http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2020.1636.1642

Research Article
Length-Weight Relationship and Condition Factor of Two-Spot Catfish (*Mystus nigriceps* [Valenciennes, 1840]) (Pisces, Bagridae), from Kampar Kanan River and Kampar Kiri River in Indonesia

[1]Syafrialdi, [2]Dahelmi, [2]Dewi Imelda Roesma and [3]Hafrijal Syandri

[1]Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Muara Bungo University, 37214 Jambi, Indonesia
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University 25163 Padang, West Sumatra, Indonesia
[3]Department of Aquaculture, Faculty of Fisheries and Marine Science, Bung Hatta University, West Sumatera, 25133 Padang, West Sumatra Indonesia

Abstract

Background and Objective: *Mystus nigriceps* is a consumption fish species and also preferred as ornamental fish. The existence of this species population in Kampar Kanan and Kampar Kiri river continues to decline due to non-selective fishing. While conservation efforts through domestication are currently not done. The purpose of this study was to analyze the relationship between length and weight and relative condition factors of *M. nigriceps* on Kampar Kanan and Kampar Kiri river. **Materials and Methods:** A total of 414 fish were collected from both rivers. Fish samples were collected from local fishermen in Kampar Kanan and Kampar Kiri rivers. The fish length measured by using calipers with an accuracy of 0.01 mm and the weight measured with a digital scale with 0.01 g accuracy. **Results:** The total length of *M. nigriceps* from Kampar Kanan river ranges from 97.48-160.45 mm and weighs 5.58-59.54 g, while from Kampar Kiri river has a total length ranging from 94.66-198.64 and weight of 6.28-60.44 g. The length and weight relationship of *M. negriceps* in Kampar Kanan river can be estimated with equation $W = 0.0029*L^{3.393}$ ($R^2 = 0.86$) with relative condition factor value (Kn) 3.37 and have positive allometric growth pattern. While the length and weight relationship in Kampar Kiri river is $W = 0.0034*L^{3.256}$ ($R^2 = 0.91$) with relative condition factor value (Kn) 4.62 and also have positive allometric growth. **Conclusion:** This study provides the first baseline data on the relationship between length and weight and relative condition factors of *M. nigriceps* from Kampar Kanan and Kampar Kiri rivers in Riau Province, Indonesia. The data is very valuable to build a management system and domestication for the fish species.

Key words: *Mystus nigriceps,* length-weight relationships, regression coefficients, condition factor

Citation: Syafrialdi, Dahelmi, Dewi Imelda Roesma and Hafrijal Syandri, 2020. Length-weight relationship and condition factor of two-spot catfish (*Mystus nigriceps* [Valenciennes, 1840]) (Pisces, Bagridae), from Kampar Kanan river and Kampar Kiri river in Indonesia. Pak. J. Biol. Sci., 23: 1636-1642.

Corresponding Author: Hafrijal Syandri, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bung Hatta University, West Sumatera, 25133 Padang, West Sumatra Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Two spot Catfish, *Mystus nigriceps* (Valenciennes 1840) is group of Bagridae family that exist in slow-flowing waters and muddy substrates[1]. This species founded in Kampar Kanan river[2] also subsist in oxbow lake area around Kampar Kiri river[3]. *M. nigriceps* widely spread in Sumatera, Java and Borneo[1,4]. *M. nigriceps* is popular consumption fish because of its delicious taste and also popular as ornamental fish[5], so the demand for this species at various sizes is very high.

The increase of demand of *M. nigriceps,* leads to species exploitation of smaller size fish and population in nature is endangered[6]. Exploitation, industrialization, water pollution that causes habitat degradation is a threat to population sustainability of *M. nigriceps*[7,8,9]. IUCN reported that *M. nigriceps* as a not evaluated species and conservation management are needed for the sustainability of this species[2,10].

Information about growth patterns and body shapes required for conservation and domestication of *M. nigriceps.* This species growth pattern can be analyzed from the length-weight relationship and condition factors. Determining the relationship between length-weight and condition factors is very important to understand and assess stock production and the factors that influence the population growth of *M. nigriceps*[11-13]. Several studies on the length-weight relationship and condition factors or relative condition factors of the Mystus genus have been carried out by Hossain *et al.*[8] and Sani *et al.*[9]. Until today, there is no report from Kampar Kanan (KKA) and Kampar Kiri (KKI) river except *M. nigriceps* from Batang river[14]. The purpose of this study was to analyze the relationship between length-weight, growth patterns and relative condition factors of *M. nigriceps* in Kampar Kanan (KKA) and Kampar Kiri (KKI) river.

MATERIALS AND METHODS

Sampling area: *M. nigriceps* sample were collected with the help of local fishermen in accordance with the fishers fishing habits of Kampar Kanan (KKA) (N: 0°21'3.78'' E: 101°61'9.00''), Kampar Kiri (KKI) (N: 0°8'8.40'' E: 101°14'57.60''), Kampar Regency, Riau Province. Sample collected from October 2015 to June 2016. A total of 414 fish were collected using traditional fishing gear (gillnet, bubu and fishing rod). The total length measured using digital calipers with an accuracy of 0.01 mm and weight measured using digital scale Kern: ABS 220-4 Analytical Balance with an accuracy of 0.01 g. Samples grouped according to sex and study location. Fish samples were preserved with 10% formalin and species identification confirmed with relevant guidance[1,15].

Length-weight relationship*:*Length-weight relationships calculated based on population origin and sex[16,17]. The equation used is:

$$W = aL$$

Transformed into logarithm:

$$\text{Log } W = \log a + b \log L$$

where, W is the total weight (g), L is total length (mm), a = regression intercept, b = regression slope[12,17]. Regression analysis and the correlation between length-weight and condition factors by using Microsoft Excel 2007.

Growth pattern. Growth patterns comparing regression coefficients (b) were analyzed according to Froese[17] and Okgerman[18]: 1. if b <3, fish growth is negative allometric (body length growing faster than weight gain); 2. if b> 3, positive allometric (weight gain is faster than body length); 3. if b = 3, isometrik (balanced in body length growth and weight gain). Relative condition factor. The relative condition factor (Kn) calculated based on population origin and sex. If $b \neq 3$, The relative condition factor or Kn is calculated based on population origin and sex[19]. $Kn = W/aL^b$, where Kn is a relative condition factor; W is fish weight (g); L is fish total length (mm); a = constant and b = coefficient obtained from the length-weight relationship.

RESULTS

Distribution based on body size: Total of 414 *M. nigriceps* were analyzed in this study, 202 individuals of *M. nigriceps* from Kampar Kanan (KKA) and 212 individuals from Kampar Kiri (KKI). Male-female ratio is 40.10-59.90%, respectively. The average length and weight of female fish were greater than males. Total length and weight based on population origin and sex indicated on Table 1.

Length-weight Relationship (LWR): Statistic description of Length-weight Relationship (LWR) of *M. nigriceps* population from KKA and KKI showed on Table 2. The r values of 0.894 and 0.949 are close to 1 which indicates a very strong and positive relationship between weight gain and length growth of *M. nigriceps*. While based on sex category, the correlation coefficient ranges from 0.723 to 0.949, meaning that origin and sex also have a very strong relationship. The coefficient of

Table 1: The total number of male, female *M. nigriceps* and their total length and body weight observed from population KKA and KKI rivers

Habitat	Sex	N	Range total length (mm)	Mean total length (±SD)	Range body weight (g)	Mean body weight (±SD)
Kampar Kanan (KKA)	Male	96	99.84-153.94	127.66±11.25	6.06-28.55	14.60±4.61
	Female	106	97.48-160.45	129.14±14.01	5.58-55.54	16.23±7.63
	Population	202	97.48-160.45	128.06±12.57	5.58-59.54	15.26±6.169
Kampar Kiri (KKI)	Male	70	103.07-169.38	134.79±12.86	6.90-89.09	19.48±10.54
	Female	142	94.66-198.64	139.93±18.58	6.28-60.44	21.84±11.04
	Population	212	94.66-198.64	138.15±17.01	6.28-60.44	20.76±9.83

Table 2: The length-weight relationship and relative condition factor of *M. nigriceps*

Habitat	Category	N	A	B	R	R^2	Kn	$W = aL^b$	p-value
Kampar Kanan (KKA)	Male	96	0.0029	3.308	0.935	0.884	3.29	$W = 0.0029\ L^{3.308}$	0.01
	Female	106	0.0022	3.446	0.897	0.845	3.45	$W = 0.0022\ L^{3.446}$	0.01
	Population	202	0.0025	3.393	0.894	0.859	3.37	$W = 0.0025\ L^{3.393}$	0.01
Kampar Kiri (KKI)	Male	70	0.0031	3.293	0.723	0.716	4.31	$W = 0.0031\ L^{3.293}$	0.01
	Female	142	0.0028	3.339	0.949	0.908	4.74	$W = 0.0028\ L^{3.339}$	0.01
	Population	212	0.0034	3.256	0.949	0.908	4.62	$W = 0.0034\ L^{3.256}$	0.01

N-Number of fish samples; A-intercept; B-slope; R-correlation coefficient; R^2-coefficient determination; Kn-condition factor

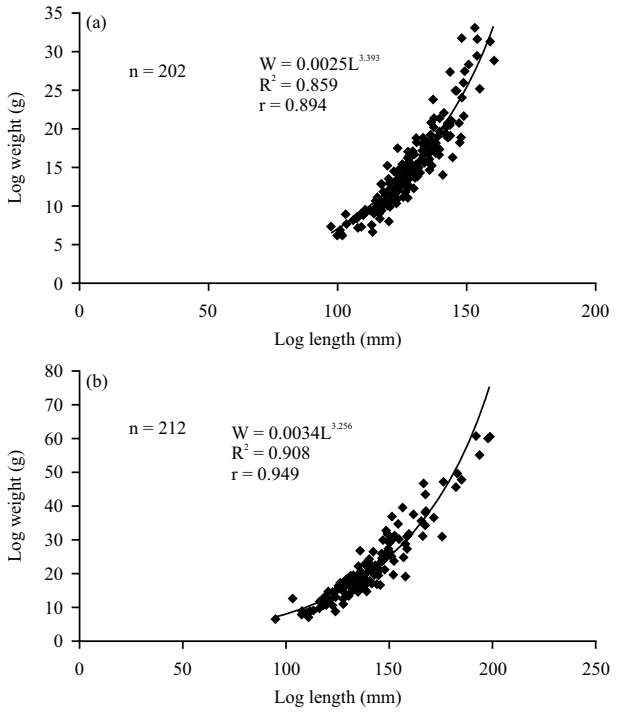

Fig. 1(a-b): Length-weight relationship of *M. nigriceps* in (a) Kampar Kanan river and (b) Kampar Kiri river

determination (R^2) presented in Fig. 1a-b. The R^2 values from KKA and KKI in this study were 0.859 and 0.908 respectively, while the value of R^2 based on sex, ranges from 0.716 to 0.908. This value indicates the body length affects total body weight. Both population origin and sex categories showed significant value ($p<0.01$). Calculation of length-weight relationship (LWR) of *M. nigriceps* shows the value of a (intercept) of 0.0025; b (slope) 3,393 for KKA river population and a (intercept) value of 0.0034; b (slope) of 3,256 for KKI river population (Fig. 1a-b). Based on sex category, the value of a (intercept) ranges from 0.0022 to 0.0031 and; b (slope) ranges from 3,308 to 3,446. All values of b>3 indicate positive allometric growth patterns for *M. nigrceps* (Table 2).

Relative condition factor (Kn): Table 2 shows the relative condition factors (Kn) of *M. nigriceps* from KKA and KKI rivers. The average Kn value is 3.36 and 4.56 for the entire population of KKA and KKI population, respectively. The average Kn values for male and female KKA populations are 3.29 and 3.45, respectively. The average Kn values for male and female KKI populations are 4.31 and 4.74, respectively. Based on sex category the average female fish has a larger Kn size than the male. Average Kn value from KKI river population also greater than KKA river. Kn values are highly correlated with length-weight relationships and therefore exponent b is very important for assessing fish species in good condition. This study provides new information of *M. nigriceps* species from KKA and KKI rivers because there is no previous study conducted about LWR from this location.

DISCUSSION

Size variety of fish caught from KKA and KKI rivers cannot be separated from the use of fishing gear. This condition was previously reported in *Cirrhinus reba* in Padma river of Bangladesh[20] and *Hamapala macrolepidota* in Singkarak lake, West Sumatra, Indonesia[21]. The maximum length of *M. nigriceps* founded in this study is 198.64 mm, longer than *M. nigriceps* (195 mm) caught in the Batang Martapura river, South Kalimantan[14] and *M. pancalus* (126 mm), *M. tengara* (112 mm) from Brahmaputra river, Bangladesh[22]. In contrary, with *M. cavasius* (274 mm) and *M. tengara* (330 mm) from Betwa river and Gomti, Uttar Pradesh, India[9,23]. The difference in size may be due to the use of different sizes and type of

fishing gear. Variations in size most likely caused by the size of fishing gear and the effects of formalin during preservation[24]. In addition, geographic, ecological and water quality parameters as fish habitat largely determine the morphological differences and size[25].

Table 1 showed that the catch number is not balanced between male and female fish. The ratio of male and female fish caught compared to 0.91: 1.1 for KKA river and 0.4: 2.03 for KKI river. According to Mitu *et al.*[26] natural population ratios range from 1:1. This ratio can shift before and during spawning, especially by fish-catching factors. In KKA and KKI rivers, the population of female fish is greater than the male. Many possibilities cause the differences in the sex ratio, including community activities in river banks and along the river[2].

On the upstream of KKA river, there are Koto Panjang reservoir and community and plantations floating net cages, while on KKI river there are flooding swamps with plantation activities, rubber plantations and sand mining activities. The difference in activities that occur estimated to have an effect on fish quality, food composition, changes in water levels including sediment travel which ultimately affects fish metabolism and biology. The activities mentioned brought different impacts to the habitat including non-selective fishing. Thus, it becomes necessary to standardize the sampling size, water depth, mating season and fish biology[27]. Banik *et al.*[28] reported that in the *Ompok pabda,* the sex ratio of female fish was higher than male fish. Mitu *et al.*[26] also recently reported that *M. tengara* showed a greater ratio of female than male fish. The difference in sex ratio of male fish can be caused by differences in metabolic strain. Older male fish at spawning have higher possibilities to die than female and can occur in other fish species[26].

Table 2 showed the relationship of length-weight of *M. nigriceps* in KKA and KKI river with value of b> 3 indicating a positive allometric growth pattern. This means that weight gain is faster than body length growth. Differences in growth patterns can be caused by fish length, gonad maturity size and stomach fullness[29-31], included differences in habitats[32]. Other researchers also stated that the level of fish gonad maturation positively correlated with water chemical-physical properties, food availability, age differences[17,33-36], including waters conditions for spawning, such as currents, water substrate[37]. But in this study we did not analyze the relationship between water quality parameters and the level of maturity of *M. nigriceps* gonads.

Khan and Sabah[38] pointed out that fish LWR cannot be separated from spatial and temporal factor, sex and sexual maturity. Variations in the value of b highly dependent on geographical factors, biological conditions, environmental, temporal and sampling time[17,39]. Thus, isometric or allometric growth patterns can occur in the same or different species[40]. In addition to growth patterns, condition factors are part of growth parameters. The condition factor shows if the fish in good condition, in terms of physical capacity for survival and reproduction[19]. The average value of *M. nigriceps* relative conditions in KKA is 3.37 and KKI is 4.62, which mean that *M. nigriceps* in the KKA and KKI rivers were in good condition with all positive allometric patterns. According to Shinkafi and Ipinjolu[41] that fish growth is in good condition, if Kn value> 2. The relative condition factor-factor of *M. nigrceps* from KKA and KKI rivers is higher compared to *M. nigriceps* from Batang river[14]. The differences in this condition factors related to biological interactions involving intra-specific competition for food, sex, space between species, feeding intensity, gonad development and food availability[20]. But in this study, the number of *M. nigriceps* populations continues to decline due to non-selective fishing activities. The non-selective capture and habitat degradation results in a decline of fish populations including *M. nigriceps* [42].

Fluctuations in condition factors also caused by the suitability and availability of food at a certain time and the feeding intensity related to the fish gonad development process[20,33,43]. The relative condition factor of *M. nigriceps* is probably caused by the relatively small population and proportional body length-weight. Fluctuations in condition factors that calculated from different size groups give an indication of the fish is in its growth period. The first peak shows the condition of sexual maturity, which generally shows a fast growth rate, while the second peak coincides with a measure of reproductive sexual maturity, which generally shows a fast growth rate at the time for spawning[33,43,44]. In addition, conditions factors fluctuated due to metabolic tension during maturity or spawning and the habit of eating and changing seasons[13,33]. The condition factor is inseparable from changes in water temperature, where the season causes a drastic change in environmental conditions[45,46]. This means that the relative condition factor shows the suitability of fish with their habitat. The greater the condition factors, means fish are in the better condition[36]. The relative condition factor can be one of the tools to identify sustainable fishing management by involving the community and local government.

CONCLUSION

Kampar Kanan and Kampar Kiri river ecosystem support *M. nigriceps* to have positive allometric growth patterns with almost the same Kn value. This data can be used for the management and domestication of *M. negriceps* in the future. In addition, the capture of this species must be done selectively in these two rivers.

SIGNIFICANCE STATEMENT

This study provide important information regarding growth patterns and relative condition factors of *M. nigriceps* that carried out for the first time on Kampar Kanan and Kampar Kiri rivers, which the population in numbers continues to decline due to non-selective fishing. Data on growth patterns and relative condition factors can be used in understanding the frameworks regarding management and domestication of *M. nigriceps* species in Riau province, Indonesia. This study also can be the tools to control fishing activities and identify sustainable fishing management by involving the community and local government.

ACKNOWLEDGMENTS

The author is grateful for the educational assistance from the Ministry of Research and Technology, Directorate of Higher Education, which provides opportunities for continuing education through the Domestic Postgraduate Education Scholarship (BPPDN) scheme. Thank you for the material and moral assistance given by Muara Bungo University and the Genetics and Biomolecular Laboratory, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, West Sumatra, Indonesia.

REFERENCES

1. Ng, H.H., 2002. The identity of *Mystus nigriceps* (Valenciennes in Cuvier and Valenciennes, 1840), with the description of a new bagrid catfish (Teleostei: Siluriformes) from Southeast Asia. Raffles Bull. Zool., 50: 161-168.
2. Aryani, N., I. Suharman, Azrita, H. Syandri and A. Mardiah, 2020. Diversity and distribution of fish fauna of upstream and downstream areas at Koto Panjang Reservoir, Riau Province, Indonesia. J. F1000Res., Vol. 8.
3. Simanjuntak, C.P.H., M.F. Rahardjo and S. Sukimin, 2006. [Ichthyofauna in floodplain of Kampar Kiri river]. J. Ikhtiologi Indonesia, 6: 99-109, (In Indonesian).
4. Kottelat, M., 2013. The fishes of the inland waters of Southeast Asia : a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. 1st Edn., National University of Singapore, Singapore, Pages: 663.
5. Haniffa, M.A., 2009. Native catfish culture: A technology package for fish farmers. Aquacult. Asia Mag., 14: 23-24.
6. Lim K.K.P. and H.H. Ng, 2008. *Pseudomytus heokhuii*, a new species of bagrid catfish from Sumatra (Teleostei: Bagridae). Zootaxa., 1686: 37-47.
7. Mijkherjee, M., A. Praharaj and S. Das, 2002. Conservation of endangered fish stocks through artificial propagation and larval rearing technique in West Bengal, India. Aquacult. Asia, 2: 8-11.
8. Hossain, M.Y., M.A Hossen, M.N.U. Pramanik, S. Sharmin and F. Nawer *et al*., 2016. Length-weight and length-length relationships of five *Mystus* species from the Ganges and Rupsha rivers, Bangladesh. J. Appl. Ichthyol., 32: 994-997.
9. Sani, R., B.K. Gupta, U.K. Sarkar, A. Pandey, V.K. Dubey and W.S. Lakra, 2010. Length-weight relationships of 14 Indian freshwater fish species from the Betwa (Yamuna River tributary) and Gomti (Ganga River tributary) rivers. J. Appl. Icthyol., 26: 456-459.
10. Ng. H.H., 2019. *Mystus nigriceps*. The IUCN Red List of Threatened Species 2019.
11. Esmaeili, H.R., G. Sayyadzadeh, S. Ghasemian, S. Mirghiyasi, R.Z. Nejad and J. Freyhof, 2013. Length-weight relationships of *Turcinoemacheilus kosswigi* Banarescu and Nalbant, 1964 (Teleostei: Nemacheilidae) in southwestern Iran and its relation to habitat structure. J. Appl. Ichthyol., 29: 290-291.
12. Datta, S.N., V.I. Kaur, A. Dhawan and G. Jassal, 2013. Estimation of length-weight relationship and condition factor of spotted snakehead *Channa punctata* (Bloch) under different feeding regimes. SpringerPlus, 10.1186/2193-1801-2-436
13. Rahman, M.A.U., S.A. Khan, P.S. Lyla, K. Kadharsha, P.M. Chander and B.A. John, 2013. Length-weight relationship and condition factor of *Liza subviridis* (Valenciennes, 1836) of Parangipettai waters, Southeast coast of India. Pak. J. Biol. Sci., 16: 345-350.
14. Ahmadi, 2018. Length-weight relationship and condition factor of the *Mystus nigriceps* from Sungai Batang river, Indonesian. Int. J. Innovative Studies Aqua. Biol. Fish., 4: 26-35.
15. Kottelat, M., A.J. Whitten, S.N. Kartikasari and S. Wirjoatmodjo, 1993. Freshwater Fishes of Western Indonesia and Sulawesi. Periplus Editions (HK) Ltd., Hong Kong, Pages: 221.
16. Le Cren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis*). J. Anim. Ecol., 20: 201-219.

17. Froese, R., 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. J. Applied Ichthyol., 22: 241-253.
18. Okgerman, H., 2005. Seasonal variations in the length-weight relationship and condition factor of rudd (*Scardinius erythrophthalmus* L.) in sapanca lake. Int. J. Zool. Res., 1: 6-10.
19. Effendie, M.I, 2006. Fisheries Biology. Putra Nusatama Foundation, Indonesia, Pages: 163.
20. Jewel, M.A.S., M.A. Haque, M.S. Ferdous, M.S. Khatun and S. Akter, 2019. Length-weight relationships and condition factors of *Cirrhinus reba* (Hamilton, 1822) in Padma River, Bangladesh. J. Fish. Aquat. Sci., 14: 39-45.
21. Risdawati, R., D. Dahelmi, J. Nurdin and H. Syandri, 2020. Bioecological aspects of *Hampala macrolepidota* in Lake Singkarak, West Sumatera, Indonesia. AACL Bioflux., 13: 893-901.
22. Islam, M.R. M.G. Azom., M. Faridullah and M. Mamun, 2017. Length-weight relationship and condition factor of 13 fish species collected from the Atrai and Brahmaputra rivers, Bangladesh. J. Biodiver. Environ. Sci., 10: 123-133.
23. Kumar, R., S.S. Yadav and M. Tripath, 2014. Studies on length–weight relationship of seven commercially important freshwater fish species of Gomti River Lucknow (U.P.) India. Int. J. Fish. Aqua. Stud., 1: 1-3.
24. Hossain, M.Y., 2010. Morphometric relationships of length-weight and length-length of four cyprinid small indigenous fish species from the Padma River (NW Bangladesh). Turk. J. Fish. Aquat. Sci., 10: 131-134.
25. Syandri, H., N. Aryani, S. Hasibuan and A. Mardiah, 2017. Morphometric characteristics of asian catfish, *Hemibagrus wyckii* (Bleeker, 1858) (Bagridae), from the riau province of Indonesia. Pakistan J. Biol. Sci., 20: 382-389.
26. Mitu, N.R. and M.M. Alam, M.A. Hussain, M.R. Hasan amd A.C. Singha, 2019. Length-weight and length-length relationships, sex ratio and condition factors of the Asian striped dwarf catfish *Mystus tengara* (Hamilton, 1822) (Siluriformes: Bagridae) in the Ganges River, Northwestern Bangladesh. Northwestern Bangladesh Iran. J. Ichthyol., 6: 21-30.
27. Hamid, M., M. Mansor and S.A.M. Nor, 2015. Length-weight relationship and condition factor of fish populations in Temengor reservoir: Indication of environmental health. Sains Malaysiana, 44: 61-66.
28. Banik, S.K., P. Goswami, T. Acharjee and S. Malla, 2012. *Ompok pabda* (Hamilton-Buchanan, 1822): An endangered catfish of Tripura, India; reproductive physiology related to freshwater lotic environment. J. Envir., 1: 45-55.
29. Ozaydin, O., D. Uckun, S. Akalin, S. Leblebici and Z. Tosunoglu, 2007. Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea. J. Applied Ichthyol., 23: 695-696.
30. Cherif, M., R. Zarrad, H. Gharbi, H. Missaoui and O. Jarboui, 2008. Length-weight relationships for 11 fish species from the Gulf of Tunis (SW Mediterranean Sea, Tunisia). Pan-Am. J. Aquatic Sci., 3: 1-5.
31. Karna, S.K., D.K. Sahoo and S. Panda, 2012. Length Weight Relationship (LWR) and Growth estimation of *Lates calcarifer* (Bloch) in Chilika Lagoon, India. Bull. Environ. Pharmacol. Life Sci., 1: 61-66.
32. Aryani, N., I. Suharman and H. Syandri, 2018. Reproductive performance of asian catfish (*Hemibagrus wyckii* Bagridae), a candidate species for aquaculture. F1000 Res., Vol. 7. 10.12688/f1000research.14746.1
33. Gupta, S., 2014. Morphology, growth pattern, feeding and reproductive biology of *Mystus gulio* (Hamilton-Buchanan, 1822) (Siluriformes: Bagridae). Int. J. Aquatic Biol., 2: 201-205.
34. Rajagopal, B. and P. Davidar, 2008. On the population and breeding aspects of catfish in fresh water wetlands of Tamil Nadu, Peninsular India. Electron. J. Ichthyol., 1: 18-30.
35. Hasri. I., M.M. Kamal and Zairion, 2011. Growth and exploitation rate of endemic fish *Rasbora tawarensis* (Weber and de Beaufort, 1916) at Laut Tawar Lake in Central Aceh. Jurnal Iktiologi Indonesia., 11: 21-28.
36. Nehemia, A., J.D. Maganira and C. Rumisha, 2012. Length-weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. Agric. Biol. J. North Am., 3: 117-124.
37. Syandri, H., Azrita and N. Aryani, 2013. [Size distribution, reproduction and spawning habitat of Bilih fish (*Mystacoleucus padangensis* Blkr.) in lake Singkarak]. Bawal, 5: 1-8, (In Indonesian).
38. Khan, M.A. and Sabah, 2013. Length-weight and length-length relationships for five fish species from Kashmir Valley. J. Appl. Ichthyol., 29: 283-284.
39. Nofrita, Dahelmi, H. Syandri and D.H. Tjong, 2013. The Relationship between Growth Appearance and the Characteristics of Bilih Fish Habitat (*Mystacoleucus padangensis* Blekeer) Semirata FMIPA University Lampung, Mei 10-12, 2013, pp: 179-183.
40. Olurin, K.B. and O.A. Aderibigbe, 2006. Length-weight relationship and condition factor of pond reared juvenile *Oreochromis niloticus*. World J. Zool., 1: 82-85.
41. Shinkafi, B.A. and J.K. Ipinjolu, 2012. Gonadosomatic index, fecundity and egg size of *Auchenoglanis occidentalis* (Cuvier and Valenciennes) in Rima River, North-western Nigeria. Niger. J. Basic Appl. Sci., 20: 217-224.
42. Directorate General of Capture Fisheries, 2010. Maritime and fisheries statistical data. Ministry of Maritime Affairs and Fisheries. Indonesia, Pages: 282.
43. Mathialagan, R., R. Sivakumar, N. Rajasekaran and S. Chandrasekar, 2014. Length-frequency distribution and length-weight relationship of Reba carp *Cirrhinus reba* (Hamilton, 1822 Cypriniformes: Cyprinidae) from lower anicut, Tamil Nadu, India. Int. J. Fish. Aquatic Stud., 2: 115-125.

44. Begum, M. H.K. Pal, M.A. Islam and M.J. Alam, 2010. Length-weight relationship and growth condition of *Mystus gulio* (Ham.) in different months and sexes. Univ. J. Zool. Rajshahi Univ., 28: 73-75.
45. Godad, S.P., P.D. Naidu and B.A. Malmgren, 2011. Sea surface temperature changes during May and August in the western Arabian Sea over the last 22kyr: Implications as to shifting of the upwelling season. Marine Micropaleontol., 78: 25-29.
46. Nahdi, A.A.L., C.G. De Leaniz and A.J. King, 2016. Spatio-temporal variation in length-weight relationships and condition of the ribbonfish *Trichiurus lepturus* (Linnaeus, 1758): Implications for fisheries management. PLoS ONE, Vol. 11. 10.1371/journal.pone.0161989