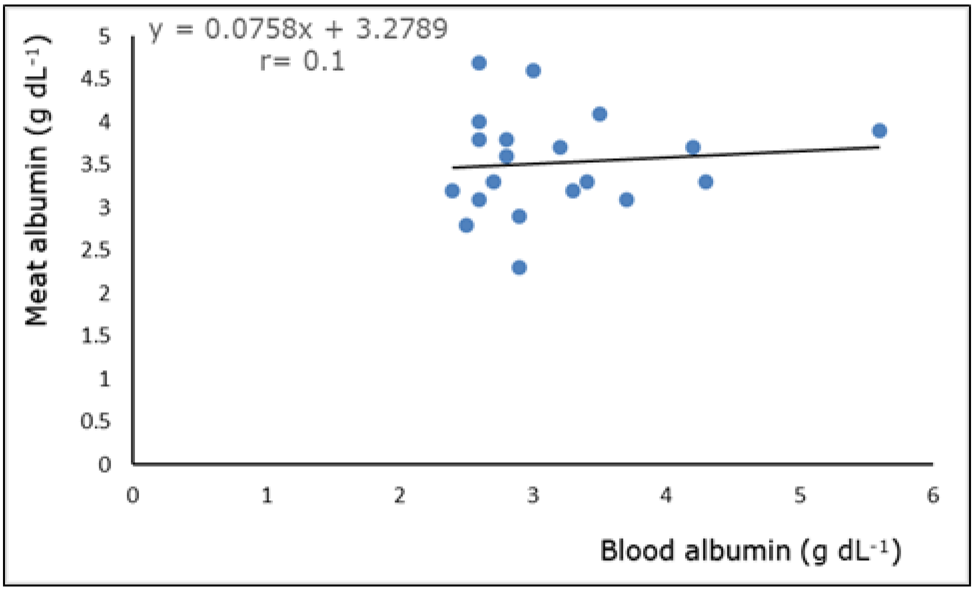


Figure 3. The correlation between albumin content in the blood and albumin content in the meat of Snakehead fish (*Channa striata*).

Referring to the correlation value, the blood albumin is not an appropriate predictor to determine the meat albumin levels of the SHF. Based on the results, individual selection to obtain SHF with high albumin levels is not possible if it is based on the blood albumin content. Fish breeding to improve meat quality has been conducted on several fish, including salmon (Rye 1991; Wold et al 2004), river catfish (Sang et al 2009), or rainbow trout (Folkestad et al 2008), using indirect selection based on the correlation between the value of the predictor and the value of the main trait. The correlation between predicted and observed trait values in these studies was higher, above of 0.84. Unfortunately, most of the genetic gain of the breeding for meat quality in aquaculture is lower than 10% (Gjedrem et al 2017).

***Growth and survival rate***. In addition to albumin content, productivity (multiplication between survival rate and growth) is an important parameter for SHF farming. The high productivity of the SHF will affect the total albumin that will be produced. The productivities or total biomass of the three populations were not different (P>0.05). The growth of the SHF during the 75 days of study is presented in Table 1.

Table 1
Growth parameters and biomass of snakehead fish from Sumatera, Java and Kalimantan populations, after 75 days of rearing

| *Parameters* | *Population* | | |
|---|---|---|---|
| | Sumatera | Java | Kalimantan |
| ΔTL (mm) | 92.23 ±6.81[a] | 103.25±16.48[a] | 100.75±18.82[a] |
| ΔSL (mm) | 79.67±7.57[a] | 85.25±14.5[a] | 82.25±2.56[a] |
| ΔBW (g) | 18.69±4.22[a] | 24.01±9.28[a] | 21.47±4.28[a] |
| SGR (%) | 5.82±0.15[ab] | 6.15±0.39[a] | 5.60±0.19[b] |
| Biomass (g) | 398.7±84.5[a] | 293.8±262.5[a] | 164.5±51.2[a] |

Note: Values followed the same superscript in a similar row are not statistically different (P>0.05). ΔTL - total length gain; ΔSL - standard length gain; ΔBW - body weight gain; SGR - specific growth rate.

In culture conditions, SHF is categorized as a slow growing fish because of its slow response to the pelleted feed in comparison with other farmed fish, such as walking catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*) or tilapia (*Oreochromis niloticus*). Qiufen et al (2013) reported that in the polyculture system of SHF and silver carp (*Hypophthalmichthys molitrix*), the SHF has a lower weight (700 g) than the carp (1150 g) after 190 days. Rahman et al (2012) stated that the SGR of the SHF cultured for 8 months in the grow-out earthen pond was between 1.17–1.34%. Purnamawati et al (2017) reported that the specific growth rate of the SHF in rainwater medium was 4.40% day$^{-1}$. Muliati et al (2018) reported that the SGR of the SHF fed snails was 3.15%, higher than those fed pelleted feed (33% crude protein). The SGR of the SHF from Java and Sumatera were 2.4±0.05% (Ath-thar et al 2017). Furthermore, Muthmainna (2013) reported that after 3 months, both in the fence system and cages system, the SHF grow from 2.69 g to 58.25 g and 48.25 g, respectively. Based on the previous reports, the SGR of the SHF in this study is relatively high, which might be caused by the low stocking density and short duration of the culture.

Meanwhile, the survival rate of the Sumatera population (84±4%) was significantly higher (P<0.05) than the one from Java (42±27%) and Kalimantan (31±11%) (Figure 4).

The SHF is famous as a strong and tolerant fish and it is highly adaptive in marginal waters, especially in low oxygen waters. Courtenay & Williams (2004) and Rahman et al (2018) stated that the SHF is tolerant to water lacking dissolved oxygen and could survive without water for a number of months, as long as the skin and breathing apparatus are kept moist. The fish can live in water with low pH values, 4-5. Commonly, the low survival rate is caused by cannibalism among the fish when feed is scarce (Qin 2003).

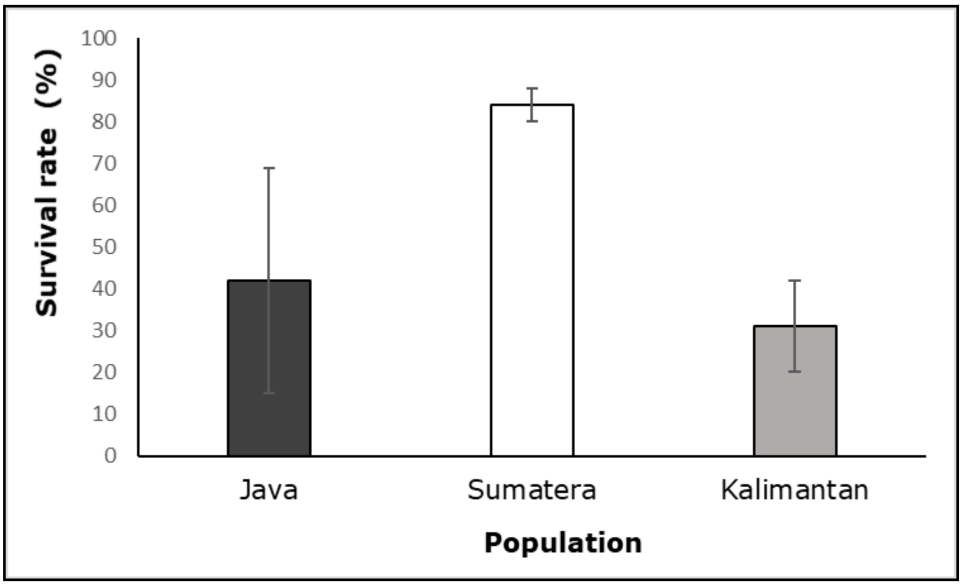


Figure 4. The survival rate of snakehead fish from Sumatera, Java and Kalimantan after 75 days of rearing.

Rahman et al (2012) reported that the survival rate of the SHF in grow-out earthen ponds for 8 months was about 54–67%, depending on the initial stocking density. A similar result is observed by Rahman et al (2013), where the survival rate of the SHF fry after 8 weeks of rearing in earthen ponds was 55–76%. Meanwhile, Purnamawati et al (2017) reported that the survival rate of the SHF cultured for 40 days was about 54.44% and 73.89% in acid sulfate water and rainwater, respectively. The survival rate of the SHF in the present study is categorized as high for the SM population and low for the JV and KL populations. The low survival rate of the SM and KL SHF is mainly caused by high temperatures in the pond, up to 34$^o$C (Table 2), especially in the midday. The study was conducted in the dry season and the air temperature reached 38$^o$C. The shallow concrete pond (50 cm of water) used in the study causes high fluctuations of the water temperatures. Based on the results, the SM population are more tolerant to high temperatures than JV and KL populations. The JV and KL populations are based on either domesticated strains, or resulted from culture. Commonly, selection based on growth characters for parents was conducted to obtain fry with faster growth. Some consequences could be that some other genes (adaptive or tolerance genes) might be reduced, if the selection is not done properly.

***Water Quality***. Pond water quality parameters, including temperature, dissolved oxygen (DO), pH, ammonia ($NH_3$) and nitrites ($NO_2$) during this study are presented in Table 2. Most of the water quality parameters during the SHF rearing were suitable for SHF development, except for the low dissolved oxygen in the early morning and high water temperatures in the midday. The survival rate of SM SHF in this study was higher ($P<0.05$) than the one for the JV and KL populations, which indicates a better tolerance level of the SM population to pond conditions, especially to temperature. Low dissolved oxygen in the early morning is not a serious factor for the SHF, considering the air breathing capacity of the fish (Ishimatsu & Itazawa 1981). The SHF were either obligated or facultative air breathers. Therefore, survival in hypoxic waters is not problematic to these fish (Courtenay & Williams 2004). Meanwhile, high fluctuations of the pond water temperatures have the potential to reduce fish metabolism and influence the fish response to feed. As consequences, the fish become weak and can even die.

Table 2
The values of physical and chemical parameters of water in the snakehead rearing tanks

| *Parameters* | *Populations* | | | *Tolerance range* and optimum range*** |
|---|---|---|---|---|
| | Sumatera | Java | Kalimantan | |
| Temperature (°C) | 25–34.6 | 25–34.6 | 25–34.5 | 26–32** (1) |
| DO (mg $L^{-1}$) | 1.3–6.7 | 1.4–6.8 | 1.4–6.8 | >5 ** |
| pH | 7.3–8.4 | 7.5–8.4 | 7.5–8.4 | 4.25–9.4* (1) |
| Ammonia (mg $L^{-1}$) | 0.01–0.03 | 0.01-0.02 | 0.01–0.02 | 0.54–1.57* (2) |
| Nitrites (mg $L^{-1}$) | 0.01–0.1 | 0.01–0.1 | 0.01–0.1 | <0.1* (3) |

Note: * - tolerance range; ** - optimum range; (1) - Courtenay & Williams (2004); (2) - Qin et al (1997); (3) - Boyd (1990).

**Conclusions**. The albumin content of the snakehead fish from Sumatera, Java and Kalimantan populations is relatively similar. The biomass production from these SHF populations is not different. The low correlation value indicates that blood albumin is not an appropriate predictor to determine the meat albumin levels in the SHF. This implies that the improvement of albumin content through individual selection could be difficult to achieve.

**Acknowledgements**. This study was carried out at the Research Institute for Fish Breeding (RIFB), Ministry of Marine Affairs and Fisheries Indonesia. The authors are thankful to the Director of RIFB for encouragement and for providing facilities and special thanks go to all the members of the research team of the snakehead for close collaboration during this research.

**References**

Andreeva A. M., 2011 Mechanisms of the plurality of *Scorpaena porcus* L. Serum Albumin. Open Journal of Marine Science 1(2):31–35.
Asikin A. N., Kusumaningrum I., 2018 [Characteristics of snakehead fish protein extract based on fish weight size from Mahakam, East Kalimantan]. Jurnal Hasil Perikanan Indonesia 21(1):132–142. [in Indonesian]
Ath-thar M. H. F., Gustiano R., Kusmini I. I., Prakoso V. A., Putri F. P., 2017 [Hormonal induction for gonadal maturation of the stripped snakehead, *Channa striata*]. Jurnal Riset Akuakultur 12(1):9-20. [in Indonesian]
Baker M. E., 2002 Albumin, steroid hormones and the origin of vertebrates. Journal of Endocrinology 175:121–127.
Boyd C. E., 1990 Water Quality in Ponds for Aquaculture. Birmingham, Alabama: Auburn University Press, 359 p.
Chasanah E., Nurilmala M., Purnamasari A. R., Fithriani D., 2015 [Chemical Composition, Albumin Content and Bioactivity of Crude Protein Extract of Native and Cultured *Channa striata*]. Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan 10(2):123–132. [in Indonesian]
Courtenay J. W. R., Williams J. D., 2004 Snakeheads (Pisces, Channidae) - A biological synopsis and risk assesment. U.S. Geological Survey, Denver, 143 p.
Doumas B. T., Watson W. A., Biggs H. G., 1971 Albumin standards and the measurement of serum albumin with bromcresol green. International Journal of Clinical Chemistry 31(1):87-96.
Folkestad A., Wold J. P., Rørvik K. J., Tschudi J., Haugholt K. H., Kolstad K., Mørkøre T., 2008 Rapid and non-invasive measurments of fat and pigment concentrations in live and slaughtered Atlantic salmon (*Salmo salar* L). Aquaculture 280:129-135.
Fuadi M., Santoso H., Syauqi A., 2017 [Albumin level test of snakehead fish (*Channa striata*) in different salinity environment]. Bioscience-Tropic 3(1):23–30. [in Indonesian]

Gjedrem T., 1983 Genetic variation in quantitative traits and selective breeding in fish and shellfish. Aquaculture 33:51-72.
Gjedrem T., 2017 Possibility for improving carcass composition and meat quality traits by selective breeding. International Journal of Currrent Research and Review 9(10):11–18.
Gjedrem T., Robinson N., Rye M., 2012 The importance of selective breeding in aquaculture to meet future demands for animal protein: A review. Aquaculture 350-353:117-129.
Gjerde B., Martens H., 1987 Predicting carcass composition of rainbow trout by near-infrared reflectance spectoscopy. Journal of Animal Breeding and Genetics 104:137-148.
Hariati A. M., Endariani A. Y., Kusuma W. E., Wiadnya D. G. R., 2019 Albumin and enzyme profiles of dwarf snakehead, *Channa gachua* caught from River Brantas, East Java. Journal of Physics: Conference Series 1146:1-5.
Ishimatsu A., Itazawa Y., 1981 Ventilation of the air-breathing organ in the snakehead *Channa argus*. Japanese Journal of Ichtyology 28(3):276–282.
Kovyrshina T. B., Rudneva I. I., 2012 Comparative study of serum albumin level in round goby *Neogobius melanostomus* form Black Sea and Azov Sea. International Journal of Advanced Biological Research 2:203–208.
Kusumaningrum G. A., Alamsjah M. A., Masithah E. D., 2014 [Albumin level test and snakehead fish (*Channa striata*) growth with different commercial feed protein level]. Jurnal Ilmiah Perikanan dan Kelautan 6(1):25–29. [in Indonesian]
Muliati W. O., Kurnia A., Astuti O., 2018 [Comparative study of the growth of snakehead fish (*Channa striata*) fed with pellets and channeled applesnail (*Pamacea cenaliculata*)]. Media Akuatika 3(1):572-580. [in Indonesian]
Mustafa A., Widodo M. A., Kristianto Y., 2012 Albumin and zinc content of snakehead fish (*Channa striata*) extract and its role in health. IEESE International Journal of Science and Technology 1(2):1–8.
Muthmainna D., 2013 Grow out of striped snakehead (*Channa striata*) in swamp water system using fences and cage. 4th International Conference on Biology, Environment and Chemistry 58:52-55.
Permadi J., Sukmarani D., Mudiono, 2017 The effect of toffu to albumin level of snakehead fish (*Channa gachua*). Iogenesis 5(1):7-12.
Ponce-Palafoxa J. T., Lopez-Uriosteguia F., Arredondo-Figueroab J. L., Benitez-Mandujanoc M. A., Gomeza M. G., Esparza-Leald H. M., Hernandeze S. M., 2015 Effect of stocking size on growth performance, biomass, production, yield, and survival of caridean shrimp cage-cultured in a pond system. North American Journal of Aquaculture 76:430–435.
Purnamawati, Djokosetiyanto D., Nirmala K., Harris E., Affandi R., 2017 Survival and growth of striped snakehead fish (*Channa striata* Bloch) juvenile reared in acid sulfate water and rainwater medium. AACL Bioflux 10(2):265-273.
Purnamawati, Nurmala, Shilman M. I., Dewantoro E., Utami D. A. S., 2018 Effects of ameliorant on the growth of snakehead fish (*Channa striata*) juvenile reared in acid sulfate water medium located in tidal land. AACL Bioflux 11(6):1919-1926.
Qin J. G, Fast A. W., Kai A. T., 1997 Tolerance of snakehead *Channa striatus* to ammonia at different pH. Journal of the World Aquaculture Society 28:87-90.
Qin J. G., Fast A. W., 2003 Intensive culture of an air-breathing fish, snakehead (*Channa striatus*) during larval, fingering and growout stages. American Fisheries Society Symposium 38:33–41.
Qiufen D., Zhidong P., Gaoshang M., Song Z., Yong Y., 2013 Hybrid snakehead fish farming in China. AQUA Culture Asia Pacific 9(6):32–36.
Rahman M. A., Arshad A., Amin S. M. N., 2012 Growth and production performance of threatened snakehead fish, *Channa striatus* (Bloch), at different stocking densities in earthen ponds. Aquaculture Research 43:297–302.
Rahman M. A., Arshad A., Amin S. M. N., Shamsudin M. N., 2013 Growth and survival of fingerlings of a threatened snakehead, *Channa striatus* (Bloch) in earthen nursery ponds. Asian Journal of Animal and Veterinary Advances 8:216–226.

Rahman M. A., Molla M. H. R., Sarker M. K., Chowdhury S. H., Shaikh M. M., 2018 Snakehead fish (*Channa striata*) and its biochemical properties for therapeutics and health benefits. Science Forecast Journal Biotechnology Biomedical Engineering 1(1):1-5.
Rye M., 1991 Prediction of carcass composition in Atlantic salmon by computerized tomography. Aquaculture 99(1):35-48.
Sang N., Thomassen M., Klemetsdal H., Gjøen H. M., 2009 Prediction of fillet weight, fillet yield, and fillet fat for live river Catfish (*Pangasianodon hypophthalmus*). Aquaculture 288:166-171.
Siswanto A., Dewi N., Hayatie L., 2016 Effect of haruan (*Channa striata*) extract on fibroblast cells count in wound healing. Journal of Dentomaxillofacial Science 1(2):89-94.
Susilowati R., Januar H. I., Fithriani D., Chasanah E., 2015 [The potency of aquaculture Freshwater Fishes as a Raw Material for Fish Serum Albumin Based Nutraceutical Products]. Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan 10(1):37-44. [in Indonesian]
Wold J. P., Marquardt B. K., Dable B. K., Robb D., Halen B., 2004 Rapid quantification of carotenoids and fat in Atlantic salmon (*Salmo salar* L.) by Raman spectroscopy and chemometrics. Applied Spectroscopy 58:395-403.
Zhang Y. X., Lai R., Lee W. H., Zhang Y., 2005 Frog albumin is expressed in skin and characterized as a novel potent trypsin inhibitor. Protein Science 14:2469–2477.
***APHA, 1998 Standard methods for the examination of the water and wastewater. American Public Health Association, Washington D. C., 1268 p.
*** http://www.big.go.id

Received: 3 June 2019. Accepted: 7 July 2019. Published online: 16 October 2019.
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How to cite this article:
Khasani I., Astuti D. N., 2019 Albumin level, growth and survival rate of snakehead fish (*Channa striata*) from three islands of Indonesia. AACL Bioflux 12(5):1688-1697.